

# Energy Outlook and Energy Saving Potential in East Asia 2025



Economic Research Institute  
for ASEAN and East Asia

## **Energy Outlook and Energy Saving Potential in East Asia 2025**

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# Foreword

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The preparation of the East Asia Summit (EAS) Energy Outlook and Energy Saving Potential reports began in 2007 alongside the establishment of the EAS Energy Cooperation Task Force, a forum comprising high-level policymakers from EAS participating countries. Since their inception, the Energy Outlook studies have assessed how ambitious energy-saving measures and low-carbon energy targets – particularly the expansion of renewable energy – reported by EAS countries contribute to reductions in energy consumption and CO<sub>2</sub> emissions across the region.

To support this analysis, the Energy Outlook traditionally developed two scenarios: a business-as-usual (BAU) scenario and an alternative policy scenario (APS). The APS reflects the implementation of aggressive energy-saving and low-carbon energy policies, while the difference between the BAU and APS scenarios represents the potential energy savings and CO<sub>2</sub> emissions reductions. This analytical framework has been continuously applied and refined over time.

In recent years, the global policy focus has shifted decisively towards achieving carbon neutrality by mid-century or later, particularly following the United Nations Climate Change Conference (COP26) in 2021. In response, the EAS Energy Outlook was expanded during the 2021–22 update to include a low-carbon energy transition (LCET) scenario, in addition to the BAU and APS scenarios. Decarbonisation in this context entails a broad transition away from fossil fuels through the deployment of energy efficiency and conservation (EEC) measures, renewable energy – both variable and traditional – and nuclear power.

At the same time, many thermal power plants in the Asian region are relatively young, with an average age of less than 10 years. This underscores the importance of managing a gradual transition through the application of abatement measures, including the co-firing of hydrogen, ammonia, and biomass, as well as the deployment of carbon capture, utilisation, and storage (CCUS) technologies. While energy technology selection is often based on optimisation approaches, the EAS Energy Outlook adopts an econometric modelling framework. This approach allows national model teams to select low-carbon technologies based on country-specific circumstances and policy priorities in pursuit of carbon neutrality by 2050 or later.

Although the LCET scenario does not represent a least-cost pathway, it illustrates a plausible transition towards carbon neutrality for EAS countries. To better understand the economic implications of this transition, the EAS Energy Outlook includes a comparative analysis of energy costs under the BAU and LCET scenarios. These costs comprise additional fuel expenditures (including fossil fuels and hydrogen and/or ammonia) projected for 2060, power sector investment costs required between 2021 and 2060, and carbon capture and storage costs in 2060. As both scenarios entail substantial energy demand by 2060, the comparison provides insights into the relative cost implications of maintaining current practices versus pursuing a low-carbon transition.

It is hoped that this report will serve as a valuable reference and a basis for informed discussion on pathways towards carbon neutrality in the EAS region.



**Tetsuya Watanabe**

President,  
Economic Research Institute for ASEAN and East Asia

# Preface

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The 2023–2024 update of the East Asia Summit (EAS) Energy Outlook analyses carbon-neutral pathways for EAS member countries, with the exception of Russia. The Outlook presents two scenarios: a business-as-usual (BAU) scenario and a low-carbon energy transition (LCET) scenario, which illustrates pathways towards achieving carbon neutrality between 2050 and 2070.

Originally, the EAS Energy Outlook was designed to assess the effectiveness of energy efficiency and conservation (EEC) and renewable energy (RE) policies reported by EAS member countries. However, achieving carbon neutrality requires more than EEC and RE alone. The LCET scenario therefore incorporates innovative clean energy technologies, including electrification, clean fuels such as hydrogen and ammonia, and carbon capture and storage (CCS).

Under the LCET scenario, fossil fuel consumption is substantially reduced, while electricity demand increases significantly. This transition drives a rapid shift in the power generation mix—from conventional thermal power plants to renewable energy sources such as solar photovoltaics and wind power, alongside hydro and nuclear power, as well as abated thermal power plants using hydrogen and ammonia co-firing. Given the relatively low capacity factors of variable renewable energy sources—such as solar photovoltaics, which average around 17% in the ASEAN region—a substantial expansion of renewable energy capacity is required. As a result, renewable energy accounts for the largest share of the power generation mix under the LCET scenario.

In the 2023–2024 Outlook, an energy cost comparison between the BAU and LCET scenarios is also conducted. Total energy costs comprise fuel costs, power generation investment costs, and CCS costs. Fuel costs include fossil fuels (coal, oil, and natural gas) as well as clean fuels (hydrogen and ammonia). Power generation investment costs cover all technologies, including thermal power plants, conventional renewable energy (hydro and geothermal), variable renewable energy (solar and wind), nuclear power, and abated thermal power plants. CCS costs are calculated based on the volume of CO<sub>2</sub> captured and stored, multiplied by an assumed unit cost (US dollars per tonne of CO<sub>2</sub>). Estimates of fuel consumption, required and additional generation capacity, and CO<sub>2</sub> volumes treated by CCS are derived from the EAS Energy Outlook modelling results.

It should be noted that unit costs for fuels, power plants, and CCS are based on assumed values; therefore, total energy cost outcomes are sensitive to changes in these assumptions. Nevertheless, the analysis indicates that the LCET scenario can be competitive with the BAU scenario in terms of overall energy costs. At the same time, it is important to recognise that the costs of battery energy storage systems (BESS), which will be increasingly necessary to manage the variability of renewable energy, are not yet included in the analysis and should be addressed in future updates.

The carbon-neutral pathways and associated energy cost analysis presented in the EAS Energy Outlook 2023–2024 provide valuable insights for energy policymakers across EAS member countries. It is my hope that this Outlook will serve as a widely referenced resource in supporting informed, evidence-based energy policy decisions in the region.



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# Acknowledgements

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I would first like to express my sincere appreciation to the members from the EAS17 countries – Australia, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, the Republic of Korea, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, New Zealand, the Philippines, Singapore, Thailand, the United States, and Viet Nam – for their valuable contributions to the development and finalisation of their respective energy outlooks and energy-saving potential analyses.

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# List of Abbreviations and Acronyms

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|                          |                                                     |
|--------------------------|-----------------------------------------------------|
| <b>AAGR</b>              | average annual growth rate                          |
| <b>ACE</b>               | ASEAN Centre for Energy                             |
| <b>ASEAN</b>             | Association of Southeast Asian Nations              |
| <b>BAU</b>               | business as usual                                   |
| <b>CAPEX</b>             | capital expenditure                                 |
| <b>CCGT</b>              | combined cycle gas turbine                          |
| <b>CCS</b>               | carbon capture and utilisation                      |
| <b>CCUS</b>              | carbon capture, utilisation, and storage            |
| <b>CO<sub>2</sub></b>    | carbon dioxide                                      |
| <b>COVID-19</b>          | novel coronavirus disease                           |
| <b>EDL</b>               | Électricité du Laos                                 |
| <b>EDL-GEN</b>           | EDL-Generation Public Company                       |
| <b>ERIA</b>              | Economic Research Institute for ASEAN and East Asia |
| <b>GDP</b>               | gross domestic product                              |
| <b>GHG</b>               | greenhouse gas                                      |
| <b>IEA</b>               | International Energy Agency                         |
| <b>IEEJ</b>              | The Institute of Energy Economics, Japan            |
| <b>IFC</b>               | International Finance Corporation                   |
| <b>IMF</b>               | International Monetary Fund                         |
| <b>IRENA</b>             | International Renewable Energy Agency               |
| <b>JOGMEC</b>            | Japan Oil, Gas and Metals National Corporation      |
| <b>KW</b>                | kilowatt                                            |
| <b>KWh</b>               | kilowatt-hour                                       |
| <b>Lao PDR</b>           | Lao People's Democratic Republic                    |
| <b>LCET-CN</b>           | low-carbon energy transition and carbon neutral     |
| <b>LEAP</b>              | Low Emissions Analysis Platform                     |
| <b>NREL</b>              | National Renewable Energy Laboratory                |
| <b>METI</b>              | Ministry of Economy, Trade and Industry             |
| <b>MW</b>                | megawatt                                            |
| <b>Mt-CO<sub>2</sub></b> | million tonnes of CO <sub>2</sub>                   |
| <b>Mtoe</b>              | million tonnes of oil equivalent                    |
| <b>NDC</b>               | nationally determined contribution                  |
| <b>OPEX</b>              | operating expense                                   |
| <b>PV</b>                | photovoltaic                                        |
| <b>SC</b>                | super critical                                      |

|              |                                         |
|--------------|-----------------------------------------|
| <b>TFEC</b>  | total final energy consumption          |
| <b>TPES</b>  | total primary energy supply             |
| <b>TWh</b>   | terawatt-hours                          |
| <b>UN</b>    | United Nations                          |
| <b>US</b>    | United States                           |
| <b>USAID</b> | US Agency for International Development |
| <b>USC</b>   | ultra-supercritical                     |
| <b>VRE</b>   | variable renewable energy               |



# Executive Summary

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Achieving carbon neutrality requires a fundamental shift from fossil fuels to low-carbon energy sources and technologies. The United Nations Framework Convention on Climate Change defines carbon neutrality as a balance in which carbon dioxide (CO<sub>2</sub>) emissions from human activities are equal to or lower than the amount of CO<sub>2</sub> removed from the atmosphere, including absorption by natural carbon sinks such as forests. Reforestation and the preservation of existing forests are therefore essential components of carbon-neutral strategies. However, given the limited availability of carbon sinks and the long time horizons required to expand them, the deployment of low-carbon energy technologies to reduce emissions at source is indispensable.

In the final energy consumption sectors, key measures include the promotion of energy efficiency and conservation (EEC), electrification through electric vehicles and electric cooking appliances, and the increased use of clean fuels such as biofuels, hydrogen, ammonia, and synthetic fuels (including e-fuels, e-methane, and sustainable aviation fuels). In the power sector, achieving carbon neutrality will require a substantial expansion of renewable energy – both variable and traditional – along with increased deployment of nuclear power and the application of abated thermal power plants through biomass and hydrogen or ammonia co-firing, as well as carbon capture and storage (CCS).

Pathways to carbon neutrality differ significantly between developed and developing countries in the East Asia Summit (EAS) region. Developing countries are expected to experience higher economic growth as they continue to catch up with advanced economies. As a result, despite the implementation of EEC policies, a substantial reduction in absolute energy consumption is unlikely. These countries will therefore need to expand renewable energy deployment significantly while continuing to utilise existing thermal power plants with increasing levels of abatement. Abatement technologies are assumed to be introduced gradually from around 2030, with relatively low abatement ratios initially, followed by a sharp increase after 2040 as technologies mature and markets expand.

In contrast, carbon-neutral pathways in developed EAS countries place greater emphasis on reducing energy consumption through EEC, accelerating electrification – particularly in the transport sector – and increasing the use of clean fuels in industry and transport. In the power sector, developed countries are assumed to expand variable renewable energy more aggressively, supported by large-scale battery energy storage systems and nuclear power generation. Although abated thermal power plants also appear in the low-carbon energy transition (LCET) scenario, they play a more limited role than in developing countries.

This report employs the EAS Energy Outlook model, which uses an econometric approach to develop carbon-neutral pathways for the EAS17 countries. As this approach does not guarantee cost-minimising outcomes, a comparative energy cost analysis between the business-as-usual (BAU) and LCET scenarios is conducted. Energy costs are assessed across three components: (i) fuel costs, reflecting changes in fossil fuel and hydrogen consumption between 2021 and 2050 valued at 2050 prices; (ii) power investment costs, based on additional generation capacity required for each power source during 2021–2050; and (iii) CCS costs, calculated from the incremental volume of CO<sub>2</sub> captured and stored in 2050.

Under the LCET scenario, fossil fuel consumption declines substantially, leading to lower fuel costs than under BAU despite increased hydrogen use. However, the LCET scenario requires significant investment in renewable energy capacity, as variable renewable technologies typically have lower capacity factors than thermal power plants. CCS costs are incurred only under LCET, as CCS is generally not deployed in the BAU scenario. Energy costs therefore comprise both annual operating costs (fuel and CCS) and capital costs for power generation investment, making direct comparison complex. Countries with a high reliance on fossil fuels tend to achieve substantial fuel cost savings under LCET, but these are partly offset by higher investments in renewable energy, hydrogen supply, and CCS deployment.

Fuel costs are calculated as changes in fuel consumption multiplied by assumed unit costs, while power investment and CCS costs are estimated using assumed unit cost parameters drawn from existing studies and publicly available sources. Consequently, total energy costs are sensitive to these assumptions, particularly for hydrogen and CCS technologies. Future improvements to the EAS Energy Outlook should incorporate additional cost components, including battery energy storage systems, direct air capture with CCS, bioenergy with CCS, and synthetic fuel production.

In conclusion, this report presents carbon-neutral pathways for the EAS17 countries, highlighting the need for tailored combinations of low-carbon energy sources and technologies reflecting national economic conditions and resource endowments. Achieving carbon neutrality by 2050 or later will require substantial investment in low-carbon power generation, increased use of hydrogen, and expanded deployment of CCS, with significant implications for long-term energy costs across the region.



# Chapter 1

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## Energy Outlook and Saving Potential in East Asia: Main Report

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# 1. Introduction

The Economic Research Institute for ASEAN and East Asia (ERIA) updates the energy outlook and analyses energy-saving potential in the East Asia Summit (EAS)<sup>1</sup> region every 2 years. The last update was in 2021–2022. In 2022–2023, ERIA conducted a study comparing energy costs under the business-as-usual (BAU) and low-carbon energy transition (LCET) scenarios, using updated energy outlook models developed in 2021–2022 (ERIA, 2023). The analysis of energy costs included a) fuel costs, comprising fossil fuels and hydrogen; b) power investment costs by generation type, limited to power generation plants; and c) carbon capture and storage (CCS) costs, defined in terms of US dollars per tonne of carbon dioxide (CO<sub>2</sub>) treated using CCS technology.

Since the United Nations Climate Change Conference (COP26) in Glasgow and COP 27 in Sharm El-Sheikh, many countries have pledged to achieve net-zero emissions by mid-century. However, the ongoing rise in oil and gas prices, partly driven by geopolitical conflicts, may discourage fuel switching from coal to natural gas, which is considered a relatively low-hanging mitigation opportunity for fossil fuel-dependent economies. Consequently, fossil fuels, especially coal, are expected to remain in the energy mix of several Asian countries for longer than previously anticipated.

Decarbonisation pathways must therefore account for varying socio-economic and political circumstances across the region, which will shape each country's journey towards carbon neutrality. The Working Group for the Analysis of Energy Saving Potential in East Asia has continued to include both the BAU and LCET scenarios in the 2023–2024 Energy Outlook. Notably, the LCET scenario has been improved to reflect a more comprehensive carbon-neutral trajectory aligned with the net-zero emissions target for 2050 or 2060.

The improvements to the LCET modelling scheme include a) estimation of electricity consumption from electric vehicles (EVs); b) introduction of ammonia production processes derived from hydrogen; c) inclusion of co-firing technologies using biomass, hydrogen, and ammonia in thermal power plants; and d) other supporting measures and assumptions relevant to carbon neutrality.

This outlook aims to shed light on the policy implications necessary for informed decision-making, ensuring that the region can achieve sustained economic growth and attract investment whilst addressing energy security threats and environmental problems. Whilst there are multiple potential pathways to a low-carbon energy transition, this report presents a modelled scenario offering one viable route for each EAS country to achieve carbon neutrality by 2050 or 2060.

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<sup>1</sup> The EAS is an annual regional forum initially comprising 16 countries: the 10 member states of the Association of Southeast Asian Nations (ASEAN), along with Australia, China, India, Japan, the Republic of Korea (henceforth, Korea), and New Zealand. At the Sixth EAS in 2011, membership was expanded to include the Russian Federation and the United States (US), bringing the total number of participating countries to 18. Since its inception, ASEAN has taken the lead in guiding the forum. EAS meetings are convened following the annual ASEAN Leaders' Meetings and have become a cornerstone of the region's institutional architecture. The EAS plays a critical role in shaping the political, economic, and strategic landscape of Asia and the Pacific.

## 1.1. East Asia Summit

The 17 EAS (EAS17) countries vary widely in per capita income, standards of living, energy resource endowments, climate conditions, and per capita energy consumption. These countries include the 10 ASEAN member countries—Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam—alongside Australia, China, India, Japan, Republic of Korea (henceforth, Korea), New Zealand, and the United States (US).

Whilst some EAS17 countries are mature economies, most are still developing. In 2021, several had a per capita gross domestic product (GDP) of less than US\$1,500 (at 2015 prices),<sup>2</sup> whilst others, notably the more mature economies, recorded per capita GDP of more than US\$50,000. Unsurprisingly, mature economies tend to have significantly higher per capita energy consumption than developing ones. In many developing countries, a large percentage of the population still relies on traditional biomass fuels to meet basic energy needs.

These differences partly explain why energy efficiency and conservation (EEC) goals, action plans, and policies are prioritised differently across countries. Developed economies often focus on reducing energy consumption, whilst developing countries are more inclined to prioritise economic growth and improvements in living standards. Nevertheless, as developing economies continue to grow, their per capita energy consumption is also expected to increase.

Despite these differences, the first EAS in 2005 acknowledged that the EAS 'could play a significant role in community building', a vision that remains a cornerstone for fostering deeper regional cooperation in the years to come (ASEAN Secretariat, 2005).

## 1.2. Objective and Rationale

This study aims to analyse the potential impacts of proposed additional energy-saving goals, action plans, and policies designed to support achievement of carbon neutrality in EAS17. Specifically, it examines the implications for energy consumption, by fuel and sector, and greenhouse gas (GHG) emissions. The study also serves as a collaborative platform for EAS17 countries to engage in regional energy cooperation and to strengthen their capacity in energy modelling and policy development.

The study supports the Cebu Declaration on East Asian Energy Security (ASEAN Secretariat, 2007), which highlights key objectives, including

- (i) improving the efficiency and environmental performance of fossil fuel use;
- (ii) reducing dependence on conventional fuels through intensified EEC programmes, increased deployment of hydropower and renewable energy systems, expanded biofuel production and utilisation, and, for interested countries, the development of civilian nuclear power; and
- (iii) mitigating GHG emissions through effective policies and measures to contribute to global climate change mitigation efforts.

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<sup>2</sup> Unless specified, all US dollars in this document are stated at constant year 2015 values.

The Government of Japan, on behalf of the Energy Cooperation Task Force (ECTF) under the EAS framework, requested that ERIA conduct a study on energy saving and carbon dioxide (CO<sub>2</sub>) emission-reduction potential in East Asia. Japan has acted as the coordinating country for the energy efficiency work stream under the ECTF. As a result, a working group was convened, with representation from all EAS17 countries.

Following the adoption of the Paris Agreement in 2015 and the subsequent pledges made at COP26 in Glasgow, the 17 EAS members submitted or updated their nationally determined contributions (NDCs) as part of their commitments to global climate action. These NDCs outline each country's strategies and targets for reducing GHG emissions and adapting to climate change, in line with the Paris Agreement's overarching goal to limit global warming to well below 2°C—preferably 1.5°C—above pre-industrial levels (UNFCCC, 2015).

At COP26, nations were urged to raise their ambitions and align their commitments with more stringent climate pathways, reflecting the urgency of the climate crisis (UNFCCC, 2021). The EAS countries, which include major emitters such as China, India, and Indonesia, as well as smaller developing economies, face varying challenges in implementing their NDCs due to differences in economic development levels, energy dependencies, and policy frameworks. Nonetheless, their collective pledges underscore a shared commitment to transitioning towards more sustainable energy systems and low-carbon development. However, many countries will require continued support in the form of technology transfer, finance, and capacity building to fully achieve these targets. The LCET scenario in this energy outlook provides a feasible pathway for countries to transition to clean energy to achieve carbon neutrality by 2050 or 2060.

## 2. Data and Methodology

### 2.1. Scenarios

In 2023–24, the study continues to examine two scenarios: BAU, which reflects each country's current goals, action plans, and policies; and LCET, which includes a) the promotion of EEC; b) an increase in the share of renewable sources, such as solar and wind; c) the re-evaluation of nuclear power generation; and d) the installation of clean energy technologies, including hydrogen, ammonia, and CCS or carbon capture, utilisation, and storage (CCUS).

The energy models are designed to estimate the individual impacts of BAU and LCET on primary energy supply and CO<sub>2</sub> emissions. This main report highlights only the consolidated results for the EAS region as a whole.

Detailed assumptions for LCET include the following:

- (i) **Energy efficiency and conservation.** EEC remains a top priority for both ASEAN and +7 countries. However, ASEAN countries assume higher economic growth until 2060 to catch up with developed countries. As a result, the relative impact of EEC may be less significant compared with the +7 countries.
- (ii) **Electrification.** As electricity consumption does not emit CO<sub>2</sub>, electrification is an important policy in the final energy consumption sector. Key examples include the adoption of battery electric vehicles (BEVs), electric cooking appliances such as induction heating stoves, and heat-pump systems for water heating.
- (iii) **Fuel switching.** a) Fossil fuels are used for heating in the final energy consumption sector. Switching from fossil fuels to alternatives such as biomass (including biofuels), hydrogen, and ammonia is therefore a viable strategy. In the short term, particularly until 2030, the transition from coal to gas is an important step. b) Co-firing technologies involving biomass, ammonia, and hydrogen will be applied in thermal power plants to substitute coal and gas for electricity generation. The co-firing ratio will gradually increase from 2030 and is expected to reach 100% by 2050 to 2060.
- (iv) **Application of CCS.** CCS technology will be applied in industry, including cement production, and in thermal power generation. Cross-border CO<sub>2</sub> transport infrastructure will be indispensable to support this deployment.

However, the EAS17 differ significantly in the pace, scope, and maturity of their carbon neutrality efforts. Some countries have already incorporated substantial carbon neutrality goals, action plans, and policies into their BAU scenarios, whilst others are only starting to define and quantify such goals.

## 2.2. Data

Amongst the ASEAN Member States, Cambodia, Lao PDR, and Myanmar use national energy statistics compiled with support from ERIA. The remaining seven ASEAN countries use data from the Asia-Pacific Economic Cooperation (APEC) energy database, which includes national energy data submissions. The +7 countries, including China and India, use energy balance tables published by the International Energy Agency (IEA). Socio-economic data for all 17 countries were obtained from the World Bank's World Databank–World Development Indicators and Global Development Finance databases. Additional data on transport, buildings, and industrial production indices, where available, were provided by working group members from each EAS17 country. In cases where official data were not available, alternative estimates were sourced externally or developed by the Institute of Energy Economics, Japan (IEEJ), especially for international energy prices such as crude oil.



## 2.3. Methodology

Since 2008, all 10 ASEAN members have developed their national energy models, with technical support from ERIA. The remaining +7 countries use the IEEJ model but provide their key assumptions, including population and GDP growth rates, electricity generation fuel mixes, and national carbon neutrality goals, action plans, and policies.

Each country's energy demand is projected using an econometric approach, in which future trends are influenced by historical data. This approach incorporates assumed future prices for crude oil, natural gas, and coal. Demand equations are estimated using historical data and then used to project future energy demand based on explanatory variables.

**ASEAN countries.** The ASEAN energy models apply the econometrics approach to forecast energy balance tables based on final energy consumption and energy transformation input– output flows. Final energy consumption is projected by sector and fuel type using energy demand equations alongside macroeconomic assumptions. For this study, all 10 ASEAN members used the Low Energy Analysis Platform (LEAP) software.

**Other countries.** The IEEJ developed energy outlooks for the +7 countries using its model, which incorporates a range of explanatory variables. GDP growth rates were specified exogenously by working group members. Future energy prices were assumed for crude oil, natural gas, and coal. Demand equations were estimated econometrically based on historical data, whilst future energy demand was projected using these estimates. Energy supply and the introduction of new technologies were treated exogenously. For electricity generation, each working group member specified assumptions on the expected fuel mix, which were used to model the future composition of electricity generation by energy source.

## 3. Assumptions of the Study

Growth in energy consumption and GHG emissions is driven by various socio-economic factors. In the EAS17 region, rising population, sustained economic growth, increased vehicle ownership, and expanding access to electricity are all expected to contribute to higher energy demand. Together, these factors create a huge growth headwind that works against efforts to limit energy consumption. Understanding the nature and magnitude of this headwind is critical for any analysis of regional energy demand. Nevertheless, increased consumption of energy services remains fundamental to achieving a range of socio-economic development goals.

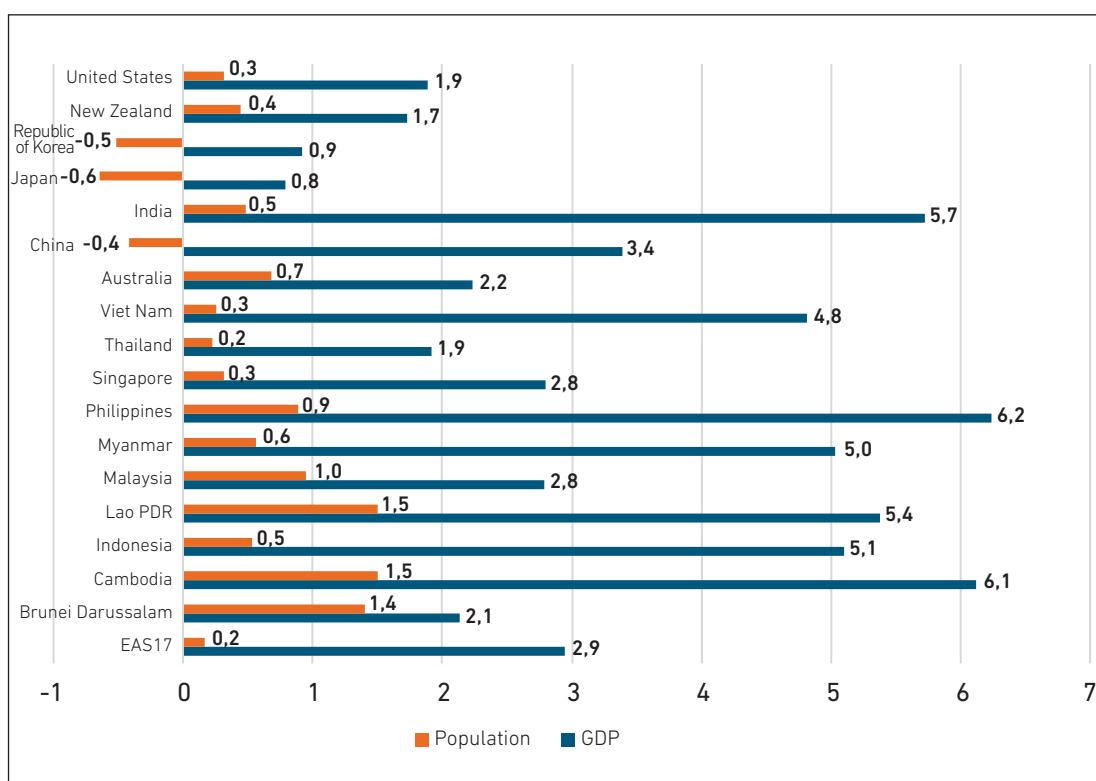
This section discusses the key assumptions regarding socio-economic indicators and energy policies for the EAS17 region until 2060.

### 3.1. Population, Gross Domestic Product, and Their Growth Rates in East Asia Summit 17

The study assumes that changes in population through to 2060 are determined exogenously. No population differences are assumed between BAU and LCET. Except for China, the EAS17 countries submitted their population projections, generally based on United Nations projections.

In 2021, the total population of the EAS17 stood at about 4.03 billion. It is projected to increase at an average annual growth rate (AAGR) of about 0.2%, reaching roughly 4.3 billion by 2060.

**Figure 1.1. Average Annual Growth Rates of Gross Domestic Product and Population in East Asia Summit 17 Countries**



Lao PDR = Lao People's Democratic Republic.

Source: Authors.

Brunei Darussalam, Cambodia, and Lao PDR are projected to have the fastest population AAGR, ranging from 1.4% to 1.5% in 2021–2060. Australia, India, Indonesia, Malaysia, Myanmar, New Zealand, Singapore, Thailand, Viet Nam, the Philippines, and the US are expected to experience moderate population growth rates, from 0.2% to 1.0%. In contrast, the populations of China, Japan, and Korea are expected to decline gradually over the projection period due to demographic ageing. Their population AAGRs are projected at –0.4%, –0.6%, and –0.5%, respectively.

Long-term economic growth is assumed to be particularly high in developing economies, with the Philippines projected to have the highest AAGR of 6.2%, followed by Cambodia with an AAGR of 6.1% in 2021–2060. India, Indonesia, Lao PDR, Myanmar, and Viet Nam are also expected to experience high economic growth (Figure 1.1), with average growth rates ranging from 4.8% to 5.7%. Brunei Darussalam, Malaysia, Singapore, and Thailand are expected to have moderate GDP growth rates of 1.9%–2.8% in 2021–2060. Similarly, developed EAS17 countries—Australia, Japan, Korea, New Zealand, and the US—will also experience similar moderate annual GDP growth rate. Due to their large economies, China, India, and Indonesia are likely to drive substantial increases in energy demand.

In 2021, the total GDP of the EAS17 was about US\$49.9 trillion, accounting for about half of global GDP. The region's GDP is projected to grow at an average annual rate of 2.9% in 2021–2060, reaching about US\$153.2 trillion by 2060. China is projected to lead in real GDP by 2060, with an estimated US\$58 trillion, followed by the US (US\$42.6 trillion), India (US\$20.6 trillion), and Japan (US\$6.03 trillion) (Table 1.1).

**Table 1.1. Gross Domestic Product and Population in East Asia Summit 17 Countries (2021–2060)**

| Country           | GDP (2015 US\$ billion) |           | Population (million) |         | Per Capita GDP | Per Capita GDP |
|-------------------|-------------------------|-----------|----------------------|---------|----------------|----------------|
|                   | 2021                    | 2060      | 2021                 | 2060    | 2021           | 2060           |
| Brunei Darussalam | 13.2                    | 30.1      | 0.4                  | 0.8     | 29,673.2       | 39,287.7       |
| Cambodia          | 23.7                    | 240.1     | 16.6                 | 29.6    | 1,429.9        | 8,099.8        |
| Indonesia         | 1,065.7                 | 7,421.6   | 273.8                | 336.8   | 3,893.0        | 22,032.6       |
| Lao PDR           | 19.1                    | 147.1     | 7.4                  | 13.3    | 2,566.3        | 11,083.0       |
| Malaysia          | 356.1                   | 1,040.9   | 33.6                 | 48.6    | 10,606.8       | 21,424.4       |
| Myanmar           | 60.9                    | 413.0     | 53.8                 | 66.9    | 1,131.7        | 6,171.3        |
| Philippines       | 379.0                   | 4,004.1   | 111.4                | 157.2   | 3,402.4        | 25,472.4       |
| Singapore         | 367.6                   | 1,079.1   | 5.5                  | 6.2     | 67,456.6       | 175,167.6      |
| Thailand          | 460.8                   | 965.6     | 69.6                 | 75.9    | 6,617.5        | 12,718.3       |
| Viet Nam          | 332.3                   | 2,079.2   | 98.5                 | 108.9   | 3,373.2        | 19,092.6       |
| Australia         | 1,376.4                 | 3,251.3   | 25.7                 | 33.5    | 53,581.8       | 96,954.0       |
| China             | 15,801.9                | 58,004.3  | 1,412.4              | 1,200.0 | 11,188.3       | 48,337.4       |
| India             | 2,782.3                 | 24,404.6  | 1,407.6              | 1,700.5 | 1,976.7        | 14,351.2       |
| Japan             | 4,435.4                 | 6,026.8   | 125.7                | 97.6    | 35,291.0       | 61,767.1       |
| Republic of Korea | 1,694.0                 | 2,415.2   | 51.7                 | 42.3    | 32,736.6       | 57,094.3       |
| New Zealand       | 207.0                   | 403.6     | 5.1                  | 6.1     | 40,415.5       | 66,318.1       |
| United States     | 20,529.5                | 42,581.8  | 331.9                | 375.4   | 61,855.5       | 113,436.6      |
| EAS17             | 49,904.9                | 154,508.5 | 4,030.6              | 4,299.6 | 12,381.5       | 35,935.4       |

GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.

Source: Authors.

The average real per capita GDP in the EAS17 region is projected to increase from about US\$12,381 in 2021 to about US\$35,935 in 2060. However, significant differences in per capita GDP will persist across the region. In 2021, per capita GDP ranged from about US\$1,132 in Myanmar to over US\$35,000 in Australia, Japan, New Zealand, the US, and Singapore. By 2060, these figures are expected to rise to over US\$100,000 in the US and Singapore, whilst Myanmar's per capita GDP is expected to reach about US\$6,171.

## 3.2. Thermal Efficiency of Power Generation

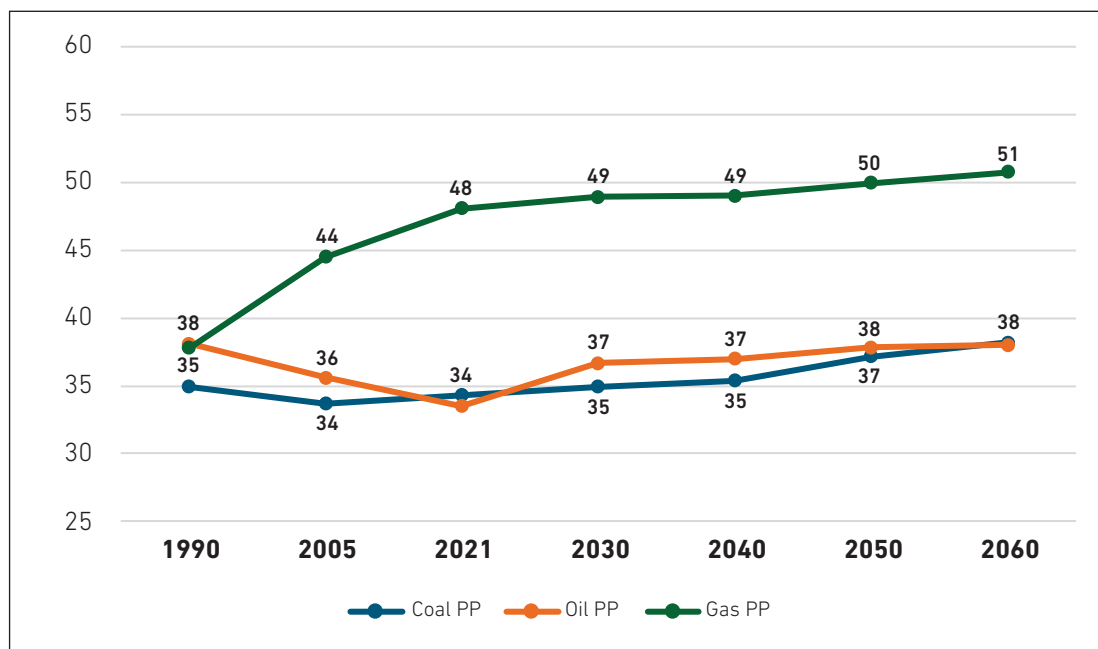
Thermal efficiency in electricity generation indicates the amount of fuel required to produce a unit of electricity. In this study, thermal efficiency was treated as an exogenous assumption. Base year (2021) thermal efficiencies for coal, gas, and oil were calculated using data on fossil fuel inputs and electricity outputs.

Projections for thermal efficiency by fuel type (coal, gas, and oil) were submitted by Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam. For the remaining countries, assumptions about potential changes in thermal efficiency were based on IEEJ's Asia/World Energy Outlook 2020.

As the analysis introduces new fuels (hydrogen and ammonia) for electricity generation under LCET, data on their thermal efficiency are available from 2021 onwards and projected through to 2060.

Thermal efficiencies may vary significantly across countries due to differences in technological maturity, the age of existing infrastructure, capital costs, and the availability of fuel inputs. In ASEAN and EAS17 countries, thermal efficiency is expected to improve considerably under BAU as more advanced technologies, such as natural gas combined-cycle and supercritical coal-fired power plants, become available. In many countries, additional improvements are also assumed under LCET (Figure 1.2 and Figure 1.3).

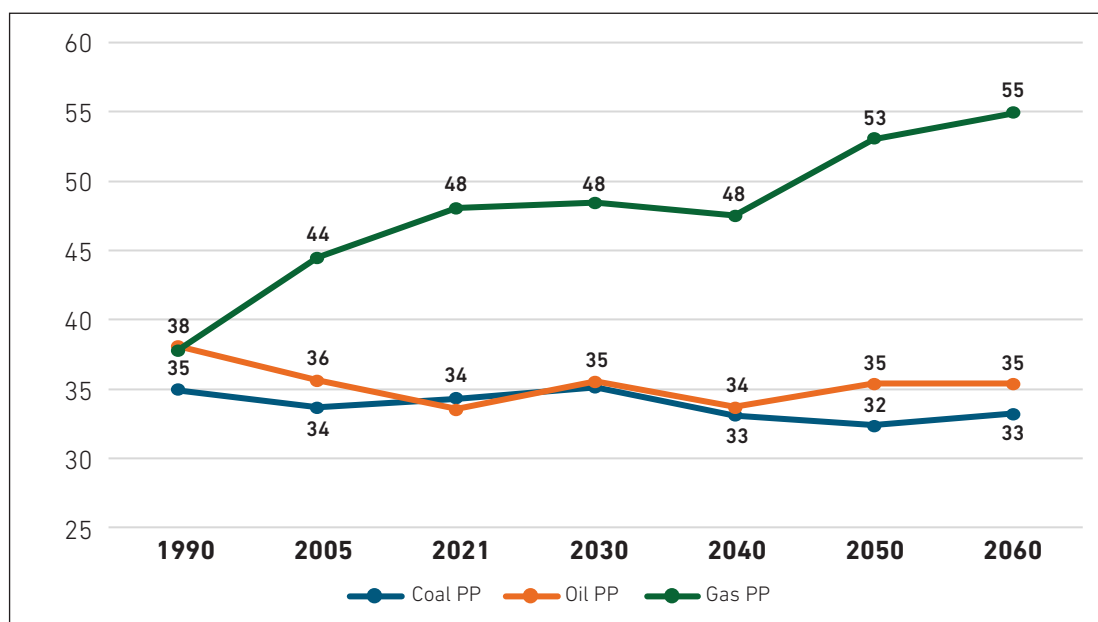
**Figure 1.2. Average Thermal Efficiency in East Asia Summit  
17 Countries, Business-as-Usual Scenario**



PP = power plant.

Source: Authors.

**Figure 1.3. Average Thermal Efficiency in East Asia Summit  
Countries, Low-carbon Energy Transition Scenario**



PP = power plant.

Source: Authors.

### 3.3. Imported Price Assumptions for Oil, Coal, and Natural Gas

Table 1.2 depicts the imported price assumptions for oil, coal, and natural gas used in the modelling, based on data from the world energy model price database of IEA (2024), as adapted by IEEJ.

In the reference scenario, the crude oil price was US\$41 per blue barrel (bbl) in 2020. It is projected to rise to US\$80/bbl by 2030 and to US\$100/bbl by 2050. These increases are driven by a combination of factors, such as robust demand growth in non–Organisation for Economic Co-operation and Development (OECD) countries, full economic recovery from the COVID-19 pandemic, the emergence of new geopolitical risks, weak investment in the oil and gas sector due to carbon neutrality commitments, and supply constraints arising from the increasing depletion of oil fields, amongst others.

**Table 1.2. Assumed Imported Prices of Real Oil, Natural Gas, and Coal**

| Year | Crude Oil (US\$/bbl) | Coal (US\$/tonne) | Natural Gas (US\$/MBtu) |        |       |
|------|----------------------|-------------------|-------------------------|--------|-------|
|      |                      |                   | US                      | Europe | Asia  |
| 2000 | 28.66                | 34.64             | 4.23                    | 2.71   | 4.72  |
| 2010 | 79.61                | 107.14            | 4.39                    | 6.56   | 10.91 |
| 2015 | 52.39                | 79.62             | 2.60                    | 6.44   | 10.31 |
| 2020 | 41.00                | 80.03             | 2.13                    | 3.25   | 7.77  |
| 2030 | 80.00                | 96.00             | 3.30                    | 7.50   | 7.60  |
| 2040 | 95.00                | 97.00             | 3.80                    | 7.50   | 7.60  |
| 2050 | 100.00               | 98.00             | 3.80                    | 7.40   | 7.50  |
| 2060 | 100.00               | 98.00             | 3.80                    | 7.40   | 7.50  |

bbl= blue barrel, MBtu = 1 million British thermal units, toe = tonne of oil equivalent, US = United States.

Source: Institute for Energy Economics, Japan (2024) oil price assumptions.

### 3.4. Carbon-neutral Goals and Other Policy Assumptions

Working group members from each country provided policy assumptions and targets for both the BAU and LCET scenarios. Table 1.3 shows only the policy assumptions for the LCET scenario. Several EAS17 countries have clearly defined targets for energy savings or emissions reductions. The table summarises the key assumptions related to carbon neutrality and alignment with NDCs across the EAS17 region.

**Table 1.3. Carbon-neutral Target Alignment and Other Policy Assumptions in the Low-carbon Energy Transition for East Asia Summit 17 Countries**

| Country                          | Assumptions                                                                                                                                                                                                                                                                                                                                                                             | Carbon-neutral Target Year |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| Australia                        | Reduce GHG emissions by 43% below 2005 levels by 2030, and achieve net-zero by 2050.                                                                                                                                                                                                                                                                                                    | 2050                       |
| Brunei Darussalam                | Reduce GHG emissions by 20% relative to BAU. Cut total energy consumption by 63% from BAU by 2035. Achieve a 10% share of renewables in the power mix by 2035.                                                                                                                                                                                                                          | NA                         |
| Cambodia                         | Achieve total energy savings of 27% from BAU by 2030. By 2050, reach fuel efficiency targets of 10% for fossil fuels (coal, oil, gas, biomass industry) and 20% for electricity. Under the updated NDC, reduce total emissions by 41.7% to about 64.6 million tonnes of carbon dioxide equivalent per year (CO <sub>2</sub> eq/year) by 2030.                                           | 2050                       |
| China                            | Peak CO <sub>2</sub> emissions before 2030 and achieve carbon neutrality before 2060. Lower CO <sub>2</sub> emissions per unit of GDP by over 65% from 2005 levels. Increase the share of non-fossil fuels in primary energy to 25%, increase forest stock by 6 billion cubic metres (m <sup>3</sup> ), and reach over 1.2 billion kilowatts (kW) of installed wind and solar capacity. | 2060                       |
| India                            | Reduce the emission intensity of GDP by 33%–35% from 2005 levels by 2030. Achieve 40% of cumulative installed electricity capacity from non-fossil fuel sources by 2030, supported by technology transfer and international climate finance. Create an additional carbon sink of 2.5–3 billion tonnes of carbon dioxide equivalent (BtCO <sub>2</sub> e) through reforestation by 2030. | 2070                       |
| Indonesia                        | Reduce GHG emissions by 31.89% (unconditional) and up to 43.20% (conditional) from 2030 BAU levels, higher than the previous targets of 29% and 41%, respectively. Aim for net-zero emission by 2060.                                                                                                                                                                                   | 2060                       |
| Japan                            | Reduce GHG emissions by 46% by 2030 from 2013 levels, with a net-zero target for 2050. Intensify efforts to reach a 50% reduction.                                                                                                                                                                                                                                                      | 2050                       |
| Republic of Korea                | Reduce GHG emissions by 40% from 2018 levels by 2030. Increase the share of renewables to 20% by 2030. Achieve carbon neutrality by 2050.                                                                                                                                                                                                                                               | 2050                       |
| Lao People's Democratic Republic | Unconditionally reduce GHG emissions by 60% by 2030 compared to BAU. Conditionally increase forest cover to 70% of the total land area, develop 1 gigawatt (GW) of wind and solar capacity, add 300 megawatts (MW) of biomass-fired capacity, and reduce final energy consumption by 10% from BAU.                                                                                      | 2050                       |
| Malaysia                         | Unconditionally reduce economy-wide GHG emissions intensity by 45% by 2030 relative to 2005 levels.                                                                                                                                                                                                                                                                                     | 2050                       |
| Myanmar                          | Achieve unconditional emissions reductions of 244.52 million tonnes of CO <sub>2</sub> equivalent, and up to 414.75 million tonnes of CO <sub>2</sub> equivalent with international financial and technical support, by 2030                                                                                                                                                            | 2060                       |

| Country       | Assumptions                                                                                                                                                                                                                                                                                  | Carbon-neutral Target Year |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| New Zealand   | Adopt an emissions budget under the updated NDC, covering total net emissions for 2021–2030. The provisional budget is 571 MtCO <sub>2</sub> eq, reflecting a linear reduction from 2020 levels to the 2030 target. The previous target was a 30% reduction below gross 2005 levels by 2030. | 2050                       |
| Philippines   | Commit to a 75% GHG emission reduction and avoidance from 2020 to 2030, of which 2.71% is unconditional and 72.29% conditional, covering agriculture, waste, industry, transport, and energy sectors. This is based on a projected BAU cumulative emission of 3,340.3 MtCO <sub>2</sub> eq.  | NA                         |
| Singapore     | Peak emissions at 60 MtCO <sub>2</sub> eq by 2030 and reduce to 45–50 MtCO <sub>2</sub> eq by 2035. This is an enhanced target from the previous 65 MtCO <sub>2</sub> eq peak in 2030.                                                                                                       | 2050                       |
| Thailand      | Reduce GHG emissions by 30% (unconditional) from BAU by 2030. Commit to carbon neutrality by 2050 and net-zero emissions by 2065.                                                                                                                                                            | 2050                       |
| United States | Reduce net GHG emissions by 61%–66% below 2005 levels by 2035. The reduction trajectory is consistent with achieving net-zero emissions by 2050.                                                                                                                                             | 2050                       |
| Viet Nam      | Reduce GHG emissions in the energy sector by 43.5% from BAU by 2030, limiting emissions to 457 MtCO <sub>2</sub> e. By 2050, achieve net-zero emissions nationwide, with a 91.6% reduction in energy-sector emissions and a ceiling of 101 MtCO <sub>2</sub> e.                              | 2050                       |

BAU = business as usual, BtCO<sub>2</sub>e = billion tonnes of carbon dioxide equivalent, CO<sub>2</sub>e = carbon dioxide equivalent, GHG = greenhouse gas, MtCO<sub>2</sub>eq = million tonnes of carbon dioxide equivalent, NDC = nationally determined contribution, tCO<sub>2</sub>eq = tonnes of carbon dioxide equivalent.

Source: United Nations Climate Change, 2024.

## 4. Energy Outlook for the East Asia Summit Region

### 4.1. Business-as-Usual Scenario

#### 4.1.1. Final Energy Consumption

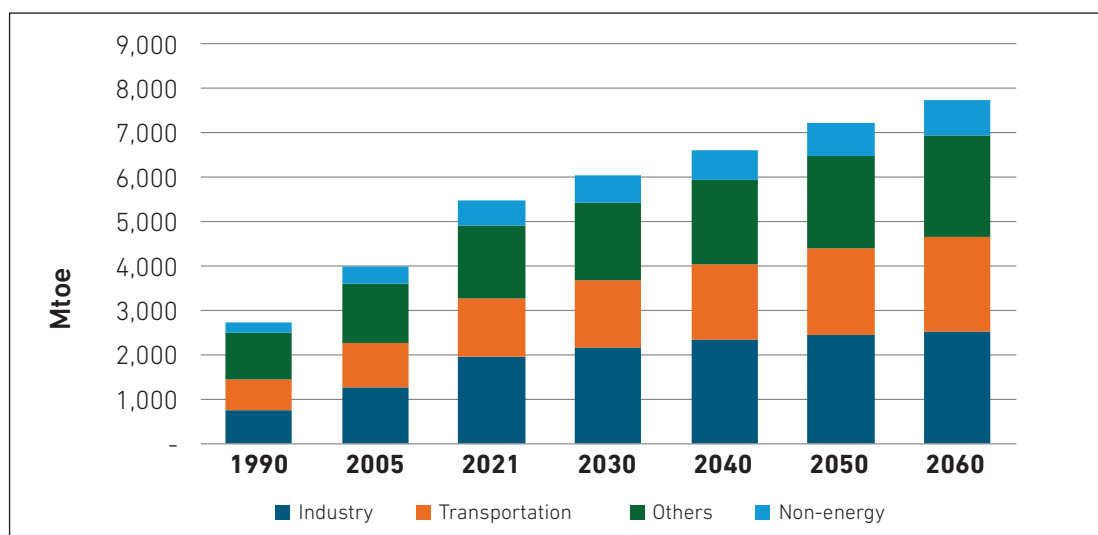
In 2021–2060, final energy consumption<sup>3</sup> in EAS17 is projected to grow at an average annual rate of 0.9%, reflecting the assumed 2.9% annual GDP growth and 0.2% population growth. Final energy consumption is projected to increase from 5,457 Mtoe in 2021 to 7,770 Mtoe in 2060.

<sup>3</sup> Refers to energy in the form in which it is consumed, i.e. including electricity but not fuels and/or energy sources used to generate electricity.



Transport energy demand is projected to grow at an average annual rate of 1.2% in 2021–2060, accounting for 27.6% of total final energy consumption by 2060. Industrial energy demand will increase at a slower rate of 0.6% per year, but the sector will hold the largest consumption share, projected at 32.7% by 2060. Energy demand in the commercial and residential (classified as ‘others’) is expected to grow by 0.8% per year, faster than that of industry, but its share will reach 29.5% in 2060, making it the second-largest consuming sector. Figure 1.4 shows final energy consumption by sector under BAU in EAS17 in 1990–2060, and Figure 1.5 shows details of sector shares in final energy consumption.

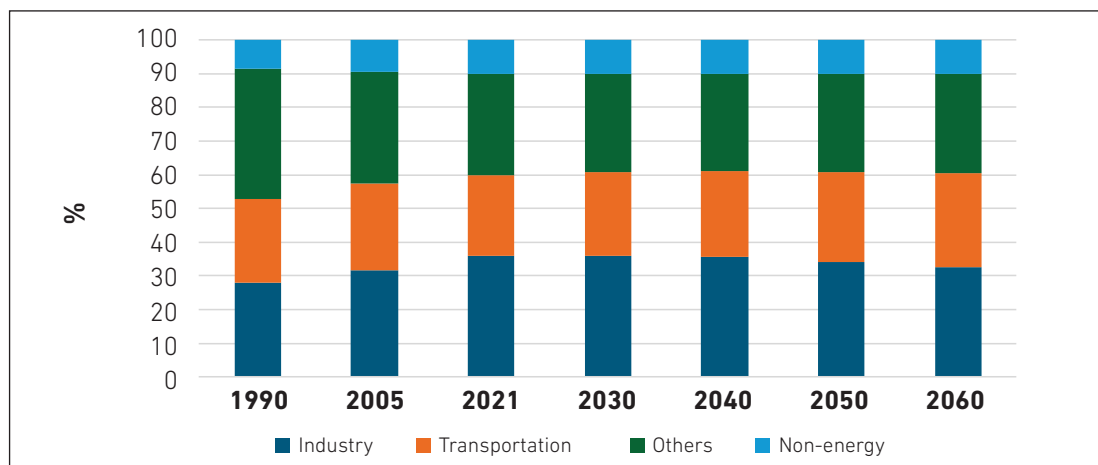
**Figure 1.4. Final Energy Consumption by Sector, Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

**Figure 1.5. Final Energy Consumption Share by Sector, 1990–2060**



Source: Authors.

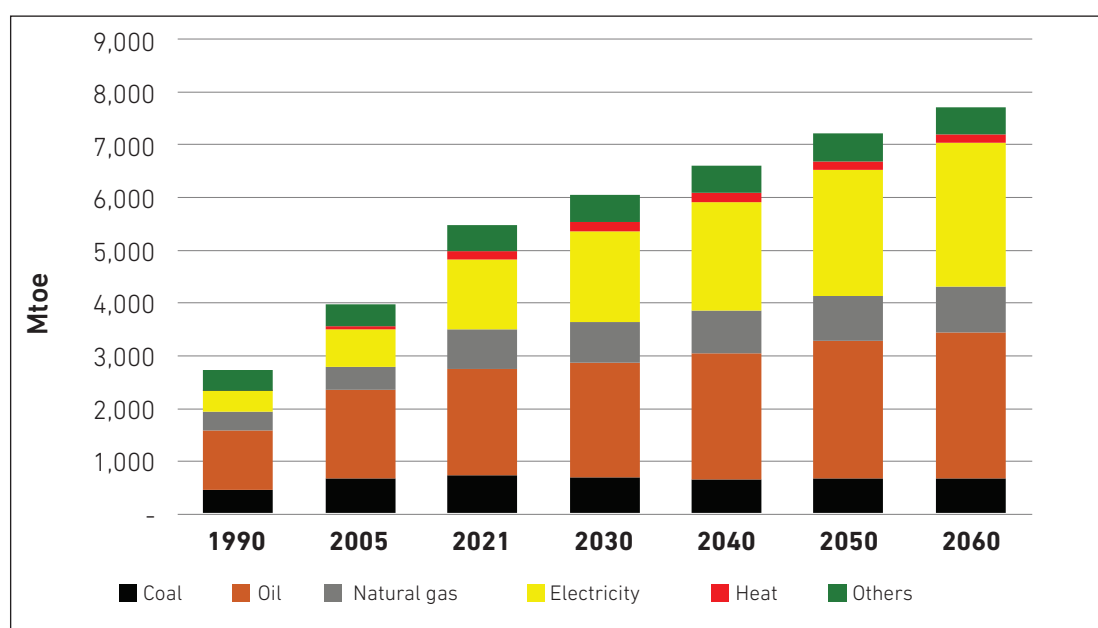
Figure 1.6 and Figure 1.7 show the final energy consumption and corresponding shares by fuel type in EAS17 region under BAU in 1990–2060. Amongst all energy sources, electricity is projected to experience the fastest growth, with an average annual increase of 1.8% in 2021–2060. Its share of final energy consumption is expected to reach 35.5% by 2060.

Oil will remain the largest energy source, accounting for 35.7% of final energy consumption by 2060. However, its growth rate will be relatively modest at 0.8% per year, increasing to 2,724 Mtoe in 2060. Oil's share will decrease slightly from 37.1% in 2021 to 35.7% in 2060.

Coal demand is expected to decrease at an average annual rate of –0.2%, reaching 682 Mtoe by 2060. The share of other fuels, such as biomass, is projected to decline from 8.5% in 2021 to 6.7% in 2060. This reflects a gradual shift in the residential sector from non-commercial biomass to conventional fuels such as liquefied petroleum gas (LPG) and electricity.

Heat energy demand will also decline, with its share falling from 2.9% in 2021 to 1.9% in 2060, indicating slow growth and reduced significance in the overall energy mix.

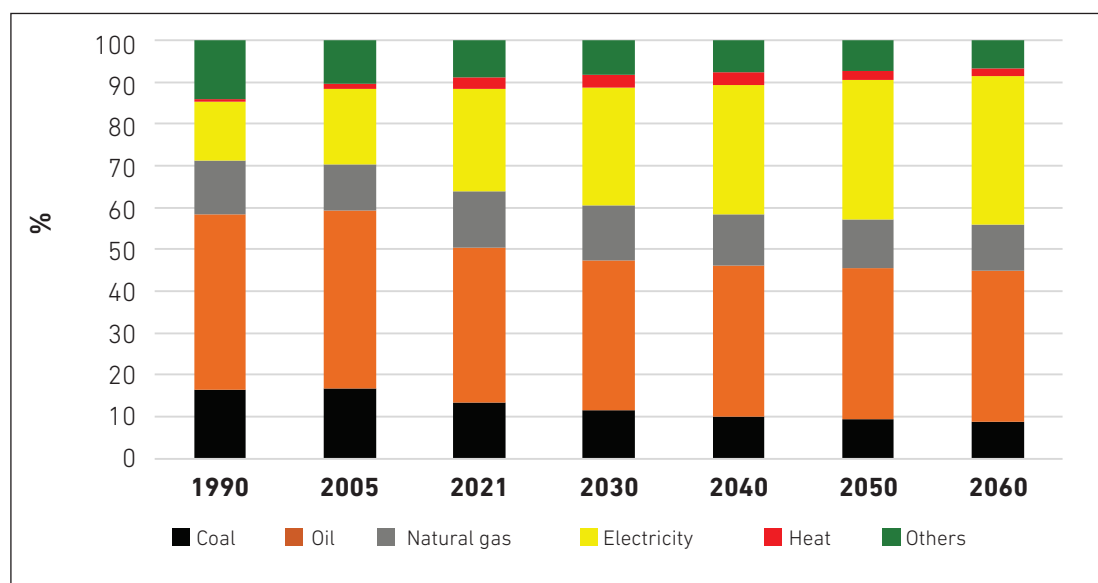
**Figure 1.6. Final Energy Consumption by Fuel, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

**Figure 1.7. Final Energy Consumption Share by Fuel, 1990–2060**

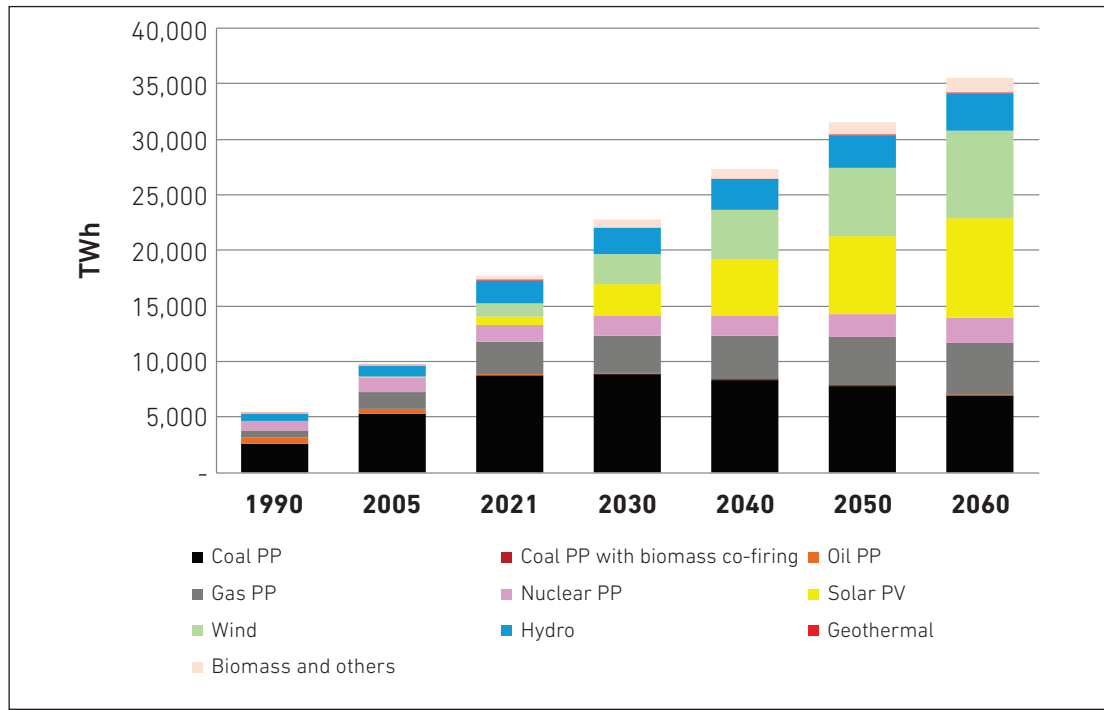


Source: Authors.

### 4.1.2. Power Generation

Figure 1.8 shows power generation in the EAS17 countries. In 2021–2060, total power generation is projected to grow at an average annual rate of 1.8%, increasing from 17,685 terawatt-hours (TWh) in 2021 to 35,392 TWh by 2060. Thermal power generation is expected to have less significance in the power generation mix from 2021 levels through to 2060, given that its output is projected to remain relatively unchanged. The growing electricity demand is projected to be met primarily by renewable power sources. This trend reflects the rapid expansion of renewable power generation, particularly amongst the +7 countries.

**Figure 1.8. Energy Mix of Power Generation in East Asia  
Summit 17, Business-as-Usual Scenario, 1990–2060**

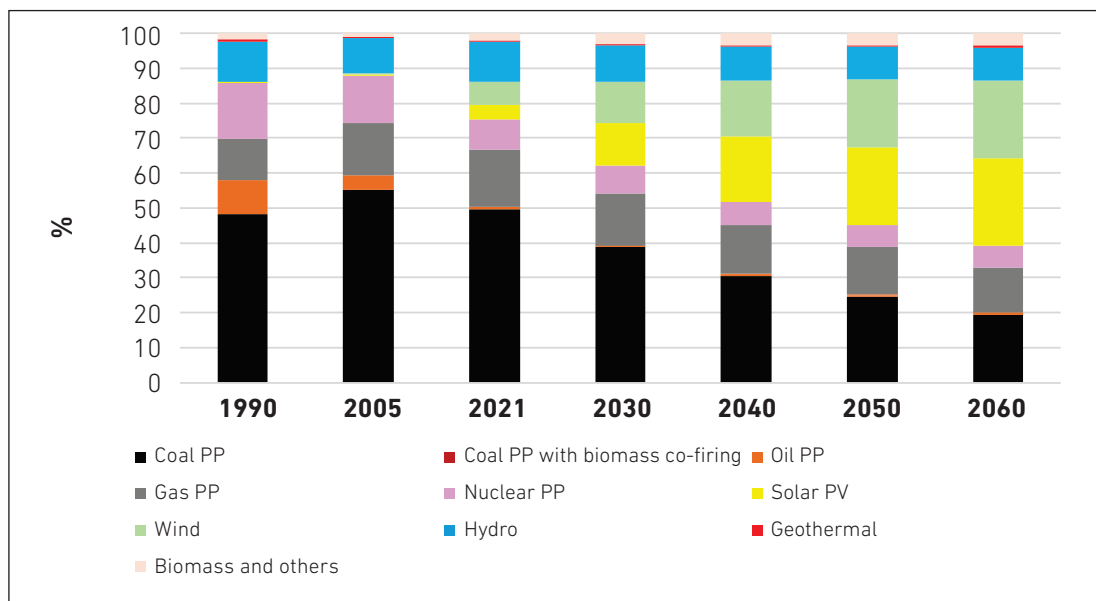


PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors.

Figure 1.9 shows the projected shares of each energy source in electricity generation from 1990 to 2060. Despite currently holding the largest share, coal-fired power generation is projected to decrease significantly, from 49.5% in 2021 to 19.5% in 2060. The share of natural gas is also projected to decrease from 16.5% in 2021 to 12.8% in 2060. The share of oil in power generation will decline even more markedly, from 0.7% in 2021 to just 0.07% in 2060, with an average annual growth rate of  $-4.2\%$ . This is largely due to its higher fuel cost and declining relevance in power generation. Nuclear power share is projected to decrease from 8.5% in 2021 to 6.4% in 2060. Geothermal energy, which accounted for 0.3% of electricity generation in 2021, is projected to increase modestly to 0.5% in 2060. In contrast, solar, wind, and biomass are expected to record the highest AAGR: 6.5%, 5.0%, and 3.2%, respectively, in 2021–2060. The combined share of wind and solar is expected to dominate the electricity mix, rising from 10.9% in 2021 to 47.5% in 2060. Hydropower's share is projected to decrease from 11.6% in 2021 to 9.4% in 2060, despite an average annual growth rate of 1.3% during the period.

**Figure 1.9. Share of Power Generation Mix in East Asia Summit 17, Business-as-Usual Scenario, 1990–2060**



PP = power plant, PV = photovoltaic.

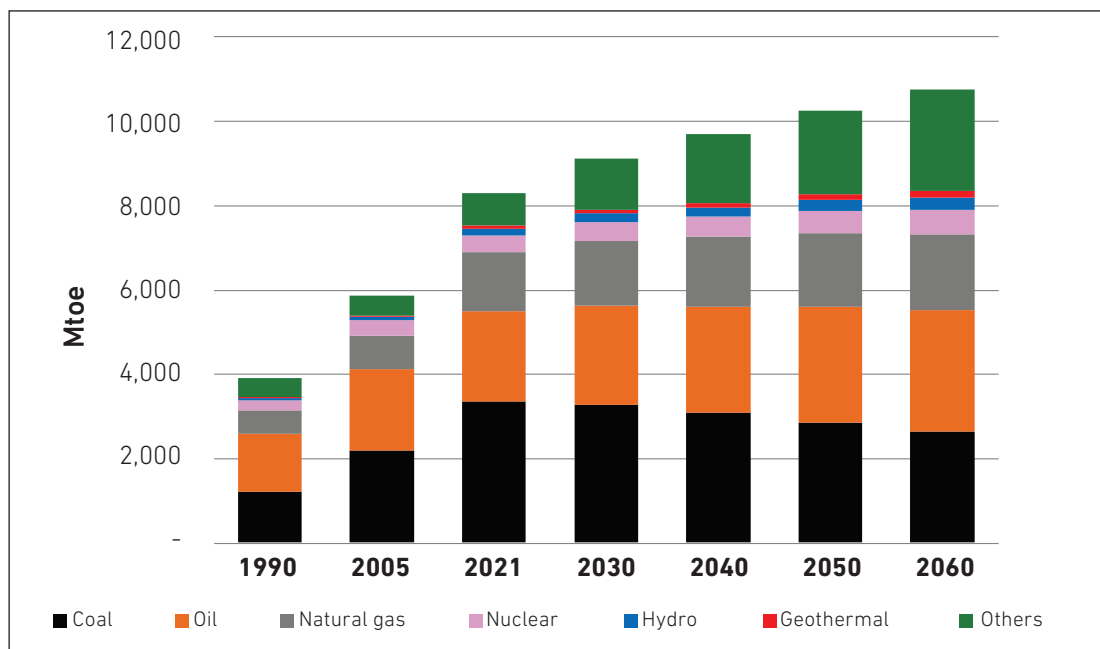
Source: Authors.

### 4.1.3. Primary Energy Supply

Figure 1.10 shows the primary energy supply in the EAS17 countries from 1990 to 2060. The primary energy supply<sup>4</sup> is projected to grow at a slower pace, averaging 0.7% per year, compared with the growth in final energy consumption. Total supply is projected to increase from 8,274 Mtoe in 2021 to 10,696 Mtoe in 2060. Oil is expected to retain the largest share of the primary energy mix in 2060, accounting for 26.8%. In contrast, coal's share will decrease significantly, from 40.7% in 2021 to 24.7% in 2060, reflecting an AAGR of -0.6%. Oil, by comparison, will grow at 0.7% per year over the same period. Natural gas is projected to experience moderate growth, with an average annual increase of 0.6% during 2021–2060. Its share of total supply will increase slightly from 16.7% (1,382 Mtoe) in 2021 to 17% (1,734 Mtoe) in 2050, before decreasing marginally to 16.6% (1,773 Mtoe) in 2060.

<sup>4</sup> Refers to energy in its raw form, before any transformation, most significantly the generation of electricity.

**Figure 1.10. Primary Energy Supply in East Asia Summit 17, 1990–2060**



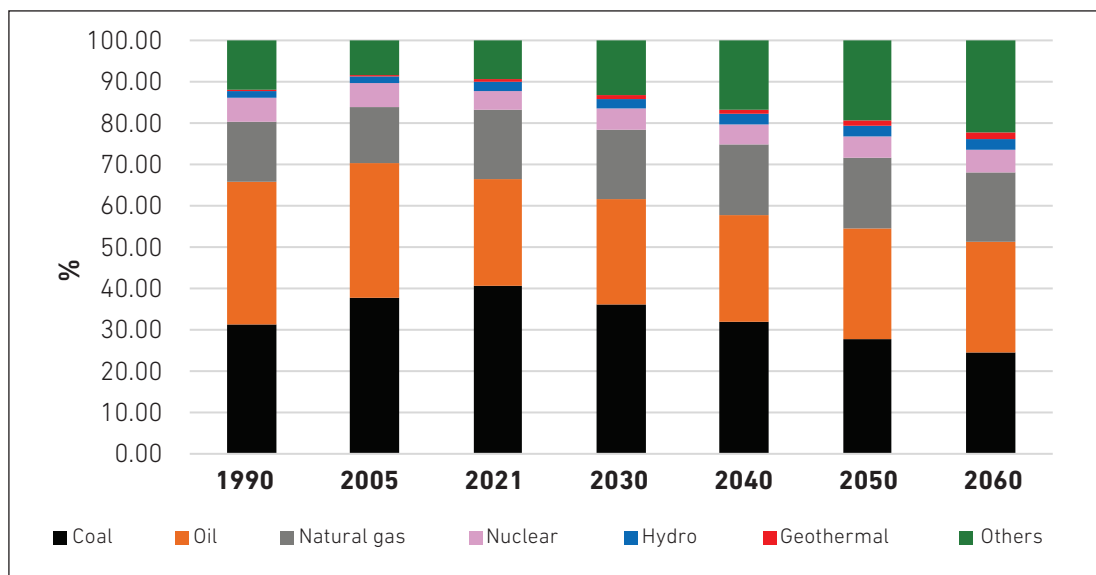
Mtoe = million tonnes of oil equivalent.

Source: Authors.

Nuclear energy is projected to increase at a slightly faster pace than oil and gas, averaging 1.1% per year in 2021–2060. Its share of the primary energy mix is projected to increase slightly from 4.7% in 2021 to 5.5% in 2060. Hydropower is also projected to increase its share, from 2.1% to 2.7% over the same period. Geothermal energy is projected to grow at an average annual rate of 2.4% in 2021–2060, the second-fastest amongst energy sources, although its contribution will remain relatively small, rising from 0.8% in 2021 to 1.5% by 2060.

The ‘others’ category, comprising biomass, biofuels, electricity trade, and variable renewables (solar, wind, ocean), is projected to record the highest AAGR, at 3.0% in 2021–2060. By 2060, these sources will account for 22.3% of the total primary energy supply. Most remarkably, wind and solar energy will see rapid expansion, growing at an AAGR of 5.4%. Their combined share of the primary energy mix is expected to increase from 2.4% in 2021 to 14.3% in 2060. This surge is largely driven by the rapid deployment of solar and wind technologies in countries such as China, the US, and India. Figure 1.11 shows the shares of each energy source in the total primary energy mix in 1990–2060.

**Figure 1.11. Share of Primary Energy Mix by Source, 1990–2060**



Source: Authors.

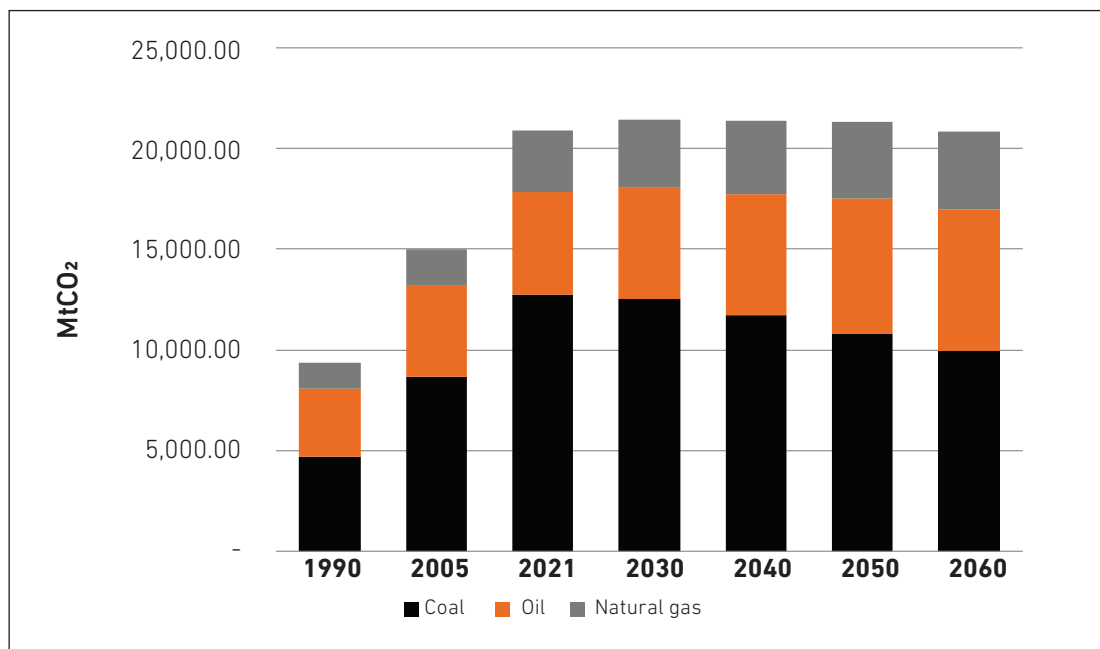
#### 4.1.4. Carbon Dioxide Emissions

Under BAU, CO<sub>2</sub> emissions in the EAS17 countries are projected to follow a broadly stabilising trend in 2021–2060. In 2021, total emissions stood at 20,870 MtCO<sub>2</sub>, increasing slightly to 21,372 MtCO<sub>2</sub> by 2030 before declining marginally to 20,616 MtCO<sub>2</sub> by 2060. This trend is driven by rising final energy consumption alongside a gradual shift in the power generation mix towards lower-carbon sources such as solar and wind.

In terms of emission sources, CO<sub>2</sub> emissions from coal are expected to decrease steadily, from 12,731 MtCO<sub>2</sub> in 2021 to 9,839 MtCO<sub>2</sub> in 2060. In contrast, emissions from oil and gas are projected to increase. Oil-related emissions will rise from 5,060 MtCO<sub>2</sub> in 2021 to 6,989 MtCO<sub>2</sub> in 2060, whilst gas-related emissions will grow from 3,078 MtCO<sub>2</sub> to 3,788 MtCO<sub>2</sub> over the same period.

These trends indicate that even under BAU, there is a strategic shift away from coal use, especially in the power sectors of the +7 countries, most notably China. Figure 1.12 shows CO<sub>2</sub> emissions in the EAS17 countries under BAU in 1990–2060.

**Figure 1.12. Carbon Dioxide Emissions in East Asia Summit 17, Business-as-Usual Scenario, 1990–2060**



MtCO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Authors.

## 4.2. Low-carbon Energy Transition Scenario

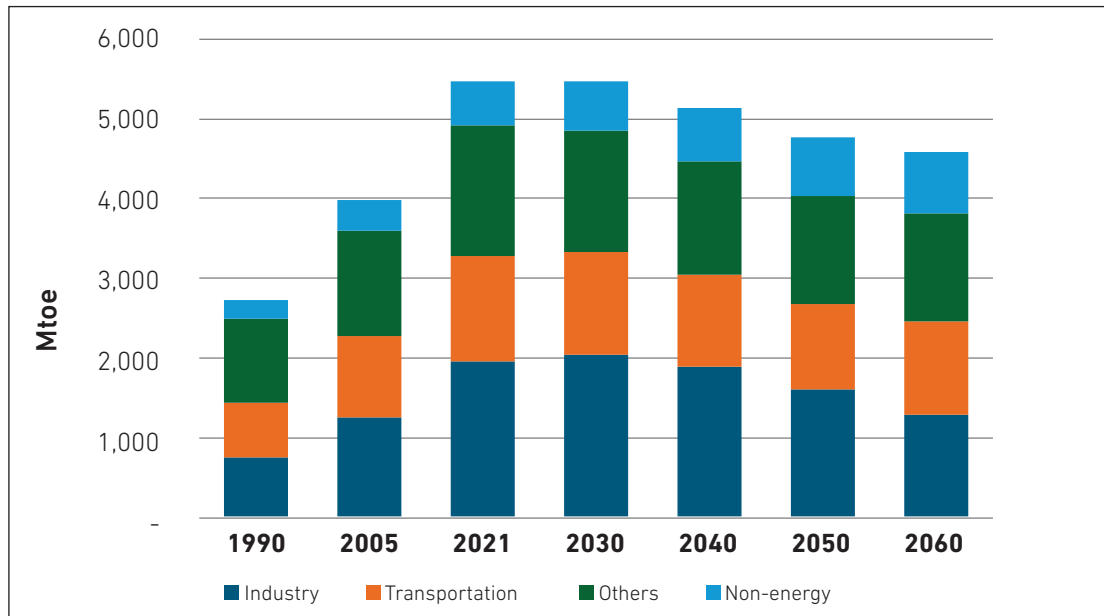
### 4.2.1. Final Energy Consumption

Final energy consumption in the EAS17 countries under LCET is projected to decline from 5,457 Mtoe in 2021 to 4,551 Mtoe in 2060, representing an AAGR of –0.5%. Compared with BAU, this reflects a 40.7% reduction. The lower consumption under LCET is due to the achievements of various energy efficiency plans and programmes, supported by the development of innovative technologies and the widespread adoption of EVs.

Under LCET, all final energy consumption sectors, except non-energy use, will have a declining trend. The industry, transport, and 'others' sectors will experience AAGRs of –1.1%, –0.3%, and –0.5%, respectively. Industry, which accounted for a significant share of 35.9% in 2021, is expected to increase to 37.3% by 2030 before decreasing to 28.3% by 2060. The 'others' sector is projected to have the biggest share by 2060, reaching 29.7% or 1,350 Mtoe, whilst transport will account for 25.2% (1,147 Mtoe). Figure 1.13 shows final energy consumption by sector under LCET in EAS17 countries in 1990–2060, whilst Figure 1.14 shows details of sector shares.



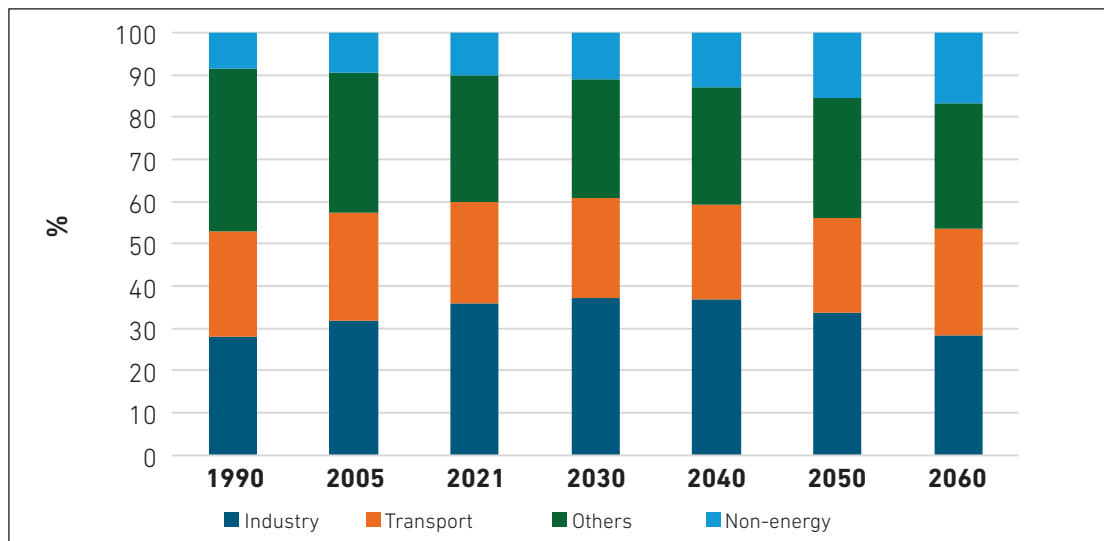
**Figure 1.13. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

**Figure 1.14. Final Energy Consumption Share by Sector, 1990–2060**



Source: Authors.

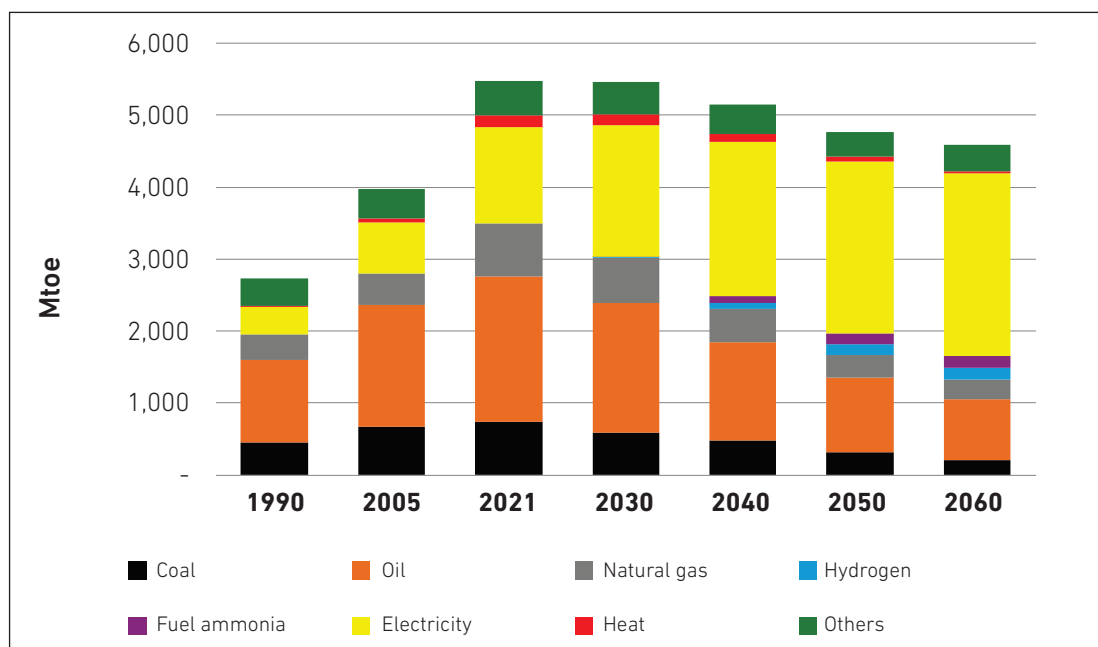
By energy source, electricity is projected to dominate the final energy consumption mix, with an AAGR of 1.7% from 2021 to 2060. It is expected to reach 2,531 Mtoe by 2060, accounting for 55.6% of total final energy consumption. The growth is due to the higher electrification rate under LCET, including the heavy penetration of EVs.

Hydrogen and fuel ammonia will begin contributing from 2030 onwards and are expected to expand steadily. By 2060, their combined consumption is expected to reach 312 Mtoe, comprising 6.9% of final energy consumption.

Conversely, other energy sources, such as fossil fuels (coal, oil, and gas), heat, and 'others', are projected to decrease. Coal, oil, and natural gas will see decreasing shares in final energy consumption, with AAGRs of  $-3.3\%$ ,  $-2.2\%$ , and  $-2.5\%$ , respectively. By 2060, the combined demand for these fossil fuels is projected at 1,328 Mtoe, or 29% of final energy consumption.

'Other' fuels, such as biomass, are also expected to decline, with an AAGR of  $-0.7\%$ . As under BAU, this negative growth is due to the shift from traditional biomass to more modern energy sources such as LPG and electricity in the residential sector. Heat is projected to experience the sharpest decline, with an annual rate of  $-5\%$  from 2021 to 2060, ultimately reaching only a 0.5% share in final energy consumption by 2060. Figure 1.15 and Figure 1.16 show final energy consumption and corresponding fuel shares under the LCET scenario in 1990–2060.

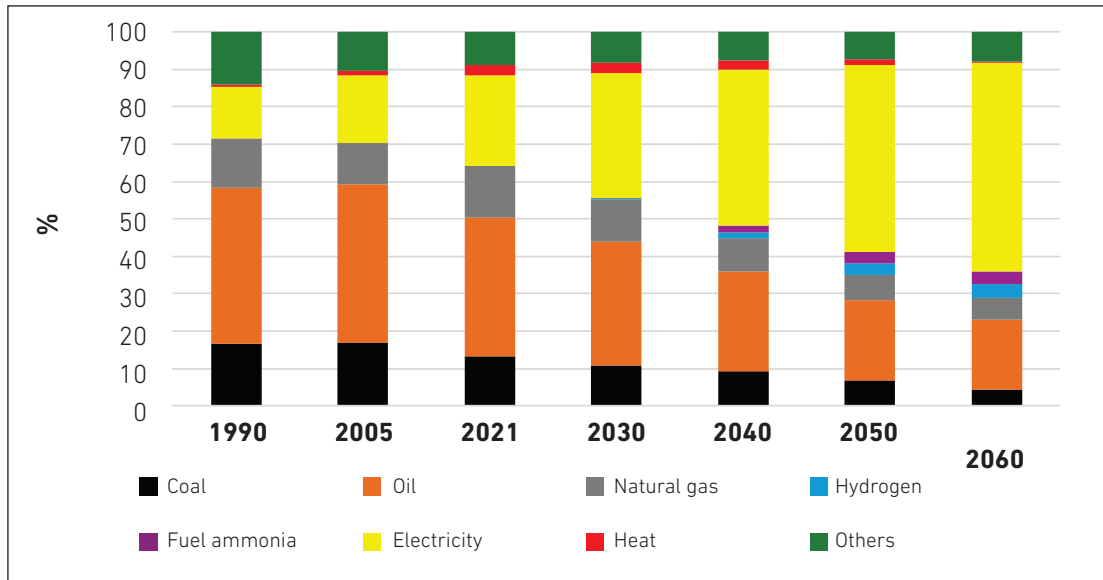
**Figure 1.15. Final Energy Consumption by Fuel,  
Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

**Figure 1.16. Final Energy Consumption Share by Fuel, 1990–2060**



Source: Authors.

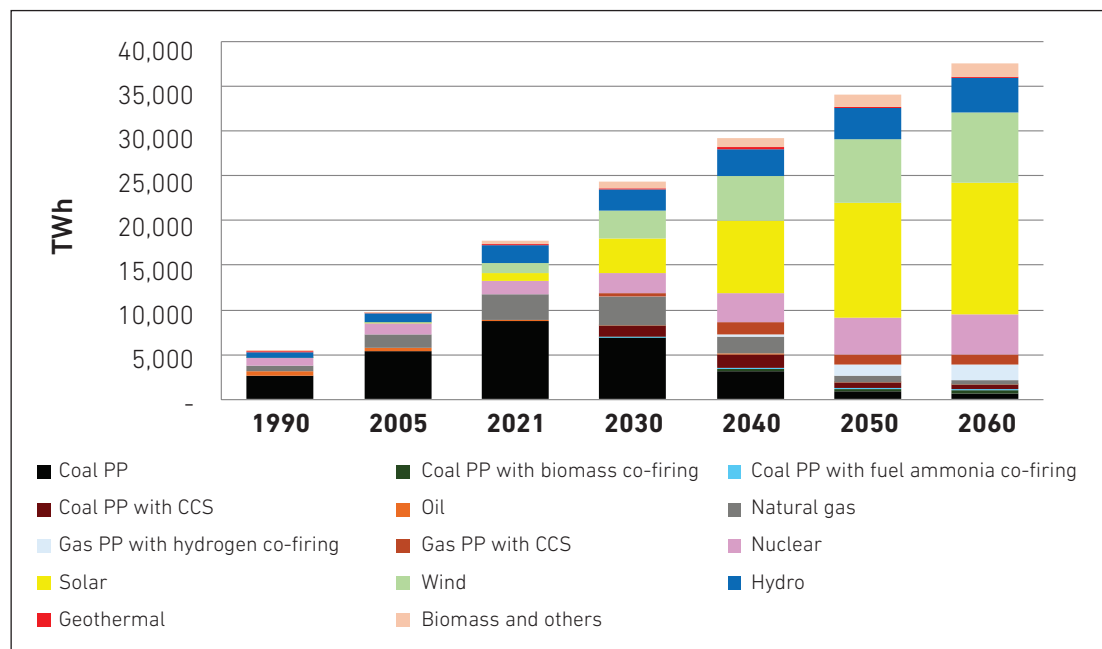
Overall, the potential energy savings under LCET, compared with BAU, are estimated at 3,119 Mtoe (40.7%). These savings are largely attributed to the increased efficiency of technologies and the electrification of final energy sectors such as transport, industry, commercial, and residential.

#### 4.2.2. Power Generation

Figure 1.17 shows the projected power generation output in EAS17 countries under LCET. Total output is expected to grow at an AAGR of 1.9%, rising from 17,685 TWh in 2021 to 37,291 TWh by 2060. Solar photovoltaic (PV) will have the biggest share at 39% (14,629 TWh) in 2060, followed by wind at 21% (7,914 TWh).

From 2030 onwards, clean technologies such as CCS and CCUS and co-firing systems are assumed to be introduced across the region. Coal- and gas-fired power plants equipped with CCS or CCUS are expected to account for up to 9.9% of total generation by 2040, decreasing to 3.9% by 2060. Meanwhile, ammonia and hydrogen co-firing technologies are expected to contribute 5.1% to the generation mix by 2060. Nuclear power generation is expected to nearly triple, increasing from 1,495 TWh in 2021 to 4,441 TWh by 2060. Figure 1.17 shows the power generation output in the EAS17 countries under LCET in 2021–2060.

**Figure 1.17. Share of Power Generation Mix in East Asia Summit 17, Low-carbon Energy Transition Scenario, 2021–2060**



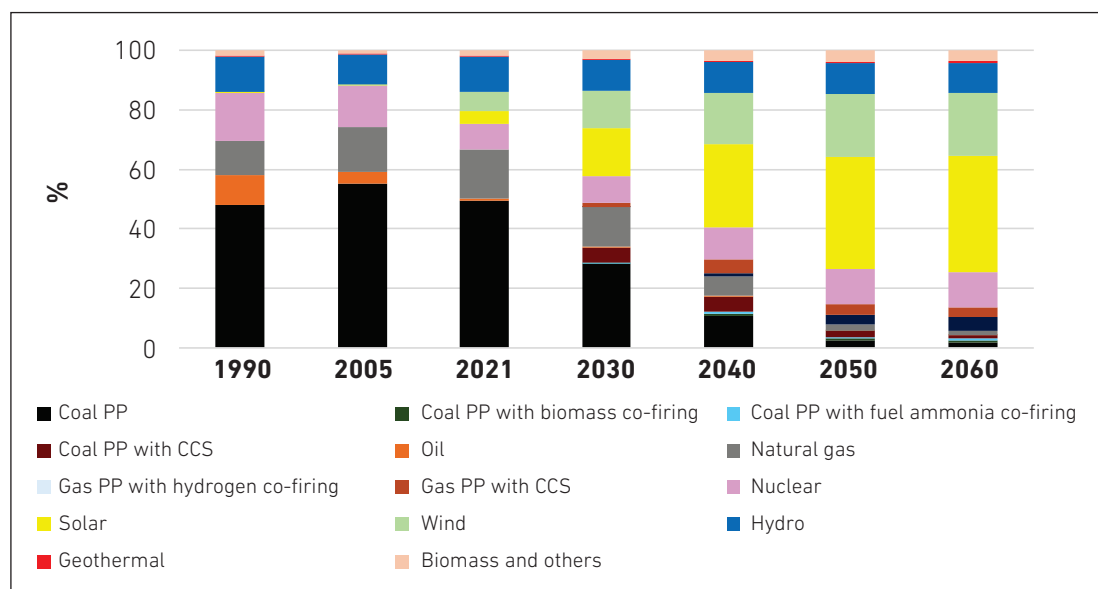
CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, TWh = terawatt-hours.

Source: Authors.

Figure 1.18 shows the projected share of each energy source in electricity generation from 1990 to 2060 under LCET. The share of unabated coal-fired generation is projected to decline sharply, with an AAGR of  $-6.3\%$ , comprising only  $1.9\%$  of the generation mix by 2060. Similarly, the share of natural gas power plants without abatement will fall significantly from  $16.5\%$  in 2021 to  $1.5\%$  in 2060, with an AAGR of  $-4.1\%$ . Oil-fired generation will decline at an even faster rate, with an AAGR of  $-6.6\%$  over the same period, due to high fuel costs and limited use in power generation. Overall, thermal generation with abatement is expected to represent about  $9.9\%$  of total generation by 2060.

Wind, solar, and biomass are projected to register the highest growth rates:  $5.0\%$ ,  $7.9\%$ , and  $3.6\%$  per year, respectively, in 2021–2060. Combined, wind and solar are expected to dominate the generation mix, accounting for  $60.4\%$  of the total by 2060, a share significantly higher than under BAU. Whilst hydropower's share in the generation mix is projected to decrease slightly, from  $11.6\%$  in 2021 to  $9.9\%$  in 2060, its absolute output is expected to increase steadily from  $2,044$  TWh to  $3,678$  TWh.

**Figure 1.18. Share of Power Generation Mix in East Asia Summit 17, Low-carbon Energy Transition Scenario, 1990–2060**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

Source: Authors.

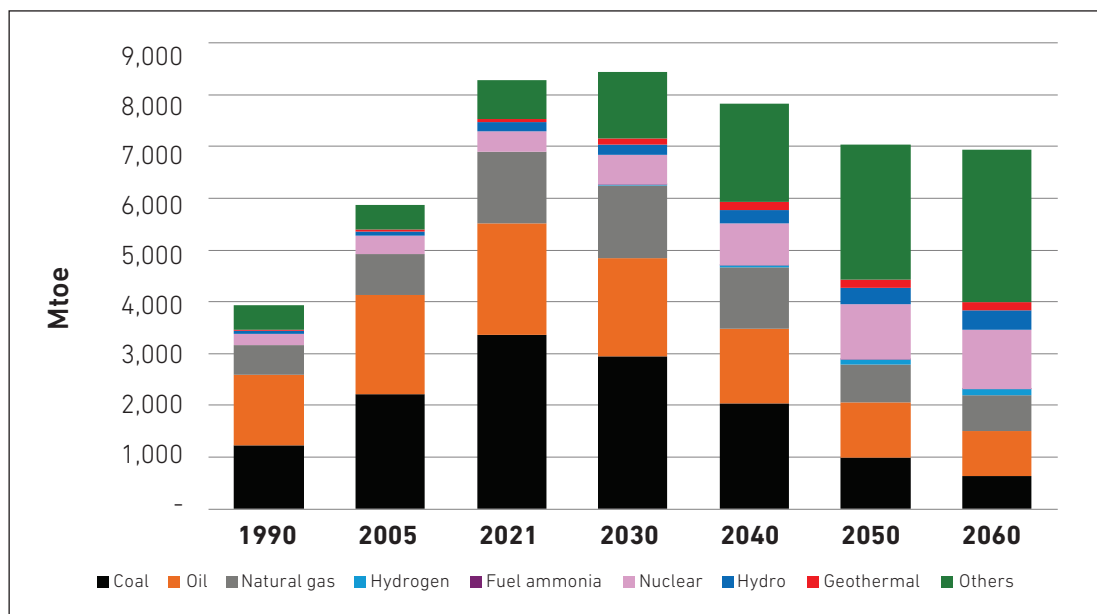
### 4.2.3. Primary Energy Supply

The substantial energy savings in primary energy supply under LCET result from reductions in total final energy consumption (through energy efficiency and electrification) and from the declining utilisation of thermal power generation, which has relatively low efficiency (typically 40%–50%). At the same time, there is a marked shift towards renewable electricity generation, which is assumed to have 100% efficiency as it involves no heat loss.

Figure 1.19 shows the primary energy supply mix in the EAS17 countries in 1990–2060 under LCET. Whilst primary energy supply under BAU is projected to grow continuously until 2060, LCET shows only a slight increase up to 2030, after which it declines. Primary energy supply is expected to grow from 8,273 Mtoe in 2021 to 8,422 Mtoe in 2030, before decreasing to 6,896 Mtoe by 2060. Compared with BAU, LCET offers a potential saving of 3,800 Mtoe, representing a 35.5% reduction.

‘Others’ is projected to account for the largest share of primary energy supply in 2060 (42.6%), largely driven by variable renewables, which are projected to grow significantly from 2021 to 2060, with an AAGR of 6.3%. Fossil fuels, by contrast, will decrease substantially, falling from 83.3% of the primary energy supply in 2021 to only 31.4% in 2060.

**Figure 1.19. Primary Energy Supply in East Asia Summit 17, 1990–2060**



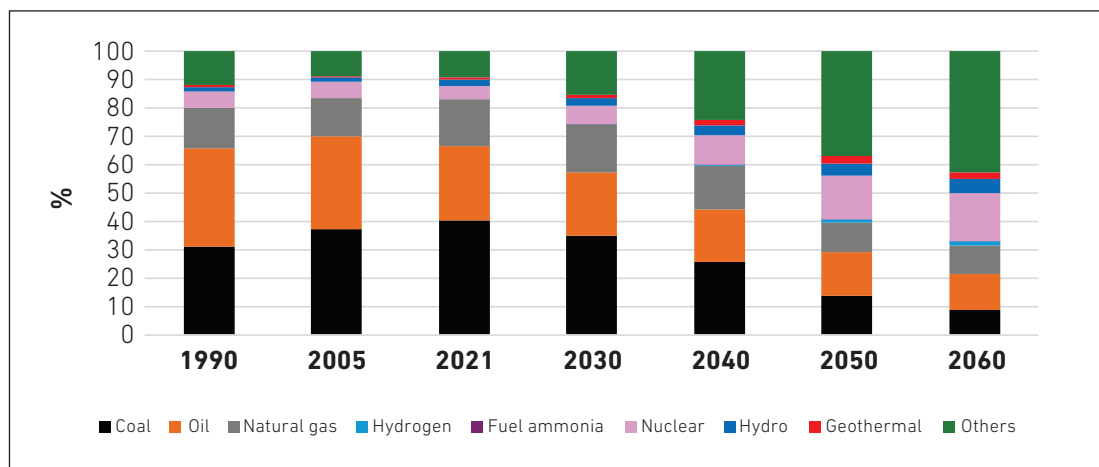
Mtoe = million tonnes of oil equivalent.

Source: Authors.

Nuclear energy is projected to increase at an AAGR of 2.8% in 2021–2060, with its share increasing from 4.7% in 2021 to 16.8% in 2060. Hydropower is projected to increase its share from 2.1% 5.2% over the same period, whilst geothermal energy is projected to grow at an AAGR of 2.5%.

‘Others’, comprising biomass, biofuels, trade electricity, and variable renewables (solar, wind, ocean, etc.), is projected to grow at an AAGR of 3.5% in 2021–2060, reaching a 42.6% share of primary energy supply in 2060. The share of variable renewables will increase dramatically, from 2.4% in 2021 to 30.9% in 2060, a significant increase compared with the BAU scenario. Figure 1.20 shows the share of each energy source in the total primary energy mix in 1990–2060 under LCET.

**Figure 1.20. Share of Primary Energy Mix by Source, 1990–2060**



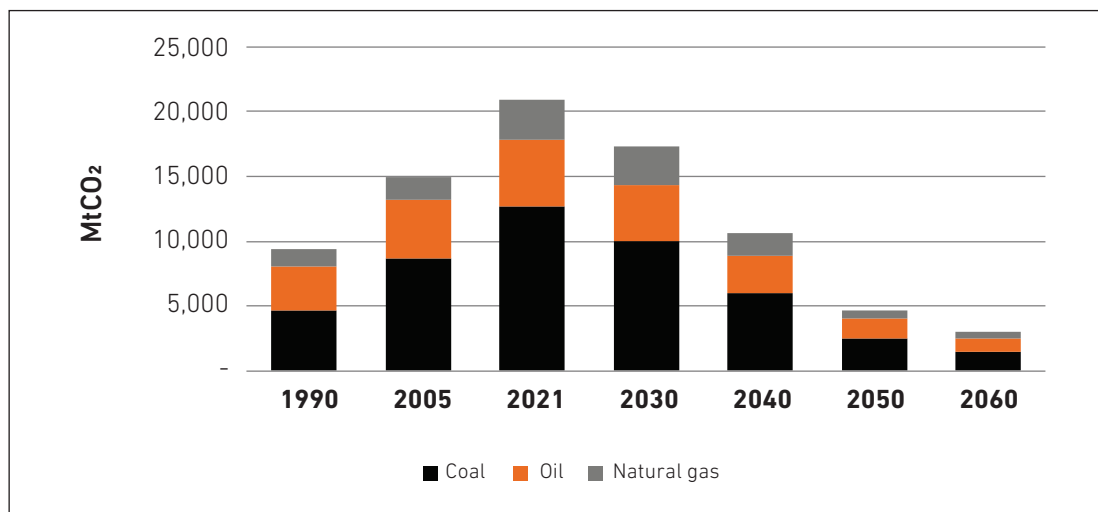
Source: Authors.

#### 4.2.4 Carbon Dioxide Emissions

CO<sub>2</sub> emissions under LCET are projected to decrease continuously in 2021–2060, at an AAGR of –4.9%. By 2060, CO<sub>2</sub> emissions in 2060 are projected to fall to 2,970 MtCO<sub>2</sub>, a reduction of nearly 86% (equivalent to 17,646 MtCO<sub>2</sub>) compared with BAU. The 2060 emission level is far lower than the 1990 baseline of 9,360 MtCO<sub>2</sub>. Figure 1.21 shows the CO<sub>2</sub> emission in 1990–2060 under LCET.

In terms of emission sources, coal remains the dominant source, accounting for 50.8% (1,508 MtCO<sub>2</sub>) of total emissions in 2060. This represents an 84.7% reduction compared with coal-related emissions in 2060 under BAU. This reduction is attributed not only to the more extensive deployment of renewable energy but also to the use of co-firing technologies, which substitute part of the coal with ammonia and biomass.

**Figure 1.21. Carbon Dioxide Emissions in East Asia Summit 17,  
Low-carbon Energy Transition Scenario, 1990–2060**



MtCO<sub>2</sub> = million tonnes of oil equivalent.

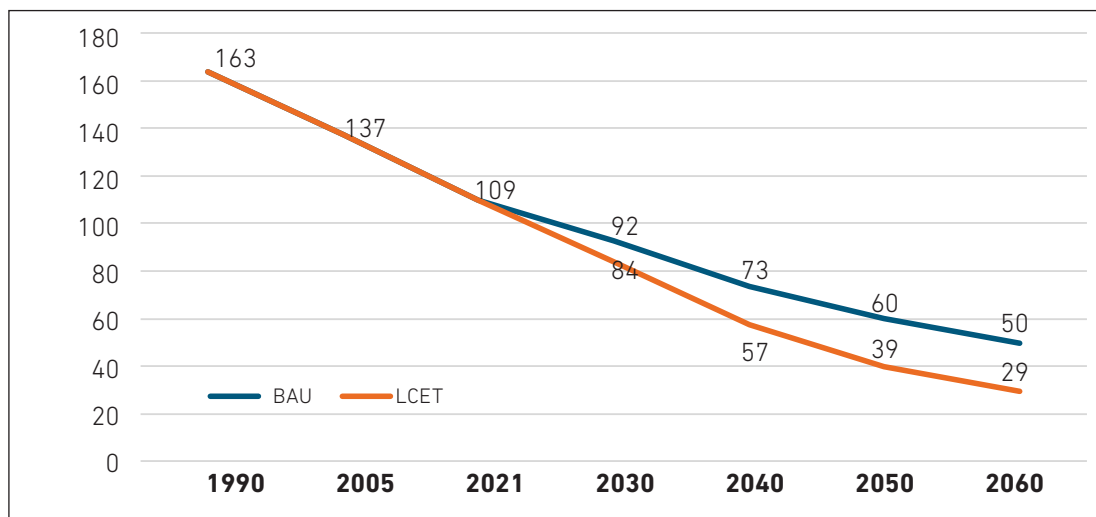
Source: Authors.

### 4.3. Energy Indicators in East Asia Summit 17

Figure 1.22 and Figure 1.23 show trends in final energy intensity and primary energy intensity from 1990 to 2060 under the BAU and LCET scenarios. Final energy intensity (tonnes of oil equivalent per million 2015 US dollars) in the EAS17 countries is projected to decline by 55% under the BAU scenario and 73% under the LCET scenario by 2060, relative to 2021 levels. This indicator shows how efficiently final energy is used to produce a unit of GDP. In general, the steady decline in final energy intensity demonstrates improved energy efficiency across all sectors: industry, transport, commercial, and residential. This indicates a decoupling of economic growth from energy consumption (Figure 1.22).



**Figure 1.22. Final Energy Intensity: Final Energy Consumption per Unit of Gross Domestic Product (toe/million 2015 US\$)**

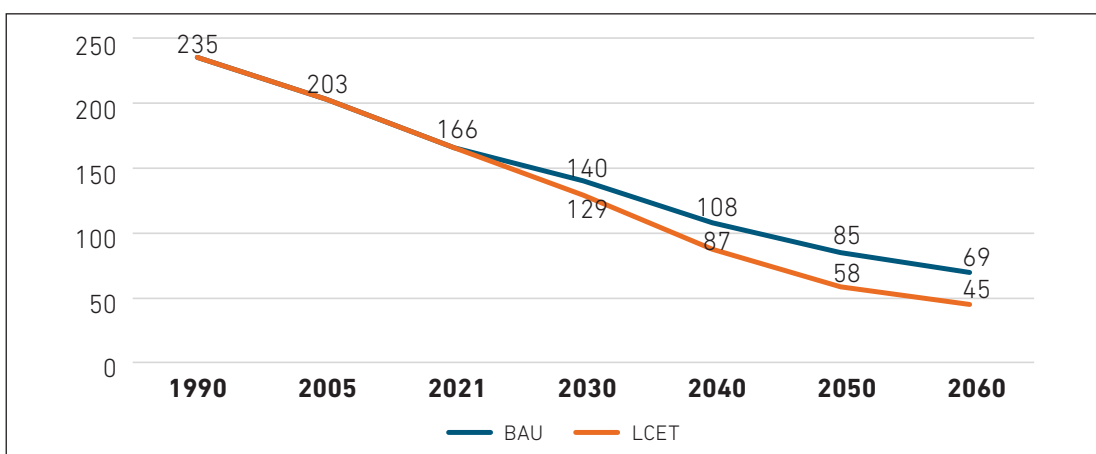


BAU = business as usual, LCET = low-carbon energy transition, toe = tonnes of oil equivalent.

Source: Authors.

Primary energy intensity measures the overall efficiency of the economy in using energy to produce GDP. It includes both the efficiency of energy transformation processes and final energy consumption. As shown in Figure 1.23, primary energy intensity in EAS17 is projected to decline by 58% under BAU and 73% under LCET by 2060, compared with 2021 levels. This improvement is also partially reflected in the trend of declining CO<sub>2</sub> intensity (tCO<sub>2</sub> per million 2015 US dollars).

**Figure 1.23. Primary Energy Intensity: Primary Energy Consumption per Unit of Gross Domestic Product (toe/million 2015 US\$)**

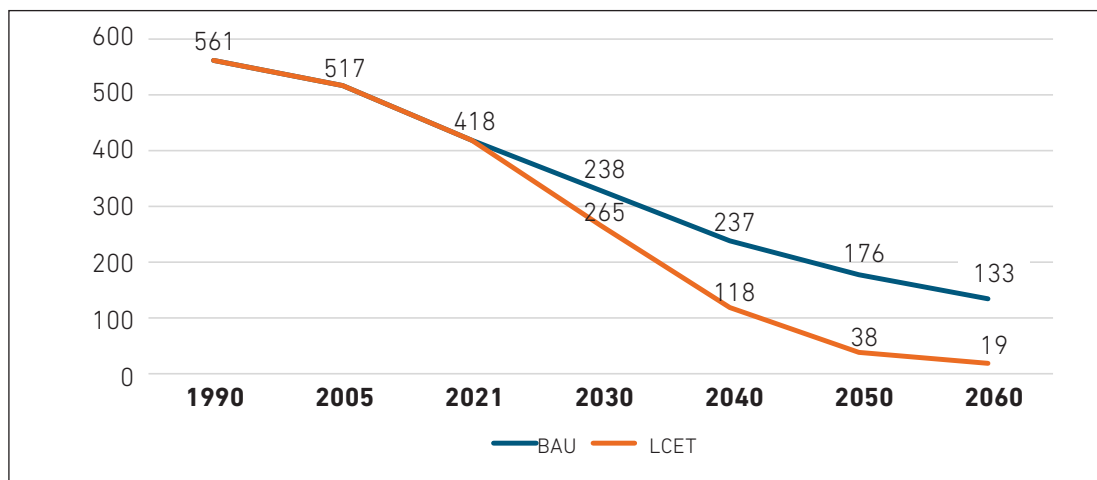


BAU = business as usual, LCET = low-carbon energy transition, toe = tonne of oil equivalent.

Source: Authors.

The CO<sub>2</sub> intensity of GDP is expected to drop by 68% under BAU and 95% under LCET by 2060, relative to 2021 levels (Figure 1.24). The differences in carbon intensity between the two scenarios reflect a structural shift away from fossil fuels towards renewable energy and clean technologies

**Figure 1.24. Carbon Dioxide Intensity of Gross Domestic Product (tCO<sub>2</sub>/million 2015 US\$)**

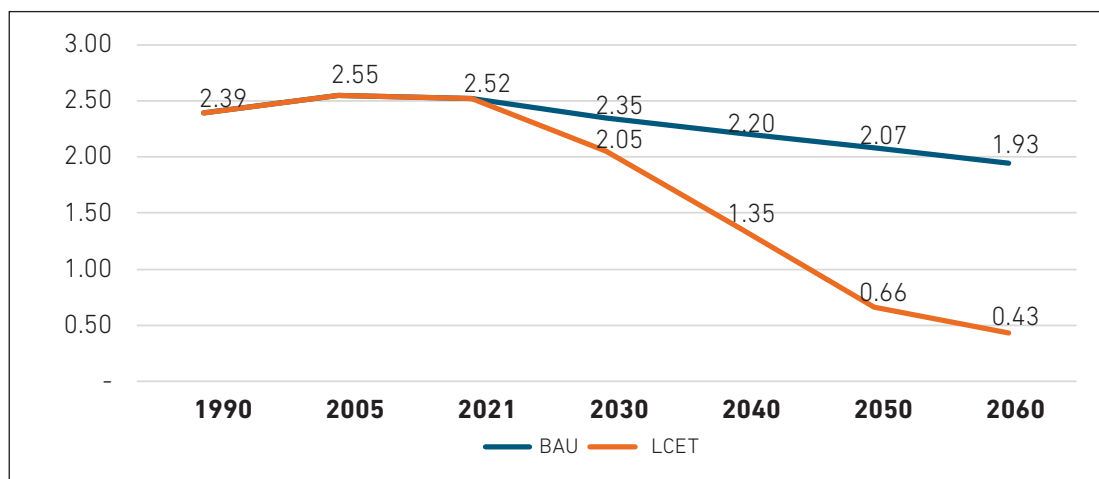


BAU = business as usual, LCET = low-carbon energy transition, tCO<sub>2</sub> = tonne of carbon dioxide.

Source: Authors.

CO<sub>2</sub> intensity of primary energy supply measures the amount of carbon emitted per unit of energy consumed and indicates how clean a country or region's energy system is. A shift towards renewables and low-carbon technologies results in a lower intensity. In EAS17 countries, the CO<sub>2</sub> intensity of primary supply is projected to decline by 24% under BAU and 83% under LCET by 2060 compared with 2021. If the LCET pathway is achieved, the energy systems of EAS17 countries will become significantly cleaner, emitting less carbon per unit of primary energy consumed.

**Figure 1.25. Carbon Intensity of Primary Energy Supply (tCO<sub>2</sub>/toe)**

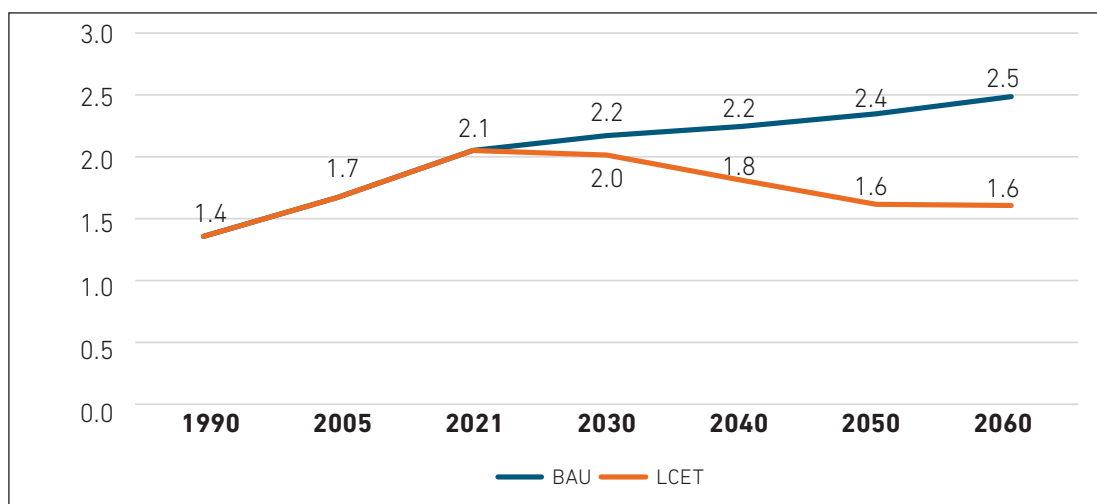


BAU = business as usual, LCET = low-carbon energy transition, tCO<sub>2</sub> = tonne of carbon dioxide, toe = tonne of oil equivalent.  
Source: Authors.

Under BAU, per capita energy demand is projected to increase by 21% by 2060 relative to 2021. In contrast, under LCET, it is expected to decrease by 22%. This divergence reflects the fundamental transformation in energy systems under LCET, driven by efficiency improvements and electrification. The decline in per capita energy demand under LCET may be attributed to heightened energy conservation efforts and growing awareness, as well as to widespread electrification across EAS17 countries.

Given that EAS17 comprises well-developed economies with high levels of per capita energy consumption, such as Australia, China, Japan, Korea, New Zealand, and the US, per capita energy use is expected to plateau or decline as energy demand saturates. Conversely, in developing EAS17 countries, rising income levels are expected to increase energy consumption per capita as households acquire vehicles, appliances, and other energy-intensive goods. Figure 1.26 shows trends in per capita energy demand in 1990–2060 under both scenarios.

**Figure 1.26. Primary Energy Consumption per Capita (toe/person)**



BAU = business as usual, LCET = low-carbon energy transition, toe = tonne of oil equivalent.

Source: Authors.

## 4.4. Energy Cost Comparison

Based on the energy outlook results from the modelling exercise, an energy cost comparison analysis was conducted. The aim is to compare the cost associated with transitioning to low-carbon energy technologies against those incurred under a BAU pathway. The transition is represented by LCET, whilst BAU reflects the continuation of current practices. The analysis comprises three main cost components: fuel costs, power plant investment costs, and CCS costs.

### 4.4.1. Calculation Approach

#### (1) Fuel Cost

The estimation covers fossil fuels (coal, oil, and gas) as well as hydrogen. The formula for calculating fuel cost estimation is as follows:

$$FC_{i2060} = (C_{i2060} - C_{i2021}) \times UC_{i2060}$$

Where:

$FC_{i2060}$ : Fuel cost of fuel  $i$  in 2060 (million US\$)

$C_{i2060}$ : Consumption of fuel  $i$  in 2060 (Mtoe)

$C_{i2021}$ : Consumption of fuel  $i$  in 2021 (Mtoe)

$UC_{i2060}$ : Unit cost of fuel  $i$  in 2060 (US\$/toe)

Fuel costs are calculated by multiplying the change in fuel consumption between 2021 and 2060 and 2021 by the 2060 unit cost. The resulting figure indicates either an additional expenditure or a saving in annual fuel costs in 2060 compared with the 2021 level. However, some countries calculate costs directly using  $C_{i2060}$ .

(2) Power investment cost

The formula for estimating power investment costs is as follows:

$$PIC_i = (PG_{2060} - PG_{2021}) / (24 \times 365 \times CFI) \times UPIC_i / 1000$$

Where:

PIC<sub>i</sub>: Power investment cost of power source *i* in 2021–2060 (million US\$)

PG<sub>2060</sub>: Power generation of power source *i* in 2060 (TWh)

PG<sub>2021</sub>: Power generation of power source *i* in 2021 (TWh)

CFI: Capacity factor of power source *i*

UPIC<sub>i</sub>: Unit construction cost of power source *i* in 2021–2060 (US\$/kW)

Investment costs are calculated as the total required expansion of generation capacity to meet projected electricity demand. This involves estimating the additional power generation needed between 2021 and 2060, adjusting for capacity factors, and multiplying by the unit cost of construction. The total is then converted into an annualised figure for comparison purposes.

(3) CCS cost

CCS entails substantial capital requirements, covering the capture, transport, and storage of CO<sub>2</sub> into saline aquifer basins. In this analysis, CCS costs refer to operating costs, expressed as US\$/tonne of CO<sub>2</sub> captured. The formula is as follows:

$$CCS_{2060} = (CO_{2060} - CO_{2021}) \times UCCS_{2060}$$

Where:

CCS<sub>2060</sub>: CCS cost in 2060 (million US\$)

CO<sub>2060</sub>: Amount of CO<sub>2</sub> treated by CCS in 2060 (million tonnes)

CO<sub>2021</sub>: Amount of CO<sub>2</sub> treated by CCS in 2021 (million tonnes)

UCCS<sub>2060</sub>: Unit cost of CCS in 2060 (US\$/tonne of CO<sub>2</sub>)

The CCS cost is calculated by the increase in the volume of CO<sub>2</sub> treated between 2021 and 2060, multiplied by the unit cost in 2060. This produces the annual operating cost required for CCS in that year.

The total energy cost is obtained by summing all three components. The comparison is presented on an annualised basis: fuel costs reflect annual potential savings or additional expenses for fuel provision, power plant investment costs represent the total investment divided across the modelling period, and CCS costs denote the annual operating expenditure required in 2060. It should be noted, however, that some country reports adopt an alternative method, using cumulative power investment costs together with annualised fuel and CCS costs.

#### 4.4.2. Basic Assumptions

The energy cost comparison analysis is conducted based on assumptions regarding unit costs for fuels, power plant investments, and CCS. These assumptions are set for 2021 and 2060, reflecting an anticipated increase in fossil fuel costs and a decrease in the costs of clean technologies (i.e. renewables, hydrogen, and CCS) due to economies of scale and technology learning curves. Table 1.4, Table 1.5, and Table 1.6 present the basic assumptions underpinning the analysis, covering fuel costs, power plant construction costs, and capacity factor assumptions, respectively.

**Table 1.4. Fuel Cost Assumptions**

|          | 2021  | 2060* | Unit                       |
|----------|-------|-------|----------------------------|
| Coal     | 80.03 | 98    | US\$/tonne                 |
| Oil      | 41    | 100   | US\$/bbl                   |
| Gas      | 7.77  | 7.5   | US\$/MMBtu                 |
| Hydrogen | 0.8   | 0.3   | US\$/Nm <sup>3</sup>       |
| CCS      |       | 60    | US\$/tonne CO <sub>2</sub> |

bbl = barrel, CCS = carbon-capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal unit, Nm<sup>3</sup> = normal cubic metre.

\*Note: All 2060 figures are in 2021 constant price.

Source: Authors.

**Table 1.5. Construction Cost Assumptions for Power Plants (US\$/kW)**

|                        | 2021  | by 2060 |
|------------------------|-------|---------|
| Coal                   | 1,500 | 1,525   |
| Coal co-firing biomass |       | 1,600   |
| Coal co-firing ammonia |       | 1,600   |
| Coal with CCS          |       | 1,525   |
| Oil                    | 600   | 600     |
| Gas                    | 700   | 700     |
| Gas co-firing hydrogen |       | 800     |
| Gas with CCS           |       | 700     |
| Nuclear                | 4,500 | 3,575   |
| Hydro                  | 2,000 | 2,223   |
| Geothermal             | 4,000 | 4,256   |
| Solar                  | 1,600 | 307     |
| Wind                   | 1,600 | 1,235   |
| Biomass                | 2,000 | 3,019   |

CCS = carbon capture and storage, kW = kilowatt.

Source: Authors.

**Table 1.6. Capacity Factor Assumptions of Power Plants (%)**

|                        | 2021 | 2060 |
|------------------------|------|------|
| Coal                   | 75   | 80   |
| Coal co-firing biomass |      | 80   |
| Coal co-firing ammonia |      | 80   |
| Coal with CCS          |      | 80   |
| Oil                    | 75   | 80   |
| Gas                    | 75   | 80   |
| Gas co-firing hydrogen |      | 80   |
| Gas with CCS           |      | 80   |
| Nuclear                | 100  | 80   |
| Hydro                  | 50   | 40   |
| Geothermal             | 50   | 50   |
| Solar                  | 17   | 17   |
| Wind                   | 40   | 40   |
| Biomass                | 50   | 70   |

CCS = carbon capture and storage.

Source: Authors.

### 4.4.3. Cost Comparison Results

#### 4.4.3.1. Fuel Cost

Based on the assumptions and the results of BAU and LCET, a fuel cost comparison was conducted. The analysis measures the difference in fuel consumption in 2060 compared with the 2021 level, presented on an annual cost basis. Its goal is to determine the additional expenditure required, or the savings achieved, by 2060 under BAU or LCET. Table 1.7 shows the fuel cost comparison between BAU and LCET in 2060.

**Table 1.7. Fuel Cost Comparison Between the Business-as-Usual Scenario and the Low-carbon Energy Transition Scenario, 2060**

|              | Primary Energy Consumption (Mtoe), 2021 | BAU Primary Energy Consumption (Mtoe), 2060 | LCET Primary Energy Consumption (Mtoe), 2060 | BAU Fuel Cost, (Million US\$), 2060 | LCET Fuel Cost, (Million US\$), 2060 |
|--------------|-----------------------------------------|---------------------------------------------|----------------------------------------------|-------------------------------------|--------------------------------------|
| Coal         | 3,365.34                                | 2,639.74                                    | 629.57                                       | -114,662                            | -432,319                             |
| Oil          | 2,143.18                                | 2,864.95                                    | 874.71                                       | 496,433                             | -872,462                             |
| Gas          | 1,381.72                                | 1,773.16                                    | 659.59                                       | 113,027                             | -208,515                             |
| Hydrogen     | 0.00                                    | 0.00                                        | 116.56                                       | 0.00                                | 135,814                              |
| <b>Total</b> | <b>6,890.24</b>                         | <b>7,277.85</b>                             | <b>2,280.43</b>                              | <b>494,797</b>                      | <b>-1,377,482</b>                    |

Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Under BAU, EAS17 countries are projected to incur an additional US\$495 billion annually in fuel costs by 2060 compared with 2021. The largest increase stems from oil consumption, amounting to US\$496 billion, whilst a shift away from coal will generate annual savings of US\$115 billion.

In contrast, LCET is expected to deliver significant savings, reducing annual fuel costs by US\$1,377 billion in 2060 compared with 2021. These savings are primarily driven by reduced reliance on fossil fuels and improvements in final energy efficiency. The largest saving comes from avoiding oil consumption, totalling US\$872 billion, followed by coal (US\$432 billion) and gas (US\$209 billion). However, the adoption of hydrogen is projected to add an annual cost of US\$136 billion. Overall, LCET highlights a substantial reduction in fossil fuel costs compared with BAU.

#### 4.4.3.2. Power Plant Investment Cost

The analysis of power plant investment costs is based on electricity generation in 2021 and 2060 under both BAU and LCET, multiplied by the assumed unit construction costs shown in Table 1.5. The purpose is to estimate the additional power plant capacity required by 2060 under each scenario, calculated as the difference in electricity generation in 2021–2060. The resulting capacity figures are then used to determine the corresponding investment costs. Table 1.8 shows the estimated power plant investment cost comparison between the two scenarios in 2060.



**Table 1.8. Power Plant Investment Cost Comparison Between the Business-as-Usual Scenario and the Low-carbon Energy Transition Scenario, 2060**

| Technology                | Generation, 2021 | Generation, BAU, 2060 (TWh) | Generation, LCET, 2060 (TWh) | Additional Capacity, BAU (MW) | Additional Capacity, LCET (MW) | Total Investment, BAU, 2060 (Million US\$) | Total Investment, LCET in 2060 (Million US\$) |
|---------------------------|------------------|-----------------------------|------------------------------|-------------------------------|--------------------------------|--------------------------------------------|-----------------------------------------------|
| Coal PP                   | 8,758.3          | 6,898.5                     | 706.5                        | 0                             | 0                              | 0                                          | 0                                             |
| Coal PP biomass co-firing | 0.0              | 149.7                       | 315.1                        | 21,356                        | 44,956                         | 34,170                                     | 71,930                                        |
| Coal PP ammonia co-firing | 0.0              | 0.0                         | 193.3                        | 0                             | 27,577                         | 0                                          | 44,124                                        |
| Coal PP with CCS          | 0.0              | 0.0                         | 404.3                        | 0                             | 57,692                         | 0                                          | 87,980                                        |
| Oil PP                    | 120.5            | 23.0                        | 8.4                          | 0                             | 0                              | 0                                          | 0                                             |
| Gas PP                    | 2,924.6          | 4,519.9                     | 566.9                        | 227,639                       | 0                              | 159,347                                    | 0                                             |
| Gas PP hydrogen co-firing | 0.0              | 0.0                         | 1,728.4                      | 0                             | 246,634                        | 0                                          | 197,307                                       |
| Gas PP with CCS           | 0.0              | 0.0                         | 1,064.0                      | 0                             | 151,821                        | 0                                          | 106,275                                       |
| Nuclear PP                | 1,495.0          | 2,247.8                     | 4,440.9                      | 107,415                       | 420,368                        | 384,008                                    | 1,502,817                                     |
| Solar PV                  | 757.1            | 8,920.5                     | 14,628.5                     | 5,481,691                     | 9,314,643                      | 1,682,879                                  | 2,859,595                                     |
| Wind                      | 1,166.6          | 7,880.8                     | 7,914.3                      | 1,916,128                     | 1,925,696                      | 2,366,418                                  | 2,378,235                                     |
| Hydro                     | 2,044.0          | 3,328.0                     | 3,677.8                      | 366,418                       | 466,249                        | 814,548                                    | 1,036,472                                     |
| Geothermal                | 55.4             | 169.0                       | 208.7                        | 25,929                        | 34,996                         | 110,354                                    | 148,944                                       |
| Biomass and others        | 363.7            | 1,254.4                     | 1,434.4                      | 145,245                       | 174,599                        | 438,495                                    | 527,113                                       |
| <b>Total</b>              | <b>17,685.43</b> | <b>35,391.5</b>             | <b>37,291.4</b>              | <b>8,291,822</b>              | <b>12,865,232</b>              | <b>5,990,219</b>                           | <b>8,960,793</b>                              |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, MW = megawatts, PP = power plant, TWh = terawatt-hours.

Source: Author's calculations.

The analysis shows that LCET will require significantly greater additional capacity, amounting to 12,865 GW by 2060, compared with 8,292 GW under BAU. Consequently, total investment costs will also be higher under LCET, reaching US\$8,961 billion, as opposed to US\$5,990 billion by 2060 under BAU.

Solar PV accounts for the biggest share of additional capacity in both scenarios, with 5,482 GW under BAU and 9,315 GW under LCET. Investments in solar and wind together will dominate, representing US\$4,050 billion (68% of total investment) under BAU and US\$5,238 billion (58% of total investment) under LCET by 2060. Nuclear power will also see a marked increase under LCET, requiring US\$1,503 billion compared with US\$384 billion under BAU. Additionally, hydrogen and ammonia co-firing plants will require investments of US\$241 billion under LCET by 2060.

#### 4.4.3.3. Cost of Carbon Capture and Storage

The deployment of CCS technology is a central element of LCET. CCS technology is assumed to be introduced from 2030 at the initial commercial stage. It is projected to be applied to coal-fired and gas-fired power plants to substantially reduce their carbon emissions.

The calculation is based on the CO<sub>2</sub> emissions from coal and gas power plants equipped with CCS technology, derived from the amount of coal and gas consumed. Conversion factors are applied: 1.017 MtC/Mtoe for coal and 0.58 MtC/Mtoe for gas. These are then converted from MtC to MtCO<sub>2</sub> using the stoichiometric ratio of carbon to CO<sub>2</sub>, equivalent to 1:3.67. The capture efficiency of the technology is also considered, with CCS assumed to operate at 90% efficiency. The final amount of CO<sub>2</sub> captured is used to calculate the total CCS cost.

Cost estimation employs the assumed unit cost of CCS shown in Table 1.9. This assumption sets the CCS unit cost at US\$60 per tonne of CO<sub>2</sub>. Based on this, the CCS cost under the LCET scenario is estimated.

**Table 1.9. Total Investment Cost of Carbon Capture and Storage Technology Under the Low-carbon Energy Transition Scenario, 2060**

|               | Consumption,<br>LCET, 2060 (Mtoe) | Estimated CO <sub>2</sub><br>Emission, LCET,<br>2060 (MtCO <sub>2</sub> ) | Estimated CO <sub>2</sub><br>Captured, LCET,<br>2060 (MtCO <sub>2</sub> ) | Total CCS<br>Investment Cost,<br>LCET (Million US\$) |
|---------------|-----------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------|
| Coal with CCS | 64.05                             | 239.04                                                                    | 215.14                                                                    | 12,908                                               |
| Gas with CCS  | 83.94                             | 178.78                                                                    | 160.90                                                                    | 9,654                                                |
| <b>Total</b>  | <b>158.97</b>                     | <b>417.82</b>                                                             | <b>376.04</b>                                                             | <b>22,562</b>                                        |

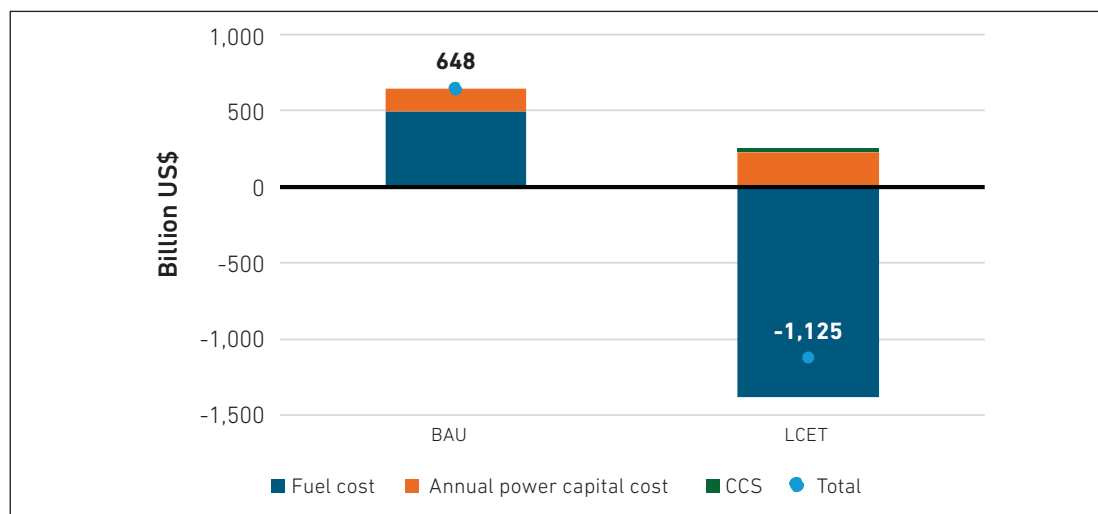
CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MtCO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author's calculations.

#### 4.4.3.4. Total Cost

The results of the cost analysis presented in the previous sections, covering fuel costs, power plant investment costs, and CCS costs, are consolidated here. The power investment cost component has already been converted into an annual basis to allow for a consistent comparison of average annual cost additions or savings expected by 2060 under each scenario. Figure 1.18 shows the overall annual total cost for both BAU and LCET.

**Figure 1.27. Overall Annual Total Cost for Business-as-Usual and Low-carbon Energy Transition Scenarios (US\$ billion)**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Author's calculations.

As shown in Figure 1.18, under BAU, EAS17 countries will require an additional US\$648 billion annually in 2060 compared with 2021. About 76.3% of this cost will come from fuel expenditures, largely due to rising demand and prices for fossil fuels, i.e. oil and gas. The remaining US\$153.6 billion is attributed to power plant investment to meet the growing electricity demand.

By contrast, LCET yields a net negative additional cost, reflecting a substantial annual saving of US\$1,125 billion by 2060 compared with 2021. This saving is primarily driven by reduced reliance on fossil fuels, the widespread deployment of renewables, the adoption of clean technologies, and improvements in energy efficiency. Specifically, fuel costs are projected to decline by US\$1,377 billion annually, offsetting the additional costs associated with increased power plant investment (US\$229.8 billion annually) and CCS (US\$22.6 billion annually).

The slightly higher investment in power plants under LCET compared with BAU reflects the higher rate of electrification and the reliance on renewables, which generally have lower capacity factors than thermal power plants, thus requiring greater installed capacity.

Overall, BAU remains heavily dependent on fossil fuels, resulting in persistently high energy costs. In contrast, LCET achieves large-scale cost savings by shifting towards solar and wind power sources. However, the analysis may underestimate the future power investment costs of LCET. Greater deployment of variable renewable energy would likely necessitate backup systems such as battery energy storage systems or additional base load capacity from nuclear and gas power plants equipped with abatement technologies, to address intermittency issues. These costs are not included in the current analysis. The inclusion of such systems, along with potential changes in the underlying assumptions, would significantly affect energy costs and present important considerations for decision-makers.

## 5. Conclusions and Recommendations

LCET aims to provide each EAS country with a carbon-neutral pathway by mid-century (2050 or 2060). The choice of pathway depends on national situations, including levels of economic development, population size, land area, and the availability of natural resources. There is, however, a common concept: reducing fossil fuel consumption whilst increasing the use of low-carbon energy sources and technologies. In other words, the selection of low-carbon options will vary by country, but the overall direction remains the same.

The detailed measures underpinning this concept are specified below for both the final energy consumption and power generation sectors:

- **Final energy consumption sector:** a. promotion of energy efficiency and conservation to reduce overall consumption; b. electrification to replace fossil fuels with electricity, through measures such as electric vehicles, induction heating stoves, and heat pumps for heating water; c. expansion of clean fuels, including hydrogen, ammonia, and biomass (such as biofuels), to displace fossil fuels; d. application of CCS to major industrial emitters.
- **Power generation sector:** a. increase of renewable energy, including traditional sources such as hydropower and variable sources such as solar; b. re-evaluation of nuclear power, including the restart of existing plants and the development of new, advanced facilities; c. deployment of abated thermal power plants, including co-firing with biomass, hydrogen, and ammonia, alongside CCS applications.

The energy cost structure of LCET differs significantly from that of BAU. Under BAU, fossil fuel procurement costs remain dominant in the long term. By contrast, LCET requires substantial investment in low-carbon power plants, alongside the procurement of low-carbon fuels (such as hydrogen or ammonia) and technologies such as CCS. Japan's GX (Green Transformation) initiative illustrates this approach, emphasising the simultaneous achievement of economic growth and carbon neutrality. Its central premise is that investment in innovative energy technologies can induce new economic growth, a perspective now widely recognised across the globe.

This study analyses the energy outlook and CO<sub>2</sub> emission trajectories of EAS17 countries, reflecting macroeconomic assumptions and the energy policies and development plans of each member country. The results provide two scenarios—BAU and LCET—and include a comparative analysis of their respective energy costs. The key findings from this analysis are summarised below

### 5.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and CO<sub>2</sub> emissions under BAU and LCET, the outlook study identified several key findings, as outlined below:

- (i) The final energy consumption under LCET is expected to be lower than under BAU, reflecting the achievement of long-term carbon neutrality targets and the implementation of various energy efficiency policies. Across most sectors, final energy consumption is significantly lower under LCET. In percentage terms, reductions are largest in industry (48.6%), followed by transport (45.9%), and 'others' (40.2%).

- (ii) The fuel mix for final energy consumption in 2060 differs markedly between BAU and LCET. Under BAU, fossil fuels account for more than 50% of consumption, whilst under LCET, their share is less than 30%, largely due to a rapid increase in electricity use and a greater share of clean fuels, including biomass.
- (iii) The potential energy savings in final energy consumption across EAS17 countries under LCET are projected to reach 3,130 Mtoe. Most of these savings are expected to come from industry, due to improvements in energy efficiency. Overall, total savings under LCET are expected to represent a 40.6% reduction compared with BAU in 2060.
- (iv) Total power generation under BAU is projected to grow by an average of 1.8% per year, rising from 17,685 TWh in 2021 to 35,391 TWh in 2060. By 2060, solar and wind are predicted to provide 8,920 TWh (25.2%) and 7,881 TWh (22.3%), respectively. Coal and gas together are expected to contribute 32.3% of generation, indicating the continuous role of fossil fuels. Under LCET, total power generation will grow slightly faster at 1.9%, reaching 37,291 TWh in 2060. Solar and wind generation is expected to contribute 14,629 TWh (39.2%) and 7,914 TWh (21.2%), respectively, in 2060. Hydrogen and ammonia enter the generation mix by 2030, with shares increasing from 0.2% in 2030 to 5.2% in 2060. Hydropower and nuclear energy also play significant roles in decarbonising power generation under LCET, contributing 9.9% and 11.9%, respectively, by 2060.
- (v) Oil supply under LCET in 2060 is expected to be 69.5% lower than under BAU, representing a reduction of about 1,990.2 Mtoe. This decline is driven largely by the shift to electricity consumption, especially in transport, where EVs are expected to be rolled out extensively. Under BAU, natural gas use is expected to increase by 28.3% from 2021 levels by 2060. In contrast, LCET projects a 62.8% reduction in natural gas by 2060.
- (vi) CO<sub>2</sub> emissions from energy consumption under BAU are projected to remain largely unchanged in 2021–2060. Under LCET, however, CO<sub>2</sub> emissions drop sharply, from 20,870 MtCO<sub>2</sub> in 2021 to 2,970 MtCO<sub>2</sub> in 2060, representing an 85.6% reduction. This major reduction is due to the shift to cleaner energy sources for energy provision and significant improvements in energy efficiency through innovative technologies. As a result, CO<sub>2</sub> emissions per unit of primary energy consumption (tCO<sub>2</sub>/toe) will decline from 2.52 in 2021 to 0.43 by 2060.
- (vii) Primary energy intensity (toe/million 2015 US dollars) in EAS17 countries is expected to decline significantly by 2060: 58% under BAU and 73% under LCET compared with 2021. This indicator reflects the efficiency of the economy in using primary energy to produce a unit of GDP, accounting for transformation sector efficiency. In general, primary energy intensity improves remarkably, reflecting increased energy efficiency, greater electrification across industry, transport, commercial, and residential sectors, and a significant shift from thermal to renewable power generation.
- (viii) The energy cost comparison highlights a contrasting cost structure between BAU and LCET. Under BAU, high fossil fuel dependency keeps fuel costs dominant. LCET, in contrast, requires substantial investment in low-carbon power plants, including abated thermal power plants, and increased spending on hydrogen and CCS. Whilst the total energy cost of LCET seems lower than that of BAU, results are sensitive to assumptions about future unit costs of fossil fuels, power plants, hydrogen, and CCS. These uncertainties must be considered when comparing BAU and LCET costs.

## 5.2. Policy Implications

Based on the above findings, this outlook study identifies five major categories of policy implications aimed at enhancing sector action plans, advancing energy efficiency policies, shifting from fossil to non-fossil energy sources, rationalising energy pricing mechanisms, and improving energy consumption statistics to better understand the current energy situation. The design of appropriate policies will vary across countries, reflecting their specific circumstances, policy objectives, and market structures, and not all members may agree to every recommendation. The implications are outlined as follows:

### (i) Promotion of energy efficiency and conservation

Final energy consumption under BAU increases steadily in 2021–2060. By contrast, under LCET, it declines due to the assumed aggressive promotion of energy efficiency and conservation in ASEAN and the +7 countries. The first step should be the enactment of an EEC law, which should a. set energy-saving targets across sectors; b. establish standards and labelling systems to introduce efficient appliances and equipment; c. promote education and awareness campaigns, including awards; d. develop energy efficiency indicators across sectors to measure progress; and e. create financing mechanisms such as an EEC fund.

Government support is essential for developing innovative EEC technologies based on digital transformation. Publicly supported research and development should focus on improving the efficiency of appliances, electrical equipment, and heat-demand systems such as boilers and furnaces, enabling private companies to drive innovation effectively.

### (ii) Promotion of electrification

Electrification is an important low-carbon measure in final energy consumption, as electricity consumption itself emits no CO<sub>2</sub>. Significant heat demand exists across sectors, and electrification can address part of this demand. Replacing fossil fuels with electricity is therefore a priority for achieving carbon neutrality in final energy consumption. BEVs exemplify electrification in the transport sector, shifting from petrol and diesel to electricity. In residential and commercial sectors, electric cooking stoves and water-heating equipment can replace liquefied petroleum gas. Traditional water heaters are less efficient when heating large volumes of water, whilst heat pump technology, powered solely by electricity, offers a highly efficient solution.

### (iii) Application of clean fuels

Although electrification is important for carbon neutrality, some heat demands, such as those for large boilers and furnaces, cannot be met efficiently by electricity. Clean fuels are therefore needed. Hydrogen and ammonia can be combusted like fossil fuels but without CO<sub>2</sub> emissions. Biomass and biofuels emit CO<sub>2</sub>, yet these emissions are considered carbon-neutral as they only release the carbon absorbed during growth. Synthetic fuels (e-fuels) produced through carbon recycling technologies also fall into this category. Produced from captured CO<sub>2</sub> and hydrogen, particularly green hydrogen, synthetic fuels are likewise defined as carbon-neutral.

#### **(iv) Penetration of low-carbon power sources**

Renewable energy is important for achieving carbon neutrality by mid-century in ASEAN and the +7 countries. Renewable energy sources comprise two categories: traditional renewable energy, such as hydropower and geothermal, with higher capacity factors, and variable renewable energy (mainly solar and wind). Given their lower costs and minimal geographical constraints, all EAS countries are expected to increase solar PV significantly.

Several +7 countries are re-evaluating nuclear energy, planning to restart existing nuclear power plants and deploy new, advanced technologies such as small modular reactors and advanced light water reactors.

Highly efficient coal power plants in Asia, many of which are less than 10 years old, may continue operating with abatement measures. Two key approaches are recommended: co-firing with biomass, hydrogen, and ammonia, and the application of CCS. With gradually increasing abatement ratios, such measures can significantly cut emissions, enabling coal plants to achieve carbon neutrality by mid-century.

#### **(v) Carbon market and financing**

In the early stages of the low-carbon transition, zero-emission and CO<sub>2</sub> abatement technologies remain costly. A well-designed carbon market providing an appropriate carbon price is therefore indispensable. Carbon pricing will incentivise private companies to develop such technologies under fair competition with fossil fuels.

At this stage, government support is also critical. Public financing will reduce the costs of deploying zero-emission and CO<sub>2</sub> abatement technologies.

## Bibliography

- ASEAN Secretariat (2005), Chairman's Statement of the First East Asia Summit, Kuala Lumpur, 14 December 2005. Jakarta.
- ASEAN Secretariat (2007), Cebu Declaration on East Asian Energy Security 2007. Jakarta.
- The Institute of Energy Economics, Japan (2014), Asia/World Energy Outlook 2014. Tokyo.
- The Institute of Energy Economics, Japan (2017), Asia/World Energy Outlook 2017. Tokyo.
- International Energy Agency (2019), World Energy Model. Paris.
- International Energy Agency (2020a), Oil Stocks of IEA Countries, 15 September.
- International Energy Agency (2020b), World Energy Balances. Paris: Organisation for Economic Co-operation and Development Publishing.
- Economic Research Institute for ASEAN and East Asia (2015), Scenario Analysis of Energy Security in the East Asia Summit Region. Jakarta (accessed 15 June 2020).
- Economic Research Institute for ASEAN and East Asia (2022), Special Report of COVID-19 Impacts on Energy Demand and Energy-Saving Potential in East Asia, 2021. Jakarta.
- Economic Research Institute for ASEAN and East Asia (2022), Technology List and Perspectives for Transition Finance in Asia. Jakarta. (accessed 14 February 2025).
- United Nations Framework Convention on Climate Change (2015), Adoption of the Paris Agreement.
- United Nations Framework Convention on Climate Change (2021), Glasgow Climate Change Conference—October–November 2021.
- United Nations Framework Convention on Climate Change (2022), Intended Nationally Determined Contributions: Submissions. New York.
- United Nations Framework Convention on Climate Change (2024), 2024 NDC Synthesis Report. New York.





# Chapter 2

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## Australia Country Report<sup>1</sup>

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<sup>1</sup> Unless otherwise cited, all data in the report are attributed to the Institute of Energy Economics, Japan's economic modelling results for Australia, which are included in full as an appendix to the publication (IEEJ, 2024).

# 1. Introduction

In June 2022, the Australian Government submitted a revised 2030 Nationally Determined Contribution (NDC) to the Secretariat of the United Nations Framework Convention on Climate Change. The revised NDC commits Australia to a more ambitious emissions-reduction target of 43% below 2005 levels and reaffirms Australia's commitment to net-zero emissions by 2050. In October 2022, the country also signed up to the Global Methane Pledge alongside 130 signatories who are collectively targeting a reduction in methane emissions of at least 30% from the 2020 level by 2030 (IEA, 2023).

Currently, Australia's energy consumption is strongly dominated by fossil fuels. In 2021, share of fossil fuels in the primary energy mix was about 91.5%, and nearly 73.5% of total electricity was produced from fossil fuels.

Australia is implementing a suite of policies for accelerating the development and deployment of low-emissions technologies to achieve economy-wide net-zero emissions. The country has the potential to play a key role in clean energy transition globally by supplying critical minerals used in many clean energy technologies. Australia aims to decarbonise its power sector, and the government has put forward a plan to increase the share of renewable electricity generation to 82% of the national electricity market by 2030 (IEA, 2023).

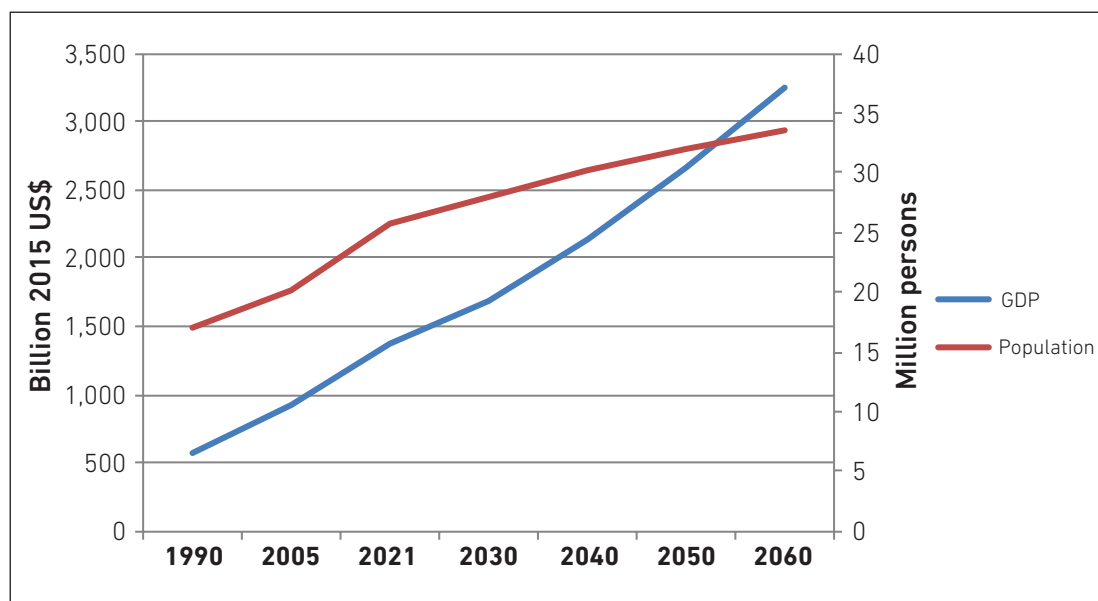
This study presents a low-carbon energy transition (LCET) scenario – a back-cast scenario for carbon neutrality for Australia – whilst the business-as-usual (BAU) scenario assumes continuation of existing policies. It analyses the BAU and LCET scenario results for the outlook period to 2060 and identifies key energy technologies which could contribute to the carbon neutrality of Australia's energy-related activities. Carbon neutrality of energy systems refers to a condition where carbon emissions and carbon removal from the atmosphere are balanced for energy-related activities.

The LCET of an economy consists of a pathway towards the transformation of energy-related activities that produces low levels of greenhouse gas emissions. Achieving the LCET scenario would require major structural changes of energy systems. However, mapping a single pathway for net-zero targets involves a high level of uncertainty.

## 2. Modelling Assumptions

Both the BAU and LCET scenarios apply the same gross domestic product (GDP) and population assumptions. Australia's population growth is driven primarily by its migration programme. The coronavirus disease (COVID-19) pandemic slowed migration, impacting GDP growth. Australia's GDP is assumed to grow at an average annual rate of 2.2% over the outlook period (2021–2060), compared with average annual growth of 2.9% during 1990–2021. The population is assumed to grow at an average annual rate of 0.7% during 2021–2060, which is marginally slower than the average annual growth rate of about 1.3% during 1990–2021 (Figure 2.1).

**Figure 2.1. Gross Domestic Product and Population (1990–2060)**



US\$ = United States dollar, GDP = gross domestic product.

Source: GDP: IMF(2023) and authors' calculations, Population: UNDESA (2022).

BAU reflects the continuation of current trends of energy demand and supply, and existing goals, action plans, and policy commitments. No aggressive action to achieve the emission-reduction goal will be taken in BAU. The economy will gradually shift from energy-intensive industries to less energy-intensive ones. Fossil fuels will remain dominant in the primary energy mix because they are abundant and cheap. New coal plants will not be installed to generate electricity, and the share of coal-fired electricity will decrease because of the scheduled closure and/or retirement of a few coal-fired electricity plants. No nuclear power plants will be installed. Gas-fired electricity and non-hydro renewable electricity generation are assumed to rise to meet increasing demand over the projection period.

LCET applies the same GDP and population assumptions as BAU. LCET assumes improved efficiency of final energy consumption in end-use sectors. Energy saving in industry would be achieved from improvements in large energy-intensive industries and closure of small, inefficient plants. Structural changes will gradually move the economy away from energy-intensive industries. In the residential and commercial sectors, efficient end-use technologies and energy-management systems would further contribute to saving energy. Transport is assumed to be more energy efficient because of improved vehicle standards and fuel economy. Rapid uptake of energy-efficient electric vehicles for private and public transport is assumed to occur during the second half of the projection period.

LCET will see more efficient thermal power generation, and a greater contribution of renewable energy to total supply with no nuclear power plants. It assumes substantial deployment of advanced technologies to decarbonise industry, power generation, and transport. Carbon capture and storage (CCS) in industry and power generation will begin by 2030. Hydrogen and ammonia, including co-firing in power generation and boilers in industry, will be used after 2040.

By analysing the LCET and BAU results, the study provides a basis for determining the impacts of promoting energy efficiency and increased use of renewable energy on energy saving and carbon dioxide (CO<sub>2</sub>) emission reduction. The LCET results provide a basis for exploring carbon neutrality pathways for Australia's energy-related activities.

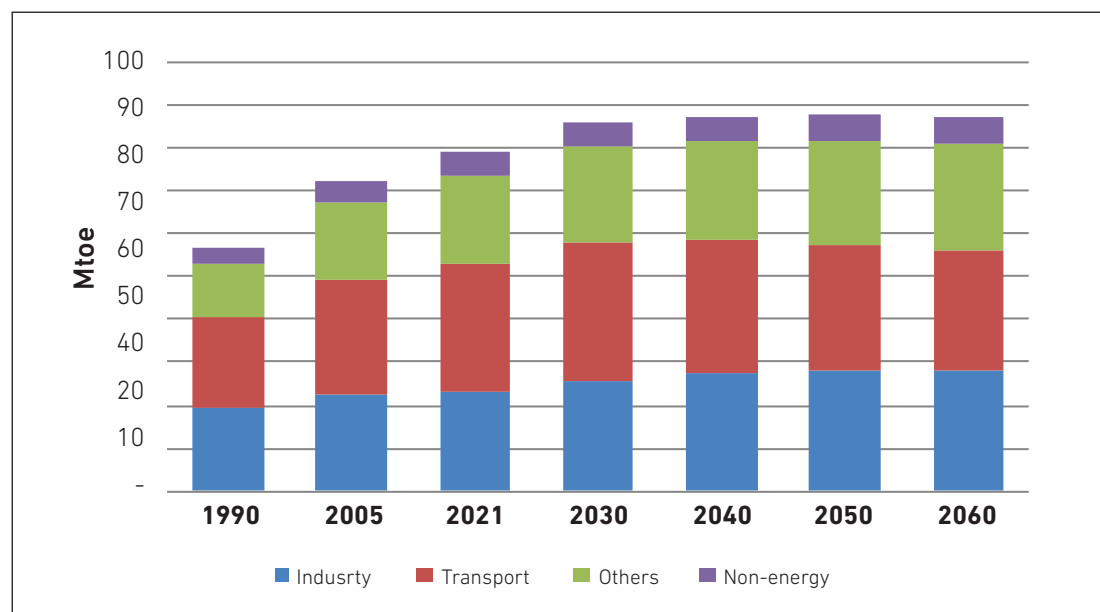
## 3. Outlook Results

### 3.1. Business-As-Usual Scenario

#### 3.1.1. Final Energy Consumption

In the BAU scenario, total final energy consumption is projected to increase from 79.0 million tonnes of oil equivalent (Mtoe) in 2021 to 87.1 Mtoe in 2060 (about 10.2% rise) at an average annual growth rate of 0.3%. The strongest growth is projected in industry, increasing at 0.5% per year during 2021–2060. Energy consumption in the transport sector is projected to increase at 0.8% per year during 2021–2030, but will decline after, with an average rate of 0.5% per year during 2030–2060. The transport sector saw relatively strong growth in energy consumption (1.1% per year) during 1990–2021. Efficiency improvements, fuel switching, and other structural changes within the sector, including remote working arrangements, will reduce transport fuel consumption despite continued growth in vehicle ownership over the projection period. Energy consumption in other sectors (e.g., residential and service sectors) is anticipated to increase at 0.5% per year during 2021–2060 (Figure 2.2).

**Figure 2.2. Final Energy Consumption by Sector, Business-as-Usual (1990–2060)**

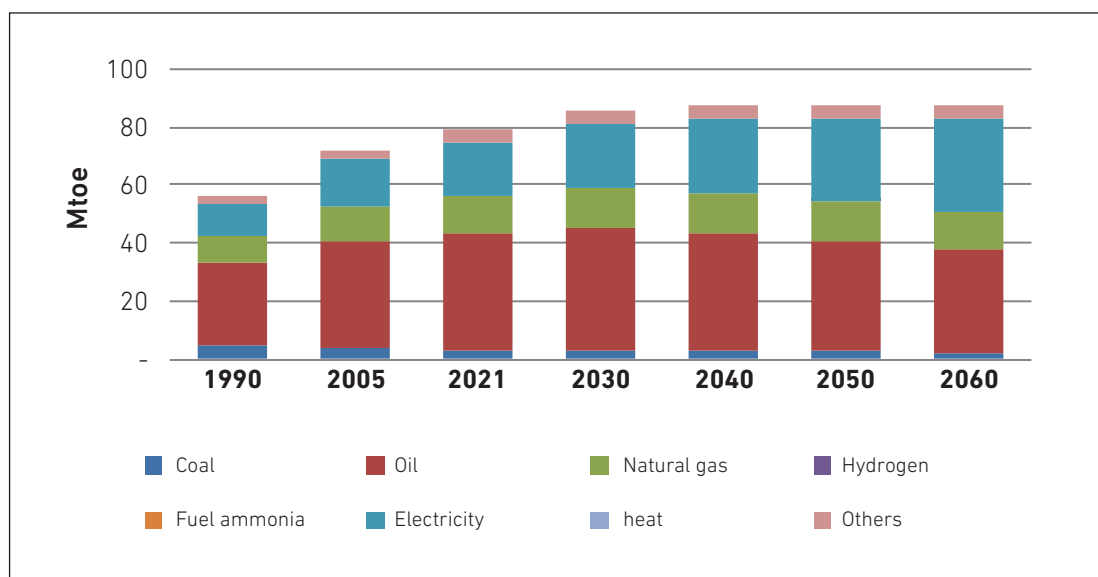


Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

Electricity consumption is projected to grow fastest, at an average rate of 1.4% per year during 2021–2060. Natural gas consumption will increase at a rate of 0.1% per year. Petroleum product consumption is projected to increase at 0.5% per year during 2021–2030, but will decline after, at an average rate of 0.7% per year. Coal consumption will remain relatively flat over the period to 2040 and will then decline at an average rate of 0.5% per year during 2040–2060 (Figure 2.3).

**Figure 2.3. Final Energy Consumption by Fuel Type, Business-as-Usual (1990–2060)**



Mtoe = million tonnes of oil equivalent.

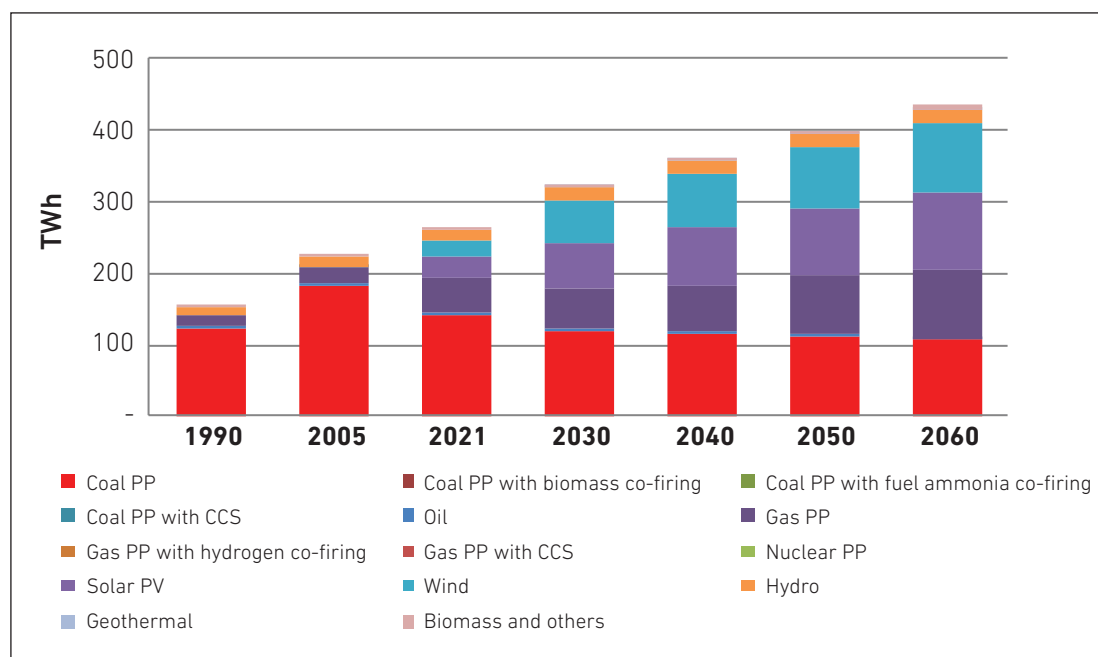
Source: Authors' calculations.

### 3.1.2. Power Generation

Electricity generation is projected to increase from 265.1 terawatt-hours (TWh) in 2021 to 433.6 TWh in 2060 at an average rate of 1.3% per year. The share of coal in the power generation mix is projected to fall from 52.9% in 2021 to 24.6% in 2060. Coal's share will decline because of the scheduled closure and retirement of some old coal-fired generation plants. Generation from oil is projected to decline at an average rate of 1.9% per year, and the share of oil in the generation mix will decline from 1.8% in 2021 to 0.5% in 2060. In contrast, the share of natural gas in the generation mix will increase from 18.8% in 2021 to 22.1% in 2060, and natural gas use in electricity generation is projected to grow at an average rate of 1.7% per year over this period.

Hydroelectricity's share in the power generation mix is expected to decline from 5.6% in 2021 to 4.1% by 2060. Electricity generation from others (non-hydro renewables) is expected to grow faster, at an average rate of 3.5% per year during 2021–2060. Declining costs of wind and solar technology will partly contribute to the faster growth of electricity generation from others (including wind and solar energy) (Figure 2.4).

**Figure 2.4. Power Generation, Business-as-Usual (1990–2060)**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors' calculations.

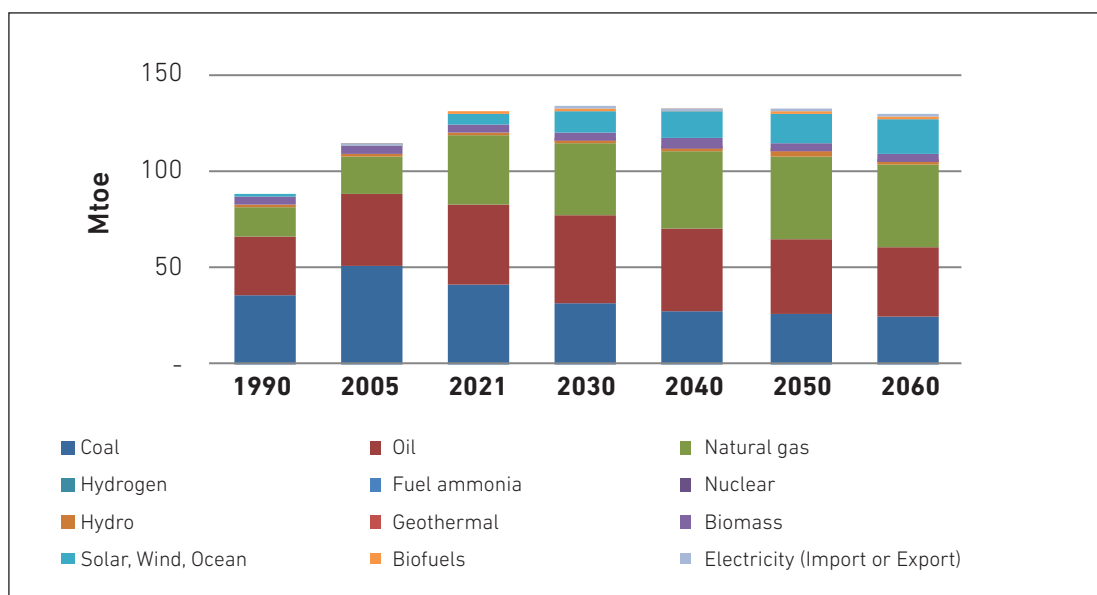
Thermal efficiency of power generation is projected to improve for coal-fired power plants, from 34.4% in 2021 to 49.0% in 2060. Similarly, gas power plants are expected to improve thermal efficiency, from 38.1% to 55.0%, whilst oil power plants will remain flat with a modest increase, from 37.4% to 39.9% over the outlook period under BAU.

### 3.1.3. Primary Energy Supply

Primary energy supply is projected to increase marginally from 130.2 Mtoe in 2021 to 132.5 in 2030 (at an average increase of 0.2% per year) and then decline at an average rate of 0.1% per year between 2030 and 2060. Coal consumption will decline at an average rate of 1.3% per year between 2021 and 2060. Oil consumption will increase from 42.5 Mtoe in 2021 to 45.5 Mtoe in 2030 and then decline between 2030 and 2060 at an annual average rate of 0.8%. Natural gas supply will increase at 0.5% per year during 2021–2060, where its share in the primary energy mix is expected to increase from 28.1% in 2021 to 34.0% in 2060.

The overall share of fossil fuels in primary energy supply will decline from 91.5% in 2021 to 80.5% in 2060. The share of non-hydro renewables is expected to increase from 7.5% in 2021 to 18.3% in 2060, with the biggest contribution coming from solar and wind energy, followed by biofuels and biomass. Solar and wind energy together are expected to grow at an average annual rate of 3.4% during 2021–2060 (Figure 2.5).

**Figure 2.5. Primary Energy Supply, Business-as-Usual (1990–2060)**



Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

### 3.1.4. Carbon Dioxide Emissions

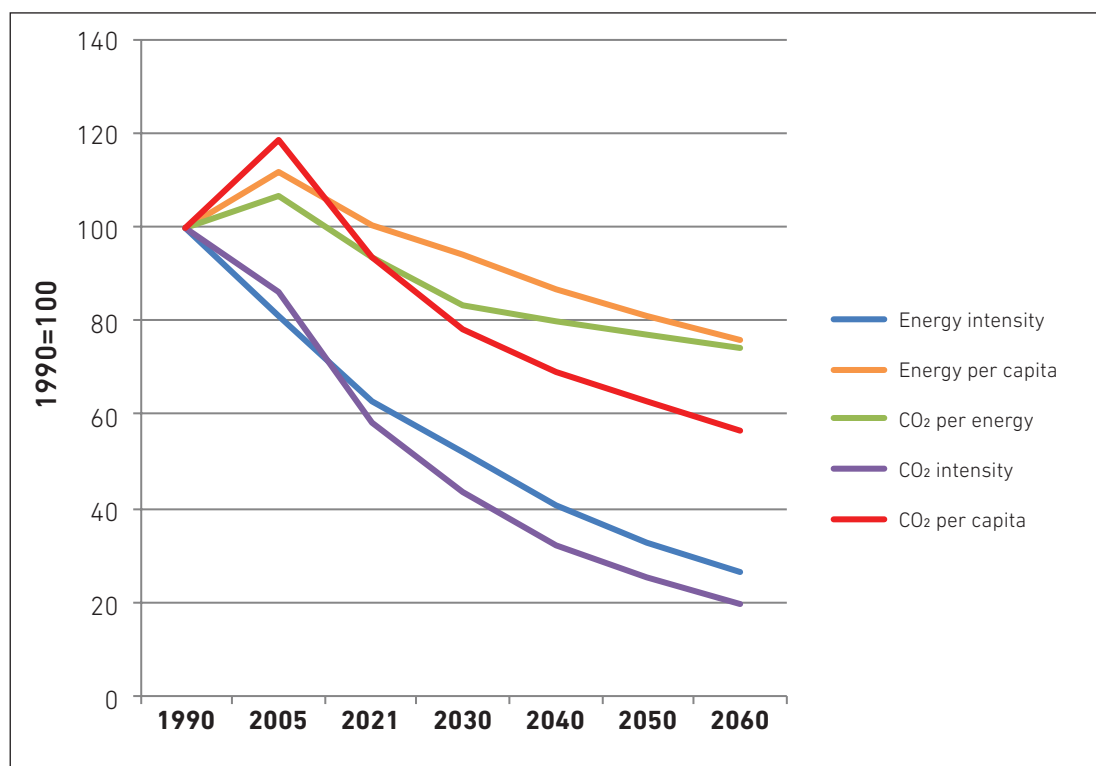
In BAU, CO<sub>2</sub> emissions from energy consumption will decline from 360.9 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2021 to 283.3 Mt-CO<sub>2</sub> in 2060 or an equivalent decrease by an average rate of 0.6% per year. Under BAU, emissions in 2030 are projected to be 328.4 Mt-CO<sub>2</sub> which is 8.5% lower than 2005 levels.

### 3.1.5. Energy Indicators

Under BAU, primary energy intensity (primary energy consumption per unit of GDP) is projected to decrease at average annual rate of 2.2% during 2021–2060, compared with an average annual decrease of 1.5% during 1990–2021. Final energy intensity (final energy consumption per unit of GDP) will decline at 1.9% per year during 2021–2060, compared with 1.8% per year during 1990–2021. CO<sub>2</sub> emission intensity (CO<sub>2</sub> emissions per unit of GDP) is projected to reduce by 2.8% per year over the outlook period (2021–2060), compared with an average decrease of 1.7% per year during 1990–2021 (Figure 2.6).



**Figure 2.6. Indices of Energy Indicators, Business-as-Usual (1990–2060)**



CO<sub>2</sub> = carbon dioxide.

Source: Authors' calculations.

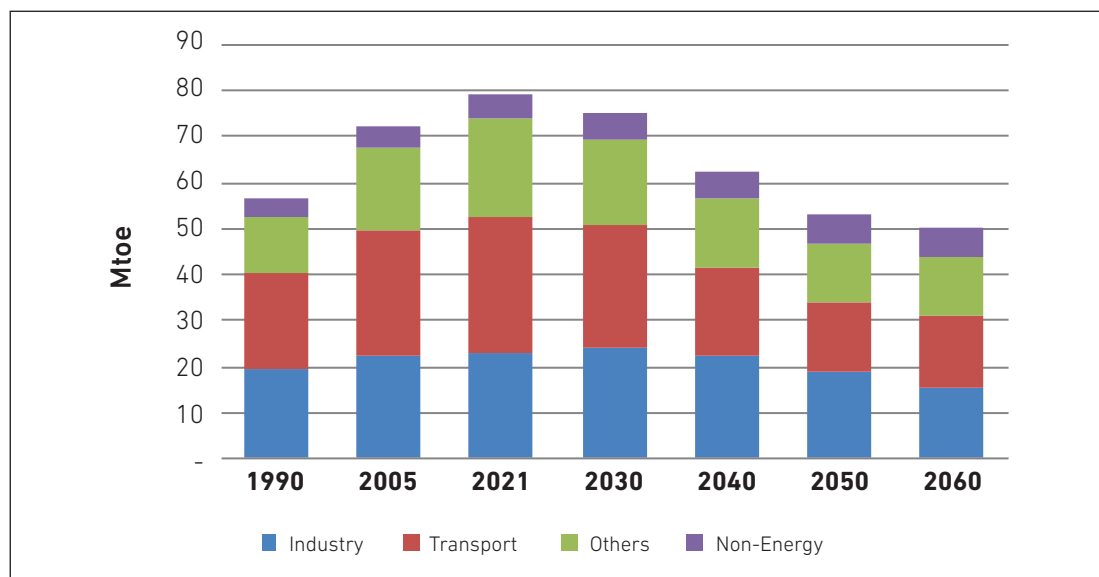
## 3.2. Low-Carbon Energy Transition Scenario

### 3.2.1. Final Energy Consumption

In the LCET scenario, total final energy consumption will decrease from 79.0 Mtoe in 2021 to 50.1 Mtoe in 2060, or by about 36.6% (an average of 1.2% per year). Energy consumption in the transport sector will decline strongly at an average annual rate of 1.7% over the outlook period because of efficiency improvements and other structural changes, despite continued growth in vehicle ownership. Energy use in 'others' sectors, i.e., residential and the service sector, will decrease at an average annual rate of 1.2%, from 21.0 Mtoe in 2021 to 12.9 Mtoe in 2060 because of electrification and efficiency improvements. The industry sector's energy use will decline by 1.0% per year during the same period but non-energy's use will grow by 0.3% per year. Full electrification of some parts of industry sector will be difficult due to the need for high-temperature heat sources and the lock-in effect of existing machinery. Implementation of CCS is assumed for reducing CO<sub>2</sub> emissions from those industries.

Consumption of coal, oil, and natural gas will decline sharply, but demand for electricity and other renewables will grow. Hydrogen consumption will start in 2030. In 2060, the share of hydrogen and fuel ammonia in the final energy mix is expected to be the second highest (17.3%), behind electricity. Electricity's share will increase from 23.6% in 2021 to 58.4% in 2060. (Figures 2.7 and 2.8).

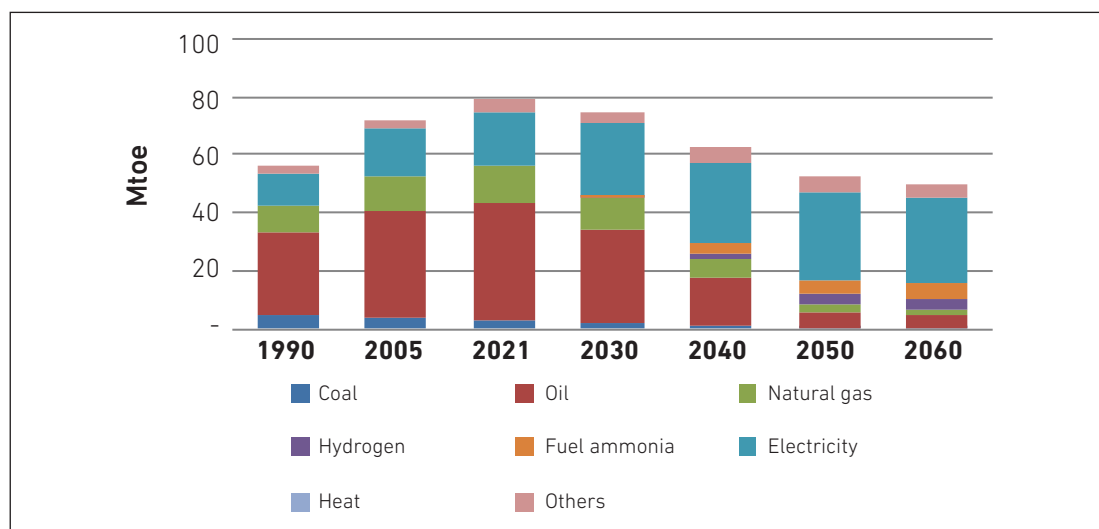
**Figure 2.7. Final Energy Consumption by Sector, Low-Carbon Energy Transition (1990–2060)**



Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

**Figure 2.8. Final Energy Consumption by Fuel Type, Low-Carbon Energy Transition (1990–2060)**



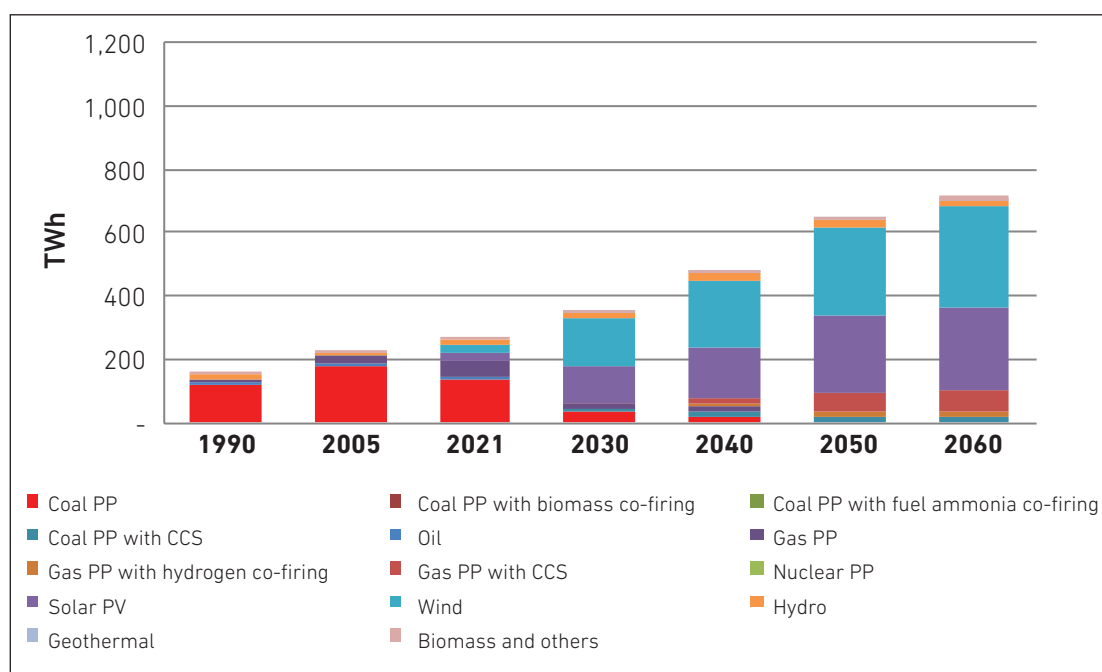
Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

### 3.2.2. Power Generation

In the LCET scenario, electricity generation will grow from 265.1 TWh in 2021 to 714.1 TWh in 2060 at an equivalent average growth rate of 2.6% per year. The share of fossil fuels in the power generation mix will fall sharply from 73.5% in 2021 to 14.0% in 2060, of which 8.5% will be gas power plants with CCS, 2.5% will be gas power plants with hydrogen co-firing, and the remaining 3.0% will be coal-fired power plants with CCS. All inefficient coal-, gas-, and oil-fired power plants will be closed by 2040. Share of variable renewable energy in the power generation mix will reach 81.2% over the outlook period. Expansion of the electricity grid with backup energy storage will be necessary to support the integration of variable renewable energy in the grid. Solar energy will take up 37.4% of generation in 2060, wind energy will account for 43.8%, hydropower for 2.8%, and other renewables, 2.0% (Figure 2.9).

**Figure 2.9. Electricity Generation by Fuel Type, Low-Carbon Energy Transition (1990–2060)**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

TWh = terawatt-hour.

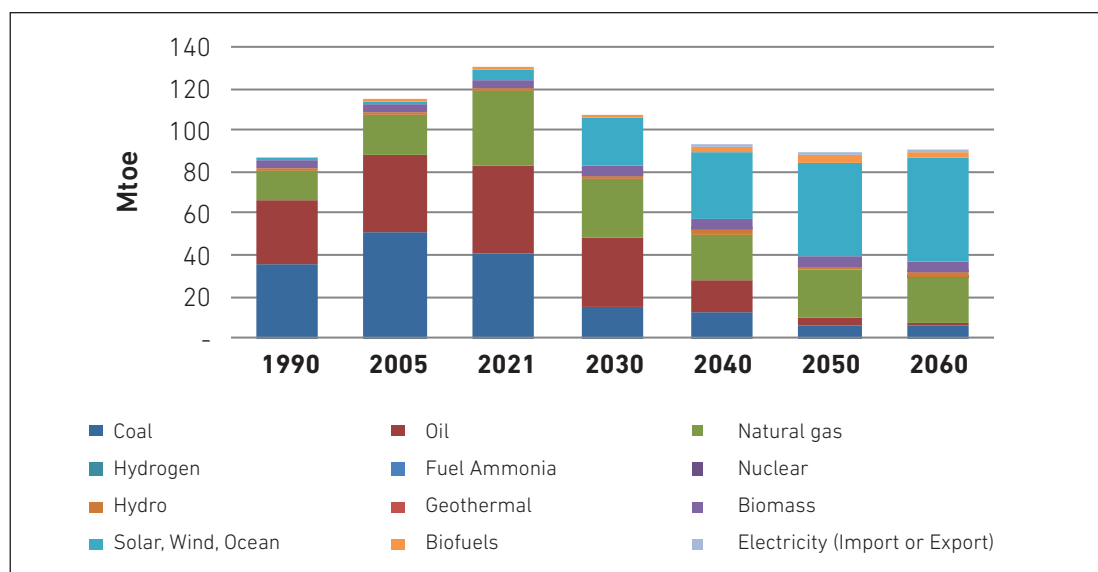
Source: Authors' calculations.

### 3.2.3. Primary Energy Supply

In the LCET, total primary energy consumption is projected to decrease from 130.2 Mtoe in 2021 to 90.0 Mtoe in 2060, with an equivalent average decreasing rate of 0.9% per year. During the period, coal consumption will decline sharply by 4.9% per year, and oil consumption by 7.5% per year. The use of natural gas will decline from 36.5 Mtoe in 2021 to 21.5 Mtoe in 2060, with an equivalent average decline rate of 1.4% per year. Natural gas is expected to remain in Australia's economy as a dominant fuel over the outlook period.

The share of fossil fuels in the primary energy mix will drop from 91.5% in 2021 to 32.5% in 2060. Hydropower's share will increase modestly from 1.0% in 2021 to 1.9% in 2060. In contrast, the share of non-hydro renewable energy (others) will grow rapidly from 7.5% in 2021 to 65.4% in 2060. The demand for non-hydro renewable energy is projected to grow at 4.7% per year during the outlook period, supported by a sharp increase in solar and wind energy from 5.0 Mtoe in 2021 to 50.1 Mtoe in 2060 (Figure 2.10).

**Figure 2.10. Primary Energy Supply, Low-Carbon Energy Transition (1990–2060)**



Mtoe = million tonnes of oil equivalent.

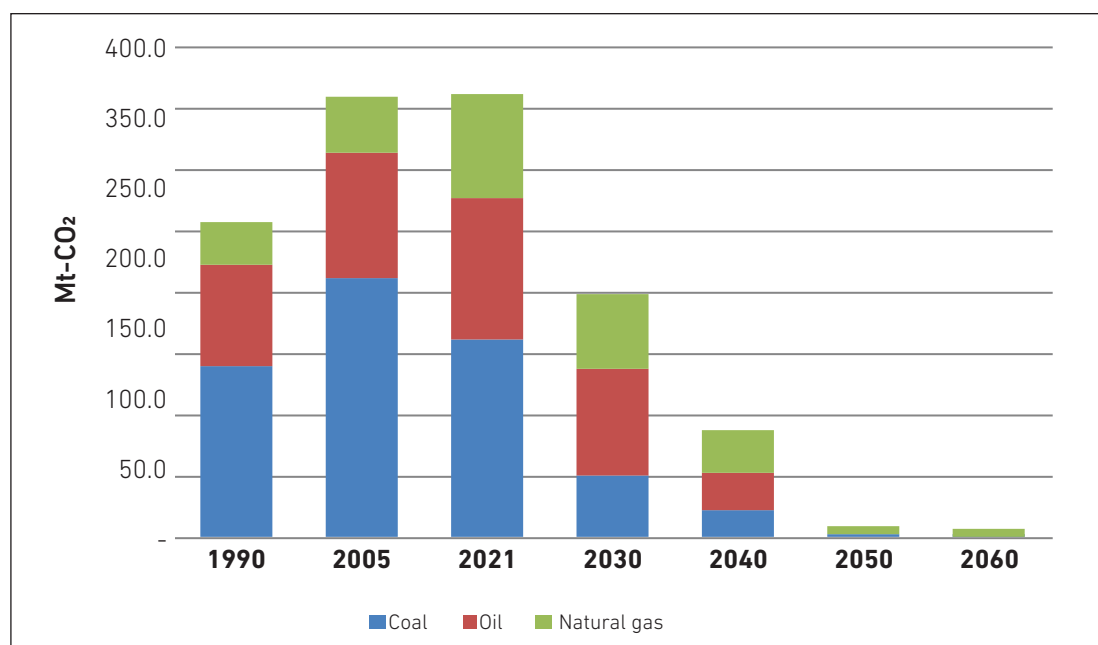
Source: Authors' calculations.

### 3.2.4 Carbon Dioxide Emissions

The LCET scenario was developed to analyse the decarbonisation pathway of energy-related activities. In the LCET, CO<sub>2</sub> emissions from energy consumption will decline from 360.9 Mt-CO<sub>2</sub> in 2021 to negative emissions (-4.5 Mt-CO<sub>2</sub>) in 2060, which is an equivalent average decreasing rate of 189.4% per year. Under this scenario, CO<sub>2</sub> emissions decline to 198.2 Mt-CO<sub>2</sub> in 2030, which is 44.8% lower than the 2005 level. This is consistent with Australia's NDC emissions-reduction target by 2030 (43% below 2005 level) (Figure 2.11).

Decreased fossil-fuel use has a direct impact on CO<sub>2</sub> emissions reduction. In the LCET, the rate of emissions reduction over the outlook period is faster than the declining rate of primary energy consumption, reflecting the increased use of less carbon-intensive sources and renewable energy sources in the primary energy supply. To achieve carbon neutrality, the residual emission will be offset by the negative emissions of biomass and CCS applications.

**Figure 2.11. Carbon Dioxide Emissions from Energy, Low-Carbon Energy Transition (1990–2060)**



MtCO<sub>2</sub> = million tonnes of carbon dioxide.

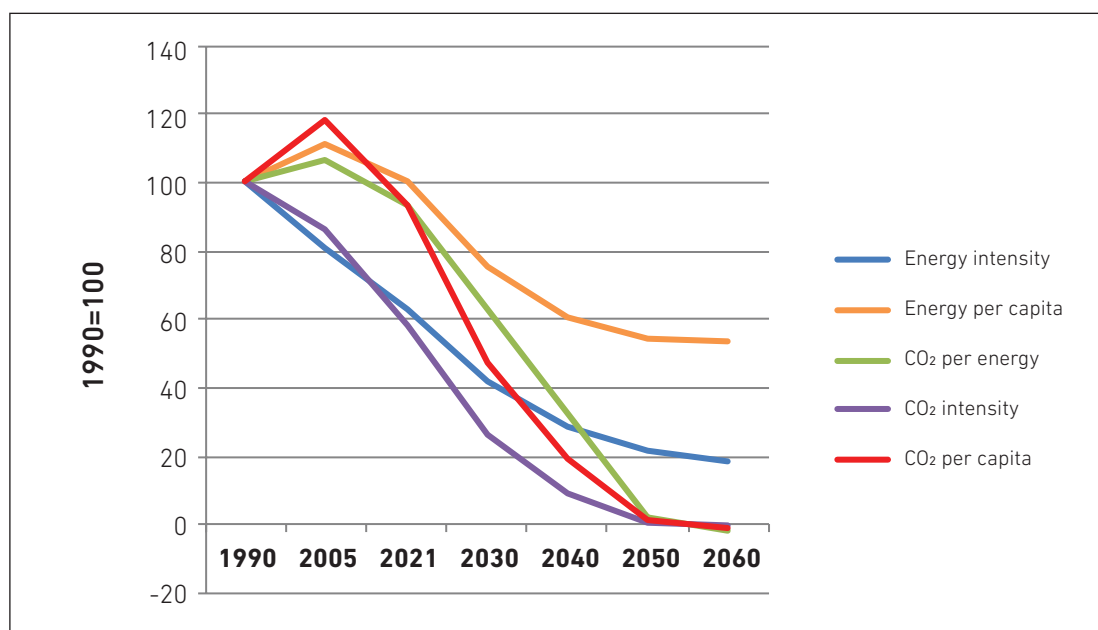
Source: Authors' calculations.

### 3.2.5. Energy Indicators

Under the LCET, primary energy intensity is projected to decrease at average annual rate of 3.1% during 2021–2060, compared with a 2.2% average annual decrease in the BAU scenario. Final energy intensity will decline at 3.3% per year during 2021–2060, compared with 1.9% per year in BAU. Therefore, greater energy productivity improvement would be achieved under the LCET compared to BAU.

In the LCET, CO<sub>2</sub> emission intensity is projected to reduce at an average annual rate of 23.4% over the outlook period (2021–2060) to achieve carbon neutrality for energy-related activities in the country (Figure 2.12).

**Figure 2.12. Indices of Energy Indicators, Low-Carbon Energy Transition (1990–2060)**



Note: CO<sub>2</sub> = carbon dioxide.

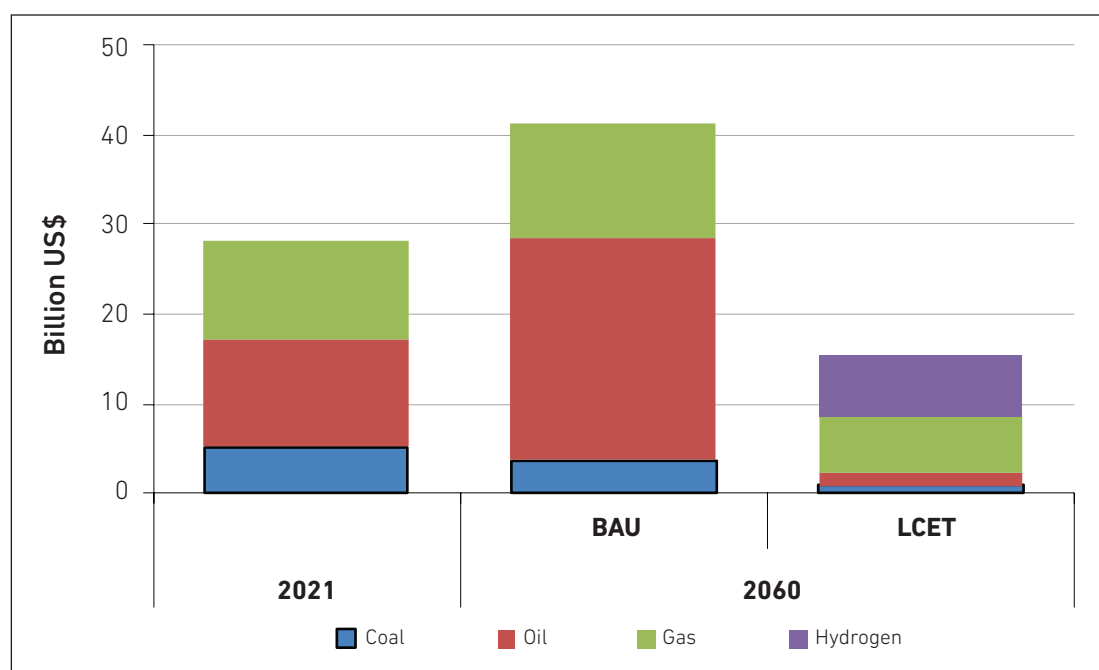
Source: Authors' calculations.

## 4. Energy Cost Under Business-As-Usual and Low-Carbon Energy Transition Scenarios

### 4.1. Fuel Cost

The results in this study show the decline of fossil-fuel demand over the outlook period under both the BAU and LCET scenarios. A sharp decline in fossil-fuel use and a large uptake of renewable energy use are projected in the LCET. In 2060, total fuel cost is projected to be about US\$15.3 billion<sup>2</sup> in the LCET, compared to US\$41.1 billion in BAU. It is assumed that hydrogen production costs will decline over the outlook period. However, hydrogen will make up the major share of total fuel cost in the LCET by 2060 (Figure 2.13).

**Figure 2.13. Fuel Costs in Business-as-Usual and Low-Carbon Energy Transition**



US\$ = United States dollar, BAU = business-as-usual, LCET = low-carbon energy transition

Source: Authors' calculations.

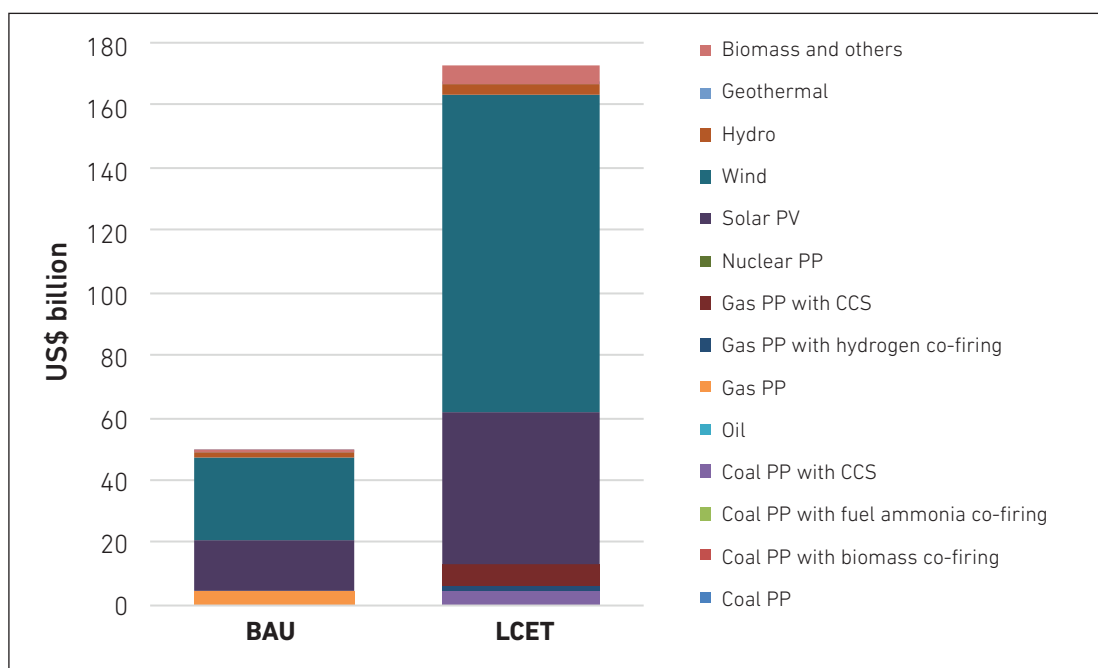
<sup>2</sup> In this chapter, US\$ refers to United States dollar.

## 4.2. Power Generation Investment

This section provides a high-level analysis of the investment costs for the additional generation capacity that would be required to meet the electricity demand in 2060 under the BAU and LCET scenarios. Capacity investment cost is estimated by multiplying the unit cost of each power technology with the additional power generation capacity requirements for the outlook period to 2060.

The net impact of these trends is that between 2021 and 2060, power plant construction costs are projected to be roughly US\$172.4 billion under the LCET scenario versus US\$50.2 billion in BAU – or roughly 3.4 times higher in the LCET than BAU. A major share of total investment will be required for wind and solar power plants (Figure 2.14).

**Figure 2.14. Power Generation Capacity Investments by 2060**



US\$ = United States dollar, BAU = business-as-usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, PV = photovoltaic.

Source: Authors' calculations.



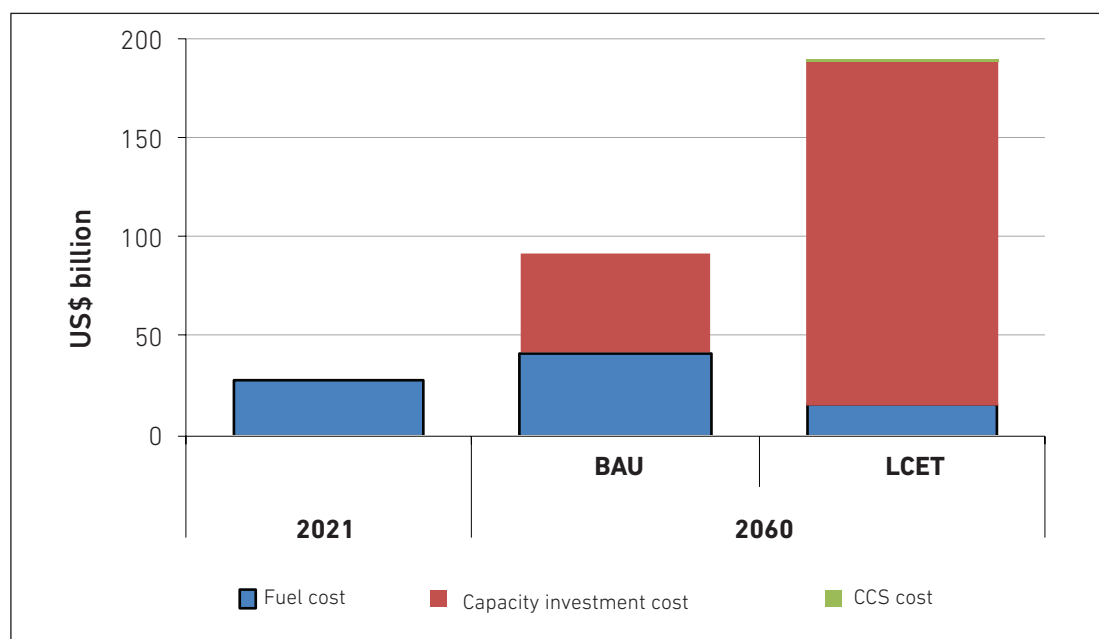
### 4.3. Carbon Capture and Storage Cost

The BAU scenario does not consider CCS, but the LCET scenario assumes that CCS projects will be incorporated into all remaining gas and coal power plants. Implementation of CCS projects will start from 2030, and deployment of CCS in the power sector is estimated to cost about US\$1.67 billion in 2060 under the LCET scenario.

### 4.4. Overall Cost

This study provides an analysis of fuel costs, generation capacity investments, and CCS deployment for the outlook period. This analysis does not include costs for energy efficiency improvement, energy storage, and transmission- and distribution-related costs. The cost components of the BAU and LCET scenarios are summarised in Figure 2.15.

**Figure 2.15. Energy Cost Comparison of Business-as-Usual and Low-Carbon Energy Transition**



US\$ = United States dollar, BAU = business-as-usual, LCET = low-carbon energy transition.

Source: Authors' calculations.

It is expected that power plants will require US\$50.2 billion in capital investment by 2060 under the BAU. In contrast, investment costs in power plant including CCS are expected to be US\$174.1 billion in the LCET scenario over the projection period. However, a reduction in fuel costs would be more under the LCET when compared with the BAU scenario.

## 5. Conclusions and Recommendations

### 5.1. Conclusions

Australia's emissions-reduction target is economy-wide and aims to reduce greenhouse gas emissions by 43% by 2030 (compared to 2005 levels), and to achieve net-zero emissions by 2050. In the LCET, the country achieves its NDC target for energy-related activities. The results show that Australia's energy-related CO<sub>2</sub> emissions are about 45% lower than the 2005 level in 2030 and almost 99% lower in 2050. A well-designed information-management system is required for periodic assessment and reporting of the country's progress on energy transition and emissions-reduction goals.

In the LCET, fossil-fuel consumption decreases over the outlook period to 2060, but natural gas still remains a prominent fuel. Reduced coal power capacity resulting from the closure of coal plants would be replaced by solar and wind generation. Gas power plants will support solar and wind plants, along with battery storage for maintaining stability in supply when sunlight and/or wind are insufficient. Gas power plants will provide reasonable stability to the grid due to their quicker ramp-up and ramp-down time.

In LCET, liquid fossil fuels decline over the outlook period. Green hydrogen fuel will replace the high density liquid fuel, which is currently being used for long-distance transport vehicles, freight transports, water transport etc. Hydrogen will also replace coal for steel-making, industrial process heating, building heating, etc. Hydrogen fuel will be produced mainly through water electrolysis using renewable electricity.

Investment costs under the LCET are much higher when compared with BAU, because implementation of non-hydro renewables and CCS in the power sector will require a large amount of investment. However, LCET offers significant environmental benefits in terms of CO<sub>2</sub> emissions reduction. The overall cost under the LCET scenario reduces if carbon prices are introduced into the analysis. The electricity-generation sector will drive and enable other sectors (i.e., industry and transport) to achieve their emissions-reduction goals.

### 5.2. Recommendations

Decarbonisation of the power-generation system requires earlier and faster closure of inefficient fossil-fuel power plants. It is important to ensure that orderly closures of coal-fired power plants are well-managed. If it is left completely to the market, without any guiding policy, then the national electricity market might suffer a long-lasting, messy period. Faster deployment of technologies is critical to reach net-zero targets by 2050. It is also important to implement CCS technology in existing efficient coal-fired and gas-fired power plants.

Greater attention is required to replace ageing electricity grid infrastructure. The national electricity grid has not been upgraded fast enough to accommodate and interconnect all new renewables projects. A policy framework regarding the sources of investment for grid development needs to be prepared at the federal level, in consultation with state and territory governments. Obtaining social acceptance through consultation with local communities, consumers, and other stakeholder is important before commencing construction and operation of any infrastructure project.

Major investment in solar, wind, batteries, pumped hydro, and transmission infrastructure is required for the power system. Earlier and faster deployment of renewable energy technologies in the power system will reduce greenhouse gas emissions faster than the current 2030 target. Deployment of adequate energy storage technologies is essential to support faster growth of non-hydro renewable electricity technologies. Using green hydrogen and ammonia fuel in power plants is also required to decarbonise the power generation system.

New vehicle efficiency standards are required for promoting energy-efficient, low-emission vehicles in the market. This would force manufacturers to sell a larger number of fuel-efficient cars at affordable prices. Affordable hydrogen fuel cell vehicles and the development of adequate infrastructure for hydrogen refuelling stations and electric vehicle charging stations will be required for increased use of hydrogen and electric vehicles in the transport sector.

Low-carbon technologies must be adopted earlier and faster to decarbonise the industry, transport, residential, and services sectors. Faster electrification is critical for transport and heavy industry.

Energy efficiency improvement is faster in the LCET than in BAU. Improved and efficient end-use technologies must be adopted faster to reduce final energy consumption in end-use sectors. Transport has more opportunities for energy saving. Energy saving in industry comes from efficiency improvement in large, energy-intensive industries. Improved energy efficiency and energy savings will play an important role in decarbonising the end-use sector.

## References

International Energy Agency (IEA) (2023), *Australia 2023: Energy Policy Review*. Paris : IEA. <https://www.iea.org/reports/australia-2023> (accessed 15 November 2023).

International Monetary Fund (IMF) (2023), *World Economic Outlook October 2021. Recovery During a Pandemic: Health Concerns, Supply Disruptions, and Price Pressures*. Washington, D.C.: IMF. <https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021> (Accessed June 2023)

United Nations, Department of Economic and Social Affairs (UNDESA), Population Division (2022), *World Population Prospects*. New York: UN. <https://population.un.org/wpp/> (Accessed June 2023)

# Chapter 3

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## Brunei Darussalam Country Report

Ministry of Energy, Brunei Darussalam  
Updated by Cecilya Malik, ASEAN Expert

# 1. Basic Concept of Low-carbon Energy Transition

Carbon neutrality means balancing carbon emissions and carbon absorption through carbon sinks. Put simply, it involves eliminating net carbon emissions. Carbon sinks are systems that absorb more carbon than they emit, such as forests, soils, and oceans.

Decarbonising the global energy system requires redirecting investments from fossil fuels towards renewable energy, electrification technologies, and energy efficiency. The low-carbon pathways under the low-carbon energy transition (LCET) scenario encompass four broad actions: efficiency and conservation, fuel-switching, decarbonising electricity and electrification, and decarbonising liquid and gaseous fuels.

The following actions and measures are generally considered necessary to achieve carbon neutrality:

1. Final energy consumption (FEC) sectors, covering industry, transport, residential, and commercial sectors
  - 1.1. Promotion of energy efficiency and conservation (EEC)
  - 1.2. Electrification (e.g. electric vehicles [EVs], heat pumps)
  - 1.3. Transition from fossil fuels to clean fuels such as hydrogen or ammonia
  - 1.4. Use of biomass, including wood chips, pellets, and biofuels, for heating and transport fuels
2. Power sector
  - 2.1. Deployment of traditional renewable energy (RE), such as hydropower and geothermal power
  - 2.2. Expansion of new RE sources, including solar photovoltaic (PV) and wind
  - 2.3. Development of nuclear power plants
  - 2.4. Operation of thermal power plants with co-firing of biomass, hydrogen, and fuel ammonia
  - 2.5. Operation of thermal power plants equipped with carbon capture and storage (CCS)
  - 2.6. Deployment of biomass power plants

The previous Economic Research Institute for ASEAN and East Asia (ERIA)–East Asia Summit (EAS) energy outlook (Energy Outlook and Energy Saving Potential in East Asia, 2023)<sup>1</sup> also included an analysis of how EAS17 member countries can achieve carbon neutrality under different economic and social circumstances.

The basic concept applies a macroeconomic approach to identify pathways for achieving carbon neutrality by the target year. Although the resulting scenario may not represent the least-cost pathway, further analysis will compare the costs of LCET with those of the business-as-usual (BAU) scenario. The cost comparison will focus on the following:

1. Fuel costs: fossil fuels, hydrogen, and ammonia
2. Power investment costs: thermal power plants (both traditional and co-firing), nuclear power plants, and renewable power plants

## 2. Modelling Assumptions

Brunei Darussalam's energy model, along with those of other member countries of the Association of Southeast Asian Nations (ASEAN), was developed using the Low Emission Analysis Platform (LEAP) software, previously known as the Long-range Alternative Planning System. LEAP is used to project energy balance tables based on final energy consumption and energy input and/or output in the transformation sector. Final energy consumption is forecast using energy demand equations by energy type and sector, combined with future macroeconomic assumptions.

The estimation of the energy demand function was done using an econometric, top-down approach that links the macroeconomic model with the energy model. Historical correlations between energy demand, macroeconomic indicators, and activity levels were derived through regression analysis using Microfit, an interactive software package designed for econometric modelling of time-series data. Historical energy demand data were sourced from the energy statistics of the Asia-Pacific Economic Cooperation member countries, whilst socio-economic data were obtained from the World Bank's World Development Indicators.

Not all consumption in every sector or subsector can be explained by a demand function. Where regression analysis is not applicable due to insufficient data or failure to derive a statistically sound equation, the demand function is not estimated. In this regard, energy demand is forecast using alternative assumptions, such as gross domestic product (GDP) growth projections or existing programmes and targets.

### 2.1. Macroeconomy

Growth in energy consumption is largely driven by socio-economic factors, including population growth, economic expansion, vehicle ownership, and access to electricity. This study covers 2021–2060.

For Brunei Darussalam, the projected GDP and population trends through to 2060 are shown in Figure 3.1. GDP is expected to grow at an average annual rate of 2.1%, whilst population growth is projected at 1.4% per year. Energy demand will primarily be driven by GDP and population, given that the oil and gas sector continues to serve as the country's main economic pillar.

**Table 3.1. Population and Gross Domestic Product Prospects**

|                      | Historical Data |      | Projection |      |      |      |      |                       |
|----------------------|-----------------|------|------------|------|------|------|------|-----------------------|
|                      | 1990            | 2005 | 2021       | 2030 | 2040 | 2050 | 2060 | AAGR (%)<br>2021–2060 |
| GDP (billion US\$)   | 9.1             | 12.6 | 13.2       | 16.6 | 21.1 | 25.3 | 30.1 | 2.1                   |
| Population (million) | 0.3             | 0.3  | 0.4        | 0.5  | 0.6  | 0.7  | 0.8  | 1.4                   |

AAGR = average annual growth rate, GDP = gross domestic product.

Source: Author; World Bank (2022).

## 2.2. Scenarios

This study projects energy supply and demand under two scenarios: BAU extends past trends whilst incorporating the effects of current energy and environmental policies and technologies; the backcasting LCET assumes carbon neutrality by 2060.

For Brunei Darussalam, LCET assumes the application of CCS. Specifically, it is assumed that electricity requirements for the second phase of the Yenghi Integrated Refinery and Petrochemical Complex, from 2029 onwards, will be met not by a coal-fired power plant as initially planned, but by a gas-fired power plant equipped with CCS. The coal-fired power plant built for the first phase of the Yenghi project will cease operations by 2060, upon reaching its 35-year technical lifespan. Its electricity demand will likewise be met by the gas-fired power plant using CCS.

LCET for Brunei Darussalam considers a higher penetration of EVs, increased adoption of electric boilers in industry, greater use of electric stoves in the residential sector, and an expansion of solar photovoltaic (PV) in power generation.

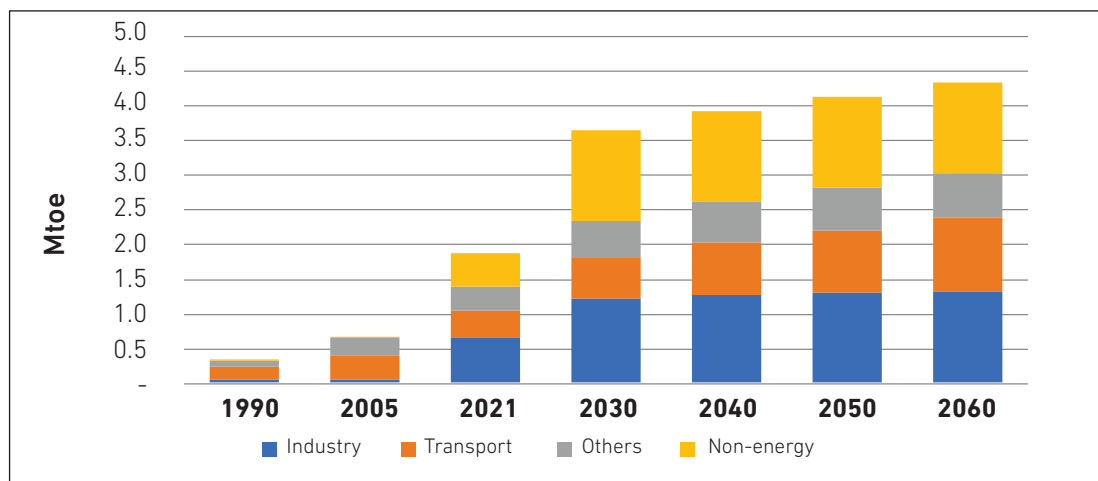
## 3. Final Energy Consumption

Under BAU, Brunei Darussalam's total final energy consumption (TFEC) is projected to increase by 2.2% annually, rising from 1.9 Mtoe in 2021 to 4.3 Mtoe in 2060 (Figure 3.1). From 2030 onwards, industry will contribute the largest share of TFEC, growing at an average rate of 1.8% per year. In 2021, industry accounted for around 34.8%. The rapid increase in industrial energy demand is primarily due to the second phase of the Hengyi Industries Sdn Bhd, which became operational in 2020. The electricity required for these downstream industries is included in the industry's TFEC. Growing demand for natural gas as feedstock will drive non-energy sector consumption, which is projected to expand at an average rate of 2.6% per year. By 2060, this sector's share will reach the second largest, at 30.6%.

In 2021, transport accounted for the third largest share of TFEC (21.6%). By 2060, this share will increase to 24.6%, as the sector's energy demand grows at an average rate of 2.5% per year, outpacing industry.

Final energy consumption in the 'others' category, comprising the residential, commercial, agricultural, and fisheries sectors, will grow at an average annual rate of 1.6% throughout the planning period (2021–2060).

**Figure 3.1. Final Energy Consumption by Sector, Business-as-Usual Scenario**

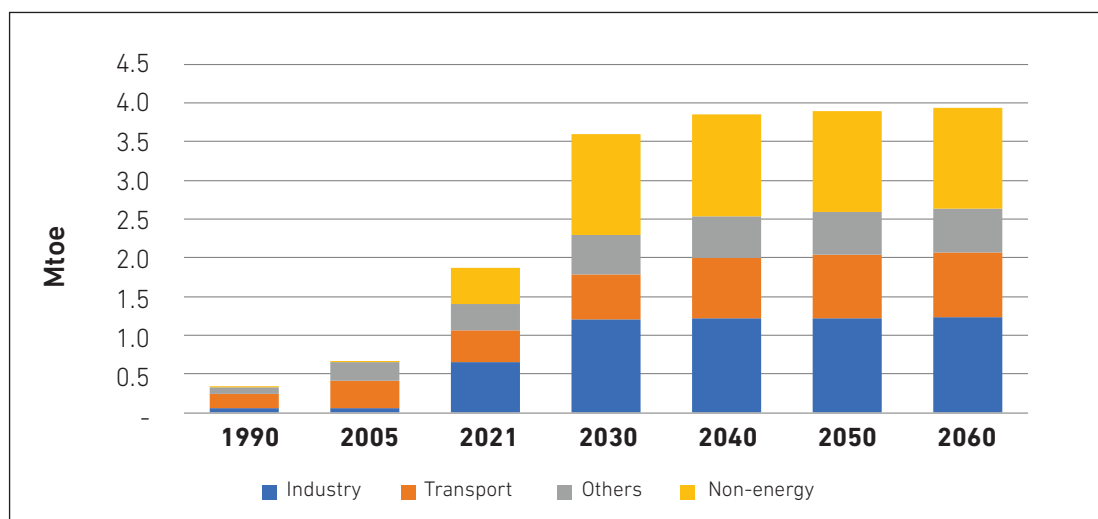


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Under LCET, Brunei Darussalam's TFEC is expected to reach 3.9 Mtoe in 2060, with an average annual growth rate of 1.9% in 2021–2060. This is lower than the 2.2% annual growth rate under BAU. The lower growth is expected primarily in transport, whose share will decline to 21% as a result of stricter fuel efficiency regulations and the widespread adoption of EVs. Further reductions will be achieved in 'others' through the implementation of stringent EEC measures for buildings.

**Figure 3.2. Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario**



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

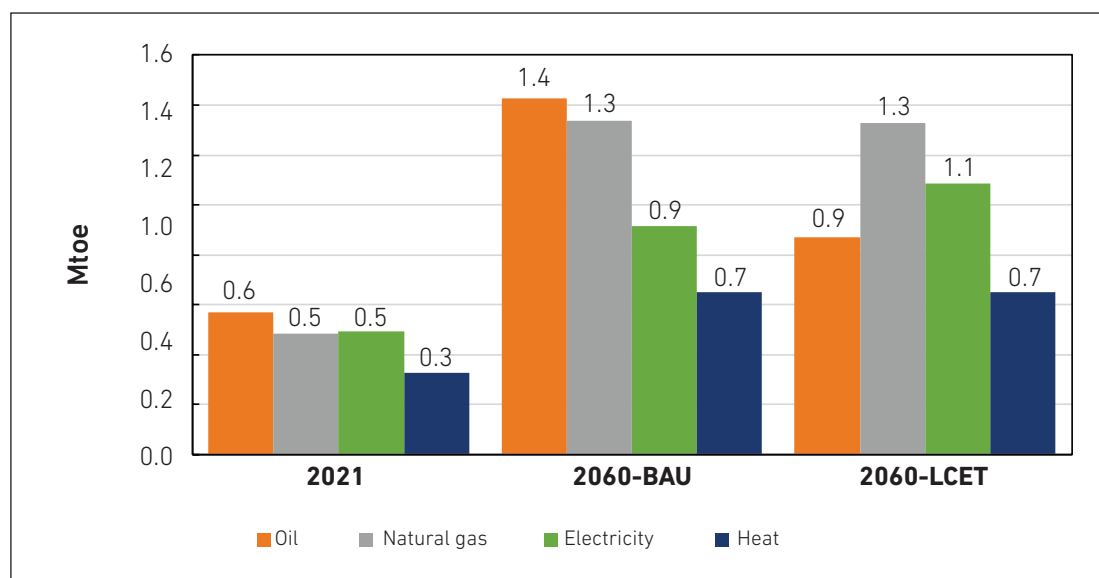


Historically, oil has been the dominant fuel, largely due to transport demand. Oil accounted for 30% of TFEC in 2021. By 2060, under BAU, its share will increase to almost 33%, indicating faster growth than total consumption. Oil demand is projected to grow at an average rate of 2.4% per year, increasing from 0.6 Mtoe in 2021 to 1.4 Mtoe in 2060. Under LCET, however, oil consumption is expected to decrease significantly to 0.9 Mtoe by 2060 as a result of fuel efficiency measures in transport and the rapid expansion of EVs. Average annual oil demand growth under LCET will be only 1.1% over the planning period.

Natural gas consumption will continue to increase, driven by new downstream facilities such as Brunei Methanol Company and the country's fertiliser industries. Under BAU, natural gas consumption is forecast to grow at an average annual rate of 2.6% in 2021–2060. Its share of TFEC will increase from 26% in 2021 to 31% in 2060, with most consumption occurring as feedstock in downstream facilities. Under LCET, natural gas demand will remain broadly similar to BAU.

Electricity consumption, by contrast, is expected to grow faster under LCET than BAU. This is in line with the government programme to promote EVs and the assumption that households will increase electricity use as incomes rise. Electricity consumption is projected to grow from 0.5 Mtoe in 2021 to 1.1 Mtoe in 2060 under LCET, compared with only 0.9 Mtoe in 2060 under BAU.

**Figure 3.3. Final Energy Consumption by Fuel, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2021 and 2060**



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

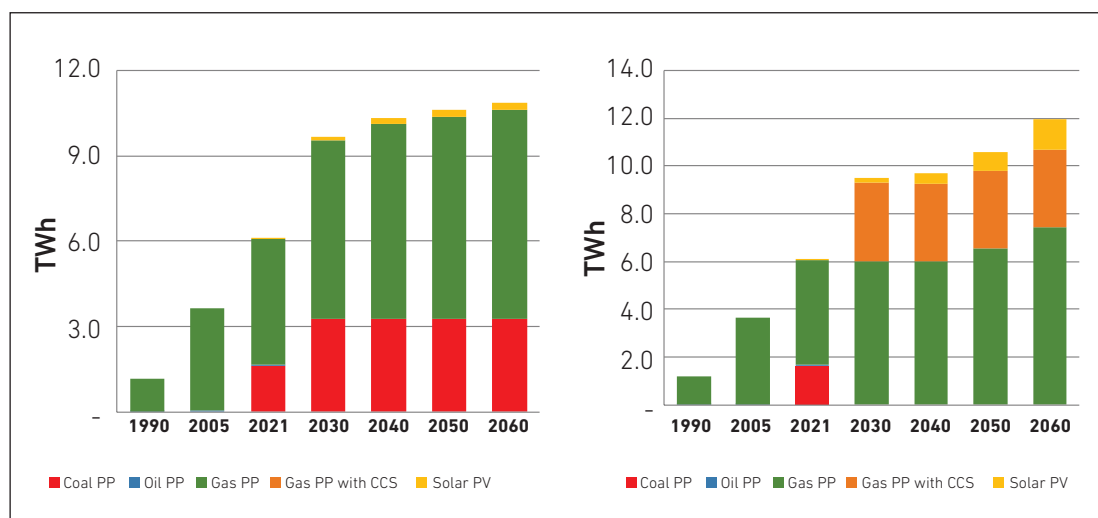
## 4. Power Generation

Under LCET, total electricity generation is projected to grow at an average annual rate of 1.8% from 2021 to 2060, reaching 12 terawatt-hours (TWh). This represents a 10% increase compared with BAU, where total generation is expected to reach 11 TWh in 2060, growing at an average annual rate of 1.5%.

Brunei Darussalam's total power generation includes captive coal-based generation for the first and second phases of the Hengyi Integrated Refinery and Petrochemical Complex. Under LCET, the electricity supply for the second phase will come not from coal-fired power plants but from natural gas-fired power plants equipped with CCS. The coal-fired power plant serving the first phase of the Hengyi complex will remain in operation until around 2050, when it is expected to reach the end of its service life and cease operations. Thereafter, its electricity requirements will also be met by natural gas plants with CCS. Despite these changes, fossil fuels are expected to remain the dominant source of generation under both scenarios. By 2060, natural gas will account for the largest share: 68% under BAU and 89% under LCET. Coal will contribute about 30% in 2060 under BAU, whilst under LCET, coal-fired generation plants will cease entirely. Natural gas power plants will be equipped with CCS technology after 2030.

Renewable energy in Brunei Darussalam is expected to come exclusively from solar power. Under BAU, solar PV generation will reach 0.3 TWh in 2060 compared with 1.3 TWh under LCET.

**Figure 3.4. Electricity Generation by Fuel, Business-as-Usual and Low-carbon Energy Transition Scenarios**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculation.

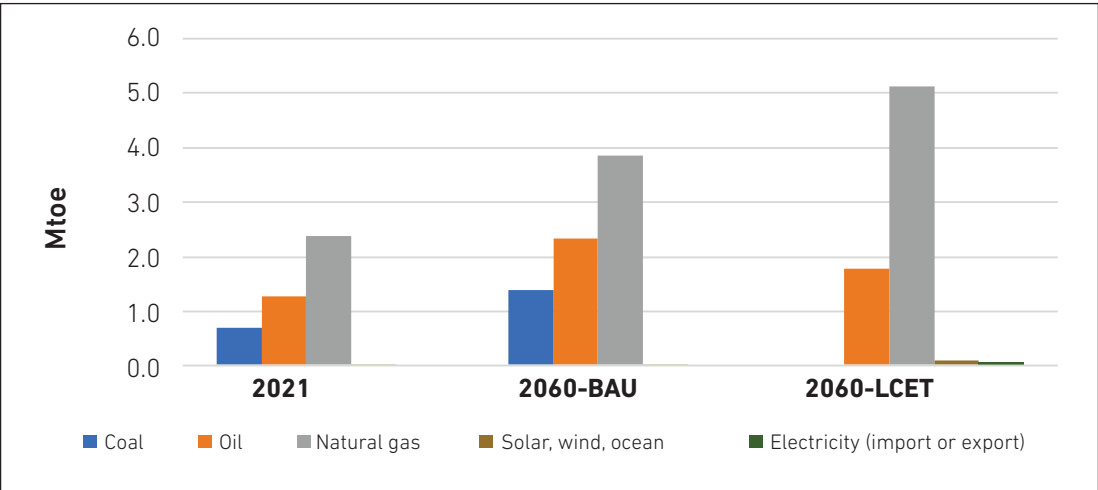
# 5. Primary Energy Supply

Under BAU, Brunei Darussalam’s total primary energy supply (TPES) is expected to reach 7.6 Mtoe in 2060, increasing at an average annual rate of 1.4% from 2021 (Figure 3.5). Coal will dominate the TPES as the Hengyi plants continue operations, with coal serving as the primary fuel input for the complex’s power generation facility.

Under LCET, the coal-fired power plant serving the second phase of the Hengyi petrochemical complex will be replaced with a natural gas–fired facility equipped with CCS. Meanwhile, the coal-fired power plant for the first phase will reach the end of its technical lifetime, resulting in the complete phase-out of coal use by 2060. Consequently, natural gas will become the dominant source of TPES. Oil’s share will also decline, reflecting decreased consumption, particularly in the transport sector.

Solar PV generation is expected to increase significantly under LCET, reaching 0.11 Mtoe, compared with around 0.02 Mtoe under BAU. Overall, TPES growth in LCET will be slightly lower than under BAU, averaging 1.3% per year over 2021–2060.

**Figure 3.5. Total Primary Energy Supply by Fuel Type, Business-as-Usual and Low-carbon Energy Transition Scenarios**



Mtoe = million tonnes of oil equivalent.

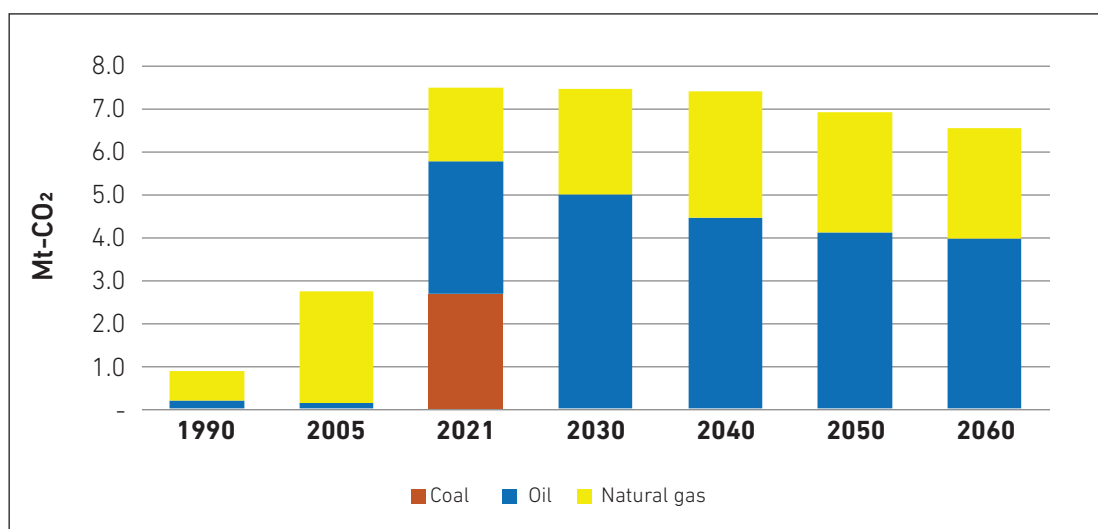
Source: Author’s calculations.

## 6. Carbon Dioxide Emissions

LCET targets carbon neutrality by 2060. In 2021, total CO<sub>2</sub> emissions stood at 7.5 MtCO<sub>2</sub> and are expected to remain at a similar level until around 2030. Thereafter, emissions are projected to decline steadily, reaching 6.6 MtCO<sub>2</sub> by 2060. This represents an average annual reduction of -0.3% in 2021–2060.

Most CO<sub>2</sub> emissions arise from oil (61%), followed by natural gas (39%). The deployment of CCS units in natural gas-fired power plants is expected to reduce CO<sub>2</sub> emissions by 50% in 2060 under LCET compared with BAU.

**Figure 3.6. Total Carbon Dioxide Emissions by Fuel Type, Low-carbon Energy Transition Scenario**



MtCO<sub>2</sub> = metric tonne of carbon dioxide.

Source: Author's calculations.

## 7. Hydrogen Demand Across the Sector

As in the previous outlook, the present assessment continues to exclude the use of hydrogen fuel under LCET.

## 8. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

An analysis of energy costs was carried out to compare BAU and LCET. The objective was to assess the total energy costs required to implement the assumptions under LCET and compare them with those under BAU. The key energy-related costs considered in the analysis are fuel, investment for power generation, and CCS. These costs are evaluated based on the outlook results and are presented in real 2020 prices.

### 8.1. Fuel costs

In 2060, Brunei Darussalam's fuel costs are projected to reach US\$1,259 million under BAU, compared with US\$1,133 million under LCET (Table 3.2).

**Table 3.2. Fuel Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060**

|              | Primary Energy Consumption (Mtoe), BAU, 2021 | Primary Energy Consumption (Mtoe), BAU, 2060 | Primary Energy Consumption (Mtoe), LCET, 2060 | Total Investment Cost, BAU, 2060 (Million US\$) | Total Investment Cost, LCET, 2060 (Million US\$) |
|--------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|-------------------------------------------------|--------------------------------------------------|
| Coal         | 0.70                                         | 1.39                                         | 0.00                                          | 110                                             | 0                                                |
| Oil          | 1.28                                         | 2.33                                         | 1.77                                          | 722                                             | 341                                              |
| Gas          | 2.37                                         | 3.86                                         | 5.12                                          | 428                                             | 791                                              |
| Hydrogen     | 0                                            | 0                                            | 0                                             | 0                                               | 0                                                |
| <b>Total</b> | <b>4.35</b>                                  | <b>7.58</b>                                  | <b>6.89</b>                                   | <b>1,259</b>                                    | <b>1,133</b>                                     |

BAU = business-as-usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 8.2. Power generation investment

The four major plants in Brunei Darussalam are fuelled by coal, oil, natural gas, and solar power. Under BAU, coal continues to provide electricity for the Hengyi petrochemical complex. Under LCET, however, coal in the second phase of Hengyi will be substituted with natural gas equipped with CCS. The coal-fired power plant supplying the first phase of Hengyi will cease operation at the end of its lifetime, with its electricity requirements also supplied from natural gas-fired power plants with CCS.

The investment analysis therefore covers coal, oil, natural gas, and solar power plants. Results for 2060 under both BAU and LCET are shown in Table 3.3.

**Table 3.3. Fuel Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060**

|              | Electricity Generation, 2021 (TWh) | Electricity Generation, BAU, 2060 (TWh) | Electricity Generation, LCET, 2060 (TWh) | Additional Capacity, BAU (MW) | Additional Capacity, LCET (MW) | Total Investment Cost, BAU, 2060 (Million US\$) | Total Investment Cost, LCET, 2060 (Million US\$) |
|--------------|------------------------------------|-----------------------------------------|------------------------------------------|-------------------------------|--------------------------------|-------------------------------------------------|--------------------------------------------------|
| Coal         | 1.63                               | 3.25                                    | 0.00                                     | 232                           | 0.00                           | 354                                             | 0.00                                             |
| Oil          | 0.04                               | 0.00                                    | 0.00                                     | 0.00                          | 0.00                           | 0.00                                            | 0.00                                             |
| Gas          | 4.42                               | 7.36                                    | 10.69                                    | 420                           | 894.70                         | 294                                             | 627                                              |
| Solar        | 0.00                               | 0.25                                    | 1.28                                     | 168                           | 857.80                         | 52                                              | 263                                              |
| <b>Total</b> | <b>6.08</b>                        | <b>10.86</b>                            | <b>11.97</b>                             | <b>820</b>                    | <b>1,752</b>                   | <b>699</b>                                      | <b>890</b>                                       |

BAU = business-as-usual, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt-hour.

Source: Author's calculations.

BAU requires an additional 820 MW of capacity compared with 2021, whilst LCET requires 1,752 MW. This increase is largely due to the use of carbon capture, utilisation, and storage (CCUS) in natural gas power plants for the Yenghi petrochemical complex. LCET includes a significant expansion of solar PV capacity—857 MW compared to 168 MW under BAU—to reduce CO<sub>2</sub> emissions. Total investment in power plants by 2060 is estimated at US\$699 million under BAU and US\$890 million under LCET.

## 8.3. Carbon capture and storage cost

The introduction of CCS is assumed under LCET from 2041 onwards, applied exclusively to natural gas-fired power plants. The estimated CCS cost is about US\$30 per tonne of CO<sub>2</sub>. The total CCS investment cost in 2060 is projected to be US\$76 million (Table 3.4).

**Table 3.4. Total Investment Cost of Carbon Capture and Storage,  
Low-carbon Energy Transition Scenario, 2060**

|                            | Consumption<br>LCET, 2060<br>(Mtoe) | CO <sub>2</sub> Emissions,<br>LCET<br>(MtCO <sub>2</sub> ) | CO <sub>2</sub> Emissions,<br>LCET<br>(MtC) | Total<br>Investment<br>Cost (US\$<br>Million) |
|----------------------------|-------------------------------------|------------------------------------------------------------|---------------------------------------------|-----------------------------------------------|
| Coal Power Plant with CCS  | 0.00                                | 0.00                                                       | 0.00                                        | 0.00                                          |
| Natural Gas Plant with CCS | 0.66                                | 1.41                                                       | 0.38                                        | 76                                            |
| <b>Total</b>               | <b>0.66</b>                         | <b>1.41</b>                                                | <b>0.38</b>                                 | <b>76</b>                                     |

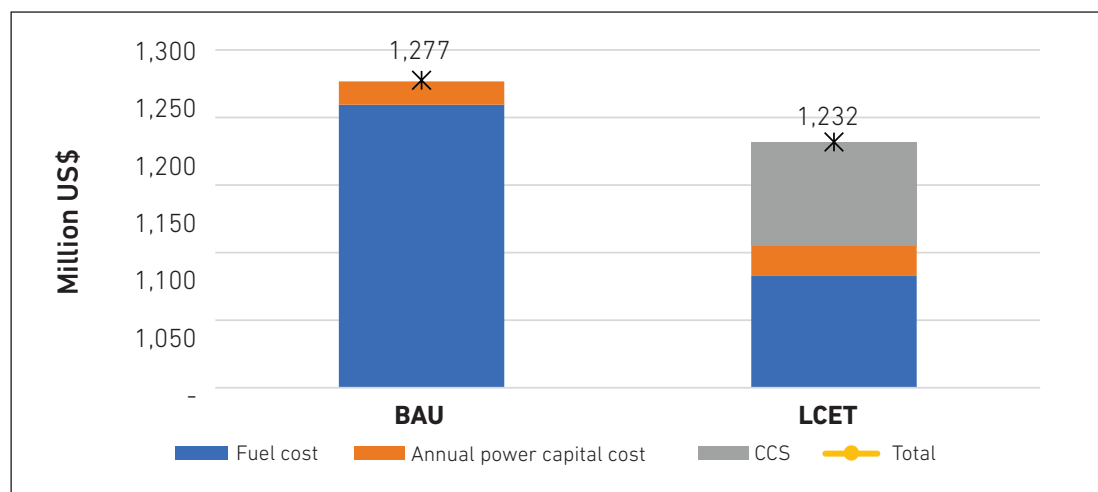
BAU = business-as-usual, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, LCET = low-carbon energy transition, MtC = million tonnes of carbon, MtCO<sub>2</sub> = million tonnes of carbon dioxide, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 8.4. Overall cost

Based on the analysis presented in Sections 8.1 to 8.3, the overall investment cost in 2060 is projected at US\$1,277 million under BAU and US\$1,232 million under LCET.

**Figure 3.7. Energy Cost Comparison for Business-as-Usual  
and Low-carbon Energy Transition Scenarios, 2060**



BAU = business-as-usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Author's calculations.

All costs are expressed on an annualised basis and exclude expenditures for energy efficiency improvements, energy storage, distribution, and transmission. Fuel costs remain the largest component, estimated at US\$1,259 million under BAU and US\$1,133 million under LCET.

## 9. Conclusions and Recommendations

Brunei Darussalam is projected to remain heavily reliant on fossil fuels to meet its growing energy demand, even under LCET. The non-energy sector will continue to drive demand, as significant volumes of natural gas will be needed to support the expansion of downstream industries in line with the country's diversification efforts.

The greatest energy savings under LCET are expected in transport, primarily through improved vehicle efficiency and the wider adoption of EVs. In the power sector, decarbonisation will be achieved through the deployment of CCS technologies and a rising share of renewable energy, particularly solar PV. Overall, Brunei Darussalam's energy-related CO<sub>2</sub> emissions are projected to decline by 50% in 2060 under LCET compared with BAU.

The total investment cost of LCET is estimated at US\$1,232 million, lower than the US\$1,277 million projected under BAU. This indicates that implementing the measures assumed in LCET can enable Brunei Darussalam to attain net-zero emissions by 2060, in line with the government's energy strategies.

Fuel costs will constitute the major portion of the total investment: 99% under BAU and 92% under LCET. The introduction of CCS is assumed to begin in 2030, with the associated investment reaching US\$76 million by 2060, representing around 6% of total investment. Should the cost of CCS technology fall by 2060, the required investment is expected to decline significantly.





# Chapter 4

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## Cambodia Country Report

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# 1. Social and Economic Situation, Energy Situation, and Energy Development Plan

## 1.1. Energy Development Plan and Targets

Cambodia's Power Development Plan was revised in 2024 to emphasise renewable energy. The country's primary target is to achieve 70% renewable energy integration into the national grid by 2030. Whilst this goal is challenging, Cambodia is confident it can achieve it by harnessing its solar potential and hydro, wind, biomass resources; adopting emerging energy technologies; and strengthening regional energy cooperation.

Energy efficiency—the invisible fuel—is another key area of focus. The government is actively supporting the development of energy service companies to drive efficiency improvements across the residential, agricultural, and industrial sectors. Efforts include addressing skill shortages, certifying energy professionals, and conducting targeted public awareness campaigns.

Cambodia is advancing electrification where feasible. In August 2024, the government held a consultative workshop with international and multilateral organisations and diplomatic representatives to discuss the electric vehicle (EV) road map and charging network. The initiative aims to accelerate EV adoption, build a robust charging infrastructure, bridge workforce skill gaps, and ensure EV battery and e-waste management.

To meet the expected rise in electricity demand from EVs, Cambodia is expanding grid capacity by enhancing infrastructure, improving energy efficiency, and deploying storage systems, including a 1-gigawatt pumped-storage hydro system, to support variable renewable energy outputs.

Whilst transitioning to decarbonisation, Cambodia recognises the short-term role of hydrocarbons. Responsible oil and gas exploration and exploitation are crucial for energy security during the transition. The country remains open to constructive dialogue on resolving overlapping claims.

As the country manages its immediate energy needs, the government looks ahead, focusing on clean energy manufacturing to capitalise on the industrial and economic opportunities presented by the transition to net zero. This focus includes attracting and facilitating investment to strengthen economic security. The country sees significant potential for collaboration in building clean energy supply chains, boosting trade, and increasing investment. Its goal is to establish itself as an indispensable player in the net-zero economy, supporting regional sustainability whilst benefiting from the global energy transition.

## 1.2. Social and Economic Situation

Cambodia has experienced steady economic growth. In 1995–2019, its economy expanded at an annual rate of 7.6%, driven by tourism, manufacturing, real estate, and construction (World Bank, 2024). However, due to the impact of the coronavirus disease (COVID-19) pandemic, the economy contracted by 3.1% in 2020 before rebounding with growth rates of 3% in 2021 and 5.2% in 2022. The population has grown at an average annual rate of 2.6% in 1990–2025 and 1.4% in 2005–2021.

With sustainable peace, social order, security, and political stability as strong foundations, Cambodia has sustained high economic growth, significantly reducing poverty and achieving lower-middle-income status in 2015. The economy is projected to grow by approximately 6% in 2024 and 6.3% in 2025, driven by export-oriented industries, particularly garments. Accommodation, tourism, and other supporting sectors are expected to continue rising, nearing pre-pandemic levels. Growth in non-garment industries remains resilient, with emerging sectors such as automotive assembly and food and beverage manufacturing contributing to economic expansion. Inflation is forecast at 2.7% in 2024 and 2.5% in 2025, although current economic performance suggests that 2024 inflation may be lower than initially projected.

Cambodia has established itself as one of the fastest-growing investment destinations in the region. In the first 9 months of 2024, the Council for the Development of Cambodia registered 315 projects, bringing in US\$5.3 billion in investment and generating over 252,000 jobs. From September 2023 to September 2024, foreign direct investment inflows surged to US\$8.1 billion, reflecting strong international confidence in Cambodia's growth-oriented policies and stable economic condition.

Cambodia maintains an open stance towards foreign business ownership and capital repatriation. It allows 100% foreign ownership in most sectors, except for land, and allows investors to freely purchase foreign currencies and repatriate foreign currencies. The Law on Investment offers generous tax breaks of up to 9 years, investment guarantees, and a streamlined business registration process. The government's Special Program to Promote Investment in Preah Sihanouk Province provides procedural facilitation and special incentives beyond those outlined in the Law on Investment.

The transformation has been driven by foreign and economic policies, which prioritise cooperative relationships and the mutual benefits of economic growth. Cambodia actively participates in numerous bilateral and regional free trade agreements, including the Regional Comprehensive Economic Partnership (RCEP), the ASEAN–China Free Trade Area, and the Cambodia–China Free Trade Agreement. In the first 10 months of 2024, Cambodia's trade with RCEP member countries reached US\$27.7 billion, accounting for 61.4% of its total trade volume.

The Digital Economy and Society Policy Framework is a comprehensive road map for digital transformation, focusing on digital infrastructure, cybersecurity, and workforce development. To support its digital and industrial ambitions, the government launched the Comprehensive Master Plan on the Cambodian Transit and Logistics System, which outlines 174 projects with a total investment of US\$36.68 billion over the next decade.

To foster resilient, inclusive, and sustainable economic growth, the government recently introduced regulations under Article 6 of the Paris Agreement, enabling carbon credit trading through internationally transferred mitigation outcomes. The credits, linked to the nationally determined contributions, provide international investors with structured opportunities to contribute to global carbon reduction whilst supporting the green economy.

Energy consumption growth is influenced by socio-economic factors such as population size, economic development, vehicle ownership, and access to electricity. This study covers 2021–2050. Based on historical trends in economic and population growth, gross domestic product (GDP) and population are projected to increase at an average annual growth rate of 6.1% and 1.5%, respectively. These trends are expected to be the primary drivers of rising energy demand.

**Table 4.1. Population and Gross Domestic Product Projections, 2030–2060**

|                      | Historical Data |      |      | Projection |      |       |       |                       |
|----------------------|-----------------|------|------|------------|------|-------|-------|-----------------------|
|                      | 1990            | 2005 | 2021 | 2030       | 2040 | 2050  | 2060  | AAGR (%)<br>2021–2060 |
| GDP (billion US\$)   | 3.7             | 9.2  | 23.7 | 41.3       | 74.9 | 134.1 | 240.1 | 6.1                   |
| Population (million) | 9.0             | 13.2 | 16.6 | 19.0       | 22.0 | 25.5  | 29.6  | 1.5                   |

AAGR = average annual growth rate, GDP = gross domestic product.

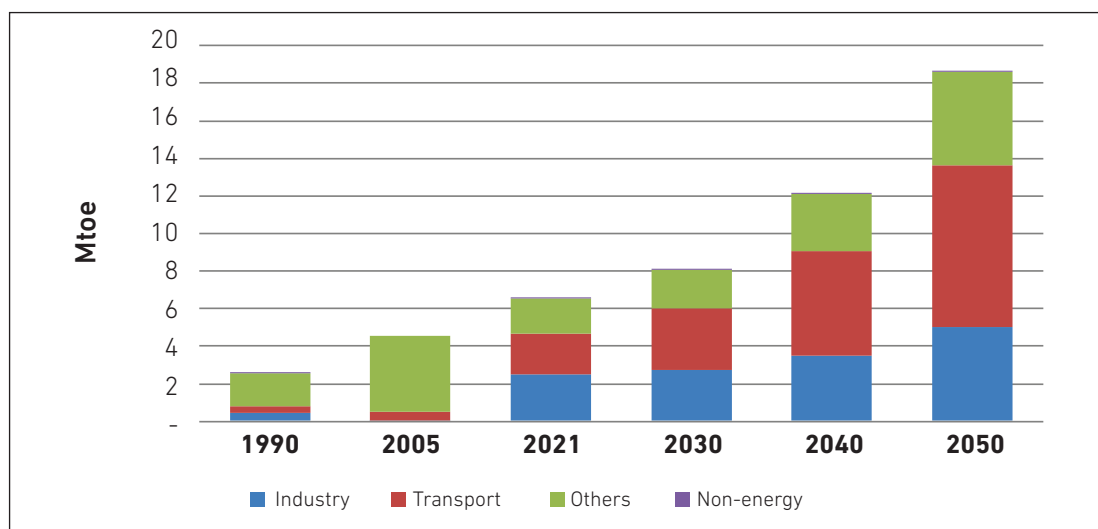
Source: Authors. Projections based on World Bank (2022).

## 2. Final Energy Consumption

Under the business-as-usual (BAU) scenario, final energy consumption is projected to grow at an average annual rate of 3.6%, increasing from 6.6 million tonnes of oil equivalent (Mtoe) in 2021 to 18.66 Mtoe by 2050 (Figure 4.1). Transport is expected to experience the highest demand growth, with an average annual increase of 4.8%. In 2021, transport accounted for approximately 33.4% of final energy consumption; by 2050, this share is projected to rise to 46.1%. The sharp increase in transport energy demand is driven by rapid motorisation in recent decades, a trend anticipated to continue.

Other sectors in final energy consumption are expected to have the second-highest demand growth, averaging 3.5% annually, rising from 1.84 Mtoe in 2021 to 4.96 Mtoe in 2050. The main contributors to this growth are the residential and commercial sectors, which are projected to grow consistently over the period. Final energy consumption in industry is expected to grow at an average annual rate of 2.5% over the planning period.

**Figure 4.1. Final Energy Consumption by Sector, Business-as-Usual Scenario, 1990–2050**

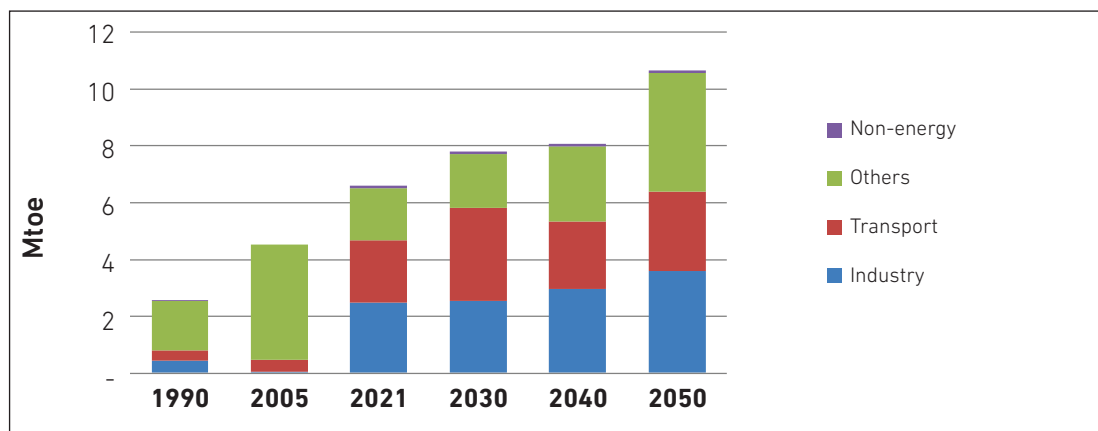


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Under the low-carbon energy transition (LCET) scenario, final energy consumption is projected to reach 10.65 Mtoe by 2050, growing at an average annual rate of 1.7% in 2021–2050, significantly lower than BAU's 3.6%. The reduced growth rate is primarily attributed to transport, where demand in 2050 is expected to be 67.56% lower than under BAU due to stringent fuel efficiency regulations and widespread EV adoption. Industry is expected to consume 28.1% less energy, whilst other sectors will see a 15.73% reduction compared with BAU, owing to the implementation of stringent energy efficiency and conservation measures. Figure 4.2 shows the sector distribution of final energy consumption under LCET.

**Figure 4.2. Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario, 1990–2050**



Mtoe = million tonnes of oil equivalent.

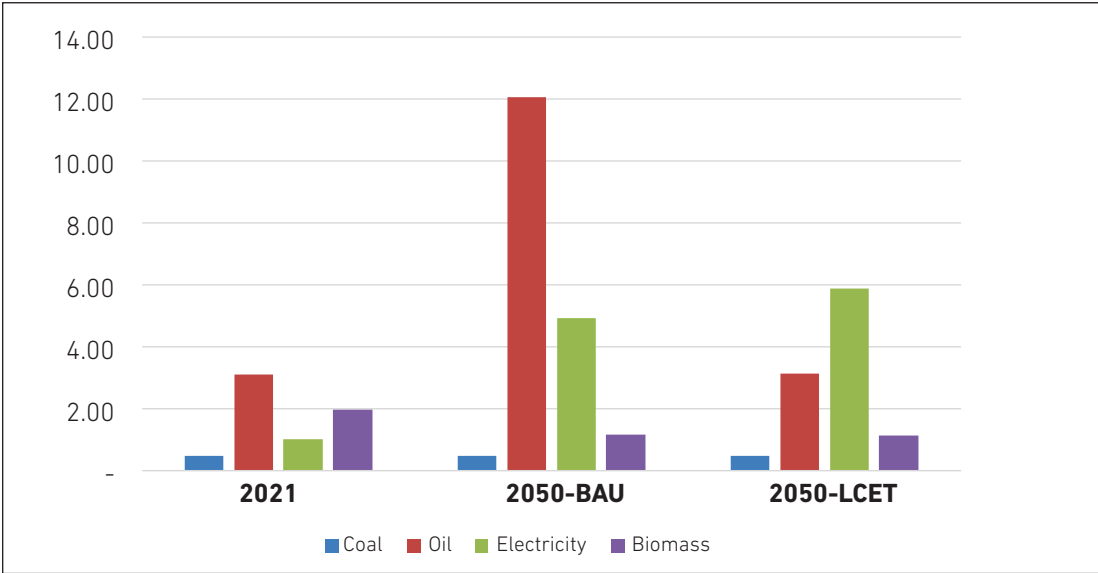
Source: Authors.

Historically, oil has been the dominant fuel, driving growth in transport and other sectors, particularly in the form of liquefied petroleum gas (LPG) for cooking in the residential and commercial sectors. Oil accounted for 47.3% of final energy consumption and, under BAU, its share is projected to increase to 64.6% by 2050. Oil consumption is expected to grow at an average annual rate of 4.8%, rising from 3.12 Mtoe in 2021 to 12.06 Mtoe by 2050. However, under LCET, oil consumption will decrease significantly to 3.13 Mtoe in 2050, driven by fuel efficiency measures in transport and other sectors and rapid EV adoption.

Biomass has been used extensively for cooking in the residential and commercial sectors, but its use is projected to decline with the increasing adoption of LPG. In 2021, biomass consumption stood at 1.97 Mtoe but is projected to decrease to 1.17 Mtoe under BAU and 1.14 Mtoe under LCET by 2050. Coal consumption for final energy demand is expected to remain at 2021 levels through to 2050 under both scenarios.

Electricity consumption is projected to grow faster under LCET than under BAU, which aligns with government initiatives promoting EV adoption and the assumption that households will increase electricity usage as incomes rise. Under BAU, electricity consumption is expected to increase from 1.02 Mtoe in 2021 to 4.93 Mtoe by 2050, whilst under LCET, it is projected to reach 5.89 Mtoe by 2050. Figure 4.3 shows final energy consumption by fuel type in 2021 and projected levels for 2050 under both scenarios.

**Figure 4.3. Final Energy Consumption by Fuel, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2021 and 2050**



BAU = business as usual, LCET = low-carbon energy transition.

Source: Authors.

### 3. Power Generation

Total electricity generation under LCET is projected to increase at an average annual rate of 7.3% in 2021–2050, reaching 77.45 terawatt-hours (TWh). Electricity generation under LCET is expected to be 19.3% higher than under BAU by 2050. Under BAU, total electricity generation will grow at an average annual rate of 6.6%, reaching 6.89 TWh by 2050.

BAU is expected to maintain a significant share of fossil fuel-based generation, accounting for 53.8% of total electricity production in 2050. Whilst coal-fired power generation is expected to expand continuously, reaching 6.66 TWh in 2050, natural gas power plants will dominate the grid, contributing 27.38 TWh to total generation. The remaining share will come primarily from hydropower and solar photovoltaic (PV), which are projected to account for 22.7% and 16.4% of the generation mix, respectively.

Under LCET, renewable energy is expected to dominate the power generation mix, with hydropower projected to supply 41% of total electricity generation by 2050. Other renewable sources, including solar PV, wind, and biomass, will contribute significantly, generating 14.61 TWh, 3.65 TWh, and 3.15 TWh, respectively. However, fossil fuel power plants will still play a role in the energy mix. Coal-fired power plants will continue to operate in 2021–2050, with carbon capture and storage (CCS) technology being implemented from 2040 onwards. By 2050, coal-fired power plants with CCS will supply 10% of total generation. From 2040 onwards, gas power plants will be complemented by CCS and hydrogen co-firing. By 2050, gas power plants with CCS and those co-firing with hydrogen will each account for 10% of the generation mix.

**Figure 4.4. Electricity Generation by Fuel, Business-as-Usual and Low-carbon Energy Transition Scenarios, 1990–2050**

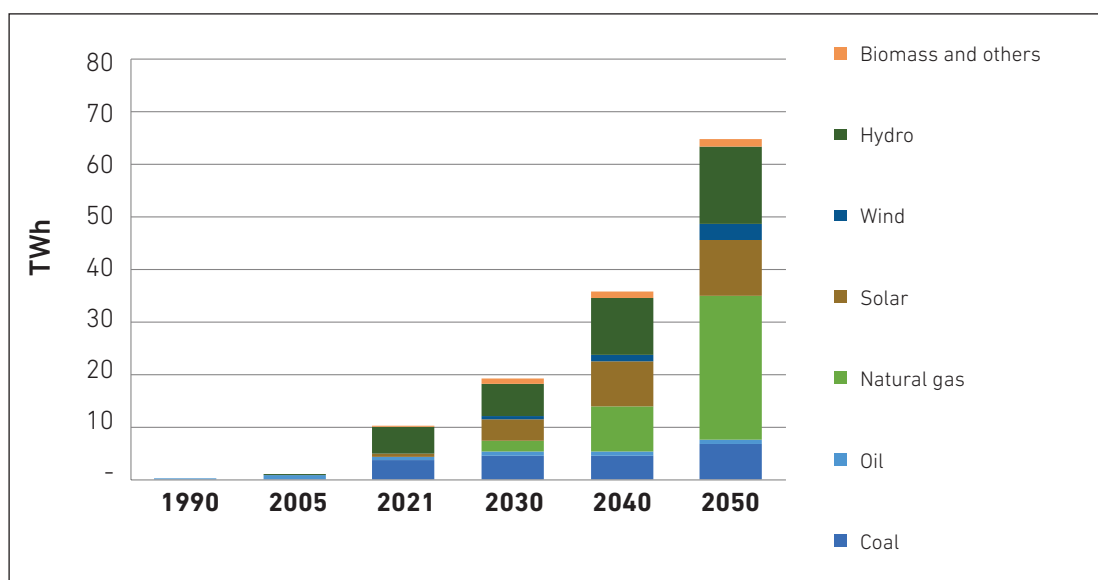
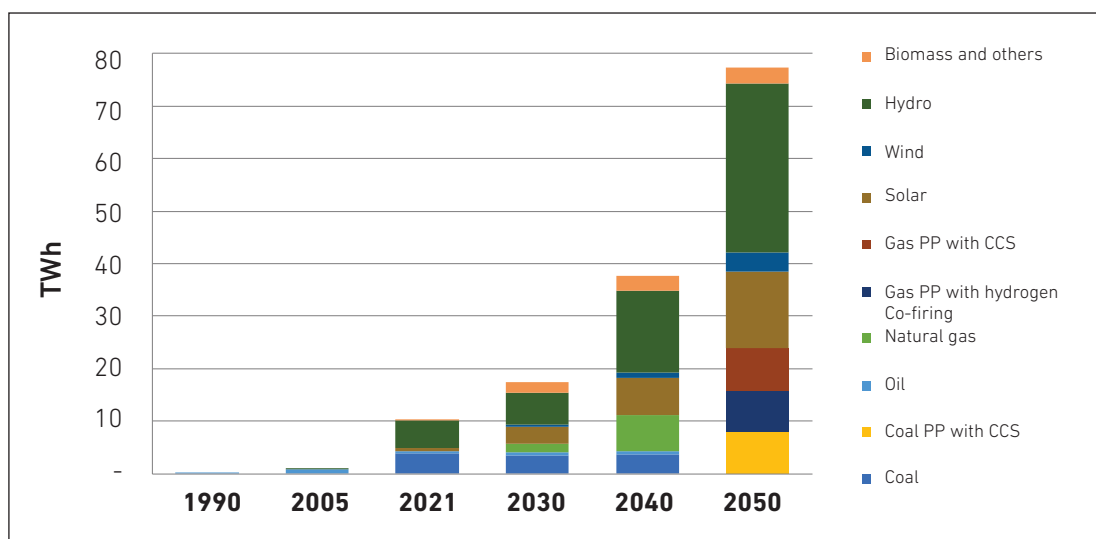




Figure 4.4. Continued



CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

Source: Authors.

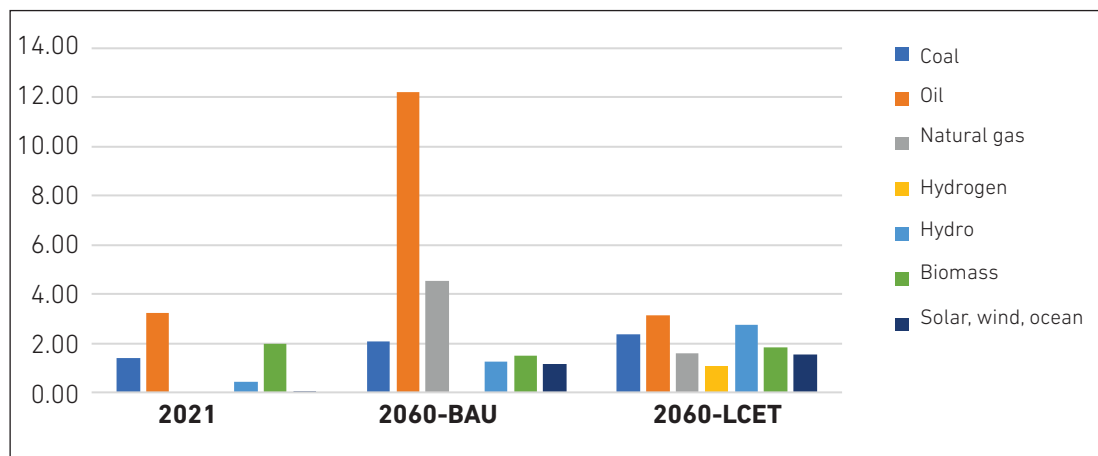
## 4. Primary Energy Supply

Primary energy supply under BAU is expected to reach 22.78 Mtoe by 2050, increasing at an average annual rate of 3.9% from 2021 (Figure 4.5). Oil is expected to dominate primary energy supply, reaching 12.23 Mtoe (53.7%) by 2050. The second-highest share of primary energy supply will come from natural gas, which is projected to reach 4.53 Mtoe (19.9%) by 2050.

Under LCET, hydropower use is expected to increase significantly, reaching 2.76 Mtoe by 2050, more than double the 1.26 Mtoe projected under BAU. Hydrogen will be utilised as a co-firing fuel for gas power plants, with consumption expected to reach 1.05 Mtoe by 2050. Other renewable sources, such as biomass and solar, wind, and ocean energy, are expected to increase, reaching 1.83 Mtoe and 1.57 Mtoe, respectively, surpassing their expected levels under BAU.

Primary energy supply under LCET will grow at a slower annual rate of 2.3% in 2021–2050, compared with 3.9% under BAU. Figure 4.5 shows primary energy supply under BAU and LCET.

**Figure 4.5. Total Primary Energy Supply by Fuel Type, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2021–2050**



BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

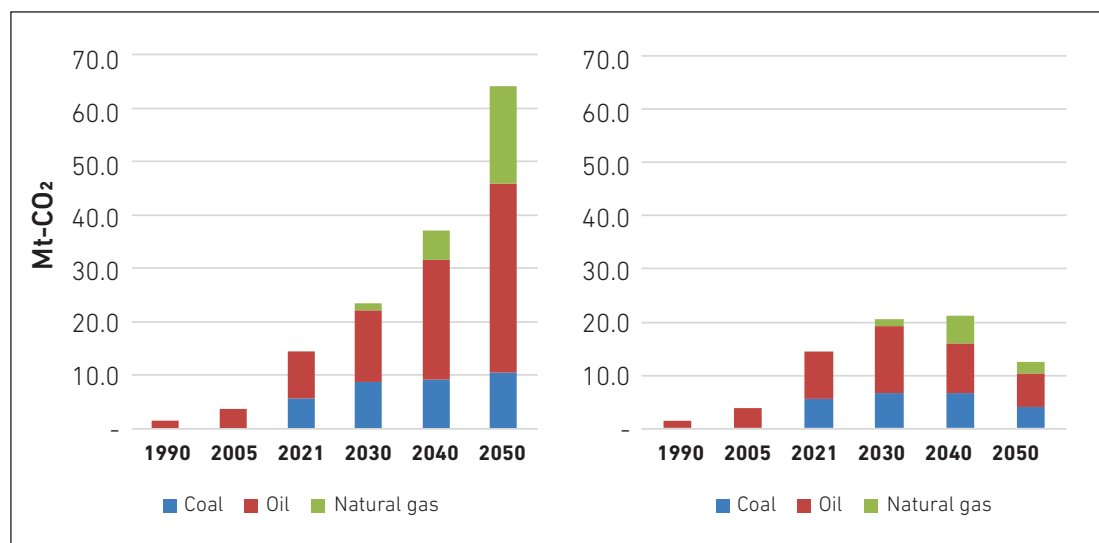
## 5. Carbon Dioxide Emissions

Total carbon dioxide (CO<sub>2</sub>) emissions were 14.5 metric tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2021. Under BAU, emissions are projected to rise continuously, reaching 64 Mt-CO<sub>2</sub> by 2050. The most significant contributor to this increase is oil combustion, which is projected to produce 35.3 Mt-CO<sub>2</sub> by 2050. The projected annual emissions growth rate under BAU is 5.3% in 2021–2050.

Under LCET, CO<sub>2</sub> emissions are projected to peak at 21.2 Mt-CO<sub>2</sub> by 2040 before declining to 12.5 Mt-CO<sub>2</sub> by 2050. The average annual growth rate of total CO<sub>2</sub> emissions under LCET is estimated at –0.5% in 2021–2050.

The implementation of clean technologies, including CCS, hydrogen co-firing, energy efficiency measures, and EVs, is expected to reduce CO<sub>2</sub> emissions by 80.5% by 2050 compared with BAU.

**Figure 4.6. Total Carbon Dioxide Emissions, Business-as-Usual and Low-carbon Energy Transition Scenarios, 1990–2050**



BAU = business as usual, LCET = low-carbon energy transition, Mt-CO<sub>2</sub> = metric tonnes of carbon dioxide.

Source: Authors.

## 6. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

Energy costs were analysed to compare BAU and LCET, evaluating the total energy cost of implementing all LCET assumptions against BAU. The analysis considered fuel costs, power generation investment, and CCS implementation, based on outlook results, with all figures in real 2020 prices.

### 6.1. Fuel Costs

Fuel costs are projected to reach US\$7,602 million by 2050 under BAU but significantly lower at US\$1,767 million under LCET. Table 4.2 compares fuel costs for both scenarios by 2050.

**Table 4.2. Fuel Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios, 2050**

|              | Primary Energy Consumption (Mtoe), BAU in 2021 | Primary Energy Consumption (Mtoe), BAU | Primary Energy Consumption (Mtoe), LCET | Total Cost, BAU (US\$ million) | Total Cost, LCET (US\$ million) |
|--------------|------------------------------------------------|----------------------------------------|-----------------------------------------|--------------------------------|---------------------------------|
| Coal         | 1.39                                           | 2.07                                   | 2.36                                    | 108                            | 153                             |
| Oil          | 3.23                                           | 12.23                                  | 3.13                                    | 6,188                          | 72                              |
| Gas          | 0                                              | 4.53                                   | 1.60                                    | 1,307                          | 463                             |
| Hydrogen     | 0                                              | 0                                      | 1.05                                    | 0                              | 1,222                           |
| <b>Total</b> | <b>3.23</b>                                    | <b>11.37</b>                           | <b>8.27</b>                             | <b>7,602</b>                   | <b>1,767</b>                    |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

## 6.2. Power Generation Investment

LCET has a higher share of renewable energy—mainly hydropower, solar, and wind—whilst BAU relies more on fossil fuels. Total power generation is higher under LCET, requiring an additional 22,070 megawatts (MW) compared with 2021, versus 15,025 MW under BAU. As a result, total investment under LCET is higher at US\$26,271 million, compared with US\$13,384 million under BAU. The cost difference is largely due to hydropower investments, which account for more than half (US\$17,143) of LCET's total. Table 4.3 details power plant investment costs under BAU and LCET by 2050.

**Table 4.3. Comparison of Power Plant Investment Costs Under Business-as-Usual and Low-carbon Energy Transition Scenarios, 2050**

|               | Electricity Generation in 2021 (TWh) | Electricity Generation, BAU (TWh) | Electricity Generation, LCET (TWh) | Additional Capacity, BAU (MW) | Additional Capacity, LCET (MW) | Total Investment Cost, BAU (US\$ million) | Total Investment Cost, LCET (US\$ million) |
|---------------|--------------------------------------|-----------------------------------|------------------------------------|-------------------------------|--------------------------------|-------------------------------------------|--------------------------------------------|
| Coal          | 3.78                                 | 6.66                              | 0                                  | 411                           | 0                              | 627                                       | 0                                          |
| Coal with CCS | 0                                    | 0                                 | 7.88                               | 0                             | 1,125                          | 0                                         | 1,715                                      |
| Oil           | 0.56                                 | 0.86                              | 0                                  | 42                            | 0                              | 25                                        | 0                                          |
| Gas           | 0                                    | 27.38                             | 0                                  | 3,906                         | 0                              | 2,734                                     | 0                                          |
| Gas with CCS  | 0                                    | 0                                 | 8.10                               | 0                             | 1,156                          | 0                                         | 809                                        |

|                              | Electricity Generation in 2021 (TWh) | Electricity Generation, BAU (TWh) | Electricity Generation, LCET (TWh) | Additional Capacity, BAU (MW) | Additional Capacity, LCET (MW) | Total Investment Cost, BAU (US\$ million) | Total Investment Cost, LCET (US\$ million) |
|------------------------------|--------------------------------------|-----------------------------------|------------------------------------|-------------------------------|--------------------------------|-------------------------------------------|--------------------------------------------|
| Gas co-firing H <sub>2</sub> | 0                                    | 0                                 | 7.93                               | 0                             | 1,132                          | 0                                         | 905                                        |
| Solar                        | 0.61                                 | 10.67                             | 14.61                              | 6,757                         | 9,399                          | 2,074                                     | 2,886                                      |
| Wind                         | 0                                    | 3.08                              | 3.65                               | 879                           | 1,040                          | 1,085                                     | 1,285                                      |
| Hydro                        | 5.11                                 | 14.71                             | 32.13                              | 2,740                         | 7,712                          | 6,091                                     | 17,143                                     |
| Biomass                      | 0.05                                 | 1.57                              | 3.15                               | 247                           | 506                            | 747                                       | 1,528                                      |
| <b>Total</b>                 | <b>10.11</b>                         | <b>64.92</b>                      | <b>77.45</b>                       | <b>15,025</b>                 | <b>22,070</b>                  | <b>13,384</b>                             | <b>26,271</b>                              |

BAU = business as usual, CCS = carbon capture and storage, H<sub>2</sub> = hydrogen, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt-hour.

Source: Authors.

## 6.3. Carbon Capture and Storage Cost

CCS implementation under LCET is projected to begin in 2041 for coal and gas power plants, with an estimated cost of US\$60 per tonne of CO<sub>2</sub>. The CCS investment by 2050 is projected at US\$469 million (Table 4.4).

**Table 4.4. Total Investment Cost of Carbon Capture and Storage Under Low-carbon Energy Transition Scenario, 2050**

|                            | Consumption (Mtoe) | CO <sub>2</sub> Emission (Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emissions (Mt-C) | Total CCS Investment Cost (US\$ million) |
|----------------------------|--------------------|------------------------------------------------|----------------------------------|------------------------------------------|
| Coal Power Plant with CCS  | 1.86               | 6.95                                           | 1.89                             | 376                                      |
| Natural Gas Plant with CCS | 0.81               | 1.72                                           | 0.46                             | 93                                       |
| <b>Total</b>               | <b>2.67</b>        | <b>8.68</b>                                    | <b>2.36</b>                      | <b>469</b>                               |

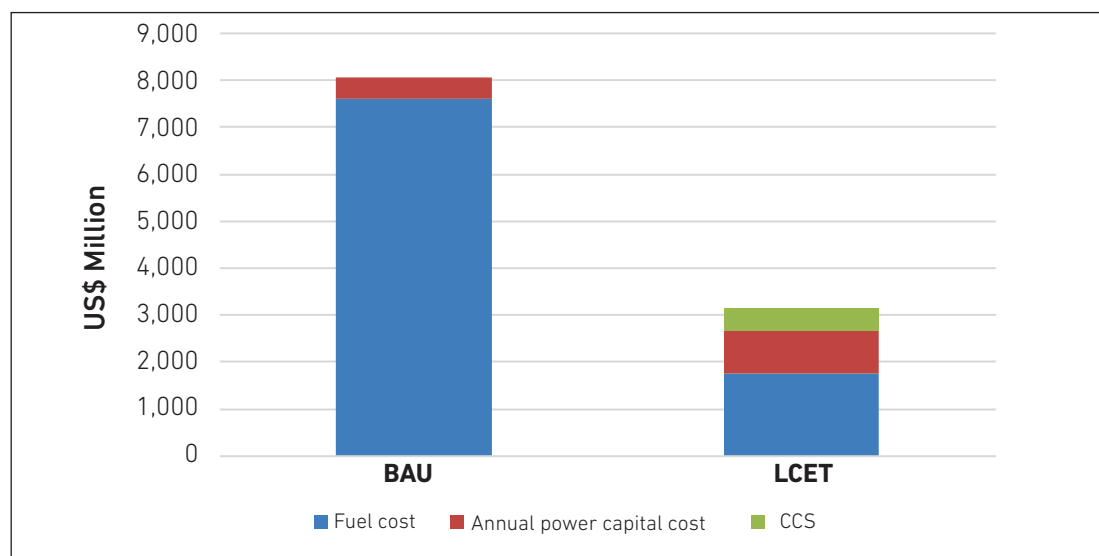
CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, Mt-C = metric tonne of carbon, Mt-CO<sub>2</sub> = metric tonne of carbon dioxide, Mtoe = metric tonne of oil equivalent.

Source: Authors.

## 6.4. Overall Cost

A cost comparison analysis assessed the economic implications of each scenario, presenting annual costs, excluding investments in energy efficiency, storage, and transmission. Annual costs are estimated at US\$8,064 million under BAU and significantly lower at US\$3,141 million under LCET. Fuel costs account for the largest share of total expenditure: 94% under BAU and 56% under LCET. Figure 4.8 illustrates total annual costs for both scenarios.

**Figure 4.7. Overall Annual Total Costs, Business-as-Usual and Low-carbon Energy Transition**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors.

## 7. Conclusions and Recommendations

Cambodia targets carbon neutrality by 2050, with LCET providing a viable pathway. Its implementation could drive down emissions by up to 80.5% compared with BAU. Both scenarios rely on fossil fuels to meet growing energy demand, but BAU sees greater usage, leading to higher costs. Primary energy supply under BAU will be dominated by oil and natural gas, increasing fuel import dependency.

Transport has the highest energy-saving potential under LCET, achieved through more efficient vehicles and greater EV adoption. In the residential and commercial sectors, LPG consumption for cooking is expected to rise. Under BAU, increased LPG use will increase petroleum product use, exacerbating fuel import dependency. To mitigate this dependency, the government should promote electric stoves, as modelled in LCET.

In power generation, both scenarios rely on hydropower and thermal power plants (coal and natural gas). By 2050, gas power plants are projected to generate 42% of total electricity under BAU, whilst LCET projects hydropower at 41% and solar PV at 19%. Coal will remain a baseload source, with gas acting as a transitional power generator in 2030–2040, highlighting the need to prioritise advancements in hydropower and thermal power technologies.

Power generation investment under LCET will be higher, with annual costs reaching US\$906 million, compared with US\$462 million under BAU. Integrating CCS, set to begin in 2041, will add US\$469 million annually. However, LCET is projected to yield annual fuel cost savings of US\$5,835 million by 2050 whilst significantly reducing emissions, supporting the carbon neutrality target, and lowering fuel dependency.

## References

Ministry of Economy and Finance, Cambodia (2025), *Macroeconomic Indicators: Cambodia's economic growth assessment in 2023-2025* (accessed 23 February 2025)

Ministry of Mines and Energy, Cambodia (2022a), *Cambodia Power Development Master Plan (2022–2040)*.

Ministry of Mines and Energy, Cambodia (2022b), *National Energy Efficiency Policy 2022–2030*.

World Bank, *World Bank Statistic and Energy Balance Table 2021–2022. The World Bank in Cambodia* (last updated April 2024) (accessed 1 December 2024).

World Bank (2022), *World Development Indicators* (accessed 1 December 2024).

# Chapter 5

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## China Country Report<sup>1</sup>

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<sup>1</sup> The views expressed in this chapter are those of the authors alone and do not necessarily reflect the views of the supporting agencies or the authors' affiliations.



# 1. Introduction

In pursuit of low-carbon development and to advance China's 'dual-carbon' goals, which were formally announced in 2020, authorities in China have implemented various initiatives. These efforts have significantly driven the nation's shift towards low-carbon energy sources. According to the National Bureau of Statistics of China (NBS, 2024), the total annual energy consumption in 2023 reached 5.72 billion tonnes of standard coal, marking a 5.7% increase from the previous year. Specifically, crude oil consumption saw a 9.1% increase, natural gas consumption rose 7.2%, and electricity consumption increased 6.7%. Coal utilisation accounted for 55.3% of total energy consumption in 2023, a decrease of 0.7 percentage points compared to 2022. Renewable energy sources – including natural gas, hydropower, nuclear power, wind power, and solar power – constituted 26.4% of the total energy consumption, reflecting a 0.4% increase.

Progress has been made in transitioning to environmentally sustainable practices and fostering economic growth. The National Bureau of Statistics of China (NBS, 2024) reported that the average coal usage per kilowatt-hour (KWh) of thermal power generation in major industrial consumers has decreased by 19% since 2005. In 2023, the volume of carbon emission allowances traded in the national carbon market was 212 million tonnes, with a transaction value of CNY14.44 billion (yuan). The energy intensity of gross domestic product (GDP) for 2023 decreased by 42% compared to 2005, measured per CNY10,000 of GDP. Amongst the 339 prefecture-level and higher cities monitored, 59.9% met the annual air quality standards.

This report presents projections for future energy demand, production, and carbon emissions under low-carbon energy transition (LCET) scenarios and provides policy recommendations.

## 2. Macro Assumptions

China's GDP in 2023 reached CNY126 trillion, an increase of 5.2% over the previous year at constant prices. Table 5.1 shows the assumptions of the average annual growth rate of GDP and population. Based on author's estimation, the annual growth rates of GDP are projected to be 3.9% during 2021–2030, 3.8% during 2030–2040, 3.3% during 2040–2050, and 2.5% during 2050–2060.

**Table 5.1. Annual Growth Rates of Gross Domestic Product and Population in China**

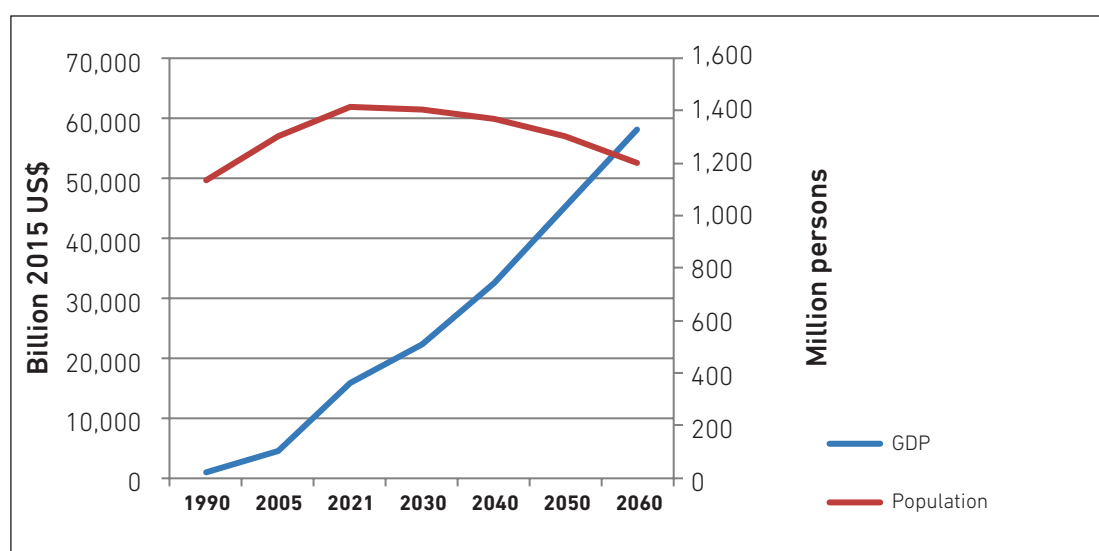
|            | 2019–2021 | 2021–2030 | 2030–2040 | 2040–2050 | 2050–2060 |
|------------|-----------|-----------|-----------|-----------|-----------|
| GDP        | 9.2%      | 3.9%      | 3.8%      | 3.3%      | 2.5%      |
| Population | 0.7%      | -0.1%     | -0.3%     | -0.5%     | -0.8%     |

GDP = gross domestic product.

Source: Author's calculations.

Figure 5.1 illustrates China's GDP and population projections. The population growth rate is anticipated to decline progressively, with decreases of 0.1% during 2021–2030, 0.3% during 2030–2040, 0.5% during 2040–2050, and 0.8% during 2050–2060. By 2060, the population is projected to stabilise at 1.20 billion. At the end of 2023, China's population stood at 1.41 billion, marking a decrease of 2.08 million from the previous year, with a natural population growth rate of -1.48‰. Concurrently, the proportion of the population aged 60 and above has continued to rise, reaching 297 million, or 21.1% of the total population. The working-age population, comprising 61% of the total, was recorded at 865 million. With the demographic dividend diminishing, China must adapt its growth model significantly to address the challenges posed by its ageing population in the foreseeable future.

**Figure 5.1. Assumptions about the Average Annual Growth Rate of Gross Domestic Product and Population in China**



US\$ = United States dollar, GDP = gross domestic product.

Source: Author's calculations.

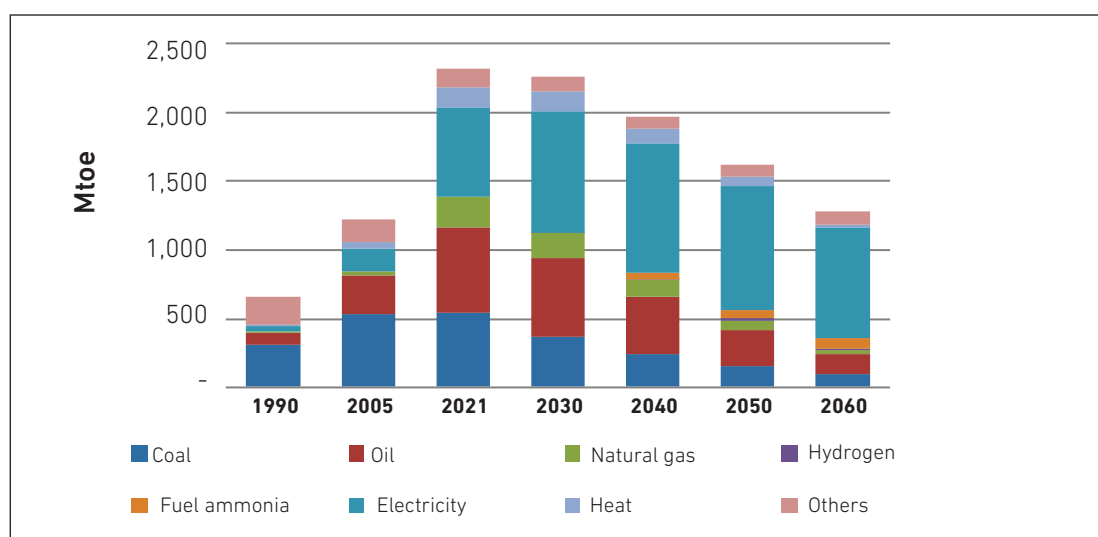
## 3. Outlook Results

### 3.1. Final Energy Consumption

Figure 5.2 shows total energy consumption by fuel during 1990–2060 under a LCET scenario. China's total final energy consumption (TFEC) has experienced a significant increase, from 658 million tonnes of oil equivalent (Mtoe) in 1990 to 2,317 Mtoe in 2021. Projections indicate that the TFEC will begin to decrease, reaching 2,261 Mtoe by 2030. Furthermore, it is predicted to continue to fall thereafter, reaching 1,619 Mtoe by 2050 and 1,278 Mtoe by 2060. In terms of energy type, China is the biggest coal user in the world (BP, 2024). The development of a LCET in China has led to a decrease in the share of final coal consumption. Between 1990 and 2021, the

proportion of coal in final energy consumption was estimated to have decreased from 47% to 23%. This will drop to 17% in 2030 and 8% in 2060. The use of coal at finals increased from 311 Mtoe to 542 Mtoe between 1990 and 2021, and is expected to decrease to 103 Mtoe in 2060. The consumption of oil and gas is expected to decrease from 567 Mtoe and 181 Mtoe in 2030 to 144 Mtoe and 29 Mtoe in 2060. China's electric power infrastructure has experienced rapid growth, bolstered by government laws, positioning it as an exemplar of clean energy and a hallmark of an advanced civilisation. The utilisation of electricity as a final energy source has significantly increased, escalating from 39 Mtoe in 1990 to 652 Mtoe in 2021. Consequently, the level of domestic electricity consumption has been steadily increasing. According to the National Bureau of Statistics (2024), China's whole electricity consumption was projected to reach 9.2 trillion KWh in 2023, with total power generation expected to reach 9.5 trillion KWh. By 2060, final electricity consumption is expected to reach 803.41 Mtoe, or 63% of total final energy, making electricity the predominant energy source for final consumption.

**Figure 5.2. Final Energy Consumption by Fuel Type, Low-Carbon Energy Transition in China (1990–2060)**

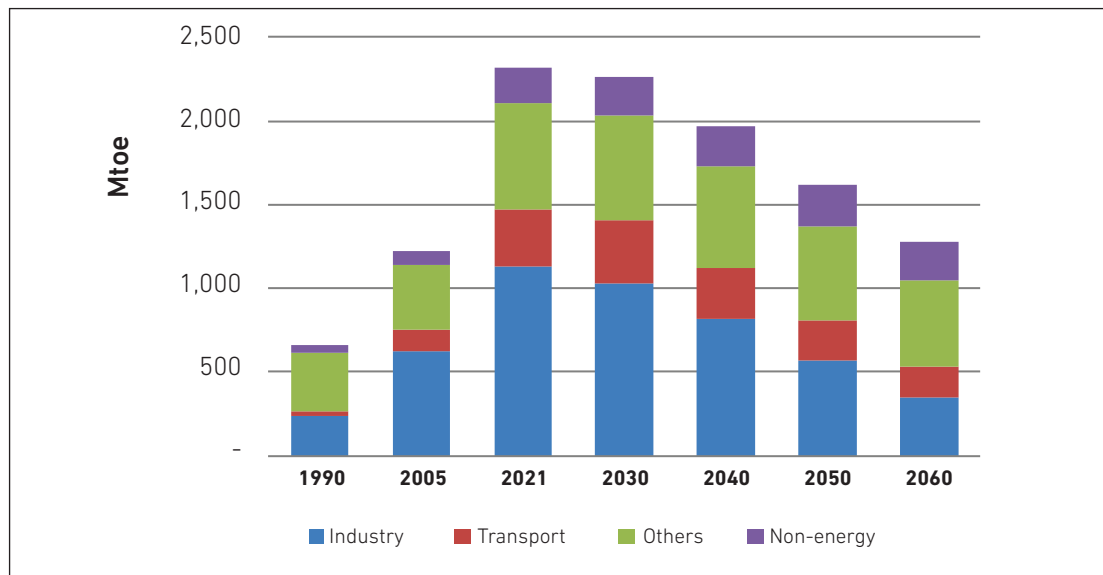


Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 5.3 shows the TFEC by sector during 1990–2060 under the LCET scenario. Most of the current energy use is attributed to industry and transportation. Between 1990 and 2021, the proportion of energy consumed by the industrial sector rose from 36% to 49%. Significant advancements have been made in the field of energy conservation and reduction of energy consumption, leading to a rapid improvement in energy efficiency. As part of efforts to expedite the establishment of an energy-efficient society, the 14th Five-Year Plan (2021–2025) in China has incorporated the objective of 'achieving a 13.5% reduction in energy consumption per unit of GDP' as a key benchmark for economic and social progress (Government of China, 2021), which would speed up enhancing the efficiency of traditional energy-intensive sectors and contribute to the growth of low-energy businesses. Projections indicate that the future share of industrial energy consumption will decline to 46% by 2030 and further decrease to 27% by 2060.

**Figure 5.3. Final Energy Consumption by Sector,  
Low-Carbon Energy Transition in China (1990–2060)**



Mtoe = million tonnes of oil equivalent.

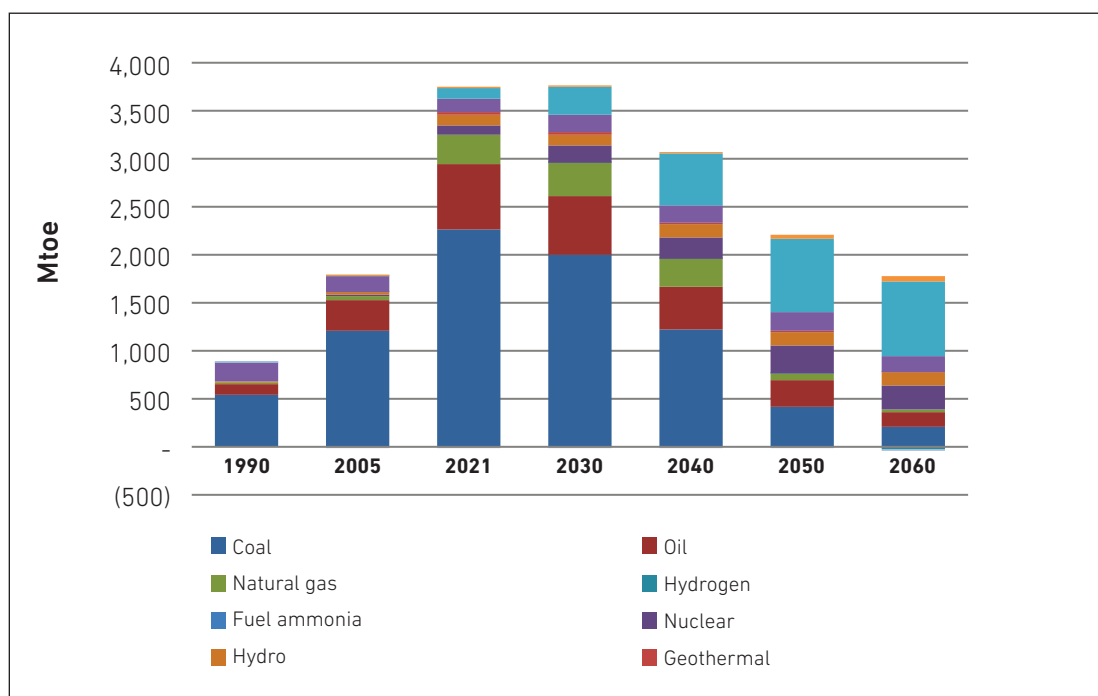
Source: Author's calculations.

China is currently experiencing a period of rapid industrialisation and urbanisation, resulting in an increasing demand for energy in the transport sector. China's transport sector consumed 346 Mtoe in 2021, representing approximately 15% of the total energy consumption. The infrastructure in China is expanding dramatically in both scope and capacity, whilst the use of private vehicles is growing because of the quick expansion of the social economy. Due to that, transport-related energy use in China has progressively escalated, with an anticipated surge to 381 Mtoe by 2030, constituting 17% of the total. Conversely, the Government of China has released China's Green Transport 14th Five-Year Development Plan and other official papers to advance energy preservation, effectiveness, and sustainable growth in the transport industry. According to the Economic Research Institute for ASEAN and East Asia (ERIA), it is anticipated that the share of energy consumption attributed to transportation will drop to 14% by 2060.

## 3.2. Primary Energy Supply

Figure 5.4 shows total primary energy supply by source during 1990–2060 in the LCET scenario. China possesses abundant coal resources, limited oil reserves, and scarce natural gas. Coal remained the predominant source of China's primary energy supply in 2021, representing 61% of the total supply. Oil is the second largest contributor to primary energy supply, making up 18%, whilst natural gas accounts for 8%. China heavily depends on oil and gas imports due to its comparatively limited natural gas and oil resources. Global energy security uncertainties persist due to the impact of geopolitical conflicts, climate change, exchange rate volatility, and other causes. The government is actively engaged in developing renewable energy and enhancing the diverse energy supply. Hydropower generated 112 Mtoe in 2021 and was projected to increase to 136 Mtoe by 2050 and drop to 131 by 2060. Nuclear production, which was 106 Mtoe in 2021, is predicted to be 254 Mtoe in 2060. China has abundant solar and wind energy resources in its northeast, north, and northwest regions. Recent years have seen a rise in the use of solar and wind power by the Government of China; the share of photovoltaic power generation, wind power, and other energy sources is predicted to rise to 58% in 2060.

**Figure 5.4. Total Primary Energy Supply by Fuel Type, Low-Carbon Energy Transition in China (1990–2060)**



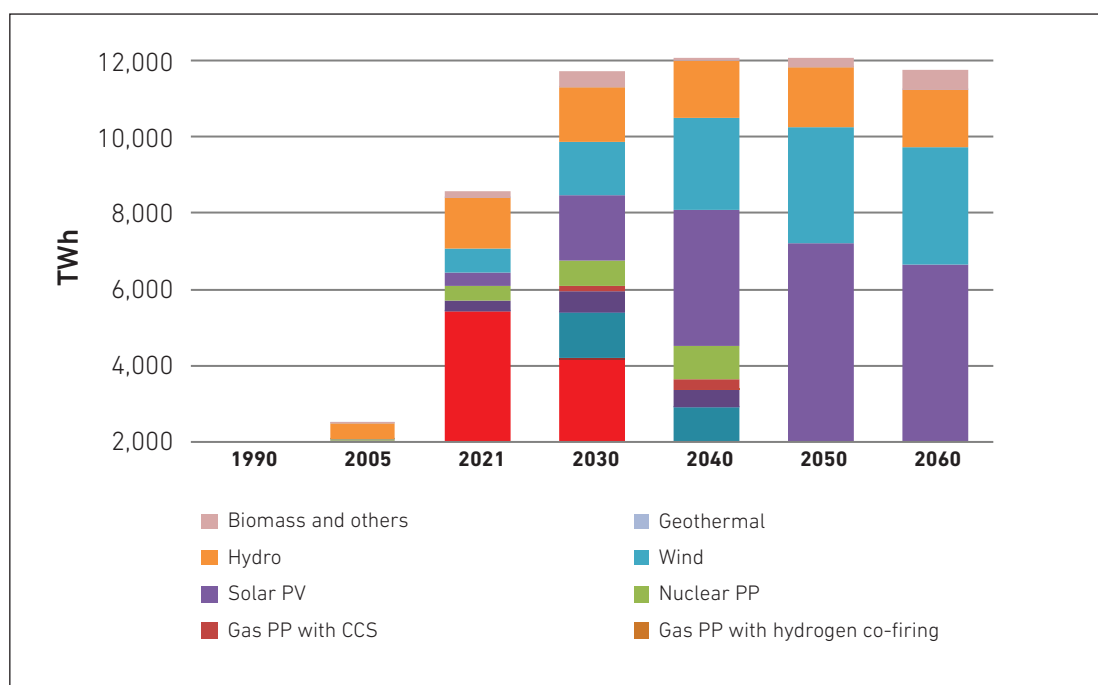
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

### 3.3. Electricity Generation

Figure 5.5 shows historical and future power generation in the LCET scenario. China's power generation has been steadily increasing alongside its economic development. From 1990 to 2021, power generation rose from 621 TWh to 8,560 TWh, reflecting an average yearly growth rate of approximately 8.8%. China's reliance on coal as a power source has made it a primary source of electricity for an extended duration. By 2021, coal-fired power plants contributed 63% of overall electricity generation. Nevertheless, as the transition towards clean electricity gains momentum, the proportion of coal-fired power plants in the electricity generation mix is projected to decrease significantly. It is anticipated to decline to 35.8% by 2030 and a mere 0.1% by 2050 (0.0% by 2060). In addition, the Government of China is actively advocating for the adoption of carbon capture and storage (CCS) technology to facilitate the environmentally friendly utilisation of coal. By 2030, it is projected that coal-fired power plants incorporating CCS technology will contribute around 10% to the overall electricity supply. Natural gas is considered a comparatively environmentally friendly energy source. The utilisation of natural gas as a power source is expected to rise to 438.73 TWh by 2040 and then decline to zero by 2050. The utilisation of oil and geothermal energy for power generation in China is minimal and negligible.

**Figure 5.5. Power Generation by Source, Low-Carbon Energy Transition in China (1990–2060)**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

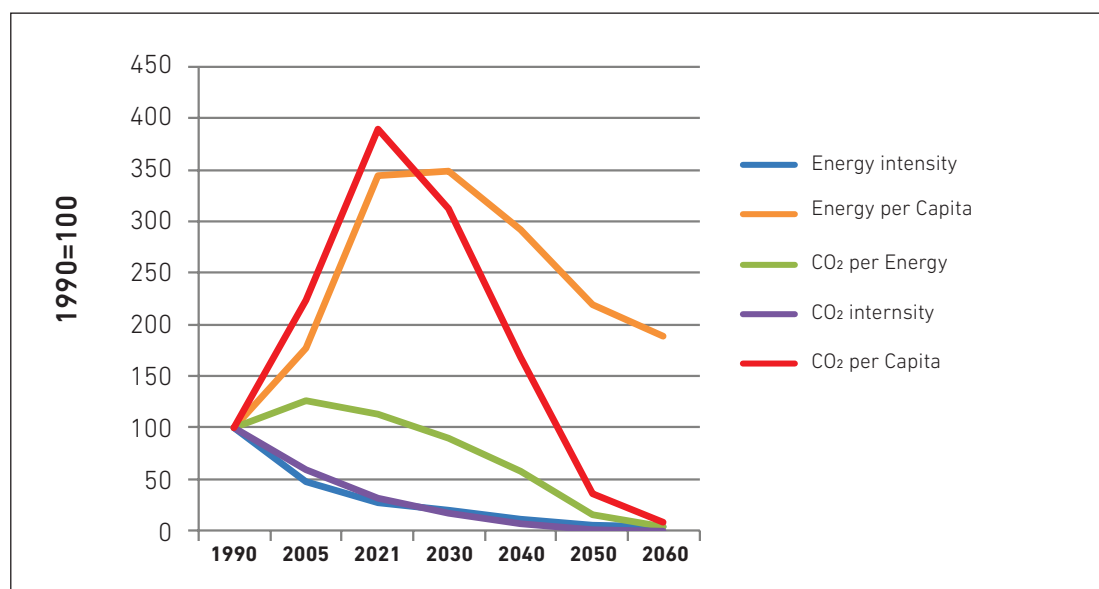
Source: Author's calculations.

By 2060, nuclear power generation is projected to account for 8% of the total energy produced. Hydropower has historically been the primary source of renewable energy production in China. It generated 397 TWh in 2005, 1,300 TWh in 2021, and is projected to reach 1,524 TWh in 2060. The progress of hydropower has been largely stable over time. By contrast, the expansion of solar and wind power generation has been swift in recent years. Solar power's energy market share was a mere 0.003% in 2005. By 2021, it had increased to 4%. Projections indicate that it will reach 15% by 2030 and 48% by 2060. In 2005, wind power made up only 0.080% of the total energy production; however, it is projected to increase significantly and reach 26% by 2060. Renewable energy generation is projected to become the primary source of electricity generation in the future.

### 3.4. Energy Indicators

Figure 5.6 shows the energy indicators in the LCET scenario. The energy and carbon dioxide (CO<sub>2</sub>) intensity are expected to decrease steadily from 1990 to 2060. The year 1990 serves as the baseline. By 2060, the energy intensity will decline to around 3.6% of the level observed in 1990. The projected CO<sub>2</sub> intensity will probably drop to around 0.2% of the level documented in 1990. Energy per capita and CO<sub>2</sub> per energy are forecast to increase and decrease between 1990 and 2060. Energy per capita is expected to increase to 349% of the 1990 levels by 2030, peak in the 2030s, and decrease after that. In 2060, energy per capita is projected to be 189% higher than that in 1990. CO<sub>2</sub> per energy reached its highest level in 2005, at 126% of the level recorded in 1990. However, by 2060, it had decreased significantly to only 4% of the 1990 level.

**Figure 5.6. Energy Indicators, Low-Carbon Energy Transition in China (1990–2060)**



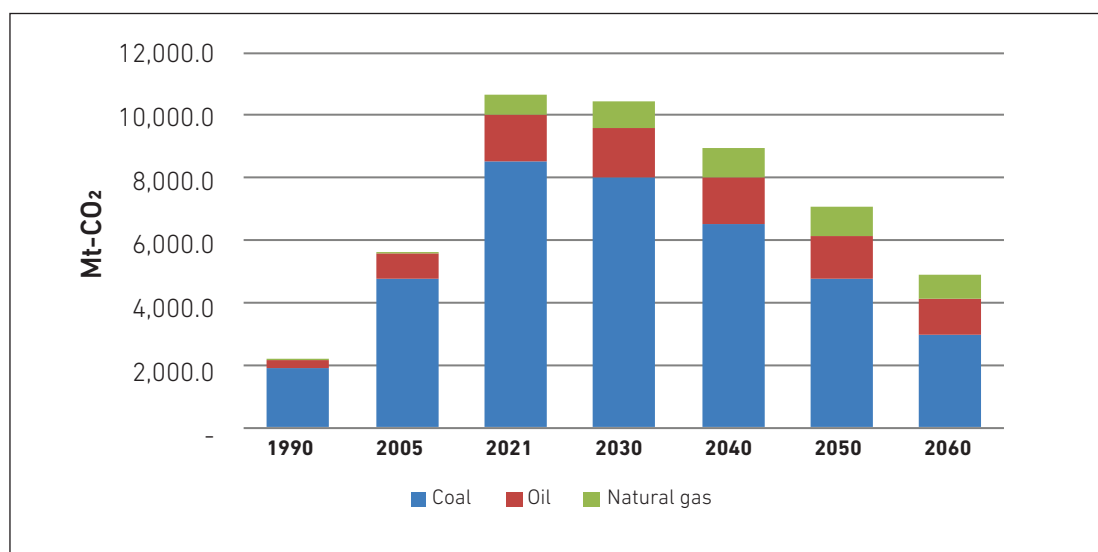
CO<sub>2</sub> = carbon dioxide.

Source: Author's calculations.

### 3.5. Carbon Dioxide Emissions

Figure 5.7 shows CO<sub>2</sub> emissions during 1990–2060 in the business-as-usual (BAU) scenario. Under this scenario, the amount of CO<sub>2</sub> emitted from burning fossil fuels is projected to reach its highest point in the 2020s. By 2030, coal is expected to be the dominant contributor to CO<sub>2</sub> emissions, accounting for a staggering 77% of the total. Oil and natural gas follow with significant, yet comparatively lower contributions of 15% for oil and 8% for natural gas. Projections indicate that there will be a reduction in CO<sub>2</sub> emissions to 4,908Mt- CO<sub>2</sub> by 2060 in the BAU scenario. In 2060, coal's share of emissions is projected to decrease to 61%, whilst crude oil's contribution is expected to rise slightly to 23%, and natural gas's share is anticipated to remain relatively stable at 16%. Whilst coal remains a significant contributor, the decline in its share indicates a potential move away from this high-emission source. The slight increase in the share of crude oil emissions could be attributed to its continued use in transportation and other sectors that may be slower to adopt cleaner alternatives.

**Figure 5.7. Carbon Dioxide Emissions by Fossil Fuel Type, Business-as-Usual Scenario in China (1990–2060)**



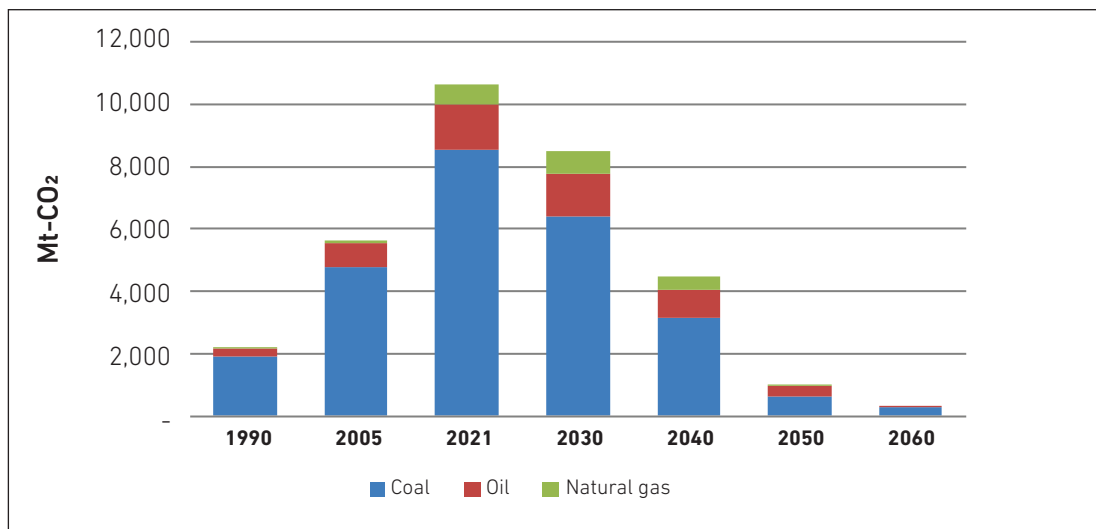
CO<sub>2</sub> = carbon dioxide, Mt- CO<sub>2</sub> = million metric tonnes of CO<sub>2</sub>.

Source: Author's calculations.

Figure 5.8 delineates the projected CO<sub>2</sub> emissions across the timeline from 1990 to 2060 within the framework of the LCET scenario. A marked contrast is observed when compared to the BAU scenario, with the LCET illustrating a more precipitous reduction in CO<sub>2</sub> emissions. ERIA forecasts that emissions will peak in the 2020s under the LCET scenario. By 2060, emissions will settle at 187.3 million Mt- CO<sub>2</sub>. The combustion of coal and crude oil is projected to yield emissions of 303 Mt- CO<sub>2</sub> (for coal) and 33 Mt- CO<sub>2</sub> (for crude oil) by 2060 and the CO<sub>2</sub> emissions from burning natural gas are reduced to zero.



**Figure 5.8. Carbon Dioxide Emissions by Fossil Fuel Type, Low-Carbon Energy Transition in China (1990–2060)**



Mt- CO<sub>2</sub> = million metric tonnes of CO<sub>2</sub>.

Source: Author's calculations.

## 4. Cost Analysis

Increasing investment in clean energy technology is necessary to reach carbon neutrality, but doing so will also incur costs. This section estimates and calculates final energy consumption costs, power plant construction costs, and CCS costs in both the BAU and LCET scenarios.

### 4.1. Fuel Cost

Fuel cost assumptions are shown in Table 5.2. Based on the assumption of fuel cost and corresponding final energy consumption, the cost of coal, oil, gas, and hydrogen in 2021 and 2050 or 2060 in both the BAU and LCET scenarios are estimated and compared.

**Table 5.2. Assumption of Fuel Cost**

|          | 2021  | 2050 or 2060<br>(2021 constant price) | Unit                 |
|----------|-------|---------------------------------------|----------------------|
| Coal     | 80.03 | 98                                    | US\$/tonne           |
| Oil      | 41    | 100                                   | US\$/bbl             |
| Gas      | 7.77  | 7.5                                   | US\$/MMBtu           |
| Hydrogen | 0.8   | 0.3                                   | US\$/Nm <sup>3</sup> |

US\$ = United States dollar, bbl = barrel, MMBtu = 1 million British thermal units, Nm<sup>3</sup> = normal cubic metre.

Source: Author's calculations.

Table 5.3 presents the final energy consumption and corresponding costs for various fuels in 2021 and 2050 or 2060. The data shows that under both the BAU and LCET scenarios, China's final energy consumption of coal and oil will significantly decrease by 2050 or 2060 compared to 2021, leading to a substantial reduction in costs. Specifically, in the BAU scenario, coal and oil costs will drop by US\$220.2 billion<sup>2</sup> for coal and US\$86.5 billion for oil. In the LCET scenario, these costs will decrease even more, by US\$326 billion for coal and US\$359 billion for oil. However, the cost of gas as an end-energy source will increase by US\$20 billion in the BAU scenario but will decrease by US\$80 billion in the LCET scenario. Additionally, hydrogen consumption in the BAU scenario remains zero, whilst it is projected to reach 20 Mtoe in the LCET scenario by 2050 or 2060, adding an extra cost of US\$23 billion. Overall, the total cost for coal, oil, gas, and hydrogen as end-energy fuels in 2050 or 2060 is expected to decrease by US\$286.6 billion in the BAU scenario and by US\$741.5 billion in the LCET scenario compared to 2021.

**Table 5.3. Fuel Cost in Business-as-Usual and Low-Carbon Energy Transition Scenarios (2021–2050 or 2060)**

|                      | Final Energy Consumption in 2021, BAU (Mtoe) | Final Energy Consumption in 2050 or 2060, BAU (Mtoe) | Final Energy Consumption in 2050 or 2060, LCET (Mtoe) | Fuel Cost 2050 or 2060–2021, BAU (US\$ million) | Fuel Cost 2050 or 2060–2021, LCET (US\$ million) |
|----------------------|----------------------------------------------|------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------|--------------------------------------------------|
| Coal                 | 2,266.17                                     | 872.89                                               | 204.85                                                | -220,174                                        | -325,741                                         |
| Oil                  | 677.70                                       | 551.98                                               | 155.92                                                | -86,472                                         | -358,880                                         |
| Gas                  | 299.07                                       | 368.48                                               | 21.52                                                 | 20,043                                          | -80,142                                          |
| Hydrogen/<br>ammonia | 0                                            | 0                                                    | 19.94                                                 | 0                                               | 23,237                                           |
| <b>Total</b>         | <b>3,242.94</b>                              | <b>1,793.35</b>                                      | <b>402.24</b>                                         | <b>-286,603</b>                                 | <b>-741,526</b>                                  |

US\$ = United States dollar, - = negative number, BAU = business-as-usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Note: 2050 or 2060–2021 means the increased fuel costs in 2050 or 2060 compared to 2021. If the number of 2050 or 2060–2021 is less than zero, it means that the cost in 2050 or 2060 is lower than that in 2021.

Source: Author's calculations.

<sup>2</sup> In this chapter, US\$ refers to United States dollar.

## 4.2. Power Generation Investment

Table 5.4 shows the assumption of construction costs and capacity factors for power plants. Based on this assumption, the additional capacity and corresponding investment cost of power plants with different fuel types in the BAU and LCET scenarios are calculated.

**Table 5.4. Power Plant Assumptions**

|            | Construction Costs of Power Plants<br>(US\$/KW) |                 | Capacity Factor of Power Plants<br>(%) |                 |
|------------|-------------------------------------------------|-----------------|----------------------------------------|-----------------|
|            | 2021                                            | by 2050 or 2060 | 2021                                   | by 2050 or 2060 |
| Coal       | 1,500                                           | 1,525           | 75                                     | 80              |
| Oil        | 600                                             | 600             | 75                                     | 80              |
| Gas        | 700                                             | 700             | 75                                     | 80              |
| Hydrogen   | --                                              | 800             | --                                     | 80              |
| Nuclear    | 4,500                                           | 3,575           | 100                                    | 80              |
| Hydro      | 2,000                                           | 2,223           | 50                                     | 40              |
| Geothermal | 4,000                                           | 4,256           | 50                                     | 50              |
| Solar      | 1,600                                           | 307             | 17                                     | 17              |
| Wind       | 1,600                                           | 1,235           | 40                                     | 40              |
| Biomass    | 2,000                                           | 3,019           | 50                                     | 70              |

US\$ = United States dollar, % = percent, KW = kilowatt.

Source: Author's calculations.

The future of energy production is set to undergo a significant transformation, as depicted in Table 5.5. Over the next 30 to 40 years, non-fossil fuels are poised to become the main fuel used in new power plants being constructed, marking a pivotal shift in the energy landscape. This transition is expected to be so profound that no new coal-fired or oil-fired power plants will be established, irrespective of the scenario considered (the BAU or LCET). Natural gas, known for its stability and cleanliness, will see expansion in gas-fired power plants with an additional investment of US\$39 billion under the BAU scenario, but no expansion is planned under LCET. Nuclear power, whilst not as dominant, will still play a modest role, contributing 2%–3% to the additional capacity over the next three decades. Despite the higher costs associated with nuclear power – accounting for 5.2% of the total investment in the BAU scenario and 4.6% in the LCET scenario – the technology remains a key component in the energy mix for its low greenhouse gas emissions and high energy density. The real stars of the future energy stage, however, are solar and wind power. Solar power generation is expected to experience a surge, with the BAU scenario predicting a staggering increase in capacity, amounting to 2,153,009 megawatts and the LCET scenario is even more optimistic, forecasting a remarkable increase, totalling 3,569,725 megawatts. These figures underscore the immense potential and rapid advancement of solar technology, which is becoming more efficient and affordable. Wind power, though not as significant as solar, will still contribute notably, with wind capacity additions accounting for 31% in the BAU scenario and 15% in the LCET scenario.

**Table 5.5. Total Investment Cost of Power Plants (2021–2050 or 2060)**

|            | Electricity Generation (TWh) |              |        | Additional Capacity (MW) |           | Total Investment Cost (US\$ million) |           |
|------------|------------------------------|--------------|--------|--------------------------|-----------|--------------------------------------|-----------|
|            | 2021                         | 2050 or 2060 |        | BAU                      | LCET      | BAU                                  | LCET      |
|            | BAU                          | BAU          | LCET   |                          |           |                                      |           |
| Coal       | 5,417                        | 2,045        | 6      | 0                        | 924       | 0                                    | 1,412     |
| Oil        | 11                           | 1            | 0      | 0                        | 0         | 0                                    | 0         |
| Gas        | 268                          | 659          | 0      | 55,778                   | 0         | 39,044                               | 0         |
| Hydrogen   | 0                            | 0            | 41     | 0                        | 5,899     | 0                                    | 4,719     |
| Nuclear    | 408                          | 1,083        | 976    | 96,331                   | 81,052    | 344,385                              | 289,761   |
| Hydro      | 1,300                        | 1,793        | 1,524  | 140,795                  | 63,816    | 312,987                              | 141,863   |
| Geothermal | 0                            | 2            | 3      | 354                      | 561       | 1,508                                | 2,387     |
| Solar      | 329                          | 3,535        | 5,645  | 2,153,099                | 3,569,725 | 661,001                              | 1,095,906 |
| Wind       | 656                          | 4,644        | 3,040  | 1,138,175                | 680,235   | 1,405,646                            | 840,090   |
| Biomass    | 170                          | 587          | 516    | 67,980                   | 56,360    | 205,232                              | 170,150   |
| Total      | 8,560                        | 14,349       | 11,750 | 3,652,512                | 4,458,573 | 2,969,803                            | 2,546,288 |

US\$ = United States dollar, BAU = business-as-usual, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt-hour

Source: Authors' calculations.

### 4.3. Carbon Capture and Storage Cost

CCS is estimated to cost about US\$70 per tonne of CO<sub>2</sub>. The overall cost of CCS investment for coal-fired and natural gas-fired power plants in the LCET scenario is assessed assuming only these plants will be outfitted with CCS technology. In the LCET scenario, gas will not be used for power generation, and only a small fraction of coal will be utilised for this purpose by 2050 or 2060. It is predicted that 95% of all coal-fired power plants will be equipped with CCS. Based on this assumption, the total coal consumption for CCS-equipped coal-fired power plants is approximately 1.83 Mtoe. From this, 72.7 Mt- CO<sub>2</sub> will be produced, with 5.83 Mt-CO<sub>2</sub> anticipated to be captured by CCS. Consequently, the cost of CCS for coal-fired power plants is expected to reach US\$350 billion in 2050 or 2060 (Table 5.6).

**Table 5.6. Total Investment Cost of Carbon Capture and Storage, Low-Cost Energy Transition**

|                                        | Consumption of coal or gas in 2050 or 2060 (Mtoe) | CO <sub>2</sub> for CCS (Mt- CO <sub>2</sub> ) | Total investment cost of CCS (US\$ million) |
|----------------------------------------|---------------------------------------------------|------------------------------------------------|---------------------------------------------|
| Coal-fired Power Plant with CCS        | 1.74                                              | 5.83                                           | 350                                         |
| Natural Gas-fired Power Plant with CCS | 0                                                 | 0                                              | 0                                           |
| <b>Total</b>                           | <b>1.74</b>                                       | <b>5.83</b>                                    | <b>350</b>                                  |

US\$ = United States dollar, CCS = carbon capture and storage, Mtoe = million tonnes of oil equivalent,

Mt-CO<sub>2</sub> = million metric tonnes of CO<sub>2</sub>.

Source: Authors' calculations.

## 4.4. Overall Costs

Based on the results, the overall costs in 2050 or 2060 – including additional fuel, power plant investments, and CCS costs – have been calculated. Table 5.7 shows that, despite the high costs of clean energy and CCS, the LCET scenario significantly reduces fossil fuel use, resulting in lower overall energy costs in 2050 or 2060 compared to 2021. By 2050 or 2060, overall costs are lower than in 2021 for both scenarios, with reductions of US\$210.5 billion under BAU and US\$352.9 billion under LCET.

**Table 5.7. Energy Costs Comparison**

|                                                       | BAU             | LCET            |
|-------------------------------------------------------|-----------------|-----------------|
| Total fuel cost investment (US\$ million)             | -286,603        | -741,526        |
| Annual investment cost of power plants (US\$ million) | 76,149          | 65,289          |
| CCS Cost in 2050 or 2060 (US\$ million)               | 0               | 350             |
| <b>Total (US\$ million)</b>                           | <b>-210,454</b> | <b>-352,908</b> |

US\$ = United States dollar, - = negative number, BAU = business-as-usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors' calculations.

## 5. Implications and Policy Implications

Global climate change poses a threat to humankind's capacity for long-term prosperity. China has long prioritised combating climate change, has been a leader in green development, and has advocated for integrating human and environmental well-being. The urgency of the energy transition arises from the increasing unpredictability brought about by climate change. This report primarily predicts the TFEC, total primary energy supply, electricity generation, energy indicators, and carbon emissions in a LCET scenario. The main findings are as follows:

First, China's low-carbon revolution has resulted in a decline in the country's final coal use share. Coal in TFEC will drop to 16% in 2030 and 9% in 2060. By contrast, electricity consumption is predicted to reach 63% of TFEC, by 2060, making it the main energy source for final consumption. Most energy is used for industry and transport. As China's industrial energy utilisation efficiency improves, future industrial energy consumption is expected to drop to 46% by 2030 and 27% by 2060. As China's transport infrastructure improves and private automobiles become more popular, energy use in the transport sector is predicted to rise to 17% by 2030 and reduce to 14% by 2060. Second, China's major energy supply continues to rely predominantly on coal. To ensure energy security, the Government of China will promote the eco-friendly use of coal. Simultaneously, the government is proactively advancing the development of renewable energy. The share of photovoltaics, wind power, and other energy sources is expected to rise to 58% in 2060.

Third, the switch to sustainable electricity will see coal's share of electricity fall steadily, from 63% in 2021 to 0% by 2060. To reduce CO<sub>2</sub> emissions, China is promoting CCS technology in coal-fired and natural gas-fired power plants. Furthermore, the production of renewable energy is expected to rise quickly and become the primary source of electricity. It is projected that renewable energy will account for 91% in 2060.

Fourth, despite the high cost of building renewable energy power plants and CCS facilities, the LCET scenario lowers overall costs in 2050 or 2060 compared to 2021 by reducing fossil fuel consumption by a considerable amount on an annual average. By 2060, overall costs will be lower than in 2021 for both scenarios, with reductions of US\$210.5 billion under BAU and US\$352.9 billion under LCET.

Given the current energy outlook, three policy implications are put forward. First, enterprises are the primary entities responsible for implementing energy conservation and carbon reduction measures. The prominent position of leading companies should be promoted, environmentally friendly supply chain management should be implemented, and a novel framework for energy efficiency and carbon reduction in small and medium-sized businesses should be provided, led by larger corporations. Enterprises in the supply chain that proactively engage in low-carbon technology research and development can receive enhanced policy support from the government, including financial assistance, green procurement, green credit, and tax relief.

Second, it is important to include several socioeconomic aspects when evaluating the benefits and costs of energy transition. Whilst energy transition may have long-term positive impacts on society, it is essential to note that not all groups will benefit equally. Conversely, a sizeable portion of the coal industry's workforce is unemployed, and it is challenging for the unemployed to find jobs in the emerging energy sector. Simultaneously, energy transition will cause talent losses in areas rich in coal resources, stalling economic growth. The interests of different groups and areas should be adequately recognised, and policy support should be given to those impaired by the transition, to guarantee fairness and justice.

Third, reducing demand-side energy use and carbon emissions is critical. Ecological civilisation education can be incorporated into the national education system to guide young people to establish green, low-carbon, environmental protection concepts. It is recommended that the government encourage residents to prioritise the acquisition and utilisation of energy-efficient and water-efficient equipment whilst also minimising the use of disposable products like plastic shopping bags. The government actively advocates for the implementation of a 'carbon inclusive' system, employing the 'internet + big data + carbon finance' strategy to establish a comprehensive framework for tracking, quantifying, and incentivising citizens' efforts to reduce carbon emissions. This initiative aims to guide the entire society towards adopting a sustainable and environmentally friendly lifestyle.

## References

British Petroleum (BP) (2024), *BP Energy Outlook 2024*. London: BP.

Government of China (2021), *14th 5-Year Plan (2021-2025)*. [https://www.gov.cn/xinwen/2021-03/13/content\\_5592681.htm](https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm). Accessed May 2025.

National Bureau of Statistics of China (NBS) (2024), *Statistical Bulletin of the People's Republic of China on National Economic and Social Development for 2023*. Beijing: NBS. [https://www.stats.gov.cn/sj/zxfb/202402/t20240228\\_1947915.html](https://www.stats.gov.cn/sj/zxfb/202402/t20240228_1947915.html)

# Chapter 6

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## India Country Report<sup>1</sup>

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<sup>1</sup> This chapter is based on the Institute of Energy Economics, Japan (IEEJ) model and assumptions.



# 1. Background

India is at a critical economic juncture. It ranks as the world's third-largest economy by purchasing power parity (World Bank Group, 2024) and the fifth largest by nominal gross domestic product (GDP) (Srivastava, 2023). Its real GDP growth is 7%, with a GDP of US\$3.89 trillion (International Monetary Fund, 2024).

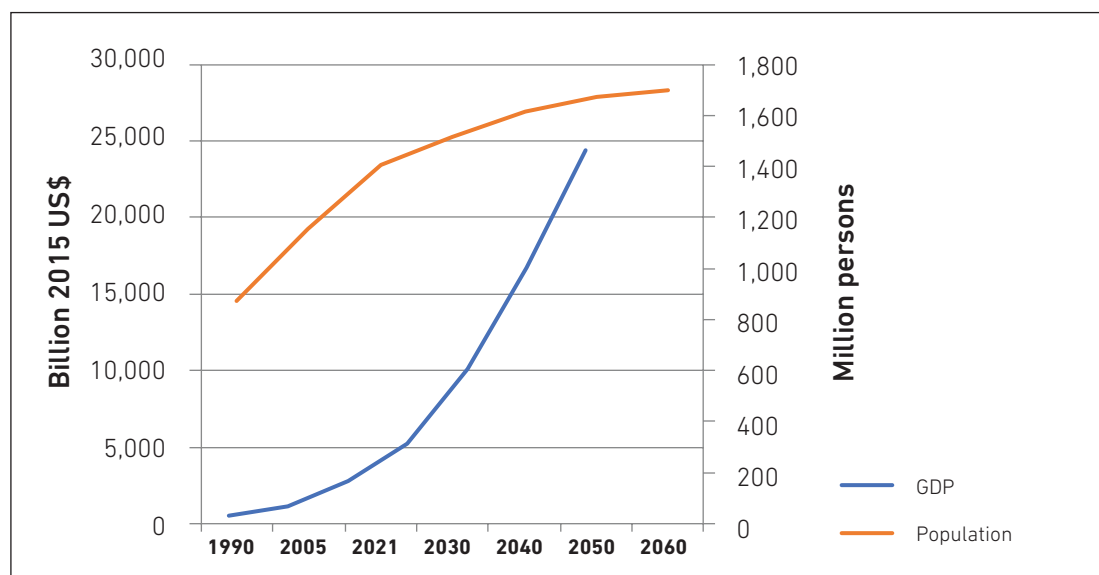
In 2000–2022, electricity consumption rose by 182%, as 900 million citizens gained access to electricity and per capita consumption reached 1.081 megawatt-hours (International Energy Agency, 2022). Whilst this signals major progress in energy access, per capita energy use was only 0.7 tonnes of oil equivalent (toe) in 2021 – half the Asian average – highlighting the need for further development (Enerdata, 2022). This disparity is reflected in India's Human Development Index score of 0.644 in 2022, ranking 134th out of 193 countries (United Nations Development Programme, 2024). Although an improvement from 2021, the score remains below the 2019 level, reinforcing the urgency of development for a large, underserved yet aspirational population. A growing population, rapid urbanisation, rising commercial energy demand, global fuel price volatility, international unrest, and mounting pressure to curb greenhouse gas emissions pose significant challenges.

Sustainable development – balancing economic growth, infrastructure expansion, and environmental stewardship – is essential to improving living standards nationwide. Policymakers must prioritise these goals. As a signatory to international agreements such as the Paris Agreement (United Nations Climate Change, 2024), India has committed to aligning its development with global climate goals. To this end, it has announced nationally determined contributions and a target of net-zero greenhouse gas emissions by 2070 (Press Information Bureau, Ministry of Information and Broadcasting, Government of India, 2015, 2023a, 2023b). These strategies aim to integrate economic growth, energy security, and environmental sustainability by promoting renewable energy, boosting energy efficiency, and reducing dependence on fossil fuels.

## 2. Modelling Assumptions

The Institute of Energy Economics (IEEJ) model for India analyses two scenarios: business as usual (BAU) and low-carbon energy transition (LCET). In both, the cumulative annual growth rate of GDP in 2021–2060 is assumed at 5.7%, with population growth projected at a compound annual growth rate (CAGR) of 0.5% (Figure 6.1).

**Figure 6.1. Population and Gross Domestic Product Prospect, Business-as-Usual and Low-carbon Energy Transition Scenarios, 1990–2060**



GDP = gross domestic product.

Source: Authors, based on the Institute of Energy Economics, Japan model.

BAU reflects current trends in energy production and use under existing policies, without additional measures to curb energy demand or carbon dioxide (CO<sub>2</sub>) emissions. LCET aligns with India's net-zero greenhouse gas emissions target, assuming greater integration of renewable energy, improved energy efficiency across sectors, and higher overall energy savings compared with BAU.

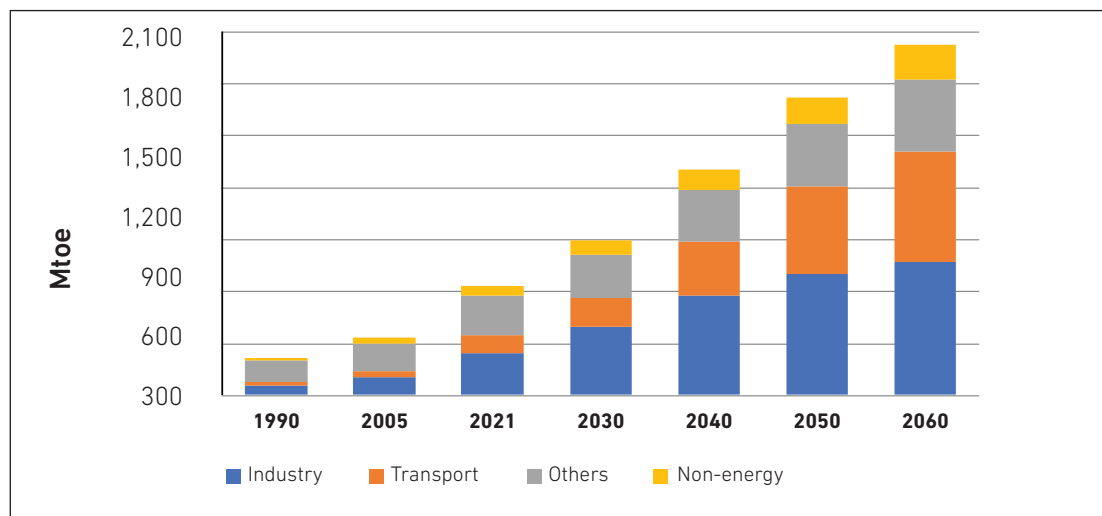
## 3. Outlook Results

### 3.1. Business-as-Usual Scenario

#### 3.1.1. Final energy consumption

Final energy consumption grows at an average annual rate of 3% over the modelling period (Figure 6.2). Under BAU, industry remains the largest energy-consuming sector. However, transport records the highest CAGR at 4.8%, followed by the non-energy sector at 3.3% and industry at 3%. This trend reflects rising mobility demand driven by population growth.

**Figure 6.2. Final Energy Consumption by Sector, Business-as-Usual Scenario, 1990–2060**

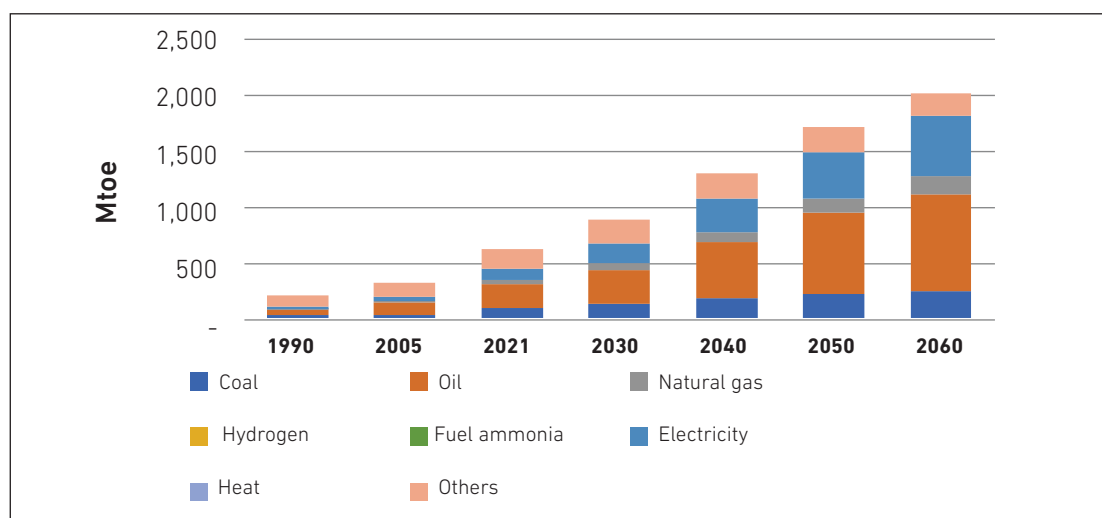


Mtoe = million tonnes of oil equivalent.

Source: Authors, based on the Institute of Energy Economics, Japan model.

Although electricity exhibits the highest CAGR over the modelling period, fossil fuels, including oil and natural gas, remain the dominant energy sources under BAU. Oil, with 864 million tonnes of oil equivalent (Mtoe), continues to be the primary fuel by 2060, followed by electricity, coal, other sources (including renewables), and natural gas (Figure 6.3).

**Figure 6.3. Final Energy Consumption by Fuel Type, Business-as-Usual Scenario, 1990–2060**



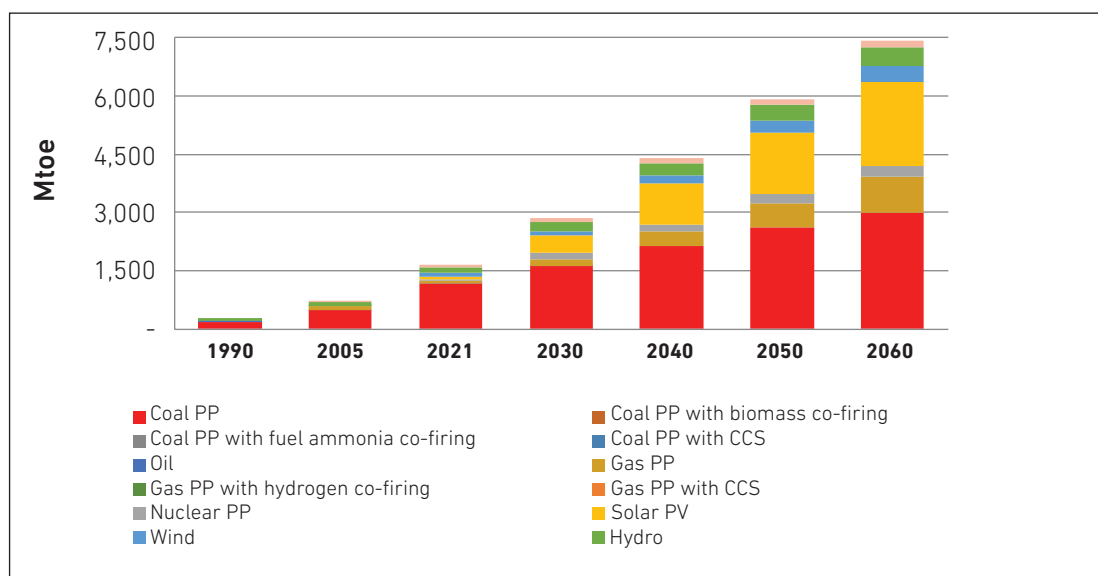
Mtoe = million tonnes of oil equivalent.

Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.1.2. Electricity generation

Electricity generation stood at 1,635 terawatt-hours (TWh) in 2021. Under BAU, this is projected to rise to 7,412 TWh by 2060, growing at an average annual rate of 4% (Figure 6.4). Although coal remains the dominant source in both 2021 and 2060, its share falls significantly from 71.5% to 40.2%. Over the modelling period, the contribution of low-carbon fuels increases, with renewables and alternative energy sources gaining prominence. Figure 6.4 illustrates projected electricity generation under BAU in 1990–2060.

**Figure 6.4. Electricity Generation, Business-as-Usual Scenario, 1990–2060**



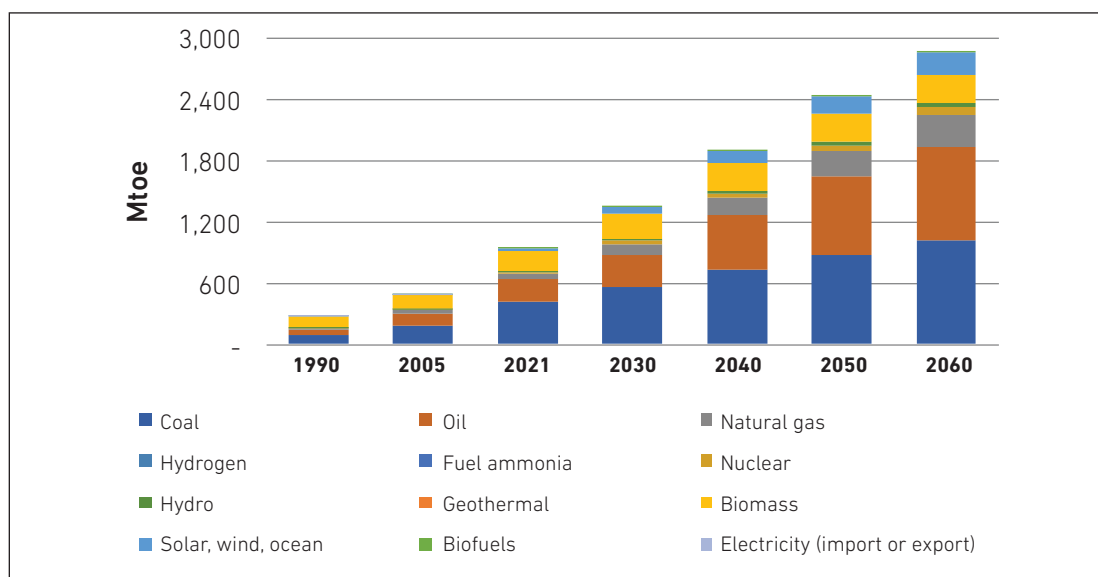
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic. TWh = terawatt-hour

Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.1.3. Primary energy supply

Primary energy supply under BAU grows at an average annual rate of 2.9% in 2021–2060, rising from 944 Mtoe to 2,880 Mtoe (Figure 6.5).

**Figure 6.5. Primary Energy Supply, Business-as-Usual Scenario, 1990–2060**



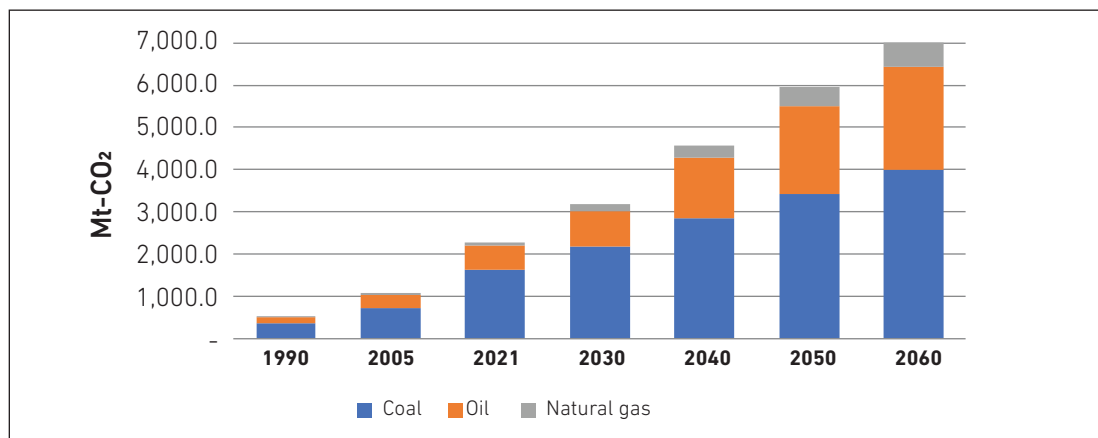
Mtoe = million tonnes of oil equivalent.

Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.1.4. Carbon dioxide emissions

CO<sub>2</sub> emissions under BAU are primarily driven by fossil fuels, including coal, oil, and natural gas (Figure 6.6). Total emissions increase from 2,279 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2021 to 7,000 Mt-CO<sub>2</sub> in 2060.

**Figure 6.6. Carbon Dioxide Emissions from Energy, Business-as-Usual Scenario, 1990–2060**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

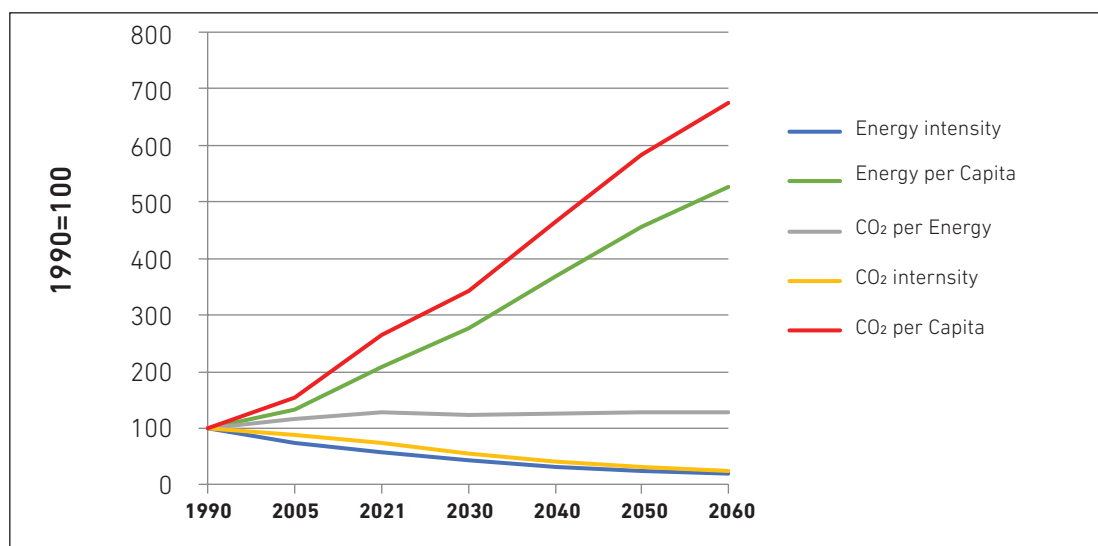
Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.1.5. Energy indicators

Figure 6.7 presents projected energy indicators for BAU in 1990–2060. With increased energy efficiency and conservation improvements, energy intensity declines at an average annual rate of 2.7% in 2021–2060. Per capita energy consumption rises at 2.4% per year, increasing from 0.67 toe in 2021 to 1.69 toe by 2060, reflecting broader energy access across the population.

As renewable and clean energy sources expand their share in the energy mix, CO<sub>2</sub> emissions per unit of GDP decline at an average annual rate of 2.7% over the modelling period. However, as shown in Figure 6.7, emissions per unit of primary energy consumption remain relatively stable in 2021–2060.

**Figure 6.7. Indices of Energy and Carbon Dioxide, Business-as-Usual Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Authors, based on the Institute of Energy Economics, Japan model.

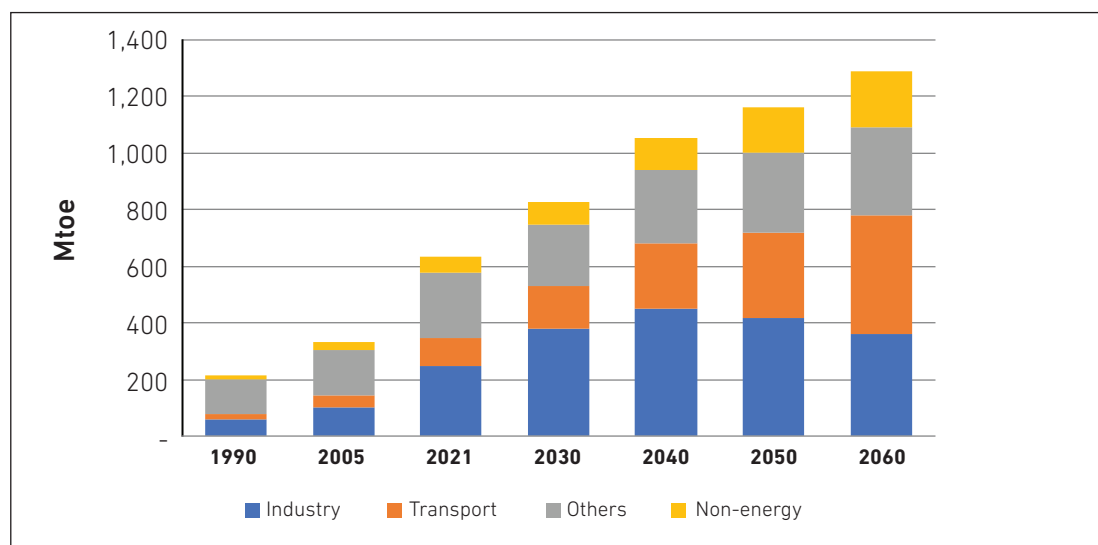
## 3.2. Low-carbon Energy Transition Scenario

LCET outlines trends in energy production and use based on LCET pathways. Unlike BAU, it incorporates policies and assumptions aimed at meeting climate change and energy goals.

### 3.2.1. Final energy consumption

Under LCET, final energy consumption reaches 1,287 Mtoe by 2060, compared with 2,022 Mtoe under BAU – a 36.4% reduction (Figure 6.8) primarily driven by improved energy efficiency.

**Figure 6.8. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario, 1990–2060**



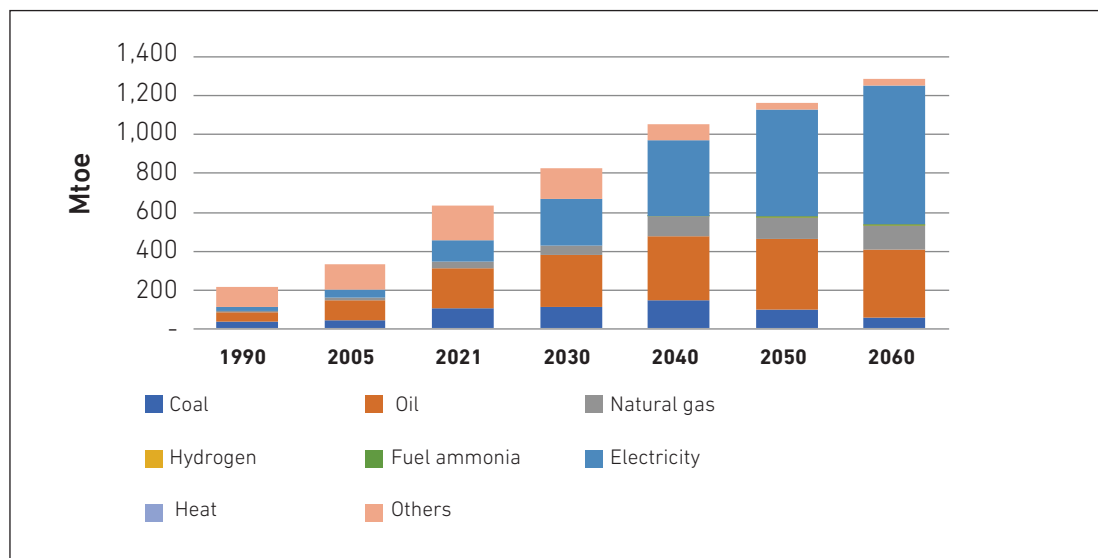
Mtoe = million tonnes of oil equivalent.

Source: Authors, based on the Institute of Energy Economics, Japan model.

A sector-wise breakdown of final energy consumption under LCET shows that industry consumption grows at an average annual rate of 1.0% in 2021–2060, a 53% reduction compared with BAU. Transport records the highest sector growth at 3.7% per year, followed by non-energy sectors at 3.3%. However, despite being the dominant energy-consuming sector in LCET, transport still sees a 34.4% reduction in energy use relative to BAU by 2060. The other sectors in the model grow at 0.8% annually. The overall decline across these sectors reflects the adoption of sustainable practices, improved efficiency measures, technological progress, and policy interventions to reduce energy use.

Figure 6.9 shows a fuel-wise analysis of final energy consumption, showing that coal consumption under LCET rises until 2040 before plummeting for the rest of the modelling period. Other fossil fuels, such as oil, grow at 1.4% annually, whilst natural gas increases by 3% per year. Electricity, as under BAU, records the highest average annual growth rate at 5.1%. Other fuels decline at an average rate of 4.5% over the period.

**Figure 6.9. Final Energy Consumption by Fuel Type, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

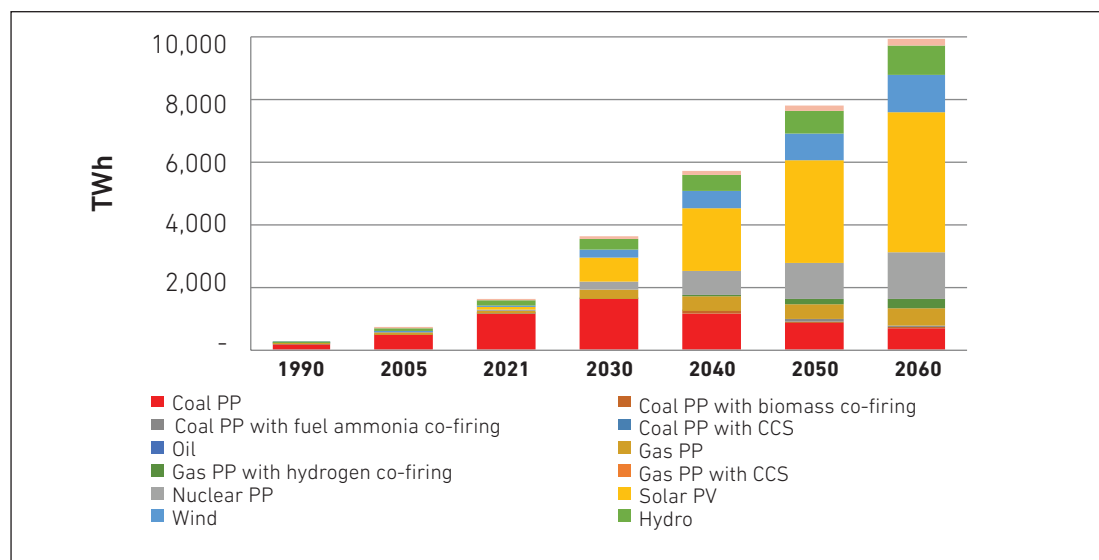
Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.2.2. Electricity generation

Under LCET, total electricity generation by 2060 is 34% higher than under BAU. From 1,635 TWh in 2021, it rises to 9,946 TWh by 2060 under LCET, compared with 7,412 TWh under BAU, an average annual growth rate of 4.7% over the modelling period.



**Figure 6.10. Electricity Generation, Low-carbon Energy Transition Scenario, 1990–2060**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour

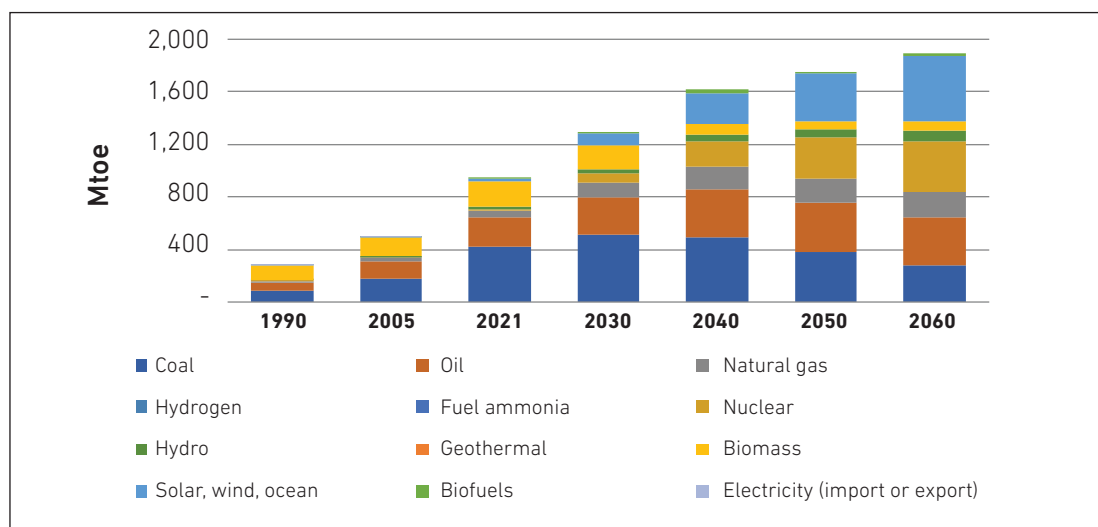
Source: Authors, based on the Institute of Energy Economics, Japan model.

Coal accounted for the largest share of electricity generation in 2021, making up 71.5% of the total mix (Figure 6.10). However, under LCET, this share falls sharply to just 6.9% by 2060, reflecting an average annual decline rate of 1.4%. Under LCET, gas power plants with hydrogen co-firing are deployed after 2040, unlike under BAU. Nuclear power grows at 9.3% per year, signalling a strong shift to cleaner sources. Wind power increases at 7.3% annually, whilst hydropower grows at 4.6%. The largest rise amongst renewables is observed in solar photovoltaic, whose share increases from 76 TWh in 2021 to 4,482 TWh in 2060, growing at an average annual rate of 11% in 2021–2060. Biomass and other sources grow at 4.8% annually.

### 3.2.3. Primary energy supply

Primary energy supply in the LCET scenario grows at an average annual rate of 1.8%, increasing from 944 Mtoe in 2021 to 1,888 Mtoe in 2060 (Figure 6.11), resulting in a 34.5% reduction (992 Mtoe) relative to BAU.

**Figure 6.11. Primary Energy Supply, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors, based on the Institute of Energy Economics, Japan model.

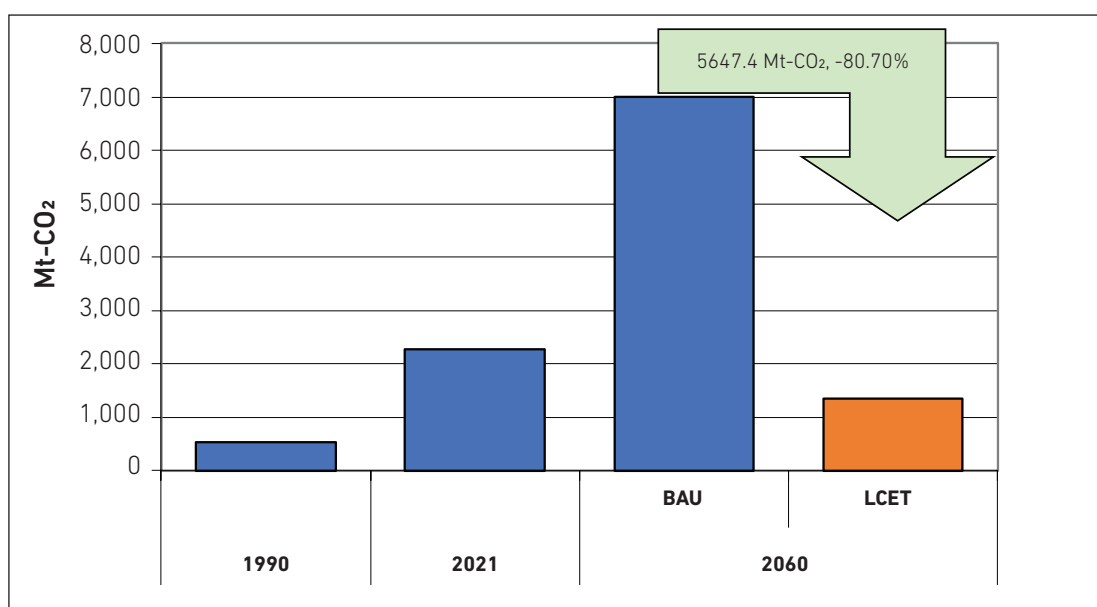
In 2021, coal accounted for 44.6% of the primary energy supply, but its share declines to 14.8% by 2060, showing an annual decline rate of 1.0%. The share of oil decreases from 23.7% in 2021 to 19.3% by 2060, although its absolute consumption grows at an annual rate of 1.3%. Compared with BAU, coal consumption under LCET falls by 72.7% in 2060, whilst oil decreases by 60.1%. Conversely, nuclear energy grows at the annual average rate of 9.3%, increasing its share from a mere 1.3% in 2021 to 20.6% by 2060.

Hydropower grows at 4.6% per year, whilst other sources – biomass, solar, wind, ocean energy, biofuels, and electricity imports – grow collectively at 2.5%. Electricity registers the highest average annual growth in the mix, rising by 12.9% over the modelling period. Under LCET, these sources grow by 66.9% compared with BAU, highlighting the scenario's focus on sustainability and a progressively cleaner energy mix.

### 3.2.4. Carbon dioxide emissions

Total CO<sub>2</sub> emissions in 2021 stood at 2,279 Mt-CO<sub>2</sub> (Figure 6.12). Under BAU, emissions are projected to grow at 2.9% annually, reaching 7,000 Mt-CO<sub>2</sub> by 2060. In contrast, LCET shows a more optimistic outlook, with emissions rising until 2040 before declining. By 2060, emissions fall to 1,352 Mt-CO<sub>2</sub>, a 41% reduction from 2021 and an average annual decline of 1.3%. Compared with BAU, LCET achieves an 81% reduction (5,647 Mt-CO<sub>2</sub>) by 2060, driven by cleaner fuels, efficiency gains across end-use sectors, and natural carbon sequestration. As a result, CO<sub>2</sub> emissions under LCET are 80.7% lower than under BAU by 2060.

**Figure 6.12. Carbon Dioxide Emissions Under Business-as-Usual and Low-carbon Energy Transition Scenarios, 1990–2060**



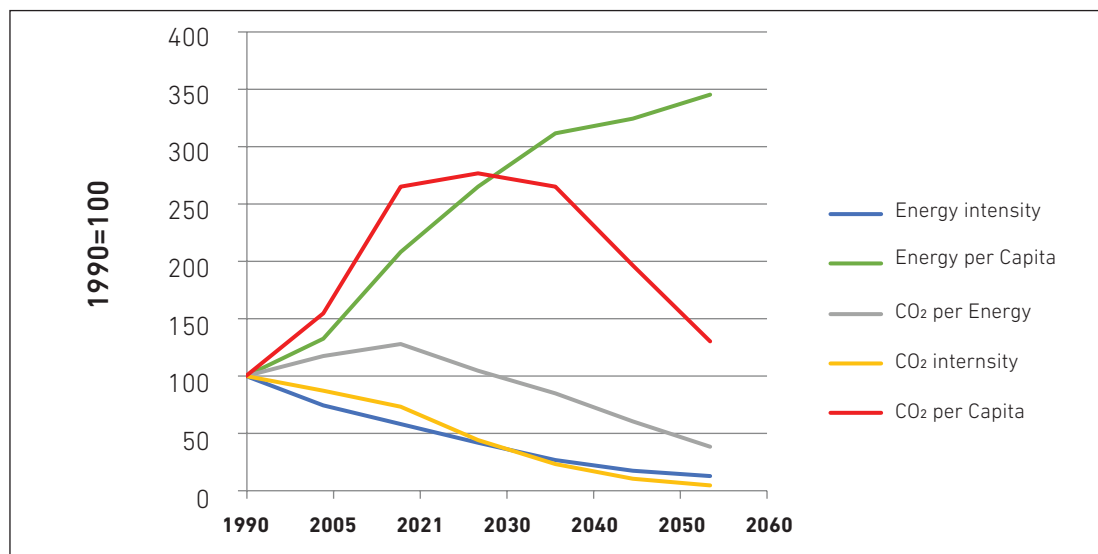
BAU = business as usual, LCET = low-carbon energy transition, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Authors, based on the Institute of Energy Economics, Japan model.

### 3.2.5. Energy indicators

Figure 6.13 shows projected energy indicators under LCET in 1990–2060, based on socio-economic projections and IEEJ model results. As LCET prioritises energy conservation and efficiency, energy intensity declines more sharply than under BAU. Defined as primary energy consumption per unit of GDP, energy intensity under LCET falls at an average annual rate of 3.7% in 2021–2060 – from 339 toe per million 2015 US dollars in 2021 to 77 toe by 2060 – reflecting an annual average decline of 6.7%.

**Figure 6.13. Indices of Energy and Carbon Dioxide,  
Low-carbon Energy Transition Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Authors, based on the Institute of Energy Economics, Japan model.

In contrast, per capita energy consumption increases at an annual rate of 1.3%, rising from 0.67 toe in 2021 to 1.11 toe in 2060. CO<sub>2</sub> emissions per unit of GDP fall from 819 t-CO<sub>2</sub> per million 2015 US dollars in 2021 to 55 t-CO<sub>2</sub> in 2060, an average decrease of 6.7%. CO<sub>2</sub> emissions per unit of primary energy consumption decline from 2.41 t-CO<sub>2</sub> per toe in 2021 to 0.72 t-CO<sub>2</sub> in 2060, at an annual rate of 3.1% (Figure 6.13). CO<sub>2</sub> emissions per capita drop from 1.6 Mt-CO<sub>2</sub> per million people in 2021 to 0.8 Mt-CO<sub>2</sub> in 2060, reflecting the shift to cleaner energy policies under LCET.

## 4. Indicative Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transitions

Table 6.1 compares the costs of BAU and LCET in the IEEJ model in 2021–2060. The 39-year modelling period exceeds the typical operational lifetime of power plants, implying that all generation capacity in place by 2060 must still be developed. The model assumes capacity growth based on current projections. It is worthwhile to note that these estimates are based on IEEJ model results, cost estimation methodology, and cost assumptions that are not specific to India. Energy storage costs are not included in the estimates, which may increase significantly if factored in.

## 4.1. Fuel Cost

Table 6.1 illustrates that fuel costs by 2060 are higher under BAU than under LCET. This reflects BAU's greater reliance on traditional fossil fuels, which are vulnerable to price volatility due to their finite nature and links to global trade and geopolitical factors. In contrast, LCET relies more on cleaner, renewable fuels, which are generally less expensive and more energy-efficient. Policy interventions differ between the scenarios, contributing to the variation in fuel costs.

## 4.2. Power Generation Investment

LCET incurs significantly higher annual capital costs for power generation and is exponentially more expensive than BAU. This is due to the need for entirely new infrastructure to process clean, renewable fuels into usable energy across sectors. The cost of developing new generation infrastructure is higher under LCET. Whilst BAU investments mainly focus on replacing retiring power plants within the modelling period, LCET requires investment in new, often costlier technologies over the same timeframe.

## 4.3. Overall Cost

The overall annual average cost under LCET is 33% lower than under BAU (Table 6.1). It is important to mention here that this analysis does not include electricity transmission and distribution and energy storage costs. Given the high share of intermittent renewable sources such as solar and wind in LCET power generation, storage becomes essential. Including storage costs would significantly raise the overall cost of LCET.

**Table 6.1. Energy Cost Comparison Across Business-as-Usual  
and Low-carbon Energy Transition Scenarios**  
(US\$ million)

|                                         | BAU            | LCET           |
|-----------------------------------------|----------------|----------------|
| Fuel cost by 2060                       | 644,528        | 162,971        |
| Annual average power plant capital cost | 36,320         | 69,854         |
| Energy-saving measures cost by 2060     | -              | 217,070        |
| <b>Total (US\$ million)</b>             | <b>680,848</b> | <b>449,895</b> |

BAU = business as usual, LCET = low-carbon energy transition.

Source: Estimated by the Institute of Energy Economics, Japan (IEEJ) team based on the IEEJ model results and various assumptions of input parameters.

## 5. Implications and Policy Implications

Based on the IEEJ model interpretations for BAU and LCET, and in line with India's ambitious global climate commitments, achieving net zero by 2070 will require a significant reduction in CO<sub>2</sub> emissions and a swift yet stable transition to renewable energy. Several pathways and strategies can facilitate this transition:

- i. A comprehensive set of policies is required to guide the energy transition, supporting the adoption of clean fuels, renewables, and alternative technologies within a defined timeframe.
- ii. Substantial investment is needed to expand and strengthen grid infrastructure, improve flexibility, advance energy storage, and develop energy-efficient systems across the economy.
- iii. Hydrogen's share in the energy mix must increase, with efforts focused on advancing it from its current nascent phase to a viable alternative for heavy industries and transport.
- iv. India can reduce the carbon footprint of its power generation mix by shifting from fossil fuel-based plants – particularly coal-fired ones – to renewable and clean energy sources, including nuclear power.
- v. Afforestation is needed to restore and expand the country's declining carbon sinks and naturally offset emissions from fossil fuel-dependent sectors such as industry and transport.
- vi. Adopting technologies such as electric vehicles can reduce oil dependence in the energy mix and pave the way for low-carbon solutions in transport.

Whilst these strategies can support a sustainable future, their financial feasibility must be carefully assessed. Reducing capital costs across the energy mix is essential to ensuring viability. With a holistic approach and an integrated framework, India can achieve its climate goals and energy targets.

## References

Enerdata (2022), [India Energy Information](#) (accessed 25 December 2024).

International Energy Agency (2024), [India – Electricity](#) (accessed 25 December 2024) International Monetary Fund (2024), (accessed 25 December 2024).

Press Information Bureau, Ministry of Information and Broadcasting, Government of India (2015), [India's Intended Nationally Determined Contribution Is Balanced and Comprehensive: Environment Minister.](#) (accessed 25 December 2024).

Press Information Bureau, Ministry of Information and Broadcasting, Government of India (2022), India Submits Its Long-Term Low Emission Development Strategy to UNFCCC (accessed 25 December 2024).

Press Information Bureau, Ministry of Information and Broadcasting, Government of India (2023a), [Net Zero Emissions Target.](#) (accessed 25 December 2024).

Press Information Bureau, Ministry of Information and Broadcasting, Government of India (2023b), [India Achieves Two Targets of Nationally Determined Contribution Well Ahead of the Time.](#) (accessed 25 December 2024).

Srivastava, D.K. (2023), '[India – towards becoming the third largest economy in the world](#)', EY. (accessed 25 December 2024).

United Nations Development Programme (2024), [India shows progress in Human Development Index, ranks 134 out of 193 countries.](#) (accessed 25 December 2024).

United Nations Climate Change (2024), [The Paris Agreement.](#) (accessed 25 December 2024). World Bank Group (2024), [The World Bank in India.](#) (accessed 25 December 2024).

# Chapter 7

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## Indonesia Country Report

**Suharyati**

Secretary General, National Energy Council



# 1. Introduction

Net-zero emissions refer to the balance between greenhouse gas emissions released and those removed from the atmosphere.

To achieve net-zero emissions, fossil fuel use must be reduced whilst renewable energy adoption is significantly increased. Fossil fuels may still be used but must be paired with clean technologies such as clean coal; carbon capture and storage (CCS); and carbon capture, utilisation, and storage (CCUS). Accelerating renewable energy uptake requires increased electricity consumption through the replacement of conventional vehicles with electric vehicles, and the use of biofuels, hydrogen, and battery technologies. This transition must be supported by smart grids and energy conservation measures to ensure energy security and sustainable development.

The Government of Indonesia, through the National Energy Council, is updating the National Energy Policy, which is expected to be finalised soon.

The policy aims to achieve long-term energy security at affordable prices whilst prioritising clean energy. It seeks to meet rational national energy demand to support Human Development Index targets and Indonesia's goal of becoming a developed country by 2045. The policy is designed to support the transition to a low-carbon energy system and achieve net-zero emissions by 2060, as targeted by the government.

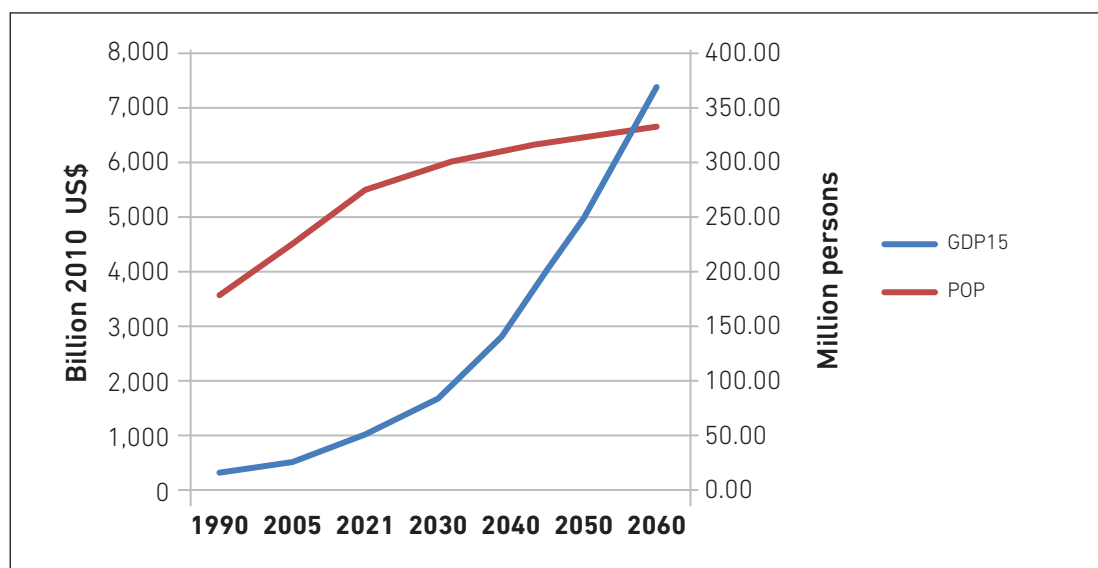
By 2060, renewable energy is projected to account for 70%–72% of primary energy supply (PES), with final energy consumption estimated at 1.1–1.27 tonnes of oil equivalent per capita. Residual emissions are expected to be limited to 129 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>), thereby achieving net-zero emissions.

## 2. Modelling and Assumptions

Growth in energy consumption is driven by socio-economic factors, especially economic growth and population dynamics. Following the coronavirus disease (COVID-19) pandemic, gross domestic product (GDP) increased by 3.7% in 2021 and 5% in 2022 and 2023. In this outlook, the economy is projected to grow at an average annual rate of 5.1% in 2021–2060.

The population in 2021 was approximately 273 million and is expected to grow at an average annual rate of 0.5% in 2021–2060. Figure 7.1 shows the GDP and population projections used in this outlook.

**Figure 7.1. Population and Gross Domestic Product Projections, 1990–2060**



GDP = gross domestic product, POP = population.

Source: Author.

Energy supply and demand are projected under two scenarios. The first, business as usual (BAU), reflects the expected effects of past trends and extends current energy and environmental policies and technologies. The second, low-carbon energy transition (LCET), is a backcasting approach that assumes carbon neutrality by 2060. Under this scenario, several measures are undertaken to achieve net-zero emissions in the demand sector. These include substituting gasoline and diesel with electric vehicles, biofuels (bioethanol and biodiesel), and hydrogen in transport; replacing coal and gas with hydrogen in industry; and shifting from liquefied petroleum gas (LPG) to electric stoves in other sectors (residential etc.).

Efforts to reduce emissions in the power sector include increasing renewable energy generation from hydropower, geothermal, solar, wind, and biomass sources. Nuclear power is expected to be introduced in 2032, with coal-fired power plants phased out after 2040. This transition will be supported by biomass and ammonia co-firing. Under LCET, gas-fired power plants will be gradually replaced with hydrogen. Whilst fossil fuels will remain in use for power generation, CCS technology will be deployed after 2040 to mitigate emissions.

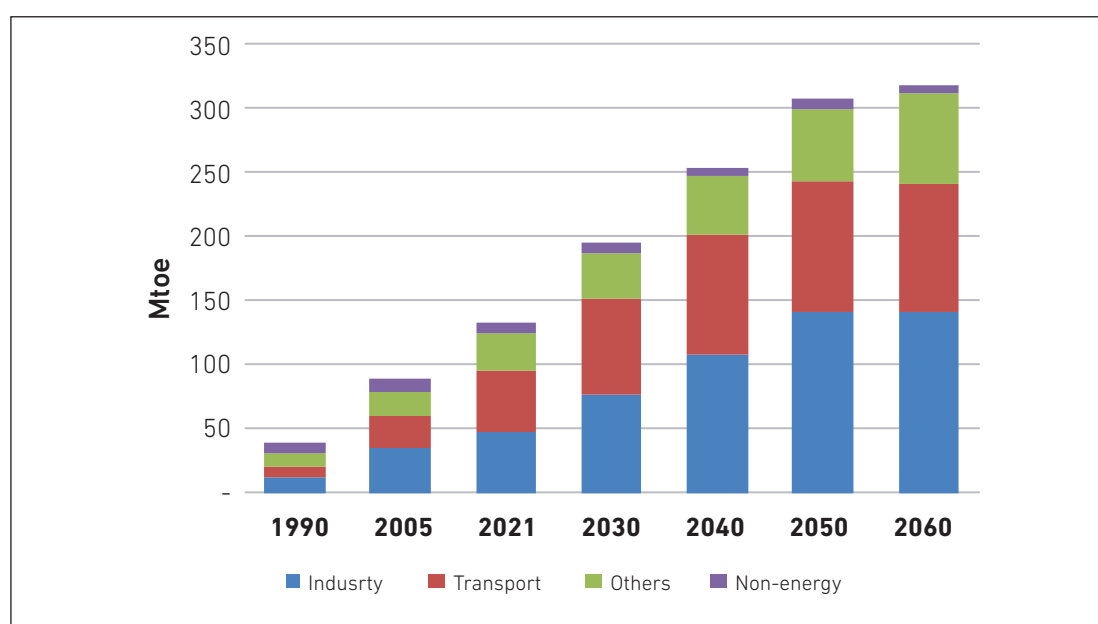
## 3. Outlook Results

### 3.1. Business-As-Usual Scenario

#### 3.1.1. Final energy consumption by sector

Final energy consumption is projected to rise steadily through 2060, with an average annual growth rate of 4.1% in 2021–2060 (Figure 7.2). In 2021, transport held the largest share of final energy consumption. By 2060, however, industry is expected to dominate, driven by increasing energy demand from industries such as smelting, in line with the government's programme to increase value-added processing of mineral resources.

**Figure 7.2. Final Energy Consumption, Business-as-Usual Scenario, 1990–2060**



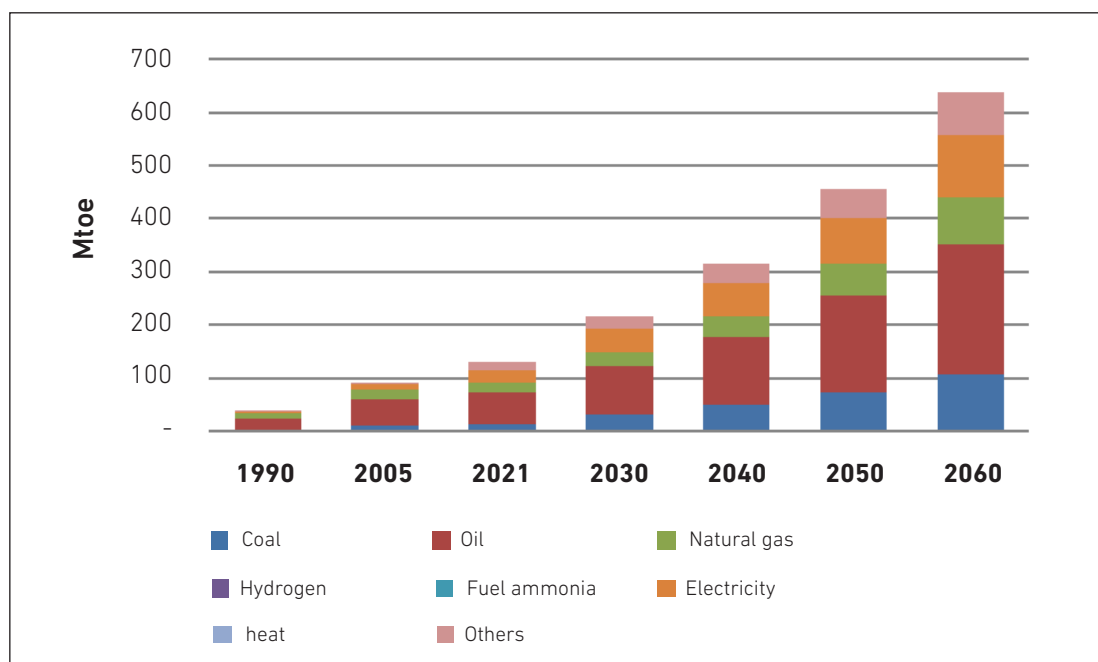
Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

#### 3.1.2. Final energy consumption by source

Coal is projected to grow the fastest in 2021–2060, with an average annual growth rate of 5.7%, mainly due to rising coal consumption in industry, particularly cement and metal (notably nickel ore). Whilst oil will remain the dominant energy source by 2060, its consumption will grow more slowly – at an average annual growth rate of 3.6% – due to fuel substitution with electric vehicles and increased use of biodiesel with a 35% biofuel blend (Figure 7.3).

**Figure 7.3. Final Energy Consumption by Source,  
Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

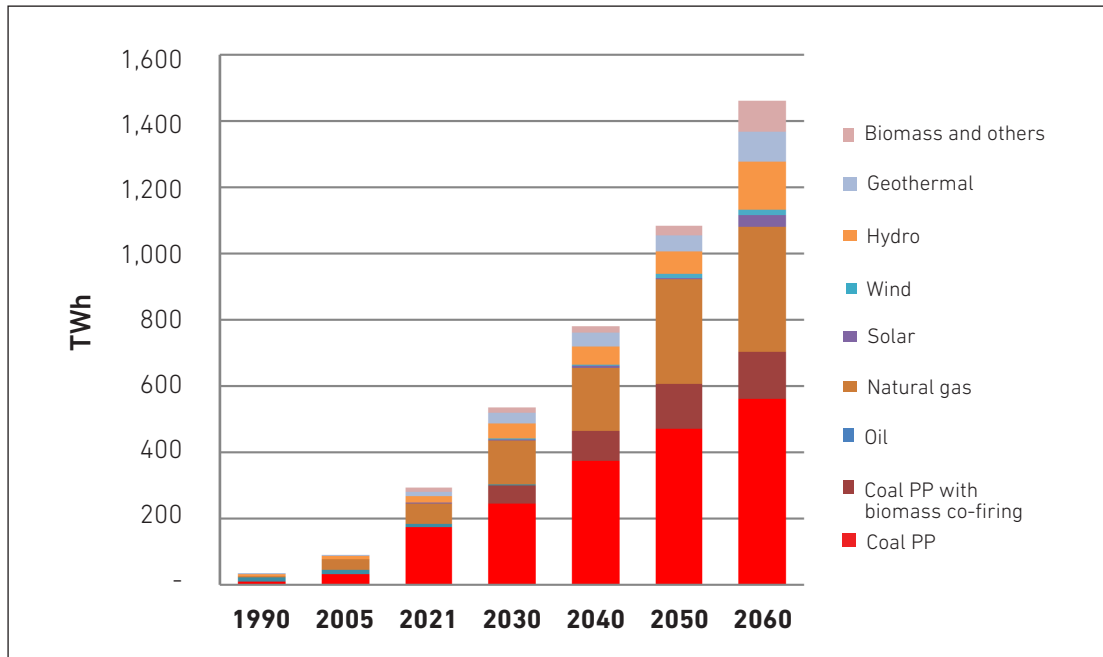
Source: Author.

### 3.1.3. Power generation

Power generation output is projected to increase from 293 terawatt-hours (TWh) in 2021 to 1,461 TWh in 2060, with an average annual growth of 4.2%. In 2021, coal accounted for 60% of total power generation output, but its share is expected to fall to 38% due to the gradual shift to coal co-firing with biomass, reaching a 5% biomass blend by 2060. Electricity generation from gas-fired power plants is expected to grow at an average annual growth rate of 5%, reaching a 26% share of total power output by 2060.

Renewable energy generation is projected to increase from 15% in 2021 to 26% in 2060, with the largest contributions from hydropower, geothermal, and biomass sources. However, solar power is expected to grow the fastest amongst renewable sources, with an average annual growth rate of around 16%, driven by falling solar panel costs and the expansion of rooftop solar installations in the commercial and residential sectors (Figure 7.4).

**Figure 7.4. Output Electricity by Source, Business-as-Usual Scenario, 1990–2060**



PP = power plant, TWh = terawatt hour.

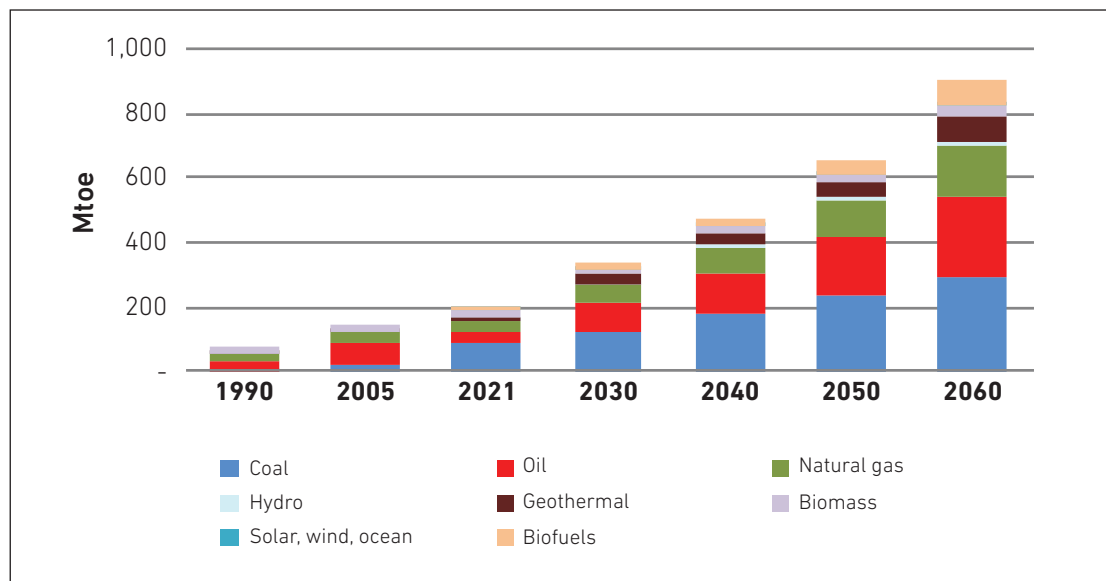
Source: Author.

### 3.1.4. Primary energy supply

Under BAU, primary energy supply is projected to increase at an average annual rate of 4%, reaching 899 million tonnes of oil equivalent (Mtoe) by 2060 (Figure 7.5). Oil supply is expected to increase at an average annual rate of 5.2% in 2021–2060, whilst natural gas will grow at 4.2% and coal at 3.1%. Amongst renewable energy sources, biofuel is projected to have the highest growth rate (6.9%), primarily due to government policies promoting biodiesel B-35 implementation from June 2023 onwards.

Despite these developments, fossil fuels are expected to remain the dominant source in primary energy supply by 2060, with renewable energy accounting for only 23%. Within the renewable mix, geothermal and biofuels will have the largest shares at 9% and 8%, respectively.

**Figure 7.5. Primary Energy Supply, Business-as-Usual Scenario, 1990–2060**



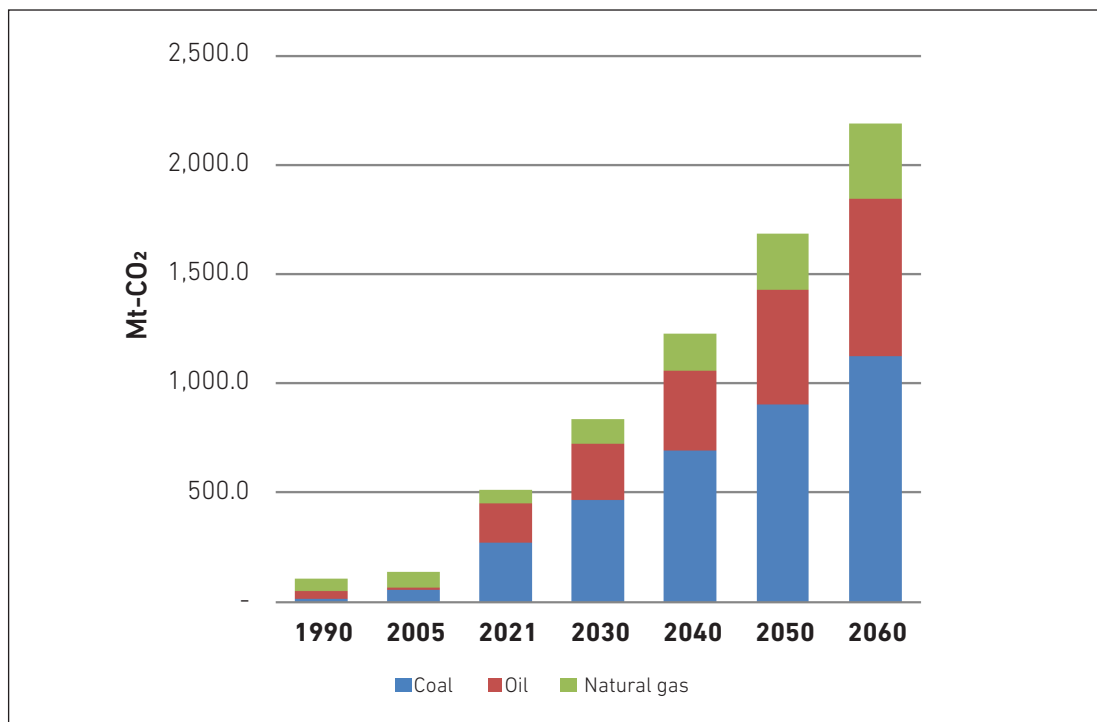
Mtoe = million tonnes of oil equivalent.

Source: Author.

### 3.1.5. Carbon dioxide emissions

Carbon dioxide (CO<sub>2</sub>) emissions are expected to grow at an average annual rate of 3.8% in 2021–2060. Coal will remain the largest contributor, driven by rising electricity generation from coal-fired power plants, which are projected to grow at about 3% per year (Figure 7.6).

**Figure 7.6. Carbon Dioxide Emissions, Business-as-Usual Scenario, 1990–2060**



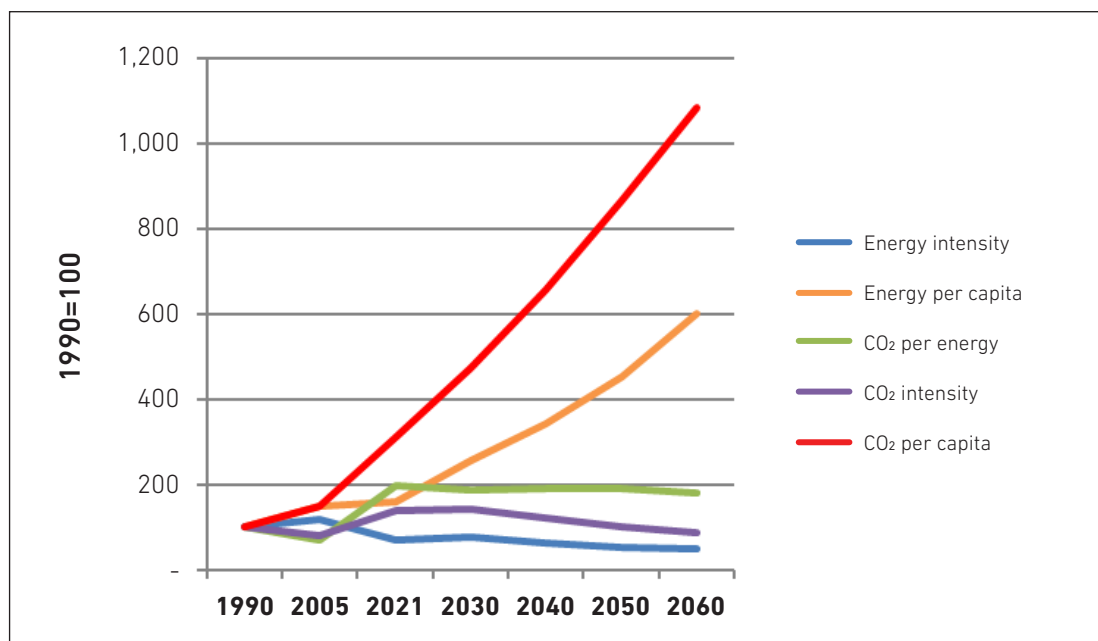
Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

### 3.1.6. Energy indicators

GDP is projected to reach US\$7,422 billion by 2060. As a result, energy intensity and CO<sub>2</sub> intensity are expected to decrease at average annual rates of 1% and 0.9%, respectively (Figure 7.7).

**Figure 7.7. Energy Indicators, Business-as-Usual Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Author.

## 3.2. Low-carbon Energy Transition Scenario

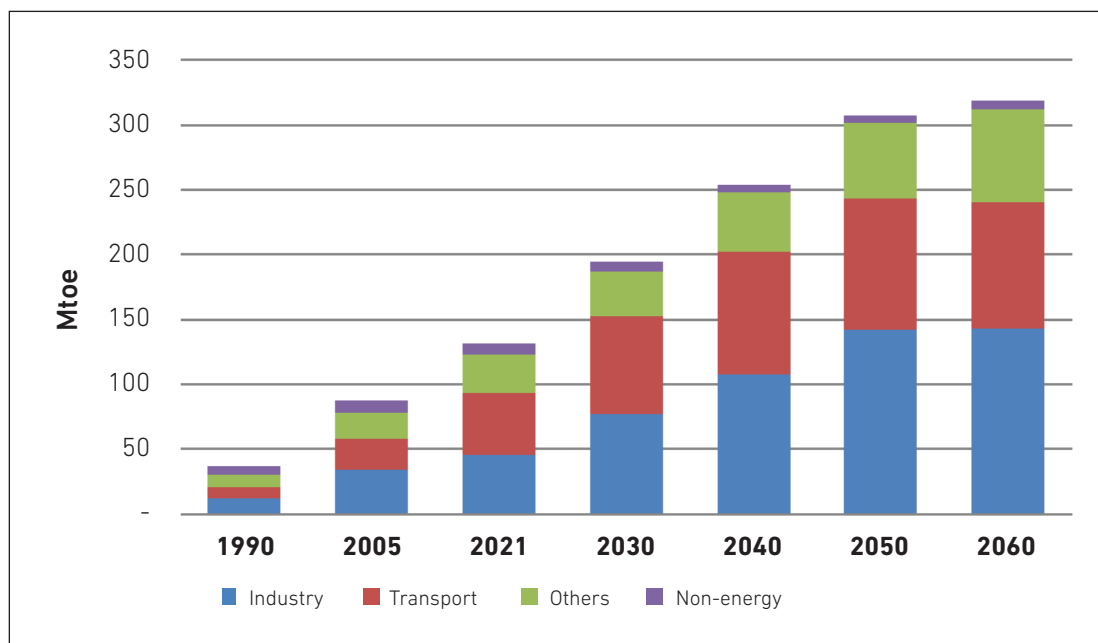
Achieving the net-zero emissions target requires reducing fossil fuel use and increasing renewable energy deployment. Whilst fossil fuels may still be used, they must be supported by clean technologies such as clean coal, CCS, and CCUS.

### 3.2.1. Final energy consumption by sector

By 2060, final energy consumption is projected to reach 319 Mtoe, growing at an average annual rate of 2.3% in 2021–2060. Industry will see the highest growth, averaging 2.9% per year, as Indonesia pursues developed-country status by 2045. As a result, industry's share of total energy consumption will rise from 35% in 2021 to 44.7% in 2060. Transport will grow at 1.9% per year, and other sectors at 2.3% (Figure 7.8).



**Figure 7.8. Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

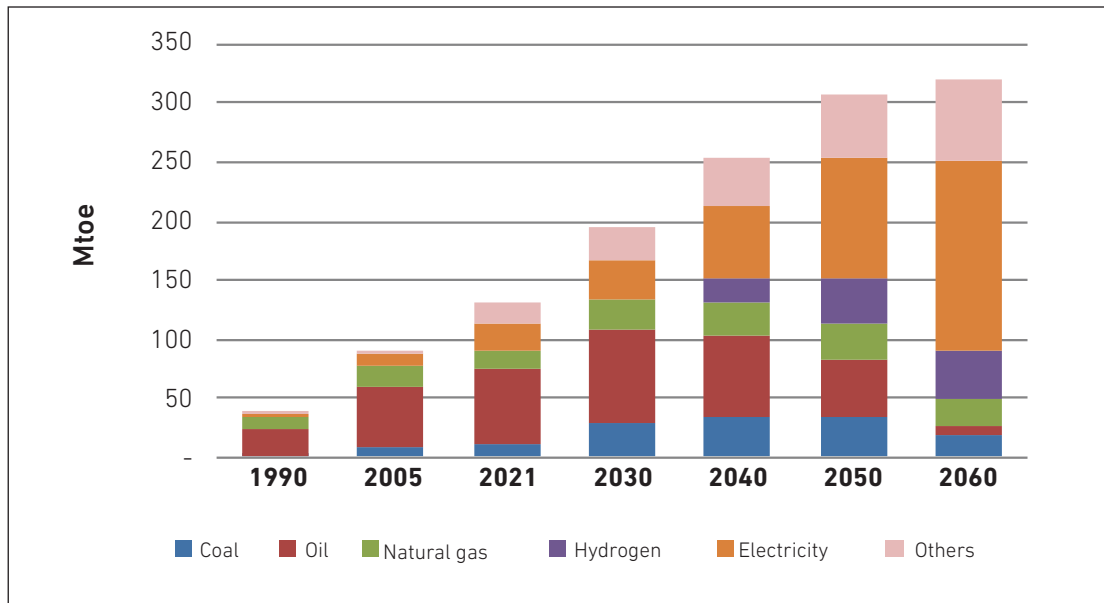
Source: Author.

### 3.2.2. Final energy demand by source

Fossil fuel consumption is projected to slow in 2021–2060, with oil declining by 4.7% per year and gas increasing marginally by 0.7% annually. Only coal is expected to grow, at about 1% per year. In contrast, electricity and other energy sources (biofuels and biomass) are projected to grow at an average annual rate of 5% and 3.5%, respectively.

The share of fossil fuels in final energy consumption is projected to fall from 68.7% in 2021 to 15.3% in 2060, driven by a shift to cleaner renewable energy sources, including hydrogen, which is expected to be introduced in 2035 (Figure 7.9).

**Figure 7.9. Final Energy Consumption by Source, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

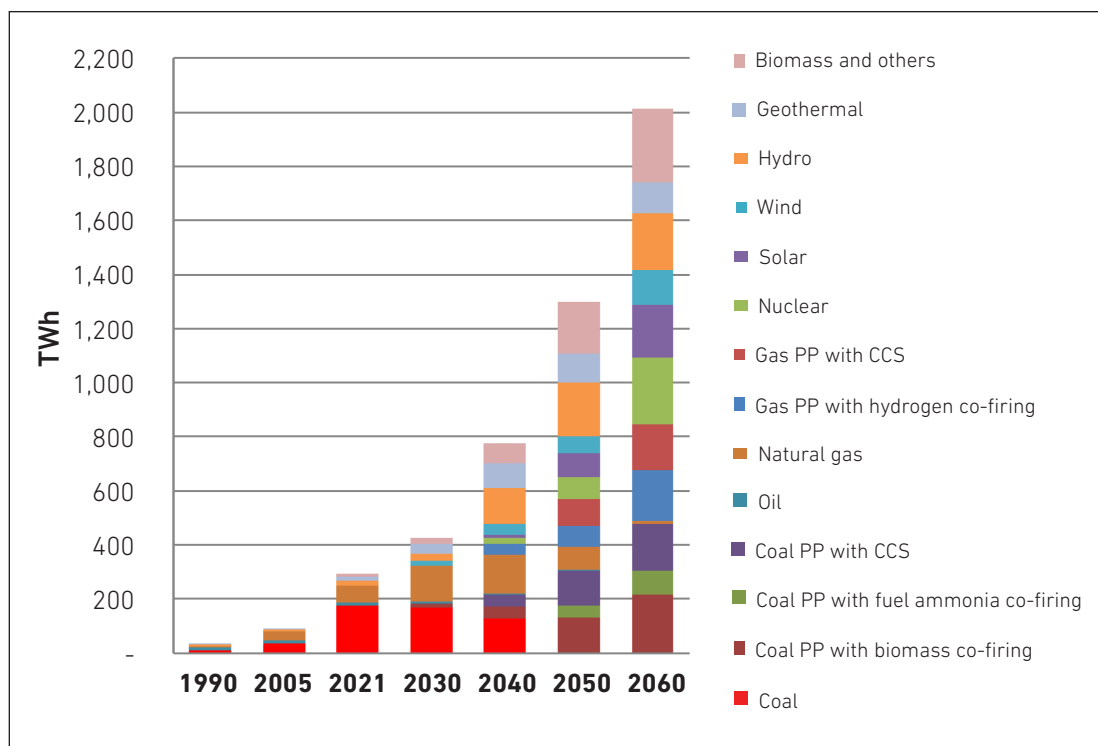
Source: Author.

### 3.2.3. Power generation

Electricity output is projected to grow at an average annual rate of 5.1%, reaching 2,014 TWh by 2060, in line with the anticipated 5% annual increase in electricity demand. Notably, output from coal-, gas-, and oil-fired power plants is expected to decline, whilst output from renewable sources will rise. Solar and wind energy will see the highest growth rates, at 21% and 15% per year, respectively.

By 2060, biomass (including municipal solid waste) is forecast to account for 14% of electricity generation, with nuclear power contributing 12% and coal co-firing with biomass, 11%. Fossil fuels will remain part of the energy mix but will be used alongside CCS, resulting in a 9% share for coal CCS and 8.5% for gas CCS. Gas will be used with hydrogen co-firing, accounting for about 9% (Figure 7.10).

**Figure 7.10. Power Generation, Low-carbon Energy Transition Scenario, 1990–2060**



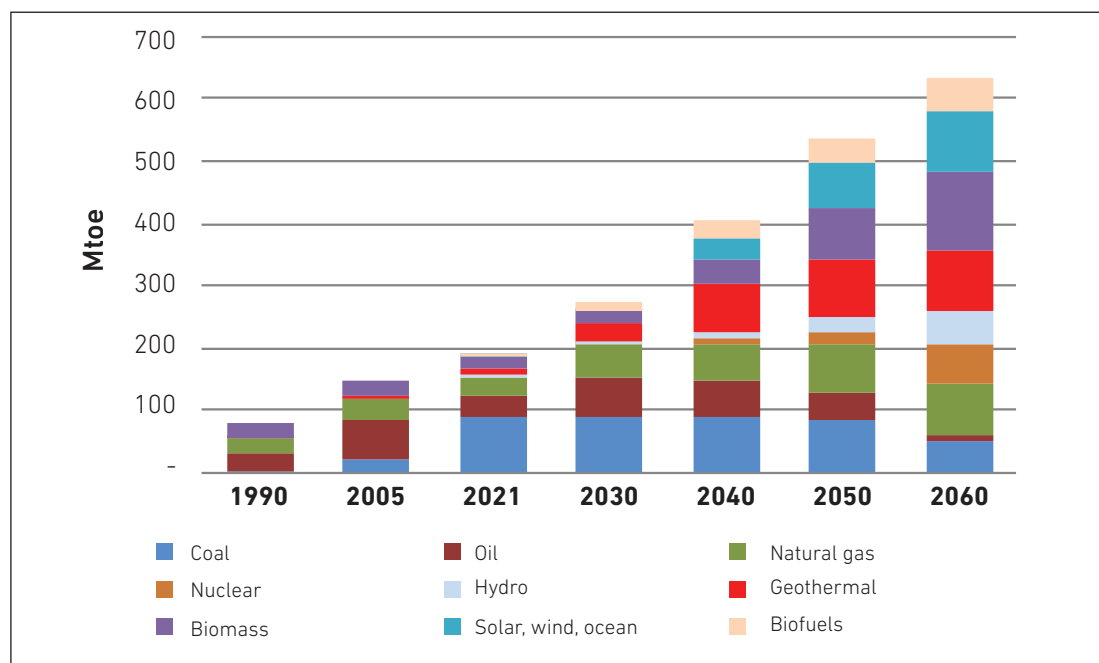
CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

Source: Author.

### 3.2.4 Primary energy supply

Under LCET, primary energy supply is expected to reach 629.9 Mtoe by 2060, with an average annual growth rate of 3.1% from 2021 (Figure 7.11). Whilst coal, gas, and oil are still projected to grow, their average annual rates will remain below 3%. In contrast, total renewable energy is projected to grow at over 5%. Solar, wind, and ocean energy are anticipated to grow at 11% per year, followed by hydropower at about 9% per year. As a result, the fossil energy share will decline to 23% by 2060, whilst renewable energy will rise to 77%.

**Figure 7.11. Primary Energy Supply, Low-carbon Energy Transition Scenario, 1990–2060**



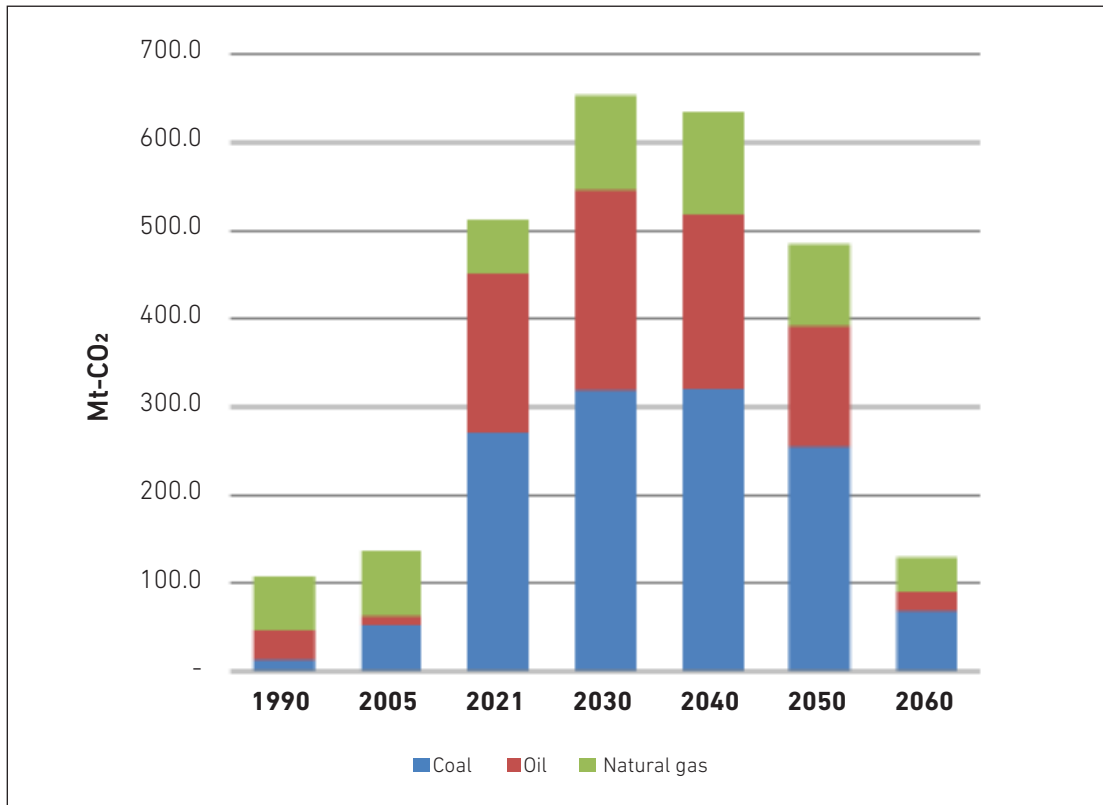
Mtoe = million tonnes of oil equivalent.

Source: Author.

### 3.2.5. Carbon dioxide emissions

Under LCET, CO<sub>2</sub> emissions are projected to decrease at an average annual rate of 3.5%, reaching 129.5 Mt-CO<sub>2</sub> by 2060 (Figure 7.12). This reduction aligns with Indonesia's commitment made at the 2021 United Nations Climate Change Conference (COP26). Coal will remain the largest contributor, accounting for approximately 50% of emissions in 2060. Several industries will continue to use coal as fuel, whilst in the power sector, it will be used alongside CCS.

**Figure 7.12. Carbon Dioxide Emissions, Low-carbon Energy Transition Scenario, 1990–2026**



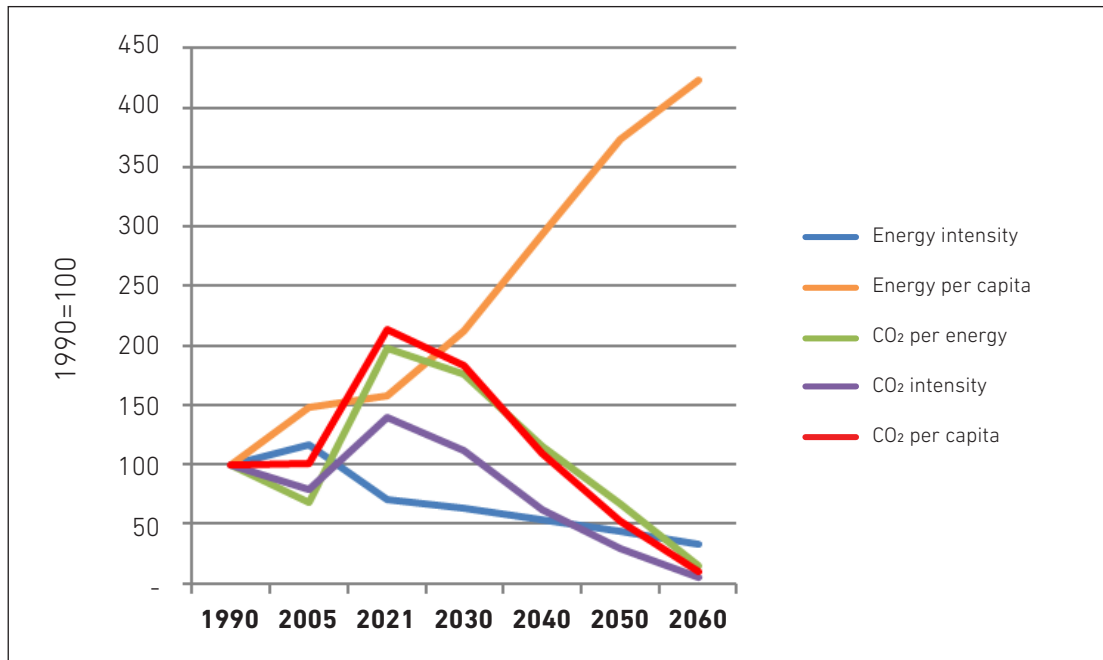
Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

### 3.2.6. Energy indicators

Energy intensity and CO<sub>2</sub> per unit of energy are expected to decline at an average annual rate of 1.9% and 8.2%, respectively, in 2021–2060 (Figure 7.13). As a result, CO<sub>2</sub> intensity will decrease at an average annual rate of 6.4% through 2060.

**Figure 7.13. Carbon Dioxide Emissions, Low-carbon Energy Transition Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Author.

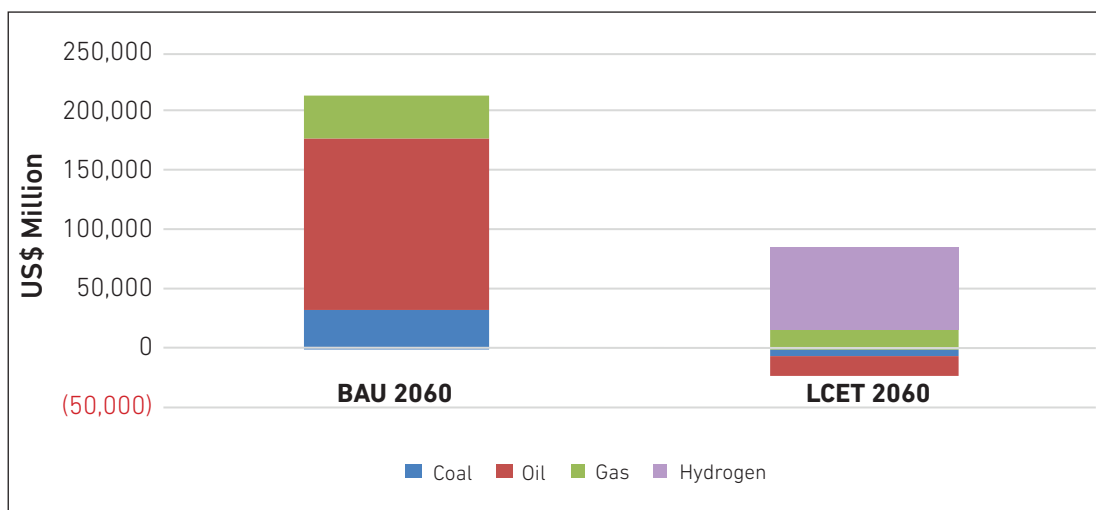
## 4. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

To evaluate the cost implications of the energy transition, key energy-related expenses—fuel, power generation investment, and CCS—for both BAU and LCET are analysed based on the outlook results.

## 4.1. Fuel Cost

By 2060, fuel costs under LCET are projected at US\$206 billion, significantly lower than under BAU due to reduced fossil fuel demand. However, with the inclusion of hydrogen, total fuel costs will still amount to about 30% of those under BAU (Figure 7.14).

**Figure 7.14. Fuel Cost Comparison, Business as Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition.

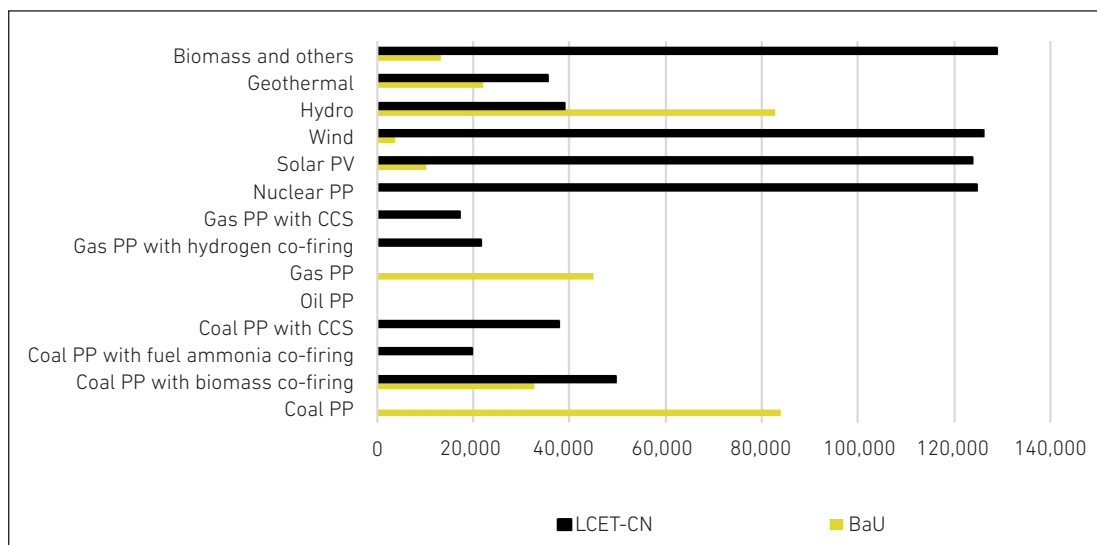
Source: Author.

## 4.2. Power Generation Investment

To estimate the investment cost for power generation equipment, the unit cost of each energy source was multiplied by the increase in installed capacity projected by 2060.

Cumulative capital investment for power generation under LCET in 2021–2060 is approximately US\$703.2 billion – more than 2.7 times that under BAU. Significant investments are needed for biomass, hydropower, and nuclear energy (Figure 7.15).

**Figure 7.15. Power Generation Investment Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios (US\$ million)**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, PV = photovoltaic.

Source: Author.

### 4.3. Carbon Capture and Storage Cost

BAU does not consider CCS, resulting in zero associated costs. In contrast, LCET assumes CCS integration into all coal- and gas-fired power plants, with an estimated cost of US\$4.7 billion (Table 7.1).

**Table 7.1. Carbon Capture and Storage Cost**

|                  | TWh | CCS Cost (US\$ Million) |
|------------------|-----|-------------------------|
| Coal PP with CCS | 174 | 2,556                   |
| Gas PP with CCS  | 171 | 2,125                   |
| Total Cost       |     | 4,681                   |

CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

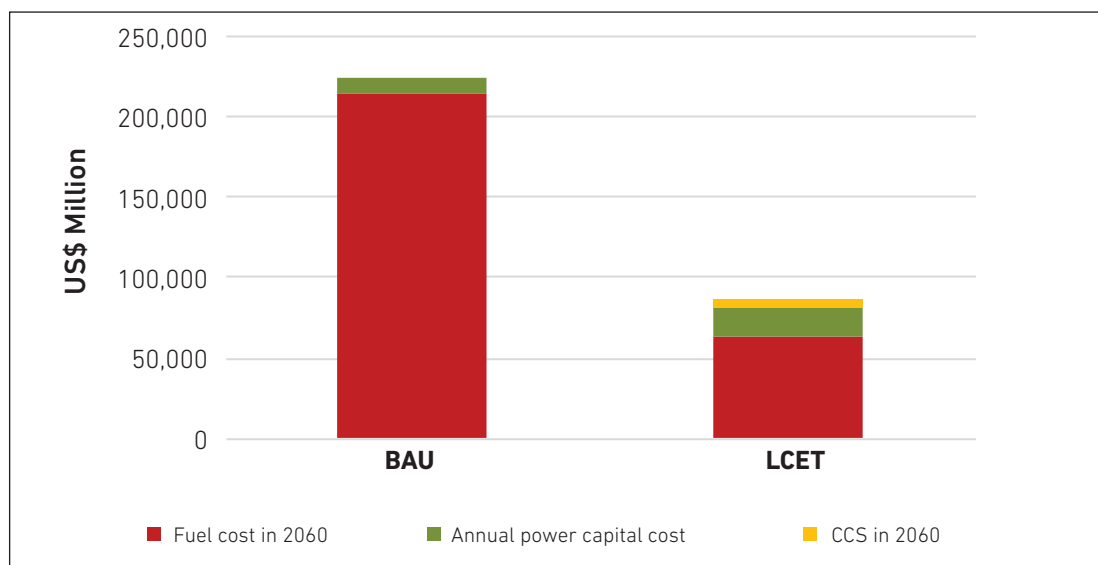
Source: Author.



## 4.4. Overall Cost

Total costs related to fuel, power generation investment, and CCS by 2060 have been evaluated, with combined costs for each scenario summarised in Figure 7.16.

**Figure 7.16. Energy Cost Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Author.

## 5. Conclusions and Policy Recommendations

Indonesia is committed to achieving net-zero emissions by 2060, targeting a reduction of approximately 129 Mt-CO<sub>2</sub>. To reach this goal, the government must develop a comprehensive road map outlining key programme activities, including the transition to electricity, biofuels, and hydrogen in transport; the substitution of oil, gas, and coal with hydrogen in industry; and the shift from LPG to electric stoves in the residential sector. The road map should include the phasedown of coal-fired power plants and increased use of renewable energy for electricity generation, including nuclear power. Collaboration amongst the Ministry of Environment, the Ministry of Energy, and other ministries is essential in developing these programmes. By 2030, Indonesia should meet its emission reduction targets under the enhanced nationally determined contribution, paving the way for net-zero emissions by 2060.

Based on the overall energy cost analysis, LCET is expected to result in lower fuel costs than BAU. However, power investment and CCS costs under LCET are higher. This indicates that LCET could provide a viable pathway to achieving net-zero emissions by 2060.

Beyond financial considerations, several other factors must be prioritised to ensure achievement of the net-zero emissions target, including a robust legal framework, improved knowledge of clean energy technologies, and greater public awareness. Cooperation with developed countries remains crucial, particularly in investment, technology transfer, and other supporting activities to facilitate emission reductions.

## References

Center for Data and Information Technology–Pusdatin (2021), *Handbook of Energy and Economic Statistics of Indonesia 2019*. Jakarta: Ministry of Energy and Mineral Resources of Indonesia (accessed 15 May 2024).

Central Bureau of Statistics (2019), *Statistical Yearbook of Indonesia 2023* (accessed 25 May 2024).

World Bank, *World Development Indicators* (accessed 25 May 2024).



# Chapter 8

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## Japan Country Report

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# 1. Introduction

In October 2020, the Government of Japan committed to achieving carbon neutrality by 2050. In 2021, it updated its nationally determined contribution (NDC), targeting a 46% reduction in greenhouse gas (GHG) emissions from 2013 levels by 2030.

The 6th Strategic Energy Plan (Ministry of Economy, Trade and Industry, 2021), approved by the Cabinet in the same year as the NDC update, outlines the quantitative targets and the sector actions needed to achieve carbon neutrality by 2050 and the 2030 NDC targets.

Despite Japan's goal of achieving carbon neutrality, its energy mix remains heavily dependent on fossil fuels. In 2022, fossil fuels accounted for 83% of the primary energy supply (PES) (Ministry of Economy, Trade and Industry Japan, 2024). Although power generation has made progress in decarbonisation, coal, oil, and natural gas still produce 73% of total electricity. Achieving net-zero emissions will require either replacing fossil fuels with alternative energy sources or using carbon capture and storage (CCS) technologies to offset emissions.

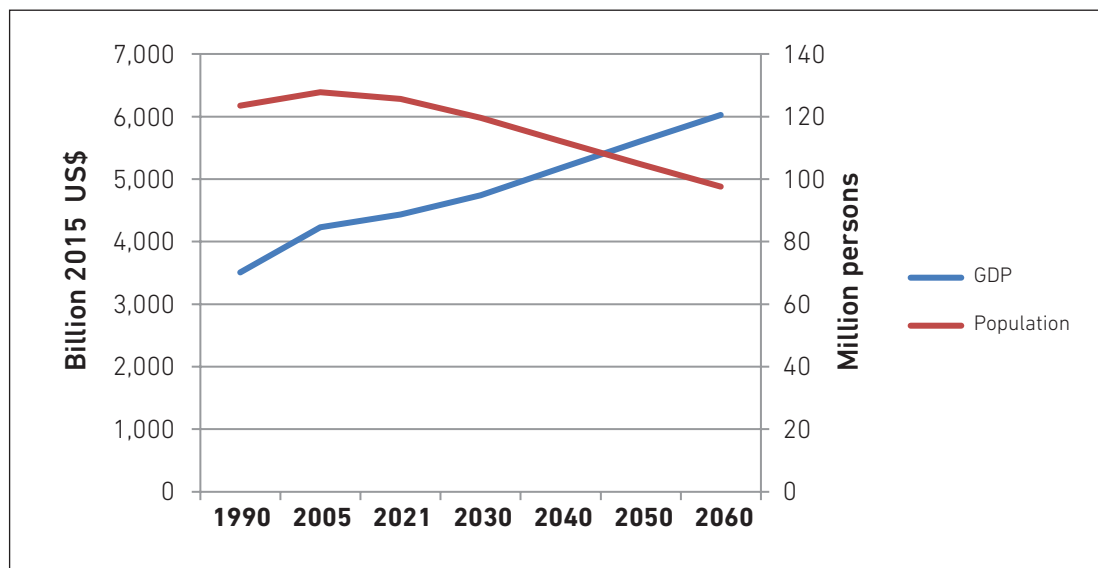
## 2. Modelling Assumptions

### 2.1. Macro-economy

Gross domestic product (GDP) grew at a moderate and steady average rate of 1.2% in 2010–2019. In 2020, it declined by 4.2% due to the economic impact of the coronavirus disease (COVID-19) pandemic. GDP is projected to grow slowly but steadily, averaging 0.8% annually in 2021–2060.

The population peaked around 2010 and has been declining since. It is expected to fall by about 0.6% per year due to a persistently low birth rate, decreasing from 126 million in 2021 to 98 million in 2060. Figure 8.1 presents the GDP and population assumptions used in this outlook.

**Figure 8.1. Population and Gross Domestic Product Outlook, 1990–2060**



GDP = gross domestic product.

Source: GDP: International Monetary Fund (2023) and authors. Population: United Nations Development Programme (2022).

Energy supply and demand are projected under two scenarios. The first is the business-as-usual (BAU) scenario, which extends current energy and environmental policies and technologies whilst reflecting the anticipated effects of past trends. The second is the low-carbon energy transition (LCET) scenario, a backcasting approach that assumes carbon neutrality by 2050 and identifies the measures needed to achieve it, regardless of economic constraints. Given Japan's limited CCS potential, LCET assumes CCS deployment in existing thermal power plants and industrial processes to support carbon neutrality efforts.

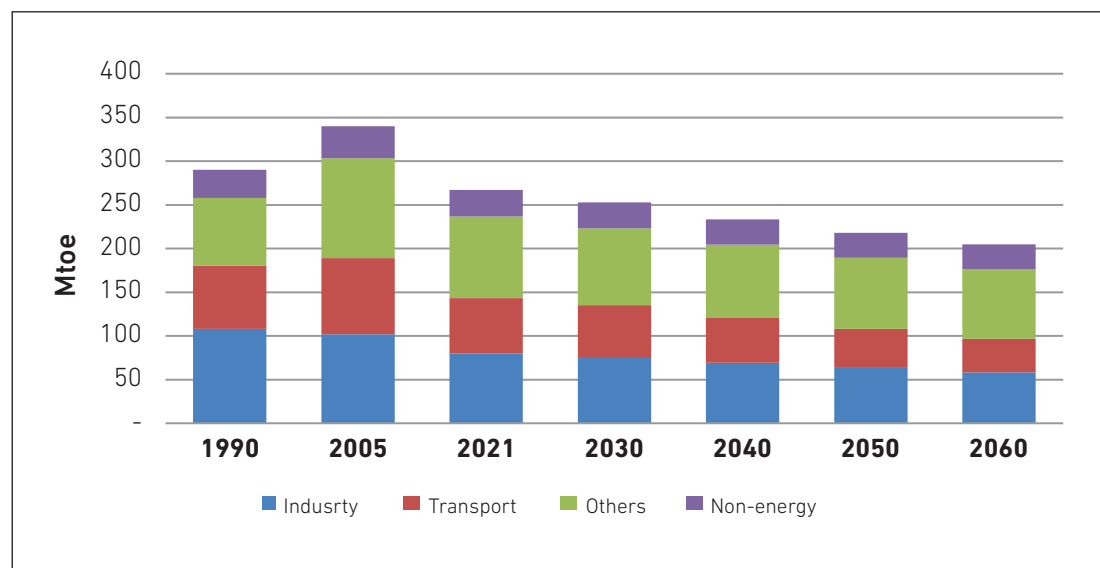
## 3. Outlook Results

### 3.1. Business-As-Usual Scenario

#### 3.1.1. Final energy consumption

Japan's final energy consumption (FEC) is projected to decline through 2060 (Figure 8.2). Transport sector demand will fall at an average annual rate of 1.3% in 2021–2060, mainly due to the shift from conventional petrol vehicles to hybrid and electric vehicles, improving fuel efficiency. Industry sector demand will decline, averaging 0.8% per year, driven by structural changes and energy efficiency measures aligned with existing policies.

**Figure 8.2. Final Energy Consumption by Sector,  
Business-as-Usual Scenario, 1990–2060**

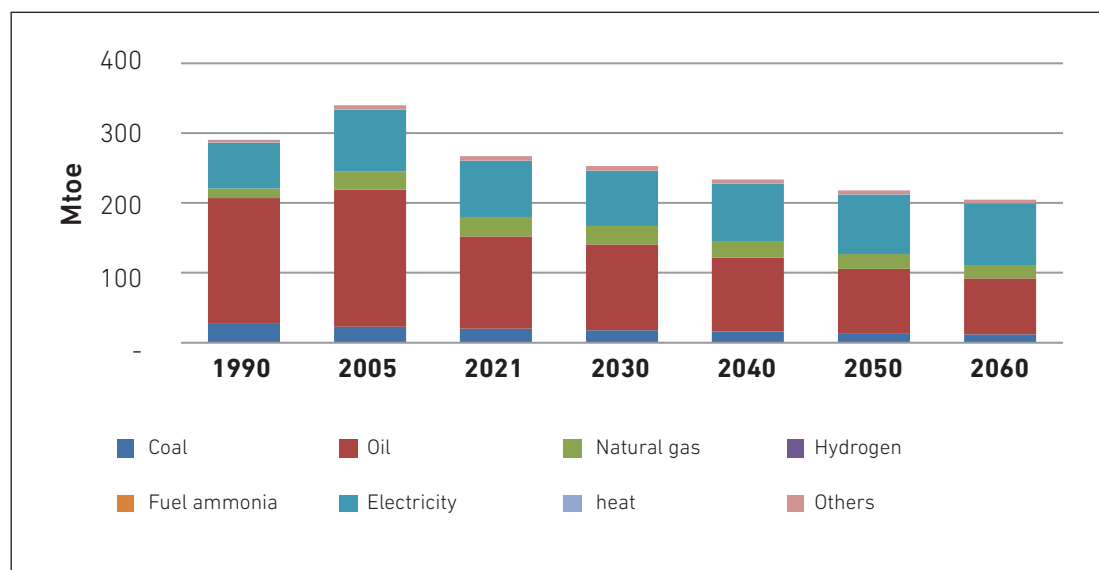


Mtoe = million tonnes of oil equivalent.

Source: Author.

FEC by source shows coal and oil use declining at average annual rates of 1.4% and 1.3%, respectively, driven by reduced demand in transport and industry (Figure 8.3). In contrast, electricity demand is expected to grow by 0.3% per year due to increased electrification on the demand side.

**Figure 8.3. Final Energy Consumption by Source, Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

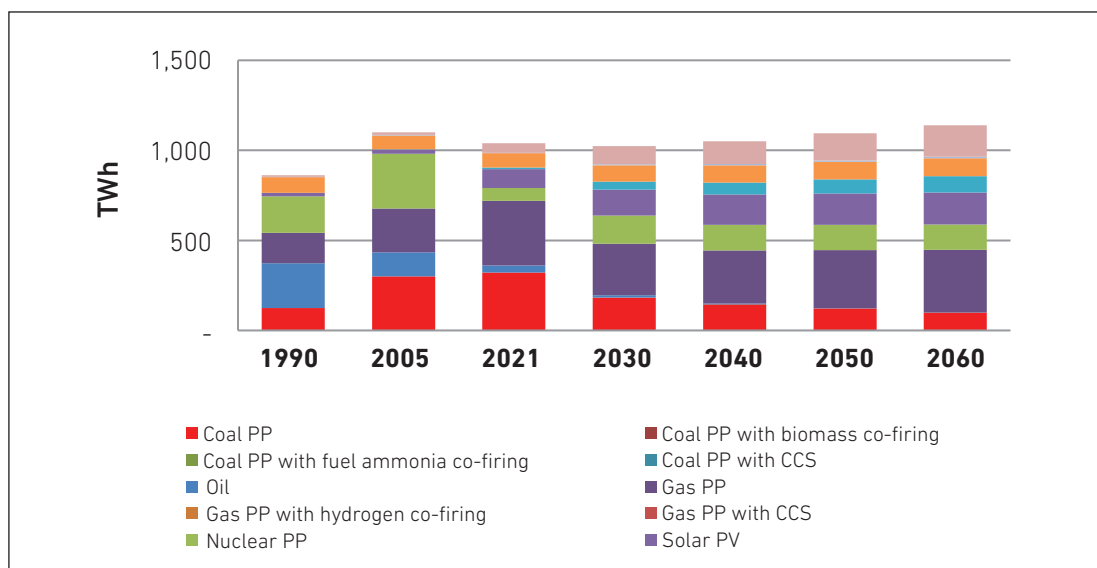
Source: Author.

### 3.1.2. Power Generation

Total power generation declined in 2020 due to the coronavirus disease (COVID-19) pandemic, but is projected to increase through to 2060 (Figure 8.4). Whilst fossil fuel-fired power generation will decrease, nuclear power and renewables such as solar photovoltaic (PV), wind, and geothermal will expand in line with existing policies. Under BAU, non-fossil fuels will account for 61% of power generation by 2060.



**Figure 8.4. Power Generation, Business-as-Usual Scenario, 1990–2060**



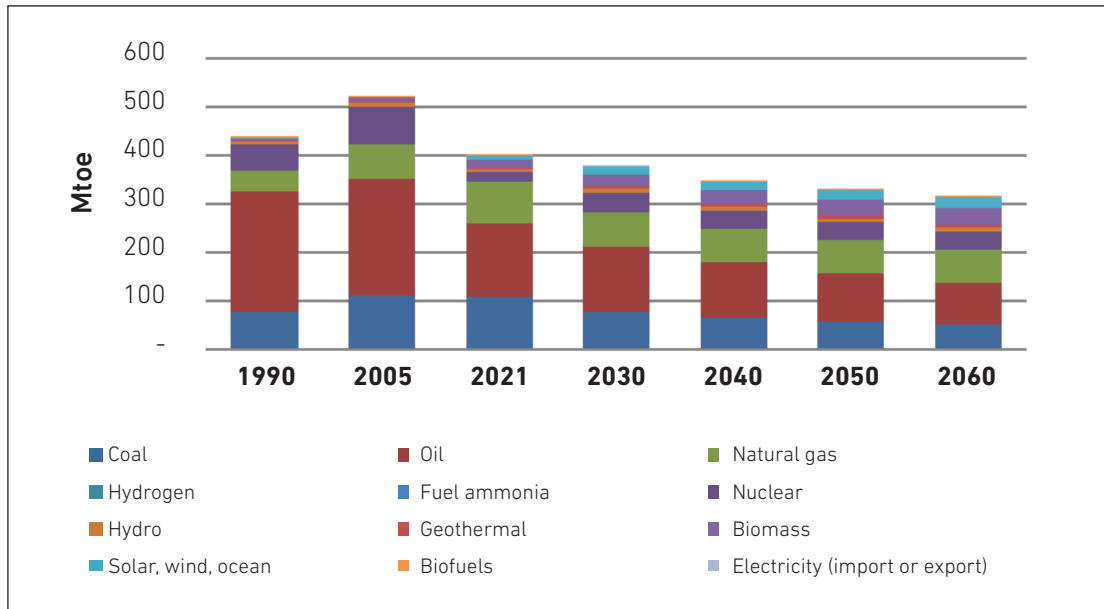
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author.

### 3.1.3. Primary energy supply

Driven by energy conservation measures under existing policies, PES is expected to decline at an average annual rate of 0.6% through 2060 (Figure 8.5). Coal, oil, and natural gas will decrease at average annual rates of 2.0%, 1.4%, and 0.7%, respectively, reflecting reduced fossil fuel use in both final energy consumption and power generation. In contrast, renewables such as solar PV, wind, and geothermal will increase, particularly as the power sector shifts to greater renewable energy adoption under current policies.

**Figure 8.5. Primary Energy Supply, Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Author.

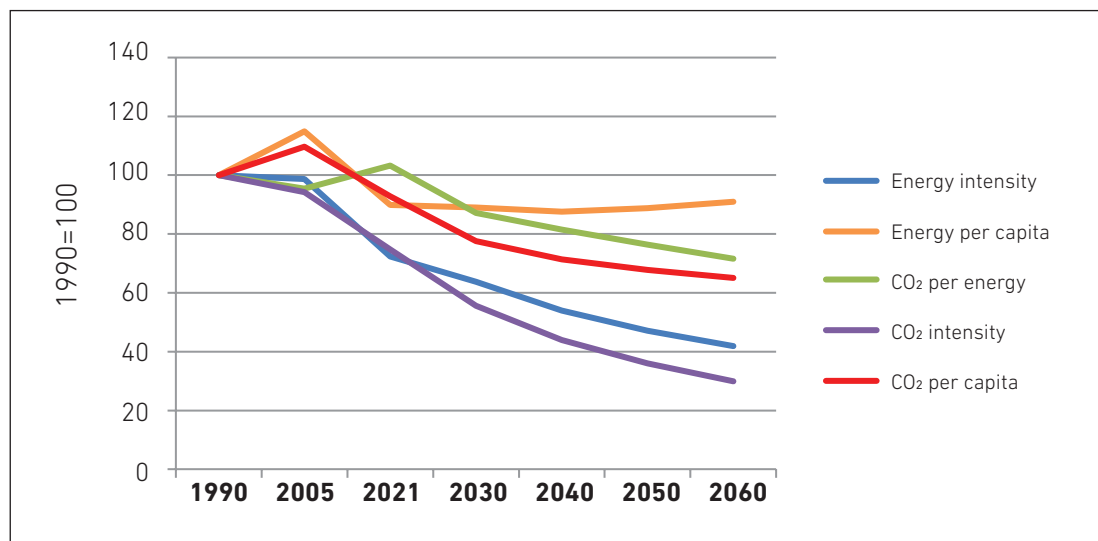
### 3.1.4. Carbon dioxide emissions

Under BAU, emissions are projected to reach 793 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>), exceeding Japan's 2030 NDC target of 677 Mt-CO<sub>2</sub> – a 45% reduction from 2013 levels. However, emissions will continue to decline beyond 2030, falling to 544 Mt-CO<sub>2</sub> by 2060.

### 3.1.5. Energy indicators

Energy intensity – measured as PES per unit of GDP – and CO<sub>2</sub> emissions per unit of energy will decline at an average annual rate of 1.4% and 0.9%, respectively, in 2021–2060 (Figure 8.6). As a result, CO<sub>2</sub> intensity is expected to decrease by 2.3% over the same period.

**Figure 8.6. Indices of Energy and Carbon Dioxide Intensities, Energy per Capita, and Carbonisation Rate, Business-as-Usual Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Author.

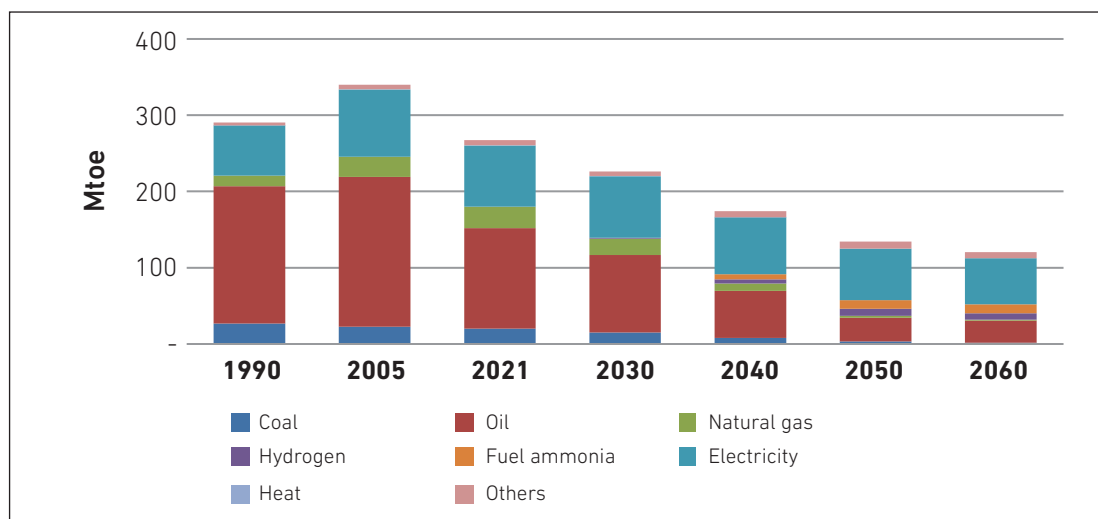
## 3.2. Low-carbon Energy Transition Scenario

This section presents the results of the LCET scenario.

### 3.2.1. Final Energy Consumption

Under LCET, total FEC is projected to decline to 120 Mtoe by 2060 (Figure 8.7). Achieving carbon neutrality will require a significant transition from fossil fuels to electricity and hydrogen. The fossil fuel share will fall sharply from 67% of FEC in 2021 to 27% by 2050. In contrast, electricity's share will rise from 30% in 2021 to 50% by 2060. Hydrogen and ammonia use will start in 2030 and account for 17% of final consumption by 2060.

**Figure 8.7. Final Energy Consumption by Source,  
Low-carbon Energy Transition Scenario, 1990–2060**

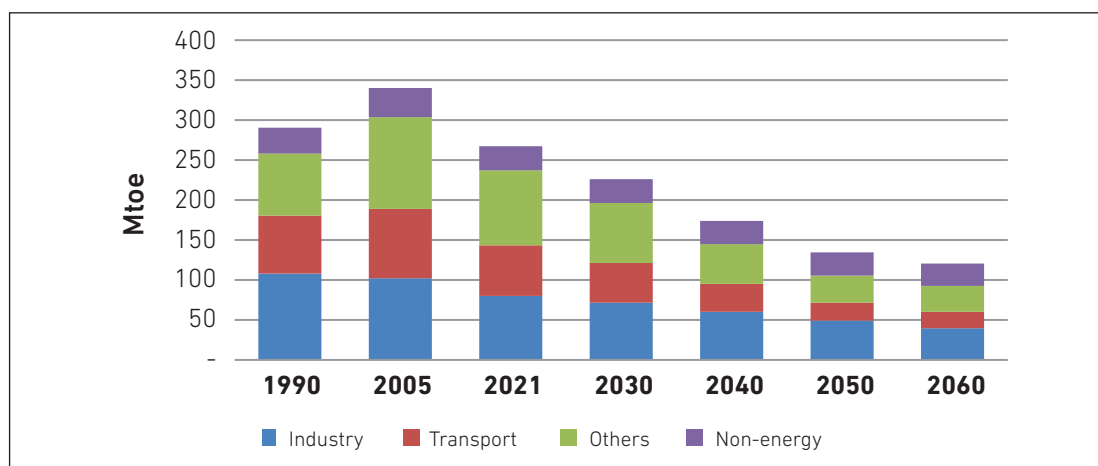


Mtoe = million tonnes of oil equivalent.

Source: Author.

In the transport, residential, and service sectors, energy demand will decline significantly due to intensive energy conservation efforts and widespread electrification, resulting in major efficiency gains (Figure 8.8). In transport, the higher efficiency of electric vehicles and fuel cell vehicles will drive substantial energy savings. Electrification will advance considerably in the residential and service sectors. In contrast, industry will see a more modest decline in energy consumption. Fully replacing fossil fuels with electricity or hydrogen will be challenging due to the need for high-temperature heat sources and the lock-in effect of existing equipment. Instead, CCS will be used to reduce CO<sub>2</sub> emissions.

**Figure 8.8. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario, 1990–2060**



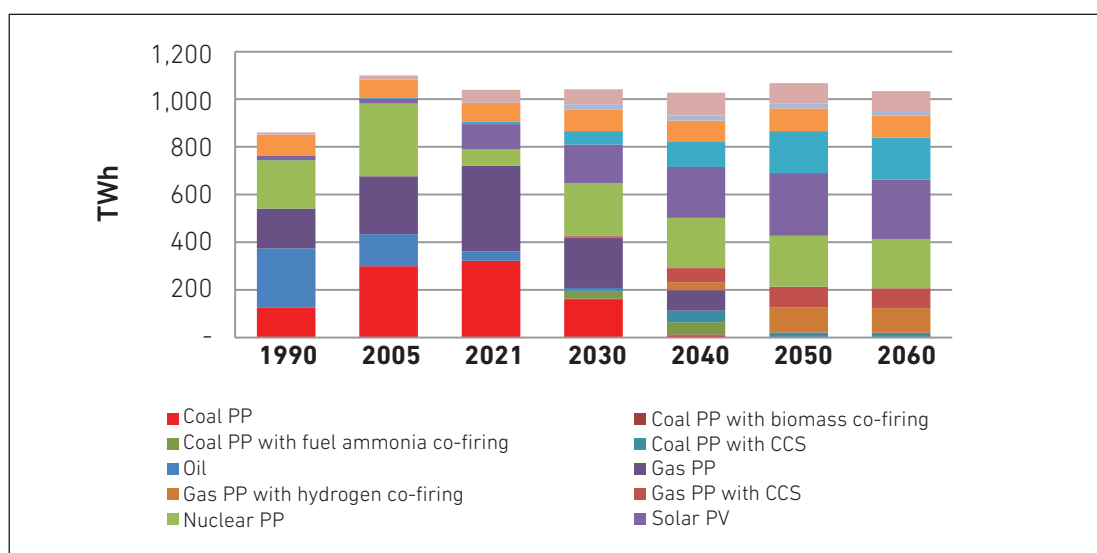
Mtoe = million tonnes of oil equivalent.

Source: Author.

## 4. Power Generation

Under LCET, power generation by 2060 is projected to reach 1,034 terawatt-hours. Despite rapid electrification and rising demand for green hydrogen, electricity generation in 2060 will remain close to 2021 levels. However, total energy supply will decline to 51% of 2021 levels due to major efficiency gains. Variable renewable energy (VRE), including solar PV and wind, will provide 41% of total power generation. As VRE output is unstable, backup storage and grid expansion will be necessary. Other renewables – hydropower, geothermal, and biomass – will contribute 19%, whilst nuclear energy will supply 20%. The remaining 20% will come from thermal power, evenly split between hydrogen-fired generation and coal and natural gas with CCS.

**Figure 8.9. Power Generation, Low-carbon Energy Transition Scenario, 1990–2060**



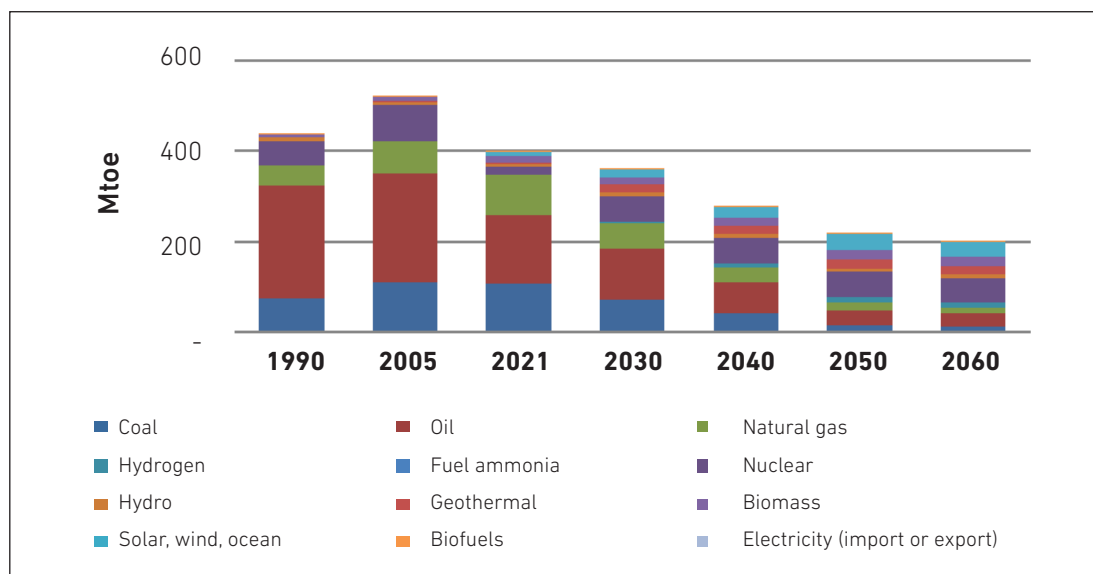
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author.

## 5. Primary Energy Supply

Under LCET, PES will decline alongside the reduction in final energy demand, reaching an estimated 204 Mtoe by 2060 (Figure 8.10). The share of fossil fuels, which made up 87% of PES in 2021, will shrink to 27% by 2060. However, even in this progressively decarbonised scenario, fossil fuel demand will not disappear entirely. Securing a stable fossil fuel supply will remain a key component of energy policy.

**Figure 8.10. Primary Energy Supply by Source, Low-carbon Energy Transition Scenario, 1990–2060**



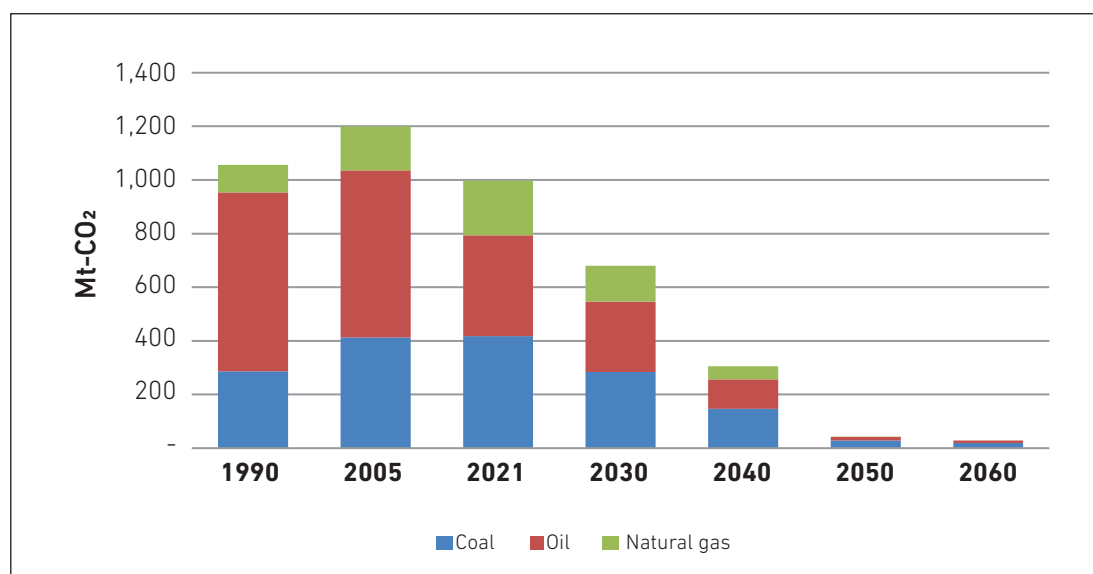
Mtoe = million tonnes of oil equivalent.

Source: Author.

## 6. Carbon Dioxide Emissions

Under LCET, CO<sub>2</sub> emissions will decline more rapidly than the current trend (Figure 8.11). The scenario is consistent with the NDC target for energy-related CO<sub>2</sub> emissions in 2030 – a 45% reduction from 2013 levels. By 2060, some fossil fuel use will remain, as certain demands cannot be fully met by carbon-free energy sources, resulting in about 6 Mt-CO<sub>2</sub> of residual emissions from coal and oil. These will be offset by negative emissions technologies, such as biomass with CCS and forestry initiatives, ensuring carbon neutrality.

**Figure 8.11. Carbon Dioxide Emissions from Energy, Low-carbon Energy Transition Scenario, 1990–2060**

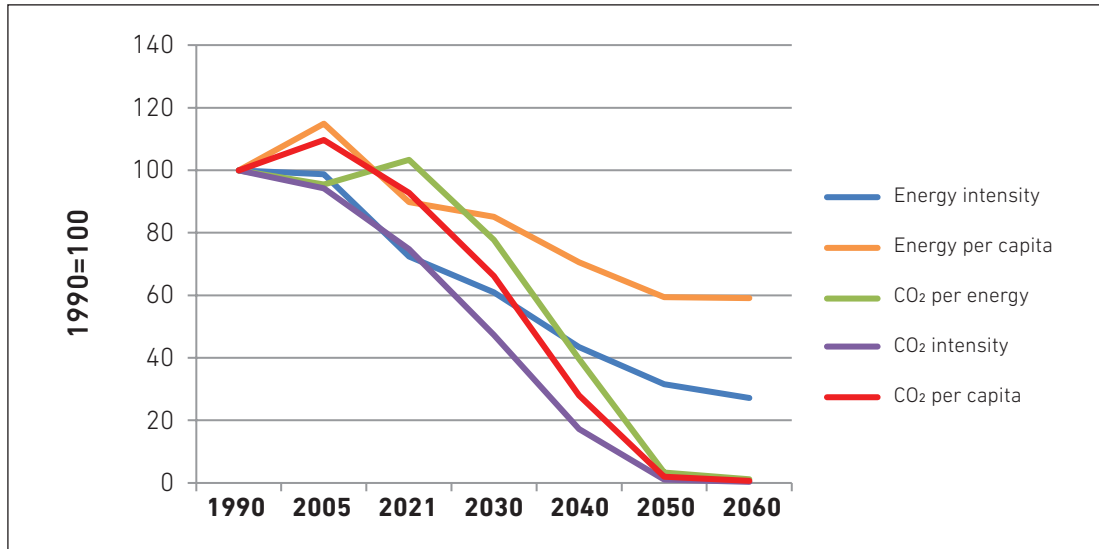


Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

Energy intensity – measured as PES per unit of GDP – and CO<sub>2</sub> emissions per unit of energy will decline at average annual rates of 2.5% and 10.8%, respectively, in 2021–2060 (Figure 8.12). As a result, CO<sub>2</sub> intensity will decrease at an average annual rate of 13.1% over the same period.

**Figure 8.12. Indices of Energy and Carbon Dioxide Intensities, Energy per Capita, and Carbonisation Rate, Low-carbon Energy Transition Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Author.

## 7. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

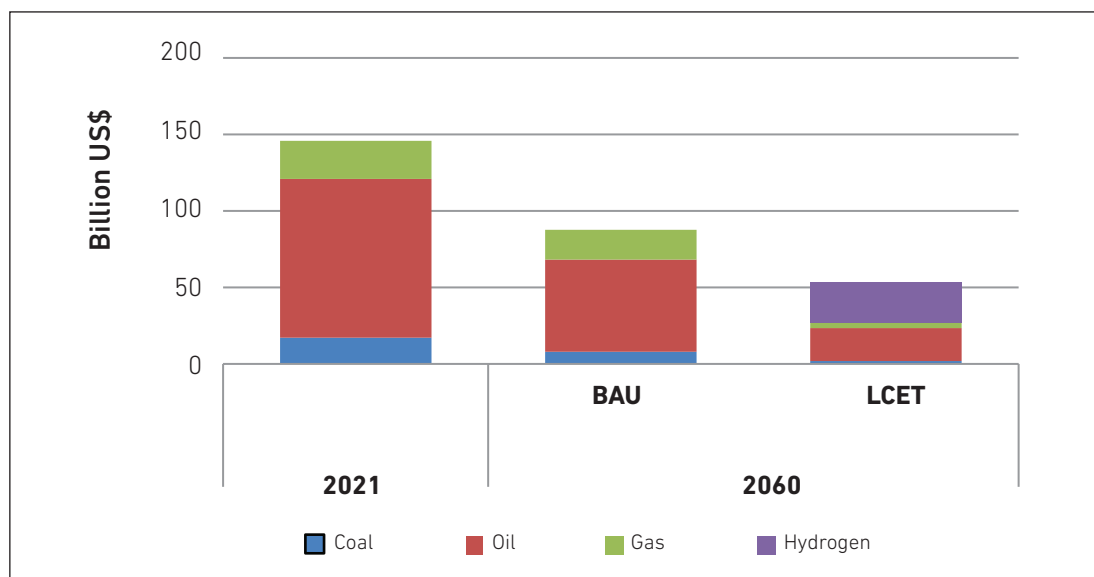
To assess the cost of the energy transition, key energy-related expenditures – fuel, investment in power generation, and CCS – are evaluated for both BAU and LCET based on outlook results. All values in this section are expressed in real 2020 US dollars.

### 7.1. Fuel Costs

Under LCET, fuel costs in 2060 are projected at US\$54 billion – significantly lower than under BAU due to reduced fossil fuel demand. Although LCET involves additional costs for hydrogen, total fuel expenditure remains about 60% of that under BAU. However, this assessment relies on ambitious assumptions about cost reductions for hydrogen and ammonia; actual costs may vary depending on technological progress.



**Figure 8.13. Fuel Costs**



BAU = business as usual, LCET = low-carbon energy transition.

Note: The cost of hydrogen includes only imported hydrogen and excludes the cost of green hydrogen to avoid double counting with power generation investment.

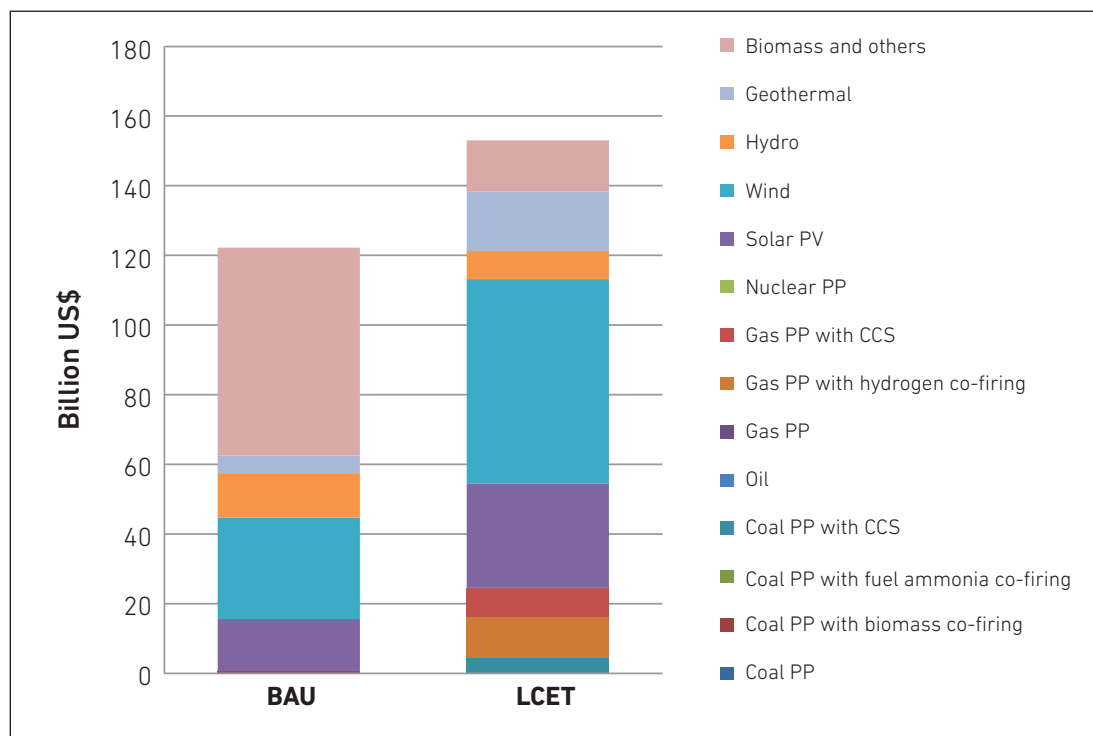
Source: Author.

## 7.2. Power Generation Investment

The cost of power generation investment is estimated by multiplying the unit cost of each energy source by the increase in installed capacity by 2060.

Under LCET, cumulative capital investment in power generation in 2021–2060 is projected at US\$153 billion – more than 1.5 times the investment required under BAU. Large-scale investment will be needed for solar PV and wind power.

**Figure 8.14. Power Generation Investment**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, PV = photovoltaic.

Source: Author.

### 7.3. Carbon Capture and Storage Cost

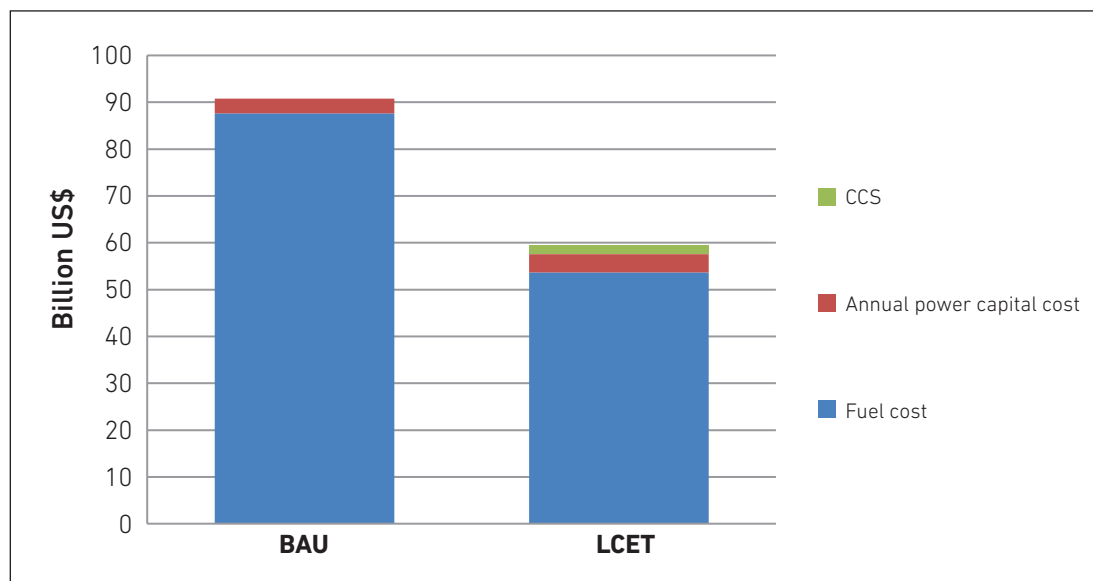
This cost element covers expenditures related to the implementation of CCS in gas- and coal-fired power generation.

BAU does not include CCS, resulting in no associated costs. In contrast, LCET assumes CCS will be applied to all coal- and gas-fired power plants, with total capture and storage costs estimated at US\$1.8 trillion.

### 7.4 Overall Cost

Fuel costs, power generation investments, and CCS costs have been evaluated. The total annual cost in 2060, including these elements, is projected at US\$59 billion (Figure 8.15).

**Figure 8.15. Energy Cost Comparison Under Business-as-Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Note: All costs are presented on an annual basis. This evaluation excludes expenditures for energy efficiency improvement, as well as energy storage, distribution, and transmission.

Source: Author.

Due to the significant reduction in fuel costs, total expenditure under LCET is projected to be less than half that of BAU. However, this does not necessarily imply that the cost of achieving carbon neutrality is low.

A key factor in LCET is the significant reduction in energy demand through efficiency improvements. This assessment does not include associated costs, which can vary widely and are difficult to estimate accurately. The cost per unit of energy saved tends to rise as more energy is conserved, potentially becoming a major additional cost element in LCET.

## 8. Conclusions and Policy Recommendations

Japan's net-zero policy shows that energy demand and CO<sub>2</sub> emissions can be reduced. However, net-zero emissions cannot be achieved under BAU, where CO<sub>2</sub> emissions by 2060 are projected to remain at 54% of 2021 levels. This indicates that achieving carbon neutrality will require greater CO<sub>2</sub> reduction efforts than those assumed in forecast-based scenarios such as BAU. In contrast, LCET, a backcasting approach based on achieving carbon neutrality by 2050, addresses this challenge.

Nonetheless, CO<sub>2</sub> reduction is not the sole focus of energy policy. Japan's fundamental approach is guided by the 3E+S principle: environment, energy security, economic efficiency + safety. Whilst LCET prioritises environmental goals, it also presents challenges for the other two Es – energy security and economic efficiency.

### (i) Energy Security

- o Under LCET, fossil fuels will account for only 27% of PES but will remain a necessary energy source. Ensuring a stable supply – from upstream investments to downstream infrastructure maintenance – will remain essential.
- o Electricity and hydrogen will largely replace fossil fuels, but energy security concerns related to these sources must also be addressed.
  - Electricity must be supplied reliably, in greater quantities than at present, and without CO<sub>2</sub> emissions. By 2060, electricity generation under LCET is projected to be nearly the same as in 2021. The government has already designated renewable energy as the main power source.
  - To ensure stability, it is essential to expand dispatchable capacity and strengthen the ability to manage fluctuations in renewable output. Investment in thermal power generation, which provides this flexibility, is hindered by volatile wholesale electricity prices and decarbonisation policies. Nonetheless, policy efforts must continue to secure sufficient capacity through 2060 and in the interim.
- o Hydrogen will primarily be sourced through water electrolysis and imports, given Japan's limited fossil fuel resources. Building strong relationships with supplier countries and developing an international hydrogen market – similar to existing fossil fuel supply networks – will be essential. At the same time, efforts to achieve carbon neutrality are expected to significantly increase Japan's energy self-sufficiency rate, from 13% in 2021 to 65% in 2050 under LCET.

### (ii) Economic Efficiency

- o Energy costs are another critical concern. Whilst the costs of solar PV and wind power – both key components of electricity generation – are declining, additional investment will be needed in batteries to manage output, transmission infrastructure, and other supporting systems. In general, as the share of VRE increases, the cost per kilowatt-hour tends to rise cumulatively. It is therefore important to diversify the energy mix by including nuclear power, hydrogen, and fossil fuels with CCS, rather than relying too heavily on renewables.
- o The costs associated with energy efficiency improvements are expected to be enormous. Whilst the cost evaluation indicates that carbon neutrality efforts may lower fuel and power generation costs, it does not fully reflect the expenses of energy conservation measures, such as installing high-efficiency equipment or modifying operational practices.

Achieving carbon neutrality using only existing and mature technologies is highly challenging. LCET includes emerging solutions such as CCS and hydrogen, which will require substantial financial and technical support from the government. During the transition period, around 2040, current technologies and facilities will need to coexist with developing technologies such as hydrogen and CCS. A careful and strategic approach to replacing existing systems with new ones is essential to maintain energy supply stability throughout the transition.

## References

Ministry of Economy, Trade and Industry Japan (2021), Cabinet Decision on the Sixth Strategic Energy Plan (accessed 30 September 2024).

Ministry of Economy, Trade and Industry Japan (2024), General Energy Statistics (accessed 30 September 2024).

International Monetary Fund (2023), World Economic Outlook October 2023 (accessed 30 June 2023).

United Nations Population Division, World Population Prospects (accessed 30 June 2023).

# Chapter 9

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## Republic of Korea Country Report

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of Korea

# 1. Background: Current Socioeconomic Situation, Energy Situation, and Energy Development Plan

The Republic of Korea (henceforth Korea) is located in the southern half of the Korean Peninsula with an area of 100,188 square kilometres, including about 3,000 mostly small, uninhabited islands. Korea is a mountainous country with lowlands accounting for only 30% of the total land area. The climate is temperate, with heavy rainfall in summer. As of 2022, Korea had a population of 51,673,000, over 90% of whom live in urban areas. Korea has recorded tremendous economic growth over the past half century, overcoming the Asian financial crisis in 1998 and the global financial crisis in 2007–2008. However, in the aftermath of the global financial crisis, growth has slowed. The Korean economy quickly recovered from the adverse growth fallout from the novel coronavirus disease (COVID-19) pandemic and recorded a high economic growth rate of 4.1% in 2021. However, in 2022, the economic growth rate slowed down to 2.6% due to sluggish exports caused by worsening external conditions (KDI, 2023).

Since the 1990s, the Korean government has implemented a series of policies to facilitate its low-carbon energy transition and achieve carbon neutrality by 2050. These policies cover various sectors, including energy production, residential buildings, social innovation, and renewable energy deployment. Below is a list of key policies and a brief description of each that demonstrate the nation's commitment to sustainability, technological innovation, and active citizen participation.

- **2050 Carbon Neutrality Strategy:** This comprehensive plan aims to transform the Korean economy into a sustainable and green one. Key elements include reducing greenhouse gas (GHG) emissions across all sectors, enhancing energy efficiency, and promoting the use of renewable energy sources.
- **Green New Deal:** Launched as a post-COVID-19 economic stimulus plan, the Green New Deal focuses on green urban development, low-carbon decentralised energy, and innovative green industries. It aims to build a low-carbon, climate-neutral economy whilst protecting vulnerable sectors during the transition.
- **Renewable Energy 3020 (RE3020):** This ambitious plan's goal is to increase the share of renewable energy in electricity generation up to 20% by 2030. It aims to create new jobs in the renewable energy sector, contributing to economic growth and employment opportunities, aligned with global efforts to reduce GHG emissions and mitigate climate change, and by diversifying energy sources, the plan aims to strengthen Korea's energy security and reduce vulnerability to external shocks.
- **Hydrogen Economy Roadmap:** The goal of the roadmap is for Korea to become a global leader in the hydrogen economy with hydrogen cars and fuel cells as two major axes, whilst proposing the hydrogen economy as a growth engine of innovative technology and a driving force of eco-friendly energy. The roadmap includes policy directions, goals, and implementation strategies of hydrogen production, storage, transportation, and revitalising the hydrogen economy by 2040.
- **The First Basic Plan for Implementing the Hydrogen Economy:** The plan, published in November 2021, set hydrogen supply and demand targets for 2030 and 2050 and proposed various strategies and tasks. A number of demonstration projects and research are underway, and the hydrogen industry is steadily expanding along with strengthening the legal and institutional foundation and promoting private investment in the future.

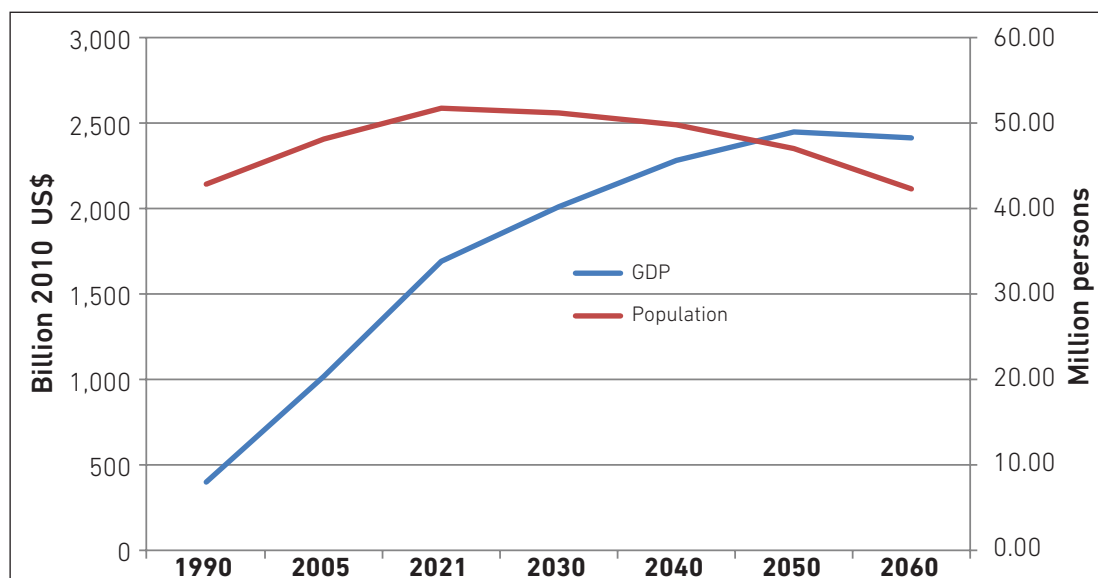
- **Basic Plans for Electricity Demand and Supply:** The plans, focusing on the government's long-term target and strategy for meeting the nation's electricity needs, play a crucial role in shaping the nation's sustainable energy future in response to the current global electrification platform. These electricity basic plans consist of projected electricity demand, planned power generation facilities, and measures for managing electricity consumption.
- **Basic Plans for Rational Energy Use:** The government has announced a variety of policy tools and programmes to attain the nation's energy saving target such as voluntary agreements, energy audits, energy service companies, appliance labelling and standards, fuel economy, and public transit and mode shifting.

## 2. Analysis of Business-as-Usual Results

### 2.1. Final Energy Consumption

Korea's total final energy consumption in 2021 was 181.7 million tonnes of oil equivalent (Mtoe), increasing at an average annual rate of 3.4% from that in 1990. The industry sector accounted for 26.1% of final energy consumption in 2021, followed by non-energy (29.2%) and transport (25.1%). Whilst the consumption of coal has gradually decreased, natural gas in the final energy consumption share rapidly grew at a rate of 11.9% per annum between 1990 and 2021. In the case of oil, despite its increase in volume, the share in the final energy consumption has continued to shrink.

**Figure 9.1. Assumptions for Gross Domestic Product and Population (1990–2060)**



GDP = gross domestic product.

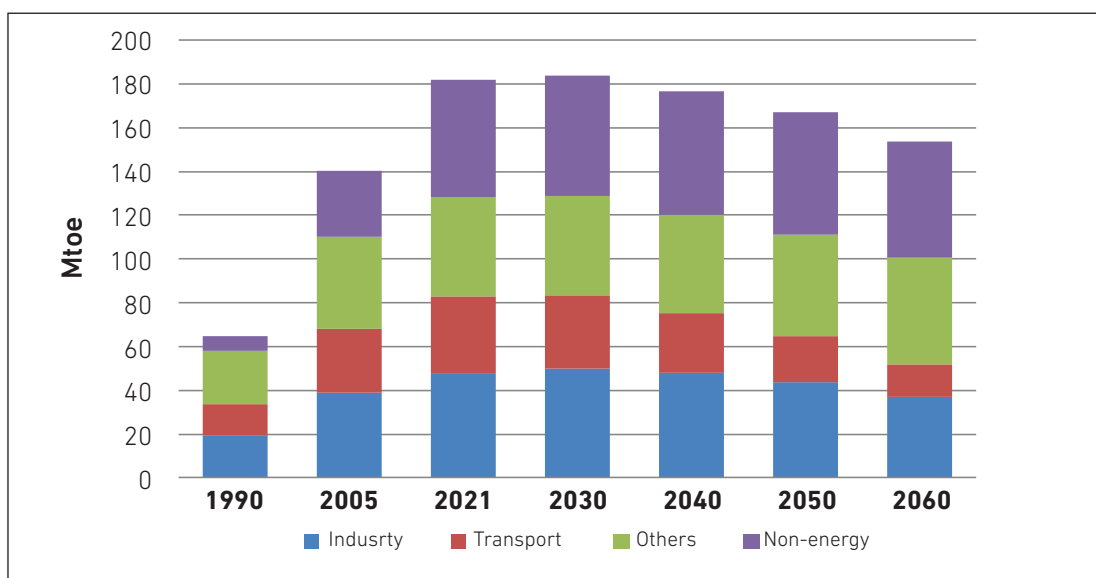
Sources: Korea Development Institute (KDI) (2022), Prospects and Implications for Long-Term Economic Growth; Statistics Korea (2023), Long-term Estimation of Population: 2022–2072.



## Final energy consumption by sector

Based on assumptions of gross domestic product (GDP) and population between 2021 and 2060 shown in Figure 9.1, final energy demand is projected to grow at an average annual growth rate (AAGR) of  $-0.4\%$  from 181.70 Mtoe in 2021 to 153.72 Mtoe in 2060 under the business-as-usual (BAU) scenario. This is largely due to the negative growth in energy consumption in the transport sector, which is projected to decrease at an AAGR of  $-2.2\%$  between 2021 and 2060, followed by the industry and the non-energy sectors at  $-0.6\%$  and  $0.2\%$  per annum, respectively (Figure 9.2). All sectors are expected to slow down or show a negative AAGR.

**Figure 9.2. Final Energy Consumption by Sector, Business-as-Usual Scenario**



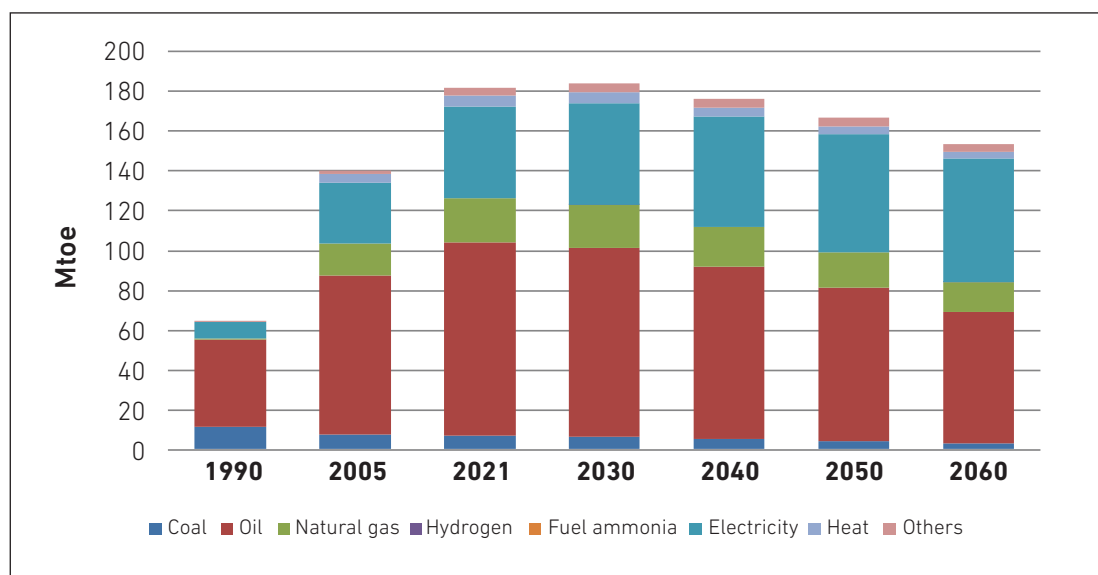
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## Final energy consumption by energy source

Final energy consumption by energy source is expected to be patterned after energy consumption by sector. The AAGR shows  $-1.9\%$  for coal,  $-1.0\%$  for oil,  $-1.0\%$  for natural gas,  $0.8\%$  for electricity, and  $-1.1\%$  for heat over the period between 2021 and 2060 (Figure 9.3). Coal, oil, and natural gas consumption will gradually decrease, showing a negative growth rate. Heat energy consumption is anticipated to follow the same pattern as oil because of the expected decrease in population and the changing lifestyle oriented towards using more electricity for heating. The case of oil is more noticeable due to the decreasing energy consumption in the transport sector caused by an increasing deployment of electric vehicles. Other energy types, including new and renewable energies, will increase as clean and green energy will contribute considerably to reduced carbon dioxide (CO<sub>2</sub>) emissions.

**Figure 9.3. Final Energy Consumption by Energy Source, Business-as-Usual Scenario**



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

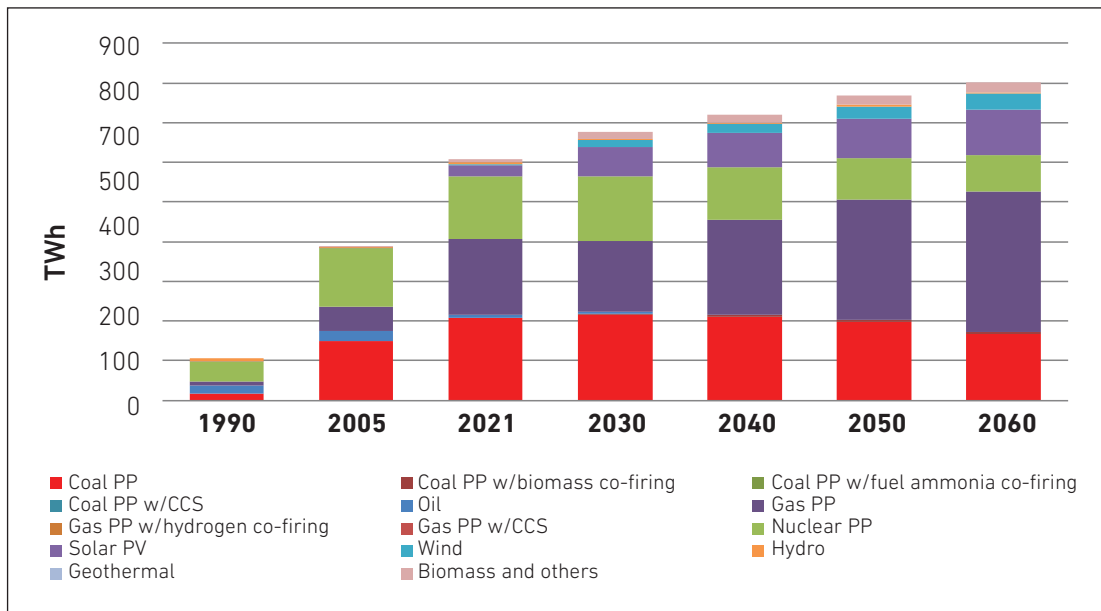
## 2.2. Power Generation

In 2021, electric power generation amounted to 608.08 terawatt-hours (TWh), with the share of coal at 34.3%, followed by natural gas at 31.3%, and nuclear power at 26.0%. Total electricity consumption grew at an AAGR of 5.8% between 1990 and 2021. When broken down by fuel type, coal increased at an annual rate of 8.3%, natural gas at 10.1%, and nuclear at 3.6% between 1990 and 2021. Over the same period, oil had a negative annual growth rate of  $-2.7\%$  whilst hydro had  $-2.3\%$ . Meanwhile, other energy sources such as new and renewable energy have grown rapidly, with solar photovoltaic (PV) cells in particular having grown amazingly quickly at an annual rate of 39.2%.

### Business-as-usual scenario

As shown in Figure 9.4, electric power generation in the BAU scenario is projected to increase from 608.08 TWh in 2021 to 802.48 TWh in 2060. In terms of fuel mix in the power generation, it is predicted that coal-fired power generation is expected to decrease at an AAGR of  $-0.6\%$  between 2021 and 2060. Oil's share will continue to reduce until 2040, and thereafter there will no longer be any power generation by oil. The share of nuclear power shows a similar trend, reducing slowly, reaching 11.4% in 2060 compared to 26.0% in 2021. On the contrary, the share of natural gas is predicted to reduce slightly, reaching 26.7% in 2030, then to increase slowly, reaching 44.4% in 2060. In the case of new and renewable energies, including solar PVs, wind power, and biomass, their share is expected to increase up to 22.7% in 2060 compared to 7.1% in 2021.

**Figure 9.4. Electricity Generation by Energy Source, Business-as-Usual Scenario**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculations.

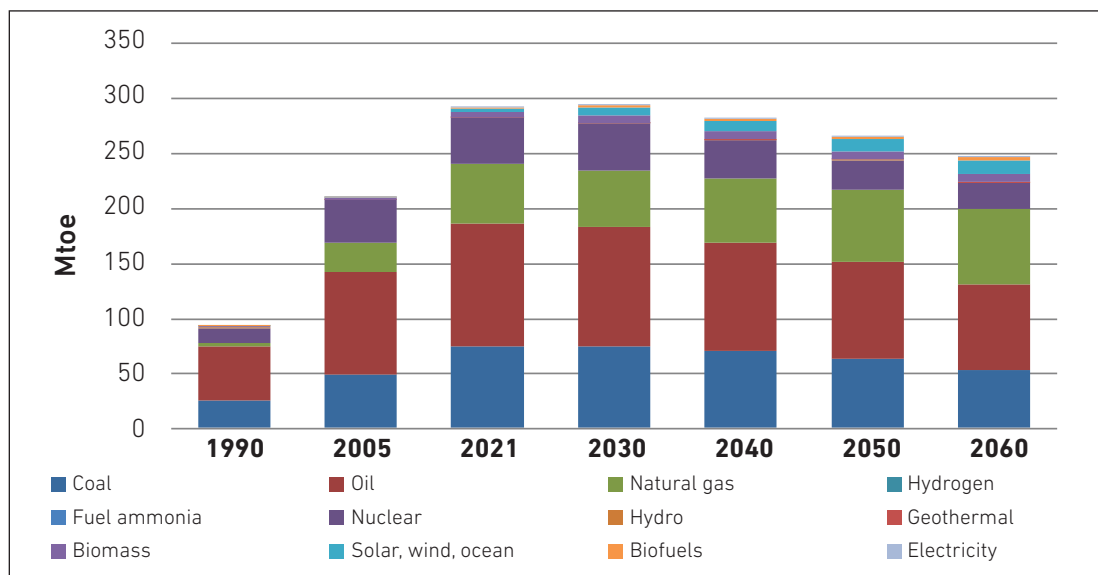
## 2.3. Primary Energy Supply

The total primary energy supply in 2021 was 291.8 Mtoe, increasing at an AAGR of 3.8% from 92.91 Mtoe in 1990. Although primary energy consumption is dominated by oil and coal, nuclear power and natural gas also supply a significant share of the country's primary energy. The strongest growth occurred in natural gas (10.1% per annum), followed by others such as renewable energy (8.4% per annum), coal (3.6% per annum), and nuclear (3.6% per annum). On the other hand, oil has increased at a relatively slower 2.6% per annum.

### Business-as-usual scenario

In the BAU scenario, the primary energy supply in Korea is expected to decrease at an AAGR of -0.4%, from 291.8 Mtoe in 2021 to 246.63 Mtoe in 2060. All major energy sources show negative AAGRs except for natural gas. Whilst growth of natural gas is slowing down at an AAGR of 0.6%, coal, oil, and nuclear show negative AAGRs of -0.8%, -0.9%, and -1.4% respectively, between 2021 and 2060. On the other hand, other energy sources such as new and renewable energies show a fast speed of growth at an AAGR of 2.4% with its share of 3.1% in 2021 to 9.2% in 2060. Also, hydrogen, even if at a small scale, is projected to grow quickly from 2030 (Figure 9.5).

**Figure 9.5. Primary Energy Supply by Fuel, Business-as-Usual Scenario**



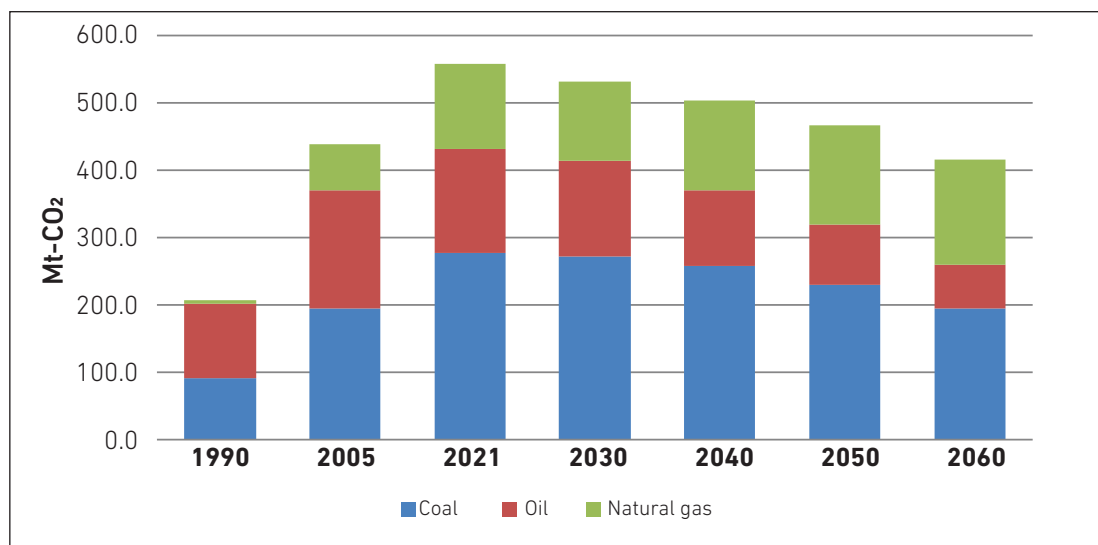
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 2.4. CO<sub>2</sub> Emissions by Fuel

CO<sub>2</sub> emissions from energy consumption in the BAU scenario are projected to decrease at an AAGR of  $-0.8\%$ , from 558.6 million tonnes of CO<sub>2</sub> (Mt-CO<sub>2</sub>) in 2021 to 416.1 Mt-CO<sub>2</sub> in 2060 (Figure 9.6). Such a decreasing rate is faster than that in primary energy consumption. This indicates that Korea will be using fewer carbon-intensive fuels such as nuclear, natural gas, and renewable energy and employing more energy-efficient green technologies.

**Figure 9.6. CO<sub>2</sub> Emissions by Fuel Type, Business-as-Usual Scenario**



Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>.

Source: Author's calculations.

## 3. Analysis of the Low-carbon Energy Transition Scenario

### 3.1. Concept of the Scenario

The global effort to achieve net-zero carbon requires innovation in the energy sector. The energy sector accounts for approximately 75% of global carbon emissions. The main levers for the energy sector to achieve carbon neutrality are low-carbon energy transition and carbon neutrality (LCET-CN) including energy reduction through behaviour change, energy efficiency, clean energy, electrification, carbon capture, utilisation, and storage (CCUS), etc. Electrification, which increases the proportion of electricity in final energy consumption, is being considered by countries around the world as a major means of carbon neutrality.

The energy sector is the leading contributor of GHG emissions, making the low-carbon energy transition a global trend since GHG emissions affect global warming and climate change, the most important issues globally. To achieve carbon neutrality by 2050, the overall structure of the energy sector needs to be transformed in addition to reducing the use of fossil fuels. Consequently, most countries are trying to transform their energy systems from the current fossil energy-oriented one to a sustainable green energy-oriented one relying on energy efficiency and renewable energy.

In this context, the Republic of Korea has established and implemented several basic plans and roadmaps as introduced in Section 1. The government takes these basic plans and roadmaps as stepping stones to mobilise nation-wide resources in relevant energy sectors to reduce CO<sub>2</sub> emissions in response to the historic Paris Agreement in 2015 as well as the global trend of energy transition to a sustainable energy system.

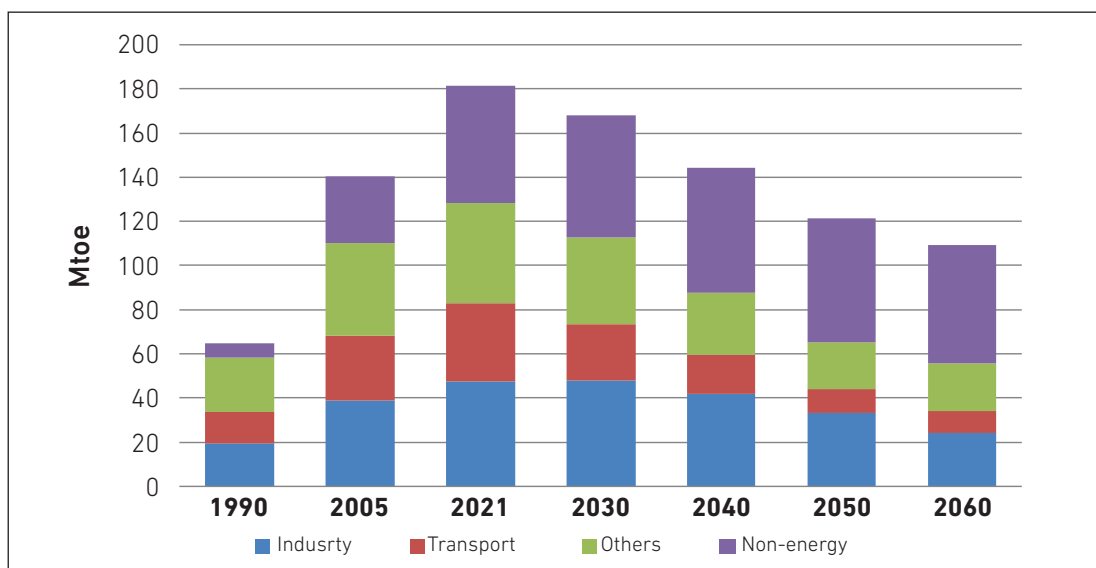
Despite these efforts and government's commitment, these are not enough. In order to cost-effectively implement these plans supported by consensus amongst stakeholders and national participants, it should be preceded or directly followed by technical as well as economic feasibility analyses based on calculations of investment costs in terms of fuel costs, power generation, carbon capture and storage (CCS), etc. With this in mind, the Korean government has prepared a technology-specific path to achieve carbon neutrality in the power generation based on social consensus on the social costs and benefits that may occur in the transition to carbon neutrality.

## 3.2. Final Energy Consumption

### Final energy consumption by sector: LCET scenario

The total final energy demand in the LCET scenario is to be reduced to 109.2 Mtoe, a decrease of 72.6 Mtoe or 40.0% from 181.7 Mtoe in 2021 at a negative AAGR of –1.3% (Figure 9.7). The transport sector shows the fastest decreasing rate at –3.2% per annum, followed by the 'others' sector at –1.9% per annum. The share of final energy demand by sector shows a structural change from 2021. Whilst the share of transport is forecast to decrease quickly, the share of industry and 'others' sectors will slowly decrease at first and decrease more quickly later. The share of the non-energy sector will increase at a faster speed, reaching 49.1 % in 2060.

**Figure 9.7. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario**

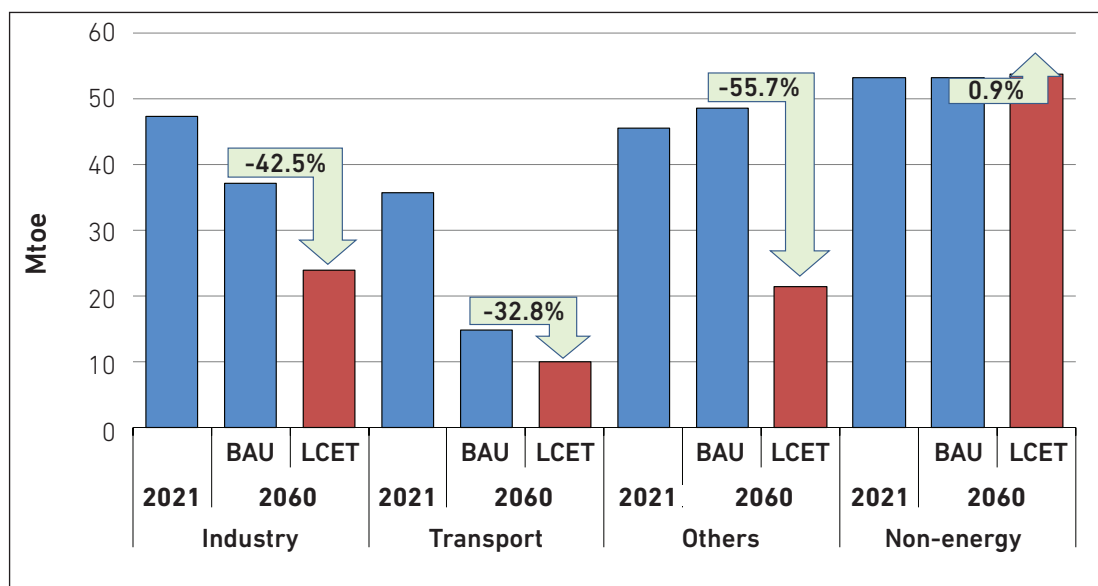


Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Energy savings between the BAU and LCET scenarios in the final energy consumption is estimated to be 44.566 Mtoe, which is 29.0% of BAU (Figure 9.8). Whilst energy consumption in the LCET scenario will decrease in all sectors, non-energy consumption will increase by 0.9% compared to that in the BAU scenario.

**Figure 9.8. Final Energy Consumption by Sector, Business-as-Usual vs Low-carbon Energy Transition Scenarios**



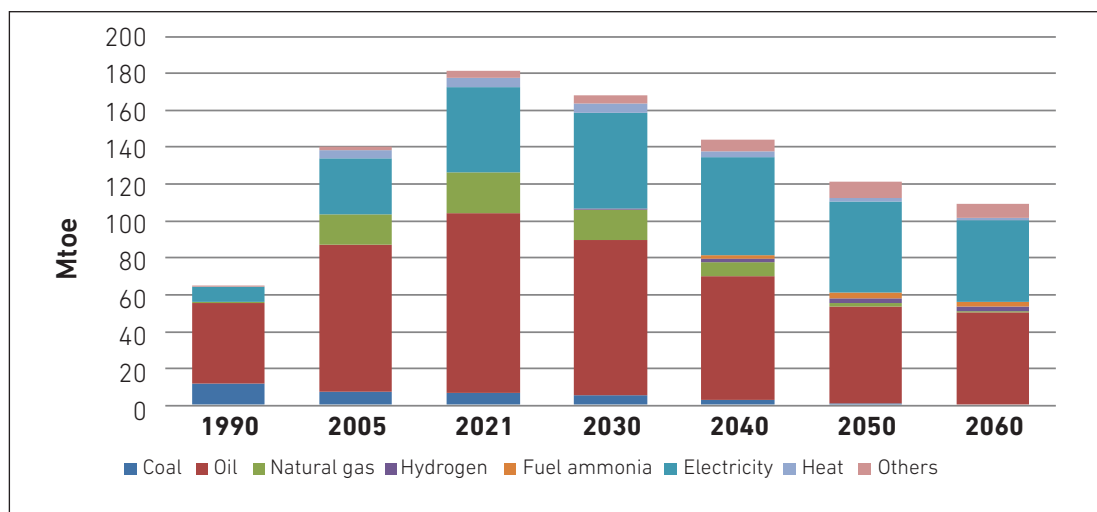
BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

### Final energy consumption by energy source: LCET scenario

Figure 9.9. shows the final energy consumption by source. Oil will continue to be a dominant energy source, accounting for 45.4% of the share, followed by electricity (40.4%), hydrogen/ ammonia (4.8%), and natural gas (0.7%) in 2060. Coal will be marginalised at a share of 0.6% as a minor energy source for industrial, residential, and commercial use. Others such as biomass, heat, and other renewable energies, are expected to increasing their share from 5.1% in 2021 to 8.1% in 2060.

**Figure 9.9. Final Energy Consumption by Fuel Type,  
Low-carbon Energy Transition Scenario**



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

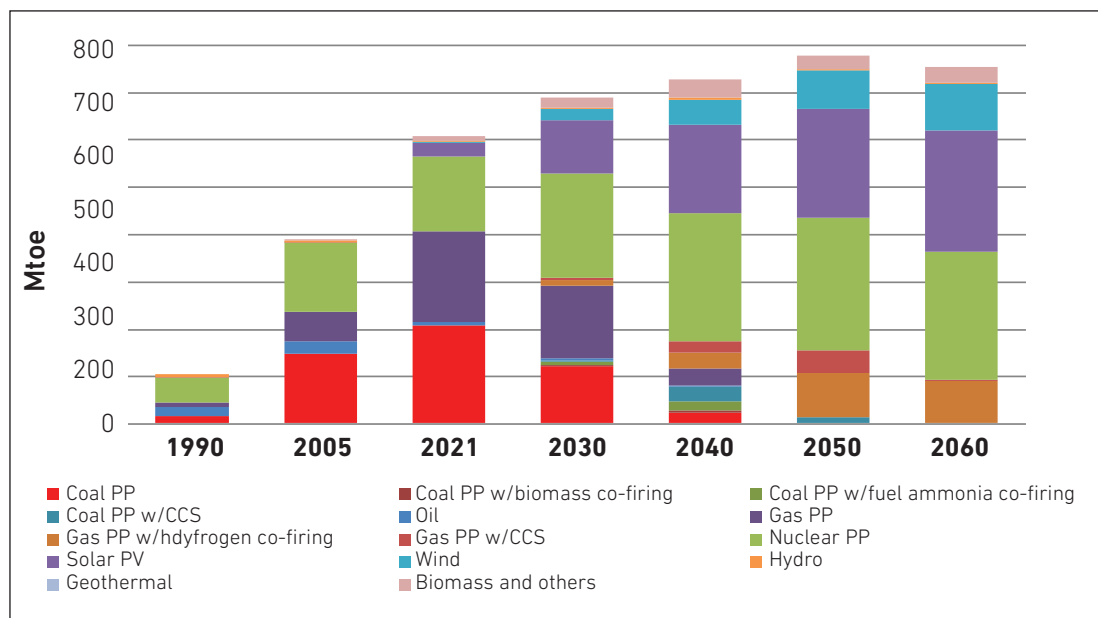
### 3.3. Power Generation: Low-carbon Energy Transition Scenario

As shown in Figure 9.10, electric power generation in the LCET scenario is projected to increase from 608.1 TWh in 2021 to 752.9 TWh in 2060. In terms of fuel mix in the power generation, it is predicted that clean and carbon-free energy sources, such as solar PV cells and wind power, will experience a rapid increase. Power generation by fossil fuels equipped with CCS will replace the existing coal and natural gas power plants. The fuel mix is expected to include hydrogen, making up approximately 12% of the total. Other fuels, including nuclear and other renewables, are expected to hold higher shares in the fuel mix.

In the case of coal-fired power plants, it is predicted that they will gradually decrease and disappear completely by 2060. Coal-only-fired power plants, in particular, will no longer operate from 2040, but from 2030, some existing coal-fired power plants, cofired with biomass or ammonia, will continue to operate until the expiration of the facility life. On the other hand, a number of facilities equipped with CCS in existing coal-fired power plants will operate until 2040, but will no longer be in operation after 2050. Gas-fired power plants will undergo a similar path but with a bigger scale and later exit. However, gas-fired power plants with hydrogen co-firing and equipped with CCS will continue to be in operation after 2060. Oil will remain as small-scale electricity generators to supply electricity in remote areas or supporting equipment for a micro-grid with renewable energies.



**Figure 9.10 Electricity Generation, Low-carbon Energy Transition Scenario**



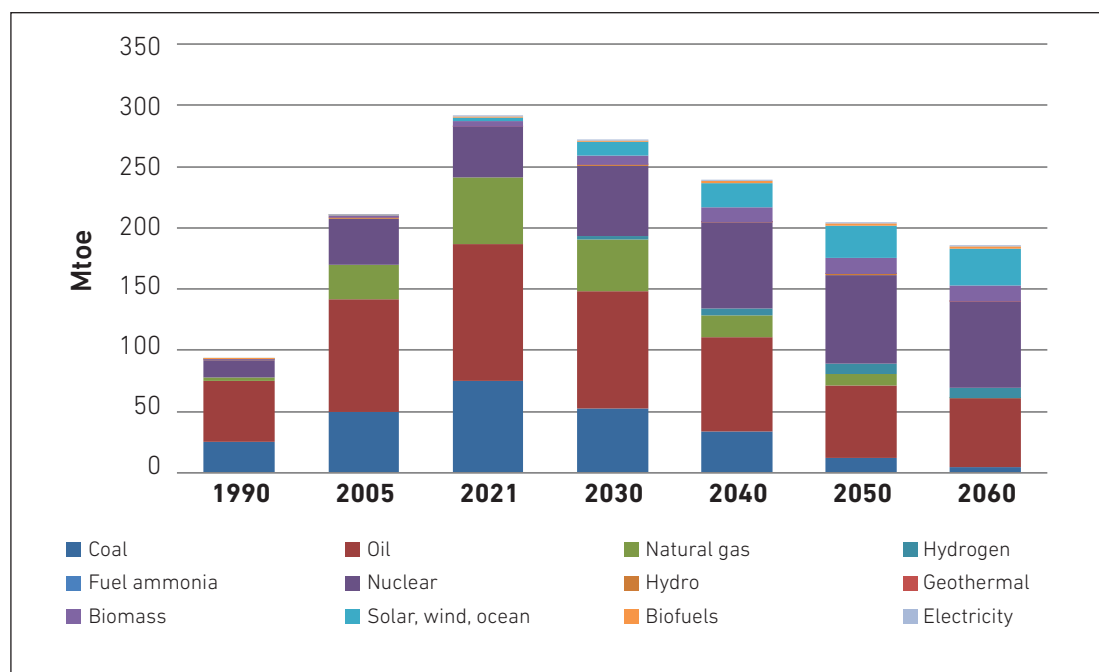
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculations.

### 3.4. Primary Energy Supply: Low-carbon Energy Transition Scenario

In the LCET scenario, primary energy supply is projected to decrease at an AAGR of  $-1.2\%$  from 291.76 Mtoe in 2021 to 185 Mtoe in 2060. Supply of fossil fuels, such as coal, oil, and natural gas will gradually decrease between 2021 and 2060, with natural gas at an AAGR of  $-10.5\%$ , followed by coal ( $-6.7\%$ ) and oil ( $1.8\%$ ). On the other hand, the supply of clean energy such as hydropower and new and renewable energy will increase by  $4.1\%$  per annum over the projection period as shown in Figure 9.11. Aggressive implementation of energy efficiency and conservation measures on the demand side, along with a larger uptake of renewable energy on the supply side and accelerated adoption of CCS in power generation by coal and gas, will be the major contributors to reduced fossil fuel consumption.

**Figure 9.11. Total Primary Energy Supply, Low-carbon Energy Transition Scenario**

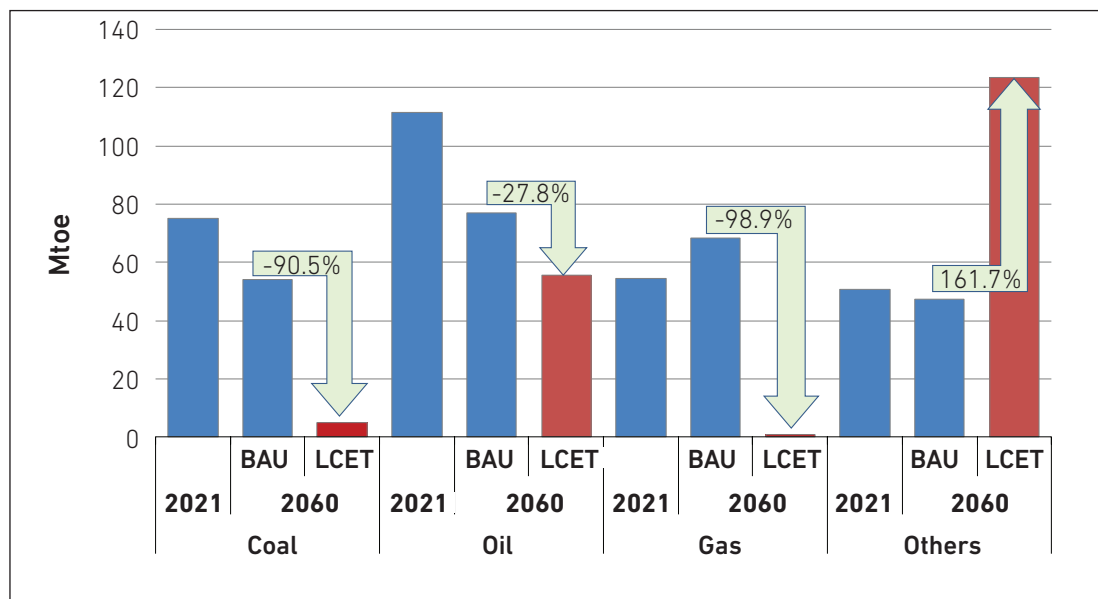


Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

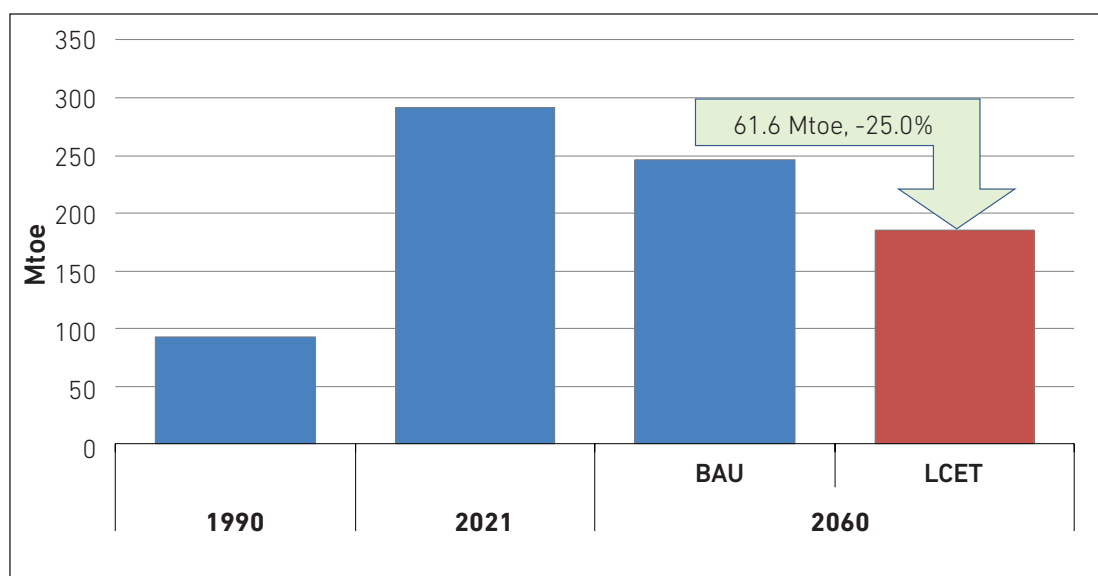
Figure 9.12 shows the comparison between the BAU and LCET scenarios in primary energy consumption by energy and in total, respectively, whilst Figure 9.13 shows the comparison in primary energy supply.

**Figure 9.12 Primary Energy Consumption by Energy,  
Business-as-Usual vs Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.  
Source: Author's calculations.

**Figure 9.13. Primary Energy Supply, Business-as-Usual  
vs Low-carbon Energy Transition Scenarios**

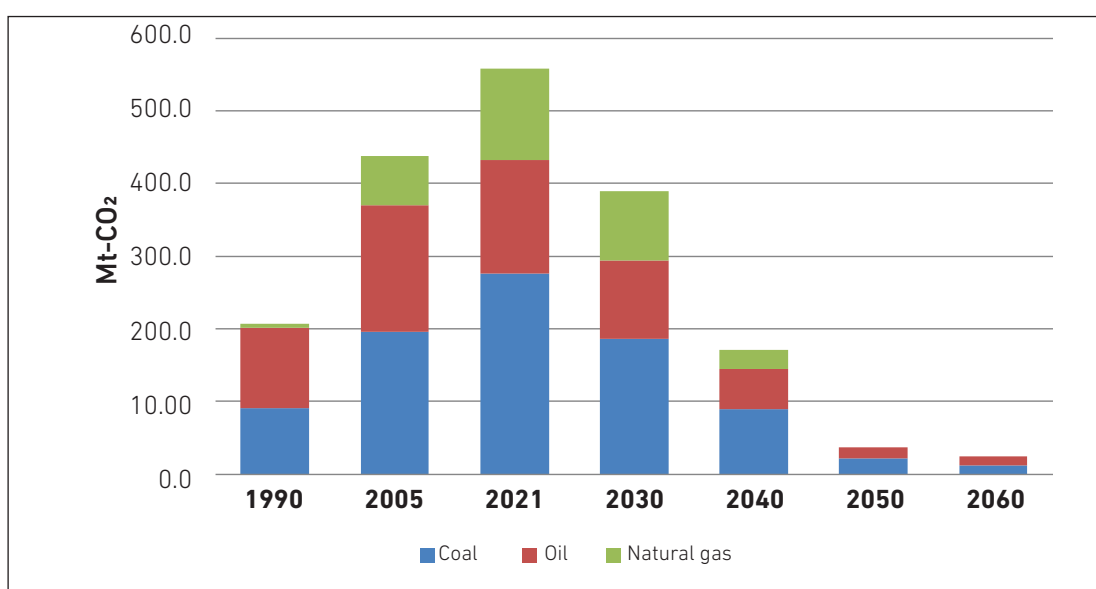


BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent  
Source: Author's calculation.

### 3.5. CO<sub>2</sub> Emissions: Low-carbon Energy Transition Scenario

CO<sub>2</sub> emissions from energy consumption in the LCET scenario are projected to abruptly decrease at an AAGR of –8.5%, from 558.6 Mt-CO<sub>2</sub> in 2021 to 17.4 Mt-CO<sub>2</sub> in 2060 (Figure 9.14). Such a negative growth rate is much lower than that of primary energy consumption which is estimated to be –1.2% per annum. This indicates that Korea will be using fewer carbon-intensive fuels such as nuclear, natural gas, and renewable energy and employing more energy-efficient green technologies. To attain such an ambitious target, the Korean government must develop and implement cost-effective and consensus-based action plans to save energy and reduce CO<sub>2</sub> emissions.

**Figure 9.14. CO<sub>2</sub> Emissions, Low-carbon Energy Transition Scenario**



Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>.

Source: Author's calculations.

## 4. Energy Cost Comparison between Business-as-Usual vs Low-carbon Energy Transition Scenarios

This section conducts an analysis on energy cost in order to compare the cost difference between the BAU and LCET scenarios. This analysis enables us to estimate the total investment cost in implementing policies and programmes under the LCET scenario in comparison with the BAU scenario. The basic assumptions for this analysis are shown in Tables 9.1, 9.2, and 9.3.

**Table 9.1. Assumptions for Fuel Costs**

| Energy Source (units)            | 2020/2021 | 2060 <sup>1)</sup> |
|----------------------------------|-----------|--------------------|
| Coal (US\$/tonne)                | 80.03     | 98.00              |
| Oil (US\$/bbl)                   | 41        | 100                |
| Gas (US\$/MMBtu)                 | 7.77      | 7.50               |
| Hydrogen (US\$/Nm <sup>3</sup> ) | 0.8       | 0.3                |
| CCS (US\$/CO <sub>2</sub> tonne) | 0         | 60                 |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = metric million British thermal unit, Nm<sup>3</sup> = normal cubic metre.

Note: <sup>1)</sup> 2019 constant price.

Source: Author's calculations.

**Table 9.2. Assumptions for Construction Cost of Power Plants  
(US\$/KW)**

| Fuel Source                 | 2021  | 2060 <sup>1)</sup> |
|-----------------------------|-------|--------------------|
| Coal                        | 1,500 | 1,525              |
| Coal co-firing with biomass | -     | 1,600              |
| Coal co-firing with ammonia | -     | 1,600              |
| Coal with CCS               | -     | 1,525              |
| Oil                         | 600   | 600                |
| Gas                         | 700   | 700                |
| Gas co-firing with hydrogen | -     | 800                |
| Gas with CCS                | -     | 700                |
| Nuclear                     | 4,500 | 3,575              |
| Hydro                       | 2,000 | 2,223              |
| Geothermal                  | 4,000 | 4,256              |
| Solar                       | 1,600 | 307                |
| Wind                        | 1,600 | 1,235              |
| Biomass                     | 2,000 | 3,019              |

CCS = carbon capture and storage, KW = kilowatt.

Note: <sup>1)</sup> 2019 constant price.

Source: Author's calculations.

**Table 9.3. Assumptions for Capacity Factors of Power Plants**  
(%)

| Fuel Source                 | 2021 | 2060 <sup>1)</sup> |
|-----------------------------|------|--------------------|
| Coal                        | 75   | 80                 |
| Coal co-firing with biomass | -    | 80                 |
| Coal co-firing with ammonia | -    | 80                 |
| Coal with CCS               | -    | 80                 |
| Oil                         | 75   | 80                 |
| Gas                         | 75   | 80                 |
| Gas co-firing with hydrogen | -    | 80                 |
| Gas with CCS                | -    | 80                 |
| Nuclear                     | 100  | 80                 |
| Hydro                       | 50   | 40                 |
| Geothermal                  | 50   | 50                 |
| Solar                       | 17   | 17                 |
| Wind                        | 40   | 40                 |
| Biomass                     | 50   | 70                 |

Note: <sup>1)</sup> 2019 constant price.

Source: Author's calculations.

## 4.1. Fuel Costs

Based on fuel costs assumed for each of energy sources as shown in Table 9.1, the total investment fuel cost of the BAU and LCET scenarios in 2060 compared to those in 2021 was calculated as shown in Table 9.4. Primary energy consumption in the LCET scenario will be 77.35 Mtoe, which is much lower than that of BAU scenario at 199.44 Mtoe. Primary energy consumptions in 2060 compared with those in 2021 by BAU and LCET scenarios are calculated as shown in Table 9.4. The total investment fuel cost in 2060 in the LCET scenario is estimated to be reduced by US\$46,503 million, which is a lot bigger than that under the BAU scenario at US\$22,977 million. Amongst energy sources, coal is expected to decrease the fastest, followed by oil and gas. In the case of natural gas, primary energy consumption is expected to increase in 2060 under the BAU scenario, but, is expected to decrease under the LCET scenario. Hydrogen as a newly-emerging clean and carbon-free energy source is expected to enter under the LCET scenario.

**Table 9.4. Total Investment by Energy Source, Business-as-Usual vs Low-carbon Energy Transition Scenarios**

|              | Primary Energy Consumption (Mtoe) |               |              | Total Investment (US\$ million) |                |                |
|--------------|-----------------------------------|---------------|--------------|---------------------------------|----------------|----------------|
|              | BAU                               |               | LCET         | BAU                             | LCET           | LCET-BAU       |
|              | 2021                              | 2060          | 2060         | 2060-2021                       | 2060-2021      |                |
| Coal         | 74.99                             | 53.89         | 5.12         | -3,335                          | -11,042        | -7,707         |
| Oil          | 111.55                            | 77.08         | 55.64        | -23,705                         | -38,455        | -14,750        |
| Gas          | 54.40                             | 68.47         | 0.73         | 4,063                           | -15,497        | -19,560        |
| Hydrogen     | 0.00                              | 0.00          | 15.87        | 0                               | 18,491         | 18,491         |
| <b>Total</b> | <b>240.94</b>                     | <b>199.44</b> | <b>77.35</b> | <b>-22,977</b>                  | <b>-46,502</b> | <b>-23,526</b> |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 4.2. Power Generation Investment

Based on assumptions for power generation investment shown in Table 9.2 and Table 9.3, the total investment cost for power plants was calculated in 2060 for the BAU and LCET scenarios shown in Table 9.5. The total additional capacity required by 2060 under the BAU scenario is 95,201 megawatts (MW) since 2021. However, the additional capacity under the LCET scenario is estimated to be 213,413 MW which is much bigger than that under the BAU scenario. This is due to more aggressive uptake of renewable energy for power plants in 2060 under the LCET scenario in pursuit of greater reduction in CO<sub>2</sub> emissions. Accordingly, the total investment for power plants in 2060 under the BAU scenario is estimated to be US\$56,858 million whereas it is estimated to be US\$159,814 million under the LCET scenario.

**Table 9.5. Total Investment in Power Plants, Business-as-Usual vs Low-carbon Energy Transition Scenarios**

|                                | Power Generation (TWh) |      |      | Additional Capacity (MW) |           | Total Investment (US\$ million) |           |
|--------------------------------|------------------------|------|------|--------------------------|-----------|---------------------------------|-----------|
|                                | BAU                    |      | LCET | BAU                      | LCET      | BAU                             | LCET      |
|                                | 2021                   | 2060 | 2060 | 2021-2060                | 2021-2060 | 2021-2060                       | 2060-2021 |
| Coal PP                        | 208                    | 167  | 0    | 0                        | 0         | 0                               | 0         |
| Coal PP with biomass co-firing | 0                      | 4    | 0    | 610                      | 0         | 977                             | 0         |
| Coal PP with ammonia           | 0                      | 0    | 0    | 0                        | 0         | 0                               | 0         |
| Coal PP with CCS               | 0                      | 0    | 0    | 0                        | 0         | 0                               | 0         |
| Oil                            | 8                      | 0    | 0    | 0                        | 0         | 0                               | 0         |

**Table 9.5. Continued**

|                                      | Power Generation (TWh) |            |            | Additional Capacity (MW) |                | Total Investment (US\$ million) |                |
|--------------------------------------|------------------------|------------|------------|--------------------------|----------------|---------------------------------|----------------|
|                                      | BAU                    |            | LCET       | BAU                      | LCET           | BAU                             | LCET           |
|                                      | 2021                   | 2060       | 2060       | 2021–2060                | 2021–2060      | 2021–2060                       | 2060–2021      |
| Gas PP                               | 190                    | 357        | 0          | 23,731                   | 0              | 16,661                          | 0              |
| Gas PP with H <sub>2</sub> co-firing | 0                      | 0          | 90         | 0                        | 12,892         | 0                               | 10,314         |
| Gas PP with CCS                      | 0                      | 0          | 3          | 0                        | 409            | 0                               | 286            |
| Nuclear PP                           | 158                    | 92         | 271        | 0                        | 16,129         | 0                               | 57,661         |
| Solar PV                             | 23                     | 114        | 257        | 57,516                   | 153,409        | 17,658                          | 47,097         |
| Wind                                 | 3                      | 40         | 97         | 10,402                   | 26,769         | 12,846                          | 33,059         |
| Hydro                                | 3                      | 4          | 3          | 145                      | 112            | 322                             | 249            |
| Geothermal                           | 0                      | 0          | 0          | 0                        | 0              | 0                               | 0              |
| Biomass and others                   | 9                      | 26         | 31         | 2,797                    | 3,692          | 8,445                           | 11,147         |
| <b>Total</b>                         | <b>608</b>             | <b>802</b> | <b>753</b> | <b>95,201</b>            | <b>213,413</b> | <b>56,858</b>                   | <b>159,814</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, MW = megawatt, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author's calculations.

### 4.3. Carbon Capture and Storage Costs

Power generation, fuel consumption, and investment cost for CCS were calculated for power generation by coal-fired and natural gas-fired power plants equipped with CCS. Assuming that CCS devices can capture up to 90% of CO<sub>2</sub> emissions and the average cost of capture is about US\$60/CO<sub>2</sub> tonne, the total investment for CCS is estimated to be US\$1.67 million for gas-fired power plants.

**Table 9.6. Total Investment for Carbon Capture and Storage under Low-carbon Energy Transition Scenario in 2060**

|                        | Power Generation (TWh) | Fuel Consumption (Mtoe) | CO <sub>2</sub> Emissions (Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emissions (Mt-C) | Total Investment (US\$ million) |
|------------------------|------------------------|-------------------------|-------------------------------------------------|----------------------------------|---------------------------------|
| Coal-fired PP with CCS | 0.00                   | 0.00                    | 0.00                                            | 0.00                             | 0                               |
| Gas-fired PP with CCS  | 2.87                   | 0.47                    | 0.03                                            | 0.01                             | 1.67                            |
| <b>Total</b>           | <b>2.87</b>            | <b>0.47</b>             | <b>0.03</b>                                     | <b>0.01</b>                      | <b>1.67</b>                     |

CCS = carbon capture and storage, Mt-C = million tonnes of carbon, Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>, Mtoe = million tonnes of oil equivalent, PP = power plant, TWh = terawatt-hour.

Source: Author's calculations.



## 4.4. Energy Savings

Total energy saved pursuant to the LCET scenario in the final energy consumption is estimated to be 44.57 million Mtoe as shown in Table 9.7. Amongst energy sources, electricity is the largest to be saved, 17.73 Mtoe (39.78%), followed by oil, 16.62 Mtoe, 37.29%, and gas, 14.10 Mtoe, 31.64%. Energy savings by sector is shown in Table 9.8 in which the others sector such as residential and commercial sectors share more than half, 27.09 Mtoe, 55.75%, followed by the industry sector, 13.08 Mtoe, 29.35% and the transport sector 4.87 Mtoe, 10.93%.

**Table 9.7. Energy Savings, Carbon Capture and Storage and Low-carbon Energy Transition Scenarios by Energy Source**

|              | BAU(a)<br>(Mtoe) | LCET(b)<br>(Mtoe) | LCET vs BAU  |              |               |
|--------------|------------------|-------------------|--------------|--------------|---------------|
|              |                  |                   | Mtoe(c)      | c/a (%)      | Share (%)     |
| Coal         | 3.36             | 0.67              | 2.69         | 80.06        | 6.04          |
| Oil          | 66.16            | 49.54             | 16.62        | 25.12        | 37.29         |
| Gas          | 14.89            | 0.79              | 14.10        | 94.69        | 31.64         |
| Hydrogen     | 0.00             | 2.77              | -2.77        | -            | -6.21         |
| Ammonia      | 0.00             | 2.49              | -2.49        | -            | -5.59         |
| Electricity  | 61.83            | 44.10             | 17.73        | 28.68        | 39.78         |
| Heat         | 3.56             | 1.30              | 2.26         | 63.48        | 5.07          |
| Biomass      | 3.91             | 7.49              | -3.57        | -            | -8.01         |
| <b>Total</b> | <b>153.72</b>    | <b>109.15</b>     | <b>44.57</b> | <b>28.99</b> | <b>100.00</b> |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

**Table 9.8. Energy Savings, Carbon Capture and Storage and Low-carbon Energy Transition Scenarios by Sector**

|              | BAU(a)<br>(Mtoe) | LCET(b)<br>(Mtoe) | LCET vs BAU  |              |               |
|--------------|------------------|-------------------|--------------|--------------|---------------|
|              |                  |                   | Mtoe(c)      | c/a (%)      | Share (%)     |
| Industry     | 37.11            | 24.03             | 13.08        | 35.25        | 29.35         |
| Transport    | 14.85            | 9.98              | 4.87         | 32.79        | 10.93         |
| Others       | 48.59            | 21.51             | 27.09        | 55.75        | 60.78         |
| Non-energy   | 53.17            | 53.64             | -0.47        | -            | -1.05         |
| <b>Total</b> | <b>153.72</b>    | <b>109.15</b>     | <b>44.57</b> | <b>28.99</b> | <b>100.00</b> |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 4.5. Overall Cost

Based on the above calculation results, it is possible to compare total costs between the LCET and the BAU scenarios as shown in Table 9.9. Overall investment cost under the BAU scenario in 2060 is projected to be US\$56,858 million, whilst the investment cost in the LCET scenario is estimated at US\$159,814 million. The total investment cost in the LCET scenario will increase 18.6% of that amount in the BAU scenario. However, when power capital cost is reflected, i.e. US\$56,858 million and US\$159,814 million for the BAU and LCET scenarios, respectively, the overall cost of LCET at US\$113,313 million is expected to be more than three times as much as that of BAU at US\$33,882 million.

**Table 9.9. Energy Cost Comparison, Carbon Capture and Storage and Low-carbon Energy Transition Scenarios in 2060 (US\$ million)**

|                           | BAU(a)         | LCET(b)        | LCET vs BAU   |              |
|---------------------------|----------------|----------------|---------------|--------------|
|                           |                |                | b-a           | (b-a)/a (%)  |
| Fuel cost in 2060         | -22,977        | -46,502        | -23,525       | 102.38       |
| Annual power capital cost | 1,485          | 4,098          | 2,613         | 175.96       |
| CCS in 2060               | 0              | 2              | 2             | -            |
| Energy saving in 2060     | 0              | 16,876         | 16,876        | -            |
| <b>Total (1)</b>          | <b>-21,519</b> | <b>-25,527</b> | <b>-4,034</b> | <b>18.75</b> |
| Power capital cost        | 56,858         | 159,814        | 102,956       | 181.1        |
| <b>Total (2)</b>          | <b>33,882</b>  | <b>113,313</b> | <b>79,431</b> | <b>134.4</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Author's calculations.

## 5. Implications and Policy Implications

Up to now, starting with a series of assumptions on fuel costs and construction costs as well as capacity factors of power plants by energy source, investment costs under the BAU and the LCET scenarios were calculated and compared with each other in terms of primary energy supply, power generation, CCS, and energy savings followed by overall cost analysis.

## 5.1. Conclusions

As compared to those in 2021, the total investment cost by energy source in the LCET scenario is estimated to lead to a reduction in the total investment cost by US\$25,526 million, which is somewhat bigger compared to that in the BAU scenario at US\$21,527 million in the energy sector alone. It is ensured that the Republic of Korea will be able to attain the target of net zero by 2050 by implementing all policy measures available under the LCET scenario. In addition, it will lead to a reduction in the total investment by US\$4,034 million compared to that in the BAU scenario in the energy sector alone.

Amongst investment costs, only the fuel cost is estimated to be reduced by US\$46,502 million, which covers more than increases in power capital cost and CCS, along with energy savings. This indicates that fuel cost is critical in terms of share and capital investment. Investment in CCS is estimated to reach US\$1,667 million in 2060. If more policy efforts are taken along with technological advancements, the investment cost of CCS is expected to be reduced by a bigger margin.

In addition to these investments, accumulated power capital cost from 2021 to 2060 is estimated to US\$159,814 million in the LCET scenario compared to US\$56,858 million, which indicates that the overall cost in the LCET scenario reaches 134% higher than that in the BAU one. In this context, the Korean government has to put a lot of effort in terms of research and development as well as financial support to reduce the total cost in the coming years.

## 5.2. Policy Recommendations

As the worldwide economy is quickly entering into a transition to respond to the climate crisis, the importance of climate issues has emerged in the context of strengthening global industrial competitiveness. Under international pressure, in response to the Paris Agreement, the Korean government established the 2030 Nationally Determined Contribution in June 2015 and prepared the Basic Roadmap for Achieving 2030 Nationally Determined Contribution at the end of 2016, which embodies the implementation of the goal. As a follow-up to this initiative, specific implementation measures for each sector were presented to achieve the goals, such as the Energy Carbon Neutral Innovation Strategy (Korean Government, 2021) and the Carbon Neutral Vision and Strategy for Industry and Energy (MOTIE, 2021).

Energy transition and carbon neutrality are becoming an irreversible global trend. The government is proactively implementing the Energy Transition, Carbon Neutral, and Green New Deal policies and the Hydrogen Economy Roadmap. In this context, the LCET scenario indicates an ambitious CO<sub>2</sub> reduction target compared to the BAU scenario. Investment costs show a big margin between the BAU and LCET scenarios, calling for an exceptional effort in policy development and implementation. The government must develop and implement cost-effective and nation-wide consensus-based action plans to reduce CO<sub>2</sub> emissions by a huge margin. The government should take a more balanced approach in response to addressing the LCET scenario, reviving nuclear power by abandoning the previous government's denuclearisation policy. It is also necessary to continue the hydrogen economy and Renewable Energy 3020 along with fossil fuels with CCUS.

## References

Korea Development Institute (KDI) (2023), KDI Economic Outlook |Update.

Ministry of Trade, Industry and Energy (MOTIE) (2021), Carbon Neutrality Vision and Strategy for Industry and Energy.

Korean Government (2021), Energy Carbon Neutral Innovation Strategy.



# Chapter 10

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## Lao People's Democratic Republic Country Report

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# 1. Current Social and Economic Situation, Energy Situation, and Energy Development Plan

The Lao People's Democratic Republic (Lao PDR) is rich in natural resources, especially water resources, with the geographical location along the coast of rivers and tributaries that are potential for water resources. Including the suitability of the landscape that is conducive to the development of hydropower also has the potential to develop coal thermal power, solar, wind, and biomass. Since 1971, the energy sector has developed the infrastructure of energy sources continuously and in a progressive manner, which can produce energy to provide domestic consumption and export more than 10,000 megawatts (MW) (including projects completed in 2020).

In its Ninth Five-Year National Socio-Economic Development Plan (2021–2025), the Lao PDR government has made the use of renewable energy and the promotion of electric vehicles a priority in promoting green growth and addressing climate change mitigation. In addition, the Nationally Determined Contribution's (NDC) conditional mitigation measures, which were updated in 2024, call for net-zero emissions by 2050, and aim to promote the introduction of renewable energy as well as electric vehicles and biofuels. Major greenhouse gas (GHG) emissions in the energy sector come from coal-fired power plants for export and the transport sector, which consumes transport fuel produced from crude oil, and they are challenges.

The Lao PDR is rich in clean and renewable hydropower resources, with 89.68% or 8,924 MW of its 10,971 MW installed capacity in 2021 coming from hydropower. Therefore, since its GHG emissions are lower than those of other Asian countries, it has the potential to contribute to the low carbonisation of neighbouring countries through the maximum utilisation of existing hydropower and other renewable energy resources, taking into account the environmental and social impact.

On the other hand, the power system has a large generation capacity compared to the capacity required for domestic power supply, and a surplus of electricity during the rainy season has become apparent. Possible measures include increasing domestic demand during the rainy season, increasing exports from the domestic power system to neighbouring countries, reducing supply during the rainy season, and increasing supply during the dry season. Future electricity demand trends will be greatly influenced by the creation of untapped industries in addition to existing industries. In addition to exploring potential domestic electricity demand, it is necessary to set up a policy framework with clear goals, as it is expected to contribute to a low-carbon and decarbonised society in neighbouring countries in the Mekong region through the export of clean electricity.

## 1.1. Power Demand

The Lao PDR's energy consumption from 2000 to 2020 had an average growth rate of about 13% per year. In the period from 2000 to 2012, the sector with the highest percentage of electricity consumption was the residential sector. From 2013 to 2018, it was seen that the industry sector had a higher growth trend, making this the sector with the highest percentage of electricity consumption. In 2020, the country's total electricity demand will be 7.779 million kilowatt-hours (KWh) per year, with a growth rate of 18% compared to 2019. The highest consumption of electricity in the country was 1.299 MW in June 2020, which had a growth rate of about 6% compared to 2019.

## 1.2. Electricity Production

The Lao PDR is a nation with a wealth of natural resources, particularly water resources, and a mountainous topography that make it suitable for development as a hydropower source. Since 1970, the Lao PDR has been developing projects for the production of electricity. Public sector investment, public sector collaboration with the private sector, and private investors are all involved in the Lao PDR's electricity production projects. State-owned businesses that take part in co-investments as the government's proxies for shareholders are state-owned enterprises. Currently, the percentage of generation for export and domestic service of Independent Power Producer or IPP (export), IPP (import) coverage of 91.12%, whilst 8.88% is managed by Électricité du Laos (EDL) and the EDL-Generation Public Company (EDL-GEN). By the end of 2020, the country had total installed capacity of 10,091 MW.

From 2011 to 2020, EDL had been purchasing, selling, and exchanging electricity with other countries. When it rains, the Lao PDR produces more electricity than is needed, which allows the country to export it. Producing less electricity during the dry season means that producers must import electricity to balance domestic demand. Additionally, the Lao PDR imports electricity to serve the border regions where the EDL grid system does not reach.

From 2011 to 2020, total import of 11.212 million KWh, the average annual import is about 1.121 million KWh per year.

From 2011 to 2020, the total of 13.646 million KWh of electricity was exported from EDL's system, the average annual export is about 1.365 million KWh per year.

Electricity is imported using the high voltage transmission line systems in Vientiane, Thakhek, Savannakhet, and Borikhamxay, and sometimes using several medium voltage distribution systems adjacent to the borders of Viet Nam, China, and Thailand.

## 1.3. Power Transmission Line Systems

The development of power transmission lines and distribution systems is one of the fundamental factors of the electricity sector, which is important to drive the country's economy to achieve the goals of the national socioeconomic development plan. The transmission line plays a significant role as the connection point between electricity supply and demand, linking generation sourced to substations and the distribution system to ensure power reached each sector for consumption. There are also social responsibilities such as the stability and long-term sustainability of the system. From 2011 until 2020, the government has focused on the expansion of electricity production sources to ensure domestic electricity consumption increases and exports are increased. In response to this problem, it has directly affected the development of the electricity transmission lines and the distribution systems. It requires a huge investment in the development of transmission lines and electricity distribution systems to match reality. Therefore, in the period from 2010 to 2016, to plan to cope with the leap in investment, the development of the electricity production source, the planning of the development of the transmission line systems, and the distribution systems of the relevant sectors, the following responsibilities are required:



- First, the Ministry of Energy and Mines is responsible for promoting the sale of electricity abroad as well as commenting on the electricity development plan and EDL's distribution system to be in line with the socioeconomic development plan that is laid out as the period.
- Second, EDL-GEN has the task of investing in the electricity production sources and EDL has the role of managing and creating a plan to connect the electricity transmission lines to the whole system, at the same time ensuring the stability of the system nation-wide.

## 2. Modelling Assumption

The Lao PDR's energy model, as with the other Association of Southeast Asian Nations (ASEAN) Member Countries, was developed using the Low Emissions Analysis Platform (LEAP) software, previously known as Long-range Alternative Planning System. LEAP is used to project energy balance tables based on final energy consumption and energy input and/or output in the transformation sector. Final energy consumption is forecast using energy demand equations by energy and sector and future macroeconomic assumptions.

Estimation of energy demand function was done using the econometric approach, a top-down approach linking macroeconomic model with energy model. The historical correlation between energy demand as well as macroeconomic and activity indicators were derived by regression analysis using Microfit, an interactive software package designed especially for the econometric modelling of time series data. The historical energy demand data were based on the energy statistics of the Department of Energy Policy and Planning and the Department of Planning and Cooperation, the Ministry of Energy and Mines of the Lao PDR, whilst the socioeconomic data were obtained from the World Bank's World Development Indicators and the Lao Statistics Bureau of the Ministry of Planning and Investment (Ministry of Mines and Energy, the Lao PDR, and Economic Research Institute for ASEAN and East Asia, 2020).

Not all consumption in each of the sectors or subsectors can be explained by a demand function. In cases where regression analysis is not applicable due to insufficient data or failure to derive a statistically sound equation, it is not necessary to estimate the demand function. In this regard, the energy demand is forecasted using other assumptions such as related to gross domestic product (GDP) growth or existing programmes or targets.

### Macroeconomy

Growth in energy consumption is driven by socioeconomic factors such as population, economic growth, vehicle ownership, and access to electricity. This study covers the period 2021 to 2060.

The population and economic growth assumed for the Lao PDR is shown in Table 10.1. The GDP and population trajectories through to 2060 will grow at an annual rate of 5.4% and 1.5%, respectively. Energy demand is expected to be driven by GDP and population, with coal constitutes the major share of total primary energy supply (TPES), whilst oil dominates total final energy consumption (TFEC) in the current situation.

**Table 10.1. Population and Gross Domestic Product Prospect**

|                      | Historical Data |      | Projection |      |      |      |       |                       |
|----------------------|-----------------|------|------------|------|------|------|-------|-----------------------|
|                      | 1990            | 2005 | 2021       | 2030 | 2040 | 2050 | 2060  | AAGR (%)<br>2021–2060 |
| GDP (billion US\$)   | 2.7             | 6.7  | 19.1       | 27.9 | 48.5 | 84.5 | 147.1 | 5.4                   |
| Population (million) | 4.3             | 5.9  | 7.4        | 8.5  | 9.9  | 11.4 | 13.3  | 1.5                   |

AAGR = average annual growth rate, GDP = gross domestic product.

Source: Authors. Data are processed using Microfit.

### Scenario

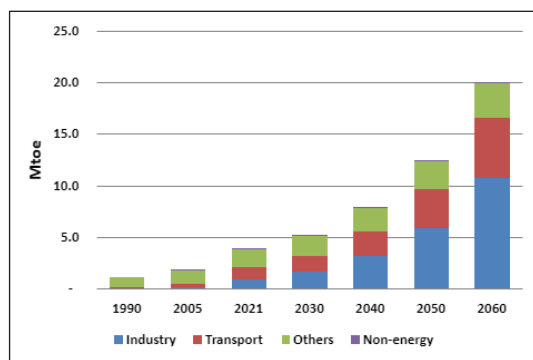
Energy supply and demand are projected under two scenarios in this study. The business-as-usual (BAU) scenario reflects the continuation of past trends, incorporating existing energy and environmental policies and technologies. The low-carbon energy transition (LCET) scenario, on the other hand, is a back-casting scenario that assumes carbon neutrality by 2060.

Under the LCET scenario, hydropower will remain the primary source of electricity generation in the Lao PDR, supplying not only final demand but also powering electrolyzers for green hydrogen production. Green hydrogen will contribute to decarbonising both the demand and transformation sectors, serving as feedstock for green ammonia used in co-firing with coal-fired power plants. Additionally, carbon capture, utilisation, and storage (CCUS) is considered a viable option for decarbonising the power sector. As a net exporter of electricity, the Lao PDR is also expected to experience growing electricity demand from neighbouring countries, including Thailand, Viet Nam, and Cambodia.

Furthermore, the LCET scenario envisions greater energy efficiency deployment, adoption of electric vehicles, electric boilers and furnaces in industries, and electric stoves, along with increased integration of solar photovoltaic (PV) cells, wind, and biomass in the power generation sector.

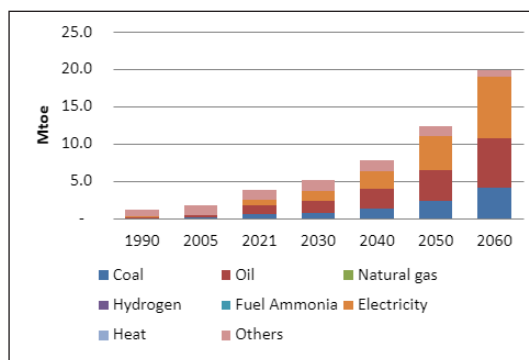
### 3. Final Energy Consumption

**Figure 10.1. Total Final Energy Consumption by Sector, Business-as Usual Scenrio**



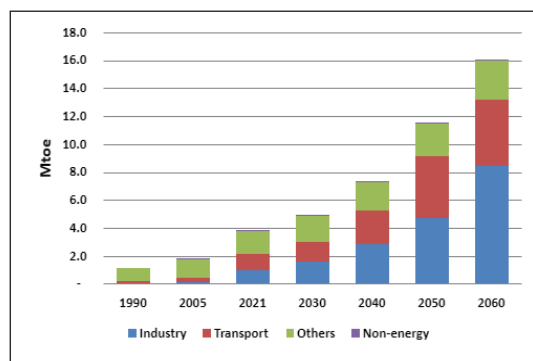
Mtoe = million tonnes of oil equivalent.  
Source: Authors. LEAP simulation result.

**Figure 10.2. Total Final Energy Consumption by Fuel Type, Business-as Usual Scenario**



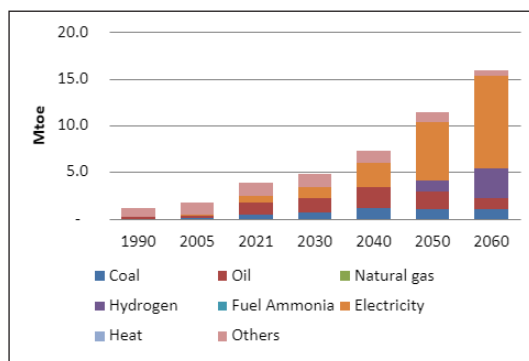
Mtoe = million tonnes of oil equivalent.  
Source: Authors. LEAP simulation result.

**Figure 10.3. Total Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario**



Mtoe = million tonnes of oil equivalent.  
Source: Authors. LEAP simulation result.

**Figure 10.4. Total Final Energy Consumption by Fuel Type, Low-carbon Energy Transition Scenario**



Mtoe = million tonnes of oil equivalent.  
Source: Authors. LEAP simulation result.

Under the BAU scenario (see Figure 10.1 and 10.2), TFEC is projected to reach 19.88 million tonnes of oil equivalent (Mtoe) by 2060, growing at 4.3% annually. According to the sectoral basis, from 1990 to around 2021, the 'others' sector (residential, commercial, and agriculture) dominates, consuming 0.89 Mtoe (81.7%) and 1.9 Mtoe (37.5%), respectively. However, its share declines to 16.8% by 2060. From 2030 onwards, industry and transport become the dominant energy consumers. In 2030, their consumption is nearly equal at 1.64 Mtoe (32.3%) and 1.53 Mtoe (30.2%), respectively. However, industry grows more rapidly, reaching 10.78 Mtoe (54.2%) by 2060, whilst transport rises more moderately to 5.76 Mtoe (29%).

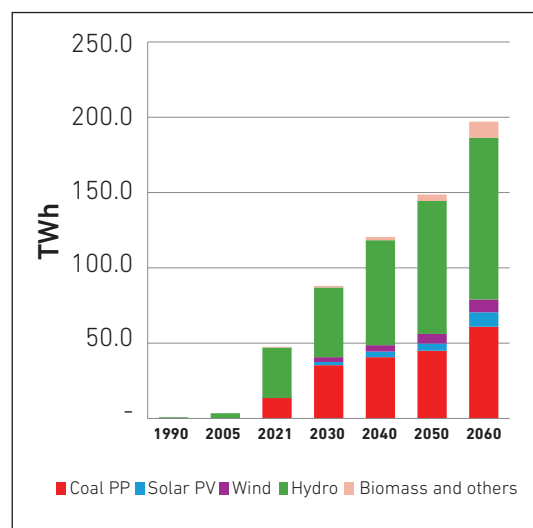
From 1990 to 2021, biomass dominated TFEC, contributing 0.92 Mtoe (83.3%) and later 1.4 Mtoe (36.9%), mainly due to biomass's crucial role in the residential sector as the primary source of energy for cooking, heating water, and other basic needs due to its economic accessibility and abundant resources. Oil consumption surged from 0.34 Mtoe in 2005 to 1.25 Mtoe in 2021 (32.8% of TFEC) due to the rise of internal combustion engine vehicles, mainly in the road transport sector. Whilst oil consumption increases to 6.63 Mtoe by 2060, its TFEC share remains stable, mirroring the moderate growth in the transport sector.

Electricity and coal have the highest annual growth rates in TFEC at 6.6% and 5.7%, reaching 8.34 Mtoe and 4.09 Mtoe by 2060. Over 70% of electricity is used by industry, 27% by residential and commercial sectors, and the rest by transport and agriculture. On the other hand, in TFEC, coal is exclusively used in industry, mainly for heating. As the Lao PDR advances its industrialisation strategy under the 10-year National Socio-Economic Development Plan (2016–2025), the push for a more export-oriented and manufacturing-based economy drives increased energy demand (UNIDO, 2020). This aligns with industry becoming the most energy-intensive sector after 2030, reinforcing its role as the dominant consumer in TFEC.

Under the LCET scenario (see Figure 10.3 and 10.4), overall TFEC decreases to 15.94 Mtoe, with sectoral shares remaining largely similar to the BAU scenario. The key differences lie in fuel composition. Coal and oil peak around 2040 at 1.14 Mtoe and 2.18 Mtoe, respectively, before declining to 0.98 Mtoe and 1.23 Mtoe by 2060. Meanwhile, hydrogen enters the energy mix in 2040 at 0.08 Mtoe and grows to 3.19 Mtoe (20% of TFEC) by 2060, replacing coal and oil in industry and transport. Electricity sees a faster growth rate of 7.1%, reaching 9.88 Mtoe (62% of TFEC) by 2060, driven by increased electrification, including electric furnaces, stoves, and electric vehicle adoption.

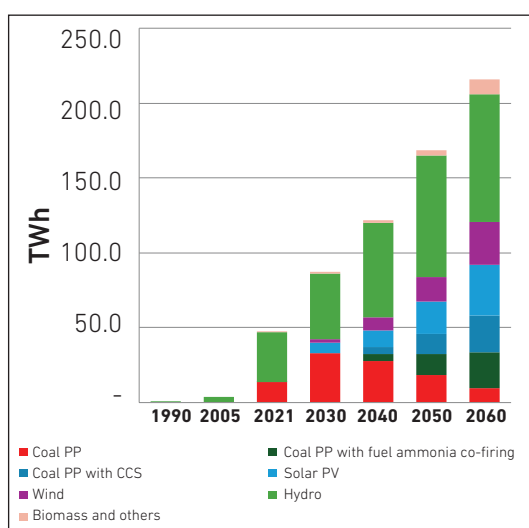
## 4. Power Generation

**Figure 10.5 Power Generation in Business-as Usual Scenario**



PP = power plant, PV = photovoltaic, TWh = terawatt-hour.  
Source: Authors. LEAP simulation result.

**Figure 10.6 Power Generation in Low-carbon Energy Transition Scenario**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.  
Source: Authors. LEAP simulation result.

Under the BAU scenario (see Figure 10.5), total electricity generation in 2060 is projected to reach 197.15 TWh – four times the 2021 level – growing at an average annual rate of 3.9%. Hydropower maintains a dominant share, despite a gradual decline, contributing 71% (33.57 TWh) in 2021 and 54% (107.15 TWh) in 2060. Although its share decreases, hydropower remains the primary electricity source in the Lao PDR, benefiting from the country's access to run-of-river potential from the Mekong River.

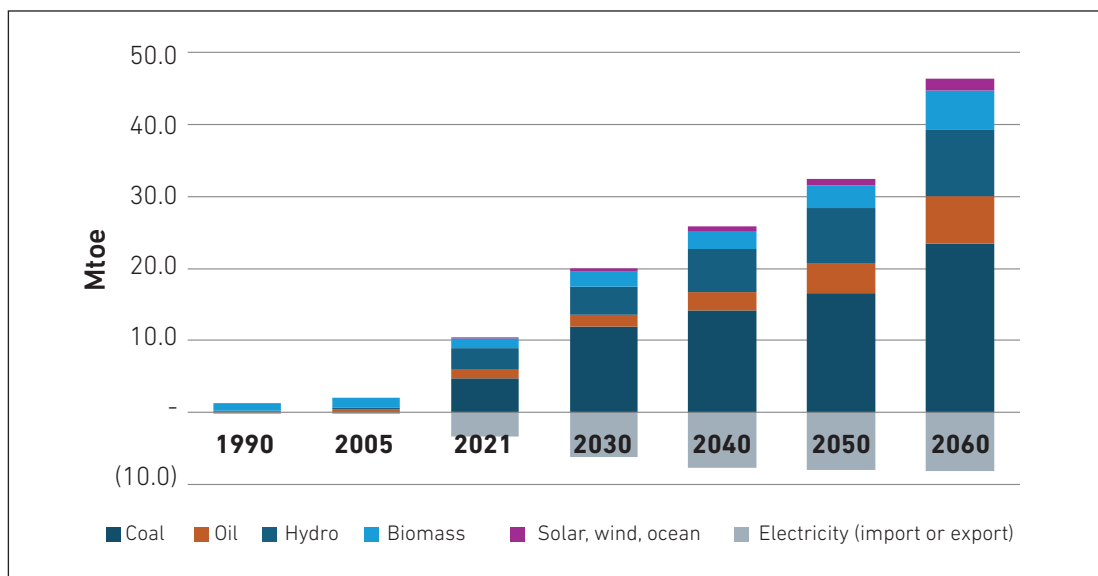
Coal is expected to be the second-largest contributor to the electricity generation mix, accounting for 31% (60.72 TWh) in 2060, following a peak in 2030, as the Lao PDR continues domestic lignite exploration and mining. Currently, the Hongsa Power Plant (1,878 MW) is the only operational coal-fired power plant, with 95% of its capacity designated for electricity exports to Thailand's Electricity Generating Authority, whilst the remaining 5% supplies electricity to nearby areas (Global Energy Monitor, n.d.). Although the Hongsa Power Plant is set to be phased out by 2040, the Government of the Lao PDR continues to approve new coal-fired power projects, such as the Phonesack Xekong plant, which is expected to begin operations between 2028 and 2030.

Moreover, in order to meet growing electricity demand, renewable energy sources – including solar, wind, and biomass – are expected to play an increasingly important role, generating a combined 29.3 TWh (14% of the electricity mix) by 2060. This shift towards renewable energy is already evident, as demonstrated by the establishment of the Chaengsavang Village solar power plant, inaugurated in 2017 (Sipaphay, 2017). Furthermore, wind energy development is advancing, with the Government of the Lao PDR signing an agreement in February 2024 for the 1,200 MW Savan Vayu Renewable Energy wind power project, which is expected to commence operations soon (IEA, 2024).

In the LCET scenario (see Figure 10.6), the Lao PDR's electricity generation is projected to reach 215.94 TWh by 2060, growing at an average annual rate of 4% from the 2021 level. Despite increasing electricity demand, energy efficiency measures are implemented, moderating the growth in power generation compared to the BAU scenario. Whilst coal remains part of the energy mix, various decarbonisation measures are integrated. Carbon capture and storage (CCS) and ammonia co-firing each contribute 11% (24.15 TWh) of total generation. Additionally, solar and wind power see significant growth, making up 29% (62.5 TWh) of the electricity mix. Hydropower follows a trajectory similar to the BAU scenario. Although its share declines over time, it remains the dominant source of electricity, accounting for 39% (85.24 TWh) of total generation in 2060.

## 5. Primary Energy Supply

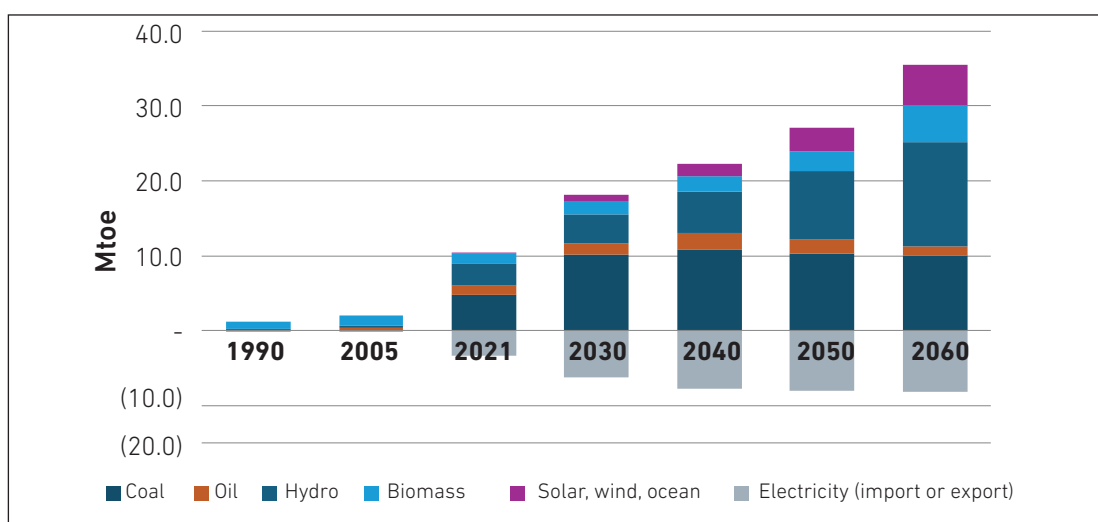
**Figure 10.7. Total Primary Energy Supply in Business-as-Usual Scenario**



Mtoe = million tonnes of carbon equivalent.

Source: Authors. LEAP simulation result.

**Figure 10.8. Total Primary Energy Supply in Low-carbon Energy Scenario**



Mtoe = million tonnes of carbon equivalent.

Source: Authors. LEAP simulation result.

The total primary energy supply under the BAU scenario is expected to reach 38.12 Mtoe in 2060, growing at an average annual rate of 4.45% from the 2021 level (see Figure 10.7). Coal, hydro, and oil will account for the majority of the TPES share, with percentages of 61.4%, 24.2%, and 17.4%, respectively, in 2060. In this case, coal dominates the energy mix due to the country's large domestic geological and mineable reserves. Consequently, the government is expanding coal-fired power plants, primarily to generate electricity for export to neighbouring countries such as Thailand, Cambodia, and even China. Besides the Hongsa coal-fired power plant, the Phonesack Xekong project is currently under development. It consists of six units with various production commencement dates ranging from 2028 to 2030. Although 83% of the coal in TPES will be used for power generation, the remainder will be allocated to the final demand sector, primarily for heating purposes in the industry sector.

Hydropower is an integral part of the Lao PDR's energy landscape, providing electricity alongside coal-fired power plants. Whilst hydropower use is projected to increase from 2.81 Mtoe in 2021 to 9.21 Mtoe in 2060, its share of TPES will decline year by year (from 41% to 24.2%) due to the increasing contribution of other renewable sources such as solar and wind. In total, wind and solar energy will rise from 0.01 Mtoe in 2021 to 1.6 Mtoe in 2060.

Electricity generated from coal and hydropower has significantly benefited the Lao PDR as an export commodity, contributing substantially to the country's GDP. This solidifies the Lao PDR's position as the 'Battery of ASEAN' and an electricity net exporter. By 2060, electricity exports are projected to grow at an average annual rate of 2.3%, reaching 8.17 Mtoe compared to 2021 levels, despite the Lao PDR importing electricity from Thailand at higher unit prices during the dry season (Yogo and Sudo, 2024).

Additionally, oil products are imported to meet the country's energy demand, rising from 1.25 Mtoe in 2021 to 6.63 Mtoe in 2060. The Lao PDR primarily imports refined petroleum products (such as diesel and gasoline) from Thailand, Viet Nam, and China (Observatory of Economic Complexity, n.d.; Lao PDR Trade Portal, n.d.).

Under the LCET scenario, the overall TPES is expected to decline to 27.35 Mtoe in 2060, mainly due to significant reductions in coal consumption (57% lower than BAU) and oil consumption (81% lower than BAU) (see Figure 10.8). Coal consumption will grow at a slower rate of 1.9% from 2021 levels, peaking at 10.86 Mtoe in 2040 before gradually declining to 10.07 Mtoe in 2060. The primary energy use of coal will decrease significantly due to lower consumption in the transformation sector, following the introduction of ammonia for co-firing purposes starting in 2040. This will reduce the coal requirement for power plant combustion from 19.34 Mtoe under the BAU scenario to 9.09 Mtoe under the LCET scenario by 2060.

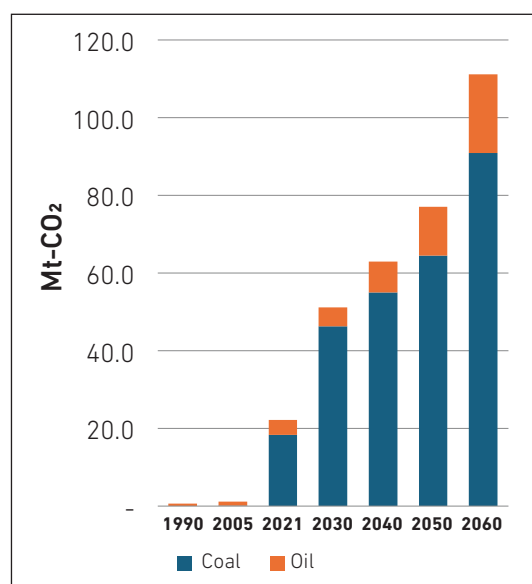
In the LCET scenario, hydropower will dominate the TPES share, reaching 13.80 Mtoe, equivalent to 50% of total TPES in 2060. Hydropower will primarily be used for electricity generation, with around 53% of the total output allocated to final demand (TFEC), whilst the remainder will power electrolyzers for green hydrogen production. By 2060, green hydrogen production is expected to reach 5.5 Mtoe, with 2.31 Mtoe serving as feedstock for green ammonia production and the remainder directed towards final demand (TFEC). From the 2.31 Mtoe of green hydrogen, 2.08 Mtoe of ammonia will be produced exclusively for co-firing purposes. Thus, hydropower will play a crucial role in decarbonising both power generation and final energy demand in the Lao PDR.

To complement hydropower in the renewable energy portfolio, solar and wind energy will expand significantly, growing 3.4 times from 1.6 Mtoe under BAU to 5.37 Mtoe under LCET by 2060. This reflects the Lao PDR's commitment to diversifying renewable energy sources, with most renewables dedicated to power generation. In contrast, biomass consumption will remain relatively unchanged in both the BAU and LCET scenarios.

Meanwhile, oil product consumption will peak around 2040 before gradually declining from 2.18 Mtoe in 2040 and further to 1.23 Mtoe in 2060. This trend indicates the Lao PDR's transition away from oil towards electricity and hydrogen, particularly in the transport and industry sectors.

## 6. Carbon Dioxide Emissions

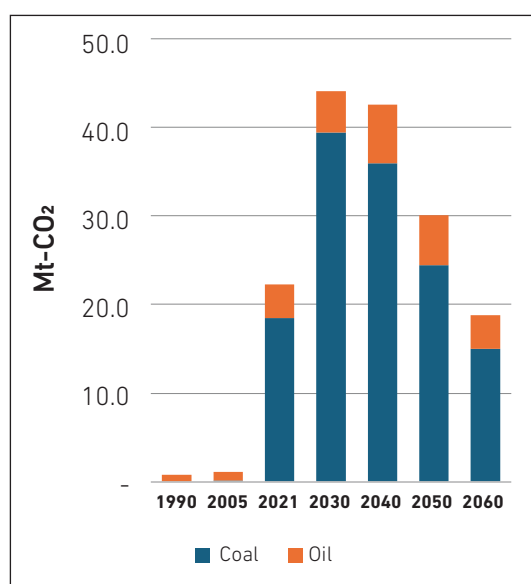
**Figure 10.9. Carbon Dioxide Emissions in Business-as-Usual Scenario**



Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>.

Source: Authors. LEAP simulation result.

**Figure 10.10. Carbon Dioxide Emissions in Low-carbon Energy Transition Scenario**



Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>.

Source: Authors. LEAP simulation result.

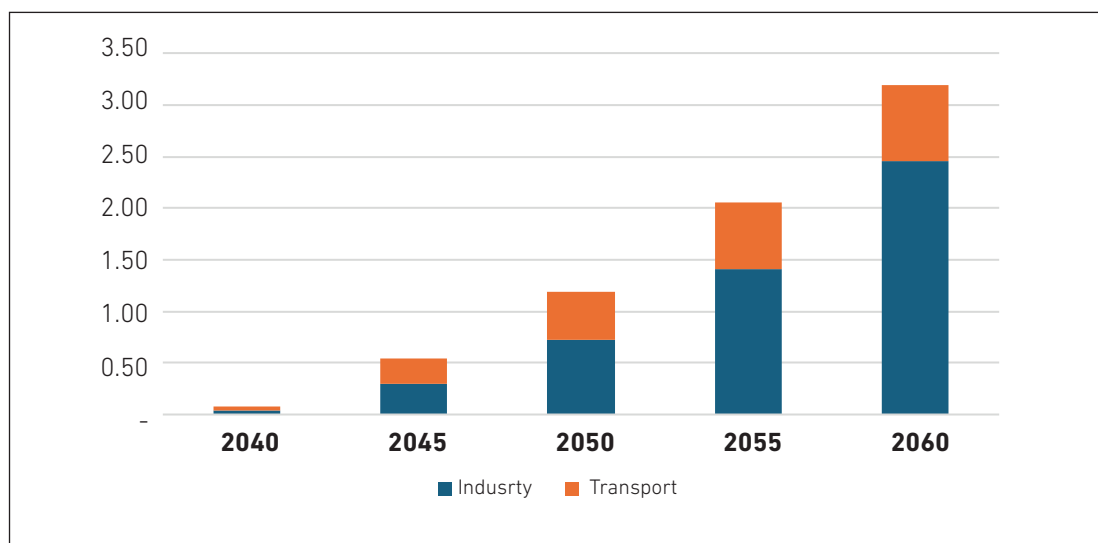
Figures 10.9 and 10.10 compare the Lao PDR's CO<sub>2</sub> emissions under the BAU and LCET scenarios. In the BAU scenario, emissions are projected to peak at 111.0 MtCO<sub>2</sub> in 2060, reflecting a 4.2% annual average growth rate from 2021 levels. In contrast, the LCET scenario shows an earlier peak in 2030 at 42.6 MtCO<sub>2</sub>, followed by a steady decline to 18.73 MtCO<sub>2</sub> by 2060.

Total emissions comprise contributions from both demand and transformation sectors. Under the BAU scenario, the transformation sector consistently accounts for around 70% of total emissions. However, in the LCET scenario, this share declines to approximately 60% by 2060 as decarbonisation efforts take effect. A significant reduction in overall emissions occurs from 2040 onwards, driven by the introduction of CCS technology and co-firing with green ammonia, marking a major step in the Lao PDR's decarbonisation effort.



## 7. Hydrogen Demand Across Sectors

Figure 10.11. Hydrogen Sectoral Demand in the Lao PDR



Mtoe = million tonnes of carbon equivalent.

Source: Authors. LEAP simulation result.

Hydrogen demand in the LCET scenario starts contributing to TFEC by 2040, mainly in the industry and transport sectors (see Figure 10.11). It serves as a key pathway for decarbonisation, produced domestically from hydropower through electrolysis. In 2040, hydrogen demand is projected at 0.08 Mtoe, steadily increasing to 1.19 Mtoe in 2050 and 3.19 Mtoe in 2060. The industry sector will dominate hydrogen use, accounting for 77% of total consumption in 2060, as hydrogen can be combusted like fossil fuels. However, the industry sector must replace fossil fuel boilers and furnaces with hydrogen-compatible ones.

In contrast, hydrogen's role in the transport sector will be more limited, mainly for long-haul transportation. Whilst hydrogen fuel cell vehicles exist, they are less common than electric vehicles due to their application being largely limited to heavy-duty vehicles, such as large trucks and buses. Additionally, hydrogen internal combustion engines are still in research and development, making it harder for hydrogen to compete with battery-electric vehicles.

## 8. Analysis of Energy Cost Comparison

An analysis on energy cost was carried out to see the comparison between the BAU and LCET scenarios. The objective of this analysis to see the total energy cost that needed to implement all assumptions under the LCET and try to compare with BAU. The key energy-related costs considered in the analysis are Fuel, Investment for power generation, and CCS. These costs are evaluated based on the outlook results. The cost is in real price 2021.

### 8.1. Fuel Cost

To compare the total fuel cost of the BAU and LCET scenarios, the assumptions in Table 10.2 are used.

**Table 10.2. Fuel Cost Assumptions**

|          | 2021  | 2060 (2019<br>constant price) | Unit                       |
|----------|-------|-------------------------------|----------------------------|
| Coal     | 80.03 | 98.00                         | US\$/tonne                 |
| Oil      | 41    | 100                           | US\$/bbl                   |
| Gas      | 7.77  | 7.50                          | US\$/MMBtu                 |
| Hydrogen | 0.8   | 0.3                           | US\$/Nm <sup>3</sup>       |
| CCS      | 0     | 60                            | US\$/CO <sub>2</sub> tonne |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal units, Nm<sup>3</sup> = normal cubic metre.

Source: Authors.

By calculating using the cost assumption above, the total investment for fuel cost in the Lao PDR in 2060 under BAU scenario is US\$ 6,652 million, whilst under the LCET scenario is slightly lower, marking US\$4,546 million of investment. The results can be seen in Table 10.3.

**Table 10.3. Total Investment Cost of Fuel Comparison, Business-as-Usual and Low-carbon Energy Transition Scenario in 2060**

|              | Primary Energy Consumption (Mtoe), BAU in 2021 | Primary Energy Consumption (Mtoe), BAU in 2060 | Primary Energy Consumption (Mtoe), LCET-CN in 2060 | Total Investment Cost, BAU in 2060 (million US\$) | Total Investment Cost, LCET-CN in 2060 (million US\$) |
|--------------|------------------------------------------------|------------------------------------------------|----------------------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| Coal         | 4.76                                           | 23.42                                          | 10.07                                              | 2,949                                             | 838                                                   |
| Oil          | 1.25                                           | 6.63                                           | 1.23                                               | 3,704                                             | -14                                                   |
| Gas          | 0                                              | 0                                              | 0                                                  | 0                                                 | 0                                                     |
| Hydrogen     | 0                                              | 0                                              | 3.19                                               | 0                                                 | 3,722                                                 |
| <b>Total</b> | <b>6.01</b>                                    | <b>30.06</b>                                   | <b>23.65</b>                                       | <b>6,652</b>                                      | <b>4,546</b>                                          |

BAU = business as usual, LCET-CN = low-carbon energy transition-carbon neutral, Mtoe = million tonnes of oil equivalent.  
Source: Authors.

## 8.2. Power Generation Cost

To compare the power generation investment cost of the BAU and LCET scenarios, the assumptions on Table 10.4 are used.

**Table 10.4. Construction Cost of Power Plants Assumptions (US\$/KW)**

| Fuel Source                 | 2021  | 2060  |
|-----------------------------|-------|-------|
| Coal                        | 1,500 | 1,525 |
| Coal co-firing with biomass | -     | 1,600 |
| Coal co-firing with ammonia | -     | 1,600 |
| Coal with CCS               | -     | 1,525 |
| Oil                         | 600   | 600   |
| Gas                         | 700   | 700   |
| Gas co-firing hydrogen      | -     | 800   |
| Gas with CCS                | -     | 700   |
| Nuclear                     | 4,500 | 3,575 |
| Hydro                       | 2,000 | 2,223 |
| Geothermal                  | 4,000 | 4,256 |
| Solar                       | 1,600 | 307   |
| Wind                        | 1,600 | 1,235 |
| Biomass                     | 2,000 | 3,019 |

CCS = carbon capture and storage, KW = kilowatt.

Source: Authors.

**Table 10.5. Total Investment Cost of Power Plants Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios in 2060**

|                  | Electricity Generation in 2021 (TWh) | Electricity Generation in BAU for 2060 (TWh) | Electricity Generation in LCET-CN for 2060 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET-CN (MW) | Total Investment Cost, BAU in 2060 (US\$ million) | Total Investment Cost, LCET-CN in 2060 (US\$ million) |
|------------------|--------------------------------------|----------------------------------------------|--------------------------------------------------|----------------------------------|--------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| Coal             | 13.50                                | 60.72                                        | 57.96                                            | 6,738                            | 6,892                                | 10,275                                            | 12,314                                                |
| Solar            | 0.06                                 | 10.00                                        | 34.10                                            | 6,674                            | 22,854                               | 2,049                                             | 10,967                                                |
| Wind             | 0                                    | 8.57                                         | 28.41                                            | 2,446                            | 8,109                                | 3,021                                             | 9,386                                                 |
| Hydro            | 33.57                                | 107.15                                       | 85.24                                            | 20,999                           | 14,746                               | 46,680                                            | 42,059                                                |
| Biomass & Others | 0.08                                 | 10.71                                        | 10.23                                            | 1,735                            | 1,655                                | 5,237                                             | 5,861                                                 |
| <b>Total</b>     | <b>47.21</b>                         | <b>197.15</b>                                | <b>215.94</b>                                    | <b>38,591</b>                    | <b>54,257</b>                        | <b>67,262</b>                                     | <b>65,578</b>                                         |

BAU = business as usual, LCET = low-carbon energy transition–carbon neutral, MW = megawatt, TWh= terawatt-hour.

Source: Authors.

Referring to Table 10.5, under the BAU scenario, power generation is projected to reach 197.15 TWh by 2060, an increase of 149.95 TWh from 2021 levels. This additional electricity generation requires 38,591 MW of new power capacity, with a total investment cost of US\$67,262 million.

More than half of this new capacity will come from hydropower, contributing 20,999 MW with an investment of US\$46,680 million. The second-largest contributors are conventional coal-fired power plants (6,738 MW) and solar power plants (6,674 MW), though their investment costs differ significantly: US\$10,275 million for coal and US\$2,049 million for solar. Wind and biomass will contribute more moderately, adding a total of 4,181 MW with an investment of US\$8,258 million.

Under the LCET scenario, power generation is expected to reach 215.94 TWh by 2060, an increase of 168.73 TWh from 2021 levels. This will require 54,257 MW of additional capacity, with an estimated investment of US\$ 65,578 million. Hydropower will still contribute significantly, adding 14,746 MW and generating 51.67 TWh. However, solar PV will account for most of the additional capacity, reaching 22,554 MW, due to its lower capacity factor. To achieve this large capacity increase, both ground-mounted and floating PV systems will be utilised, particularly in conjunction with hydropower plants on the Mekong River and its tributaries. In fact, the Lao PDR has signed a memorandum of understanding to conduct a floating solar farm feasibility study at the Nam Ngum 1 River Basin, although the progress report has not yet been submitted to the government (Lao News Agency, 2024). By incorporating hydropower plants with floating PV systems, energy harvest can be maximised by complementing the diurnal generation patterns of solar and hydro resources, avoiding the electricity shortage during dry season, as well as enhancing the overall system's reliability and efficiency (Kimura, et al., 2024). However, in terms of investment, hydropower remains the largest cost component at US\$ 21,781 million, nearly five times higher than solar PV, due to its complex construction process.

Additionally, unlike in the BAU scenario, wind power capacity will surge, reaching 8,109 MW with an investment of US\$ 10,014 million—more than three times higher than in the BAU scenario—highlighting the Lao PDR’s commitment to diversifying its renewable energy portfolio beyond hydropower.

Meanwhile, no additional capacity will be built for conventional coal-fired power plants. Instead, coal-fired power with CCS and ammonia co-firing will contribute 6,892 MW (48.3 TWh), requiring an investment of US\$10,769 million.

### 8.3. CCS Cost

Besides ammonia co-firing, equipping coal-fired power plants with CCS is another pathway to decarbonise the Lao PDR’s power sector. In the LCET scenario, electricity generated from coal with CCS is projected to reach 24.15 TWh, equivalent to 3.79 Mtoe of coal consumption, producing 14.13 MtCO<sub>2</sub>. CCS will capture 90% of these emissions (12.72 MtCO<sub>2</sub>), and by calculating with the cost assumptions in Table 10.2, the CCS cost in 2060 is estimated at US\$763 million (Table 10.6).

**Table 10.6. Total Investment Cost of Carbon Capture and Storage for Low-carbon Energy Transition Scenario in 2060**

|                            | Consumption for LCET in 2060 (Mtoe) | CO <sub>2</sub> Emissions for LCET (Mt-CO <sub>2</sub> ) | Total Investment Cost of CCS for LCET (US\$ million) |
|----------------------------|-------------------------------------|----------------------------------------------------------|------------------------------------------------------|
| Coal Power Plant with CCS  | 3.79                                | 14.13                                                    | 763                                                  |
| Natural Gas Plant with CCS | 0                                   | 0                                                        | 0                                                    |
| <b>Total</b>               | <b>3.79</b>                         | <b>14.13</b>                                             | <b>763</b>                                           |

CCS = carbon capture and storage, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, Mt-CO<sub>2</sub> = million tonnes of CO<sub>2</sub>, MW = megawatt, TWh= terawatt-hour.

Source: Authors.

## 8.4. Overall Cost

Based on analysis on the overall calculation from the 10.1–10.3 subsections, the overall investment cost for BAU scenario in 2060 is projected to be at US\$8,377 million, whilst in the LCET scenario it will be US\$6,991million (Table 10.7). The cost comparisons are illustrated in Figure 10.12.

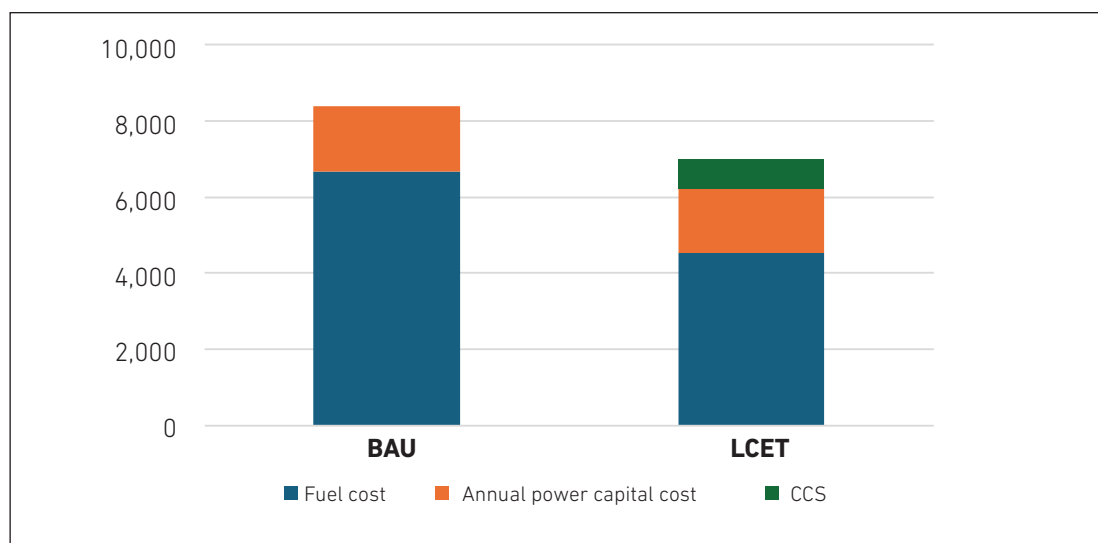
**Table 10.7. Energy Cost Comparison for Business-as-Usual and Low-carbon Energy Transition Scenarios in 2060**

|                                                   | BAU          | LCET-CN      |
|---------------------------------------------------|--------------|--------------|
| Cost of fuel (US\$ million)                       | 6,652        | 4,546        |
| Annual power plants cost (US\$ million)           | 1,725        | 1,681        |
| Cost of carbon capture and storage (US\$ million) | 0            | 763          |
| <b>Total (US\$ million)</b>                       | <b>8,377</b> | <b>6,991</b> |

BAU = business as usual, LCET = low-carbon energy transition–carbon neutral.

Source: Authors.

**Figure 10.12. Cost Comparison of Business-as Usual and Low Carbon Energy Transition Scenarios**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors.

## 9. Conclusion and Recommendations

The Lao PDR energy landscape is shaped by coal and hydropower, due to abundant reserves, which are mainly utilised to generate power. As of 2023, the Lao PDR generated more than 80% of its total electricity capacity from hydropower, around 16% from coal, and a small share from solar and biomass, which are exclusively for domestic electricity supply. This reliance on hydropower and coal for power generation solidifies the Lao PDR's position as the 'Battery of ASEAN' as around 60% of the generated electricity serves as export commodity and contributes significantly to the country's GDP. However, whilst coal-fired power plants offer stable and non-intermittent energy output, they depend on locally sourced lignite, a low-grade coal that considerably increases CO<sub>2</sub> emissions. Refined oil, another vital energy source, is imported mainly from Thailand to support the industrial and transport sector.

Therefore, for transitioning towards a low-carbon future, the Lao PDR must implement a range of decarbonisation strategies:

- **Continuing Hydropower Utilisation**

Hydropower serves as the backbone of the Lao PDR's renewable energy sector. Hydropower not only meets domestic electricity needs but also underscores the country's commitment to leveraging its abundant natural resources for clean energy generation. Hydropower continues to play a central role in these efforts, particularly in:

- o **Electrifying the Transport Sector**

The penetration of electric vehicles contributes to the reduction of CO<sub>2</sub> emissions in the road transport sector because the electricity is supplied by hydropower generation. Compared to other renewable sources such as solar and wind, hydropower provides a more stable and less intermittent energy output but paying attention to seasonality which has dry and wet season. By electrifying the road transport sector with green energy, the consumption of conventional fossil fuels will be reduced, decreasing import of refined petroleum products from neighbouring countries.

- o **Producing Green Hydrogen and Ammonia**

Besides directly generating electricity to supply the final demand, the Lao PDR's abundant hydropower can support the production of green hydrogen and ammonia via an electrolysis process. In the case of the Lao PDR, domestically produced green hydrogen can be converted to green ammonia via the Haber-Bosch process,<sup>1</sup> then utilised for co-firing with coal in power plants. The Lao PDR can gradually increase the co-firing ratio, starting from 10% and ultimately reaching 100%.

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<sup>1</sup> Haber-Bosch is a process of synthesising ammonia (NH<sub>3</sub>) by reacting nitrogen (N<sub>2</sub>) with hydrogen (H<sub>2</sub>), typically using an iron-based catalyst.

Green hydrogen and ammonia have market potential in the industry and transport sectors. In industry, hydrogen is preferred as it burns more efficiently without nitrogen oxide emissions. In contrast, ammonia combustion generates nitrogen oxide emissions, requiring additional treatment to comply with environmental facilities under the regulations. However, ammonia has advantages as a marine bunker fuel due to its easier storage and transport compared to hydrogen. However, its toxicity and handling requirements remain significant challenges.

In the transport sector, hydrogen can be utilised in fuel cells or combustion engines for vehicles and machinery. Additionally, synthetic fuel, or e-fuel, is produced through Fischer-Tropsch synthesis by combining green hydrogen with captured CO<sub>2</sub>. Since the Fischer-Tropsch process requires carbon monoxide (CO) rather than CO<sub>2</sub>, the captured CO<sub>2</sub> must be first converted into CO through the reverse water-gas shift<sup>2</sup> reaction, in which CO<sub>2</sub> reacts with hydrogen. The resulting syngas (a mixture of CO and H<sub>2</sub>) is then processed through Fischer-Tropsch synthesis to produce longer-chain hydrocarbons, enabling the gas-to-liquid conversion and resulting in synthetic fuels. With the adoption of CCS/CCUS for capturing CO<sub>2</sub>, the Lao PDR could develop e-fuel as an industrial energy source, potentially reducing dependence on fuel imports, although economic feasibility remains a key consideration.

The directive for the Lao PDR to generate green hydrogen and/or ammonia aligns with the government's targets through 'Eight National Strategic Objectives', which include promoting hydrogen and ammonia to achieve the 2050 NDC goals, developing storage and transportation infrastructure, advancing hydrogen turbines for power generation, replacing fossil fuels in the transport sector, decarbonising industries, supporting food security through domestic ammonia fertiliser production, positioning hydrogen and ammonia as export commodities, and utilising hydrogen for a carbon offset programme.

- **Adopting Carbon Capture Technologies**

One alternative that the Lao PDR can do to decarbonise the power sector is by capturing the emitted CO<sub>2</sub> from coal-fired power plants with CCS/CCUS technologies. However, this requires further studies of the capture method, where the CO<sub>2</sub> should be stored or utilised.

For ease of retrofitting, post-combustion capture via amine-based CO<sub>2</sub> capture (chemical absorption) is a viable option, as it is widely practiced. Once captured, CO<sub>2</sub> can be either stored or utilised. If the Lao PDR opts for storage, domestic investigation and regional cooperation with Thailand and Malaysia may be necessary, as both countries are developing CCS hubs to inject captured CO<sub>2</sub> into saline aquifers or depleted oil and gas reservoirs. If utilisation is preferred, one option is producing synthetic fuels. However, investment remains one of the greatest considerations for CCS/CCUS implementation, thus participation and collaboration with international or regional CCUS frameworks such as an Asia CCUS network are indispensable to share affordable CCUS technologies in the future.

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<sup>2</sup> Reverse water-gas shift is a reaction to convert carbon dioxide (CO<sub>2</sub>) into carbon monoxide (CO) by reacting it with hydrogen (H<sub>2</sub>), producing CO and water (H<sub>2</sub>O) as the outputs.



- **Diversifying Renewable Energy Sources**

Integrating solar and hydropower, including innovative solutions like floating PV systems at hydropower sites, will diversify the Lao PDR's renewable energy mix. This approach reduces reliance on hydropower during the dry season and contributes to a more balanced and resilient energy system. Whilst wind power will play a role; its contribution will be less significant compared to hydro and solar power. Diversification strengthens the Lao PDR's renewable energy portfolio and ensures stable electricity supply during the dry season, reducing dependence on higher-tariff electricity imports.

These combined efforts will enable the Lao PDR to contribute significantly to the ASEAN power grid by supplying green electricity to neighbouring countries. The country also aims to reduce its reliance on imported fossil fuels from regional partners, reinforcing energy security and supporting economic growth. By pursuing these strategies, the Lao PDR is accelerating progress towards achieving its 2050 NDC targets for emissions reductions and fostering a more sustainable, resilient energy system.

As per its latest NDC, the Lao PDR aims to achieve carbon neutrality by 2050. However, based on simulations and further analysis, even with mitigation efforts under the LCET scenario, the Lao PDR is likely to continue emitting CO<sub>2</sub> until 2060. The total cost for the LCET scenario is estimated at US\$6,991 million, slightly lower than BAU scenario at US\$8,377 million. However, achieving carbon neutrality earlier would require even greater investment. This analysis supports the Lao PDR to implement the LCET scenario with the presence of regional and international cooperation, particularly in the form of financial support, capacity-building initiatives, and technology transfer. Over time, advancements in technology – leading to reduced equipment costs and improved efficiency – will play a critical role in facilitating the Lao PDR's transition and accelerating its progress towards achieving net-zero emissions.

Fuel costs constitute a significant portion of the total cost, accounting for 79.4% in the BAU scenario and 65% in the LCET scenario. The introduction of CCS technology is assumed to begin in 2040, with total cost in CCS projected to reach US\$763 million by 2060, representing approximately 11% of the total cost. If the cost of CCS technology decreases by 2060, it is expected to result in a reduction in the overall cost required for CCS implementation.

## References

- Global Energy Monitor (n.d.), *Hongsa Power Station – Global Energy Monitor*. [https://www.gem.wiki/Hongsa\\_power\\_station](https://www.gem.wiki/Hongsa_power_station) (accessed 25 November 2024).
- International Energy Agency (IEA) (2024), *The Wind Power Project – Policies*. <https://www.iea.org/policies/19776-the-wind-power-project> (accessed 4 December 2024).
- Kimura, S., K. Sudo, A.R. Keely, and K. Komatsubara (eds) (2024), *Effectiveness of the Hybrid System Combining Hydropower and Floating Solar in the Lao PDR*. ERIA Research Project Report FY2023 No. 25. Economic Research Institute for ASEAN and East Asia. <https://www.eria.org/uploads/Effectiveness-of-the-Hybrid-System-Lao-PDR.pdf>
- Lao News Agency (2024), 'Laos Approves Feasibility Study of Floating Solar Farm', 15 May. <https://kpl.gov.la/En/detail.aspx?id=82638> (accessed 4 December 2024).
- Lao PDR Trade Portal (n.d.), Department of Foreign Trade, Ministry of Industry and Commerce of Lao PDR. <https://www.laotradeportal.gov.la/en-gb/site/display/1825#:~:text=The%20oil%20and%20diesel%20imported,iron%20and%20steel%20US%20Commercial> (accessed 4 December 2024).
- Ministry of Mines and Energy, the Lao People's Democratic Republic (Lao PDR) & Economic Research Institute for ASEAN and East Asia (2020), '*Energy Demand and Supply of the Lao People's Democratic Republic 2010-2018*'; *ERIA Research Project Report 2018, No. 21*. <https://www.eria.org/uploads/media/Research-Project-Report/Energy-Demand-and-Supply-of-the-Lao-Peoples-Democratic-Republic-2010-2018.pdf>
- Observatory of Economic Complexity. (n.d.), Refined Petroleum in Laos. <https://oec.world/en/profile/bilateral-product/refined-petroleum/reporter/lao> (accessed 25 November 2024).
- Sipaphay, M. (2017), 'First Solar Power Plant in Laos Kicks Off Operations', Lao News Agency, 8 February. <https://kpl.gov.la/en/detail.aspx?id=21847#:~:text=The%20grand%20opening%20of%20the,MW%20hours%20in%20Lao%20PDR>. (accessed 4 December 2024).
- United Nations Industrial Development Organization (UNIDO) (2020), *Lao PDR Country and Industry Profile*. [https://laopdr.un.org/sites/default/files/2021-09/ASP\\_Lao%20PDR%20Country%20Profile%2030July2021.pdf](https://laopdr.un.org/sites/default/files/2021-09/ASP_Lao%20PDR%20Country%20Profile%2030July2021.pdf) (accessed 25 November 2024).
- Yogo, M. and K. Sudo (2024), 'A Resilient Power System and Power Market in Lao PDR', in H. Phoumin and A. Phongsavath (eds), *Energy Security White Paper: Policy Directions for Inclusive and Sustainable Development for Lao PDR and the Implications for ASEAN* (pp.70–87). ERIA. [https://www.eria.org/uploads/4\\_Part\\_2-Ch\\_3\\_Resilient\\_Power\\_System.pdf](https://www.eria.org/uploads/4_Part_2-Ch_3_Resilient_Power_System.pdf)





# Chapter 11

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## Malaysia Country Report

**Zaharin Zulkifli**

Energy Commission of Malaysia

# 1. Social and Economic Situation, Energy Situation, and Energy Development Plan

The Government of Malaysia, through the National Climate Change Action Council, has set 2050 as the target year for achieving net-zero emissions, based on the findings of the Nationally Determined Contribution (NDC) Roadmap Study and Long-Term Low-Carbon Development Strategy. To achieve the target, the government has agreed to accelerate the implementation of the New Industrial Master Plan, the National Energy Transition Roadmap (NETR), and the Hydrogen Economy and Technology Roadmap (HETR), along with new policies such as the National Climate Change Bill, to reach net-zero emissions by 2050.

On 11 October 2023, the Dewan Rakyat (House of Representatives) passed what became the Energy Efficiency and Conservation Act 2023 (EECA). This landmark legislation, a key component of the NETR, aims to promote demand-side energy management by regulating energy conservation and improving energy efficiency.

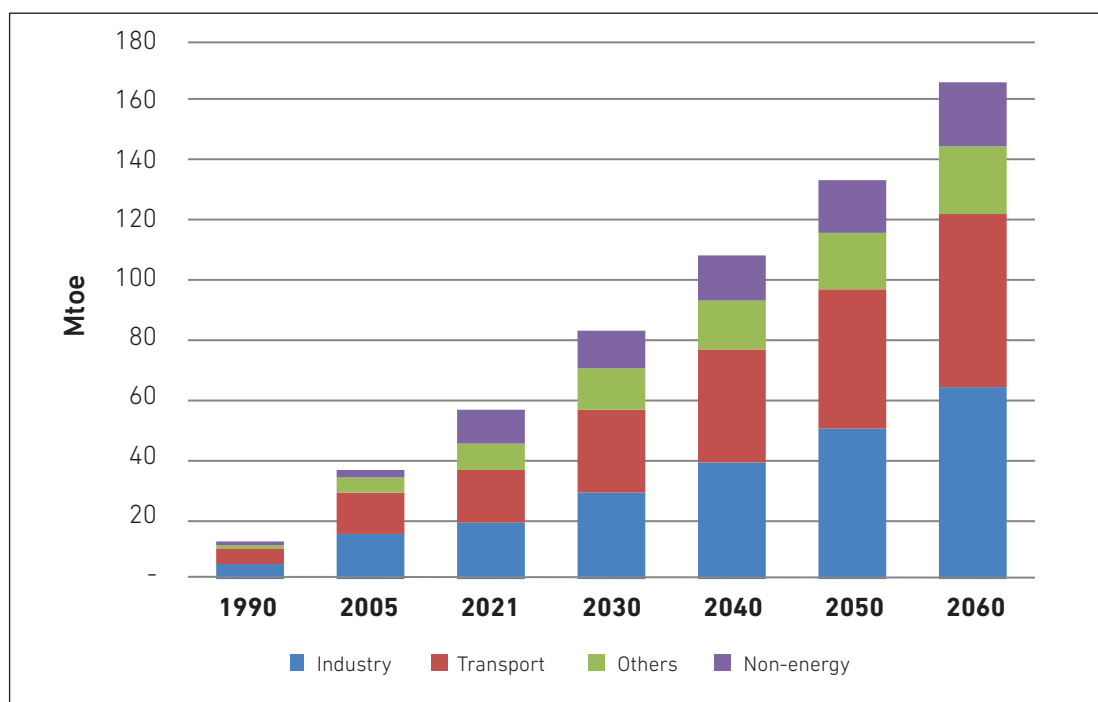
These initiatives will catalyse Malaysia's green economic growth and create green jobs.

## 2. Analysis of Business-as-Usual Results

The business-as-usual (BAU) scenario is driven purely by historical trends and basic economic assumptions, such as gross domestic product (GDP), population, and energy prices. A 1990–2021 time-series dataset was used for this regression analysis. It was compiled from various sources, including the Malaysia Energy Information Hub website, the World Bank's World Development Indicators, and energy price indicators from the Institute of Energy Economics, Japan.

The regression analysis was conducted using Microfit software to develop demand equations for each parameter based on the energy balance concept of final energy consumption by fuel and sector. The Low Emissions Analysis Platform (LEAP) software by the Stockholm Environment Institute was used to analyse long-term projections for energy and emissions until 2060.

**Figure 11.1. Final Energy Consumption by Sector,  
Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

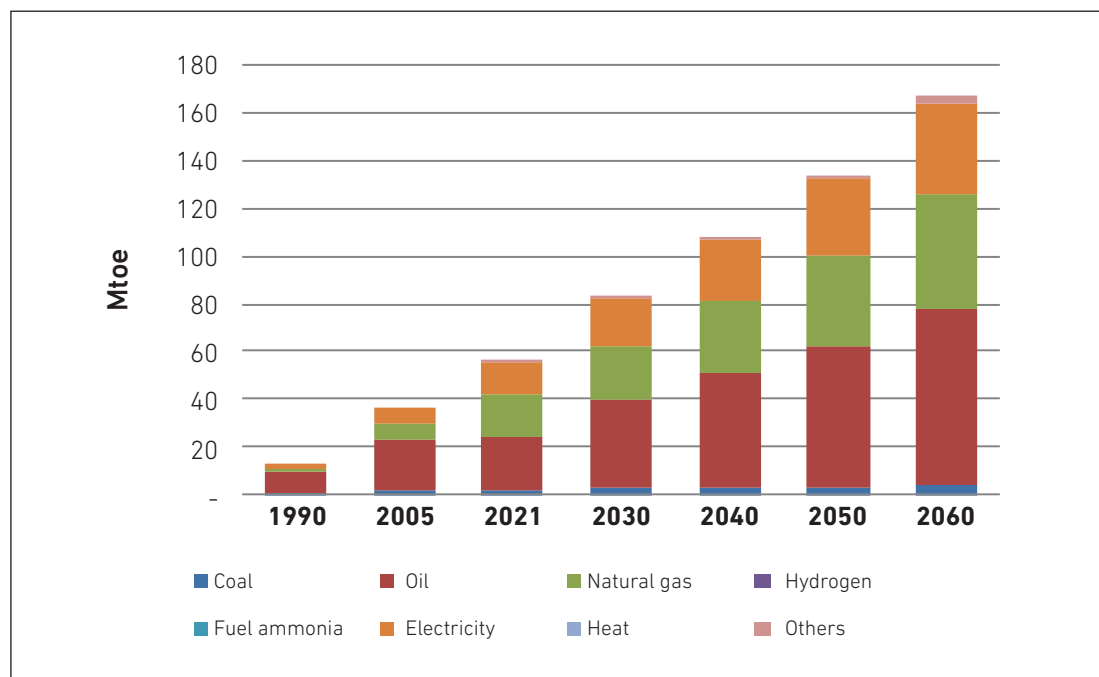
Source: Author.

Under BAU, final energy consumption is expected to grow by 2.8% annually in 2021–2060. Industry and transport will lead this increase by 3.1% per year, followed by other sectors at 2.4% per year and the non-energy sector at 1.7% per year. By 2060, industry will account for the largest share (38.5%), followed by transport (34.8%), others (13.8%), and non-energy (12.8%).

Figure 11.1 illustrates the historical trend and projected final energy consumption by sector in 1990–2060. Without new policy interventions, the sector structure of final energy consumption is expected to remain unchanged. The same assumption applies to the availability of energy resources and production throughout the projection period.

The annual increase of final energy consumption by sector, at 2.8% per year in 2021–2060, aligns with GDP growth over the same period. Since the elasticity rate is 1.00, significant opportunities for energy savings exist across all sectors. Implementing EECA can drive energy efficiency initiatives.

**Figure 11.2. Final Energy Consumption by Fuel Type,  
Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

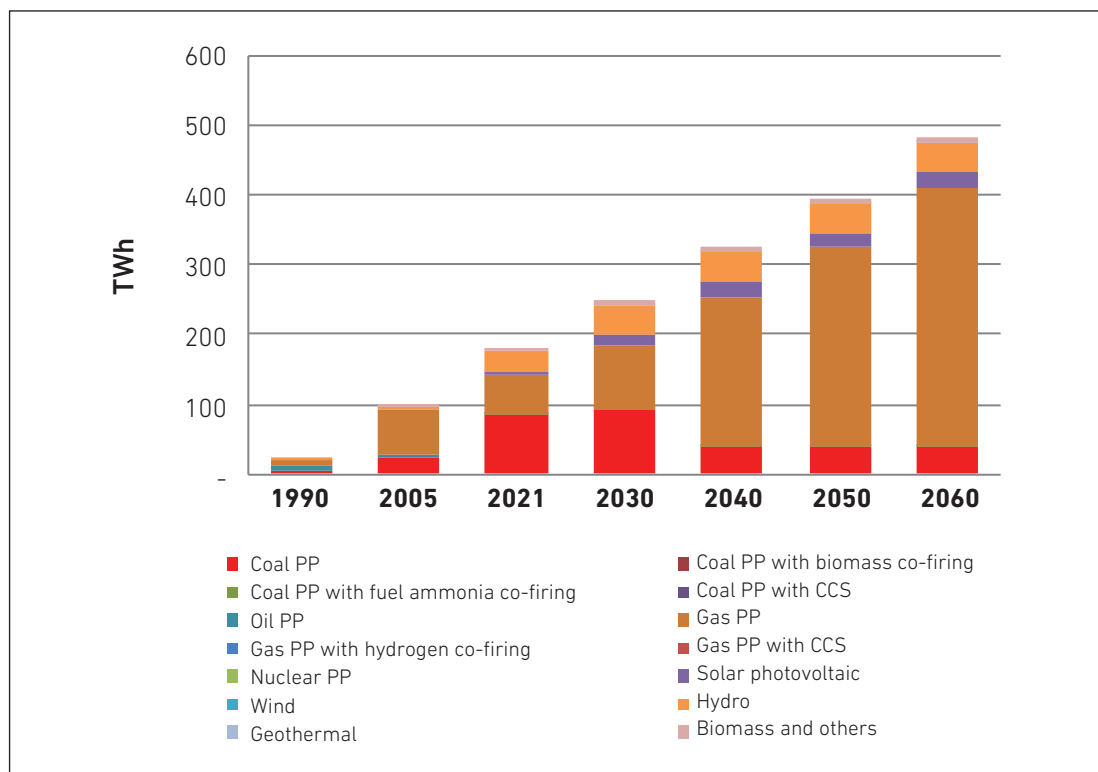
Source: Author.

Figure 11.2 illustrates final energy consumption by fuel type under BAU in 1990–2060. Oil remains the dominant energy source, accounting for 44.2% by 2060, although its share has declined from 73.9% in 1990. The introduction of natural gas in the 1990s significantly increased its share in final energy consumption, which is expected to remain strong at 29.2% by 2060.

With better electrification in rural areas, electricity's share in final energy consumption is projected to reach 23% by 2060. Coal consumption, primarily used in cement, iron, and steel manufacturing, is expected to constitute 2.1% of final energy consumption.

Other fuels, mainly biodiesel, fall under the National Biofuel Programme led by the Ministry of Plantation and Commodities. Launched in March 2006, the programme is built on five pillars: transport, industry, technology, export, and a cleaner environment. It was introduced in phases, starting with the B5 biodiesel blend (5% palm biodiesel, 95% petroleum diesel) for land transport in June 2011. It was upgraded to B7 nationwide in December 2014, followed by B10 in 2019. The B20 programme began in 2020, with a phased nationwide rollout subject to infrastructure readiness.

**Figure 11.3. Power Generation Mix by Source,  
Business-as-Usual Scenario, 1990–2060**



CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

Source: Author.

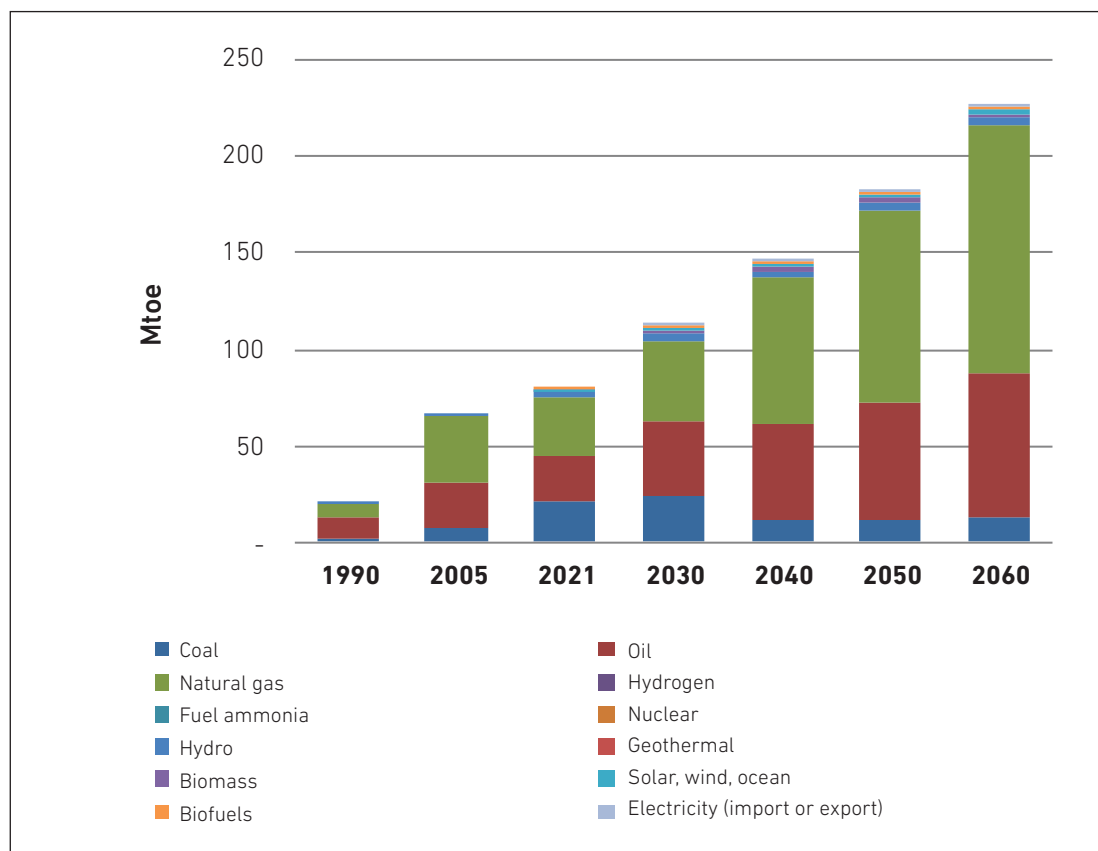
Total installed capacity in 2021 was 37,422 megawatts (MW). Natural gas and coal dominated fuel, accounting for three-quarters of total capacity, followed by hydro (16.6%), solar (4.5%), diesel and fuel oil (1.2%), biomass (1.1%), others (industrial waste heat) (0.6%), and biogas (0.3%).

Under BAU, total power generation is projected to grow by 2.6% annually in 2021–2060, reaching 481.43 terawatt-hours (TWh). By 2060, natural gas is expected to dominate the power generation mix at 77%. The government's NETR aims to phase out coal as an energy source by 2050, leading to a sharp decline in coal's share to just 8% by 2060. The remaining 15% will come from renewables (hydro, solar, biomass, and others).

Biomass and other sources are expected to grow the fastest, at 6.1% annually in 2021–2060, followed by solar photovoltaic (PV) at 5.9% and natural gas at 4.9%. Oil power generation will remain stable at 0.4% per year, whilst coal is the only source projected to decline, with a growth rate of –1.9% per year, reaching 39.37 TWh by 2060.



**Figure 11.4. Primary Energy Supply by Fuel, Business-as-Usual Scenario, 1990–2060**



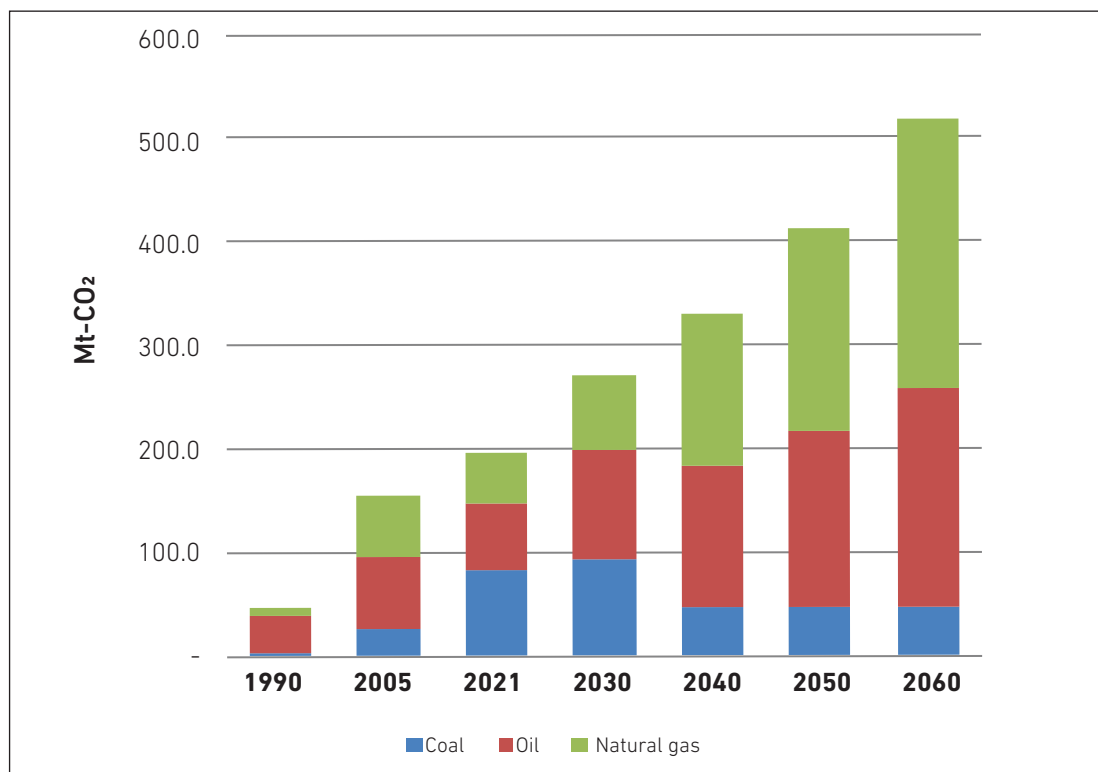
Mtoe = million tonnes of oil equivalent.

Source: Author.

Primary energy supply is defined as energy production plus imports, minus exports and international bunkers, with adjustments for stock changes. Under BAU, primary energy supply is projected to grow by 2.7% annually in 2021–2060, reaching 226.4 million tonnes of oil equivalent (Mtoe) – nearly triple the 2021 level. By 2060, fossil fuels will account for 95.6% of the primary energy supply, comprising natural gas (56.7%), oil (33.3%), and coal (5.5%).

Although fossil fuel dependency is expected to remain strong, the primary energy supply from renewables is projected to grow at the highest rate, increasing by 7.9% annually in 2021–2060. Without policy intervention, renewable energy has significant potential for further growth. Among the primary renewable sources, excluding wind and ocean energy, biomass is expected to grow by 6.2% per year and solar by 5.9% per year.

**Figure 11.5. Carbon Dioxide Emissions by Fuel, Business-as-Usual Scenario, 1990–2060**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

LEAP users can estimate carbon dioxide (CO<sub>2</sub>) emissions from fuel combustion activities. The global warming potential values are set to the default 100-year integration standard recommended by the Intergovernmental Panel on Climate Change. Total CO<sub>2</sub> emissions are projected to rise by 2.5% annually in 2021–2060, reaching 516.7 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) by 2060 (Figure 11.5). By then, natural gas is expected to account for 50% of emissions, oil for 41%, and coal for 9%.

The demand sector is expected to contribute 57% of total CO<sub>2</sub> emissions by 2060, with the transformation sector accounting for the remaining 43%. The share of CO<sub>2</sub> emissions from coal is projected to shrink starting in 2030 due to the government's policy of phasing out new coal power plants and switching to natural gas and renewables.

### 3. Analysis of Low-carbon Energy Transition Results

The low-carbon energy transition (LCET) scenario was developed to assess the potential of energy savings and CO<sub>2</sub> emission reductions through a combination of ongoing and possible future efforts. Mitigation assumptions for each sector are presented in Table 11.1.

**Table 11.1. Mitigation Assumptions Under the Low-carbon Energy Transition Scenario by Sector**

| Sector      | Mitigation Assumptions                                                             |
|-------------|------------------------------------------------------------------------------------|
| Residential | Potential savings of 20% by 2050 and 30% by 2060 compared with BAU                 |
| Commercial  | Potential savings of 23% by 2050 and 34% by 2060 compared with BAU                 |
| Industrial  | Potential savings of 23% by 2050 and 34% by 2060 compared with BAU                 |
| Industrial  | Application of CCUS technology from 2041 with a 10% utilisation rate               |
| Power       | Capacity mix of renewable energy at 70% by 2050                                    |
| Power       | Capacity mix of coal at 0% by 2050                                                 |
| Power       | Introduction of small modular reactors in 2050 (300 megawatts x 5 units)           |
| Transport   | Electric vehicle consumption will be at 70,222 gigawatt-hours by 2050              |
| Transport   | B30 biodiesel for vehicles by 2030                                                 |
| Transport   | 100 ktoe of petrol in road transport will be replaced by hydrogen starting in 2050 |

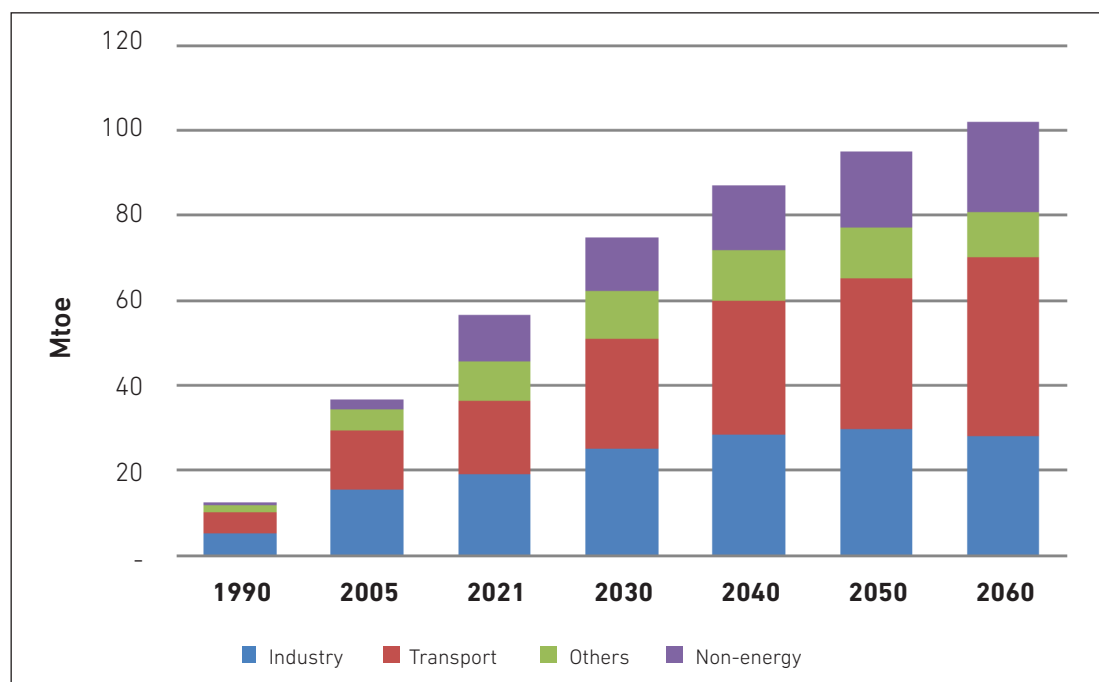
BAU = business as usual; CCUS = carbon capture, utilisation, and storage; ktoe = kilotonnes of oil equivalent.

Source: Author.

The mitigation assumptions under LCET were developed using input from various documents, including the NETR and the HETR. This information was combined with expert judgement based on the author's experience in the energy sector. Further discussion and refinement of these assumptions are encouraged to assess the readiness and acceptability of selected technologies for implementation.

The author is fully aware of potential limitations, including investment costs, financial mechanisms, and business models needed to implement the mitigation assumptions within the given timeline. The involvement of policymakers may influence the inclusivity of the selected sectors, as only certain areas in the country may be subject to these measures (Table 11.1).

**Figure 11.6. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario, 1990–2060**



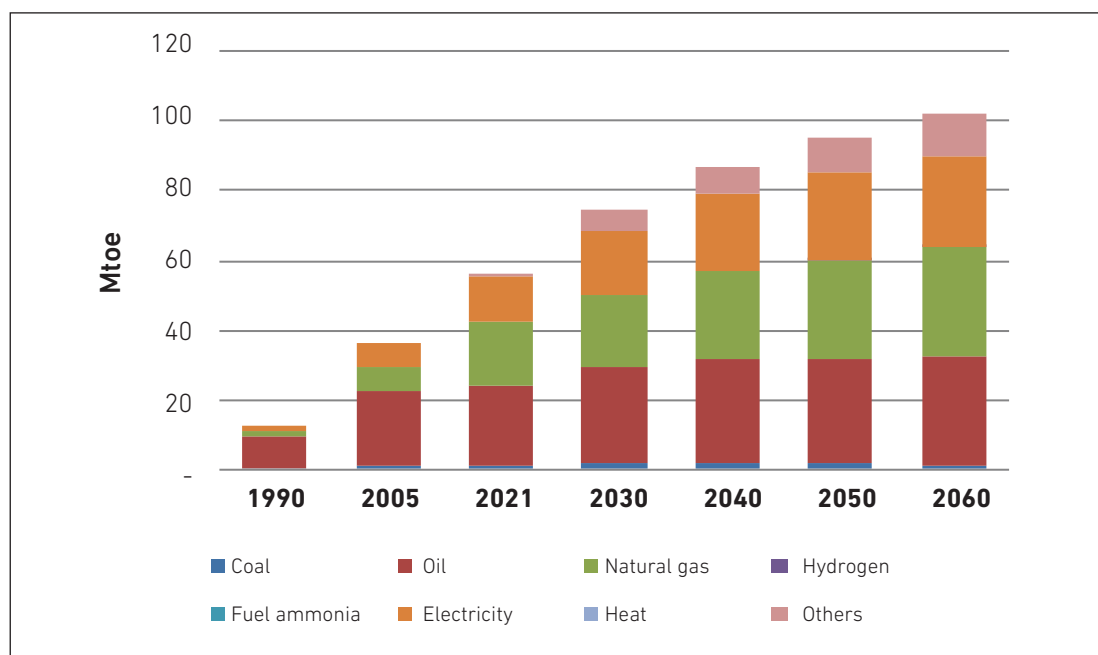
Mtoe = million tonnes of oil equivalent.

Source: Author.

Figure 11.6 illustrates final energy consumption by sector under LCET in 1990–2060. As expected, final energy consumption grows at 1.5% per year in 2021–2060, compared with 2.8% under BAU. This reduction is driven by higher potential residential, commercial, and industrial savings. Only transport grows by more than 2.0% per year, whilst all other sectors remain below this level. The non-energy sector maintains the same growth rate as under BAU, as no mitigation assumptions were applied.

The residential, commercial, and industrial sectors have the greatest potential for energy savings, as they are the main targets of EECA. The new act focuses on improving energy efficiency and preventing energy waste by regulating consumption and promoting conservation. Including thermal energy in the act enhances energy savings beyond those achieved through electricity regulation alone.

**Figure 11.7. Final Energy Consumption by Fuel,  
Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Author.

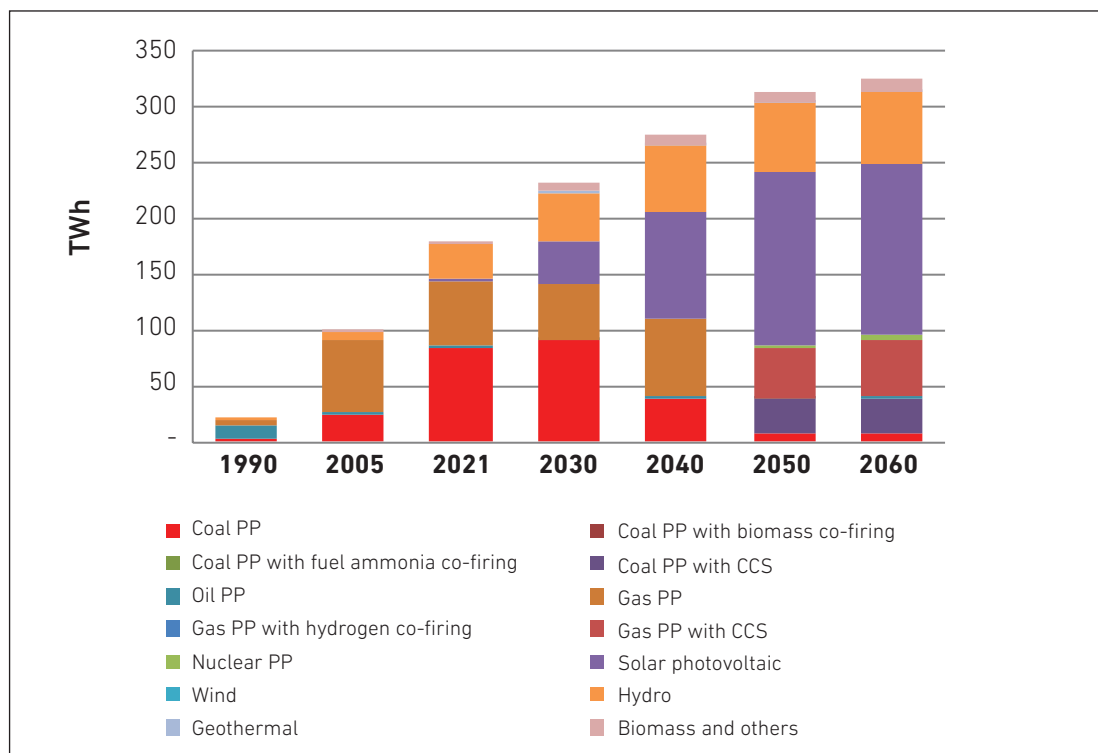
Biodiesel recorded the highest annual growth rate in 2021–2060 at 7.2%, driven by a higher blending target, particularly for heavy vehicles, reaching 30% by 2030. Increased biodiesel use helps offset CO<sub>2</sub> emissions from fuel combustion in transport.

Electricity consumption is expected to grow at 1.7% per year until 2060, lower than under BAU. The new energy efficiency and conservation law plays a key role in achieving significant savings during this period. Ongoing awareness programmes and activities will support target groups in fostering public acceptance of energy efficiency.

Greater natural gas efficiency in industry could save up to 17.3 Mtoe by 2060 under LCET compared with BAU. Advanced machinery with higher energy efficiency features will drive these huge savings. More than half of coal consumption could be reduced by 2060, with its annual growth rate expected to drop to 0.3%, compared with 2.4% under BAU. Investment in new technologies that can absorb the energy savings is essential to reduce fuel use.

Oil's share in final energy consumption is projected to decline sharply from 40.9% in 2021 to 30.2% by 2060. Energy-saving measures and fuel switching, particularly in transport, play a key role in driving this reduction.

**Figure 11.8. Power Generation Mix: Each Source,  
Low-carbon Energy Transition Scenario, 1990–2060**



CCS = carbon capture and storage; PP = power plant. TWh = terawatt-hours

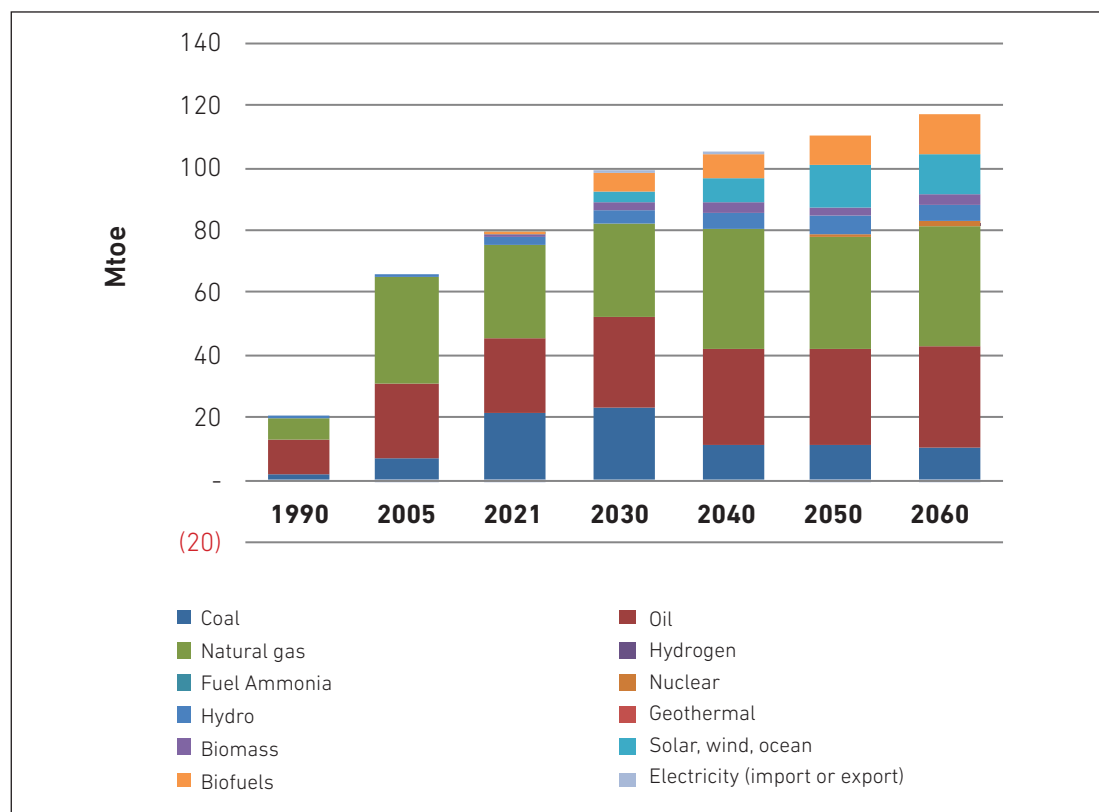
Source: Author.

Under LCET, total electricity generation is projected to grow at 1.5% per year, reaching 323.64 TWh by 2060. This growth rate is slightly lower than the 2.6% under BAU. With lower electricity consumption through the projection, electricity supply follows the same trend.

By 2060, the electricity generation mix will be dominated by solar PV at 48%, followed by hydroelectricity (20%), natural gas (16%), coal (12%), bioenergy (3%), and small modular reactors (1%). Fossil fuel energy sources are projected to decline whilst renewables continue to grow. Solar PV is expected to grow by 11.6% annually until 2060, which aligns with the earlier target of achieving 70% renewable energy capacity mix by 2050.

The renewable energy programme includes large-scale solar, feed-in tariff, net energy metering, and self-consumption. According to the NETR, the programme outlines a gradual increase in renewable energy capacity, targeting 31% by 2025, 40% by 2035, and 70% by 2050.

**Figure 11.9. Primary Energy Supply by Fuel, Low-carbon Energy Transition–Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Author.

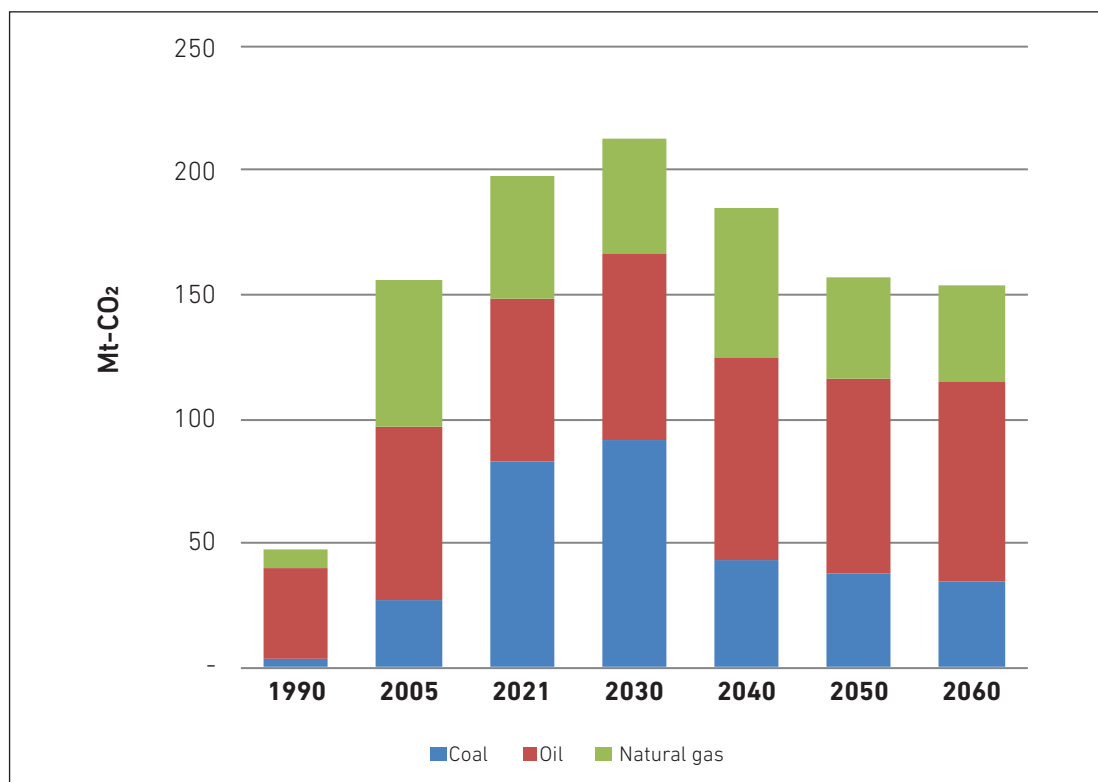
Primary energy supply under LCET is projected to reach 116.99 Mtoe by 2060, growing at an annual rate of 1.0% in 2021–2060, lower than the 2.7% under BAU, reflecting the impact of demand-side management initiatives to reduce energy consumption.

Energy savings under LCET are estimated at 109.4 Mtoe, or 48.3% of primary energy supply. Natural gas has the highest savings potential at 69.8% by 2060, followed by oil at 57.1% and coal at 16.2%.

Renewable energy has been identified as a key solution to reducing CO<sub>2</sub> emissions, particularly by replacing fossil fuels in the power sector. Other fuels (mainly renewables) are, therefore, projected to grow at more than twice the rate in BAU, reaching 251.8% by 2060.

The introduction of new technologies, such as small modular reactors and hydrogen, will help the country transition from fossil fuel dependency. By 2060, fossil fuels are expected to account for 69.7% of the energy mix under LCET, compared with 95.6% under BAU.

**Figure 11.10. Carbon Dioxide Emissions by Fuel, Low-carbon Energy Transition Scenario, 1990–2060**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

Figure 11.10 illustrates CO<sub>2</sub> emissions by fuel type under LCET in 1990–2060. Total CO<sub>2</sub> emissions are projected to reach 153.2 Mt-CO<sub>2</sub> by 2060, a 70.3% reduction from the BAU level of 516.7 Mt-CO<sub>2</sub>. Potential CO<sub>2</sub> emissions savings amount to 363.5 Mt-CO<sub>2</sub>, a significant reduction that supports the country's aspiration to achieve the NDC target.

Coal has the highest potential for CO<sub>2</sub> emission reduction, with an average annual growth rate of –2.3% in 2021–2060, followed by natural gas at –0.6% per year. Oil is the only fuel projected to register positive annual growth, at 0.6%. By 2060, oil CO<sub>2</sub> emissions are expected to account for 52.4% of total emissions, whilst natural gas will contribute 25.2% and coal 22.3%.



## 4. Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

An energy cost analysis was carried out to compare BAU and LCET. The objective is to estimate the total cost of implementing all mitigation assumptions under LCET and compare the results with those under BAU. The basic assumptions for this analysis are stated in Table 11.2, Table 11.3, and Table 11.4.

**Table 11.2. Fuel Cost: Assumptions**

|          | 2021  | 2060<br>(2021 constant price) | Unit                     |
|----------|-------|-------------------------------|--------------------------|
| Coal     | 80.03 | 98.00                         | US\$/tonne               |
| Oil      | 41    | 100                           | US\$/bbl                 |
| Gas      | 7.77  | 7.50                          | US\$/MMBtu               |
| Hydrogen | 0.8   | 0.3                           | US\$/Nm <sup>3</sup>     |
| CCS      | 0     | 30                            | US\$/CO <sub>2</sub> ton |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal units, Nm<sup>3</sup> = normal cubic metre.

Source: Author.

**Table 11.3. Construction Cost of Power Plants: Assumptions**  
(US\$/kilowatt)

|                        | 2021  | by 2060 |
|------------------------|-------|---------|
| Coal                   | 1,500 | 1,525   |
| Coal co-firing biomass | -     | 1,600   |
| Coal co-firing ammonia | -     | 1,600   |
| Coal with CCS          | -     | 1,525   |
| Oil                    | 600   | 600     |
| Gas                    | 700   | 700     |
| Gas co-firing hydrogen | -     | 800     |
| Gas with CCS           | -     | 700     |
| Nuclear                | 4,500 | 3,575   |
| Hydro                  | 2,000 | 2,223   |
| Geothermal             | 4,000 | 4,256   |
| Solar                  | 1,600 | 307     |
| Wind                   | 1,600 | 1,235   |
| Biomass                | 2,000 | 3,019   |

CCS = carbon capture and storage.

Source: Author.

**Table 11.4. Capacity Factor of Power Plants: Assumptions**  
(%)

|                        | 2021 | by 2060 |
|------------------------|------|---------|
| Coal                   | 75   | 80      |
| Coal co-firing biomass | -    | 80      |
| Coal co-firing ammonia | -    | 80      |
| Coal with CCS          | -    | 80      |
| Oil                    | 75   | 80      |
| Gas                    | 75   | 80      |
| Gas co-firing hydrogen | -    | 80      |
| Gas with CCS           | -    | 80      |
| Nuclear                | 100  | 80      |
| Hydro                  | 50   | 40      |
| Geothermal             | 50   | 50      |
| Solar                  | 17   | 17      |
| Wind                   | 40   | 40      |
| Biomass                | 50   | 70      |

CCS = carbon capture and storage.

Source: Author.

## 4.1. Fuel Cost

Based on the fuel cost assumptions in Table 11.2, the fuel cost results are presented in Table 11.5.

**Table 11.5. Comparison of Fuel Cost, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060**

|              | Final Energy Consumption (Mtoe), BAU in 2021 | Final Energy Consumption (Mtoe), BAU by 2060 | Final Energy Consumption (Mtoe), LCET by 2060 | Total Fuel Cost, BAU by 2060 (US\$ million) | Total Fuel Cost, LCET by 2060 (US\$ million) |
|--------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|---------------------------------------------|----------------------------------------------|
| Coal         | 21.41                                        | 12.43                                        | 10.42                                         | -1,419                                      | -1,737                                       |
| Oil          | 23.85                                        | 75.48                                        | 32.40                                         | 35,506                                      | 5,876                                        |
| Gas          | 30.37                                        | 128.43                                       | 38.73                                         | 28,313                                      | 2,412                                        |
| Hydrogen     | 0.00                                         | 0.00                                         | 0.15                                          | 0                                           | 175                                          |
| <b>Total</b> | <b>75.63</b>                                 | <b>216.34</b>                                | <b>81.69</b>                                  | <b>62,400</b>                               | <b>6,726</b>                                 |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author.

From the results in Table 11.5, total fuel cost by 2060 under BAU is projected to reach US\$62,400 million, significantly higher than the US\$6,726 million under LCET. Lower oil and gas consumption contributes to the lower cost under LCET, driven by better energy-saving targets and a shift to cleaner fuels.

## 4.2. Power Investment Cost

Based on construction cost and capacity factor assumptions for power plants in Table 11.3 and Table 11.4, the total cost analysis for power plants by 2060 for BAU and LCET is presented in Table 11.6.

**Table 11.6. Comparison of Total Power Plant Cost, Business-as-Usual and Low-carbon Energy Transition Scenarios by 2060**

|                                     | Electricity Generation, BAU, 2021 (TWh) | Electricity Generation, BAU, 2060 (TWh) | Electricity Generation, LCET, 2060 (TWh) | Additional Capacity, BAU (MW), from 2021 | Additional Capacity, LCET (MW), from 2021 | Total Cost, BAU, 2060 (US\$ million) | Total Cost, LCET, 2060 (US\$ million) |
|-------------------------------------|-----------------------------------------|-----------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------|--------------------------------------|---------------------------------------|
| Coal PP                             | 85                                      | 39                                      | 8                                        | -                                        | -                                         | -                                    | -                                     |
| Coal PP with biomass co-firing      | -                                       | -                                       | -                                        | -                                        | -                                         | -                                    | -                                     |
| Coal PP with fuel ammonia co-firing | -                                       | -                                       | -                                        | -                                        | -                                         | -                                    | -                                     |
| Coal PP with CCS                    | -                                       | -                                       | 32                                       | -                                        | 4,500                                     | -                                    | 6,863                                 |
| Oil PP                              | 1                                       | 1                                       | 1                                        | 24                                       | -                                         | 14                                   | -                                     |
| Gas PP                              | 58                                      | 371                                     | -                                        | 44,636                                   | -                                         | 31,245                               | -                                     |
| Gas PP with hydrogen co-firing      | -                                       | -                                       | -                                        | -                                        | -                                         | -                                    | -                                     |
| Gas PP with CCS                     | -                                       | -                                       | 78                                       | -                                        | 11,082                                    | -                                    | 7,758                                 |
| Nuclear PP                          | -                                       | -                                       | 7                                        | -                                        | 990                                       | -                                    | 3,540                                 |
| Solar PV                            | 2                                       | 20                                      | 154                                      | 12,252                                   | 101,918                                   | 3,761                                | 31,289                                |
| Wind                                | -                                       | -                                       | -                                        | -                                        | -                                         | -                                    | -                                     |
| Hydro                               | 31                                      | 41                                      | 73                                       | 2,961                                    | 11,916                                    | 6,583                                | 26,488                                |
| Geothermal                          | -                                       | 0                                       | 0                                        | 36                                       | 36                                        | 153                                  | 153                                   |
| Biomass and others                  | 1                                       | 8                                       | 11                                       | 1,125                                    | 1,630                                     | 3,398                                | 4,922                                 |
| <b>Total</b>                        | <b>178</b>                              | <b>481</b>                              | <b>363</b>                               | <b>61,035</b>                            | <b>132,073</b>                            | <b>45,155</b>                        | <b>81,013</b>                         |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, MW = megawatt,

PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Author.

Table 11.6 shows that the total additional capacity needed under BAU is 61,035 megawatts (MW) from the 2021 level, whilst LCET requires 132,073 MW by 2060. The increase results from more ambitious assumptions and targets under LCET, which prioritises renewable energy in power generation to reduce CO<sub>2</sub> emissions. As a result, the total cost for power plants by 2060 is projected at US\$45,155 million under BAU and US\$81,013 million under LCET.

### 4.3. Carbon Capture and Storage Cost

CCS is projected to be introduced under LCET starting from 2041. CCS projects are expected for coal-fired and natural gas-fired power plants. As stated in Table 11.2, the CCS costs about US\$30 per tonne of CO<sub>2</sub>, allowing for total cost estimation. The total CCS cost is presented in Table 11.7.

**Table 11.7. Total Cost of Carbon Capture and Storage,  
Low-carbon Energy Transition Scenario, 2060**

|                            | Consumption<br>for LCET by<br>2060 (Mtoe) | CO <sub>2</sub> Emissions<br>for LCET<br>(Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emissions<br>for LCET (Mt-C) | Total Cost of<br>CCS for LCET<br>(US\$ million) |
|----------------------------|-------------------------------------------|----------------------------------------------------------------|----------------------------------------------|-------------------------------------------------|
| Coal power plant with CCS  | 7.096                                     | 23.837                                                         | 7.217                                        | 1,430                                           |
| Natural gas plant with CCS | 7.291                                     | 13.976                                                         | 4.231                                        | 839                                             |
| <b>Total</b>               | <b>14.387</b>                             | <b>37.813</b>                                                  | <b>11.448</b>                                | <b>2,269</b>                                    |

CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide, Mt-C = million tonnes of carbon.

Source: Author.

Table 11.7 shows that the total potential cost for CCS is US\$2,269 million, with US\$1,430 million allocated for coal-fired power plants and US\$839 million for natural gas-fired power plants.

### 4.4. Total Cost

Based on the overall calculation analysis in Sections 4.1–4.3, the total cost breakdown is presented in Table 11.8.

**Table 11.8. Energy Cost Comparison for Business-as-Usual  
and Low-carbon Energy Transition Scenarios, 2060  
(US\$)**

|                            | BAU            | LCET          |
|----------------------------|----------------|---------------|
| Fuel                       | 62,400         | 6,726         |
| Plant                      | 45,155         | 81,013        |
| Carbon capture and storage | 0              | 2,269         |
| <b>Total</b>               | <b>107,555</b> | <b>90,008</b> |

BAU = business as usual, LCET = low-carbon energy transition.

Source: Author.

As stated in Table 11.8, the total investment cost by 2060 is projected at US\$107,555 million under BAU and US\$90,008 million under LCET.

## 5. Conclusions and Policy Recommendations

LCET offers a viable pathway to significantly reducing GHG emissions, energy demand, and fossil fuel dependency by 2060. Compared with BAU, it demonstrates significant savings across sectors, with markedly lower CO<sub>2</sub> emissions, reduced primary energy consumption, and a notable shift to renewables such as solar and hydroelectric power. These measures are pivotal for meeting the NDC commitment and advancing a low-carbon economy. Whilst LCET requires higher investment – particularly in renewable capacity and CCS – it ultimately supports a more sustainable resilient energy future.

To ensure the success of the LCET pathway, several policy recommendations are proposed. Accelerating the adoption of renewable energy requires stronger support for programmes such as feed-in tariff, large-scale solar, and net energy metering. Establishing fiscal incentives and subsidies for solar PV and biomass energy systems can further expedite the transition to a renewables-heavy grid.

Implementing comprehensive regulations under EECA is essential to promoting energy efficiency, particularly in the residential, commercial, and industrial sectors. These measures should include stringent building and appliance standards, tax incentives for energy-efficient upgrades, and public awareness campaigns on energy conservation.

Given the considerable share of fossil fuels expected to remain through 2060, CCS should be prioritised as a transitional technology. Policymakers can introduce grants and low-interest loans to support CCS deployment in high-emission industries, particularly coal and gas power plants, to mitigate their environmental impact.

To reduce transport emissions, policies should support the shift to electric vehicles through financial incentives, expansion of charging infrastructure, and collaboration with automotive manufacturers. Encouraging the use of biofuels and hydrogen for heavy transport can further reduce reliance on conventional fossil fuels.

To encourage investment in a low-carbon economy, the government should develop innovative financing models, including green bonds, carbon credits, and public-private partnerships, to reduce the financial burden of energy transition projects. International collaboration on funding mechanisms and technology transfer can further ease the costs associated with LCET investments.

Establishing a transparent monitoring and evaluation framework is essential to regularly assessing progress towards emission reduction and energy transition goals. It should involve multi-stakeholder participation to ensure policy alignment with Malaysia's long-term climate goals.

These policies will not only support Malaysia's net-zero emissions target by 2050 but also foster sustainable economic growth, positioning the country as a leader in ASEAN's clean energy transition.

## References

- Energy Commission (Malaysia) (2024), Energy Efficiency and Conservation Act (EECA) (accessed 19 December 2023).
- Malaysian Science and Technology Information Centre, Ministry of Science, Technology and Innovation (2023), Hydrogen Economy & Technology Roadmap. October (accessed 24 May 2024).
- Ministry of Economy (Malaysia) (2023), National Energy Transition Roadmap (accessed 19 December 2023).
- Ministry of Investment, Trade and Industry (Malaysia) (2023), New Industry Masterplan (accessed 24 May 2024).
- National Climate Change Action Council (2024), Fifth Meeting, Press Release (accessed 15 July 2024).



# Chapter 12

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## Myanmar Country Report

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# 1. Social and Economic Situation, Energy Situation, and Energy Development Plan

Myanmar's population grew at an average annual rate of 1.0% in 1990–2019, reaching 56 million in 2023. Gross domestic product (GDP) was US\$74.28 billion (constant 2010) in 2019, with GDP per capita rising from about US\$200 in 1990 to US\$1,370 in 2019. To drive economic development, Myanmar implemented a series of 5-year plans in 1992–2013. The first (1992–1995) achieved an average annual GDP growth rate of 7.5%, the second (1996–2000) 8.5%, the third (2001–2005) 12.8%, and the fourth (2006–2010) 12%. The most recent 5-year plan (2011–2016) targeted 7% average annual growth. Subsequent GDP growth rates were 6.4% in 2017–2018, 6.8% in 2018–2019, 3.2% in 2019–2020, -5.9% in 2020–2021, 2.4% in 2021–2022, 3.4% in 2022–2023, and 3.5% in 2023–2024.

As of 2024, proven energy reserves comprise 89.4 million barrels of oil, 2.9 trillion cubic feet of gas, and over 500 million metric tonnes of coal. The country remains a net energy exporter, mainly supplying natural gas and coal to neighbouring countries, but imports around 90% of its total oil requirements.

Primary energy consumption in 2023 was 18.8 million tonnes of oil equivalent (Mtoe). Natural gas is used mainly for electricity generation and industrial purposes. The country has an installed generation capacity of 7,330.267 megawatts (MW) and in 2023 produced 20.942 terawatt-hours (TWh) of electricity. That year, thermal sources (coal, natural gas, and oil) accounted for 56% of total electricity generation, and hydropower 44%.

**Table 12.1. Installed Capacity and Power Generation by Fuel Type, 2022**

| No. | Type of Fuel | Installed (MW)* | Generation (GWh)** |
|-----|--------------|-----------------|--------------------|
| 1   | Hydro        | 3,225           | 10,050             |
| 2   | Gas + steam  | 3,567           | 5,310              |
| 3   | Coal         | 138             | 2,100              |
| 4   | Solar        | 192             | 300                |
| 5   | Others       | -               | 390                |
|     | Total        | 7,110           | 18,150             |

GWh = gigawatt-hour, MW = megawatt.

Sources: \*World Bank (2023). \*\*Our World in Data (2025).

Hydropower and natural gas dominate electricity generation. Although coal is part of the energy mix, they contributed less than 5% of total generation in 2023. The government aims to further increase the share of natural gas, coal, hydropower, and other renewables whilst reducing oil dependency.

Myanmar's Energy Master Plan outlines three potential scenarios for the power sector by 2030 (Table 12.2).

**Table 12.2. Installed Capacity and Power Supply, by Scenario, 2030**

| No.   | Energy Resources         | Scenario 1 (Domestic Energy Consumption) |    | Scenario 2 (Least Cost) |    | Scenario 3 (Power Resources Balance) |    |
|-------|--------------------------|------------------------------------------|----|-------------------------|----|--------------------------------------|----|
|       |                          | Installed Capacity                       |    | Installed Capacity      |    | Installed Capacity                   |    |
|       |                          | (MW)                                     | %  | (MW)                    | %  | (MW)                                 | %  |
| 1     | Hydro (large)            | 12,147                                   | 42 | 12,147                  | 43 | 1,412                                | 6  |
| 2     | Hydro (small and medium) | 6,891                                    | 24 | 6,891                   | 24 | 7,484                                | 32 |
| 3     | Gas                      | 4,986                                    | 17 | 2,484                   | 9  | 4,758                                | 20 |
| 4     | Coal                     | 2,760                                    | 10 | 5,030                   | 18 | 7,940                                | 34 |
| 5     | Renewables               | 2,000                                    | 7  | 2,000                   | 7  | 2,000                                | 8  |
| Total |                          | 28,784                                   |    | 28,552                  |    | 23,594                               |    |

MW = megawatt.

Source: Asian Development Bank (2015).

Each scenario presents a different energy mix. The power resource balance scenario projects total installed capacity of 23,594 MW by 2030, with hydropower accounting for 32%, coal 34%, gas 20%, and renewables (solar, wind) 8%. This projection has been incorporated into the reference scenario of the current energy outlook model.

Myanmar aims for 100% of power generation from renewable energy by 2060, with hydropower contributing 60%. Achieving this goal will require greater use of renewables and adoption of fuel-switching technologies such as coal-biomass and gas-hydrogen co-firing. Transport will undergo significant electrification through widespread use of battery electric vehicles and internal combustion electric vehicles. Biofuels will be crucial in reducing oil import dependency whilst harnessing Myanmar's natural resources for renewable energy expansion.

Myanmar has committed to halving deforestation by 2030, targeting a cumulative emissions reduction of 256.5 million tonnes of carbon dioxide equivalent (Mt-CO<sub>2</sub>e) in 2021–2030. With international assistance, the Department of Agriculture will promote tree planting and agroforestry to expand canopy cover across 275,000 hectares of agricultural land with less than 10% tree cover per hectare. This initiative is expected to sequester more than 10.4 Mt-CO<sub>2</sub>e in 2021–2030.

Improving energy efficiency is central to the urban energy strategy. Reduction targets have been set for the following sectors: residential, 7.8%; industry, 6.63%; commercial, 4%; and others, 1.36%. To meet these targets, energy efficiency initiatives are being implemented across industry, buildings, transport, and machinery and equipment. Key measures include setting up minimum energy performance standards and introducing energy labelling programmes.

## 2. Analysis of Business-as-Usual Results

The business-as-usual (BAU) scenario is modelled for 2021–2060 and serves as the baseline for comparison with other scenarios. It represents the existing energy landscape, assuming the current regulatory framework remains unchanged throughout the period.

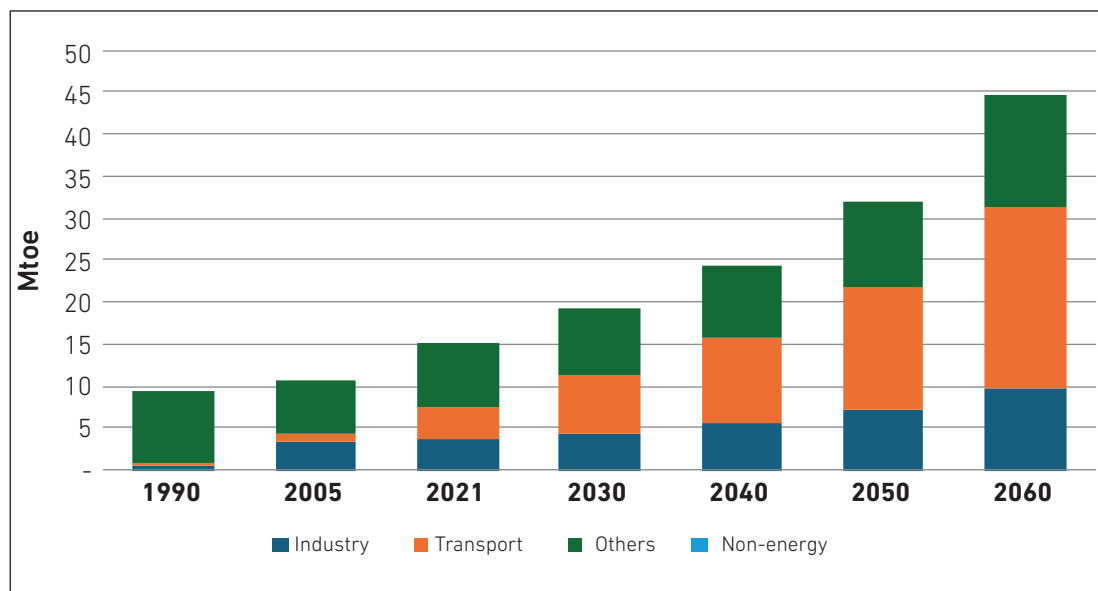
The input data includes demand equations derived from regression analysis of 1990–2021 data, using factors such as population, energy prices, and GDP, through MicroFIT. Data sources include the World Bank's World Development Indicators and Myanmar's energy statistics. These demand equations are then used as input data for the Low Emission Analysis Platform (LEAP) software.

Where demand functions cannot be derived due to insufficient data or statistical limitations, energy consumption in certain sectors or sub-sectors is forecast using alternative assumptions, such as GDP growth or existing programmes and targets.

### 2.1. Final Energy Consumption

Figure 12.1 and Figure 12.2 illustrate final energy consumption by sector and fuel under BAU, which imposes no constraints on power generation. Final energy consumption continues without specific limits on carbon emissions or policies targeting them.

**Figure 12.1. Final Energy Consumption by Sector,  
Business-as-Usual Scenario, 1990–2060**

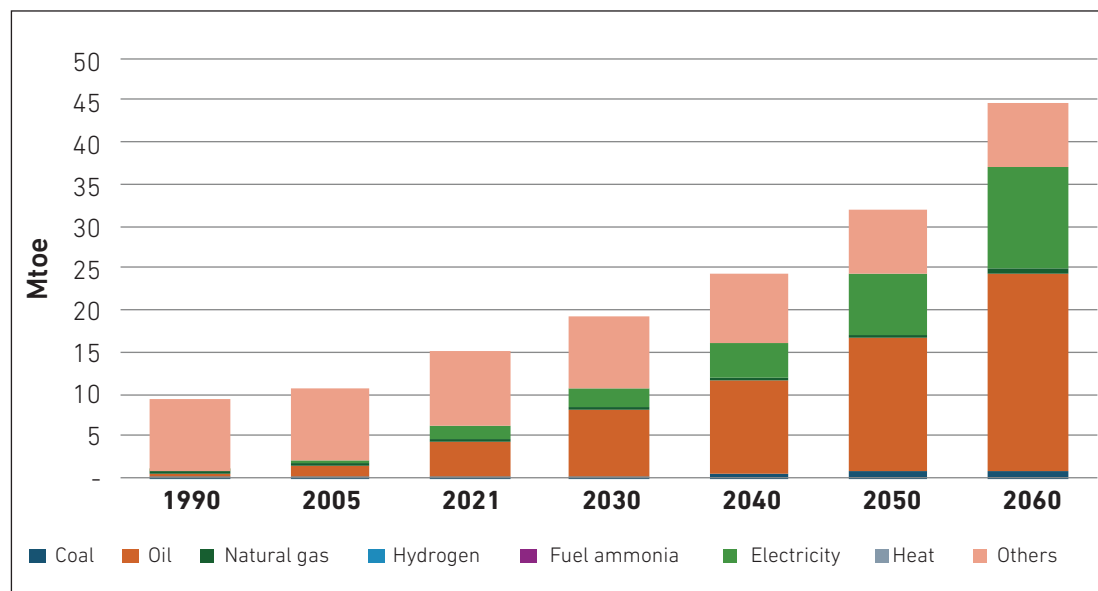


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Final energy consumption is projected to grow at an average annual rate of 2.8% in 2021–2060. The main driver is other sectors (residential, commercial, and agricultural) (51.1%). By 2060, however, transport is projected to lead, reaching 21.5 Mtoe or 48.2% of primary energy consumption – an increase of 4.7% from 2021. 'Others' sectors are projected to be the second-largest contributor, consuming 13.2 Mtoe (29.7% of the total) with annual growth of 1.4%. Industry is expected to grow at 2.5% per year, reaching 9.8 Mtoe by 2060.

**Figure 12.2. Final Energy Consumption by Fuel Type,  
Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

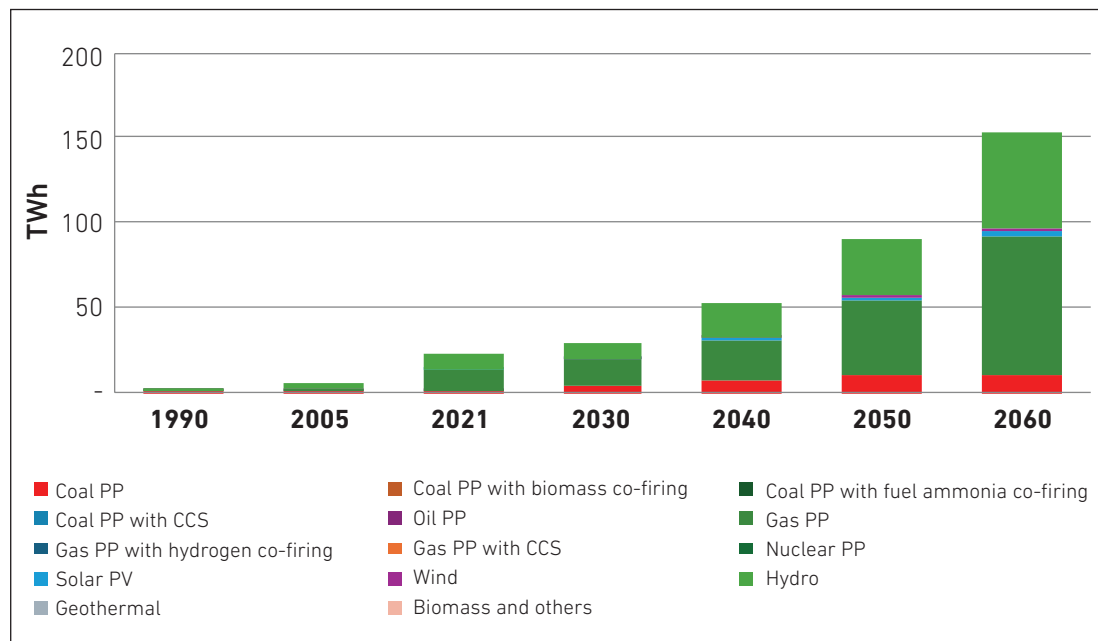
Myanmar's final energy consumption has historically been dominated by biomass, which accounted for 79.1% in 2005 and 58.6% in 2021. This share is projected to decline to 16.8% (7.5 Mtoe) by 2060. In contrast, energy demand is expected to shift increasingly to oil and electricity. Oil consumption is projected to rise by 4.5% per year, reaching 23.5 Mtoe in 2060, whilst electricity consumption is projected to grow by 5.4% per year to 12.2 Mtoe. Coal consumption is expected to increase by 3.4% to 0.9 Mtoe, and natural gas by 1.3% to 0.4 Mtoe.

## 2.2. Power Generation Mix by Source

Total electricity generation is projected to grow at an annual rate of 4.9%, reaching 152.2 TWh by 2060 (Figure 12.3). In 2021, electricity generation was mainly generated from gas power plants (53.6%), hydropower (42.6%), coal (2.8%), oil power plants, and solar photovoltaic (PV), each contributing 0.5%. By 2060, gas power plants are expected to remain the dominant source, producing 81.9 TWh.

However, major oil companies, including Chevron and TotalEnergies, stopped oil and gas operations in Myanmar in 2022 due to geopolitical and other factors. As a result, oil power plants are projected to cease operations entirely by 2030. In response, the government is promoting solar and wind power, which are expected to contribute 1.5% and 1.2%, respectively, to electricity generation by 2060. As a result, baseload power supply by 2060 is expected to remain primarily dependent on gas and hydropower.

**Figure 12.3. Power Generation Mix by Source,  
Business-as-Usual Scenario, 1990–2060**



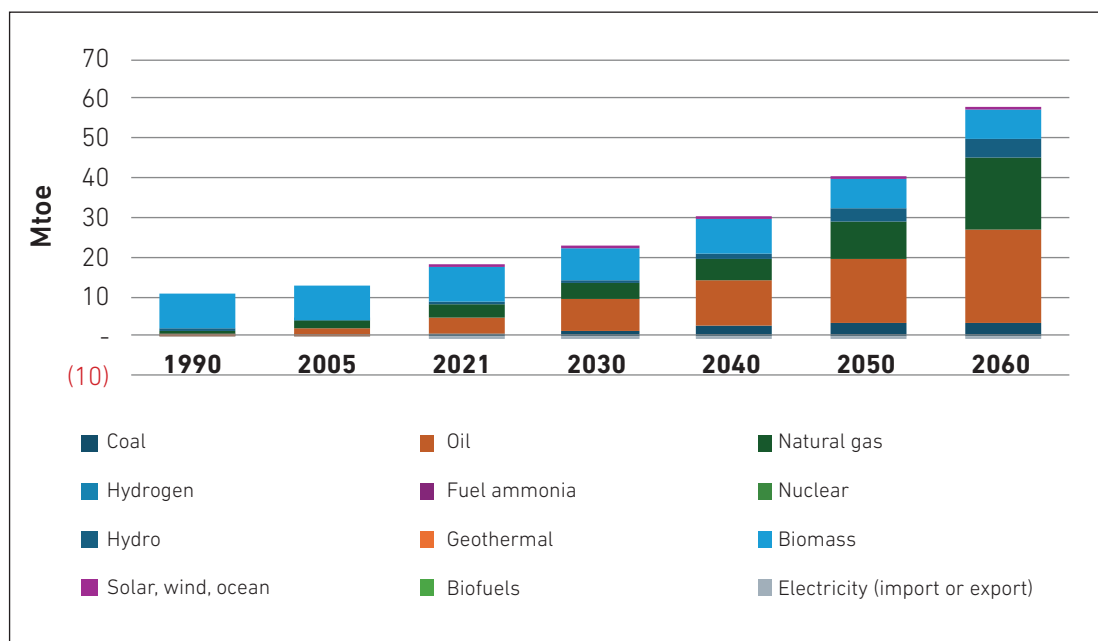
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors.

## 2.3. Primary Energy Supply by Fuel

Primary energy supply is defined as energy production plus imports, minus exports, international bunkers, and stock changes. Under BAU, primary energy supply is projected to grow at an average annual rate of 3.1% in 2021–2060, reaching 57.7 Mtoe – nearly triple the 2021 level. In 2021, energy supply relied heavily on biomass (50.5%), oil (24.1%), and natural gas (19%). Biomass dependence is expected to decline to 13.4% by 2060. Oil and gas production will remain significant, whilst renewables such as solar, wind, and ocean energy will contribute only 0.6%. Without appropriate regulations, Myanmar is likely to remain heavily dependent on fossil fuels for power generation.

**Figure 12.4. Primary Energy Supply by Fuel, Business-as-Usual Scenario, 1990–2060**



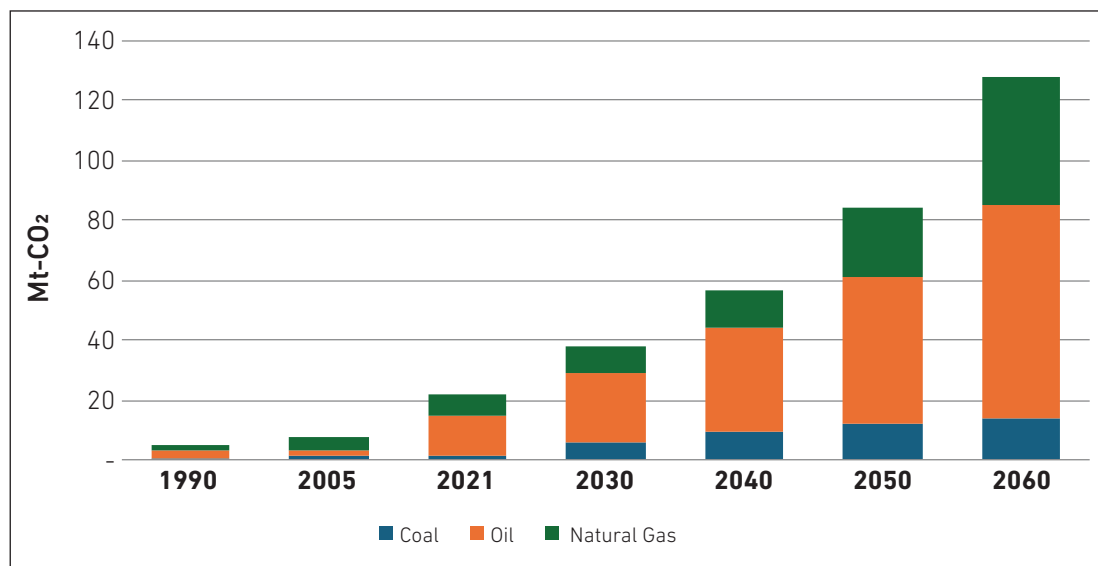
Mtoe = million tonnes of oil equivalent.

Source: Authors.

## 2.4. Carbon Dioxide Emissions by Fuel

In 2021, total carbon dioxide (CO<sub>2</sub>) emissions stood at 22.1 Mt-CO<sub>2</sub>, with oil accounting for the biggest share (57%), followed by natural gas (34.9%) and coal (8.2%). This reflects the dominance of oil and gas in primary energy supply. Under BAU, the country will continue to rely on fossil fuels, with oil and gas remaining central to its energy landscape. Total CO<sub>2</sub> emissions are projected to rise at an average annual rate of 4.6%, reaching 127.3 Mt-CO<sub>2</sub> by 2060 (Figure 12.5). The distribution of emissions by fuel source remains consistent with 2021 levels, with oil at 56.3%, natural gas at 33%, and coal at 10.7%, underscoring the continued dominance of oil and gas in the energy mix.

**Figure 12.5. Carbon Dioxide Emissions by Fuel, Business-as-Usual Scenario, 1990–2060**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Authors.

### 3. Analysis of Low-carbon Energy Transition Results

As a comparison with BAU, the low-carbon energy transition (LCET) scenario has been modelled for 2022–2060 to analyse the impact of incorporating carbon reduction targets. Carbon neutrality refers to achieving net-zero greenhouse gas emissions by balancing emissions with an equal or greater amount removed from the atmosphere. Achieving this goal requires accelerating renewable energy deployment, adopting electrification technologies, and improving energy efficiency.

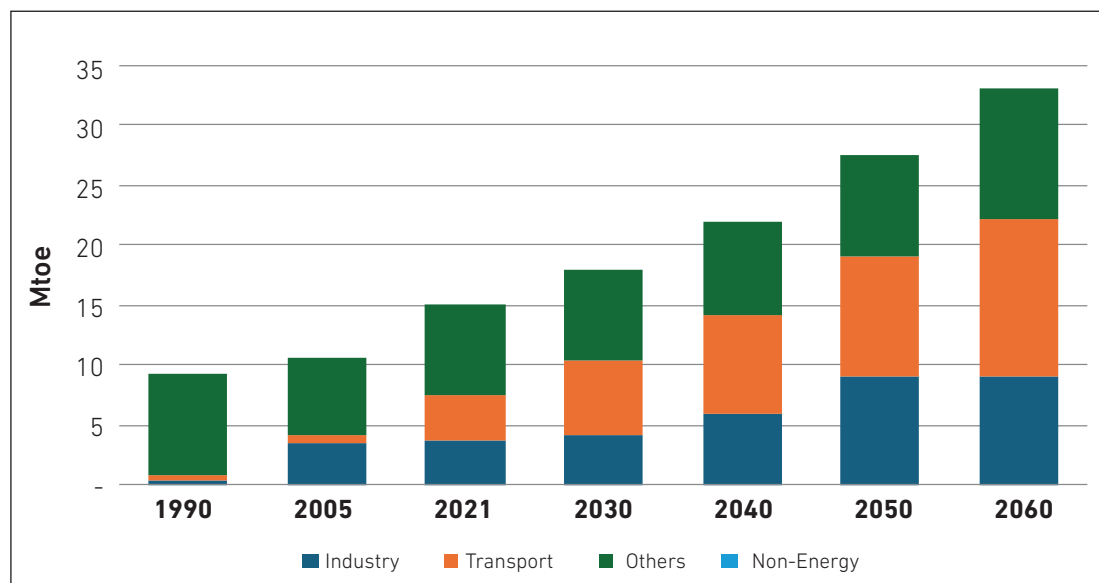
Renewable energy deployment includes increasing hydropower, solar PV, wind, thermal with CCS technologies, and biomass power plants. Electrification measures cover the adoption of electric vehicles, heat pumps, and other technologies. Energy efficiency improvements will be implemented across all analysed sectors. The study considers the potential for hydrogen production in Myanmar.



### 3.1. Final Energy Consumption

Under LCET, final energy consumption is projected to grow at an average annual rate of 2% in 2021–2060 – 0.8% lower than under BAU – reaching 33.1 Mtoe by 2060. Transport remains the largest energy consumer by 2060, although its consumption is lower than under BAU. By 2060, final energy consumption is distributed as follows: transport at 39.3%, others (e.g. residential, commercial, agricultural sectors) at 33.2%, and industry at 27.5%. 'Others' sectors are projected to grow at 0.9% per year, reflecting the impact of energy efficiency measures and other interventions. Further details on final energy consumption under LCET are shown in Figure 12.6.

**Figure 12.6. Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario, 1990–2060**

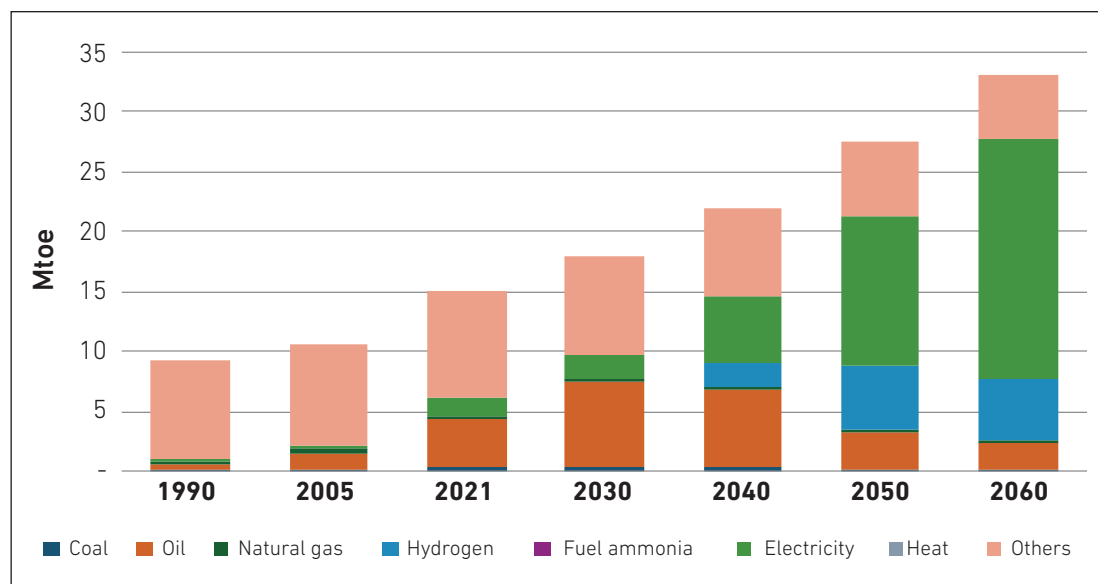


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Electricity dominates final energy consumption, accounting for 60.4% (20 Mtoe). The remaining share includes 16.5% from other sources (including biomass), 15.3% from hydrogen, 6.9% from oil, 0.5% from natural gas, and 0.4% from coal. Hydrogen production is expected to support Myanmar's shift away from fossil fuels. To achieve carbon neutrality by 2060, the country must adopt hydrogen technology and accelerate production to 5.1 Mtoe. Figure 12.7 presents final energy consumption by fuel.

**Figure 12.7. Final Energy Consumption by Fuel, Low-carbon Energy Transition Scenario, 1990–2060**



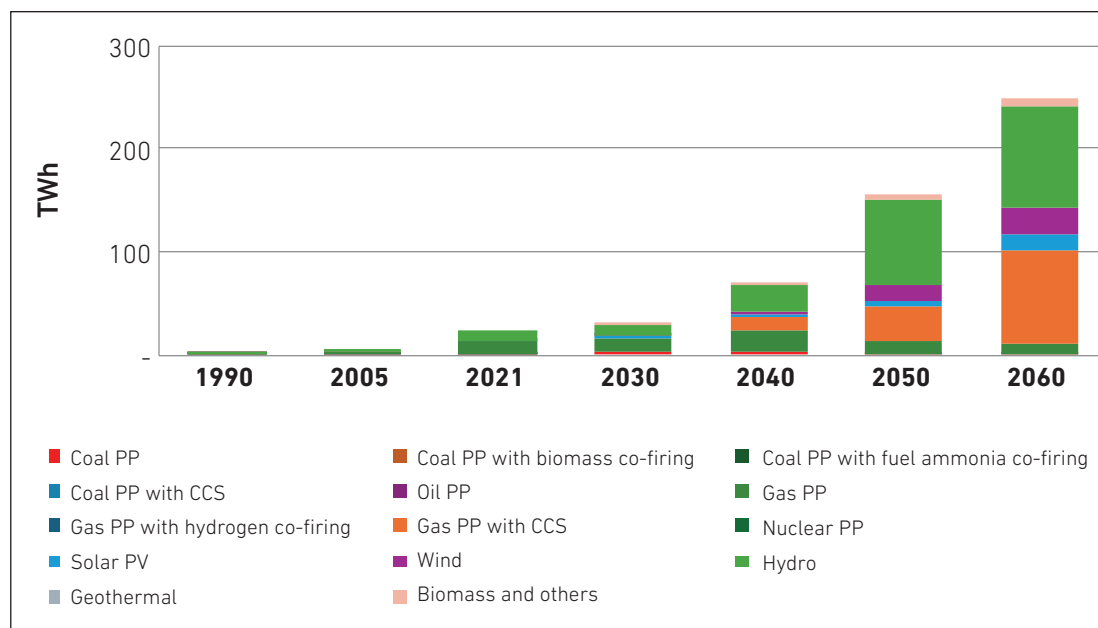
Mtoe = million tonnes of oil equivalent.

Source: Authors.

## 3.2. Power Generation Mix by Source

Under LCET, power generation is projected to grow at an average annual rate of 6.3%, reaching 247.8 TWh by 2060. The generation mix will be led by hydropower (39.8%), followed by gas with CCS (36.5%), wind (10.3%), solar PV (6.9%), gas without CCS (3.7%), and biomass and other sources (2.6%). Coal-fired generation will be gradually phased out, contributing just 0.6 TWh by 2060. Whilst hydropower will remain the primary baseload source, adequate battery and storage capacity will be essential. Gas power plants equipped with CCS are expected to become the second-largest source of electricity. Achieving the projected output of 90.5 TWh from these plants by 2060 will require early investment in CCS technology.

**Figure 12.8. Power Generation Mix by Source,  
Low-carbon Energy Transition Scenario, 1990–2060**



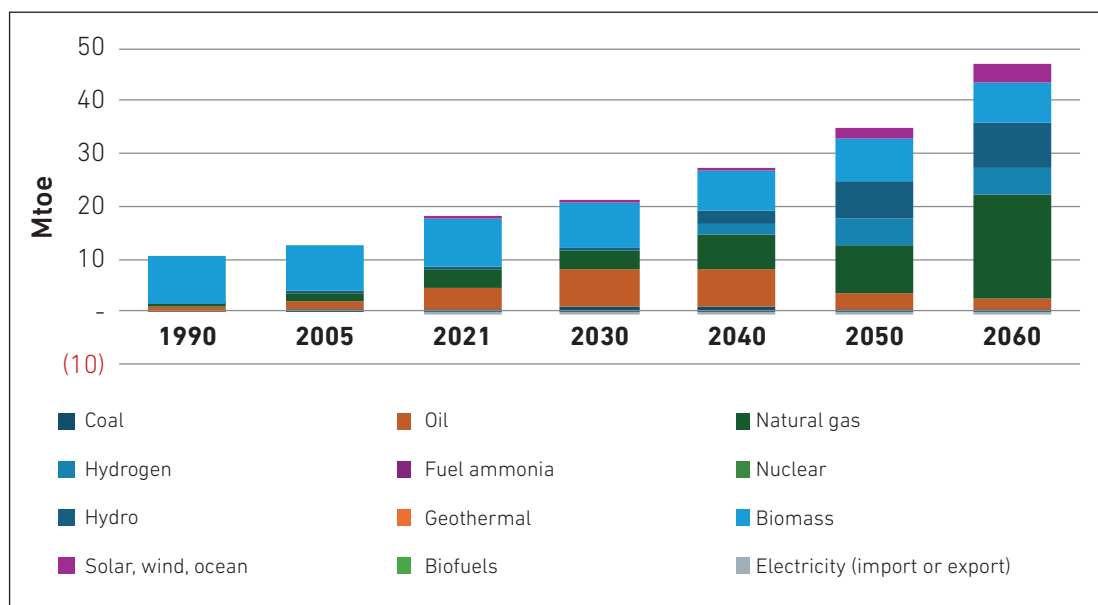
CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors.

### 3.3. Primary Energy Supply by Fuel

Under LCET, primary energy supply is projected to reach 46.8 Mtoe by 2060, growing at an average annual rate of 2.6%, compared with 3.1% under BAU. The primary energy mix consists of natural gas (41.8%), hydropower (18.1%), biomass (15.9%), hydrogen (10.8%), oil (5.3%), and coal (0.6%). Despite greater deployment of new and renewable energy, biomass will remain a key energy source due to Myanmar's abundant resources. Coal and oil consumption, however, will decline sharply, with coal supply shrinking to 0.3 Mtoe (a 0.7% annual decline from 2021) and oil to 2.5 Mtoe (a 1.4% annual decline). Hydropower is expected to grow at an average annual rate of 6.1%, supporting the shift away from coal and oil. Hydrogen supply is projected to rise from 2.0 Mtoe in 2040 to 5.1 Mtoe by 2060. To support this transition, Myanmar should develop strategies for hydrogen deployment.

**Figure 12.9. Primary Energy Supply by Fuel,  
Low-carbon Energy Transition Scenario, 1990–2060**



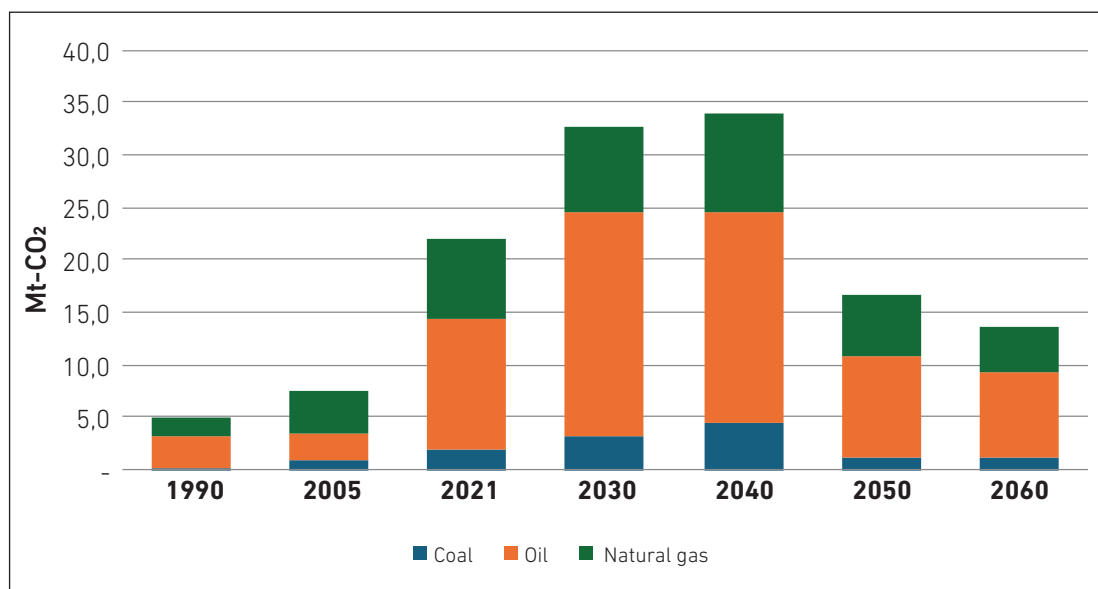
Mtoe = million tonnes of oil equivalent.

Source: Authors.

### 3.4. Carbon Dioxide Emissions by Fuel

Under LCET, CO<sub>2</sub> emissions are projected to decline by an average of 1.2% per year, reaching 13.6 Mt-CO<sub>2</sub> by 2060 – 86% lower than the projected level under BAU. This sharp decline results from the extensive deployment of new and renewable energy, hydrogen, and CCS technology. In 2021–2060, average annual emissions from coal, oil, and gas are expected to fall by 1.3%, 1.1%, and 1.5%, respectively, in contrast to the sharp increases projected under BAU. Figure 12.10 shows CO<sub>2</sub> emissions by fuel under LCET in 1990–2060.

**Figure 12.10. Carbon Dioxide Emissions by Fuel,  
Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of carbon dioxide.

Source: Authors.

## 4. Analysis of Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

An energy cost analysis was conducted to compare BAU and LCET to assess the total energy costs required to implement all assumptions under LCET and compare them with BAU. Key energy-related costs considered include fuel, investment in power generation, and CCS implementation. These costs are evaluated based on the outlook results and are presented in 2020 real prices.

The basic assumptions for this analysis are in Table 12.3, Table 12.4, and Table 12.5.

**Table 12.3. Fuel Cost Assumptions, 2060**

|          | Unit                       | 2021  | 2060 (2021 constant price) |
|----------|----------------------------|-------|----------------------------|
| Coal     | US\$/tonne                 | 80.03 | 98.00                      |
| Oil      | US\$/bbl                   | 41    | 100                        |
| Gas      | US\$/MMBtu                 | 7.77  | 7.50                       |
| Hydrogen | US\$/Nm <sup>3</sup>       | 0.8   | 0.3                        |
| CCS      | US\$/CO <sub>2</sub> tonne | 0     | 30                         |

bbl = barrel, CO<sub>2</sub> = carbon dioxide, CCS = carbon-capture and storage, MMBtu = million British thermal unit, Nm<sup>3</sup> = normal cubic metre.

Source: Authors.

**Table 12.4. Construction Cost of Power Plants, 2060  
(US\$/kilowatt)**

|                             | 2021  | by 2060 |
|-----------------------------|-------|---------|
| Coal                        | 1,500 | 1,525   |
| Coal co-firing with biomass |       | 1,600   |
| Coal co-firing with ammonia |       | 1,600   |
| Coal with CCS               |       | 1,525   |
| Oil                         | 600   | 600     |
| Gas                         | 700   | 700     |
| Gas co-firing with hydrogen |       | 800     |
| Gas with CCS                |       | 700     |
| Nuclear                     | 4,500 | 3,575   |
| Hydro                       | 2,000 | 2,223   |
| Geothermal                  | 4,000 | 4,256   |
| Solar                       | 1,600 | 307     |
| Wind                        | 1,600 | 1,235   |
| Biomass                     | 2,000 | 3,019   |

CCS = carbon capture and storage.

Source: Authors.

**Table 12.5. Capacity Factor of Power Plants, 2021 and 2060**

|                             | 2021 | 2060 |
|-----------------------------|------|------|
| Coal                        | 75%  | 80%  |
| Coal co-firing with biomass |      | 80%  |
| Coal co-firing with ammonia |      | 80%  |
| Coal with CCS               |      | 80%  |
| Oil                         | 75%  | 80%  |
| Gas                         | 75%  | 80%  |
| Gas co-firing with hydrogen |      | 80%  |
| Gas with CCS                |      | 80%  |
| Nuclear                     | 100% | 80%  |
| Hydro                       | 50%  | 40%  |
| Geothermal                  | 50%  | 50%  |
| Solar                       | 17%  | 17%  |
| Wind                        | 40%  | 40%  |
| Biomass                     | 50%  | 70%  |

CCS = carbon capture and storage.

Source: Authors.

## 4.1. Fuel Cost

Under BAU, total fuel cost is projected at US\$18,124 million, significantly higher than the US\$9,384 million estimated under LCET. This substantial reduction reflects the lower energy consumption under LCET. Supporting the LCET pathway is therefore energy- and cost-efficient.

**Table 12.6. Total Fuel Cost, Business as Usual and Low-carbon Energy Transition Scenarios, 2060**

|              | Final Energy Consumption (Mtoe) |              |              | Total Fuel Cost (US\$ million) |              |
|--------------|---------------------------------|--------------|--------------|--------------------------------|--------------|
|              | BAU (2021)                      | BAU (2060)   | LCET (2060)  | BAU (2060)                     | LCET (2060)  |
| Coal         | 0.36                            | 3.49         | 0.28         | 495                            | -13          |
| Oil          | 4.21                            | 23.68        | 2.47         | 13,390                         | -1,195       |
| Gas          | 3.31                            | 17.99        | 19.54        | 4,239                          | 4,686        |
| Hydrogen     | 0.00                            | 0.00         | 5.07         | 0                              | 5,906        |
| <b>Total</b> | <b>7.88</b>                     | <b>45.16</b> | <b>27.35</b> | <b>18,124</b>                  | <b>9,384</b> |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

## 4.2. Power Investment Cost

Table 12.7 presents the total investment cost for power plants, based on the assumptions in Table 12.4 and Table 12.5. Achieving the LCET target requires an additional 57,896 MW of capacity – 31,547 MW more than under BAU. This includes 25,279 MW of hydropower, 12,915 MW of gas with CCS, 11,366 MW of solar PV, 7,293 MW of wind power, and 1,042 MW of biomass. These capacity requirements result in higher overall costs under LCET. Figure 12.11 compares the additional capacity required under BAU and LCET.

**Table 12.7. Total Investment Cost for Power Plants, Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060**

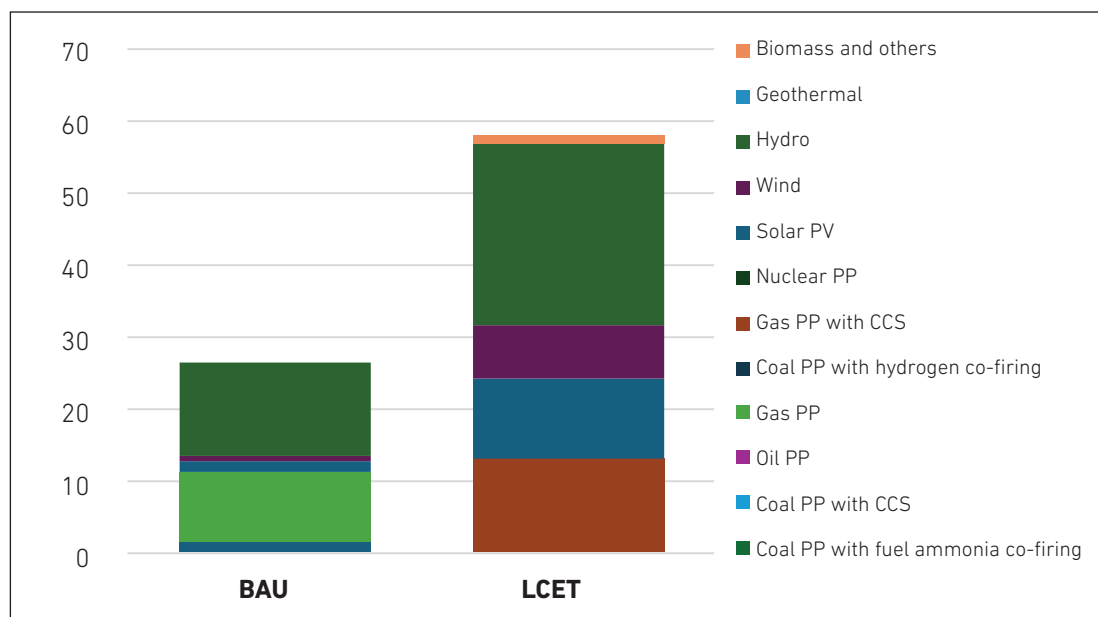
|                                     | Electricity Generation (TWh) |            |             | Additional Capacity (MW) |               | Total Investment Cost (US\$ million) |               |
|-------------------------------------|------------------------------|------------|-------------|--------------------------|---------------|--------------------------------------|---------------|
|                                     | BAU (2021)                   | BAU (2060) | LCET (2060) | BAU                      | LCET          | BAU (2060)                           | LCET (2060)   |
| Coal PP                             | 1                            | 10         | 1           | 1,399                    | 0             | 2,133                                | 10            |
| Coal PP with biomass co-firing      | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Coal PP with fuel ammonia co-firing | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Coal PP with CCS                    | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Oil PP                              | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Gas PP                              | 12                           | 82         | 9           | 9,899                    | 0             | 6,930                                | 0             |
| Gas PP with hydrogen co-firing      | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Gas PP with CCS                     | 0                            | 0          | 91          | 0                        | 12,915        | 0                                    | 9,041         |
| Nuclear PP                          | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Solar PV                            | 0                            | 2          | 17          | 1,424                    | 11,366        | 437                                  | 3,489         |
| Wind                                | 0                            | 2          | 26          | 531                      | 7,293         | 656                                  | 9,007         |
| Hydro                               | 10                           | 56         | 98          | 13,096                   | 25,279        | 29,112                               | 56,196        |
| Geothermal                          | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Biomass and others                  | 0                            | 0          | 6           | 0                        | 1,042         | 0                                    | 3,146         |
| <b>Total</b>                        | <b>23</b>                    | <b>152</b> | <b>248</b>  | <b>26,349</b>            | <b>57,896</b> | <b>39,267</b>                        | <b>80,879</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, MW = megawatt, PP = power plant, PV = photovoltaic, TWh = terawatt hour.

Source: Authors.



**Figure 12.11. Additional Capacity of Business-as-Usual and Low-carbon Energy Transition Scenarios (gigawatt)**



BAU = business as usual, CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

Source: Authors.

### 4.3. Carbon Capture and Storage

CCS technology is expected to be introduced under LCET from 2041 for natural gas power plants. The assumed CCS cost is about US\$60 per tonne of CO<sub>2</sub>, with an efficiency of 0.9. As a result, the total investment cost for CCS by 2060 is estimated at US\$2,022 million. Further details are in Table 12.8.

**Table 12.8. Total Investment Cost of Carbon Capture and Storage for Low-carbon Energy Transition Scenario, 2060**

| LCET in 2060                     | Energy Consumption (Mtoe) | CO <sub>2</sub> Emissions (Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emissions (Mt-C) | Total Investment Cost of CCS (US\$ million) |
|----------------------------------|---------------------------|-------------------------------------------------|----------------------------------|---------------------------------------------|
| Coal power plant with CCS        | 0.00                      | 0.00                                            | 0.00                             | 0.00                                        |
| Natural gas power plant with CCS | 90.51                     | 37.44                                           | 10.20                            | 2,022                                       |
| <b>Total</b>                     | <b>90.51</b>              | <b>37.44</b>                                    | <b>10.20</b>                     | <b>2,022</b>                                |

CO<sub>2</sub> = carbon dioxide, CCS = carbon capture and storage, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide, Mt-C = million tonnes of carbon.

Source: Authors.

## 4.4. Overall Cost

Based on the preceding analysis, total investment costs differ between BAU and LCET. Fuel costs represent a significant portion of overall investment (Table 12.9). Whilst LCET involves lower fuel costs due to the widespread use of renewables with minimal fuel expenses, it requires substantial investment in new power generation technologies, CCS, and additional capacity for existing plants, particularly hydropower and natural gas. All costs have been converted to an annual basis. This analysis excludes expenses related to energy efficiency improvements, energy storage, and transmission and distribution infrastructure.

In summary, the total investment cost by 2060 is projected to be US\$19,131 million under BAU and US\$14,729 million under LCET.

**Table 12.9. Energy Cost Comparison for Business-as-Usual  
and Low-carbon Energy Transition Scenarios, 2060  
(US\$ million)**

|                                                 | BAU           | LCET          |
|-------------------------------------------------|---------------|---------------|
| Fuel cost                                       | 18,124        | 9,384         |
| Power plant investment cost (average 2021–2060) | 1,007         | 2,074         |
| Investment cost of CCS                          | 0             | 2,022         |
| <b>Total in 2060</b>                            | <b>19,131</b> | <b>14,729</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors.

## 5. Conclusions and Policy Recommendations

The nationally determined contribution targets outline Myanmar's short-term plan, but long-term strategies must be analysed to identify future investment and infrastructure needs. To bridge gaps in long-term energy planning, this study explores alternative pathways through LCET, considering resource availability, historical and projected GDP and population trends, and the energy landscape up to 2060.

Myanmar has set an ambitious goal of reducing emissions by 244.52 Mt-CO<sub>2</sub> across all sectors by 2030 under its nationally determined contribution. However, specific targets for individual energy sub-sectors are lacking, limiting structured planning and goal setting. This gap is particularly evident in transport, which has no national framework on urban planning. Based on this study, LCET could achieve an annual CO<sub>2</sub> emissions reduction of 1.2% from 2021, with total emissions projected to fall by 86% by 2060 compared with 2021 levels.

To support the shift from fossil fuels to cleaner energy sources, Myanmar should prioritise accelerating investment in hydrogen and CCS technologies. Expanding the capacity of natural gas and hydropower plants – expected to remain the backbone of the country's energy supply through 2060 – is essential. Meeting the rising demand for battery storage solutions will be critical. Although biomass has historically been a major primary energy source, its share is expected to decline over time.

Meeting these energy targets will require substantial investment in new technologies and capacity expansion. It is therefore imperative to start energy planning immediately – assessing investment needs, engaging stakeholders, promoting strategic initiatives, and identifying funding opportunities. Whilst LCET involves higher initial investment than BAU, it represents a crucial step towards achieving net-zero emissions by 2060.

## References

- Asian Development Bank (2015), *Myanmar Energy Master Plan: Final Report* (accessed 15 January 2025).
- Our World in Data (2025), *Myanmar: Energy Country Profile* (accessed 15 April 2025).
- World Bank (2023), *In the Dark: Power Sector Challenges in Myanmar* (accessed 15 April 2025).
- World Bank (2022), World Development Indicators, *World Development Indicators | DataBank* (accessed 15 January 2025).

# Chapter 13

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## New Zealand Country Report

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# 1. Background

In 2024, New Zealand's current price gross domestic product (GDP) was US\$257.6 billion (constant 2015 US dollars) or about US\$48,500 per capita. New Zealand has substantial indigenous energy resources, including hydropower, geothermal, wind, natural gas, and coal. It is a net coal exporter, with national self-sufficiency at 73% in 2023, driven mainly by coal and oil. Following the March 2022 closure of Marsden Point Oil Refinery, importers switched from crude oil and refined product imports to solely refined products. As a result, refinery product imports rose more than 24% in 2023, whilst crude oil imports fell to zero. Marsden Point now operates as an import terminal under Channel Infrastructure.

As of 1 January 2024, total proven and probable oil and condensate reserves stood at 44.7 million barrels, whilst natural gas reserves totalled 34.0 billion cubic metres. In-ground coal resources exceed 15 billion tonnes, with 80% classified as lignite in the South Island (Ministry of Business, Innovation and Employment, 2024b).

On 12 December 2015, 196 Parties to the United Nations Framework Convention on Climate Change adopted the Paris Agreement, committing to reduce greenhouse gas emissions and work together on climate adaptation. The agreement entered into force on 4 November 2016.

Since 2020, countries have been submitting their nationally determined contributions (NDCs), which outline their climate action plans. These include long-term strategies to lower greenhouse gas emissions and achieve the goals of the Paris Agreement.

In 2021, the Government of New Zealand updated Aotearoa New Zealand's first NDC, committing to a 50% reduction in net emissions below gross 2005 levels by 2030. In 2022, it published its first emissions reduction plan and three emissions budgets (2022–2025, 2026–2030, 2031–2035) as required by the Climate Change Response Act 2002.

In 2025, the government must establish New Zealand's second NDC (NDC2) (2031–2035) under the Paris Agreement and set the fourth emissions budget (2036–2040) as required under the act.

The Climate Change Response (Zero Carbon) Amendment Act, passed in late 2019, provides the framework for developing and implementing clear, stable policies that support the global effort under the Paris Agreement to limit global temperature rise to 1.5°C above pre-industrial levels and help New Zealand prepare for and adapt to climate change.

The Zero Carbon Act, which established the Climate Change Commission on 1 December 2019, provides a legal framework to help New Zealand respond to climate change and meet its international obligations. The commission, an expert group, offers independent advice to the government.

New Zealand has a low-emissions electricity system, with significant generation from hydropower and geothermal energy, providing an opportunity to leverage clean electricity for decarbonising end-user sectors. The government has set ambitious targets, including achieving net-zero greenhouse gas emissions by 2050.

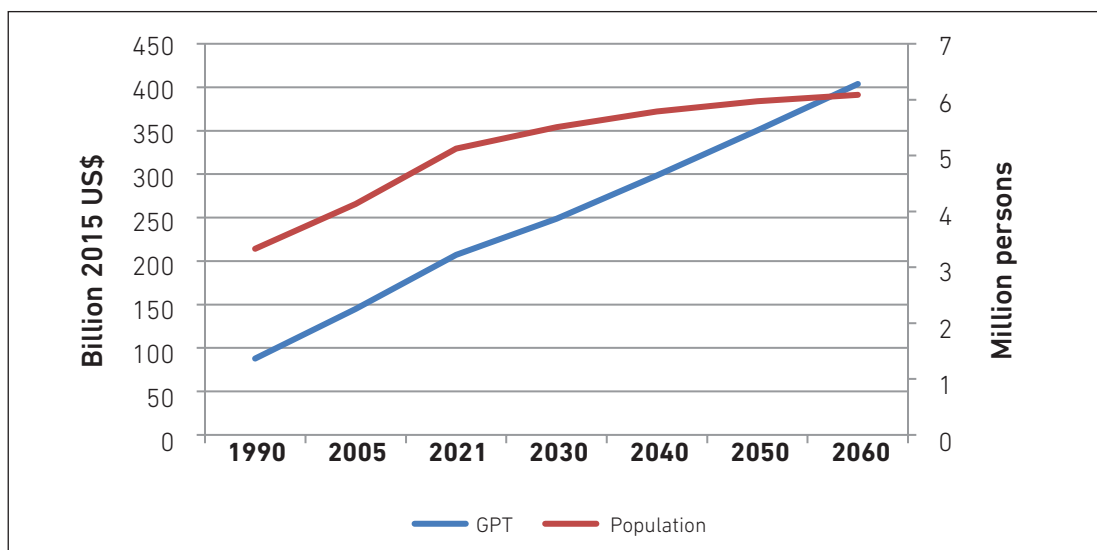
This chapter presents the business-as-usual (BAU) scenario, reflecting current energy policies, and the low-carbon energy transition (LCET) scenario, which models a pathway to net-zero emissions by 2050 or 2060. The analysis includes investment cost calculations and emissions reduction benefits under LCET compared with BAU.

## 2. Modelling Assumptions

According to the International Monetary Fund DataMapper, in April 2024, real GDP growth is projected to slow to 0% before rising to 1.9% in 2025. The stagnation reflects a slowdown in economic activity in 2024, whilst lower interest rates in 2025 are expected to support a recovery.

This outlook projects GDP to grow at an average annual rate of 1.7% per year in 2021–2060, with population increasing by 0.4% per year from 5.1 million in 2021 to 6.1 million by 2060 (Figure 13.1).

**Figure 13.1. Gross Domestic Product and Population, 1990–2060**



GDP = gross domestic product.

Sources: GDP: International Monetary Fund (2023) and authors.

Population: United Nations (2022), World Population Prospects.

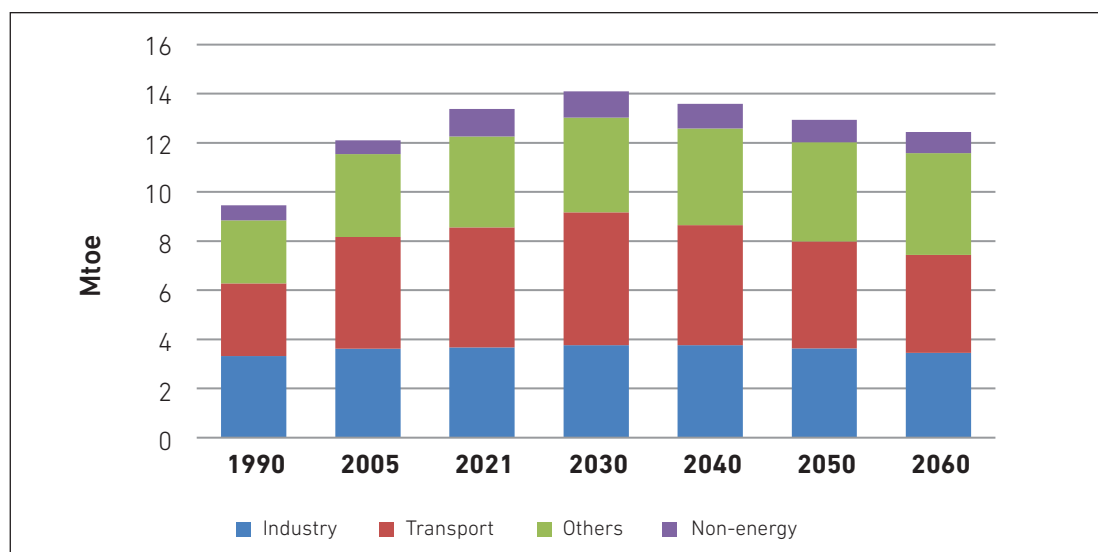
## 3. Outlook Results

### 3.1. Business-as-Usual Scenario

#### 3.1.1. Final energy consumption

Final energy consumption is expected to decline through 2060. Under BAU, final energy consumption is projected to decrease by 0.2% per year in 2021–2060, resulting in a reduction of 0.9 million tonnes of oil equivalent (Mtoe). The non-energy sector is predicted to decline by 0.3 Mtoe at an average rate of 0.7% per year. Transport and industry energy consumption are projected to decrease at an average rate of 0.5% and 0.2% per year, respectively, whilst others (agricultural, residential, and commercial sectors) are expected to grow by 0.5 Mtoe at an average rate of 0.3% per year (Figure 13.2).

**Figure 13.2. Final Energy Consumption by Sector, Business-as-Usual Scenario, 1990–2060**



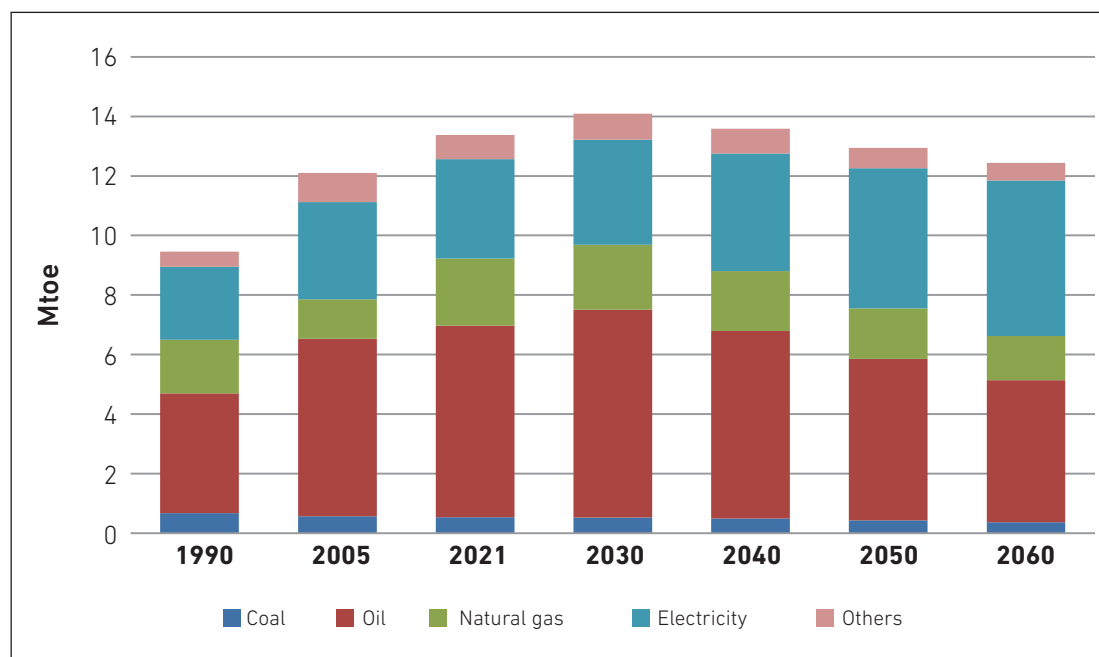
Mtoe = million tonnes of oil equivalent.

Note: Others include the agricultural, residential, and commercial sectors.

Source: Authors.

In 2021–2060, final energy consumption of gas and coal will decline at an average rate of 1.0% and 0.9% per year, respectively. Oil and others (geothermal, solar, biogas, and woody biomass) will decrease by 0.8% per year, whilst electricity demand will increase by 1.9 Mtoe at an average rate of 1.1% per year (Figure 13.3).

**Figure 13.3. Final Energy Consumption by Source, Business-as-Usual Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Note: Others include geothermal, solar, biogas, and woody biomass energy.

Source: Authors.

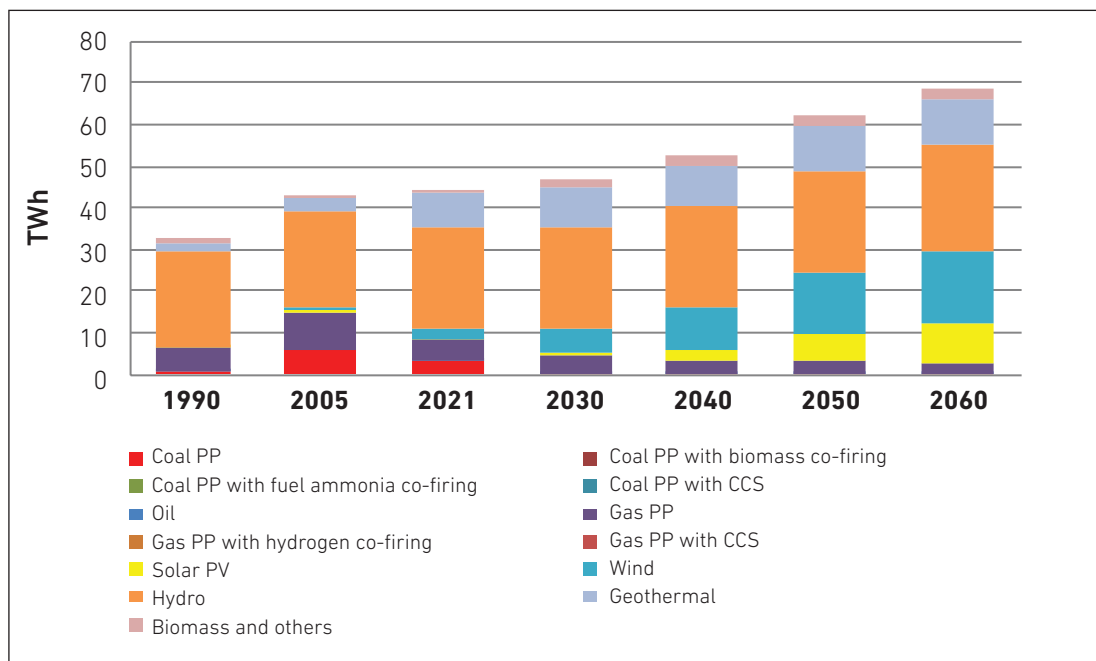
### 3.1.2. Power generation

In 2020, total power generation declined by over 1.1% due to the coronavirus disease (COVID-19) pandemic but rose by 0.6% in 2021. Under BAU, power generation is projected to grow at an average rate of 1.1% per year in 2021–2060. Coal, oil, and gas power generation will decline at annual rates of 179%, 11.2%, and 1.5%, respectively, whilst solar, wind, biomass, and other sources (biogas and waste heat) will increase by 9.7%, 5.0%, 2.7%, and 0.8% per year, respectively. Geothermal is expected to increase by 0.8% per year, whilst hydropower is projected to see minimal growth at less than 0.1% per year.

Under BAU, renewable sources will account for 96% of power generation by 2060, driven by strong growth in wind, solar, and geothermal capacity. Fossil fuel-based generation is projected to decline by 67%, contributing only 4% of total power generation by 2060 (Figure 13.4).



**Figure 13.4. Power Generation by Source, Business-as-Usual Scenario, 1990–2060**



CCS = carbon capture and storage, hydro = hydropower, PP = power plant, PV = photovoltaic.

TWh = terawatt-hour

Note: Others include biogas and waste heat.

Source: Authors.

### 3.1.3. Primary energy supply

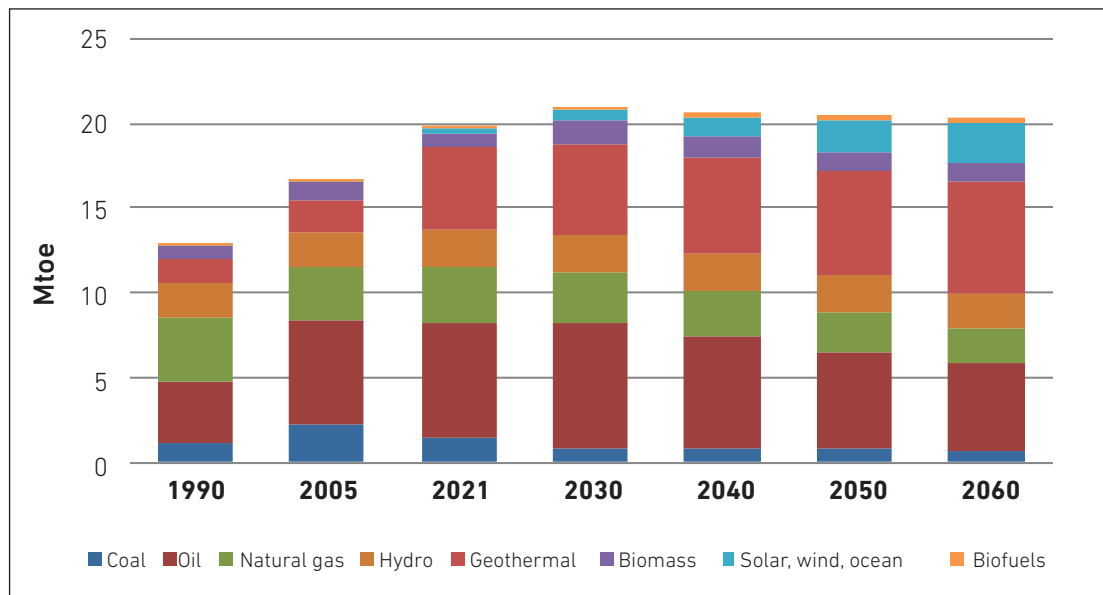
Primary energy supply is projected to decline slightly, averaging less than 0.1% per year in 2021–2060. Coal, gas, and oil supply will decrease by 1.8%, 1.2%, and 0.7%, respectively, due to reduced fossil fuel consumption in the non-energy, transport, industry, and power sectors. Coal supply will decline in the industry and power sectors. The shift to more efficient liquid-fuelled vehicles, including hybrids, along with the adoption of electric, biofuel, and hydrogen fuel cell vehicles, will drive the sharp decline in oil consumption in primary energy supply.

Under BAU, coal-fired power plants will cease operations by 2030, with none using carbon capture and storage (CCS). By 2060, gas-fired power plants will still be in operation, but none will use CCS.

Other energy sources, including biomass, solar, wind, liquid biofuels, biogas, and waste heat, are projected to increase at an average annual rate of 2.9% in 2021–2060. Geothermal and hydro supply are projected to increase slightly, averaging 0.7% and 0.1% per year, respectively, by 2060.

By 2060, under BAU, renewable sources will provide 61% of primary energy supply, whilst fossil fuels will make up the remaining 39%. In contrast, in 2021, renewables accounted for 41% of primary energy supply, with fossil fuels at 59% (Figure 13.5).

**Figure 13.5. Primary Energy Supply by Source, Business-as-Usual Scenario, 1990–2060**



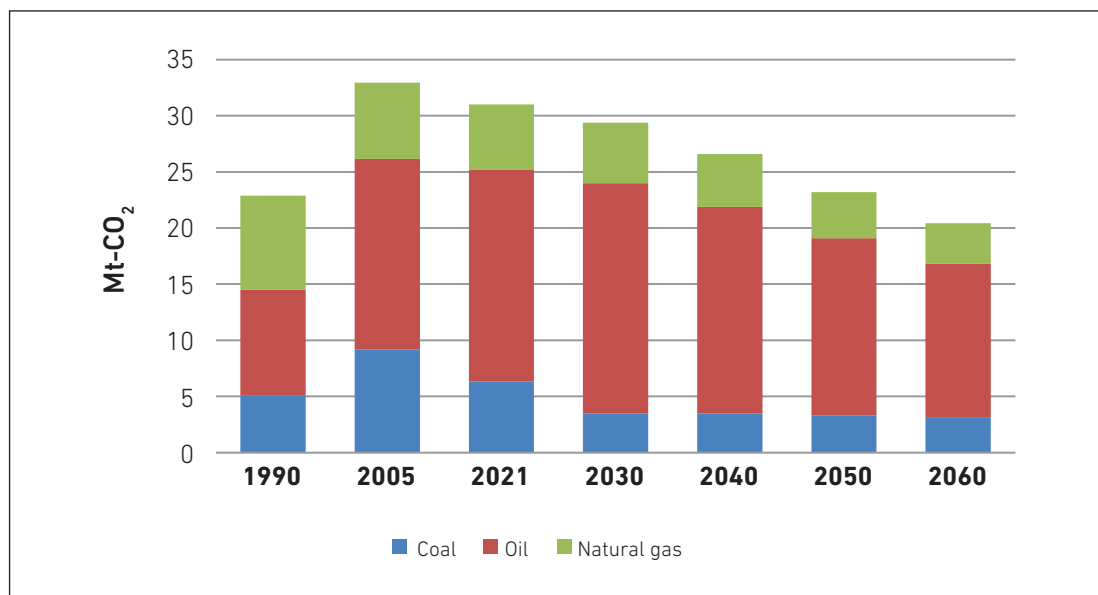
Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Authors.

### 3.1.4. Carbon dioxide emissions

Under BAU, carbon dioxide (CO<sub>2</sub>) emissions will decrease from 31.0 million tonnes (Mt-CO<sub>2</sub>) in 2021 to 20.4 Mt-CO<sub>2</sub> by 2060 (Figure 13.6). This reduction is driven by decreased gas, coal, and oil use in final energy consumption and the power sector, along with a shift to renewable energy in electricity generation and increased adoption of electric vehicles.

**Figure 13.6. Carbon Dioxide Emissions by Source,  
Business-as-Usual Scenario, 1990–2060**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

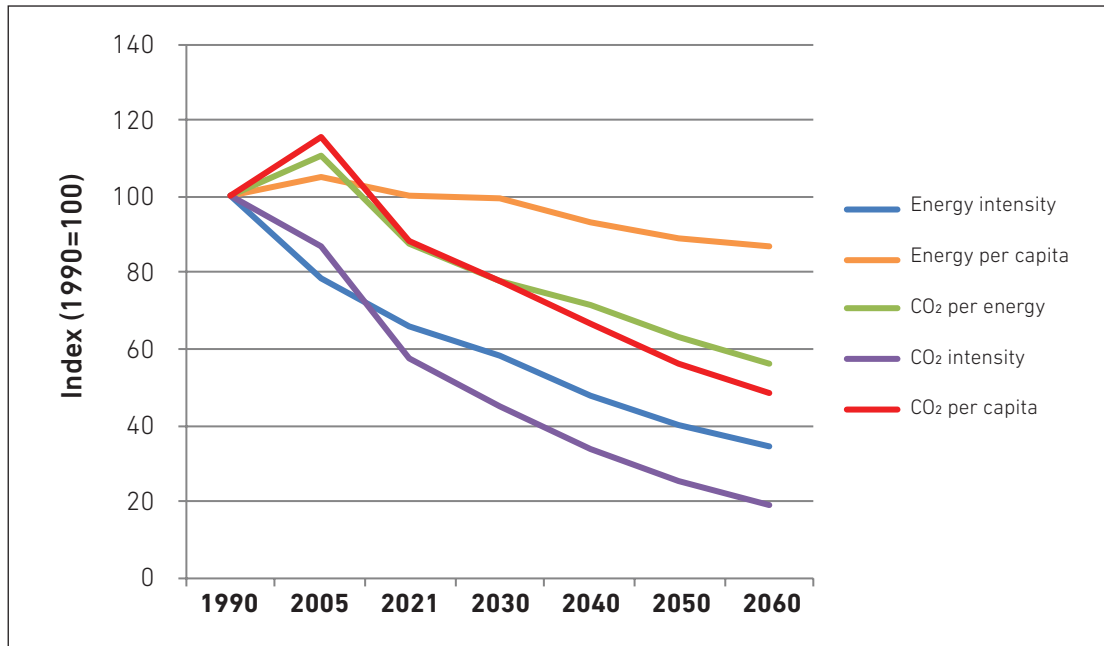
Source: Authors.

### 3.1.5. Energy indicators

Primary energy intensity is measured as the ratio of primary energy supply to GDP, representing primary energy consumption per million US dollars (constant 2015 US dollars). Slower growth in primary energy supply relative to GDP will lead to lower energy intensity over time. Energy intensity will improve from 96 tonnes of oil equivalent per million US dollars (toe/US\$ million) in 2021 to 50 toe/US\$ million by 2060. Primary energy supply per capita will decline from 3.9 toe per person in 2021 to 3.3 toe per person by 2060.

CO<sub>2</sub> intensity, measured as the ratio of emissions to GDP, is projected to drop by an average rate of 2.7% per year in 2021–2060. Under BAU, all energy and CO<sub>2</sub> emissions indicators are expected to follow similar downward trends (Figure 13.7).

**Figure 13.7. Energy Indicators, Business-as-Usual Scenario, 1990–2060**



CO<sub>2</sub>= carbon dioxide.

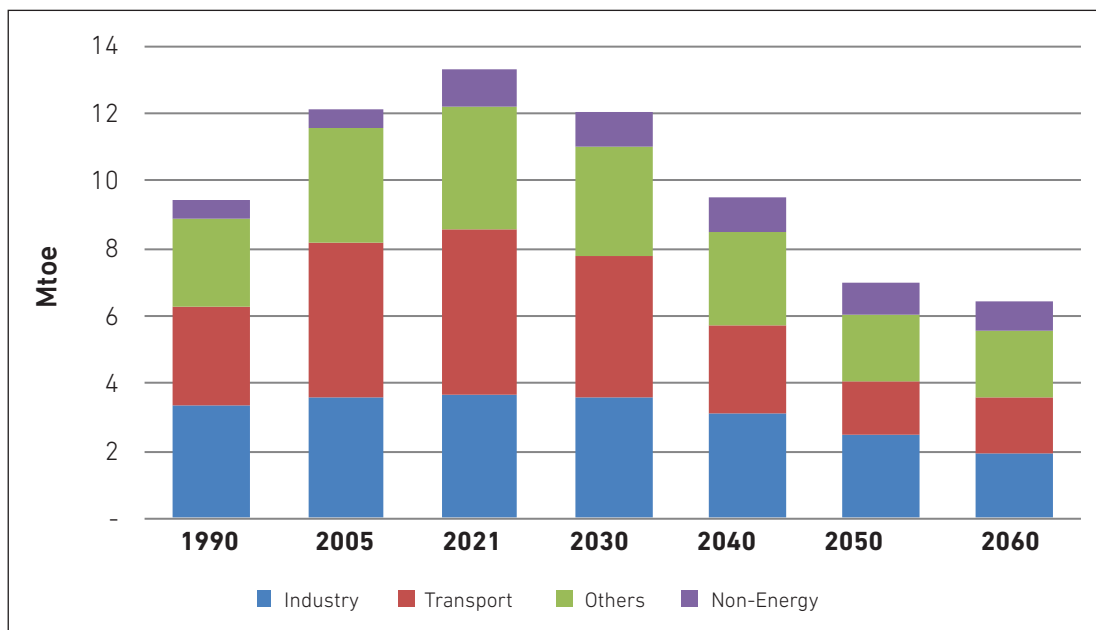
Source: Authors.

## 3.2. Low-carbon Energy Transition Scenario

### 3.2.1. Final energy consumption

Under LCET-CN, final energy consumption will decline at an average annual rate of 1.9%, dropping from 13.3 Mtoe in 2021 to 6.4 Mtoe by 2060. By 2060, final energy consumption will be 49% lower than in BAU. The largest reduction will occur in transport, which will decrease by 66% due to improved fuel efficiency and fuel substitution. Greater efficiency in liquid-fuelled internal combustion engines and a shift to highly efficient electric vehicles will reduce liquid fuel consumption. Energy use in industry will decline by 47%; in the 'others' sectors (agricultural, residential, and commercial) by 46%; and in the non-energy sector by 23% (Figure 13.8).

**Figure 13.8. Final Energy Consumption by Sector, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Note: Others include the agricultural, residential, and commercial sectors.

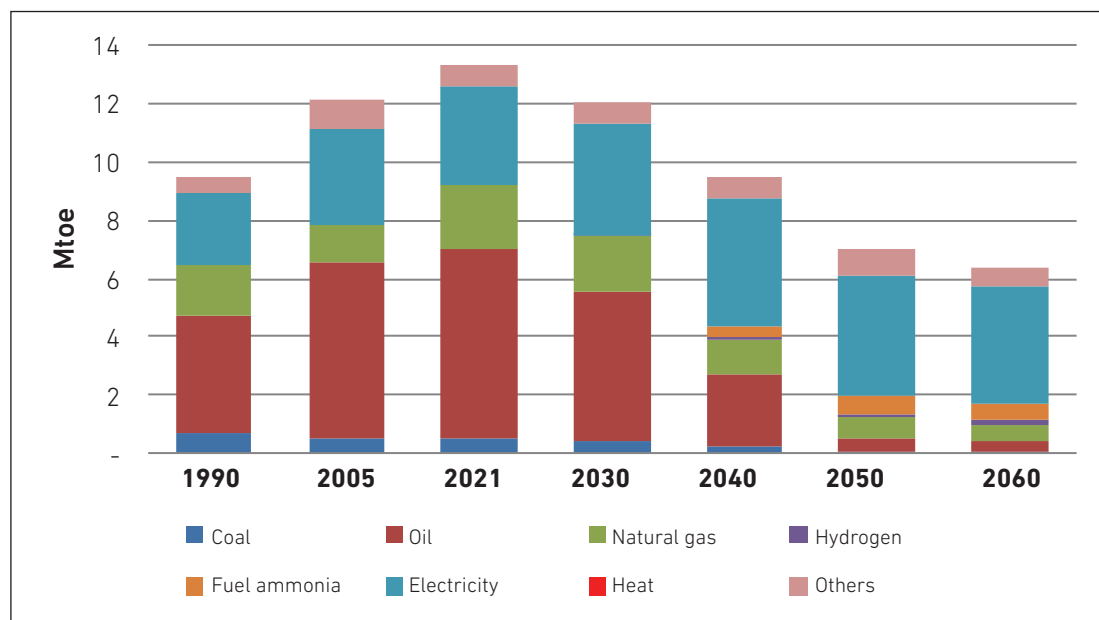
Source: Authors.

For final energy consumption by source, oil, coal, and gas demand will decline at average annual rates of 7.2%, 5.8%, and 3.5%, respectively, in 2021–2060. Demand for other renewable energy sources, including geothermal, solar, biogas, and woody biomass used for direct-use heat applications, will decline slightly at 0.2% per year. In contrast, electricity demand will rise by 0.4% per year.

Under LCET, the large reduction in final energy consumption will come from fossil fuels, with oil, coal, and natural gas decreasing by 95%, 90%, and 75%, respectively, in 2021–2060. These reductions will significantly lower CO<sub>2</sub> emissions.

Hydrogen consumption will begin in 2030, reaching 0.2 Mtoe by 2060, primarily in industry and transport. Fuel ammonia consumption will start in 2040, rising to 0.6 Mtoe by 2060. Together, hydrogen and fuel ammonia will account for about 11.9% of final energy consumption by 2060 (Figure 13.9).

**Figure 13.9. Final Energy Consumption by Source, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Note: Others include geothermal, solar, biogas, and woody biomass.

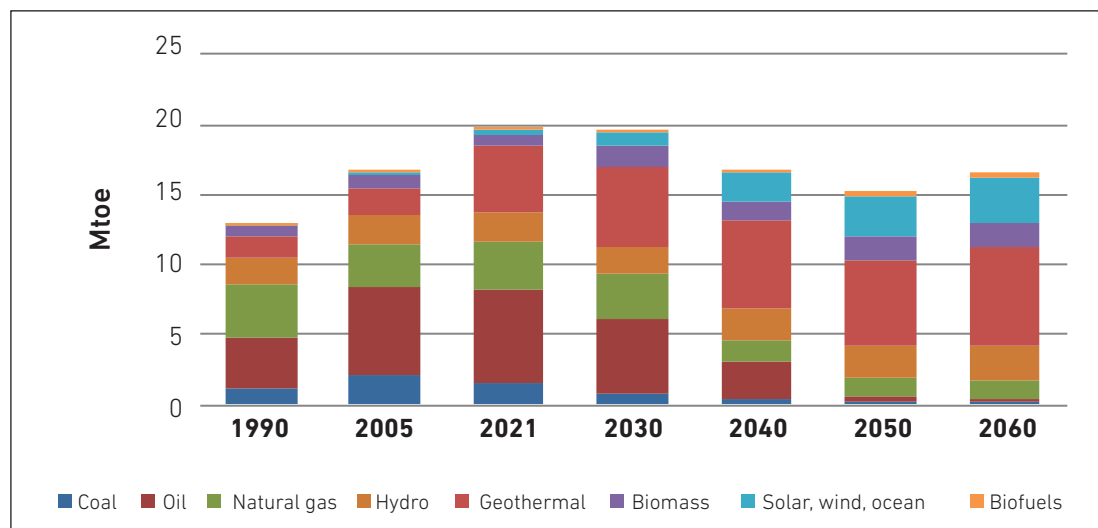
Source: Authors.

### 3.2.2. Primary energy supply

Under LCET, primary energy supply will decline at an average rate of 0.5%, from 19.7 Mtoe in 2021 to 16.5 Mtoe by 2060. The share of fossil fuels, which made up 59% of primary energy supply in 2021, will drop to 11% by 2060. Fossil fuel supply will decline significantly as more sustainable low-carbon fuels are adopted.

Oil, coal, and gas supply will decline at average annual rates of 8.4%, 5.3%, and 2.2%, respectively, in 2021–2060. Other renewable sources (biomass, solar, wind, liquid biofuels, biogas, and waste heat), geothermal, and hydropower will grow by 3.8%, 1.0%, and 0.5% per year, respectively (Figure 13.10).

**Figure 13.10. Primary Energy Supply by Source, Low-carbon Energy Transition Scenario, 1990–2060**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

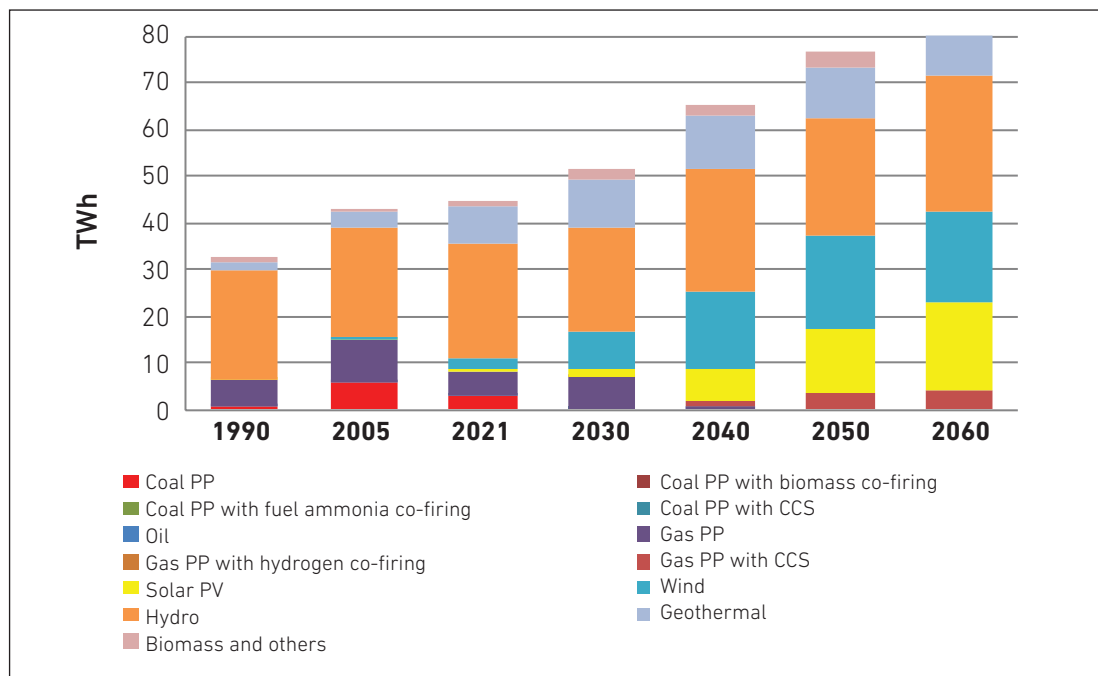
### 3.2.3. Power generation

Under LCET, power generation is projected to increase at an average rate of 1.8% per year, from 44.6 TWh in 2021 to 87.8 TWh by 2060.

The share of renewable sources in power generation is projected to rise from 81.5% in 2021 to 95.3% by 2060. Hydropower will remain dominant, although its share of total generation will decline from 54% in 2021 to 33% by 2060. Geothermal power generation will see a decrease, from 18.9% to 14.3%. The shares of wind, biomass, and others (including biogas and waste heat), and solar photovoltaic (PV) power generation will grow from 5.9%, 1.8%, and 0.6%, respectively, in 2021, to 22.7%, 4.0%, and 21.3%, respectively, by 2060. Overall, renewable sources will contribute over 95% of total power generation in 2060.

The share of gas and coal will decline significantly. Gas, which accounted for 11.2% of generation in 2021, coal at 7.2%, and oil at 0.1% are all expected to drop to 0.0% by 2060. Under LCET, power generation from natural gas using CCS is projected to reach 4.1 TWh by 2060, whilst no coal-based power will use CCS. Gas power generation with CCS will account for 4.7% by 2060 (Figure 13.11).

**Figure 13.11. Power Generation, Low-carbon Energy Transition Scenario, 1990–2060**



CCS = carbon capture and storage, hydro = hydropower, PP = power plant, PV = photovoltaics, TWh = terawatt-hour.

Note: Others include biogas and waste heat.

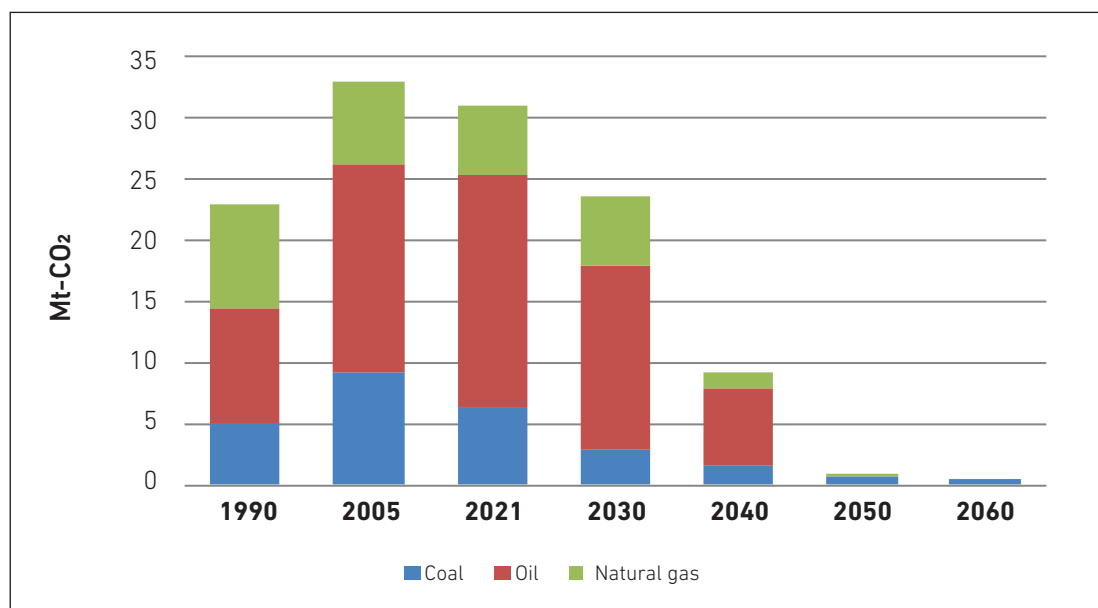
Source: Authors.

### 3.2.4. Carbon dioxide emissions

CO<sub>2</sub> emissions under LCET are expected to decline more rapidly than under BAU, with an annual reduction of 10.3% from energy demand. Emissions are expected to fall from 31.0 Mt-CO<sub>2</sub> in 2021 to about 0.4 Mt-CO<sub>2</sub> by 2060. The total reduction from 1990 to 2050 or 2060 will be nearly 100%, aligning with the government's net-zero emissions target by 2050. However, this reduction excludes biogenic methane, which has a reduction target of 24%–47% below 2017 levels, and ensures that New Zealand meets its commitments under the Paris Agreement. Figure 13.12 illustrates CO<sub>2</sub> emissions trends in 1990–2021 and projections for 2030–2060 under LCET.



**Figure 13.12. Carbon Dioxide Emissions by Source, Low-carbon Energy Transition Scenario, 1990–2060**



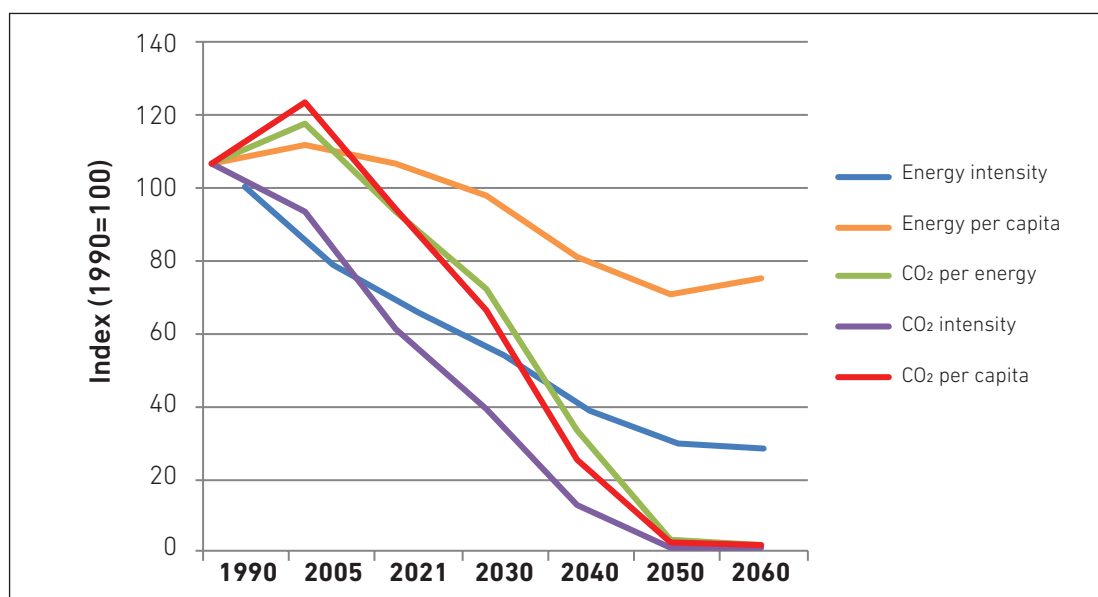
Mt-CO<sub>2</sub> = million tonnes of carbon dioxide. Source: Authors.

### 3.2.5. Energy indicators

CO<sub>2</sub> intensity is measured as the ratio of emissions to GDP, expressed in grammes of CO<sub>2</sub> per US dollar at constant 2015 US dollar values.

Figure 13.13 illustrates CO<sub>2</sub> intensity under LCET in 1990–2060. The projections indicate an average annual reduction of 11.9% in CO<sub>2</sub> intensity in 1990–2060, leading to net-zero emissions in 2050–2060.

**Figure 13.13. Energy Indicators, Low-carbon Energy Transition Scenario, 1990–2060**



CO<sub>2</sub> = carbon dioxide.

Source: Authors.

### 3.3. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

This section analyses energy costs to compare the differences between BAU and LCET. Implementing LCET requires investment in low-carbon technologies, including energy-saving technologies, renewable energy, hydrogen, and CCS. The energy cost analysis estimates the total investment needed to implement policies and programmes under LCET compared with BAU. The analysis is based on fuel costs (Table 13.1), power plant construction costs (Table 13.2), and power plant capacity factors (Table 13.3).

**Table 13.1. Fuel Cost Assumptions**

|          | 2020/2021 | 2050 or 2060<br>(2019 constant price) | Unit                       |
|----------|-----------|---------------------------------------|----------------------------|
| Coal     | 80.03     | 98.00                                 | US\$/tonne                 |
| Oil      | 41.00     | 100.00                                | US\$/bbl                   |
| Gas      | 7.77      | 7.50                                  | US\$/MMBTU                 |
| hydrogen | 0.80      | 0.30                                  | US\$/Nm <sup>3</sup>       |
| CCS      | 0.00      | 60.00                                 | US\$/CO <sub>2</sub> tonne |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal unit, Nm<sup>3</sup> = normal cubic metre.

Source: Authors.

**Table 13.2. Construction Cost of Power Plants Assumptions  
(US\$/kilowatt)**

|                             | 2021  | by 2050 Or 2060 |
|-----------------------------|-------|-----------------|
| Coal                        | 1,500 | 1,525           |
| Coal co-firing with biomass | 0     | 1,600           |
| Coal co-firing with ammonia | 0     | 1,600           |
| Coal with CCS               | 0     | 1,525           |
| Oil                         | 600   | 600             |
| Gas                         | 700   | 700             |
| Gas co-firing with hydrogen | 0     | 800             |
| Gas with CCS                | 0     | 700             |
| Hydro                       | 2,000 | 2,223           |
| Geothermal                  | 4,000 | 4,256           |
| Solar                       | 1,600 | 307             |
| Wind                        | 1,600 | 1,235           |
| Biomass                     | 2,000 | 3,019           |

CCS = carbon capture and storage.

Source: Authors.

**Table 13.3. Capacity Factor of Power Plants Assumptions by 2060  
(%)**

|                             | 2021 | by 2050 Or 2060 |
|-----------------------------|------|-----------------|
| Coal                        | 54   | 0               |
| Coal co-firing with biomass | 0    | 0               |
| Coal co-firing with ammonia | 0    | 0               |
| Coal with CCS               | 0    | 80              |
| Oil                         | 2    | 2               |
| Gas                         | 43   | 15              |
| Gas co-firing with hydrogen | 0    | 0               |
| Gas with CCS                | 0    | 80              |
| Hydro                       | 50   | 40              |
| Geothermal                  | 92   | 97              |
| Solar                       | 12   | 23              |
| Wind                        | 43   | 40              |
| Biomass                     | 50   | 70              |

CCS = carbon capture and storage.

Source: Authors.

### 3.3.1. Fuel cost

The fuel cost comparison is based on primary energy consumption under BAU and LCET. By 2060, primary energy consumption will be 1.9 Mtoe, compared with 7.9 Mtoe under BAU. As a result, total fuel investment costs by 2060 are estimated at US\$763 million under LCET, significantly lower than the US\$4,197 million under BAU (Table 13.4).

**Table 13.4. Total Investment Fuel Cost Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios by 2060**

|              | Primary Energy Consumption (Mtoe) |             |              | Total Investment Cost (US\$ million) |              |
|--------------|-----------------------------------|-------------|--------------|--------------------------------------|--------------|
|              | BAU 2021                          | BAU 2060    | LCET-CN 2060 | BAU 2060                             | LCET-CN 2060 |
| Coal         | 1.51                              | 0.74        | 0.18         | 118                                  | 28           |
| Oil          | 6.77                              | 5.07        | 0.22         | 3,484                                | 154          |
| Gas          | 3.32                              | 2.06        | 1.37         | 595                                  | 396          |
| Hydrogen     | 0.00                              | 0.00        | 0.16         | 0                                    | 185          |
| <b>Total</b> | <b>11.60</b>                      | <b>7.87</b> | <b>1.93</b>  | <b>4,197</b>                         | <b>763</b>   |

BAU = business as usual, LCET = low-carbon energy transition.

Source: Authors.

### 3.3.2. Power generation investment

The construction cost and capacity factor assumptions in Table 13.2 and Table 13.3 form the basis for calculating total power plant investment cost by 2060 under BAU and LCET. The capacity factor for each power plant in both scenarios determines the additional capacity needed to generate electricity by 2060. Table 13.5 presents the total investment cost for constructing these plants in each scenario.

The total additional capacity required by 2060 under BAU is 9,667 megawatts (MW) from 2021. However, under LCET, the additional capacity is estimated at 16,957 MW, significantly higher due to the accelerated adoption of renewable energy for power generation. This shift aims to reduce CO<sub>2</sub> emissions and increase energy independence. As a result, the total investment cost for power plants by 2060 is estimated at US\$9,509 million under BAU and US\$15,719 million under LCET.

**Table 13.5. Total Investment Power Plants Cost Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios by 2060**

|                                     | Electricity Generation (TWh) |            |             | Additional Capacity (MW) |               | Total Investment Cost (US\$ million) |               |
|-------------------------------------|------------------------------|------------|-------------|--------------------------|---------------|--------------------------------------|---------------|
|                                     | BAU (2021)                   | BAU (2060) | LCET (2060) | BAU (2060)               | LCET (2060)   | BAU (2060)                           | LCET (2060)   |
| Coal PP                             | 3                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Coal PP with biomass co-firing      | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Coal PP with fuel ammonia co-firing | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Coal PP with CCS                    | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Oil                                 | 0.027                        | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Gas PP                              | 5                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Gas PP with hydrogen co-firing      | 0                            | 0          | 0           | 0                        | 0             | 0                                    | 0             |
| Gas PP with CCS                     | 0                            | 0          | 4           | 0                        | 584           | 0                                    | 409           |
| Solar PV                            | 0.254                        | 9          | 19          | 4,484                    | 9,166         | 1,376                                | 2,814         |
| Wind                                | 3                            | 18         | 20          | 4,345                    | 4,927         | 5,366                                | 6,084         |
| Hydro                               | 24                           | 25         | 29          | 244                      | 1,352         | 543                                  | 3,005         |
| Geothermal                          | 8                            | 11         | 13          | 349                      | 487           | 1,484                                | 2,073         |
| Biomass and others                  | 1                            | 2          | 4           | 245                      | 442           | 739                                  | 1,334         |
| <b>Total</b>                        | <b>45</b>                    | <b>69</b>  | <b>88</b>   | <b>9,667</b>             | <b>16,957</b> | <b>9,509</b>                         | <b>15,719</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET= low-carbon energy transition, MW = megawatt, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors.

Table 13.5 shows that electricity generation by 2060 will be higher under LCET, reaching 88 TWh compared with 69 TWh under BAU. Under BAU, electricity will be generated from gas and renewable energy power plants. Under LCET, renewable energy generation will increase significantly, aligning with achieving net-zero CO<sub>2</sub> emissions.

Based on the assumed capacity factors for each plant, BAU will require an additional 9,667 MW by 2060, with solar PV (4,484 MW) and wind (4,345 MW) making up most of new capacity. Under LCET, the total additional capacity requirement will be 16,957 MW, including 9,166 MW from solar PV and 4,927 MW from wind power plants.

Based on construction cost assumptions, renewable energy power plants are expected to have higher costs than fossil fuel plants. As a result, the total investment cost for power plants by 2060 will be US\$9,509 million under BAU, lower than the US\$15,719 million under LCET.

### 3.3.3. Carbon capture and storage cost

CCS technology is assumed to be introduced under LCET starting in 2030. The investment cost for CCS was calculated only for natural gas-fired power plants equipped with CCS, as coal-based power plants will no longer be operating by 2060. If CCS devices can capture up to 90% of CO<sub>2</sub> emissions and the average capture cost is about US\$60 per tonne of CO<sub>2</sub>, the total investment for CCS is estimated at US\$75 million (Table 13.6).

**Table 13.6. Total Investment Cost of Carbon Capture and Storage under the Low-carbon Energy Transition Scenario by 2060**

|                                        | Fuel Consumption (Mtoe) | CO <sub>2</sub> Emissions (Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emissions (Mt-C) | Total Investment Cost of CCS (US\$ million) |
|----------------------------------------|-------------------------|-------------------------------------------------|----------------------------------|---------------------------------------------|
| Coal-fired power plant with CCS        | 0.00                    | 0.00                                            | 0.00                             | 0.00                                        |
| Natural gas-fired power plant with CCS | 0.65                    | 1.39                                            | 0.38                             | 75.11                                       |
| <b>Total</b>                           | <b>0.65</b>             | <b>1.39</b>                                     | <b>0.38</b>                      | <b>75.11</b>                                |

CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, Mtoe= million tonnes of oil equivalent, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide, Mt-C= million tonnes of carbon.

Source: Authors.

### 3.3.4. Overall cost

The overall total cost comparison between BAU and LCET is shown in Table 13.7. By 2060, total investment is projected at US\$7,851 million under BAU and at US\$10,703 million under LCET. The additional investment required to implement LCET is 36% (US\$2,852 million) higher than BAU. Power capital costs will rise by 65% (US\$6,210 million) under LCET due to significant investments in renewable energy, including solar PV, wind, hydropower, geothermal, and biomass. However, fuel cost savings under LCET will exceed 200%.

**Table 13.7. Energy Cost Comparison for Business-as-Usual and Low-carbon Energy Transition Scenarios in 2060 (US\$ million)**

|                                                 | BAU          | LCET          | LCET vs BAU  |
|-------------------------------------------------|--------------|---------------|--------------|
| Fuel cost                                       | -1658        | -5091         | -3434        |
| Power plant investment cost (average 2021–2060) | 9,509        | 15,719        | 6,210        |
| Investment cost of CCS                          | 0            | 75            | 75           |
| <b>Total</b>                                    | <b>7,851</b> | <b>10,703</b> | <b>2,852</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors.

## 4. Conclusions and Policy Recommendations

As a result of the analysis, total investment under LCET by 2060 is estimated at US\$10,703 million, higher than the US\$7,851 million under BAU. This increase is driven by significant investments in solar PV, wind, hydro, and geothermal power generation, enabling New Zealand to achieve net-zero emissions by 2050 or 2060. Power generation under LCET is 28% greater than under BAU, requiring more capital investment to support the additional generation.

As of the second quarter of 2024 (April–June), New Zealand generated over 81% of its electricity from renewable sources. Renewable energy plays a key role in meeting domestic and international emissions reduction commitments and mitigating the environmental and health impacts of emissions. The government has committed to reaching net-zero emissions for long-lived gases by 2050 and reducing biogenic methane emissions by 24%–47% by the same year.

The results in Table 13.7 indicate that implementing LCET will require a total investment of US\$2,852 million more than BAU. This increase is driven by the need for renewable energy, hydrogen, and CCS technologies to support the transition of the power sector.

Under LCET, the largest reduction in total investment will come from fuel costs, saving US\$3,434 million. However, increasing renewable power generation and implementing CCS in gas-fired power plants will require an additional US\$6,285 million by 2060 compared with BAU.

In April 2024, the Cabinet set nine government targets to focus the public sector on improving results in health, law and order, work, housing, and the environment. Target 9 is to reduce net greenhouse gas emissions and meet New Zealand's 2050 net-zero climate goals, limiting total net emissions to no more than 290 megatonnes in 2022–2025 and 305 megatonnes in 2026–2030. In December 2024, the Minister of Climate Change released the second reduction plan 2026–2030. This plan reflects our commitment to delivering effective climate policies, allowing our climate and economy to thrive.

In November 2024, the Minister of Climate Change released a report by the Climate Change Commission that outlines the domestic emissions reductions under NDC2, provided further action begins before 2031. In January 2025, the government submitted to the United Nations New Zealand's second international climate target under the Paris Agreement. New Zealand's second NDC aims to reduce emissions by 51%–55% compared to 2005 levels, by 2035.

## References

- Climate Change Commission (2024), Progress Report: National Adaptation Plan (accessed 20 November 2024). [https://www.climatecommission.govt.nz/public/Monitoring-and-reporting/NAPPA-2024/CCC-NAPPA\\_bookmarked2.pdf](https://www.climatecommission.govt.nz/public/Monitoring-and-reporting/NAPPA-2024/CCC-NAPPA_bookmarked2.pdf)
- Climate Change Commission (2024), Report on the Potential Domestic Contribution to Aotearoa New Zealand's Second Nationally Determined Contribution (accessed 20 November 2024). <https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/nationally-determined-contributions/ndc2-report/>
- Climate Change Commission (2024c), Terms of Reference (accessed 20 November 2024). <https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/NDC2/NDC2-s5k-CCRA-TOR.pdf>
- Climate Change Commission (2023), Briefing to the Incoming Minister of Climate Change Hon Simon Watts (accessed 20 November 2024). <https://www.climatecommission.govt.nz/public/Corporate-publications/BIM/2023-12-06-BIM-Hon-Simon-Watts.pdf>
- Climate Change Commission (2021), Ināia tonu nei: Modelling and data, Electricity market modelling (accessed 20 November 2024). <https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/modelling/>
- Energy Efficiency and Conservation Authority New Zealand (2024), Accelerate renewable energy (accessed 20 November 2024). <https://www.eeca.govt.nz/strategic-focus-areas/accelerate-renewable-energy/>
- International Monetary Fund (2024), At a Glance, Country Data (accessed 20 October 2024). <https://www.imf.org/en/Countries/NZL>
- International Monetary Fund (2023), World Economic Outlook (accessed 20 June 2024). <https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021>
- Ministry of Business, Innovation and Employment (2024a), Electricity statistics (last updated 12 September 2024) (accessed 20 November 2024). <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/>
- Ministry of Business, Innovation and Employment (2024b), Energy in New Zealand 2024. Wellington (accessed 20 October 2024). <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand/energy-in-new-zealand-2024>
- Ministry for the Environment (2024), Government Response to the Climate Change Commission, Monitoring Report: Emissions Reduction 2024 (accessed 20 November 2024). <https://environment.govt.nz/publications/government-response-to-the-climate-change-commission-monitoring-report-emissions-reduction-2024/>



Ministry for the Environment (2022), Towards a Productive, Sustainable and Inclusive economy, Aotearoa New Zealand's First Emissions Reduction Plan (accessed 20 October 2024). <https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/>

Ministry for the Environment (2024), Our journey towards net zero, New Zealand's second emissions reduction plan 2026–30 (accessed 28 March 2025). <https://environment.govt.nz/publications/second-emissions-reduction-plan-technical-annex/>

Ministry for the Environment (2025), Submission under the Paris Agreement, New Zealand's second Nationally Determined Contribution (accessed 28 March 2025). <https://environment.govt.nz/assets/publications/climate-change/New-Zealands-second-Nationally-Determined-Contribution-Submission-under-the-Paris-Agreement.pdf>

Ministry for the Environment, Climate Change Response (Zero Carbon) Amendment Act 2019 (last updated 5 April 2021) (accessed 20 November 2024). <https://environment.govt.nz/acts-and-regulations/acts/climate-change-response-amendment-act-2019/>

New Zealand Institute of Economic Research (Inc) (2024), NZIER Consensus Forecasts. Media release (accessed 20 November 2024). <https://www.nzier.org.nz/publications/nzier-consensus-forecasts-suggest-a-sluggish-economy-for-the-coming-year>

Ministry for the Environment (2022), Towards a Productive, Sustainable and Inclusive economy, Aotearoa New Zealand's First Emissions Reduction Plan. (accessed 20 October 2024). <https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/>

Statistics New Zealand (2024), Population estimates and projections (accessed 20 November 2024). <https://www.stats.govt.nz/topics/population-estimates-and-projections/>

United Nations Climate Change (2022), New Zealand's Second Nationally Determined Contribution (updated) (accessed 20 October 2024). <https://unfccc.int/documents/497818>

United Nations Climate Change (2015), The Paris Agreement (accessed 20 October 2024). <https://unfccc.int/process-and-meetings/the-paris-agreement>

United Nations, Department of Economic and Social Affairs Population Division, World Population Prospects 2024 (accessed 20 June 2023). <https://population.un.org/wpp/>

Climate Change Response (Zero Carbon) Amendment Act, Wikipedia, The Free Encyclopedia, last modified 12 April 2024 (accessed 20 October 2024). [https://en.wikipedia.org/wiki/Climate\\_Change\\_Response\\_\(Zero\\_Carbon\)\\_Amen%20ment\\_Act#:~:text=The%20Act%20amends%20the%20Climate,Celsius%20above%20pre%2Dindustrial%20levels.](https://en.wikipedia.org/wiki/Climate_Change_Response_(Zero_Carbon)_Amen%20ment_Act#:~:text=The%20Act%20amends%20the%20Climate,Celsius%20above%20pre%2Dindustrial%20levels.)

# Chapter 14

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## Philippines Country Report

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# 1. Basic Concept of LCET

The Philippine energy sector is mandated to ensure a sustainable, stable, sufficient, accessible, and reasonably priced energy supply through the formulation and implementation of policies and programmes aimed at improving the quality of life of Filipinos.

At present, the country's total primary energy supply (TPES) is largely supported by coal, which is predominantly used for power generation. Under the Philippine Energy Plan (PEP) 2023–2050, a Clean Energy Scenario (CES) has been developed that incorporates decarbonisation targets. These include, amongst others, a higher share of renewable energy in power generation, the deployment of new and emerging technologies, increased electric vehicle penetration, and higher biofuel blending in the transport sector.

These plans and programmes are aligned with the country's Energy Transition Plan (ETP) towards a low-carbon future and contribute to the achievement of the United Nations Sustainable Development Goal (SDG) 7: ensuring access to affordable, reliable, sustainable, and modern energy for all, which forms part of the Department of Energy's goals and objectives.

Energy sustainability has become a key global priority in efforts to reduce environmental emissions, driving the transition towards a clean energy future. This transition is expected to bring significant structural changes to the energy sector, which is currently dominated by fossil fuels such as coal and oil. In this context, a low-carbon energy transition (LCET) is being examined. An LCET can be achieved through investment in low-carbon technologies, including renewable energy, energy efficiency measures, and emerging options such as hydrogen and carbon capture, utilisation, and storage (CCUS).

This study develops an LCET scenario and estimates the associated investment costs and emission-reduction benefits relative to a business-as-usual (BAU) scenario.

## 2. Modelling Assumptions

The Philippine energy model, consistent with those developed for other ASEAN Member States, was constructed using the Low Emissions Analysis Platform (LEAP) software, previously known as the Long-range Energy Alternatives Planning (LEAP) System. LEAP is used to project energy balance tables based on final energy consumption and energy inputs and outputs in the transformation sector. Final energy consumption is forecast using sector- and fuel-specific demand equations, informed by macroeconomic assumptions.

Energy demand functions are estimated using an econometric, top-down approach that links macroeconomic variables with energy demand. Historical relationships between energy consumption and key macroeconomic and activity indicators are derived through regression analysis using Microfit, an interactive software package designed for econometric modelling of time-series data. Historical energy demand data are sourced from energy statistics published by the Asia-Pacific Economic Cooperation (APEC), while socio-economic data are obtained from the World Bank's World Development Indicators (WDI).

Not all energy consumption in each sector or subsector can be adequately explained using econometric demand functions. In cases where regression analysis is not feasible due to data limitations or where statistically robust equations cannot be derived, energy demand is projected using alternative assumptions, such as GDP growth rates, sectoral targets, or the continuation of existing policies and programmes.

## 2.1. Macroeconomic Assumptions

Growth in energy consumption is influenced by key socio-economic factors, including population growth, economic activity, vehicle ownership, and access to electricity. This study covers the period from 2021 to 2060.

Assumed population and economic growth trajectories for the Philippines are presented in Table 14.1. Over the projection period, gross domestic product (GDP) and population are assumed to grow at average annual rates of 2.1% and 1.4%, respectively. Energy demand is therefore expected to be driven primarily by economic growth and population increases, reflecting the continued importance of energy-intensive activities in the economy.

**Table 14.1. Population and GDP Prospect**

|                      | Historical Data |      | Projection |      |       |       |       |                       |
|----------------------|-----------------|------|------------|------|-------|-------|-------|-----------------------|
|                      | 1990            | 2005 | 2021       | 2030 | 2040  | 2050  | 2060  | AAGR (%)<br>2021–2060 |
| GDP (billion US\$)   | 143             | 179  | 379        | 607  | 1,032 | 1,680 | 2,737 | 5.2                   |
| Population (million) | 62              | 85   | 111        | 123  | 134   | 145   | 157   | 0.9                   |

POP = population, GDP = gross domestic product.

Source: Author; and World Bank, 2022. World Development Indicators for historical data.

## 2.2. Scenarios

This study projects energy supply, demand, and carbon dioxide (CO<sub>2</sub>) emissions under two scenarios: a business-as-usual (BAU) scenario and a low-carbon energy transition (LCET) scenario.

The BAU scenario serves as the baseline and reflects the continuation of existing energy policies, plans, and programmes that are currently in place or expected to be implemented over the projection period. Under this scenario, energy demand and CO<sub>2</sub> emissions evolve in line with current policy settings and historical trends.

The LCET scenario represents a more ambitious transition pathway aimed at reducing CO<sub>2</sub> emissions in line with net-zero objectives. It assumes the accelerated deployment of clean energy technologies, new fuels, and enhanced energy efficiency measures that are expected to form part of the future global energy mix.

Key assumptions under the LCET scenario include the introduction of carbon capture, utilisation, and storage (CCUS) in natural gas and coal-fired power plants after 2050; the gradual replacement of diesel with hydrogen fuel in road transport beginning in 2040; higher penetration of electric vehicles; and an increase in bioethanol and biodiesel blending rates to 30% by 2060. Energy savings in final energy consumption are also assumed to reach approximately 30% by 2060.

In the power sector, renewable energy is assumed to account for around 50% of total generation by 2060. The scenario also includes contributions from nuclear power and the use of hydrogen as a co-firing fuel in natural gas power plants.

### 3. Final Energy Consumption

From 1990 to 2021, the Philippines experienced a steady increase in final energy demand, rising from 19 million tonnes of oil equivalent (Mtoe) in 1990 to 38 Mtoe in 2021, at an average annual growth rate of approximately 2.3%. Over this period, the transport sector recorded the fastest growth, expanding at an average annual rate of 3.3%, followed by the industrial sector at 1.8%.

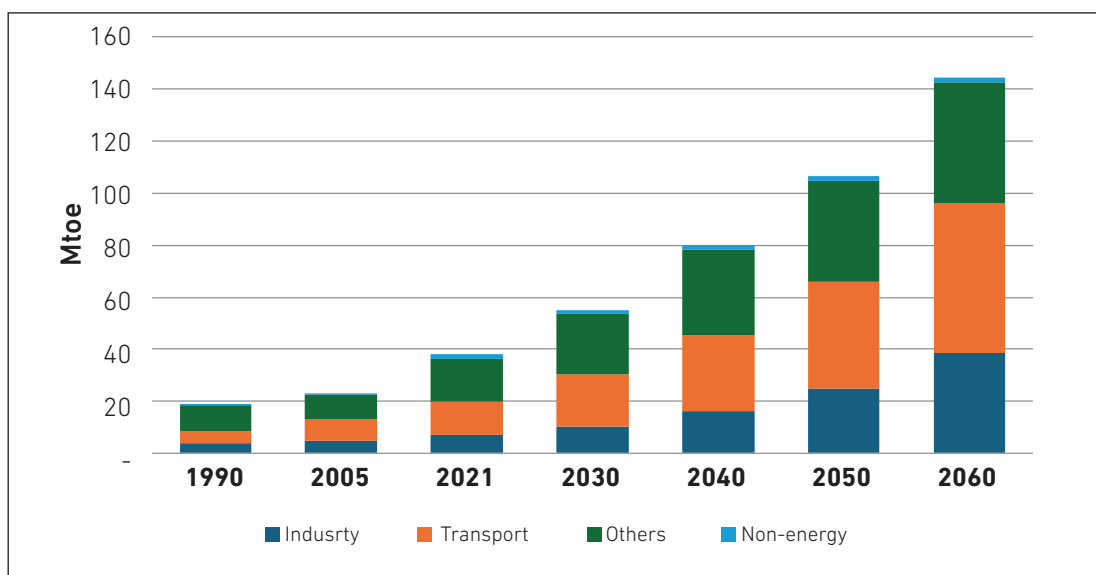
Other sectors – including residential, commercial, and agriculture, forestry, and fisheries (AFF) – which accounted for the largest share of final energy demand in 1990 at 46%, saw a gradual decline in their combined share to 44% by 2021. This reflects relatively slower growth in these sectors, averaging 1.7% per year over the period.

Over the projection period from 2021 to 2060, the business-as-usual (BAU) scenario indicates an average annual growth rate of 3.5% in final energy demand. By 2060, the transport sector is projected to become the largest energy-consuming sector, with its share increasing from around 33% in 2021 to nearly 40%. Energy demand in transport is expected to grow at an average annual rate of 3.9%.

The industrial sector is projected to grow the fastest, at an average annual rate of 4.4%, driven by government initiatives to strengthen the manufacturing base. Meanwhile, the combined demand from residential, commercial, and AFF sectors is projected to account for about 32% of total final energy demand by 2060, growing at an average annual rate of 2.7%. This trend reflects continued expansion of the commercial sector, improvements in the services and business environment, and ongoing modernisation programmes in agriculture.

Figure 14.1 illustrates the projected sectoral composition of final energy demand in the Philippines.

**Figure 14.1. Final Energy Demand by Sector, BAU Scenario (1990-2060)**



Source: Author's calculations.

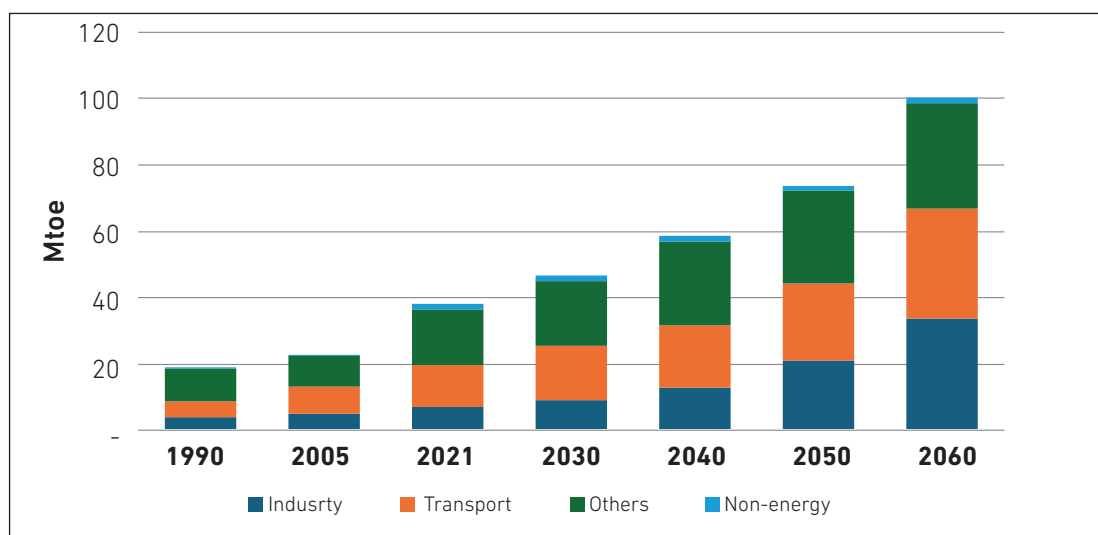
Under the Low-Carbon Energy Transition (LCET) scenario, the Philippines' total final energy demand is projected to increase at an average annual rate of 2.7% between 2021 and 2060 (Figure 14.2), significantly lower than under the business-as-usual (BAU) scenario. This slower growth reflects improvements in energy efficiency and conservation across end-use sectors, particularly industry, residential, and commercial activities.

Additional factors contributing to lower energy demand growth under the LCET scenario include the introduction of hydrogen to replace coal- and oil-fired boilers in industry and diesel in road transport, higher penetration of electric vehicles, and increased biofuel blending in the transport sector.

Total final energy demand is projected to reach approximately 100 Mtoe by 2060. As in the BAU scenario, the 'other sectors' category – comprising residential, commercial, and other end uses – accounts for the largest share of final energy demand in 2060, at around 38%. The industrial sector is projected to be the second-largest consumer, with a share of approximately 34% and an estimated consumption level of about 34 Mtoe.

Despite its large share, the 'other sectors' category is expected to record the slowest average annual growth rate over the 2021–2060 period, at 1.8%. In contrast, the transport sector is projected to experience the fastest growth, at an average annual rate of 3.8%.

**Figure 14.2. Final Energy Consumption by Fuel, LCET Scenario (1990-2060)**



Source: Author's calculations.

By fuel type, oil has historically been the dominant source of final energy consumption in the Philippines, accounting for 49% of total final energy consumption in 2021. Under the business-as-usual (BAU) scenario, oil remains the largest fuel by 2060. However, the share of electricity increases significantly as electrification expands and commercial building development accelerates, particularly in major urban centres. The share of electricity in total final energy consumption rises from 21% in 2021 to 35% in 2060. Over the 2021–2060 period, electricity demand grows at an average annual rate of 4.9%, while oil demand grows more slowly, at 3.5%.

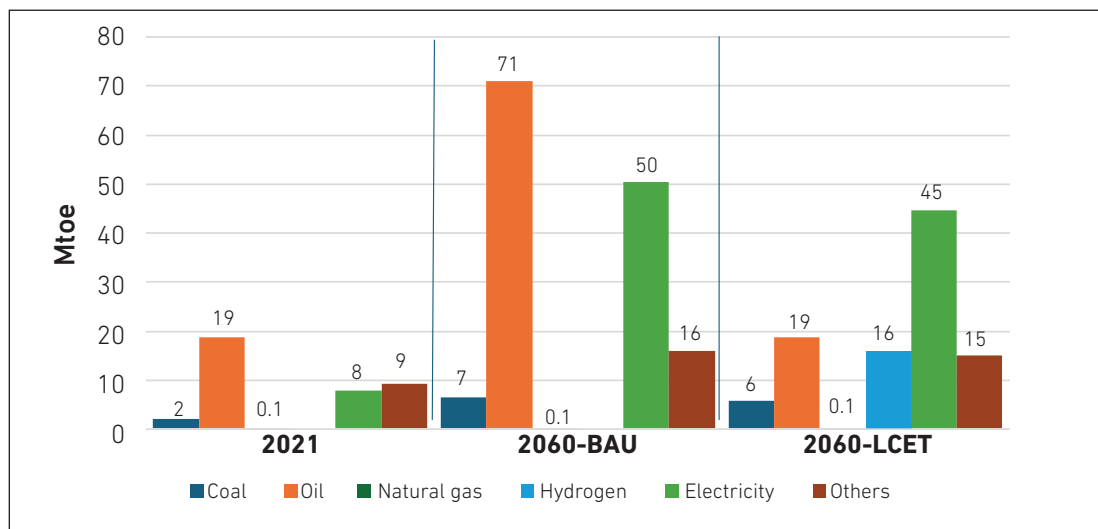
Coal and natural gas are consumed mainly in the industrial sector, with relatively small volumes used for non-energy purposes. Coal demand is projected to grow at an average annual rate of 2.9% between 2021 and 2060, which is slower than the growth of total final energy consumption. As a result, coal's share declines from 5.7% in 2021 to 4.5% in 2060. Natural gas accounts for only 0.2% of total final energy consumption in 2021 and declines further to 0.1% by 2060, reflecting its relatively slow growth rate of 0.8% per year compared with other fuels.

The LCET scenario underscores the role of clean energy in reducing carbon dioxide (CO<sub>2</sub>) emissions and achieving net-zero emissions by 2060. Under this scenario, the share of oil in total final energy consumption declines sharply to 19% by 2060, compared with 49% under the BAU scenario. This reduction is driven by enhanced energy efficiency across all sectors, increased deployment of electric vehicles, higher biofuel blending, improvements in internal combustion engine efficiency, and the introduction of hydrogen.

By the end of the projection period, hydrogen is expected to account for approximately 16% of total final energy consumption under the LCET scenario. The share of electricity also rises substantially, reaching 44% by 2060, compared with 35% under BAU. Similarly, the contribution of other fuels increases relative to BAU, reflecting higher biofuel blending rates.

Figure 14.3 presents final energy consumption by fuel under the BAU and LCET scenarios for 2021 and 2060.

**Figure 14.3. Final Energy Consumption by Fuel, BAU and LCET Scenario (1990-2060)**



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 4. Power Generation

Under the Low Carbon Energy Transition (LCET) scenario, total electricity generation is projected to reach 803 TWh in 2060, which is approximately 23% higher than under the business-as-usual (BAU) scenario, where generation reaches 651 TWh. This increase is driven by rising electricity demand across all sectors, including the expanded deployment of electric vehicles and electric rail, as well as additional electricity requirements for hydrogen production. Producing 1 kilotonne of hydrogen is assumed to require approximately 4.57 GWh of electricity.

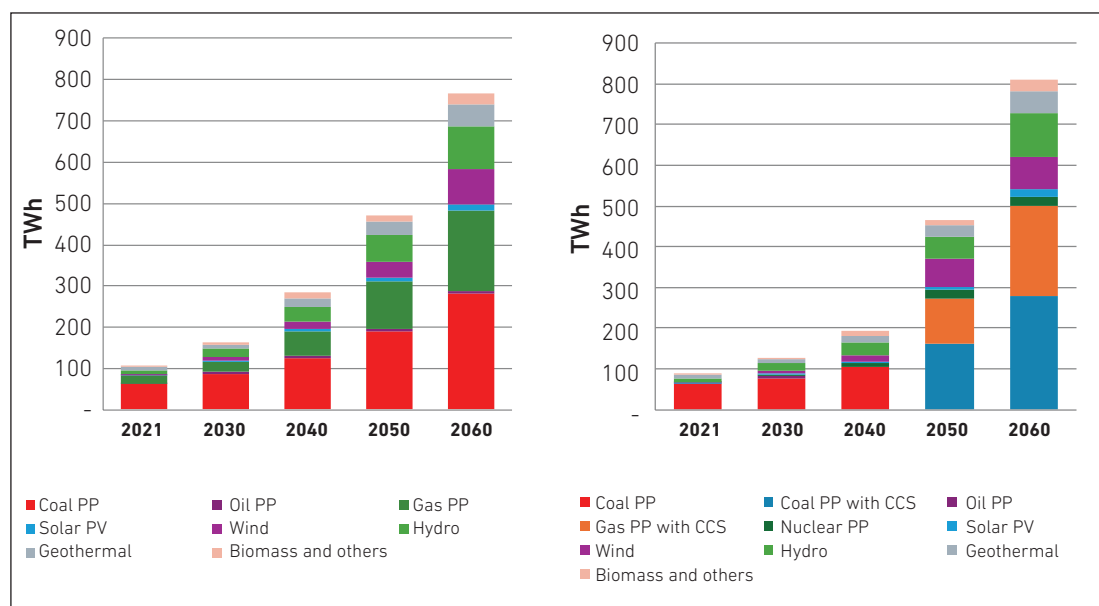
By fuel type, as illustrated in Figure 14.4, natural gas remains the dominant source of power generation under both scenarios, accounting for 37% of total generation under BAU and 35% under LCET in 2060. Under the LCET scenario, coal-fired power plants are assumed to be equipped with carbon capture and storage (CCS) technology. Similarly, natural gas-fired power generation under LCET also incorporates CCS. By 2060, the share of gas-fired generation reaches 27% under LCET, compared with 25% under BAU.

Renewable energy is projected to account for around 37% of total electricity generation in 2060 under both scenarios. Renewable electricity generation comprises hydropower, solar, wind, geothermal, and biomass.

The LCET scenario also includes electricity generation from nuclear power. Nuclear power is assumed to be introduced in 2030 with an initial generation level of 4 TWh, increasing steadily to 23 TWh by 2060. As a result, nuclear power accounts for approximately 4% of total electricity generation by the end of the projection period.



**Figure 14.4 . Electricity Generation by Fuel, LCET Scenario (1990-2060)**



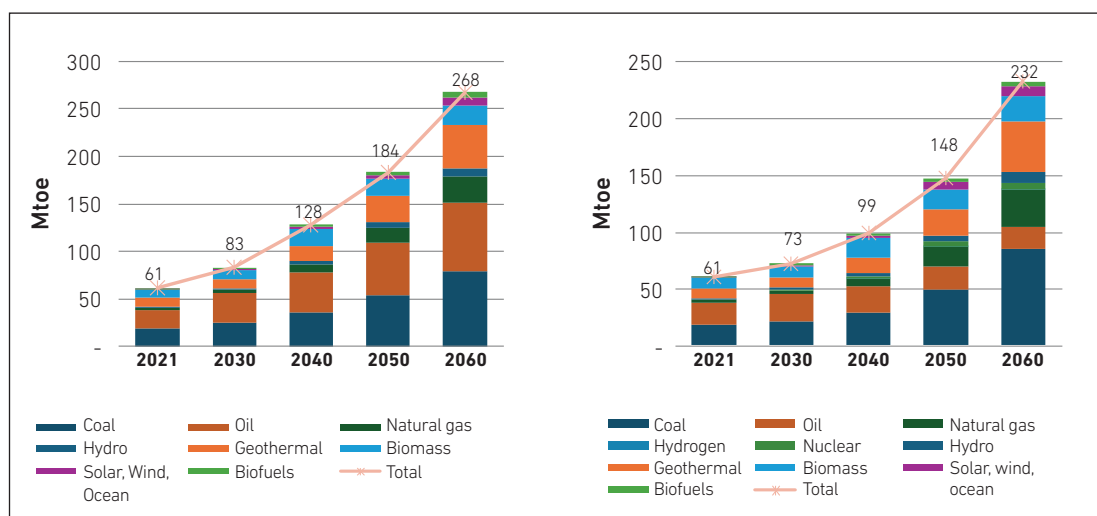
Source: Author's calculations.

## 5. Primary Energy Supply

Under the Low Carbon Energy Transition (LCET) scenario, total primary energy supply (TPES) is projected to grow at an average annual rate of 3.5% from 2021, reaching 232 Mtoe by 2060 (Figure 14.5). This growth rate is lower than under the business-as-usual (BAU) scenario, which is estimated at 3.9% per year, reflecting improvements in energy efficiency across vehicles, industrial boilers, household appliances, and power plants with higher thermal efficiency.

Under the BAU scenario, fossil fuels remain the dominant sources of primary energy supply in the Philippines in 2060. Oil and coal each account for approximately 31% of total TPES, while natural gas contributes around 10.3%. Although fossil fuels continue to hold the largest shares in the energy mix, their growth is slower compared with renewable energy sources. Over the period 2021–2060, the average annual growth rate of coal supply is projected at 3.7%, while oil grows at 3.5% and natural gas at 5.6%.

**Figure 14.5. Total Primary Energy Supply by Fuel Type, LCET Scenario (1990-2060)**



Source: Author's calculations.

Amongst renewable energy sources, the combined capacity of wind, solar, and ocean energy grows the fastest, at around 10% per year. Hydropower also records relatively strong growth, averaging 6.4% annually. This trend is consistent with global developments, where solar and wind are the fastest-growing renewable energy sources.

Under the Low Carbon Energy Transition (LCET) scenario, oil accounts for the smallest share of total primary energy supply (TPES) by 2060. This outcome reflects a significant reduction in oil consumption in end-use sectors, particularly road transport and industry. Coal remains largely concentrated in the power sector, and its share in TPES under the LCET scenario remains relatively high due to the deployment of carbon capture and storage (CCS) technologies. Natural gas-fired power plants under the LCET scenario are also assumed to be equipped with CCS, resulting in a slight increase in the share of natural gas in TPES.

Renewable energy sources continue to exhibit the fastest growth under the LCET scenario. The combined group of solar, wind, ocean, and other renewables grows at nearly the same rate as under the BAU scenario, at around 10% per year over the 2021–2060 period. Solar energy expands slightly faster under LCET than under BAU, while hydropower grows at an average annual rate of 6.5% under LCET, compared with 6.4% under BAU.

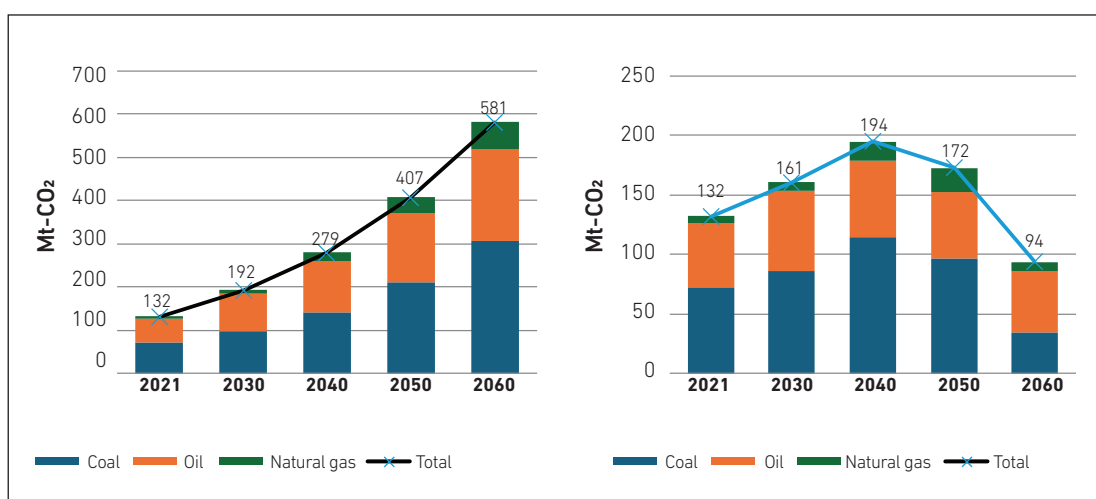
In addition to renewables, the LCET scenario introduces nuclear energy in the power sector and hydrogen as a substitute for oil in the industrial and transport sectors. Hydrogen is assumed to be produced domestically in sufficient quantities to meet projected demand. The share of nuclear energy in TPES increases from 1.5% in 2030 to 3.5% by 2060.

## 6. CO<sub>2</sub> Emissions

Total CO<sub>2</sub> emissions under the Low Carbon Energy Transition (LCET) scenario are projected to reach 93.5 MtCO<sub>2</sub> by 2060, representing a reduction of around 90% compared with the business-as-usual (BAU) scenario (Figure 14.6). Under BAU, total CO<sub>2</sub> emissions increase at an average annual rate of about 4%, rising from 132 MtCO<sub>2</sub> in 2021 to 581 MtCO<sub>2</sub> by 2060.

The deployment of carbon capture and storage (CCS) technologies results in substantial emissions reductions from coal- and natural gas-fired power generation, lowering emissions from coal by around 89% and from natural gas by approximately 88%. Significant reductions in oil-related emissions (around 75%) are driven by the replacement of diesel with hydrogen in industrial applications and road transport, together with the increasing penetration of electric vehicles across the country.

**Figure 14.6. Total CO<sub>2</sub> Emissions by Fuel Type, LCET Scenario (1990-2050)**



Source: Author's calculations.

Although CO<sub>2</sub> emissions are significantly reduced by 2060, additional measures will still be required for the Philippines to achieve its net-zero emissions target. Coal continues to account for a substantial share of total emissions in 2060, indicating the need for further mitigation options beyond CCS. The adoption of additional technologies, such as hydrogen co-firing in coal-fired power plants, could further reduce coal consumption and associated emissions in the power sector. Similarly, hydrogen co-firing in natural gas-fired power plants by 2060 would contribute to further reductions in CO<sub>2</sub> emissions from electricity generation.

## 7. Energy Cost Comparison Between BAU and LCET

An energy cost analysis was conducted to compare the business-as-usual (BAU) and Low Carbon Energy Transition (LCET) scenarios. The objective of this analysis is to estimate the total energy-related costs required to implement the assumptions under the LCET scenario and to assess how these costs compare with those under BAU.

The analysis considers key cost components, including fuel costs, investment costs for power generation, and costs associated with carbon capture and storage (CCS). All costs are evaluated based on the modelled outlook results and are expressed in constant 2020 prices.

### 7.1. Fuel Cost

To compare the total fuel cost of the BAU and LCET scenarios, the assumptions in Table 14.2 are used.

**Table 14.2. Fuel Cost Assumptions**

|          | 2020/2020 | 2060 (2020 price) | Unit                     |
|----------|-----------|-------------------|--------------------------|
| Coal     | 80.03     | 98.00             | US\$/ton                 |
| Oil      | 41        | 100               | US\$/bbl                 |
| Gas      | 7.77      | 7.50              | US\$/MMBTU               |
| Hydrogen | 0.8       | 0.3               | US\$/Nm <sup>3</sup>     |
| CCS      | 0         | 30                | US\$/CO <sub>2</sub> ton |

Source: Author's calculations.

Based on the fuel cost assumptions presented in Table 14.2, the resulting total fuel investment costs under the BAU and LCET scenarios are summarised in Table 14.3.

**Table 14.3. Total Fuel Investment Cost Comparison under BAU and LCET in 2060**

|              | Primary Energy Consumption (Mtoe), BAU in 2021 | Primary Energy Consumption (Mtoe), BAU in 2060 | Primary Energy Consumption (Mtoe), LCET-CN in 2060 | Total Investment Cost, BAU in 2060 (US\$ million) | Total Investment Cost, LCET-CN in 2060 (US\$ million) |
|--------------|------------------------------------------------|------------------------------------------------|----------------------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| Coal         | 18.91                                          | 79.18                                          | 85.96                                              | 9,524                                             | 10,595                                                |
| Oil          | 19.17                                          | 72.38                                          | 18.76                                              | 36,600                                            | (278)                                                 |
| Gas          | 3.29                                           | 27.48                                          | 33.22                                              | 6,985                                             | 8,642                                                 |
| Hydrogen     | 0.00                                           | 0.00                                           | 16.53                                              | 0                                                 | 19,266                                                |
| <b>Total</b> | <b>41.37</b>                                   | <b>179.04</b>                                  | <b>154.47</b>                                      | <b>53,109</b>                                     | <b>38,224</b>                                         |

Source: Author's calculations.

As shown in the table above, total fuel investment costs under the BAU scenario are projected to reach US\$53 billion in 2050. This is significantly higher than the corresponding cost under the LCET scenario, which is estimated at US\$38 billion.

## 7.2. Power generation investment

The estimation of power generation investment is based on assumptions regarding power plant construction costs and capacity factors. The resulting total investment requirements for power plants under the BAU and LCET scenarios in 2060 are presented in Table 14.4.

**Table 14.4. Total Power Plant Investment Cost Comparison under BAU and LCET in 2060**

|              | Electricity Generation in 2021 (TWh) | Electricity Generation in BAU for 2060 (TWh) | Electricity Generation in LCET-CN for 2060 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET-CN (MW) | Total Investment Cost, BAU in 2060 (US\$ million) | Total Investment Cost, LCET-CN in 2060 (US\$ million) |
|--------------|--------------------------------------|----------------------------------------------|--------------------------------------------------|----------------------------------|--------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| Coal         | 62                                   | 282                                          | 279                                              | 31,344                           | 39,872                               | 47,800                                            | 60,805                                                |
| Oil          | 2                                    | 6                                            | 0.00                                             | 608                              | 0                                    | 365                                               | 0.00                                                  |
| Gas          | 19                                   | 194                                          | 220                                              | 24,984                           | 31,342                               | 17,489                                            | 21,939                                                |
| Nuclear      | 0                                    | 0                                            | 23                                               | 0                                | 3,295                                |                                                   | 11,779                                                |
| Solar        | 1                                    | 16                                           | 20                                               | 9,923                            | 12,418                               | 3,046                                             | 3,812                                                 |
| Wind         | 1                                    | 87                                           | 79                                               | 24,396                           | 22,165                               | 30,129                                            | 27,373                                                |
| Hydro        | 9                                    | 104                                          | 109                                              | 26,950                           | 28,426                               | 59,910                                            | 63,190                                                |
| Geothermal   | 11                                   | 52                                           | 52                                               | 9,445                            | 9,348                                | 40,197                                            | 39,786                                                |
| Biomass etc. | 1                                    | 86                                           | 28                                               | 4,036                            | 4,394                                | 12,185                                            | 13,266                                                |
| <b>Total</b> | <b>106</b>                           | <b>766</b>                                   | <b>810</b>                                       | <b>132,294</b>                   | <b>151,259</b>                       | <b>211,121</b>                                    | <b>241,950</b>                                        |

Source: Author's calculations.

Under the BAU scenario, total additional generation capacity required by 2060 is estimated at 132,294 MW relative to 2021 levels. In contrast, the LCET scenario requires a higher level of additional capacity, reaching 151,259 MW by 2060, reflecting increased electricity demand to substitute for oil-fired boilers in industry, internal combustion engine vehicles in road transport, and the production of hydrogen through electrolysis.

As a result, total investment in power generation capacity under the LCET scenario is projected to reach around US\$242 billion by 2060, compared with US\$211 billion under the BAU scenario.

### 7.3. Carbon Capture and Storage (CCS) cost

The deployment of carbon capture and storage (CCS) is assumed under the Low Carbon Energy Transition (LCET) scenario starting from 2041. CCS is applied to both coal- and natural gas-fired power plants. Based on the assumptions presented in Table 14.1, the unit cost of CCS is estimated at US\$30 per tonne of CO<sub>2</sub> captured. Using these assumptions, total CCS investment costs are calculated.

The resulting total investment cost for CCS under the LCET scenario in 2060 is presented in Table 14.5.

**Table 14.5. Total Investment Cost of CCS under the LCET Scenario in 2060**

|                            | Consumption<br>for LCET in 2060<br>(Mtoe) | CO <sub>2</sub> Emission<br>for LCET<br>(Mt-CO <sub>2</sub> ) | CO <sub>2</sub> Emission<br>for LCET (Mt-C) | Total<br>Investment Cost<br>of CCS for LCET<br>(US\$ million) |
|----------------------------|-------------------------------------------|---------------------------------------------------------------|---------------------------------------------|---------------------------------------------------------------|
| Coal Power Plant with CCS  | 80.09                                     | 298.91                                                        | 81.44                                       | 16,141                                                        |
| Natural Gas Plant with CCS | 33.13                                     | 70.57                                                         | 19.23                                       | 3,811                                                         |
| <b>Total</b>               | <b>113.22</b>                             | <b>369.48</b>                                                 | <b>100.67</b>                               | <b>19,952</b>                                                 |

Source: Author's calculations.

Total investment in carbon capture and storage (CCS) is projected to approach US\$20 billion. This comprises approximately US\$16 billion for CCS deployment in coal-fired power plants and around US\$4 billion for CCS applied to natural gas-fired power plants.

### 7.4. Overall cost

Based on the analysis presented in Sections 7.1 to 7.3, the breakdown of total investment costs under the BAU and LCET scenarios is summarised below.

**Table 14.6. Overall Total Investment Cost under BAU and LCET Scenarios in 2060 (US\$ Million)**

|                                     | BAU           | LCET          |
|-------------------------------------|---------------|---------------|
| Total Fuel Cost Investment          | 53,109        | 38,224        |
| Total Power Capital Cost Investment | 5,413         | 6,204         |
| Total CCS Cost Investment           | 0             | 19,952        |
| <b>Total Investment</b>             | <b>58,523</b> | <b>64,380</b> |

Source: Author's calculations.

All costs are converted to an annual basis and exclude expenditures related to energy efficiency improvements, energy storage, and electricity distribution and transmission. The total annual investment cost under the BAU scenario in 2060 is projected at approximately US\$58,000 million, while the corresponding cost under the LCET scenario is estimated at around US\$64,000 million.

Fuel costs constitute the largest component of total costs under the BAU scenario, amounting to about US\$53,000 million, or 91% of the total. Under the LCET scenario, fuel costs decline substantially to approximately US\$38,000 million, accounting for around 31% of total costs. Investment in carbon capture, utilisation, and storage (CCUS) represents a significant cost component under the LCET scenario, comprising roughly 31% of total investment costs, or nearly US\$20,000 million.

## 8. Conclusions and Recommendations

The Low Carbon Energy Transition (LCET) scenario is designed to support the Philippines' pathway towards a net-zero emissions target by 2060. Compared with the business-as-usual (BAU) scenario, the LCET assumes more stringent energy efficiency and conservation measures across all sectors. Additional mitigation measures include higher biofuel blending, increased penetration of electric vehicles (EVs), substitution of oil with hydrogen in industrial boilers and heavy-duty transport (including trucks, buses, and rail), accelerated expansion of renewable energy capacity, the introduction of nuclear power, deployment of carbon capture, utilisation, and storage (CCUS) technologies in coal- and natural gas-fired power plants, and hydrogen co-firing in gas power generation. Together, these measures contribute to a substantial reduction in the country's CO<sub>2</sub> emissions.

As a result, total CO<sub>2</sub> emissions under the LCET scenario decline significantly, reaching 93.5 MtCO<sub>2</sub> by 2060—approximately a 90% reduction compared with BAU. A large share of this reduction is attributable to the application of CCUS technologies in the power sector, particularly in coal-fired power plants. CCUS deployment in natural gas-fired power plants also contributes meaningfully to emissions reductions, although to a lesser extent than in coal-based generation.

In end-use sectors, especially transport, the reduction in oil consumption plays a critical role in lowering CO<sub>2</sub> emissions by 2060. This is driven by the replacement of diesel with hydrogen in selected transport modes and by the increased adoption of EVs to substitute gasoline-powered cars and motorcycles. The implementation of the Electric Vehicle Industry Development Act (EVIDA) is expected to further accelerate this transition. To support higher EV penetration, adequate charging infrastructure must be developed, and the government can play a catalytic role by creating an enabling investment environment. Further emissions reductions may be achieved by intensifying targets and promoting alternative fuels to partially or fully substitute oil use in the transport sector.

From a cost perspective, the total annual investment required to implement the LCET measures is estimated at around US\$64,000 million in 2060, compared with approximately US\$58,000 million under the BAU scenario. This suggests that achieving a near net-zero emissions pathway by 2060 would require additional annual investment of around US\$6,000 million. Fuel costs remain the dominant component of total costs under both scenarios, accounting for about US\$53,000 million under BAU and US\$38,000 million under LCET. While overall costs under LCET are higher, they are accompanied by substantial fuel cost savings and emissions reductions.



## References

Congress of the Philippines (2007), *Republic Act No. 9367, Biofuels Act of 2006*, Manila.

Congress of the Philippines (2008), *Republic Act No. 9513, Renewable Energy Act of 2008*, Manila.

Congress of the Philippines (2019), *Republic Act No. 11285, Energy Efficiency and Conservation Act*, Manila.

Congress of the Philippines (2022), *Republic Act No. 11697, Electric Vehicles Industry Development Act*, Manila.

Department of Energy (2021), *Philippine Energy Plan 2020-2040*, Manila.

Department of Energy (2020), *Energy Sector Accomplishment Report 2020*.

Energy Policy and Planning Bureau, Department of Energy, Philippines, '2019 Philippine Energy Situationer.'

Energy Policy and Planning Bureau, Department of Energy, Philippines, '2019 Philippine Energy Supply and Demand Outlook.'

International Monetary Fund, *World Economic Outlook*.

Philippine Statistical Authority (2019), *Philippine Statistical Yearbook*, Manila.

World Bank (2022), World Bank ICP database/World Development Indicators.

# Chapter 15

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## Singapore Country Report

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# 1. Background

In 2022, Singapore enhanced its climate targets in the Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (Government of Singapore, 2022b). Compared to the first update of the NDC released in 2020 (Government of Singapore, 2020), Singapore lowered its target of peak emissions in 2030 to 60 metric tonnes of carbon dioxide equivalent (MtCO<sub>2e</sub>), and previously the peak emissions target was 65 MtCO<sub>2e</sub>. More importantly, Singapore has announced the target of achieving net-zero emissions by 2050 in its Long-Term Low-Emissions Development Strategy (NCCS, 2021a).

To achieve the NDC and net-zero emissions targets, Singapore has committed to accelerate the low-carbon transition for industry, economy, and society through various measures. This includes natural gas (Government of Singapore, 2022a), regional power grids (EMA, 2024), solar energy (NCCS, 2020), and emerging low-carbon technologies such as carbon capture and storage (CCS) (Srivastav, et al., 2021), and hydrogen (NCCS, 2021b). In addition, Singapore has established a target of 100% of vehicles to run on cleaner energy by 2040 (LTA, 2024).

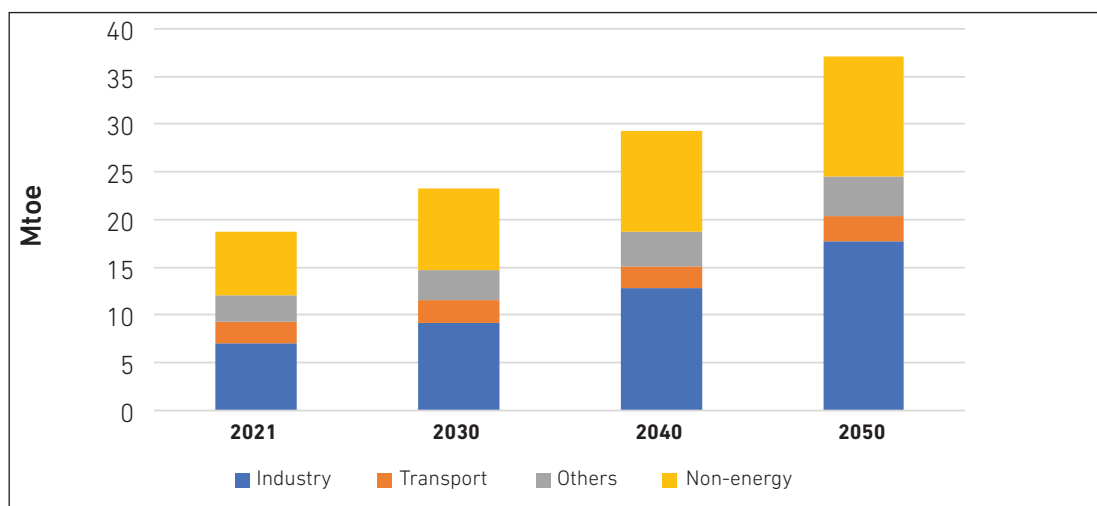
This report will present Singapore's energy outlook results under the low-carbon energy transition (LCET) scenario by integrating those key mitigation strategies. As Singapore's net-zero emissions target is set for 2050, the end year of the modelling is 2050. In particular, this study will consider the biomass with CCS for electricity generation as a negative emissions technology which can offset carbon emissions from other sectors. The results presented here are derived based on a series of assumptions and should not be interpreted as a precise prediction of the future.

## 2. Final Energy Consumption, 2021–2050

Under the LCET scenario, the total final energy consumption of Singapore is projected to grow to 37.16 million tonnes of oil equivalent (Mtoe) in 2050 from 18.71 Mtoe in 2021 (about a 98.63% growth over the entire period), meaning an increase of 2.39% per year by 2050 from the 2021 level. As a comparison, the total final energy consumption under the LCET scenario is slightly smaller than that under the business-as-usual (BAU) scenario (i.e. 38.19 Mtoe in 2050). This is mostly contributed by the mitigation measures in the road transport sector. Under the LCET scenario, gasoline vehicles would be replaced by electric vehicles (EVs) and diesel vehicles (mostly heavy-duty trucks) will be replaced by hydrogen fuel cells. Both EVs and vehicles with hydrogen fuel cells have much higher efficiency than those using gasoline and diesel.

Figure 15.1 shows the final energy consumption by sector of Singapore under the LCET scenario. In 2050, the total final energy consumption is projected to be 37.16 Mtoe. The industry sector will be expected to be the sector consuming the most energy in 2050 (about 48% of the total). Moreover, the industry sector has the higher annual growth rate as compared to other sectors (i.e. about 3.25% per year over 2021–2050). The non-energy sector, which will be the second largest energy consuming sector in 2050, will consume 12.61 Mtoe (or 34% from the total share) in 2050. The annual growth rate of the non-energy sector is about 2.21%. The 'others' sector (i.e. residential and commercial sectors) is projected to consume 4.12 Mtoe (or about 11% of the total) in 2050. The annual growth rate of the 'others' sector is about 1.45%. Lastly, the transport sector is projected to consume 2.68 Mtoe (about 7% of the total), with an annual growth rate of 0.55%. This is because the number of vehicles is regulated in Singapore.

**Figure 15.1. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario (2021–2050)**

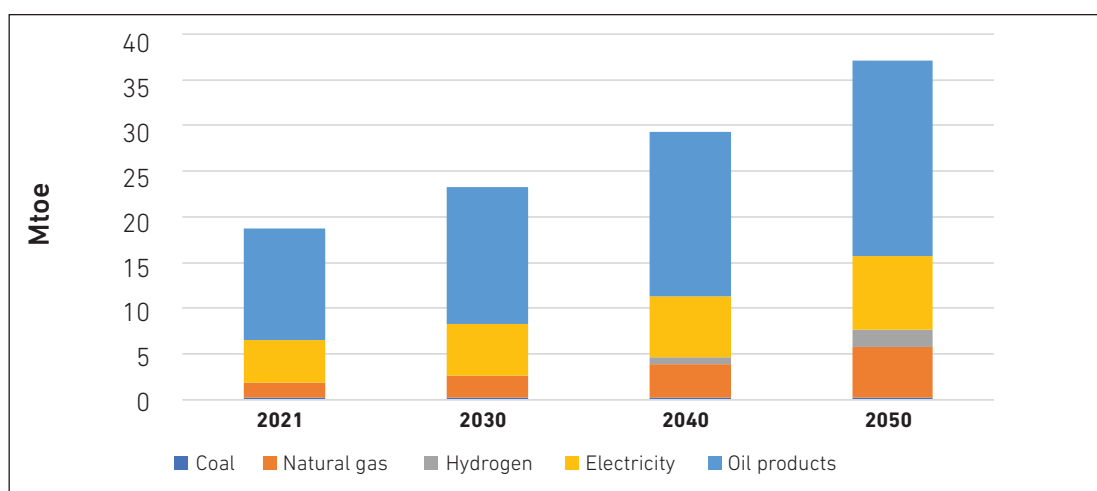


LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 15.2 shows the final energy consumption by fuel type under the LCET scenario. In this scenario, hydrogen is introduced to road transport, and will affect energy consumption structure of Singapore in 2050. Hydrogen and electricity together will contribute about 26.9% of the total final energy consumption in 2050, i.e. 5.1% for hydrogen and 21.8% for electricity, respectively. The oil share will be expected to reduce to 57.7% in 2050 from 65.2% in 2021. The share of natural gas share is projected to grow from 9.3% in 2021 to 15% in 2050.

**Figure 15.2. Final Energy Consumption by Fuel Type,  
Low-carbon Energy Transition Scenario (2021–2050)**



LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

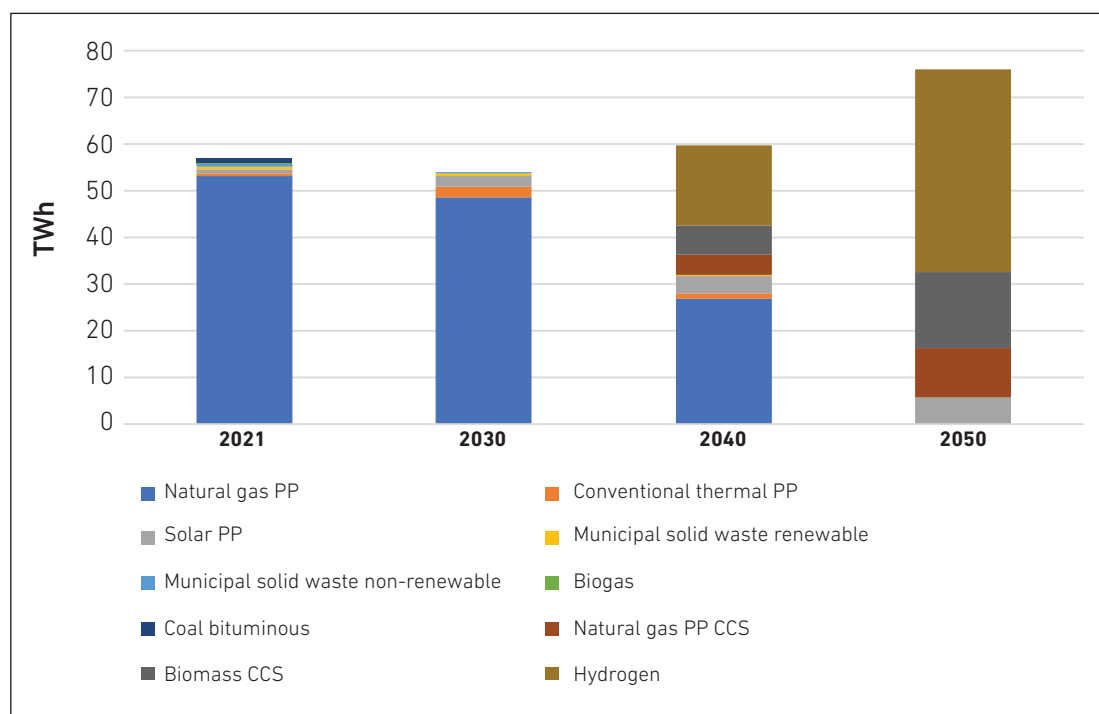
Source: Author's calculations.

### 3. Power Generation, 2021–2050

In 2050, the total domestic power generation is projected to be 75.89 terawatt hours (TWh) under the LCET scenario. This is lower than those under the BAU scenario, which is 93.71 TWh. Due to the applications of CCS in the industry sector, there would be additional consumption under the LCET scenario, compared to the BAU scenario. The LCET scenario assumes electricity imports, which will increase from 0% in 2021 to 33% of domestic electricity demand by 2035. The amount of electricity import is then assumed to be unchanged over the period 2035–2050.

The electricity generation mix under the LCET scenario is shown in Figure 14.3. Total electricity generation under the LCET scenario is projected to increase at about 1% per year from 2021 until 2050. As shown in Figure 15.3, hydrogen (100% volume hydrogen using combined-cycle gas turbine) is projected to have the highest share with 57% in the total electricity generation in 2050. This is followed by biomass with CCS with a share of 21.5%, and natural gas with CCS with a share of 14% in generation mix in 2050. Solar PV will account for 7.4% in generation mix. Conventional thermal power plants will contribute to the remaining generation (about 0.1% in the total). In the LCET scenario, natural gas, coal, and biogas will be phased out by 2050.

**Figure 15.3. Electricity Generation by Fuel Type,  
Low-carbon Energy Transition Scenario (2021–2050)**



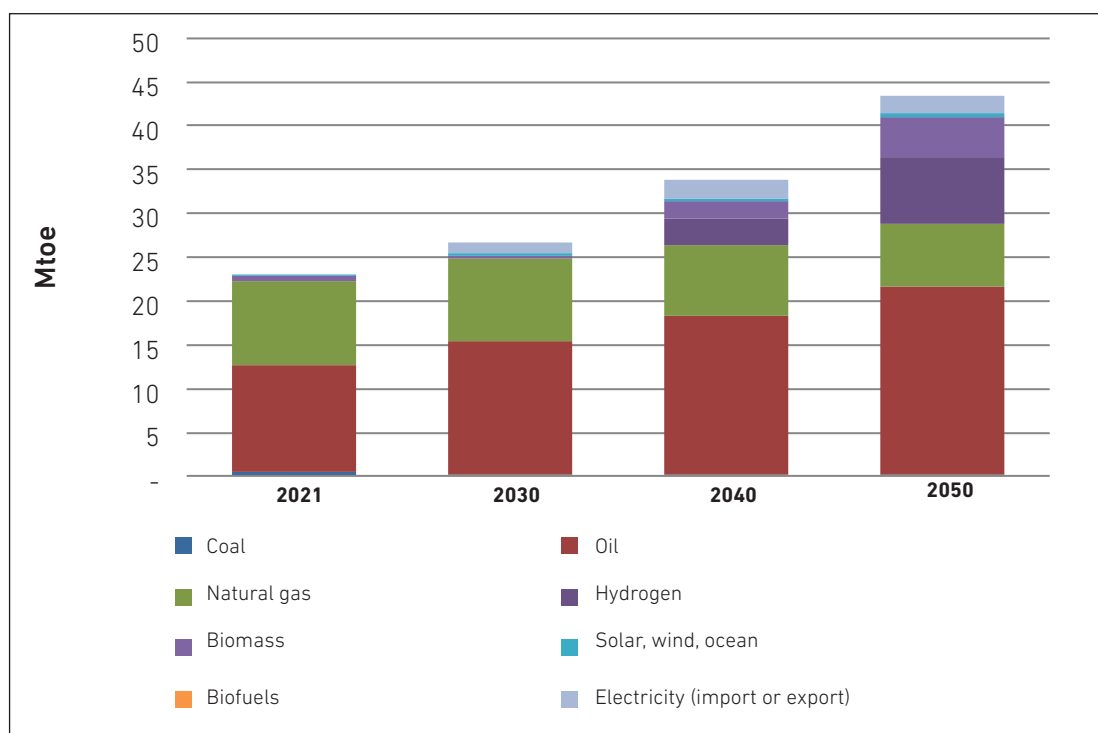
CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, TWh = terawatt hour.

Source: Author's calculations.

## 4. Primary Energy Supply, 2021–2050

The total primary energy supply under the LCET scenario is projected to increase by about 1.9% per year over the period 2021–2050. This annual growth rate is lower than that under the BAU scenario (i.e. 2.2% per year).

**Figure 15.4. Total Primary Energy Supply by Fuel Type, Low-carbon Energy Transition Scenario (2021–2050)**



LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

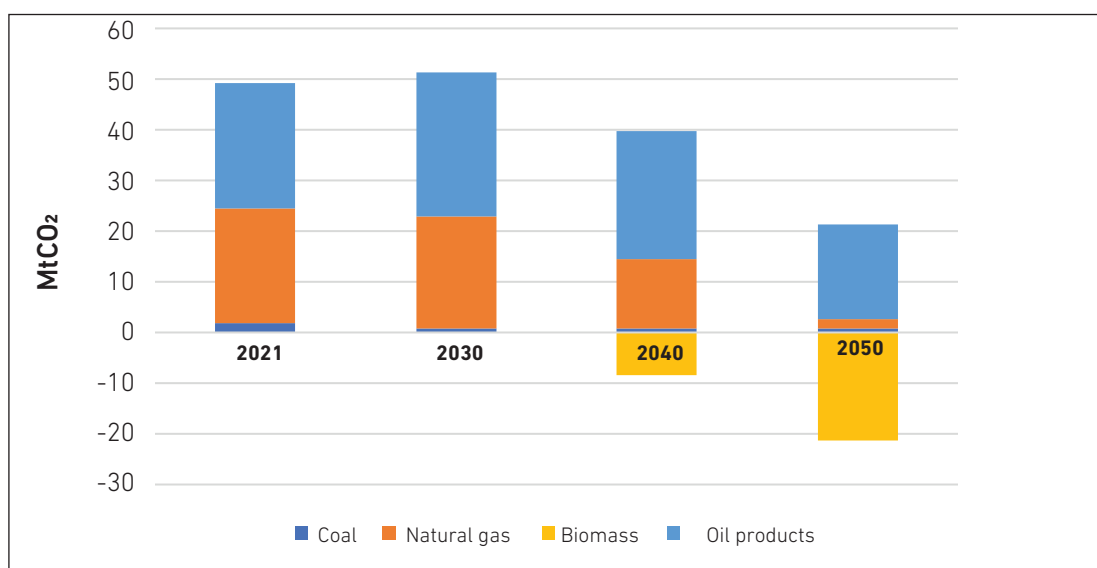
Source: Author's calculations.

Across all years, oil products still account for the highest share (53.4% in 2021 and 49.3% in 2050). In the LCET scenario, electricity imports and hydrogen are becoming more important. In 2050, electricity imports and hydrogen account for 4.7% and 17.5% in total primary energy supply, respectively, which increase from 0% in 2021. The share of renewable energy would also significantly increase. Biomass and solar energy will contribute to 10.3% and 1.1% in total primary energy supply, respectively. The other fossil fuels, natural gas and coal, are expected to decline in total primary energy supply. Specifically, the amount of coal would decrease from 0.47 Mtoe in 2021 to 0.18 Mtoe in 2050, with an annual decrease rate of 3.2%. The amount of natural gas would decrease from 9.55 Mtoe in 2021 to 7.22 Mtoe in 2050, with an annual decrease rate of 1%. In the LCET scenario, natural gas with CCS will account for a relatively large share in power generation through 2050, leading to natural gas demand.

## 5. Carbon Dioxide Emissions

Overall, in 2050, the total economy-wide carbon dioxide (CO<sub>2</sub>) emissions under the LCET scenario are projected to be about 0.05 MtCO<sub>2</sub>. In the LCET scenario, biomass with CCS is introduced to the electricity generation. This is a carbon-negative electricity generation technology (i.e. with a negative grid emission factor of –1.31 kg CO<sub>2</sub>/kWh), and thus biomass with CCS can lead to negative emissions, which can offset the emissions from other sectors or sources (Sanchez, et al., 2015). In 2021, natural gas and oil contribute to the most emissions. Emissions from natural gas greatly drop from 22.73 MtCO<sub>2</sub> in 2021 to 2.36 MtCO<sub>2</sub> in 2050. In 2050, emissions from oil products still account for the most emissions, decreasing from 24.67 MtCO<sub>2</sub> in 2021 to 18.71 MtCO<sub>2</sub> in 2050.

**Figure 15.5. Total CO<sub>2</sub> Emissions by Fuel Type, Low-carbon Energy Transition Scenario (2021–2050)**



CO<sub>2</sub> = carbon dioxide, LCET = low-carbon energy transition, MtCO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author's calculations.

## 6. Hydrogen Demand across the Sector

In the current analysis, hydrogen will be introduced to two sectors under the LCET scenario, i.e. transport and electricity. In the transport sector, hydrogen is expected to replace diesel used in vehicles. Such a fuel switching is assumed to start in 2031, and hydrogen is assumed to replace all diesel vehicles by 2050. This needs to be supported by proper hydrogen infrastructure (e.g. hydrogen fuelling station, transportation, and storage) and supporting policies and regulatory framework. In 2050, final consumption of hydrogen in the road transport sector is projected to be 1.89 Mtoe, accounting for 70.8% of total final energy consumption in the transport sector.

In the LCET scenario, hydrogen as a fuel (100% volume with combined-cycle gas turbine) is also introduced to the electricity sector from 2031 and onwards. This assumes sufficient hydrogen supply to Singapore. In 2050, the total power generation from hydrogen power plant is projected to be 43.26 TWh, accounting for 57% in domestic electricity generation.

## 7. Energy Cost Comparison between the Business-as-Usual and Low-carbon Energy Transition Scenarios

In addition, the current analysis compares the energy costs between BAU and the LCET scenarios. The comparison can provide useful information about the investment needed to achieve the climate targets in the LCET scenario. Tables 15.1 to 15.3 present the basic techno-economic assumptions used in such a comparison. Note that not all technologies are applicable to Singapore (e.g. nuclear and coal with CCS).

**Table 15.1. Fuel Cost Assumptions**

|          | 2020/2020 | 2050<br>(2019 constant price) | Unit                       |
|----------|-----------|-------------------------------|----------------------------|
| Coal     | 80.03     | 98.00                         | US\$/tonne                 |
| Oil      | 41        | 100                           | US\$/bbl                   |
| Gas      | 7.77      | 7.50                          | US\$/MMBtu                 |
| Hydrogen | 0.8       | 0.3                           | US\$/Nm <sup>3</sup>       |
| CCS      | 0         | 60                            | US\$/CO <sub>2</sub> tonne |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal units, Nm<sup>3</sup> = normal cubic metre.

Source: Author's calculations.



**Table 15.2. Construction Cost of Power Plants Assumptions (US\$/KW)**

|            | 2021  | by 2050 |
|------------|-------|---------|
| Coal       | 1,500 | 1,525   |
| Oil        | 600   | 600     |
| Gas        | 700   | 700     |
| Hydrogen   | 0     | 800     |
| Nuclear    | 4,500 | 3,575   |
| Hydro      | 2,000 | 2,223   |
| Geothermal | 4,000 | 4,256   |
| Solar      | 1,600 | 307     |
| Wind       | 1,600 | 1,235   |
| Biomass    | 2,000 | 3,019   |

KW = kilowatt.

Source: Author's calculations.

**Table 15.3. Capacity Factor of Power Plants Assumptions (%)**

|            | 2021 | by 2050 |
|------------|------|---------|
| Coal       | 75   | 80      |
| Oil        | 75   | 80      |
| Gas        | 75   | 80      |
| Hydrogen   |      | 80      |
| Nuclear    | 100  | 100     |
| Hydro      | 50   | 40      |
| Geothermal | 50   | 50      |
| Solar      | 17   | 17      |
| Wind       | 40   | 40      |
| Biomass    | 50   | 70      |

Source: Author's calculations.

## 7.1. Fuel Cost

Based on fuel cost assumptions shown in Table 15.1, Table 15.4 shows the comparison of total fuel cost between the two scenarios of interest. As shown in Table 15.4, the total fuel cost of the BAU scenario is projected to be US\$11,328 million in 2050, whilst the fuel cost in the LCET scenario will be US\$14,462 million in 2050. This is driven by the great increase in hydrogen consumption in the LCET scenario.

**Table 15.4. Comparison of Total Fuel Cost, Business-as-Usual and Low-carbon Energy Transition Scenarios in 2050**

|              | Primary Energy Consumption (Mtoe), BAU in 2021 | Final Energy Consumption (Mtoe), BAU in 2050 | Final Energy Consumption (Mtoe), LCET in 2050 | Total Investment Cost, BAU in 2050 (US\$ million) | Total Investment Cost, LCET in 2050 (US\$ million) |
|--------------|------------------------------------------------|----------------------------------------------|-----------------------------------------------|---------------------------------------------------|----------------------------------------------------|
| Coal         | 0.46                                           | 0.65                                         | 0.18                                          | 30                                                | -44                                                |
| Oil          | 12.26                                          | 25.07                                        | 21.43                                         | 8,814                                             | 6,311                                              |
| Gas          | 9.55                                           | 18.15                                        | 7.22                                          | 2,485                                             | -671                                               |
| Hydrogen     | 0                                              | 0                                            | 7.61                                          | 0                                                 | 8,867                                              |
| <b>Total</b> | <b>22.26</b>                                   | <b>43.87</b>                                 | <b>36.44</b>                                  | <b>11,328</b>                                     | <b>14,462</b>                                      |

BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

## 7.2. Power Generation Investment

According to Table 15.2 and Table 15.3, total investment costs in the BAU and LCET scenarios are presented in Table 15.5.

**Table 15.5. Comparison of Total Investment in Power Plants, Business-as-AU and Low-carbon Energy Transition Scenarios in 2050**

|              | Electricity Generation in BAU for 2021 (TWh) | Electricity Generation in BAU for 2050 (TWh) | Electricity Generation in LCET for 2050 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET (MW) | Total Investment Cost, BAU in 2050 (US\$ million) | Total Investment Cost, LCET in 2050 (US\$ million) |
|--------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------|----------------------------------------------------|
| Coal         | 1                                            | 1                                            | 0                                             | 67                               | 0                                 | 102                                               | 0                                                  |
| Oil          | 0                                            | 2                                            | 0                                             | 230                              | 0                                 | 138                                               | 0                                                  |
| Gas          | 52                                           | 84                                           | 0                                             | 4,561                            | 0                                 | 3,913                                             | 0                                                  |
| Gas with CCS | 0                                            | 0                                            | 11                                            | 0                                | 1,515                             | 0                                                 | 1,061                                              |
| Hydrogen     | 0                                            | 0                                            | 43                                            | 0                                | 6,173                             | 0                                                 | 4,938                                              |
| Hydro        | 0                                            | 0                                            | 0                                             | 0                                | 0                                 | 0                                                 | 0                                                  |

**Table 15.5. Continued**

|              | Electricity Generation in BAU for 2021 (TWh) | Electricity Generation in BAU for 2050 (TWh) | Electricity Generation in LCET for 2050 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET (MW) | Total Investment Cost, BAU in 2050 (US\$ million) | Total Investment Cost, LCET in 2050 (US\$ million) |
|--------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------|----------------------------------------------------|
| Solar        | 1                                            | 3                                            | 6                                             | 1,631                            | 3,263                             | 501                                               | 1,002                                              |
| Wind         | 0                                            | 0                                            | 0                                             | 0                                | 0                                 | 0                                                 | 0                                                  |
| Biomass      | 2                                            | 3                                            | 16                                            | 237                              | 2,414                             | 715                                               | 7,288                                              |
| <b>Total</b> | <b>56</b>                                    | <b>94</b>                                    | <b>76</b>                                     | <b>6,955</b>                     | <b>13,365</b>                     | <b>4,648</b>                                      | <b>14,289</b>                                      |

BAU = business as usual, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt-hour.

Source: Author's calculations.

As shown in Table 15.5, the total additional capacity under the BAU scenario is 6,955 MW from the 2021 level. The additional capacity under the LCET scenario in 2050 is larger than that in the BAU scenario, i.e. 13,365 MW. This is due to more radical expansions in hydrogen, solar, and biomass (particularly biomass with CCS). Total investment in 2050 under BAU is US\$4,648 million, whereas the investment needed for the LCET scenario in 2050 is much higher at US\$14,289 million. This is due to the radical expansion in hydrogen and biomass with CCS.

### 7.3. Overall Cost

With the results obtained from Section 7.1 and Section 7.2, the breakdown of the total investment cost in 2050 is showed in Table 14.6. Note that in current assumptions of LCET, natural gas-based electricity generation (without CCS) will be phased out in 2050, and the electricity generation mix will be dominated by hydrogen, biomass with CCS and natural gas with CCS.

Total investment cost for the BAU scenario between 2021 and 2050 is projected to be US\$15,976 million. This is lower than that in the LCET scenario, i.e. US\$28,789 million.

**Table 15.6. Energy Cost Comparison under Business-as-Usual and Low-carbon Energy Transition Scenarios in 2050**

|                                                    | BAU           | LCET          |
|----------------------------------------------------|---------------|---------------|
| Total fuel cost investment (US\$ million) in 2050  | 11,328        | 14,462        |
| Total power capital cost investment (US\$ million) | 4,648         | 14,289        |
| Total CCS cost investment (US\$ million)           | 0             | 37            |
| <b>Total (US\$ million)</b>                        | <b>15,976</b> | <b>28,789</b> |

CCS = carbon capture and storage, BAU = business as usual, LCET = low-carbon energy transition.

Source: Author's calculations.

## 8. Concluding Remarks

This study presents a scenario of net-zero emissions by 2050 for Singapore. Based on the assumptions specified in the current study, the target of net-zero emissions is achievable for Singapore, whilst the investment needed in 2050 would be much higher than that under the BAU scenario.

To achieve net-zero emissions, there are several strategies, including electricity imports through cross-border grids, applications of emerging decarbonisation technologies (i.e. CCS and hydrogen), and more expansions in renewable energy (i.e. solar and biomass). Under the current scenario settings, natural gas would be a transition fuel. Emerging low-carbon technologies, i.e. CCS and hydrogen, are expected to play an important role in Singapore's net-zero pathways. In addition, carbon-negative technologies, for example, biomass with CCS, is a necessary component for achieving net-zero emissions.

A greater effort from government, industry, the academic community, and society is needed for the net-zero pathways. The key role of the emerging decarbonisation technologies should be recognised, and policy support (e.g. regulatory frameworks for CCS and hydrogen applications, research and development support) should be in place. Regional cooperation and integration through regional power grids should be further enhanced as well. The results presented in the current study show a pathway for net-zero emissions, whilst this is not the only definite one. Future studies are also needed to explore those alternative pathways.

## References

- Energy Market Authority (EMA) (2024), Regional Power Grids. <https://www.ema.gov.sg/our-energy-story/energy-supply/regional-power-grids>
- Government of Singapore (2020), Singapore's Update of its First Nationally Determined Contribution (NDC) and Accompanying Information. <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Singapore%20First/Singapore%27s%20Update%20of%201st%20NDC.pdf>
- Government of Singapore (2022a), Singapore's Fifth National Communication and Fifth Biennial Update Report. <https://unfccc.int/sites/default/files/resource/Singapore%20-%20NC5BUR5.pdf>
- Government of Singapore (2022b), Singapore's Second Update of its First Nationally Determined Contribution (NDC) and Accompanying Information. <https://unfccc.int/sites/default/files/NDC/2022-11/Singapore%20Second%20Update%20of%20First%20NDC.pdf>
- Land Transport Authority (LTA) (2024), Our EV Vision. [https://www.lta.gov.sg/content/ltagov/en/industry\\_innovations/technologies/electric\\_vehicles/our\\_ev\\_vision.html](https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/electric_vehicles/our_ev_vision.html)
- National Climate Change Secretariat (NCCS) (2020), *Update of the Solar Photovoltaic (PV) Roadmap for Singapore*. <https://www.nccs.gov.sg/docs/default-source/default-document-library/Solar%20PV%20Roadmap%20for%20Singapore%202020.pdf>
- NCCS (2021a), Singapore's Long-Term Low-Emissions Development Strategy. <https://www.nccs.gov.sg/media/publications/singapores-long-term-low-emissions-development-strategy>
- NCCS (2021b), *Study of Hydrogen Imports and Downstream Applications for Singapore*. <https://www.nccs.gov.sg/singapores-climate-action/low-carbon-tech/>
- Sanchez, D.L., J.H. Nelson, J. Johnston, A. Mileva, and D.M. Kammen (2015), 'Biomass Enables the Transition to a Carbon-Negative Power System across Western North America', *Nature Climate Change*, 5(3), 230–234. doi:10.1038/nclimate2488
- Srivastav, P., M. Schenkel, G.U. Rehman Mir, T. Berg, and M. Staats (2021), *Carbon Capture, Utilisation and Storage (CCUS): Decarbonisation Pathways for Singapore's Energy and Chemicals Sectors*. <https://www.nccs.gov.sg/media/press-release/singapore-looks-to-develop-and-deploy-lc-technological-solution/>

# Chapter 16

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## Thailand Country Report

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# 1. Background

Thailand is in the middle of the Southeast Asian mainland, with the Pacific Ocean on the southeast coast, and the Indian Ocean on the southwest coast. Its land area is approximately 513,115 square kilometres, with great plains at the centre, mountainous areas in the north, and highlands in the northeast. Its gross domestic product (GDP) in 2021 was around US\$439 billion (in constant 2015 US\$). In 2021, the population was 71.7 million and income per capita was around \$6,122 (World Bank, 2025).

Thailand is an energy importer, especially crude oil, because of its very limited domestic oil resources. Thailand's indigenous energy resources include natural gas, coal (only lignite), and biomass. In 2019, proven reserves were 15.0 million cubic metres of oil and 0.14 trillion cubic metres of natural gas.

Thailand's total primary energy supply (TPES) reached 131.8 million tonnes of oil equivalent (Mtoe) in 2021. Oil accounted for the largest share at around 34.1%, followed by natural gas at 28.5%, and coal at 13.5%. 'Others' (biomass, solar, wind, ocean, biofuels and electricity imports) accounted for the remaining 22.6%. In 2021, net imports of energy accounted for 56% of the TPES. Due to limited indigenous oil and coal resources, Thailand imported around 79% of its oil and most of its bituminous coal. Although Thailand produces large quantities of natural gas, it imported about 28% from Myanmar and other countries. Thailand uses natural gas as a major energy source for power generation. In 2021, primary natural gas supply registered at 28.6 Mtoe, around 72% of which was sourced from domestic supplies and the rest imported from neighbouring countries. Coal was mainly used for power generation, but it was also heavily used in industrial cement and paper production.

Thailand has 45.3 gigawatts of installed electricity generation capacity. In 2021, power generation was about 201.8 terawatt-hours (TWh). Most of Thailand's power came from thermal generation (coal, natural gas, and oil), which accounted for 82.8% of generation. Hydro contributed 10.1% to the generation mix, whilst the remaining portion was made up of geothermal, solar, small hydro, and biomass.

## 2. Modelling Assumptions

According to the World Bank (2025), the annual GDP growth rate from 1990 to 2021 was a moderate 3.9% per year. For 2021–2050, an average GDP growth rate of 1.9% per year is assumed for Thailand. Population growth is also projected to be quite slow at around 0.2% per year between 2021 and 2050, which is comparable to average growth of about 0.7% per year between 1990 and 2021.

Efficiency programmes in all sectors are expected to help Thailand achieve its energy-saving goals. The industry sector can improve energy efficiency through better manufacturing processes. Programmes promoting public awareness on energy efficiency and energy efficiency labelling would drive large energy savings in the residential and commercial sectors, which are included in the 'others' category. In the transport sector, further development in the Bangkok metro area railway network would contribute to energy savings. The 30@30 programme, which aims to produce zero-emissions vehicles comprising at least 30% total vehicle production by 2030, will encourage road-travel efficiency.

Thailand's government policies in 2022 not only continue to encourage the increased use of alternative fuels but also focus on carbon neutrality in 2050. Reductions in CO<sub>2</sub> emissions are also expected to be achieved through the increased adoption of more energy-efficient technologies. In particular, in the alternative policy scenario, renewable energy sources are expected to help reduce CO<sub>2</sub> emissions from electricity generation. Gasohol and biodiesel as oil alternatives are also expected to help curb CO<sub>2</sub> emissions from transportation. Thailand has set the target to achieve carbon neutrality by 2050, around 120 Mt-CO<sub>2</sub> (equal to around 32 Mt-C). This amount of emissions will be able to offset the carbon sink in Thailand. This means that the energy sector is allocated a carbon emissions quota of 100 Mt-CO<sub>2</sub> (around 27 Mt-C), out of the total quota.

## 3. Outlook Results

### 3.1. Business-as-Usual Scenario

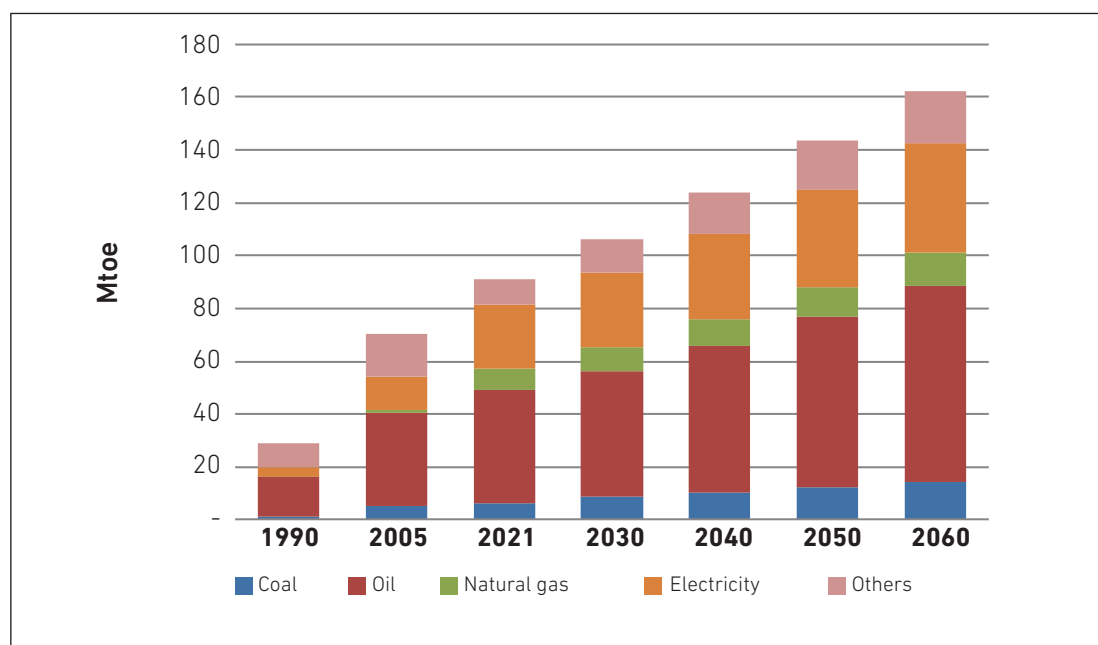
#### Final Energy Consumption

Between 1990 and 2021, Thailand's final energy consumption grew at an average rate of 3.8% per year from 28.9 Mtoe in 1990 to 90.8 Mtoe in 2021 (Figure 16.1). Given moderate economic growth and a low population growth rate, final energy consumption is projected to grow at a slower rate of 1.5% per year between 2021 and 2060.

Oil has been the dominant fuel in Thailand's final energy consumption, accounting for 42.73 Mtoe, or a 47% share, in 2021. Electricity was the second-largest energy fuel, accounting for 24.7 Mtoe, or a 26.5% share, in 2021. Oil is expected to remain the largest final energy source throughout the projection period. Its share is expected to remain the highest share until 2060, and its share will be around 45.7% in 2060. In 2060, the share of electricity in final energy consumption will be 25.6%, whilst coal will be 8.9%.



**Figure 16.1. Final Energy Consumption by Fuel, Business-as-Usual Scenario**



Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes biomass, solar, wind, and biofuels.

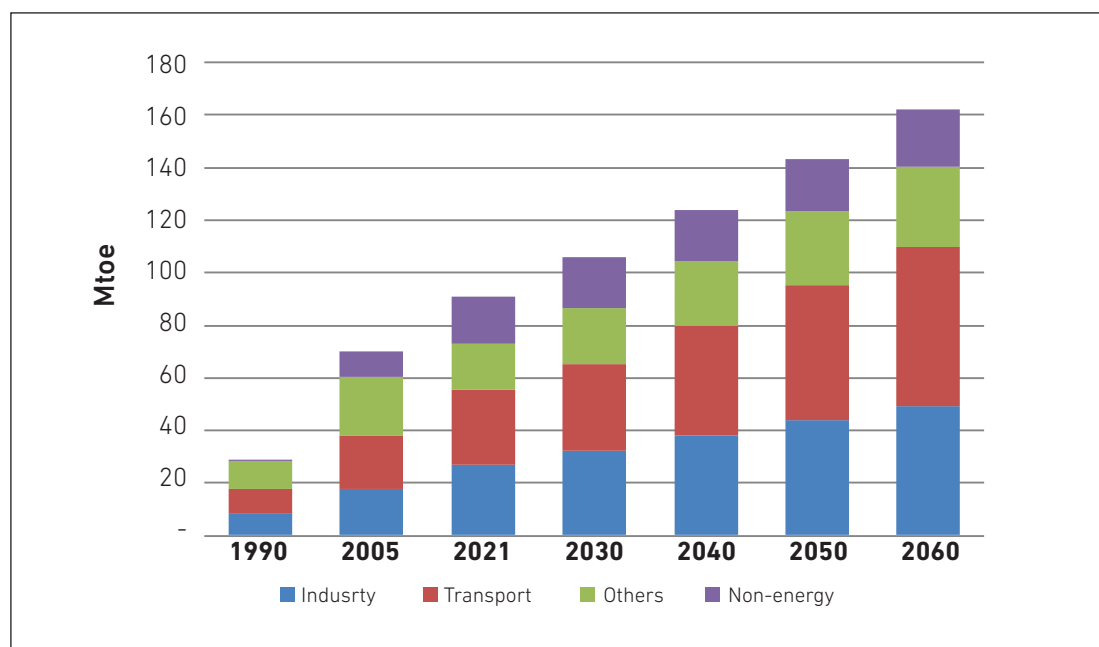
Source: Authors' calculations.

In 1990, the industry sector's contribution to Thailand's total final energy consumption was 30.0%, with a level of 8.7 Mtoe (Figure 16.2). The transport sector's demand grew by an average rate of 3.8% a year between 1990 and 2021, its share around 31.5% (equivalent to 28.7 Mtoe) in 2021, making it the second largest consuming sector. It is projected to become the largest consumer, accounting for 37.5% (equivalent to 60.7 Mtoe) in 2060. In contrast, the 'others' sector (mainly residential and commercial) will account for the smallest proportion of final energy consumption in 2060, at 18.8%, compared to its 37.3% share in 1990.

## Primary Energy Supply

Primary energy supply grew at an average annual rate of 3.8% from 41.9 Mtoe in 1990 to 131.8 Mtoe in 2021, driven largely by fast economic development between 1990 and 1996. This growth in primary energy supply was achieved despite the severe economic crisis in 1997–1998 and the global financial crisis in 2008 and followed by the novel coronavirus disease (COVID-19) pandemic in 2019. In 2021, the major sources of primary energy were oil with a 34.1% (44.9 Mtoe) share; natural gas with 28.5% (37.5 Mtoe); and coal with 13.5% (17.8 Mtoe).

**Figure 16.2. Final Energy Consumption by Sector, Business-as-Usual Scenario**



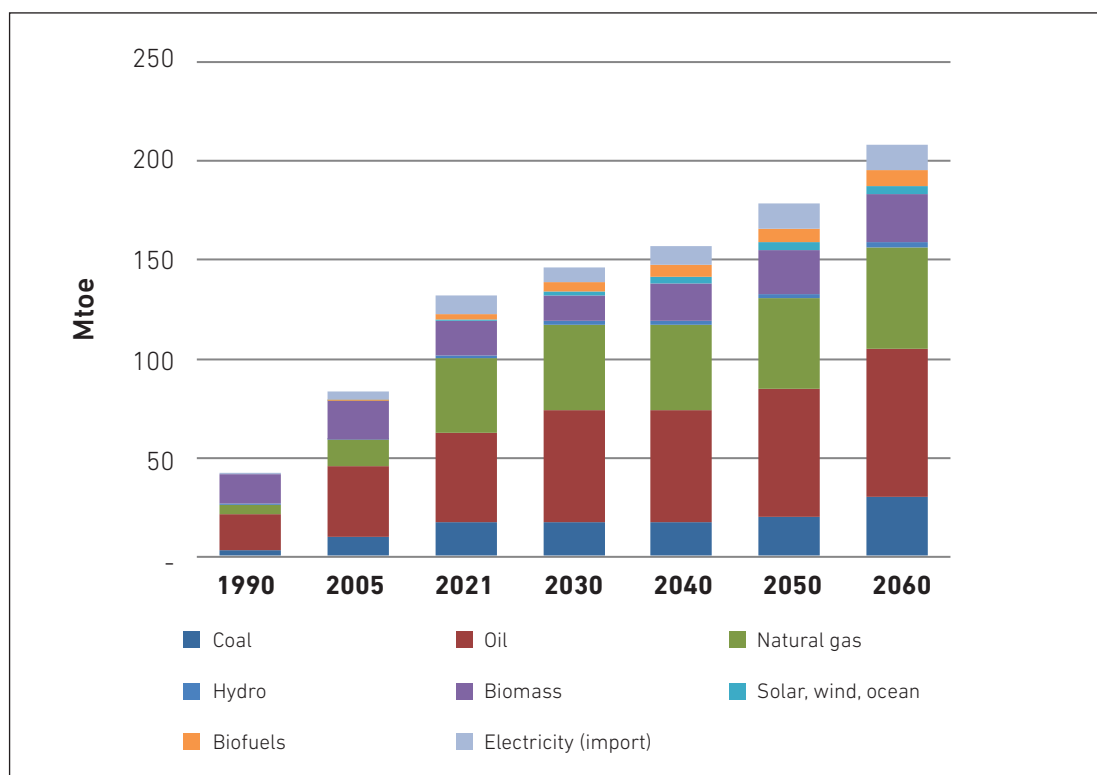
Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

In the business-as-usual (BAU) scenario, primary energy supply is projected to grow by an average of 1.2% per year from 2021 to 2060, reaching 207.7 Mtoe in 2060 (Figure 16.3). The highest average annual growth rate is expected in coal (1.4%), with consumption projected to reach 30.6 Mtoe in 2060. Oil will follow at an annual average growth rate of 1.3%, reaching 74.3 Mtoe in 2060. Natural gas is projected to increase at an average rate of 0.8% per year. The share of oil will be almost the same around 35.8% in 2060, whilst the shares of coal and natural gas will be around 14.7% and 24.9%, respectively. Biomass is expected to grow at an average rate of 0.9% per year between 2021 and 2060.

The share of biomass in the total primary energy consumption will decline somewhat from 12.9% in 2021 to 11.5% in 2060.

**Figure 16.3. Primary Energy Supply by Fuel, Business-as-Usual Scenario**



Mtoe = million tonnes of oil equivalent.

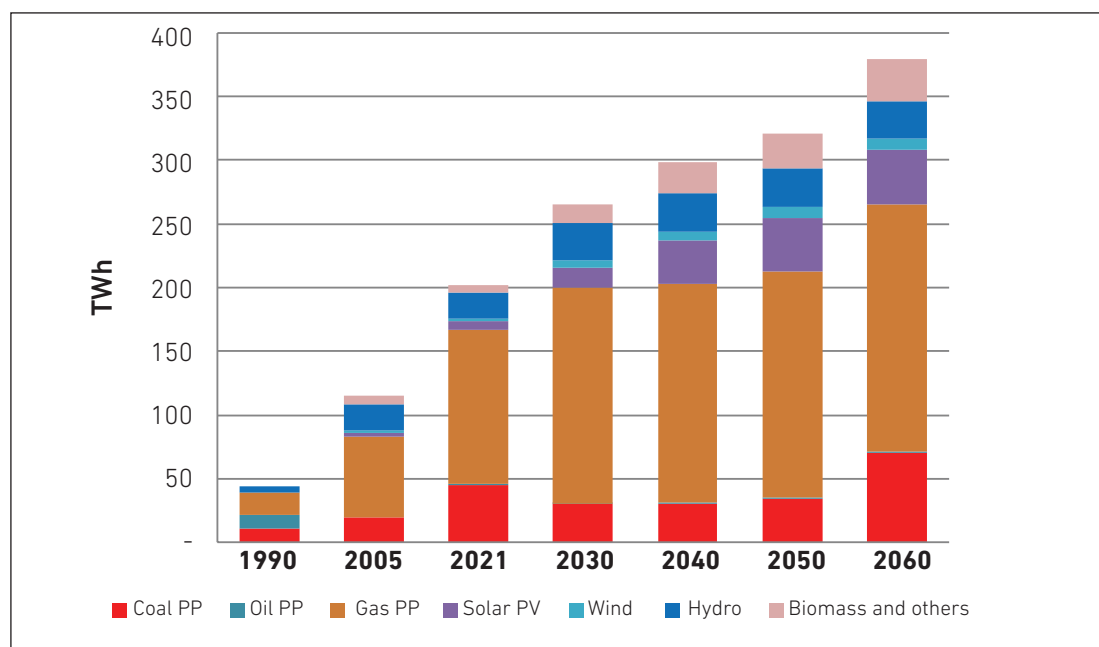
Source: Authors' calculations.

## Power Generation

In 1990, the total power generation was 44.2 TWh. It reached 201.8 TWh in 2021, with an average growth rate of 5.0% per year. As shown in Figure 16.4, natural gas has been a major fuel for power generation since 1990. Natural gas in power generation grew at a robust rate of 6.4% per year from 17.8 TWh (40.2% share) in 1990 to 121.4 TWh (60.2% share) in 2021. Coal had the second largest share at 25.0% in 1990 but dropped to 22.4% in 2021. Oil was the least used fuel in power generation, with only 0.4 TWh in 2021.

In the BAU scenario, power generation is expected to grow at around 1.6% per year from 2021 to 2060 and will reach 378.7 TWh in 2060. In 2060, natural gas will remain the dominant fuel used in power generation with the highest share of 51.3% or 194.2 TWh. Coal will remain the second largest source of power generation, with a share of 18.6% or a level of 70.4 TWh in 2060. Power generation from hydro will increase by 1.0% per year from 20.4 TWh in 2021 to 29.8 TWh in 2060 (Figure 16.4).

**Figure 16.4. Power Generation by Fuel Type, Business-as-Usual Scenario**



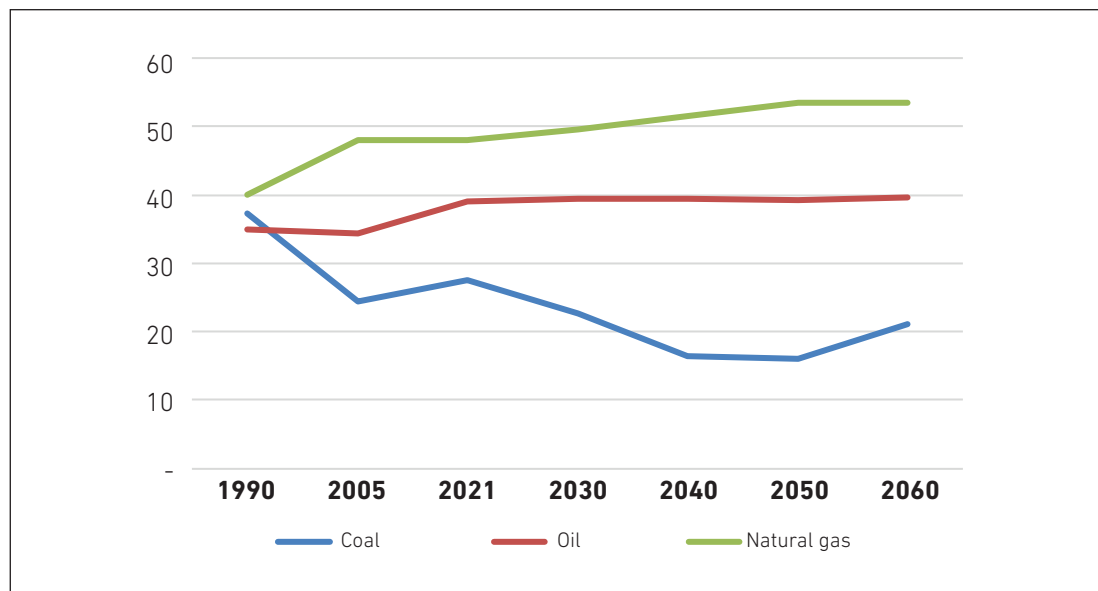
PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Note: 'Others' includes solar, wind, small hydro, geothermal, biomass, and nuclear.

Source: Authors' calculations.

Out of all energy sources, natural gas has shown the greatest improvement in thermal efficiency. Its efficiency increased from 40.0% in 1990 to almost 47.9% in 2021 and is expected to reach 53.4% in 2060. In contrast, coal's thermal efficiency declined on an average of 1.0% a year from 1990 to 2021 and is expected to continuously decline an average of 0.1 a year over the study period (Figure 16.5).

**Figure 16.5. Thermal Efficiency by Fuel Type, Business-as-Usual Scenario, 1990–2060 (%)**



Source: Author's calculation.

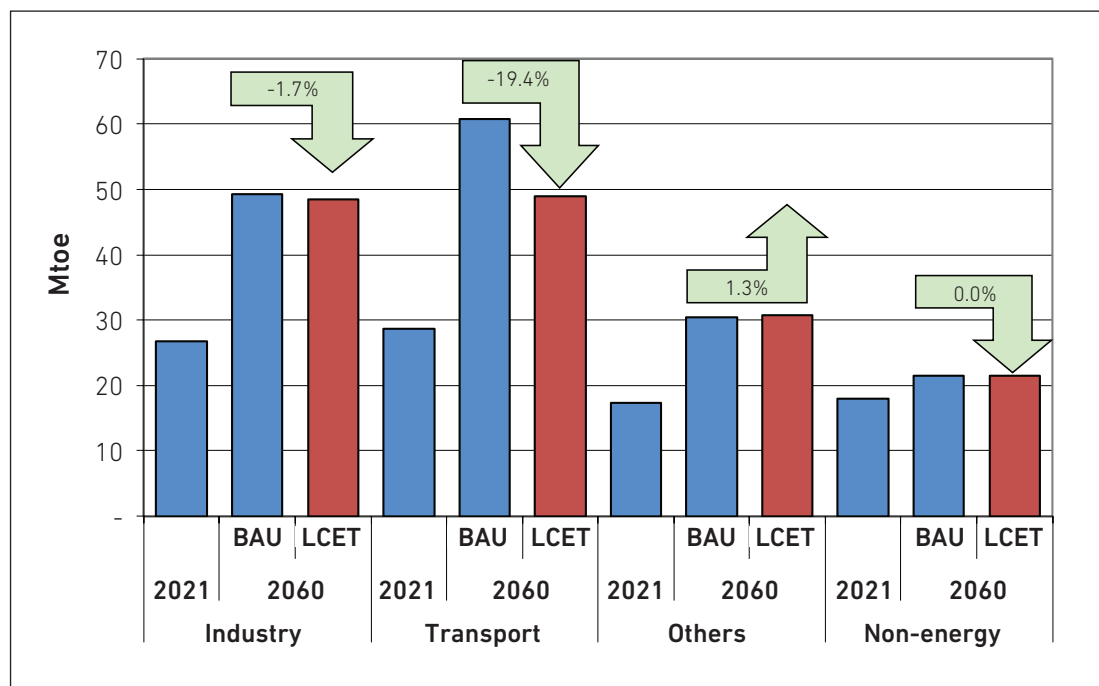
## 4. Basic Concept of Low-carbon Energy Transition

Thailand targets to achieve carbon neutrality in 2050. For the energy sector, the Office Natural Resources and Environmental Policy and Planning set the carbon dioxide (CO<sub>2</sub>) offset to be within 100 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2050. The low-carbon energy transition (LCET) scenario focuses on how to achieve this target in 2050. The low-carbon technology of carbon capture and storage (CCS) and low carbon energy (blue and green hydrogen) will be assumed to replace the conventional fossil fuels in use today. These probably take action a lot in power generation and somewhat in final energy consumption. In the case of Thailand, the LCET scenario assumes hydrogen will be used in the industry sector, and probably in iron and steel and clicker, but not in transport and the 'others' sectors.

### 4.1. Final Energy Consumption

In the LCET scenario, final energy consumption is projected to grow by 1.3% per year, from 90.9 million tonnes of oil equivalent (Mtoe) in 2021 to 149.8 Mtoe in 2060. This is around 7.0% lower than in the BAU scenario. The stock of electric vehicles will lower the use of oil. The consumption is different from the BAU scenario in transport and the 'others' sectors, but much greater in transport, –19.3%, in industry –1.7%, and in the 'others' only 1.3%, as shown in Figure 16.6.

**Figure 16.6. Final Energy Consumption by Sector,  
Business-as-Usual and Low-carbon Energy Transition Scenarios**



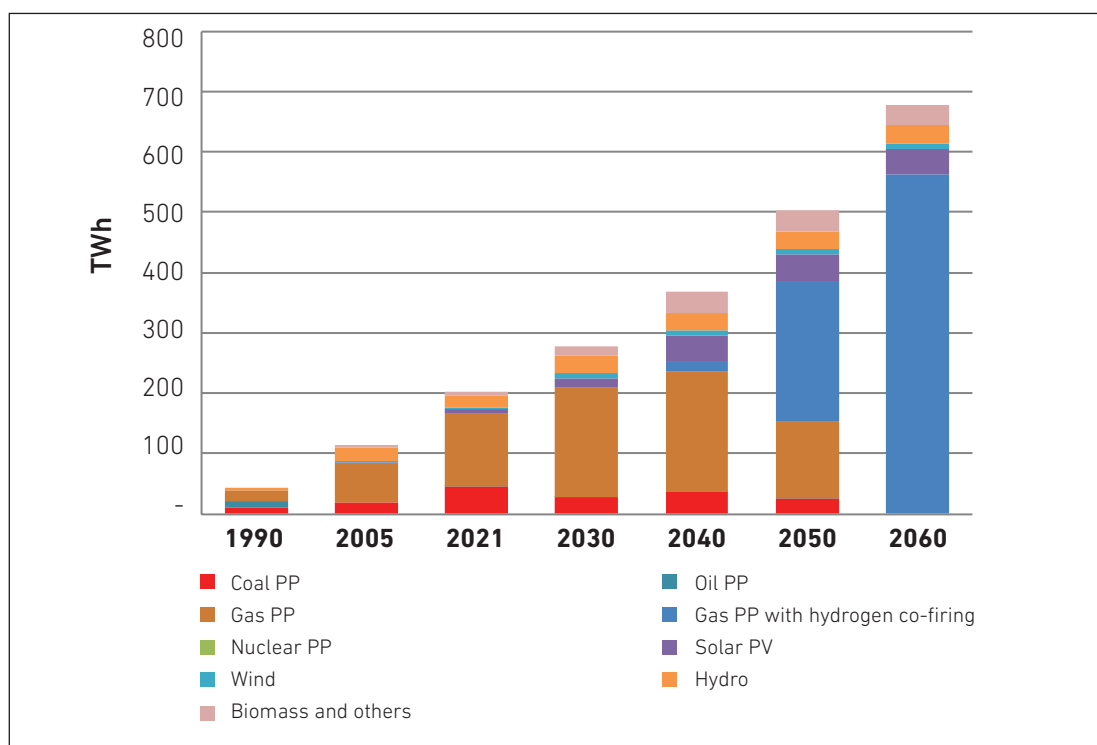
BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculations.

## 4.2. Power Generation

In the LCET scenario, power generation is expected to grow at around 3.2% per year from 2021 to 2060 and will reach 678.6 TWh in 2060. In 2060, hydrogen will be the dominant fuel used in power generation with the highest share of 82.8% or 561.9 TWh. The second largest source of power generation will be solar photovoltaic (PV), a share of 6.3% or a level of 42.7 TWh in 2060. The rest will be biomass, hydro, wind, and oil, with shares of 5.1%, 4.4%, 1.3%, and 0.1%, respectively (Figure 16.7).

**Figure 16.7. Power Generation by Fuel Type, Low-carbon Energy Transition Scenario**



CCS = carbon capture and storage, PP= power plant, TWh = terawatt-hour.

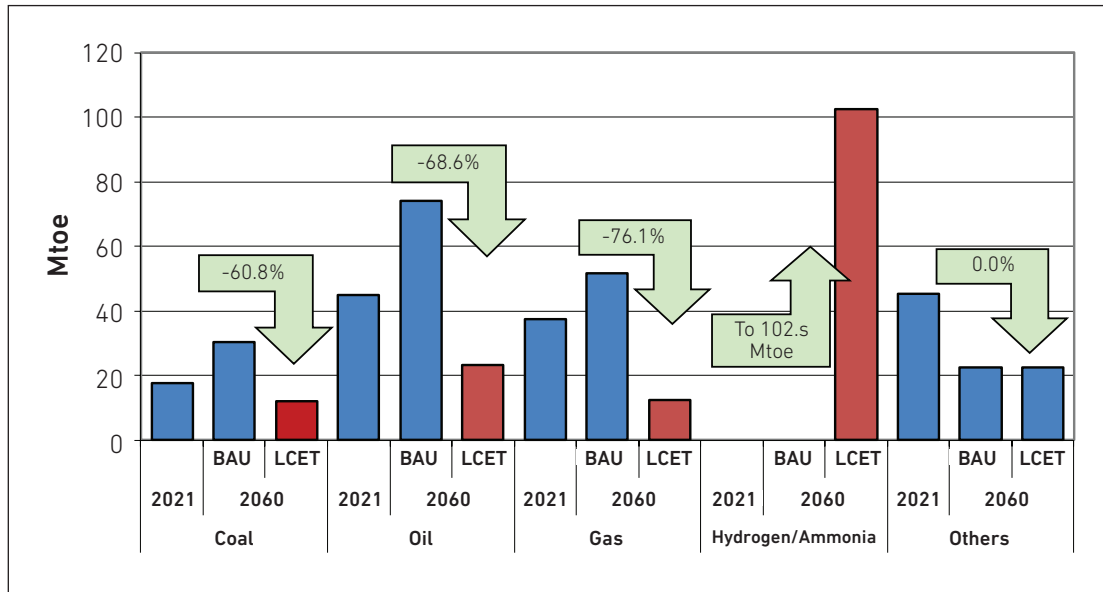
Source: Authors' calculations.

### 4.3. Primary Energy

The growth rate of primary energy supply in the LCET scenario is projected to be the same as that in the BAU scenario, increasing at 1.3% annually and reaching 220.0 Mtoe in 2060. However, primary LCET energy supply in the LCET scenario has a different fuel mix from the BAU scenario.

To achieve carbon neutrality in 2050, fossil fuels, coal, oil, and natural gas must be replaced by alternative fuels, new energy sources such as hydrogen and ammonia, and renewable energy. In the LCET scenario, coal, oil, and natural gas are projected to be lower compared to the BAU scenario; 60.8%, 68.6%, and 76.1%, respectively. However, they are expected to increase in hydrogen/ammonia (from 0 Mtoe in 2021 to 102.5 Mtoe). The differences in the projections between the two scenarios are shown in Figure 16.8.

**Figure 16.8. Primary Energy Supply by Source,  
Business-as-Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

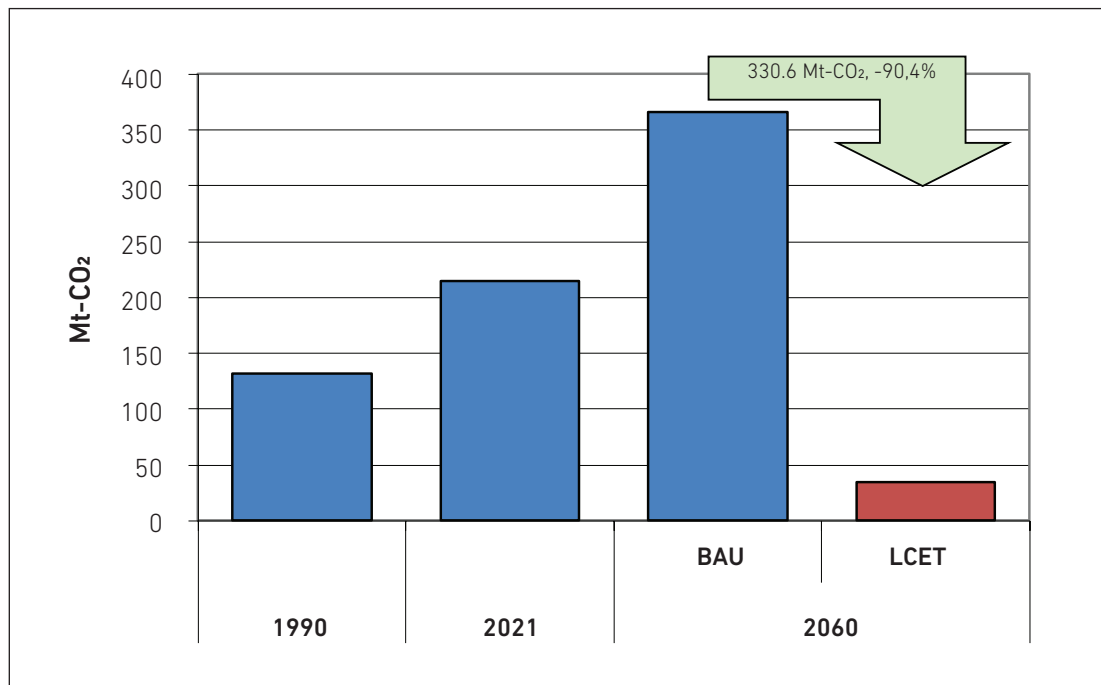
Source: Authors' calculations.

## 5. Carbon Dioxide Emissions Reduction

Under the LCET scenario, the average annual growth in CO<sub>2</sub> emissions from 2021 to 2060 is projected to be -4.5%, with an emissions level of 35.2 Mt-CO<sub>2</sub> in 2060. The difference in CO<sub>2</sub> emissions between the BAU and the LCET scenarios is 330.6 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>), or -90.4%. This can achieve carbon neutrality, which is less than the offset capability in Thailand in 2050 of 27 Mt-C. The reduction in CO<sub>2</sub> emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans, environmentally-friendly fuels, and CCS in industry and in power generation for coal and natural gas (Figure 16.9).



**Figure 16.9. Carbon Dioxide Emissions from Energy Consumption, Business-as-Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, CO<sub>2</sub> = carbon dioxide, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon dioxide.

Source: Authors' calculations.

## 6. Energy Cost Comparison between Business-as-Usual and Low-carbon Energy Transition Scenarios

The energy cost is the estimation that covers costs of fuel, power generation investment, and CCS. A comparison will be to see the difference of primary energy and power generation of 2021 to 2050, and it will compare between BAU and LCET scenarios using assumptions that are listed in Tables 16.1, 16.2, and 16.3. This cost comparison will be a helpful tool for making a final decision.

**Table 16.1. Fuel Cost Assumptions**

|          | 2020/2021 | 2050 or 2060 (2019 constant price) | Unit                       |
|----------|-----------|------------------------------------|----------------------------|
| Coal     | 80.03     | 98.00                              | US\$/tonne                 |
| Oil      | 41.00     | 100.00                             | US\$/bbl                   |
| Gas      | 7.77      | 7.50                               | US\$/MMBtu                 |
| Hydrogen | 0.80      | 0.10                               | US\$/Nm <sup>3</sup>       |
| CCS      | 0         | 70.00                              | US\$/CO <sub>2</sub> tonne |

bbl = barrel, CCS = carbon-capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = million British thermal units, Nm<sup>3</sup> = normal cubic metre.

Source: Authors' calculations.

**Table 16.2. Construction Cost of Power Plants Assumptions (US\$/KW)**

| Power Plants | 2021  | by 2050 |
|--------------|-------|---------|
| Coal         | 1,500 | 1,525   |
| Oil          | 600   | 600     |
| Gas          | 700   | 700     |
| Hydrogen     | 0     | 700     |
| Nuclear      | 4,500 | 3,575   |
| Hydro        | 2,000 | 2,223   |
| Geothermal   | 4,000 | 4,256   |
| Solar        | 1,600 | 307     |
| Wind         | 1,600 | 1,235   |
| Biomass      | 2,000 | 3,019   |

KW = kilowatt.

Source: Authors' calculations.

**Table 16.3. Capacity Factor of Power Plants Assumptions**

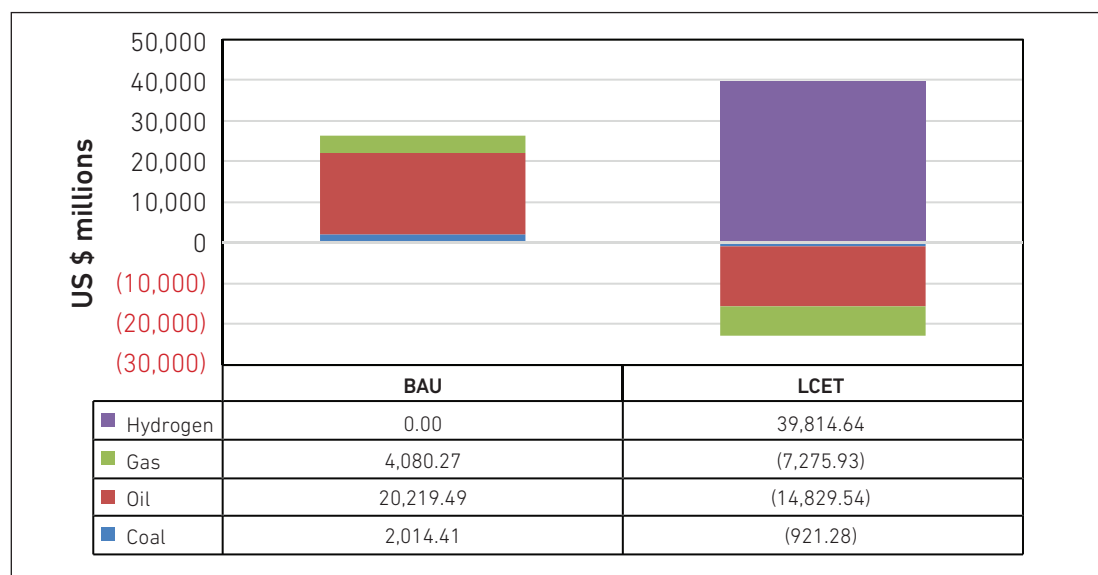
| Power Plants | 2021 | by 2050 |
|--------------|------|---------|
| Coal         | 75   | 80      |
| Oil          | 75   | 80      |
| Gas          | 75   | 80      |
| Hydrogen     | 0    | 80      |
| Nuclear      | 100  | 80      |
| Hydro        | 50   | 40      |
| Geothermal   | 50   | 50      |
| Solar        | 17   | 17      |
| Wind         | 40   | 40      |
| Biomass      | 50   | 70      |

Source: Authors' calculations.

## 6.1. Fuel Cost

The change in Thailand's fossil fuel cost (coal oil and natural gas) and hydrogen cost from primary energy in 2021 and 2060 in the BAU scenario is around US\$26,314 million, and the LCET scenario is US\$16,788 million (Figure 16.10). In a comparison between increases of cost from 2021 to 2060 of the BAU and LCET scenarios, the BAU is supposed to be much greater than the LCET scenario. The LCET scenario can save in the use of fossil fuels, especially in oil, although the cost of hydrogen will be high. In terms of fuel cost, Thailand might be better off.

**Figure 16.10. Change of Fuel Cost 2021 to 2060, Comparison between Business-as-Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition.

Source: Authors' calculations.

## 6.2. Power Generation Investment

According to the BAU and LCET scenarios from 2021 until 2060, the difference of the install capacity of power generation, Thailand might increase install capacity 47,209 MW in BAU and 113,828 MW in LCET scenarios. The investment in new additional power generation of both cases expects to be US\$41,618 million in BAU and US\$86,204 million in LCET scenario. In the case of the LCET scenario, its cost soared by the new investment in hydrogen power plants. Total power plants investment cost is further listed on Table 16.4.

**Table 16.4. Total Investment Power Plants Cost Comparison, Business-as-Usual and Low-carbon Energy Transition Scenarios in 2060**

|          | Electricity Generation in BAU for 2021 (TWh) | Electricity Generation in BAU for 2060 (TWh) | Electricity Generation in LCET for 2060 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET (MW) | Total Investment Cost, BAU in 2060 (US\$ million) | Total Investment Cost, LCET in 2060 (US\$ million) |
|----------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------|----------------------------------------------------|
| Coal     | 45                                           | 70                                           | 0                                             | 3,590                            | 0                                 | 5,475                                             | 0                                                  |
| Oil      | 0                                            | 1                                            | 1                                             | 25                               | 58                                | 15                                                | 35                                                 |
| Gas      | 121                                          | 194                                          | 0                                             | 10,397                           | 0                                 | 7,278                                             | 0                                                  |
| Hydrogen | 0                                            | 0                                            | 562                                           | 0                                | 80,173                            | 0                                                 | 56,121                                             |
| Solar    | 6                                            | 43                                           | 43                                            | 24,318                           | 24,318                            | 7,466                                             | 7,466                                              |
| Wind     | 2                                            | 9                                            | 9                                             | 1,836                            | 1,836                             | 2,267                                             | 2,267                                              |

|                                 | Electricity Generation in BAU for 2021 (TWh) | Electricity Generation in BAU for 2060 (TWh) | Electricity Generation in LCET for 2060 (TWh) | Additional Capacity for BAU (MW) | Additional Capacity for LCET (MW) | Total Investment Cost, BAU in 2060 (US\$ million) | Total Investment Cost, LCET in 2060 (US\$ million) |
|---------------------------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------|-----------------------------------|---------------------------------------------------|----------------------------------------------------|
| Hydro                           | 20                                           | 30                                           | 30                                            | 2,693                            | 2,709                             | 5,988                                             | 6,021                                              |
| Geothermal                      | 0                                            | 0                                            | 0                                             | 0                                | 0                                 | 0                                                 | 0                                                  |
| Biomass + Municipal Solid Waste | 6                                            | 32                                           | 35                                            | 4,349                            | 4,735                             | 13,130                                            | 14,294                                             |
| <b>Total</b>                    | <b>202</b>                                   | <b>379</b>                                   | <b>679</b>                                    | <b>47,209</b>                    | <b>113,828</b>                    | <b>41,618</b>                                     | <b>86,204</b>                                      |

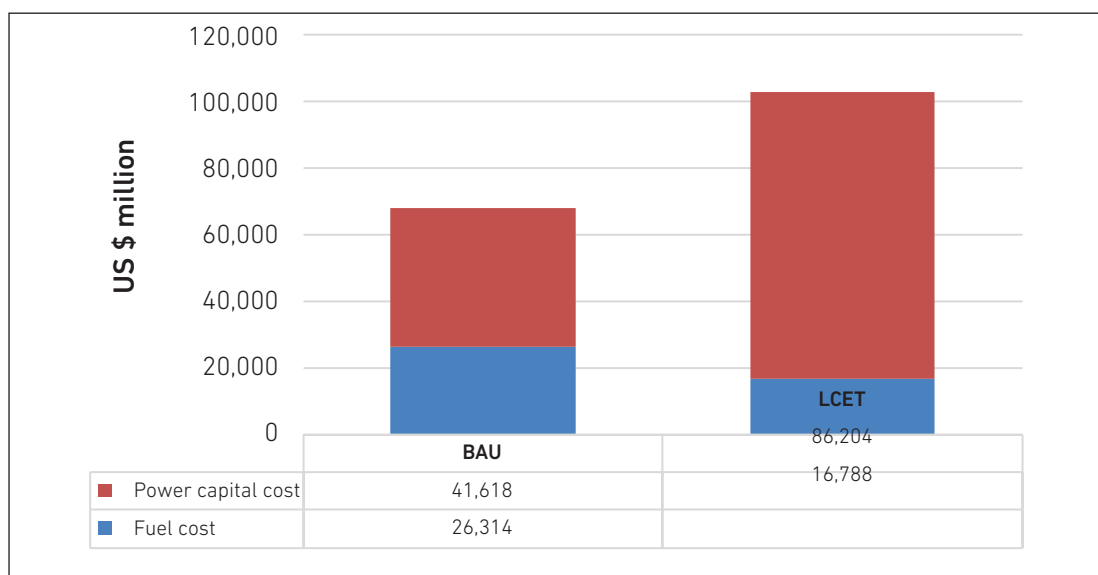
BAU = business as usual, LCET = low-carbon energy transition, MW = megawatt, TWh = terawatt hour.

Source: Authors' calculations.

### 6.3. Overall Cost

When fuel cost and power generation investment are combined together, an increasing energy cost in the BAU scenario in 2060 will be US\$67,932 million and US\$102,992 million in the LCET scenario, approximately (Figure 16.11). The different amount between these two cases is around US\$35,060 million, but higher in the LCET scenario.

**Figure 16.11. Energy Cost Comparison between Business-as-Usual and Low-carbon Energy Transition Scenarios**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors' calculations.

## 7. Conclusions and Recommendation

Hydrogen/ammonia and CCS might help Thailand to achieve low-carbon energy transition. Hydrogen and CCS will cut carbon dioxide from 365.8 Mt-CO<sub>2</sub> in the BAU scenario to 35.2 MT-CO<sub>2</sub> in the LCET scenario, which is CO<sub>2</sub> emissions lower than the carbon neutrality target of 27 Mt-C or 100 Mt-CO<sub>2</sub> (carbon offset) in the energy sector in 2050. However, when cost is considered, power generation investment cost and CCS cost, the energy cost of low carbon will be higher than in the BAU scenario at around US\$35,060 million. Moreover, carbon neutrality will impact the way of using energy. It will change the use of conventional energy, coal, natural gas, and oil, to new energy types – hydrogen, in particular.

## References

World Bank (2025), World Development Indicators. <https://databank.worldbank.org/reports.aspx?source=2&country=ARE> (accessed 15 January 2025).



# Chapter 17

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## Viet Nam Country Report

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# 1. Socio-economic Situation, Energy Situation, and Energy Development

## 1.1. Socio-economic Situation

Viet Nam has a total land area of 331,100 square kilometres, 50% of which is in productive use. In 2021, the population reached 98.5 million, reflecting an average annual increase of 1.3% (or 32.5 million) from its 1990 level of 66.0 million.

Gross domestic product (GDP) grew at an average annual rate of 7.4%, increasing from US\$36.8 billion in 1990 to US\$332.3 billion in 2021 (constant 2015 US dollars). The commercial sector contributed the largest share to GDP (42.1%), followed by industry (36.7%), agriculture (12.4%), and other activities (8.8%). In 2021, GDP per capita was US\$3,373.

## 1.2. Energy Situation

Viet Nam has substantial indigenous energy resources, including 3.39 billion tonnes of proven recoverable coal, 460 million cubic metres (m<sup>3</sup>) of crude oil, and 610 billion m<sup>3</sup> of natural gas. In 2021, the country produced 48.32 million tonnes of coal, 7.46 billion m<sup>3</sup> of natural gas, and 10.97 million tonnes of crude oil. Almost all crude oil was processed in domestic oil refineries, with the remainder exported. Coal was mainly used by industry, whilst natural gas was largely used for electricity generation.

Viet Nam generated over 256.9 terawatt-hours (TWh) of electricity in 2021. Coal-fired power accounted for 46.3% of total generation, followed by hydropower (30.6%), natural gas, oil-fired power (10.9%), and other sources (12.2%).

The rural electrification programme has advanced significantly in recent years. According to Viet Nam Electricity (EVN), by the end of 2021, 100% of communes and 99.65% of households had access to electricity from the national grid – one of the highest electrification rates amongst countries with similar GDP levels.

Viet Nam has strong potential for renewable energy – including small-scale hydropower, biomass, wind, and solar – which can help meet national energy demand and support electrification in remote areas.

## 1.3. Energy Development and Mitigation Targets

A reliable power supply is essential for the emerging economy. By the end of 2021, total installed power generation capacity reached about 76.4 gigawatts (GW) (EVN, 2022), a 12% increase from 2018 (EVN, 2018). Coal accounted for the largest share (32.3%), followed by hydropower (28.6%) and natural gas (9.4%).

According to the National Power Development Plan 2021–2030, with outlook to 2050, renewable power (including hydropower) will drive capacity expansion, making up 49.6% of total installed capacity by 2030 and rising to at least 82% by 2050. Natural gas is expected to contribute 24.8% by 2030, transitioning to hydrogen co-firing by 2050. Coal-fired thermal power is projected to account for 20% by 2030, gradually shifting to biomass or ammonia by 2050. The remaining capacity will come from other sources, including energy storage, flexible power, and imported electricity.

Viet Nam has committed to strong emissions reduction measures to achieve net-zero emissions by 2050, using domestic resources alongside international cooperation and support.

The Government of Viet Nam has recently introduced strategies and policies to increase the share of renewable energy in power generation, improve energy efficiency, and promote fuel switching to reduce greenhouse gas emissions. The mitigation targets outlined in key legal documents are summarised in Table 17.1.

**Table 17.1. Mitigation Targets and Related Legal Documents**

| Legal Document                                                                                        | Mitigation Targets and Actions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| National Climate Change Strategy, Vision to 2050                                                      | <p><b>Targets.</b> Achieve net-zero emissions by 2050.</p> <ul style="list-style-type: none"> <li>• By 2030. Reduce energy greenhouse gas emissions by 43.5% from BAU levels, with total emissions not exceeding 457 Mt-CO<sub>2</sub>e.</li> <li>• By 2050. Achieve net-zero emissions, with energy sector emissions reduced by 91.6% from BAU levels and not exceeding 101 Mt-CO<sub>2</sub>e.</li> </ul>                                                                                                    |
| National Power Development Plan 2021–2030, with outlook to 2050                                       | <p><b>Targets</b></p> <ul style="list-style-type: none"> <li>• Increase the share of renewable energy in installed power generation capacity to 49.6% by 2030 and 82.0%–91.8% by 2050.</li> <li>• Increase the share of electricity generated from renewables to 30.9%–39.2% by 2030 and 67.5%–71.5% by 2050.</li> </ul>                                                                                                                                                                                       |
| MOIT's Action Plan for Implementing Viet Nam's Commitments at COP26                                   | <ul style="list-style-type: none"> <li>• Strengthen energy efficiency measures by improving the minimum energy performance standards.</li> <li>• Phase out fossil fuel use.</li> <li>• Apply CCS technologies in industries such as cement, steel, and chemicals. Develop renewable energy projects, including solar PV, wind power, hydropower, hydrogen, CCS, and energy storage technologies.</li> <li>• Promote electrification and energy efficiency in the residential and transport sectors.</li> </ul> |
| Action Plan on Green Energy Transition and Greenhouse Gas Emissions Reduction in the Transport Sector | <p><b>Targets.</b> Develop a green transport system to achieve net-zero emissions by 2050.</p> <ul style="list-style-type: none"> <li>• By 2030. Promote energy efficiency and encourage the switch to electricity and green energy with appropriate technologies and institutional and resource support.</li> <li>• By 2050. Prioritise sustainable transport development, ensuring all transport modes, equipment, and infrastructure transition to electricity and green energy.</li> </ul>                 |

BAU= business as usual, CCS = carbon capture and storage, COP26 = 26th Session of the Conference of Parties, MOIT = Ministry of Industry and Trade, Mt-CO<sub>2</sub>e = metric tonnes of carbon dioxide equivalent, NDC = nationally determined contribution, PV = photovoltaic.

Source: Author.

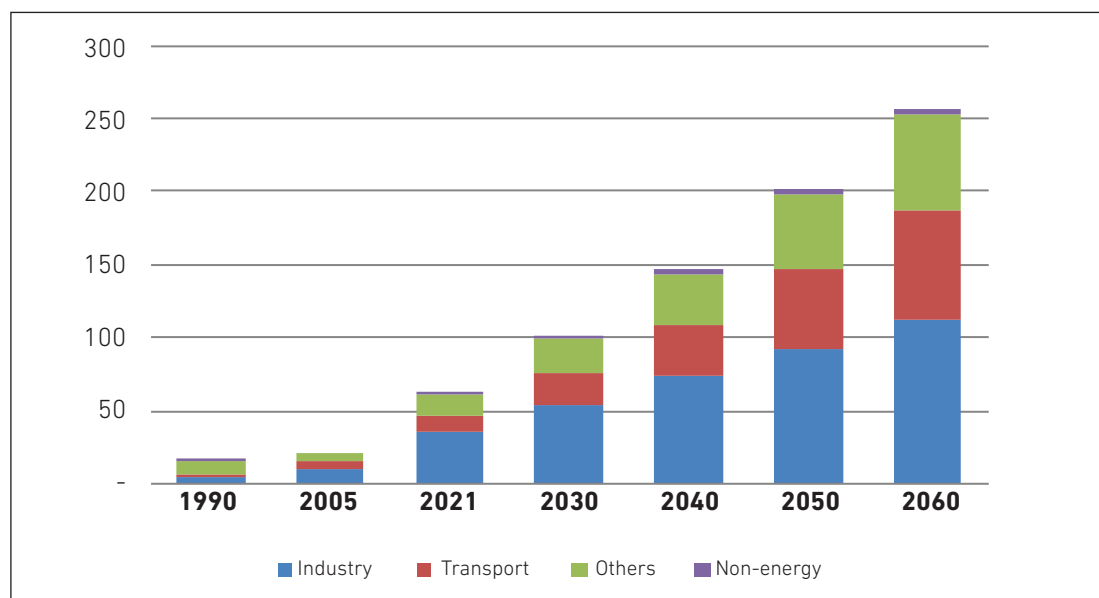
## 2. Analysis of Business-as-Usual Results

### 2.1. Final Energy Consumption

Final energy consumption reached 63.8 million tonnes of oil equivalent (Mtoe) in 2021, increasing at an annual rate of 4.6% – four times higher than the 1990 level of 16.1 Mtoe. The fastest growth was in transport (6.9% per year), followed by industry (6.8%) and other sectors (residential and commercial) (1.4%). Non-energy use grew at 15% per year.

In 2021–2060, final energy consumption is projected to grow at an average annual rate of 3.6% under the business-as-usual (BAU) scenario, driven by strong economic growth averaging 4.8% per year and population growth of 0.3% per year. Transport is expected to see the highest growth in energy consumption at 5.1% per year, followed by other sectors (residential and commercial) at 3.8% and industry at 3.0%. Non-energy use is expected to grow at 1.9% per year. Figure 17.1 shows final energy consumption by sector in 1990–2060.

**Figure 17.1. Final Energy Consumption by Sector,  
Business-as-Usual Scenario, 1990–2060**  
(million tonnes of oil equivalent)



Note: Others include residential and commercial sectors.

Source: Author.

In 1990, other sectors accounted for about 63% of total energy consumption, mainly due to widespread biomass use for residential cooking. By 2021, this share had fallen to 24.1% as economic growth drove a shift from biomass to more efficient commercial energy sources. As the economy continues to grow, rising living standards are expected to further accelerate the transition to modern fuels such as electricity and liquefied petroleum gas.

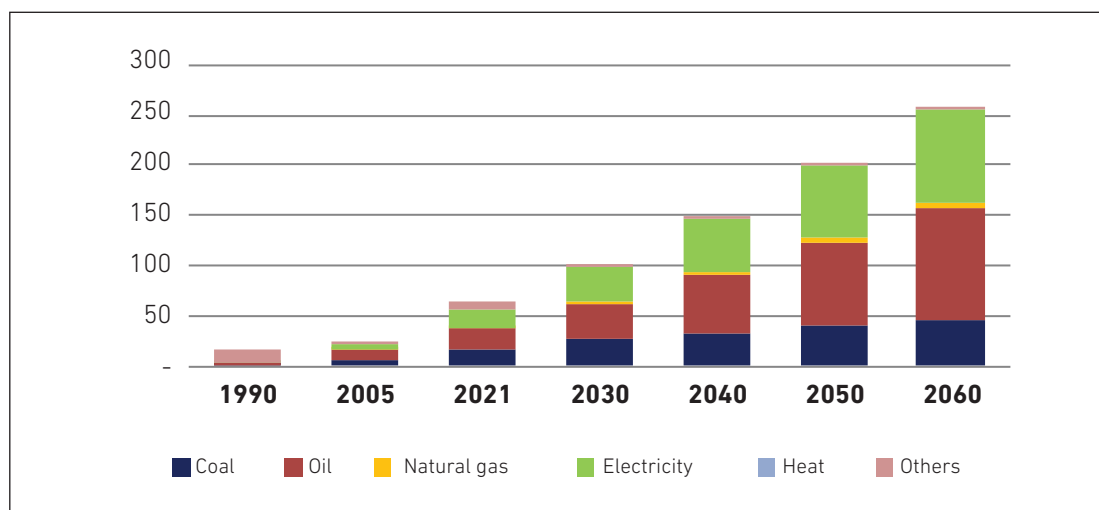
In 2021–2060, industry is expected to remain the largest energy consumer, although its share of total consumption will decline from 55.5% in 2021 to 43.7% by 2060. Other sectors will become the second-largest consumer, with their share gradually falling from 24.1% in 2021 to 22.6% by 2030, then rising slightly to 25.5% by 2060. Transport will rank third, with its share increasing from 17.1% in 2021 to 29.1% by 2060.

In 1990, other fuels – mainly biomass – accounted for the largest share of final energy consumption at 73.9%, falling sharply to 11.2% by 2021. Oil, the second-most consumed fuel, rose from 14.5% in 1990 to 32.2% in 2021. Coal use increased from 8.3% to 25.9%, whilst electricity grew from just 3.3% in 1990 to 29.4% in 2021.

Under BAU, oil is projected to have the highest growth rate in final energy consumption, rising by 4.5% per year in 2021–2060. Electricity is projected to grow at 4.2% per year, followed by natural gas at 3.8% and coal at 2.6%. In contrast, other fuels (mainly biomass) are projected to decline by 6.2% per year due to the shift to modern energy sources.

In 2021, oil products accounted for 32.2% of energy, with the share projected to rise to 44.0% by 2060. Electricity is projected to grow from 29.4% to 36.7%, whilst coal will decline from 25.9% to 17.7%. Other fuels (mainly biomass) will fall sharply from 11.2% to 0.2%. Natural gas is expected to increase slightly, from 1.3% to 1.4% (Figure 17.2).

**Figure 17.2. Final Energy Consumption by Fuel,  
Business-as-Usual Scenario, 1990–2060**  
(million tonnes of oil equivalent)



Note: Others are mainly biomass.

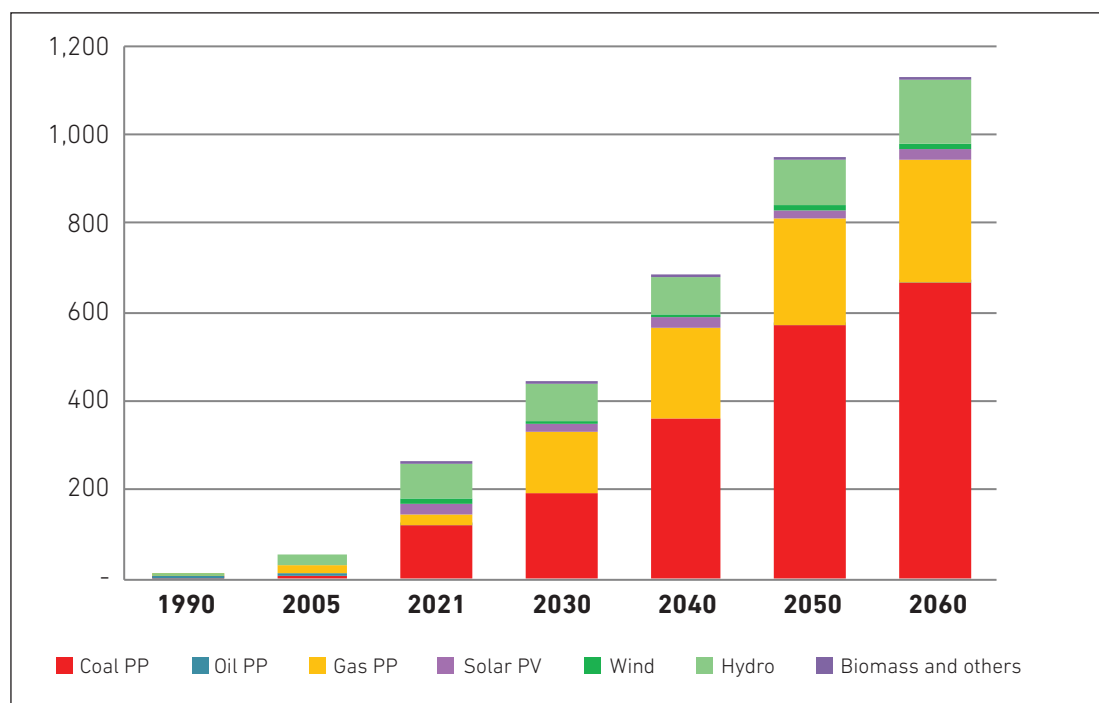
Source: Author.

## 2.2. Power Generation Mix

In 1990–2021, power generation output grew at an average annual rate of 11.5%, increasing 29.6 times from 8.7 TWh to 256.9 TWh. The fastest growth occurred in natural gas power generation (31.1% per year), followed by coal (14.1%), hydropower (9.0%), and oil (0.4%).

Under BAU, power generation is projected to grow by an average of 3.9% per year – 4.4 times higher in 2021–2060 – to meet rising electricity demand. Natural gas is projected to grow fastest at 6.2% per year, followed by coal (4.5%), biomass and imported electricity (4.3%), hydropower (1.6%), wind (0.5%), and solar photovoltaic (PV) (0.1%). Figure 17.3 shows projected power generation output by fuel type under BAU in 1990–2060.

**Figure 17.3. Power Generation by Fuel Type, Business-as-Usual Scenario, 1990–2060**  
(terawatt-hour)



PP = power plant, PV = photovoltaic.

Note: Others include biomass and imported electricity.

Source: Author.

By the end of 2021, coal accounted for 46.3% of total power generation. Hydropower contributed 30.6%, natural gas 10.3%, solar 9.5%, wind 2.6%, oil 0.6%, and others 0.1%.

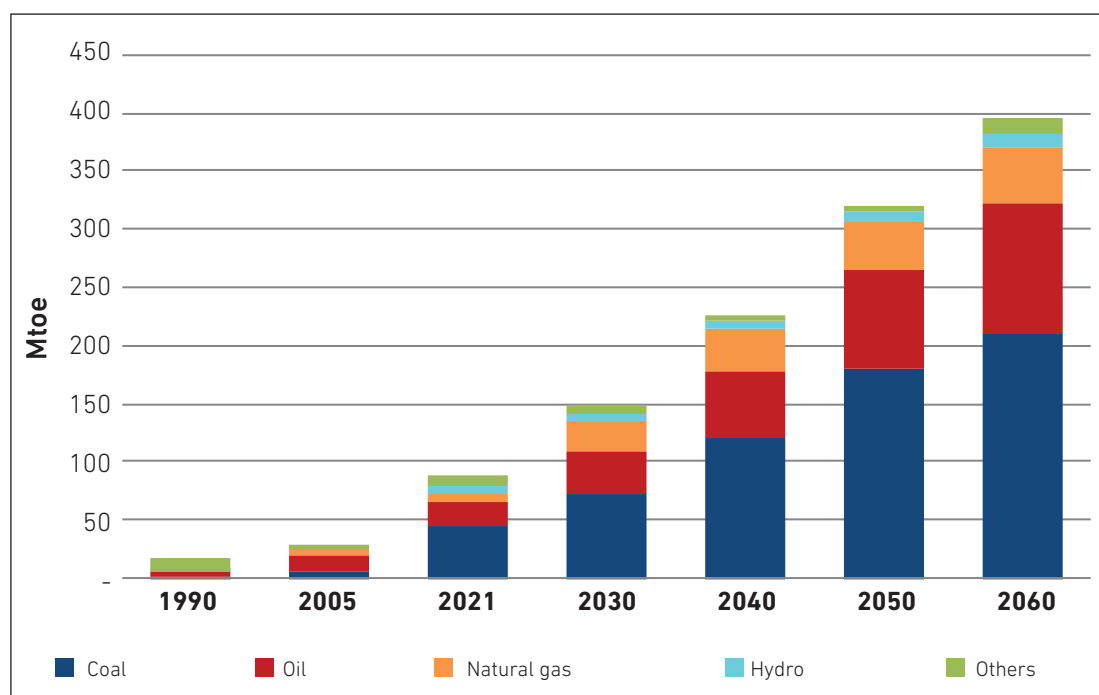
In 2022–2060, coal is projected to remain the primary fuel for power generation, with its share rising to 59.3% by 2060. Natural gas is expected to become the second-largest source, increasing to 24.4%. In contrast, hydropower's share will decline from 30.6% in 2021 to 13.1% in 2060.

## 2.3. Primary Energy Supply

Primary energy supply grew faster than final energy consumption, increasing by 5.3% per year from 17.9 Mtoe in 1990 to 88.0 Mtoe by 2021. During this period, natural gas consumption recorded the highest growth at 27.6% per year, followed by solar and wind (21.7%), coal (10.1%), hydropower (9.0%), and oil (7.0%).

Under BAU, primary energy supply is projected to grow at an annual rate of 3.9%, increasing 4.5 times from 88.0 Mtoe in 2021 to 395.3 Mtoe by 2060. Natural gas is expected to grow fastest at 5.6% per year, followed by oil (4.3%), coal (4.1%), and hydropower (1.8%). Other fuels (mainly biomass) are projected to grow modestly at 0.7% per year. Figure 17.4 shows primary energy supply by source in 1990–2060.

**Figure 17.4. Primary Energy Supply, Business-as-Usual Scenario, 1990–2060**  
(million tonnes of oil equivalent)



Mtoe = million tonnes of oil equivalent.

Note: Others include biomass, solar, wind, and imported electricity.

Source: Author.

In 2021, coal held the largest share of primary energy supply at 50.2%, with a slight increase projected to 53.0% by 2060. Over the same period, oil's share is projected to rise from 25.2% to 28.5%, and natural gas from 6.5% to 12%. This shift is largely driven by a projected decline in hydropower, from 7.7% in 2021 to 3.4% by 2060, and in other sources, from 10.5% to 3.1%.

## 2.4. Carbon Dioxide Emissions

Carbon dioxide (CO<sub>2</sub>) emissions grew at an average annual rate of 9.3%, increasing 15.7 times from 17.2 metric tonnes of carbon dioxide equivalent (Mt-CO<sub>2</sub>) in 1990 to 271.3 Mt-CO<sub>2</sub> in 2021. Coal contributed the most to this rise, with emissions growing at 10.2% per year, followed by oil at 7.3%.

Under BAU, CO<sub>2</sub> emissions are projected to grow at an annual rate of 4.2%, reaching 271.3 Mt-CO<sub>2</sub> by 2060 – five times the 2021 level. Natural gas is expected to see the fastest emissions growth, averaging 5.2% per year, followed by oil at 4.5% and coal at 4.0%.

## 3. Analysis of Low-carbon Energy Transition Results

### 3.1. Concept of Low-carbon Energy Transition Scenario

The energy sector is the largest source of greenhouse gas emissions, accounting for about 65% of total emissions in 2016 (Ministry of Natural Resources and Environment, 2020). A transition to a low-carbon energy system is therefore essential for reducing energy-related CO<sub>2</sub> emissions from fossil fuels and achieving the carbon neutrality target by 2050.

The low-carbon energy transition (LCET) scenario reflects a major structural shift in energy supply and consumption to achieve carbon neutrality by balancing carbon emissions with carbon absorption from the atmosphere. The transition involves investment in low-carbon technologies such as renewable energy, energy efficiency and conservation, and emerging solutions such as hydrogen with carbon capture and storage (CCS).

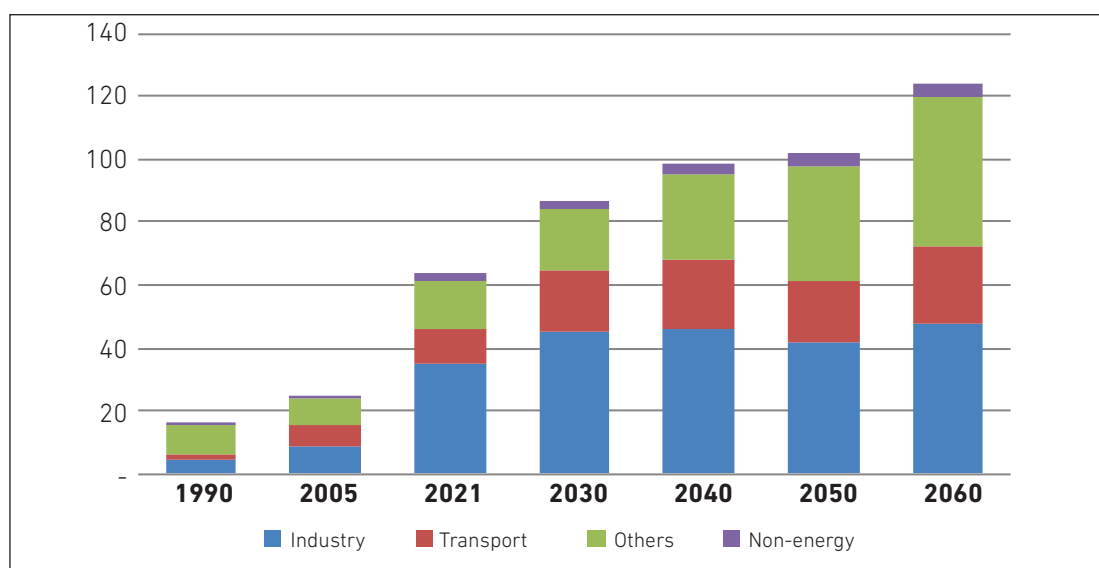
Investments in renewable energy and energy efficiency will be prioritised from 2021 to 2050 and 2060, whilst the adoption of hydrogen and CCS technologies will be considered once they become commercially viable, with implementation expected by 2030. Although investments in low-carbon technologies will initially raise costs due to the high price of emerging solutions, they will ultimately result in energy savings and lower CO<sub>2</sub> emissions.

This study develops LCET and assesses its investment costs and emissions reduction benefits compared with BAU.

## 3.2. Final Energy Consumption

Under LCET, final energy consumption is projected to grow at an average annual rate of 1.7% in 2021–2060. The other sectors (including agriculture, commercial, and residential sectors) are expected to see the fastest growth at 2.9% per year, followed by transport at 2.1% and industry at 0.8%. Non-energy use is projected to grow at 1.9% per year. Figure 16.5 shows final energy consumption by sector in 1990–2060.

**Figure 17.5. Final Energy Consumption by Sector,  
Low-carbon Energy Transition Scenario, 1990–2060**  
(million tonnes of oil equivalent)



Note: Others include the residential and commercial sectors.

Source: Author.

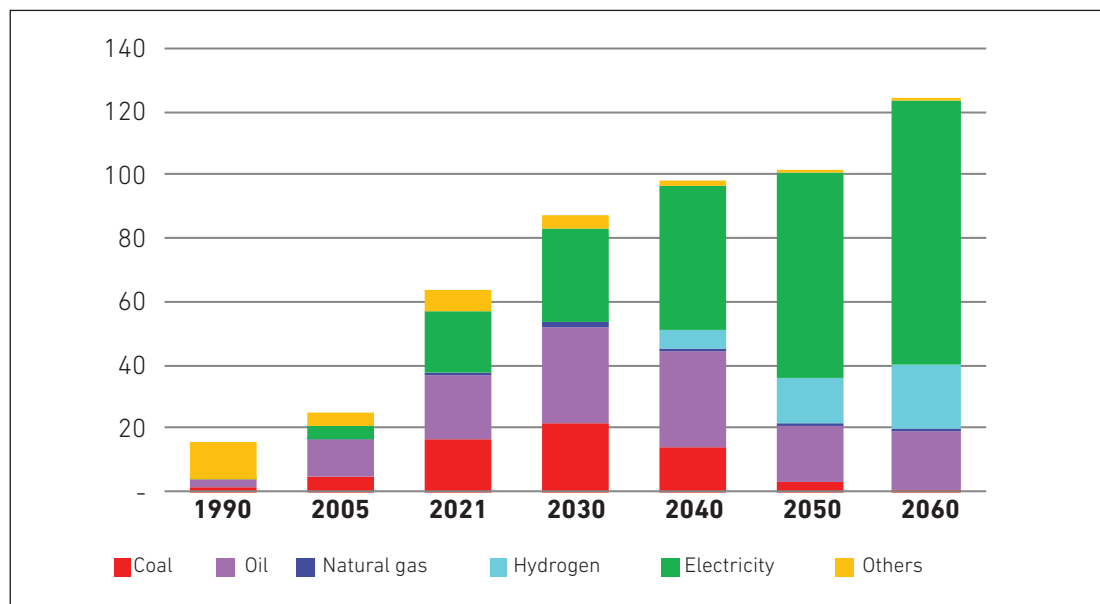
In 2021–2060, industry is expected to remain the largest energy consumer, although its share will decline from 55.5% to 38.5%. Other sectors will become the second-largest, with their shares rising from 24.1% to 38.3%. Transport’s share is projected to increase from 17.1% in 2021 to 22.6% by 2040, then decline slightly to 19.6% by 2060.

Under LCET, electricity is projected to see the fastest growth in final energy consumption, rising by 3.9% per year in 2021–2060, driven by increased transport electrification. Other fuel sources are projected to decline due to a shift from fossil fuels to cleaner alternatives such as hydrogen and electricity. Coal consumption is projected to fall the most, at 7.8% per year, followed by other sectors at 6.2%, natural gas at 1.1%, and oil at 0.3%.

In 2021, oil products accounted for the largest share of energy at 32.2%, but this is projected to decline to 15.0% by 2060. In contrast, electricity demand is projected to rise sharply from 29.4% in 2021 to 67.2% by 2060. By 2060, coal consumption is projected to fall from 25.9% in 2021 to just 0.6% by 2060, followed by other fuels (mainly biomass), decreasing from 11.2% to 0.5%, and natural gas, declining from 1.3% to 0.4% (Figure 17.6).



**Figure 17.6. Final Energy Consumption by Fuel Type,  
Low-carbon Energy Transition, 1990–2060**  
(million tonnes of oil equivalent)



Note: Others are mainly biomass.

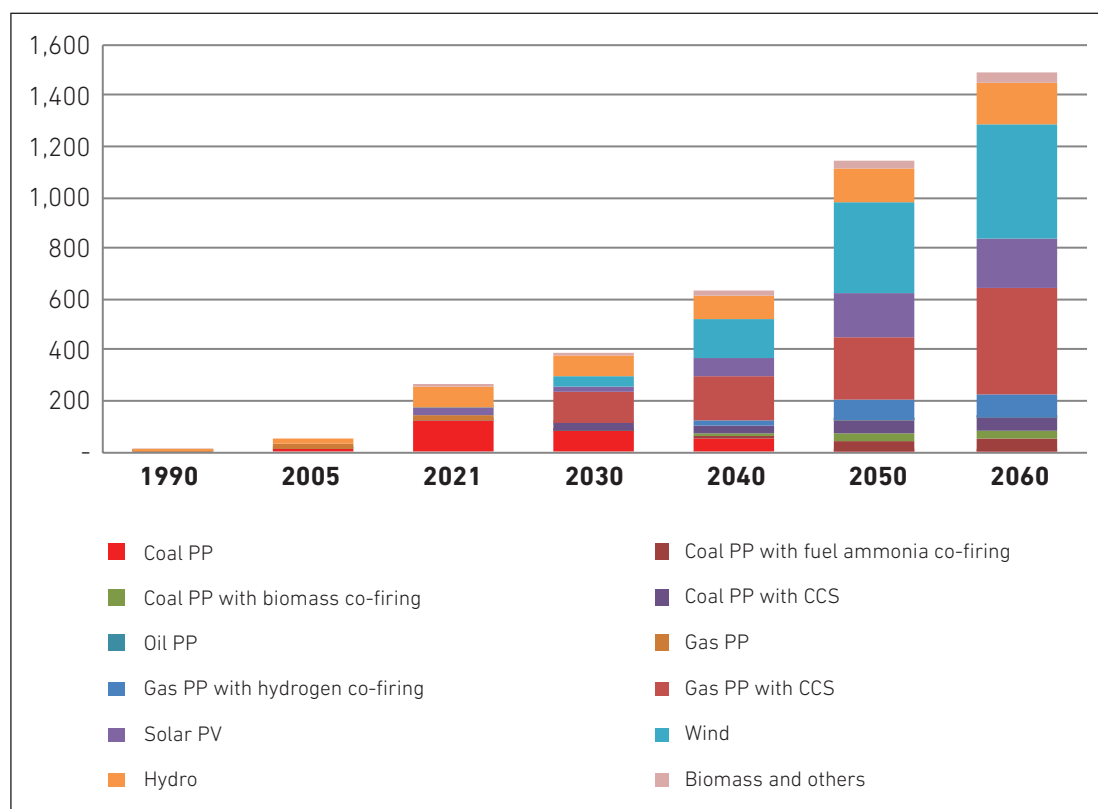
Source: Author.

### 3.3. Power Generation

Under LCET, power generation is projected to grow at an average annual rate of 4.6%, expanding 5.8 times in 2021–2060 to meet electricity demand. Amongst all sources, biomass is projected to record the highest growth at 12.6% per year, followed by wind (11.4%), solar (5.4%), and hydropower (2.0%). The high growth rates of wind and solar reflect their role in replacing coal, projected to decline by 10.9%; natural gas, by 13.7%; and oil, by 4.5%.

Figure 17.7 shows power generation output by fuel type under LCET in 1990–2060.

**Figure 17.7. Power Generation by Fuel Type,  
Low-carbon Energy Transition Scenario, 1990–2060**  
(terawatt-hour)



CCS = carbon capture and storage, PP = power plant, PV photovoltaic.

Note: Others include biomass, wind, solar, and imported electricity.

Source: Author.

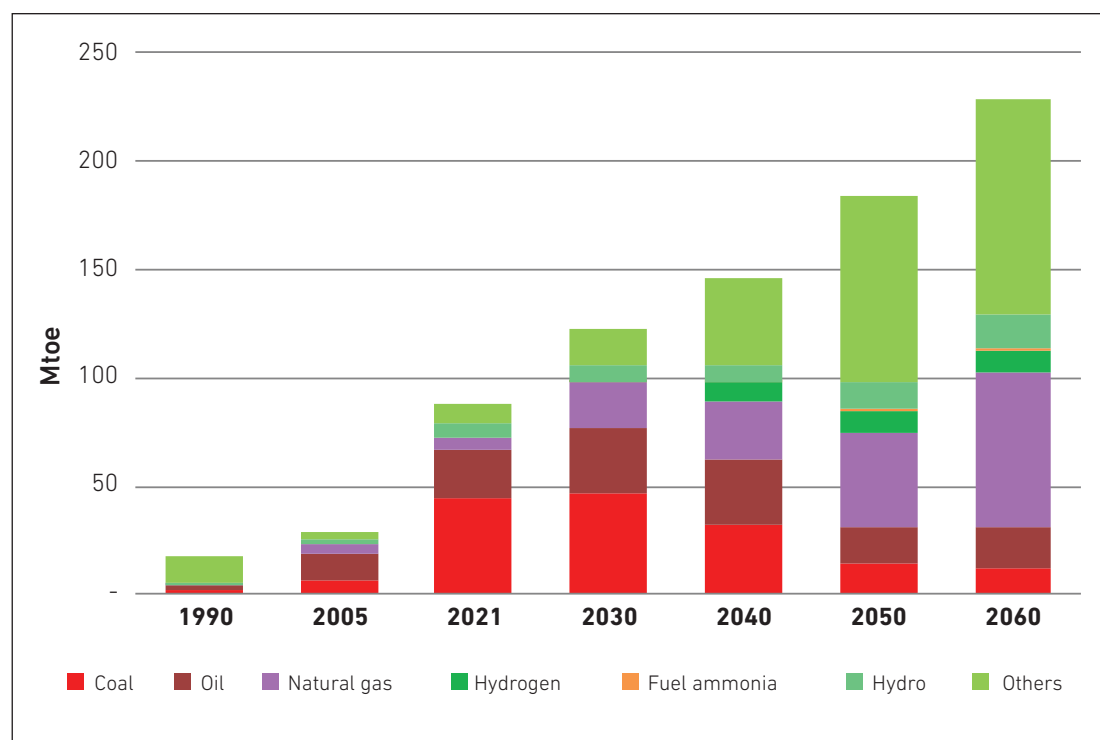
By the end of 2021, the total installed capacity of the power generation system was about 76.4 gigawatts (GW) (EVN, 2022). Most power supply came from coal, which comprised about 44.3% of the total power generation mix. Hydropower contributed about 32.4%, whilst the remaining share comprised renewables (12.2%), natural gas and oil (10.5%), and imported power (0.6%).

In 2021–2060, wind energy is projected to see the most significant transition under LCET, replacing coal in power generation. Its share is expected to rise from 2.6% in 2021 to 30.2% by 2060, making it the dominant energy source. Natural gas is anticipated to undergo the second-largest transition, shifting from 10.3% in 2021 to 28.1% with CCS and 6.4% with hydrogen co-firing by 2060. Solar power ranks third, with its share growing from 9.5% in 2021 to 12.8% by 2060. The significant growth of these sources corresponds to the projected decline of coal, which will fall from 46.3% without CCS in 2021 to 3.5% with CCS, 3.2% with biomass co-firing, and 2.1% with ammonia co-firing by 2060. Hydropower's share in the total power generation mix will decline, from 30.6% in 2021 to 11.4% by 2060.

### 3.4. Primary Energy Supply

Under LCET, primary energy supply is projected to grow at an average annual rate of 2.5%, increasing from 88.0 Mtoe in 2021 to 228.4 Mtoe by 2060. Natural gas is expected to be the fastest-growing energy source, rising 6.7% per year, followed by other fuels (mainly biomass) at 6.3% and hydropower at 2.1%. In contrast, coal and oil consumption are projected to decrease by 3.2% and 0.4% per year, respectively. Figure 17.8 shows primary energy supply by source in 1990–2060.

**Figure 17.8. Primary Energy Supply, Low-carbon Energy Transition Scenario, 1990–2060**  
(million tonnes of oil equivalent)



Source: Author.

Note: Others include biomass, solar, wind, and imported electricity.

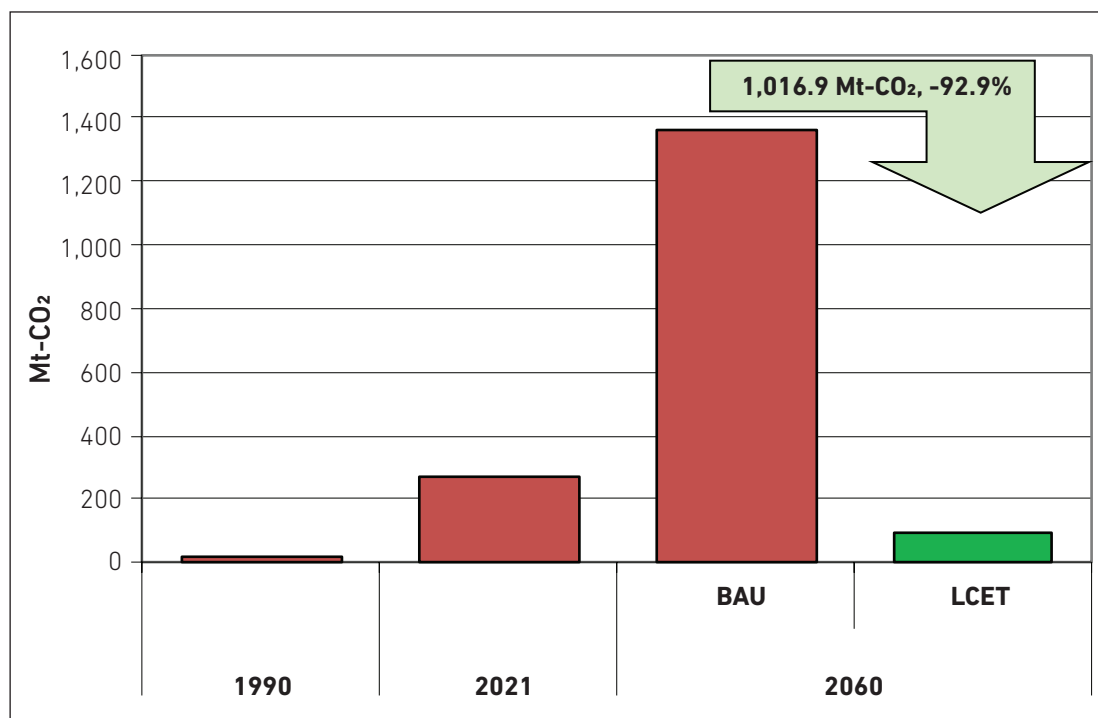
In 2021, other sources held the smallest share of primary energy supply at 10.5%, but this is expected to increase significantly, reaching 43.6% by 2060 – the largest share. Natural gas is projected to rise, from 6.5% in 2021 to 31.3% by 2060. These increases align with a sharp decline in coal's share, from 50.2% to 5.5%, along with reductions in oil (from 25.2% to 8.2%) and hydropower (from 7.7% to 6.6%).

### 3.5. Carbon Dioxide Emissions

Under LCET, total CO<sub>2</sub> emissions are projected to decline at an average annual rate of 2.6%, falling from 271.3 Mt-CO<sub>2</sub> in 2021 to 96.2 Mt-CO<sub>2</sub> by 2060 – below the 2021 target level of 175.1 Mt-CO<sub>2</sub>. In contrast, emissions under BAU are projected to reach 1,360.1 Mt-CO<sub>2</sub> in 2060. This indicates that LCET would achieve a reduction of about 1,016.9 Mt-CO<sub>2</sub> or 92.9%, compared with BAU (Figure 17.9).

The results show that Viet Nam could achieve carbon neutrality by 2050 and sustain it through 2060. Under LCET, CO<sub>2</sub> emissions are projected to reach 96.2 Mt-CO<sub>2</sub> – below the estimated carbon sequestration capacity of forests at 100 Mt-CO<sub>2</sub> by 2060. LCET includes energy efficiency and conservation measures, extensive deployment of variable renewable energy sources such as solar PV and wind, and the adoption of new energy technologies, including hydrogen from the national grid and CCS for coal and gas power plants. Ambitious energy efficiency and conservation implementation, accelerated renewable energy development, and integration of advanced technologies will be crucial to reducing CO<sub>2</sub> emissions across sectors. Whilst the transition poses significant challenges, LCET suggests that, if the transition is effectively managed, the country can achieve and sustain carbon neutrality by 2050 and beyond.

**Figure 17.9. Evolution of Carbon Dioxide Emissions, Business-as-Usual and Low-carbon Energy Transition Scenarios, 1990, 2019, and 2060**



BAU = business as usual, LCET= low-carbon energy transition, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Author.

## 4. Analysis of Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios

To achieve carbon neutrality by 2050 and maintain it through 2060, investment in energy-saving technologies, renewable energy, hydrogen, and CCS under LCET will reduce energy consumption and emissions but will result in higher investment costs compared with BAU. This section presents the cost calculation and comparison between the two scenarios. Given the complexity of scenario-based assessments and the limited availability of input data, this study bases its calculations on available fuel consumption data across sectors. These include fuel inputs for power generation and electricity output from various power generation technologies in the base years 2021 and 2060. The analysis assumes that the difference in energy use between these years reflects improvements in energy efficiency and the energy transition in 2021–2060.

### 4.1. Fuel Cost

The implementation of energy efficiency measures on the demand side and a strong shift from fossil fuels to clean energy – particularly renewable energy and hydrogen in power generation – will significantly reduce primary energy demand under LCET. Based on assumed fuel prices for each energy, fuel costs can be calculated and compared between the two scenarios

#### Fuel Cost Assumptions

Fuel cost assumptions in physical units at constant 2021 prices are presented in Table 17.2.

**Table 17.2. Fuel Cost Assumptions, 2060**

| Fuel     | 2021/2020 |                            | 2060 (2019 constant price, US\$) |                            |
|----------|-----------|----------------------------|----------------------------------|----------------------------|
| Coal     | 80.03     | US\$/tonne                 | 98                               | US\$/tonne                 |
| Oil      | 41        | US\$/bbl                   | 100                              | US\$/bbl                   |
| Gas      | 7.77      | US\$/MMBtu                 | 7.5                              | US\$/MMBtu                 |
| Hydrogen | 0.8       | US\$/Nm <sup>3</sup>       | 0.3                              | US\$/Nm <sup>3</sup>       |
| CCS      |           | US\$/CO <sub>2</sub> tonne | 60                               | US\$/CO <sub>2</sub> tonne |

bbl = barrel, CCS = carbon capture and storage, CO<sub>2</sub> = carbon dioxide, MMBtu = one million British thermal unit,

Nm<sup>3</sup> = normal cubic metre.

Source: Author.

The calculation results show that under BAU, coal demand increases to 165.3 Mtoe in 2021–2060, with an associated cost of US\$26,117.4 million. Oil demand rises to 90.6 Mtoe, costing US\$62,337.3 million, whilst natural gas consumption reaches 41.6 Mtoe at a cost of US\$12,024.8 million. The total incremental cost under BAU amounts to US\$100,479.4 million (Table 17.3).

**Table 17.3. Fuel Costs, Business-as-Usual Scenario, 2021–2060**

| Fuel     | Primary Energy Consumption |       |           | Fuel Cost (US\$ million) |
|----------|----------------------------|-------|-----------|--------------------------|
|          | 2021                       | 2060  | 2060–2021 | 2060–2021                |
| Coal     | 44.2                       | 209.5 | 165.3     | 26,117.4                 |
| Oil      | 22.2                       | 112.8 | 90.6      | 62,337.3                 |
| Gas      | 5.7                        | 47.3  | 41.6      | 12,024.8                 |
| Hydrogen | 0.0                        | 0.0   | 0.0       | 0.0                      |
| Total    | 72.1                       | 369.6 | 297.6     | 100,479.4                |

Source: Author.

Under LCET, coal demand decreases by 31.6 Mtoe by 2060, reducing costs by US\$4,998.6 million. Oil consumption falls by 3.6 Mtoe, lowering costs by US\$2,445.5 million, primarily due to the substitution of coal with renewable energy in power generation and the replacement of oil with clean fuels (electricity and hydrogen) in transport. In contrast, natural gas demand rises by 65.9 Mtoe, increasing costs by US\$19,027.6 million, whilst hydrogen consumption grows by 33.8 Mtoe, adding US\$39,343.5 million. The total additional cost under LCET, relative to 2021, is US\$50,927.1 million (Table 17.4).

**Table 17.4. Fuel Costs, Low-carbon Energy Transition Scenario, 2021–2060**

| Fuel     | Primary Energy Consumption<br>(million tonnes of oil equivalent) |       |           | Fuel Cost (US\$ million) |
|----------|------------------------------------------------------------------|-------|-----------|--------------------------|
|          | 2021                                                             | 2060  | 2060–2021 | 2060–2021                |
| Coal     | 44.2                                                             | 12.5  | –31.6     | –4,998.6                 |
| Oil      | 22.2                                                             | 18.6  | –3.6      | –2,445.5                 |
| Gas      | 5.7                                                              | 71.6  | 65.9      | 19,027.6                 |
| Hydrogen | 0.0                                                              | 33.8  | 33.8      | 39,343.5                 |
| Total    | 72.1                                                             | 136.5 | 64.5      | 50,927.1                 |

Source: Author.

## 4.2. Power Investment Cost

Investment costs for power generation technologies are calculated using input data such as investment cost per unit of capacity, capacity factors, and the corresponding power output of each power plant.

Table 17.5 shows investment costs and capacity factors for power generation technologies in 2021 and 2060.

**Table 17.5. Investment Cost and Capacity Factors, 2021–2060**

| Technology                | Investment Cost (US\$/kilowatt) |       | Capacity Factors (%) |      |
|---------------------------|---------------------------------|-------|----------------------|------|
|                           | 2021                            | 2060  | 2021                 | 2060 |
| Coal PP                   | 1,500                           | 1,525 | 75                   | 80   |
| Coal PP co-firing biomass | -                               | 1,600 | -                    | 80   |
| Coal PP co-firing ammonia | -                               | 1,600 | -                    | 80   |
| Coal PP with CCS          | -                               | 1,525 | -                    | 80   |
| Oil PP                    | 600                             | 600   | 75                   | 80   |
| Gas PP                    | 700                             | 700   | 75                   | 80   |
| Gas PP co-firing hydrogen | -                               | 800   | -                    | 80   |
| Gas PP with CCS           |                                 | 700   |                      | 80   |
| Hydro                     | 2,000                           | 2,223 | 50                   | 40   |
| Solar PV                  | 1,600                           | 307   | 17                   | 17   |
| Wind                      | 1,600                           | 1,235 | 40                   | 40   |
| Biomass                   | 2,000                           | 3,019 | 50                   | 70   |

CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

Source: Author.

Using data on investment cost per unit of capacity, capacity factors, and the difference in power output in 2060 and 2021, the additional capacity required in 2021–2060 can be estimated. These figures form the basis for calculating power generation investment costs under BAU and LCET (Table 17.6).

**Table 17.6. Power Generation Investment Cost,  
Business-as-Usual Scenario, 2021–2060**

| Technology                          | Generation Output (terawatt-hour) |                |              | Additional Capacity (megawatt) | Cost (US\$ million) |
|-------------------------------------|-----------------------------------|----------------|--------------|--------------------------------|---------------------|
|                                     | 2021                              | 2060           | 2060–2021    | 2021–2060                      | 2021–2060           |
| Coal PP                             | 119.0                             | 668.1          | 549.1        | 78,348.2                       | 119,481.1           |
| Coal PP with biomass co-firing      | 0.0                               | 0.0            | 0.0          | 0.0                            | 0.0                 |
| Coal PP with fuel ammonia co-firing | 0.0                               | 0.0            | 0.0          | 0.0                            | 0.0                 |
| Coal PP with CCS                    | 0.0                               | 0.0            | 0.0          | 0.0                            | 0.0                 |
| Oil PP                              | 1.5                               | 0.3            | –1.2         | 0.0                            | 0.0                 |
| Gas PP                              | 26.4                              | 275.0          | 248.6        | 35,474.9                       | 24,832.4            |
| Gas PP with hydrogen co-firing      | 0.0                               | 0.0            | 0.0          | 0.0                            | 0.0                 |
| Gas PP with CCS                     | 0.0                               | 0.0            | 0.0          | 0.0                            | 0.0                 |
| Solar PV                            | 24.3                              | 25.7           | 1.3          | 896.5                          | 275.2               |
| Wind                                | 6.8                               | 8.3            | 1.5          | 424.8                          | 524.6               |
| Hydro                               | 78.6                              | 147.9          | 69.3         | 19,789.4                       | 43,991.9            |
| Biomass and others                  | 0.3                               | 1.7            | 1.4          | 222.0                          | 670.3               |
| <b>Total</b>                        | <b>256.9</b>                      | <b>1,126.9</b> | <b>870.0</b> | <b>135,155.8</b>               | <b>189,775.5</b>    |

CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

Source: Author.

Under BAU, power coal-fired power output in 2060 increases significantly by 549.1 TWh compared with 2021, requiring an additional 78,348.2 MW of capacity and an investment of US\$119,481.1 million. Coal records the highest increase in power output, followed by gas at 248.6 TWh, requiring 35,474.9 MW of capacity and an investment of US\$24,832.4 million. Hydropower rises by 69.3 TWh, adding 19,789.4 MW at a cost of US\$43,991.9 million. Renewable power sources (solar, wind, and biomass) see only a modest increase of 4.2 TWh, equivalent to 1,543.3 MW of additional capacity and an investment of US\$1,470.1 million.

Under LCET, a major shift from coal to clean energy sources – including renewable energy and emerging technologies such as hydrogen, biomass, ammonia co-firing, and CCS – results in substantial increases in power generation from these sources. Amongst renewable sources, wind power sees the largest increase, rising by 442.8 TWh, requiring 126,382.8 MW of additional capacity and an investment of US\$156,082.7 million. Solar power follows with a 166.3 TWh increase, requiring 111,653.8 MW and US\$34,277.7 million. Biomass power grows by 32.5 TWh, requiring 5,292.8 MW and US\$15,979.1 million.



Amongst other new technologies, gas power plants with CCS show the largest increase, generating an additional 417.1 TWh, requiring 59,517.0 MW and an investment of US\$41,661.9. Power generation from coal power plants with CCS increases by 51.6 TWh, requiring 7,366.3 MW and US\$11,233.7 million. Power generation from gas power plants with hydrogen co-firing increases by 94.5 TWh, requiring 13,491.5 MW and US\$10,793.2 million. Power generation from coal power plants with biomass co-firing increases by 47.3 TWh, requiring 6,745.7 MW and US\$10,793.2 million. Coal power plants with ammonia co-firing generate an additional 31.5 TWh, requiring 4,497.2 MW and US\$7,195.4 million. Hydropower increases by 91.2 TWh, requiring 26,023.6 MW and US\$57,850.4 million (Table 17.7).

**Table 17.7. Power Generation Investment Costs, Low-carbon Energy Transition Scenario, 2021–2060**

| Technology                          | Generation Outputs (terawatt-hour) |                |                | Additional Capacity | Costs            |
|-------------------------------------|------------------------------------|----------------|----------------|---------------------|------------------|
|                                     | 2021                               | 2060           | 2060–2021      | 2021–2060           | 2021–2060        |
| Coal PP                             | 119.0                              | 1.3            | –117.7         | 0.0                 | 0.0              |
| Coal PP with biomass co-firing      | 0.0                                | 47.3           | 47.3           | 6,745.7             | 10,793.2         |
| Coal PP with fuel ammonia co-firing | 0.0                                | 31.5           | 31.5           | 4,497.2             | 7,195.4          |
| Coal PP with CCS                    | 0.0                                | 51.6           | 51.6           | 7,366.3             | 11,233.7         |
| Oil PP                              | 1.5                                | 0.2            | –1.2           | 0.0                 | 0.0              |
| Gas PP                              | 26.4                               | 0.1            | –26.3          | 0.0                 | 0.0              |
| Gas PP with hydrogen co-firing      | 0.0                                | 94.5           | 94.5           | 13,491.5            | 10,793.2         |
| Gas PP with CCS                     | 0.0                                | 417.1          | 417.1          | 59,517.0            | 41,661.9         |
| Solar PV                            | 24.3                               | 190.6          | 166.3          | 111,653.8           | 34,277.7         |
| Wind                                | 6.8                                | 449.6          | 442.8          | 126,382.8           | 156,082.7        |
| Hydro                               | 78.6                               | 169.7          | 91.2           | 26,023.6            | 57,850.4         |
| Biomass and others                  | 0.3                                | 32.8           | 32.5           | 5,292.8             | 15,979.1         |
| <b>Total</b>                        | <b>256.9</b>                       | <b>1,486.5</b> | <b>1,229.6</b> | <b>360,970.7</b>    | <b>345,867.4</b> |

CCS = carbon capture and storage, PP = power plant, PV = photovoltaic.

Source: Author.

### 4.3. Carbon Capture and Storage Cost

CCS costs are calculated for fossil fuel-based power generation, including coal and natural gas, with CCS equipment installed. Assuming a 90% CO<sub>2</sub> capture rate and an average cost of US\$60 per tonne of CO<sub>2</sub>, the total CCS cost is estimated at US\$7,529.4 million – US\$6,593.7 million for gas power and US\$935.7 million for coal power.

## 4.4. Total Cost Comparison

Based on the above calculations, Table 17.8 presents the cost comparison between BAU and LCET.

**Table 17.8. Energy Cost Comparison Between Business-as-Usual and Low-carbon Energy Transition Scenarios, 2060 (US\$ million)**

| Category           | BAU     | LCET    | LCET vs. BAU |
|--------------------|---------|---------|--------------|
| Fuel cost          | 100,479 | 50,927  | –49,552      |
| Power capital cost | 189,776 | 345,867 | 156,092      |
| CCS                | 0       | 7,529   | 7,529        |
| Total              | 290,255 | 404,323 | 114,069      |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Author.

Table 17.8 shows that investing in energy efficiency and conservation measures and clean energy sources – such as renewable energy and hydrogen – to replace coal in power generation and oil products in transport under LCET results in power capital costs that are US\$156,092 million higher than under BAU. However, this transition reduces fuel costs by US\$49,552 million. Although investment in renewable energy and hydrogen is substantial, it delivers significant benefits in reducing CO<sub>2</sub> emissions. If carbon pricing is considered, overall costs under LCET could be significantly reduced.

The cost of CCS under LCET is estimated at US\$7,529 million. As a result, the total cost under LCET is US\$114,069 million higher than under BAU.

## 5. Conclusions and Policy Recommendations

### 5.1. Conclusions

- The transition in energy use and power generation is crucial for achieving carbon neutrality by 2050 and sustaining it through 2060. Increasing investment in the energy transition – especially in renewable energy and hydrogen – will lower fossil fuel consumption costs, such as those for coal and oil products, and reduce CO<sub>2</sub> emissions.
- The total cost under LCET is US\$114,069 million higher than under BAU, mainly due to the greater investment required for renewable energy sources. However, if carbon pricing is factored in, overall costs under LCET could be significantly reduced.
- The additional investment cost for CCS is estimated at US\$7,529 million. As CCS deployment is expected to start in 2030 and expand significantly by 2050 and 2060, a reduction in CCS technology costs by 2060 could lower overall investment requirements.

### 5.2. Policy Recommendations

To achieve net-zero emissions from 2050 through 2060, Viet Nam must rapidly reduce its dependence on fossil fuels – especially coal-fired power – and switch to renewable energy sources and low-emission technologies such as CCS and hydrogen. Whilst the costs of solar and wind energy have declined significantly, their reliability remains dependent on weather conditions and time of day. CCS and hydrogen technologies are still at an early stage and require substantial financial investment. Promoting energy efficiency and conservation measures will therefore be essential in the coming years to reduce overall energy consumption, especially from fossil fuels. To support this transition, the government should do the following:

- Strengthen standards and technical regulations for energy consumption across sectors and improve the implementation of energy efficiency measures.
- Develop policies to promote energy service companies, supporting the assessment of energy efficiency potential and attracting external investment in energy efficiency and conservation measures.
- Promote the adoption of energy-efficient solutions and accelerate the transition to clean energy and electrification across industry, transport, services, and trade.

Coal-fired power plants play a significant role in meeting growing electricity demand. However, in pursuit of net-zero emissions, the country is shifting from coal to natural gas for power generation and exploring options for importing natural gas or liquefied natural gas (LNG). Developing transparent energy markets in Asia will help strengthen Viet Nam's LNG supply security.

Petroleum product demand is expected to increase in the coming years. Although Viet Nam is a net exporter of crude oil, it depends on petroleum product imports due to limited domestic refinery capacity. Whilst efforts are underway to expand this capacity, imports will remain necessary until at least 2040. To reduce dependence on energy imports, Viet Nam is implementing policies to promote fuel switching from oil to electricity and hydrogen, especially in road transport.

As renewable energy sources expand rapidly, ensuring a safe and stable electricity supply system is crucial. Developing a well-balanced power generation portfolio that maximises hydropower resources whilst integrating natural gas power as a key energy source is essential. With the growing share of renewables in the energy mix, investment in other clean energy sources, including nuclear power, should be considered to stabilise and secure electricity production and supply.

Transitioning to net-zero emissions from 2050 through 2060 presents major challenges, especially in financing, technology, institutional capacity, and the regulatory environment. To meet these challenges, the following policy recommendations are proposed:

- Formulate a renewable energy law to support the development of the renewable energy manufacturing industry, renewable energy deployment, electricity transmission and storage, green hydrogen production and use, amongst others.
- Develop policies to encourage research and development collaboration between public and private sector entities, focusing on technological innovation in solar and wind power, energy storage, energy efficiency, green hydrogen and its derivatives, CCS, and information technology applications in the power sector.
- Establish a long-term legal framework to support the shift from fossil fuels to low-emission energy sources and achieve net-zero emissions.
- Complete the legal framework for green credit, including mechanisms, policies, and enforcement measures to support credit growth for projects related to green investment, climate change mitigation, and energy transition initiatives.

## References

General Statistics Office, Government of Viet Nam (2011), *Viet Nam's Population Forecasts 2009–2049*. Ha Noi.

General Statistics Office, Government of Viet Nam (2020), *Statistical Yearbook of Viet Nam*. Ha Noi.

Government of Viet Nam (2017), Decision No. 60/QĐ-TTg dated 16 January 2017 of the Prime Minister for Approving the Development Plan of the Gas Industry of Vietnam by 2025, with Vision to 2035. Ha Noi.

Government of Viet Nam (2019), Decision 280/QĐ-TTg dated 13 March 2019 of the Prime Minister on Approval for National Program for Thrifty and Efficient Use of Energy for the Period of 2019–2030. Ha Noi.

Government of Viet Nam (2022a), Decision No. 876/QĐ-TTg dated 22 July 2022 of the Prime Minister on Approving the Action Plan on Green Energy Transition and Mitigation of Carbon Dioxide and Methane Emissions from Transportation. Ha Noi.

Government of Viet Nam (2022b), Decision No. 896/QĐ-TTg dated 26 July 2022 of the Prime Minister on Approving the National Strategy for Climate Change until 2050. Ha Noi.

Government of Viet Nam (2023), Decision No. 500/QĐ-TTg dated 15 May 2023 of the Prime Minister on Approving the National Power Development Plan for the Period 2021–2030, with Vision to 2050. Ha Noi.

Ministry of Industry and Trade, Government of Viet Nam (2022), Decision No. 626/QĐ-TTg dated 05 April 2022 on Approving the Action Plan of Ministry of Industry and Trade for Implementing Viet Nam's Commitments at COP26. Ha Noi.

Ministry of Natural Resources and Environment, Government of Viet Nam (2020), *Viet Nam – Report on National GHG Inventory for 2016*. Ha Noi.

Viet Nam Electricity (2022), *Annual Report, 2022*. Ha Noi.

# Chapter 18

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## United States Country Report<sup>1</sup>

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<sup>1</sup> Unless otherwise cited, all data in this report can be attributed to the IEEJ's economic modelling results for the United States, which are included in full as an appendix to this publication.

# 1. Introduction

In 2021, the United States (US) submitted a revised Nationally Determined Contribution, pledging to reduce its greenhouse gas emissions by 50%–52% from 2005 levels by 2030 and to reach net-zero greenhouse gas emissions by 2050. These targets – a significant increase over earlier pledges – were envisioned as reflecting not only the urgency of climate action, but also several seismic shifts in US energy outlooks in recent years (US Government, 2021). To wit, the country's overall demand for energy is lower today than it was in 2005. During this same period, the country has also seen a surge in domestic production of oil, natural gas, and wind and solar energy – something that has upended otherwise expected outlooks for how the US might be able to meet its demands for energy. The combined effect of these trends, to date, has been to bolster the shift towards a cleaner energy mix. This includes by making it newly viable and more attractive to switch from coal to lower- and zero-carbon energy inputs in the power sector. Yet, for some, anxieties linger that the gap between the country's 2021 pledges and current pace of decarbonisation is still 'too' large – and that efforts to close this gap, if not done well, could undermine US energy and economic security.

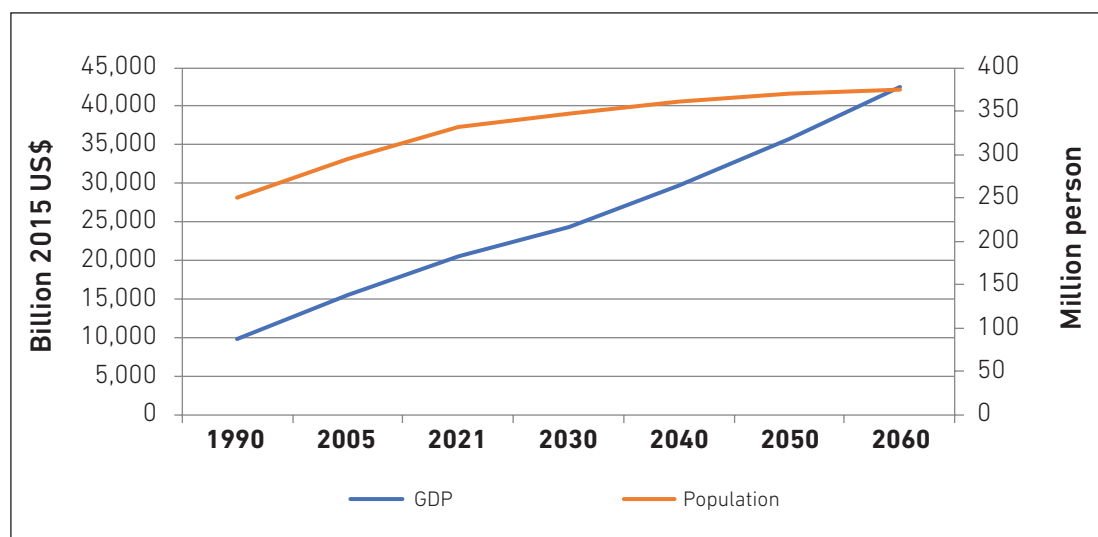
This chapter thus draws on modelling produced by the Institute of Energy Economics, Japan (IEEJ) to explore the question of how the US might be able to reach net-zero carbon dioxide (CO<sub>2</sub>) emissions by mid-century – and how much of a departure from 'business as usual' that might that be. It begins by detailing some of the key assumptions of the IEEJ's model before diving into its results. Next, it compares select costs in the model's different scenarios, as a means of highlighting shared as well as divergent capital requirements in these different futures. The chapter then concludes by offering several implications and recommendations for public policy.

## 2. Macro Assumptions

### 2.1. Macroeconomic Conditions

Over this study's outlook period of 2021–2060, the IEEJ's model assumes that the US' gross domestic product (GDP) and population count will continue to grow, although at markedly different rates – resulting in a trend of an overall rising per capita GDP (Figure 18.1). Whilst US birth rates are projected to remain below replacement levels during the outlook window, the population continues to grow overall due to expectations for sustained immigration and improved life expectancies. However, at 0.3% per year, the growth rate for the outlook period is still at a notably slower pace than the 0.9% per year of the 1990–2021 period.

**Figure 18.1. Gross Domestic Product and Population, 1990–2060**



GDP = gross domestic product.

Source: Authors' calculations.

Between 1990 and 2021, the United States' GDP grew at an average annual rate of 2.4%. Despite significant disruption during the 2007–2008 global economic crisis and once again during the 2020–2021 novel coronavirus disease (COVID-19) crisis, the US economy has generally been able to realise steady (albeit relatively modest) growth.<sup>2</sup> Hence, the IEEJ's model projects that the GDP will grow over the outlook period, although at a slightly lower annual average rate of 1.9% per year. This estimate aligns with expectations of continued efficiency and productivity gains yet increasingly modest population growth. It also assumes continued US leadership on innovation and attention to boosting industrial competitiveness as (amongst other things) supporting US export potential.

## 2.2. Distinctive Features of Key Scenarios

With the above conditions set, the IEEJ's model looks at US energy outlooks and savings potential under two different scenarios: a business-as-usual (BAU) scenario and a low-carbon energy transition (LCET) scenario. In the BAU scenario, numerous longstanding market trends are expected to continue to hold true. Such trends include a weakening domestic outlook for coal and nuclear energy, given longstanding unfavourable economics and social license in the United States for these two inputs when compared with that for non-hydro renewables and natural gas. Coal in particular is expected to undergo a dramatic decline, given the growing market competitiveness of alternative generation options as well as the expected retirement of a number of older, less efficient coal-fired plants during the outlook period. Alongside this, an ongoing buildout of new and

<sup>2</sup> For more on this, see Gillispie (2022).



more flexible US energy infrastructure – already underway of this writing in 2024 – is expected to continue to enable more efficient energy consumption as well as greater utilisation of variable renewable energy supplies. Meanwhile, despite expectations for an uptick in the use of alternative fuels and in the pace of electric vehicle adoption, the US transport sector is nonetheless anticipated to remain heavily reliant on oil in this scenario. This is due (at least in part) to relatively more modest means and incentives for sparking large-scale input switching when compared with the tools available within the power sector.

In contrast, the LCET scenario models what shifts (if any) might enable a country to reach net-zero CO<sub>2</sub> emissions on an annual basis by 2050. In the case of the United States, such shifts include the adoption of specific new incentives, tools, and approaches that are more aggressive in prioritising decarbonisation than the BAU scenario, but that nonetheless remain technically feasible and at least potentially socially acceptable.<sup>3</sup> Here, the United States' Pathways to Net-Zero Greenhouse Gas Emissions by 2050 (US Department of State and Executive Office of the President, 2021) serves an important basis for such scenario modelling. This chapter's authors are also mindful that whilst this policy document details multiple pathways for how the US might fully decarbonise its economy by mid-century, some are more closely aligned than others with the expressed priorities and interests of the Trump administration. To that end, the authors have also given elevated consideration to the decarbonisation pathways that feature a robust role for nuclear energy in meeting the country's energy needs; an outcome that both the past (Biden) and current administration have expressed an interest in championing. However, in some cases, divergences between the findings of official US modelling and the IEEJ's modelling do occur, given modest differences in their methodologies (including assumptions about likely economic conditions and technological advances between 2021 and 2050). The IEEJ's model also extends its projections of the US' energy outlook and energy-savings potential up to 2060, which is currently a decade beyond the period covered in official US modelling.

## 3. Outlook Results

### 3.1. Business-as-Usual Scenario

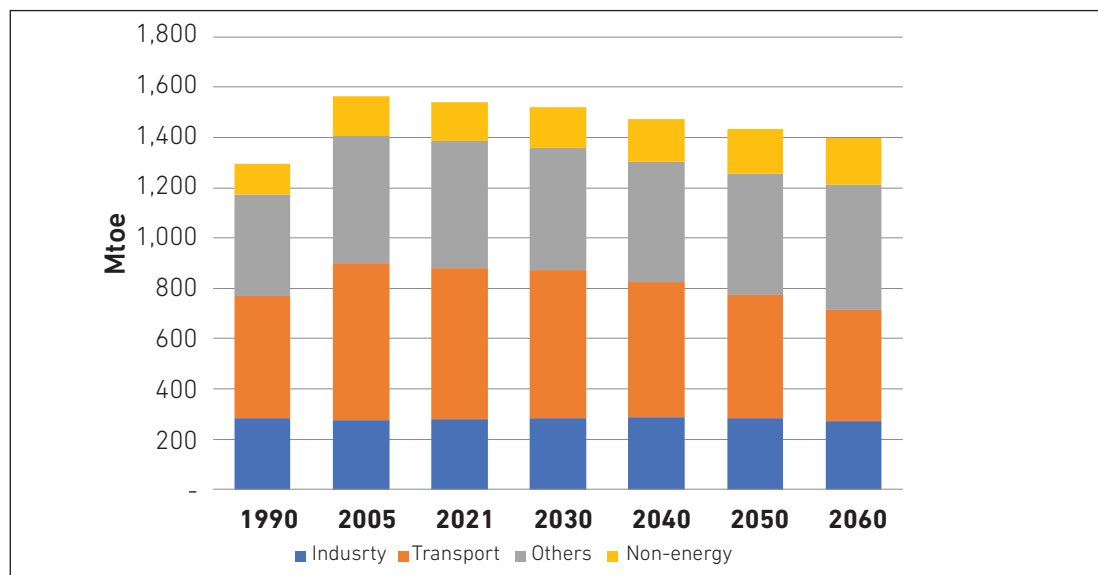
#### Final Energy Consumption

Under the BAU scenario, total final energy consumption is anticipated to decline between 2021 and 2060, at an average annual rate of decrease of 0.2% (Figure 18.2). The main contributor to this decline is changes in the US transport sector, as an otherwise expected growth linked to a modest rise in vehicle ownership and utilisation is more than offset by an increased switch to cleaner, more efficient vehicles as well as other structural changes within the sector. However, an otherwise steeper decline in total US energy consumption is offset by a rise in non-energy sector consumption, which is expected to see average annual growth of 0.5%. Meanwhile, both the industry and others sector are expected to see relatively flat growth during the outlook period.

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<sup>3</sup> E.g. more aggressive dates for phasing out combustion engines, but not the suggestion of eliminating all motorised vehicles.

**Figure 18.2. Final Energy Consumption by Sector, 1990–2060, Business-as-Usual Scenario**

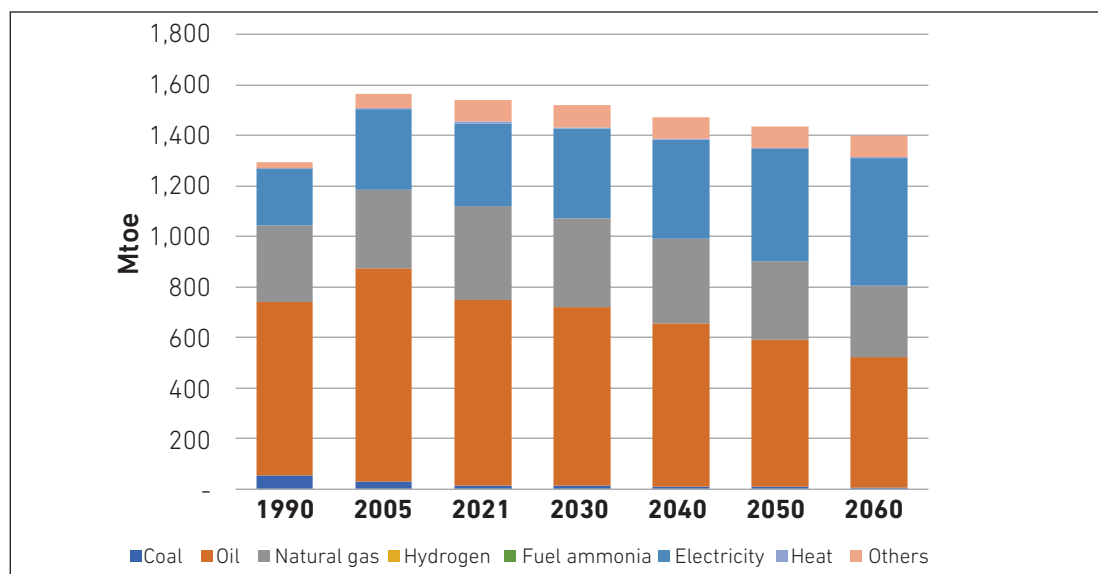


Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculations.

**Figure 18.3. Final Energy Consumption by Fuel Type, 1990–2060, Business-as-Usual Scenario**



Mtoe = million tonnes of oil equivalent.

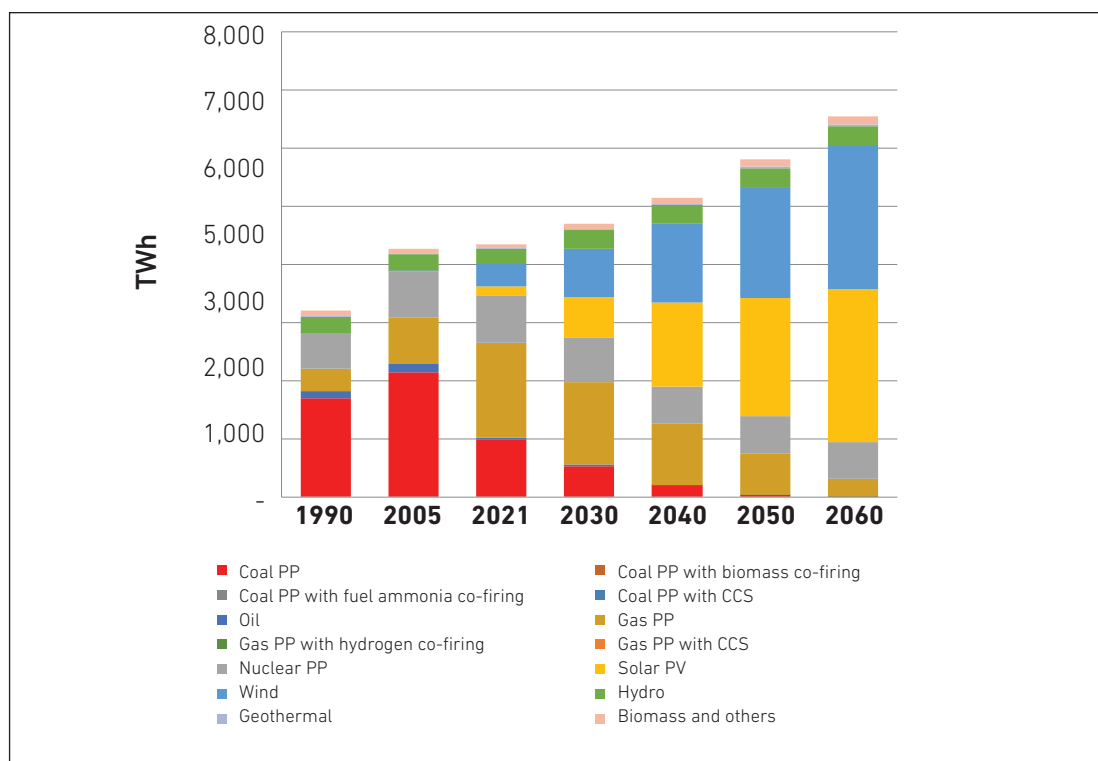
Note: 'Others' includes all kinds of biomass – e.g. biofuel, charcoal, and biogas – as well as heat.

Source: Authors' calculations.

In line with these shifts, oil consumption declines and, by 2060, it is anticipated to fall to 516.66 million tonnes of oil equivalent (Mtoe) (29.8% below levels in 2021). Coal consumption also declines and does so consistently throughout the entire 2021–2060 period. In contrast, electricity consumption grows sharply (from 330.03 Mtoe in 2021 to 503.42 Mtoe in 2060), which (amongst other things) reflects headwinds in newly electrifying various sectors of the US economy (e.g. transport). Meanwhile – and in a notable departure from recent trends – US consumption of natural gas is also expected to decline throughout the outlook period, as the fuel faces growing competition from other energy sources in multiple end-use sectors. Lastly, under the BAU scenario neither hydrogen nor fuel ammonia are projected to account for any of the US’ total final energy consumption in 2060 (Figure 18.3).

## Power Generation

**Figure 18.4. Power Generation, 1990–2060, Business-as-Usual Scenario**



CCS = carbon capture and storage, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

Source: Authors' calculations.

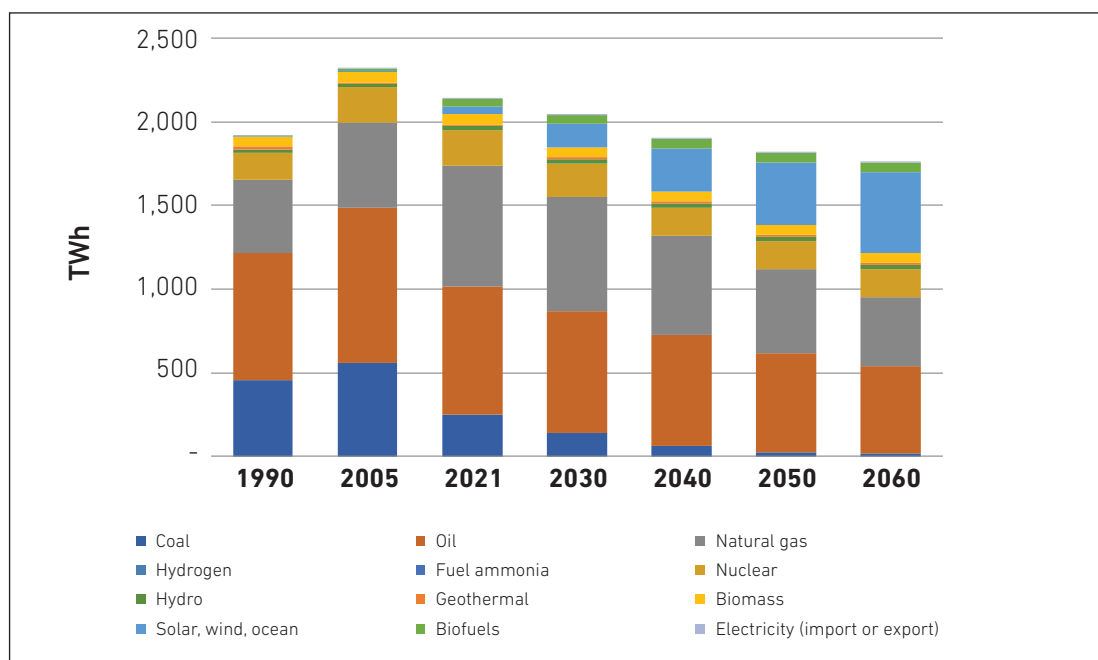
Electricity generation in the United States, under the BAU scenario, is projected to increase over the outlook period. Generation output increases from 4,354.06 terawatt-hour (TWh) to 6,549.44 TWh between 2021 and 2060, for an average annual growth rate of 1.1%. The retirement of older (typically less efficient) power plants as well as ongoing technological improvements promoting more efficient consumption are assumed to play important roles in shaping this outlook, alongside

broader market and policy forces that incentivise input switching. In line with these trends, coal declines steadily – at 10.3% a year – and by 2060 it is anticipated to account for only 0.2% of all US power generation (down from 22.8% in 2021). Natural gas also declines sharply, such that by 2060, it represents only 4.5% of the overall mix (versus 37.5% in 2021). Nuclear also declines as a share of the US power generation mix, with a sizeable drop in output expected between 2021 and 2040. In contrast, large average annual growth rates are seen in non-hydro renewables, most prominently solar and wind – such that by 2060, 78% of US power generation output could come from just these two zero-carbon energy sources (Figure 18.4).

## Primary Energy Supply

Under the BAU scenario, total primary energy supply is anticipated to decline from 2,138.97 Mtoe in 2021 to 1,763.41 Mtoe in 2060, for an average annual rate of decrease of 0.5%. The fastest rates of decline are seen in fossil fuels, with coal anticipated to decline at a rate of 6.4% per year during this period; natural gas at 1.4% per year; and oil at 1% per year. Nuclear also declines, although at a relatively more modest 0.6% per year. In contrast, virtually all forms of renewable energy see absolute growth, with wind, solar, and ocean energy collectively experiencing the largest growth in consumption in this period (at 6% per year), followed by geothermal (at 1.2% per year). Even so, fossil fuels are still anticipated to account for over half of the US's total primary energy supply in 2060, with oil accounting for 29.4% of the total and natural gas for 23.4% of the total (Figure 18.5).

**Figure 18.5. Primary Energy Supply, 1990–2060, Business-as-Usual Scenario**



Mtoe = million tonnes of oil equivalent.

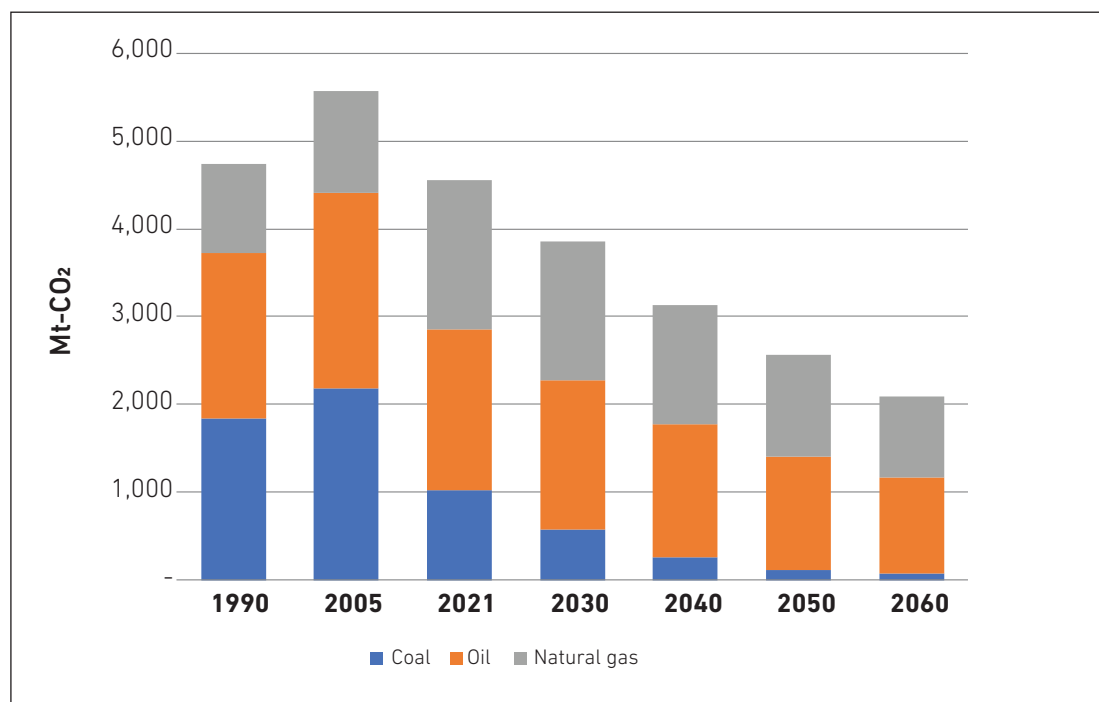
Source: Authors' calculations.

## 4. Carbon Dioxide Emissions

Under the BAU scenario, US CO<sub>2</sub> emissions from energy consumption are anticipated to decline to an annual average rate of decrease of 2% – going from 4,549.3 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2021 to 2,092.1 Mt-CO<sub>2</sub> in 2060. This level of decline reflects (amongst other things) the aforementioned decline in total US energy consumption; continued switching to lower- (and, increasingly, zero-) carbon inputs in the power sector; and greater electrification of other end-use sectors. However, it also suggests that although the US is likely to continue to make steady progress in decarbonising its economy, under the BAU scenario the country is not on track to meet its emissions reduction targets for 2030, much less those for 2050.

Figure 18.6 offers a breakdown of lingering US energy-linked CO<sub>2</sub> emissions by fuel type over time in this scenario. It suggests, amongst other things, that the largest single source of these emissions is linked to US consumption of oil, followed by natural gas. Meanwhile, CO<sub>2</sub> emissions from coal are expected to fall sharply in both absolute and relative terms. Even so, these emissions are not expected to reach zero by mid-century.

**Figure 18.6. CO<sub>2</sub> Emissions by Fuel Type, 1990–2060, Business-as-Usual Scenario**



Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Authors' calculations.

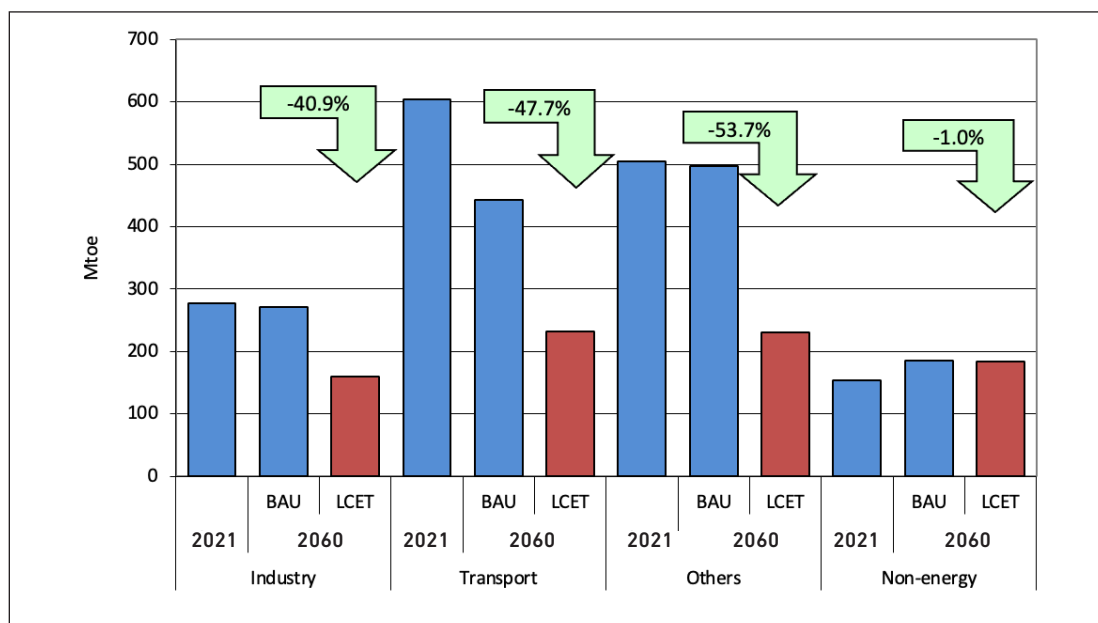
## 4.1. Low-carbon Energy Transition Scenario

### Final Energy Consumption

Under the LCET scenario, efforts in several areas – including to accelerate the deployment of technologies that enable more efficient consumption of energy – contribute to offsetting the otherwise expected growth in demand for energy. To that end, the LCET scenario sees US final energy consumption falling from 1,539.73 Mtoe to 806.10 Mtoe during the 2021–2060 period (Figure 18.7). This suggests a savings in 2060 that is an additional 591.2 Mtoe (or 42.3%) lower than in the BAU scenario. Residential and commercial (others) is now 267.4 Mtoe (53.7%) lower than the BAU scenario, whilst transport also realises a significant additional saving of 211.5 Mtoe (47.7%). Although the saving under the LCET scenario relative to the BAU scenario is less pronounced for industry, it is nonetheless notable at an additional decline of 110.8 Mtoe (40.9%).

Alongside these changes are also shifts in the composition of the US' final energy consumption. Both hydrogen and fuel ammonia capture a share of this mix, for example, coal, natural gas, and oil all decline at an accelerated rate relative to the BAU scenario. Meanwhile, consumption of electricity still increases substantially between 2021 and 2060. Yet at 0.8% per year, it does so at what is still a modestly lower rate than that under the BAU scenario (i.e. 1.1% per year).

**Figure 18.7. Final Energy Consumption by Sector, Business-as-Usual vs Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent. Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculations.

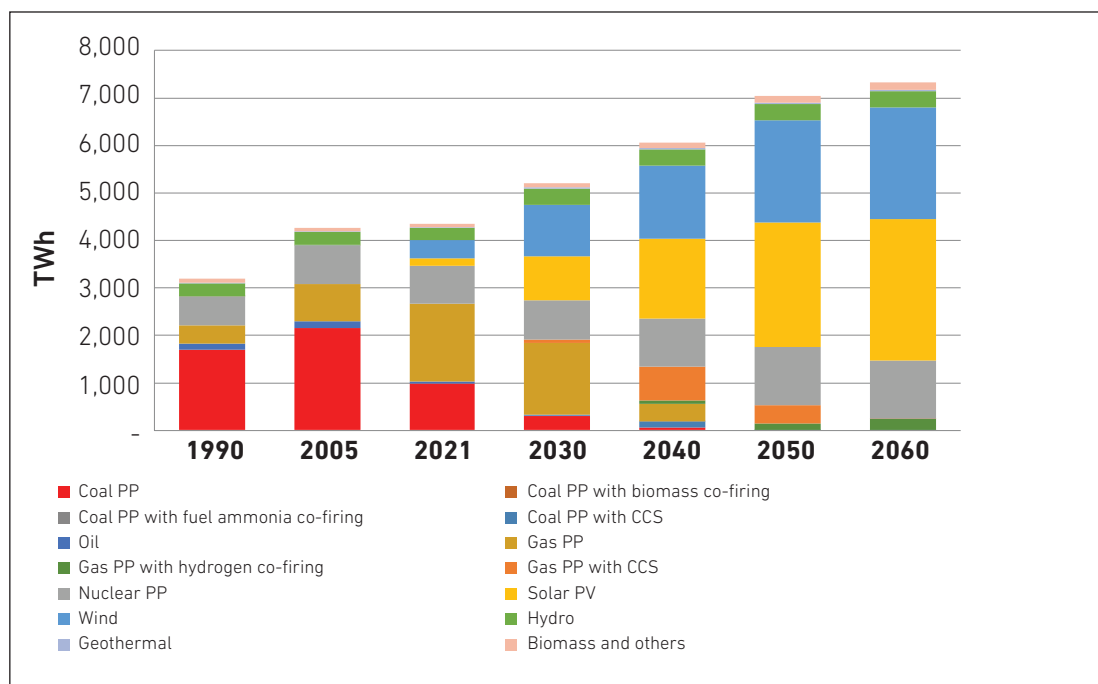
## Power Generation

Alongside the above, the LCET scenario also anticipates even greater progress towards the goal of electrifying the US economy as well as the buildout of relevant infrastructure. Thus, and perhaps not surprisingly, this scenario sees a significant increase in power generation output – by 785.6 TWh (or 12%) (Figure 18.8) more than under the BAU scenario in 2060.

A key assumption under the LCET scenario is that market and policy breakthroughs increase the attractiveness of technologies that support the decarbonisation of coal and natural gas. To that end, all generation from coal and natural gas are anticipated to be paired with either carbon capture and storage (CCS), hydrogen co-firing, or biomass co-firing by no later than 2050. Even so, non-fossil sources remain highly competitive and even capture a slightly larger share of total power generation output in 2060 under the LCET scenario relative to their share under the BAU scenario (an additional 1.3%).

Arguably more notable here, although, is that the LCET scenario nonetheless finds that an intentional approach to decarbonisation ultimately delivers a more diversified power generation mix. To that end, it finds a sharp uptick in generation from nuclear power as reducing the country's (still high) relative reliance on generation from variable renewable energy. Wind energy is also anticipated to play a slightly less prominent role in 2060 under the LCET scenario, when compared with its share and absolute total under the BAU scenario, although it is still a significant aspect of the country's power generation mix. In turn, the collective impact of these trends is also a profound transformation of the US power sector relative to the BAU scenario, suggesting that, by mid-century, virtually all US power generation output could be fully decarbonised.

**Figure 18.8. Power Generation, 1990–2060, Low-carbon Energy Transition Scenario**



BAU = business as usual, CCS = carbon capture and storage, LCET = low carbon energy transition, PP = power plant, PV = photovoltaic, TWh = terawatt-hour.

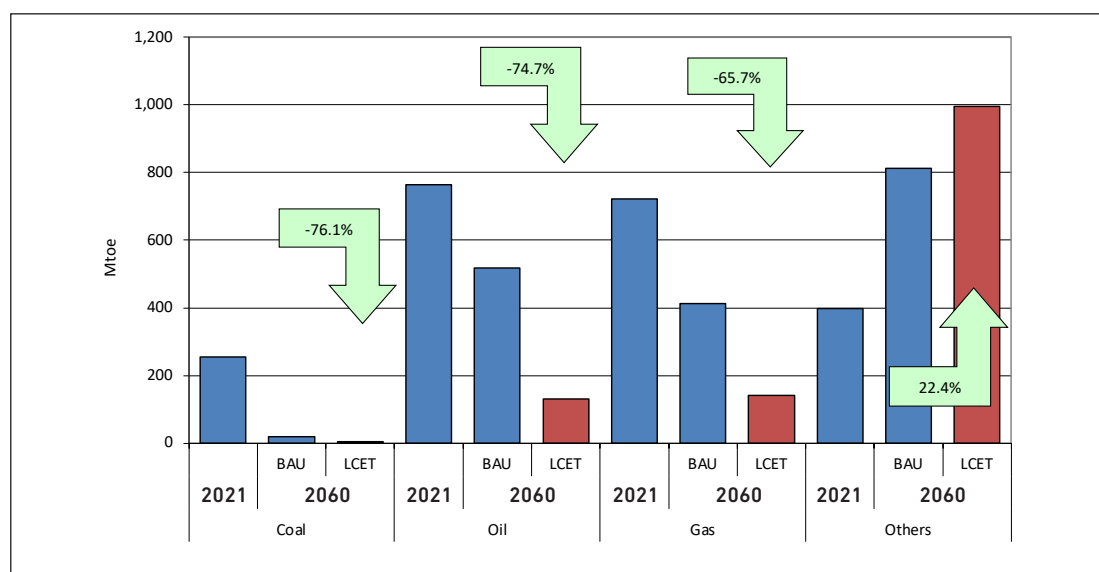
Source: Authors' calculations.

## Primary Energy Supply

Under the LCET scenario, the United States' primary energy supply is anticipated to decrease from 2,138.97 Mtoe in 2021 to 1,272.14 Mtoe in 2060. This implies that in 2060, under the LCET scenario, total primary energy supply will be around 491.3 Mtoe (27.9%) lower compared with the BAU scenario (Figure 18.9).

As part of this, primary energy supply for coal declines to 4.6 Mtoe. This represents an additional decrease of 14.6 Mtoe (or 76.1%) in 2060 over the already dramatic decline in the BAU scenario. Oil is also anticipated to decline compared to the BAU scenario, with a potential decrease of 387.7 Mtoe (or 74.7%) by 2060, whilst natural gas declines by 271.3 Mtoe (or 65.7%) relative to the BAU scenario. Perhaps unsurprisingly given trends in the preceding subsections, nuclear increases in the LCET scenario (versus a projected decline in the BAU scenario) whilst solar, wind, and ocean energy collectively grow at an average annual rate of 6.3% between 2021 and 2060. Meanwhile, amidst other shifts in the US energy system, neither hydrogen nor fuel ammonia play a role in US total primary energy supply under the LCET scenario during any part of the outlook period – the same finding as under the BAU scenario.

**Figure 18.9. Primary Energy Supply in Business-as-Usual vs Low-carbon Energy Transition Scenarios**



BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes nuclear, hydro, geothermal, solar, wind, and ocean energy as well as biofuels and electricity.

Source: Authors' calculations.

## CO<sub>2</sub> Emissions

In the LCET scenario, CO<sub>2</sub> emissions are anticipated to fall sharply throughout the outlook period, and by 2060 are 2,085.4 Mt-CO<sub>2</sub> lower than the projections under the BAU scenario.<sup>4</sup> Even so, this

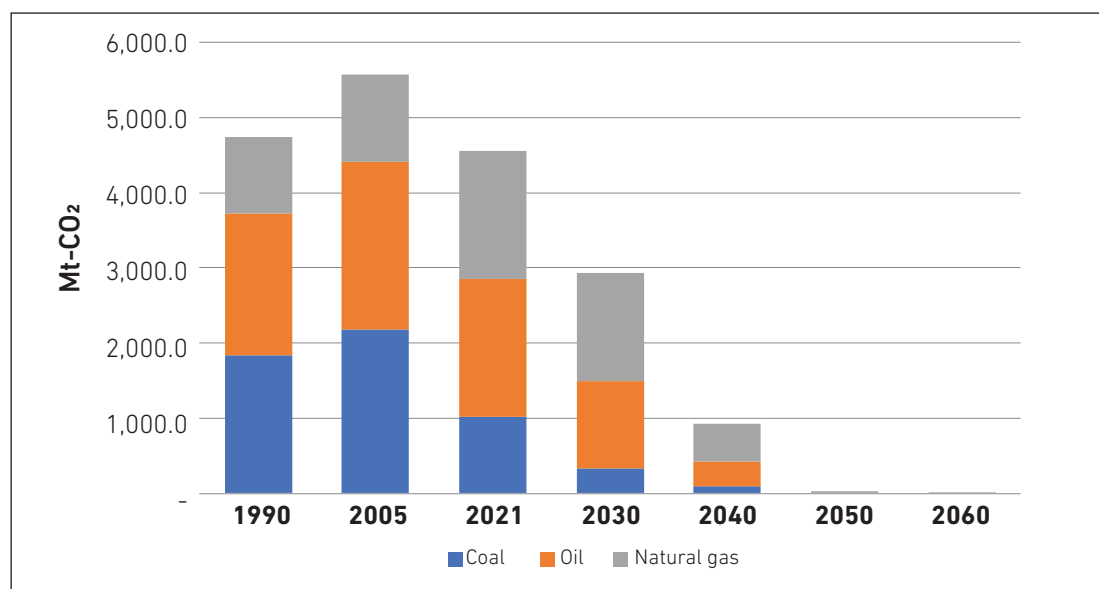
<sup>4</sup> Or 2,097.9 Mt-CO<sub>2</sub> lower if carbon capture and storage and direct air capture are taken into account.



decrease does not ensure that the United States' energy system is truly 'carbon-emissions free' by 2060 (much less 2050), as roughly 6.7 Mt-CO<sub>2</sub> is still emitted annually in this scenario. Key to this picture is lingering emissions from natural gas – which make up over two-thirds of remaining emissions – as well as from coal. Encouraging, although emissions from oil do reach zero by mid-century in this scenario, despite expectations for continued consumption of this fuel in the United States. This suggests the enormous potential of various tools to support cleaner consumption of this fossil fuel when well-aligned with other decarbonisation efforts.

As noted at the outset, in its 2021 Nationally Determined Contribution submission, the United States pledged to reduce its greenhouse gas emissions by 50%–52% from 2005 levels by 2030 and to reach net-zero emissions by 2050. The findings of this section suggests that under the LCET scenario, the US may still miss the country's emissions reduction targets for 2030. That being said, it does see a pathway for the United States to reach carbon neutrality by 2050 – but one that is expected to also require leveraging bioenergy with CCS, carbon sinks, and other tools that can deliver negative emissions. As suggested by Figure 18.10, even a relatively modest additional valuation of US efforts in this space could bring the country to net-zero emissions by 2050. Moreover, the IEEJ's model also suggests that, under the LCET scenario, the US is already on track to achieve net-negative emissions by 2060 once contributions from CCS and direct air capture are taken into account. However, scaling-up negative emissions tools is not expected to be able to provide a full or partial alternative to the more aggressive transformations of US energy systems suggested in this section.

**Figure 18.10. CO<sub>2</sub> Emissions, 1990–2060, Low-carbon Energy Transition Scenario**



BAU = business as usual, LCET = low-carbon energy transition, Mt-CO<sub>2</sub> = million tonnes of carbon dioxide.

Source: Authors' calculations.

## 5. Energy Cost Comparisons between Business-as Usual and Low-carbon Energy Transition Scenarios

### 5.1. Fuel Costs

Given the scale of US demand for energy generally and for oil, natural gas, and coal specifically, current US spending on fuel is considerable. This study estimates that in 2021 alone, US fuel costs totalled US\$774,113 million. Roughly 68% of these costs were connected to oil, with natural gas accounting for an additional 27%. Meanwhile, coal accounted for roughly 5%.

Both scenarios in this study project that US fuel costs will decline over the outlook period – although to very different degrees (see Figure 18.11). Under the BAU scenario, whilst the per unit costs of oil and coal are both assumed to rise, US consumption of these two fuels nonetheless declines at an even faster pace. In slight contrast, this scenario assumes that the per unit cost of natural gas falls slightly whilst finding that US consumption of natural gas also declines sharply. The result of these trends is an overall decline in US fuel costs, to US\$479,071 million in 2060 – a savings of US\$295,041 million relative to 2021.

Under the LCET scenario, US fuel costs in 2060 are expected to decline to US\$220,043 million – US\$554,070 million lower than in 2021 and an additional US\$259,028 million in savings beyond the BAU scenario. This is primarily driven by the scenario's steeper decline in oil consumption, followed by a (relatively) more modest additional decline in natural gas. Alongside this, although, the LCET scenario envisions that US spending on hydrogen will grow steadily over the outlook period, reaching US\$88,251 million a year in 2060. In contrast, US spending on hydrogen in 2060 under the BAU scenario is zero, given the absence of demand for this fuel in that scenario. Even so, US spending on hydrogen in 2060 under the LCET scenario is equivalent to only 43.2% of spending on natural gas in 2021.

**Figure 18.11. Fuel Costs Savings in 2060 in Business-as-Usual vs Low-carbon Energy Transition Scenarios**



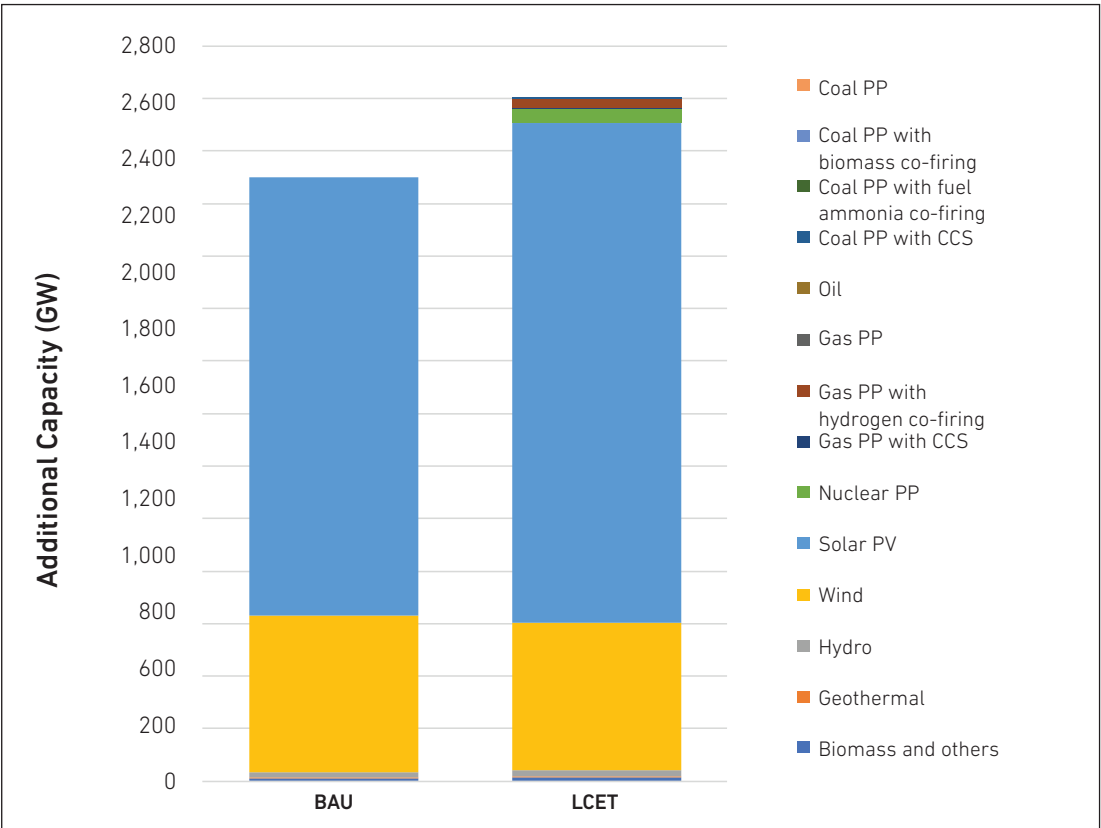
BAU = business as usual, LCET = low-carbon energy transition.

Source: Authors' calculations.

## 6. Power Generation Investment

In contrast with the savings observed in fuel costs, US power plant construction costs are anticipated to increase throughout the outlook period, and are also higher under the LCET scenario than the BAU scenario. Key to this picture is the additional power generation capacity requirements of the LCET scenario (2,598,411 megawatts) versus those of the BAU scenario (2,298,395 megawatts). However, scenario variations in the kinds of new capacity coming online – as shown in Figure 18.12 – also contribute to further widening cost differences, given the relatively higher per kilowatt construction costs of nuclear projects (which are more prominent under the LCET scenario) versus wind projects (which are more prominent under the BAU scenario). As suggested by Figure 18.13, the net impact of these trends is that over this report’s 39-year outlook period, power plant construction costs are projected to be roughly US\$1,624,193 million under the LCET scenario versus US\$1,339,236 million under the BAU scenario – or roughly 21.3% higher under the LCET scenario than the BAU scenario.

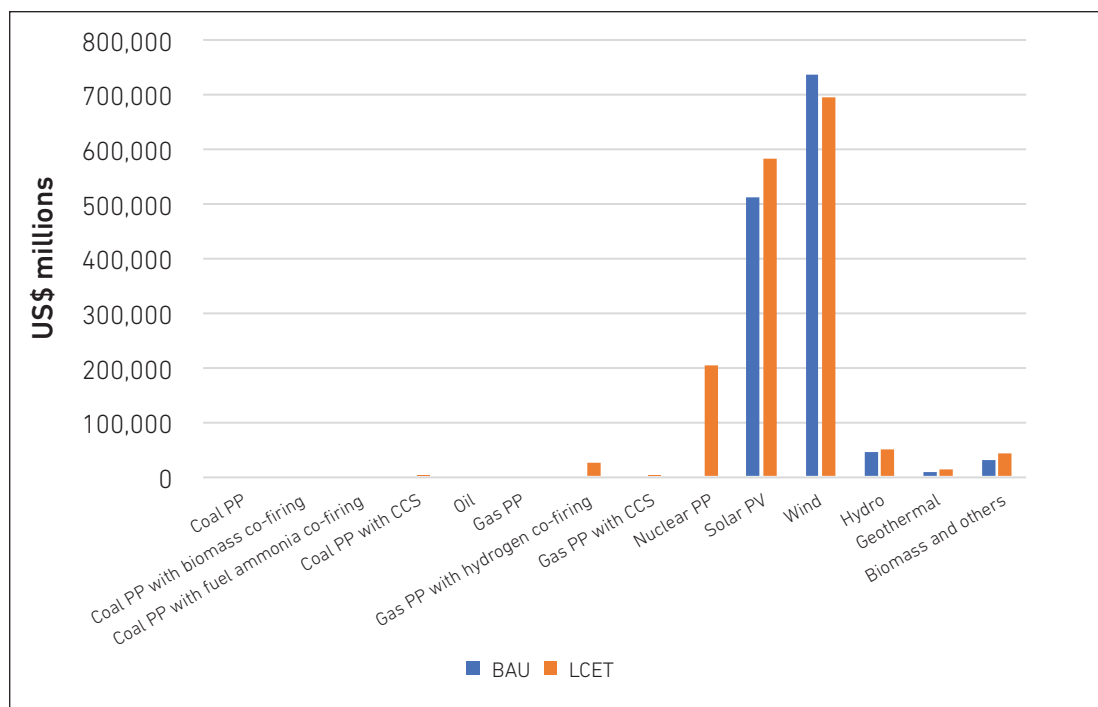
**Figure 18.12. Additional Power Plant Capacity, 2021–2060,  
Business-as-Usual vs Low-carbon Energy Transition Scenarios**



BAU = business as usual, CCS = carbon capture and storage, GW = gigawatt, LCET = low-carbon energy transition, PP = power plant, PV = photovoltaic.

Source: Authors' calculations.

**Figure 18.13. Investment in Power Plants, 2021–2060, in Business-as-Usual vs Low-carbon Energy Transition Scenarios**



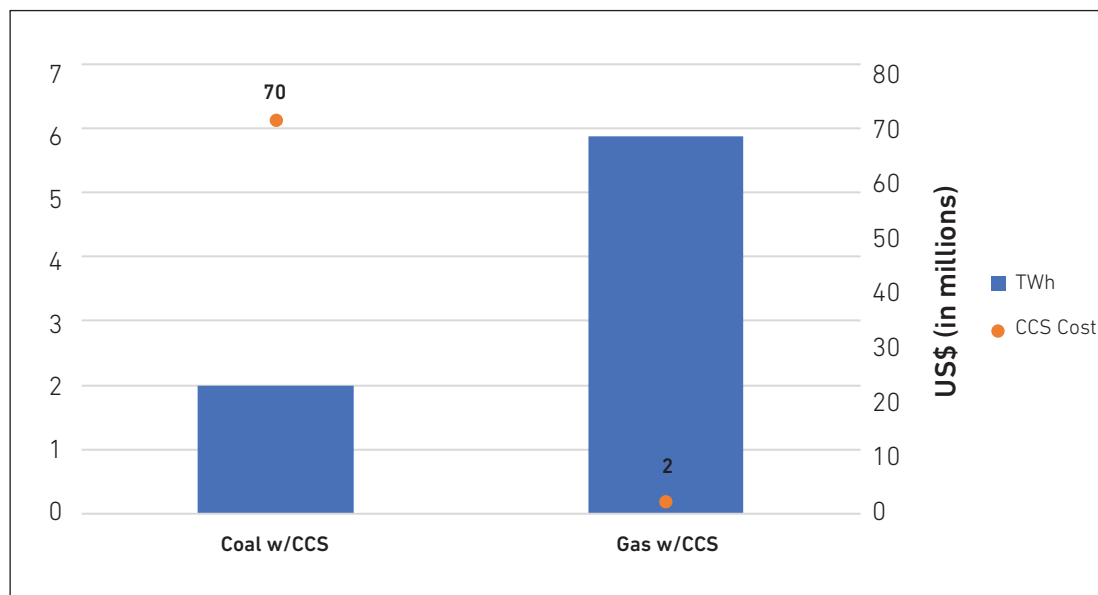
BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant, PV = photovoltaic.

Source: Authors' calculations.

## 7. Carbon Capture and Storage Costs

Spending on CCS is also higher under the LCET scenario than the BAU scenario; unsurprising given technology's use in LCET and absence in BAU. As shown in Figure 18.14, the vast majority of these costs are associated with applications of CCS technologies in the country's increasingly modest fleet of coal-fired power plants, with relevant costs in 2060 alone amounting to US\$70 million. Spending associated with of gas-fired power plants is roughly US\$2 million in 2060. As might be inferred from the preceding subsections, these CCS costs (even when combined) are thus expected to be incredibly modestly when compared to other costs projected under the LCET scenario as well as those under the BAU scenario.

**Figure 18.14. Carbon Capture and Storage Capacity and Costs in 2060 under Low-carbon Energy Transition Scenario**



CCS = carbon capture and storage, TWh = terawatt-hour.

Source: Authors' calculation.

## 8. Overall Cost

Table 18.1 summarises the overall differences in costs between the BAU and LCET scenarios in 2060. It suggests that, over time, the LCET scenario's higher costs in power plant construction requirements and spending on CCS are offset by its significant savings on fuel costs; such that, in 2060, the annual cost in the LCET scenario is roughly US\$251,649 million (or 49% less) than in the BAU scenario. That being said, the LCET scenario's power plant capacity investments needs are expected to be weighted towards the front half of the outlook period, until 2030, whilst its deepest fuel expenditure declines are during the back half. Thus, initially, it is expected to require greater new spending and yield only modest additional savings, making it at least appear less attractive than the BAU scenario in some individual years – even as the LCET scenario's post-2030 declines are still steep enough that it delivers greater overall cost savings during the outlook period.

**Table 18.1. Cost Comparison of in Business-as-Usual vs Low-carbon Energy Transition Scenarios in 2060**  
(US\$ million)

|                                                                       | BAU            | LCET           |
|-----------------------------------------------------------------------|----------------|----------------|
| Fuel costs in 2060                                                    | 479,071        | 220,043        |
| Power plant construction costs<br>(average annual cost for 2021–2060) | 34,339         | 41,646         |
| CCS costs in 2060                                                     | 0              | 72             |
| <b>Total</b>                                                          | <b>513,410</b> | <b>261,761</b> |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition.

Source: Authors' calculations.

## 9. Implications

The modelling reviewed in this chapter explores just two of the many possible energy futures for the United States. Encouragingly, both scenarios see the United States as likely to substantially reduce its energy-linked CO<sub>2</sub> emissions over the outlook period. And, when viewed together, the scenarios suggest several ways in which the US might be able to accelerate its emission reductions, whilst also bolstering its energy security more broadly. Even so, both scenarios hint at lingering challenges for unlocking a cleaner, more secure, and more economically advantageous energy future.

- In both the LCET and BAU scenarios, wind and solar energy combined are anticipated to account for the vast majority of the US electricity generation mix in 2060. To ensure that strong reliance on variable renewable sources does not undermine the reliability or stability of US power supply, greater attention to bolstering enabling infrastructure as well as advancing new breakthroughs in storage technologies will be crucial.
- Continued efforts to strengthen the transport sector are envisioned as a critical opportunity for energy saving. In addition to accelerated deployment of electric vehicles, greater attention to fuel efficiency and technologies for overall cleaner consumption will be critical.
- Even amidst the changes above, oil and natural gas are anticipated to represent a sizeable share of the United States' energy mix in the BAU scenario and are still relatively prominent under the LCET scenario. To get to net zero by 2050, finding ways to radically decarbonise the consumption of these fuels is thus an important imperative alongside switching to renewable and other alternative energy sources. In turn, leading on these efforts could also bolster the long-term competitiveness of US fossil fuel exports as a means of how Asia might advance its own energy and environmental security goals.

- Pursuing a carbon-neutral energy mix is likely to dramatically reduce US expenditures on fuel – especially, but not only, on oil. However, it will also require greater investment in power plant infrastructure and, in at least some of the early years of the outlook period, is expected to have higher associated costs than the BAU scenario. Whilst this report finds the LCET scenario ultimately producing strong environmental and economic benefits for the US, clear communication and ongoing engagement with key stakeholders and the public will be essential to sustaining support for what, at times, is expected to be a challenging transformation. Alongside this, continued US–Asia dialogue can also play an important role in helping to refine planning and overall best practices.

## References

- Gillispie, C. (2022), 'Low-Carbon Green Recovery from the Pandemic in the United States' in V. Anbumozhi, K. Kalirajan, and X. Yao (eds.) *Assessing the Impacts of COVID-19: Regional Policies and Practices for Green Recovery*. Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA), pp.229–51.
- United States (US) Department of State and Executive Office of the President (2021), *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*. <https://unfccc.int/documents/308100>
- US Government (2021), 'The United States of America: Nationally Determined Contribution. Reducing Greenhouse Gas in the United States. A 2030 Emissions Target'. <https://unfccc.int/sites/default/files/NDC/2022-06/United%20States%20NDC%20April%2021%202021%20Final.pdf>





# ANNEX 1

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## Energy Outlook Results of the Association of Southeast Asian Nations

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Southeast Asia

# 1. Background

According to the World Bank's World Development Indicators database (World Bank, 2025), the 10 Member States of the Association of Southeast Asian Nations (ASEAN) recorded a combined gross domestic product (GDP) of approximately US\$3.54 trillion in 2024. Following the COVID-19 shock, which saw regional GDP contract by 3.9% in 2019–2020, ASEAN's economy rebounded strongly, posting annual growth rates of 3.7%, 5.7%, 4.0%, and 4.8% in the periods 2020–2021, 2021–2022, 2022–2023, and 2023–2024, respectively.

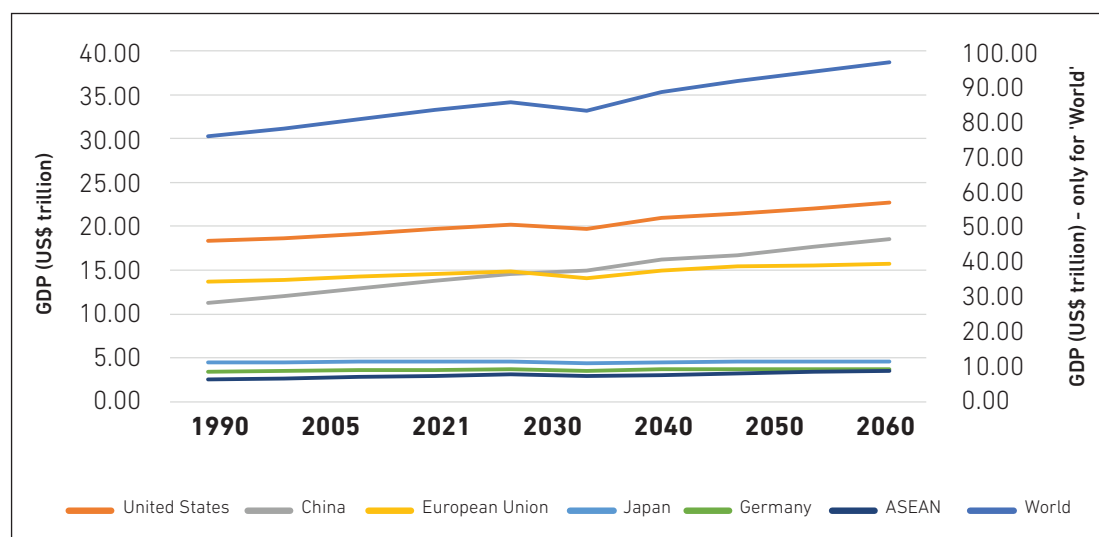
From 2021–2022 onwards, ASEAN's GDP growth consistently outpaced global growth. During the 2021–2022, 2022–2023, and 2023–2024 periods, ASEAN recorded growth rates of 5.7%, 4.0%, and 4.8%, compared with global growth rates of 3.4%, 2.9%, and 2.9%, respectively.

Figure A1.1 illustrates the evolution of global GDP alongside selected major economies and regions, highlighting ASEAN's position as the world's fifth-largest economy since at least 2015. In 2024, ASEAN ranked behind only the United States (US\$22.68 trillion), China (US\$18.49 trillion), Japan (US\$4.60 trillion), and Germany (US\$3.68 trillion).

Notably, ASEAN's GDP has been steadily converging towards that of Germany. In 2015, ASEAN's GDP was equivalent to approximately 74% of Germany's GDP; by 2024, this figure had risen to 96%.

In terms of its share of global output, ASEAN's contribution to world GDP increased from 3.3% in 2015 to 3.7% in 2024, underscoring the region's growing importance in the global economy.

**Figure A1.1. World's GDP (right vertical axis) and Some Major Countries and Regions' GDP (left vertical axis)**  
(trillion US\$)



Source: The World Bank (2025).

The International Monetary Fund (IMF, 2025) projects ASEAN's GDP growth to moderate to 4.1% in 2024–2025 and 3.9% in 2025–2026. This deceleration is likely to reflect recent tariff announcements by the United States, countermeasures by major trading partners, and heightened policy uncertainty, all of which may weaken external demand and contribute to a broader global economic slowdown.

The economic assumptions underpinning this East Asia Energy Outlook and Saving Potential were formulated at the outset of the modelling exercise and therefore adopt a more optimistic GDP growth trajectory. Average annual GDP growth is assumed at 4.6% for 2021–2030, 4.9% for 2030–2040, 4.53% for 2040–2050, and 4.2% for 2050–2060. Under these assumptions, the combined GDP of the 10 ASEAN Member States is projected to increase from approximately US\$3.08 trillion in 2021 to around US\$17.4 trillion in 2060, corresponding to an average annual growth rate (AAGR) of about 4.5%.

Over the same period, ASEAN's total population is projected to grow at an AAGR of 0.6%, from around 670.5 million in 2021 to approximately 844.2 million in 2060. As a result, GDP per capita is expected to rise substantially, from around US\$4,590 in 2019 to about US\$20,640 in 2060, equivalent to an AAGR of approximately 3.9% during 2021–2060.

This chapter presents the energy outlook based on aggregated results for ASEAN Member States. It begins with an assessment of the business-as-usual (BAU) scenario, followed by an analysis of the low-carbon energy transition (LCET) scenario.

The BAU scenario reflects each ASEAN Member State's existing goals, action plans, and policy frameworks. In contrast, the LCET scenario assumes that ASEAN Member States pursue their respective carbon neutrality targets by 2050 or 2060, depending on national commitments. Under the LCET scenario, the following measures are assumed:

- Prioritisation of energy efficiency and conservation (EEC) measures across ASEAN Member States;
- Accelerated electrification, including the adoption of battery electric vehicles (BEVs), electric cooking appliances such as induction stoves, and heat-pump systems for water heating;
- Promotion of fuel switching from fossil fuels to alternative energy sources, including biomass (notably biofuels), hydrogen, and ammonia. In the short term, particularly up to 2030, a transition from coal to natural gas is assumed. Beyond 2030, co-firing technologies using biomass, ammonia, and hydrogen are gradually deployed in thermal power plants to substitute coal and gas in electricity generation, with co-firing ratios increasing progressively and reaching 100% by 2050–2060;
- Expansion of renewable energy, particularly solar and wind;
- Re-evaluation of the role of nuclear power generation; and
- Deployment of clean energy technologies, including hydrogen, ammonia, and carbon capture, utilisation, and storage (CCUS), in industry – particularly in hard-to-abate sectors such as cement – and in thermal power generation, supported by cross-border CO<sub>2</sub> transport infrastructure.

Under the LCET scenario, the analysis tracks developments in final energy demand, primary energy consumption, and the power generation sector, alongside key energy indicators that reflect improvements in energy efficiency, reductions in energy intensity, and declines in carbon emissions across the region.

## 2. Outlook Results

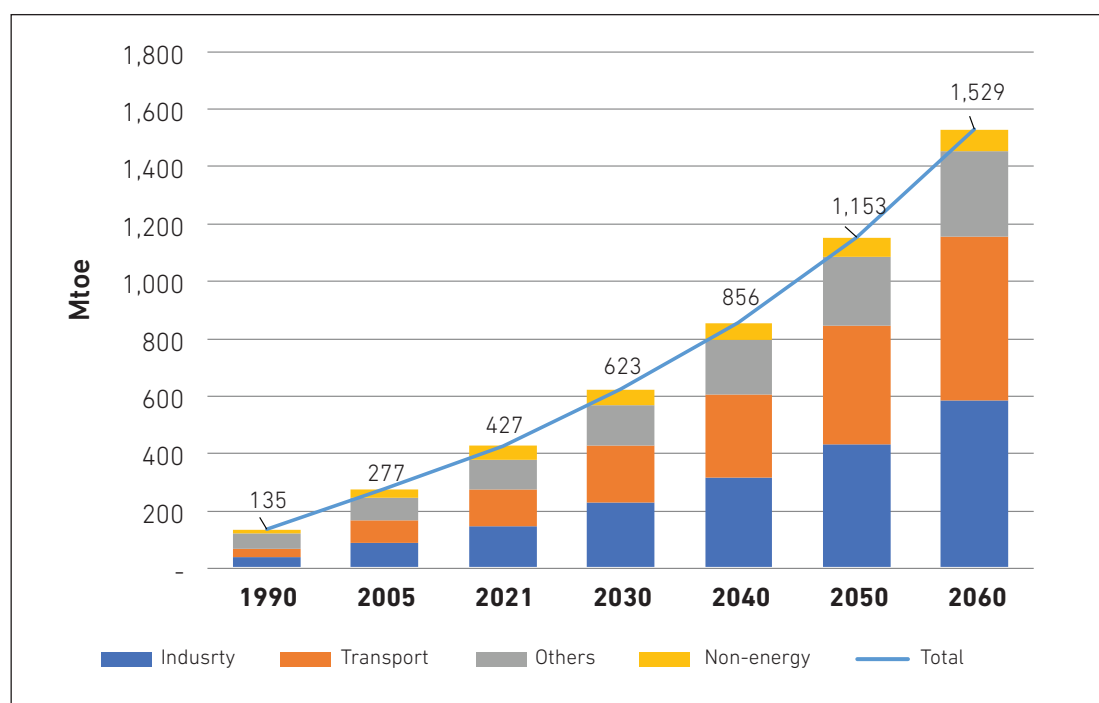
### 2.1. Business-As-Usual

#### 2.1.1. Final Energy Demand

ASEAN's final energy demand increased at an average annual rate of 3.8%, rising from 135 million tonnes of oil equivalent (Mtoe) in 1990 to 426 Mtoe in 2021. In 1990, the 'others' sector – comprising residential and commercial consumption – was the largest energy-consuming sector, accounting for 40% of total final energy demand. By 2021, however, its share had declined significantly to 24%.

By contrast, the industrial sector had become the largest final energy consumer by 2021, accounting for 28% of total final energy demand, followed by the transport sector at 23%. In addition, approximately 11% of ASEAN's total final energy consumption in 2021 – equivalent to 48 Mtoe – was used for non-energy purposes, primarily as feedstock for petrochemical production.

**Figure A1.2. Final Energy Demand by Sector, Business-As-Usual, 1990–2060**  
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers subsectors such as residential, agriculture, services, and commerce.

Source: Author's compilation.

Under the business-as-usual (BAU) scenario, ASEAN's final energy demand is projected to grow at an average annual rate of 3.3% from 2021 to 2060. The transport sector is expected to record the fastest growth, at 3.9% per year, followed by the industrial sector at 3.6% and the 'others' sector – comprising residential and commercial consumption – at 2.8%. Demand in the non-energy sector is projected to grow more slowly, at an average annual rate of 1.2%. The relatively modest growth in the 'others' sector reflects a continued shift away from traditional biomass use, particularly in households, towards more commercial and efficient energy sources such as oil products and electricity.

By 2060, the industrial sector is projected to account for the largest share of ASEAN's total final energy demand, at 38.3%, followed closely by the transport sector at 37.2%. The share of the 'others' sector is expected to decline further to 19.6%.

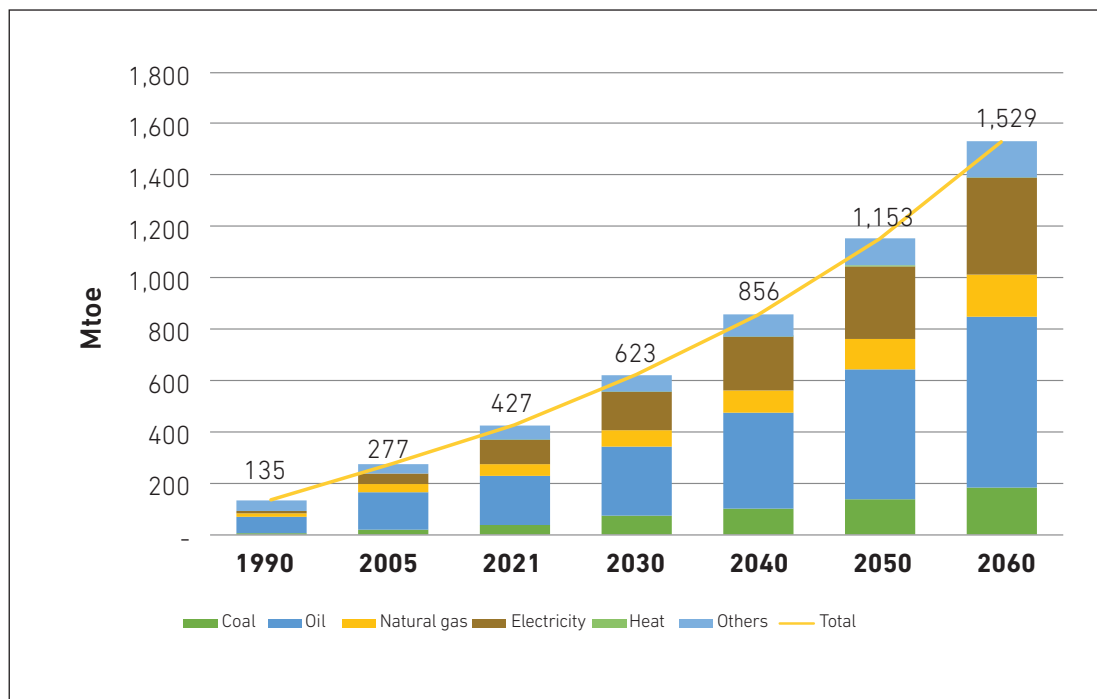
By fuel type, coal recorded the fastest growth between 1990 and 2021, expanding at an average annual rate of 7.2%, driven primarily by rapid industrial expansion. Electricity demand also grew strongly over the same period, at 6.8% per year, followed by natural gas at 4.6%. Oil demand increased at a more moderate rate of 3.4% per year, while demand for 'other' fuels – largely traditional biomass – grew by 1.0% annually.

Oil remained the dominant fuel throughout the period, accounting for 66.0 Mtoe, or 49% of total final energy demand, in 1990. By 2021, oil consumption had increased to 188 Mtoe, although its share declined slightly to 44.1%. In that year, oil continued to be the largest energy source in ASEAN's final energy mix, followed by electricity (22.6%), 'others' (13.2%), natural gas (10.6%), and coal (9.4%).

Under the BAU scenario, demand for all fuels is projected to continue increasing between 2021 and 2060, albeit at slower rates than in the past. Coal is expected to grow the fastest, at an average annual rate of 4.0%, followed by electricity at 3.6%, oil and natural gas at around 3.3% each, and 'other' fuels at 2.4%.

Despite gradual diversification, oil is projected to remain a major component of ASEAN's final energy demand under BAU, accounting for approximately 43.6% in 2060. While oil's share declined modestly from 48.8% in 1990 to 44.1% in 2021, it is expected to remain broadly stable at around 44% over the 2020–2060 period. In contrast, electricity's share of final energy demand increased substantially from 9.2% in 1990 to 22.6% in 2021 and is projected to approach 25% by 2025. Figure A1.3 illustrates the evolution of final energy demand by fuel.

**Figure A1.3. Final Energy Demand by Fuel, Business-As-Usual, 1990–2060**  
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solid and liquid biofuels.

Source: Author's compilation.

## 2.1.2. Primary Energy Consumption

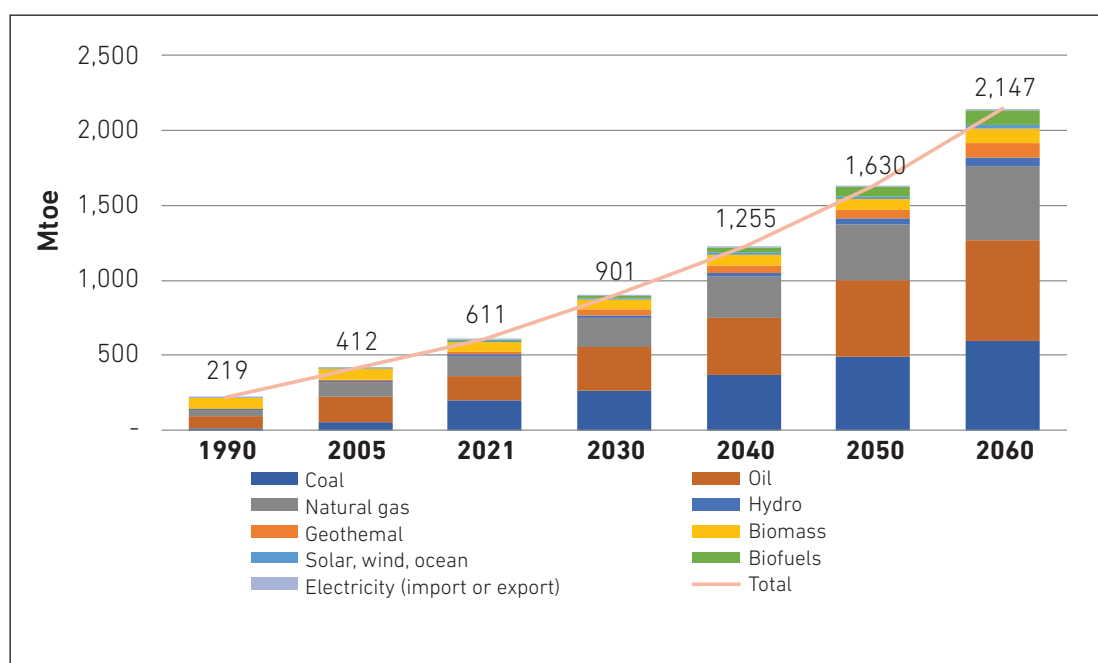
Total primary energy consumption (TPEC) in ASEAN grew at an average annual rate of 3.3%, increasing from 219 Mtoe in 1990 to 611 Mtoe in 2021. In 1990, oil was the dominant energy source, accounting for nearly 39% of TPEC. Oil consumption rose from about 84 Mtoe in 1990 to 167 Mtoe in 2021, corresponding to an average annual growth rate (AAGR) of 2.2%.

The second-largest energy source in 1990 was the category 'others', which was largely composed of traditional biomass. Consumption of traditional biomass declined from 72 Mtoe (33% of TPEC) in 1990 to 63 Mtoe (10.4% of TPEC) in 2021, reflecting an average annual decrease of 0.4%. In contrast, modern renewable energy sources expanded rapidly. Solar and wind power recorded the fastest growth, increasing from just 0.01 Mtoe in 1990 to 5.52 Mtoe in 2021 – an AAGR of nearly 25%. Electricity imports also rose significantly, from negligible levels in 1990 to 4.12 Mtoe in 2021. Coal and hydropower consumption also grew rapidly over the period, at average annual rates of 9.4% and 6.0%, respectively.

As illustrated in Figure A1.4, under the business-as-usual (BAU) scenario, total primary energy consumption is projected to continue growing at an average annual rate of 3.3% between 2021 and 2060. Amongst energy sources, liquid biofuels are expected to record the fastest growth, at 5.9% per year, followed by geothermal energy at 4.1% and solar and wind power at 4.0%. Oil and natural gas consumption are each projected to grow at an average annual rate of 3.6%, while coal is expected to increase more moderately, at 2.9% per year.

By 2060, oil is projected to remain the largest energy source in ASEAN, accounting for around 31% of TPEC, followed by coal at 28% and natural gas at 23%. Hydropower's share is expected to remain limited, at about 2.4%, while geothermal energy is projected to reach nearly 5% of TPEC. The share of 'other' energy sources is expected to increase to around 11% by 2060, growing at an average annual rate of 2.6% over the 2021–2060 period.

**Figure A1.4. Primary Energy Consumption, Business-As-Usual, 1990–2060**  
(Mtoe)



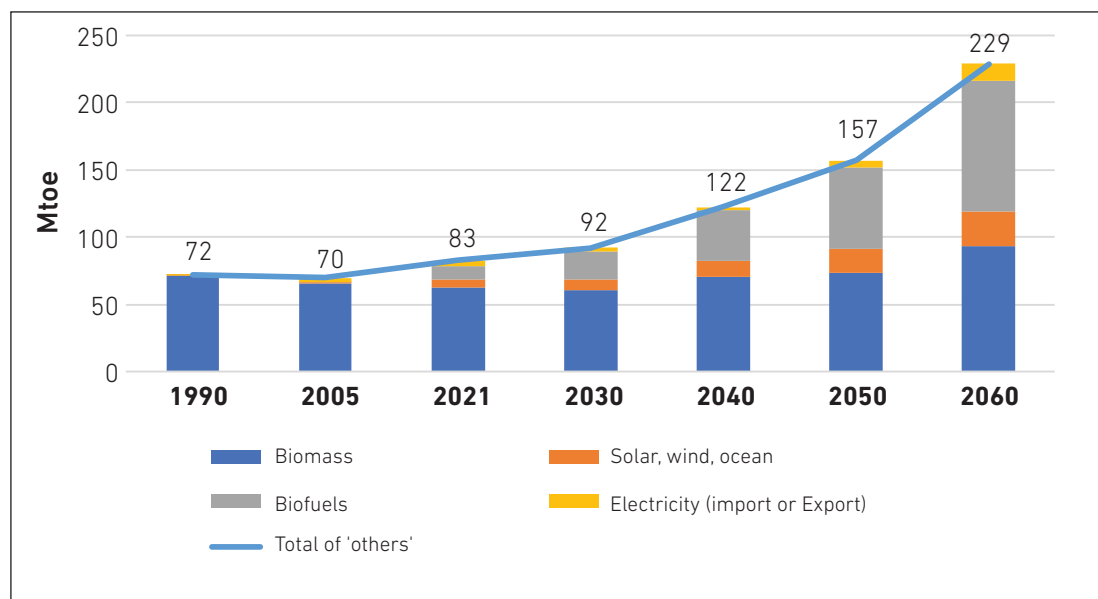
Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solar, wind, and solid and liquid biofuels.

Source: Author's compilation.



**Figure A1.5. Primary Energy Consumption from  
'Others', Business-As-Usual, 1990–2060**  
(Mtoe)



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solar, wind, and solid and liquid biofuels.

Source: Author's compilation.

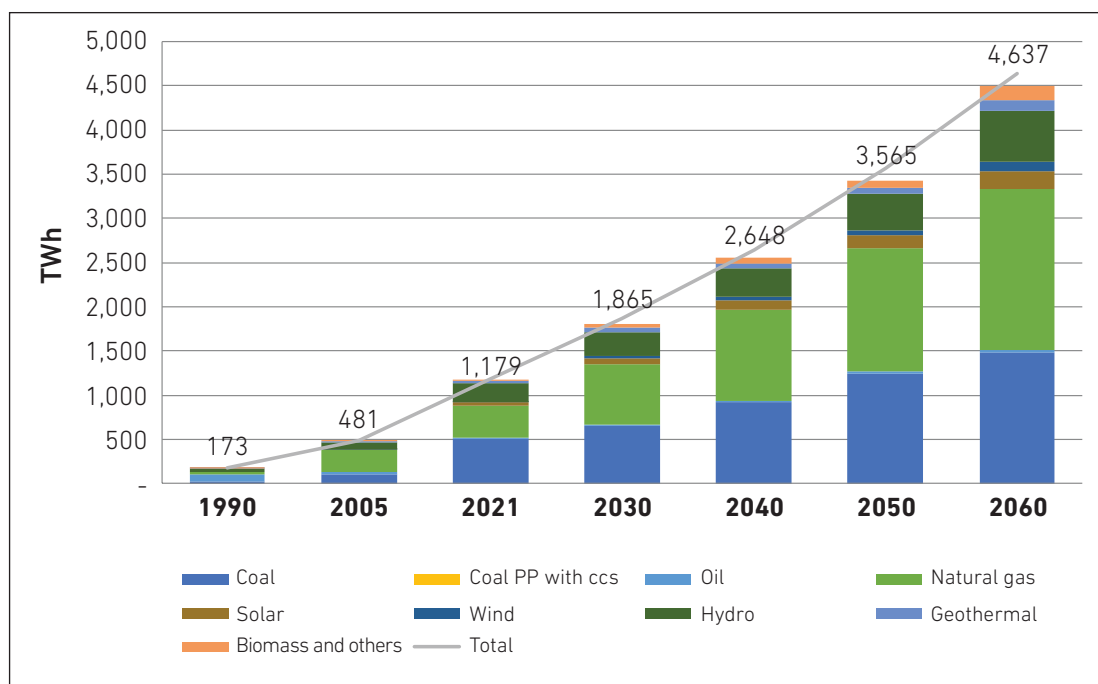
### 2.1.3. Power Generation

Electricity generation in ASEAN grew at an average annual rate of 6.4%, increasing from 173 TWh in 1990 to 1,179 TWh in 2021. Over this period, the power generation mix changed substantially, shifting from oil dominance to coal. In 1990, oil accounted for 71 TWh, or about 41% of total generation. By 2021, coal had become the dominant fuel, generating 506 TWh and accounting for 43% of total electricity output. Natural gas consistently ranked second, with a 22% share (38 TWh) in 1990 and a 30% share (357 TWh) in 2021.

Hydropower generation increased from 29 TWh in 1990 to 207 TWh in 2021; however, its share of total generation remained broadly stable at around 18% in both years. In contrast, fuel oil-based power generation declined sharply, falling from 71 TWh (40% share) in 1990 to just 16 TWh (1% share) in 2021. Other energy sources – including solar PV, wind, geothermal, and biomass – accounted for only a small share of the generation mix, although their contribution increased from 4.5% (8 TWh) in 1990 to around 7% (93 TWh) in 2021. Within this group, solar PV and wind expanded from negligible levels in 1990 to about 47 TWh in 2021, representing nearly 4% of total power generation. By 2021, geothermal power generation reached around 25 TWh, while biomass and other sources contributed approximately 21 TWh.

Under the business-as-usual (BAU) scenario, total electricity generation is projected to grow at an average annual rate of 3.6% between 2021 and 2060, reaching 4,637 TWh (Figure A1.6). Coal and natural gas are expected to continue dominating the generation mix, accounting for 32% and 39% of total electricity output by 2060, respectively, followed by hydropower at 13%. Electricity generation from other energy sources is projected to grow more rapidly over the period, with wind increasing at 5.7% per year, biomass and other sources at 5.2%, solar PV at 4.5%, and geothermal at 4.1%.

**Figure A1.6. Electricity Generation, Business-As-Usual, 1990–2060**  
(TWh)



Hydro = hydropower, TWh = terawatt-hour.

Note: 'Others' covers wind, solar, and biomass sources

Source: Author's compilation.

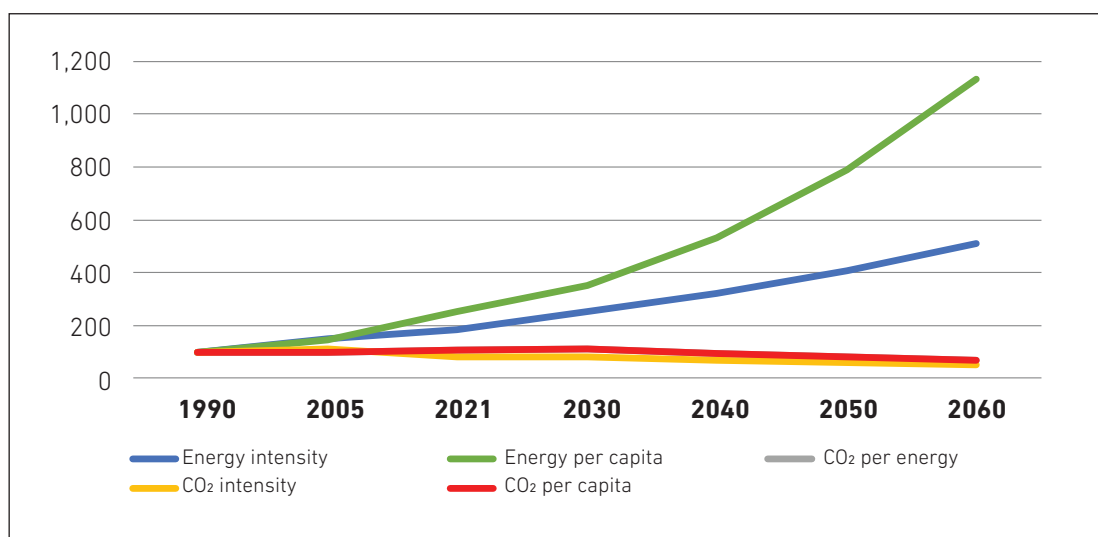
The average thermal efficiency of fossil-fuelled power plants in ASEAN improved from around 34% in 1990 to 35% in 2021, driven mainly by the increasing deployment of natural gas-fired power plants, particularly combined-cycle gas turbines. Over the period 1990–2021, the average annual improvement in thermal efficiency was approximately 0.1%. Looking ahead, natural gas-fired power plants are projected to achieve an average thermal efficiency of about 49% by 2060, while oil- and coal-fired power plants are expected to reach efficiencies of around 38% and 33%, respectively.

## 2.1.4 Energy Indicators

Figure A1.7 illustrates the projected decline in primary energy intensity, defined as the ratio of primary energy consumption to GDP. Energy intensity is expected to continue falling as total primary energy supply grows more slowly than the economy. Similarly, carbon intensity – measured as CO<sub>2</sub> emissions per unit of GDP – is projected to decline, indicating an increasing decoupling of economic growth from energy use and carbon emissions.

In contrast, energy use and carbon emissions per capita are projected to increase, driven by rapid industrialisation, lifestyle shifts toward more energy-intensive consumption patterns, and relatively slow population growth compared with the growth in fossil fuel demand.

**Figure A1.7. Energy Indicators, Business-As-Usual, 1990–2060**



Source: Author's compilation.

## 2.2. Energy Saving and Carbon Emission Reduction Potential in the Low-carbon Energy Transition Scenario

The low-carbon energy transition (LCET) scenario adopts the same GDP and population assumptions as the BAU scenario. However, it assumes that each ASEAN Member State achieves carbon neutrality by either 2050 or 2060, in line with its respective commitments and pledges.

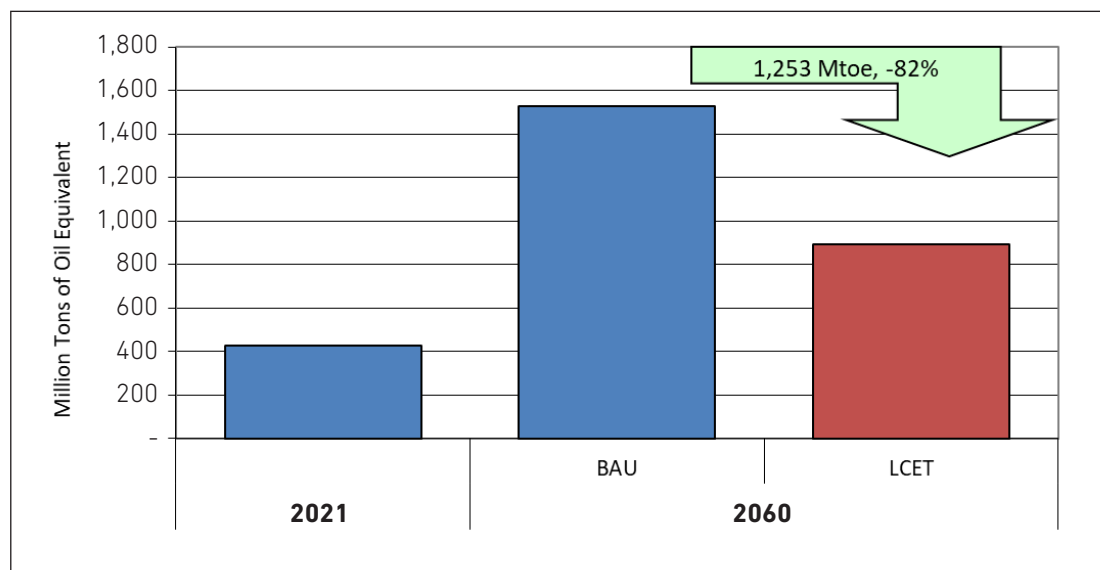
This section provides the basis for assessing the impacts of integrating energy efficiency and conservation (EEC) measures, accelerating electrification and fuel switching, introducing low-carbon technologies and new energy resources and carriers, and deploying carbon capture, utilisation, and storage (CCUS) technologies across ASEAN. By comparing the LCET results with those of the BAU scenario, the analysis highlights the effects and effectiveness of these measures.

### 2.2.1. Final Energy Demand

Final Under the LCET scenario, final energy demand is projected to increase at an average annual growth rate (AAGR) of 1.9% from 2021 to 2060, significantly slower than under BAU (3.3%). As shown in Figure A1.8, total final energy demand under the LCET is expected to reach around 893 Mtoe by 2050, nearly 31% lower than the BAU projection of 1,493 Mtoe.

Over the 2021–2060 period, the transport, industry, and 'others' sectors are each projected to grow at AAGRs of approximately 1.9%–2.1%. Meanwhile, final energy demand in the non-energy sector is forecast to grow at an AAGR of 0.9%, lower than under BAU (1.2%).

**Figure A1.8. Total Final Energy Demand, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(Mtoe)

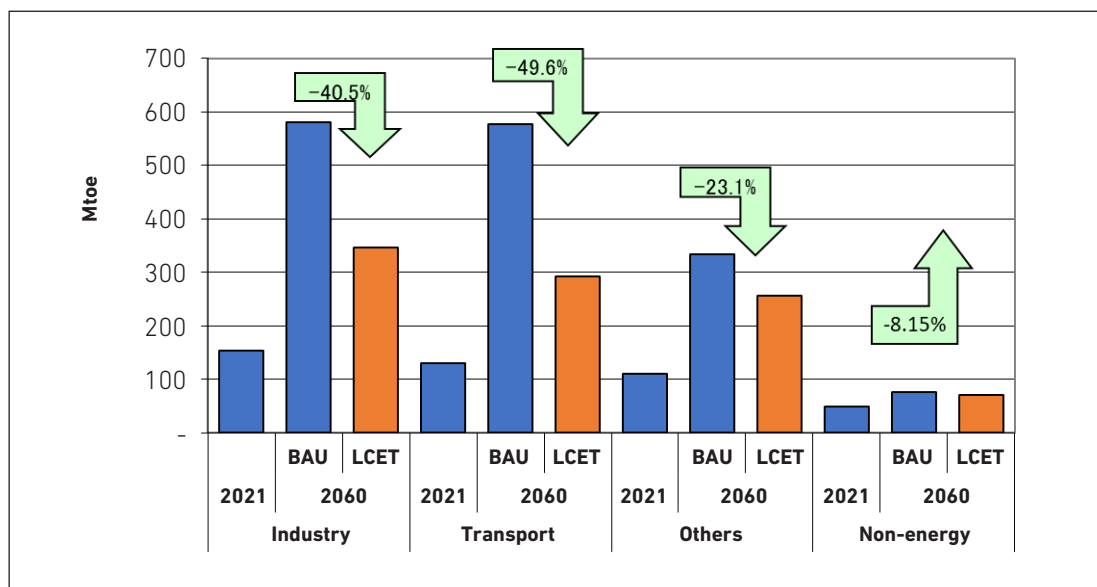


BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's compilation.

Under the LCET scenario, the transport sector is expected to experience the largest reduction in energy use, with consumption almost halved compared to BAU, as shown in Figure A1.9. By 2060, energy consumption in the industry and 'others' sectors under the LCET is projected to be around 40% and 23% lower, respectively, than under BAU.

**Figure A1.9. Total Final Energy Demand by Sector,  
Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(Mtoe)



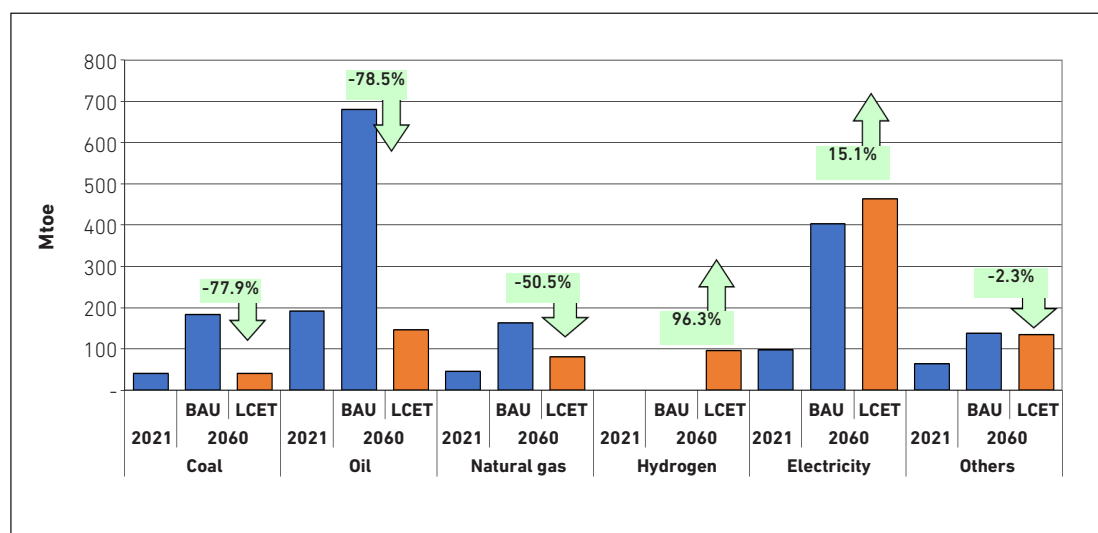
BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers subsectors such as residential, agriculture, services, and commerce.

Source: Author's compilation.

By 2060, the LCET scenario is expected to deliver substantial reductions in fuel consumption compared to BAU. Oil consumption is projected to decline by more than 80%, coal by around 80%, and natural gas by over 46%, while electricity imports are expected to increase by more than 15% (Figure A1.10). Consumption of 'others' (other fuel types) under the LCET scenario is projected to be slightly lower – by just over 2% – than under BAU. In addition, hydrogen is assumed to be introduced for co-firing in gas-fired power plants from 2040 onwards. As a result, total final hydrogen demand is projected to reach around 80 Mtoe by 2060 under the LCET scenario.

**Figure A1.10. Total Final Energy Demand by Fuel, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(Mtoe)



BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solid and liquid biofuels.

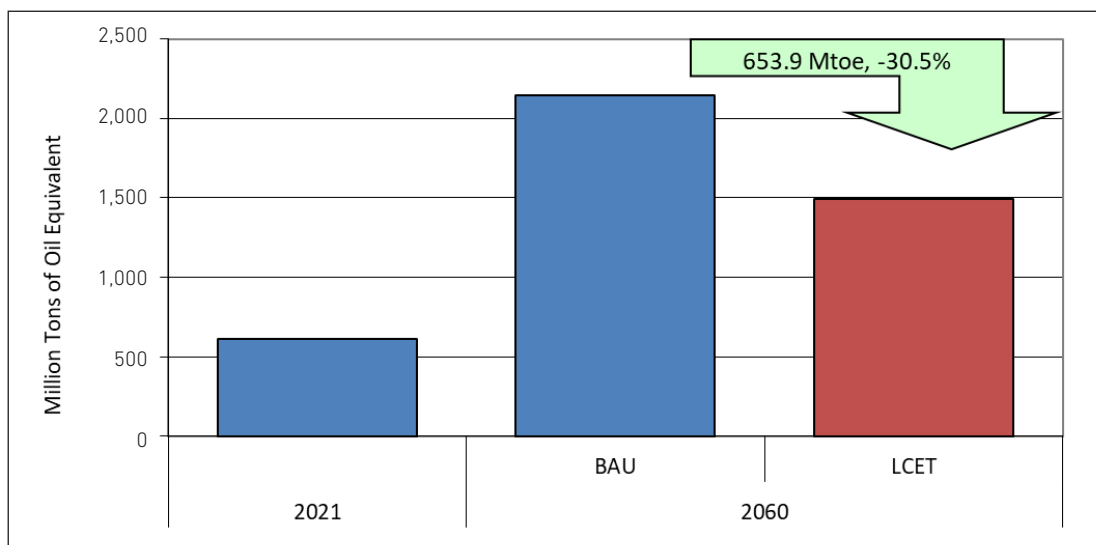
Source: Author's compilation from individual Association of Southeast Asian Nations member states' results.

## 2.2.2. Primary Energy Consumption

By 2060, relative to BAU, the measures assumed under the LCET scenario are projected to reduce total primary energy consumption (TPEC) by nearly 654 Mtoe, equivalent to just over a 30% reduction (Figure A1.11). The largest contribution to this reduction comes from oil, with consumption falling by about 541 Mtoe – more than an 80% decrease compared to BAU (Figure A1.12). Coal consumption is also expected to decline significantly, by around 80% (478 Mtoe), while natural gas consumption is projected to decrease by over 46% (229 Mtoe) relative to BAU.

In contrast, low-carbon energy sources expand substantially under the LCET scenario. Hydropower and geothermal generation are projected to increase by 102% and 18%, respectively, by 2060. Consumption of other renewable fuels – including solar, wind, and biomass – is expected to rise sharply, increasing by 141% compared to BAU, from 228 Mtoe under BAU to 550 Mtoe under LCET.

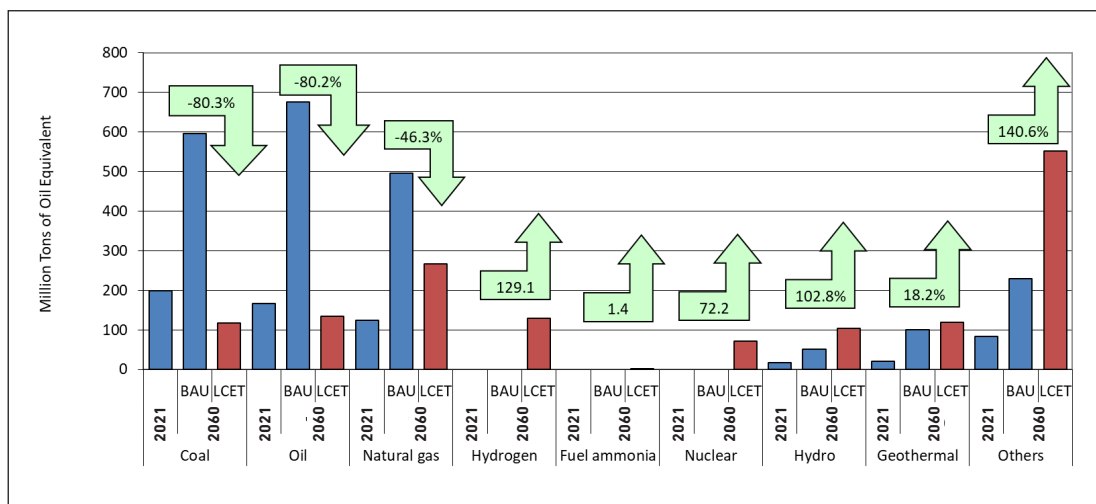
**Figure A1.11. Total Primary Energy Consumption, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(Mtoe)



BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's compilation.

**Figure A1.12. Total Primary Energy Consumption by Fuel, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**



BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

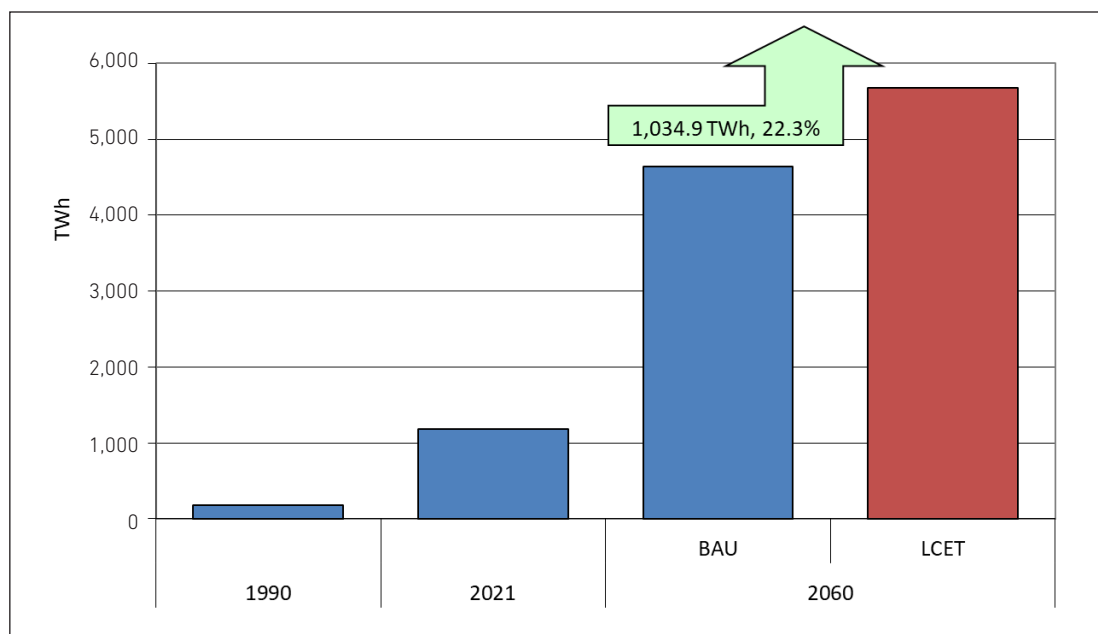
Note: 'Others' covers solar, wind, and solid and liquid biofuels.

Source: Author's compilation.

### 2.2.3. Power Generation

In the LCET scenario, electricity generation in 2060 is projected to reach around 5,671 TWh, representing an increase of about 28% (1,391 TWh) compared with the BAU level of 4,975 TWh (Figure A1.13). This additional power generation is primarily driven by strong electrification measures, particularly in the transport sector, which constitute one of the most important factors underpinning higher electricity demand under the LCET scenario.

**Figure A1.13. Electricity Generation, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060 (TWh)**



BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author's compilation.

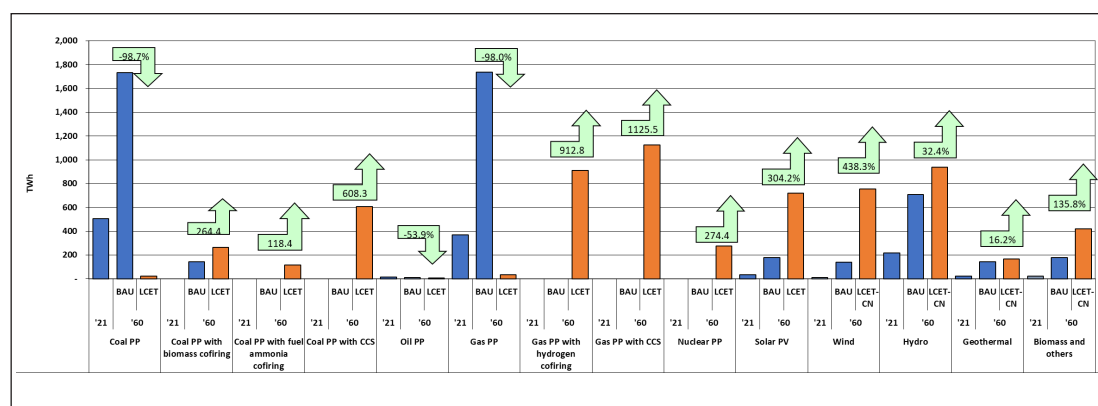
As shown in Figure A1.14, by 2060 the policy measures under the LCET scenario are projected to reduce coal-fired electricity generation by nearly 99% (1,713 TWh) and gas-fired electricity generation by 98% (1,471 TWh) compared with BAU. In contrast, electricity generation from 'other' energy sources – including solar PV, wind, hydropower, geothermal, nuclear, biomass, and others – is expected to increase by a factor of about 2.5, rising from 1,157 TWh under BAU to nearly 3,000 TWh under LCET.

Amongst these sources, wind power shows the strongest growth, increasing by a factor of 7.5 relative to BAU, from 94 TWh under BAU to 713 TWh under LCET by 2060. Coal-fired power plants equipped with carbon capture and storage (CCS) are assumed to begin operation from 2030, reaching 353 TWh of electricity generation by 2060. Similarly, gas-fired power plants with CCS are assumed to enter operation from 2030 and are projected to produce around 908 TWh by 2060.



The gradual deployment of hydrogen and/or ammonia co-firing in coal- and gas-fired power generation is also assumed to begin from 2030. By 2060, electricity generation from co-firing technologies is expected to reach around 1,092 TWh. Nuclear power generation is assumed to commence in 2030 under the LCET scenario, with total electricity output reaching 277 TWh by 2060. In addition, electricity generation from hydropower is projected to be 32% higher under LCET than under BAU by 2060, while geothermal power generation is expected to increase by nearly 16% relative to BAU.

**Figure A1.14. Electricity Generation by Source, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(TWh)



BAU = business-as-usual, Hydro = hydropower, LCET = low carbon energy transition, TWh = terawatt hour.

Note: 'Others' covers wind, solar, and biomass sources.

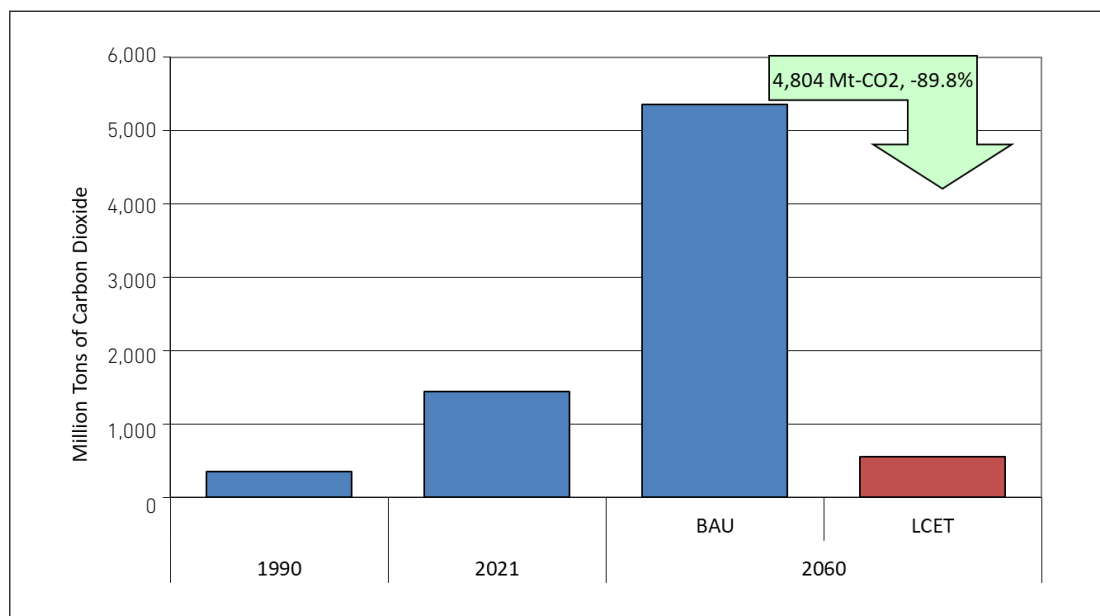
Source: Author's compilation.

## 2.2.4. Carbon Reduction Potential

Under the BAU scenario, carbon emissions from energy demand are projected to increase at an average annual growth rate (AAGR) of 3.4%, rising from 1,444 million tonnes of carbon dioxide (Mt-CO<sub>2</sub>) in 2021 to around 5,352 Mt-CO<sub>2</sub> by 2060 (Figure A1.15). Over the same period, emissions under the LCET scenario are projected to decline at an average rate of 2.5%, reaching approximately 548 Mt-CO<sub>2</sub> by 2060.

By 2060, CO<sub>2</sub> emissions under the LCET scenario are around 62% lower than in 2021 and nearly 90% lower than projected emissions under the BAU scenario in the same year. These results indicate that the measures assumed in the LCET scenario could significantly reduce regional CO<sub>2</sub> emissions, delivering cumulative savings of around 4,804 Mt-CO<sub>2</sub> by 2060.

**Figure A1.15. Carbon Emissions from Energy Consumption, Business-As-Usual and Low-carbon Energy Transition, 2021 and 2060**  
(Mt-CO<sub>2</sub>)



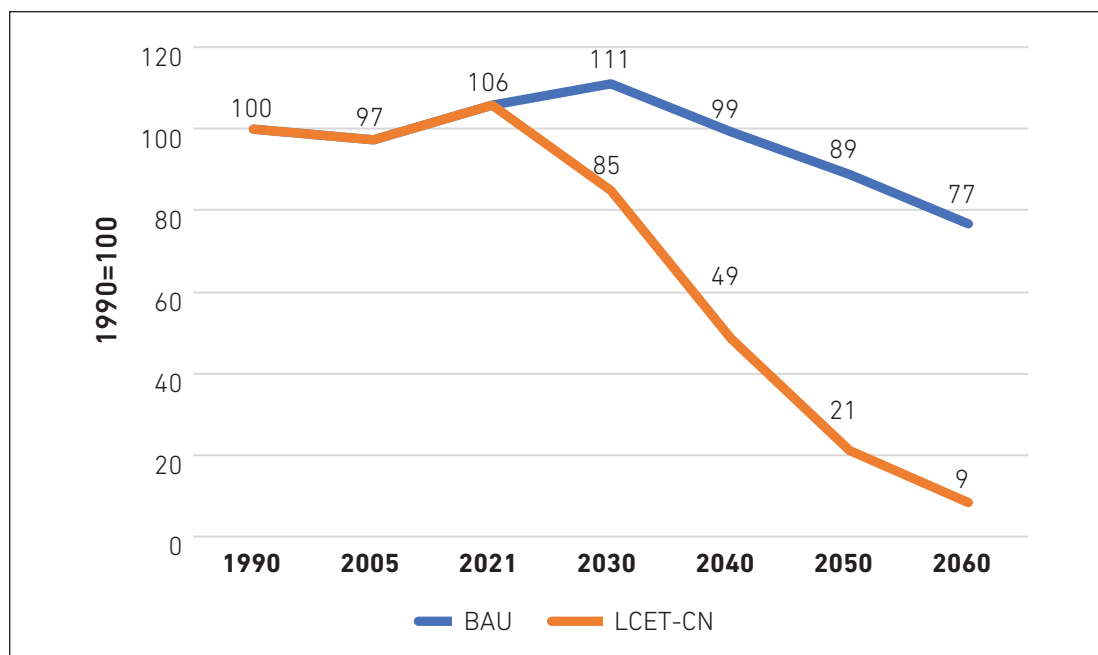
BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author's compilation.

As shown in Figure A1.16, the decoupling of economic activity from energy use and CO<sub>2</sub> emissions is expected to begin under the BAU scenario from around 2030. By 2060, the CO<sub>2</sub> intensity under BAU is projected to be approximately 20% lower than in 2021.

In contrast, decoupling in the LCET scenario is expected to take effect immediately, reflecting the early deployment of low-carbon measures. By 2060, CO<sub>2</sub> intensity under the LCET scenario is projected to be more than 89% lower than in 2021, indicating a much stronger and earlier decoupling of economic growth from carbon emissions.

**Figure A1.16. CO<sub>2</sub> Intensity: Business-As-Usual and Low-carbon Energy Transition, 1990 - 2060**

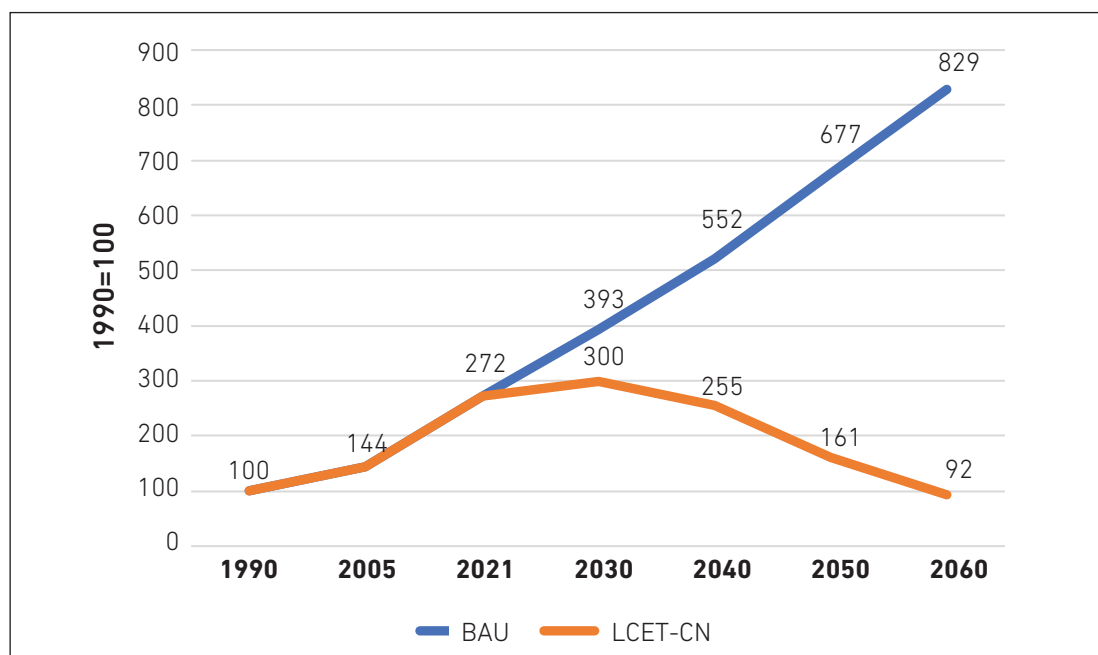


BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author's compilation.

Continued industrialisation in ASEAN is expected to drive a significant increase in CO<sub>2</sub> emissions per capita under the BAU scenario, with the 2060 level projected to be more than eight times higher than in 1990. In contrast, under the LCET-CN scenario, CO<sub>2</sub> emissions per capita are expected to rise until around 2030, followed by a steep decline. By 2060, per capita emissions under the LCET-CN scenario are projected to be approximately 8% lower than the 1990 level.

**Figure A1.17. CO<sub>2</sub> Emissions per Capita: Business-As-Usual and Low-carbon Energy Transition, 1990 - 2060**



BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author's compilation.

### 3. Energy Cost Comparison

Based on the energy outlook results from the modelling exercise, an energy cost comparison analysis was conducted to assess the economic implications of transitioning to low-carbon energy technologies relative to a business-as-usual (BAU) pathway. The low-carbon transition is represented by the LCET scenario, while BAU reflects the continuation of existing policies and practices. The analysis focuses on three main cost components: fuel costs, power generation investment costs, and carbon capture and storage (CCS) costs.

As explained in Chapter 1, total energy costs are composed of fuel costs, power generation investment costs, and CCS costs. Fuel costs are estimated by multiplying the change in fuel consumption between 2021 and 2060 by the unit fuel cost projected for 2060. The resulting value represents either additional annual expenditure or annual savings in fuel costs in 2060 relative to the 2021 level.

Power generation investment costs are calculated based on the total expansion in generation capacity required to meet projected electricity demand. This involves estimating the additional capacity needed between 2021 and 2060, adjusting for plant capacity factors, and multiplying by the corresponding unit construction costs. The total investment is then converted into an annualised figure to allow comparison with other cost components.

CCS costs are estimated by multiplying the increase in the volume of CO<sub>2</sub> captured between 2021 and 2060 by the unit CCS cost projected for 2060. This yields the annual operating cost required for CCS deployment in that year.

The total energy cost is derived by summing these three components. All results are presented on an annualised basis: fuel costs reflect annual changes in fuel expenditure, power generation investment costs represent total capital investment spread over the modelling period, and CCS costs indicate the annual operating expenditure in 2060. It should be noted that some country-level analyses adopt an alternative approach, combining cumulative power generation investment costs with annualised fuel and CCS costs.

### 3.1. Fuel Costs

Table A1.1 shows the fuel cost comparison between BAU and LCET in 2060.

**Table A1.1. Fuel Cost Comparison Between the Business-as-Usual Scenario and the Low-cost Energy Transition Scenario, 2060**

|              | Primary Energy Consumption (Mtoe), 2021 | BAU Primary Energy Consumption (Mtoe), 2060 | LCET Primary Energy Consumption (Mtoe), 2060 | BAU Fuel Cost (million US\$), 2060 | LCET Fuel Cost (million US\$), 2060 |
|--------------|-----------------------------------------|---------------------------------------------|----------------------------------------------|------------------------------------|-------------------------------------|
| Coal         | 198.01                                  | 596.22                                      | 117.75                                       | 62,927                             | -12,683                             |
| Oil          | 167.09                                  | 675.31                                      | 133.94                                       | 349,558                            | -22,802                             |
| Gas          | 123.50                                  | 495.19                                      | 265.74                                       | 107,324                            | 41,070                              |
| Hydrogen     | 0.00                                    | 0.00                                        | 228.12                                       | 0                                  | 265,803                             |
| <b>Total</b> | <b>488.60</b>                           | <b>1,766.72</b>                             | <b>745.54</b>                                | <b>519,808</b>                     | <b>271,389</b>                      |

Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Under the BAU scenario, ASEAN countries are projected to incur an additional US\$519 billion per year in fuel costs by 2060 compared with 2021. The bulk of this increase comes from oil consumption, which accounts for about US\$350 billion, followed by natural gas at US\$107 billion and coal at US\$63 billion.

In contrast, the LCET scenario is expected to generate substantial fuel cost savings, reducing annual fuel expenditure by around US\$248 billion in 2060 relative to 2021. These savings are driven mainly by lower reliance on fossil fuels and improvements in final energy efficiency. Avoided oil consumption delivers the largest savings, estimated at US\$372 billion, followed by coal (US\$76 billion) and natural gas (US\$66 billion). These gains are partially offset by the adoption of hydrogen, which is projected to add approximately US\$266 billion per year in fuel costs. Overall, the LCET scenario demonstrates a significant reduction in fossil fuel expenditure compared with BAU, despite the additional costs associated with new low-carbon energy carriers.

## 3.2. Power Generation Investment Costs

Table A1.2 presents a comparison of estimated power plant investment costs under the BAU and LCET scenarios in 2060. The analysis indicates that the LCET scenario requires substantially greater additional generation capacity, reaching 1,228 GW by 2060, compared with 741 GW under BAU. As a result, total power generation investment costs under LCET are significantly higher, amounting to approximately US\$1,966 billion, whereas investment under the BAU scenario is estimated at US\$758 billion by 2060.

**Table A1.2. Power Plant Investment Cost Comparison Between the Business-as-Usual Scenario and the Low-carbon Energy Transition Scenario, 2060**

|                                           | Generation,<br>2021 (TWh) | Generation,<br>BAU, 2060<br>(TWh) | Generation,<br>LCET, 2060<br>(TWh) | Additional<br>Capacity,<br>BAU (MW) | Additional<br>Capacity,<br>LCET (MW) | Total<br>Investment,<br>BAU, 2060<br>(million<br>US\$) | Total<br>Investment,<br>LCET, 2060<br>(million<br>US\$) |
|-------------------------------------------|---------------------------|-----------------------------------|------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------------------------|---------------------------------------------------------|
| Coal PP                                   | 506                       | 1,490                             | 19                                 | 140,483                             | 0                                    | 214,236                                                | 0                                                       |
| Coal PP with<br>biomass co-<br>firing     | 0                         | 143                               | 264                                | 20,387                              | 37,723                               | 32,619                                                 | 60,356                                                  |
| Coal PP with<br>fuel ammonia<br>co-firing | 0                         | 0                                 | 143                                | 0                                   | 20,334                               | 0                                                      | 32,535                                                  |
| Coal PP with<br>CCS                       | 0                         | 0                                 | 354                                | 0                                   | 50,491                               | 0                                                      | 76,998                                                  |
| Oil PP                                    | 16                        | 20                                | 8                                  | 506                                 | 0                                    | 303                                                    | 0                                                       |
| Gas PP                                    | 356                       | 1,828                             | 25                                 | 209,922                             | 0                                    | 146,945                                                | 0                                                       |
| Gas PP with<br>hydrogen co-<br>firing     | 0                         | 0                                 | 950                                | 0                                   | 135,495                              | 0                                                      | 108,396                                                 |
| Gas PP with CCS                           | 0                         | 0                                 | 908                                | 0                                   | 129,527                              | 0                                                      | 90,669                                                  |
| Nuclear PP                                | 0                         | 0                                 | 277                                | 0                                   | 39,542                               | 0                                                      | 141,363                                                 |
| Solar PV                                  | 36                        | 203                               | 721                                | 47,714                              | 195,557                              | 106,068                                                | 434,722                                                 |
| Wind                                      | 11                        | 94                                | 713                                | 19,025                              | 160,389                              | 80,969                                                 | 682,613                                                 |

**Table A1.2. Continued**

|                       | Generation,<br>2021 (TWh) | Generation,<br>BAU, 2060<br>(TWh) | Generation,<br>LCET, 2060<br>(TWh) | Additional<br>Capacity,<br>BAU (MW) | Additional<br>Capacity,<br>LCET (MW) | Total<br>Investment,<br>BAU, 2060<br>(million<br>US\$) | Total<br>Investment,<br>LCET, 2060<br>(million<br>US\$) |
|-----------------------|---------------------------|-----------------------------------|------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------------------------|---------------------------------------------------------|
| Hydro                 | 207                       | 586                               | 751                                | 254,539                             | 364,865                              | 78,144                                                 | 112,013                                                 |
| Geothermal            | 25                        | 117                               | 138                                | 26,351                              | 32,428                               | 32,544                                                 | 40,048                                                  |
| Biomass and<br>others | 21                        | 156                               | 400                                | 21,955                              | 61,762                               | 66,282                                                 | 186,460                                                 |
| <b>Total</b>          | <b>1,179</b>              | <b>4,637</b>                      | <b>5,671</b>                       | <b>740,881</b>                      | <b>1,228,111</b>                     | <b>758,111</b>                                         | <b>1,966,174</b>                                        |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, MW = megawatts, PP = power plant, TWh = terawatt-hours.

Source: Author's calculations.

Hydropower accounts for the largest share of additional generation capacity in both scenarios, reaching 255 GW under BAU and 365 GW under LCET by 2060. Under the BAU scenario, the second- and third-largest additions in capacity are gas-fired power plants (210 GW) and coal-fired power plants (140 GW), respectively. In contrast, under the LCET scenario, solar PV represents the second-largest capacity expansion (196 GW), followed by wind power plants (160 GW).

In terms of investment, coal-fired power plants dominate under BAU, accounting for approximately US\$214 billion, or 28% of total power generation investment by 2060. Under the LCET scenario, however, no additional coal capacity is built between 2021 and 2060, resulting in zero investment in new coal power plants. Instead, the largest investment under LCET is directed toward wind power, totalling US\$682 billion (35% of total investment), followed by solar PV at US\$435 billion (22%).

Nuclear power also plays a more prominent role under LCET, requiring investments of approximately US\$141 billion by 2060, compared with no nuclear investment under BAU. In addition, hydrogen and ammonia co-firing power plants are expected to require around US\$140 billion in investment, representing about 3% of total power generation investment under the LCET scenario.

### 3.3. CCS Costs

The deployment of carbon capture and storage (CCS) technology is a central element of the LCET scenario. CCS is assumed to be introduced from 2030 at an initial commercial stage and progressively scaled up thereafter. Under LCET, CCS is applied to both coal-fired and gas-fired power plants to substantially reduce their carbon emissions. Table A1.3 presents a comparison of CCS costs between the BAU and LCET scenarios in 2060.

**Table A1.3. Cost Comparison of CCS Between the Business-as-Usual Scenario and the Low-carbon Energy Transition Scenario, 2060**

|                  | Consumption<br>LCET, 2060<br>(Mtoe) | Estimated CO <sub>2</sub><br>Emission, LCET,<br>2060 (MtCO <sub>2</sub> ) | Estimated<br>CO <sub>2</sub> Captured,<br>LCET, 2060<br>(MtCO <sub>2</sub> ) | Total CCS<br>Investment<br>Cost, LCET<br>(million US\$) |
|------------------|-------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------|
| Coal PP with CCS | 37.4                                | 139.8                                                                     | 125.8                                                                        | 7,548                                                   |
| Gas PP with CCS  | 80.9                                | 172.4                                                                     | 155.1                                                                        | 9,308                                                   |
| <b>Total</b>     | <b>118.4</b>                        | <b>312.1</b>                                                              | <b>280.9</b>                                                                 | <b>16,855</b>                                           |

BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, MW = megawatts, PP = power plant, TWh = terawatt-hours, MtCO<sub>2</sub> = million tonnes of carbon dioxide, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

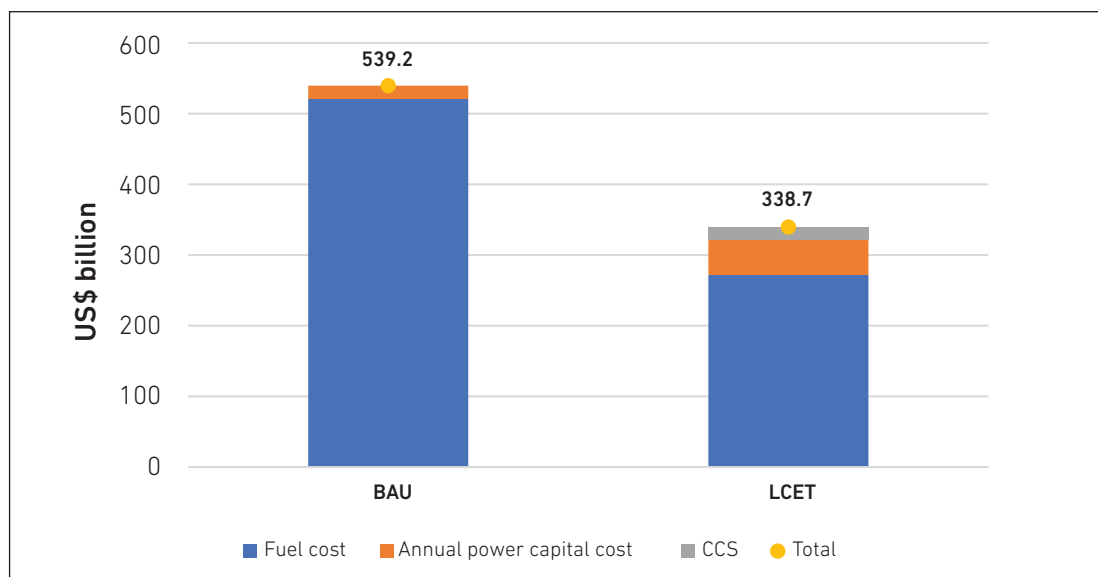
The cost of deploying CCS technology is estimated based on the amount of coal and natural gas consumed in coal-fired and gas-fired power plants equipped with CCS. The assumptions on conversion factors, CCS unit costs, and a capture efficiency of 90% are described in Chapter 1. The resulting volume of CO<sub>2</sub> captured is then used to calculate the total CCS cost, which is estimated at approximately US\$ 16.9 billion per year by 2060. About 55% of this cost is attributable to gas-fired power plants with CCS, with the remainder incurred by coal-fired power plants with CCS.

### 3.4. Total Energy Costs

The results of the cost analysis presented in the previous sections – covering fuel costs, power plant investment costs, and CCS costs – are consolidated here. Power generation investment costs have already been converted to an annualised basis to ensure a consistent comparison of the average annual cost increases or savings expected by 2060 under each scenario. The resulting estimates show the overall annual total costs for both the BAU and LCET scenarios.



**Figure A1.18. Overall Annual Cost Comparison Between the Business-as-Usual Scenario and the Low-carbon Energy Transition Scenario, 2060**



BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PP = power plant.

Source: Author's calculations.

As shown in Figure A1.18, under the BAU scenario, ASEAN Member States would require an additional US\$539 billion annually by 2060 compared with 2021. Approximately 96% of this increase is attributable to higher fuel expenditures, driven mainly by rising demand for and prices of fossil fuels such as coal, oil, and natural gas. The remaining US\$19 billion reflects additional power plant investment needed to meet growing electricity demand.

By contrast, the LCET scenario results in a substantially lower overall cost, generating net annual savings of approximately US\$201 billion by 2060 relative to 2021. Consistent with the findings for the EAS-17 economies discussed in Chapter 1, these savings are primarily driven by reduced reliance on fossil fuels, large-scale deployment of renewable energy, adoption of clean technologies, and improvements in energy efficiency. In particular, annual fuel cost savings under the LCET are estimated at US\$248 billion, which more than offset the additional annual costs associated with higher power generation investment (US\$50 billion) and the deployment of CCS (US\$16 billion).

As with the cost comparison analysis for the EAS-17 economies in Chapter 1, these estimates may understate the total investment requirements under the LCET scenario. Specifically, the analysis does not account for the costs of backup and flexibility solutions – such as battery energy storage systems (BESS) or additional baseload capacity from nuclear and gas-fired power plants equipped with abatement technologies – that may be required to address the intermittency of renewable energy sources.

## 4. Implications and Policy Recommendations

At least six key conclusions can be drawn from the outlook results.

First, under the BAU scenario, energy consumption in ASEAN is projected to increase steadily through 2060, driven by sustained economic growth across the region.

Second, ASEAN Member States have been implementing a range of sector-specific measures to promote the adoption of clean energy technologies and energy sources, as well as to reduce emissions. If these measures enable Member States to achieve their energy efficiency and renewable energy penetration targets over the next three decades, ASEAN as a region could significantly reduce both energy consumption and carbon emissions.

Third, achieving carbon neutrality in ASEAN Member States will require not only the aggressive implementation of energy efficiency and conservation (EEC) measures and the expansion of renewable energy (RE), but also the deployment of advanced low-carbon technologies. These include carbon capture, utilisation, and storage (CCUS/CCS) in power generation and industry, high-efficiency combined-cycle gas turbines (CCGT), and the introduction of new energy carriers such as hydrogen and ammonia for co-firing in natural gas- and coal-fired power plants and in industrial applications. Electrification across final energy-use sectors – particularly transport – is a central element of the LCET scenario. Successful implementation of these low-carbon fuel-switching technologies, energy sources, and carriers would result in carbon emissions in 2060 falling below 2021 levels.

Fourth, at the regional level, ASEAN should advance additional initiatives and programmes to improve energy efficiency and increase the share of renewable energy by accelerating regional collaboration and international co-operation.

Fifth, the promotion of energy efficiency in transport fuels and electricity generation will be essential, alongside ensuring the affordable and reliable deployment of renewable energy. In this context, the parallel use of affordable natural gas can play a supporting role. Establishing an Asia-wide liquefied natural gas (LNG) hub is one potential option to secure a stable and affordable natural gas supply for ASEAN.

Sixth, as the world's fifth-largest economy, ASEAN plays a critical role in global energy consumption and greenhouse gas emissions. Continuous monitoring of energy savings and emissions reductions at the ASEAN level, together with regular updates to the regional energy outlook such as that presented in this chapter, is therefore essential.

Finally, the analysis indicates that the average annual costs of achieving carbon-neutral or net-zero emissions pathways may not necessarily exceed those under the BAU scenario and may even be lower. While higher investment costs for power generation and the deployment of CCS are required, these are largely offset by significantly lower fuel expenditures resulting from reduced fossil fuel use. Nonetheless, future analyses should incorporate investment costs for energy storage systems to provide a more realistic assessment of the overall cost implications.

## References

International Monetary Fund (2025), *Regional Economic Outlook for Asia and Pacific, Regional Economic Outlook*, April. <https://www.imf.org/en/Publications/REO/APAC/Issues/2025/04/24/regional-economic-outlook-for-asia-and-pacific-April-2025>

The World Bank (2025), *World Development Indicators*. <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD> (accessed 26 September 2025).

# ANNEX 2

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## Results Summary Tables

## Australia [BAU]

### Primary energy consumption

|                                | MTOE  |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------------------------|-------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | 1990  | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                          | 86.14 | 113.48 | 130.24 | 132.50 | 131.49 | 131.04 | 128.51 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.3       | 0.2       | -0.1      | 0.0       | -0.2      | 0.0       |
| Coal                           | 34.89 | 51.03  | 40.22  | 31.17  | 27.50  | 25.65  | 23.78  | 40.5 | 45.0 | 30.9 | 23.5 | 20.9 | 19.6 | 18.5 | 0.5       | -2.8      | -1.2      | -0.7      | -0.8      | -1.3      |
| Oil                            | 31.20 | 36.91  | 42.45  | 45.49  | 42.67  | 39.50  | 35.94  | 36.2 | 32.5 | 32.6 | 34.3 | 32.5 | 30.1 | 28.0 | 1.0       | 0.8       | -0.6      | -0.8      | -0.9      | -0.4      |
| Natural gas                    | 14.79 | 18.97  | 36.54  | 38.08  | 40.60  | 42.93  | 43.71  | 17.2 | 16.7 | 28.1 | 28.7 | 30.9 | 32.8 | 34.0 | 3.0       | 0.5       | 0.6       | 0.6       | 0.2       | 0.5       |
| Hydrogen                       | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Fuel Ammonia                   | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear                        | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Hydro                          | 1.22  | 1.32   | 1.27   | 1.49   | 1.51   | 1.52   | 1.54   | 1.4  | 1.2  | 1.0  | 1.1  | 1.1  | 1.2  | 1.2  | 0.1       | 1.8       | 0.1       | 0.1       | 0.1       | 0.5       |
| Geothermal                     | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | 0.0       | 0.0       | 0.0       |           |
| Others                         | 4.04  | 5.25   | 9.76   | 16.27  | 19.21  | 21.44  | 23.53  | 4.7  | 4.6  | 7.5  | 12.3 | 14.6 | 16.4 | 18.3 | 2.9       | 5.8       | 1.7       | 1.1       | 0.9       | 2.3       |
| Biomass                        | 3.96  | 4.90   | 4.28   | 4.39   | 4.38   | 4.29   | 4.25   | 4.6  | 4.3  | 3.3  | 3.3  | 3.3  | 3.3  | 3.3  | 0.3       | 0.3       | 0.0       | -0.2      | -0.1      | 0.0       |
| Solar.Wind. Ocean              | 0.08  | 0.15   | 0.46   | 11.11  | 13.87  | 16.00  | 18.11  | 0.1  | 0.1  | 3.8  | 8.4  | 10.5 | 12.2 | 14.1 | 14.2      | 9.4       | 2.2       | 1.4       | 1.3       | 3.4       |
| Biofuels                       | 0.00  | 0.20   | 0.52   | 0.77   | 0.97   | 1.15   | 1.16   | 0.0  | 0.2  | 0.4  | 0.6  | 0.7  | 0.9  | 0.9  | -         | 4.6       | 2.2       | 1.7       | 0.1       | 2.1       |
| Electricity (Import or Export) | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | 26.0      | 7.8       | -1.9      | -1.5      | 6.6       |

### Final energy demand

|              | MTOE  |       |       |       |       |       |       |      |      |      |      |      |      |      | AAGR (%)  |           |           |           |           |           |
|--------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 56.66 | 72.23 | 78.98 | 85.68 | 87.11 | 87.52 | 87.08 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.1       | 0.9       | 0.2       | 0.0       | -0.1      | 0.3       |
| Industry     | 19.32 | 22.27 | 22.83 | 25.85 | 27.61 | 28.31 | 28.24 | 34.1 | 30.8 | 28.9 | 30.2 | 31.7 | 32.3 | 32.4 | 0.5       | 1.4       | 0.7       | 0.2       | 0.0       | 0.5       |
| Transport    | 21.11 | 27.14 | 29.86 | 32.09 | 30.70 | 29.25 | 27.48 | 37.3 | 37.6 | 37.8 | 37.5 | 35.2 | 33.4 | 31.6 | 1.1       | 0.8       | -0.4      | -0.5      | -0.6      | -0.2      |
| Others       | 12.27 | 17.83 | 20.98 | 22.21 | 23.08 | 24.13 | 25.29 | 21.7 | 24.7 | 26.6 | 25.9 | 26.5 | 27.6 | 29.0 | 1.7       | 0.6       | 0.4       | 0.4       | 0.5       | 0.5       |
| Non-energy   | 3.95  | 4.99  | 5.31  | 5.53  | 5.71  | 5.83  | 6.08  | 7.0  | 6.9  | 6.7  | 6.4  | 6.6  | 6.7  | 7.0  | 1.0       | 0.4       | 0.3       | 0.2       | 0.4       | 0.3       |
| Total        | 56.66 | 72.23 | 78.98 | 85.68 | 87.11 | 87.52 | 87.08 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.1       | 0.9       | 0.2       | 0.0       | -0.1      | 0.3       |
| Coal         | 4.56  | 3.90  | 2.71  | 2.78  | 2.82  | 2.70  | 2.56  | 8.0  | 5.4  | 3.4  | 3.2  | 3.2  | 3.1  | 2.9  | -1.7      | 0.3       | 0.2       | -0.4      | -0.6      | -0.1      |
| Oil          | 29.00 | 36.55 | 40.84 | 42.70 | 40.45 | 37.92 | 34.94 | 51.2 | 50.6 | 51.7 | 49.8 | 46.6 | 43.3 | 40.1 | 1.1       | 0.5       | -0.5      | -0.7      | -0.8      | -0.4      |
| Natural gas  | 8.66  | 12.33 | 12.59 | 13.15 | 13.46 | 13.42 | 13.09 | 15.3 | 17.1 | 15.9 | 15.4 | 15.5 | 15.3 | 15.0 | 1.2       | 0.5       | 0.2       | 0.0       | -0.2      | 0.1       |
| Hydrogen     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -1.2      | 5.5       | -2.1      | -         |
| Fuel Ammonia | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Electricity  | 11.11 | 16.27 | 18.60 | 22.77 | 25.91 | 29.08 | 32.19 | 19.6 | 22.5 | 23.6 | 26.6 | 29.7 | 33.2 | 37.0 | 1.7       | 2.3       | 1.3       | 1.2       | 1.0       | 1.4       |
| Heat         | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Others       | 3.33  | 3.18  | 4.23  | 4.29  | 4.35  | 4.39  | 4.30  | 5.9  | 4.4  | 5.4  | 5.0  | 5.0  | 5.0  | 4.9  | 0.8       | 0.2       | 0.1       | 0.1       | -0.2      | 0.0       |

### Power generation Output

|                                     | TWh    |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990   | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 154.29 | 228.35 | 265.12 | 322.72 | 362.13 | 399.20 | 433.58 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.8       | 2.2       | 1.2       | 1.0       | 0.8       | 1.3       |
| Coal PP                             | 121.48 | 181.60 | 140.31 | 119.15 | 114.28 | 111.77 | 106.66 | 78.7 | 79.5 | 52.9 | 36.9 | 31.6 | 28.0 | 24.6 | 0.5       | -1.8      | -0.4      | -0.2      | -0.5      | -0.7      |
| Coal PP with biomass co-firing      | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Coal PP with CCS                    | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Oil                                 | 3.55   | 2.84   | 4.66   | 3.52   | 3.10   | 2.70   | 2.21   | 2.3  | 1.2  | 1.8  | 1.1  | 0.9  | 0.7  | 0.5  | 0.9       | -3.1      | -1.3      | -1.4      | -2.0      | -1.9      |
| Gas PP                              | 14.36  | 23.80  | 49.78  | 54.51  | 66.31  | 80.99  | 95.66  | 9.3  | 10.4 | 18.8 | 16.9 | 18.3 | 20.3 | 22.1 | 4.1       | 1.0       | 2.0       | 2.0       | 1.7       | 1.7       |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Gas PP with CCS                     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear PP                          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Solar PV                            | 0.00   | 0.08   | 27.72  | 63.90  | 81.05  | 93.67  | 106.28 | 0.0  | 0.0  | 10.5 | 19.8 | 22.4 | 23.5 | 24.5 | -         | 9.7       | 2.4       | 1.5       | 1.3       | 3.5       |
| Wind                                | 0.00   | 0.89   | 24.54  | 59.95  | 74.99  | 87.20  | 99.40  | 0.0  | 0.4  | 9.3  | 18.6 | 20.7 | 21.8 | 22.9 | -         | 10.4      | 2.3       | 1.5       | 1.3       | 3.7       |
| Hydro                               | 14.15  | 15.31  | 14.76  | 17.30  | 17.52  | 17.73  | 17.95  | 9.2  | 6.7  | 5.6  | 5.4  | 4.8  | 4.4  | 4.1  | 0.1       | 1.8       | 0.1       | 0.1       | 0.1       | 0.5       |
| Geothermal                          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | 0.0       | 0.0       | 0.0       | -         |
| Biomass and others                  | 0.75   | 3.83   | 3.35   | 4.39   | 4.87   | 5.15   | 5.43   | 0.5  | 1.7  | 1.3  | 1.4  | 1.3  | 1.3  | 1.3  | 4.9       | 3.1       | 1.1       | 0.6       | 0.5       | 1.2       |

### Power generation Input

|                      | MTOE  |       |       |       |       |       |       |      |      |      |      |      |      |      | AAGR (%)  |           |           |           |           |           |
|----------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                      | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                | 33.30 | 51.37 | 47.37 | 39.66 | 36.93 | 36.32 | 35.64 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.1       | -2.0      | -0.7      | -0.2      | -0.2      | -0.7      |
| Coal                 | 28.88 | 45.14 | 35.05 | 25.84 | 22.14 | 20.41 | 18.71 | 86.7 | 87.9 | 74.0 | 65.2 | 59.9 | 56.2 | 52.5 | 0.6       | -3.3      | -1.5      | -0.8      | -0.9      | -1.6      |
| Fuel ammonia         | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass (Co-firing)  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Oil                  | 0.95  | 0.82  | 1.07  | 0.83  | 0.72  | 0.60  | 0.48  | 2.8  | 1.6  | 2.3  | 2.1  | 1.9  | 1.7  | 1.3  | 0.4       | -2.8      | -1.4      | -1.7      | -2.4      | -2.1      |
| Gas                  | 3.47  | 5.41  | 11.25 | 11.67 | 12.65 | 13.85 | 14.95 | 10.4 | 10.5 | 23.7 | 29.4 | 34.2 | 38.1 | 42.0 | 3.9       | 0.4       | 0.8       | 0.9       | 0.8       | 0.7       |
| Hydrogen             | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass (Biomass PP) | 0.00  | 0.00  | 0.00  | 1.32  | 1.43  | 1.46  | 1.50  | 0.0  | 0.0  | 0.0  | 3.3  | 3.9  | 4.0  | 4.2  | -         | -         | 0.8       | 0.3       | 0.2       |           |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total      | 36.2 | 35.5 | 36.0 | 39.4 | 43.9 | 47.5 | 50.7 |  |  |  |  |  |  |  |  |  |  | 0.0       | 1.0       | 1.1       | 0.8       | 0.6       | 0.9       |
| Coal PP    | 36.2 | 34.6 | 34.4 | 39.7 | 44.4 | 47.1 | 49.0 |  |  |  |  |  |  |  |  |  |  | -0.2      | 1.6       | 1.1       | 0.6       | 0.4       | 0.9       |
| Oil PP     | 32.3 | 29.6 | 37.4 | 36.6 | 37.1 | 38.5 | 39.9 |  |  |  |  |  |  |  |  |  |  | 0.5       | -0.2      | 0.1       | 0.4       | 0.4       | 0.2       |
| Gas PP     | 35.6 | 37.9 | 38.1 | 40.2 | 45.1 | 50.3 | 55.0 |  |  |  |  |  |  |  |  |  |  |           |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 28.5 | 29.4 | 30.3 | 31.2 |  |  |  |  |  |  |  |  |  |  | -         | -         | 0.3       | 0.3       | 0.3       |           |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>256.1</b>       | <b>359.1</b> | <b>360.9</b> | <b>328.4</b> | <b>311.3</b> | <b>300.1</b> | <b>283.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-1.0</b> | <b>-0.5</b> | <b>-0.4</b> | <b>-0.6</b> | <b>-0.6</b> |
| Coal         | 139.2              | 212.2        | 161.4        | 121.8        | 107.3        | 100.0        | 92.7         | 54.3       | 59.1       | 44.7       | 37.1       | 34.5       | 33.3       | 32.7       | 0.5        | -3.1        | -1.3        | -0.7        | -0.8        | -1.4        |
| Oil          | 83.2               | 102.1        | 116.0        | 122.0        | 113.9        | 105.0        | 94.1         | 32.5       | 28.4       | 32.1       | 37.2       | 36.6       | 35.0       | 33.2       | 1.1        | 0.6         | -0.7        | -0.8        | -1.1        | -0.5        |
| Natural Gas  | 33.8               | 44.8         | 83.5         | 84.6         | 90.0         | 95.1         | 96.5         | 13.2       | 12.5       | 23.1       | 25.8       | 28.9       | 31.7       | 34.1       | 3.0        | 0.1         | 0.6         | 0.6         | 0.1         | 0.4         |
| CCS/DAC (-)  | 0.0                | 0.0          | 0.0          | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 570   | 928   | 1,376 | 1,690 | 2,143 | 2,665 | 3,251 | 2.9       | 2.3       | 2.4       | 2.2       | 2.0       | 2.2       |
| Population (millions of people)                                                           | 17    | 20    | 26    | 28    | 30    | 32    | 34    | 1.3       | 0.9       | 0.7       | 0.6       | 0.5       | 0.7       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 33.38 | 45.97 | 53.58 | 60.45 | 71.12 | 83.34 | 96.95 | 1.5       | 1.3       | 1.6       | 1.6       | 1.5       | 1.5       |
| Primary energy consumption per capita (toe/person)                                        | 5.05  | 5.62  | 5.07  | 4.74  | 4.36  | 4.10  | 3.83  | 0.0       | -0.8      | -0.8      | -0.6      | -0.7      | -0.7      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 151   | 122   | 95    | 78    | 61    | 49    | 40    | -1.5      | -2.1      | -2.4      | -2.2      | -2.2      | -2.2      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 99    | 78    | 57    | 51    | 41    | 33    | 27    | -1.8      | -1.4      | -2.2      | -2.1      | -2.0      | -1.9      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 450   | 387   | 262   | 194   | 145   | 113   | 87    | -1.7      | -3.3      | -2.9      | -2.5      | -2.5      | -2.8      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.97  | 3.16  | 2.77  | 2.48  | 2.37  | 2.29  | 2.20  | -0.2      | -1.2      | -0.5      | -0.3      | -0.4      | -0.6      |
| Automobile ownership volume (millions of vehicles)                                        | 10    | 13    | 19    | 21    | 23    | 25    | 27    | 2.2       | 1.1       | 0.9       | 0.7       | 0.6       | 0.8       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.573 | 0.669 | 0.749 | 0.760 | 0.771 | 0.782 | 0.793 | 0.9       | 0.2       | 0.1       | 0.1       | 0.1       | 0.1       |

## Australia [LCET]

### Primary energy consumption

|                                | MTOE         |               |               |               |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |            |
|--------------------------------|--------------|---------------|---------------|---------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|------------|
|                                | 1990         | 2005          | 2021          | 2030          | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060  |
| <b>Total</b>                   | <b>86.14</b> | <b>113.48</b> | <b>130.24</b> | <b>106.56</b> | <b>91.75</b> | <b>88.28</b> | <b>90.04</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.3</b> | <b>-2.2</b> | <b>-1.5</b> | <b>-0.4</b> | <b>0.2</b> |
| Coal                           | 34.89        | 51.03         | 40.22         | 14.39         | 11.88        | 6.37         | 5.76         | 40.5       | 45.0       | 30.9       | 13.5       | 12.9       | 7.2        | 6.4        | 0.5        | -10.8       | -1.9        | -6.0        | -1.0       |
| Oil                            | 31.20        | 36.91         | 42.45         | 33.71         | 15.55        | 2.94         | 2.01         | 36.2       | 32.5       | 32.6       | 31.6       | 16.9       | 3.3        | 2.2        | 1.0        | -2.5        | -7.4        | -15.3       | -3.7       |
| Natural gas                    | 14.79        | 18.97         | 36.54         | 27.88         | 22.72        | 23.06        | 21.46        | 17.2       | 16.7       | 28.1       | 26.2       | 24.8       | 26.1       | 23.8       | 3.0        | -3.0        | -2.0        | 0.1         | -0.7       |
| Hydrogen                       | 0.00         | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.21         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.2        | -          | -           | -           | 288.5       | -          |
| Fuel Ammonia                   | 0.00         | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          |
| Nuclear                        | 0.00         | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          |
| Hydro                          | 1.22         | 1.32          | 1.27          | 1.53          | 1.76         | 1.81         | 1.72         | 1.4        | 1.2        | 1.0        | 1.4        | 1.9        | 2.1        | 1.9        | 0.1        | 2.1         | 1.4         | 0.3         | -0.5       |
| Geothermal                     | 0.00         | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | 0.6         | 0.2         | -0.6       |
| Others                         | 4.04         | 5.25          | 9.76          | 29.05         | 39.85        | 54.10        | 58.87        | 4.7        | 4.6        | 7.5        | 27.3       | 43.4       | 61.3       | 65.4       | 2.9        | 12.9        | 3.2         | 3.1         | 0.8        |
| Biomass                        | 3.96         | 4.90          | 4.28          | 5.10          | 5.19         | 5.51         | 5.10         | 4.6        | 4.3        | 3.3        | 4.8        | 5.7        | 6.2        | 5.7        | 0.3        | 2.0         | 0.2         | 0.6         | -0.8       |
| Solar Wind Ocean               | 0.08         | 0.15          | 4.96          | 23.27         | 32.48        | 44.98        | 50.10        | 0.1        | 0.1        | 3.8        | 21.8       | 35.4       | 50.9       | 55.6       | 14.2       | 18.7        | 3.4         | 3.3         | 1.1        |
| Biofuels                       | 0.00         | 0.02          | 0.52          | 0.68          | 2.17         | 3.62         | 3.67         | 0.0        | 0.2        | 0.4        | 0.6        | 2.4        | 4.1        | 4.1        | -          | 3.1         | 12.3        | 5.2         | 0.1        |
| Electricity (Import or Export) | 0.00         | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | 8.0         | 9.6         | -2.2        | 0.0        |

### Final energy demand

|              | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|              | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>56.66</b> | <b>72.23</b> | <b>78.98</b> | <b>74.78</b> | <b>62.44</b> | <b>52.86</b> | <b>50.05</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-0.6</b> | <b>-1.8</b> | <b>-1.7</b> | <b>-0.5</b> |
| Industry     | 19.32        | 22.27        | 22.83        | 24.22        | 22.41        | 19.04        | 15.56        | 34.1       | 30.8       | 28.9       | 32.4       | 35.9       | 36.0       | 31.1       | 0.5        | 0.7         | -0.8        | -1.6        | -2.0        |
| Transport    | 21.11        | 27.14        | 29.86        | 26.57        | 18.91        | 15.01        | 15.53        | 37.3       | 37.6       | 37.8       | 35.5       | 30.3       | 28.4       | 31.0       | 1.1        | -1.3        | -3.3        | -2.3        | 0.3         |
| Others       | 12.27        | 17.83        | 20.98        | 18.47        | 15.40        | 12.77        | 12.88        | 21.7       | 24.7       | 26.6       | 24.7       | 24.7       | 24.2       | 25.7       | 1.7        | -1.4        | -1.8        | -1.9        | 0.1         |
| Non-energy   | 3.95         | 4.99         | 5.31         | 5.53         | 5.71         | 6.04         | 6.08         | 7.0        | 6.9        | 6.7        | 7.4        | 9.1        | 11.4       | 12.1       | 1.0        | 0.4         | 0.3         | 0.6         | 0.1         |
| <b>Total</b> | <b>56.66</b> | <b>72.23</b> | <b>78.98</b> | <b>74.78</b> | <b>62.44</b> | <b>52.86</b> | <b>50.05</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-0.6</b> | <b>-1.8</b> | <b>-1.7</b> | <b>-0.5</b> |
| Coal         | 4.56         | 3.90         | 2.71         | 2.28         | 1.40         | 0.59         | 0.32         | 8.0        | 5.4        | 3.4        | 3.1        | 2.2        | 1.1        | 0.6        | -1.7       | -1.9        | -4.8        | -8.3        | -5.9        |
| Oil          | 29.00        | 36.55        | 40.84        | 32.16        | 16.66        | 5.10         | 4.48         | 51.2       | 50.6       | 51.7       | 43.0       | 26.7       | 9.7        | 9.0        | 1.1        | -2.6        | -6.4        | -11.2       | -1.3        |
| Natural gas  | 8.66         | 12.33        | 12.59        | 10.49        | 6.31         | 3.07         | 2.21         | 15.3       | 17.1       | 15.9       | 14.0       | 10.1       | 5.8        | 4.4        | 1.2        | -2.0        | -5.0        | -6.9        | -3.3        |
| Hydrogen     | 0.00         | 0.00         | 0.00         | 0.56         | 1.89         | 3.12         | 3.28         | 0.0        | 0.0        | 0.0        | 33.2       | 3.0        | 5.9        | 6.6        | -          | -           | -22.7       | 5.1         | 0.5         |
| Fuel Ammonia | 0.00         | 0.00         | 0.00         | 0.42         | 3.04         | 4.83         | 5.36         | 0.0        | 0.0        | 0.0        | 0.0        | 4.9        | 9.1        | 10.7       | -          | -           | -           | 4.7         | 1.1         |
| Electricity  | 11.11        | 16.27        | 18.60        | 24.85        | 28.25        | 30.39        | 29.23        | 19.6       | 22.5       | 23.6       | 0.0        | 45.3       | 57.5       | 58.4       | 1.7        | -100.0      | -           | 0.7         | -0.4        |
| Heat         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 5.4        | 0.0        | 0.0        | 0.0        | -          | -           | -100.0      | -           | -           |
| Others       | 3.33         | 3.18         | 4.23         | 4.01         | 4.89         | 5.76         | 5.18         | 5.9        | 4.4        | 5.4        | 0.0        | 7.8        | 10.9       | 10.3       | 0.8        | -           | -           | 1.7         | -1.1        |

### Power generation Output

|                                     | TWh           |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>154.29</b> | <b>228.35</b> | <b>265.12</b> | <b>355.07</b> | <b>481.19</b> | <b>651.86</b> | <b>714.14</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.8</b> | <b>3.3</b> | <b>3.1</b> | <b>3.1</b> | <b>0.9</b> |
| Coal PP                             | 121.48        | 181.60        | 140.31        | 38.35         | 16.24         | 0.00          | 0.00          | 78.7       | 79.5       | 52.9       | 10.8       | 3.4        | 0.0        | 0.0        | 0.5        | -13.4      | -8.2       | -100.0     | -          |
| Coal PP with biomass co-firing      | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00          | 0.00          | 0.00          | 4.26          | 19.85         | 19.56         | 21.42         | 0.0        | 0.0        | 0.0        | 1.2        | 4.1        | 3.0        | 3.0        | -          | -          | 16.6       | -0.1       | 0.9        |
| Oil                                 | 3.55          | 2.84          | 4.66          | 2.33          | 0.00          | 0.00          | 0.00          | 2.3        | 1.2        | 1.8        | 0.7        | 0.0        | 0.0        | 0.0        | 0.9        | -7.4       | -71.0      | -100.0     | -          |
| Gas PP                              | 14.36         | 23.80         | 49.78         | 17.07         | 14.07         | 0.00          | 0.00          | 9.3        | 10.4       | 18.8       | 4.8        | 2.9        | 0.0        | 0.0        | 4.1        | -11.2      | -1.9       | -100.0     | -          |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00          | 0.00          | 0.00          | 9.62          | 16.30         | 17.85         | 0.0        | 0.0        | 0.0        | 0.0        | 2.0        | 2.5        | 2.5        | -          | -          | -          | 5.4        | 0.9        |
| Gas PP with CCS                     | 0.00          | 0.00          | 0.00          | 1.90          | 17.20         | 61.93         | 60.70         | 0.0        | 0.0        | 0.0        | 0.5        | 3.6        | 9.5        | 8.5        | -          | -          | 24.7       | 13.7       | -0.2       |
| Nuclear PP                          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00          | 0.08          | 27.72         | 116.27        | 163.77        | 238.54        | 267.23        | 0.0        | 0.0        | 10.5       | 32.7       | 34.0       | 36.6       | 37.4       | -          | 17.3       | 3.5        | 3.8        | 1.1        |
| Wind                                | 0.00          | 0.89          | 24.54         | 150.04        | 210.35        | 281.42        | 312.62        | 0.0        | 0.4        | 9.3        | 42.3       | 43.7       | 43.2       | 43.8       | -          | 22.3       | 3.4        | 3.0        | 1.1        |
| Hydro                               | 14.15         | 15.31         | 14.76         | 17.75         | 20.45         | 21.08         | 20.03         | 9.2        | 6.7        | 5.6        | 5.0        | 4.3        | 3.2        | 2.8        | 0.1        | 2.1        | 1.4        | 0.3        | -0.5       |
| Geothermal                          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | 0.6        | 0.2        | -0.6       |
| Biomass and others                  | 0.75          | 3.83          | 3.35          | 7.10          | 9.62          | 13.04         | 14.28         | 0.5        | 1.7        | 1.3        | 2.0        | 2.0        | 2.0        | 2.0        | 4.9        | 8.7        | 3.1        | 3.1        | 0.9        |

### Power generation Input

|                      | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |              |            |            |             |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|------------|------------|-------------|
|                      | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030    | 2030-2040  | 2040-2050  | 2050-2060   |
| <b>Total</b>         | <b>33.30</b> | <b>51.37</b> | <b>47.37</b> | <b>16.08</b> | <b>18.86</b> | <b>22.49</b> | <b>20.11</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-11.3</b> | <b>1.6</b> | <b>1.8</b> | <b>-1.1</b> |
| Coal                 | 28.88        | 45.14        | 35.05        | 9.32         | 7.61         | 3.97         | 3.92         | 86.7       | 87.9       | 74.0       | 58.0       | 40.3       | 17.7       | 19.5       | 0.6        | -13.7        | -2.0       | -6.3       | -0.1        |
| Fuel ammonia         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -            | -          | -          | -           |
| Biomass (Co-firing)  | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -            | -          | -          | -           |
| Oil                  | 0.95         | 0.82         | 1.07         | 0.55         | 0.00         | 0.00         | 0.00         | 2.8        | 1.6        | 2.3        | 3.4        | 0.0        | 0.0        | 0.0        | 0.4        | -7.2         | -70.1      | -100.0     | -           |
| Gas                  | 3.47         | 5.41         | 11.25        | 4.09         | 6.63         | 12.15        | 9.85         | 10.4       | 10.5       | 23.7       | 25.4       | 35.1       | 54.0       | 49.0       | 3.9        | -10.6        | 4.9        | 6.2        | -2.1        |
| Hydrogen             | 0.00         | 0.00         | 0.00         | 0.00         | 1.86         | 2.76         | 2.56         | 0.0        | 0.0        | 0.0        | 0.0        | 9.8        | 12.3       | 12.7       | -          | -            | -          | 4.1        | -0.8        |
| Biomass (Biomass PP) | 0.00         | 0.00         | 0.00         | 2.12         | 2.77         | 3.60         | 3.79         | 0.0        | 0.0        | 0.0        | 13.2       | 14.7       | 16.0       | 18.9       | -          | -            | 2.7        | 2.7        | 0.5         |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |  |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|--|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |  |
| Total      | 36.2 | 35.5 | 36.0 | 38.0 | 39.5 | 42.4 | 48.9 |  |  |  |  |  |  |  | 0.0       | 0.6       | 0.4       | 0.7       | 1.4       |  |
| Coal PP    | 36.2 | 34.6 | 34.4 | 39.3 | 40.8 | 42.3 | 47.0 |  |  |  |  |  |  |  | -0.2      | 1.5       | 0.4       | 0.4       | 1.1       |  |
| Oil PP     | 32.3 | 29.6 | 37.4 | 36.7 | 26.7 | -    | -    |  |  |  |  |  |  |  | 0.5       | -0.2      | -3.1      | -         | -         |  |
| Gas PP     | 35.6 | 37.9 | 38.1 | 39.9 | 41.5 | 45.1 | 54.5 |  |  |  |  |  |  |  |           |           |           |           |           |  |
| Biomass PP | -    | -    | -    | 28.8 | 29.9 | 31.1 | 32.4 |  |  |  |  |  |  |  | -         | -         | 0.4       | 0.4       | 0.4       |  |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |             |            |             |            |            |            |            |            |            |            | AAGR(%)    |             |             |              |           |               |
|--------------|--------------------|--------------|--------------|--------------|-------------|------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|-----------|---------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040        | 2050       | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050    | 2050-2060 | 2021-2060     |
| <b>Total</b> | <b>256.1</b>       | <b>359.1</b> | <b>360.9</b> | <b>198.2</b> | <b>87.8</b> | <b>5.3</b> | <b>-4.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-6.4</b> | <b>-7.8</b> | <b>-24.4</b> | <b>-</b>  | <b>-189.4</b> |
| Coal         | 139.2              | 212.2        | 161.4        | 51.3         | 22.9        | 2.7        | 1.0         | 54.3       | 59.1       | 44.7       | 25.9       | 26.1       | 50.5       | -21.9      | 0.5        | -11.9       | -7.8        | -19.3        | -9.6      | -12.3         |
| Oil          | 83.2               | 102.1        | 116.0        | 87.0         | 29.9        | 0.0        | 0.0         | 32.5       | 28.4       | 32.1       | 43.9       | 34.0       | 0.0        | 0.0        | 1.1        | -3.2        | -10.1       | -100.0       | -         | -100.0        |
| Natural Gas  | 33.8               | 44.8         | 83.5         | 59.9         | 35.7        | 7.7        | 5.2         | 13.2       | 12.5       | 23.1       | 30.2       | 40.6       | 144.4      | -116.2     | 3.0        | -3.6        | -5.0        | -14.2        | -3.8      | -6.9          |
| CCS/DAC (-)  | 0.0                | 0.0          | 0.0          | 0.0          | -0.6        | -5.1       | -10.7       | 0.0        | 0.0        | 0.0        | 0.0        | -0.7       | -94.8      | 238.2      | -          | -           | -           | 22.8         | 7.7       | -             |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 570   | 928   | 1,376 | 1,690 | 2,143 | 2,665 | 3,251  | 2.9       | 2.3       | 2.4       | 2.2       | 2.0       | 2.2       |
| Population (millions of people)                                                           | 17    | 20    | 26    | 28    | 30    | 32    | 34     | 1.3       | 0.9       | 0.7       | 0.6       | 0.5       | 0.7       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 33.38 | 45.97 | 53.58 | 60.45 | 71.12 | 83.34 | 96.95  | 1.5       | 1.3       | 1.6       | 1.6       | 1.5       | 1.5       |
| Primary energy consumption per capita (toe/person)                                        | 5.05  | 5.62  | 5.07  | 3.81  | 3.05  | 2.76  | 2.69   | 0.0       | -3.1      | -2.2      | -1.0      | -0.3      | -1.6      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 151   | 122   | 95    | 63    | 43    | 33    | 28     | -1.5      | -4.4      | -3.8      | -2.5      | -1.8      | -3.1      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 99    | 78    | 57    | 44    | 29    | 20    | 15     | -1.8      | -2.8      | -4.1      | -3.8      | -2.5      | -3.3      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 450   | 387   | 262   | 117   | 41    | 2     | (1)    | -1.7      | -8.6      | -10.0     | -26.1     | -         | -187.4    |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.97  | 3.16  | 2.77  | 1.86  | 0.96  | 0.06  | (0.05) | -0.2      | -4.3      | -6.4      | -24.1     | -         | -190.2    |
| Automobile ownership volume (millions of vehicles)                                        | 10    | 13    | 19    | 21    | 23    | 25    | 27     | 2.2       | 1.1       | 0.9       | 0.7       | 0.6       | 0.8       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.573 | 0.669 | 0.749 | 0.760 | 0.771 | 0.782 | 0.793  | 0.9       | 0.2       | 0.1       | 0.1       | 0.1       | 0.1       |



## Brunei [BAU]

### Primary energy consumption

|                                | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>1.28</b> | <b>2.86</b> | <b>4.35</b> | <b>6.52</b> | <b>6.84</b> | <b>7.07</b> | <b>7.60</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.0</b> | <b>4.6</b> | <b>0.5</b> | <b>0.3</b> | <b>0.7</b> | <b>1.4</b> |
| Coal                           | 0.00        | 0.00        | 0.70        | 1.39        | 1.39        | 1.39        | 1.39        | 0.0        | 0.0        | 16.0       | 21.3       | 20.3       | 19.7       | 18.3       | -          | 8.0        | 0.0        | 0.0        | 0.0        | 1.8        |
| Oil                            | 0.08        | 0.52        | 1.28        | 1.76        | 1.98        | 2.15        | 2.33        | 6.6        | 18.0       | 29.4       | 27.0       | 28.9       | 30.4       | 30.7       | 9.2        | 3.6        | 1.2        | 0.8        | 0.8        | 1.5        |
| Natural gas                    | 1.19        | 2.34        | 2.37        | 3.36        | 3.45        | 3.51        | 3.86        | 93.4       | 82.0       | 54.6       | 51.5       | 50.4       | 49.7       | 50.8       | 2.2        | 3.9        | 0.3        | 0.2        | 0.9        | 1.3        |
| Hydrogen                       |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Geothermal                     |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 0.00        | 0.00        | 0.00        | 0.01        | 0.02        | 0.02        | 0.02        | 0.0        | 0.0        | 0.0        | 0.2        | 0.3        | 0.3        | 0.3        | -          | 47.8       | 4.7        | 0.4        | 0.4        | 10.9       |
| Biomass                        |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Solar Wind. Ocean              | 0.00        | 0.00        | 0.00        | 0.01        | 0.02        | 0.02        | 0.02        | 0.0        | 0.0        | 0.0        | 0.2        | 0.3        | 0.3        | 0.3        | -          | 47.9       | 4.7        | 0.4        | 0.4        | 10.9       |
| Biofuels                       | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | 4.807.0    | 0.0        | 0.0        | 0.0        | 145.6      |

### Final energy demand

|              | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>0.35</b> | <b>0.67</b> | <b>1.88</b> | <b>3.64</b> | <b>3.92</b> | <b>4.13</b> | <b>4.33</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.6</b> | <b>7.6</b> | <b>0.7</b> | <b>0.5</b> | <b>0.5</b> | <b>2.2</b> |
| Industry     | 0.06        | 0.07        | 0.65        | 1.23        | 1.28        | 1.30        | 1.32        | 17.4       | 9.8        | 34.8       | 33.7       | 32.6       | 31.6       | 30.6       | 7.9        | 7.3        | 0.4        | 0.2        | 0.1        | 1.8        |
| Transport    | 0.19        | 0.34        | 0.41        | 0.58        | 0.76        | 0.90        | 1.07        | 53.6       | 51.3       | 21.6       | 16.0       | 19.3       | 21.8       | 24.6       | 2.5        | 4.1        | 2.6        | 1.8        | 1.7        | 2.5        |
| Others       | 0.09        | 0.25        | 0.35        | 0.53        | 0.58        | 0.62        | 0.64        | 24.2       | 37.0       | 18.5       | 14.4       | 14.9       | 14.9       | 14.7       | 4.6        | 4.7        | 1.0        | 0.6        | 0.3        | 1.6        |
| Non-energy   | 0.02        | 0.01        | 0.47        | 1.30        | 1.30        | 1.30        | 1.30        | 4.8        | 1.9        | 25.1       | 35.8       | 33.3       | 31.6       | 30.1       | 11.3       | 12.0       | 0.0        | 0.0        | 0.0        | 2.6        |
| <b>Total</b> | <b>0.35</b> | <b>0.67</b> | <b>1.88</b> | <b>3.64</b> | <b>3.92</b> | <b>4.13</b> | <b>4.33</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.6</b> | <b>7.6</b> | <b>0.7</b> | <b>0.5</b> | <b>0.5</b> | <b>2.2</b> |
| Coal         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil          | 0.26        | 0.42        | 0.57        | 0.86        | 1.08        | 1.25        | 1.43        | 75.0       | 62.6       | 30.4       | 23.5       | 27.4       | 30.2       | 32.9       | 2.6        | 4.6        | 2.3        | 1.5        | 1.4        | 2.4        |
| Natural gas  | 0.00        | 0.02        | 0.49        | 1.33        | 1.33        | 1.34        | 1.34        | 0.0        | 3.5        | 25.9       | 36.4       | 34.0       | 32.4       | 30.9       | -          | 11.8       | 0.0        | 0.0        | 0.0        | 2.6        |
| Hydrogen     |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 0.09        | 0.23        | 0.49        | 0.80        | 0.86        | 0.89        | 0.91        | 25.0       | 33.9       | 26.3       | 22.1       | 21.9       | 21.6       | 21.1       | 5.8        | 5.6        | 0.6        | 0.4        | 0.2        | 1.6        |
| Heat         |             |             | 0.33        | 0.65        | 0.65        | 0.65        | 0.65        | 0.0        | 0.0        | 17.4       | 17.9       | 16.6       | 15.8       | 15.1       | -          | 8.0        | 0.0        | 0.0        | 0.0        | 1.8        |
| Others       |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Power generation Output

|                                     | TWh         |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>1.17</b> | <b>3.63</b> | <b>6.08</b> | <b>9.68</b> | <b>10.34</b> | <b>10.60</b> | <b>10.86</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.5</b> | <b>5.3</b> | <b>0.7</b> | <b>0.3</b> | <b>0.2</b> | <b>1.5</b> |
| Coal PP                             | 0.00        | 0.00        | 1.63        | 3.25        | 3.25         | 3.25         | 3.25         | 0          | 0          | 27         | 34         | 31         | 31         | 30         | -          | 8.0        | 0.0        | 0.0        | 0.0        | 1.8        |
| Coal PP with biomass co-firing      |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Oil PP                              | 0.01        | 0.03        | 0.04        | 0.00        | 0.00         | 0.00         | 0.00         | 1          | 1          | 1          | 0          | 0          | 0          | 0          | 3.9        | -100.0     | -          | -          | -          | -100.0     |
| Gas PP                              | 1.16        | 3.60        | 4.42        | 6.28        | 6.85         | 7.10         | 7.36         | 99         | 99         | 73         | 65         | 66         | 67         | 68         | 4.4        | 4.0        | 0.9        | 0.4        | 0.4        | 1.3        |
| Gas PP with hydrogen co-firing      |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00        | 0.004       | 0.15        | 0.24         | 0.24         | 0.25         | 0.0        | 0.0        | 0.1        | 1.5        | 2.3        | 2.3        | 2.3        | -          | 47.9       | 4.7        | 0.4        | 0.4        | 10.9       |
| Wind                                |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Hydro                               |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Geothermal                          |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Biomass and others                  |             |             |             |             |              |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |

### Power generation Input

|                      | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>0.46</b> | <b>1.13</b> | <b>1.71</b> | <b>2.22</b> | <b>2.25</b> | <b>2.27</b> | <b>2.31</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.3</b> | <b>2.9</b> | <b>0.2</b> | <b>0.1</b> | <b>0.2</b> | <b>0.8</b> |
| Coal                 | 0.00        | 0.00        | 0.40        | 0.80        | 0.80        | 0.80        | 0.80        | 0.0        | 0.0        | 23.3       | 36.0       | 35.4       | 35.2       | 34.6       | -          | 8.0        | 0.0        | 0.0        | 0.0        | 1.8        |
| Fuel ammonia         |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                  | 0.00        | 0.01        | 0.01        | 0.00        | 0.00        | 0.00        | 0.00        | 0.6        | 0.7        | 0.6        | 0.0        | 0.0        | 0.0        | 0.0        | 4.1        | -100.0     | -          | -          | -          | -100.0     |
| Gas                  | 0.46        | 1.12        | 1.30        | 1.42        | 1.46        | 1.47        | 1.51        | 99.4       | 99.3       | 76.0       | 64.0       | 64.6       | 64.8       | 65.4       | 3.4        | 1.0        | 0.2        | 0.1        | 0.2        | 0.4        |
| Hydrogen             |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) |             |             |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Thermal Efficiency

|              | %         |           |           |           |           |           |           |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |            |            |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|--|--|--|--|--|--|------------|------------|------------|------------|------------|------------|
|              | 1990      | 2005      | 2021      | 2030      | 2040      | 2050      | 2060      |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>22</b> | <b>28</b> | <b>31</b> | <b>37</b> | <b>39</b> | <b>39</b> | <b>40</b> |  |  |  |  |  |  |  | <b>1.1</b> | <b>2.1</b> | <b>0.4</b> | <b>0.2</b> | <b>0.1</b> | <b>0.7</b> |
| Coal         | -         | -         | 35        | 35        | 35        | 35        | 35        |  |  |  |  |  |  |  | -          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil          | 32        | 28        | 30        | -         | -         | -         | -         |  |  |  |  |  |  |  | -0.1       | -          | -          | -          | -          | -          |
| Gas          | 22        | 28        | 29        | 38        | 40        | 42        | 42        |  |  |  |  |  |  |  | 1.0        | 3.0        | 0.6        | 0.3        | 0.1        | 0.9        |
| Biomass      | -         | -         | -         | -         | -         | -         | -         |  |  |  |  |  |  |  | -          | -          | -          | -          | -          | -          |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |            |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|------------|------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005       | 2021       | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>0.9</b>         | <b>2.8</b> | <b>7.5</b> | <b>11.3</b> | <b>12.0</b> | <b>12.6</b> | <b>13.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.1</b> | <b>4.7</b> | <b>0.6</b> | <b>0.4</b> | <b>0.5</b> | <b>1.5</b> |
| Coal         | 0.0                | 0.0        | 2.7        | 5.4         | 5.4         | 5.4         | 5.4         | 0.0        | 0.0        | 36.0       | 47.7       | 44.8       | 42.8       | 40.9       | -          | 8.0        | 0.0        | 0.0        | 0.0        | 1.8        |
| Oil          | 0.2                | 0.2        | 1.7        | 2.5         | 3.2         | 3.7         | 4.2         | 22.4       | 5.9        | 22.9       | 22.4       | 26.4       | 29.2       | 31.8       | 7.2        | 4.4        | 2.3        | 1.5        | 1.3        | 2.3        |
| Natural Gas  | 0.7                | 2.6        | 3.1        | 3.4         | 3.5         | 3.5         | 3.6         | 77.6       | 94.1       | 41.2       | 29.9       | 28.9       | 28.0       | 27.3       | 5.0        | 1.0        | 0.3        | 0.1        | 0.2        | 0.4        |
| CCS/DAC (-)  |                    |            |            |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 9.1  | 12.6 | 13.2 | 16.6 | 21.1 | 25.3 | 30.1 | 1.2       | 2.6       | 2.43      | 1.80      | 1.8       | 2.1       |
| Population (millions of people)                                                           | 0.3  | 0.3  | 0.4  | 0.5  | 0.6  | 0.7  | 0.8  | 1.7       | 1.4       | 1.4       | 1.4       | 1.4       | 1.4       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 34.7 | 37.7 | 29.7 | 33.0 | 36.5 | 37.9 | 39.3 | -0.5      | 1.2       | 1.0       | 0.4       | 0.4       | 0.7       |
| Primary energy consumption per capita (toe/person)                                        | 4.9  | 8.6  | 9.8  | 12.9 | 11.8 | 10.6 | 9.9  | 2.3       | 3.2       | -0.9      | -1.0      | -0.7      | 0.0       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 140  | 227  | 329  | 392  | 323  | 280  | 252  | 2.8       | 2.0       | -1.9      | -1.4      | -1.0      | -0.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 39   | 53   | 142  | 219  | 185  | 163  | 144  | 4.3       | 4.9       | -1.6      | -1.3      | -1.3      | 0.0       |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 97   | 220  | 567  | 680  | 570  | 498  | 439  | 5.9       | 2.0       | -1.8      | -1.3      | -1.3      | -0.7      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.69 | 0.97 | 1.72 | 1.73 | 1.76 | 1.78 | 1.74 | 3.0       | 0.1       | 0.2       | 0.1       | -0.2      | 0.0       |
| Automobile ownership volume (millions of vehicles)                                        |      |      |      |      |      |      |      | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -    | -    | -    | -         | -         | -         | -         | -         | -         |

## Brunei [LCET]

### Primary energy consumption

|                                | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>1.28</b> | <b>2.86</b> | <b>4.35</b> | <b>6.18</b> | <b>6.48</b> | <b>6.62</b> | <b>7.08</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.0</b> | <b>4.0</b> | <b>0.5</b> | <b>0.2</b> | <b>0.7</b> |
| Coal                           | 0.00        | 0.00        | 0.70        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 16.0       | 0.0        | 0.0        | 0.0        | 0.0        | -          | -100.0     | -          | -          | -100.0     |
| Oil                            | 0.08        | 0.52        | 1.28        | 1.74        | 1.91        | 1.86        | 1.77        | 6.6        | 18.0       | 29.4       | 28.1       | 29.4       | 28.2       | 25.1       | 9.2        | 3.5        | 0.9        | -0.2       | -0.5       |
| Natural gas                    | 1.19        | 2.34        | 2.37        | 4.43        | 4.48        | 4.62        | 5.12        | 93.4       | 82.0       | 54.6       | 71.6       | 69.1       | 69.7       | 72.2       | 2.2        | 7.2        | 0.1        | 0.3        | 1.0        |
| Hydrogen                       | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Geothermal                     | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 0.00        | 0.00        | 0.00        | 0.02        | 0.10        | 0.14        | 0.19        | 0.0        | 0.0        | 0.0        | 0.3        | 1.5        | 2.1        | 2.7        | -          | 53.4       | 18.5       | 3.6        | 3.2        |
| Biomass                        | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Solar Wind Ocean               | 0.00        | 0.00        | 0.00        | 0.02        | 0.04        | 0.07        | 0.11        | 0.0        | 0.0        | 0.0        | 0.3        | 0.6        | 1.1        | 1.6        | -          | 53.4       | 8.2        | 5.9        | 4.7        |
| Biofuels                       | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00        | 0.00        | 0.00        | 0.00        | 0.06        | 0.07        | 0.08        | 0.0        | 0.0        | 0.00       | 0.00       | 0.9        | 1.1        | 1.1        | -          | -          | -          | 1.7        | 1.5        |

### Final energy demand

|              | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>0.35</b> | <b>0.67</b> | <b>1.88</b> | <b>3.60</b> | <b>3.85</b> | <b>3.90</b> | <b>3.94</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.6</b> | <b>7.5</b> | <b>0.7</b> | <b>0.1</b> | <b>0.1</b> |
| Industry     | 0.06        | 0.07        | 0.65        | 1.21        | 1.22        | 1.23        | 1.23        | 17.4       | 9.8        | 34.8       | 33.5       | 31.7       | 31.4       | 31.3       | 7.9        | 7.0        | 0.1        | 0.0        | 0.1        |
| Transport    | 0.19        | 0.34        | 0.41        | 0.58        | 0.78        | 0.82        | 0.84        | 53.6       | 51.3       | 21.6       | 16.2       | 20.3       | 21.1       | 21.2       | 2.5        | 4.1        | 3.0        | 0.5        | 0.2        |
| Others       | 0.09        | 0.25        | 0.35        | 0.51        | 0.54        | 0.55        | 0.56        | 24.2       | 37.0       | 18.5       | 14.1       | 14.0       | 14.0       | 14.3       | 4.6        | 4.3        | 0.6        | 0.1        | 0.3        |
| Non-energy   | 0.02        | 0.01        | 0.47        | 1.30        | 1.30        | 1.30        | 1.30        | 4.8        | 1.9        | 25.1       | 36.2       | 33.9       | 33.5       | 33.1       | 11.3       | 12.0       | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>0.35</b> | <b>0.67</b> | <b>1.88</b> | <b>3.60</b> | <b>3.85</b> | <b>3.90</b> | <b>3.94</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.6</b> | <b>7.5</b> | <b>0.7</b> | <b>0.1</b> | <b>0.1</b> |
| Coal         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil          | 0.26        | 0.42        | 0.57        | 0.83        | 1.01        | 0.96        | 0.87        | 75.0       | 62.6       | 30.4       | 23.2       | 26.1       | 24.7       | 22.2       | 2.6        | 4.3        | 1.9        | -0.4       | -1.0       |
| Natural gas  | 0.00        | 0.02        | 0.49        | 1.32        | 1.33        | 1.33        | 1.33        | 0.0        | 3.5        | 25.9       | 36.8       | 34.5       | 34.0       | 33.7       | -          | 11.8       | 0.0        | 0.0        | 0.0        |
| Hydrogen     | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 0.09        | 0.23        | 0.49        | 0.79        | 0.86        | 0.96        | 1.09        | 25.0       | 33.9       | 26.3       | 21.9       | 22.4       | 24.6       | 27.6       | 5.8        | 5.3        | 0.9        | 1.1        | 1.2        |
| Heat         | 0.00        | 0.00        | 0.33        | 0.65        | 0.65        | 0.65        | 0.65        | 0.0        | 0.0        | 17.4       | 18.1       | 17.0       | 16.7       | 16.6       | -          | 8.0        | 0.0        | 0.0        | 0.0        |
| Others       | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

### Power generation Output

|                                     | TWh         |             |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>1.17</b> | <b>3.63</b> | <b>6.08</b> | <b>9.49</b> | <b>9.71</b> | <b>10.60</b> | <b>11.97</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.5</b> | <b>5.1</b> | <b>0.2</b> | <b>0.9</b> | <b>1.2</b> |
| Coal PP                             | 0.00        | 0.00        | 1.63        |             |             |              |              | 0          | 0          | 27         | 0          | 0          | 0          | 0          | -          | -100.0     | -          | -          | -100.0     |
| Coal PP with biomass co-firing      | 0.00        | 0.00        |             |             |             |              |              | 1          | 1          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00        | 0.00        |             |             |             |              |              | 99         | 99         | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Oil PP                              | 0.01        | 0.03        | 0.04        | 0.00        | 0.00        | 0.00         | 0.00         | 0          | 0          | 1          | 0          | 0          | 0          | 0          | 3.9        | -100.0     | -          | -          | -100.0     |
| Gas PP                              | 1.16        | 3.60        | 4.42        | 6.03        | 6.00        | 6.53         | 7.44         | 0          | 0          | 73         | 64         | 62         | 62         | 62         | 4.4        | 3.5        | 0.0        | 0.8        | 1.3        |
| Gas PP with hydrogen co-firing      | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00        | 0.00        |             | 3.25        | 3.25        | 3.25         | 3.25         | 0          | 0          | 0          | 34         | 33         | 31         | 27         | -          | -          | 0.0        | 0.0        | 0.0        |
| Nuclear PP                          | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00        | 0.00        | 0.21        | 0.46        | 0.81         | 1.28         | 0          | 0          | 0          | 2          | 5          | 8          | 11         | -          | 53.4       | 8.2        | 5.9        | 4.7        |
| Wind                                | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Hydro                               | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Geothermal                          | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.00        | 0.00        |             |             |             |              |              | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |

### Power generation Input

|                      | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>0.46</b> | <b>1.13</b> | <b>1.71</b> | <b>1.89</b> | <b>1.90</b> | <b>1.99</b> | <b>2.18</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.3</b> | <b>1.1</b> | <b>0.0</b> | <b>0.5</b> | <b>0.9</b> |
| Coal                 | 0.00        | 0.00        | 0.40        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 23.3       | 0.0        | 0.0        | 0.0        | 0.0        | -          | -100.0     | -          | -          | -100.0     |
| Fuel ammonia         | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                  | 0.00        | 0.01        | 0.01        | 0.00        | 0.00        | 0.00        | 0.00        | 0.6        | 0.7        | 0.6        | 0.0        | 0.0        | 0.0        | 0.0        | 4.1        | -100.0     | -          | -          | -100.0     |
| Gas                  | 0.46        | 1.12        | 1.30        | 1.89        | 1.90        | 1.99        | 2.18        | 99.4       | 99.3       | 76.0       | 100.0      | 100.0      | 100.0      | 100.0      | 3.4        | 4.3        | 0.0        | 0.5        | 0.9        |
| Hydrogen             | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00        | 0.00        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>21.8</b> | <b>27.6</b> | <b>30.6</b> | <b>42.1</b> | <b>42.0</b> | <b>42.3</b> | <b>42.1</b> |  |  |  |  |  |  |  | <b>1.1</b> | <b>3.6</b> | <b>0.0</b> | <b>0.1</b> | <b>0.0</b> |
| Coal         | -           | -           | 35.0        | -           | -           | -           | -           |  |  |  |  |  |  |  | -          | -          | -          | -          | -          |
| Oil          | 31.5        | 28.2        | 30.2        | -           | -           | -           | -           |  |  |  |  |  |  |  | -0.1       | -          | -          | -          | -          |
| Gas          | 21.8        | 27.6        | 29.2        | 42.1        | 42.0        | 42.3        | 42.1        |  |  |  |  |  |  |  | 1.0        | 4.2        | 0.0        | 0.1        | 0.0        |
| Biomass      | -           | -           | -           | -           | -           | -           | -           |  |  |  |  |  |  |  | -          | -          | -          | -          | -          |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |            |            |            |            |            |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |             |
|--------------|--------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>0.9</b>         | <b>2.8</b> | <b>7.5</b> | <b>7.5</b> | <b>7.4</b> | <b>6.9</b> | <b>6.6</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.1</b> | <b>0.0</b> | <b>-0.1</b> | <b>-0.7</b> | <b>-0.6</b> | <b>-0.3</b> |
| Coal         | 0.00               | 0.00       | 2.7        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 36.0       | 0.0        | 0.0        | 0.0        | 0.0        | -          | -100.0     | -           | -           | -           | -100.0      |
| Oil          | 0.20               | 0.16       | 3.1        | 5.0        | 4.5        | 4.1        | 4.0        | 22.4       | 5.9        | 41.2       | 67.1       | 60.1       | 59.2       | 60.9       | 9.3        | 5.6        | -1.2        | -0.8        | -0.3        | 0.7         |
| Natural Gas  | 0.68               | 2.60       | 1.7        | 2.5        | 3.0        | 2.8        | 2.6        | 77.6       | 94.1       | 22.9       | 32.9       | 39.9       | 40.8       | 39.1       | 3.0        | 4.1        | 1.9         | -0.5        | -1.0        | 1.0         |
| CCS/DAC (-)  |                    |            |            |            |            |            |            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |

## Energy and economic indicators

|                                                                                           |      |      |        |      |      |      |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|--------|------|------|------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021   | 2030 | 2040 | 2050 | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 9    | 13   | 13.2   | 17   | 21   | 25   | 30.1   | 1.2       | 2.6       | 2.43      | 1.80      | 1.8       | 2.1       |
| Population (millions of people)                                                           | 0    | 0    | 0.4    | 1    | 1    | 1    | 0.8    | 1.7       | 1.4       | 1.4       | 1.4       | 1.4       | 1.4       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 34.7 | 37.7 | 29.673 | 33.0 | 36.5 | 37.9 | 39.288 | -0.5      | 1.2       | 1.0       | 0.4       | 0.4       | 0.7       |
| Primary energy consumption per capita (toe/person)                                        | 4.9  | 8.6  | 9.8    | 12.2 | 11.2 | 9.9  | 9.2    | 2.3       | 2.5       | -0.9      | -1.2      | -0.7      | -0.1      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 140  | 227  | 329    | 372  | 307  | 262  | 235    | 2.8       | 1.4       | -1.9      | -1.6      | -1.1      | -0.9      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 39   | 53   | 142    | 216  | 182  | 154  | 131    | 4.3       | 4.8       | -1.7      | -1.6      | -1.6      | -0.2      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 97   | 220  | 567    | 450  | 351  | 275  | 218    | 5.9       | -2.5      | -2.5      | -2.4      | -2.3      | -2.4      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.69 | 0.97 | 1.72   | 1.21 | 1.15 | 1.05 | 0.93   | 3.0       | -3.8      | -0.6      | -0.9      | -1.2      | -1.6      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |        |      |      |      |        | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -      | -    | -    | -    | -      | -         | -         | -         | -         | -         | -         |

## Cambodia [BAU]

### Primary energy consumption

|                                | MTOE        |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>2.84</b> | <b>4.83</b> | <b>7.44</b> | <b>9.41</b> | <b>14.20</b> | <b>22.78</b> | <b>36.97</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.2</b> | <b>2.6</b> | <b>4.2</b> | <b>4.8</b> | <b>5.0</b> |
| Coal                           | 0.00        | 0.00        | 1.39        | 1.56        | 1.56         | 2.07         | 3.52         | 0.0        | 0.0        | 18.6       | 16.6       | 11.0       | 9.1        | 9.5        | -          | 1.3        | 0.0        | 2.8        | 5.5        |
| Oil                            | 0.51        | 1.28        | 3.23        | 4.73        | 7.80         | 12.23        | 19.75        | 18.0       | 26.6       | 43.4       | 50.3       | 55.0       | 53.7       | 53.4       | 6.1        | 4.3        | 5.1        | 4.6        | 4.9        |
| Natural gas                    | 0.00        | 0.00        | 0.00        | 0.33        | 1.42         | 4.53         | 7.69         | 0.0        | 0.0        | 0.0        | 3.5        | 10.0       | 19.9       | 20.8       | -          | -          | 15.6       | 12.3       | 5.4        |
| Hydrogen                       | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.00        | 0.00        | 0.44        | 0.52        | 0.93         | 1.26         | 2.18         | 0.0        | 0.1        | 5.9        | 5.6        | 6.6        | 5.6        | 5.9        | -          | 2.0        | 5.9        | 3.1        | 5.6        |
| Geothermal                     | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 82.0       | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -100.0     | -          | -          | -          | -          |
| Others                         | 2.33        | 3.54        | 2.38        | 2.26        | 2.47         | 2.70         | 3.82         | 82.0       | 73.4       | 32.0       | 24.0       | 17.4       | 11.8       | 10.3       | 0.1        | -0.6       | 0.9        | 0.9        | 3.5        |
| Biomass                        | 2.33        | 3.54        | 1.98        | 1.84        | 1.62         | 1.51         | 1.55         | 0.0        | 73.2       | 26.7       | 19.6       | 11.4       | 6.6        | 4.2        | -          | -0.8       | -1.3       | -0.7       | 0.2        |
| Solar Wind Ocean               | 0.00        | 0.00        | 0.05        | 0.42        | 0.85         | 1.18         | 2.28         | 0.0        | 0.0        | 0.7        | 4.4        | 6.0        | 5.2        | 6.2        | -          | 25.9       | 7.4        | 3.3        | 6.8        |
| Biofuels                       | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00        | 0.01        | 0.35        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.1        | 4.68       | 0.00       | 0.0        | 0.0        | 0.0        | -          | -100.0     | -          | -          | -100.0     |

### Final energy demand

|              | MTOE        |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>2.54</b> | <b>4.53</b> | <b>6.60</b> | <b>8.12</b> | <b>12.19</b> | <b>18.66</b> | <b>29.74</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.1</b> | <b>2.3</b> | <b>4.1</b> | <b>4.4</b> | <b>4.8</b> |
| Industry     | 0.44        | 0.05        | 2.48        | 2.72        | 3.52         | 5.02         | 7.77         | 17.2       | 1.1        | 37.5       | 33.5       | 28.9       | 26.9       | 26.1       | 5.7        | 1.1        | 2.6        | 3.6        | 4.5        |
| Transport    | 0.38        | 0.43        | 2.20        | 3.28        | 5.55         | 8.60         | 13.42        | 15.0       | 9.5        | 33.4       | 40.5       | 45.5       | 46.1       | 45.1       | 5.8        | 4.5        | 5.4        | 4.5        | 4.6        |
| Others       | 1.72        | 4.05        | 1.84        | 2.03        | 3.04         | 4.96         | 8.47         | 67.5       | 89.3       | 27.9       | 25.0       | 24.9       | 26.6       | 28.5       | 0.2        | 1.1        | 4.1        | 5.0        | 5.5        |
| Non-energy   | 0.01        | 0.00        | 0.08        | 0.08        | 0.08         | 0.08         | 0.08         | 0.3        | 0.0        | 1.2        | 1.0        | 0.6        | 0.4        | 0.3        | 8.1        | 0.0        | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>2.54</b> | <b>4.53</b> | <b>6.60</b> | <b>8.12</b> | <b>12.19</b> | <b>18.66</b> | <b>29.74</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.1</b> | <b>2.3</b> | <b>4.1</b> | <b>4.4</b> | <b>4.8</b> |
| Coal         | 0.00        | 0.00        | 0.49        | 0.49        | 0.49         | 0.49         | 0.49         | 0.0        | 0.0        | 7.5        | 6.1        | 4.1        | 2.6        | 1.7        | -          | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil          | 0.44        | 0.93        | 3.12        | 4.59        | 7.66         | 12.06        | 19.49        | 17.3       | 20.6       | 47.3       | 56.5       | 62.8       | 64.6       | 65.6       | 6.5        | 4.4        | 5.3        | 4.6        | 4.9        |
| Natural gas  | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydrogen     | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 0.01        | 0.06        | 1.02        | 1.40        | 2.67         | 4.93         | 8.73         | 0.4        | 1.4        | 15.4       | 17.2       | 21.9       | 26.4       | 29.4       | 15.7       | 3.6        | 6.7        | 6.3        | 5.9        |
| Heat         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 2.09        | 3.54        | 1.97        | 1.64        | 1.37         | 1.17         | 1.02         | 82.4       | 78.0       | 29.9       | 20.2       | 11.2       | 6.3        | 3.4        | -0.2       | -2.1       | -1.8       | -1.6       | -1.4       |

### Power generation Output

|                                     | TWh         |             |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |
|-------------------------------------|-------------|-------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>0.20</b> | <b>0.88</b> | <b>10.11</b> | <b>19.13</b> | <b>35.80</b> | <b>64.92</b> | <b>114.89</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>13.5</b> | <b>7.3</b> | <b>6.5</b> | <b>6.1</b> | <b>5.9</b> |
| Coal PP                             | 0.00        | 0.00        | 3.78         | 4.51         | 4.52         | 6.66         | 12.78         | 0.0        | 0.0        | 37.4       | 23.6       | 12.6       | 10.3       | 11.1       | -           | 2.0        | 0.0        | 3.9        | 6.7        |
| Coal PP with biomass co-firing      | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Oil PP                              | 0.20        | 0.84        | 0.56         | 0.74         | 0.75         | 0.86         | 1.32          | 100        | 95.0       | 5.6        | 3.9        | 2.1        | 1.3        | 1.1        | 3.4         | 3.1        | 0.0        | 1.4        | 4.4        |
| Gas PP                              | 0.00        | 0.00        | 0.00         | 2.02         | 8.60         | 27.38        | 46.53         | 0          | 0.0        | 0.0        | 10.5       | 24.0       | 42.2       | 40.5       | -           | -          | 15.6       | 12.3       | 5.4        |
| Gas PP with hydrogen co-firing      | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Nuclear PP                          | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00        | 0.61         | 4.19         | 8.69         | 10.67        | 19.17         | 0          | 0.0        | 6.0        | 21.9       | 24.3       | 16.4       | 16.7       | -           | 23.9       | 7.6        | 2.1        | 6.0        |
| Wind                                | 0.00        | 0.00        | 0.00         | 0.65         | 1.23         | 3.08         | 7.29          | 0          | 0.0        | 0.0        | 3.4        | 3.4        | 4.7        | 6.3        | -           | -          | 6.6        | 9.6        | 9.0        |
| Hydro                               | 0.00        | 0.04        | 5.11         | 6.10         | 10.87        | 14.71        | 25.39         | 0          | 5.0        | 50.5       | 31.9       | 30.4       | 22.7       | 22.1       | -           | 2.0        | 5.9        | 3.1        | 5.6        |
| Geothermal                          | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Biomass and others                  | 0.00        | 0.00        | 0.05         | 0.92         | 1.14         | 1.57         | 2.41          | 0          | 0.0        | 0.5        | 4.8        | 3.2        | 2.4        | 2.1        | -           | 38.3       | 2.2        | 3.2        | 4.4        |

### Power generation Input

|                      | MTOE        |             |             |             |             |             |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>0.10</b> | <b>0.34</b> | <b>1.01</b> | <b>1.75</b> | <b>2.89</b> | <b>6.61</b> | <b>11.50</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.8</b> | <b>6.2</b> | <b>5.2</b> | <b>8.6</b> | <b>5.7</b> |
| Coal                 | 0.00        | 0.00        | 0.89        | 1.07        | 1.07        | 1.57        | 3.02         | 0.0        | 0.0        | 88.0       | 60.9       | 37.0       | 23.8       | 26.3       | -          | 2.0        | 0.0        | 3.9        | 6.7        |
| Fuel ammonia         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 100.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                  | 0.10        | 0.34        | 0.11        | 0.15        | 0.15        | 0.17        | 0.26         | 0.0        | 100.0      | 1.1        | 8.4        | 5.1        | 2.6        | 2.3        | 0.4        | 3.1        | 0.0        | 1.4        | 4.4        |
| Gas                  | 0.00        | 0.00        | 0.00        | 0.33        | 1.42        | 4.53        | 7.69         | 0.0        | 0.0        | 0.0        | 19.1       | 49.2       | 68.4       | 66.9       | -          | -          | 15.6       | 12.3       | 5.4        |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.01        | 0.20        | 0.25        | 0.34        | 0.53         | 0.0        | 0.0        | 0.0        | 11.6       | 8.7        | 5.2        | 4.6        | -          | 38.3       | 2.2        | 3.2        | 4.4        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |             |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|------------|------------|-------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060   |
| <b>Total</b> | <b>17.2</b> | <b>21.1</b> | <b>37.2</b> | <b>40.3</b> | <b>44.7</b> | <b>47.4</b> | <b>47.1</b> |  |  |  |  |  |  |  | <b>2.5</b> | <b>0.9</b> | <b>1.0</b> | <b>0.6</b> | <b>-0.1</b> |
| Coal PP      | -           | -           | -           | 30.6        | 29.4        | 29.8        | 31.0        |  |  |  |  |  |  |  | -          | -          | -0.4       | -0.1       | 0.4         |
| Oil PP       | 17.2        | 21.1        | 43.6        | 43.6        | 43.6        | 43.6        | 43.6        |  |  |  |  |  |  |  | 3.0        | 0.0        | 0.0        | 0.0        | 0.0         |
| Gas PP       | -           | -           | -           | 52.0        | 52.0        | 52.0        | 52.0        |  |  |  |  |  |  |  | -          | -          | 0.0        | 0.0        | 0.0         |
| Biomass PP   | -           | -           | 39.1        | 39.1        | 39.1        | 39.1        | 39.1        |  |  |  |  |  |  |  | -          | 0.0        | 0.0        | 0.0        | 0.0         |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>1.51</b>        | <b>3.8</b> | <b>14.5</b> | <b>23.4</b> | <b>37.0</b> | <b>64.0</b> | <b>91.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.6</b> | <b>5.5</b> | <b>4.7</b> | <b>5.6</b> | <b>3.7</b> | <b>4.8</b> |
| Coal         | 0.00               | 0.00       | 5.6         | 8.7         | 9.1         | 10.5        | 12.4        | 0.0        | 0.0        | 38.5       | 37.2       | 24.6       | 16.4       | 13.5       | -          | 5.1        | 0.5        | 1.5        | 1.7        | 2.1        |
| Oil          | 1.51               | 3.78       | 8.9         | 13.5        | 22.4        | 35.3        | 57.2        | 100.0      | 100.0      | 61.5       | 57.5       | 60.5       | 55.1       | 62.3       | 5.9        | 4.7        | 5.2        | 4.7        | 4.9        | 4.9        |
| Natural Gas  | 0.00               | 0.00       | 0.0         | 1.2         | 5.5         | 18.2        | 22.3        | 0.0        | 0.0        | 0.0        | 5.2        | 14.9       | 28.5       | 24.2       | -          | -          | 16.2       | 12.7       | 2.0        | -          |

## Energy and economic Indicators

|                                                                                           |      |      |       |      |      |      |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|-------|------|------|------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021  | 2030 | 2040 | 2050 | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 4    | 9    | 23.72 | 41   | 75   | 134  | 240.1 | 6.2       | 6.4       | 6.12      | 6.00      | 6.0       | 6.1       |
| Population (millions of people)                                                           | 9    | 13   | 16.6  | 19   | 22   | 26   | 29.6  | 2.0       | 1.5       | 1.5       | 1.5       | 1.5       | 1.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.4  | 0.7  | 1.430 | 2.2  | 3.4  | 5.2  | 8.100 | 4.1       | 4.8       | 4.6       | 4.4       | 4.4       | 4.5       |
| Primary energy consumption per capita (toe/person)                                        | 0.3  | 0.4  | 0.4   | 0.5  | 0.6  | 0.9  | 1.2   | 1.1       | 1.1       | 2.7       | 3.3       | 3.4       | 2.7       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 775  | 523  | 314   | 228  | 190  | 170  | 154   | -2.9      | -3.5      | -1.8      | -1.1      | -1.0      | -1.8      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 695  | 491  | 278   | 196  | 163  | 139  | 124   | -2.9      | -3.8      | -1.9      | -1.6      | -1.2      | -2.1      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 412  | 409  | 611   | 566  | 494  | 478  | 383   | 1.3       | -0.8      | -1.3      | -0.3      | -2.2      | -1.2      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.53 | 0.78 | 1.95  | 2.49 | 2.61 | 2.81 | 2.49  | 4.3       | 2.8       | 0.5       | 0.8       | -1.2      | 0.6       |
| Automobile ownership volume (millions of vehicles)                                        | -    | -    | -     | -    | -    | -    | -     | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -     | -    | -    | -    | -     | -         | -         | -         | -         | -         | -         |

## Cambodia [LCET]

### Primary energy consumption

|                                | MTOE        |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>2.84</b> | <b>4.83</b> | <b>7.44</b> | <b>9.02</b> | <b>10.02</b> | <b>14.30</b> | <b>22.00</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.2</b> | <b>2.2</b> | <b>1.1</b> | <b>3.6</b> | <b>4.4</b> |
| Coal                           | 0.00        | 0.00        | 1.39        | 1.32        | 1.35         | 2.36         | 4.16         | 0.0        | 0.0        | 18.6       | 14.6       | 13.5       | 16.5       | 18.9       | -          | -0.6       | 0.2        | 5.7        | 5.8        |
| Oil                            | 0.51        | 1.28        | 3.23        | 4.55        | 3.54         | 3.13         | 2.95         | 18.0       | 26.6       | 43.4       | 50.4       | 35.3       | 21.9       | 13.4       | 6.1        | 3.9        | -2.5       | -1.2       | -0.6       |
| Natural gas                    | 0.00        | 0.00        | 0.00        | 0.26        | 1.14         | 1.60         | 2.08         | 0.0        | 0.0        | 0.0        | 2.9        | 11.4       | 11.2       | 9.4        | -          | -          | 16.0       | 3.5        | 2.6        |
| Hydrogen                       | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 1.05         | 3.32         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 7.3        | 15.1       | -          | -          | -          | 12.2       | -          |
| Fuel Ammonia                   | 0.00        | 0.00        |             |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00        | 0.00        |             |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.00        | 0.00        | 0.44        | 0.51        | 1.35         | 2.76         | 4.56         | 0.0        | 0.1        | 5.9        | 5.7        | 13.5       | 19.3       | 20.7       | -          | 1.7        | 10.2       | 7.4        | 5.1        |
| Geothermal                     | 0.00        | 0.00        |             |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 2.33        | 3.54        | 2.38        | 2.38        | 2.64         | 3.40         | 4.93         | 82.0       | 73.4       | 32.0       | 26.4       | 26.4       | 23.8       | 22.4       | 0.1        | 0.0        | 1.1        | 2.6        | 3.8        |
| Biomass                        | 2.33        | 3.54        | 1.98        | 2.06        | 1.95         | 1.83         | 2.15         | 82.0       | 73.2       | 26.7       | 22.8       | 19.4       | 12.8       | 9.8        | -0.5       | 0.4        | -0.6       | -0.6       | 1.6        |
| Solar Wind Ocean               | 0.00        | 0.00        | 0.05        | 0.32        | 0.70         | 1.57         | 2.78         | 0.0        | 0.0        | 0.7        | 3.6        | 7.0        | 11.0       | 12.6       | -          | 22.3       | 8.0        | 8.5        | 5.9        |
| Biofuels                       | 0.00        | 0.00        |             |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00        | 0.01        | 0.35        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.1        | 4.68       | 0.00       | 0.0        | 0.0        | 0.0        | -          | -100.0     | -          | -          | -100.0     |

### Final energy demand

|              | MTOE        |             |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>2.54</b> | <b>4.53</b> | <b>6.60</b> | <b>7.81</b> | <b>8.06</b> | <b>10.65</b> | <b>14.99</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.1</b> | <b>1.9</b> | <b>0.3</b> | <b>2.8</b> | <b>3.5</b> |
| Industry     | 0.44        | 0.05        | 2.48        | 2.56        | 2.98        | 3.61         | 4.78         | 17.2       | 1.1        | 37.5       | 32.8       | 37.0       | 33.9       | 31.9       | 5.7        | 0.4        | 1.5        | 1.9        | 2.9        |
| Transport    | 0.38        | 0.43        | 2.20        | 3.26        | 2.37        | 2.79         | 3.32         | 15.0       | 9.5        | 33.4       | 41.8       | 29.4       | 26.2       | 22.2       | 5.8        | 4.5        | -3.2       | 1.6        | 1.8        |
| Others       | 1.72        | 4.05        | 1.84        | 1.91        | 2.63        | 4.18         | 6.80         | 67.5       | 89.3       | 27.9       | 24.4       | 32.7       | 39.2       | 45.4       | 0.2        | 0.4        | 3.3        | 4.7        | 5.0        |
| Non-energy   | 0.01        | 0.00        | 0.08        | 0.08        | 0.08        | 0.08         | 0.08         | 0.3        | 0.0        | 1.2        | 1.0        | 1.0        | 0.7        | 0.5        | 8.1        | 0.0        | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>2.54</b> | <b>4.53</b> | <b>6.60</b> | <b>7.81</b> | <b>8.06</b> | <b>10.65</b> | <b>14.99</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.1</b> | <b>1.9</b> | <b>0.3</b> | <b>2.8</b> | <b>3.5</b> |
| Coal         | 0.00        | 0.00        | 0.49        | 0.49        | 0.49        | 0.49         | 0.49         | 0.0        | 0.0        | 7.5        | 6.3        | 6.1        | 4.6        | 3.3        | -          | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil          | 0.44        | 0.93        | 3.12        | 4.43        | 3.42        | 3.13         | 2.95         | 17.3       | 20.6       | 47.3       | 56.8       | 42.5       | 29.4       | 19.7       | 6.5        | 4.0        | -2.6       | -0.9       | -0.1       |
| Natural gas  | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydrogen     | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 0.01        | 0.06        | 1.02        | 1.27        | 2.81        | 5.89         | 10.55        | 0.4        | 1.4        | 15.4       | 16.2       | 34.8       | 55.3       | 70.4       | 15.7       | 2.5        | 8.3        | 7.7        | 6.0        |
| Heat         | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 2.09        | 3.54        | 1.97        | 1.61        | 1.34        | 1.14         | 0.99         | 82.3       | 78.0       | 29.9       | 20.6       | 16.6       | 10.7       | 6.6        | -0.2       | -2.2       | -1.9       | -1.6       | -1.4       |

### Power generation Output

|                                     | TWh         |             |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |
|-------------------------------------|-------------|-------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>0.20</b> | <b>0.88</b> | <b>10.11</b> | <b>17.35</b> | <b>37.66</b> | <b>77.45</b> | <b>138.78</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>13.5</b> | <b>6.2</b> | <b>8.1</b> | <b>7.5</b> | <b>6.0</b> |
| Coal PP                             | 0.00        | 0.00        | 3.78         | 3.49         | 3.62         | 0.00         | 0.00          | 0          | 0          | 37         | 20         | 10         | 0          | 0          | -           | -0.9       | 0.4        | -100.0     | -100.0     |
| Coal PP with biomass co-firing      | 0.00        | 0.00        |              |              |              |              |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00        | 0.00        |              |              |              |              |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 7.88         | 15.49         | 0          | 0          | 0          | 0          | 0          | 10         | 11         | -           | -          | -          | -          | 7.0        |
| Oil PP                              | 0.20        | 0.84        | 0.56         | 0.57         | 0.60         | 0.00         | 0.00          | 100        | 95         | 6          | 3          | 2          | 0          | 0          | 3.4         | 0.2        | 0.4        | -100.0     | -100.0     |
| Gas PP                              | 0.00        | 0.00        | 0.00         | 1.56         | 6.88         | 0.00         | 0.00          | 0          | 0          | 0          | 9          | 18         | 0          | 0          | -           | -          | 16.0       | -100.0     | -          |
| Gas PP with hydrogen co-firing      | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 7.93         | 20.09         | 0          | 0          | 0          | 0          | 0          | 10         | 14         | -           | -          | -          | -          | 9.7        |
| Gas PP with CCS                     | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 8.10         | 12.55         | 0          | 0          | 0          | 0          | 0          | 10         | 9          | -           | -          | -          | -          | 4.5        |
| Nuclear PP                          | 0.00        | 0.00        |              |              |              |              |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00        | 0.61         | 3.25         | 7.13         | 14.61        | 24.14         | 0          | 0          | 0          | 3          | 3          | 5          | 6          | -           | 20.4       | 8.2        | 7.4        | 5.2        |
| Wind                                | 0.00        | 0.00        | 0.00         | 0.50         | 0.98         | 3.65         | 8.18          | 0          | 0          | 6          | 19         | 19         | 19         | 17         | -           | -          | 7.0        | 14.0       | 8.4        |
| Hydro                               | 0.00        | 0.04        | 5.11         | 5.95         | 15.69        | 32.13        | 53.07         | 0          | 5          | 51         | 34         | 42         | 41         | 38         | -           | 1.7        | 10.2       | 7.4        | 5.1        |
| Geothermal                          | 0.00        | 0.00        |              |              |              |              |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Biomass and others                  | 0.00        | 0.00        | 0.05         | 2.03         | 2.78         | 3.15         | 5.26          | 0          | 0          | 0          | 12         | 7          | 4          | 4          | -           | 51.0       | 3.2        | 1.3        | 5.2        |

### Power generation Input

|                      | MTOE        |             |             |             |             |             |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>0.10</b> | <b>0.34</b> | <b>1.01</b> | <b>1.64</b> | <b>2.72</b> | <b>5.21</b> | <b>10.22</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.8</b> | <b>5.5</b> | <b>5.2</b> | <b>6.7</b> | <b>7.0</b> |
| Coal                 | 0.00        | 0.00        | 0.89        | 0.82        | 0.86        | 1.86        | 3.66         | 0.0        | 0.0        | 88.0       | 50.2       | 31.4       | 35.8       | 35.9       | -          | -0.9       | 0.4        | 8.1        | 7.0        |
| Fuel ammonia         | 0.00        | 0.00        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                  | 0.10        | 0.34        | 0.11        | 0.11        | 0.12        | 0.00        | 0.00         | 100.0      | 100.0      | 10.9       | 6.9        | 4.3        | 0.0        | 0.0        | 0.4        | 0.2        | 0.4        | -100.0     | -100.0     |
| Gas                  | 0.00        | 0.00        | 0.00        | 0.26        | 1.14        | 1.60        | 2.08         | 0.0        | 0.0        | 0.0        | 15.7       | 41.8       | 30.8       | 20.3       | -          | -          | 16.0       | 3.5        | 2.6        |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 1.05        | 3.32         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 20.1       | 32.5       | -          | -          | -          | -          | 12.2       |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.01        | 0.45        | 0.61        | 0.69        | 1.16         | 0.0        | 0.0        | 1.1        | 27.2       | 22.4       | 13.3       | 11.3       | -          | 51.0       | 3.2        | 1.3        | 5.2        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>17.2</b> | <b>21.1</b> | <b>37.2</b> | <b>40.1</b> | <b>43.8</b> | <b>44.7</b> | <b>44.9</b> |  |  |  |  |  |  |  | <b>2.5</b> | <b>0.8</b> | <b>0.9</b> | <b>0.2</b> | <b>0.1</b> |
| Coal PP      | -           | -           | 36.4        | 36.4        | 36.4        | 36.4        | 36.4        |  |  |  |  |  |  |  | -          | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil PP       | 17.2        | 21.1        | 43.6        | 43.6        | 43.6        | -           | -           |  |  |  |  |  |  |  | 3.0        | 0.0        | 0.0        | -          | -          |
| Gas PP       | -           | -           | -           | 52.0        | 52.0        | 52.0        | 52.0        |  |  |  |  |  |  |  | -          | -          | 0.0        | 0.0        | 0.0        |
| Biomass PP   | -           | -           | 39.1        | 39.1        | 39.1        | 39.1        | 39.1        |  |  |  |  |  |  |  | -          | 0.0        | 0.0        | 0.0        | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |             |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>1.5</b>         | <b>3.8</b> | <b>14.5</b> | <b>20.5</b> | <b>21.2</b> | <b>12.5</b> | <b>11.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.6</b> | <b>3.9</b> | <b>0.3</b> | <b>-5.2</b> | <b>-1.0</b> | <b>-0.6</b> |
| Coal         | 0.00               | 0.00       | 5.6         | 6.6         | 6.7         | 4.1         | 4.1         | 0.0        | 0.0        | 38.5       | 32.3       | 31.5       | 32.7       | 36.7       | -          | 1.9        | 0.1        | -4.8        | 0.1         | -0.8        |
| Oil          | 1.51               | 3.78       | 8.9         | 12.7        | 9.4         | 6.3         | 6.2         | 100.0      | 100.0      | 61.5       | 61.9       | 44.3       | 50.4       | 54.9       | 5.9        | 4.0        | -3.0       | -3.9        | -0.1        | -0.9        |
| Natural Gas  | 0.00               | 0.00       | 0.0         | 1.2         | 5.1         | 2.1         | 1.0         | 0.0        | 0.0        | 0.0        | 5.8        | 24.2       | 16.9       | 8.4        | -          | -          | 15.7       | -8.5        | -7.6        | -           |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 4    | 9    | 24   | 41   | 75   | 134  | 240  | 6.2       | 6.4       | 6.12      | 6.00      | 6.0       | 6.1       |
| Population (millions of people)                                                           | 9    | 13   | 17   | 19   | 22   | 26   | 30   | 2.0       | 1.5       | 1.5       | 1.5       | 1.5       | 1.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.4  | 0.7  | 1.4  | 2.2  | 3.4  | 5.2  | 8.1  | 4.1       | 4.8       | 4.6       | 4.4       | 4.4       | 4.5       |
| Primary energy consumption per capita (toe/person)                                        | 0.3  | 0.4  | 0.4  | 0.5  | 0.5  | 0.6  | 0.7  | 1.1       | 0.6       | -0.4      | 2.1       | 2.9       | 1.3       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 775  | 523  | 314  | 218  | 134  | 107  | 92   | -2.9      | -4.0      | -4.8      | -2.2      | -1.5      | -3.1      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 695  | 491  | 278  | 189  | 108  | 79   | 62   | -2.9      | -4.2      | -5.5      | -3.0      | -2.4      | -3.8      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 412  | 409  | 611  | 495  | 283  | 93   | 47   | 1.3       | -2.3      | -5.4      | -10.5     | -6.6      | -6.4      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.53 | 0.78 | 1.95 | 2.27 | 2.12 | 0.87 | 0.51 | 4.3       | 1.7       | -0.7      | -8.5      | -5.2      | -3.4      |
| Automobile ownership volume (millions of vehicles)                                        | -    | -    | -    | -    | -    | -    | -    | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -    | -    | -    | -         | -         | -         | -         | -         | -         |



# China [BAU]

## Primary energy consumption

|                                | MTOE          |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |             |
|--------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|                                | 1990          | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b>                   | <b>873.64</b> | <b>1,781.34</b> | <b>3,738.22</b> | <b>3,977.00</b> | <b>3,848.36</b> | <b>3,573.32</b> | <b>3,195.40</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.8</b> | <b>0.7</b> | <b>-0.3</b> | <b>-0.7</b> | <b>-1.1</b> | <b>-0.4</b> |
| Coal                           | 530.52        | 1,203.61        | 2,246.17        | 2,142.52        | 1,749.69        | 1,325.84        | 872.89          | 60.7       | 67.6       | 60.6       | 53.9       | 46.0       | 37.1       | 27.3       | 4.8        | -0.6       | -1.9        | -2.8        | -4.1        | -2.4        |
| Oil                            | 118.79        | 317.82          | 677.70          | 682.13          | 656.61          | 620.35          | 551.98          | 13.6       | 17.8       | 18.1       | 17.2       | 17.1       | 17.4       | 17.3       | 5.8        | 0.1        | -0.4        | -0.6        | -1.2        | -0.5        |
| Natural gas                    | 12.80         | 38.79           | 299.07          | 391.03          | 434.59          | 433.08          | 368.48          | 1.5        | 2.2        | 8.0        | 9.8        | 11.3       | 12.1       | 11.5       | 10.7       | 3.0        | 1.1         | 0.0         | -1.6        | 0.5         |
| Hydrogen                       | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |
| Fuel Ammonia                   | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |
| Nuclear                        | 0.00          | 13.83           | 106.18          | 147.02          | 192.57          | 237.06          | 282.08          | 0.0        | 0.8        | 2.8        | 3.7        | 5.0        | 6.6        | 8.8        | -          | 3.7        | 2.7         | 2.1         | 1.8         | 2.5         |
| Hydro                          | 10.90         | 34.14           | 111.78          | 120.86          | 134.67          | 144.84          | 154.20          | 1.2        | 1.9        | 3.0        | 3.0        | 3.5        | 4.1        | 4.8        | 7.8        | 0.9        | 1.1         | 0.7         | 0.6         | 0.8         |
| Geothermal                     | 0.00          | 2.34            | 23.86           | 27.87           | 30.49           | 31.30           | 28.53           | 0.0        | 0.1        | 0.6        | 0.7        | 0.8        | 0.9        | 0.9        | -          | 1.7        | 0.9         | 0.3         | -0.9        | 0.5         |
| Others                         | 200.64        | 170.80          | 253.45          | 465.58          | 629.76          | 780.84          | 937.43          | 23.0       | 9.6        | 6.8        | 11.7       | 16.4       | 21.9       | 29.3       | 0.8        | 7.0        | 3.1         | 2.2         | 1.8         | 3.4         |
| Biomass                        | 200.45        | 164.24          | 133.49          | 178.77          | 176.47          | 177.68          | 189.14          | 22.9       | 9.2        | 3.6        | 4.5        | 4.6        | 5.0        | 5.9        | -1.3       | 3.3        | -0.1        | 0.1         | 0.6         | 0.9         |
| Solar Wind Ocean               | 0.03          | 2.94            | 110.64          | 274.83          | 440.45          | 589.37          | 735.21          | 0.0        | 0.2        | 3.0        | 6.9        | 11.4       | 16.5       | 23.0       | 29.9       | 10.6       | 4.8         | 3.0         | 2.2         | 5.0         |
| Biofuels                       | 0.00          | 4.15            | 10.55           | 13.43           | 14.27           | 15.24           | 14.53           | 0.0        | 0.2        | 0.3        | 0.3        | 0.4        | 0.4        | 0.5        | -          | 2.7        | 0.6         | 0.7         | -0.5        | 0.8         |
| Electricity (Import or Export) | 0.16          | -0.53           | -1.22           | -1.44           | -1.42           | -1.44           | -1.44           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -206.8     | 1.8        | -0.1        | 0.2         | 0.0         | 0.4         |

## Final energy demand

|              | MTOE          |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |             |
|--------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|              | 1990          | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>657.59</b> | <b>1,227.11</b> | <b>2,316.69</b> | <b>2,450.29</b> | <b>2,441.11</b> | <b>2,388.28</b> | <b>2,262.73</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>0.6</b> | <b>0.0</b> | <b>-0.2</b> | <b>-0.5</b> | <b>-0.1</b> |
| Industry     | 233.85        | 620.43          | 1,129.05        | 1,100.22        | 1,014.65        | 891.63          | 751.52          | 35.6       | 50.6       | 48.7       | 44.9       | 41.6       | 37.3       | 33.2       | 5.2        | -0.3       | -0.8       | -1.3        | -1.7        | -1.0        |
| Transport    | 30.20         | 134.00          | 346.34          | 420.27          | 422.98          | 416.06          | 386.87          | 4.6        | 10.9       | 14.9       | 17.2       | 17.3       | 17.4       | 17.1       | 8.2        | 2.2        | 0.1        | -0.2        | -0.7        | 0.3         |
| Others       | 350.68        | 387.08          | 629.04          | 703.29          | 767.47          | 840.10          | 883.50          | 53.3       | 31.5       | 27.2       | 28.7       | 31.4       | 35.2       | 39.0       | 1.9        | 1.2        | 0.9        | 0.9         | 0.5         | 0.9         |
| Non-energy   | 42.86         | 85.60           | 212.27          | 226.51          | 236.01          | 240.49          | 240.83          | 6.5        | 7.0        | 9.2        | 9.2        | 9.7        | 10.1       | 10.6       | 5.3        | 0.7        | 0.4        | 0.2         | 0.0         | 0.3         |
| <b>Total</b> | <b>657.59</b> | <b>1,227.11</b> | <b>2,316.69</b> | <b>2,450.29</b> | <b>2,441.11</b> | <b>2,388.28</b> | <b>2,262.73</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>0.6</b> | <b>0.0</b> | <b>-0.2</b> | <b>-0.5</b> | <b>-0.1</b> |
| Coal         | 311.40        | 538.34          | 542.27          | 436.78          | 346.49          | 279.15          | 223.62          | 47.4       | 43.9       | 23.4       | 17.8       | 14.2       | 11.7       | 9.9        | 1.8        | -2.4       | -2.3       | -2.1        | -2.2        | -2.2        |
| Oil          | 84.60         | 273.66          | 618.91          | 624.72          | 604.09          | 573.51          | 513.39          | 12.9       | 22.3       | 26.7       | 25.5       | 24.7       | 24.0       | 22.7       | 6.6        | 0.1        | -0.3       | -0.5        | -1.1        | -0.5        |
| Natural gas  | 8.87          | 29.10           | 223.01          | 242.35          | 241.47          | 230.00          | 202.46          | 1.3        | 2.4        | 9.6        | 9.9        | 9.9        | 9.6        | 8.9        | 11.0       | 0.9        | 0.0        | -0.5        | -1.3        | -0.2        |
| Hydrogen     | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -           | -           | -           |
| Fuel Ammonia | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -           | -           | -           |
| Electricity  | 39.03         | 171.51          | 651.85          | 856.02          | 982.54          | 1,061.00        | 1,108.17        | 5.9        | 14.0       | 28.1       | 34.9       | 40.2       | 44.4       | 49.0       | 9.5        | 3.1        | 1.4        | 0.8         | 0.4         | 1.4         |
| Heat         | 13.21         | 43.39           | 147.36          | 175.57          | 173.91          | 160.82          | 137.23          | 2.0        | 3.5        | 6.4        | 7.2        | 7.1        | 6.7        | 6.1        | 8.1        | 2.0        | -0.1       | -0.8        | -1.6        | -0.2        |
| Others       | 200.48        | 171.12          | 133.29          | 114.85          | 92.61           | 83.80           | 77.85           | 30.5       | 13.9       | 5.8        | 4.7        | 3.8        | 3.5        | 3.4        | -1.3       | -1.6       | -2.1       | -1.0        | -0.7        | -1.4        |

## Power generation Output

|                                     | TWh           |                 |                 |                  |                  |                  |                  |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|---------------|-----------------|-----------------|------------------|------------------|------------------|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990          | 2005            | 2021            | 2030             | 2040             | 2050             | 2060             | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>621.27</b> | <b>2,500.47</b> | <b>8,559.98</b> | <b>11,304.69</b> | <b>12,928.98</b> | <b>13,857.27</b> | <b>14,349.31</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>8.8</b> | <b>3.1</b> | <b>1.4</b> | <b>0.7</b> | <b>0.3</b> | <b>1.3</b> |
| Coal PP                             | 441.34        | 1,980.27        | 5,417.49        | 5,504.73         | 4,600.83         | 3,429.09         | 2,045.11         | 71.0       | 79.2       | 63.3       | 48.7       | 35.6       | 24.7       | 14.3       | 8.4        | 0.2        | -1.8       | -2.9       | -5.0       | -2.5       |
| Coal PP with biomass co-firing      | 0.00          | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00          | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                                 | 50.37         | 50.51           | 11.41           | 9.79             | 6.32             | 3.15             | 0.82             | 8.1        | 2.0        | 0.1        | 0.1        | 0.0        | 0.0        | 0.0        | -4.7       | -1.7       | -4.3       | -6.7       | -12.5      | -6.5       |
| Gas PP                              | 2.77          | 12.14           | 267.97          | 561.39           | 767.46           | 821.86           | 658.86           | 0.4        | 0.5        | 3.1        | 5.0        | 5.9        | 5.9        | 4.6        | 15.9       | 8.6        | 3.2        | 0.7        | -2.2       | 2.3        |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00          | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.00          | 53.09           | 407.52          | 564.24           | 739.05           | 909.82           | 1,082.61         | 0.0        | 2.1        | 4.8        | 5.0        | 5.7        | 6.6        | 7.5        | -          | 3.7        | 2.7        | 2.1        | 1.8        | 2.5        |
| Solar PV                            | 0.01          | 0.09            | 329.02          | 1,279.10         | 2,117.89         | 2,826.65         | 3,535.41         | 0.0        | 0.0        | 3.8        | 11.3       | 16.4       | 20.4       | 24.6       | 40.3       | 16.3       | 5.2        | 2.9        | 2.3        | 6.3        |
| Wind                                | 0.00          | 2.03            | 656.10          | 1,591.08         | 2,653.71         | 3,648.99         | 4,644.27         | 0.0        | 0.1        | 7.7        | 14.1       | 20.5       | 26.3       | 32.4       | 50.6       | 10.3       | 5.2        | 3.2        | 2.4        | 5.1        |
| Hydro                               | 126.72        | 397.02          | 1,300.00        | 1,405.59         | 1,566.15         | 1,684.50         | 1,793.34         | 20.4       | 15.9       | 15.2       | 12.4       | 12.1       | 12.2       | 12.5       | 7.8        | 0.9        | 1.1        | 0.7        | 0.6        | 0.8        |
| Geothermal                          | 0.06          | 0.12            | 0.13            | 1.15             | 1.47             | 1.57             | 1.68             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 2.6        | 27.9       | 2.5        | 0.7        | 0.6        | 6.9        |
| Biomass and others                  | 0             | 5.20            | 170.35          | 387.63           | 476.09           | 531.65           | 587.20           | 0.0        | 0.2        | 2.0        | 3.4        | 3.7        | 3.8        | 4.1        | -          | 9.6        | 2.1        | 1.1        | 1.0        | 3.2        |

## Power generation Input

|                      | MTOE          |               |                 |                 |                 |                 |               |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |             |
|----------------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|                      | 1990          | 2005          | 2021            | 2030            | 2040            | 2050            | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b>         | <b>144.73</b> | <b>579.87</b> | <b>1,450.49</b> | <b>1,660.73</b> | <b>1,482.45</b> | <b>1,166.83</b> | <b>777.95</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.7</b> | <b>1.5</b> | <b>-1.1</b> | <b>-2.4</b> | <b>-4.0</b> | <b>-1.6</b> |
| Coal                 | 131.74        | 564.39        | 1,389.32        | 1,401.88        | 1,156.15        | 818.77          | 455.36        | 91.0       | 97.3       | 95.8       | 84.4       | 78.0       | 70.2       | 58.5       | 7.9        | 0.1        | -1.9        | -3.4        | -5.7        | -2.8        |
| Fuel ammonia         | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |
| Biomass (Co-firing)  | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |
| Oil                  | 12.37         | 12.41         | 2.80            | 2.36            | 1.50            | 0.74            | 0.19          | 8.5        | 2.1        | 0.2        | 0.1        | 0.1        | 0.1        | 0.0        | -4.7       | -1.9       | -4.4        | -6.8        | -12.6       | -6.7        |
| Gas                  | 0.61          | 3.07          | 58.37           | 126.76          | 170.16          | 179.73          | 142.68        | 0.4        | 0.5        | 4.0        | 7.6        | 11.5       | 15.4       | 18.3       | 15.8       | 9.0        | 3.0         | 0.5         | -2.3        | 2.3         |
| Hydrogen             | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |
| Biomass (Biomass PP) | 0.00          | 0.00          | 0.00            | 129.74          | 154.64          | 167.59          | 179.73        | 0.0        | 0.0        | 0.0        | 7.8        | 10.4       | 14.4       | 23.1       | -          | -          | 1.8         | 0.8         | 0.7         | -           |

## Thermal Efficiency

|  | % |  |  |  |  |  |  |  |  |  |  |  |  |  | AAGR(%) |  |  |  |
|--|---|--|--|--|--|--|--|--|--|--|--|--|--|--|---------|--|--|--|
|--|---|--|--|--|--|--|--|--|--|--|--|--|--|--|---------|--|--|--|

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                 |                 |                |                |                |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|--------------------|----------------|-----------------|-----------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005           | 2021            | 2030            | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>2,195.4</b>     | <b>5,640.8</b> | <b>10,648.5</b> | <b>10,453.2</b> | <b>8,963.1</b> | <b>7,069.8</b> | <b>4,908.4</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.2</b> | <b>-0.2</b> | <b>-1.5</b> | <b>-2.3</b> | <b>-3.6</b> | <b>-2.0</b> |
| Coal         | 1,904.8            | 4,787.8        | 8,524.5         | 8,029.4         | 6,535.7        | 4,771.7        | 2,976.3        | 86.8       | 84.9       | 80.1       | 76.8       | 72.9       | 67.5       | 60.6       | 5.0        | -0.7        | -2.0        | -3.1        | -4.6        | -2.7        |
| Oil          | 272.7              | 778.5          | 1,472.6         | 1,556.5         | 1,465.2        | 1,346.2        | 1,136.5        | 12.4       | 13.8       | 13.8       | 14.9       | 16.3       | 19.0       | 23.2       | 5.6        | 0.6         | -0.6        | -0.8        | -1.7        | -0.7        |
| Natural Gas  | 17.9               | 74.5           | 651.5           | 867.3           | 962.2          | 951.9          | 795.7          | 0.8        | 1.3        | 6.1        | 8.3        | 10.7       | 13.5       | 16.2       | 12.3       | 3.2         | 1.0         | -0.1        | -1.8        | 0.5         |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0             | 0.0             | 0.0            | 0.0            | 0.0            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |       |        |        |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|--------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021   | 2030   | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 1,027 | 4,421 | 15,802 | 22,370 | 32,500 | 45,128 | 58,004 | 9.2       | 3.9       | 3.8       | 3.3       | 2.5       | 3.4       |
| Population (millions of people)                                                           | 1,135 | 1,304 | 1,412  | 1,404  | 1,367  | 1,305  | 1,200  | 0.7       | -0.1      | -0.3      | -0.5      | -0.8      | -0.4      |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.91  | 3.39  | 11.19  | 15.94  | 23.77  | 34.59  | 48.34  | 8.4       | 4.0       | 4.1       | 3.8       | 3.4       | 3.8       |
| Primary energy consumption per capita (toe/person)                                        | 0.77  | 1.37  | 2.65   | 2.83   | 2.81   | 2.74   | 2.66   | 4.1       | 0.8       | -0.1      | -0.3      | -0.3      | 0.0       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 850   | 403   | 237    | 178    | 118    | 79     | 55     | -4.0      | -3.1      | -4.0      | -3.9      | -3.6      | -3.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 640   | 278   | 147    | 110    | 75     | 53     | 39     | -4.6      | -3.2      | -3.7      | -3.4      | -3.0      | -3.3      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 2,137 | 1,276 | 674    | 467    | 276    | 157    | 85     | -3.7      | -4.0      | -5.1      | -5.5      | -6.0      | -5.2      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.51  | 3.17  | 2.85   | 2.63   | 2.33   | 1.98   | 1.54   | 0.4       | -0.9      | -1.2      | -1.6      | -2.5      | -1.6      |
| Automobile ownership volume (millions of vehicles)                                        | 6     | 32    | 294    | 390    | 433    | 464    | 474    | 13.7      | 3.2       | 1.0       | 0.7       | 0.2       | 1.2       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.005 | 0.024 | 0.208  | 0.278  | 0.317  | 0.355  | 0.395  | 12.9      | 3.3       | 1.3       | 1.1       | 1.1       | 1.7       |

# China [LCET]

## Primary energy consumption

|                                | MTOE   |          |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------------------------|--------|----------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | 1990   | 2005     | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                          | 873.64 | 1,781.34 | 3,738.22 | 3,747.44 | 3,064.28 | 2,202.29 | 1,746.61 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 4.8       | 0.1       | -2.0      | -3.2      | -2.3      | -1.9      |
| Coal                           | 530.52 | 1,203.61 | 2,266.17 | 1,997.09 | 1,212.50 | 405.55   | 204.85   | 60.7 | 67.6 | 60.6 | 53.0 | 39.6 | 18.4 | 11.7 | 4.8       | -1.4      | -4.9      | -10.4     | -6.6      | -6.0      |
| Oil                            | 118.79 | 317.82   | 677.70   | 614.17   | 451.31   | 289.17   | 155.92   | 13.6 | 17.8 | 18.1 | 16.3 | 14.7 | 13.1 | 8.9  | 5.8       | -1.1      | -3.0      | -4.4      | -6.0      | -3.7      |
| Natural gas                    | 12.80  | 38.79    | 299.07   | 351.55   | 288.29   | 62.07    | 21.52    | 1.5  | 2.2  | 8.0  | 9.3  | 9.4  | 2.8  | 1.2  | 10.7      | 1.8       | -2.0      | -14.2     | -10.1     | -6.5      |
| Hydrogen                       | 0.00   | 0.00     | 0.00     | 0.01     | 2.66     | 8.03     | -31.97   | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  | 0.4  | -1.8 | -         | -         | 74.8      | 11.7      | -         | -         |
| Fuel Ammonia                   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear                        | 0.00   | 13.83    | 106.18   | 170.58   | 227.60   | 286.20   | 254.18   | 0.0  | 0.8  | 2.8  | 4.5  | 7.4  | 13.0 | 14.6 | -         | 5.4       | 2.9       | 2.3       | -1.2      | 2.3       |
| Hydro                          | 10.90  | 34.14    | 111.78   | 121.61   | 128.94   | 136.09   | 131.01   | 1.2  | 1.9  | 3.0  | 3.2  | 4.2  | 6.2  | 7.5  | 7.8       | 0.9       | 0.6       | 0.5       | -0.4      | 0.4       |
| Geothermal                     | 0.00   | 2.34     | 23.86    | 25.05    | 23.47    | 16.50    | 2.33     | 0.0  | 0.1  | 0.6  | 0.7  | 0.8  | 0.7  | 0.1  | -         | 0.5       | -0.6      | -3.5      | -17.8     | -5.8      |
| Others                         | 200.64 | 170.80   | 253.45   | 487.38   | 729.50   | 998.69   | 1,008.77 | 23.0 | 9.6  | 6.8  | 12.9 | 23.8 | 45.3 | 57.8 | 0.8       | 7.5       | 4.1       | 3.2       | 0.1       | 3.6       |
| Biomass                        | 200.45 | 164.24   | 133.49   | 180.31   | 176.48   | 191.61   | 169.52   | 22.9 | 9.2  | 3.6  | 4.8  | 5.8  | 8.7  | 9.7  | -1.3      | 3.4       | -0.2      | 0.8       | -1.2      | 0.6       |
| Solar, Wind, Ocean             | 0.03   | 2.94     | 110.64   | 293.59   | 537.36   | 770.59   | 777.47   | 0.0  | 0.2  | 3.0  | 7.8  | 17.5 | 35.0 | 44.5 | 29.9      | 11.5      | 6.2       | 3.7       | 0.1       | 5.1       |
| Biofuels                       | 0.00   | 4.15     | 10.55    | 14.93    | 17.10    | 37.93    | 63.23    | 0.0  | 0.2  | 0.3  | 0.4  | 0.6  | 1.7  | 3.6  | -         | 3.9       | 1.4       | 8.3       | 5.2       | 4.7       |
| Electricity (Import or Export) | 0.16   | -0.53    | -1.22    | -1.44    | -1.44    | -1.45    | -1.44    | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -0.1 | -0.1 | -206.8    | 1.8       | 0.0       | 0.0       | 0.0       | 0.4       |

## Final energy demand

|              | MTOE   |          |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|--------|----------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990   | 2005     | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 657.59 | 1,227.11 | 2,316.69 | 2,260.92 | 1,967.13 | 1,619.46 | 1,277.95 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 4.1       | -0.3      | -1.4      | -1.9      | -2.3      | -1.5      |
| Industry     | 233.85 | 620.43   | 1,129.05 | 1,028.30 | 818.38   | 566.87   | 349.81   | 35.6 | 50.6 | 48.7 | 45.5 | 41.6 | 35.0 | 27.4 | 5.2       | -1.0      | -2.3      | -3.6      | -4.7      | -3.0      |
| Transport    | 30.20  | 134.00   | 346.34   | 381.20   | 301.24   | 238.17   | 181.41   | 4.6  | 10.9 | 14.9 | 16.9 | 15.3 | 14.7 | 14.2 | 8.2       | 1.1       | -2.3      | -2.3      | -2.7      | -1.6      |
| Others       | 350.68 | 387.08   | 629.04   | 625.54   | 613.15   | 569.39   | 516.51   | 53.3 | 31.5 | 27.2 | 27.7 | 31.2 | 35.2 | 40.4 | 1.9       | -0.1      | -0.2      | -0.7      | -1.0      | -0.5      |
| Non-energy   | 42.86  | 85.60    | 212.27   | 225.88   | 234.37   | 245.03   | 230.22   | 6.5  | 7.0  | 9.2  | 10.0 | 11.9 | 15.1 | 18.0 | 5.3       | 0.7       | 0.4       | 0.4       | -0.6      | 0.2       |
| Total        | 657.59 | 1,227.11 | 2,316.69 | 2,260.92 | 1,967.13 | 1,619.46 | 1,277.95 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 4.1       | -0.3      | -1.4      | -1.9      | -2.3      | -1.5      |
| Coal         | 311.40 | 538.34   | 542.27   | 374.29   | 243.32   | 158.68   | 102.51   | 47.4 | 43.9 | 23.4 | 16.6 | 12.4 | 9.8  | 8.0  | 1.8       | -4.0      | -4.2      | -4.2      | -4.3      | -4.2      |
| Oil          | 84.60  | 273.66   | 618.91   | 566.62   | 415.38   | 263.87   | 143.96   | 12.9 | 22.3 | 26.7 | 25.1 | 21.1 | 16.3 | 11.3 | 6.6       | -1.0      | -3.1      | -4.4      | -5.9      | -3.7      |
| Natural gas  | 8.87   | 29.10    | 223.01   | 181.12   | 123.92   | 66.50    | 29.02    | 1.3  | 2.4  | 9.6  | 8.0  | 6.3  | 4.1  | 2.3  | 11.0      | -2.3      | -3.7      | -6.0      | -8.0      | -5.1      |
| Hydrogen     | 0.00   | 0.00     | 0.00     | 0.01     | 6.95     | 14.68    | 11.55    | 0.0  | 0.0  | 0.0  | 39.2 | 0.4  | 0.9  | 0.9  | -         | -         | -38.4     | 7.8       | -2.4      | -         |
| Fuel Ammonia | 0.00   | 0.00     | 0.00     | 0.00     | 45.63    | 64.40    | 72.14    | 0.0  | 0.0  | 0.0  | 6.5  | 2.3  | 4.0  | 5.6  | -         | -         | -11.0     | 3.5       | 1.1       | -         |
| Electricity  | 39.03  | 171.51   | 651.85   | 886.57   | 939.01   | 895.93   | 803.41   | 5.9  | 14.0 | 28.1 | 6.5  | 47.7 | 55.3 | 62.9 | 9.5       | -15.3     | 20.4      | -0.5      | -1.1      | 0.5       |
| Heat         | 13.21  | 43.39    | 147.36   | 146.26   | 109.33   | 65.88    | 18.21    | 2.0  | 3.5  | 6.4  | 4.7  | 5.6  | 4.1  | 1.4  | 8.1       | -3.6      | 0.3       | -4.9      | -12.1     | -5.2      |
| Others       | 200.48 | 171.12   | 133.29   | 106.05   | 83.60    | 89.53    | 97.15    | 30.5 | 13.9 | 5.8  | 0.0  | 4.2  | 5.5  | 7.6  | -1.3      | -         | -         | 0.7       | 0.8       | -0.8      |

## Power generation Output

|                                     | TWh    |          |          |           |           |           |           |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|--------|----------|----------|-----------|-----------|-----------|-----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990   | 2005     | 2021     | 2030      | 2040      | 2050      | 2060      | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 621.27 | 2,500.47 | 8,559.98 | 11,702.94 | 12,473.02 | 12,388.86 | 11,750.42 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 8.8       | 3.5       | 0.6       | -0.1      | -0.5      | 0.8       |
| Coal PP                             | 441.34 | 1,980.27 | 5,417.49 | 4,184.37  | 1,621.88  | 10.32     | 0.22      | 71.0 | 79.2 | 63.3 | 35.8 | 13.0 | 0.1  | 0.0  | 8.4       | -2.8      | -9.0      | -39.7     | -31.8     | -22.8     |
| Coal PP with biomass co-firing      | 0.00   | 0.00     | 0.00     | 23.38     | 65.75     | 0.99      | 0.02      | 0.0  | 0.0  | 0.0  | 0.2  | 0.5  | 0.0  | 0.0  | -         | -         | 10.9      | -34.3     | -31.8     | -         |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00     | 0.00     | 0.00      | 65.75     | 4.11      | 0.09      | 0.0  | 0.0  | 0.0  | 0.0  | 0.5  | 0.0  | 0.0  | -         | -         | -         | -24.2     | -31.8     | -         |
| Coal PP with CCS                    | 0.00   | 0.00     | 0.00     | 1,186.80  | 1,168.92  | 293.10    | 6.37      | 0.0  | 0.0  | 0.0  | 10.1 | 9.4  | 2.4  | 0.1  | -         | -         | -0.2      | -12.9     | -31.8     | -         |
| Oil                                 | 50.37  | 50.51    | 11.41    | 9.81      | 4.27      | 0.00      | 0.00      | 8.1  | 2.0  | 0.1  | 0.1  | 0.0  | 0.0  | 0.0  | -4.7      | -1.7      | -8.0      | -100.0    | -         | -100.0    |
| Gas PP                              | 2.77   | 12.14    | 267.97   | 549.74    | 438.73    | 0.00      | 0.00      | 0.4  | 0.5  | 3.1  | 4.7  | 3.5  | 0.0  | 0.0  | 15.9      | 8.3       | -2.2      | -100.0    | -         | -100.0    |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00     | 0.00     | 0.00      | 4.82      | 188.58    | 41.34     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 1.5  | 0.4  | -         | -         | -         | 44.3      | -14.1     | -         |
| Gas PP with CCS                     | 0.00   | 0.00     | 0.00     | 155.05    | 292.49    | 0.00      | 0.00      | 0.0  | 0.0  | 0.0  | 1.3  | 2.3  | 0.0  | 0.0  | -         | -         | 6.6       | -100.0    | -         | -         |
| Nuclear PP                          | 0.00   | 53.09    | 407.52   | 654.68    | 873.52    | 1,098.41  | 975.54    | 0.0  | 2.1  | 4.8  | 5.6  | 7.0  | 8.9  | 8.3  | -         | 5.4       | 2.9       | 2.3       | -1.2      | 2.3       |
| Solar PV                            | 0.01   | 0.09     | 329.02   | 1,712.31  | 3,563.94  | 5,619.27  | 5,645.05  | 0.0  | 0.0  | 3.8  | 14.6 | 28.6 | 45.4 | 48.0 | 40.3      | 20.1      | 7.6       | 4.7       | 0.0       | 7.6       |
| Wind                                | 0.00   | 2.03     | 656.10   | 1,400.98  | 2,375.96  | 3,025.76  | 3,039.64  | 0.0  | 0.1  | 7.7  | 12.0 | 19.0 | 24.4 | 25.9 | 50.6      | 8.8       | 5.4       | 2.4       | 0.0       | 4.0       |
| Hydro                               | 126.72 | 397.02   | 1,300.00 | 1,414.32  | 1,499.55  | 1,582.77  | 1,523.61  | 20.4 | 15.9 | 15.2 | 12.1 | 12.0 | 12.8 | 13.0 | 7.8       | 0.9       | 0.6       | 0.5       | -0.4      | 0.4       |
| Geothermal                          | 0.06   | 0.12     | 0.13     | 2.07      | 2.45      | 2.50      | 2.58      | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 2.6       | 36.6      | 1.7       | 0.2       | 0.3       | 8.1       |
| Biomass and others                  | 0      | 5.20     | 170.35   | 409.43    | 494.98    | 563.04    | 515.95    | 0.0  | 0.2  | 2.0  | 3.5  | 4.0  | 4.5  | 4.4  | -         | 10.2      | 1.9       | 1.3       | -0.9      | 2.9       |

## Power generation Input

|                      | MTOE   |        |          |          |          |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |  |
|----------------------|--------|--------|----------|----------|----------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                      | 1990   | 2005   | 2021     | 2030     | 2040     | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                | 144.73 | 579.87 | 1,450.49 | 1,650.34 | 1,112.89 | 305.54 | 162.25 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 7.7       | 1.4       | -3.9      | -12.1     | -6.1      | -5.5      |  |
| Coal                 | 131.74 | 564.39 | 1,389.32 | 1,358.88 | 761.70   | 90.87  | 1.83   | 91.0 | 97.3 | 95.8 | 82.3 | 68.4 | 29.7 | 1.1  | 7.9       | -0.2      | -5.6      | -19.2     | -32.3     | -15.6     |  |
| Fuel ammonia         | 0.00   | 0.00   | 0.00     | 0.00     | 31.37    | 3.91   | 0.08   | 0.0  | 0.0  | 0.0  | 0.0  | 2.8  | 1.3  | 0.1  | -         | -         | -         | -18.8     | -31.8     | -         |  |
| Biomass (Co-firing)  | 0.00   | 0.00   | 0.00     | 0.82     | 4.70     | 0.09   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.4  | 0.0  | 0.0  | -         | -         | 19.1      | -32.6     | -32.1     | -         |  |
| Oil                  | 12.37  | 12.41  | 2.80     | 2.32     | 1.10     | 0.00   | 0.00   | 8.5  | 2.1  | 0.2  | 0.1  | 0.1  | 0.0  | 0.0  | -4.7      | -2.1      | -7.2      | -100.0    | -         | -100.0    |  |
| Gas                  | 0.61   | 3.07   | 58.37    | 153.34   | 161.46   | 0.00   | 0.00   | 0.4  | 0.5  | 4.0  | 9.3  | 14.5 | 0.0  | 0.0  | 15.8      | 11.3      | 0.5       | -100.0    | -         | -100.0    |  |
| Hydrogen             | 0.00   | 0.00   | 0.00     | 0.00     | 3.69     | 38.84  | 8.40   | 0.0  | 0.0  | 0.0  | 0.0  | 0.3  | 12.7 | 5.2  | -         | -         | -         | 26.6      | -14.2     | -         |  |
| Biomass (Biomass PP) | 0.00   | 0.00   | 0.00     | 134.99   | 148.86   | 171.83 | 151.94 | 0.0  | 0.0  | 0.0  | 8.2  | 13.4 | 56.2 | 93.6 | -         | -         | 1.0       | 1.4       | -1.2      | -         |  |

## Thermal Efficiency

|  | % |  |  |
|--|---|--|--|
|--|---|--|--|

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                 |                |                |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |              |              |
|--------------|--------------------|----------------|-----------------|----------------|----------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|--------------|
|              | 1990               | 2005           | 2021            | 2030           | 2040           | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050    | 2050-2060    |
| <b>Total</b> | <b>2,195.4</b>     | <b>5,640.8</b> | <b>10,648.5</b> | <b>8,484.8</b> | <b>4,449.7</b> | <b>897.0</b> | <b>187.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.2</b> | <b>-2.5</b> | <b>-6.3</b> | <b>-14.8</b> | <b>-14.5</b> |
| Coal         | 1,904.8            | 4,787.8        | 8,524.5         | 6,414.5        | 3,176.6        | 630.9        | 302.9        | 86.8       | 84.9       | 80.1       | 75.6       | 71.4       | 70.3       | 161.7      | 5.0        | -3.1        | -6.8        | -14.9        | -7.1         |
| Oil          | 272.7              | 778.5          | 1,472.6         | 1,362.4        | 859.1          | 344.8        | 33.3         | 12.4       | 13.8       | 13.8       | 16.1       | 19.3       | 38.4       | 17.8       | 5.6        | -0.9        | -4.5        | -8.7         | -20.8        |
| Natural Gas  | 17.9               | 74.5           | 651.5           | 707.9          | 464.3          | 42.0         | 0.0          | 0.8        | 1.3        | 6.1        | 8.3        | 10.4       | 4.7        | 0.0        | 12.3       | 0.9         | -4.1        | -21.4        | -100.0       |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0             | 0.0            | -50.3          | -120.7       | -142.3       | 0.0        | 0.0        | 0.0        | 0.0        | -1.1       | -13.5      | -76.0      | -          | -           | -           | 9.1          | 1.7          |

## Energy and economic Indicators

|                                                                                           |       |       |        |        |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|--------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021   | 2030   | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060-2060 |
| GDP (billions of 2015 US dollars)                                                         | 1,027 | 4,421 | 15,802 | 22,370 | 32,500 | 45,128 | 58,004 | 9.2       | 3.9       | 3.8       | 3.3       | 2.5       | 3.4       |
| Population (millions of people)                                                           | 1,135 | 1,304 | 1,412  | 1,404  | 1,367  | 1,305  | 1,200  | 0.7       | -0.1      | -0.3      | -0.5      | -0.8      | -0.4      |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.91  | 3.39  | 11.19  | 15.94  | 23.77  | 34.59  | 48.34  | 8.4       | 4.0       | 4.1       | 3.8       | 3.4       | 3.8       |
| Primary energy consumption per capita (toe/person)                                        | 0.77  | 1.37  | 2.65   | 2.68   | 2.24   | 1.69   | 1.46   | 4.1       | 0.2       | -1.8      | -2.8      | -1.5      | -1.5      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 850   | 403   | 237    | 168    | 94     | 49     | 30     | -4.0      | -3.7      | -5.6      | -6.4      | -4.7      | -5.1      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 640   | 278   | 147    | 101    | 61     | 36     | 22     | -4.6      | -4.0      | -5.0      | -5.1      | -4.8      | -4.7      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 2,137 | 1,276 | 674    | 379    | 137    | 20     | 3      | -3.7      | -6.2      | -9.7      | -17.5     | -16.6     | -12.8     |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.51  | 3.17  | 2.85   | 2.25   | 1.45   | 0.41   | 0.11   | 0.4       | -2.6      | -4.3      | -11.9     | -12.5     | -8.1      |
| Automobile ownership volume (millions of vehicles)                                        | 6     | 32    | 294    | 390    | 433    | 464    | 474    | 13.7      | 3.2       | 1.0       | 0.7       | 0.2       | 1.2       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.005 | 0.024 | 0.208  | 0.278  | 0.317  | 0.355  | 0.395  | 12.9      | 3.3       | 1.3       | 1.1       | 1.1       | 1.7       |

## India [BAU]

### Primary energy consumption

|                                | MTOE          |               |               |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|---------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990          | 2005          | 2021          | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>280.23</b> | <b>491.16</b> | <b>944.13</b> | <b>1,349.74</b> | <b>1,907.82</b> | <b>2,449.11</b> | <b>2,879.96</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.0</b> | <b>4.1</b> | <b>3.5</b> | <b>2.5</b> | <b>1.6</b> |
| Coal                           | 92.70         | 184.22        | 421.29        | 560.89          | 733.93          | 877.13          | 1,023.05        | 33.1       | 37.5       | 44.6       | 41.6       | 38.5       | 35.8       | 35.5       | 5.0        | 3.2        | 2.7        | 1.8        | 1.6        |
| Oil                            | 61.10         | 124.83        | 223.40        | 323.29          | 532.88          | 771.38          | 913.10          | 21.8       | 25.4       | 23.7       | 24.0       | 27.9       | 31.5       | 31.7       | 4.3        | 4.2        | 5.1        | 3.8        | 1.7        |
| Natural gas                    | 10.57         | 31.81         | 55.07         | 98.27           | 168.54          | 244.76          | 315.00          | 3.8        | 6.5        | 5.8        | 7.3        | 8.8        | 10.0       | 10.9       | 5.5        | 6.6        | 5.5        | 3.8        | 2.6        |
| Hydrogen                       | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 1.60          | 4.51          | 12.28         | 36.40           | 46.73           | 60.94           | 77.01           | 0.6        | 0.9        | 1.3        | 2.7        | 2.4        | 2.5        | 2.7        | 6.8        | 12.8       | 2.5        | 2.7        | 2.4        |
| Hydro                          | 6.16          | 9.30          | 13.97         | 19.79           | 26.56           | 33.60           | 40.70           | 2.2        | 1.9        | 1.5        | 1.5        | 1.4        | 1.4        | 1.4        | 2.7        | 3.9        | 3.0        | 2.4        | 1.9        |
| Geothermal                     | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 108.09        | 136.48        | 218.13        | 311.09          | 399.19          | 461.30          | 511.09          | 38.6       | 27.8       | 23.1       | 23.0       | 20.9       | 18.8       | 17.7       | 2.3        | 4.0        | 2.5        | 1.5        | 1.0        |
| Biomass                        | 107.97        | 134.85        | 198.21        | 251.92          | 277.87          | 280.59          | 272.66          | 38.5       | 27.5       | 21.0       | 18.7       | 14.6       | 11.5       | 9.5        | 2.0        | 2.7        | 1.0        | 0.1        | -0.3       |
| Solar Wind Ocean               | 0.01          | 0.63          | 14.54         | 52.55           | 113.27          | 169.48          | 225.03          | 0.0        | 0.1        | 1.5        | 3.9        | 5.9        | 6.9        | 7.8        | 26.3       | 15.3       | 8.0        | 4.1        | 2.9        |
| Biofuels                       | 0.00          | 0.87          | 5.38          | 6.89            | 8.32            | 11.50           | 13.67           | 0.0        | 0.2        | 0.6        | 0.5        | 0.4        | 0.5        | 0.5        | -          | 2.8        | 1.9        | 3.3        | 1.7        |
| Electricity (Import or Export) | 0.12          | 0.13          | 0.00          | -0.26           | -0.27           | -0.26           | -0.26           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -188.1     | 69.4       | 0.1        | -0.1       | 0.0        |

### Final energy demand

|              | MTOE          |               |               |               |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|---------------|---------------|---------------|---------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990          | 2005          | 2021          | 2030          | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>215.04</b> | <b>332.39</b> | <b>632.48</b> | <b>895.12</b> | <b>1,302.21</b> | <b>1,717.51</b> | <b>2,021.92</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.5</b> | <b>3.9</b> | <b>3.8</b> | <b>2.8</b> | <b>1.6</b> |
| Industry     | 59.05         | 103.71        | 247.02        | 399.64        | 580.47          | 705.04          | 770.52          | 27.5       | 31.2       | 39.1       | 44.6       | 44.6       | 41.1       | 38.1       | 4.7        | 5.5        | 3.8        | 2.0        | 0.9        |
| Transport    | 20.75         | 38.96         | 102.13        | 163.33        | 310.13          | 502.35          | 636.36          | 9.6        | 11.7       | 16.1       | 18.2       | 23.8       | 29.2       | 31.5       | 5.3        | 5.4        | 6.6        | 4.9        | 2.4        |
| Others       | 121.96        | 160.58        | 227.85        | 253.40        | 297.39          | 358.41          | 420.50          | 56.7       | 48.3       | 36.0       | 28.3       | 22.8       | 20.9       | 20.8       | 2.0        | 1.2        | 1.6        | 1.9        | 1.6        |
| Non-energy   | 13.28         | 29.15         | 55.48         | 78.76         | 114.22          | 151.71          | 194.54          | 6.2        | 8.8        | 8.8        | 8.8        | 8.8        | 8.8        | 8.8        | 9.6        | 4.0        | 3.8        | 2.9        | 2.5        |
| <b>Total</b> | <b>215.04</b> | <b>332.39</b> | <b>632.48</b> | <b>895.12</b> | <b>1,302.21</b> | <b>1,717.51</b> | <b>2,021.92</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.5</b> | <b>3.9</b> | <b>3.8</b> | <b>2.8</b> | <b>1.6</b> |
| Coal         | 38.24         | 44.02         | 106.82        | 139.90        | 185.01          | 222.95          | 251.81          | 17.8       | 13.2       | 16.9       | 15.6       | 14.2       | 13.0       | 12.5       | 3.4        | 3.0        | 2.8        | 1.9        | 1.2        |
| Oil          | 50.17         | 106.17        | 204.95        | 301.44        | 501.72          | 729.03          | 864.11          | 23.3       | 31.9       | 32.4       | 33.7       | 38.5       | 42.4       | 42.7       | 4.6        | 4.4        | 5.2        | 3.8        | 1.7        |
| Natural gas  | 6.09          | 13.82         | 37.72         | 58.55         | 93.67           | 129.36          | 159.22          | 2.8        | 4.2        | 6.0        | 6.5        | 7.2        | 7.5        | 7.9        | 6.1        | 5.0        | 4.8        | 3.3        | 2.1        |
| Hydrogen     | 0.00          | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00          | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 18.21         | 41.46         | 103.75        | 182.96        | 293.93          | 414.39          | 542.66          | 8.5        | 12.5       | 16.4       | 20.4       | 22.6       | 24.1       | 26.8       | 5.8        | 6.5        | 4.9        | 3.5        | 2.7        |
| Heat         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 102.33        | 126.93        | 179.25        | 212.27        | 227.89          | 221.79          | 204.11          | 47.6       | 38.2       | 28.3       | 23.7       | 17.5       | 12.9       | 10.1       | 1.8        | 1.9        | 0.7        | -0.3       | -0.8       |

### Power generation Output

|                                     | TWh           |               |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990          | 2005          | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>289.47</b> | <b>708.36</b> | <b>1,635.17</b> | <b>2,839.53</b> | <b>4,387.53</b> | <b>5,910.64</b> | <b>7,412.24</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.7</b> | <b>6.3</b> | <b>4.4</b> | <b>3.0</b> | <b>2.3</b> |
| Coal PP                             | 189.15        | 476.54        | 1,169.70        | 1,614.89        | 2,137.44        | 2,600.67        | 2,977.31        | 65.3       | 67.3       | 71.5       | 56.9       | 48.7       | 44.0       | 40.2       | 6.1        | 3.6        | 2.8        | 2.0        | 1.4        |
| Coal PP with biomass co-firing      | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                                 | 12.54         | 19.53         | 4.51            | 1.46            | 0.00            | 0.00            | 0.00            | 4.3        | 2.8        | 0.3        | 0.1        | 0.0        | 0.0        | 0.0        | -3.2       | -11.8      | -100.0     | -          | -100.0     |
| Gas PP                              | 9.96          | 75.47         | 61.73           | 189.57          | 376.75          | 628.87          | 938.13          | 3.4        | 10.7       | 3.8        | 6.7        | 8.6        | 10.6       | 12.7       | 6.1        | 13.3       | 7.1        | 5.3        | 4.1        |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear PP                          | 6.14          | 17.32         | 47.11           | 139.72          | 179.36          | 233.89          | 295.56          | 2.1        | 2.4        | 2.9        | 4.9        | 4.1        | 4.0        | 4.0        | 6.8        | 12.8       | 2.5        | 2.7        | 2.4        |
| Solar PV                            | 0.00          | 0.00          | 75.57           | 455.41          | 1,061.23        | 1,598.02        | 2,134.81        | 0.0        | 0.0        | 4.6        | 16.0       | 24.2       | 27.0       | 28.8       | -          | 22.1       | 8.8        | 4.2        | 2.9        |
| Wind                                | 0.03          | 6.21          | 77.14           | 125.90          | 214.17          | 319.90          | 425.63          | 0.0        | 0.9        | 4.7        | 4.4        | 4.9        | 5.4        | 5.7        | 28.6       | 5.6        | 5.5        | 4.1        | 2.9        |
| Hydro                               | 71.66         | 108.12        | 162.44          | 230.17          | 308.86          | 390.71          | 473.36          | 24.8       | 15.3       | 9.9        | 8.1        | 7.0        | 6.6        | 6.4        | 2.7        | 3.9        | 3.0        | 2.4        | 1.9        |
| Geothermal                          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass and others                  | 1.66E-05      | 5.16          | 36.97           | 82.42           | 109.71          | 138.57          | 167.44          | 0.0        | 0.7        | 2.3        | 2.9        | 2.5        | 2.3        | 2.3        | 60.2       | 9.3        | 2.9        | 2.4        | 1.9        |

### Power generation Input

|                      | MTOE         |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>56.84</b> | <b>148.90</b> | <b>298.77</b> | <b>452.00</b> | <b>596.12</b> | <b>715.09</b> | <b>845.21</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.5</b> | <b>4.7</b> | <b>2.8</b> | <b>1.8</b> | <b>1.7</b> |
| Coal                 | 48.37        | 127.58        | 283.95        | 375.94        | 479.69        | 550.43        | 628.58        | 85.1       | 85.7       | 95.0       | 83.2       | 80.5       | 77.0       | 74.4       | 5.9        | 3.2        | 2.5        | 1.4        | 1.3        |
| Fuel ammonia         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                  | 5.01         | 7.02          | 1.76          | 0.58          | 0.00          | 0.00          | 0.00          | 8.8        | 4.7        | 0.6        | 0.1        | 0.0        | 0.0        | 0.0        | -3.3       | -11.6      | -100.0     | -          | -100.0     |
| Gas                  | 3.46         | 14.31         | 13.07         | 33.20         | 61.81         | 97.70         | 138.08        | 6.1        | 9.6        | 4.4        | 7.3        | 10.4       | 13.7       | 16.3       | 4.4        | 10.9       | 6.4        | 4.7        | 3.5        |
| Hydrogen             | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00         | 0.00          | 0.00          | 42.28         | 54.62         | 66.95         | 78.55         | 0.0        | 0.0        | 0.0        | 9.4        | 9.2        | 9.4        | 9.3        | -          | -          | 2.6        | 2.1        | 1.6        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |
| Total      | 32.0 | 33.3 | 36.6 | 35.9 | 37.9 | 40.5 | 41.5 |  |  |  |  |  |  |  | 0.4       | -0.2      | 0.5       | 0.7       | 0.3       |
| Coal PP    | 33.6 | 32.1 | 35.4 | 36.9 | 38.3 | 40.6 | 40.7 |  |  |  |  |  |  |  | 0.2       | 0.5       | 0.4       | 0.6       | 0.0       |
| Oil PP     | 21.5 | 23.9 | 22.1 | 21.8 | -    | -    | -    |  |  |  |  |  |  |  | 0.1       | -0.2      | -         | -         | -         |
| Gas PP     | 24.7 | 45.4 | 40.6 | 49.1 | 52.4 | 55.4 | 58.4 |  |  |  |  |  |  |  |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 16.8 | 17.3 | 17.8 | 18.3 |  |  |  |  |  |  |  | -         | -         | 0.3       | 0.3       | 0.3       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                |                |                |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|----------------|----------------|----------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005           | 2021           | 2030           | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>531.1</b>       | <b>1,088.4</b> | <b>2,279.0</b> | <b>3,173.9</b> | <b>4,567.0</b> | <b>5,942.4</b> | <b>6,999.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.8</b> | <b>3.7</b> | <b>3.7</b> | <b>2.7</b> | <b>1.7</b> | <b>2.9</b> |
| Coal         | 358.1              | 716.2          | 1,627.3        | 2,178.1        | 2,861.0        | 3,426.2        | 4,000.3        | 67.4       | 65.8       | 71.4       | 68.6       | 62.6       | 57.7       | 57.2       | 5.0        | 3.3        | 2.8        | 1.8        | 1.6        | 2.3        |
| Oil          | 160.1              | 318.5          | 574.0          | 837.1          | 1,410.5        | 2,075.4        | 2,431.9        | 30.2       | 29.3       | 25.2       | 26.4       | 30.9       | 34.9       | 34.7       | 4.2        | 4.3        | 5.4        | 3.9        | 1.6        | 3.8        |
| Natural Gas  | 12.9               | 53.7           | 77.7           | 158.7          | 295.5          | 440.7          | 567.4          | 2.4        | 4.9        | 3.4        | 5.0        | 6.5        | 7.4        | 8.1        | 6.0        | 8.3        | 6.4        | 4.1        | 2.6        | 5.2        |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0            | 0.0            | 0.0            | 0.0            | 0.0            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 475   | 1,117 | 2,782 | 5,184 | 10,120 | 16,740 | 24,405 | 5.9       | 7.2       | 6.9       | 5.2       | 3.8       | 5.7       |
| Population (millions of people)                                                           | 870   | 1,155 | 1,408 | 1,514 | 1,613  | 1,674  | 1,701  | 1.6       | 0.8       | 0.6       | 0.4       | 0.2       | 0.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.55  | 0.97  | 1.98  | 3.42  | 6.27   | 10.00  | 14.35  | 4.2       | 6.3       | 6.2       | 4.8       | 3.7       | 5.2       |
| Primary energy consumption per capita (toe/person)                                        | 0.32  | 0.43  | 0.67  | 0.89  | 1.18   | 1.46   | 1.69   | 2.4       | 3.2       | 2.9       | 2.1       | 1.5       | 2.4       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 590   | 440   | 339   | 260   | 189    | 146    | 118    | -1.8      | -2.9      | -3.2      | -2.5      | -2.1      | -2.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 453   | 298   | 227   | 173   | 129    | 103    | 83     | -2.2      | -3.0      | -2.9      | -2.2      | -2.1      | -2.6      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 1,119 | 975   | 819   | 612   | 451    | 355    | 287    | -1.0      | -3.2      | -3.0      | -2.4      | -2.1      | -2.7      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.90  | 2.22  | 2.41  | 2.35  | 2.39   | 2.43   | 2.43   | 0.8       | -0.3      | 0.2       | 0.1       | 0.0       | 0.0       |
| Automobile ownership volume (millions of vehicles)                                        | 4     | 15    | 56    | 109   | 292    | 678    | 1,333  | 8.6       | 7.7       | 10.3      | 8.8       | 7.0       | 8.5       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.005 | 0.013 | 0.040 | 0.072 | 0.181  | 0.405  | 0.784  | 7.0       | 6.8       | 9.6       | 8.4       | 6.8       | 7.9       |

## India [LCET]

### Primary energy consumption

|                                | MTOE          |               |               |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|---------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990          | 2005          | 2021          | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>280.23</b> | <b>491.16</b> | <b>944.13</b> | <b>1,294.00</b> | <b>1,615.17</b> | <b>1,746.32</b> | <b>1,887.61</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.0</b> | <b>3.6</b> | <b>2.2</b> | <b>0.8</b> | <b>0.8</b> |
| Coal                           | 92.70         | 184.22        | 421.29        | 519.51          | 496.72          | 379.48          | 279.35          | 33.1       | 37.5       | 44.6       | 40.1       | 30.8       | 21.7       | 14.8       | 5.0        | 2.4        | -0.4       | -2.7       | -3.0       |
| Oil                            | 61.10         | 124.83        | 223.40        | 281.65          | 358.27          | 382.64          | 364.51          | 21.8       | 25.4       | 23.7       | 21.8       | 22.2       | 21.9       | 19.3       | 4.3        | 2.6        | 2.4        | 0.7        | -0.5       |
| Natural gas                    | 10.57         | 31.81         | 55.07         | 106.94          | 175.20          | 182.76          | 194.37          | 3.8        | 6.5        | 5.8        | 8.3        | 10.8       | 10.5       | 10.3       | 5.5        | 7.7        | 5.1        | 0.4        | 0.6        |
| Hydrogen                       | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -100.0     | -          | -          | -          |
| Fuel Ammonia                   | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 1.60          | 4.51          | 12.28         | 72.17           | 197.61          | 306.14          | 389.33          | 0.6        | 0.9        | 1.3        | 5.6        | 12.2       | 17.5       | 20.6       | 6.8        | 21.8       | 10.6       | 4.5        | 2.4        |
| Hydro                          | 6.16          | 9.30          | 13.97         | 27.90           | 42.32           | 60.21           | 79.34           | 2.2        | 1.9        | 1.5        | 2.2        | 2.6        | 3.4        | 4.2        | 2.7        | 8.0        | 4.3        | 3.6        | 2.8        |
| Geothermal                     | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 108.09        | 136.48        | 218.13        | 285.85          | 345.06          | 435.09          | 580.70          | 38.6       | 27.8       | 23.1       | 22.1       | 21.4       | 24.9       | 30.8       | 2.3        | 3.0        | 1.9        | 2.3        | 2.9        |
| Biomass                        | 107.97        | 134.85        | 198.21        | 184.28          | 90.18           | 61.74           | 66.61           | 38.5       | 27.5       | 21.0       | 14.2       | 5.6        | 3.5        | 3.5        | 2.0        | -0.8       | -6.9       | -3.7       | 0.8        |
| Solar Wind Ocean               | 0.01          | 0.63          | 14.54         | 90.55           | 224.87          | 363.08          | 499.14          | 0.0        | 0.1        | 1.5        | 7.0        | 13.9       | 20.8       | 26.4       | 26.3       | 22.5       | 9.5        | 4.9        | 3.2        |
| Biofuels                       | 0.00          | 0.87          | 5.38          | 11.28           | 30.28           | 10.54           | 15.22           | 0.0        | 0.2        | 0.6        | 0.9        | 1.9        | 0.6        | 0.8        | -          | 8.6        | 10.4       | -10.0      | 3.7        |
| Electricity (Import or Export) | 0.12          | 0.13          | 0.00          | -0.27           | -0.27           | -0.27           | -0.26           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -188.2     | 69.6       | 0.0        | 0.0        | -0.2       |

### Final energy demand

|              | MTOE          |               |               |               |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|---------------|---------------|---------------|---------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990          | 2005          | 2021          | 2030          | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>215.04</b> | <b>332.39</b> | <b>632.48</b> | <b>827.51</b> | <b>1,052.77</b> | <b>1,161.33</b> | <b>1,286.67</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.5</b> | <b>3.0</b> | <b>2.4</b> | <b>1.0</b> | <b>1.0</b> |
| Industry     | 59.05         | 103.71        | 247.02        | 382.08        | 450.88          | 417.68          | 361.80          | 27.5       | 31.2       | 39.1       | 46.2       | 42.8       | 36.0       | 28.1       | 4.7        | 5.0        | 1.7        | -0.8       | -1.4       |
| Transport    | 20.75         | 38.96         | 102.13        | 148.72        | 229.95          | 299.08          | 417.74          | 9.6        | 11.7       | 16.1       | 18.0       | 21.8       | 25.8       | 32.5       | 5.3        | 4.3        | 4.5        | 2.7        | 3.4        |
| Others       | 121.96        | 160.58        | 227.85        | 217.95        | 257.71          | 285.85          | 312.59          | 56.7       | 48.3       | 36.0       | 26.3       | 24.5       | 24.6       | 24.3       | 2.0        | -0.5       | 1.7        | 1.0        | 0.9        |
| Non-energy   | 13.28         | 29.15         | 55.48         | 78.76         | 114.22          | 158.73          | 194.54          | 6.2        | 8.8        | 8.8        | 9.5        | 10.8       | 13.7       | 15.1       | 4.7        | 4.0        | 3.8        | 3.3        | 2.1        |
| <b>Total</b> | <b>215.04</b> | <b>332.39</b> | <b>632.48</b> | <b>827.51</b> | <b>1,052.77</b> | <b>1,161.33</b> | <b>1,286.67</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.5</b> | <b>3.0</b> | <b>2.4</b> | <b>1.0</b> | <b>1.0</b> |
| Coal         | 38.24         | 44.02         | 106.82        | 114.88        | 144.92          | 98.64           | 58.08           | 17.8       | 13.2       | 16.9       | 13.9       | 13.8       | 8.5        | 4.5        | 3.4        | 0.8        | 2.4        | -3.8       | -5.2       |
| Oil          | 50.17         | 106.17        | 204.95        | 263.44        | 332.25          | 363.20          | 352.08          | 23.3       | 31.9       | 32.4       | 31.8       | 31.6       | 31.3       | 27.4       | 4.6        | 2.8        | 2.3        | 0.9        | -0.3       |
| Natural gas  | 6.09          | 13.82         | 37.72         | 53.82         | 101.14          | 110.24          | 120.48          | 2.8        | 4.2        | 6.0        | 6.5        | 9.6        | 9.5        | 9.4        | 6.1        | 4.0        | 6.5        | 0.9        | 3.0        |
| Hydrogen     | 0.00          | 0.00          | 0.00          | 0.00          | 0.14            | 0.25            | 1.40            | 0.0        | 0.0        | 0.0        | 28.7       | 0.0        | 0.0        | 0.1        | -          | -          | -52.5      | 5.9        | 19.0       |
| Fuel Ammonia | 0.00          | 0.00          | 0.00          | 0.00          | 2.89            | 7.43            | 9.70            | 0.0        | 0.0        | 0.0        | 0.0        | 0.3        | 0.6        | 0.8        | -          | -          | -          | 9.9        | 2.7        |
| Electricity  | 18.21         | 41.46         | 103.75        | 237.54        | 391.26          | 551.34          | 714.92          | 8.5        | 12.5       | 16.4       | 0.0        | 37.2       | 47.5       | 55.6       | 5.8        | -100.0     | -          | 3.5        | 2.6        |
| Heat         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 19.1       | 0.0        | 0.0        | 0.0        | -          | -          | -100.0     | -          | -          |
| Others       | 102.33        | 126.93        | 179.25        | 157.82        | 80.18           | 30.23           | 30.01           | 47.6       | 38.2       | 28.3       | 0.0        | 7.6        | 2.6        | 2.3        | 1.8        | -          | -          | -9.3       | -0.1       |

### Power generation Output

|                                     | TWh           |               |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990          | 2005          | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>289.47</b> | <b>708.36</b> | <b>1,635.17</b> | <b>3,635.43</b> | <b>5,718.18</b> | <b>7,820.86</b> | <b>9,946.14</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.7</b> | <b>9.3</b> | <b>4.6</b> | <b>3.2</b> | <b>2.4</b> |
| Coal PP                             | 189.15        | 476.54        | 1,169.70        | 1,638.79        | 1,184.94        | 857.35          | 686.86          | 65.3       | 67.3       | 71.5       | 45.1       | 20.7       | 11.0       | 6.9        | 6.1        | 3.8        | -3.2       | -3.2       | -2.2       |
| Coal PP with biomass co-firing      | 0.00          | 0.00          | 0.00            | 0.00            | 47.40           | 63.25           | 50.67           | 0.0        | 0.0        | 0.0        | 0.0        | 0.8        | 0.8        | 0.5        | -          | -          | -          | 2.9        | -2.2       |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00          | 0.00            | 0.00            | 31.60           | 63.25           | 50.67           | 0.0        | 0.0        | 0.0        | 0.0        | 0.6        | 0.8        | 0.5        | -          | -          | -          | 7.2        | -2.2       |
| Coal PP with CCS                    | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                                 | 12.54         | 19.53         | 4.51            | 0.37            | 0.00            | 0.00            | 0.00            | 4.3        | 2.8        | 0.3        | 0.0        | 0.0        | 0.0        | 0.0        | -3.2       | -24.4      | -53.8      | -          | -20.7      |
| Gas PP                              | 9.96          | 75.47         | 61.73           | 278.36          | 452.42          | 496.17          | 542.08          | 3.4        | 10.7       | 3.8        | 7.7        | 7.9        | 6.3        | 5.5        | 6.1        | 18.2       | 5.0        | 0.9        | 5.7        |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00          | 0.00            | 0.00            | 50.86           | 137.44          | 283.18          | 0.0        | 0.0        | 0.0        | 0.0        | 0.9        | 1.8        | 2.8        | -          | -          | -          | 10.5       | 7.5        |
| Gas PP with CCS                     | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear PP                          | 6.14          | 17.32         | 47.11           | 276.96          | 758.40          | 1,174.93        | 1,494.20        | 2.1        | 2.4        | 2.9        | 7.6        | 13.3       | 15.0       | 15.0       | 6.8        | 21.8       | 10.6       | 4.5        | 2.4        |
| Solar PV                            | 0.00          | 0.00          | 75.57           | 2,007.13        | 3,254.45        | 4,482.34        | 0.0             | 0.0        | 4.6        | 20.8       | 35.1       | 41.6       | 45.1       | -          | -          | 29.2       | 10.2       | 5.0        | 3.3        |
| Wind                                | 0.03          | 6.21          | 77.14           | 257.23          | 547.51          | 878.48          | 1,204.49        | 0.0        | 0.9        | 4.7        | 7.1        | 9.6        | 11.2       | 12.1       | 28.6       | 14.3       | 7.8        | 4.8        | 3.2        |
| Hydro                               | 71.66         | 108.12        | 162.44          | 324.49          | 492.16          | 700.22          | 922.77          | 24.8       | 15.3       | 9.9        | 8.9        | 8.6        | 9.0        | 9.3        | 2.7        | 8.0        | 4.3        | 3.6        | 2.8        |
| Geothermal                          | 0.00          | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass and others                  | 1.66E-05      | 5.16          | 36.97           | 101.32          | 145.76          | 195.32          | 228.87          | 0.0        | 0.7        | 2.3        | 2.8        | 2.5        | 2.5        | 2.3        | 60.2       | 11.9       | 3.7        | 3.0        | 1.6        |

### Power generation Input

|                      | MTOE         |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |            |
|----------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|------------|
|                      | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060  |
| <b>Total</b>         | <b>56.84</b> | <b>148.90</b> | <b>298.77</b> | <b>446.70</b> | <b>404.34</b> | <b>363.68</b> | <b>364.54</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.5</b> | <b>4.6</b> | <b>-1.0</b> | <b>-1.1</b> | <b>0.0</b> |
| Coal                 | 48.37        | 127.58        | 283.95        | 365.92        | 280.69        | 208.37        | 161.80        | 85.1       | 85.7       | 95.0       | 81.9       | 69.4       | 57.3       | 44.4       | 5.9        | 2.9        | -2.6        | -2.9        | -2.5       |
| Fuel ammonia         | 0.00         | 0.00          | 0.00          | 0.00          | 7.59          | 19.48         | 37.87         | 0.0        | 0.0        | 0.0        | 0.0        | 1.9        | 5.4        | 10.4       | -          | -          | -           | 9.9         | 6.9        |
| Coal (Co-firing)     | 0.00         | 0.00          | 0.00          | 0.00          | 3.73          | 6.22          | 4.48          | 0.0        | 0.0        | 0.0        | 0.0        | 0.9        | 1.7        | 1.2        | -          | -          | -           | 5.2         | -3.2       |
| Oil                  | 5.01         | 7.02          | 1.76          | 0.52          | 0.00          | 0.00          | 0.00          | 8.8        | 4.7        | 0.6        | 0.1        | 0.0        | 0.0        | 0.0        | -3.3       | -12.6      | -53.8       | -           | -18.0      |
| Gas                  | 3.46         | 14.31         | 13.07         | 45.41         | 67.55         | 70.33         | 72.48         | 6.1        | 9.6        | 4.4        | 10.2       | 16.7       | 19.3       | 19.9       | 4.4        | 14.8       | 4.1         | 0.4         | 0.3        |
| Hydrogen             | 0.00         | 0.00          | 0.00          | 0.00          | 8.54          | 22.17         | 39.90         | 0.0        | 0.0        | 0.0        | 0.0        | 2.1        | 6.1        | 10.9       | -          | -          | -           | 10.0        | 6.1        |
| Biomass (Biomass PP) | 0.00         | 0.00          | 0.00          | 34.85         | 36.23         | 37.10         | 48.01         | 0.0        | 0.0        | 0.0        | 7.8        | 9.0        | 10.2       | 13.2       | -          | -          | 0.4         | 0.2         | 2.6        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |
| Total      | 32.0 | 33.3 | 36.6 | 38.9 | 40.7 | 42.9 | 43.5 |  |  |  |  |  |  |  | 0.4       | 0.7       | 0.5       | 0.5       | 0.1       |
| Coal PP    | 33.6 | 32.1 | 35.4 | 38.5 | 38.7 | 40.6 | 41.9 |  |  |  |  |  |  |  | 0.2       | 0.9       | 0.1       | 0.5       | 0.3       |
| Oil PP     | 21.5 | 23.9 | 22.1 | 6.0  | 6.0  | 6.0  | 6.0  |  |  |  |  |  |  |  | 0.1       | -13.5     | 0.0       | 0.0       | -3.3      |
| Gas PP     | 24.7 | 45.4 | 40.6 | 52.7 | 56.9 | 58.9 | 63.2 |  |  |  |  |  |  |  |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 25.0 | 34.6 | 45.3 | 41.0 |  |  |  |  |  |  |  | -         | -         | 3.3       | 2.7       | -1.0      |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                |                |                |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |             |
|--------------|--------------------|----------------|----------------|----------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|              | 1990               | 2005           | 2021           | 2030           | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>531.1</b>       | <b>1,088.4</b> | <b>2,279.0</b> | <b>2,554.4</b> | <b>2,402.1</b> | <b>2,001.4</b> | <b>1,352.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.8</b> | <b>1.3</b> | <b>0.2</b> | <b>-2.6</b> | <b>-3.8</b> | <b>-1.3</b> |
| Coal         | 358.1              | 716.2          | 1,627.3        | 2,001.7        | 1,893.3        | 1,396.7        | 1,019.7        | 67.4       | 65.8       | 71.4       | 78.4       | 72.8       | 69.8       | 75.4       | 5.0        | 2.3        | -0.6       | -3.0        | -3.1        | -1.2        |
| Oil          | 160.1              | 318.5          | 574.0          | 704.9          | 858.3          | 817.3          | 704.4          | 30.2       | 29.3       | 25.2       | 27.6       | 33.0       | 40.8       | 52.1       | 4.2        | 2.3        | 2.0        | -0.5        | -1.5        | 0.5         |
| Natural Gas  | 12.9               | 53.7           | 77.7           | 177.8          | 307.5          | 289.5          | 280.0          | 2.4        | 4.9        | 3.4        | 7.0        | 11.8       | 14.5       | 20.7       | 6.0        | 9.6        | 5.6        | -0.6        | -0.3        | 3.3         |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0            | -330.0         | -457.0         | -502.0         | -652.0         | 0.0        | 0.0        | 0.0        | -12.9      | -17.6      | -25.1      | -48.2      | -          | -          | 3.3        | 0.9         | 2.6         | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 475   | 1,117 | 2,782 | 5,184 | 10,120 | 16,740 | 24,405 | 5.9       | 7.2       | 6.9       | 5.2       | 3.8       | 5.7       |
| Population (millions of people)                                                           | 870   | 1,155 | 1,408 | 1,514 | 1,613  | 1,674  | 1,701  | 1.6       | 0.8       | 0.6       | 0.4       | 0.2       | 0.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.55  | 0.97  | 1.98  | 3.42  | 6.27   | 10.00  | 14.35  | 4.2       | 6.3       | 6.2       | 4.8       | 3.7       | 5.2       |
| Primary energy consumption per capita (toe/person)                                        | 0.32  | 0.43  | 0.67  | 0.85  | 1.00   | 1.04   | 1.11   | 2.4       | 2.7       | 1.6       | 0.4       | 0.6       | 1.3       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 590   | 440   | 339   | 250   | 160    | 104    | 77     | -1.8      | -3.4      | -4.4      | -4.2      | -2.9      | -3.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 453   | 298   | 227   | 160   | 104    | 69     | 53     | -2.2      | -3.9      | -4.2      | -4.0      | -2.7      | -3.7      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 1,119 | 975   | 819   | 493   | 257    | 120    | 55     | -1.0      | -5.5      | -6.3      | -7.4      | -7.4      | -6.7      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.90  | 2.22  | 2.41  | 1.97  | 1.61   | 1.15   | 0.72   | 0.8       | -2.2      | -2.0      | -3.3      | -4.6      | -3.1      |
| Automobile ownership volume (millions of vehicles)                                        | 4     | 15    | 56    | 109   | 292    | 678    | 1,333  | 8.6       | 7.7       | 10.3      | 8.8       | 7.0       | 8.5       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.005 | 0.013 | 0.040 | 0.072 | 0.181  | 0.405  | 0.784  | 7.0       | 6.8       | 9.6       | 8.4       | 6.8       | 7.9       |



## Indonesia [BAU]

### Primary energy consumption

|                                | MTOE        |              |              |              |              |            |            |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005         | 2021         | 2030         | 2040         | 2050       | 2060       | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>79.1</b> | <b>148.2</b> | <b>191.8</b> | <b>332.7</b> | <b>472.2</b> | <b>648</b> | <b>899</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.9</b> | <b>6.3</b> | <b>3.6</b> | <b>3.2</b> | <b>3.3</b> |
| Coal                           | 3.4         | 24.3         | 88.0         | 120.0        | 178.1        | 232.9      | 290.3      | 4.3        | 16.4       | 46         | 36         | 38         | 36         | 32         | 11.0       | 3.5        | 4.0        | 2.7        | 2.2        |
| Oil                            | 26.6        | 61.0         | 34.8         | 92.0         | 129.9        | 182.1      | 247.0      | 33.6       | 41.2       | 18         | 28         | 28         | 28         | 27         | 0.9        | 11.4       | 3.5        | 3.4        | 3.1        |
| Natural gas                    | 26.2        | 33.3         | 31.4         | 54.9         | 77.2         | 117.6      | 156.4      | 33.1       | 22.5       | 16         | 16         | 16         | 18         | 17         | 0.6        | 6.4        | 3.5        | 4.3        | 2.9        |
| Hydrogen                       | -           | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | -           | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Nuclear                        | -           | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Hydro                          | 1.0         | 0.9          | 1.7          | 3.9          | 4.7          | 5.7        | 12.3       | 1.2        | 0.6        | 1          | 1          | 1          | 1          | 1          | 1.8        | 10.0       | 1.7        | 2.1        | 7.9        |
| Geothermal                     | 1.0         | 5.7          | 12.1         | 29.1         | 35.2         | 43.0       | 78.3       | 1.3        | 3.8        | 6          | 9          | 7          | 7          | 9          | 8.4        | 10.2       | 1.9        | 2.0        | 6.2        |
| Others                         | 21.0        | 23.0         | 23.8         | 32.8         | 47.1         | 67.2       | 115        | 27         | 16         | 12         | 10         | 10         | 10         | 13         | 0.4        | 3.6        | 3.7        | 3.6        | 5.5        |
| Biomass                        | 21.0        | 23.0         | 16.9         | 18.9         | 21.1         | 21.4       | 38.0       | 26.5       | 15.5       | 9          | 6          | 4          | 3          | 4          | -0.7       | 1.3        | 1.1        | 0.1        | 5.9        |
| Solar Wind Ocean               | -           | -            | 1.5          | 0.4          | 0.8          | 1.4        | 4.5        | -          | -          | 1          | 0          | 0          | 0          | 1          | -13.0      | 5.8        | 6.5        | 12.1       | 2.8        |
| Biofuels                       | -           | -            | 5.4          | 13.5         | 25.2         | 44.4       | 72.1       | -          | -          | 3          | 4          | 5          | 7          | 8.0        | -          | 10.7       | 6.5        | 5.8        | 5.0        |
| Electricity (Import or Export) | -           | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |

### Final energy demand

|              | MTOE        |             |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>36</b>   | <b>87</b>   | <b>131</b>   | <b>217</b>   | <b>316</b>   | <b>456</b>   | <b>640</b>   | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.2</b> | <b>5.7</b> | <b>3.8</b> | <b>3.7</b> | <b>3.4</b> |
| Industry     | 12          | 34          | 46           | 85           | 126          | 190          | 278          | 34         | 39         | 35         | 39         | 40         | 42         | 43         | 4.3        | 7.1        | 4.0        | 4.1        | 3.9        |
| Transport    | 8           | 23          | 47           | 79           | 122          | 182          | 259          | 23         | 27         | 36         | 36         | 39         | 40         | 40         | 5.8        | 5.9        | 4.4        | 4.1        | 3.6        |
| Others       | 9           | 20          | 30           | 43           | 57           | 72           | 90           | 25         | 23         | 23         | 20         | 18         | 16         | 14         | 3.9        | 4.1        | 2.8        | 2.4        | 2.2        |
| Non-energy   | 7           | 9           | 8            | 10           | 10           | 11           | 13           | 18         | 11         | 6          | 4          | 3          | 3          | 2          | 0.8        | 1.5        | 0.8        | 0.9        | 1.0        |
| <b>Total</b> | <b>36.4</b> | <b>87.2</b> | <b>131.4</b> | <b>217.1</b> | <b>315.8</b> | <b>455.9</b> | <b>639.6</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.2</b> | <b>5.7</b> | <b>3.8</b> | <b>3.7</b> | <b>3.4</b> |
| Coal         | 0.8         | 9.2         | 12.3         | 31.5         | 48.8         | 73.8         | 106.7        | 2          | 11         | 9          | 15         | 15         | 16         | 17         | 9.1        | 11.0       | 4.5        | 4.2        | 3.8        |
| Oil          | 23.6        | 50.4        | 61.7         | 89.8         | 128.1        | 180.8        | 245.7        | 65         | 58         | 47         | 41         | 41         | 40         | 38         | 3.1        | 4.3        | 3.6        | 3.5        | 3.1        |
| Natural gas  | 9.6         | 18.4        | 16.2         | 27.8         | 39.9         | 59.3         | 87.6         | 26         | 21         | 12         | 13         | 13         | 13         | 14         | 1.7        | 6.1        | 3.7        | 4.0        | 4.0        |
| Hydrogen     | -           | -           | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia | -           | -           | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Electricity  | 2.4         | 9.2         | 23.8         | 43.0         | 62.6         | 86.7         | 116.9        | 7          | 11         | 18         | 20         | 20         | 19         | 18         | 7.7        | 6.8        | 3.8        | 3.3        | 3.0        |
| Heat         | -           | -           | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Others       | 0.0         | 0.0         | 17.3         | 25.0         | 36.4         | 55.2         | 82.6         | 0          | 0          | 13         | 12         | 12         | 12         | 13         | 33.8       | 4.2        | 3.8        | 4.2        | 4.1        |

### Power generation Output

|                                     | TWh         |             |              |              |              |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|-------------|-------------|--------------|--------------|--------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040         | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>33.1</b> | <b>91.1</b> | <b>293.2</b> | <b>537.2</b> | <b>782.6</b> | <b>1,084.0</b> | <b>1,461.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.3</b> | <b>7.0</b> | <b>3.8</b> | <b>3.3</b> | <b>3.0</b> |
| Coal PP                             | 9.8         | 34.0        | 174.5        | 245.0        | 374.6        | 473.2          | 560.5          | 30         | 37         | 60         | 46         | 48         | 44         | 38         | 9.7        | 3.8        | 4.3        | 2.4        | 1.7        |
| Coal PP with biomass co-firing      | -           | -           | -            | 56.4         | 89.2         | 133.3          | 142.9          | -          | -          | -          | 11         | 11         | 12         | 10         | -          | -          | 4.7        | 4.1        | 0.7        |
| Coal PP with fuel ammonia co-firing | -           | -           | -            | -            | -            | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | -           | -           | -            | -            | -            | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Oil PP                              | 12.3        | 12.5        | 10.6         | 4.1          | 2.8          | 0.8            | 0.9            | 37         | 14         | 4          | 1          | 0          | 0          | 0          | -0.5       | -10.0      | -3.8       | -11.4      | 0.7        |
| Gas PP                              | 3.4         | 31.9        | 62.3         | 131.1        | 190.2        | 315.0          | 377.7          | 10         | 35         | 21         | 24         | 24         | 29         | 26         | 9.8        | 8.6        | 3.8        | 5.2        | 1.8        |
| Gas PP with hydrogen co-firing      | -           | -           | -            | -            | -            | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | -           | -           | -            | -            | -            | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          | -           | -           | -            | -            | -            | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Solar PV                            | -           | -           | 0.1          | 3.5          | 4.6          | 5.6            | 35.7           | -          | -          | 0          | 1          | 1          | 1          | 2          | -          | 45.9       | 2.8        | 1.8        | 20.5       |
| Wind                                | -           | -           | 0.5          | 1.6          | 4.3          | 11.1           | 16.7           | -          | -          | 0          | 0          | 1          | 1          | 1          | -          | 14.0       | 10.6       | 10.0       | 4.1        |
| Hydro                               | 6.5         | 10.0        | 19.5         | 45.8         | 54.3         | 66.7           | 142.9          | 20         | 11         | 7          | 9          | 7          | 6          | 10         | 3.6        | 10.0       | 1.7        | 2.1        | 7.9        |
| Geothermal                          | 1.1         | 2.7         | 14.1         | 33.8         | 41.0         | 50.0           | 91.1           | 3          | 3          | 5          | 6          | 5          | 5          | 6.2        | 8.5        | 10.2       | 1.9        | 2.0        | 6.2        |
| Biomass and others                  | -           | -           | 11.6         | 15.8         | 21.7         | 28.3           | 92.9           | -          | -          | 4          | 3          | 3          | 3          | 6.4        | -          | 3.5        | 3.2        | 2.7        | 12.6       |

### Power generation Input

|                      | MTOE        |              |              |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|--------------|--------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005         | 2021         | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>7.56</b> | <b>19.00</b> | <b>80.34</b> | <b>122.87</b> | <b>176.13</b> | <b>226.97</b> | <b>278.17</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.9</b> | <b>4.8</b> | <b>3.7</b> | <b>2.6</b> | <b>2.1</b> |
| Coal                 | 2.60        | 8.00         | 57.72        | 88.47         | 129.29        | 159.05        | 183.58        | 34.4       | 42.1       | 71.8       | 72.0       | 73.4       | 70.1       | 66.0       | 10.5       | 4.9        | 3.9        | 2.1        | 1.4        |
| Fuel ammonia         | -           | -            | -            | -             | -             | -             | -             | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | -           | -            | -            | 0.60          | 0.90          | 1.30          | 1.40          | -          | -          | -          | 0.5        | 0.5        | 0.6        | 0.5        | -          | -          | 4.1        | 3.7        | 0.7        |
| Oil                  | 3.99        | 5.00         | 3.14         | 1.22          | 0.83          | 0.25          | 0.26          | 52.8       | 26.3       | 3.9        | 1.0        | 0.5        | 0.1        | 0.1        | -0.8       | -10.0      | -3.8       | -11.4      | 0.7        |
| Gas                  | 0.97        | 6.00         | 14.49        | 25.88         | 36.31         | 57.57         | 68.33         | 12.8       | 31.6       | 18.0       | 21.1       | 20.6       | 25.4       | 24.6       | 9.1        | 6.7        | 3.4        | 4.7        | 1.7        |
| Hydrogen             | -           | -            | -            | -             | -             | -             | -             | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | -           | -            | 5.00         | 6.70          | 8.80          | 8.80          | 24.60         | -          | -          | 6.2        | 5.5        | 5.0        | 3.9        | 8.8        | -          | 3.3        | 2.8        | -          | 10.8       |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)     |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|-------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>29.0</b> | <b>35.5</b> | <b>27.7</b> | <b>31.7</b> | <b>33.1</b> | <b>36.0</b> | <b>36.3</b> |  |  |  |  |  |  |  | <b>-0.1</b> | <b>1.5</b> | <b>0.5</b> | <b>0.8</b> | <b>0.1</b> |
| Coal         | 32.3        | 36.6        | 26.0        | 29.1        | 30.6        | 32.5        | 32.7        |  |  |  |  |  |  |  | -0.7        | 1.3        | 0.5        | 0.6        | 0.1        |
| Oil          | 26.5        | 21.5        | 29.0        | 29.0        | 29.0        | 29.0        | 29.0        |  |  |  |  |  |  |  | 0.3         | -          | -          | -          | -          |
| Gas          | 30.2        | 45.8        | 37.0        | 43.6        | 45.0        | 47.1        | 47.5        |  |  |  |  |  |  |  | 0.7         | 1.8        | 0.3        | 0.4        | 0.1        |
| Biomass      | -           | -           | 20.0        | 20.2        | 19.9        | 26.1        | 30.0        |  |  |  |  |  |  |  | -           | 0.1        | -0.1       | 2.7        | 1.4        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |                |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|--------------|--------------|--------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>107.1</b>       | <b>136.2</b> | <b>513.0</b> | <b>835.7</b> | <b>1,224.7</b> | <b>1,685.7</b> | <b>2,191.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.2</b> | <b>5.6</b> | <b>3.9</b> | <b>3.2</b> | <b>2.7</b> | <b>3.8</b> |
| Coal         | 13.5               | 51.8         | 271.5        | 465.4        | 690.5          | 903.1          | 1,125.9        | 12.6       | 38.0       | 52.9       | 55.7       | 56.4       | 53.6       | 51.4       | 10.2       | 6.2        | 4.0        | 2.7        | 2.2        | 3.7        |
| Oil          | 33.3               | 11.2         | 179.2        | 256.8        | 369.1          | 524.3          | 717.9          | 31.1       | 8.2        | 34.9       | 30.7       | 30.1       | 31.1       | 32.8       | 5.6        | 4.1        | 3.7        | 3.6        | 3.2        | 3.6        |
| Natural Gas  | 60.3               | 73.2         | 62.2         | 113.5        | 165.1          | 258.3          | 347.4          | 56.3       | 53.8       | 12.1       | 13.6       | 13.5       | 15.3       | 15.9       | 0.1        | 6.9        | 3.8        | 4.6        | 3.0        | 4.5        |
| CCS/DAC (-)  | -                  | -            | -            | -            | -              | -              | -              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |

## Energy and economic indicators

|                                                                                           |       |       |       |       |       |       |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 310   | 498   | 1,066 | 1,699 | 2,939 | 4,801 | 7,422  | 4.1       | 5.3       | 5.6       | 5.0       | 4.5       | 5.1       |
| Population (millions of people)                                                           | 179   | 226   | 274   | 294   | 311   | 324   | 337    | 1.4       | 0.8       | 0.6       | 0.4       | 0.4       | 0.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 1.7   | 2.2   | 3.893 | 5.8   | 9.4   | 14.8  | 22.033 | 2.6       | 4.5       | 5.0       | 4.6       | 4.0       | 4.5       |
| Primary energy consumption per capita (toe/person)                                        | 0.4   | 0.7   | 0.7   | 1.1   | 1.5   | 2.0   | 2.7    | 1.5       | 5.5       | 3.0       | 2.8       | 2.9       | 3.5       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 255.4 | 297.8 | 180.0 | 195.7 | 160.7 | 135.1 | 121.1  | -1.1      | 0.9       | -2.0      | -1.7      | -1.1      | -1.01     |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 117.6 | 175.3 | 123.3 | 127.8 | 107.5 | 95.0  | 86.2   | 0.2       | 0.4       | -1.7      | -1.2      | -1.0      | -0.9      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 345.6 | 273.7 | 481.3 | 491.8 | 416.7 | 351.1 | 295.3  | 1.1       | 0.2       | -1.6      | -1.7      | -1.7      | -1.2      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.4   | 0.9   | 2.7   | 2.5   | 2.6   | 2.6   | 2.4    | 2.2       | -0.7      | 0.3       | 0.0       | -0.6      | -0.2      |
| Automobile ownership volume (millions of vehicles)                                        | -     | -     | -     | -     | -     | -     | -      | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -     | -     | -     | -     | -     | -     | -      | -         | -         | -         | -         | -         | -         |

## Indonesia [LCET]

### Primary energy consumption

|                                | MTOE      |            |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-----------|------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990      | 2005       | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>79</b> | <b>148</b> | <b>191.8</b> | <b>275.4</b> | <b>404.5</b> | <b>535.1</b> | <b>629.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.9</b> | <b>4.1</b> | <b>3.9</b> | <b>2.8</b> | <b>1.6</b> |
| Coal                           | 3         | 24         | 88.0         | 89.6         | 87.7         | 87.0         | 52.8         | 4.3        | 16.4       | 45.9       | 32.5       | 21.7       | 16.3       | 8.4        | 11.0       | 0.2        | -0.2       | -0.1       | -4.9       |
| Oil                            | 27        | 61         | 34.8         | 64.6         | 59.0         | 43.5         | 10.0         | 33.6       | 41.2       | 18.1       | 23.4       | 14.6       | 8.1        | 1.6        | 0.9        | 7.1        | -0.9       | -3.0       | -13.7      |
| Natural gas                    | 26        | 33         | 31.4         | 52.3         | 61.4         | 75.4         | 81.1         | 33.1       | 22.5       | 16.4       | 19.0       | 15.2       | 14.1       | 12.9       | 0.6        | 5.8        | 1.6        | 2.1        | 0.7        |
| Hydrogen                       | -         | -          | -            | -            | -0.1         | -0.2         | -1.4         | -          | -          | -          | -          | -0.0       | -0.0       | -0.2       | -          | -          | -          | 11.5       | 19.6       |
| Fuel Ammonia                   | -         | -          | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Nuclear                        | -         | -          | -            | 0.4          | 6.2          | 20.5         | 63.7         | -          | -          | -          | 0.2        | 1.5        | 3.8        | 10.1       | -          | -          | 30.8       | 12.8       | 12.0       |
| Hydro                          | 1         | 1          | 1.7          | 2.4          | 12.8         | 22.5         | 49.9         | 1.2        | 0.6        | 0.9        | 0.9        | 3.2        | 4.2        | 7.9        | 1.8        | 4.1        | 18.2       | 5.8        | 8.3        |
| Geothermal                     | 1         | 6          | 12.1         | 30.7         | 78.1         | 92.9         | 98.7         | 1.3        | 3.8        | 6.3        | 11.2       | 19.3       | 17.4       | 15.7       | 8.4        | 10.9       | 9.8        | 1.8        | 0.6        |
| Others                         | 21        | 23         | 23.8         | 35.5         | 99.4         | 193.5        | 275.1        | 26.5       | 15.5       | 12.4       | 12.9       | 24.6       | 36.2       | 43.7       | 0.4        | 4.5        | 10.9       | 6.9        | 3.6        |
| Biomass                        | 21        | 23         | 16.9         | 20.0         | 38.1         | 84.4         | 128.8        | 26.5       | 15.5       | 8.8        | 7.3        | 9.4        | 15.8       | 20.4       | -0.7       | 1.9        | 6.7        | 8.3        | 4.3        |
| Solar Wind Ocean               | -         | -          | 1.5          | 1.7          | 34.9         | 71.3         | 95.6         | -          | -          | 0.8        | 0.6        | 8.6        | 13.3       | 15.2       | -          | 1.0        | 35.4       | 7.4        | 3.0        |
| Biofuels                       | -         | -          | 5.4          | 13.8         | 26.4         | 37.8         | 50.7         | -          | -          | 2.8        | 5.0        | 6.5        | 7.1        | 8.0        | -          | 11.0       | 6.7        | 3.6        | 3.0        |
| Electricity (Import or Export) | -         | -          | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |

### Final energy demand

|              | MTOE        |             |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>36</b>   | <b>87</b>   | <b>131</b>   | <b>195</b>   | <b>254</b>   | <b>308</b>   | <b>319</b>   | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.2</b> | <b>4.5</b> | <b>2.7</b> | <b>1.9</b> | <b>0.4</b> |
| Industry     | 12.4        | 34.2        | 45.9         | 77.0         | 107.5        | 142.3        | 142.6        | 34         | 39.2       | 35.0       | 39.6       | 42.3       | 46.3       | 44.7       | 4.3        | 5.9        | 3.4        | 2.8        | 0.0        |
| Transport    | 8.2         | 23.2        | 46.9         | 75.4         | 94.7         | 100.8        | 98.0         | 23         | 26.6       | 35.7       | 38.8       | 37.3       | 32.8       | 30.7       | 5.8        | 5.4        | 2.3        | 0.6        | -0.3       |
| Others       | 9.2         | 20.4        | 30.0         | 35.0         | 45.5         | 58.3         | 72.0         | 25         | 23.4       | 22.9       | 18.0       | 17.9       | 18.9       | 22.6       | 3.9        | 1.7        | 2.7        | 2.5        | 2.1        |
| Non-energy   | 6.6         | 9.4         | 8.5          | 7.2          | 6.4          | 6.2          | 6.5          | 18         | 10.8       | 6.4        | 3.7        | 2.5        | 2.0        | 2.0        | 0.8        | -1.9       | -1.1       | -0.2       | 0.4        |
| <b>Total</b> | <b>36.4</b> | <b>87.2</b> | <b>131.4</b> | <b>194.5</b> | <b>254.0</b> | <b>307.6</b> | <b>319.0</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.2</b> | <b>4.5</b> | <b>2.7</b> | <b>1.9</b> | <b>0.4</b> |
| Coal         | 0.8         | 9.2         | 12.3         | 29.7         | 34.7         | 35.2         | 17.9         | 2          | 10.6       | 9.4        | 15.3       | 13.7       | 11.4       | 5.6        | 9.1        | 10.3       | 1.6        | 0.1        | -6.5       |
| Oil          | 23.6        | 50.4        | 61.7         | 77.6         | 67.6         | 48.0         | 9.5          | 65         | 57.8       | 47.0       | 39.9       | 26.6       | 15.6       | 3.0        | 3.1        | 2.6        | -1.4       | -3.4       | -14.9      |
| Natural gas  | 9.6         | 18.4        | 16.2         | 26.2         | 29.7         | 31.5         | 21.5         | 26         | 21.1       | 12.4       | 13.5       | 11.7       | 10.2       | 6.7        | 1.7        | 5.5        | 1.3        | 0.6        | -3.8       |
| Hydrogen     | -           | -           | -            | -            | 19.2         | 36.4         | 42.4         | -          | -          | -          | -          | 7.5        | 11.8       | 13.3       | -          | -          | -          | 6.6        | 1.5        |
| Fuel Ammonia | -           | -           | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Electricity  | 2.4         | 9.2         | 23.8         | 34.3         | 62.6         | 103.8        | 161.1        | 7          | 10.6       | 18.1       | 17.6       | 24.6       | 33.7       | 50.5       | 7.7        | 4.1        | 6.2        | 5.2        | 4.5        |
| Heat         | -           | -           | -            | -            | -            | -            | -            | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| Others       | 0.0         | 0.0         | 17.3         | 26.6         | 40.3         | 52.7         | 66.7         | 0          | 0.0        | 13.2       | 13.7       | 15.9       | 17.1       | 20.9       | 33.8       | 4.9        | 4.2        | 2.7        | 2.4        |

### Power generation Output

|                                     | TWh         |             |              |              |              |                |                |            |            |            |            |            |            |            | AAGR(%)   |           |           |           |           |
|-------------------------------------|-------------|-------------|--------------|--------------|--------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040         | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |
| <b>Total</b>                        | <b>33.1</b> | <b>91.1</b> | <b>293.2</b> | <b>425.0</b> | <b>775.4</b> | <b>1,298.0</b> | <b>2,014.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7</b>  | <b>4</b>  | <b>6</b>  | <b>5</b>  | <b>4</b>  |
| Coal PP                             | 9.8         | 34.0        | 174.5        | 167.5        | 126.4        | -              | -              | 29.5       | 37.3       | 59.5       | 39.4       | 16.3       | -          | -          | 9.7       | -0.5      | -2.8      | -100.0    | -         |
| Coal PP with biomass co-firing      | -           | -           | -            | 16.8         | 44.8         | 130.9          | 217.1          | -          | -          | -          | 3.9        | 5.8        | 10.1       | 10.8       | -         | -         | 10.3      | 11.3      | 5.2       |
| Coal PP with fuel ammonia co-firing | -           | -           | -            | -            | -            | 43.6           | 86.8           | -          | -          | -          | -          | -          | 3.4        | 4.3        | -         | -         | -         | -         | 7.1       |
| Coal PP with CCS                    | -           | -           | -            | -            | 44.8         | 130.9          | 173.7          | -          | -          | -          | -          | 5.8        | 10.1       | 8.6        | -         | -         | -         | 11.3      | 2.9       |
| Oil                                 | 12.3        | 12.5        | 10.6         | 4.9          | 3.4          | 0.8            | 0.8            | 37.2       | 13.7       | 3.6        | 1.1        | 0.4        | 0.1        | 0.0        | -0.5      | -8.2      | -3.7      | -13.2     | -0.1      |
| Gas PP                              | 3.4         | 31.9        | 62.3         | 131.7        | 144.4        | 85.9           | 8.1            | 10.3       | 35.0       | 21.3       | 31.0       | 18.6       | 6.6        | 0.4        | 9.8       | 8.7       | 0.9       | -5.1      | -21.0     |
| Gas PP with hydrogen co-firing      | -           | -           | -            | -            | 39.2         | 76.4           | 190.0          | -          | -          | -          | -          | 5.1        | 5.9        | 9.4        | -         | -         | -         | 6.9       | 9.5       |
| Gas PP with CCS                     | -           | -           | -            | -            | -            | 102.3          | 171.0          | -          | -          | -          | -          | -          | 7.9        | 8.5        | -         | -         | -         | -         | 5.3       |
| Nuclear PP                          | -           | -           | -            | -            | 23.7         | 78.8           | 244.4          | -          | -          | -          | -          | 3.1        | 6.1        | 12.1       | -         | -         | -         | 12.8      | 12.0      |
| Solar PV                            | -           | -           | 0.1          | 0.9          | 11.2         | 87.3           | 195.4          | -          | -          | 0.0        | 0.2        | 1.4        | 6.7        | 9.7        | -         | 25.8      | 28.3      | 22.8      | 8.4       |
| Wind                                | -           | -           | 0.5          | 18.6         | 38.1         | 65.5           | 130.3          | -          | -          | 0.2        | 4.4        | 4.9        | 5.0        | 6.5        | -         | 50.0      | 7.4       | 5.6       | 7.1       |
| Hydro                               | 6.5         | 10.0        | 19.5         | 27.9         | 134.5        | 196.4          | 208.4          | 19.6       | 11.0       | 6.6        | 6.6        | 17.4       | 15.1       | 10.3       | 3.6       | 4.1       | 17.0      | 3.9       | 0.6       |
| Geothermal                          | 1.1         | 2.7         | 14.1         | 35.7         | 90.8         | 108.0          | 114.8          | 3.4        | 2.9        | 4.8        | 8.4        | 11.7       | 8.3        | 5.7        | 8.5       | 10.9      | 9.8       | 1.8       | 0.6       |
| Biomass and others                  | -           | -           | 11.6         | 20.9         | 74.0         | 191.0          | 273.5          | -          | -          | 3.9        | 4.9        | 9.5        | 14.7       | 13.6       | -         | 6.8       | 13.5      | 9.9       | 3.7       |

### Power generation Input

|                      | MTOE       |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990       | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>7.6</b> | <b>19.0</b> | <b>80.3</b> | <b>91.2</b> | <b>103.3</b> | <b>153.3</b> | <b>199.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.9</b> | <b>1.4</b> | <b>1.3</b> | <b>4.0</b> | <b>2.7</b> |
| Coal                 | 2.6        | 8.0         | 57.7        | 59.8        | 53.0         | 51.8         | 34.9         | 34.4       | 42.1       | 71.9       | 65.6       | 51.3       | 33.8       | 17.5       | 10.5       | 0.4        | -1.2       | -0.2       | -3.9       |
| Fuel ammonia         | -          | -           | -           | -           | -            | 2.7          | 20.3         | -          | -          | -          | -          | -          | 1.7        | 10.2       | -          | -          | -          | -          | 22.4       |
| Biomass (Co-firing)  | -          | -           | -           | 0.6         | 2.6          | 24.6         | 51.9         | -          | -          | -          | 0.6        | 2.5        | 16.1       | 26.0       | -          | -          | 16.6       | 25.4       | 7.7        |
| Oil                  | 4.0        | 5.0         | 3.1         | 1.4         | 1.0          | 0.2          | 0.2          | 52.8       | 26.3       | 3.9        | 1.6        | 1.0        | 0.2        | 0.1        | -0.8       | -8.2       | -3.7       | -13.2      | -0.1       |
| Gas                  | 1.0        | 6.0         | 14.5        | 25.1        | 31.7         | 39.8         | 39.9         | 12.8       | 31.6       | 18.0       | 27.6       | 30.7       | 26.0       | 20.0       | 9.1        | 6.3        | 2.3        | 2.3        | 0.0        |
| Hydrogen             | -          | -           | -           | -           | 0.7          | 3.3          | 19.6         | -          | -          | -          | -          | 0.7        | 2.1        | 9.8        | -          | -          | -          | 17.1       | 19.6       |
| Biomass (Biomass PP) | -          | -           | 5.0         | 4.2         | 14.4         | 30.8         | 32.9         | -          | -          | 6.2        | 4.6        | 14.0       | 20.1       | 16.5       | -          | -1.8       | 13.2       | 7.9        | 0.7        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |      |      |      |      |      |      |      | AAGR(%)     |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------|------|------|------|------|------|------|-------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>29.0</b> | <b>35.5</b> | <b>27.7</b> | <b>32.2</b> | <b>39.7</b> | <b>42.7</b> | <b>48.3</b> |      |      |      |      |      |      |      | <b>-0.1</b> | <b>1.7</b> | <b>2.1</b> | <b>0.7</b> | <b>1.2</b> |
| Coal         | 32.3        | 36.6        | 26.0        | 26.2        | 33.6        | 42.4        | 43.9        |      |      |      |      |      |      |      | -0.7        | 0.1        | 2.5        | 2.3        | 0.4        |
| Oil          | 26.5        | 21.5        | 29.0        | 29.0        | 29.0        | 29.0        | 29.0        |      |      |      |      |      |      |      | 0.3         | -          | -          | -          | -          |
| Gas          | 30.2        | 45.8        | 37.0        | 45.9        | 50.6        | 53.0        | 55.0        |      |      |      |      |      |      |      | 0.7         | 2.4        | 1.0        | 0.5        | 0.4        |
| Biomass      | -           | -           | 20.0        | 20.7        | 21.5        | 23.9        | 35.2        |      |      |      |      |      |      |      | -           | 0.4        | 0.4        | 1.0        | 4.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |              |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060    |
| <b>Total</b> | <b>107.1</b>       | <b>136.2</b> | <b>513.0</b> | <b>654.3</b> | <b>634.3</b> | <b>484.5</b> | <b>129.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.2</b> | <b>2.7</b> | <b>-0.3</b> | <b>-2.7</b> | <b>-12.4</b> |
| Coal         | 13.5               | 51.8         | 271.5        | 319.2        | 320.8        | 255.4        | 68.1         | 12.6       | 38.0       | 52.9       | 48.8       | 50.6       | 52.7       | 52.6       | 10.2       | 1.8        | 0.0         | -2.3        | -12.4        |
| Oil          | 33.3               | 11.2         | 179.2        | 227.4        | 197.5        | 136.2        | 22.5         | 31.1       | 8.2        | 34.9       | 34.8       | 31.1       | 28.1       | 17.3       | 5.6        | 2.7        | -1.4        | -3.7        | -16.5        |
| Natural Gas  | 60.3               | 73.2         | 62.2         | 107.6        | 116.0        | 93.0         | 39.0         | 56.3       | 53.8       | 12.1       | 16.4       | 18.3       | 19.2       | 30.1       | 0.1        | 6.3        | 0.7         | -2.2        | -8.3         |
| CCS/DAC (-)  |                    |              |              |              |              |              |              | -          | -          | -          | -          | -          | -          | -          | -          | -          | -           | -           | -            |

## Energy and economic Indicators

|                                                                                           |       |       |         |         |         |         |         | AAGR(%)   |           |           |           |           |      |
|-------------------------------------------------------------------------------------------|-------|-------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|------|
|                                                                                           | 1990  | 2005  | 2021    | 2030    | 2040    | 2050    | 2060    | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060 |
| GDP (billions of 2015 US dollars)                                                         | 309.8 | 497.6 | 1,065.7 | 1,699.5 | 2,938.9 | 4,800.8 | 7,421.6 | 4.1       | 5.3       | 5.6       | 5.0       | 4.5       | 5.1  |
| Population (millions of people)                                                           | 178.6 | 226.3 | 273.8   | 293.5   | 311.0   | 323.7   | 336.8   | 1.4       | 0.8       | 0.6       | 0.4       | 0.4       | 0.5  |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 1.7   | 2.2   | 3.9     | 5.8     | 9.4     | 14.8    | 22.0    | 2.6       | 4.5       | 5.0       | 4.6       | 4.0       | 4.5  |
| Primary energy consumption per capita (toe/person)                                        | 0.4   | 0.7   | 0.7     | 0.9     | 1.3     | 1.7     | 1.9     | 1.5       | 3.3       | 3.3       | 2.4       | 1.2       | 2.5  |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 255.4 | 297.8 | 180.0   | 162.1   | 137.6   | 111.5   | 84.9    | -1.1      | -1.2      | -1.6      | -2.1      | -2.7      | -1.9 |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 117.6 | 175.3 | 123.3   | 114.4   | 86.4    | 64.1    | 43.0    | 0.2       | -0.8      | -2.8      | -2.9      | -3.9      | -2.7 |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 345.6 | 273.7 | 481.3   | 385.0   | 215.8   | 100.9   | 17.5    | 1.1       | -2.5      | -5.6      | -7.3      | -16.1     | -8.2 |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.4   | 0.9   | 2.7     | 2.4     | 1.6     | 0.9     | 0.2     | 2.2       | -1.3      | -4.1      | -5.3      | -13.8     | -6.4 |
| Automobile ownership volume (millions of vehicles)                                        |       |       |         |         |         |         |         | -         | -         | -         | -         | -         | -    |
| Automobile ownership volume per capita (vehicles per person)                              | -     | -     | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -    |

## Japan [BAU]

### Primary energy consumption

|                                | MTOE          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |
|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|                                | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>                   | <b>436.91</b> | <b>519.58</b> | <b>399.62</b> | <b>376.44</b> | <b>347.54</b> | <b>329.01</b> | <b>314.05</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-0.7</b> | <b>-0.8</b> | <b>-0.5</b> | <b>-0.5</b> |
| Coal                           | 76.70         | 110.46        | 109.13        | 76.83         | 64.98         | 56.64         | 49.94         | 17.6       | 21.3       | 27.3       | 20.4       | 18.7       | 17.2       | 15.9       | 1.1         | -3.8        | -1.7        | -1.4        | -1.3        |
| Oil                            | 248.81        | 240.93        | 150.66        | 134.00        | 115.23        | 100.01        | 87.78         | 56.9       | 46.4       | 37.7       | 35.6       | 33.2       | 30.4       | 28.0       | -1.6        | -1.3        | -1.5        | -1.4        | -1.3        |
| Natural gas                    | 44.12         | 70.65         | 86.72         | 72.00         | 68.62         | 68.19         | 67.16         | 10.1       | 13.6       | 21.7       | 19.1       | 19.7       | 20.7       | 21.4       | 2.2         | -2.0        | -0.5        | -0.1        | -0.2        |
| Hydrogen                       | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -32.2       | 53.2        | -           |
| Fuel Ammonia                   | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -           | -           | -           |
| Nuclear                        | 52.70         | 79.41         | 18.45         | 40.96         | 36.76         | 36.66         | 36.66         | 12.1       | 15.3       | 4.6        | 10.9       | 10.6       | 11.1       | 11.7       | -3.3        | 9.3         | -1.1        | 0.0         | 0.0         |
| Hydro                          | 7.56          | 6.61          | 6.77          | 7.90          | 8.29          | 8.42          | 8.51          | 1.7        | 1.3        | 1.7        | 2.1        | 2.4        | 2.6        | 2.7        | -0.4        | 1.7         | 0.5         | 0.2         | 0.1         |
| Geothermal                     | 1.58          | 2.90          | 2.71          | 4.39          | 5.47          | 6.30          | 7.12          | 0.4        | 0.6        | 0.7        | 1.2        | 1.6        | 1.9        | 2.3        | 1.8         | 5.5         | 2.2         | 1.4         | 1.2         |
| Others                         | 5.44          | 8.63          | 25.17         | 40.34         | 48.19         | 52.79         | 56.88         | 1.2        | 1.7        | 6.3        | 10.7       | 13.9       | 16.0       | 18.1       | 5.1         | 5.4         | 1.8         | 0.9         | 0.7         |
| Biomass                        | 4.21          | 7.80          | 16.34         | 25.06         | 28.68         | 31.71         | 34.37         | 1.0        | 1.5        | 4.1        | 6.7        | 8.3        | 9.6        | 10.9       | 4.5         | 4.9         | 1.4         | 1.0         | 0.8         |
| Solar Wind Ocean               | 1.22          | 0.83          | 8.37          | 14.67         | 18.76         | 20.20         | 21.64         | 0.3        | 0.2        | 2.1        | 3.9        | 5.4        | 6.1        | 6.9        | 6.4         | 6.4         | 2.5         | 0.7         | 0.7         |
| Biofuels                       | 0.01          | 0.00          | 0.46          | 0.61          | 0.75          | 0.88          | 0.87          | 0.0        | 0.0        | 0.1        | 0.2        | 0.2        | 0.3        | 0.3        | 12.5        | 3.1         | 2.0         | 1.6         | -0.1        |
| Electricity (Import or Export) | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | -232.4      | -3.2        | -14.0       | 2.3         |

### Final energy demand

|              | MTOE          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |
|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>290.37</b> | <b>339.93</b> | <b>267.24</b> | <b>252.91</b> | <b>233.60</b> | <b>218.16</b> | <b>204.79</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-0.6</b> | <b>-0.8</b> | <b>-0.7</b> | <b>-0.6</b> |
| Industry     | 108.15        | 102.09        | 79.92         | 74.68         | 69.19         | 63.61         | 58.25         | 37.2       | 30.0       | 29.9       | 29.5       | 29.6       | 29.2       | 28.4       | -1.0        | -0.8        | -0.8        | -0.8        | -0.9        |
| Transport    | 72.28         | 86.88         | 63.28         | 60.42         | 51.60         | 44.53         | 38.47         | 24.9       | 25.6       | 23.7       | 23.9       | 22.1       | 20.4       | 18.8       | -0.4        | -0.5        | -1.6        | -1.5        | -1.3        |
| Others       | 77.51         | 114.43        | 93.68         | 88.13         | 83.66         | 81.50         | 80.10         | 26.7       | 33.7       | 35.1       | 34.8       | 35.8       | 37.4       | 39.1       | 0.6         | -0.7        | -0.5        | -0.3        | -0.2        |
| Non-energy   | 32.42         | 36.52         | 30.36         | 29.68         | 29.15         | 28.52         | 27.97         | 11.2       | 10.7       | 11.4       | 11.7       | 12.5       | 13.1       | 13.7       | -0.2        | -0.2        | -0.2        | -0.2        | -0.2        |
| <b>Total</b> | <b>290.37</b> | <b>339.93</b> | <b>267.24</b> | <b>252.91</b> | <b>233.60</b> | <b>218.16</b> | <b>204.79</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-0.6</b> | <b>-0.8</b> | <b>-0.7</b> | <b>-0.6</b> |
| Coal         | 27.08         | 22.75         | 20.14         | 17.80         | 15.68         | 13.56         | 11.82         | 9.3        | 6.7        | 7.5        | 7.0        | 6.7        | 6.2        | 5.8        | -1.0        | -1.4        | -1.3        | -1.4        | -1.4        |
| Oil          | 179.96        | 196.39        | 131.70        | 122.65        | 106.03        | 91.96         | 79.92         | 62.0       | 57.8       | 49.3       | 48.5       | 45.4       | 42.2       | 39.0       | -1.0        | -0.8        | -1.4        | -1.4        | -1.3        |
| Natural gas  | 13.61         | 26.34         | 28.23         | 26.48         | 24.01         | 21.42         | 18.73         | 4.7        | 7.7        | 10.6       | 10.5       | 10.3       | 9.8        | 9.1        | 2.4         | -0.7        | -1.0        | -1.1        | -1.3        |
| Hydrogen     | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | 0.0         | -0.8        | -2.4        |
| Fuel Ammonia | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -           | -           | -           |
| Electricity  | 65.76         | 88.12         | 80.13         | 79.02         | 81.36         | 85.27         | 89.21         | 22.6       | 25.9       | 30.0       | 31.2       | 34.8       | 39.1       | 43.6       | 0.6         | -0.2        | 0.3         | 0.5         | 0.5         |
| Heat         | 0.20          | 0.60          | 0.51          | 0.48          | 0.38          | 0.29          | 0.20          | 0.1        | 0.2        | 0.2        | 0.2        | 0.2        | 0.1        | 0.1        | 3.1         | -2.1        | -2.1        | -2.7        | -3.5        |
| Others       | 3.75          | 5.74          | 6.52          | 6.49          | 6.13          | 5.66          | 4.90          | 1.3        | 1.7        | 2.4        | 2.6        | 2.6        | 2.6        | 2.4        | 1.8         | -0.1        | -0.6        | -0.8        | -1.4        |

### Power generation Output

|                                     | TWh           |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |             |            |            |            |
|-------------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|
|                                     | 1990          | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>861.54</b> | <b>1,099.41</b> | <b>1,039.88</b> | <b>1,023.82</b> | <b>1,049.89</b> | <b>1,094.40</b> | <b>1,138.61</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>-0.2</b> | <b>0.3</b> | <b>0.4</b> | <b>0.4</b> |
| Coal PP                             | 124.71        | 299.89          | 321.90          | 180.94          | 142.58          | 120.46          | 98.18           | 14.5       | 27.3       | 31.0       | 17.7       | 13.6       | 11.0       | 8.6        | 3.1        | -6.2        | -2.4       | -1.7       | -2.0       |
| Coal PP with biomass co-firing      | 0.00          | 0.00            | 0.00            | 2.29            | 3.66            | 3.09            | 2.52            | 0.0        | 0.0        | 0.0        | 0.2        | 0.3        | 0.3        | 0.2        | -          | -           | 4.8        | -1.7       | -2.0       |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Coal PP with CCS                    | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Oil                                 | 249.53        | 133.84          | 39.45           | 12.98           | 4.09            | 0.00            | 0.00            | 29.0       | 12.2       | 3.8        | 1.3        | 0.4        | 0.0        | 0.0        | -5.8       | -11.6       | -10.9      | -100.0     | -          |
| Gas PP                              | 167.69        | 243.23          | 359.42          | 285.12          | 294.45          | 322.67          | 346.85          | 19.5       | 22.1       | 34.6       | 27.8       | 28.0       | 29.5       | 30.5       | 2.5        | -2.5        | 0.3        | 0.9        | 0.7        |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Gas PP with CCS                     | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Nuclear PP                          | 202.27        | 304.75          | 70.81           | 157.21          | 141.09          | 140.70          | 140.70          | 23.5       | 27.7       | 6.8        | 15.4       | 13.4       | 12.9       | 12.4       | -3.3       | 9.3         | -1.1       | 0.0        | 0.0        |
| Solar PV                            | 19.59         | 22.13           | 104.08          | 143.78          | 170.39          | 173.76          | 177.13          | 2.3        | 2.0        | 10.0       | 14.0       | 16.2       | 15.9       | 15.6       | 5.5        | 3.7         | 1.7        | 0.2        | 0.2        |
| Wind                                | 0.00          | 1.75            | 9.43            | 43.42           | 64.66           | 78.27           | 91.88           | 0.0        | 0.2        | 0.9        | 4.2        | 6.2        | 7.2        | 8.1        | -          | 18.5        | 4.1        | 1.9        | 1.6        |
| Hydro                               | 87.90         | 76.92           | 78.79           | 91.93           | 96.36           | 97.92           | 98.93           | 10.2       | 7.0        | 7.6        | 9.0        | 9.2        | 8.9        | 8.7        | -0.4       | 1.7         | 0.5        | 0.2        | 0.1        |
| Geothermal                          | 1.74          | 3.23            | 3.01            | 4.96            | 6.25            | 7.23            | 8.22            | 0.2        | 0.3        | 0.3        | 0.5        | 0.6        | 0.7        | 0.7        | 1.8        | 5.7         | 2.3        | 1.5        | 1.3        |
| Biomass and others                  | 8.095         | 13.66           | 52.98           | 101.19          | 126.37          | 150.29          | 174.21          | 0.9        | 1.2        | 5.1        | 9.9        | 12.0       | 13.7       | 15.3       | 6.2        | 7.5         | 2.2        | 1.7        | 1.5        |

### Power generation Input

|                      | MTOE          |               |               |               |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |            |
|----------------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|------------|
|                      | 1990          | 2005          | 2021          | 2030          | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060  |
| <b>Total</b>         | <b>113.32</b> | <b>134.59</b> | <b>135.05</b> | <b>105.22</b> | <b>97.83</b> | <b>97.06</b> | <b>97.42</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>-2.7</b> | <b>-0.7</b> | <b>-0.1</b> | <b>0.0</b> |
| Coal                 | 27.03         | 61.27         | 65.84         | 37.38         | 28.62        | 22.97        | 18.25        | 23.8       | 45.5       | 48.8       | 35.5       | 29.3       | 23.7       | 18.7       | 2.9        | -6.1        | -2.6        | -2.2        | -3.2       |
| Fuel ammonia         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          |
| Biomass (Co-firing)  | 0.00          | 0.00          | 0.00          | 0.09          | 0.14         | 0.11         | 0.09         | 0.0        | 0.0        | 0.0        | 0.1        | 0.1        | 0.1        | 0.1        | -          | -           | 4.5         | -2.0        | -2.4       |
| Oil                  | 52.73         | 28.16         | 10.09         | 2.78          | 0.92         | 0.00         | 0.00         | 46.5       | 20.9       | 7.5        | 2.6        | 0.9        | 0.0        | 0.0        | -5.2       | -13.4       | -10.4       | -100.0      | -          |
| Gas                  | 33.56         | 45.16         | 59.12         | 45.85         | 44.99        | 47.20        | 48.90        | 29.6       | 33.6       | 43.8       | 43.6       | 46.0       | 48.6       | 50.2       | 1.8        | -2.8        | -0.2        | 0.5         | 0.4        |
| Hydrogen             | 0.00          | 0.00          | 0.00          | 0.00          | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          |
| Biomass (Biomass PP) | 0.00          | 0.00          | 0.00          | 19.13         | 23.16        | 26.78        | 30.18        | 0.0        | 0.0        | 0.0        | 18.2       | 23.7       | 27.6       | 31.0       | -          | -           | 1.9         | 1.5         | 1.2        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |     |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |     |
| Total      | 41.7 | 44.1 | 49.3 | 47.6 | 50.2 | 52.9 | 54.9 |  |  |  |  |  |  |  | 0.5       | -0.4      | 0.5       | 0.5       | 0.4       | 0.3 |
| Coal PP    | 39.7 | 42.1 | 42.0 | 42.2 | 43.9 | 46.3 | 47.4 |  |  |  |  |  |  |  | 0.2       | 0.0       | 0.4       | 0.5       | 0.3       | 0.3 |
| Oil PP     | 40.7 | 40.9 | 33.6 | 40.2 | 38.2 | -    | -    |  |  |  |  |  |  |  | -0.6      | 2.0       | -0.5      | -         | -         | -   |
| Gas PP     | 43.0 | 46.3 | 52.3 | 53.5 | 56.3 | 58.8 | 61.0 |  |  |  |  |  |  |  |           |           |           |           |           |     |
| Biomass PP | -    | -    | -    | 45.5 | 46.9 | 48.3 | 49.6 |  |  |  |  |  |  |  | -         | -         | 0.3       | 0.3       | 0.3       | -   |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |             |
|--------------|--------------------|----------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005           | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>1,054.4</b>     | <b>1,199.1</b> | <b>998.1</b> | <b>793.4</b> | <b>684.6</b> | <b>607.4</b> | <b>543.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.2</b> | <b>-2.5</b> | <b>-1.5</b> | <b>-1.2</b> | <b>-1.1</b> | <b>-1.5</b> |
| Coal         | 286.5              | 412.4          | 417.7        | 294.7        | 249.3        | 217.5        | 192.0        | 27.1       | 34.4       | 41.8       | 37.1       | 36.4       | 35.8       | 35.3       | 1.2         | -3.8        | -1.7        | -1.4        | -1.2        | -2.0        |
| Oil          | 667.3              | 623.7          | 375.5        | 327.9        | 272.2        | 227.5        | 191.3        | 63.2       | 52.0       | 37.6       | 41.3       | 39.8       | 37.5       | 35.2       | -1.8        | -1.5        | -1.8        | -1.8        | -1.7        | -1.7        |
| Natural Gas  | 102.6              | 163.0          | 204.9        | 170.8        | 163.1        | 162.4        | 160.2        | 9.7        | 13.6       | 20.5       | 21.5       | 23.8       | 26.7       | 29.5       | 2.3         | -2.0        | -0.5        | 0.0         | -0.1        | -0.6        |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0          | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 3,510 | 4,229 | 4,435 | 4,744 | 5,178 | 5,607 | 6,027 | 0.8       | 0.8       | 0.9       | 0.8       | 0.7       | 0.8       |
| Population (millions of people)                                                           | 123   | 128   | 126   | 120   | 112   | 105   | 98    | 0.1       | -0.6      | -0.6      | -0.7      | -0.7      | -0.6      |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 28.42 | 33.10 | 35.29 | 39.68 | 46.15 | 53.53 | 61.77 | 0.7       | 1.3       | 1.5       | 1.5       | 1.4       | 1.4       |
| Primary energy consumption per capita (toe/person)                                        | 3.54  | 4.07  | 3.18  | 3.15  | 3.10  | 3.14  | 3.22  | -0.3      | -0.1      | -0.2      | 0.1       | 0.2       | 0.0       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 124   | 123   | 90    | 79    | 67    | 59    | 52    | -1.0      | -1.4      | -1.7      | -1.3      | -1.2      | -1.4      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 83    | 80    | 60    | 53    | 45    | 39    | 34    | -1.0      | -1.4      | -1.7      | -1.5      | -1.3      | -1.5      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 301   | 284   | 225   | 167   | 132   | 108   | 90    | -0.9      | -3.2      | -2.3      | -2.0      | -1.8      | -2.3      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.42  | 2.31  | 2.50  | 2.11  | 1.97  | 1.85  | 1.73  | 0.1       | -1.9      | -0.7      | -0.6      | -0.6      | -0.9      |
| Automobile ownership volume (millions of vehicles)                                        | 58    | 76    | 78    | 75    | 70    | 63    | 57    | 1.0       | -0.4      | -0.8      | -0.9      | -1.1      | -0.8      |
| Automobile ownership volume per capita (vehicles per person)                              | 0.467 | 0.591 | 0.622 | 0.630 | 0.621 | 0.606 | 0.584 | 0.9       | 0.2       | -0.1      | -0.3      | -0.4      | -0.2      |

## Japan [LCET]

### Primary energy consumption

|                                | MTOE          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |
|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|                                | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>                   | <b>436.91</b> | <b>519.58</b> | <b>399.62</b> | <b>359.94</b> | <b>280.09</b> | <b>220.40</b> | <b>204.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-1.2</b> | <b>-2.5</b> | <b>-2.4</b> | <b>-0.8</b> |
| Coal                           | 76.70         | 110.46        | 109.13        | 73.31         | 44.05         | 15.86         | 11.97         | 17.6       | 21.3       | 27.3       | 20.4       | 15.7       | 7.2        | 5.9        | 1.1         | -4.3        | -5.0        | -9.7        | -2.8        |
| Oil                            | 248.81        | 240.93        | 150.66        | 111.17        | 68.06         | 34.46         | 31.43         | 56.9       | 46.4       | 37.7       | 30.9       | 24.3       | 15.6       | 15.4       | -1.6        | -3.3        | -4.8        | -6.6        | -0.9        |
| Natural gas                    | 44.12         | 70.65         | 86.72         | 55.66         | 31.78         | 15.18         | 12.61         | 10.1       | 13.6       | 21.7       | 15.5       | 11.3       | 6.9        | 6.2        | 2.2         | -4.8        | -5.5        | -7.1        | -1.8        |
| Hydrogen                       | 0.00          | 0.00          | 0.00          | 3.01          | 9.71          | 12.27         | 11.38         | 0.0        | 0.0        | 0.0        | 0.8        | 3.5        | 5.6        | 5.6        | -           | -           | 12.4        | 2.4         | -0.8        |
| Fuel Ammonia                   | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -           | -           | -           |
| Nuclear                        | 52.70         | 79.41         | 18.45         | 57.00         | 54.87         | 55.65         | 53.87         | 12.1       | 15.3       | 4.6        | 15.8       | 19.6       | 25.2       | 26.4       | -3.3        | 13.4        | -0.4        | 0.1         | -0.3        |
| Hydro                          | 7.56          | 6.61          | 6.77          | 7.85          | 7.75          | 8.12          | 7.86          | 1.7        | 1.3        | 1.7        | 2.2        | 2.8        | 3.7        | 3.9        | -0.4        | 1.7         | -0.1        | 0.5         | -0.3        |
| Geothermal                     | 1.58          | 2.90          | 2.71          | 18.00         | 17.69         | 18.36         | 17.77         | 0.4        | 0.6        | 0.7        | 5.0        | 6.3        | 8.3        | 8.7        | 1.8         | 23.4        | -0.2        | 0.4         | -0.3        |
| Others                         | 5.44          | 8.63          | 25.17         | 33.94         | 46.18         | 60.51         | 57.21         | 1.2        | 1.7        | 6.3        | 9.4        | 16.5       | 27.5       | 28.0       | 5.1         | 3.4         | 3.1         | 2.7         | -0.6        |
| Biomass                        | 4.21          | 7.80          | 16.34         | 16.24         | 18.42         | 21.49         | 19.33         | 1.0        | 1.5        | 4.1        | 4.5        | 6.6        | 9.7        | 9.5        | 4.5         | -0.1        | 1.3         | 1.6         | -1.1        |
| Solar Wind Ocean               | 1.22          | 0.83          | 8.37          | 17.29         | 25.86         | 36.16         | 35.08         | 0.3        | 0.2        | 2.1        | 4.8        | 9.2        | 16.4       | 17.2       | 6.4         | 8.4         | 4.1         | 3.4         | -0.3        |
| Biofuels                       | 0.01          | 0.00          | 0.46          | 0.41          | 1.91          | 2.86          | 2.80          | 0.0        | 0.0        | 0.1        | 0.1        | 0.7        | 1.3        | 1.4        | 12.5        | -1.2        | 16.5        | 4.1         | -0.2        |
| Electricity (Import or Export) | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | -225.1      | -           | -18.1       | -200.0      |

### Final energy demand

|              | MTOE          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |
|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>290.37</b> | <b>339.93</b> | <b>267.24</b> | <b>226.06</b> | <b>173.97</b> | <b>134.32</b> | <b>120.47</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-1.8</b> | <b>-2.6</b> | <b>-2.6</b> | <b>-1.1</b> |
| Industry     | 108.15        | 102.09        | 79.92         | 71.47         | 60.36         | 49.17         | 39.59         | 37.2       | 30.0       | 29.9       | 31.6       | 34.7       | 36.6       | 32.9       | -1.0        | -1.2        | -1.7        | -2.0        | -2.1        |
| Transport    | 72.28         | 86.88         | 63.28         | 49.75         | 34.90         | 22.49         | 20.79         | 24.9       | 25.6       | 23.7       | 22.0       | 20.1       | 16.7       | 17.3       | -0.4        | -2.6        | -3.5        | -4.3        | -0.8        |
| Others       | 77.51         | 114.43        | 93.68         | 75.15         | 49.56         | 33.94         | 32.12         | 26.7       | 33.7       | 35.1       | 33.2       | 28.5       | 25.3       | 26.7       | 0.6         | -2.4        | -4.1        | -3.7        | -0.5        |
| Non-energy   | 32.42         | 36.52         | 30.36         | 29.68         | 29.15         | 28.72         | 27.97         | 11.2       | 10.7       | 11.4       | 13.1       | 16.8       | 21.4       | 23.2       | -0.2        | -0.2        | -0.2        | -0.3        | -0.2        |
| <b>Total</b> | <b>290.37</b> | <b>339.93</b> | <b>267.24</b> | <b>226.06</b> | <b>173.97</b> | <b>134.32</b> | <b>120.47</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.3</b> | <b>-1.8</b> | <b>-2.6</b> | <b>-2.6</b> | <b>-1.1</b> |
| Coal         | 27.08         | 22.75         | 20.14         | 15.07         | 8.17          | 3.34          | 1.85          | 9.3        | 6.7        | 7.5        | 6.7        | 4.7        | 2.5        | 1.5        | -1.0        | -3.2        | -5.9        | -8.6        | -5.7        |
| Oil          | 179.96        | 196.39        | 131.70        | 101.52        | 61.59         | 31.12         | 28.74         | 62.0       | 57.8       | 49.3       | 44.9       | 35.4       | 23.2       | 23.9       | -1.0        | -2.9        | -4.9        | -6.6        | -0.8        |
| Natural gas  | 13.61         | 26.34         | 28.23         | 21.38         | 9.42          | 2.47          | 1.45          | 4.7        | 7.7        | 10.6       | 9.5        | 5.4        | 1.8        | 1.2        | 2.4         | -3.0        | -7.9        | -12.5       | -5.2        |
| Hydrogen     | 0.00          | 0.00          | 0.00          | 1.35          | 5.49          | 9.21          | 8.42          | 0.0        | 0.0        | 0.0        | 35.6       | 3.2        | 6.9        | 7.0        | -           | -           | -23.5       | 5.3         | -0.9        |
| Fuel Ammonia | 0.00          | 0.00          | 0.00          | 0.00          | 6.84          | 11.58         | 11.61         | 0.0        | 0.0        | 0.0        | 0.2        | 3.9        | 8.6        | 9.6        | -           | -           | 34.0        | 5.4         | 0.0         |
| Electricity  | 65.76         | 88.12         | 80.13         | 80.50         | 74.71         | 67.36         | 60.33         | 22.6       | 25.9       | 30.0       | 0.2        | 42.9       | 50.1       | 50.1       | 0.6         | -45.0       | 70.2        | -1.0        | -1.1        |
| Heat         | 0.20          | 0.60          | 0.51          | 0.37          | 0.13          | 0.00          | 0.00          | 0.1        | 0.2        | 0.2        | 2.6        | 0.1        | 0.0        | 0.0        | 3.1         | 31.3        | -31.6       | -           | -100.0      |
| Others       | 3.75          | 5.74          | 6.52          | 5.87          | 7.62          | 9.25          | 8.06          | 1.3        | 1.7        | 2.4        | 0.0        | 4.4        | 6.9        | 6.7        | 1.8         | -           | -           | 2.0         | -1.4        |

### Power generation Output

|                                     | TWh           |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |             |            |             |
|-------------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|-------------|
|                                     | 1990          | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050  | 2050-2060   |
| <b>Total</b>                        | <b>861.54</b> | <b>1,099.41</b> | <b>1,039.88</b> | <b>1,041.72</b> | <b>1,027.17</b> | <b>1,047.83</b> | <b>1,033.69</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>0.0</b> | <b>-0.1</b> | <b>0.4</b> | <b>-0.3</b> |
| Coal PP                             | 124.71        | 299.89          | 321.90          | 158.39          | 7.40            | 0.00            | 0.00            | 14.5       | 27.3       | 31.0       | 15.2       | 0.7        | 0.0        | 0.0        | 3.1        | -7.6       | -26.4       | -100.0     | -           |
| Coal PP with biomass co-firing      | 0.00          | 0.00            | 0.00            | 4.80            | 5.55            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.5        | 0.5        | 0.0        | 0.0        | -          | -          | 1.5         | -100.0     | -           |
| Coal PP with fuel ammonia co-firing | 0.00          | 0.00            | 0.00            | 28.80           | 51.77           | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 2.8        | 5.0        | 0.0        | 0.0        | -          | -          | 6.0         | -100.0     | -           |
| Coal PP with CCS                    | 0.00          | 0.00            | 0.00            | 5.94            | 43.14           | 21.36           | 20.67           | 0.0        | 0.0        | 0.0        | 0.6        | 4.2        | 2.0        | 2.0        | -          | -          | 21.9        | -6.8       | -0.3        |
| Oil                                 | 249.53        | 133.84          | 39.45           | 10.42           | 5.14            | 0.00            | 0.00            | 29.0       | 12.2       | 3.8        | 1.0        | 0.5        | 0.0        | 0.0        | -5.8       | -13.8      | -6.8        | -100.0     | -           |
| Gas PP                              | 167.69        | 243.23          | 359.42          | 209.48          | 85.77           | 0.00            | 0.00            | 19.5       | 22.1       | 34.6       | 20.1       | 8.3        | 0.0        | 0.0        | 2.5        | -5.8       | -8.5        | -100.0     | -           |
| Gas PP with hydrogen co-firing      | 0.00          | 0.00            | 0.00            | 4.66            | 33.27           | 106.78          | 103.37          | 0.0        | 0.0        | 0.0        | 0.4        | 3.2        | 10.0       | 10.0       | -          | -          | 21.7        | 12.4       | -0.3        |
| Gas PP with CCS                     | 0.00          | 0.00            | 0.00            | 6.48            | 59.15           | 85.43           | 82.70           | 0.0        | 0.0        | 0.0        | 0.6        | 5.8        | 8.0        | 8.0        | -          | -          | 24.8        | 3.7        | -0.3        |
| Nuclear PP                          | 202.27        | 304.75          | 70.81           | 218.76          | 210.57          | 213.57          | 206.74          | 23.5       | 27.7       | 6.8        | 21.0       | 20.5       | 20.0       | 20.0       | -3.3       | 13.4       | -0.4        | 0.1        | -0.3        |
| Solar PV                            | 19.59         | 22.13           | 104.08          | 162.11          | 213.51          | 262.67          | 249.51          | 2.3        | 2.0        | 10.0       | 15.6       | 20.8       | 24.6       | 24.1       | 5.5        | 5.0        | 2.8         | 2.1        | -0.5        |
| Wind                                | 0.00          | 1.75            | 9.43            | 56.65           | 105.71          | 176.80          | 175.94          | 0.0        | 0.2        | 0.9        | 5.4        | 10.3       | 16.6       | 17.0       | -          | 22.0       | 6.4         | 5.3        | 0.0         |
| Hydro                               | 87.90         | 76.92           | 78.79           | 91.35           | 90.14           | 94.44           | 91.39           | 10.2       | 7.0        | 7.6        | 8.8        | 8.8        | 8.8        | 8.8        | -0.4       | 1.7        | -0.1        | 0.5        | -0.3        |
| Geothermal                          | 1.74          | 3.23            | 3.01            | 20.83           | 20.54           | 21.36           | 20.67           | 0.2        | 0.3        | 0.3        | 2.0        | 2.0        | 2.0        | 2.0        | 1.8        | 24.0       | -0.1        | 0.4        | -0.3        |
| Biomass and others                  | 8,095.2       | 13.66           | 52.98           | 63.05           | 95.51           | 85.43           | 82.70           | 0.9        | 1.2        | 5.1        | 6.1        | 9.3        | 8.0        | 8.0        | 6.2        | 2.0        | 4.2         | -1.1       | -0.3        |

### Power generation Input

|                      | MTOE          |               |               |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |
|----------------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|                      | 1990          | 2005          | 2021          | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>         | <b>113.32</b> | <b>134.59</b> | <b>135.05</b> | <b>88.88</b> | <b>72.68</b> | <b>65.64</b> | <b>61.46</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>-4.5</b> | <b>-2.0</b> | <b>-1.0</b> | <b>-0.7</b> |
| Coal                 | 27.03         | 61.27         | 65.84         | 39.01        | 22.99        | 6.23         | 6.03         | 23.8       | 45.5       | 48.8       | 43.9       | 31.6       | 9.5        | 9.8        | 2.9        | -5.7        | -5.2        | -12.2       | -0.3        |
| Fuel ammonia         | 0.00          | 0.00          | 0.00          | 0.74         | 4.50         | 15.33        | 14.33        | 0.0        | 0.0        | 0.0        | 0.8        | 6.2        | 23.4       | 23.3       | -          | -           | 19.7        | 13.0        | -0.7        |
| Biomass (Co-firing)  | 0.00          | 0.00          | 0.00          | 0.19         | 0.32         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.2        | 0.4        | 0.0        | 0.0        | -          | -           | 5.1         | -100.0      | -           |
| Oil                  | 52.73         | 28.16         | 10.09         | 2.12         | 1.12         | 0.00         | 0.00         | 46.5       | 20.9       | 7.5        | 2.4        | 1.5        | 0.0        | 0.0        | -5.2       | -15.9       | -6.1        | -100.0      | -           |
| Gas                  | 33.56         | 45.16         | 59.12         | 34.57        | 23.15        | 13.90        | 12.94        | 29.6       | 33.6       | 43.8       | 38.9       | 31.8       | 21.2       | 21.1       | 1.8        | -5.8        | -3.9        | -5.0        | -0.7        |
| Hydrogen             | 0.00          | 0.00          | 0.00          | 1.66         | 8.38         | 15.33        | 14.33        | 0.0        | 0.0        | 0.0        | 1.9        | 11.5       | 23.4       | 23.3       | -          | -           | 17.6        | 6.2         | -0.7        |
| Biomass (Biomass PP) | 0.00          | 0.00          | 0.00          | 10.59        | 12.22        | 14.85        | 13.82        | 0.0        | 0.0        | 0.0        | 11.9       | 16.8       | 22.6       | 22.5       | -          | -           | 1.4         | 2.0         | -0.7        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |
| Total      | 41.7 | 44.1 | 49.3 | 47.6 | 45.8 | 39.2 | 40.5 |  |  |  |  |  |  |  | 0.5       | -0.4      | -0.4      | -1.5      | 0.3       |
| Coal PP    | 39.7 | 42.1 | 42.0 | 43.6 | 40.4 | 29.5 | 29.5 |  |  |  |  |  |  |  | 0.2       | 0.4       | -0.8      | -3.1      | 0.0       |
| Oil PP     | 40.7 | 40.9 | 33.6 | 42.4 | 39.3 | -    | -    |  |  |  |  |  |  |  | -0.6      | 2.6       | -0.7      | -         | -         |
| Gas PP     | 43.0 | 46.3 | 52.3 | 52.4 | 48.6 | 56.6 | 58.7 |  |  |  |  |  |  |  |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 51.2 | 67.2 | 49.5 | 51.4 |  |  |  |  |  |  |  | -         | -         | 2.8       | -3.0      | 0.4       |

## CO<sub>2</sub> emissions

| CO <sub>2</sub> Emissions | Mt-CO <sub>2</sub> |         |       |       |       |       |       |      |      |      |      |      |        |        | AAGR(%)   |           |           |           |           |           |
|---------------------------|--------------------|---------|-------|-------|-------|-------|-------|------|------|------|------|------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                           | 1990               | 2005    | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                     | 1,056.4            | 1,199.1 | 998.1 | 676.4 | 268.5 | 17.7  | 5.8   | 100  | 100  | 100  | 100  | 100  | 100    | 100    | -0.2      | -4.2      | -8.8      | -23.8     | -10.5     | -12.4     |
| Coal                      | 286.5              | 412.4   | 417.7 | 283.9 | 146.2 | 28.5  | 19.0  | 27.1 | 34.4 | 41.8 | 42.0 | 54.4 | 161.4  | 328.1  | 1.2       | -4.2      | -6.4      | -15.1     | -4.0      | -7.6      |
| Oil                       | 667.3              | 623.7   | 375.5 | 263.2 | 110.8 | 12.9  | 10.1  | 63.2 | 52.0 | 37.6 | 38.9 | 41.3 | 73.3   | 174.0  | -1.8      | -3.9      | -8.3      | -19.3     | -2.5      | -8.9      |
| Natural Gas               | 102.6              | 163.0   | 204.9 | 132.9 | 48.5  | 1.3   | 0.0   | 9.7  | 13.6 | 20.5 | 19.6 | 18.1 | 7.1    | 0.0    | 2.3       | -4.7      | -9.6      | -30.6     | -100.0    | -100.0    |
| CCS/DAC (-)               | 0.0                | 0.0     | 0.0   | -3.5  | -11.7 | -25.0 | -23.3 | 0.0  | 0.0  | 0.0  | -0.5 | -4.4 | -141.8 | -402.1 | -         | -         | 12.8      | 7.9       | -0.7      | -         |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |       |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060  |
| GDP (billions of 2015 US dollars)                                                         | 3,510 | 4,229 | 4,435 | 4,744 | 5,178 | 5,607 | 6,027 | 0.8       | 0.8       | 0.9       | 0.8       | 0.7       | 0.8   |
| Population (millions of people)                                                           | 123   | 128   | 126   | 120   | 112   | 105   | 98    | 0.1       | -0.6      | -0.6      | -0.7      | -0.7      | -0.6  |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 28.42 | 33.10 | 35.29 | 39.68 | 46.15 | 53.53 | 61.77 | 0.7       | 1.3       | 1.5       | 1.5       | 1.4       | 1.4   |
| Primary energy consumption per capita (toe/person)                                        | 3.54  | 4.07  | 3.18  | 3.01  | 2.50  | 2.10  | 2.09  | -0.3      | -0.6      | -1.9      | -1.7      | -0.1      | -1.1  |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 124   | 123   | 90    | 76    | 54    | 39    | 34    | -1.0      | -1.9      | -3.3      | -3.1      | -1.5      | -2.5  |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 83    | 80    | 60    | 48    | 34    | 24    | 20    | -1.0      | -2.6      | -3.4      | -3.3      | -1.8      | -2.8  |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 301   | 284   | 225   | 143   | 52    | 3     | 1     | -0.9      | -4.9      | -9.6      | -24.4     | -11.2     | -13.1 |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.42  | 2.31  | 2.50  | 1.88  | 0.96  | 0.08  | 0.03  | 0.1       | -3.1      | -6.5      | -22.0     | -9.9      | -10.8 |
| Automobile ownership volume (millions of vehicles)                                        | 58    | 76    | 78    | 75    | 70    | 63    | 57    | 1.0       | -0.4      | -0.8      | -0.9      | -1.1      | -0.8  |
| Automobile ownership volume per capita (vehicles per person)                              | 0.467 | 0.591 | 0.622 | 0.630 | 0.621 | 0.606 | 0.584 | 0.9       | 0.2       | -0.1      | -0.3      | -0.4      | -0.2  |



## Korea [BAU]

### Primary energy consumption

|                                | MTOE         |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |
|--------------------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|                                | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>                   | <b>92.91</b> | <b>210.29</b> | <b>291.76</b> | <b>293.95</b> | <b>281.19</b> | <b>265.62</b> | <b>246.63</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>0.1</b> | <b>-0.4</b> | <b>-0.6</b> | <b>-0.7</b> |
| Coal                           | 25.38        | 49.66         | 76.99         | 76.60         | 70.76         | 63.60         | 53.89         | 27.3       | 23.6       | 25.7       | 25.4       | 25.2       | 23.9       | 21.9       | 3.6        | -0.1       | -0.5        | -1.1        | -1.6        |
| Oil                            | 49.73        | 92.49         | 111.55        | 108.76        | 98.59         | 88.45         | 77.08         | 53.5       | 44.0       | 38.2       | 37.0       | 35.1       | 33.3       | 31.3       | 2.6        | -0.3       | -1.0        | -1.1        | -1.4        |
| Natural gas                    | 2.73         | 27.38         | 54.40         | 51.58         | 57.78         | 64.55         | 68.47         | 2.9        | 13.0       | 18.6       | 17.5       | 20.5       | 24.3       | 27.8       | 10.1       | -0.6       | 1.1         | 1.1         | 0.6         |
| Hydrogen                       | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | 17.0        | 3.5         | 13.5        |
| Fuel Ammonia                   | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           |
| Nuclear                        | 13.78        | 38.24         | 41.17         | 42.02         | 34.87         | 27.53         | 23.91         | 14.8       | 18.2       | 14.1       | 14.3       | 12.4       | 10.4       | 9.7        | 3.6        | 0.2        | -1.8        | -2.3        | -1.4        |
| Hydro                          | 0.55         | 0.32          | 0.26          | 0.31          | 0.31          | 0.31          | 0.31          | 0.6        | 0.2        | 0.1        | 0.1        | 0.1        | 0.1        | 0.1        | -2.3       | 1.7        | 0.0         | 0.0         | 0.4         |
| Geothermal                     | 0.00         | 0.00          | 0.26          | 0.39          | 0.42          | 0.40          | 0.33          | 0.0        | 0.0        | 0.1        | 0.1        | 0.1        | 0.2        | 0.1        | -          | 4.6        | 0.7         | -0.3        | -2.0        |
| Others                         | 0.74         | 2.20          | 9.13          | 16.29         | 18.46         | 20.77         | 22.64         | 0.8        | 1.0        | 3.1        | 5.5        | 6.6        | 7.8        | 9.2        | 8.4        | 6.6        | 1.3         | 1.2         | 0.9         |
| Biomass                        | 0.71         | 2.05          | 5.21          | 6.95          | 7.28          | 7.34          | 7.17          | 0.8        | 1.0        | 1.8        | 2.4        | 2.6        | 2.8        | 2.9        | 6.6        | 3.3        | 0.5         | 0.1         | -0.2        |
| Solar Wind. Ocean              | 0.01         | 0.05          | 2.76          | 7.51          | 8.95          | 10.86         | 12.85         | 0.0        | 0.0        | 0.9        | 2.6        | 3.2        | 4.1        | 5.2        | 19.9       | 11.8       | 1.8         | 1.9         | 1.7         |
| Biofuels                       | 0.02         | 0.09          | 1.11          | 1.78          | 2.18          | 2.53          | 2.57          | 0.0        | 0.0        | 0.4        | 0.6        | 0.8        | 1.0        | 1.0        | 14.3       | 5.4        | 2.1         | 1.5         | 0.1         |
| Electricity (Import or Export) | 0.00         | 0.02          | 0.10          | 0.10          | 0.10          | 0.10          | 0.10          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | 0.0        | 0.0         | 0.0         | 0.0         |

### Final energy demand

|              | MTOE         |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |
|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|              | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>64.91</b> | <b>140.45</b> | <b>181.70</b> | <b>183.92</b> | <b>176.41</b> | <b>166.98</b> | <b>153.72</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.4</b> | <b>0.1</b> | <b>-0.4</b> | <b>-0.5</b> | <b>-0.8</b> |
| Industry     | 19.26        | 39.06         | 47.36         | 49.79         | 48.05         | 43.77         | 37.11         | 29.7       | 27.8       | 26.1       | 27.1       | 27.2       | 26.2       | 24.1       | 2.9        | 0.6        | -0.4        | -0.9        | -1.6        |
| Transport    | 14.57        | 29.19         | 35.66         | 33.42         | 27.05         | 21.07         | 14.85         | 22.5       | 20.8       | 19.6       | 18.2       | 15.3       | 12.6       | 9.7        | 2.9        | -0.7       | -2.1        | -2.5        | -3.4        |
| Others       | 24.35        | 41.84         | 45.53         | 45.44         | 45.02         | 46.49         | 48.59         | 37.5       | 29.8       | 25.1       | 24.7       | 25.5       | 27.8       | 31.6       | 2.0        | 0.0        | -0.1        | 0.3         | 0.4         |
| Non-energy   | 6.73         | 30.37         | 53.14         | 55.26         | 56.28         | 55.65         | 53.17         | 10.4       | 21.6       | 29.2       | 30.0       | 31.9       | 33.3       | 34.6       | 6.9        | 0.4        | 0.2         | -0.1        | -0.5        |
| <b>Total</b> | <b>64.91</b> | <b>140.45</b> | <b>181.70</b> | <b>183.92</b> | <b>176.41</b> | <b>166.98</b> | <b>153.72</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.4</b> | <b>0.1</b> | <b>-0.4</b> | <b>-0.5</b> | <b>-0.8</b> |
| Coal         | 11.72        | 7.75          | 7.09          | 6.42          | 5.57          | 4.45          | 3.36          | 18.1       | 5.5        | 3.9        | 3.5        | 3.2        | 2.7        | 2.2        | -1.6       | -1.1       | -1.4        | -2.2        | -1.9        |
| Oil          | 43.66        | 79.64         | 97.30         | 94.81         | 86.25         | 76.77         | 66.16         | 67.3       | 56.7       | 53.6       | 51.6       | 48.9       | 46.0       | 43.0       | 2.6        | -0.3       | -0.9        | -1.2        | -1.5        |
| Natural gas  | 0.67         | 15.99         | 21.81         | 21.65         | 20.28         | 18.09         | 14.89         | 1.0        | 11.4       | 12.0       | 11.8       | 11.5       | 10.8       | 9.7        | 11.9       | -0.1       | -0.7        | -1.1        | -1.9        |
| Hydrogen     | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -2.7        | -3.3        | -4.7        |
| Fuel Ammonia | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           |
| Electricity  | 8.12         | 30.75         | 46.08         | 51.38         | 54.99         | 58.92         | 61.83         | 12.5       | 21.9       | 25.4       | 27.9       | 31.2       | 35.3       | 40.2       | 5.8        | 1.2        | 0.7         | 0.7         | 0.5         |
| Heat         | 0.00         | 4.50          | 5.53          | 5.29          | 4.85          | 4.28          | 3.56          | 0.0        | 3.2        | 3.0        | 2.9        | 2.7        | 2.6        | 2.3        | -          | -0.5       | -0.9        | -1.2        | -1.8        |
| Others       | 0.74         | 1.83          | 3.89          | 4.36          | 4.47          | 4.47          | 3.91          | 1.1        | 1.3        | 2.1        | 2.4        | 2.5        | 2.7        | 2.5        | 5.5        | 1.3        | 0.2         | 0.0         | -1.3        |

### Power generation Output

|                                     | TWh    |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990   | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 105.37 | 387.87 | 608.08 | 676.39 | 721.12 | 768.70 | 802.48 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 5.8       | 1.2       | 0.6       | 0.6       | 0.4       | 0.7       |
| Coal PP                             | 17.66  | 148.79 | 208.34 | 215.35 | 211.22 | 197.42 | 166.81 | 16.8 | 38.4 | 34.3 | 31.8 | 29.3 | 25.7 | 20.8 | 8.3       | 0.4       | -0.2      | -0.7      | -1.7      | -0.6      |
| Coal PP with biomass co-firing      | 0.00   | 0.00   | 0.00   | 2.73   | 5.42   | 5.06   | 4.28   | 0.0  | 0.0  | 0.0  | 0.4  | 0.8  | 0.7  | 0.5  | -         | -         | 7.1       | -0.7      | -1.7      | -         |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Coal PP with CCS                    | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Oil                                 | 18.86  | 25.99  | 8.17   | 4.44   | 0.00   | 0.00   | 0.00   | 17.9 | 6.7  | 1.3  | 0.7  | 0.0  | 0.0  | 0.0  | -2.7      | -6.5      | -100.0    | -         | -         | -100.0    |
| Gas PP                              | 9.60   | 62.15  | 190.20 | 180.27 | 238.11 | 303.30 | 356.50 | 9.1  | 16.0 | 31.3 | 26.7 | 33.0 | 39.5 | 44.4 | 10.1      | -0.6      | 2.8       | 2.4       | 1.6       | 1.6       |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Gas PP with CCS                     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear PP                          | 52.89  | 146.78 | 158.02 | 161.28 | 133.84 | 105.67 | 91.76  | 50.2 | 37.8 | 26.0 | 23.8 | 18.6 | 13.7 | 11.4 | 3.6       | 0.2       | -1.8      | -2.3      | -1.4      | -1.4      |
| Solar PV                            | 0.00   | 0.02   | 28.43  | 74.76  | 85.11  | 99.60  | 114.08 | 0.0  | 0.0  | 4.7  | 11.1 | 11.8 | 13.0 | 14.2 | 39.2      | 11.3      | 1.3       | 1.6       | 1.4       | 3.6       |
| Wind                                | 0.00   | 0.13   | 3.18   | 16.64  | 23.09  | 30.78  | 39.63  | 0.0  | 0.0  | 0.5  | 2.5  | 3.2  | 4.0  | 4.9  | -         | 20.2      | 3.3       | 2.9       | 2.6       | 6.7       |
| Hydro                               | 6.36   | 3.67   | 3.05   | 3.56   | 3.56   | 3.56   | 3.56   | 6.0  | 0.9  | 0.5  | 0.5  | 0.5  | 0.5  | 0.4  | -2.3      | 1.7       | 0.0       | 0.0       | 0.0       | 0.4       |
| Geothermal                          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass and others                  | 0      | 0.34   | 8.69   | 17.35  | 20.77  | 23.31  | 25.84  | 0.0  | 0.1  | 1.4  | 2.6  | 2.9  | 3.0  | 3.2  | -         | 8.0       | 1.8       | 1.2       | 1.0       | 2.8       |

### Power generation Input

|                      | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>12.52</b> | <b>53.77</b> | <b>81.14</b> | <b>81.94</b> | <b>87.00</b> | <b>91.75</b> | <b>92.97</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.2</b> | <b>0.1</b> | <b>0.6</b> | <b>0.5</b> | <b>0.1</b> |
| Coal                 | 5.98         | 36.33        | 47.49        | 47.58        | 45.38        | 40.72        | 34.39        | 47.7       | 67.6       | 58.5       | 58.1       | 52.2       | 44.4       | 37.0       | 6.9        | 0.0        | -0.5       | -1.1       | -1.7       |
| Fuel ammonia         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00         | 0.00         | 0.00         | 0.15         | 0.33         | 0.29         | 0.22         | 0.0        | 0.0        | 0.0        | 0.2        | 0.4        | 0.3        | 0.2        | -          | -          | 7.9        | -1.4       | -2.4       |
| Oil                  | 4.51         | 6.48         | 2.12         | 1.02         | 0.00         | 0.00         | 0.00         | 36.0       | 12.1       | 2.6        | 1.2        | 0.0        | 0.0        | 0.0        | -2.4       | -7.8       | -100.0     | -          | -100.0     |
| Gas                  | 2.04         | 10.96        | 31.53        | 29.07        | 36.65        | 45.61        | 52.74        | 16.3       | 20.4       | 38.9       | 35.5       | 42.1       | 49.7       | 56.7       | 9.2        | -0.9       | 2.3        | 2.2        | 1.5        |
| Hydrogen             | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00         | 0.00         | 0.00         | 4.12         | 4.64         | 5.13         | 5.61         | 0.0        | 0.0        | 0.0        | 5.0        | 5.3        | 5.6        | 6.0        | -          | -          | 1.2        | 1.0        | 0.9        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total      | 31.7 | 37.9 | 44.0 | 44.1 | 47.0 | 49.6 | 51.2 |  |  |  |  |  |  |  | 1.1       | 0.0       | 0.6       | 0.5       | 0.3       | 0.4       |
| Coal PP    | 25.4 | 35.2 | 37.7 | 39.4 | 41.1 | 42.8 | 42.8 |  |  |  |  |  |  |  | 1.3       | 0.5       | 0.4       | 0.4       | 0.0       | 0.3       |
| Oil PP     | 35.9 | 34.5 | 33.2 | 37.6 | -    | -    | -    |  |  |  |  |  |  |  | -0.3      | 1.4       | -         | -         | -         | -         |
| Gas PP     | 40.5 | 48.8 | 51.9 | 53.3 | 55.9 | 57.2 | 58.1 |  |  |  |  |  |  |  | -         | -         | 0.6       | 0.2       | 0.1       | -         |
| Biomass PP | -    | -    | -    | 36.2 | 38.5 | 39.1 | 39.6 |  |  |  |  |  |  |  | -         | -         | 0.6       | 0.2       | 0.1       | -         |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>207.6</b>       | <b>438.2</b> | <b>558.6</b> | <b>532.5</b> | <b>503.2</b> | <b>467.4</b> | <b>416.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.2</b> | <b>-0.5</b> | <b>-0.6</b> | <b>-0.7</b> | <b>-1.2</b> | <b>-0.8</b> |
| Coal         | 91.4               | 196.2        | 276.8        | 272.4        | 257.7        | 231.1        | 195.0        | 44.0       | 44.8       | 49.6       | 51.1       | 51.2       | 49.4       | 46.8       | 3.6        | -0.2        | -0.6        | -1.1        | -1.7        | -0.9        |
| Oil          | 110.2              | 174.6        | 155.8        | 141.9        | 113.3        | 89.0         | 65.4         | 53.1       | 39.9       | 27.9       | 26.7       | 22.5       | 19.0       | 15.7       | 1.1        | -1.0        | -2.2        | -2.4        | -3.0        | -2.2        |
| Natural Gas  | 6.1                | 67.4         | 126.0        | 118.2        | 132.2        | 147.4        | 155.8        | 2.9        | 15.4       | 22.6       | 22.2       | 26.3       | 31.5       | 37.4       | 10.3       | -0.7        | 1.1         | 1.1         | 0.6         | 0.5         |
| CCS/DAC (-)  | 0.0                | 0.0          | 0.0          | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 402   | 1,021 | 1,694 | 2,013 | 2,280 | 2,451 | 2,415 | 4.8       | 1.9       | 1.3       | 0.7       | -0.1      | 0.9       |
| Population (millions of people)                                                           | 43    | 48    | 52    | 51    | 50    | 47    | 42    | 0.6       | -0.1      | -0.3      | -0.6      | -1.1      | -0.5      |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 9.37  | 21.20 | 32.74 | 39.30 | 45.79 | 52.03 | 57.09 | 4.1       | 2.1       | 1.5       | 1.3       | 0.9       | 1.4       |
| Primary energy consumption per capita (toe/person)                                        | 2.17  | 4.36  | 5.64  | 5.74  | 5.65  | 5.64  | 5.83  | 3.1       | 0.2       | -0.2      | 0.0       | 0.3       | 0.1       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 231   | 206   | 172   | 146   | 123   | 108   | 102   | -0.9      | -1.8      | -1.7      | -1.3      | -0.6      | -1.3      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 162   | 138   | 107   | 91    | 77    | 68    | 64    | -1.3      | -1.8      | -1.6      | -1.3      | -0.7      | -1.3      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 517   | 429   | 330   | 265   | 221   | 191   | 172   | -1.4      | -2.4      | -1.8      | -1.5      | -1.0      | -1.7      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.23  | 2.08  | 1.91  | 1.81  | 1.79  | 1.76  | 1.69  | -0.5      | -0.6      | -0.1      | -0.2      | -0.4      | -0.3      |
| Automobile ownership volume (millions of vehicles)                                        | 3     | 15    | 25    | 26    | 25    | 23    | 19    | 6.6       | 0.5       | -0.5      | -1.0      | -1.9      | -0.7      |
| Automobile ownership volume per capita (vehicles per person)                              | 0.079 | 0.320 | 0.481 | 0.511 | 0.502 | 0.481 | 0.444 | 6.0       | 0.7       | -0.2      | -0.4      | -0.8      | -0.2      |

## Korea [LCET]

### Primary energy consumption

|                                | MTOE  |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------------------------|-------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | 1990  | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                          | 92.91 | 210.29 | 291.51 | 271.71 | 238.60 | 203.55 | 185.00 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.8       | -0.8      | -1.3      | -1.6      | -1.0      | -1.2      |
| Coal                           | 25.38 | 49.66  | 74.99  | 52.37  | 33.89  | 11.89  | 5.12   | 27.3 | 23.6 | 25.7 | 19.3 | 14.2 | 5.8  | 2.8  | 3.6       | -3.9      | -4.3      | -9.9      | -8.1      | -6.7      |
| Oil                            | 49.73 | 92.49  | 111.55 | 96.08  | 76.88  | 59.29  | 55.64  | 53.5 | 44.0 | 38.3 | 35.4 | 32.2 | 29.1 | 30.1 | 2.6       | -1.6      | -2.2      | -2.6      | -0.6      | -1.8      |
| Natural gas                    | 2.73  | 27.38  | 54.40  | 42.51  | 17.84  | 9.23   | 0.73   | 2.9  | 13.0 | 18.7 | 15.6 | 7.5  | 4.5  | 0.4  | 10.1      | -2.7      | -8.3      | -6.4      | -22.4     | -10.5     |
| Hydrogen                       | 0.00  | 0.00   | 0.00   | 2.32   | 5.63   | 8.37   | 7.93   | 0.0  | 0.0  | 0.0  | 0.9  | 2.4  | 4.1  | 4.3  | -         | -         | 9.3       | 4.0       | -0.5      | -         |
| Fuel Ammonia                   | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear                        | 13.78 | 38.24  | 41.17  | 57.59  | 70.19  | 72.89  | 70.62  | 14.8 | 18.2 | 14.1 | 21.2 | 29.4 | 35.8 | 38.2 | 3.6       | 3.8       | 2.0       | 0.4       | -0.3      | 1.4       |
| Hydro                          | 0.55  | 0.32   | 0.26   | 0.31   | 0.30   | 0.30   | 0.30   | 0.6  | 0.2  | 0.1  | 0.1  | 0.1  | 0.1  | 0.2  | -2.3      | 1.7       | -0.3      | 0.1       | -0.1      | 0.3       |
| Geothermal                     | 0.00  | 0.00   | 0.00   | 0.32   | 0.18   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.1  | 0.1  | 0.0  | 0.0  | -         | 59.1      | -5.6      | -31.6     | -4.7      | -1.7      |
| Others                         | 0.74  | 2.20   | 9.13   | 20.22  | 33.70  | 41.58  | 44.66  | 0.8  | 1.0  | 3.1  | 7.4  | 14.1 | 20.4 | 24.1 | 8.4       | 9.2       | 5.2       | 2.1       | 0.7       | 4.2       |
| Biomass                        | 0.71  | 2.05   | 5.21   | 7.79   | 11.73  | 13.24  | 12.74  | 0.8  | 1.0  | 1.8  | 2.9  | 4.9  | 6.5  | 6.9  | 6.6       | 4.6       | 4.2       | 1.2       | -0.4      | 2.3       |
| Solar, Wind, Ocean             | 0.01  | 0.05   | 2.76   | 11.21  | 20.08  | 26.26  | 30.03  | 0.0  | 0.0  | 0.9  | 4.1  | 8.4  | 12.9 | 16.2 | 19.9      | 16.8      | 6.0       | 2.7       | 1.4       | 6.3       |
| Biofuels                       | 0.02  | 0.09   | 1.11   | 1.17   | 1.83   | 2.03   | 1.84   | 0.0  | 0.0  | 0.4  | 0.4  | 0.8  | 1.0  | 1.0  | 14.3      | 0.6       | 4.6       | 1.0       | -1.0      | 1.3       |
| Electricity (Import or Export) | 0.00  | 0.02   | 0.10   | 0.10   | 0.10   | 0.10   | 0.10   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  | 0.1  | -         | -0.1      | 0.0       | 0.0       | 0.0       | 0.0       |

### Final energy demand

|              | MTOE  |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|-------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990  | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 64.91 | 140.45 | 181.45 | 167.89 | 144.29 | 121.33 | 109.15 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.4       | -0.9      | -1.5      | -1.7      | -1.1      | -1.3      |
| Industry     | 19.26 | 39.06  | 47.36  | 47.94  | 42.10  | 33.13  | 24.03  | 29.7 | 27.8 | 26.1 | 28.6 | 29.2 | 27.3 | 22.0 | 2.9       | 0.1       | -1.3      | -2.4      | -3.2      | -1.7      |
| Transport    | 14.57 | 29.19  | 35.66  | 25.62  | 17.35  | 11.00  | 9.98   | 22.5 | 20.8 | 19.7 | 15.3 | 12.0 | 9.1  | 9.1  | 2.9       | -3.6      | -3.8      | -4.5      | -1.0      | -3.2      |
| Others       | 24.35 | 41.84  | 45.28  | 39.00  | 28.34  | 20.93  | 21.51  | 37.5 | 29.8 | 25.0 | 23.2 | 19.6 | 17.3 | 19.7 | 2.0       | -1.6      | -3.1      | -3.0      | 0.3       | -1.9      |
| Non-energy   | 6.73  | 30.37  | 53.14  | 55.32  | 56.51  | 56.26  | 53.64  | 10.4 | 21.6 | 29.3 | 33.0 | 39.2 | 46.4 | 49.1 | 6.9       | 0.4       | 0.2       | 0.0       | -0.5      | 0.0       |
| Total        | 64.91 | 140.45 | 181.45 | 167.89 | 144.29 | 121.33 | 109.15 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.4       | -0.9      | -1.5      | -1.7      | -1.1      | -1.3      |
| Coal         | 11.72 | 7.75   | 7.09   | 5.44   | 3.04   | 1.25   | 0.67   | 18.1 | 5.5  | 3.9  | 3.2  | 2.1  | 1.0  | 0.6  | -1.6      | -2.9      | -5.6      | -8.5      | -6.0      | -5.9      |
| Oil          | 43.66 | 79.64  | 97.30  | 83.99  | 67.20  | 52.39  | 49.54  | 67.3 | 56.7 | 53.6 | 50.0 | 46.6 | 43.2 | 45.4 | 2.6       | -1.6      | -2.2      | -2.5      | -0.6      | -1.7      |
| Natural gas  | 0.67  | 15.99  | 21.81  | 16.51  | 7.51   | 1.64   | 0.79   | 1.0  | 11.4 | 12.0 | 9.8  | 5.2  | 1.4  | 0.7  | 11.9      | -3.0      | -7.6      | -14.1     | -7.1      | -8.2      |
| Hydrogen     | 0.00  | 0.00   | 0.00   | 0.61   | 1.93   | 3.02   | 2.77   | 0.0  | 0.0  | 0.0  | 31.1 | 1.3  | 2.5  | 2.5  | -         | -         | -28.1     | 4.6       | -0.9      | -         |
| Fuel Ammonia | 0.00  | 0.00   | 0.00   | 0.00   | 2.03   | 3.15   | 2.49   | 0.0  | 0.0  | 0.0  | 2.8  | 1.4  | 2.6  | 2.3  | -         | -         | -8.1      | 4.5       | -2.3      | -         |
| Electricity  | 8.12  | 30.75  | 46.08  | 52.29  | 52.82  | 49.12  | 44.10  | 12.5 | 21.9 | 25.4 | 2.8  | 36.6 | 40.5 | 40.4 | 5.8       | -22.4     | 27.3      | -0.7      | -1.1      | -0.1      |
| Heat         | 0.00  | 4.50   | 5.53   | 4.71   | 3.38   | 2.07   | 1.30   | 0.0  | 3.2  | 3.0  | 2.6  | 2.3  | 1.7  | 1.2  | -         | -2.7      | -2.5      | -4.8      | -4.6      | -3.7      |
| Others       | 0.74  | 1.83   | 3.63   | 4.33   | 6.37   | 8.68   | 7.49   | 1.1  | 1.3  | 2.0  | 0.0  | 4.4  | 7.2  | 6.9  | 5.3       | -         | -         | 3.1       | -1.5      | 1.9       |

### Power generation Output

|                                     | TWh    |        |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990   | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 105.37 | 387.87 | 608.08 | 688.60 | 728.04 | 777.09 | 752.91 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 5.8       | 1.4       | 0.6       | 0.7       | -0.3      | 0.5       |
| Coal PP                             | 17.66  | 148.79 | 208.34 | 123.36 | 24.37  | 0.00   | 0.00   | 16.8 | 38.4 | 34.3 | 17.9 | 3.3  | 0.0  | 0.0  | 8.3       | -5.7      | -15.0     | -100.0    | -         | -100.0    |
| Coal PP with biomass co-firing      | 0.00   | 0.00   | 0.00   | 1.64   | 4.06   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.2  | 0.6  | 0.0  | 0.0  | -         | -         | 9.5       | -100.0    | -         | -         |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00   | 0.00   | 6.58   | 18.96  | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 1.0  | 2.6  | 0.0  | 0.0  | -         | -         | 11.2      | -100.0    | -         | -         |
| Coal PP with CCS                    | 0.00   | 0.00   | 0.00   | 4.07   | 31.60  | 15.54  | 0.00   | 0.0  | 0.0  | 0.0  | 0.6  | 4.3  | 2.0  | 0.0  | -         | -         | 22.7      | -6.8      | -100.0    | -         |
| Oil                                 | 18.86  | 25.99  | 8.17   | 3.75   | 1.98   | 0.00   | 0.00   | 17.9 | 6.7  | 1.3  | 0.5  | 0.3  | 0.0  | 0.0  | -2.7      | -8.3      | -6.2      | -         | -         | -29.7     |
| Gas PP                              | 9.60   | 62.15  | 190.20 | 153.92 | 37.11  | 0.00   | 0.00   | 9.1  | 16.0 | 31.3 | 22.4 | 5.1  | 0.0  | 0.0  | 10.1      | -2.3      | -13.3     | -100.0    | -         | -100.0    |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00   | 0.00   | 10.39  | 32.44  | 93.25  | 90.35  | 0.0  | 0.0  | 0.0  | 1.5  | 4.5  | 12.0 | 12.0 | -         | -         | 12.1      | 11.1      | -0.3      | -         |
| Gas PP with CCS                     | 0.00   | 0.00   | 0.00   | 4.76   | 25.59  | 46.92  | 2.87   | 0.0  | 0.0  | 0.0  | 0.7  | 3.5  | 6.0  | 0.4  | -         | -         | 18.3      | 6.2       | -24.4     | -         |
| Nuclear PP                          | 52.89  | 146.78 | 158.02 | 221.02 | 269.38 | 279.75 | 271.05 | 50.2 | 37.8 | 26.0 | 32.1 | 37.0 | 36.0 | 36.0 | 3.6       | 3.8       | 2.0       | 0.4       | -0.3      | 1.4       |
| Solar PV                            | 0.00   | 0.15   | 28.43  | 111.72 | 185.71 | 230.94 | 256.89 | 0.0  | 0.0  | 4.7  | 16.2 | 25.5 | 29.7 | 34.1 | 39.2      | 16.4      | 5.2       | 2.2       | 1.1       | 5.8       |
| Wind                                | 0.00   | 0.00   | 3.18   | 24.09  | 54.54  | 79.90  | 96.98  | 0.0  | 0.0  | 0.5  | 3.5  | 7.5  | 10.3 | 12.9 | -         | 25.2      | 8.5       | 3.9       | 2.0       | 9.2       |
| Hydro                               | 6.36   | 3.67   | 3.05   | 3.56   | 3.46   | 3.49   | 3.45   | 6.0  | 0.9  | 0.5  | 0.5  | 0.5  | 0.4  | 0.5  | -2.3      | 1.7       | -0.3      | 0.1       | -0.1      | 0.3       |
| Geothermal                          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass and others                  | 0      | 0.34   | 8.69   | 19.73  | 38.83  | 27.30  | 31.33  | 0.0  | 0.1  | 1.4  | 2.9  | 5.3  | 3.5  | 4.2  | -         | 9.5       | 7.0       | -3.5      | 1.4       | 3.3       |

### Power generation Input

|                      | MTOE  |       |       |       |       |       |       |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|----------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                      | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                | 12.52 | 53.77 | 81.14 | 61.24 | 42.78 | 31.59 | 20.39 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 6.2       | -3.1      | -3.5      | -3.0      | -4.3      | -3.5      |
| Coal                 | 5.98  | 36.33 | 47.49 | 28.62 | 17.74 | 3.87  | 0.00  | 47.7 | 67.6 | 58.5 | 46.7 | 41.5 | 12.2 | 0.0  | 6.9       | -5.5      | -4.7      | -14.1     | -100.0    | -100.0    |
| Fuel ammonia         | 0.00  | 0.00  | 0.00  | 0.21  | 1.42  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.3  | 3.3  | 0.0  | 0.0  | -         | -         | 21.2      | -100.0    | -         | -         |
| Biomass (Co-firing)  | 0.00  | 0.00  | 0.00  | 0.09  | 0.32  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.1  | 0.7  | 0.0  | 0.0  | -         | -         | 13.9      | -100.0    | -         | -         |
| Oil                  | 4.51  | 6.48  | 2.12  | 0.84  | 0.48  | 0.00  | 0.00  | 36.0 | 12.1 | 2.6  | 1.4  | 1.1  | 0.0  | 0.0  | -2.4      | -9.8      | -5.4      | -         | -         | -29.6     |
| Gas                  | 2.04  | 10.96 | 31.53 | 25.22 | 10.14 | 7.84  | 0.47  | 16.3 | 20.4 | 38.9 | 41.2 | 23.7 | 24.8 | 2.3  | 9.2       | -2.5      | -8.7      | -2.5      | -24.5     | -10.2     |
| Hydrogen             | 0.00  | 0.00  | 0.00  | 1.85  | 6.12  | 13.71 | 13.10 | 0.0  | 0.0  | 0.0  | 3.0  | 14.3 | 43.4 | 64.3 | -         | -         | 12.7      | 8.4       | -0.5      | -         |
| Biomass (Biomass PP) | 0.00  | 0.00  | 0.00  | 4.41  | 6.56  | 6.17  | 6.81  | 0.0  | 0.0  | 0.0  | 7.2  | 15.3 | 19.5 | 33.4 | -         | -         | 4.0       | -0.6      | 1.0       | -         |

### Thermal Efficiency

|  | %    |      |      |      |      |      |      |  |  |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |
|--|------|------|------|------|------|------|------|--|--|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|
|  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |             |             |            |            |            |            |            |            |            | AAGR(%)    |             |             |              |             |
|--------------|--------------------|--------------|--------------|--------------|--------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|-------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050    | 2050-2060   |
| <b>Total</b> | <b>207.6</b>       | <b>438.2</b> | <b>558.6</b> | <b>388.3</b> | <b>167.4</b> | <b>30.6</b> | <b>17.4</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.2</b> | <b>-4.0</b> | <b>-8.1</b> | <b>-15.6</b> | <b>-5.5</b> |
| Coal         | 91.4               | 196.2        | 276.8        | 186.4        | 89.7         | 21.1        | 12.4        | 44.0       | 44.8       | 49.6       | 48.0       | 53.6       | 69.1       | 71.3       | 3.6        | -4.3        | -7.1        | -13.5        | -5.2        |
| Oil          | 110.2              | 174.6        | 155.8        | 108.4        | 54.9         | 15.4        | 12.2        | 53.1       | 39.9       | 27.9       | 27.9       | 32.8       | 50.4       | 69.9       | 1.1        | -3.9        | -6.6        | -11.9        | -2.3        |
| Natural Gas  | 6.1                | 67.4         | 126.0        | 95.0         | 26.0         | -0.2        | -0.8        | 2.9        | 15.4       | 22.6       | 24.5       | 15.6       | -0.6       | -4.5       | 10.3       | -3.1        | -12.1       | -            | 15.9        |
| CCS/DAC (-)  | 0.0                | 0.0          | 0.0          | -1.5         | -3.2         | -5.8        | -6.4        | 0.0        | 0.0        | 0.0        | -0.4       | -1.9       | -18.9      | -36.6      | -          | -           | 8.1         | 6.0          | 1.0         |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |      |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060 |
| GDP (billions of 2015 US dollars)                                                         | 402   | 1,021 | 1,694 | 2,013 | 2,280 | 2,451 | 2,415 | 4.8       | 1.9       | 1.3       | 0.7       | -0.1      | 0.9  |
| Population (millions of people)                                                           | 43    | 48    | 52    | 51    | 49    | 46    | 41    | 0.6       | -0.1      | -0.4      | -0.7      | -1.1      | -0.6 |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 9.37  | 21.20 | 32.74 | 39.27 | 46.18 | 53.39 | 58.82 | 4.1       | 2.0       | 1.6       | 1.5       | 1.0       | 1.5  |
| Primary energy consumption per capita (toe/person)                                        | 2.17  | 4.36  | 5.63  | 5.30  | 4.83  | 4.43  | 4.51  | 3.1       | -0.7      | -0.9      | -0.9      | 0.2       | -0.6 |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 231   | 206   | 172   | 135   | 105   | 83    | 77    | -1.0      | -2.7      | -2.5      | -2.3      | -0.8      | -2.1 |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 162   | 138   | 107   | 83    | 63    | 49    | 45    | -1.3      | -2.7      | -2.7      | -2.4      | -0.9      | -2.2 |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 517   | 429   | 330   | 193   | 73    | 12    | 7     | -1.4      | -5.8      | -9.2      | -16.2     | -5.3      | -9.3 |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.23  | 2.08  | 1.92  | 1.43  | 0.70  | 0.15  | 0.09  | -0.5      | -3.2      | -6.9      | -14.3     | -4.6      | -7.4 |
| Automobile ownership volume (millions of vehicles)                                        | 3     | 15    | 25    | 26    | 25    | 23    | 19    | 6.6       | 0.5       | -0.5      | -1.0      | -1.9      | -0.7 |
| Automobile ownership volume per capita (vehicles per person)                              | 0.079 | 0.320 | 0.481 | 0.510 | 0.506 | 0.494 | 0.457 | 6.0       | 0.6       | -0.1      | -0.2      | -0.8      | -0.1 |

## Lao PDR [BAU]

### Primary energy consumption

|                                | MTOE        |             |             |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>1.20</b> | <b>1.91</b> | <b>7.03</b> | <b>13.77</b> | <b>18.08</b> | <b>24.48</b> | <b>38.12</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.9</b> | <b>7.7</b> | <b>2.8</b> | <b>3.1</b> | <b>4.5</b> |
| Coal                           |             | 0.03        | 4.76        | 11.91        | 14.18        | 16.62        | 23.42        | 0.0        | 1.6        | 67.8       | 86.5       | 78.4       | 67.9       | 61.4       | -          | 10.7       | 1.8        | 1.6        | 3.5        |
| Oil                            | 0.16        | 0.34        | 1.25        | 1.65         | 2.62         | 4.16         | 6.63         | 13.6       | 17.9       | 17.7       | 12.0       | 14.5       | 17.0       | 17.4       | 6.8        | 3.2        | 4.7        | 4.7        | 4.8        |
| Natural gas                    |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydrogen                       |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia                   |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.07        | 0.31        | 2.89        | 3.99         | 5.96         | 7.58         | 9.21         | 5.9        | 16.1       | 41.0       | 29.0       | 33.0       | 31.0       | 24.2       | 12.7       | 3.7        | 4.1        | 2.4        | 3.0        |
| Geothermal                     |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 0.97        | 1.23        | -1.87       | -3.79        | -4.68        | -3.89        | -1.15        | 80.5       | 64.4       | -26.5      | -27.5      | -25.9      | -15.9      | -3.0       | -202.1     | 8.2        | 2.1        | -1.8       | -11.5      |
| Biomass                        | 1.01        | 1.42        | 1.44        | 1.98         | 2.34         | 3.11         | 5.42         | 84.6       | 74.2       | 20.4       | 14.4       | 12.9       | 12.7       | 14.2       | 1.1        | 3.6        | 1.7        | 2.9        | 5.7        |
| Solar Wind Ocean               |             |             | 0.01        | 0.45         | 0.72         | 0.96         | 1.60         | 0.0        | 0.0        | 0.1        | 3.3        | 4.0        | 3.9        | 4.2        | -          | 63.9       | 4.8        | 2.9        | 5.2        |
| Biofuels                       |             |             |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | -0.05       | -0.19       | -3.31       | -6.22        | -7.74        | -7.95        | -8.17        | -4.1       | -9.8       | -47.03     | -45.15     | -42.8      | -32.5      | -21.4      | 14.6       | 7.3        | 2.2        | 0.3        | 0.3        |

### Final energy demand

|              | MTOE        |             |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>1.09</b> | <b>1.78</b> | <b>3.81</b> | <b>5.07</b> | <b>7.80</b> | <b>12.33</b> | <b>19.88</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>3.2</b> | <b>4.4</b> | <b>4.7</b> | <b>4.9</b> |
| Industry     | 0.04        | 0.11        | 0.97        | 1.64        | 3.16        | 5.91         | 10.78        | 3.6        | 6.3        | 25.4       | 32.3       | 40.6       | 48.0       | 54.2       | 10.9       | 6.0        | 6.8        | 6.5        | 6.2        |
| Transport    | 0.16        | 0.33        | 1.14        | 1.53        | 2.39        | 3.71         | 5.76         | 14.7       | 18.5       | 30.0       | 30.2       | 30.6       | 30.1       | 29.0       | 6.5        | 3.3        | 4.5        | 4.5        | 4.2        |
| Others       | 0.89        | 1.34        | 1.70        | 1.90        | 2.24        | 2.70         | 3.34         | 81.7       | 75.2       | 44.6       | 37.5       | 28.8       | 21.9       | 16.8       | 2.1        | 1.3        | 1.7        | 1.9        | 2.1        |
| Non-energy   | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | 0.0        | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>1.09</b> | <b>1.78</b> | <b>3.81</b> | <b>5.07</b> | <b>7.80</b> | <b>12.33</b> | <b>19.88</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>3.2</b> | <b>4.4</b> | <b>4.7</b> | <b>4.9</b> |
| Coal         |             | 0.03        | 0.47        | 0.69        | 1.27        | 2.30         | 4.09         | 0.0        | 1.7        | 12.2       | 13.5       | 16.3       | 18.6       | 20.6       | -          | 4.4        | 6.4        | 6.1        | 5.9        |
| Oil          | 0.16        | 0.34        | 1.25        | 1.65        | 2.62        | 4.16         | 6.63         | 14.9       | 19.0       | 32.8       | 32.5       | 33.6       | 33.8       | 33.4       | 6.8        | 3.2        | 4.7        | 4.7        | 4.8        |
| Natural gas  |             |             |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydrogen     |             |             |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia |             |             |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 0.01        | 0.09        | 0.69        | 1.26        | 2.45        | 4.58         | 8.34         | 1.3        | 4.9        | 18.1       | 24.9       | 31.4       | 37.2       | 42.0       | 13.4       | 6.9        | 6.8        | 6.5        | 6.2        |
| Heat         |             |             |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 0.92        | 1.32        | 1.40        | 1.48        | 1.46        | 1.29         | 0.82         | 83.8       | 74.4       | 36.9       | 29.1       | 18.7       | 10.4       | 4.1        | 1.4        | 0.6        | -0.1       | -1.2       | -4.4       |

### Power generation Output

|                                     | TWh         |             |              |              |               |               |               |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |
|-------------------------------------|-------------|-------------|--------------|--------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>0.82</b> | <b>3.58</b> | <b>47.21</b> | <b>88.11</b> | <b>120.32</b> | <b>148.58</b> | <b>197.15</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>14.0</b> | <b>7.2</b> | <b>3.2</b> | <b>2.1</b> | <b>2.9</b> |
| Coal PP                             |             |             | 13.50        | 35.24        | 40.53         | 44.99         | 60.72         | 0          | 0          | 29         | 40         | 34         | 30         | 31         | -           | 11.3       | 1.4        | 1.0        | 3.0        |
| Coal PP with biomass co-firing      |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Coal PP with CCS                    |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Oil                                 |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Gas PP                              |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Gas PP with hydrogen co-firing      |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Gas PP with CCS                     |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Nuclear PP                          |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Solar PV                            |             |             | 0.06         | 2.43         | 3.92          | 4.94          | 10.00         | 0          | 0          | 0          | 3          | 3          | 3          | 5          | -           | 50.4       | 4.9        | 2.3        | 7.3        |
| Wind                                |             |             | 0.00         | 2.84         | 4.50          | 6.21          | 8.57          | 0          | 0          | 0          | 3          | 4          | 4          | 4          | -           | 4          | 4.7        | 3.3        | 3.3        |
| Hydro                               | 0.82        | 3.58        | 33.57        | 46.44        | 69.34         | 88.21         | 107.15        | 100        | 100        | 71         | 53         | 58         | 59         | 54         | 12.7        | 3.7        | 4.1        | 2.4        | 3.0        |
| Geothermal                          |             |             |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          |
| Biomass and others                  |             |             | 0.08         | 1.16         | 2.04          | 4.23          | 10.71         | 0          | 0          | 0          | 1          | 2          | 3          | 5          | -           | 35.0       | 5.8        | 7.6        | 9.7        |

### Power generation Input

|                      | MTOE        |             |             |              |              |              |              |          |          |            |            |            |            |            | AAGR(%)   |             |            |            |            |
|----------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|----------|----------|------------|------------|------------|------------|------------|-----------|-------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030         | 2040         | 2050         | 2060         | 1990     | 2005     | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021 | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>0.00</b> | <b>0.00</b> | <b>4.33</b> | <b>11.72</b> | <b>13.79</b> | <b>16.15</b> | <b>23.94</b> | <b>-</b> | <b>-</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-</b>  | <b>11.7</b> | <b>1.6</b> | <b>1.6</b> | <b>4.0</b> |
| Coal                 |             |             | 4.30        | 11.22        | 12.91        | 14.33        | 19.34        | 0.0      | 0.0      | 99.2       | 95.7       | 93.6       | 88.7       | 80.8       | -         | 11.3        | 1.4        | 1.0        | 3.0        |
| Fuel ammonia         |             |             |             |              |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -           | -          | -          | -          |
| Biomass (Co-firing)  |             |             |             |              |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -           | -          | -          | -          |
| Oil                  |             |             |             |              |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -           | -          | -          | -          |
| Gas                  |             |             |             |              |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -           | -          | -          | -          |
| Hydrogen             |             |             |             |              |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -           | -          | -          | -          |
| Biomass (Biomass PP) |             |             | 0.03        | 0.50         | 0.88         | 1.82         | 4.61         | 0.0      | 0.0      | 0.8        | 4.3        | 6.4        | 11.3       | 19.2       | -         | 35.0        | 5.8        | 7.6        | 13.5       |

### Thermal Efficiency

|              | %        |          |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)   |             |             |             |             |
|--------------|----------|----------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|-----------|-------------|-------------|-------------|-------------|
|              | 1990     | 2005     | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021 | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>-</b> | <b>-</b> | <b>27.0</b> | <b>26.7</b> | <b>26.6</b> | <b>26.2</b> | <b>25.7</b> |  |  |  |  |  |  |  | <b>-</b>  | <b>-0.1</b> | <b>-0.1</b> | <b>-0.1</b> | <b>-0.2</b> |
| Coal         | -        | -        | 27.0        | 27.0        | 27.0        | 27.0        | 27.0        |  |  |  |  |  |  |  | -         | 0.0         | 0.0         | 0.0         | 0.0         |
| Oil          | -        | -        | -           | -           | -           | -           | -           |  |  |  |  |  |  |  | -         | -           | -           | -           | -           |
| Gas          | -        | -        | -           | -           | -           | -           | -           |  |  |  |  |  |  |  | -         | -           | -           | -           | -           |
| Biomass      | -        | -        | 20.0        | 20.0        | 20.0        | 20.0        | 20.0        |  |  |  |  |  |  |  | -         | 0.0         | 0.0         | 0.0         | 0.0         |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |              |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |            |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>0.7</b>         | <b>1.1</b> | <b>22.3</b> | <b>51.2</b> | <b>62.9</b> | <b>77.1</b> | <b>111.0</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.6</b> | <b>9.7</b> | <b>2.1</b> | <b>2.1</b> | <b>3.7</b> | <b>4.2</b> |
| Coal         |                    | 0.12       | 18.5        | 46.2        | 55.0        | 64.5        | 90.9         | 0.0        | 10.6       | 83.0       | 90.2       | 87.4       | 83.6       | 81.9       | -           | 10.7       | 1.8        | 1.6        | 3.5        | 4.2        |
| Oil          | 0.73               | 1.03       | 3.8         | 5.0         | 7.9         | 12.6        | 20.1         | 100.0      | 89.4       | 17.0       | 9.8        | 12.6       | 16.4       | 18.1       | 5.4         | 3.2        | 4.7        | 4.7        | 4.8        | 4.4        |
| Natural Gas  |                    |            |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| CCS/DAC (-)  |                    |            |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |      |      |       |       |       |      |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|-------|-------|-------|------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021  | 2030  | 2040  | 2050 | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 2.7  | 6.7  | 19.1  | 27.9  | 48.5  | 84.5 | 147.1  | 6.5       | 4.3       | 5.70      | 5.70      | 5.7       | 5.4       |
| Population (millions of people)                                                           | 4.3  | 5.9  | 7.4   | 8.5   | 9.9   | 11.4 | 13.3   | 1.8       | 1.5       | 1.5       | 1.5       | 1.5       | 1.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.6  | 1.2  | 2.566 | 3.3   | 4.9   | 7.4  | 11.083 | 4.6       | 2.8       | 4.1       | 4.1       | 4.1       | 3.8       |
| Primary energy consumption per capita (toe/person)                                        | 0.3  | 0.3  | 0.9   | 1.6   | 1.8   | 2.1  | 2.9    | 4.0       | 6.2       | 1.2       | 1.6       | 3.0       | 2.9       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 438  | 284  | 369   | 494   | 373   | 290  | 259    | -0.6      | 3.3       | -2.8      | -2.5      | -1.1      | -0.9      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 399  | 264  | 200   | 182   | 161   | 146  | 135    | -2.2      | -1.0      | -1.2      | -1.0      | -0.8      | -1.0      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 268  | 170  | 1.169 | 1.836 | 1.297 | 913  | 755    | 4.9       | 5.2       | -3.4      | -3.5      | -1.9      | -1.1      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.61 | 0.60 | 3.17  | 3.72  | 3.48  | 3.15 | 2.91   | 5.4       | 1.8       | -0.7      | -1.0      | -0.8      | -0.2      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |       |       |       |      |        | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -     | -     | -     | -    | -      | -         | -         | -         | -         | -         | -         |

## Lao PDR [LCET]

### Primary energy consumption

|                                | MTOE        |             |             |              |              |              |              | MTOE       |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>1.20</b> | <b>1.91</b> | <b>7.03</b> | <b>11.93</b> | <b>14.58</b> | <b>19.15</b> | <b>27.35</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.9</b> | <b>6.0</b> | <b>2.0</b> | <b>2.8</b> | <b>3.6</b> | <b>3.5</b> |
| Coal                           | 0.00        | 0.03        | 4.76        | 10.14        | 10.86        | 10.29        | 10.07        | 0.0        | 1.6        | 67.8       | 85.0       | 74.5       | 53.8       | 36.8       | -          | 8.8        | 0.7        | -0.5       | -0.2       | 1.9        |
| Oil                            | 0.16        | 0.34        | 1.25        | 1.56         | 2.18         | 1.87         | 1.23         | 13.6       | 17.9       | 17.7       | 13.1       | 15.0       | 9.7        | 4.5        | 6.8        | 2.6        | 3.4        | -1.6       | -4.1       | -0.04      |
| Natural gas                    | 0.00        | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydrogen                       | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00        | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00        | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.07        | 0.31        | 2.89        | 3.75         | 5.57         | 9.20         | 13.80        | 5.9        | 16.1       | 41.0       | 31.4       | 38.2       | 48.0       | 50.5       | 12.7       | 3.0        | 4.0        | 5.1        | 4.1        | 4.1        |
| Geothermal                     | 0.00        | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 0.97        | 1.23        | -1.87       | -3.53        | -4.03        | -2.21        | 2.26         | 80.5       | 64.4       | -26.5      | -29.6      | -27.6      | -11.5      | 8.3        | -202.1     | 7.3        | 1.3        | -5.8       | -          | -200.5     |
| Biomass                        | 1.01        | 1.42        | 1.44        | 1.87         | 2.02         | 2.49         | 5.05         | 84.6       | 74.2       | 20.4       | 15.7       | 13.8       | 13.0       | 18.5       | 1.1        | 3.0        | 0.8        | 2.1        | 7.3        | 3.3        |
| Solar Wind Ocean               | 0.00        | 0.00        | 0.01        | 0.81         | 1.69         | 3.26         | 5.37         | 0.0        | 0.0        | 0.1        | 6.8        | 11.6       | 17.0       | 19.6       | -          | 75.0       | 7.6        | 6.8        | 5.1        | 19.4       |
| Biofuels                       | 0.00        | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | -0.05       | -0.19       | -3.31       | -6.22        | -7.74        | -7.95        | -8.17        | -4.1       | -9.8       | -47.03     | -52.09     | -53.1      | -41.5      | -29.9      | 14.6       | 7.3        | 2.2        | 0.3        | 0.3        | 2.3        |

### Final energy demand

|              | MTOE        |             |             |             |             |              |              | MTOE       |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>1.09</b> | <b>1.78</b> | <b>3.81</b> | <b>4.82</b> | <b>7.28</b> | <b>11.42</b> | <b>15.94</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>2.7</b> | <b>4.2</b> | <b>4.6</b> | <b>3.4</b> | <b>3.7</b> |
| Industry     | 0.04        | 0.11        | 0.97        | 1.55        | 2.87        | 4.73         | 8.44         | 3.6        | 6.3        | 25.4       | 32.2       | 39.4       | 41.4       | 52.9       | 10.9       | 5.4        | 6.3        | 5.1        | 6.0        | 5.7        |
| Transport    | 0.16        | 0.33        | 1.14        | 1.45        | 2.39        | 4.37         | 4.74         | 14.7       | 18.5       | 30.0       | 30.2       | 32.8       | 38.3       | 29.8       | 6.5        | 2.7        | 5.1        | 6.2        | 0.8        | 3.7        |
| Others       | 0.89        | 1.34        | 1.70        | 1.81        | 2.02        | 2.32         | 2.76         | 81.7       | 75.2       | 44.6       | 37.6       | 27.8       | 20.3       | 17.3       | 2.1        | 0.7        | 1.1        | 1.4        | 1.7        | 1.3        |
| Non-energy   | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>1.09</b> | <b>1.78</b> | <b>3.81</b> | <b>4.82</b> | <b>7.28</b> | <b>11.42</b> | <b>15.94</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.1</b> | <b>2.7</b> | <b>4.2</b> | <b>4.6</b> | <b>3.4</b> | <b>3.7</b> |
| Coal         | 0.00        | 0.03        | 0.47        | 0.65        | 1.14        | 1.07         | 0.98         | 0.0        | 1.7        | 12.2       | 13.5       | 15.7       | 9.4        | 6.2        | -          | 3.8        | 5.8        | -0.6       | -0.9       | 1.9        |
| Oil          | 0.16        | 0.34        | 1.25        | 1.56        | 2.18        | 1.87         | 1.23         | 14.9       | 19.0       | 32.8       | 32.5       | 29.9       | 16.3       | 7.7        | 6.8        | 2.6        | 3.4        | -1.6       | -4.1       | -0.04      |
| Natural gas  | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydrogen     | 0.00        | 0.00        | 0.00        | 0.00        | 0.08        | 1.19         | 3.19         | 0.0        | 0.0        | 0.0        | 0.0        | 1.0        | 10.4       | 20.0       | -          | -          | -          | 31.7       | 10.4       | -          |
| Fuel Ammonia | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 0.01        | 0.09        | 0.69        | 1.20        | 2.57        | 6.20         | 9.88         | 1.3        | 4.9        | 18.1       | 24.9       | 35.3       | 54.3       | 62.0       | 13.4       | 6.3        | 7.9        | 9.2        | 4.8        | 7.1        |
| Heat         | 0.00        | 0.00        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 0.92        | 1.32        | 1.40        | 1.40        | 1.31        | 1.09         | 0.65         | 83.8       | 74.4       | 36.9       | 29.1       | 18.0       | 9.6        | 4.1        | 1.4        | 0.0        | -0.7       | -1.8       | -5.0       | -1.9       |

### Power generation Output

|                                     | TWh         |             |              |              |               |               |               | TWh        |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |            |
|-------------------------------------|-------------|-------------|--------------|--------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|------------|
|                                     | 1990        | 2005        | 2021         | 2030         | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>0.82</b> | <b>3.58</b> | <b>47.21</b> | <b>87.32</b> | <b>121.83</b> | <b>168.36</b> | <b>215.94</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>14.0</b> | <b>7.1</b> | <b>3.4</b> | <b>3.3</b> | <b>2.5</b> | <b>4.0</b> |
| Coal PP                             | 0.00        | 0.00        | 13.50        | 33.12        | 27.90         | 18.41         | 9.66          | 0          | 0          | 29         | 38         | 23         | 11         | 4          | -           | 10.5       | -1.7       | -4.1       | -6.2       | -0.9       |
| Coal PP with biomass co-firing      | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00        | 0.00        | 0.00         | 0.00         | 4.65          | 13.80         | 24.15         | 0          | 0          | 0          | 0          | 4          | 8          | 11         | -           | -          | -          | 11.5       | 5.8        | -          |
| Coal PP with CCS                    | 0.00        | 0.00        | 0.00         | 0.00         | 4.65          | 13.80         | 24.15         | 0          | 0          | 0          | 0          | 4          | 8          | 11         | -           | -          | -          | 11.5       | 5.8        | -          |
| Oil                                 | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Gas PP                              | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Gas PP with hydrogen co-firing      | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00        | 0.06         | 6.80         | 10.94         | 21.65         | 34.10         | 0          | 0          | 0          | 8          | 9          | 13         | 16         | -           | 68.7       | 4.9        | 7.1        | 4.6        | 17.6       |
| Wind                                | 0.00        | 0.00        | 0.00         | 2.67         | 8.75          | 16.24         | 28.41         | 0          | 0          | 0          | 3          | 7          | 10         | 13         | -           | -          | 12.6       | 6.4        | 5.8        | -          |
| Hydro                               | 0.82        | 3.58        | 33.57        | 43.64        | 63.29         | 81.20         | 85.24         | 100        | 100        | 71         | 50         | 52         | 48         | 39         | 12.7        | 3.0        | 3.8        | 2.5        | 0.5        | 2.4        |
| Geothermal                          | 0.00        | 0.00        |              |              |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -           | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.00        | 0.00        | 0.08         | 1.09         | 1.64          | 3.25          | 10.23         | 0          | 0          | 0          | 1          | 1          | 2          | 5          | -           | 34.1       | 4.2        | 7.1        | 12.2       | 13.3       |

### Power generation Input

|                      | MTOE        |             |             |             |              |              |              | MTOE     |          |            |            |            |            |            | AAGR(%)   |            |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|----------|----------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990     | 2005     | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021 | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>0.00</b> | <b>0.00</b> | <b>4.33</b> | <b>9.96</b> | <b>10.44</b> | <b>11.24</b> | <b>15.56</b> | <b>-</b> | <b>-</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-</b>  | <b>9.7</b> | <b>0.5</b> | <b>0.7</b> | <b>3.3</b> | <b>3.3</b> |
| Coal                 | 0.00        | 0.00        | 4.30        | 9.49        | 9.71         | 9.22         | 9.09         | 0.0      | 0.0      | 99.2       | 95.3       | 93.1       | 82.0       | 58.4       | -         | 9.2        | 0.2        | -0.5       | -0.1       | 1.9        |
| Fuel ammonia         | 0.00        | 0.00        | 0.00        | 0.00        | 0.02         | 0.62         | 2.08         | 0.0      | 0.0      | 0.0        | 0.0        | 0.2        | 5.5        | 13.3       | -         | -          | -          | 41.7       | 12.8       | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        |             |             |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -          | -          | -          | -          | -          |
| Oil                  | 0.00        | 0.00        |             |             |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -          | -          | -          | -          | -          |
| Gas                  | 0.00        | 0.00        |             |             |              |              |              | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -          | -          | -          | -          | -          |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0      | 0.0      | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -         | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.03        | 0.47        | 0.71         | 1.40         | 4.40         | 0.0      | 0.0      | 0.8        | 4.7        | 6.8        | 12.4       | 28.3       | -         | 34.1       | 4.2        | 7.1        | 12.2       | 13.3       |

### Thermal Efficiency

|              | %        |          |             |             |             |             |             | %        |          |            |            |            |            |            | AAGR(%)   |            |            |            |            |            |
|--------------|----------|----------|-------------|-------------|-------------|-------------|-------------|----------|----------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|------------|------------|
|              | 1990     | 2005     | 2021        | 2030        | 2040        | 2050        | 2060        | 1990     | 2005     | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021 | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>-</b> | <b>-</b> | <b>27.0</b> | <b>29.5</b> | <b>32.0</b> | <b>37.7</b> | <b>37.7</b> | <b>-</b> | <b>-</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-</b>  | <b>1.0</b> | <b>0.8</b> | <b>1.6</b> | <b>0.0</b> | <b>0.9</b> |
| Coal         | -        | -        | 27.0        | 30.0        | 32.9        | 40.2        | 44.7        | -        | -        | 100        | 100        | 100        | 100        | 100        | -         | 1.2        | 0.9        | 2.0        | 1.1        | 1.3        |
| Oil          | -        | -        | -           | -           | -           | -           | -           | -        | -        | -          | -          | -          | -          | -          | -         | -          | -          | -          | -          | -          |
| Gas          | -        | -        | -           | -           | -           | -           | -           | -        | -        | -          | -          | -          | -          | -          | -         | -          | -          | -          | -          | -          |
| Biomass      | -        | -        | 20.0        | 20.0        | 20.0        | 20.0        | 20.0        | -        | -        | 100        | 100        | 100        | 100        | 100        | -         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)     |            |             |             |             |               |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|-------------|-------------|-------------|---------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060     |
| <b>Total</b> | <b>0.7</b>         | <b>1.1</b> | <b>22.3</b> | <b>44.1</b> | <b>42.6</b> | <b>30.0</b> | <b>18.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.6</b> | <b>7.9</b> | <b>-0.3</b> | <b>-3.4</b> | <b>-4.6</b> | <b>-0.442</b> |
| Coal         | 0.00               | 0.12       | 18.5        | 39.3        | 36.0        | 24.4        | 15.0        | 0.0        | 10.6       | 83.0       | 89.2       | 84.5       | 81.2       | 80.2       | -           | 8.8        | -0.9        | -3.8        | -4.7        | -0.528        |
| Oil          | 0.73               | 1.03       | 3.8         | 4.7         | 6.6         | 5.7         | 3.7         | 100.0      | 89.4       | 17.0       | 10.8       | 15.5       | 18.8       | 19.8       | 5.4         | 2.5        | 3.4         | -1.6        | -4.1        | -0.06         |
| Natural Gas  | 0.00               | 0.00       |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -           | -           | -           | -             |
| CCS/DAC (-)  | 0.00               | 0.00       |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -           | -           | -           | -             |

## Energy and economic Indicators

|                                                                                           |      |      |       |       |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|-------|-------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021  | 2030  | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 3    | 7    | 19    | 28    | 49   | 84   | 147  | 6.5       | 4.3       | 5.70      | 5.70      | 5.7       | 5.4       |
| Population (millions of people)                                                           | 4    | 6    | 7     | 8     | 10   | 11   | 13   | 1.8       | 1.5       | 1.5       | 1.5       | 1.5       | 1.5       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.6  | 1.2  | 2.6   | 3.3   | 4.9  | 7.4  | 11.1 | 4.6       | 2.8       | 4.1       | 4.1       | 4.1       | 3.8       |
| Primary energy consumption per capita (toe/person)                                        | 0.3  | 0.3  | 0.9   | 1.4   | 1.5  | 1.7  | 2.1  | 4.0       | 4.5       | 0.5       | 1.2       | 2.1       | 2.0       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 438  | 284  | 369   | 428   | 300  | 227  | 186  | -0.6      | 1.7       | -3.5      | -2.8      | -2.0      | -1.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 399  | 264  | 200   | 173   | 150  | 135  | 108  | -2.2      | -1.6      | -1.4      | -1.0      | -2.2      | -1.6      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 268  | 170  | 1.169 | 1.582 | 877  | 355  | 127  | 4.9       | 3.4       | -5.7      | -8.6      | -9.8      | -5.5      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.61 | 0.60 | 3.17  | 3.70  | 2.92 | 1.57 | 0.68 | 5.4       | 1.7       | -2.3      | -6.0      | -8.0      | -3.8      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |       |       |      |      |      | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -     | -     | -    | -    | -    | -         | -         | -         | -         | -         | -         |



## Malaysia [BAU]

### Primary energy consumption

|                                | MTOE         |              |              |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005         | 2021         | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>20.40</b> | <b>65.35</b> | <b>78.65</b> | <b>112.93</b> | <b>146.44</b> | <b>182.06</b> | <b>226.40</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.4</b> | <b>4.1</b> | <b>2.6</b> | <b>2.2</b> | <b>2.2</b> | <b>2.7</b> |
| Coal                           | 1.33         | 6.89         | 21.41        | 23.89         | 11.88         | 12.15         | 12.43         | 6.5        | 10.5       | 27.2       | 21.2       | 8.1        | 6.7        | 5.5        | 9.4        | 1.2        | -6.7       | 0.2        | 0.2        | -1.4       |
| Oil                            | 11.93        | 24.29        | 23.85        | 38.71         | 49.45         | 60.84         | 75.48         | 58.5       | 37.2       | 30.3       | 34.3       | 33.8       | 33.4       | 33.3       | 2.3        | 5.5        | 2.5        | 2.1        | 2.2        | 3.0        |
| Natural gas                    | 6.80         | 33.91        | 30.37        | 42.03         | 75.84         | 99.49         | 128.43        | 33.3       | 51.9       | 38.6       | 37.2       | 51.8       | 54.7       | 56.7       | 4.9        | 3.7        | 6.1        | 2.8        | 2.6        | 3.8        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.34         | 0.45         | 2.67         | 3.49          | 3.57          | 3.57          | 3.57          | 1.7        | 0.7        | 3.4        | 3.1        | 2.4        | 2.0        | 1.6        | 6.8        | 3.0        | 0.2        | 0.0        | 0.0        | 0.7        |
| Geothermal                     | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 0.00         | -0.19        | 0.34         | 4.81          | 5.69          | 6.00          | 6.50          | 0.0        | -0.3       | 0.4        | 4.3        | 3.9        | 3.3        | 2.9        | -          | 34.4       | 1.7        | 0.5        | 0.8        | 7.9        |
| Biomass                        | 0.00         | 0.00         | 0.21         | 2.21          | 2.17          | 2.17          | 2.17          | 0.0        | 0.0        | 0.3        | 2.0        | 1.5        | 1.2        | 1.0        | -          | 29.9       | -0.2       | 0.0        | 0.0        | 6.2        |
| Solar Wind Ocean               | 0.00         | 0.00         | 0.18         | 1.32          | 1.75          | 1.75          | 1.75          | 0.0        | 0.0        | 0.2        | 1.2        | 1.2        | 1.0        | 0.8        | -          | 24.5       | 2.9        | 0.0        | 0.0        | 5.9        |
| Biofuels                       | 0.00         | 0.00         | 0.83         | 1.06          | 1.39          | 1.82          | 2.39          | 0.0        | 0.0        | 1.1        | 0.9        | 0.9        | 1.0        | 1.1        | -          | 2.8        | 2.8        | 2.8        | 2.8        | 2.8        |
| Electricity (Import or Export) | 0.00         | -0.19        | -0.88        | 0.23          | 0.38          | 0.26          | 0.19          | 0.0        | -0.3       | -1.12      | 0.20       | 0.3        | 0.1        | 0.1        | -          | -185.9     | 5.5        | -3.7       | -3.4       | -196.1     |

### Final energy demand

|              | MTOE         |              |              |              |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021         | 2030         | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>12.62</b> | <b>36.68</b> | <b>56.46</b> | <b>82.85</b> | <b>108.07</b> | <b>133.97</b> | <b>166.55</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>4.4</b> | <b>2.7</b> | <b>2.2</b> | <b>2.2</b> | <b>2.8</b> |
| Industry     | 5.28         | 15.58        | 19.16        | 28.94        | 39.41         | 50.24         | 64.14         | 41.8       | 42.5       | 33.9       | 34.9       | 36.5       | 37.5       | 38.5       | 4.2        | 4.7        | 3.1        | 2.5        | 2.5        | 3.1        |
| Transport    | 4.88         | 13.69        | 17.31        | 28.34        | 37.11         | 46.26         | 57.99         | 38.7       | 37.3       | 30.7       | 34.2       | 34.3       | 34.5       | 34.8       | 4.2        | 5.6        | 2.7        | 2.2        | 2.3        | 3.1        |
| Others       | 1.62         | 5.24         | 9.13         | 12.88        | 16.46         | 19.52         | 23.04         | 12.9       | 14.3       | 16.2       | 15.5       | 15.2       | 14.6       | 13.8       | 5.7        | 3.9        | 2.5        | 1.7        | 1.7        | 2.4        |
| Non-energy   | 0.84         | 2.17         | 10.87        | 12.69        | 15.09         | 17.95         | 21.38         | 6.6        | 5.9        | 19.3       | 15.3       | 14.0       | 13.4       | 12.8       | 8.6        | 1.7        | 1.7        | 1.8        | 1.8        | 1.7        |
| <b>Total</b> | <b>12.62</b> | <b>36.68</b> | <b>56.46</b> | <b>82.85</b> | <b>108.07</b> | <b>133.97</b> | <b>166.55</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>4.4</b> | <b>2.7</b> | <b>2.2</b> | <b>2.2</b> | <b>2.8</b> |
| Coal         | 0.51         | 1.35         | 1.39         | 2.57         | 3.03          | 3.29          | 3.57          | 4.1        | 3.7        | 2.5        | 3.1        | 2.8        | 2.5        | 2.1        | 3.3        | 7.1        | 1.6        | 0.9        | 0.8        | 2.4        |
| Oil          | 9.32         | 21.40        | 23.11        | 37.12        | 47.82         | 59.21         | 73.67         | 73.9       | 58.4       | 40.9       | 44.8       | 44.2       | 44.2       | 44.2       | 3.0        | 5.4        | 2.6        | 2.2        | 2.2        | 3.0        |
| Natural gas  | 1.07         | 6.98         | 17.82        | 22.21        | 29.79         | 38.03         | 48.63         | 8.5        | 19.0       | 31.6       | 26.8       | 27.6       | 28.4       | 29.2       | 9.5        | 2.5        | 3.0        | 2.5        | 2.5        | 2.6        |
| Hydrogen     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 1.72         | 6.94         | 13.31        | 19.89        | 26.06         | 31.61         | 38.29         | 13.6       | 18.9       | 23.6       | 24.0       | 24.1       | 23.6       | 23.0       | 6.8        | 4.6        | 2.7        | 2.0        | 1.9        | 2.7        |
| Heat         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 0.00         | 0.00         | 0.83         | 1.06         | 1.39          | 1.82          | 2.39          | 0.0        | 0.0        | 1.5        | 1.3        | 1.3        | 1.4        | 1.4        | -          | 2.8        | 2.8        | 2.8        | 2.8        | 2.8        |

### Power generation Output

|                                     | TWh          |              |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>23.01</b> | <b>98.75</b> | <b>178.13</b> | <b>248.38</b> | <b>324.51</b> | <b>396.14</b> | <b>481.43</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.8</b> | <b>3.8</b> | <b>2.7</b> | <b>2.0</b> | <b>2.0</b> | <b>2.6</b> |
| Coal PP                             | 3.00         | 25.28        | 84.73         | 91.25         | 39.37         | 39.37         | 39.37         | 13         | 26         | 48         | 37         | 12         | 10         | 8          | 11.4       | 0.8        | -8.1       | 0.0        | 0.0        | -1.9       |
| Coal PP with biomass co-firing      | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 48         | 3          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 22         | 65         | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Oil PP                              | 11.00        | 2.57         | 0.98          | 1.00          | 1.19          | 1.15          | 1.14          | 0          | 0          | 1          | 0          | 0          | 0          | 0          | -7.5       | 0.3        | 1.8        | -0.3       | -0.1       | 0.4        |
| Gas PP                              | 5.02         | 63.89        | 58.42         | 92.18         | 214.24        | 285.92        | 371.23        | 0          | 0          | 33         | 37         | 66         | 72         | 77         | 8.2        | 5.2        | 8.8        | 2.9        | 2.6        | 4.9        |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00         | 0.00         | 2.14          | 15.37         | 20.39         | 20.39         | 20.39         | 0          | 0          | 1          | 6          | 6          | 5          | 4          | -          | 24.5       | 2.9        | 0.0        | 0.0        | 5.9        |
| Wind                                | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Hydro                               | 3.99         | 6.02         | 31.11         | 40.63         | 41.50         | 41.49         | 41.48         | 17         | 6          | 17         | 16         | 13         | 10         | 9          | 6.9        | 3.0        | 0.2        | 0.0        | 0.0        | 0.7        |
| Geothermal                          | 0.00         | 0.00         | 0.00          | 0.16          | 0.16          | 0.16          | 0.16          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | 0.0        | 0.0        | 0.0        | -          |
| Biomass and others                  | 0.00         | 0.99         | 0.76          | 7.80          | 7.66          | 7.66          | 7.66          | 0          | 1          | 0          | 3          | 2          | 2          | 2          | -          | 29.6       | -0.2       | 0.0        | 0.0        | 6.1        |

### Power generation Input

|                      | MTOE        |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|----------------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>5.16</b> | <b>19.31</b> | <b>32.83</b> | <b>41.39</b> | <b>55.22</b> | <b>70.62</b> | <b>88.96</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.1</b> | <b>2.6</b> | <b>2.9</b> | <b>2.5</b> | <b>2.3</b> | <b>2.6</b> |
| Coal                 | 0.81        | 5.54         | 20.02        | 21.32        | 8.86         | 8.86         | 8.86         | 15.7       | 28.7       | 61.0       | 51.5       | 16.0       | 12.5       | 10.0       | 10.9       | 0.7        | -8.4       | 0.0        | 0.0        | -2.1       |
| Fuel ammonia         | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                  | 2.99        | 0.58         | 0.25         | 0.26         | 0.31         | 0.30         | 0.30         | 57.9       | 3.0        | 0.8        | 0.6        | 0.6        | 0.4        | 0.3        | -7.6       | 0.3        | 1.8        | -0.3       | -0.1       | 0.4        |
| Gas                  | 1.36        | 13.19        | 12.56        | 19.82        | 46.05        | 61.46        | 79.80        | 26.4       | 68.3       | 38.3       | 47.9       | 83.4       | 87.0       | 89.7       | 7.4        | 5.2        | 8.8        | 2.9        | 2.6        | 4.9        |
| Hydrogen             | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00        | 0.00         | 0.21         | 2.16         | 2.12         | 2.12         | 2.12         | 0.0        | 0.0        | 0.6        | 5.2        | 3.8        | 3.0        | 2.4        | -          | 29.6       | -0.2       | 0.0        | 0.0        | 6.1        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>31.7</b> | <b>41.3</b> | <b>38.0</b> | <b>39.9</b> | <b>40.9</b> | <b>40.7</b> | <b>40.5</b> |  |  |  |  |  |  |  | <b>0.6</b> | <b>0.6</b> | <b>0.2</b> | <b>0.0</b> | <b>0.0</b> | <b>0.2</b> |
| Coal         | 31.7        | 39.2        | 36.4        | 36.8        | 38.2        | 38.2        | 38.2        |  |  |  |  |  |  |  | 0.4        | 0.1        | 0.4        | 0.0        | 0.0        | 0.1        |
| Oil          | 31.6        | 38.4        | 33.0        | 33.0        | 33.0        | 33.0        | 33.0        |  |  |  |  |  |  |  | 0.1        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>47.4</b>        | <b>155.3</b> | <b>197.6</b> | <b>271.8</b> | <b>330.2</b> | <b>413.4</b> | <b>516.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.7</b> | <b>3.6</b> | <b>2.0</b> | <b>2.3</b> | <b>2.3</b> | <b>2.5</b> |
| Coal         | 3.20               | 27.11        | 83.4         | 93.1         | 46.3         | 47.4         | 48.5         | 6.8        | 17.5       | 42.2       | 34.3       | 14.0       | 11.5       | 9.4        | 11.1       | 1.2        | -6.7       | 0.2        | 0.2        | -1.4       |
| Oil          | 37.27              | 69.98        | 64.4         | 105.3        | 136.1        | 168.6        | 209.9        | 78.7       | 45.0       | 32.6       | 38.7       | 41.2       | 40.8       | 40.6       | 1.8        | 5.6        | 2.6        | 2.2        | 2.2        | 3.1        |
| Natural Gas  | 6.90               | 58.25        | 49.8         | 73.4         | 147.7        | 197.4        | 258.4        | 14.6       | 37.5       | 25.2       | 27.0       | 44.7       | 47.8       | 50.0       | 6.6        | 4.4        | 7.2        | 2.9        | 2.7        | 4.3        |
| CCS/DAC (-)  |                    |              |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |      |      |        |      |      |      |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|--------|------|------|------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021   | 2030 | 2040 | 2050 | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 75   | 187  | 356    | 484  | 644  | 819  | 1,041  | 5.2       | 3.5       | 2.9       | 2.4       | 2.4       | 2.8       |
| Population (millions of people)                                                           | 18.0 | 25.9 | 33.6   | 37.7 | 41.5 | 44.9 | 48.6   | 2.0       | 1.3       | 1.0       | 0.8       | 0.8       | 1.0       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 4.1  | 7.2  | 10.607 | 12.9 | 15.5 | 18.2 | 21.424 | 3.1       | 2.2       | 1.9       | 1.6       | 1.6       | 1.8       |
| Primary energy consumption per capita (toe/person)                                        | 1.1  | 2.5  | 2.3    | 3.0  | 3.5  | 4.1  | 4.7    | 2.4       | 2.8       | 1.6       | 1.4       | 1.4       | 1.8       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 273  | 350  | 221    | 233  | 227  | 222  | 218    | -0.7      | 0.6       | -0.2      | -0.2      | -0.2      | 0.0       |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 169  | 196  | 159    | 171  | 168  | 164  | 160    | -0.2      | 0.8       | -0.2      | -0.3      | -0.2      | 0.0       |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 635  | 831  | 555    | 561  | 513  | 505  | 496    | -0.4      | 0.1       | -0.9      | -0.2      | -0.2      | -0.3      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.32 | 2.38 | 2.51   | 2.41 | 2.25 | 2.27 | 2.28   | 0.3       | -0.5      | -0.6      | 0.1       | 0.1       | -0.2      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |        |      |      |      |        | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -      | -    | -    | -    | -      | -         | -         | -         | -         | -         | -         |

## Malaysia [LCET]

### Primary energy consumption

|                                | MTOE         |              |              |              |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005         | 2021         | 2030         | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>20.40</b> | <b>65.35</b> | <b>78.65</b> | <b>98.64</b> | <b>104.83</b> | <b>110.61</b> | <b>116.99</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.4</b> | <b>2.5</b> | <b>0.6</b> | <b>0.5</b> | <b>0.6</b> | <b>1.0</b> |
| Coal                           | 1.33         | 6.89         | 21.41        | 23.54        | 11.04         | 10.81         | 10.42         | 6.5        | 10.5       | 27.2       | 23.9       | 10.5       | 9.8        | 8.9        | 9.4        | 1.1        | -7.3       | -0.2       | -0.4       | -1.8       |
| Oil                            | 11.93        | 24.29        | 23.85        | 28.69        | 31.30         | 30.99         | 32.40         | 58.5       | 37.2       | 30.3       | 29.1       | 29.9       | 28.0       | 27.7       | 2.3        | 2.1        | 0.9        | -0.1       | 0.4        | 0.8        |
| Natural gas                    | 6.80         | 33.91        | 30.37        | 30.27        | 38.14         | 36.31         | 38.73         | 33.3       | 51.9       | 38.6       | 30.7       | 36.4       | 32.8       | 33.1       | 4.9        | 0.0        | 2.3        | -0.5       | 0.6        | 0.6        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.05          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 1.02          | 1.18          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.9        | 1.0        | -          | -          | -          | -          | 1.5        | -          |
| Hydro                          | 0.34         | 0.45         | 2.67         | 3.71         | 5.18          | 5.24          | 5.46          | 1.7        | 0.7        | 3.4        | 3.8        | 4.9        | 4.7        | 4.7        | 6.8        | 3.7        | 3.4        | 0.1        | 0.4        | 1.8        |
| Geothermal                     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 0.00         | -0.19        | 0.34         | 12.44        | 19.16         | 26.24         | 28.76         | 0.0        | -0.3       | 0.4        | 12.6       | 18.3       | 23.7       | 24.6       | -          | 49.3       | 4.4        | 3.2        | 0.9        | 12.1       |
| Biomass                        | 0.00         | 0.00         | 0.21         | 2.59         | 2.99          | 3.02          | 3.03          | 0.0        | 0.0        | 0.3        | 2.6        | 2.9        | 2.7        | 2.6        | -          | 32.2       | 1.4        | 0.1        | 0.0        | 7.1        |
| Solar Wind Ocean               | 0.00         | 0.00         | 0.18         | 3.43         | 8.02          | 13.23         | 13.23         | 0.0        | 0.0        | 0.2        | 3.5        | 7.6        | 12.0       | 11.3       | -          | 38.4       | 8.9        | 5.1        | 0.0        | 11.6       |
| Biofuels                       | 0.00         | 0.00         | 0.83         | 6.30         | 8.09          | 10.05         | 12.50         | 0.0        | 0.0        | 1.1        | 6.4        | 7.7        | 9.1        | 10.7       | -          | 25.3       | 2.5        | 2.2        | 2.2        | 7.2        |
| Electricity (Import or Export) | 0.00         | -0.19        | -0.88        | 0.11         | 0.07          | -0.06         | 0.00          | 0.0        | -0.3       | -1.12      | 0.11       | 0.1        | -0.1       | 0.0        | -          | -179.5     | -5.2       | -          | -31.0      | -15.0      |

### Final energy demand

|              | MTOE         |              |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>12.62</b> | <b>36.68</b> | <b>56.46</b> | <b>74.85</b> | <b>86.94</b> | <b>95.09</b> | <b>102.02</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>3.2</b> | <b>1.5</b> | <b>0.9</b> | <b>0.7</b> | <b>1.5</b> |
| Industry     | 5.28         | 15.58        | 19.16        | 24.95        | 28.43        | 29.79        | 27.94         | 41.8       | 42.5       | 33.9       | 33.3       | 32.7       | 31.3       | 27.4       | 4.2        | 3.0        | 1.3        | 0.5        | -0.6       | 1.0        |
| Transport    | 4.88         | 13.69        | 17.31        | 26.02        | 31.32        | 35.37        | 42.08         | 38.7       | 37.3       | 30.7       | 34.8       | 36.0       | 37.2       | 41.2       | 4.2        | 4.6        | 1.9        | 1.2        | 1.8        | 2.3        |
| Others       | 1.62         | 5.24         | 9.13         | 11.19        | 12.10        | 11.97        | 10.63         | 12.9       | 14.3       | 16.2       | 14.9       | 13.9       | 12.6       | 10.4       | 5.7        | 2.3        | 0.8        | -0.1       | -1.2       | 0.4        |
| Non-energy   | 0.84         | 2.17         | 10.87        | 12.69        | 15.09        | 17.95        | 21.38         | 6.6        | 5.9        | 19.3       | 17.0       | 17.4       | 18.9       | 21.0       | 8.6        | 1.7        | 1.7        | 1.8        | 1.8        | 1.7        |
| <b>Total</b> | <b>12.62</b> | <b>36.68</b> | <b>56.46</b> | <b>74.85</b> | <b>86.94</b> | <b>95.09</b> | <b>102.02</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>3.2</b> | <b>1.5</b> | <b>0.9</b> | <b>0.7</b> | <b>1.5</b> |
| Coal         | 0.51         | 1.35         | 1.39         | 2.22         | 2.18         | 1.95         | 1.56          | 4.1        | 3.7        | 2.5        | 3.0        | 2.5        | 2.1        | 1.5        | 3.3        | 5.3        | -0.2       | -1.1       | -2.2       | 0.3        |
| Oil          | 9.32         | 21.40        | 23.11        | 27.16        | 29.75        | 29.54        | 30.85         | 73.9       | 58.4       | 40.9       | 36.3       | 34.2       | 31.1       | 30.2       | 3.0        | 1.8        | 0.9        | -0.1       | 0.4        | 0.7        |
| Natural gas  | 1.07         | 6.98         | 17.82        | 20.62        | 25.03        | 28.70        | 31.34         | 8.5        | 19.0       | 31.6       | 27.6       | 28.8       | 30.2       | 30.7       | 9.5        | 1.6        | 2.0        | 1.4        | 0.9        | 1.5        |
| Hydrogen     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.10         | 0.15          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.1        | 0.1        | -          | -          | -          | -          | 4.1        | -          |
| Fuel Ammonia | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 1.72         | 6.94         | 13.31        | 18.55        | 21.89        | 24.74        | 25.63         | 13.6       | 18.9       | 23.6       | 24.8       | 25.2       | 26.0       | 25.1       | 6.8        | 3.8        | 1.7        | 1.2        | 0.4        | 1.7        |
| Heat         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 0.00         | 0.00         | 0.83         | 6.30         | 8.09         | 10.05        | 12.50         | 0.0        | 0.0        | 1.5        | 8.4        | 9.3        | 10.6       | 12.3       | -          | 25.3       | 2.5        | 2.2        | 2.2        | 7.2        |

### Power generation Output

|                                     | TWh          |              |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>23.01</b> | <b>98.75</b> | <b>178.13</b> | <b>232.77</b> | <b>275.55</b> | <b>313.14</b> | <b>323.64</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.8</b> | <b>3.0</b> | <b>3.0</b> | <b>1.7</b> | <b>1.3</b> | <b>0.3</b> |
| Coal PP                             | 3.00         | 25.28        | 84.73         | 91.25         | 39.37         | 7.84          | 7.84          | 13         | 26         | 48         | 39         | 14         | 3          | 2          | 11.4       | 0.8        | -8.1       | -14.9      | 0.0        | -5.9       |
| Coal PP with biomass co-firing      | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 31.54         | 31.54         | 0          | 0          | 0          | 0          | 0          | 10         | 10         | -          | -          | -          | -          | 0.0        | -          |
| Oil PP                              | 11.00        | 2.57         | 0.98          | 0.78          | 0.85          | 0.48          | 0.56          | 48         | 3          | 1          | 0          | 0          | 0          | 0          | -7.5       | -2.5       | 0.9        | -5.6       | 1.5        | -1.4       |
| Gas PP                              | 5.02         | 63.89        | 58.42         | 48.35         | 71.02         | 0.00          | 0.00          | 22         | 65         | 33         | 21         | 26         | 0          | 0          | 8.2        | -2.1       | 3.9        | -100.0     | -          | -100.0     |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 43.65         | 50.88         | 0          | 0          | 0          | 0          | 0          | 14         | 16         | -          | -          | -          | -          | 1.5        | -          |
| Nuclear PP                          | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 3.90          | 4.55          | 0          | 0          | 0          | 0          | 0          | 1          | 1          | -          | -          | -          | -          | 1.5        | -          |
| Solar PV                            | 0.00         | 0.00         | 2.14          | 39.89         | 93.27         | 153.92        | 153.92        | 0          | 0          | 1          | 17         | 34         | 49         | 48         | -          | 38.4       | 8.9        | 5.1        | 0.0        | 11.6       |
| Wind                                | 0.00         | 0.00         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Hydro                               | 3.99         | 6.02         | 31.11         | 43.15         | 60.26         | 60.92         | 63.46         | 17         | 6          | 17         | 19         | 22         | 19         | 20         | 6.9        | 3.7        | 3.4        | 0.1        | 0.4        | 1.8        |
| Geothermal                          | 0.00         | 0.00         | 0.00          | 0.16          | 0.16          | 0.16          | 0.16          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | 0.0        | 0.0        | 0.0        | -          |
| Biomass and others                  | 0.00         | 0.99         | 0.76          | 9.20          | 10.63         | 10.75         | 10.76         | 0          | 1          | 0          | 4          | 4          | 3          | 3          | -          | 32.0       | 1.5        | 0.1        | 0.0        | 7.0        |

### Power generation Input

|                      | MTOE        |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|----------------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|                      | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b>         | <b>5.16</b> | <b>19.31</b> | <b>32.83</b> | <b>31.17</b> | <b>22.20</b> | <b>16.49</b> | <b>16.30</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.1</b> | <b>-0.6</b> | <b>-3.3</b> | <b>-2.9</b> | <b>-0.1</b> | <b>-1.8</b> |
| Coal                 | 0.81        | 5.54         | 20.02        | 21.32        | 8.86         | 8.86         | 8.86         | 15.7       | 28.7       | 61.0       | 68.4       | 39.9       | 53.7       | 54.4       | 10.9       | 0.7         | -8.4        | 0.0         | 0.0         | -2.1        |
| Fuel ammonia         | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |
| Biomass (Co-firing)  | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |
| Oil                  | 2.99        | 0.58         | 0.25         | 0.20         | 0.22         | 0.12         | 0.15         | 57.9       | 3.0        | 0.8        | 0.6        | 1.0        | 0.8        | 0.9        | -7.6       | -2.5        | 0.9         | -5.6        | 1.5         | -1.4        |
| Gas                  | 1.36        | 13.19        | 12.56        | 9.65         | 13.12        | 7.51         | 7.29         | 26.4       | 68.3       | 38.3       | 30.9       | 59.1       | 45.5       | 44.7       | 7.4        | -2.9        | 3.1         | -5.4        | -0.3        | -1.4        |
| Hydrogen             | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |
| Biomass (Biomass PP) | 0.00        | 0.00         | 0.21         | 2.55         | 2.95         | 2.98         | 2.98         | 0.0        | 0.0        | 0.6        | 8.2        | 13.3       | 18.1       | 18.3       | -          | 32.0        | 1.5         | 0.1         | 0.0         | 7.0         |

### Thermal Efficiency

|         | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|---------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|         | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total   | 31.7 | 41.3 | 38.0 | 41.3 | 47.2 | 49.2 | 53.6 |  |  |  |  |  |  |  | 0.6       | 0.9       | 1.4       | 0.4       | 0.9       | 0.9       |
| Coal    | 31.7 | 39.2 | 36.4 | 36.8 | 38.2 | 38.2 | 38.2 |  |  |  |  |  |  |  | 0.4       | 0.1       | 0.4       | 0.0       | 0.0       | 0.1       |
| Oil     | 31.6 | 38.4 | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 |  |  |  |  |  |  |  | 0.1       | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |
| Gas     | 31.7 | 41.6 | 40.0 | 43.1 | 46.6 | 50.0 | 60.0 |  |  |  |  |  |  |  | 0.7       | 0.8       | 0.8       | 0.7       | 1.8       | 1.0       |
| Biomass | -    | -    | 31.0 | 31.0 | 31.0 | 31.0 | 31.0 |  |  |  |  |  |  |  | -         | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |             |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>47.4</b>        | <b>155.3</b> | <b>197.6</b> | <b>212.7</b> | <b>184.5</b> | <b>157.0</b> | <b>153.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.7</b> | <b>0.8</b> | <b>-1.4</b> | <b>-1.6</b> | <b>-0.2</b> | <b>-0.7</b> |
| Coal         | 3.20               | 27.11        | 83.4         | 91.7         | 43.0         | 38.0         | 34.2         | 6.8        | 17.5       | 42.2       | 43.1       | 23.3       | 24.2       | 22.3       | 11.1       | 1.1        | -7.3        | -1.2        | -1.1        | -2.3        |
| Oil          | 37.27              | 69.98        | 64.4         | 75.1         | 81.8         | 77.7         | 80.3         | 78.7       | 45.0       | 32.6       | 35.3       | 44.4       | 49.5       | 52.4       | 1.8        | 1.7        | 0.9         | -0.5        | 0.3         | 0.6         |
| Natural Gas  | 6.90               | 58.25        | 49.8         | 45.9         | 59.6         | 41.3         | 38.7         | 14.6       | 37.5       | 25.2       | 21.6       | 32.3       | 26.3       | 25.2       | 6.6        | -0.9       | 2.6         | -3.6        | -0.7        | -0.6        |
| CCS/DAC (-)  | 0.00               | 0.00         |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |      |      |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|------|------|------|------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 75   | 187  | 356  | 484  | 644  | 819  | 1,041 | 5.2       | 3.5       | 2.89      | 2.43      | 2.4       | 2.8       |
| Population (millions of people)                                                           | 18   | 26   | 34   | 38   | 42   | 45   | 49    | 2.0       | 1.3       | 1.0       | 0.8       | 0.8       | 1.0       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 4.1  | 7.2  | 10.6 | 12.9 | 15.5 | 18.2 | 21.4  | 3.1       | 2.2       | 1.9       | 1.6       | 1.6       | 1.8       |
| Primary energy consumption per capita (toe/person)                                        | 1.1  | 2.5  | 2.3  | 2.6  | 2.5  | 2.4  | 2.4   | 2.4       | 1.2       | -0.4      | -0.3      | -0.2      | 0.1       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 273  | 350  | 221  | 204  | 163  | 135  | 112   | -0.7      | -0.9      | -2.2      | -1.8      | -1.8      | -1.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 169  | 196  | 159  | 155  | 135  | 116  | 98    | -0.2      | -0.3      | -1.3      | -1.5      | -1.7      | -1.2      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 635  | 831  | 555  | 439  | 286  | 192  | 147   | -0.4      | -2.6      | -4.2      | -3.9      | -2.6      | -3.3      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.32 | 2.38 | 2.51 | 2.16 | 1.76 | 1.42 | 1.31  | 0.3       | -1.7      | -2.0      | -2.1      | -0.8      | -1.7      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |      |      |      |      |       | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -    | -    | -     | -         | -         | -         | -         | -         | -         |

## Myanmar [BAU]

### Primary energy consumption

|                                | MTOE        |             |             |             |             |             |             | MTOE       |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>10.7</b> | <b>12.5</b> | <b>17.4</b> | <b>22.4</b> | <b>29.3</b> | <b>40.0</b> | <b>57.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>2.8</b> | <b>2.7</b> | <b>3.2</b> | <b>3.7</b> | <b>3.1</b> |
| Coal                           | 0.1         | 0.3         | 0.4         | 1.4         | 2.5         | 3.2         | 3.5         | 0.6        | 2.0        | 2.1        | 6.4        | 8.6        | 7.9        | 6.0        | 5.6        | 16.5       | 5.8        | 2.4        | 1.0        | 6.0        |
| Oil                            | 0.7         | 1.7         | 4.2         | 7.9         | 11.4        | 16.2        | 23.7        | 6.8        | 13.9       | 24.1       | 35.1       | 38.8       | 40.5       | 41.0       | 5.8        | 7.2        | 3.7        | 3.6        | 3.9        | 4.5        |
| Natural gas                    | 0.8         | 1.7         | 3.3         | 3.8         | 5.6         | 9.8         | 18.0        | 7.1        | 13.5       | 19.0       | 17.1       | 19.0       | 24.6       | 31.2       | 4.9        | 1.6        | 3.8        | 5.8        | 6.2        | 4.4        |
| Hydrogen                       | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.1         | 0.3         | 0.9         | 0.9         | 1.7         | 2.9         | 4.8         | 0.9        | 2.1        | 4.9        | 3.9        | 6.0        | 7.3        | 8.3        | 7.2        | 0.2        | 7.3        | 5.3        | 5.1        | 4.5        |
| Geothermal                     | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 9.0         | 8.6         | 8.7         | 8.4         | 8.1         | 7.9         | 7.7         | 84.5       | 68.5       | 50.0       | 37.6       | 27.7       | 19.7       | 13.4       | -0.1       | -0.4       | -0.4       | -0.3       | -0.2       | -0.3       |
| Biomass                        | 9.0         | 8.6         | 8.8         | 8.5         | 8.1         | 7.8         | 7.5         | 84.5       | 68.5       | 50.5       | 37.8       | 27.7       | 19.5       | 13.0       | -0.1       | -0.5       | -0.4       | -0.4       | -0.4       | -0.4       |
| Solar Wind Ocean               | 0.0         | 0.0         | 0.0         | 0.1         | 0.1         | 0.2         | 0.4         | 0.0        | 0.0        | 0.1        | 0.2        | 0.4        | 0.5        | 0.6        | -          | 21.4       | 6.9        | 7.0        | 5.3        | 9.7        |
| Biofuels                       | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.0         | 0.0         | -0.1        | -0.1        | -0.1        | -0.1        | -0.1        | 0.0        | 0.0        | -0.6       | -0.5       | -0.4       | -0.3       | -0.2       | -          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |

### Final energy demand

|              | MTOE       |             |             |             |             |             |             | MTOE       |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990       | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>9.3</b> | <b>10.6</b> | <b>15.0</b> | <b>19.1</b> | <b>24.3</b> | <b>32.0</b> | <b>44.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>2.7</b> | <b>2.4</b> | <b>2.8</b> | <b>3.3</b> | <b>2.8</b> |
| Industry     | 0.4        | 3.4         | 3.8         | 4.3         | 5.5         | 7.2         | 9.8         | 4.2        | 32.2       | 25.1       | 22.3       | 22.5       | 22.5       | 22.1       | 7.6        | 1.4        | 2.5        | 2.8        | 3.2        | 2.5        |
| Transport    | 0.4        | 0.8         | 3.6         | 7.0         | 10.2        | 14.5        | 21.5        | 4.7        | 7.6        | 23.8       | 36.8       | 41.9       | 45.4       | 48.2       | 7.0        | 7.8        | 3.8        | 3.6        | 4.0        | 4.7        |
| Others       | 8.5        | 6.4         | 7.7         | 7.8         | 8.6         | 10.3        | 13.2        | 91.1       | 60.3       | 51.1       | 40.9       | 35.6       | 32.1       | 29.7       | -0.3       | 0.2        | 1.0        | 1.8        | 2.5        | 1.4        |
| Non-energy   | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| <b>Total</b> | <b>9.3</b> | <b>10.6</b> | <b>15.0</b> | <b>19.1</b> | <b>24.3</b> | <b>32.0</b> | <b>44.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>2.7</b> | <b>2.4</b> | <b>2.8</b> | <b>3.3</b> | <b>2.8</b> |
| Coal         | 0.1        | 0.1         | 0.3         | 0.3         | 0.5         | 0.7         | 0.9         | 0.5        | 0.9        | 1.7        | 1.7        | 2.0        | 2.1        | 2.1        | 5.3        | 3.0        | 3.9        | 3.4        | 3.3        | 3.4        |
| Oil          | 0.5        | 1.4         | 4.2         | 7.8         | 11.2        | 16.0        | 23.5        | 5.4        | 13.6       | 27.7       | 40.7       | 46.2       | 49.9       | 52.8       | 7.1        | 7.2        | 3.7        | 3.6        | 3.9        | 4.5        |
| Natural gas  | 0.2        | 0.3         | 0.2         | 0.3         | 0.3         | 0.3         | 0.4         | 2.5        | 2.8        | 1.5        | 1.3        | 1.2        | 1.0        | 0.9        | 0.0        | 1.0        | 1.4        | 1.4        | 1.4        | 1.3        |
| Hydrogen     | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 0.2        | 0.4         | 1.6         | 2.3         | 4.2         | 7.2         | 12.2        | 1.6        | 3.5        | 10.4       | 12.0       | 17.1       | 22.6       | 27.5       | 7.9        | 4.3        | 6.1        | 5.7        | 5.4        | 5.4        |
| Heat         | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 8.4        | 8.4         | 8.8         | 8.5         | 8.1         | 7.8         | 7.5         | 90.0       | 79.1       | 58.6       | 44.3       | 33.4       | 24.3       | 16.8       | 0.2        | -0.5       | -0.4       | -0.4       | -0.4       | -0.4       |

### Power generation Output

|                                     | TWh        |            |             |             |             |             |              | TWh        |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|------------|------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990       | 2005       | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>2.5</b> | <b>6.1</b> | <b>23.3</b> | <b>29.6</b> | <b>52.6</b> | <b>90.7</b> | <b>152.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.5</b> | <b>2.7</b> | <b>5.9</b> | <b>5.6</b> | <b>5.3</b> | <b>4.9</b> |
| Coal PP                             | 0.0        | 0.2        | 0.7         | 3.8         | 7.6         | 10.2        | 10.5         | 1.6        | 4.0        | 2.8        | 12.7       | 14.5       | 11.2       | 6.9        | 9.5        | 21.3       | 7.3        | 3.0        | 0.3        | 7.3        |
| Coal PP with biomass co-firing      | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil PP                              | 0.3        | 0.0        | 0.1         | 0.0         | 0.0         | 0.0         | 0.0          | 10.9       | 0.6        | 0.5        | 0.0        | 0.0        | 0.0        | 0.0        | -2.7       | -100.0     | -          | -          | -          | -100.0     |
| Gas PP                              | 1.0        | 2.8        | 12.5        | 15.2        | 23.4        | 44.1        | 81.9         | 39.3       | 45.9       | 53.6       | 51.2       | 44.6       | 48.6       | 53.8       | 8.6        | 2.2        | 4.5        | 6.5        | 6.4        | 4.9        |
| Gas PP with hydrogen co-firing      | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.0        | 0.0        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.0        | 0.0        | 0.1         | 0.3         | 0.6         | 1.1         | 2.2          | 0.0        | 0.0        | 0.5        | 1.1        | 1.1        | 1.2        | 1.5        | -          | 12.4       | 5.9        | 6.7        | 7.5        | 8.0        |
| Wind                                | 0.0        | 0.0        | 0.0         | 0.3         | 0.7         | 1.4         | 1.9          | 0.0        | 0.0        | 0.0        | 1.1        | 1.3        | 1.5        | 1.2        | -          | -          | 7.9        | 7.2        | 3.2        | -          |
| Hydro                               | 1.2        | 3.0        | 9.9         | 10.1        | 20.3        | 34.0        | 55.8         | 48.2       | 49.5       | 42.6       | 33.9       | 38.6       | 37.5       | 36.7       | 7.1        | 0.2        | 7.3        | 5.3        | 5.1        | 4.5        |
| Geothermal                          | 0.0        | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.0        | 0.0        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Power generation Input

|                      | MTOE       |            |            |            |            |             |             | MTOE       |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|----------------------|------------|------------|------------|------------|------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990       | 2005       | 2021       | 2030       | 2040       | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>0.5</b> | <b>1.2</b> | <b>3.3</b> | <b>4.7</b> | <b>7.3</b> | <b>12.0</b> | <b>20.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.3</b> | <b>3.9</b> | <b>4.6</b> | <b>5.1</b> | <b>5.3</b> | <b>4.7</b> |
| Coal                 | 0.0        | 0.2        | 0.2        | 1.1        | 2.0        | 2.5         | 2.6         | 2.4        | 13.2       | 6.4        | 23.5       | 27.8       | 20.9       | 12.7       | 9.7        | 20.2       | 6.3        | 2.1        | 0.3        | 6.6        |
| Fuel ammonia         | 0.0        | 0.0        |            |            |            |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.0        | 0.0        |            |            |            |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                  | 0.1        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | 0.0         | 12.0       | 0.9        | 0.9        | 0.0        | 0.0        | 0.0        | 0.0        | -2.1       | -100.0     | -          | -          | -          | -100.0     |
| Gas                  | 0.4        | 1.0        | 3.1        | 3.6        | 5.3        | 9.5         | 17.6        | 85.7       | 85.9       | 92.7       | 76.5       | 72.2       | 79.1       | 87.3       | 6.5        | 1.7        | 4.0        | 6.0        | 6.4        | 4.6        |
| Hydrogen             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Thermal Efficiency

|              | %         |           |           |           |           |           |           | %    |      |      |      |      |      |      | AAGR(%)    |            |            |            |            |            |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------|------|------|------|------|------|------|------------|------------|------------|------------|------------|------------|
|              | 1990      | 2005      | 2021      | 2030      | 2040      | 2050      | 2060      | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>22</b> | <b>23</b> | <b>34</b> | <b>35</b> | <b>37</b> | <b>39</b> | <b>39</b> |      |      |      |      |      |      |      | <b>1.5</b> | <b>0.1</b> | <b>0.5</b> | <b>0.6</b> | <b>0.1</b> | <b>0.3</b> |
| Coal         | 29        | 14        | 27        | 30        | 32        | 35        | 35        |      |      |      |      |      |      |      | -0.2       | 1.0        | 0.9        | 0.8        | 0.0        | 0.7        |
| Oil          | 39        | 29        | 32        | -         | -         | -         | -         |      |      |      |      |      |      |      | -0.6       | -          | -          | -          | -          | -          |
| Gas          | 19        | 24        | 35        | 37        | 38        | 40        | 40        |      |      |      |      |      |      |      | 1.9        | 0.5        | 0.5        | 0.4        | 0.0        | 0.3        |
| Biomass      | -         | -         | -         | -         | -         | -         | -         |      |      |      |      |      |      |      | -          | -          | -          | -          | -          | -          |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>5.0</b>         | <b>7.5</b> | <b>22.1</b> | <b>37.9</b> | <b>56.7</b> | <b>83.9</b> | <b>127.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.9</b> | <b>6.2</b> | <b>4.1</b> | <b>4.0</b> | <b>4.3</b> |
| Coal         | 0.3                | 1.0        | 1.8         | 5.6         | 9.8         | 12.4        | 13.6         | 5.4        | 13.5       | 8.2        | 14.6       | 17.2       | 14.7       | 10.7       | 6.3        | 13.3       | 5.8        | 2.4        | 1.0        |
| Oil          | 2.9                | 2.6        | 12.6        | 23.4        | 34.0        | 48.6        | 71.7         | 58.8       | 33.9       | 57.0       | 61.8       | 59.9       | 57.9       | 56.3       | 4.8        | 7.2        | 3.8        | 3.6        | 4.0        |
| Gas          | 1.8                | 4.0        | 7.7         | 8.9         | 13.0        | 22.9        | 42.0         | 35.8       | 52.7       | 34.9       | 23.5       | 22.9       | 27.3       | 33.0       | 4.8        | 1.7        | 3.8        | 5.8        | 6.3        |
| CCS/DAC (-)  | 0.0                | 0.0        |             |             |             |             |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |       |      |       |      |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|------|-------|------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005 | 2021  | 2030 | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 6.8   | 24.8 | 60.9  | 91.3 | 155.7 | 253.6 | 413.0 | 7.3       | 4.6       | 5.5       | 5.0       | 5.0       | 5.0       |
| Population (millions of people)                                                           | 40.1  | 47.7 | 53.8  | 57.6 | 60.8  | 63.8  | 66.9  | 1.0       | 0.8       | 0.5       | 0.5       | 0.5       | 0.6       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.2   | 0.5  | 1.132 | 1.6  | 2.6   | 4.0   | 6.171 | 6.3       | 3.8       | 4.9       | 4.5       | 4.5       | 4.4       |
| Primary energy consumption per capita (toe/person)                                        | 0.3   | 0.3  | 0.3   | 0.4  | 0.5   | 0.6   | 0.9   | 0.6       | 2.0       | 2.2       | 2.7       | 3.2       | 2.5       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 1.570 | 503  | 287   | 245  | 188   | 158   | 140   | -5.3      | -1.7      | -2.6      | -1.8      | -1.2      | -1.8      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 1.371 | 426  | 247   | 210  | 156   | 126   | 108   | -5.4      | -1.8      | -2.9      | -2.1      | -1.6      | -2.1      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 734   | 304  | 363   | 416  | 365   | 331   | 308   | -2.2      | 1.5       | -1.3      | -1.0      | -0.7      | -0.4      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.47  | 0.60 | 1.27  | 1.69 | 1.94  | 2.10  | 2.21  | 3.3       | 3.3       | 1.4       | 0.8       | 0.5       | 1.4       |
| Automobile ownership volume (millions of vehicles)                                        |       |      |       |      |       |       |       | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -     | -    | -     | -    | -     | -     | -     | -         | -         | -         | -         | -         | -         |

## Myanmar [LCET]

### Primary energy consumption

|                                | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>10.7</b> | <b>12.5</b> | <b>17.4</b> | <b>20.6</b> | <b>27.2</b> | <b>34.7</b> | <b>46.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>1.8</b> | <b>2.8</b> | <b>2.5</b> | <b>3.0</b> | <b>2.6</b> |
| Coal                           | 0.1         | 0.3         | 0.4         | 0.8         | 1.2         | 0.3         | 0.3         | 0.6        | 2.0        | 2.1        | 4.0        | 4.3        | 0.9        | 0.6        | 5.6        | 9.7        | 3.4        | -12.5      | -1.0       | -0.7       |
| Oil                            | 0.7         | 1.7         | 4.2         | 7.1         | 6.7         | 3.2         | 2.5         | 6.8        | 13.9       | 24.1       | 34.7       | 24.6       | 9.3        | 5.3        | 5.8        | 6.0        | -0.7       | -7.0       | -2.6       | -1.4       |
| Natural gas                    | 0.8         | 1.7         | 3.3         | 3.5         | 6.9         | 8.9         | 19.5        | 7.1        | 13.5       | 19.0       | 17.1       | 25.2       | 25.8       | 41.8       | 4.9        | 0.7        | 6.9        | 2.7        | 8.1        | 4.7        |
| Hydrogen                       | 0.0         | 0.0         | 0.0         | 0.0         | 2.0         | 5.3         | 5.1         | 0.0        | 0.0        | 0.0        | 0.0        | 7.2        | 15.2       | 10.8       | -          | -          | -          | 10.4       | -0.4       | -          |
| Fuel Ammonia                   | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.1         | 0.3         | 0.9         | 0.8         | 2.3         | 7.0         | 8.5         | 0.9        | 2.1        | 4.9        | 4.1        | 8.6        | 20.2       | 18.1       | 7.2        | -0.2       | 10.9       | 11.6       | 1.9        | 6.1        |
| Geothermal                     | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 9.0         | 8.6         | 8.7         | 8.3         | 8.2         | 9.9         | 11.0        | 84.5       | 68.5       | 50.0       | 40.1       | 30.1       | 28.7       | 23.4       | -0.1       | -0.6       | -0.1       | 2.0        | 1.0        | 0.6        |
| Biomass                        | 9.0         | 8.6         | 8.8         | 8.2         | 7.8         | 8.1         | 7.4         | 84.5       | 68.5       | 50.5       | 39.9       | 28.6       | 23.4       | 15.9       | -0.1       | -0.8       | -0.5       | 0.4        | -0.9       | -0.4       |
| Solar Wind Ocean               | 0.0         | 0.0         | 0.0         | 0.2         | 0.5         | 1.9         | 3.7         | 0.0        | 0.0        | 0.1        | 0.7        | 1.8        | 5.5        | 7.8        | -          | 35.7       | 12.7       | 14.4       | 6.7        | 16.5       |
| Biofuels                       | 0.0         | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.0         | 0.0         | -0.1        | -0.1        | -0.1        | -0.1        | -0.1        | 0.0        | 0.0        | -0.62      | -0.5       | -0.4       | -0.3       | -0.2       | -          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |

### Final energy demand

|              | MTOE       |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990       | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>9.3</b> | <b>10.6</b> | <b>15.0</b> | <b>17.9</b> | <b>22.0</b> | <b>27.6</b> | <b>33.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>1.9</b> | <b>2.1</b> | <b>2.3</b> | <b>1.8</b> | <b>2.0</b> |
| Industry     | 0.4        | 3.4         | 3.8         | 4.1         | 5.9         | 9.1         | 9.1         | 4.2        | 32.2       | 25.1       | 22.7       | 27.0       | 32.9       | 27.5       | 7.6        | 0.8        | 3.9        | 4.3        | 0.0        | 2.3        |
| Transport    | 0.4        | 0.8         | 3.6         | 6.3         | 8.2         | 9.9         | 13.0        | 4.7        | 7.6        | 23.8       | 35.4       | 37.3       | 36.0       | 39.3       | 7.0        | 6.5        | 2.7        | 1.9        | 2.7        | 3.4        |
| Others       | 8.5        | 6.4         | 7.7         | 7.5         | 7.9         | 8.6         | 11.0        | 91.1       | 60.3       | 51.1       | 41.9       | 35.7       | 31.0       | 33.2       | -0.3       | -0.3       | 0.5        | 0.9        | 2.5        | 0.9        |
| Non-energy   | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| <b>Total</b> | <b>9.3</b> | <b>10.6</b> | <b>15.0</b> | <b>17.9</b> | <b>22.0</b> | <b>27.6</b> | <b>33.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>1.9</b> | <b>2.1</b> | <b>2.3</b> | <b>1.8</b> | <b>2.0</b> |
| Coal         | 0.1        | 0.1         | 0.3         | 0.3         | 0.3         | 0.2         | 0.1         | 0.5        | 0.9        | 1.7        | 1.7        | 1.4        | 0.6        | 0.4        | 5.3        | 2.4        | 0.0        | -6.1       | -1.9       | -1.5       |
| Oil          | 0.5        | 1.4         | 4.2         | 7.0         | 6.5         | 3.0         | 2.3         | 5.4        | 13.6       | 27.7       | 39.4       | 29.8       | 11.0       | 6.9        | 7.1        | 6.0        | -0.7       | -7.4       | -2.8       | -1.5       |
| Natural gas  | 0.2        | 0.3         | 0.2         | 0.2         | 0.3         | 0.2         | 0.2         | 2.5        | 2.8        | 1.5        | 1.3        | 1.2        | 0.8        | 0.5        | 0.0        | 0.2        | 0.9        | -1.4       | -2.9       | -0.9       |
| Hydrogen     | 0.0        | 0.0         | 0.0         | 0.0         | 2.0         | 5.3         | 5.1         | 0.0        | 0.0        | 0.0        | 0.0        | 8.9        | 19.1       | 15.3       | -          | -          | -          | 10.4       | -0.4       | -          |
| Fuel Ammonia | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 0.2        | 0.4         | 1.6         | 2.2         | 5.6         | 12.5        | 20.0        | 1.6        | 3.5        | 10.4       | 12.3       | 25.3       | 45.2       | 60.4       | 7.9        | 3.8        | 9.8        | 8.4        | 4.8        | 6.7        |
| Heat         | 0.0        | 0.0         |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 8.4        | 8.4         | 8.8         | 8.1         | 7.4         | 6.4         | 5.5         | 90.0       | 79.1       | 58.6       | 45.3       | 33.5       | 23.3       | 16.5       | 0.2        | -0.9       | -0.9       | -1.4       | -1.6       | -1.2       |

### Power generation Output

|                                     | TWh        |            |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|------------|------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990       | 2005       | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>2.5</b> | <b>6.1</b> | <b>23.3</b> | <b>28.3</b> | <b>69.9</b> | <b>155.0</b> | <b>247.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>7.5</b> | <b>2.2</b> | <b>9.5</b> | <b>8.3</b> | <b>4.8</b> | <b>6.3</b> |
| Coal PP                             | 0.0        | 0.2        | 0.7         | 1.8         | 3.4         | 0.6          | 0.6          | 1.6        | 4.0        | 2.8        | 6.5        | 4.8        | 0.4        | 0.3        | 9.5        | 12.0       | 6.3        | -15.6      | 0.0        | -0.2       |
| Coal PP with biomass co-firing      | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil PP                              | 0.3        | 0.0        | 0.1         | 0.0         | 0.0         | 0.0          | 0.0          | 10.9       | 0.6        | 0.5        | 0.0        | 0.0        | 0.0        | 0.0        | -2.7       | -100.0     | -          | -          | -          | -100.0     |
| Gas PP                              | 1.0        | 2.8        | 12.5        | 14.6        | 18.7        | 11.7         | 9.2          | 39.3       | 45.9       | 53.6       | 51.7       | 26.7       | 7.6        | 3.7        | 8.6        | 1.8        | 2.5        | -4.5       | -2.5       | -0.8       |
| Gas PP with hydrogen co-firing      | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.0        | 0.0        | 0.0         | 0.0         | 13.5        | 33.2         | 90.5         | 0.0        | 0.0        | 0.0        | 0.0        | 19.3       | 21.4       | 36.5       | -          | -          | -          | 9.4        | 10.6       | -          |
| Nuclear PP                          | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.0        | 0.0        | 0.1         | 0.5         | 2.2         | 7.5          | 17.0         | 0.0        | 0.0        | 0.5        | 1.9        | 3.1        | 4.8        | 6.9        | -          | 18.8       | 15.3       | 13.1       | 8.6        | 13.8       |
| Wind                                | 0.0        | 0.0        | 0.0         | 1.2         | 3.6         | 14.9         | 25.6         | 0.0        | 0.0        | 0.0        | 4.3        | 5.2        | 9.6        | 10.3       | -          | -          | 11.5       | 15.2       | 5.5        | -          |
| Hydro                               | 1.2        | 3.0        | 9.9         | 9.7         | 27.2        | 81.5         | 98.5         | 48.2       | 49.5       | 42.6       | 34.3       | 38.9       | 52.6       | 39.8       | 7.1        | -0.2       | 10.9       | 11.6       | 1.9        | 6.1        |
| Geothermal                          | 0.0        | 0.0        |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.0        | 0.0        | 0.0         | 0.4         | 1.4         | 5.6          | 6.4          | 0.0        | 0.0        | 0.0        | 1.4        | 1.9        | 3.6        | 2.6        | -          | -          | 13.4       | 15.2       | 1.3        | -          |

### Power generation Input

|                      | MTOE       |            |            |            |            |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|----------------------|------------|------------|------------|------------|------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990       | 2005       | 2021       | 2030       | 2040       | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>0.5</b> | <b>1.2</b> | <b>3.3</b> | <b>3.9</b> | <b>7.9</b> | <b>10.6</b> | <b>21.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.3</b> | <b>1.9</b> | <b>7.2</b> | <b>3.0</b> | <b>7.3</b> | <b>4.9</b> |
| Coal                 | 0.0        | 0.2        | 0.2        | 0.5        | 0.8        | 0.1         | 0.1         | 2.4        | 13.2       | 6.4        | 13.2       | 10.8       | 1.3        | 0.7        | 9.7        | 10.6       | 5.1        | -16.5      | 0.0        | -1.0       |
| Fuel ammonia         | 0.0        | 0.0        |            |            |            |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.0        | 0.0        |            |            |            |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                  | 0.1        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | 0.0         | 12.0       | 0.9        | 0.9        | 0.0        | 0.0        | 0.0        | 0.0        | -2.1       | -100.0     | -          | -          | -          | -100.0     |
| Gas                  | 0.4        | 1.0        | 3.1        | 3.3        | 6.6        | 8.7         | 19.4        | 85.7       | 85.9       | 92.7       | 83.7       | 83.9       | 82.4       | 90.2       | 6.5        | 0.8        | 7.2        | 2.8        | 8.3        | 4.8        |
| Hydrogen             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.0        | 0.0        | 0.0        | 0.1        | 0.4        | 1.7         | 2.0         | 0.0        | 0.0        | 0.0        | 3.0        | 5.3        | 16.2       | 9.1        | -          | -          | 13.4       | 15.2       | 1.3        | -          |

### Thermal Efficiency

|              | %         |           |           |           |           |           |           |  |  |  |  |  |  |  | AAGR(%)    |            |            |            |            |            |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|--|--|--|--|--|--|------------|------------|------------|------------|------------|------------|
|              | 1990      | 2005      | 2021      | 2030      | 2040      | 2050      | 2060      |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>22</b> | <b>23</b> | <b>34</b> | <b>37</b> | <b>40</b> | <b>42</b> | <b>43</b> |  |  |  |  |  |  |  | <b>1.5</b> | <b>0.8</b> | <b>0.9</b> | <b>0.3</b> | <b>0.3</b> | <b>0.6</b> |
| Coal         | 29        | 14        | 27        | 30        | 34        | 38        | 38        |  |  |  |  |  |  |  | -0.2       | 1.3        | 1.2        | 1.0        | 0.0        | 0.9        |
| Oil          | 39        | 29        | 32        | -         | -         | -         | -         |  |  |  |  |  |  |  | -0.6       | -          | -          | -          | -          | -          |
| Gas          | 19        | 24        | 35        | 38        | 42        | 44        | 44        |  |  |  |  |  |  |  | 1.9        | 1.0        | 0.9        | 0.6        | 0.0        | 0.6        |
| Biomass      | -         | -         | -         | 28        | 28        | 28        | 28        |  |  |  |  |  |  |  | -          | -          | 0.0        | 0.0        | 0.0        | -          |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |            |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |             |
|--------------|--------------------|------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|
|              | 1990               | 2005       | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>5.0</b>         | <b>7.5</b> | <b>22.1</b> | <b>32.7</b> | <b>34.0</b> | <b>16.6</b> | <b>13.6</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.9</b> | <b>4.5</b> | <b>0.4</b> | <b>-6.9</b> | <b>-2.0</b> | <b>-1.2</b> |
| Coal         | 0.3                | 1.0        | 1.8         | 3.2         | 4.5         | 1.2         | 1.1         | 5.4        | 13.5       | 8.2        | 9.9        | 13.3       | 7.2        | 8.0        | 6.3        | 6.7        | 3.4        | -12.4       | -1.0        | -1.3        |
| Oil          | 2.9                | 2.6        | 12.6        | 21.3        | 19.9        | 9.7         | 8.3         | 58.8       | 33.9       | 57.0       | 65.0       | 58.6       | 58.4       | 60.5       | 4.8        | 6.0        | -0.7       | -6.9        | -1.6        | -1.1        |
| Gas          | 1.8                | 4.0        | 7.7         | 8.2         | 9.5         | 5.7         | 4.3         | 35.8       | 52.7       | 34.9       | 25.1       | 28.1       | 34.4       | 31.5       | 4.8        | 0.7        | 1.5        | -5.0        | -2.8        | -1.5        |
| CCS/DAC (-)  | 0.0                | 0.0        |             |             |             |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |      |      |      |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|------|------|------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005 | 2021 | 2030 | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 6.8   | 24.8 | 60.9 | 91.3 | 155.7 | 253.6 | 413.0 | 7.3       | 4.6       | 5.5       | 5.0       | 5.0       | 5.0       |
| Population (millions of people)                                                           | 40.1  | 47.7 | 53.8 | 57.6 | 60.8  | 63.8  | 66.9  | 1.0       | 0.8       | 0.5       | 0.5       | 0.5       | 0.6       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.2   | 0.5  | 1.1  | 1.6  | 2.6   | 4.0   | 6.2   | 6.3       | 3.8       | 4.9       | 4.5       | 4.5       | 4.4       |
| Primary energy consumption per capita (toe/person)                                        | 0.3   | 0.3  | 0.3  | 0.4  | 0.4   | 0.5   | 0.7   | 0.6       | 1.1       | 2.3       | 2.0       | 2.5       | 2.0       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 1,570 | 503  | 287  | 225  | 175   | 137   | 113   | -5.3      | -2.6      | -2.5      | -2.4      | -1.9      | -2.4      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 1,371 | 426  | 247  | 196  | 141   | 109   | 80    | -5.4      | -2.5      | -3.2      | -2.6      | -3.0      | -2.8      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 734   | 304  | 363  | 359  | 218   | 66    | 33    | -2.2      | -0.1      | -4.8      | -11.3     | -6.6      | -6.0      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.47  | 0.60 | 1.27 | 1.59 | 1.25  | 0.48  | 0.29  | 3.3       | 2.6       | -2.4      | -9.2      | -4.9      | -3.7      |
| Automobile ownership volume (millions of vehicles)                                        |       |      |      |      |       |       |       | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -     | -    | -    | -    | -     | -     | -     | -         | -         | -         | -         | -         | -         |



## New Zealand [BAU]

### Primary energy consumption

|                                | MTOE  |       |       |       |       |       |       |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                          | 12.81 | 16.66 | 19.81 | 21.04 | 20.70 | 20.50 | 20.28 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.4       | 0.7       | -0.2      | -0.1      | -0.1      | 0.06      |
| Coal                           | 1.18  | 2.19  | 1.51  | 0.83  | 0.83  | 0.79  | 0.74  | 9.3  | 13.2 | 7.6  | 4.0  | 4.0  | 3.9  | 3.7  | 0.8       | -6.4      | 0.0       | -0.5      | -0.6      | -1.8      |
| Oil                            | 3.51  | 6.12  | 6.77  | 7.37  | 6.65  | 5.75  | 5.07  | 27.4 | 36.7 | 34.2 | 35.0 | 32.1 | 28.0 | 25.0 | 2.1       | 0.9       | -1.0      | -1.4      | -1.3      | -0.7      |
| Natural gas                    | 3.87  | 3.23  | 3.32  | 3.07  | 2.68  | 2.34  | 2.06  | 30.2 | 19.4 | 16.8 | 14.6 | 13.0 | 11.4 | 10.2 | -0.5      | -0.9      | -1.3      | -1.3      | -1.3      | -1.2      |
| Hydrogen                       | 0.00  | 0.00  | 0.00  | 0.00  | 0.000 | 0.000 | 0.000 | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -7.6      | -         | -         | -         |
| Fuel Ammonia                   | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear                        | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Hydro                          | 1.99  | 2.01  | 2.08  | 2.08  | 2.09  | 2.12  | 2.16  | 15.6 | 12.0 | 10.5 | 9.9  | 10.1 | 10.4 | 10.6 | 0.1       | 0.0       | 0.0       | 0.2       | 0.2       | 0.1       |
| Geothermal                     | 1.49  | 1.95  | 4.86  | 5.36  | 5.67  | 6.13  | 6.46  | 11.7 | 11.7 | 24.6 | 25.5 | 27.4 | 29.9 | 31.8 | 3.9       | 1.1       | 0.6       | 0.8       | 0.5       | 0.73      |
| Others                         | 0.75  | 1.17  | 1.26  | 2.33  | 2.78  | 3.37  | 3.80  | 5.9  | 7.0  | 6.4  | 11.1 | 13.4 | 16.5 | 18.7 | 1.7       | 7.1       | 1.8       | 2.0       | 1.2       | 2.9       |
| Biomass                        | 0.67  | 1.00  | 0.89  | 1.42  | 1.35  | 1.22  | 1.15  | 5.2  | 6.0  | 4.5  | 6.8  | 6.5  | 5.9  | 5.7  | 0.9       | 5.4       | -0.5      | -1.0      | -0.6      | 0.7       |
| Solar Wind Ocean               | 0.04  | 0.11  | 0.28  | 0.61  | 1.11  | 1.83  | 2.34  | 0.3  | 0.7  | 1.4  | 2.9  | 5.4  | 8.9  | 11.5 | 6.2       | 8.9       | 6.2       | 5.1       | 2.5       | 5.6       |
| Biofuels                       | 0.04  | 0.06  | 0.08  | 0.29  | 0.31  | 0.33  | 0.31  | 0.3  | 0.4  | 0.4  | 1.4  | 1.5  | 1.6  | 1.5  | 2.6       | 14.7      | 0.7       | 0.4       | -0.4      | 3.4       |
| Electricity (Import or Export) | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |

### Final energy demand

|              | MTOE |       |       |       |       |       |       |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990 | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 9.46 | 12.10 | 13.38 | 14.09 | 13.58 | 12.94 | 12.44 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.1       | 0.6       | -0.4      | -0.5      | -0.4      | -0.2      |
| Industry     | 3.31 | 3.62  | 3.67  | 3.77  | 3.76  | 3.64  | 3.45  | 35.1 | 29.9 | 27.5 | 26.7 | 27.7 | 28.1 | 27.7 | 0.3       | 0.3       | 0.0       | -0.3      | -0.5      | -0.2      |
| Transport    | 2.96 | 4.54  | 4.89  | 5.41  | 4.89  | 4.35  | 3.98  | 31.3 | 37.5 | 36.5 | 38.4 | 36.0 | 33.6 | 32.0 | 1.6       | 1.1       | -1.0      | -1.2      | -0.9      | -0.5      |
| Others       | 2.57 | 3.38  | 3.69  | 3.85  | 3.94  | 4.04  | 4.15  | 27.1 | 27.9 | 27.6 | 27.3 | 29.0 | 31.2 | 33.3 | 1.2       | 0.5       | 0.2       | 0.3       | 0.3       | 0.3       |
| Non-energy   | 0.62 | 0.56  | 1.12  | 1.06  | 0.99  | 0.92  | 0.86  | 6.5  | 4.7  | 8.4  | 7.5  | 7.3  | 7.1  | 6.9  | 1.9       | -0.6      | -0.7      | -0.8      | -0.6      | -0.7      |
| Total        | 9.46 | 12.10 | 13.38 | 14.09 | 13.58 | 12.94 | 12.44 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 1.1       | 0.6       | -0.4      | -0.5      | -0.4      | -0.2      |
| Coal         | 0.67 | 0.56  | 0.53  | 0.52  | 0.50  | 0.43  | 0.37  | 7.1  | 4.7  | 4.0  | 3.7  | 3.6  | 3.3  | 3.0  | -0.8      | -0.2      | -0.5      | -1.3      | -1.6      | -0.9      |
| Oil          | 4.03 | 5.96  | 6.44  | 6.99  | 6.30  | 5.43  | 4.77  | 42.6 | 49.3 | 48.1 | 49.6 | 46.4 | 41.9 | 38.3 | 1.5       | 0.9       | -1.0      | -1.5      | -1.3      | -0.8      |
| Natural gas  | 1.80 | 1.33  | 2.25  | 2.18  | 2.00  | 1.69  | 1.49  | 19.0 | 11.0 | 16.8 | 15.4 | 14.8 | 13.1 | 12.0 | 0.7       | -0.4      | -0.8      | -1.7      | -1.2      | -1.0      |
| Hydrogen     | 0.00 | 0.00  | 0.00  | 0.000 | 0.000 | 0.000 | 0.000 | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | 0.6       | -0.3      | -2.2      | -         |
| Fuel Ammonia | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Electricity  | 2.45 | 3.26  | 3.34  | 3.53  | 3.95  | 4.71  | 5.22  | 25.9 | 26.9 | 25.0 | 25.1 | 29.1 | 36.4 | 42.0 | 1.0       | 0.6       | 1.1       | 1.8       | 1.0       | 1.1       |
| Heat         | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Others       | 0.51 | 0.98  | 0.81  | 0.87  | 0.83  | 0.69  | 0.59  | 5.3  | 8.1  | 6.1  | 6.2  | 6.1  | 5.3  | 4.8  | 1.5       | 0.8       | -0.5      | -1.9      | -1.4      | -0.8      |

### Power generation Output

|                                     | TWh   |       |       |       |       |       |       |      |      |      |      |      |      |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 32.61 | 42.98 | 44.61 | 47.01 | 52.46 | 62.14 | 68.67 | 100  | 100  | 100  | 100  | 100  | 100  | 100    | 1.0       | 0.6       | 1.1       | 1.7       | 1.0       | 1.1       |
| Coal PP                             | 0.66  | 5.85  | 3.23  | 0.00  | 0.00  | 0.00  | 0.00  | 2.0  | 13.6 | 7.2  | 0.0  | 0.0  | 0.0  | 0.0000 | 5.2       | -137.0    | -2.8      | -0.1      | -1.5      | -178.6    |
| Coal PP with biomass co-firing      | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0000 | -         | -         | -         | -         | -         | -         |
| Coal PP with fuel ammonia co-firing | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0000 | -         | -         | -         | -         | -         | -         |
| Coal PP with CCS                    | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0000 | -         | -         | -         | -         | -         | -         |
| Oil                                 | 0.01  | 0.00  | 0.03  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.1  | 0.0  | 0.0  | 0.0  | 0.0000 | 3.4       | -37.1     | -2.8      | -0.1      | -1.5      | -11.2     |
| Gas PP                              | 5.71  | 9.26  | 4.98  | 4.25  | 3.18  | 3.16  | 2.72  | 17.5 | 21.5 | 11.2 | 9.0  | 6.1  | 5.1  | 3.959  | -0.4      | -1.7      | -2.8      | -0.1      | -1.5      | -1.5      |
| Gas PP with hydrogen co-firing      | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0    | -         | -         | -         | -         | -         | -         |
| Gas PP with CCS                     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0    | -         | -         | -         | -         | -         | -         |
| Nuclear PP                          | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0    | -         | -         | -         | -         | -         | -         |
| Solar PV                            | 0.07  | 0.08  | 0.25  | 0.79  | 2.67  | 6.21  | 9.29  | 0.2  | 0.2  | 0.6  | 1.7  | 5.1  | 10.0 | 13.5   | 4.4       | 13.4      | 13.0      | 8.8       | 4.1       | 9.7       |
| Wind                                | 0.00  | 0.61  | 2.64  | 6.24  | 10.18 | 15.03 | 17.87 | 0.0  | 1.4  | 5.9  | 13.3 | 19.4 | 24.2 | 26.0   | -         | 10.0      | 5.0       | 4.0       | 1.7       | 5.0       |
| Hydro                               | 23.18 | 23.33 | 24.23 | 24.22 | 24.30 | 24.69 | 25.09 | 71.1 | 54.3 | 54.3 | 51.5 | 46.3 | 39.7 | 36.5   | 0.1       | 0.0       | 0.0       | 0.2       | 0.2       | 0.089     |
| Geothermal                          | 2.13  | 3.16  | 8.45  | 9.31  | 9.89  | 10.78 | 11.41 | 6.5  | 7.4  | 18.9 | 19.8 | 18.8 | 17.3 | 16.6   | 4.5       | 1.1       | 0.6       | 0.9       | 0.6       | 0.77      |
| Biomass and others                  | 0.850 | 0.68  | 0.80  | 2.20  | 2.23  | 2.27  | 2.30  | 2.6  | 1.6  | 1.8  | 4.7  | 4.3  | 3.6  | 3.4    | -0.2      | 11.9      | 0.1       | 0.2       | 0.1       | 2.7       |

### Power generation Input

|                      | MTOE |      |      |      |      |      |      |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                      | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                | 1.41 | 3.11 | 1.69 | 3.10 | 3.87 | 5.27 | 6.19 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 0.6       | 7.0       | 2.2       | 3.1       | 1.6       | 3.4       |
| Coal                 | 0.17 | 1.39 | 0.76 | 0.00 | 0.00 | 0.00 | 0.00 | 11.9 | 44.7 | 44.9 | 0.0  | 0.0  | 0.0  | 0.0  | 5.0       | -100.0    | -         | -         | -         | -100.0    |
| Fuel ammonia         | 0.00 | 0.00 | 0.00 | 1.21 | 2.21 | 3.65 | 4.67 | 0.0  | 0.0  | 0.0  | 39.0 | 57.1 | 69.3 | 75.4 | -         | -         | 6.2       | 5.1       | 2.5       | -         |
| Biomass (Co-firing)  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Oil                  | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.4  | 0.0  | 0.4  | 0.0  | 0.0  | 0.0  | 0.0  | 0.6       | -36.9     | -3.0      | -0.1      | -1.5      | -11.2     |
| Gas                  | 1.24 | 1.72 | 0.92 | 0.71 | 0.50 | 0.47 | 0.39 | 87.7 | 55.3 | 54.7 | 23.0 | 12.9 | 8.9  | 6.3  | -1.0      | -2.8      | -3.5      | -0.6      | -1.9      | -2.2      |
| Hydrogen             | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass (Biomass PP) | 0.00 | 0.00 | 0.00 | 1.18 | 1.16 | 1.14 | 1.13 | 0.0  | 0.0  | 0.0  | 38.0 | 30.0 | 21.7 | 18.2 | -         | -         | -0.1      | -0.1      | -0.1      | -         |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |           | AAGR(%)   |           |           |           |           |  |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|--|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total      | 44.0 | 43.7 | 46.1 | 17.9 | 12.0 | 8.9  | 7.0  |  |  |  |  |  |  | 0.2       | -10.0     | -3.9      | -3.0      | -2.4      | -4.7      |  |
| Coal PP    | 33.9 | 36.2 | 36.8 | -    | -    | -    | -    |  |  |  |  |  |  | 0.3       | -         | -         | -         | -         | -         |  |
| Oil PP     | 13.8 | 32.4 | 32.4 | 31.6 | 32.2 | 32.2 | 32.3 |  |  |  |  |  |  | 2.8       | -0.3      | 0.2       | 0.0       | 0.0       | 0.0       |  |
| Gas PP     | 39.6 | 46.4 | 46.4 | 51.2 | 54.8 | 57.6 | 59.9 |  |  |  |  |  |  |           |           |           |           |           |           |  |
| Biomass PP | -    | -    | -    | 16.1 | 16.6 | 17.0 | 17.5 |  |  |  |  |  |  | -         | -         | 0.3       | 0.3       | 0.3       | -         |  |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |             |             |             |             |             |            |            |            |            |            |            |            |            |             | AAGR(%)     |             |             |              |  |  |
|--------------|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|--------------|--|--|
|              | 1990               | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060    |  |  |
| <b>Total</b> | <b>22.9</b>        | <b>32.9</b> | <b>31.0</b> | <b>29.4</b> | <b>26.6</b> | <b>23.2</b> | <b>20.4</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.0</b> | <b>-0.6</b> | <b>-1.0</b> | <b>-1.4</b> | <b>-1.3</b> | <b>-1.06</b> |  |  |
| Coal         | 5.1                | 9.2         | 6.3         | 3.5         | 3.5         | 3.3         | 3.1         | 22.1       | 27.9       | 20.5       | 11.8       | 13.1       | 14.2       | 15.1       | 0.7        | -6.5        | 0.0         | -0.5        | -0.6        | -1.8         |  |  |
| Oil          | 9.5                | 17.0        | 18.9        | 20.5        | 18.4        | 15.8        | 13.7        | 41.3       | 51.5       | 60.9       | 69.8       | 69.2       | 68.0       | 67.3       | 2.3        | 0.9         | -1.1        | -1.5        | -1.4        | -0.8         |  |  |
| Natural Gas  | 8.4                | 6.8         | 5.8         | 5.4         | 4.7         | 4.1         | 3.6         | 36.6       | 20.6       | 18.7       | 18.4       | 17.7       | 17.7       | 17.6       | -1.2       | -0.8        | -1.4        | -1.3        | -1.3        | -1.2         |  |  |
| CCS/DAC (-)  | 0.0                | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -            |  |  |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       |           | AAGR(%)   |           |           |           |           |  |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| GDP (billions of 2015 US dollars)                                                         | 88    | 145   | 207   | 249   | 298   | 350   | 404   | 2.8       | 2.1       | 1.8       | 1.6       | 1.4       | 1.7       |  |
| Population (millions of people)                                                           | 3.3   | 4.1   | 5.1   | 5.5   | 5.8   | 6.0   | 6.1   | 1.4       | 0.8       | 0.5       | 0.3       | 0.2       | 0.4       |  |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 26.40 | 35.05 | 40.42 | 45.14 | 51.53 | 58.63 | 66.32 | 1.4       | 1.2       | 1.3       | 1.3       | 1.2       | 1.3       |  |
| Primary energy consumption per capita (toe/person)                                        | 3.85  | 4.03  | 3.87  | 3.82  | 3.57  | 3.43  | 3.33  | 0.0       | -0.1      | -0.7      | -0.4      | -0.3      | -0.4      |  |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 146   | 115   | 96    | 85    | 69    | 59    | 50.3  | -1.3      | -1.4      | -2.0      | -1.7      | -1.5      | -1.6      |  |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 108   | 84    | 65    | 57    | 46    | 37    | 31    | -1.6      | -1.4      | -2.2      | -2.1      | -1.8      | -1.9      |  |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 260   | 227   | 150   | 118   | 89    | 66    | 51    | -1.8      | -2.6      | -2.8      | -2.9      | -2.7      | -2.7      |  |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.79  | 1.98  | 1.57  | 1.40  | 1.28  | 1.13  | 1.01  | -0.4      | -1.3      | -0.8      | -1.3      | -1.2      | -1.1      |  |
| Automobile ownership volume (millions of vehicles)                                        | 2     | 3     | 4     | 5     | 5     | 5     | 5     | 2.9       | 0.7       | 0.4       | 0.2       | 0.9       | 0.5       |  |
| Automobile ownership volume per capita (vehicles per person)                              | 0.538 | 0.748 | 0.841 | 0.833 | 0.826 | 0.818 | 0.874 | 1.5       | -0.1      | -0.1      | -0.1      | 0.7       | 0.1       |  |

## New Zealand [LCET]

### Primary energy consumption

|                                | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |            |             |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|------------|-------------|
|                                | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060  | 2021-2060   |
| <b>Total</b>                   | <b>12.81</b> | <b>16.66</b> | <b>19.73</b> | <b>19.50</b> | <b>16.88</b> | <b>15.28</b> | <b>16.53</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.4</b> | <b>-0.1</b> | <b>-1.4</b> | <b>-1.0</b> | <b>0.8</b> | <b>-0.5</b> |
| Coal                           | 1.18         | 2.19         | 1.51         | 0.71         | 0.48         | 0.24         | 0.18         | 9.3        | 13.2       | 7.6        | 3.7        | 2.9        | 1.6        | 1.1        | 0.8        | -8.0        | -3.9        | -6.6        | -3.2       | -5.3        |
| Oil                            | 3.51         | 6.12         | 6.77         | 5.45         | 2.55         | 0.35         | 0.22         | 27.4       | 36.7       | 34.3       | 27.9       | 15.1       | 2.3        | 1.4        | 2.1        | -2.4        | -7.3        | -18.1       | -4.3       | -8.4        |
| Natural gas                    | 3.87         | 3.23         | 3.32         | 3.26         | 1.64         | 1.42         | 1.37         | 30.2       | 19.4       | 16.8       | 16.7       | 9.7        | 9.3        | 8.3        | -0.5       | -0.2        | -6.7        | -1.4        | -0.3       | -2.2        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.000        | 0.000        | 0.000        | -0.141       | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | 68.3        | -100.0      | -          | -           |
| Fuel Ammonia                   | 0.00         | 0.00         | 0.00         | 0.000        | 0.000        | 0.000        | 0.000        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          | -           |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -          | -           |
| Hydro                          | 1.99         | 2.01         | 2.08         | 1.92         | 2.27         | 2.17         | 2.49         | 15.6       | 12.0       | 10.6       | 9.8        | 13.5       | 14.2       | 15.1       | 0.1        | -0.9        | 1.7         | -0.5        | 1.4        | 0.5         |
| Geothermal                     | 1.49         | 1.95         | 4.79         | 5.64         | 6.22         | 6.17         | 7.05         | 11.7       | 11.7       | 24.3       | 28.9       | 36.9       | 40.4       | 42.7       | 3.8        | 1.8         | 1.0         | -0.1        | 1.3        | 1.0         |
| Others                         | 0.75         | 1.17         | 1.26         | 2.52         | 3.71         | 4.93         | 5.36         | 5.9        | 7.0        | 6.4        | 12.9       | 22.0       | 32.3       | 32.4       | 1.7        | 8.0         | 3.9         | 2.9         | 0.8        | 3.8         |
| Biomass                        | 0.67         | 1.00         | 0.89         | 1.60         | 1.39         | 1.59         | 1.61         | 5.2        | 6.0        | 4.5        | 8.2        | 8.3        | 10.4       | 9.7        | 0.9        | 6.7         | -1.4        | 1.3         | 0.1        | 1.5         |
| Solar Wind Ocean               | 0.04         | 0.11         | 0.28         | 0.84         | 2.05         | 2.90         | 3.32         | 0.3        | 0.7        | 1.4        | 4.3        | 12.1       | 19.0       | 20.1       | 6.2        | 12.7        | 9.4         | 3.5         | 1.4        | 6.5         |
| Biofuels                       | 0.04         | 0.06         | 0.08         | 0.09         | 0.27         | 0.44         | 0.42         | 0.3        | 0.4        | 0.4        | 0.5        | 1.6        | 2.9        | 2.6        | 2.6        | 0.6         | 11.7        | 4.9         | -0.3       | 4.2         |
| Electricity (Import or Export) | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | 9.6         | -3.5        | -1.5       | -           |

### Final energy demand

|              | MTOE        |              |              |              |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|-------------|--------------|--------------|--------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990        | 2005         | 2021         | 2030         | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>9.46</b> | <b>12.10</b> | <b>13.31</b> | <b>12.06</b> | <b>9.50</b> | <b>6.97</b> | <b>6.41</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-1.1</b> | <b>-2.4</b> | <b>-3.1</b> | <b>-0.8</b> | <b>-1.9</b> |
| Industry     | 3.31        | 3.62         | 3.67         | 3.58         | 3.10        | 2.49        | 1.94        | 35.1       | 29.9       | 27.6       | 29.7       | 32.6       | 35.7       | 30.3       | 0.3        | -0.3        | -1.4        | -2.2        | -2.5        | -1.6        |
| Transport    | 2.96        | 4.54         | 4.89         | 4.18         | 2.63        | 1.59        | 1.65        | 31.3       | 37.5       | 36.7       | 34.7       | 27.7       | 22.8       | 25.8       | 1.6        | -1.7        | -4.5        | -4.9        | 0.4         | -2.7        |
| Others       | 2.57        | 3.38         | 3.62         | 3.23         | 2.78        | 1.94        | 1.95        | 27.1       | 27.9       | 27.2       | 26.8       | 29.3       | 27.9       | 30.4       | 1.1        | -1.3        | -1.5        | -3.5        | 0.0         | -1.6        |
| Non-energy   | 0.62        | 0.56         | 1.12         | 1.06         | 0.99        | 0.95        | 0.86        | 6.5        | 4.7        | 8.4        | 8.8        | 10.5       | 13.6       | 13.5       | 1.9        | -0.6        | -0.7        | -0.5        | -0.9        | -0.7        |
| <b>Total</b> | <b>9.46</b> | <b>12.10</b> | <b>13.31</b> | <b>12.06</b> | <b>9.50</b> | <b>6.97</b> | <b>6.41</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.1</b> | <b>-1.1</b> | <b>-2.4</b> | <b>-3.1</b> | <b>-0.8</b> | <b>-1.9</b> |
| Coal         | 0.67        | 0.56         | 0.53         | 0.44         | 0.26        | 0.10        | 0.05        | 7.1        | 4.7        | 4.0        | 3.6        | 2.7        | 1.4        | 0.8        | -0.8       | -2.2        | -5.2        | -9.2        | -6.2        | -5.8        |
| Oil          | 4.03        | 5.96         | 6.44         | 5.12         | 2.45        | 0.41        | 0.35        | 42.6       | 49.3       | 48.4       | 42.5       | 25.8       | 5.9        | 5.4        | 1.5        | -2.5        | -7.1        | -16.3       | -1.7        | -7.2        |
| Natural gas  | 1.80        | 1.33         | 2.25         | 1.87         | 1.21        | 0.72        | 0.57        | 19.0       | 11.0       | 16.9       | 15.5       | 12.8       | 10.3       | 8.9        | 0.7        | -2.0        | -4.2        | -5.1        | -2.3        | -3.5        |
| Hydrogen     | 0.00        | 0.00         | 0.00         | 0.03         | 0.10        | 0.15        | 0.16        | 0.00       | 0.00       | 0.00       | 31.80      | 1.02       | 2.13       | 2.48       | -          | -           | -30.80      | 4.39        | 0.70        | -           |
| Fuel Ammonia | 0.00        | 0.00         | 0.00         | 0.00         | 0.38        | 0.60        | 0.60        | 0.00       | 0.00       | 0.00       | 0.00       | 3.97       | 8.66       | 9.38       | -          | -           | -           | 4.81        | -0.05       | -           |
| Electricity  | 2.45        | 3.26         | 3.34         | 3.83         | 4.34        | 4.15        | 3.98        | 25.9       | 26.9       | 25.1       | 0.0        | 45.7       | 59.6       | 62.2       | 1.0        | -100.0      | -           | -0.4        | -0.4        | 0.4         |
| Heat         | 0.00        | 0.00         | 0.00         | 0.00         | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 6.3        | 0.0        | 0.0        | 0.0        | -          | -           | -100.0      | -           | -           | -           |
| Others       | 0.51        | 0.98         | 0.74         | 0.76         | 0.77        | 0.83        | 0.69        | 5.3        | 8.1        | 5.6        | 0.0        | 8.1        | 11.9       | 10.8       | 1.2        | -           | -           | 0.8         | -1.8        | -0.2        |

### Power generation Output

|                                     | TWh          |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>32.61</b> | <b>42.98</b> | <b>44.61</b> | <b>51.38</b> | <b>65.21</b> | <b>76.52</b> | <b>87.79</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.0</b> | <b>1.6</b> | <b>2.4</b> | <b>1.6</b> | <b>1.4</b> | <b>1.8</b> |
| Coal PP                             | 0.66         | 5.85         | 3.23         | 0.00         | 0.00         | 0.00         | 0.00         | 2.0        | 13.6       | 7.2        | 0.0        | 0.0        | 0.0        | 0.0        | 5.2        | -100.0     | -          | -          | -          | -100.0     |
| Coal PP with biomass co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -2.7       | -5.8       | -0.1       | -          |
| Oil                                 | 0.01         | 0.00         | 0.03         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.1        | 0.0        | 0.0        | 0.0        | 0.0        | 3.4        | -55.0      | -2.7       | -5.8       | -0.1       | -18.7      |
| Gas PP                              | 5.71         | 9.26         | 4.98         | 6.89         | 0.93         | 0.00         | 0.00         | 17.5       | 21.5       | 11.2       | 13.4       | 1.4        | 0.0        | 0.000      | -0.4       | 3.7        | -18.1      | -100.0     | -          | -100.0     |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 0.0000       | 0.0000       | 0.0000       | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00         | 0.36         | 0.73         | 3.57         | 4.1          | 0.0        | 0.0        | 0.0        | 0.7        | 1.1        | 4.7        | 4.7        | -          | -          | 7.2        | 17.3       | 1.4        | -          |
| Nuclear PP                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.07         | 0.08         | 0.25         | 1.60         | 7.00         | 13.97        | 18.72        | 0.2        | 0.2        | 0.6        | 3.1        | 10.7       | 18.3       | 21.3       | 4.4        | 22.7       | 15.9       | 7.2        | 3.0        | 11.7       |
| Wind                                | 0.00         | 0.61         | 2.64         | 8.07         | 16.81        | 19.70        | 19.91        | 0.0        | 1.4        | 5.9        | 15.7       | 25.8       | 25.7       | 22.7       | -          | 13.2       | 7.6        | 1.6        | 0.1        | 5.3        |
| Hydro                               | 23.18        | 23.33        | 24.23        | 22.28        | 26.42        | 25.25        | 28.97        | 71.1       | 54.3       | 54.3       | 43.4       | 40.5       | 33.0       | 33.0       | 0.1        | -0.9       | 1.7        | -0.5       | 1.4        | 0.5        |
| Geothermal                          | 2.13         | 3.16         | 8.45         | 9.88         | 10.98        | 10.97        | 12.58        | 6.5        | 7.4        | 18.9       | 19.2       | 16.8       | 14.3       | 14.3       | 4.5        | 1.8        | 1.1        | 0.0        | 1.4        | 1.0        |
| Biomass and others                  | 0.850        | 0.68         | 0.80         | 2.30         | 2.34         | 3.06         | 3.51         | 2.6        | 1.6        | 1.8        | 4.5        | 3.6        | 4.0        | 4.0        | -0.2       | 12.4       | 0.2        | 2.7        | 1.4        | 3.9        |

### Power generation Input

|                      | MTOE        |             |             |             |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |             |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>1.41</b> | <b>3.11</b> | <b>1.69</b> | <b>4.03</b> | <b>5.24</b> | <b>7.11</b> | <b>7.75</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>10.2</b> | <b>2.7</b> | <b>3.1</b> | <b>0.9</b> | <b>4.0</b> |
| Coal                 | 0.17        | 1.39        | 0.76        | 0.00        | 0.00        | 0.00        | 0.00        | 11.9       | 44.7       | 44.9       | 0.0        | 0.0        | 0.0        | 0.0        | 5.0        | -73.8       | -4.5       | -6.0       | -0.1       | -28.6      |
| Fuel ammonia         | 0.00        | 0.00        | 0.00        | 1.60        | 3.77        | 5.01        | 5.45        | 0.0        | 0.0        | 0.0        | 39.7       | 71.9       | 70.5       | 70.3       | -          | -           | 8.9        | 2.9        | 0.8        | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          | -          |
| Oil                  | 0.01        | 0.00        | 0.01        | 0.00        | 0.00        | 0.00        | 0.00        | 0.4        | 0.0        | 0.4        | 0.0        | 0.0        | 0.0        | 0.0        | 0.6        | -54.9       | -2.0       | -4.5       | -0.1       | -18.2      |
| Gas                  | 1.24        | 1.72        | 0.92        | 1.21        | 0.28        | 0.60        | 0.65        | 87.7       | 55.3       | 54.7       | 30.0       | 5.3        | 8.5        | 8.4        | -1.0       | 3.1         | -13.6      | 8.0        | 0.8        | -0.9       |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.00        | 1.22        | 1.19        | 1.50        | 1.65        | 0.0        | 0.0        | 0.0        | 30.2       | 22.7       | 21.0       | 21.3       | -          | -           | -0.2       | 2.3        | 1.0        | -          |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total      | 44.0 | 43.7 | 46.1 | 20.4 | 6.6  | 8.0  | 8.4  |  |  |  |  |  |  |  | 0.2       | -8.7      | -10.7     | 2.0       | 0.5       | -4.3      |
| Coal PP    | 33.9 | 36.2 | 36.8 | 44.4 | 53.7 | 54.6 | 54.6 |  |  |  |  |  |  |  | 0.3       | 2.1       | 1.9       | 0.2       | 0.0       | 1.0       |
| Oil PP     | 13.8 | 32.4 | 32.4 | 32.1 | 30.0 | 26.1 | 26.1 |  |  |  |  |  |  |  | 2.8       | -0.1      | -0.7      | -1.4      | 0.0       | -0.6      |
| Gas PP     | 39.6 | 46.4 | 46.4 | 51.5 | 51.0 | 50.7 | 53.9 |  |  |  |  |  |  |  |           |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 16.2 | 16.9 | 17.6 | 18.3 |  |  |  |  |  |  |  | -         | -         | 0.4       | 0.4       | 0.4       | -         |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |             |             |            |            |            |            |            |            |            |            |            |            | AAGR(%)    |             |             |              |             |
|--------------|--------------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|-------------|
|              | 1990               | 2005        | 2021        | 2030        | 2040       | 2050       | 2060       | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050    | 2050-2060   |
| <b>Total</b> | <b>22.9</b>        | <b>32.9</b> | <b>31.0</b> | <b>23.6</b> | <b>9.3</b> | <b>0.8</b> | <b>0.4</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.0</b> | <b>-3.0</b> | <b>-8.9</b> | <b>-21.3</b> | <b>-6.3</b> |
| Coal         | 5.1                | 9.2         | 6.3         | 3.0         | 1.6        | 0.7        | 0.4        | 22.1       | 27.9       | 20.5       | 12.7       | 17.3       | 85.8       | 100.0      | 0.7        | -8.0        | -6.0        | -7.7         | -4.9        |
| Oil          | 9.5                | 17.0        | 18.9        | 14.9        | 6.2        | 0.0        | 0.0        | 41.3       | 51.5       | 60.9       | 63.3       | 66.8       | 0.0        | 0.0        | 2.3        | -2.6        | -8.4        | -100.0       | -           |
| Natural Gas  | 8.4                | 6.8         | 5.8         | 5.7         | 1.5        | 0.1        | 0.0        | 36.6       | 20.6       | 18.7       | 24.1       | 15.9       | 14.2       | 0.0        | -1.2       | -0.2        | -12.6       | -22.2        | -100.0      |
| CCS/DAC (-)  | 0.0                | 0.0         | 0.0         | 0.0         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -            | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060-2060 |
| GDP (billions of 2015 US dollars)                                                         | 88    | 145   | 207   | 249   | 298   | 350   | 404   | 2.8       | 2.1       | 1.8       | 1.6       | 1.4       | 1.7       |
| Population (millions of people)                                                           | 3     | 4     | 5     | 6     | 6     | 6     | 6     | 1.4       | 0.8       | 0.5       | 0.3       | 0.2       | 0.4       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 26.40 | 35.05 | 40.42 | 45.14 | 51.53 | 58.63 | 66.32 | 1.4       | 1.2       | 1.3       | 1.3       | 1.2       | 1.3       |
| Primary energy consumption per capita (toe/person)                                        | 3.85  | 4.03  | 3.85  | 3.54  | 2.91  | 2.56  | 2.72  | 0.0       | -0.9      | -1.9      | -1.3      | 0.6       | -0.9      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 146   | 115   | 95    | 78    | 57    | 44    | 41    | -1.4      | -2.1      | -3.2      | -2.6      | -0.6      | -2.1      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 108   | 84    | 64    | 49    | 32    | 20    | 16    | -1.6      | -3.1      | -4.1      | -4.6      | -2.2      | -3.5      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 260   | 227   | 150   | 95    | 31    | 2     | 1     | -1.8      | -5.0      | -10.5     | -22.6     | -7.6      | -11.9     |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.79  | 1.98  | 1.57  | 1.21  | 0.55  | 0.06  | 0.03  | -0.4      | -2.9      | -7.6      | -20.5     | -7.0      | -9.9      |
| Automobile ownership volume (millions of vehicles)                                        | 2     | 3     | 4     | 5     | 5     | 5     | 5     | 2.9       | 0.7       | 0.4       | 0.2       | 0.9       | 0.5       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.538 | 0.748 | 0.841 | 0.833 | 0.826 | 0.818 | 0.874 | 1.5       | -0.1      | -0.1      | -0.1      | 0.7       | 0.1       |

## Philippines [BAU]

### Primary energy consumption

|                                | MTOE  |       |       |       |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |  |
|--------------------------------|-------|-------|-------|-------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                                | 1990  | 2005  | 2021  | 2030  | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                          | 28.71 | 42.56 | 61.32 | 82.08 | 119.21 | 162.33 | 222.50 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 2.5       | 3.3       | 3.8       | 3.1       | 3.2       | 3.4       |  |
| Coal                           | 1.53  | 5.32  | 18.91 | 15.97 | 17.53  | 19.15  | 20.86  | 5.3  | 12.5 | 30.8 | 19.5 | 14.7 | 11.8 | 9.4  | 8.5       | -1.9      | 0.9       | 0.9       | 0.9       | 0.3       |  |
| Oil                            | 10.84 | 18.15 | 19.17 | 31.50 | 44.33  | 60.96  | 84.19  | 37.8 | 42.6 | 31.3 | 38.4 | 37.2 | 37.6 | 37.8 | 1.9       | 5.7       | 3.5       | 3.2       | 3.3       | 3.9       |  |
| Natural gas                    | 0.00  | 2.70  | 3.29  | 10.58 | 22.29  | 34.89  | 57.53  | 0.0  | 6.3  | 5.4  | 12.9 | 18.7 | 21.5 | 25.9 | -         | 13.9      | 7.7       | 4.6       | 5.1       | 7.6       |  |
| Hydrogen                       | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Fuel Ammonia                   | 0.00  | 0.00  |       |       |        |        |        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Nuclear                        | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Hydro                          | 0.52  | 2.09  | 0.79  | 1.10  | 1.61   | 2.43   | 3.09   | 1.8  | 4.9  | 1.3  | 1.3  | 1.4  | 1.5  | 1.4  | 1.4       | 3.8       | 3.9       | 4.2       | 2.4       | 3.6       |  |
| Geothermal                     | 4.70  | 8.51  | 9.18  | 9.63  | 13.12  | 18.93  | 22.25  | 16.4 | 20.0 | 15.0 | 11.7 | 11.0 | 11.7 | 10.0 | 2.2       | 0.5       | 3.1       | 3.7       | 1.6       | 2.3       |  |
| Others                         | 11.12 | 5.80  | 9.97  | 13.30 | 20.32  | 25.98  | 34.57  | 38.7 | 13.6 | 16.3 | 16.2 | 17.0 | 16.0 | 15.5 | -0.4      | 3.2       | 4.3       | 2.5       | 2.9       | 3.2       |  |
| Biomass                        | 11.12 | 5.80  | 8.87  | 10.07 | 13.88  | 13.31  | 12.55  | 38.7 | 13.6 | 14.5 | 12.3 | 11.6 | 8.2  | 5.6  | -0.7      | 1.4       | 3.3       | -0.4      | -0.6      | 0.9       |  |
| Solar, Wind, Ocean             | 0.00  | 0.00  | 0.24  | 0.98  | 4.07   | 4.89   | 7.39   | 0.0  | 0.0  | 0.4  | 1.2  | 1.7  | 3.0  | 3.3  | -         | 17.2      | 7.7       | 9.0       | 4.2       | 9.2       |  |
| Biofuels                       | 0.00  | 0.00  | 0.86  | 2.24  | 4.37   | 7.77   | 14.64  | 0.0  | 0.0  | 1.4  | 2.7  | 3.7  | 4.8  | 6.6  | -         | 11.2      | 6.9       | 5.9       | 6.5       | 7.5       |  |
| Electricity (Import or Export) | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.00 | 0.00 | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |

### Final energy demand

|              | MTOE  |       |       |       |       |        |        |       |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|-------|-------|-------|-------|-------|--------|--------|-------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990  | 2005  | 2021  | 2030  | 2040  | 2050   | 2060   | 1990  | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 19.02 | 22.67 | 38.21 | 56.10 | 83.14 | 113.65 | 159.33 | 100   | 100  | 100  | 100  | 100  | 100  | 100  | 2.3       | 4.4       | 4.0       | 3.2       | 3.4       | 3.7       |
| Industry     | 4.13  | 4.95  | 7.17  | 9.81  | 14.08 | 19.82  | 27.70  | 38.7  | 21.8 | 18.8 | 17.5 | 16.9 | 17.4 | 17.4 | 1.8       | 3.5       | 3.7       | 3.5       | 3.4       | 3.5       |
| Transport    | 4.69  | 8.23  | 12.74 | 20.89 | 31.51 | 46.73  | 70.51  | 57.4  | 36.3 | 33.3 | 37.2 | 37.9 | 41.1 | 44.2 | 3.3       | 5.7       | 4.2       | 4.0       | 4.2       | 4.5       |
| Others       | 9.82  | 9.31  | 16.66 | 23.76 | 35.91 | 45.46  | 59.48  | 46.2  | 41.0 | 43.6 | 42.3 | 43.2 | 40.0 | 37.3 | 1.7       | 4.0       | 4.2       | 2.4       | 2.7       | 3.3       |
| Non-energy   | 0.39  | 0.19  | 1.64  | 1.64  | 1.64  | 1.64   | 1.64   | 1.6   | 0.8  | 4.3  | 2.9  | 2.0  | 1.4  | 1.0  | 4.8       | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |
| Total        | 19.02 | 22.67 | 38.21 | 56.10 | 83.14 | 113.65 | 159.33 | 100   | 100  | 100  | 100  | 100  | 100  | 100  | 2.3       | 4.4       | 4.0       | 3.2       | 3.4       | 3.7       |
| Coal         | 0.70  | 1.18  | 2.16  | 2.82  | 3.85  | 5.07   | 6.55   | 6.5   | 5.2  | 5.7  | 5.0  | 4.6  | 4.5  | 4.1  | 3.7       | 3.0       | 3.2       | 2.8       | 2.6       | 2.9       |
| Oil          | 8.08  | 11.80 | 18.77 | 29.90 | 42.31 | 58.21  | 81.10  | 71.0  | 52.0 | 49.1 | 53.3 | 50.9 | 51.2 | 50.9 | 2.8       | 5.3       | 3.5       | 3.2       | 3.4       | 3.8       |
| Natural gas  | 0.00  | 0.01  | 0.06  | 0.07  | 0.08  | 0.09   | 0.10   | 0.1   | 0.1  | 0.2  | 0.1  | 0.1  | 0.1  | 0.1  | -         | 1.2       | 1.2       | 1.2       | 1.2       | 1.2       |
| Hydrogen     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.0   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Fuel Ammonia | 0.00  | 0.00  |       |       |       |        |        | -     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Electricity  | 1.82  | 3.88  | 7.93  | 12.22 | 20.01 | 30.85  | 46.09  | -50.4 | 17.1 | 20.8 | 21.8 | 24.1 | 27.1 | 28.9 | 4.9       | 4.9       | 5.1       | 4.4       | 4.1       | 4.6       |
| Heat         | 0.00  | 0.00  |       |       |       |        |        | -     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Others       | 8.42  | 5.80  | 9.28  | 11.09 | 16.89 | 19.43  | 25.50  | 16.0  | 25.6 | 24.3 | 19.8 | 20.3 | 17.1 | 16.0 | 0.3       | 2.0       | 4.3       | 1.4       | 2.8       | 2.6       |

### Power generation Output

|                                     | TWh   |       |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|-------|-------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990  | 2005  | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 26.33 | 56.57 | 106.11 | 163.53 | 267.77 | 407.77 | 595.62 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 4.6       | 4.9       | 5.1       | 4.3       | 3.9       | 4.5       |
| Coal PP                             | 1.93  | 15.26 | 62.05  | 50.99  | 55.68  | 62.20  | 63.26  | 7    | 27   | 58   | 31   | 21   | 15   | 11   | 11.8      | -2.2      | 0.9       | 1.1       | 0.2       | 0.0       |
| Coal PP with biomass co-firing      | 0.00  | 0.00  |        |        |        |        |        | 47   | 11   | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Coal PP with fuel ammonia co-firing | 0.00  | 0.00  |        |        |        |        |        | 0    | 30   | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Coal PP with CCS                    | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Oil                                 | 12.43 | 6.14  | 1.62   | 6.72   | 8.46   | 11.51  | 12.94  | 0    | 0    | 2    | 4    | 3    | 3    | 2    | -6.4      | 17.2      | 2.3       | 3.1       | 1.2       | 5.5       |
| Gas PP                              | 0.00  | 16.86 | 18.68  | 67.24  | 142.11 | 222.64 | 367.37 | 0    | 0    | 18   | 41   | 53   | 55   | 62   | -         | 15.3      | 7.8       | 4.6       | 5.1       | 7.9       |
| Gas PP with hydrogen co-firing      | 0.00  | 0.00  |        |        |        |        |        | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Gas PP with CCS                     | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Nuclear PP                          | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Solar PV                            | 0.00  | 0.00  | 1.47   | 7.77   | 13.92  | 29.68  | 43.13  | 0    | 0    | 1    | 5    | 5    | 7    | 7    | -         | 20.3      | 6.0       | 7.9       | 3.8       | 9.1       |
| Wind                                | 0.00  | 0.02  | 1.27   | 3.66   | 10.15  | 27.21  | 42.78  | 0    | 0    | 1    | 2    | 4    | 7    | 7    | -         | 12.5      | 10.8      | 10.4      | 4.6       | 9.4       |
| Hydro                               | 6.06  | 8.39  | 9.19   | 12.81  | 18.72  | 28.27  | 35.95  | 23   | 15   | 9    | 8    | 7    | 7    | 6    | 1.3       | 3.8       | 3.9       | 4.2       | 2.4       | 3.6       |
| Geothermal                          | 5.47  | 9.90  | 10.68  | 11.20  | 15.25  | 22.02  | 25.88  | 21   | 18   | 10   | 7    | 6    | 5    | 4    | 2.2       | 0.5       | 3.1       | 3.7       | 1.6       | 2.3       |
| Biomass and others                  | 0.43  | 0.00  | 1.16   | 3.13   | 3.48   | 4.24   | 4.31   | 2    | 0    | 1    | 2    | 1    | 1    | 1    | 3.3       | 11.6      | 1.1       | 2.0       | 0.2       | 3.4       |

### Power generation Input

|                      | MTOE |      |       |       |       |       |       |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |  |
|----------------------|------|------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                      | 1990 | 2005 | 2021  | 2030  | 2040  | 2050  | 2060  | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                | 2.69 | 8.09 | 20.51 | 26.48 | 39.27 | 53.28 | 76.52 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 6.8       | 2.9       | 4.0       | 3.1       | 3.7       | 3.4       |  |
| Coal                 | 0.51 | 4.13 | 16.75 | 13.15 | 13.68 | 14.07 | 14.32 | 18.9 | 51.1 | 81.7 | 49.6 | 34.8 | 26.4 | 18.7 | 11.9      | -2.7      | 0.4       | 0.3       | 0.2       | -0.4      |  |
| Fuel ammonia         | 0.00 | 0.00 |       |       |       |       |       | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Biomass (Co-firing)  | 0.00 | 0.00 |       |       |       |       |       | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Oil                  | 2.18 | 1.40 | 0.39  | 1.61  | 2.02  | 2.75  | 3.09  | 81.1 | 17.3 | 1.9  | 6.1  | 5.1  | 5.2  | 4.0  | -5.4      | 17.1      | 2.3       | 3.1       | 1.2       | 5.5       |  |
| Gas                  | 0.00 | 2.56 | 2.92  | 10.51 | 22.22 | 34.81 | 57.43 | 0.0  | 31.6 | 14.2 | 39.7 | 56.6 | 65.3 | 75.1 | -         | 15.3      | 7.8       | 4.6       | 5.1       | 7.9       |  |
| Hydrogen             | 0.00 | 0.00 | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |  |
| Biomass (Biomass PP) | 0.00 | 0.00 | 0.45  | 1.22  | 1.35  | 1.65  | 1.68  | 0.0  | 0.0  | 2.2  | 4.6  | 3.4  | 3.1  | 2.2  | -         | 11.6      | 1.1       | 2.0       | 0.2       | 3.4       |  |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total      | 47   | 41   | 35   | 42   | 46   | 49   | 50   |  |  |  |  |  |  |  | -1.0      | 1.9       | 1.0       | 0.5       | 0.4       | 0.9       |
| Coal PP    | 33   | 32   | 32   | 33   | 35   | 38   | 38   |  |  |  |  |  |  |  | -0.1      | 0.5       | 0.5       | 0.8       | 0.0       | 0.5       |
| Oil PP     | 49   | 38   | 36   | 36   | 36   | 36   | 36   |  |  |  |  |  |  |  | -1.0      | 0.1       | 0.0       | 0.0       | 0.0       | 0.0       |
| Gas PP     | -    | 57   | 55   | 55   | 55   | 55   | 55   |  |  |  |  |  |  |  | -         | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |
| Biomass PP | -    | -    | 22   | 22   | 22   | 22   | 22   |  |  |  |  |  |  |  | -         | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|-------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005        | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>10.2</b>        | <b>65.7</b> | <b>132.3</b> | <b>175.4</b> | <b>246.9</b> | <b>332.0</b> | <b>460.6</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>8.6</b> | <b>3.2</b> | <b>3.5</b> | <b>3.0</b> | <b>3.3</b> | <b>3.2</b> |
| Coal         | 1.36               | 20.20       | 72.5         | 61.1         | 67.2         | 73.4         | 80.1         | 13.4       | 30.8       | 54.8       | 34.8       | 27.2       | 22.1       | 17.4       | 13.7       | -1.9       | 1.0        | 0.9        | 0.9        | 0.3        |
| Oil          | 8.80               | 39.44       | 52.8         | 89.6         | 127.7        | 177.1        | 246.1        | 86.6       | 60.1       | 39.9       | 51.1       | 51.7       | 53.3       | 53.4       | 6.0        | 6.0        | 3.6        | 3.3        | 3.3        | 4.0        |
| Natural Gas  | 0.00               | 6.01        | 7.0          | 24.7         | 52.1         | 81.5         | 134.4        | 0.0        | 9.2        | 5.3        | 14.1       | 21.1       | 24.5       | 29.2       | -          | 15.1       | 7.7        | 4.6        | 5.1        | 7.9        |
| CCS/DAC (-)  |                    |             |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |      |      |       |       |       |       |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|-------|-------|-------|-------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021  | 2030  | 2040  | 2050  | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 143  | 179  | 379   | 678   | 1,321 | 2,355 | 4,004  | 3.2       | 6.7       | 6.90      | 5.95      | 5.4       | 6.2       |
| Population (millions of people)                                                           | 61.9 | 85.3 | 111.4 | 122.7 | 134.0 | 145.2 | 157.2  | 1.9       | 1.1       | 0.9       | 0.8       | 0.8       | 0.9       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 2.3  | 2.1  | 3,402 | 5.5   | 9.9   | 16.2  | 25,472 | 1.3       | 5.5       | 6.0       | 5.1       | 4.6       | 5.3       |
| Primary energy consumption per capita (toe/person)                                        | 0.5  | 0.5  | 0.6   | 0.7   | 0.9   | 1.1   | 1.4    | 0.6       | 2.2       | 2.9       | 2.3       | 2.4       | 2.5       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 201  | 237  | 162   | 121   | 90    | 69    | 56     | -0.7      | -3.2      | -2.9      | -2.7      | -2.1      | -2.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 133  | 126  | 101   | 83    | 63    | 48    | 40     | -0.9      | -2.2      | -2.7      | -2.6      | -1.9      | -2.4      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 71   | 366  | 349   | 259   | 187   | 141   | 115    | 5.3       | -3.3      | -3.2      | -2.8      | -2.0      | -2.8      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.35 | 1.54 | 2.16  | 2.14  | 2.07  | 2.05  | 2.07   | 6.0       | -0.1      | -0.3      | -0.1      | 0.1       | -0.1      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |       |       |       |       |        | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -     | -     | -     | -     | -      | -         | -         | -         | -         | -         | -         |

# Philippines [LCET]

## Primary energy consumption

|                                | MTOE         |              |              |              |              |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005         | 2021         | 2030         | 2040         | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>28.71</b> | <b>42.56</b> | <b>61.32</b> | <b>70.82</b> | <b>92.29</b> | <b>118.33</b> | <b>140.75</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.5</b> | <b>1.6</b> | <b>2.7</b> | <b>2.5</b> | <b>1.7</b> |
| Coal                           | 1.53         | 5.32         | 18.91        | 14.20        | 15.92        | 16.64         | 15.32         | 5.3        | 12.5       | 30.8       | 20.1       | 17.2       | 14.1       | 10.9       | 8.5        | -3.1       | 1.1        | 0.4        | -0.8       |
| Oil                            | 10.84        | 18.15        | 19.17        | 23.06        | 23.26        | 21.48         | 16.53         | 37.8       | 42.6       | 31.3       | 32.6       | 25.2       | 18.2       | 11.7       | 1.9        | 2.1        | 0.1        | -0.8       | -2.6       |
| Natural gas                    | 0.00         | 2.70         | 3.29         | 9.59         | 11.22        | 16.20         | 24.59         | 0.0        | 6.3        | 5.4        | 13.5       | 12.2       | 13.7       | 17.5       | -          | 12.6       | 1.6        | 3.7        | 4.3        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00         | 0.00         |              |              |              |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00         | 3.23         | 7.65          | 7.34          | 0.0        | 0.0        | 0.0        | 0.0        | 3.5        | 6.5        | 5.2        | -          | -          | -          | 9.0        | -0.4       |
| Hydro                          | 0.52         | 2.09         | 0.79         | 1.43         | 3.08         | 3.80          | 3.64          | 1.8        | 4.9        | 1.3        | 2.0        | 3.3        | 3.2        | 2.6        | 1.4        | 6.8        | 7.9        | 2.1        | -0.4       |
| Geothermal                     | 4.70         | 8.51         | 9.18         | 8.72         | 12.98        | 18.19         | 20.18         | 16.4       | 20.0       | 15.0       | 12.3       | 14.1       | 15.4       | 14.3       | 2.2        | -0.6       | 4.1        | 3.4        | 1.0        |
| Others                         | 11.12        | 5.80         | 9.97         | 13.82        | 22.61        | 34.38         | 53.14         | 38.7       | 13.6       | 16.3       | 19.5       | 24.5       | 29.1       | 37.8       | -0.4       | 3.7        | 5.0        | 4.3        | 4.5        |
| Biomass                        | 11.12        | 5.80         | 8.87         | 10.18        | 14.14        | 13.57         | 12.71         | 38.7       | 13.6       | 14.5       | 14.4       | 15.3       | 11.5       | 9.0        | -0.7       | 1.5        | 3.3        | -0.4       | -0.7       |
| Solar Wind Ocean               | 0.00         | 0.00         | 0.24         | 1.06         | 2.88         | 10.67         | 22.11         | 0.0        | 0.0        | 0.4        | 1.5        | 3.1        | 9.0        | 15.7       | -          | 18.2       | 10.5       | 14.0       | 7.6        |
| Biofuels                       | 0.00         | 0.00         | 0.86         | 2.58         | 5.59         | 10.13         | 18.32         | 0.0        | 0.0        | 1.4        | 3.6        | 6.1        | 8.6        | 13.0       | -          | 12.9       | 8.0        | 6.1        | 6.1        |
| Electricity (Import or Export) | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0.00          | 0.0        | 0.0        | 0.00       | 0.00       | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

## Final energy demand

|              | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>19.02</b> | <b>22.67</b> | <b>38.21</b> | <b>47.17</b> | <b>59.53</b> | <b>71.45</b> | <b>85.18</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.3</b> | <b>2.4</b> | <b>2.4</b> | <b>1.8</b> | <b>1.8</b> |
| Industry     | 4.13         | 4.95         | 7.17         | 8.86         | 11.09        | 14.47        | 18.92        | 21.7       | 21.8       | 18.8       | 18.8       | 18.6       | 20.3       | 22.2       | 1.8        | 2.4        | 2.3        | 2.7        | 2.7        |
| Transport    | 4.69         | 8.23         | 12.74        | 16.49        | 20.13        | 23.83        | 29.11        | 24.6       | 36.3       | 33.3       | 34.9       | 33.8       | 34.2       | 3.3        | 2.9        | 2.0        | 1.7        | 2.0        | 2.1        |
| Others       | 9.82         | 9.31         | 16.66        | 20.19        | 26.66        | 31.51        | 35.50        | 51.6       | 41.0       | 43.6       | 42.8       | 44.8       | 44.1       | 41.7       | 1.7        | 2.2        | 2.8        | 1.7        | 1.2        |
| Non-energy   | 0.39         | 0.19         | 1.64         | 1.64         | 1.64         | 1.64         | 1.64         | 2.0        | 0.8        | 4.3        | 3.5        | 2.8        | 2.3        | 1.9        | 4.8        | 0.0        | 0.0        | 0.0        | 0.0        |
| <b>Total</b> | <b>19.02</b> | <b>22.67</b> | <b>38.21</b> | <b>47.17</b> | <b>59.53</b> | <b>71.45</b> | <b>85.18</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.3</b> | <b>2.4</b> | <b>2.4</b> | <b>1.8</b> | <b>1.8</b> |
| Coal         | 0.70         | 1.18         | 2.16         | 2.30         | 2.38         | 1.95         | 1.23         | 3.7        | 5.2        | 5.7        | 4.9        | 4.0        | 2.7        | 1.4        | 3.7        | 0.7        | 0.3        | -1.9       | -4.5       |
| Oil          | 8.08         | 11.80        | 18.77        | 22.05        | 22.12        | 20.22        | 15.40        | 42.5       | 52.0       | 49.1       | 46.8       | 37.2       | 28.3       | 18.1       | 2.8        | 1.8        | 0.0        | -0.9       | -2.7       |
| Natural gas  | 0.00         | 0.01         | 0.06         | 0.07         | 0.08         | 0.09         | 0.10         | 0.0        | 0.1        | 0.2        | 0.1        | 0.1        | 0.1        | 0.1        | -          | 1.2        | 1.2        | 1.2        | 1.2        |
| Hydrogen     | 0.00         | 0.00         | 0.00         | 0.00         | 0.12         | 1.74         | 4.42         | 0.0        | 0.0        | 0.0        | 0.0        | 0.2        | 2.4        | 5.2        | -          | -          | -          | 30.8       | 9.7        |
| Fuel Ammonia | 0.00         | 0.00         |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 1.82         | 3.88         | 7.93         | 11.56        | 17.00        | 25.96        | 35.12        | 9.6        | 17.1       | 20.8       | 24.5       | 28.6       | 36.3       | 41.2       | 4.9        | 4.3        | 3.9        | 4.3        | 3.1        |
| Heat         | 0.00         | 0.00         |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 8.42         | 5.80         | 9.28         | 11.19        | 17.83        | 21.48        | 28.91        | 44.3       | 25.6       | 24.3       | 23.7       | 30.0       | 30.1       | 33.9       | 0.3        | 2.1        | 4.8        | 1.9        | 3.0        |

## Power generation Output

|                                     | TWh          |              |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>26.33</b> | <b>56.57</b> | <b>106.11</b> | <b>156.75</b> | <b>227.56</b> | <b>343.13</b> | <b>453.80</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>4.3</b> | <b>3.9</b> | <b>4.2</b> | <b>2.8</b> |
| Coal PP                             | 1.93         | 15.26        | 62.05         | 46.17         | 0.00          | 0.00          | 0.00          | 7          | 27         | 58         | 30         | 0          | 0          | 0          | 11.8       | -3.2       | -100.0     | -          | -100.0     |
| Coal PP with biomass co-firing      | 0.00         | 0.00         |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00          | 0.00          | 55.11         | 59.78         | 57.36         | 0          | 0          | 0          | 0          | 24         | 17         | 13         | -          | -          | -          | 0.8        | -0.4       |
| Oil PP                              | 12.43        | 6.14         | 1.62          | 5.20          | 5.93          | 6.57          | 5.87          | 47         | 11         | 2          | 3          | 3          | 2          | 1          | -6.4       | 13.9       | 1.3        | 1.0        | -1.1       |
| Gas PP                              | 0.00         | 16.86        | 18.68         | 60.88         | 0.00          | 0.00          | 0.00          | 0          | 30         | 18         | 39         | 0          | 0          | 0          | -          | 14.0       | -100.0     | -          | -100.0     |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00          | 0.00          | 6.89          | 13.59         | 26.07         | 0          | 0          | 0          | 0          | 3          | 4          | 6          | -          | -          | -          | 7.0        | 6.7        |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00          | 0.00          | 62.69         | 95.37         | 148.47        | 0          | 0          | 0          | 0          | 28         | 28         | 33         | -          | -          | -          | 4.3        | 4.5        |
| Nuclear PP                          | 0.00         | 0.00         | 0.00          | 0.00          | 12.40         | 29.34         | 28.16         | 0          | 0          | 0          | 0          | 5          | 9          | 6          | -          | -          | -          | 9.0        | -0.4       |
| Solar PV                            | 0.00         | 0.00         | 1.47          | 7.04          | 13.78         | 36.68         | 54.76         | 0          | 0          | 1          | 5          | 6          | 11         | 12         | -          | 19.0       | 7.0        | 10.3       | 4.1        |
| Wind                                | 0.00         | 0.02         | 1.27          | 5.26          | 15.75         | 31.60         | 62.58         | 0          | 0          | 1          | 3          | 7          | 9          | 14         | -          | 17.1       | 11.6       | 7.2        | 7.1        |
| Hydro                               | 6.06         | 8.39         | 9.19          | 16.65         | 35.78         | 44.15         | 42.37         | 23         | 15         | 9          | 11         | 16         | 13         | 9          | 1.3        | 6.8        | 7.9        | 2.1        | -0.4       |
| Geothermal                          | 5.47         | 9.90         | 10.68         | 10.14         | 15.10         | 21.16         | 23.47         | 21         | 18         | 10         | 7          | 7          | 6          | 5          | 2.2        | -0.6       | 4.1        | 3.4        | 1.0        |
| Biomass and others                  | 0.43         | 0.00         | 1.16          | 3.40          | 4.13          | 4.89          | 4.69          | 2          | 0          | 1          | 2          | 2          | 1          | 1          | 3.3        | 12.7       | 2.0        | 1.7        | -0.4       |

## Power generation Input

|                      | MTOE        |             |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>2.69</b> | <b>8.09</b> | <b>20.51</b> | <b>23.99</b> | <b>27.82</b> | <b>35.76</b> | <b>45.49</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>6.8</b> | <b>1.8</b> | <b>1.5</b> | <b>2.5</b> | <b>2.4</b> |
| Coal                 | 0.51        | 4.13        | 16.75        | 11.90        | 13.54        | 14.69        | 14.09        | 18.9       | 51.1       | 81.7       | 49.6       | 48.7       | 41.1       | 31.0       | 11.9       | -3.7       | 1.3        | 0.8        | -0.4       |
| Fuel ammonia         | 0.00        | 0.00        |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                  | 2.18        | 1.40        | 0.39         | 1.24         | 1.42         | 1.57         | 1.40         | 81.1       | 17.3       | 1.9        | 5.2        | 5.1        | 4.4        | 3.1        | -5.4       | 13.8       | 1.3        | 1.0        | -1.1       |
| Gas                  | 0.00        | 2.56        | 2.92         | 9.52         | 11.14        | 16.11        | 24.49        | 0.0        | 31.6       | 14.2       | 39.7       | 40.0       | 45.0       | 53.8       | -          | 14.0       | 1.6        | 3.8        | 4.3        |
| Hydrogen             | 0.00        | 0.00        | 0.00         | 0.11         | 1.49         | 3.67         | 0.00         | 0.0        | 0.0        | 0.0        | 0.4        | 4.2        | 8.1        | -          | -          | -          | 30.0       | 9.5        | -          |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.45         | 1.32         | 1.62         | 1.91         | 1.83         | 0.0        | 0.0        | 2.2        | 5.5        | 5.8        | 5.3        | 4.0        | -          | 12.6       | 2.0        | 1.7        | -0.4       |

## Thermal Efficiency

|              | %         |           |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)     |            |            |            |            |
|--------------|-----------|-----------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|-------------|------------|------------|------------|------------|
|              | 1990      | 2005      | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>47</b> | <b>41</b> | <b>35.0</b> | <b>41.5</b> | <b>41.7</b> | <b>43.3</b> | <b>45.8</b> |  |  |  |  |  |  |  | <b>-1.0</b> | <b>1.9</b> | <b>0.0</b> | <b>0.4</b> | <b>0.6</b> |
| Coal PP      | 33        | 32        | 32          | 33          | 35          | 35          | 35          |  |  |  |  |  |  |  | -0.1        | 0.5        | 0.5        | 0.0        | 0.0        |
| Oil PP       | 49        | 38        | 36          | 36          | 36          | 36          | 36          |  |  |  |  |  |  |  | -1.0        | 0.1        | 0.0        | 0.0        | 0.0        |
| Gas PP       | -         | 57        | 55          | 55          | 53          | 53          | 53          |  |  |  |  |  |  |  | -           | 0.0        | -0.3       | 0.0        | 0.0        |
| Biomass PP   | -         | -         | 22          | 22          | 22          | 22          | 22          |  |  |  |  |  |  |  | -           | 0.0        | 0.0        | 0.0        | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |              |              |              |              |             |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |
|--------------|--------------------|-------------|--------------|--------------|--------------|--------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|
|              | 1990               | 2005        | 2021         | 2030         | 2040         | 2050         | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>10.2</b>        | <b>65.7</b> | <b>132.3</b> | <b>141.7</b> | <b>149.1</b> | <b>115.0</b> | <b>60.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>8.6</b> | <b>0.8</b> | <b>0.5</b> | <b>-2.6</b> | <b>-6.1</b> |
| Coal         | 1.36               | 20.20       | 72.5         | 54.3         | 58.5         | 35.2         | 9.4         | 13.4       | 30.8       | 54.8       | 38.3       | 39.2       | 30.6       | 15.4       | 13.7       | -3.2       | 0.8        | -4.9        | -12.4       |
| Oil          | 8.80               | 39.44       | 52.8         | 65.0         | 65.5         | 60.0         | 44.7        | 86.6       | 60.1       | 39.9       | 45.9       | 43.9       | 52.2       | 73.4       | 6.0        | 2.3        | 0.1        | -0.9        | -2.9        |
| Natural Gas  | 0.00               | 6.01        | 7.0          | 22.4         | 25.1         | 19.8         | 6.8         | 0.0        | 9.2        | 5.3        | 15.8       | 16.8       | 17.2       | 11.2       | -          | 13.9       | 1.2        | -2.4        | -10.1       |
| CCS/DAC (-)  | 0.00               | 0.00        |              |              |              |              |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -           | -           |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |       |       |       | AAGR(%)   |           |           |           |           |      |
|-------------------------------------------------------------------------------------------|------|------|------|------|-------|-------|-------|-----------|-----------|-----------|-----------|-----------|------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040  | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060 |
| GDP (billions of 2015 US dollars)                                                         | 143  | 179  | 379  | 678  | 1,321 | 2,355 | 4,004 | 3.2       | 6.7       | 6.90      | 5.95      | 5.4       | 6.2  |
| Population (millions of people)                                                           | 62   | 85   | 111  | 123  | 134   | 145   | 157   | 1.9       | 1.1       | 0.9       | 0.8       | 0.8       | 0.9  |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 2.3  | 2.1  | 3.4  | 5.5  | 9.9   | 16.2  | 25.5  | 1.3       | 5.5       | 6.0       | 5.1       | 4.6       | 5.3  |
| Primary energy consumption per capita (toe/person)                                        | 0.5  | 0.5  | 0.6  | 0.6  | 0.7   | 0.8   | 0.9   | 0.6       | 0.5       | 1.8       | 1.7       | 0.9       | 1.3  |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 201  | 237  | 162  | 104  | 70    | 50    | 35    | -0.7      | -4.7      | -3.9      | -3.2      | -3.5      | -3.8 |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 133  | 126  | 101  | 70   | 45    | 30    | 21    | -0.9      | -4.0      | -4.3      | -3.9      | -3.5      | -3.9 |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 71   | 366  | 349  | 209  | 113   | 49    | 15    | 5.3       | -5.5      | -6.0      | -8.0      | -11.0     | -7.7 |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.35 | 1.54 | 2.16 | 2.00 | 1.62  | 0.97  | 0.43  | 6.0       | -0.8      | -2.1      | -5.0      | -7.8      | -4.0 |
| Automobile ownership volume (millions of vehicles)                                        |      |      |      |      |       |       |       | -         | -         | -         | -         | -         | -    |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -     | -     | -     | -         | -         | -         | -         | -         | -    |



## Singapore [BAU]

### Primary energy consumption

|                                | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>14.63</b> | <b>21.33</b> | <b>22.94</b> | <b>27.92</b> | <b>35.55</b> | <b>45.34</b> | <b>56.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.5</b> | <b>2.2</b> | <b>2.4</b> | <b>2.5</b> | <b>2.2</b> | <b>2.3</b> |
| Coal                           | 0.00         | 0.43         | 0.46         | 0.49         | 0.56         | 0.65         | 0.77         | 0.0        | 2.0        | 2.0        | 1.8        | 1.6        | 1.4        | 1.4        | -          | 0.7        | 1.3        | 1.5        | 1.7        | 1.3        |
| Oil                            | 12.36        | 12.30        | 12.26        | 15.55        | 19.92        | 25.07        | 29.14        | 84.5       | 57.7       | 53.4       | 55.7       | 56.0       | 55.3       | 51.9       | 0.0        | 2.7        | 2.5        | 2.3        | 1.5        | 2.2        |
| Natural gas                    | 1.89         | 7.87         | 9.55         | 11.07        | 13.99        | 18.15        | 24.34        | 12.9       | 36.9       | 41.6       | 39.6       | 39.4       | 40.0       | 43.4       | 5.4        | 1.7        | 2.4        | 2.6        | 3.0        | 2.4        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Geothermal                     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 0.39         | 0.74         | 0.68         | 0.81         | 1.08         | 1.47         | 1.85         | 2.7        | 3.5        | 3.0        | 2.9        | 3.0        | 3.2        | 3.3        | 1.8        | 2.0        | 2.9        | 3.1        | 2.3        | 2.6        |
| Biomass                        | 0.39         | 0.72         | 0.61         | 0.71         | 0.91         | 1.20         | 1.50         | 2.7        | 3.4        | 2.7        | 2.5        | 2.6        | 2.6        | 2.7        | 1.5        | 1.7        | 2.5        | 2.8        | 2.3        | 2.3        |
| Solar Wind Ocean               | 0.00         | 0.01         | 0.07         | 0.10         | 0.17         | 0.27         | 0.35         | 0.0        | 0.1        | 0.3        | 0.4        | 0.5        | 0.6        | 0.6        | -          | 4.0        | 5.4        | 4.7        | 2.6        | 4.2        |
| Biofuels                       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.00       | 0.00       | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Final energy demand

|              | MTOE        |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>8.90</b> | <b>17.83</b> | <b>18.71</b> | <b>23.14</b> | <b>29.76</b> | <b>38.19</b> | <b>47.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.4</b> | <b>2.4</b> | <b>2.5</b> | <b>2.5</b> | <b>2.1</b> | <b>2.4</b> |
| Industry     | 2.23        | 6.04         | 7.02         | 9.11         | 12.63        | 17.58        | 24.55        | 25.1       | 33.9       | 37.5       | 39.4       | 42.4       | 46.0       | 52.1       | 3.8        | 2.9        | 3.3        | 3.4        | 3.4        | 3.3        |
| Transport    | 1.79        | 2.67         | 2.28         | 2.62         | 3.07         | 3.67         | 4.45         | 20.1       | 15.0       | 12.2       | 11.3       | 10.3       | 9.6        | 9.4        | 0.8        | 1.6        | 1.6        | 1.8        | 1.9        | 1.7        |
| Others       | 1.71        | 2.57         | 2.72         | 2.88         | 3.49         | 4.33         | 5.49         | 19.2       | 14.4       | 14.5       | 12.4       | 11.7       | 11.3       | 11.7       | 1.5        | 0.6        | 1.9        | 2.2        | 2.4        | 1.8        |
| Non-energy   | 3.17        | 6.55         | 6.69         | 8.53         | 10.57        | 12.61        | 12.61        | 35.6       | 36.7       | 35.8       | 36.9       | 35.5       | 33.0       | 26.8       | 2.7        | 2.2        | 1.8        | 0.0        | 0.0        | 1.6        |
| <b>Total</b> | <b>8.90</b> | <b>17.83</b> | <b>18.71</b> | <b>23.14</b> | <b>29.77</b> | <b>38.20</b> | <b>47.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.4</b> | <b>2.4</b> | <b>2.6</b> | <b>2.5</b> | <b>2.1</b> | <b>2.4</b> |
| Coal         | 0.00        | 0.17         | 0.18         | 0.18         | 0.18         | 0.18         | 0.18         | 0.0        | 0.9        | 1.0        | 0.8        | 0.6        | 0.5        | 0.4        | -          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil          | 6.40        | 12.26        | 12.19        | 15.42        | 19.72        | 24.77        | 28.76        | 71.9       | 68.7       | 65.2       | 66.6       | 66.2       | 64.8       | 61.1       | 2.1        | 2.6        | 2.5        | 2.3        | 1.5        | 2.2        |
| Natural gas  | 0.11        | 1.22         | 1.74         | 2.49         | 3.74         | 5.65         | 8.58         | 1.2        | 6.9        | 9.3        | 10.8       | 12.6       | 14.8       | 18.2       | 9.4        | 4.1        | 4.2        | 4.2        | 4.3        | 4.2        |
| Hydrogen     | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 2.39        | 4.18         | 4.60         | 5.05         | 6.13         | 7.60         | 9.58         | 26.9       | 23.5       | 24.6       | 21.8       | 20.6       | 19.9       | 20.3       | 2.1        | 1.0        | 2.0        | 2.2        | 2.3        | 1.9        |
| Heat         | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

### Power generation Output

|                                     | TWh          |              |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>33.09</b> | <b>51.68</b> | <b>55.79</b> | <b>62.24</b> | <b>75.57</b> | <b>93.71</b> | <b>118.13</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.7</b> | <b>1.2</b> | <b>2.0</b> | <b>2.2</b> | <b>2.3</b> | <b>1.9</b> |
| Coal PP                             | 0.00         | 0.62         | 0.69         | 0.77         | 0.94         | 1.16         | 1.47          | 0          | 1          | 1          | 1          | 1          | 1          | 1          | -          | 1.2        | 2.0        | 2.1        | 2.4        | 1.9        |
| Coal PP with biomass co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 69         | 1          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 28         | 95         | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Oil                                 | 22.85        | 0.36         | 0.44         | 0.88         | 1.36         | 2.05         | 2.58          | 0          | 0          | 0          | 1          | 1          | 2          | 2          | -12.0      | 8.0        | 4.4        | 4.2        | 2.3        | 4.6        |
| Gas PP                              | 9.30         | 49.11        | 52.38        | 57.69        | 69.03        | 84.34        | 106.31        | 0          | 0          | 94         | 93         | 91         | 90         | 90         | 5.7        | 1.1        | 1.8        | 2.0        | 2.3        | 1.8        |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00         | 0.15         | 0.76         | 1.12         | 1.96         | 3.19         | 4.02          | 0          | 0          | 1          | 2          | 3          | 3          | 3          | -          | 4.4        | 5.8        | 5.0        | 2.3        | 4.4        |
| Wind                                | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Hydro                               | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Geothermal                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.95         | 1.44         | 1.52         | 1.78         | 2.28         | 2.97         | 3.75          | 3          | 3          | 3          | 3          | 3          | 3          | 3          | 1.5        | 1.8        | 2.5        | 2.7        | 2.4        | 2.3        |

### Power generation Input

|                      | MTOE        |             |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>7.73</b> | <b>6.95</b> | <b>8.15</b> | <b>9.02</b> | <b>10.83</b> | <b>13.27</b> | <b>16.73</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.2</b> | <b>1.1</b> | <b>1.8</b> | <b>2.1</b> | <b>2.3</b> | <b>1.9</b> |
| Coal                 | 0.00        | 0.26        | 0.28        | 0.31        | 0.38         | 0.47         | 0.59         | 0.0        | 3.7        | 3.4        | 3.4        | 3.5        | 3.5        | 3.5        | -          | 1.1        | 2.1        | 2.1        | 2.3        | 1.9        |
| Fuel ammonia         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Oil                  | 5.95        | 0.05        | 0.07        | 0.13        | 0.20         | 0.30         | 0.38         | 77.0       | 0.7        | 0.8        | 1.4        | 1.8        | 2.3        | 2.3        | -13.5      | 7.8        | 4.4        | 4.1        | 2.4        | 4.6        |
| Gas                  | 1.78        | 6.64        | 7.81        | 8.58        | 10.25        | 12.50        | 15.76        | 23.0       | 95.6       | 95.8       | 95.1       | 94.6       | 94.2       | 94.2       | 4.9        | 1.1        | 1.8        | 2.0        | 2.3        | 1.8        |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) | 0.39        | 0.72        | 0.61        | 0.71        | 0.91         | 1.20         | 1.50         | 5.0        | 10.4       | 7.5        | 7.9        | 8.4        | 9.0        | 9.0        | 1.5        | 1.7        | 2.5        | 2.8        | 2.3        | 2.3        |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total      | 36.8 | 63.8 | 58.1 | 58.3 | 58.5 | 58.7 | 58.7 |  |  |  |  |  |  |  | 1.5       | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |
| Coal PP    | -    | 20.6 | 21.3 | 21.4 | 21.3 | 21.2 | 21.4 |  |  |  |  |  |  |  | -         | 0.0       | 0.0       | 0.0       | 0.1       | 0.0       |
| Oil PP     | 33.0 | 67.5 | 57.3 | 58.2 | 58.5 | 58.8 | 58.4 |  |  |  |  |  |  |  | 1.8       | 0.2       | 0.0       | 0.0       | -0.1      | 0.0       |
| Gas PP     | 45.0 | 63.6 | 57.7 | 57.8 | 57.9 | 58.0 | 58.0 |  |  |  |  |  |  |  | 0.8       | 0.0       | 0.0       | 0.0       | 0.0       | 0.0       |
| Biomass PP | 20.9 | 17.1 | 21.4 | 21.6 | 21.5 | 21.3 | 21.5 |  |  |  |  |  |  |  | 0.1       | 0.1       | 0.0       | -0.1      | 0.1       | 0.0       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |             |             |             |             |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------------|-------------|-------------|-------------|-------------|-------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005        | 2021        | 2030        | 2040        | 2050        | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>29.0</b>        | <b>36.3</b> | <b>49.2</b> | <b>57.2</b> | <b>71.1</b> | <b>90.0</b> | <b>114.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.7</b> | <b>1.7</b> | <b>2.2</b> | <b>2.4</b> | <b>2.5</b> |
| Coal         | 0.10               | 0.00        | 1.8         | 1.9         | 2.2         | 2.5         | 3.0          | 0.3        | 0.0        | 3.7        | 3.3        | 3.1        | 2.8        | 2.6        | 9.8        | 0.6        | 1.3        | 1.5        | 1.7        |
| Oil          | 28.80              | 24.30       | 24.7        | 29.3        | 36.1        | 44.8        | 54.6         | 99.3       | 66.9       | 50.1       | 51.2       | 50.8       | 49.8       | 47.6       | -0.5       | 1.9        | 2.1        | 2.2        | 2.0        |
| Gas          | 0.10               | 12.00       | 22.7        | 26.0        | 32.9        | 42.6        | 57.2         | 0.3        | 33.1       | 46.2       | 45.5       | 46.2       | 47.4       | 49.8       | 19.1       | 1.5        | 2.4        | 2.6        | 3.0        |
| CCS/DAC (-)  | 0.00               | 0.00        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |      |      |        |      |      |       |         | AAGR(%)   |           |           |           |           |      |
|-------------------------------------------------------------------------------------------|------|------|--------|------|------|-------|---------|-----------|-----------|-----------|-----------|-----------|------|
|                                                                                           | 1990 | 2005 | 2021   | 2030 | 2040 | 2050  | 2060    | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2060 |
| GDP (billions of 2015 US dollars)                                                         | 71   | 179  | 367.6  | 458  | 609  | 811   | 1,079   | 5.4       | 2.5       | 2.90      | 2.90      | 2.9       | 2.8  |
| Population (millions of people)                                                           | 3.1  | 4.3  | 5.5    | 6.2  | 6.4  | 6.3   | 6.2     | 1.9       | 1.5       | 0.3       | -0.1      | -0.3      | 0.3  |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 23.3 | 41.9 | 67.457 | 73.4 | 95.0 | 127.9 | 175.168 | 3.5       | 0.9       | 2.6       | 3.0       | 3.2       | 2.5  |
| Primary energy consumption per capita (toe/person)                                        | 4.8  | 5.0  | 4.2    | 4.5  | 5.5  | 7.2   | 9.1     | -0.4      | 0.7       | 2.2       | 2.6       | 2.4       | 2.0  |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 206  | 119  | 62     | 61   | 58   | 56    | 52      | -3.8      | -0.3      | -0.4      | -0.4      | -0.7      | -0.5 |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 125  | 100  | 51     | 51   | 49   | 47    | 44      | -2.9      | -0.1      | -0.3      | -0.4      | -0.8      | -0.4 |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 408  | 203  | 134    | 125  | 117  | 111   | 106     | -3.5      | -0.8      | -0.7      | -0.5      | -0.4      | -0.6 |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.98 | 1.70 | 2.15   | 2.05 | 2.00 | 1.98  | 2.04    | 0.3       | -0.5      | -0.2      | -0.1      | 0.3       | -0.1 |
| Automobile ownership volume (millions of vehicles)                                        | -    | -    | -      | -    | -    | -     | -       | -         | -         | -         | -         | -         | -    |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -      | -    | -    | -     | -       | -         | -         | -         | -         | -         | -    |

## Singapore [LCET]

### Primary energy consumption

|                                | MTOE         |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>14.63</b> | <b>21.33</b> | <b>22.94</b> | <b>26.73</b> | <b>33.75</b> | <b>43.48</b> | <b>54.22</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.5</b> | <b>1.7</b> | <b>2.4</b> | <b>2.6</b> | <b>2.2</b> |
| Coal                           | 0.00         | 0.43         | 0.46         | 0.18         | 0.18         | 0.18         | 0.18         | 0.0        | 2.0        | 2.0        | 0.7        | 0.5        | 0.4        | 0.3        | -          | -9.9       | 0.0        | 0.0        | -2.4       |
| Oil                            | 12.36        | 12.30        | 12.26        | 15.31        | 18.09        | 21.43        | 24.65        | 84.5       | 57.7       | 53.4       | 57.3       | 53.6       | 49.3       | 45.5       | 0.0        | 2.5        | 1.7        | 1.7        | 1.4        |
| Natural gas                    | 1.89         | 7.87         | 9.55         | 9.43         | 8.06         | 7.22         | 10.68        | 12.9       | 36.9       | 41.6       | 35.3       | 23.9       | 16.6       | 19.7       | 5.4        | -0.1       | -1.6       | -1.1       | 4.0        |
| Hydrogen                       | 0.00         | 0.00         | 0.00         | 0.00         | 3.06         | 7.61         | 10.07        | 0.0        | 0.0        | 0.0        | 0.0        | 9.1        | 17.5       | 18.6       | -          | -          | -          | 9.5        | 2.8        |
| Fuel Ammonia                   | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Geothermal                     | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 0.39         | 0.74         | 0.68         | 1.81         | 4.36         | 7.04         | 8.64         | 2.7        | 3.5        | 3.0        | 6.8        | 12.9       | 16.2       | 15.9       | 1.8        | 11.5       | 9.2        | 4.9        | 2.1        |
| Biomass                        | 0.39         | 0.72         | 0.61         | 1.99         | 4.50         | 5.94         | 2.7          | 3.4        | 2.7        | 1.0        | 5.9        | 10.3       | 11.0       | 1.5        | -8.3       | 21.7       | 8.5        | 2.8        | 6.0        |
| Solar Wind Ocean               | 0.00         | 0.01         | 0.07         | 0.21         | 0.31         | 0.48         | 0.64         | 0.0        | 0.1        | 0.3        | 0.8        | 0.9        | 1.1        | 1.2        | -          | 13.0       | 4.0        | 4.5        | 2.9        |
| Biofuels                       | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity (Import or Export) | 0.00         | 0.00         | 0.00         | 1.32         | 2.06         | 2.06         | 2.06         | 0.0        | 0.0        | 0.00       | 4.94       | 6.1        | 4.7        | 3.8        | -          | -          | 4.6        | 0.0        | 0.0        |

### Final energy demand

|              | MTOE        |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>8.90</b> | <b>17.83</b> | <b>18.71</b> | <b>23.26</b> | <b>29.27</b> | <b>37.16</b> | <b>45.89</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.4</b> | <b>2.4</b> | <b>2.3</b> | <b>2.4</b> | <b>2.1</b> |
| Industry     | 2.23        | 6.04         | 7.02         | 9.22         | 12.77        | 17.75        | 24.76        | 25.1       | 33.9       | 37.5       | 39.6       | 43.6       | 47.8       | 54.0       | 3.8        | 3.1        | 3.3        | 3.3        | 3.4        |
| Transport    | 1.79        | 2.67         | 2.28         | 2.38         | 2.37         | 2.68         | 3.30         | 20.1       | 15.0       | 12.2       | 10.2       | 8.1        | 7.2        | 7.2        | 0.8        | 0.5        | 0.0        | 1.2        | 2.1        |
| Others       | 1.71        | 2.57         | 2.72         | 3.13         | 3.56         | 4.12         | 5.22         | 19.2       | 14.4       | 14.5       | 13.5       | 12.2       | 11.1       | 11.4       | 1.5        | 1.6        | 1.3        | 1.5        | 2.4        |
| Non-energy   | 3.17        | 6.55         | 6.69         | 8.53         | 10.57        | 12.61        | 12.61        | 35.6       | 36.7       | 35.8       | 36.7       | 36.1       | 33.9       | 27.5       | 2.4        | 2.7        | 2.2        | 1.8        | 0.0        |
| <b>Total</b> | <b>8.90</b> | <b>17.83</b> | <b>18.71</b> | <b>23.26</b> | <b>29.27</b> | <b>37.16</b> | <b>45.90</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.4</b> | <b>2.4</b> | <b>2.3</b> | <b>2.4</b> | <b>2.1</b> |
| Coal         | 0.00        | 0.17         | 0.18         | 0.18         | 0.18         | 0.18         | 0.18         | 0.0        | 0.9        | 1.0        | 0.8        | 0.6        | 0.5        | 0.4        | -          | 0.0        | 0.0        | 0.0        | 0.0        |
| Oil          | 6.40        | 12.26        | 12.19        | 14.99        | 17.91        | 21.42        | 24.64        | 71.9       | 68.7       | 65.2       | 64.4       | 61.2       | 57.7       | 53.7       | 2.1        | 2.3        | 1.8        | 1.8        | 1.4        |
| Natural gas  | 0.11        | 1.22         | 1.74         | 2.46         | 3.68         | 5.57         | 8.50         | 1.2        | 6.9        | 9.3        | 10.6       | 12.6       | 15.0       | 18.5       | 9.4        | 3.9        | 4.1        | 4.2        | 4.3        |
| Hydrogen     | 0.00        | 0.00         | 0.00         | 0.00         | 0.71         | 1.89         | 2.52         | 0.0        | 0.0        | 0.0        | 0.0        | 2.4        | 5.1        | 5.5        | -          | -          | -          | 10.3       | 2.9        |
| Fuel Ammonia | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 2.39        | 4.18         | 4.60         | 5.63         | 6.79         | 8.09         | 10.06        | 26.9       | 23.5       | 24.6       | 24.2       | 23.2       | 21.8       | 21.9       | 2.1        | 2.3        | 1.9        | 1.8        | 2.2        |
| Heat         | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 0.00        | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

### Power generation Output

|                                     | TWh          |              |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)    |             |            |            |            |
|-------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|
|                                     | 1990         | 2005         | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>33.09</b> | <b>51.68</b> | <b>55.79</b> | <b>54.06</b> | <b>59.80</b> | <b>75.90</b> | <b>100.08</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.7</b> | <b>-0.3</b> | <b>1.0</b> | <b>2.4</b> | <b>2.8</b> |
| Coal PP                             | 0.00         | 0.62         | 0.69         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 1          | 1          | 0          | 0          | 0          | 0          | -          | -100.0      | -          | -          | -100.0     |
| Coal PP with biomass co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Oil                                 | 22.85        | 0.36         | 0.44         | 2.16         | 1.22         | 0.08         | 0.10          | 69         | 1          | 1          | 4          | 2          | 0          | 0          | -12.0      | 19.3        | -5.6       | -24.3      | 2.8        |
| Gas PP                              | 9.30         | 49.11        | 52.38        | 48.65        | 26.91        | 0.00         | 0.00          | 28         | 95         | 94         | 90         | 45         | 0          | 0          | 5.7        | -0.8        | -5.7       | -100.0     | -100.0     |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00         | 0.00         | 0.00         | 17.04        | 43.26        | 57.04         | 0          | 0          | 0          | 0          | 28         | 57         | 57         | -          | -           | -          | 9.8        | 2.8        |
| Gas PP with CCS                     | 0.00         | 0.00         | 0.00         | 0.00         | 4.19         | 10.62        | 14.01         | 0          | 0          | 0          | 0          | 7          | 14         | 14         | -          | -           | -          | 9.7        | 2.8        |
| Nuclear PP                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Solar PV                            | 0.00         | 0.15         | 0.76         | 2.43         | 3.56         | 5.62         | 7.41          | 0          | 0          | 1          | 4          | 6          | 7          | 7          | -          | 13.8        | 3.9        | 4.7        | 2.8        |
| Wind                                | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Hydro                               | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Geothermal                          | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00         | 0.00          | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -           | -          | -          | -          |
| Biomass and others                  | 0.95         | 1.44         | 1.52         | 0.82         | 6.88         | 16.32        | 21.52         | 3          | 3          | 3          | 2          | 12         | 22         | 22         | 1.5        | -6.6        | 23.7       | 9.0        | 2.8        |

### Power generation Input

|                      | MTOE        |             |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |             |            |            |            |
|----------------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>8.12</b> | <b>7.67</b> | <b>8.76</b> | <b>7.57</b> | <b>8.90</b> | <b>11.88</b> | <b>15.68</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.2</b> | <b>-1.6</b> | <b>1.6</b> | <b>2.9</b> | <b>2.8</b> |
| Coal                 | 0.00        | 0.26        | 0.28        | 0.00        | 0.00        | 0.00         | 0.00         | 0.0        | 3.4        | 3.2        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -100.0      | -          | -          | -100.0     |
| Fuel ammonia         | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 0.00        | 0.00        | 0.00        | 0.00        | 0.00         | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Oil                  | 5.95        | 0.05        | 0.07        | 0.32        | 0.18        | 0.01         | 0.01         | 73.3       | 0.6        | 0.8        | 4.2        | 2.0        | 0.1        | 0.1        | -13.5      | 19.2        | -5.6       | -24.2      | 2.8        |
| Gas                  | 1.78        | 6.64        | 7.81        | 6.97        | 4.38        | 1.65         | 2.18         | 21.9       | 86.6       | 89.1       | 92.1       | 49.2       | 13.9       | 13.9       | 4.9        | -1.2        | -4.5       | -9.3       | 2.8        |
| Hydrogen             | 0.00        | 0.00        | 0.00        | 0.00        | 2.35        | 5.72         | 7.55         | 0.0        | 0.0        | 0.0        | 0.0        | 26.4       | 48.1       | 48.1       | -          | -           | -          | 9.3        | 2.8        |
| Biomass (Biomass PP) | 0.39        | 0.72        | 0.61        | 0.28        | 1.99        | 4.50         | 5.94         | 4.8        | 9.4        | 7.0        | 3.7        | 22.4       | 37.9       | 37.9       | 1.5        | -8.3        | 21.7       | 8.5        | 2.8        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |             |             |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|-------------|-------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060  |
| <b>Total</b> | <b>35.0</b> | <b>57.8</b> | <b>54.0</b> | <b>58.7</b> | <b>54.3</b> | <b>50.9</b> | <b>50.8</b> |  |  |  |  |  |  |  | <b>1.4</b> | <b>0.9</b> | <b>-0.8</b> | <b>-0.7</b> | <b>0.0</b> |
| Coal PP      | -           | 20.6        | 21.3        | -           | -           | -           | -           |  |  |  |  |  |  |  | -          | -          | -           | -           | -          |
| Oil PP       | 33.0        | 67.5        | 57.3        | 58.1        | 58.3        | 58.0        | 58.0        |  |  |  |  |  |  |  | 1.8        | 0.1        | 0.0         | 0.0         | 0.0        |
| Gas PP       | 45.0        | 63.6        | 57.7        | 60.0        | 61.5        | 62.9        | 62.8        |  |  |  |  |  |  |  | 0.8        | 0.4        | 0.2         | 0.2         | 0.0        |
| Biomass PP   | 20.9        | 17.1        | 21.4        | 25.2        | 29.7        | 31.2        | 31.2        |  |  |  |  |  |  |  | 0.1        | 1.8        | 1.7         | 0.5         | 1.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |             |             |             |            |             |            |            |            |            |            |            |            | AAGR(%)    |            |             |              |           |               |
|--------------|--------------------|-------------|-------------|-------------|-------------|------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|--------------|-----------|---------------|
|              | 1990               | 2005        | 2021        | 2030        | 2040        | 2050       | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050    | 2050-2060 | 2021-2060     |
| <b>Total</b> | <b>29.0</b>        | <b>36.3</b> | <b>49.2</b> | <b>51.4</b> | <b>31.3</b> | <b>0.0</b> | <b>-4.6</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.7</b> | <b>0.5</b> | <b>-4.8</b> | <b>-48.6</b> | <b>-</b>  | <b>-194.1</b> |
| Coal         | 0.10               | 0.00        | 1.8         | 0.7         | 0.7         | 0.7        | 0.7         | 0.3        | 0.0        | 3.7        | 1.4        | 2.3        | 1775.0     | -15.5      | 9.8        | -9.9       | 0.0         | 0.0          | 0.0       | -2.4          |
| Oil          | 28.80              | 24.30       | 24.7        | 28.5        | 25.2        | 18.7       | 20.0        | 99.3       | 66.9       | 50.1       | 55.5       | 80.6       | 46775.0    | -437.3     | -0.5       | 1.6        | -1.2        | -2.9         | 0.7       | -0.5          |
| Natural Gas  | 0.10               | 12.00       | 22.7        | 22.2        | 13.6        | 1.6        | 2.4         | 0.3        | 33.1       | 46.2       | 43.1       | 43.5       | 4025.0     | -51.3      | 19.1       | -0.3       | -4.8        | -19.2        | 3.9       | -5.7          |
| CCS/DAC (-)  | 0.00               | 0.00        | 0.0         | 0.0         | -8.3        | -21.0      | -27.7       | 0.0        | 0.0        | 0.0        | 0.0        | -26.4      | -52475.0   | 604.1      | -          | -          | -           | 9.8          | 2.8       | -             |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |      |       |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|------|------|------|-------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040 | 2050  | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 71   | 179  | 368  | 458  | 609  | 811   | 1,079  | 5.4       | 2.5       | 2.90      | 2.90      | 2.9       | 2.8       |
| Population (millions of people)                                                           | 3    | 4    | 5    | 6    | 6    | 6     | 6      | 1.9       | 1.5       | 0.3       | -0.1      | -0.3      | 0.3       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 23.3 | 41.9 | 67.5 | 73.4 | 95.0 | 127.9 | 175.2  | 3.5       | 0.9       | 2.6       | 3.0       | 3.2       | 2.5       |
| Primary energy consumption per capita (toe/person)                                        | 4.8  | 5.0  | 4.2  | 4.3  | 5.3  | 6.9   | 8.8    | -0.4      | 0.2       | 2.1       | 2.7       | 2.5       | 1.9       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 206  | 119  | 62   | 58   | 55   | 54    | 50     | -3.8      | -0.7      | -0.5      | -0.3      | -0.6      | -0.6      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 125  | 100  | 51   | 51   | 48   | 46    | 43     | -2.9      | 0.0       | -0.6      | -0.5      | -0.7      | -0.5      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 408  | 203  | 134  | 112  | 51   | 0     | (4)    | -3.5      | -1.9      | -7.5      | -50.1     | -         | -191.5    |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.98 | 1.70 | 2.15 | 1.92 | 0.93 | 0.00  | (0.08) | 0.3       | -1.2      | -7.0      | -49.9     | -         | -192.0    |
| Automobile ownership volume (millions of vehicles)                                        | -    | -    | -    | -    | -    | -     | -      | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -    | -     | -      | -         | -         | -         | -         | -         | -         |

## Thailand [BAU]

### Primary energy consumption

|                      | MTOE         |              |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990         | 2005         | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>41.94</b> | <b>83.32</b> | <b>131.83</b> | <b>146.41</b> | <b>157.07</b> | <b>178.43</b> | <b>207.74</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>1.2</b> | <b>0.7</b> | <b>1.3</b> | <b>1.5</b> |
| Coal                 | 3.82         | 10.22        | 17.81         | 17.83         | 17.83         | 20.38         | 30.56         | 9.1        | 12.3       | 13.5       | 12.2       | 11.4       | 11.4       | 14.7       | 5.1        | 0.0        | 0.0        | 1.3        | 4.1        |
| Oil                  | 17.96        | 35.46        | 44.91         | 56.38         | 56.38         | 64.69         | 74.30         | 42.8       | 42.6       | 34.1       | 38.5       | 35.9       | 36.3       | 35.8       | 3.0        | 2.6        | 0.0        | 1.4        | 1.4        |
| Natural gas          | 4.99         | 13.49        | 37.54         | 42.78         | 42.78         | 45.44         | 51.67         | 11.9       | 16.2       | 28.5       | 29.2       | 27.2       | 25.5       | 24.9       | 6.7        | 1.5        | 0.0        | 0.6        | 1.3        |
| Hydrogen             |              |              |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia         |              |              |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear              |              |              |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                | 0.43         | 0.52         | 1.75          | 2.55          | 2.55          | 2.55          | 2.56          | 1.0        | 0.6        | 1.3        | 1.7        | 1.6        | 1.4        | 1.2        | 4.6        | 4.3        | 0.0        | 0.0        | 1.0        |
| Geothermal           |              |              |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others               | 14.74        | 23.62        | 29.83         | 26.87         | 37.53         | 45.37         | 48.65         | 35.1       | 28.4       | 22.6       | 18.4       | 23.9       | 25.4       | 23.4       | 2.3        | -1.2       | 3.4        | 1.9        | 0.7        |
| Biomass              | 14.69        | 19.00        | 17.03         | 12.65         | 18.36         | 21.80         | 23.81         | 35.0       | 22.8       | 12.9       | 8.6        | 11.7       | 12.2       | 11.5       | 0.5        | -3.2       | 3.8        | 1.7        | 0.9        |
| Solar Wind Ocean     |              |              | 0.42          | 0.76          | 1.93          | 3.57          | 4.27          | 0.0        | 0.5        | 0.6        | 1.3        | 2.3        | 2.4        | 2.1        | -          | 11.0       | 6.3        | 1.8        | 0.0        |
| Biofuels             |              | 0.39         | 3.11          | 4.48          | 6.06          | 6.90          | 7.82          | 0.0        | 0.5        | 2.4        | 3.1        | 3.9        | 3.9        | 3.8        | -          | 4.1        | 3.1        | 1.3        | 1.3        |
| Electricity (Import) | 0.05         | 3.82         | 8.93          | 7.81          | 9.54          | 12.40         | 12.74         | 0.1        | 4.6        | 6.78       | 5.33       | 6.1        | 7.0        | 6.1        | 18.0       | -1.5       | 2.0        | 2.7        | 0.3        |

### Final energy demand

|              | MTOE         |              |              |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021         | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>28.87</b> | <b>70.19</b> | <b>90.83</b> | <b>105.96</b> | <b>124.02</b> | <b>143.42</b> | <b>161.97</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>1.7</b> | <b>1.6</b> | <b>1.5</b> | <b>1.2</b> |
| Industry     | 8.65         | 18.03        | 26.80        | 32.11         | 37.91         | 44.03         | 49.26         | 30.0       | 25.7       | 29.5       | 30.3       | 30.6       | 30.7       | 30.4       | 3.7        | 2.0        | 1.7        | 1.5        | 1.1        |
| Transport    | 9.01         | 20.00        | 28.65        | 33.37         | 41.80         | 51.17         | 60.74         | 31.2       | 28.5       | 31.5       | 31.5       | 33.7       | 35.7       | 37.5       | 3.8        | 1.7        | 2.3        | 2.0        | 1.7        |
| Others       | 10.78        | 22.26        | 17.39        | 21.04         | 24.65         | 28.27         | 30.44         | 37.3       | 31.7       | 19.1       | 19.9       | 19.9       | 19.7       | 18.8       | 1.6        | 2.1        | 1.6        | 1.4        | 0.7        |
| Non-energy   | 0.43         | 9.89         | 17.99        | 19.45         | 19.66         | 19.95         | 21.53         | 1.5        | 14.1       | 19.8       | 18.4       | 15.9       | 13.9       | 13.3       | 12.8       | 0.9        | 0.1        | 0.1        | 0.8        |
| <b>Total</b> | <b>28.87</b> | <b>70.19</b> | <b>90.83</b> | <b>105.96</b> | <b>124.02</b> | <b>143.42</b> | <b>161.97</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>1.7</b> | <b>1.6</b> | <b>1.5</b> | <b>1.2</b> |
| Coal         | 1.31         | 5.32         | 6.38         | 8.59          | 10.50         | 12.44         | 14.34         | 4.5        | 7.6        | 7.0        | 8.1        | 8.5        | 8.7        | 8.9        | 5.2        | 3.4        | 2.0        | 1.7        | 1.4        |
| Oil          | 14.93        | 35.28        | 42.73        | 47.86         | 55.50         | 64.45         | 74.01         | 51.7       | 50.3       | 47.0       | 45.2       | 44.8       | 44.9       | 45.7       | 3.5        | 1.3        | 1.5        | 1.5        | 1.4        |
| Natural gas  | 0.14         | 0.79         | 8.04         | 8.81          | 10.03         | 11.16         | 12.53         | 0.5        | 1.1        | 8.9        | 8.3        | 8.1        | 7.8        | 7.7        | 14.0       | 1.0        | 1.3        | 1.1        | 1.2        |
| Hydrogen     |              |              |              |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Fuel Ammonia |              |              |              |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 3.30         | 12.72        | 24.07        | 28.16         | 32.39         | 36.71         | 41.50         | 11.4       | 18.1       | 26.5       | 26.6       | 26.1       | 25.6       | 25.6       | 6.6        | 1.8        | 1.4        | 1.3        | 1.2        |
| Heat         |              |              |              |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 9.20         | 16.08        | 9.61         | 12.54         | 15.59         | 18.66         | 19.59         | 31.9       | 22.9       | 10.6       | 11.8       | 12.6       | 13.0       | 12.1       | 0.1        | 3.0        | 2.2        | 1.8        | 0.5        |

### Power generation Output

|                                     | TWh          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>44.18</b> | <b>114.98</b> | <b>201.79</b> | <b>265.31</b> | <b>298.35</b> | <b>320.84</b> | <b>378.74</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>3.1</b> | <b>1.2</b> | <b>0.7</b> | <b>1.7</b> |
| Coal PP                             | 11.05        | 19.45         | 45.22         | 30.37         | 30.82         | 34.47         | 70.37         | 25.0       | 16.9       | 22.4       | 11.4       | 10.3       | 10.7       | 18.6       | 4.6        | -4.3       | 0.1        | 1.1        | 7.4        |
| Coal PP with biomass co-firing      |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with CCS                    |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                                 | 10.38        | 0.00          | 0.36          | 0.28          | 0.16          | 0.29          | 0.54          | 23.5       | 0.0        | 0.2        | 0.1        | 0.1        | 0.1        | 0.1        | -10.3      | -2.8       | -5.6       | 6.3        | 6.4        |
| Gas PP                              | 17.77        | 63.26         | 121.38        | 168.79        | 171.40        | 177.38        | 194.24        | 40.2       | 55.0       | 60.2       | 63.6       | 57.4       | 55.3       | 51.3       | 6.4        | 3.7        | 0.2        | 0.3        | 0.9        |
| Gas PP with hydrogen co-firing      |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Gas PP with CCS                     |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear PP                          |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Solar PV                            |              | 3.21          | 6.44          | 15.69         | 34.65         | 42.65         | 42.65         | 0.0        | 2.8        | 3.2        | 5.9        | 11.6       | 13.3       | 11.3       | -          | 10.4       | 8.2        | 2.1        | 0.0        |
| Wind                                |              | 1.74          | 2.25          | 6.60          | 7.06          | 8.68          | 8.68          | 0.0        | 1.5        | 1.1        | 2.5        | 2.4        | 2.7        | 2.3        | -          | 12.7       | 0.7        | 2.1        | 0.0        |
| Hydro                               | 4.98         | 21.07         | 20.35         | 28.82         | 29.63         | 29.63         | 29.79         | 11.3       | 18.3       | 10.1       | 10.9       | 9.9        | 9.2        | 7.9        | 4.6        | 3.9        | 0.3        | 0.0        | 1.0        |
| Geothermal                          |              |               |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass and others                  |              | 6.25          | 5.79          | 14.77         | 24.65         | 27.73         | 32.46         | 0.0        | 5.4        | 2.9        | 5.6        | 8.3        | 8.6        | 8.6        | -          | 11.0       | 5.3        | 1.2        | 1.6        |

### Power generation Input

|                      | MTOE        |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>8.92</b> | <b>18.16</b> | <b>35.94</b> | <b>40.84</b> | <b>44.77</b> | <b>47.06</b> | <b>60.12</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>1.4</b> | <b>0.9</b> | <b>0.5</b> | <b>2.5</b> |
| Coal                 | 2.55        | 4.90         | 11.44        | 7.47         | 7.33         | 7.95         | 16.22        | 28.6       | 27.0       | 31.8       | 18.3       | 16.4       | 16.9       | 27.0       | 5.0        | -4.6       | -0.2       | 0.8        | 7.4        |
| Fuel ammonia         |             |              |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  |             | 1.93         | 2.65         | 4.07         | 8.79         | 10.49        | 12.50        | 0.0        | 10.6       | 7.4        | 10.0       | 19.6       | 22.3       | 20.8       | -          | 4.9        | 8.0        | 1.8        | 1.8        |
| Oil                  | 2.55        | 0.00         | 0.08         | 0.06         | 0.03         | 0.06         | 0.12         | 28.6       | 0.0        | 0.2        | 0.1        | 0.1        | 0.1        | 0.2        | -10.6      | -2.8       | -5.7       | 6.4        | 6.3        |
| Gas                  | 3.82        | 11.32        | 21.77        | 29.24        | 28.61        | 28.56        | 31.28        | 42.9       | 62.4       | 60.6       | 71.6       | 63.9       | 60.7       | 52.0       | 5.8        | 3.3        | -0.2       | 0.0        | 0.9        |
| Hydrogen             |             |              |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) |             |              |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |             |            |             |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|-------------|------------|-------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050  | 2050-2060   |
| <b>Total</b> | <b>37.8</b> | <b>42.1</b> | <b>41.3</b> | <b>45.1</b> | <b>43.6</b> | <b>43.8</b> | <b>42.6</b> |  |  |  |  |  |  |  | <b>0.3</b> | <b>1.0</b> | <b>-0.3</b> | <b>0.1</b> | <b>-0.3</b> |
| Coal         | 37.3        | 24.5        | 27.6        | 22.6        | 16.4        | 16.1        | 21.1        |  |  |  |  |  |  |  | -1.0       | -2.2       | -3.2        | -0.2       | 2.7         |
| Oil          | 35.0        | 34.4        | 39.1        | 39.3        | 39.5        | 39.2        | 39.7        |  |  |  |  |  |  |  | 0.4        | 0.1        | 0.0         | -0.1       | 0.1         |
| Gas          | 40.0        | 48.1        | 47.9        | 49.6        | 51.5        | 53.4        | 53.4        |  |  |  |  |  |  |  | 0.6        | 0.4        | 0.4         | 0.4        | 0.0         |
| Biomass      | -           | -           | -           | -           | -           | -           | -           |  |  |  |  |  |  |  | -          | -          | -           | -          | -           |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>131.6</b>       | <b>150.1</b> | <b>214.3</b> | <b>232.6</b> | <b>259.8</b> | <b>295.2</b> | <b>365.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>0.9</b> | <b>1.1</b> | <b>1.3</b> | <b>2.2</b> | <b>1.4</b> |
| Coal         | 37.50              | 31.43        | 47.7         | 33.9         | 35.1         | 39.4         | 73.3         | 28.5       | 20.9       | 22.2       | 14.6       | 13.5       | 13.3       | 20.0       | 0.8        | -3.7       | 0.4        | 1.1        | 6.4        | 1.1        |
| Oil          | 44.67              | 90.54        | 103.2        | 115.7        | 140.0        | 168.3        | 195.4        | 34.0       | 60.3       | 48.2       | 49.8       | 53.9       | 57.0       | 53.4       | 2.7        | 1.3        | 1.9        | 1.9        | 1.5        | 1.7        |
| Natural Gas  | 49.38              | 28.17        | 63.4         | 82.9         | 84.6         | 87.5         | 97.1         | 37.5       | 18.8       | 29.6       | 35.7       | 32.6       | 29.6       | 26.5       | 0.8        | 3.0        | 0.2        | 0.3        | 1.0        | 1.1        |
| CCS/DAC (-)  |                    |              |              |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 142   | 284   | 461   | 549   | 663   | 800    | 966    | 3.9       | 2.0       | 1.90      | 1.90      | 1.9       | 1.9       |
| Population (millions of people)                                                           | 56.6  | 65.4  | 69.6  | 71.1  | 72.7  | 74.3   | 75.9   | 0.7       | 0.2       | 0.2       | 0.2       | 0.2       | 0.2       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 2.5   | 4.3   | 6.6   | 7.7   | 9.1   | 10.8   | 12.7   | 3.2       | 1.7       | 1.7       | 1.7       | 1.7       | 1.7       |
| Primary energy consumption per capita (toe/person)                                        | 0.7   | 1.3   | 1.9   | 2.1   | 2.2   | 2.4    | 2.7    | 3.1       | 0.9       | 0.5       | 1.1       | 1.3       | 0.9       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 296   | 294   | 286   | 267   | 237   | 223    | 215    | -0.1      | -0.8      | -1.2      | -0.6      | -0.4      | -0.7      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 204   | 247   | 197   | 193   | 187   | 179    | 168    | -0.1      | -0.2      | -0.3      | -0.4      | -0.7      | -0.4      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 929   | 529   | 465   | 424   | 392   | 369    | 379    | -2.2      | -1.0      | -0.8      | -0.6      | 0.3       | -0.5      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 3.14  | 1.80  | 1.63  | 1.59  | 1.65  | 1.65   | 1.76   | -2.1      | -0.3      | 0.4       | 0.0       | 0.6       | 0.2       |
| Automobile ownership volume (millions of vehicles)                                        | 7.52  | 22.57 | 40.71 | 57.45 | 84.22 | 123.47 | 181.02 | 5.6       | 3.9       | 3.9       | 3.9       | 8.0       | 3.9       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.133 | 0.345 | 0.585 | 0.808 | 1.159 | 1.662  | 2.384  | 4.9       | 3.7       | 3.7       | 3.7       | 7.5       | 3.7       |

## Thailand [LCET]

### Primary energy consumption

|                      | MTOE         |              |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |             |            |            |            |
|----------------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|
|                      | 1990         | 2005         | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>41.94</b> | <b>83.32</b> | <b>131.83</b> | <b>129.77</b> | <b>149.96</b> | <b>183.79</b> | <b>219.96</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>-0.2</b> | <b>1.5</b> | <b>2.1</b> | <b>1.8</b> |
| Coal                 | 3.82         | 10.22        | 17.81         | 15.07         | 17.96         | 16.08         | 11.98         | 9.1        | 12.3       | 13.5       | 11.6       | 12.0       | 8.7        | 5.4        | 5.1        | -1.8        | 1.8        | -1.1       | -2.9       |
| Oil                  | 17.96        | 35.46        | 44.91         | 36.98         | 29.33         | 22.28         | 23.35         | 42.8       | 42.6       | 34.1       | 28.5       | 19.6       | 12.1       | 10.6       | 3.0        | -2.1        | -2.3       | -2.7       | 0.5        |
| Natural gas          | 4.99         | 13.49        | 37.54         | 43.44         | 49.42         | 33.23         | 12.34         | 11.9       | 16.2       | 28.5       | 33.5       | 33.0       | 18.1       | 5.6        | 6.7        | 1.6         | 1.3        | -3.9       | -2.8       |
| Hydrogen             | 0.00         | 0.00         |               |               | 3.41          | 43.16         | 102.51        | 0.0        | 0.0        | 0.0        | 0.0        | 2.3        | 23.5       | 46.6       | -          | -           | -          | 28.9       | 9.0        |
| Fuel Ammonia         | 0.00         | 0.00         |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Nuclear              | 0.00         | 0.00         |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Hydro                | 0.43         | 0.52         | 1.75          | 2.48          | 2.57          | 2.57          | 2.57          | 1.0        | 0.6        | 1.3        | 1.9        | 1.7        | 1.4        | 1.2        | 4.6        | 3.9         | 0.4        | 0.0        | 1.0        |
| Geothermal           | 0.00         | 0.00         |               |               |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -          | -          | -          |
| Others               | 14.74        | 23.62        | 29.83         | 31.79         | 47.27         | 66.47         | 67.22         | 35.1       | 28.4       | 22.6       | 24.5       | 31.5       | 36.2       | 30.6       | 2.3        | 0.7         | 4.0        | 3.5        | 0.1        |
| Biomass              | 14.69        | 19.00        | 17.03         | 12.92         | 22.87         | 24.82         | 24.82         | 35.0       | 22.8       | 12.9       | 10.0       | 15.3       | 13.5       | 11.3       | 0.5        | -3.0        | 5.9        | 0.8        | 0.0        |
| Solar Wind Ocean     | 0.00         | 0.42         | 0.76          | 4.57          | 3.57          | 12.30         | 12.43         | 0.0        | 0.5        | 0.6        | 3.5        | 2.4        | 6.7        | 5.7        | -          | 22.1        | -2.4       | 13.2       | 0.1        |
| Biofuels             | 0.00         | 0.39         | 3.11          | 4.48          | 6.06          | 6.90          | 7.82          | 0.0        | 0.5        | 2.4        | 3.4        | 4.0        | 3.8        | 3.6        | -          | 4.1         | 3.1        | 1.3        | 1.3        |
| Electricity (Import) | 0.05         | 3.82         | 8.93          | 9.83          | 14.77         | 22.45         | 22.15         | 0.1        | 4.6        | 6.78       | 7.57       | 9.9        | 12.2       | 10.1       | 18.0       | 1.1         | 4.2        | 4.3        | -0.1       |

### Final energy demand

|              | MTOE         |              |              |              |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021         | 2030         | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>28.87</b> | <b>70.19</b> | <b>90.83</b> | <b>98.13</b> | <b>111.03</b> | <b>131.23</b> | <b>149.79</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>0.9</b> | <b>1.2</b> | <b>1.7</b> | <b>1.3</b> |
| Industry     | 8.65         | 18.03        | 26.80        | 31.57        | 36.75         | 43.27         | 48.43         | 30.0       | 25.7       | 29.5       | 32.2       | 33.1       | 33.0       | 32.3       | 3.7        | 1.8        | 1.5        | 1.6        | 1.1        |
| Transport    | 9.01         | 20.00        | 28.65        | 26.06        | 29.16         | 38.14         | 48.99         | 31.2       | 28.5       | 31.5       | 26.6       | 26.3       | 29.1       | 32.7       | 3.8        | -1.0       | 1.1        | 2.7        | 2.5        |
| Others       | 10.78        | 22.26        | 17.39        | 21.05        | 25.46         | 29.87         | 30.84         | 37.3       | 31.7       | 19.1       | 21.4       | 22.9       | 22.8       | 20.6       | 1.6        | 2.1        | 1.9        | 1.6        | 0.3        |
| Non-energy   | 0.43         | 9.89         | 17.99        | 19.45        | 19.66         | 19.95         | 21.53         | 1.5        | 14.1       | 19.8       | 19.8       | 17.7       | 15.2       | 14.4       | 12.8       | 0.9        | 0.1        | 0.1        | 0.8        |
| <b>Total</b> | <b>28.87</b> | <b>70.19</b> | <b>90.83</b> | <b>98.13</b> | <b>111.03</b> | <b>131.23</b> | <b>149.79</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.8</b> | <b>0.9</b> | <b>1.2</b> | <b>1.7</b> | <b>1.3</b> |
| Coal         | 1.31         | 5.32         | 6.38         | 8.09         | 9.31          | 10.37         | 11.98         | 4.5        | 7.6        | 7.0        | 8.2        | 8.4        | 7.9        | 8.0        | 5.2        | 2.7        | 1.4        | 1.1        | 1.5        |
| Oil          | 14.93        | 35.28        | 42.73        | 35.37        | 28.34         | 21.93         | 23.00         | 51.7       | 50.3       | 47.0       | 36.0       | 25.5       | 16.7       | 15.4       | 3.5        | -2.1       | -2.2       | -2.5       | -1.6       |
| Natural gas  | 0.14         | 0.79         | 8.04         | 8.77         | 9.93          | 10.99         | 12.34         | 0.5        | 1.1        | 8.9        | 8.9        | 8.9        | 8.4        | 8.2        | 14.0       | 1.0        | 1.3        | 1.0        | 1.2        |
| Hydrogen     | 0.00         | 0.00         |              |              | 0.12          | 1.47          | 1.72          | 0.0        | 0.0        | 0.0        | 0.0        | 0.1        | 1.1        | 1.1        | -          | -          | -          | 28.2       | 1.6        |
| Fuel Ammonia | 0.00         | 0.00         |              |              |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 3.30         | 12.72        | 24.07        | 30.87        | 42.49         | 59.82         | 73.17         | 11.4       | 18.1       | 26.5       | 31.5       | 38.3       | 45.6       | 48.9       | 6.6        | 2.8        | 3.2        | 3.5        | 2.0        |
| Heat         | 0.00         | 0.00         |              |              |               |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 9.20         | 16.08        | 9.61         | 15.02        | 20.83         | 26.65         | 27.57         | 31.9       | 22.9       | 10.6       | 15.3       | 18.8       | 20.3       | 18.4       | 0.1        | 5.1        | 3.3        | 2.5        | 0.3        |

### Power generation Output

|                                     | TWh          |               |               |               |               |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990         | 2005          | 2021          | 2030          | 2040          | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>44.18</b> | <b>114.98</b> | <b>201.79</b> | <b>276.81</b> | <b>367.95</b> | <b>502.59</b> | <b>678.62</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.0</b> | <b>3.6</b> | <b>2.9</b> | <b>3.2</b> | <b>3.0</b> |
| Coal PP                             | 11.05        | 19.45         | 45.22         | 28.18         | 36.14         | 24.78         | 0.00          | 25         | 17         | 22         | 10         | 10         | 5          | 0          | 4.6        | -5.1       | 2.5        | -3.7       | -81.8      |
| Coal PP with biomass co-firing      | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0          | -          | -          | -          | -          | -          |
| Oil                                 | 10.38        | 0.00          | 0.36          | 0.47          | 0.68          | 0.76          | 0.76          | 23         | 0          | 0          | 0          | 0          | 0          | 0          | -10.3      | 2.9        | 3.8        | 1.2        | 0.0        |
| Gas PP                              | 17.77        | 63.26         | 121.38        | 180.01        | 198.06        | 128.61        | 0.00          | 40         | 55         | 60         | 65         | 54         | 26         | 0.00       | 6.4        | 4.5        | 1.0        | -4.2       | -100.0     |
| Gas PP with hydrogen co-firing      | 0.00         | 0.00          | 0.00          | 0.00          | 18.35         | 232.44        | 561.85        | 0          | 0          | 0          | 0          | 5          | 46         | 82.79      | -          | -          | -          | 28.9       | 9.2        |
| Gas PP with CCS                     | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0.00       | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0.00       | -          | -          | -          | -          | -          |
| Solar PV                            | 0.00         | 3.21          | 6.44          | 16.95         | 41.92         | 42.65         | 42.65         | 0          | 3          | 3          | 6          | 11         | 8          | 6.28       | -          | 11.4       | 9.5        | 0.2        | 0.0        |
| Wind                                | 0.00         | 1.74          | 2.25          | 7.13          | 8.54          | 8.68          | 8.68          | 0          | 2          | 1          | 3          | 2          | 2          | 1.28       | -          | 13.7       | 1.8        | 0.2        | 0.0        |
| Hydro                               | 4.98         | 21.07         | 20.35         | 28.82         | 29.84         | 29.84         | 29.84         | 11         | 18         | 10         | 10         | 8          | 6          | 4.40       | 4.6        | 3.9        | 0.4        | 0.0        | 1.0        |
| Geothermal                          | 0.00         | 0.00          |               |               |               |               |               | 0          | 0          | 0          | 0          | 0          | 0          | 0.00       | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.00         | 6.25          | 5.79          | 15.26         | 34.42         | 34.83         | 34.83         | 0          | 5          | 3          | 6          | 9          | 7          | 5.13       | -          | 11.4       | 8.5        | 0.1        | 0.0        |

### Power generation Input

|                      | MTOE        |              |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|----------------------|-------------|--------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                      | 1990        | 2005         | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>8.92</b> | <b>18.16</b> | <b>35.94</b> | <b>42.61</b> | <b>58.45</b> | <b>81.79</b> | <b>114.47</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>1.9</b> | <b>3.2</b> | <b>3.4</b> | <b>3.0</b> |
| Coal                 | 2.55        | 4.90         | 11.44        | 6.98         | 8.64         | 5.71         | 0.00          | 28.6       | 27.0       | 31.8       | 16.4       | 14.8       | 7.0        | 0.0        | 5.0        | -5.3       | 2.2        | -4.1       | -100.0     |
| Fuel ammonia         | 0.00        | 0.00         |              |              |              |              |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.00        | 1.93         | 2.65         | 4.34         | 13.31        | 13.51        | 13.51         | 0.0        | 10.6       | 7.4        | 10.2       | 22.8       | 16.5       | 11.8       | -          | 5.6        | 11.9       | 0.2        | 0.0        |
| Oil                  | 2.55        | 0.00         | 0.08         | 0.10         | 0.15         | 0.17         | 0.17          | 28.6       | 0.0        | 0.2        | 0.2        | 0.3        | 0.2        | 0.1        | -10.6      | 2.9        | 3.8        | 1.2        | 0.0        |
| Gas                  | 3.82        | 11.32        | 21.77        | 31.19        | 33.06        | 20.71        | 0.00          | 42.9       | 62.4       | 60.6       | 73.2       | 56.6       | 25.3       | 0.0        | 5.8        | 4.1        | 0.6        | -4.6       | -100.0     |
| Hydrogen             | 0.00        | 0.00         |              |              | 3.29         | 41.70        | 100.7882      | 0.0        | 0.0        | 0.0        | 0.0        | 5.6        | 51.0       | 88.1       | -          | -          | -          | 28.9       | 9.2        |
| Biomass (Biomass PP) | 0.00        | 0.00         |              |              |              |              |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |

### Thermal Efficiency

|              | %           |             |             |             |             |             |            |  |  |  |  |  |  |  | AAGR(%)    |            |             |             |              |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|--|--|--|--|--|--|--|------------|------------|-------------|-------------|--------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060       |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060    |
| <b>Total</b> | <b>37.8</b> | <b>42.1</b> | <b>39.9</b> | <b>42.1</b> | <b>37.3</b> | <b>16.2</b> | <b>0.1</b> |  |  |  |  |  |  |  | <b>0.2</b> | <b>0.6</b> | <b>-1.2</b> | <b>-8.0</b> | <b>-43.1</b> |
| Coal         | 37.3        | 24.5        | 27.6        | 21.4        | 14.2        | 11.1        | 0.0        |  |  |  |  |  |  |  | -1.0       | -2.8       | -4.0        | -2.4        | -100.0       |
| Oil          | 35.0        | 34.4        | 39.1        | 39.2        | 39.2        | 39.5        | 39.5       |  |  |  |  |  |  |  | 0.4        | 0.0        | 0.0         | 0.1         | 0.0          |
| Gas          | 40.0        | 48.1        | 47.9        | 49.6        | 51.2        | 49.8        | 47.9       |  |  |  |  |  |  |  | 0.6        | 0.4        | 0.3         | -0.3        | -0.4         |
| Biomass      | -           | -           | -           | -           | -           | -           | -          |  |  |  |  |  |  |  | -          | -          | -           | -           | -            |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |              |              |             |             |             |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|--------------------|--------------|--------------|--------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005         | 2021         | 2030         | 2040        | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>131.6</b>       | <b>150.1</b> | <b>214.3</b> | <b>140.2</b> | <b>96.7</b> | <b>41.3</b> | <b>35.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.6</b> | <b>-4.6</b> | <b>-3.6</b> | <b>-8.2</b> | <b>-1.6</b> | <b>-4.5</b> |
| Coal         | 37.50              | 31.43        | 47.7         | 17.8         | 13.4        | 3.4         | 1.1         | 28.5       | 20.9       | 22.2       | 12.7       | 13.8       | 8.2        | 3.2        | 0.8        | -10.4       | -2.8        | -12.9       | -10.3       | -9.1        |
| Oil          | 44.67              | 90.54        | 103.2        | 72.9         | 50.3        | 28.6        | 30.0        | 34.0       | 60.3       | 48.2       | 52.0       | 52.0       | 69.2       | 85.5       | 2.7        | -3.8        | -3.6        | -5.5        | 0.5         | -3.1        |
| Natural Gas  | 49.38              | 28.17        | 63.4         | 49.5         | 33.0        | 9.3         | 4.0         | 37.5       | 18.8       | 29.6       | 35.3       | 34.2       | 22.6       | 11.3       | 0.8        | -2.7        | -4.0        | -11.9       | -8.2        | -6.9        |
| CCS/DAC (-)  | 0.00               | 0.00         | 0.00         | 0.00         | 0.00        | 0.00        | 0.00        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 142   | 284   | 461   | 549   | 663   | 800    | 966    | 3.9       | 2.0       | 1.90      | 1.90      | 1.9       | 1.9       |
| Population (millions of people)                                                           | 57    | 65    | 70    | 71    | 73    | 74     | 76     | 0.7       | 0.2       | 0.2       | 0.2       | 0.2       | 0.2       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 2.5   | 4.3   | 6.6   | 7.7   | 9.1   | 10.8   | 12.7   | 3.2       | 1.7       | 1.7       | 1.7       | 1.7       | 1.7       |
| Primary energy consumption per capita (toe/person)                                        | 0.7   | 1.3   | 1.9   | 1.8   | 2.1   | 2.5    | 2.9    | 3.1       | -0.4      | 1.2       | 1.8       | 1.6       | 1.1       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 296   | 294   | 286   | 236   | 226   | 230    | 228    | -0.1      | -2.1      | -0.4      | 0.2       | -0.1      | -0.6      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 204   | 247   | 197   | 179   | 168   | 164    | 155    | -0.1      | -1.1      | -0.6      | -0.2      | -0.6      | -0.6      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 929   | 529   | 465   | 255   | 146   | 52     | 36     | -2.2      | -6.4      | -5.4      | -9.9      | -3.4      | -6.3      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 3.14  | 1.80  | 1.63  | 1.08  | 0.64  | 0.22   | 0.16   | -2.1      | -4.4      | -5.0      | -10.0     | -3.3      | -5.8      |
| Automobile ownership volume (millions of vehicles)                                        | 7.52  | 22.57 | 40.71 | 57.45 | 84.22 | 123.47 | 181.02 | 5.6       | 3.9       | 3.9       | 3.9       | 3.9       | 3.9       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.133 | 0.345 | 0.585 | 0.808 | 1.159 | 1.662  | 2.384  | 4.9       | 3.7       | 3.7       | 3.7       | 3.7       | 3.7       |



## Viet Nam [BAU]

### Primary energy consumption

|                                | MTOE        |             |             |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990        | 2005        | 2021        | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                   | <b>17.9</b> | <b>28.9</b> | <b>88.0</b> | <b>147.1</b> | <b>226.1</b> | <b>318.9</b> | <b>395.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.3</b> | <b>5.9</b> | <b>4.4</b> | <b>3.5</b> | <b>2.2</b> | <b>3.9</b> |
| Coal                           | 2.2         | 7.1         | 44.2        | 72.4         | 121.2        | 180.8        | 209.5        | 12.4       | 24.5       | 50.2       | 49.2       | 53.6       | 56.7       | 53.0       | 10.1       | 5.6        | 5.3        | 4.1        | 1.5        | 4.1        |
| Oil                            | 2.7         | 11.9        | 22.2        | 36.1         | 57.3         | 84.2         | 112.8        | 15.2       | 41.0       | 25.2       | 24.5       | 25.4       | 26.4       | 28.5       | 7.0        | 5.5        | 4.7        | 3.9        | 3.0        | 4.3        |
| Natural gas                    | 0.0         | 4.6         | 5.7         | 24.9         | 35.5         | 40.4         | 47.3         | 0.0        | 16.1       | 6.5        | 17.0       | 15.7       | 12.7       | 12.0       | 27.6       | 17.9       | 3.6        | 1.3        | 1.6        | 5.6        |
| Hydrogen                       | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia                   | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Nuclear                        | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Hydro                          | 0.5         | 1.5         | 6.8         | 7.2          | 7.5          | 9.4          | 13.4         | 2.6        | 5.2        | 7.7        | 4.9        | 3.3        | 2.9        | 3.4        | 9.0        | 0.7        | 0.4        | 2.3        | 3.6        | 1.8        |
| Geothermal                     | 0.0         | 0.0         |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others                         | 12.5        | 3.9         | 9.2         | 6.6          | 4.6          | 4.3          | 12.3         | 69.8       | 13.3       | 10.5       | 4.5        | 2.0        | 1.3        | 3.1        | -1.0       | -3.7       | -3.5       | -0.8       | 11.2       | 0.7        |
| Biomass                        | 12.5        | 3.9         | 7.4         | 4.1          | 2.0          | 1.3          | 1.1          | 69.8       | 13.3       | 8.4        | 2.8        | 0.9        | 0.4        | 0.3        | -1.7       | -6.4       | -6.8       | -4.0       | -2.1       | -4.8       |
| Solar Wind Ocean               | 0.0         | 0.0         | 2.7         | 2.1          | 2.2          | 2.5          | 2.9          | 0.0        | 0.0        | 3.0        | 1.4        | 1.0        | 0.8        | 0.7        | 21.7       | -2.8       | 0.4        | 1.5        | 1.5        | 0.2        |
| Biofuels                       | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -3.4       | -3.8       | -2.8       | 0.0        | -2.5       |
| Electricity (Import or Export) |             |             | -0.9        | 0.4          | 0.4          | 0.4          | 8.3          | 0.0        | 0.0        | -0.97      | 0.28       | 0.2        | 0.1        | 2.1        | -          | -192.1     | 0.0        | 0.0        | 35.2       | -206.0     |

### Final energy demand

|              | MTOE        |             |             |              |              |               |               |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|-------------|-------------|-------------|--------------|--------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030         | 2040         | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>16.1</b> | <b>24.7</b> | <b>63.8</b> | <b>101.8</b> | <b>147.3</b> | <b>201.1</b>  | <b>256.5</b>  | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>5.3</b> | <b>3.8</b> | <b>3.2</b> | <b>2.5</b> | <b>3.6</b> |
| Industry     | 4.5         | 9.0         | 35.4        | 54.2         | 73.2         | 92.8          | 112.0         | 28.3       | 36.3       | 55.5       | 53.2       | 49.7       | 46.1       | 43.7       | 6.8        | 4.8        | 3.0        | 2.4        | 1.9        | 3.0        |
| Transport    | 1.4         | 6.9         | 10.9        | 22.0         | 36.3         | 54.8          | 74.7          | 8.6        | 27.9       | 17.1       | 21.6       | 24.7       | 27.2       | 29.1       | 6.9        | 8.1        | 5.1        | 4.2        | 3.1        | 5.1        |
| Others       | 10.1        | 8.5         | 15.4        | 23.0         | 34.6         | 49.7          | 65.4          | 63.0       | 34.6       | 24.1       | 22.6       | 23.5       | 24.7       | 25.5       | 1.4        | 4.6        | 4.2        | 3.7        | 2.8        | 3.8        |
| Non-energy   | 0.0         | 0.3         | 2.1         | 2.6          | 3.2          | 3.8           | 4.4           | 0.2        | 1.2        | 3.3        | 2.6        | 2.2        | 1.9        | 1.7        | 15.0       | 2.2        | 2.0        | 1.9        | 1.5        | 1.9        |
| <b>Total</b> | <b>16.1</b> | <b>24.7</b> | <b>63.8</b> | <b>101.8</b> | <b>147.3</b> | <b>201.14</b> | <b>256.49</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>5.3</b> | <b>3.8</b> | <b>3.2</b> | <b>2.5</b> | <b>3.6</b> |
| Coal         | 1.3         | 5.0         | 16.5        | 26.6         | 33.7         | 39.9          | 45.3          | 8.3        | 20.0       | 25.9       | 26.1       | 22.9       | 19.8       | 17.7       | 8.5        | 5.4        | 2.4        | 1.7        | 1.3        | 2.6        |
| Oil          | 2.3         | 11.6        | 20.5        | 36.1         | 57.3         | 84.1          | 112.7         | 14.5       | 46.7       | 32.2       | 35.4       | 38.9       | 41.8       | 44.0       | 7.3        | 6.5        | 4.7        | 3.9        | 3.0        | 4.5        |
| Natural gas  | 0.0         | 0.1         | 0.8         | 1.4          | 2.2          | 2.9           | 3.6           | 0.0        | 0.4        | 1.3        | 1.4        | 1.5        | 1.4        | 1.4        | -          | 6.3        | 4.2        | 3.0        | 2.2        | 3.8        |
| Hydrogen     | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0           | 0.0           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Fuel Ammonia | 0.0         | 0.0         |             |              |              |               |               | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Electricity  | 0.5         | 4.0         | 18.8        | 34.0         | 52.5         | 73.3          | 94.2          | 3.3        | 16.0       | 29.4       | 33.4       | 35.7       | 36.4       | 36.7       | 12.2       | 6.8        | 4.4        | 3.4        | 2.5        | 4.2        |
| Heat         | 0.0         | 0.0         | 0.0         | 0.0          | 0.0          | 0.0           | 0.0           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |
| Others       | 11.87       | 4.15        | 7.17        | 3.75         | 1.67         | 0.93          | 0.60          | 73.9       | 16.8       | 11.2       | 3.7        | 1.1        | 0.5        | 0.2        | -1.6       | -6.9       | -7.8       | -5.7       | -4.3       | -6.2       |

### Power generation Output

|                                     | TWh        |             |              |              |              |              |                |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |            |
|-------------------------------------|------------|-------------|--------------|--------------|--------------|--------------|----------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|------------|
|                                     | 1990       | 2005        | 2021         | 2030         | 2040         | 2050         | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>                        | <b>8.7</b> | <b>53.5</b> | <b>256.9</b> | <b>441.6</b> | <b>680.5</b> | <b>947.4</b> | <b>1,126.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.5</b> | <b>6.2</b> | <b>4.4</b> | <b>3.4</b> | <b>1.8</b> | <b>3.9</b> |
| Coal PP                             | 2.0        | 8.9         | 119.0        | 193.8        | 363.4        | 573.5        | 668.1          | 23.1       | 16.7       | 46.3       | 43.9       | 53.4       | 60.5       | 59.3       | 14.1        | 5.6        | 6.5        | 4.7        | 1.5        | 4.5        |
| Coal PP with biomass co-firing      | 0.0        | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0            | 15.0       | 4.6        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.0        | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0            | 0.1        | 38.5       | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.0        | 0.0         |              |              |              |              |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Oil PP                              | 1.3        | 2.5         | 1.5          | 0.0          | 0.0          | 0.1          | 0.3            | 0.0        | 0.0        | 0.6        | 0.0        | 0.0        | 0.0        | 0.0        | 0.4         | -100.0     | -          | -          | 16.3       | -4.0       |
| Gas PP                              | 0.0        | 20.6        | 26.4         | 138.9        | 203.9        | 236.0        | 275.0          | 0.0        | 0.0        | 10.3       | 31.5       | 30.0       | 24.9       | 24.4       | 31.1        | 20.3       | 3.9        | 1.5        | 1.5        | 6.2        |
| Gas PP with hydrogen co-firing      | 0.0        | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.0        | 0.0         |              |              |              |              |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Nuclear PP                          | 0.0        | 0.0         |              |              |              |              |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Solar PV                            | 0.0        | 0.0         | 24.3         | 18.3         | 19.0         | 22.0         | 25.7           | 0.0        | 0.0        | 9.5        | 4.1        | 2.8        | 2.3        | 2.3        | -           | -3.1       | 0.4        | 1.5        | 1.5        | 0.1        |
| Wind                                | 0.0        | 0.0         | 6.8          | 5.9          | 6.1          | 7.1          | 8.3            | 0.0        | 0.0        | 2.6        | 1.3        | 0.9        | 0.7        | 0.7        | -           | -1.5       | 0.4        | 1.5        | 1.5        | 0.5        |
| Hydro                               | 5.4        | 21.5        | 78.6         | 83.4         | 86.8         | 107.3        | 147.9          | 61.8       | 40.1       | 30.6       | 18.9       | 12.8       | 11.3       | 13.1       | 9.0         | 0.7        | 0.4        | 2.1        | 3.3        | 1.6        |
| Geothermal                          | 0.0        | 0.0         |              |              |              |              |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Biomass and others                  | 0.0        | 0.0         | 0.3          | 1.2          | 1.2          | 1.4          | 1.7            | 0.0        | 0.0        | 0.1        | 0.3        | 0.2        | 0.2        | 0.1        | -           | 15.8       | 0.4        | 1.5        | 1.5        | 4.3        |

### Power generation Input

|                      | MTOE       |            |             |             |              |              |              |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |            |
|----------------------|------------|------------|-------------|-------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|------------|
|                      | 1990       | 2005       | 2021        | 2030        | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b>         | <b>1.3</b> | <b>7.7</b> | <b>32.7</b> | <b>69.2</b> | <b>120.7</b> | <b>178.2</b> | <b>207.7</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.0</b> | <b>8.7</b> | <b>5.7</b> | <b>4.0</b> | <b>1.5</b> | <b>4.9</b> |
| Coal                 | 0.9        | 2.1        | 27.7        | 45.8        | 87.5         | 140.9        | 164.1        | 69.8       | 27.6       | 84.6       | 66.2       | 72.5       | 79.1       | 79.0       | 11.7        | 5.8        | 6.7        | 4.9        | 1.5        | 4.7        |
| Fuel ammonia         | 0.0        | 0.0        | 0.0         |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Biomass (Co-firing)  | 0.0        | 0.0        | 0.1         |             |              |              |              | 0.0        | 0.0        | 0.3        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -100.0     | -          | -          | -          | -100.0     |
| Oil                  | 0.4        | 0.8        | 0.4         | 0.0         | 0.0          | 0.0          | 0.1          | 30.0       | 10.0       | 1.1        | 0.0        | 0.0        | 0.0        | 0.0        | -0.2        | -100.0     | -          | -          | 16.3       | -4.0       |
| Gas                  | 0.0        | 4.8        | 4.5         | 23.0        | 32.8         | 36.9         | 43.0         | 0.2        | 62.4       | 13.8       | 33.3       | 27.2       | 20.7       | 20.7       | 26.6        | 19.9       | 3.6        | 1.2        | 1.5        | 6.0        |
| Hydrogen             | 0.0        | 0.0        | 0.0         |             |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          | -          |
| Biomass (Biomass PP) |            |            | 0.1         | 0.3         | 0.4          | 0.4          | 0.5          | 0.0        | 0.0        | 0.3        | 0.5        | 0.3        | 0.2        | 0.2        | -           | 15.8       | 0.4        | 1.5        | 1.5        | 4.3        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |             |             |            |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|-------------|-------------|------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>22.4</b> | <b>35.7</b> | <b>38.7</b> | <b>41.5</b> | <b>40.5</b> | <b>39.1</b> | <b>39.1</b> |  |  |  |  |  |  |  | <b>1.8</b> | <b>0.8</b> | <b>-0.2</b> | <b>-0.3</b> | <b>0.0</b> | <b>0.0</b> |
| Coal         | 19.4        | 36.1        | 36.9        | 36.4        | 35.7        | 35.0        | 35.0        |  |  |  |  |  |  |  | 2.1        | -0.2       | -0.2        | -0.2        | 0.0        | -0.1       |
| Oil          | 29.4        | 27.6        | 35.1        | -           | -           | 35.0        | 35.0        |  |  |  |  |  |  |  | 0.6        | -          | -           | -           | 0.0        | 0.0        |
| Gas          | 17.2        | 36.8        | 50.4        | 51.9        | 53.5        | 55.0        | 55.0        |  |  |  |  |  |  |  | 3.5        | 0.3        | 0.3         | 0.3         | 0.0        | 0.2        |
| Biomass      | -           | -           | 30.0        | 30.0        | 30.0        | 30.0        | 30.0        |  |  |  |  |  |  |  | -          | 0.0        | 0.0         | 0.0         | 0.0        | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |              |              |              |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|-------------|--------------|--------------|--------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005        | 2021         | 2030         | 2040         | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>17.2</b>        | <b>83.2</b> | <b>271.3</b> | <b>505.4</b> | <b>800.1</b> | <b>1,142.1</b> | <b>1,360.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>9.3</b> | <b>7.2</b> | <b>4.7</b> | <b>3.6</b> | <b>1.8</b> | <b>4.2</b> |
| Coal         | 9.2                | 33.4        | 184.1        | 299.1        | 494.7        | 731.9          | 847.5          | 53.2       | 40.2       | 67.9       | 59.2       | 61.8       | 64.1       | 62.3       | 10.2       | 5.5        | 5.2        | 4.0        | 1.5        | 4.0        |
| Oil          | 8.1                | 36.8        | 70.7         | 143.3        | 217.3        | 309.8          | 395.0          | 46.8       | 44.3       | 26.1       | 28.4       | 27.2       | 27.1       | 29.0       | 7.3        | 8.2        | 4.2        | 3.6        | 2.5        | 4.5        |
| Gas          | 0.0                | 12.9        | 16.5         | 63.0         | 88.1         | 100.4          | 117.7          | 0.0        | 15.6       | 6.1        | 12.5       | 11.0       | 8.8        | 8.6        | -          | 16.1       | 3.4        | 1.3        | 1.6        | 5.2        |
| CCS/DAC (-)  |                    |             |              |              |              |                |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |       |       |       |       |       |         |         | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005  | 2021  | 2030  | 2040  | 2050    | 2060    | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 36.8  | 106.7 | 332.3 | 572.0 | 977.1 | 1,517.4 | 2,079.2 | 7.4       | 6.2       | 5.50      | 4.50      | 3.2       | 4.8       |
| Population (millions of people)                                                           | 66.0  | 83.1  | 98.5  | 103.1 | 107.0 | 108.9   | 108.9   | 1.3       | 0.5       | 0.4       | 0.2       | 0.0       | 0.3       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.6   | 1.3   | 3.4   | 5.5   | 9.1   | 13.9    | 19.1    | 6.0       | 5.7       | 5.1       | 4.3       | 3.2       | 4.5       |
| Primary energy consumption per capita (toe/person)                                        | 0.3   | 0.3   | 0.9   | 1.4   | 2.1   | 2.9     | 3.6     | 3.9       | 5.3       | 4.0       | 3.3       | 2.2       | 3.7       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 484.8 | 271.2 | 265.0 | 257   | 231   | 210     | 190     | -1.9      | -0.3      | -1.1      | -1.0      | -1.0      | -0.8      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 435.8 | 231.6 | 192.0 | 178.0 | 150.7 | 132.6   | 123.4   | -2.6      | -0.8      | -1.7      | -1.3      | -0.7      | -1.1      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 467.7 | 779.4 | 816.4 | 883   | 819   | 753     | 654     | 1.8       | 0.9       | -0.8      | -0.8      | -1.4      | -0.6      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.0   | 2.9   | 3.1   | 3.43  | 3.54  | 3.58    | 3.44    | 3.8       | 1.2       | 0.3       | 0.1       | -0.4      | 0.3       |
| Automobile ownership volume (millions of vehicles)                                        |       |       |       |       |       |         |         | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -     | -     | -     | -     | -     | -       | -       | -         | -         | -         | -         | -         | -         |

## Viet Nam [LCET]

### Primary energy consumption

|                                | MTOE         |             |             |              |              |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|--------------|-------------|-------------|--------------|--------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990         | 2005        | 2021        | 2030         | 2040         | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>17.86</b> | <b>28.9</b> | <b>88.0</b> | <b>122.6</b> | <b>146.1</b> | <b>183.1</b> | <b>228.4</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>5.3</b> | <b>3.7</b> | <b>1.8</b> | <b>2.3</b> | <b>2.2</b> |
| Coal                           | 2.21         | 7.08        | 44.2        | 46.2         | 32.3         | 14.2         | 12.5         | 12.4       | 24.5       | 50.2       | 37.7       | 22.1       | 7.7        | 5.5        | 10.1       | 0.5        | -3.5       | -7.9       | -1.2       |
| Oil                            | 2.71         | 11.86       | 22.2        | 30.5         | 29.6         | 17.2         | 18.6         | 15.2       | 41.0       | 25.2       | 24.9       | 20.3       | 9.4        | 8.2        | 7.0        | 3.6        | -0.3       | -5.3       | 0.8        |
| Natural gas                    | 0.00         | 4.65        | 5.7         | 21.2         | 27.4         | 43.7         | 71.6         | 0.0        | 16.1       | 6.5        | 17.3       | 18.8       | 23.8       | 31.3       | 27.6       | 15.7       | 2.6        | 4.8        | 5.1        |
| Hydrogen                       | 0.00         | 0.00        | 0.0         | 0.4          | 8.2          | 9.7          | 9.5          | 0.0        | 0.0        | 0.0        | 0.3        | 5.6        | 5.3        | 4.2        | -          | -          | 34.4       | 1.7        | -0.1       |
| Fuel Ammonia                   | 0.00         | 0.00        | 0.0         | 0.1          | 0.1          | 0.7          | 1.4          | 0.0        | 0.0        | 0.0        | 0.1        | 0.0        | 0.4        | 0.6        | -          | -          | -3.3       | 30.4       | 7.1        |
| Nuclear                        | 0.00         | 0.00        | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Hydro                          | 0.46         | 1.50        | 6.8         | 7.3          | 8.1          | 12.1         | 15.1         | 2.6        | 5.2        | 7.7        | 6.0        | 5.6        | 6.6        | 6.6        | 9.0        | 0.9        | 1.0        | 4.1        | 2.3        |
| Geothermal                     | 0.00         | 0.00        |             |              |              |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others                         | 12.47        | 3.85        | 9.2         | 16.9         | 40.4         | 85.6         | 99.5         | 69.8       | 13.3       | 10.5       | 13.8       | 27.7       | 46.8       | 43.6       | -1.0       | 7.0        | 9.1        | 7.8        | 1.5        |
| Biomass                        | 12.47        | 3.85        | 7.4         | 11.3         | 20.6         | 40.1         | 43.9         | 69.8       | 13.3       | 8.4        | 9.2        | 14.1       | 21.9       | 19.2       | -1.7       | 4.8        | 6.2        | 6.9        | 0.9        |
| Solar Wind Ocean               | 0.01         | 0.00        | 2.7         | 5.2          | 19.4         | 45.2         | 55.1         | 0.0        | 0.0        | 3.0        | 4.2        | 13.3       | 24.7       | 24.1       | 21.7       | 7.6        | 14.1       | 8.8        | 2.0        |
| Biofuels                       | 0.00         | 0.00        | 0.0         | 0.0          | 0.0          | 0.0          | 0.0          | 0.0        | 0.0        | 0.0        | 0.0        |            |            |            | -          | -3.4       | -3.8       | -2.8       | 0.1        |
| Electricity (Import or Export) |              |             | -0.9        | 0.4          | 0.4          | 0.4          | 0.6          | 0.0        | 0.0        | -0.97      | 0.33       | 0.3        | 0.2        | 0.3        | -          | -192.1     | 0.0        | 0.0        | 3.9        |

### Final energy demand

|              | MTOE         |              |             |             |             |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|--------------|--------------|-------------|-------------|-------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990         | 2005         | 2021        | 2030        | 2040        | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>16.06</b> | <b>24.72</b> | <b>63.8</b> | <b>86.9</b> | <b>98.4</b> | <b>101.6</b> | <b>123.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>3.5</b> | <b>1.2</b> | <b>0.3</b> | <b>2.0</b> |
| Industry     | 4.54         | 8.98         | 35.4        | 45.5        | 45.8        | 41.5         | 47.7         | 28.3       | 36.3       | 55.5       | 52.4       | 46.6       | 40.9       | 38.5       | 6.8        | 2.8        | 0.1        | -1.0       | 1.4        |
| Transport    | 1.38         | 6.90         | 10.9        | 19.3        | 22.2        | 20.1         | 24.3         | 8.6        | 27.9       | 17.1       | 22.2       | 22.6       | 19.8       | 19.6       | 6.9        | 6.6        | 1.4        | -1.0       | 1.9        |
| Others       | 10.11        | 8.54         | 15.4        | 19.5        | 27.1        | 36.1         | 47.4         | 63.0       | 34.6       | 24.1       | 22.4       | 27.6       | 35.6       | 38.3       | 1.4        | 2.7        | 3.4        | 2.9        | 2.8        |
| Non-energy   | 0.03         | 0.30         | 2.1         | 2.6         | 3.2         | 3.8          | 4.4          | 0.2        | 1.2        | 3.3        | 3.0        | 3.2        | 3.8        | 3.6        | 15.0       | 2.2        | 2.0        | 1.9        | 1.5        |
| <b>Total</b> | <b>16.06</b> | <b>24.72</b> | <b>63.8</b> | <b>86.9</b> | <b>98.4</b> | <b>101.6</b> | <b>123.9</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.6</b> | <b>3.5</b> | <b>1.2</b> | <b>0.3</b> | <b>2.0</b> |
| Coal         | 1.33         | 4.95         | 16.5        | 21.6        | 14.4        | 3.5          | 0.7          | 8.3        | 20.0       | 25.9       | 24.9       | 14.7       | 3.4        | 0.6        | 8.5        | 3.0        | -4.0       | -13.2      | -14.8      |
| Oil          | 2.33         | 11.55        | 20.5        | 30.4        | 29.6        | 17.2         | 18.6         | 14.5       | 46.7       | 32.2       | 35.0       | 30.1       | 16.9       | 15.0       | 7.3        | 4.5        | -0.3       | -5.3       | 0.8        |
| Natural gas  | 0.00         | 0.10         | 0.8         | 1.2         | 1.2         | 1.0          | 0.5          | 0.0        | 0.4        | 1.3        | 1.4        | 1.3        | 1.0        | 0.4        | -          | 4.1        | 0.4        | -2.2       | -5.9       |
| Hydrogen     | 0.00         | 0.00         | 0.0         | 0.3         | 5.4         | 14.5         | 20.2         | 0.0        | 0.0        | 0.0        | 0.4        | 5.5        | 14.3       | 16.3       | -          | -          | 32.6       | 10.3       | 3.4        |
| Fuel Ammonia | 0.00         | 0.00         |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 0.53         | 3.97         | 18.8        | 29.6        | 46.0        | 64.5         | 83.2         | 3.3        | 16.0       | 29.4       | 34.0       | 46.7       | 63.5       | 67.2       | 12.2       | 5.2        | 4.5        | 3.5        | 2.6        |
| Heat         | 0.00         | 0.00         |             |             |             |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Others       | 11.87        | 4.15         | 7.2         | 3.8         | 1.7         | 0.9          | 0.6          | 73.9       | 16.8       | 11.2       | 4.3        | 1.7        | 0.9        | 0.5        | -1.6       | -6.9       | -7.8       | -5.7       | -4.3       |

### Power generation Output

|                                     | TWh         |              |              |              |              |                |                |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |
|-------------------------------------|-------------|--------------|--------------|--------------|--------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                                     | 1990        | 2005         | 2021         | 2030         | 2040         | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>8.68</b> | <b>53.46</b> | <b>256.9</b> | <b>383.4</b> | <b>633.0</b> | <b>1,147.0</b> | <b>1,486.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.5</b> | <b>4.6</b> | <b>5.1</b> | <b>6.1</b> | <b>2.6</b> |
| Coal PP                             | 2.00        | 8.94         | 119.0        | 80.4         | 51.1         | 1.2            | 1.3            | 23         | 16.7       | 46.3       | 21.0       | 8.1        | 0.1        | 0.1        | 14.1        | -4.3       | -4.4       | -31.4      | 1.0        |
| Coal PP with biomass co-firing      | 0.00        | 0.00         | 0.0          | 0.6          | 13.0         | 42.7           | 47.3           | 0          | 0.0        | 0.0        | 0.2        | 2.1        | 3.7        | 3.2        | -           | -          | 35.6       | 12.6       | 1.0        |
| Coal PP with fuel ammonia co-firing | 0.00        | 0.00         | 0.0          | 0.3          | 8.2          | 28.5           | 31.5           | 0          | 0.0        | 0.0        | 0.1        | 1.3        | 2.5        | 2.1        | -           | -          | 38.8       | 13.2       | 1.0        |
| Coal PP with CCS                    | 0.00        | 0.00         | 0.0          | 29.0         | 32.2         | 46.6           | 51.6           | 0          | 0.0        | 0.0        | 7.6        | 5.1        | 4.1        | 3.5        | -           | -          | 1.0        | 3.8        | 1.0        |
| Oil PP                              | 1.31        | 2.48         | 1.5          | 0.0          | 0.0          | 0.1            | 0.2            | 15         | 4.6        | 0.6        | 0.0        | 0.0        | 0.0        | 0.0        | 0.4         | -100.0     | -          | -          | -4.5       |
| Gas PP                              | 0.01        | 20.59        | 26.4         | 0.0          | 0.0          | 0.1            | 0.1            | 0          | 38.5       | 10.3       | 0.0        | 0.0        | 0.0        | 0.0        | 31.1        | -100.0     | -          | -          | -13.7      |
| Gas PP with hydrogen co-firing      | 0.00        | 0.00         | 0.0          | 0.6          | 23.3         | 85.4           | 94.5           | 0          | 0.0        | 0.0        | 0.2        | 3.7        | 7.4        | 6.4        | -           | -          | 43.7       | 13.9       | 1.0        |
| Gas PP with CCS                     | 0.00        | 0.00         | 0.0          | 121.5        | 167.3        | 249.1          | 417.1          | 0          | 0.0        | 0.0        | 31.7       | 26.4       | 21.7       | 28.1       | -           | -          | 3.2        | 4.1        | 5.3        |
| Nuclear PP                          | 0.00        | 0.00         | 0.0          | 0.0          |              |                |                | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Solar PV                            | 0.00        | 0.00         | 24.3         | 26.3         | 76.4         | 172.1          | 190.6          | 0          | 0.0        | 9.5        | 6.9        | 12.1       | 15.0       | 12.8       | -           | 0.9        | 11.3       | 8.5        | 1.0        |
| Wind                                | 0.00        | 0.00         | 6.8          | 34.1         | 149.4        | 353.3          | 449.6          | 0          | 0.0        | 2.6        | 8.9        | 23.6       | 30.8       | 30.2       | -           | 19.6       | 15.9       | 9.0        | 2.4        |
| Hydro                               | 5.37        | 21.45        | 78.6         | 85.5         | 94.4         | 138.5          | 169.7          | 62         | 40.1       | 30.6       | 22.3       | 14.9       | 12.1       | 11.4       | 9.0         | 0.9        | 1.0        | 3.9        | 2.1        |
| Geothermal                          | 0.00        | 0.00         | 0.0          | 0.0          | 0.0          |                |                | 0          | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -          | -          | -          | -          |
| Biomass and others                  | 0.00        | 0.00         | 0.3          | 5.1          | 17.7         | 29.6           | 32.8           | 0          | 0.0        | 0.1        | 1.3        | 2.8        | 2.6        | 2.2        | -           | 35.9       | 13.3       | 5.3        | 1.0        |

### Power generation Input

|                      | MTOE        |             |              |              |              |              |               |            |            |            |            |            |            |            | AAGR(%)     |            |            |            |            |
|----------------------|-------------|-------------|--------------|--------------|--------------|--------------|---------------|------------|------------|------------|------------|------------|------------|------------|-------------|------------|------------|------------|------------|
|                      | 1990        | 2005        | 2021         | 2030         | 2040         | 2050         | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>         | <b>1.27</b> | <b>7.72</b> | <b>32.70</b> | <b>45.50</b> | <b>56.50</b> | <b>88.94</b> | <b>122.37</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>11.0</b> | <b>3.7</b> | <b>2.2</b> | <b>4.6</b> | <b>3.2</b> |
| Coal                 | 0.89        | 2.13        | 27.7         | 24.6         | 17.9         | 10.7         | 11.8          | 69.8       | 27.6       | 84.6       | 54.0       | 31.6       | 12.0       | 9.7        | 11.7        | -1.3       | -3.1       | -5.0       | 1.0        |
| Fuel ammonia         | 0.00        | 0.00        | 0.0          | 0.1          | 1.9          | 6.6          | 7.3           | 0.0        | 0.0        | 0.0        | 0.2        | 3.4        | 7.4        | 6.0        | -           | -          | 38.8       | 13.2       | 1.0        |
| Biomass (Co-firing)  | 0.00        | 0.00        | 0.1          | 0.1          | 3.0          | 9.9          | 11.0          | 0.0        | 0.0        | 0.3        | 0.3        | 5.4        | 11.2       | 9.0        | -           | 5.1        | 35.6       | 12.6       | 1.0        |
| Oil                  | 0.38        | 0.77        | 0.4          | 0.0          | 0.0          | 0.0          | 0.1           | 30.0       | 10.0       | 1.1        | 0.0        | 0.0        | 0.0        | 0.0        | -0.2        | -100.0     | -          | -          | -4.5       |
| Gas                  | 0.00        | 4.81        | 4.5          | 19.6         | 25.7         | 42.0         | 70.3          | 0.2        | 62.4       | 13.8       | 43.0       | 45.5       | 47.2       | 57.5       | 26.6        | 17.7       | 2.8        | 5.0        | 5.3        |
| Hydrogen             | 0.00        | 0.00        | 0.0          | 0.1          | 3.5          | 12.2         | 13.5          | 0.0        | 0.0        | 0.0        | 0.2        | 6.2        | 13.8       | 11.1       | -           | -          | 42.9       | 13.3       | 1.0        |
| Biomass (Biomass PP) | 0.00        | 0.00        | 0.1          | 1.1          | 4.5          | 7.5          | 8.3           | 0.0        | 0.0        | 0.3        | 2.4        | 7.9        | 8.4        | 6.8        | -           | 31.4       | 15.4       | 5.2        | 1.0        |

### Thermal Efficiency

|              | %           |             |             |             |             |             |             |  |  |  |  |  |  |  | AAGR(%)    |            |            |             |            |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|--|--|--|--|--|------------|------------|------------|-------------|------------|
|              | 1990        | 2005        | 2021        | 2030        | 2040        | 2050        | 2060        |  |  |  |  |  |  |  | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060  |
| <b>Total</b> | <b>22.4</b> | <b>35.7</b> | <b>38.7</b> | <b>44.9</b> | <b>47.6</b> | <b>46.7</b> | <b>47.5</b> |  |  |  |  |  |  |  | <b>1.8</b> | <b>1.7</b> | <b>0.6</b> | <b>-0.2</b> | <b>0.2</b> |
| Coal         | 19.4        | 36.1        | 36.9        | 38.3        | 39.5        | 37.6        | 37.6        |  |  |  |  |  |  |  | 2.1        | 0.4        | 0.3        | -0.5        | 0.0        |
| Oil          | 29.4        | 27.6        | 35.1        | -           | -           | 35.0        | 35.0        |  |  |  |  |  |  |  | 0.6        | -          | -          | -           | 0.0        |
| Gas          | 17.2        | 36.8        | 50.4        | 53.5        | 56.1        | 53.0        | 52.5        |  |  |  |  |  |  |  | 3.5        | 0.6        | 0.5        | -0.6        | -0.1       |
| Biomass      | -           | -           | 30.0        | 40.6        | 33.9        | 34.1        | 34.1        |  |  |  |  |  |  |  | -          | 3.4        | -1.8       | 0.1         | 0.0        |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |             |              |              |              |             |             |            |            |            |            |            |            |            | AAGR(%)    |            |             |              |             |             |
|--------------|--------------------|-------------|--------------|--------------|--------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|--------------|-------------|-------------|
|              | 1990               | 2005        | 2021         | 2030         | 2040         | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050    | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>17.2</b>        | <b>83.2</b> | <b>271.3</b> | <b>363.4</b> | <b>282.3</b> | <b>98.6</b> | <b>96.2</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>9.3</b> | <b>3.3</b> | <b>-2.5</b> | <b>-10.0</b> | <b>-0.3</b> | <b>-2.6</b> |
| Coal         | 9.2                | 33.4        | 184.06       | 191.8        | 124.1        | 23.3        | 12.4        | 53.2       | 40.2       | 67.9       | 52.8       | 44.0       | 23.6       | 12.9       | 10.2       | 0.5        | -4.3        | -15.4        | -6.1        | -6.7        |
| Oil          | 8.1                | 36.8        | 70.71        | 120.1        | 118.4        | 55.8        | 58.0        | 46.8       | 44.3       | 26.1       | 33.0       | 41.9       | 56.6       | 60.3       | 7.3        | 6.1        | -0.1        | -7.2         | 0.4         | -0.5        |
| Gas          | 0.0                | 12.9        | 16.48        | 51.5         | 39.8         | 19.6        | 25.8        | 0.0        | 15.6       | 6.1        | 14.2       | 14.1       | 19.9       | 26.8       | -          | 13.5       | -2.5        | -6.8         | 2.8         | 1.2         |
| CCS/DAC (-)  | 0.00               | 0.00        |              |              |              |             |             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -            | -           | -           |

## Energy and economic Indicators

|                                                                                           |      |      |      |      |      |       |       | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|------|------|------|------|------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990 | 2005 | 2021 | 2030 | 2040 | 2050  | 2060  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 37   | 107  | 332  | 572  | 977  | 1,517 | 2,079 | 7.4       | 6.2       | 5.50      | 4.50      | 3.2       | 4.8       |
| Population (millions of people)                                                           | 66   | 83   | 99   | 103  | 107  | 109   | 109   | 1.3       | 0.5       | 0.4       | 0.2       | 0.0       | 0.3       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 0.6  | 1.3  | 3.4  | 5.5  | 9.1  | 13.9  | 19.1  | 6.0       | 5.7       | 5.1       | 4.3       | 3.2       | 4.5       |
| Primary energy consumption per capita (toe/person)                                        | 0.3  | 0.3  | 0.9  | 1.2  | 1.4  | 1.7   | 2.1   | 3.9       | 3.2       | 1.4       | 2.1       | 2.2       | 2.2       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 485  | 271  | 265  | 214  | 149  | 121   | 110   | -1.9      | -2.3      | -3.5      | -2.1      | -0.9      | -2.2      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 436  | 232  | 192  | 152  | 101  | 67    | 60    | -2.6      | -2.6      | -4.0      | -4.0      | -1.2      | -3.0      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 468  | 779  | 816  | 635  | 289  | 65    | 46    | 1.8       | -2.7      | -7.6      | -13.9     | -3.3      | -7.1      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 0.96 | 2.87 | 3.08 | 2.96 | 1.93 | 0.54  | 0.42  | 3.8       | -0.4      | -4.2      | -12.0     | -2.4      | -5.0      |
| Automobile ownership volume (millions of vehicles)                                        |      |      |      |      |      |       |       | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -    | -    | -    | -    | -    | -     | -     | -         | -         | -         | -         | -         | -         |



## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                |                |                |                |                |            |            |            |            |            |            |            | AAGR(%)     |             |             |             |             |             |
|--------------|--------------------|----------------|----------------|----------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005           | 2021           | 2030           | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>4,739.7</b>     | <b>5,561.9</b> | <b>4,549.3</b> | <b>3,858.9</b> | <b>3,137.8</b> | <b>2,560.8</b> | <b>2,092.1</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.1</b> | <b>-1.8</b> | <b>-2.0</b> | <b>-2.0</b> | <b>-2.0</b> | <b>-2.0</b> |
| Coal         | 1,843.5            | 2,187.3        | 1,027.2        | 569.5          | 266.1          | 113.0          | 78.8           | 38.9       | 39.3       | 22.6       | 14.8       | 8.5        | 4.4        | 3.8        | -1.9        | -6.3        | -7.3        | -8.2        | -3.5        | -6.4        |
| Oil          | 1,885.5            | 2,218.6        | 1,825.5        | 1,710.1        | 1,505.2        | 1,296.9        | 1,084.3        | 39.8       | 39.9       | 40.1       | 44.3       | 48.0       | 50.6       | 51.8       | -0.1        | -0.7        | -1.3        | -1.5        | -1.8        | -1.3        |
| Natural Gas  | 1,010.6            | 1,155.9        | 1,696.6        | 1,579.2        | 1,366.5        | 1,150.9        | 929.0          | 21.3       | 20.8       | 37.3       | 40.9       | 43.6       | 44.9       | 44.4       | 1.7         | -0.8        | -1.4        | -1.7        | -2.1        | -1.5        |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0            | 0.0            | 0.0            | 0.0            | 0.0            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -           | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |       |        |        |        |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|--------|--------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 9,811 | 15,600 | 20,529 | 24,290 | 29,711 | 35,745 | 42,582 | 2.4       | 1.9       | 2.0       | 1.9       | 1.8       | 1.9       |
| Population (millions of people)                                                           | 250   | 296    | 332    | 347    | 361    | 370    | 375    | 0.9       | 0.5       | 0.4       | 0.2       | 0.1       | 0.3       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 39.30 | 52.79  | 61.86  | 70.09  | 82.29  | 96.62  | 113.44 | 1.5       | 1.4       | 1.6       | 1.6       | 1.6       | 1.6       |
| Primary energy consumption per capita (toe/person)                                        | 7.67  | 7.84   | 6.44   | 5.90   | 5.26   | 4.91   | 4.70   | -0.6      | -1.0      | -1.1      | -0.7      | -0.4      | -0.8      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 195   | 149    | 104    | 84     | 64     | 51     | 41     | -2.0      | -2.3      | -2.7      | -2.3      | -2.0      | -2.3      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 132   | 100    | 75     | 63     | 50     | 40     | 33     | -1.8      | -2.0      | -2.3      | -2.1      | -2.0      | -2.1      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 483   | 357    | 222    | 159    | 106    | 72     | 49     | -2.5      | -3.6      | -4.0      | -3.8      | -3.7      | -3.8      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.48  | 2.40   | 2.13   | 1.89   | 1.65   | 1.41   | 1.19   | -0.5      | -1.3      | -1.3      | -1.6      | -1.7      | -1.5      |
| Automobile ownership volume (millions of vehicles)                                        | 189   | 245    | 272    | 287    | 309    | 329    | 348    | 1.2       | 0.6       | 0.7       | 0.6       | 0.6       | 0.6       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.756 | 0.829  | 0.821  | 0.829  | 0.855  | 0.888  | 0.926  | 0.3       | 0.1       | 0.3       | 0.4       | 0.4       | 0.3       |

## United States [LCET]

### Primary energy consumption

|                                | MTOE            |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |
|--------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|                                | 1990            | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>                   | <b>1,914.47</b> | <b>2,317.85</b> | <b>2,138.97</b> | <b>1,831.55</b> | <b>1,506.98</b> | <b>1,286.57</b> | <b>1,272.14</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.4</b> | <b>-1.7</b> | <b>-1.9</b> | <b>-1.6</b> | <b>-0.1</b> |
| Coal                           | 459.57          | 557.29          | 254.02          | 87.69           | 58.45           | 7.61            | 4.59            | 24.0       | 24.0       | 11.9       | 4.8        | 3.9        | 0.6        | 0.4        | -1.9       | -11.1       | -4.0        | -18.4       | -4.9        |
| Oil                            | 756.84          | 929.18          | 763.56          | 538.08          | 260.18          | 132.72          | 131.03          | 39.5       | 40.1       | 35.7       | 29.4       | 17.3       | 10.3       | 10.3       | 0.0        | -3.8        | -7.0        | -6.5        | -0.1        |
| Natural gas                    | 438.36          | 507.22          | 723.10          | 640.58          | 430.25          | 200.06          | 141.79          | 22.9       | 21.9       | 33.8       | 35.0       | 28.6       | 15.5       | 11.1       | 1.6        | -1.3        | -3.9        | -7.4        | -4.1        |
| Hydrogen                       | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | 101.8       | -100.0      | -           |
| Fuel Ammonia                   | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           |
| Nuclear                        | 159.36          | 211.24          | 211.46          | 214.12          | 263.38          | 322.27          | 316.92          | 8.3        | 9.1        | 9.9        | 11.7       | 17.5       | 25.0       | 24.9       | 0.9        | 0.1         | 2.1         | 2.0         | -0.2        |
| Hydro                          | 23.49           | 23.43           | 21.80           | 28.85           | 29.45           | 29.38           | 28.97           | 1.2        | 1.0        | 1.0        | 1.6        | 2.0        | 2.3        | 2.3        | -0.2       | 3.2         | 0.2         | 0.0         | -0.1        |
| Geothermal                     | 14.10           | 8.63            | 9.45            | 13.16           | 14.37           | 15.67           | 16.46           | 0.7        | 0.4        | 0.4        | 0.7        | 1.0        | 1.2        | 1.3        | -1.3       | 3.8         | 0.9         | 0.9         | 0.5         |
| Others                         | 62.76           | 80.87           | 155.61          | 309.06          | 450.91          | 578.87          | 632.37          | 3.3        | 3.5        | 7.3        | 16.9       | 29.9       | 45.0       | 49.7       | 3.0        | 7.9         | 3.8         | 2.5         | 0.9         |
| Biomass                        | 61.53           | 63.61           | 61.36           | 59.01           | 58.10           | 62.16           | 58.66           | 3.2        | 2.7        | 2.9        | 3.2        | 3.9        | 4.8        | 4.6        | 0.0        | -0.4        | -0.2        | 0.7         | -0.6        |
| Solar Wind Ocean               | 0.32            | 2.95            | 49.21           | 191.01          | 309.23          | 462.18          | 524.73          | 0.0        | 0.1        | 2.3        | 10.4       | 20.5       | 35.9       | 41.2       | 17.6       | 16.3        | 4.9         | 4.1         | 1.3         |
| Biofuels                       | 0.73            | 12.18           | 41.66           | 55.69           | 80.23           | 51.17           | 45.63           | 0.0        | 0.5        | 1.9        | 3.0        | 5.3        | 4.0        | 3.6        | 13.9       | 3.3         | 3.7         | -4.4        | -1.1        |
| Electricity (Import or Export) | 0.17            | 2.13            | 3.38            | 3.36            | 3.36            | 3.36            | 3.36            | 0.0        | 0.1        | 0.2        | 0.2        | 0.2        | 0.3        | 0.3        | 10.1       | -0.1        | 0.0         | 0.0         | 0.0         |

### Final energy demand

|              | MTOE            |                 |                 |                 |                 |               |               |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|---------------|---------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|              | 1990            | 2005            | 2021            | 2030            | 2040            | 2050          | 2060          | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b> | <b>1,293.54</b> | <b>1,563.06</b> | <b>1,539.73</b> | <b>1,318.36</b> | <b>1,030.51</b> | <b>849.46</b> | <b>806.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>-1.7</b> | <b>-2.4</b> | <b>-1.9</b> | <b>-0.5</b> |
| Industry     | 283.74          | 276.40          | 277.87          | 270.17          | 242.95          | 201.93        | 160.19        | 21.9       | 17.7       | 18.0       | 20.5       | 23.6       | 23.8       | 19.9       | -0.1       | -0.3        | -1.1        | -1.8        | -2.3        |
| Transport    | 487.57          | 622.89          | 603.81          | 465.12          | 313.32          | 239.09        | 231.93        | 37.7       | 39.9       | 39.2       | 35.3       | 30.4       | 28.1       | 28.8       | 0.7        | -2.9        | -3.9        | -2.7        | -0.3        |
| Others       | 403.18          | 507.27          | 504.22          | 421.51          | 303.88          | 228.08        | 230.18        | 31.2       | 32.5       | 32.7       | 32.0       | 29.5       | 26.9       | 28.6       | 0.7        | -2.0        | -3.2        | -2.8        | 0.1         |
| Non-energy   | 119.05          | 156.50          | 153.82          | 161.56          | 170.36          | 180.35        | 183.81        | 9.2        | 10.0       | 10.0       | 12.3       | 16.5       | 21.2       | 22.8       | 0.8        | 0.5         | 0.5         | 0.6         | 0.2         |
| <b>Total</b> | <b>1,293.54</b> | <b>1,563.06</b> | <b>1,539.73</b> | <b>1,318.36</b> | <b>1,030.51</b> | <b>849.46</b> | <b>806.10</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.6</b> | <b>-1.7</b> | <b>-2.4</b> | <b>-1.9</b> | <b>-0.5</b> |
| Coal         | 55.64           | 31.32           | 13.56           | 10.15           | 6.00            | 2.43          | 1.28          | 4.3        | 2.0        | 0.9        | 0.8        | 0.6        | 0.3        | 0.2        | -4.5       | -3.2        | -5.1        | -8.6        | -6.2        |
| Oil          | 683.29          | 842.42          | 735.49          | 524.62          | 264.53          | 148.57        | 146.57        | 52.8       | 53.9       | 47.8       | 39.8       | 25.7       | 17.5       | 18.2       | 0.2        | -3.7        | -6.6        | -5.6        | -0.1        |
| Natural gas  | 303.08          | 309.09          | 369.63          | 283.55          | 142.63          | 53.82         | 42.58         | 23.4       | 19.8       | 24.0       | 21.5       | 13.8       | 6.3        | 5.3        | 0.6        | -2.9        | -6.6        | -9.3        | -2.3        |
| Hydrogen     | 0.00            | 0.00            | 0.00            | 9.12            | 29.74           | 44.47         | 45.29         | 0.0        | 0.0        | 0.0        | 29.9       | 2.9        | 5.2        | 5.6        | -          | -           | -22.8       | 4.1         | 0.2         |
| Fuel Ammonia | 0.00            | 0.00            | 0.00            | 0.00            | 34.19           | 57.05         | 57.10         | 0.0        | 0.0        | 0.0        | 0.4        | 3.3        | 6.7        | 7.1        | -          | -           | 22.1        | 5.3         | 0.0         |
| Electricity  | 226.45          | 320.85          | 330.03          | 394.79          | 440.60          | 461.80        | 444.89        | 17.5       | 20.5       | 21.4       | 0.4        | 42.8       | 54.4       | 55.2       | 1.2        | -37.7       | 57.6        | 0.5         | -0.4        |
| Heat         | 2.15            | 3.26            | 5.62            | 4.66            | 3.57            | 2.44          | 1.41          | 0.2        | 0.2        | 0.4        | 6.9        | 0.3        | 0.3        | 0.2        | 3.1        | 36.3        | -27.7       | -3.7        | -5.3        |
| Others       | 22.93           | 56.12           | 85.40           | 91.47           | 109.25          | 78.87         | 66.97         | 1.8        | 3.6        | 5.5        | 0.0        | 10.6       | 9.3        | 8.3        | 4.3        | -           | -           | -3.2        | -1.6        |

### Power generation Output

|                                     | TWh             |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990            | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>3,202.81</b> | <b>4,268.89</b> | <b>4,354.06</b> | <b>5,204.65</b> | <b>6,064.88</b> | <b>7,049.91</b> | <b>7,335.05</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>1.0</b> | <b>2.0</b> | <b>1.5</b> | <b>1.5</b> | <b>0.6</b> |
| Coal PP                             | 1,699.65        | 2,153.96        | 991.56          | 296.67          | 62.46           | 0.00            | 0.00            | 53.1       | 50.5       | 22.8       | 5.7        | 1.0        | 0.0        | 0.0        | -1.7       | -12.5      | -14.4      | -100.0     | -          |
| Coal PP with biomass co-firing      | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with fuel ammonia co-firing | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00            | 0.00            | 0.00            | 15.61           | 121.24          | 4.08            | 1.99            | 0.0        | 0.0        | 0.0        | 0.3        | 2.0        | 0.1        | 0.0        | -          | -          | 22.7       | -28.8      | -6.9       |
| Oil                                 | 130.65          | 141.29          | 36.13           | 18.85           | 11.05           | 0.16            | 0.06            | 4.1        | 3.3        | 0.8        | 0.4        | 0.2        | 0.0        | 0.0        | -4.1       | -7.0       | -5.2       | -34.6      | -9.5       |
| Gas PP                              | 381.67          | 782.83          | 1,634.09        | 1,507.06        | 369.89          | 0.00            | 0.00            | 11.9       | 18.3       | 37.5       | 29.0       | 6.1        | 0.0        | 0.0        | 4.8        | -0.9       | -13.1      | -100.0     | -          |
| Gas PP with hydrogen co-firing      | 0.00            | 0.00            | 0.00            | 0.00            | 60.65           | 141.00          | 242.77          | 0.0        | 0.0        | 0.0        | 0.0        | 1.0        | 2.0        | 3.3        | -          | -          | -          | 8.8        | 5.6        |
| Gas PP with CCS                     | 0.00            | 0.00            | 0.00            | 79.32           | 718.03          | 380.42          | 5.88            | 0.0        | 0.0        | 0.0        | 1.5        | 11.8       | 5.4        | 0.1        | -          | -          | 24.6       | -6.2       | -34.1      |
| Nuclear PP                          | 611.59          | 810.73          | 811.55          | 821.79          | 1,010.81        | 1,236.83        | 1,216.31        | 19.1       | 19.0       | 18.6       | 15.8       | 16.7       | 17.5       | 16.6       | 0.9        | 0.1        | 2.1        | 2.0        | -0.2       |
| Solar PV                            | 0.67            | 1.77            | 156.01          | 927.13          | 1,681.28        | 2,622.04        | 2,987.47        | 0.0        | 0.0        | 3.6        | 17.8       | 27.7       | 37.2       | 40.7       | 19.2       | 21.9       | 6.1        | 4.5        | 1.3        |
| Wind                                | 3.07            | 17.88           | 382.81          | 1,083.85        | 1,542.01        | 2,147.61        | 2,351.41        | 0.1        | 0.4        | 8.8        | 20.8       | 25.4       | 30.5       | 32.1       | 16.8       | 12.3       | 3.6        | 3.4        | 0.9        |
| Hydro                               | 273.15          | 272.45          | 253.48          | 335.56          | 342.50          | 341.72          | 336.93          | 8.5        | 6.4        | 5.8        | 6.4        | 5.6        | 4.8        | 4.6        | -0.2       | 3.2        | 0.2        | 0.0        | -0.1       |
| Geothermal                          | 16.01           | 16.78           | 19.08           | 27.10           | 29.90           | 32.80           | 34.47           | 0.5        | 0.4        | 0.4        | 0.5        | 0.5        | 0.5        | 0.5        | 0.6        | 4.0        | 1.0        | 0.9        | 0.5        |
| Biomass and others                  | 86.362          | 71.22           | 69.35           | 91.72           | 115.06          | 143.26          | 157.77          | 2.7        | 1.7        | 1.6        | 1.8        | 1.9        | 2.0        | 2.2        | -0.7       | 3.2        | 2.3        | 2.2        | 1.0        |

### Power generation Input

|                      | MTOE          |               |               |               |               |               |              |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |
|----------------------|---------------|---------------|---------------|---------------|---------------|---------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|                      | 1990          | 2005          | 2021          | 2030          | 2040          | 2050          | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   |
| <b>Total</b>         | <b>513.01</b> | <b>691.07</b> | <b>518.72</b> | <b>360.06</b> | <b>278.47</b> | <b>116.12</b> | <b>68.22</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>0.0</b> | <b>-4.0</b> | <b>-2.5</b> | <b>-8.4</b> | <b>-5.2</b> |
| Coal                 | 396.00        | 503.06        | 230.30        | 67.60         | 44.51         | 0.85          | 0.35         | 77.2       | 72.8       | 44.4       | 18.8       | 16.0       | 0.7        | 0.5        | -1.7       | -12.7       | -4.1        | -32.7       | -8.6        |
| Fuel ammonia         | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           |
| Biomass (Co-firing)  | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          | 0.00         | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           |
| Oil                  | 27.25         | 33.34         | 8.65          | 4.66          | 3.17          | 0.04          | 0.01         | 5.3        | 4.8        | 1.7        | 1.3        | 1.1        | 0.0        | 0.0        | -3.6       | -6.6        | -3.8        | -35.3       | -10.7       |
| Gas                  | 89.76         | 154.66        | 279.76        | 263.84        | 192.15        | 60.77         | 0.82         | 17.5       | 22.4       | 53.9       | 73.3       | 69.0       | 52.3       | 1.2        | 3.7        | -0.6        | -3.1        | -10.9       | -35.0       |
| Hydrogen             | 0.00          | 0.00          | 0.00          | 0.00          | 9.75          | 19.91         | 30.44        | 0.0        | 0.0        | 0.0        | 0.0        | 3.5        | 17.1       | 44.6       | -          | -           | -           | 7.4         | 4.3         |
| Biomass (Biomass PP) | 0.00          | 0.00          | 0.00          | 23.96         | 28.88         | 34.55         | 36.59        | 0.0        | 0.0        | 0.0        | 6.7        | 10.4       | 29.8       | 53.6       | -          | -           | 1.9         | 1.8         | 0.6         |

### Thermal Efficiency

|            | %    |      |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |
|------------|------|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|
|            | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 |
| Total      | 38.5 | 39.2 | 45.3 | 48.0 | 45.0 | 49.5 | 51.5 |  |  |  |  |  |  |  | 0.5       | 0.6       | -0.6      | 1.0       | 0.4       |
| Coal PP    | 36.9 | 36.8 | 37.0 | 39.7 | 35.5 | 41.2 | 49.4 |  |  |  |  |  |  |  | 0.0       | 0.8       | -1.1      | 1.5       | 1.8       |
| Oil PP     | 41.2 | 36.4 | 35.9 | 34.8 | 29.9 | 33.4 | 38.1 |  |  |  |  |  |  |  | -0.4      | -0.4      | -1.5      | 1.1       | 1.3       |
| Gas PP     | 36.6 | 43.5 | 50.2 | 51.7 | 48.9 | 55.6 | 68.4 |  |  |  |  |  |  |  |           |           |           |           |           |
| Biomass PP | -    | -    | -    | 32.9 | 34.3 | 35.7 | 37.1 |  |  |  |  |  |  |  | -         | -         | 0.4       | 0.4       | 0.4       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                |                |                |              |             |             |            |            |            |            |            |            |            | AAGR(%)     |             |              |              |           |               |
|--------------|--------------------|----------------|----------------|----------------|--------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|--------------|--------------|-----------|---------------|
|              | 1990               | 2005           | 2021           | 2030           | 2040         | 2050        | 2060        | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021   | 2021-2030   | 2030-2040    | 2040-2050    | 2050-2060 | 2021-2060     |
| <b>Total</b> | <b>4,739.7</b>     | <b>5,561.9</b> | <b>4,549.3</b> | <b>2,927.8</b> | <b>920.4</b> | <b>14.7</b> | <b>-5.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>-0.1</b> | <b>-4.8</b> | <b>-10.9</b> | <b>-33.9</b> | <b>-</b>  | <b>-184.3</b> |
| Coal         | 1,843.5            | 2,187.3        | 1,027.2        | 340.7          | 107.8        | 10.0        | 6.7         | 38.9       | 39.3       | 22.6       | 11.6       | 11.7       | 68.0       | -115.9     | -1.9        | -11.5       | -10.9        | -21.2        | -3.9      | -12.1         |
| Oil          | 1,885.5            | 2,218.6        | 1,825.5        | 1,161.8        | 329.4        | 0.0         | 0.0         | 39.8       | 39.9       | 40.1       | 39.7       | 35.8       | 0.0        | 0.0        | -0.1        | -4.9        | -11.8        | -100.0       | -         | -100.0        |
| Natural Gas  | 1,010.6            | 1,155.9        | 1,696.6        | 1,425.4        | 490.6        | 22.5        | 14.9        | 21.3       | 20.8       | 37.3       | 48.7       | 53.3       | 153.2      | -257.8     | 1.7         | -1.9        | -10.1        | -26.5        | -4.0      | -11.4         |
| CCS/DAC (-)  | 0.0                | 0.0            | 0.0            | 0.0            | -7.4         | -17.8       | -27.4       | 0.0        | 0.0        | 0.0        | 0.0        | -0.8       | -121.1     | 473.7      | -           | -           | -            | 9.1          | 4.4       | -             |

## Energy and economic Indicators

|                                                                                           |       |        |        |        |        |        |        | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-------|--------|--------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990  | 2005   | 2021   | 2030   | 2040   | 2050   | 2060   | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 9,811 | 15,600 | 20,529 | 24,290 | 29,711 | 35,745 | 42,582 | 2.4       | 1.9       | 2.0       | 1.9       | 1.8       | 1.9       |
| Population (millions of people)                                                           | 250   | 296    | 332    | 347    | 361    | 370    | 375    | 0.9       | 0.5       | 0.4       | 0.2       | 0.1       | 0.3       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 39.30 | 52.79  | 61.86  | 70.09  | 82.29  | 96.62  | 113.44 | 1.5       | 1.4       | 1.6       | 1.6       | 1.6       | 1.6       |
| Primary energy consumption per capita (toe/person)                                        | 7.67  | 7.84   | 6.44   | 5.29   | 4.17   | 3.48   | 3.39   | -0.6      | -2.2      | -2.3      | -1.8      | -0.3      | -1.6      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 195   | 149    | 104    | 75     | 51     | 36     | 30     | -2.0      | -3.5      | -3.9      | -3.4      | -1.8      | -3.2      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 132   | 100    | 75     | 54     | 35     | 24     | 19     | -1.8      | -3.5      | -4.4      | -3.7      | -2.2      | -3.5      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 483   | 357    | 222    | 121    | 31     | 0      | (0)    | -2.5      | -6.5      | -12.7     | -35.1     | -         | -182.7    |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.48  | 2.40   | 2.13   | 1.60   | 0.61   | 0.01   | (0.00) | -0.5      | -3.1      | -9.2      | -32.8     | -         | -185.4    |
| Automobile ownership volume (millions of vehicles)                                        | 189   | 245    | 272    | 287    | 309    | 329    | 348    | 1.2       | 0.6       | 0.7       | 0.6       | 0.6       | 0.6       |
| Automobile ownership volume per capita (vehicles per person)                              | 0.756 | 0.829  | 0.821  | 0.829  | 0.855  | 0.888  | 0.926  | 0.3       | 0.1       | 0.3       | 0.4       | 0.4       | 0.3       |



## ASEAN [BAU]

### Primary energy consumption

|                                | MTOE   |        |        |        |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------------------------|--------|--------|--------|--------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                | 1990   | 2005   | 2021   | 2030   | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                          | 218.67 | 411.78 | 610.83 | 901.24 | 1,224.94 | 1,629.87 | 2,147.28 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.4       | 4.4       | 3.1       | 2.9       | 2.8       | 3.3       |
| Coal                           | 12.37  | 54.53  | 198.01 | 266.85 | 366.71   | 489.20   | 596.22   | 5.7  | 13.2 | 32.4 | 29.6 | 29.9 | 30.0 | 27.8 | 9.4       | 3.4       | 3.2       | 2.9       | 2.0       | 2.9       |
| Oil                            | 83.88  | 166.93 | 167.09 | 286.16 | 381.07   | 512.50   | 675.31   | 38.4 | 40.5 | 27.4 | 31.8 | 31.1 | 31.4 | 31.4 | 2.2       | 6.2       | 2.9       | 3.0       | 2.8       | 3.6       |
| Natural gas                    | 41.79  | 99.92  | 123.50 | 193.79 | 278.03   | 373.83   | 495.19   | 19.1 | 24.3 | 20.2 | 21.5 | 22.7 | 22.9 | 23.1 | 3.6       | 5.1       | 3.7       | 3.0       | 2.9       | 3.6       |
| Hydrogen                       | 0.00   | 0.00   | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Fuel Ammonia                   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Nuclear                        | 0.00   | 0.00   | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Hydro                          | 2.89   | 6.05   | 17.82  | 23.64  | 28.50    | 35.42    | 51.08    | 1.3  | 1.5  | 2.9  | 2.6  | 2.3  | 2.2  | 2.4  | 6.0       | 3.2       | 1.9       | 2.2       | 3.7       | 2.7       |
| Geothermal                     | 5.70   | 14.19  | 21.31  | 38.74  | 48.34    | 61.93    | 100.58   | 2.6  | 3.4  | 3.5  | 4.3  | 3.9  | 3.8  | 4.7  | 4.3       | 6.9       | 2.2       | 2.5       | 5.0       | 4.1       |
| Others                         | 72.03  | 70.15  | 83.10  | 92.06  | 122.29   | 156.98   | 228.90   | 32.9 | 17.0 | 13.6 | 10.2 | 10.0 | 9.6  | 10.7 | 0.5       | 1.1       | 2.9       | 2.5       | 3.8       | 2.6       |
| Biomass                        | 72.02  | 65.89  | 63.25  | 60.89  | 70.56    | 73.63    | 93.58    | 32.9 | 16.0 | 10.4 | 6.8  | 5.8  | 4.5  | 4.4  | -0.4      | -0.4      | 1.5       | 0.4       | 2.4       | 1.0       |
| Solar, Wind, Ocean             | 0.01   | 0.43   | 5.52   | 7.79   | 12.20    | 17.49    | 25.43    | 0.0  | 0.1  | 0.9  | 0.9  | 1.0  | 1.1  | 1.2  | 24.6      | 3.9       | 4.6       | 3.7       | 3.8       | 4.0       |
| Biofuels                       | 0.00   | 0.39   | 10.20  | 21.26  | 37.05    | 60.85    | 96.92    | 0.0  | 0.1  | 1.7  | 2.4  | 3.0  | 3.7  | 4.5  | -         | 8.5       | 5.7       | 5.1       | 4.8       | 5.9       |
| Electricity (Import or Export) | 0.00   | 3.45   | 4.12   | 2.11   | 2.48     | 5.01     | 12.97    | 0.0  | 0.8  | 0.67 | 0.23 | 0.2  | 0.3  | 0.6  | 24.9      | -7.2      | 1.6       | 7.3       | 10.0      | 3.0       |

### Final energy demand

|              | MTOE   |        |        |        |        |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|--------|--------|--------|--------|--------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990   | 2005   | 2021   | 2030   | 2040   | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 135.21 | 276.88 | 426.70 | 622.97 | 856.25 | 1,153.40 | 1,529.49 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.8       | 4.3       | 3.2       | 3.0       | 2.9       | 3.3       |
| Industry     | 38.17  | 91.45  | 149.33 | 229.32 | 316.99 | 433.43   | 585.25   | 28.2 | 33.0 | 35.0 | 36.8 | 37.0 | 37.6 | 38.3 | 4.5       | 4.9       | 3.3       | 3.2       | 3.0       | 3.6       |
| Transport    | 31.14  | 76.63  | 126.11 | 198.57 | 290.59 | 412.85   | 569.03   | 23.0 | 27.7 | 29.6 | 31.9 | 33.9 | 35.8 | 37.2 | 4.6       | 5.2       | 3.9       | 3.6       | 3.3       | 3.9       |
| Others       | 54.40  | 80.30  | 102.91 | 139.11 | 186.69 | 238.30   | 299.62   | 40.2 | 29.0 | 24.1 | 22.3 | 21.8 | 20.7 | 19.6 | 2.1       | 3.4       | 3.0       | 2.5       | 2.3       | 2.8       |
| Non-energy   | 11.50  | 28.50  | 48.34  | 55.97  | 61.98  | 68.82    | 75.59    | 8.5  | 10.3 | 11.3 | 9.0  | 7.2  | 6.0  | 4.9  | 4.7       | 1.6       | 1.0       | 1.1       | 0.9       | 1.2       |
| Total        | 125.89 | 266.29 | 411.66 | 603.85 | 832.00 | 1,121.39 | 1,484.98 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.9       | 4.3       | 3.3       | 3.0       | 2.8       | 3.3       |
| Coal         | 4.66   | 22.22  | 39.89  | 73.45  | 101.75 | 137.46   | 181.29   | 3.7  | 8.3  | 9.7  | 12.2 | 12.2 | 12.3 | 12.2 | 7.2       | 7.0       | 3.3       | 3.1       | 2.8       | 4.0       |
| Oil          | 65.54  | 144.39 | 183.95 | 263.23 | 362.07 | 489.06   | 643.55   | 52.1 | 54.2 | 44.7 | 43.6 | 43.5 | 43.6 | 43.3 | 3.4       | 4.1       | 3.2       | 3.1       | 2.8       | 3.3       |
| Natural gas  | 10.94  | 27.53  | 45.21  | 64.12  | 87.06  | 118.49   | 162.40   | 8.7  | 10.3 | 11.0 | 10.6 | 10.5 | 10.6 | 10.9 | 4.7       | 4.0       | 3.1       | 3.1       | 3.2       | 3.3       |
| Hydrogen     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Fuel Ammonia | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00     | 0.00     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Electricity  | 12.26  | 41.28  | 94.72  | 145.80 | 205.66 | 277.20   | 364.54   | 9.7  | 15.5 | 23.0 | 24.1 | 24.7 | 24.7 | 24.5 | 6.8       | 4.9       | 3.5       | 3.0       | 2.8       | 3.5       |
| Heat         | 0.00   | 0.00   | 0.33   | 0.65   | 0.65   | 0.65     | 0.65     | 0.0  | 0.0  | 0.1  | 0.1  | 0.1  | 0.1  | 0.0  | -         | 8.0       | 0.0       | 0.0       | 0.0       | 1.8       |
| Others       | 32.50  | 30.88  | 47.57  | 56.59  | 74.81  | 98.52    | 132.55   | 25.8 | 11.6 | 11.6 | 9.4  | 9.0  | 8.8  | 8.9  | 1.2       | 1.9       | 2.8       | 2.8       | 3.0       | 2.7       |

### Power generation Output

|                                     | TWh    |        |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|--------|--------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990   | 2005   | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 173.05 | 480.70 | 1,178.55 | 1,864.76 | 2,648.43 | 3,564.66 | 4,637.14 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 6.4       | 5.2       | 3.6       | 3.0       | 2.7       | 3.6       |
| Coal PP                             | 27.80  | 103.79 | 505.75   | 658.97   | 920.71   | 1,248.95 | 1,490.26 | 16   | 22   | 43   | 35   | 35   | 35   | 32   | 9.8       | 3.0       | 3.4       | 3.1       | 1.8       | 2.8       |
| Coal PP with biomass co-firing      | 0.00   | 0.00   | 0.00     | 56.41    | 89.17    | 133.34   | 142.87   | 41   | 5    | 0    | 3    | 3    | 4    | 3    | -         | -         | 4.7       | 4.1       | 0.7       | -         |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 22   | 52   | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Coal PP with CCS                    | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Oil PP                              | 70.77  | 24.95  | 16.16    | 13.73    | 14.69    | 16.76    | 19.71    | 0    | 0    | 1    | 1    | 1    | 0    | 0    | -4.7      | -1.8      | 0.7       | 1.3       | 1.6       | 0.5       |
| Gas PP                              | 37.63  | 252.02 | 356.48   | 679.38   | 1,029.78 | 1,399.87 | 1,827.61 | 0    | 0    | 30   | 36   | 39   | 39   | 39   | 7.5       | 7.4       | 4.2       | 3.1       | 2.7       | 4.3       |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Gas PP with CCS                     | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Nuclear PP                          | 0.00   | 0.00   | 0.00     | 0.00     | 0.00     | 0.00     | 0.00     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | -         | -         | -         | -         | -         | -         |
| Solar PV                            | 0.00   | 3.36   | 36.06    | 68.88    | 108.02   | 140.46   | 203.25   | 0    | 1    | 3    | 4    | 4    | 4    | 4    | -         | 7.5       | 4.6       | 2.7       | 3.8       | 4.5       |
| Wind                                | 0.00   | 1.76   | 10.79    | 21.53    | 34.02    | 64.76    | 94.12    | 0    | 0    | 1    | 1    | 1    | 2    | 2    | -         | 8.0       | 4.7       | 6.6       | 3.8       | 5.7       |
| Hydro                               | 28.90  | 73.58  | 207.27   | 274.11   | 331.49   | 410.23   | 586.33   | 17   | 15   | 18   | 15   | 13   | 12   | 13   | 6.6       | 3.2       | 1.9       | 2.2       | 3.6       | 2.7       |
| Geothermal                          | 6.59   | 12.55  | 24.78    | 45.20    | 56.37    | 72.18    | 117.12   | 4    | 3    | 2    | 2    | 2    | 2    | 3    | 4.4       | 6.9       | 2.2       | 2.5       | 5.0       | 4.1       |
| Biomass and others                  | 1.38   | 8.68   | 21.25    | 46.54    | 64.18    | 78.12    | 155.88   | 1    | 2    | 2    | 2    | 2    | 2    | 3    | 9.2       | 9.1       | 3.3       | 2.0       | 7.2       | 5.2       |

### Power generation Input

|                      | MTOE  |       |        |        |        |        |        |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|----------------------|-------|-------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                      | 1990  | 2005  | 2021   | 2030   | 2040   | 2050   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                | 34.79 | 82.58 | 221.67 | 333.00 | 476.19 | 629.75 | 789.72 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 6.2       | 4.6       | 3.6       | 2.8       | 2.3       | 3.3       |
| Coal                 | 7.37  | 25.12 | 139.66 | 190.71 | 263.89 | 350.48 | 413.41 | 21.2 | 30.4 | 63.0 | 57.3 | 55.4 | 55.7 | 52.3 | 10.0      | 3.5       | 3.3       | 2.9       | 1.7       | 2.8       |
| Fuel ammonia         | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass (Co-firing)  | 0.00  | 1.93  | 2.75   | 4.67   | 9.69   | 11.79  | 13.90  | 0.0  | 2.3  | 1.2  | 1.4  | 2.0  | 1.9  | 1.8  | -         | 6.1       | 7.6       | 2.0       | 1.7       | 4.2       |
| Oil                  | 18.21 | 8.15  | 4.44   | 3.42   | 3.54   | 3.85   | 4.48   | 52.3 | 9.9  | 2.0  | 1.0  | 0.7  | 0.6  | 0.6  | -4.5      | -2.9      | 0.3       | 0.8       | 1.5       | 0.0       |
| Gas                  | 8.82  | 46.65 | 68.41  | 122.37 | 184.39 | 247.28 | 322.40 | 25.4 | 56.5 | 30.9 | 36.7 | 38.7 | 39.3 | 40.8 | 6.8       | 6.7       | 4.2       | 3.0       | 2.7       | 4.1       |
| Hydrogen             | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -         | -         | -         | -         |
| Biomass (Biomass PP) | 0.39  | 0.72  | 6.41   | 11.84  | 14.68  | 16.35  | 35.52  | 1.1  | 0.9  | 2.9  | 3.6  | 3.1  | 2.6  | 4.5  | 9.5       | 7.1       | 2.2       | 1.1       | 8.1       | 4.5       |

### Thermal Efficiency

|         | %    |       |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|---------|------|-------|------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|         | 1990 | 2005  | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total   | 34.0 | 40.6  | 34.9 | 37.6 | 38.3 | 39.3 | 39.6 |  |  |  |  |  |  |  | 0.1       | 0.8       | 0.2       | 0.3       | 0.1       | 0.3       |
| Coal    | 32.4 | 33.0  | 30.5 | 31.5 | 31.7 | 32.8 | 32.9 |  |  |  |  |  |  |  | -0.2      | 0.3       | 0.1       | 0.3       | 0.0       | 0.2       |
| Oil     | 33.4 | 26.3  | 31.3 | 34.5 | 35.7 | 37.5 | 37.8 |  |  |  |  |  |  |  | -0.2      | 1.1       | 0.3       | 0.5       | 0.1       | 0.5       |
| Gas     | 36.7 | 46.5  | 44.8 | 47.7 | 48.0 | 48.7 | 48.8 |  |  |  |  |  |  |  | 0.6       | 0.7       | 0.1       | 0.1       | 0.0       | 0.2       |
| Biomass | 30.4 | 103.1 | 28.5 | 33.8 | 37.6 | 41.1 | 37.7 |  |  |  |  |  |  |  | -0.2      | 1.9       | 1.1       | 0.9       | -0.8      | 0.7       |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |                |                |                |                |                |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |            |
|--------------|--------------------|--------------|----------------|----------------|----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990               | 2005         | 2021           | 2030           | 2040           | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  | 2021-2060  |
| <b>Total</b> | <b>350.5</b>       | <b>642.1</b> | <b>1,444.0</b> | <b>2,201.8</b> | <b>3,101.5</b> | <b>4,196.0</b> | <b>5,352.5</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.7</b> | <b>4.8</b> | <b>3.5</b> | <b>3.1</b> | <b>2.5</b> | <b>3.4</b> |
| Coal         | 65.10              | 165.13       | 689.58         | 1,020.31       | 1,415.36       | 1,890.47       | 2,300.51       | 18.6       | 25.7       | 47.8       | 46.3       | 45.6       | 45.1       | 43.0       | 7.9        | 4.4        | 3.3        | 2.9        | 2.0        | 3.1        |
| Oil          | 166.25             | 279.77       | 522.13         | 784.39         | 1,093.75       | 1,493.11       | 1,972.05       | 47.4       | 43.6       | 36.2       | 35.6       | 35.3       | 35.6       | 36.8       | 3.8        | 4.6        | 3.4        | 3.2        | 2.8        | 3.5        |
| Gas          | 119.16             | 197.18       | 232.34         | 397.11         | 592.42         | 812.44         | 1,079.92       | 34.0       | 30.7       | 16.1       | 18.0       | 19.1       | 19.4       | 20.2       | 2.2        | 6.1        | 4.1        | 3.2        | 2.9        | 4.0        |
| CCS/DAC (-)  |                    |              |                |                |                |                |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          | -          |

## Energy and economic Indicators

|                                                                                           |        |          |          |          |          |           |           | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|--------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990   | 2005     | 2021     | 2030     | 2040     | 2050      | 2060      | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 799.15 | 1,486.74 | 3,078.31 | 4,617.81 | 7,453.53 | 11,600.38 | 17,420.84 | 4.4       | 4.6       | 4.90      | 4.52      | 4.2       | 4.5       |
| Population (millions of people)                                                           | 437.86 | 557.41   | 670.55   | 719.89   | 765.88   | 804.69    | 844.22    | 1.4       | 0.8       | 0.6       | 0.5       | 0.5       | 0.6       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 1.83   | 2.67     | 4.59     | 6.41     | 9.73     | 14.42     | 20.64     | 3.0       | 3.8       | 4.3       | 4.0       | 3.7       | 3.9       |
| Primary energy consumption per capita (toe/person)                                        | 0.50   | 0.74     | 0.91     | 1.25     | 1.60     | 2.03      | 2.54      | 2.0       | 3.6       | 2.5       | 2.4       | 2.3       | 2.7       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 273.62 | 276.97   | 198.43   | 195.16   | 164.34   | 140.50    | 123.26    | -1.0      | -0.2      | -1.7      | -1.6      | -1.3      | -1.2      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 169.19 | 186.23   | 138.62   | 134.91   | 114.88   | 99.43     | 87.80     | -0.6      | -0.3      | -1.6      | -1.4      | -1.2      | -1.2      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 438.60 | 431.87   | 469.10   | 476.81   | 416.12   | 361.71    | 307.25    | 0.2       | 0.2       | -1.4      | -1.4      | -1.6      | -1.1      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.60   | 1.56     | 2.36     | 2.44     | 2.53     | 2.57      | 2.49      | 1.3       | 0.4       | 0.4       | 0.2       | -0.3      | 0.1       |
| Automobile ownership volume (millions of vehicles)                                        |        |          |          |          |          |           |           | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -      | -        | -        | -        | -        | -         | -         | -         | -         | -         | -         | -         | -         |

## ASEAN [LCET]

### Primary energy consumption

|                                | Energy consumption |        |        |        |        |          |          |                   |      |      |      |      |      |      |                  |           | Energy efficiency |           |           |           |  | Energy intensity |  |  |  |  |
|--------------------------------|--------------------|--------|--------|--------|--------|----------|----------|-------------------|------|------|------|------|------|------|------------------|-----------|-------------------|-----------|-----------|-----------|--|------------------|--|--|--|--|
|                                | MTOE               |        |        |        |        |          |          | Energy efficiency |      |      |      |      |      |      | Energy intensity |           |                   |           |           |           |  |                  |  |  |  |  |
|                                | 1990               | 2005   | 2021   | 2030   | 2040   | 2050     | 2060     | 1990              | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021        | 2021-2030 | 2030-2040         | 2040-2050 | 2050-2060 | 2021-2060 |  |                  |  |  |  |  |
| Total                          | 218.67             | 411.78 | 610.83 | 771.68 | 989.66 | 1,249.24 | 1,493.42 | 100               | 100  | 100  | 100  | 100  | 100  | 100  | 3.4              | 2.6       | 2.5               | 2.4       | 1.8       | 2.3       |  |                  |  |  |  |  |
| Coal                           | 12.37              | 54.53  | 198.01 | 201.05 | 178.43 | 157.85   | 117.75   | 5.7               | 13.2 | 32.4 | 26.1 | 18.0 | 12.6 | 7.9  | 9.4              | 0.2       | -1.2              | -1.2      | -2.9      | -1.3      |  |                  |  |  |  |  |
| Oil                            | 83.88              | 166.93 | 167.09 | 214.03 | 204.90 | 166.97   | 133.94   | 38.4              | 40.5 | 27.4 | 27.7 | 20.7 | 13.4 | 9.0  | 2.2              | 2.8       | -0.4              | -2.0      | -2.2      | -0.6      |  |                  |  |  |  |  |
| Natural gas                    | 41.79              | 99.92  | 123.50 | 174.41 | 208.12 | 227.15   | 265.74   | 19.1              | 24.3 | 20.2 | 22.6 | 21.0 | 18.2 | 17.8 | 3.6              | 3.9       | 1.8               | 0.9       | 1.6       | 2.0       |  |                  |  |  |  |  |
| Hydrogen                       | 0.00               | 0.00   | 0.00   | 0.42   | 16.52  | 66.52    | 129.15   | 0.0               | 0.0  | 0.0  | 0.1  | 1.7  | 5.3  | 8.6  | -                | -         | 44.3              | 14.9      | 6.9       | -         |  |                  |  |  |  |  |
| Fuel Ammonia                   | 0.00               | 0.00   | 0.00   | 0.07   | 0.05   | 0.73     | 1.44     | 0.0               | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  | 0.1  | -                | -         | -3.3              | 30.4      | 7.1       | -         |  |                  |  |  |  |  |
| Nuclear                        | 0.00               | 0.00   | 0.00   | 0.42   | 9.39   | 29.21    | 72.22    | 0.0               | 0.0  | 0.0  | 0.1  | 0.9  | 2.3  | 4.8  | -                | -         | 36.4              | 12.0      | 9.5       | -         |  |                  |  |  |  |  |
| Hydro                          | 2.89               | 6.05   | 17.82  | 22.47  | 41.02  | 65.20    | 103.57   | 1.3               | 1.5  | 2.9  | 2.9  | 4.1  | 5.2  | 6.9  | 6.0              | 2.6       | 6.2               | 4.7       | 4.7       | 4.6       |  |                  |  |  |  |  |
| Geothermal                     | 5.70               | 14.19  | 21.31  | 39.45  | 91.08  | 111.10   | 118.89   | 2.6               | 3.4  | 3.5  | 5.1  | 9.2  | 8.9  | 8.0  | 4.3              | 7.1       | 8.7               | 2.0       | 0.7       | 4.5       |  |                  |  |  |  |  |
| Others                         | 72.03              | 70.15  | 83.10  | 119.37 | 240.15 | 424.52   | 550.72   | 32.9              | 17.0 | 13.6 | 15.5 | 24.3 | 34.0 | 36.9 | 0.5              | 4.1       | 7.2               | 5.9       | 2.6       | 5.0       |  |                  |  |  |  |  |
| Biomass                        | 72.02              | 65.89  | 63.25  | 69.43  | 112.47 | 182.84   | 233.77   | 32.9              | 16.0 | 10.4 | 9.0  | 11.4 | 14.6 | 15.7 | -0.4             | 1.0       | 4.9               | 5.0       | 2.5       | 3.4       |  |                  |  |  |  |  |
| Solar.Wind.Ocean               | 0.01               | 0.43   | 5.52   | 17.44  | 72.01  | 159.95   | 211.00   | 0.0               | 0.1  | 0.9  | 2.3  | 7.3  | 12.8 | 14.1 | 24.6             | 13.6      | 15.2              | 8.3       | 2.8       | 9.8       |  |                  |  |  |  |  |
| Biofuels                       | 0.00               | 0.39   | 10.20  | 27.15  | 46.14  | 64.87    | 89.35    | 0.0               | 0.1  | 1.7  | 3.5  | 4.7  | 5.2  | 6.0  | -                | 11.5      | 5.4               | 3.5       | 3.3       | 5.7       |  |                  |  |  |  |  |
| Electricity (Import or Export) | 0.00               | 3.45   | 4.12   | 5.34   | 9.52   | 16.86    | 16.60    | 0.0               | 0.8  | 0.67 | 0.69 | 1.0  | 1.3  | 1.1  | 24.9             | 2.9       | 5.9               | 5.9       | -0.2      | 3.6       |  |                  |  |  |  |  |

### Final energy demand

|              | MTOE   |        |        |        |        |        |        |        |      |      |      |      |      |      | AAGR(%) |           |           |           |           |           |           |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|------|------|------|------|------|------|---------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990   | 2005   | 2021   | 2030   | 2040   | 680.35 | 797.64 | 893.72 | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060    | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 135.21 | 276.88 | 426.70 | 558.94 | 680.35 | 797.64 | 893.72 | 100    | 100  | 100  | 100  | 100  | 100  | 100  | 100     | 3.8       | 3.0       | 2.0       | 1.6       | 1.1       | 1.9       |
| Industry     | 38.17  | 91.45  | 149.33 | 206.46 | 255.35 | 307.76 | 333.93 | 28.2   | 33.0 | 35.0 | 36.9 | 37.5 | 38.6 | 37.4 | 4.5     | 3.7       | 2.1       | 1.9       | 0.8       | 2.1       |           |
| Transport    | 31.14  | 76.63  | 126.11 | 177.24 | 213.68 | 238.86 | 267.71 | 23.0   | 27.7 | 29.6 | 31.7 | 31.4 | 29.9 | 30.0 | 4.6     | 3.9       | 1.9       | 1.1       | 1.1       | 1.9       |           |
| Others       | 54.40  | 80.30  | 102.91 | 121.79 | 153.43 | 187.45 | 222.64 | 4.0    | 29.2 | 26.1 | 21.8 | 22.6 | 23.5 | 24.9 | 2.1     | 1.9       | 2.3       | 2.0       | 1.7       | 2.0       |           |
| Non-energy   | 11.50  | 28.50  | 48.34  | 53.46  | 57.89  | 63.60  | 69.43  | 8.5    | 10.3 | 11.3 | 9.6  | 8.5  | 8.0  | 7.8  | 4.7     | 1.1       | 0.8       | 0.9       | 0.9       | 0.9       |           |
| Total        | 135.21 | 276.88 | 426.70 | 558.94 | 680.35 | 797.65 | 893.73 | 100    | 100  | 100  | 100  | 100  | 100  | 100  | 100     | 3.8       | 3.0       | 2.0       | 1.6       | 1.1       | 1.9       |
| Coal         | 4.71   | 22.31  | 40.14  | 65.62  | 65.14  | 54.86  | 35.18  | 3.5    | 8.1  | 9.4  | 11.7 | 9.6  | 6.9  | 3.9  | 7.2     | 5.6       | -0.1      | -1.7      | -4.3      | -0.3      |           |
| Oil          | 66.04  | 145.83 | 188.12 | 221.52 | 208.50 | 167.25 | 129.31 | 48.8   | 52.7 | 44.1 | 39.6 | 30.6 | 21.0 | 14.5 | 3.4     | 1.8       | -0.6      | -2.2      | -2.5      | -1.0      |           |
| Natural gas  | 11.17  | 27.83  | 45.44  | 60.85  | 71.28  | 79.42  | 75.80  | 8.3    | 10.1 | 10.6 | 10.9 | 10.5 | 10.0 | 8.5  | 4.6     | 3.3       | 1.6       | 1.1       | -0.5      | 1.3       |           |
| Hydrogen     | 0.00   | 0.00   | 0.00   | 0.32   | 27.59  | 62.57  | 79.64  | 0.0    | 0.0  | 0.0  | 0.1  | 4.1  | 7.8  | 8.9  | -       | -         | -         | 56.0      | 8.5       | 2.4       | -         |
| Fuel Ammonia | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.0    | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0     | -         | -         | -         | -         | -         | -         |
| Electricity  | 12.41  | 41.65  | 96.29  | 135.98 | 208.48 | 312.45 | 429.80 | 9.2    | 15.0 | 22.6 | 24.3 | 30.6 | 39.2 | 48.1 | 6.8     | 3.9       | 4.4       | 4.1       | 3.2       | 3.9       |           |
| Heat         | 0.00   | 0.00   | 0.33   | 0.65   | 0.65   | 0.65   | 0.65   | 0.0    | 0.0  | 0.1  | 0.1  | 0.1  | 0.1  | 0.1  | 0.1     | -         | 8.0       | 0.0       | 0.0       | 0.0       | 1.8       |
| Others       | 40.89  | 39.26  | 56.39  | 74.00  | 98.71  | 120.46 | 143.35 | 30.2   | 14.2 | 13.2 | 13.2 | 14.5 | 15.1 | 16.0 | 1.0     | 3.1       | 2.9       | 2.0       | 1.8       | 2.4       |           |

### Power generation Output

| Power generation output             | TWh    |        |          |          |          |          |          |      |      |      |      |      |      |           | AAGR(%)   |           |           |           |           |  |
|-------------------------------------|--------|--------|----------|----------|----------|----------|----------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                                     | 1990   | 2021   | 2030     | 2040     | 2050     | 2060     | 1990     | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                               | 173.05 | 480.70 | 1,178.55 | 1,669.29 | 2,578.38 | 4,091.17 | 5,671.26 | 100  | 100  | 100  | 100  | 100  | 100  | 6.4       | 3.9       | 4.4       | 4.7       | 3.5       | 4.1       |  |
| Coal PP                             | 27.80  | 103.79 | 505.75   | 451.99   | 287.97   | 52.81    | 19.42    | 16   | 22   | 43   | 27   | 11   | 1    | 0         | 9.8       | -1.2      | -4.4      | -15.6     | -9.5      |  |
| Coal PP with biomass co-firing      | 0.00   | 0.00   | 0.00     | 17.37    | 57.86    | 173.62   | 264.36   | 41   | 5    | 0    | 1    | 2    | 4    | 5         | -         | -         | 12.8      | 11.6      | 4.3       |  |
| Coal PP with fuel ammonia co-firing | 0.00   | 0.00   | 0.00     | 0.31     | 12.87    | 85.90    | 142.50   | 22   | 52   | 0    | 0    | 0    | 2    | 3         | -         | -         | 45.1      | 20.9      | 5.2       |  |
| Coal PP with CCS                    | 0.00   | 0.00   | 0.00     | 29.02    | 136.81   | 290.55   | 353.84   | 0    | 0    | 0    | 2    | 5    | 7    | 6         | -         | -         | 16.8      | 7.8       | 2.0       |  |
| Oil PP                              | 70.77  | 24.95  | 16.16    | 14.07    | 12.64    | 8.78     | 8.34     | 0    | 0    | 1    | 1    | 0    | 0    | 0         | -4.7      | -1.5      | -1.1      | -3.6      | -0.5      |  |
| Gas PP                              | 37.63  | 252.02 | 356.48   | 491.82   | 471.90   | 232.87   | 24.82    | 0    | 0    | 30   | 29   | 18   | 6    | 0         | 7.5       | 3.6       | -0.4      | -6.8      | -20.1     |  |
| Gas PP with hydrogen co-firing      | 0.00   | 0.00   | 0.00     | 0.62     | 104.81   | 458.95   | 949.55   | 0    | 0    | 0    | 0    | 4    | 11   | 17        | -         | -         | 67.0      | 15.9      | 7.5       |  |
| Gas PP with CCS                     | 0.00   | 0.00   | 0.00     | 124.79   | 250.94   | 545.59   | 907.72   | 0    | 0    | 0    | 7    | 10   | 13   | 16        | -         | -         | 7.2       | 8.1       | 5.2       |  |
| Nuclear PP                          | 0.00   | 0.00   | 0.00     | 0.00     | 36.05    | 112.08   | 277.11   | 0    | 0    | 0    | 0    | 1    | 3    | 5         | -         | -         | -         | 12.0      | 9.5       |  |
| Solar PV                            | 0.00   | 3.36   | 36.06    | 104.32   | 260.83   | 542.77   | 721.29   | 0    | 1    | 3    | 6    | 10   | 13   | 13        | -         | 12.5      | 9.6       | 7.6       | 2.9       |  |
| Wind                                | 0.00   | 1.76   | 10.79    | 69.46    | 225.13   | 493.82   | 713.30   | 0    | 0    | 1    | 4    | 9    | 12   | 13        | -         | 23.0      | 12.5      | 8.2       | 3.7       |  |
| Hydro                               | 28.90  | 73.58  | 207.27   | 261.29   | 460.97   | 664.75   | 750.62   | 17   | 15   | 18   | 16   | 18   | 16   | 13        | 6.6       | 2.6       | 5.8       | 3.7       | 1.2       |  |
| Geothermal                          | 6.59   | 12.55  | 24.78    | 46.03    | 106.07   | 129.35   | 138.41   | 4    | 3    | 2    | 3    | 4    | 3    | 2         | 4.4       | 7.1       | 8.7       | 2.0       | 4.5       |  |
| Biomass and others                  | 1.38   | 8.68   | 21.25    | 58.20    | 153.51   | 299.33   | 399.97   | 1    | 2    | 2    | 3    | 6    | 7    | 7         | 9.2       | 11.8      | 10.2      | 6.9       | 2.9       |  |

### Power generation Input

| Energy generation type | MTOE  |       |        |        |        |        |        |      |      |      |      |      |      |      |           | AAGR(%)   |           |           |           |           |  |
|------------------------|-------|-------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                        | 1990  | 2005  | 2021   | 2038   | 2040   | 2040   | 2060   | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2038 | 2038-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                  | 34.79 | 82.58 | 221.63 | 261.98 | 303.07 | 420.15 | 566.39 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 6.2       | 1.9       | 1.5       | 3.3       | 3.0       | 2.3       |  |
| Coal                   | 7.37  | 25.12 | 139.66 | 135.43 | 113.29 | 103.00 | 82.56  | 21.2 | 30.4 | 63.0 | 51.7 | 37.4 | 24.5 | 14.6 | 10.0      | -0.3      | -1.8      | -0.9      | -2.2      | -1.3      |  |
| Fuel ammonia           | 0.00  | 0.00  | 0.00   | 0.07   | 1.93   | 9.91   | 29.67  | 0.0  | 0.0  | 0.0  | 0.0  | 0.6  | 2.4  | 5.2  | -         | -         | 38.9      | 17.8      | 11.6      | -         |  |
| Biomass (Co-firing)    | 0.00  | 1.93  | 2.75   | 5.04   | 18.90  | 48.06  | 76.36  | 0.0  | 2.3  | 1.2  | 1.9  | 6.2  | 11.4 | 13.5 | -         | 7.0       | 14.1      | 9.8       | 4.7       | 8.9       |  |
| Oil                    | 18.21 | 8.15  | 4.44   | 3.43   | 3.08   | 2.13   | 2.03   | 52.3 | 9.9  | 2.0  | 1.3  | 1.0  | 0.5  | 0.4  | -4.5      | -2.8      | -1.1      | -3.6      | -0.5      | -2.0      |  |
| Gas                    | 8.82  | 46.65 | 68.41  | 140.15 | 128.71 | 140.12 | 167.80 | 25.4 | 56.5 | 30.9 | 41.0 | 42.5 | 33.3 | 29.6 | 6.8       | 5.1       | 1.8       | 0.9       | 1.8       | 2.3       |  |
| Hydrogen               | 0.00  | 0.00  | 0.00   | 0.10   | 9.94   | 65.47  | 148.48 | 0.0  | 0.0  | 0.0  | 0.0  | 3.3  | 15.6 | 26.2 | -         | -         | 58.5      | 20.7      | 8.5       | -         |  |
| Biomass (Biomass PP)   | 0.39  | 0.72  | 6.37   | 10.46  | 27.21  | 51.45  | 59.48  | 1.1  | 0.9  | 2.9  | 4.0  | 9.0  | 12.2 | 10.5 | 9.4       | 5.7       | 10.0      | 6.6       | 1.5       | 5.9       |  |

### Thermal Efficiency

| Thermal Efficiency |  | %    |       |      |      |      |      |      |  |  |  |  |  |  |  | AAGR(%) |           |           |           |           |           |     |
|--------------------|--|------|-------|------|------|------|------|------|--|--|--|--|--|--|--|---------|-----------|-----------|-----------|-----------|-----------|-----|
|                    |  | 1990 | 2005  | 2021 | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  |         | 1990-2030 | 2010-2030 | 2040-2050 | 2050-2060 | 2010-2060 |     |
| Total              |  | 34.0 | 40.6  | 34.9 | 39.0 | 42.3 | 44.0 | 46.6 |  |  |  |  |  |  |  |         | 0.1       | 1.2       | 0.8       | 0.4       | 0.6       | 0.7 |
| Coal               |  | 32.4 | 33.0  | 30.5 | 30.5 | 31.8 | 32.2 | 35.6 |  |  |  |  |  |  |  |         | -0.2      | 0.0       | 0.4       | 0.1       | 1.0       | 0.4 |
| Oil                |  | 33.4 | 26.3  | 31.3 | 35.3 | 35.3 | 35.4 | 35.4 |  |  |  |  |  |  |  |         | -0.2      | 1.3       | 0.0       | 0.0       | 0.0       | 0.3 |
| Gas                |  | 36.7 | 46.5  | 44.8 | 49.4 | 51.3 | 51.8 | 51.2 |  |  |  |  |  |  |  |         | 0.6       | 1.1       | 0.4       | 0.1       | -0.1      | 0.3 |
| Biomass            |  | 30.4 | 103.1 | 28.7 | 47.9 | 48.5 | 50.0 | 57.8 |  |  |  |  |  |  |  |         | -0.2      | 5.8       | 0.1       | 0.3       | 1.5       | 1.1 |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |              |                |                |                |              |              |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |             |             |
|--------------|--------------------|--------------|----------------|----------------|----------------|--------------|--------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005         | 2021           | 2030           | 2040           | 2050         | 2060         | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>350.5</b>       | <b>642.1</b> | <b>1,444.0</b> | <b>1,448.4</b> | <b>1,491.6</b> | <b>983.5</b> | <b>548.3</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>4.7</b> | <b>1.6</b> | <b>-1.1</b> | <b>-4.1</b> | <b>-5.7</b> | <b>-2.5</b> |
| Coal         | 65.1               | 165.1        | 689.6          | 724.7          | 607.7          | 385.7        | 146.2        | 18.6       | 25.7       | 47.8       | 43.4       | 40.7       | 39.2       | 26.7       | 7.9        | 0.6        | -1.7        | -4.4        | -9.2        | -3.9        |
| Oil          | 166.3              | 279.8        | 523.5          | 632.7          | 579.2          | 402.6        | 277.8        | 47.4       | 43.6       | 36.3       | 37.9       | 38.8       | 40.9       | 50.7       | 3.8        | 2.1        | -0.9        | -3.6        | -3.6        | -1.6        |
| Gas          | 119.2              | 197.2        | 231.0          | 311.0          | 304.8          | 195.2        | 124.4        | 34.0       | 30.7       | 16.0       | 18.6       | 20.4       | 19.8       | 22.7       | 2.2        | 3.4        | -0.2        | -4.4        | -4.4        | -1.6        |
| CCS/DAC (-)  |                    |              |                |                |                |              |              | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |        |          |          |          |          |           |           | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|--------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990   | 2005     | 2021     | 2030     | 2040     | 2050      | 2060      | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 799.15 | 1,486.74 | 3,078.31 | 4,617.81 | 7,453.53 | 11,600.38 | 17,420.84 | 4.4       | 4.6       | 4.90      | 4.52      | 4.2       | 4.5       |
| Population (millions of people)                                                           | 437.86 | 557.41   | 670.55   | 719.89   | 765.88   | 804.69    | 844.22    | 1.4       | 0.8       | 0.6       | 0.5       | 0.5       | 0.6       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 1.83   | 2.67     | 4.59     | 6.41     | 9.73     | 14.42     | 20.64     | 3.0       | 3.8       | 4.3       | 4.0       | 3.7       | 3.9       |
| Primary energy consumption per capita (toe/person)                                        | 0.50   | 0.74     | 0.91     | 1.07     | 1.29     | 1.55      | 1.77      | 2.0       | 1.8       | 1.9       | 1.9       | 1.3       | 1.7       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 273.62 | 276.97   | 198.43   | 167.11   | 132.78   | 107.69    | 85.73     | -1.0      | -1.9      | -2.3      | -2.1      | -2.3      | -2.1      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 169.19 | 186.23   | 138.62   | 121.04   | 91.28    | 68.76     | 51.30     | -0.6      | -1.5      | -2.8      | -2.8      | -2.9      | -2.5      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 438.60 | 431.87   | 469.10   | 361.30   | 200.12   | 84.78     | 31.48     | 0.2       | -2.9      | -5.7      | -8.2      | -9.4      | -6.7      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 1.60   | 1.56     | 2.36     | 2.16     | 1.51     | 0.79      | 0.37      | 1.3       | -1.0      | -3.5      | -6.3      | -7.3      | -4.7      |
| Automobile ownership volume (millions of vehicles)                                        |        |          |          |          |          |           |           | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -      | -        | -        | -        | -        | -         | -         | -         | -         | -         | -         | -         | -         |

# EAS17 [BAU]

## Primary energy consumption

|                                | MTOE            |                 |                 |                 |                 |                  |                  |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                | 1990            | 2005            | 2021            | 2030            | 2040            | 2050             | 2060             | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                   | <b>3,915.77</b> | <b>5,862.16</b> | <b>8,273.65</b> | <b>9,096.77</b> | <b>9,661.48</b> | <b>10,215.41</b> | <b>10,695.77</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.4</b> | <b>1.1</b> | <b>0.6</b> | <b>0.6</b> | <b>0.5</b> |
| Coal                           | 1,233.31        | 2,213.00        | 3,365.34        | 3,294.96        | 3,100.11        | 2,866.62         | 2,639.74         | 31.5       | 37.8       | 40.7       | 36.2       | 32.1       | 28.1       | 24.7       | 3.3        | -0.2       | -0.6       | -0.8       | -0.6       |
| Oil                            | 1,353.86        | 1,915.21        | 2,143.18        | 2,314.71        | 2,493.37        | 2,726.52         | 2,864.95         | 34.6       | 32.7       | 25.9       | 25.4       | 25.8       | 26.7       | 26.8       | 1.5        | 0.9        | 0.7        | 0.9        | 0.5        |
| Natural gas                    | 569.03          | 797.96          | 1,381.72        | 1,529.05        | 1,643.80        | 1,733.71         | 1,773.16         | 14.5       | 13.6       | 16.7       | 16.8       | 17.0       | 17.0       | 16.6       | 2.9        | 1.1        | 0.7        | 0.5        | 0.2        |
| Hydrogen                       | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00             | -0.001           | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | 17.0       | 3.5        | 77.8       |
| Fuel Ammonia                   | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear                        | 227.44          | 347.24          | 389.54          | 468.50          | 477.40          | 528.21           | 585.68           | 5.8        | 5.9        | 4.7        | 5.2        | 4.9        | 5.2        | 5.5        | 1.8        | 2.1        | 0.2        | 1.0        | 1.0        |
| Hydro                          | 54.75           | 83.16           | 175.75          | 202.80          | 229.33          | 254.12           | 286.82           | 1.4        | 1.4        | 2.1        | 2.2        | 2.4        | 2.5        | 2.7        | 3.8        | 1.6        | 1.2        | 1.0        | 1.2        |
| Geothermal                     | 22.87           | 30.02           | 62.46           | 87.60           | 103.31          | 119.90           | 157.80           | 0.6        | 0.5        | 0.8        | 1.0        | 1.1        | 1.2        | 1.5        | 3.3        | 3.8        | 1.7        | 1.5        | 2.8        |
| Others                         | 454.50          | 475.57          | 755.65          | 1,199.15        | 1,614.16        | 1,986.32         | 2,387.62         | 11.6       | 8.1        | 9.1        | 13.2       | 16.7       | 19.4       | 22.3       | 1.7        | 5.3        | 3.0        | 2.1        | 1.9        |
| Biomass                        | 451.52          | 444.35          | 483.03          | 588.77          | 624.25          | 632.56           | 658.05           | 11.5       | 7.6        | 5.8        | 6.5        | 6.5        | 6.2        | 6.2        | 0.2        | 2.2        | 0.6        | 0.1        | 0.4        |
| Solar Wind Ocean               | 1.73            | 8.08            | 196.29          | 511.57          | 868.61          | 1,197.75         | 1,525.38         | 0.0        | 0.1        | 2.4        | 5.6        | 9.0        | 11.7       | 14.3       | 16.5       | 11.2       | 5.4        | 3.3        | 2.4        |
| Biofuels                       | 0.80            | 17.93           | 69.96           | 99.94           | 117.05          | 149.24           | 189.47           | 0.0        | 0.3        | 0.8        | 1.0        | 1.2        | 1.5        | 1.8        | 15.5       | 3.5        | 2.1        | 2.5        | 2.4        |
| Electricity (Import or Export) | 0.45            | 5.20            | 6.38            | 3.87            | 4.25            | 6.77             | 14.72            | 0.0        | 0.1        | 0.08       | 0.04       | 0.0        | 0.1        | 0.1        | 8.9        | -5.4       | 0.9        | 4.7        | 8.1        |

## Final energy demand

|              | MTOE            |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|              | 1990            | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b> | <b>2,722.77</b> | <b>3,964.18</b> | <b>5,456.90</b> | <b>6,025.78</b> | <b>6,583.35</b> | <b>7,178.43</b> | <b>7,669.50</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.3</b> | <b>1.1</b> | <b>0.9</b> | <b>0.9</b> | <b>0.7</b> |
| Industry     | 764.85          | 1,259.05        | 1,957.07        | 2,167.76        | 2,348.61        | 2,451.58        | 2,505.27        | 28.1       | 31.8       | 35.9       | 36.0       | 35.7       | 34.2       | 32.7       | 3.1        | 1.1        | 0.8        | 0.4        | 0.2        |
| Transport    | 680.59          | 1,020.24        | 1,312.08        | 1,500.02        | 1,673.95        | 1,920.05        | 2,120.11        | 25.0       | 25.7       | 24.0       | 24.9       | 25.4       | 26.7       | 27.6       | 2.1        | 1.5        | 1.1        | 1.4        | 1.0        |
| Others       | 1,046.92        | 1,312.71        | 1,627.91        | 1,743.67        | 1,885.96        | 2,077.51        | 2,259.35        | 38.5       | 33.1       | 29.8       | 28.9       | 28.6       | 28.9       | 29.5       | 1.4        | 0.8        | 0.8        | 1.0        | 0.8        |
| Non-energy   | 230.41          | 372.18          | 559.84          | 614.33          | 674.83          | 729.28          | 784.76          | 8.5        | 9.4        | 10.3       | 10.2       | 10.3       | 10.2       | 10.2       | 2.9        | 1.0        | 0.9        | 0.8        | 0.7        |
| <b>Total</b> | <b>2,713.44</b> | <b>3,953.59</b> | <b>5,441.86</b> | <b>6,006.46</b> | <b>6,559.11</b> | <b>7,146.42</b> | <b>7,624.98</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.3</b> | <b>1.1</b> | <b>0.9</b> | <b>0.9</b> | <b>0.7</b> |
| Coal         | 453.98          | 670.85          | 733.01          | 690.23          | 669.03          | 669.84          | 682.13          | 16.7       | 17.0       | 13.5       | 11.5       | 10.2       | 9.4        | 8.9        | 1.6        | -0.7       | -0.3       | 0.0        | 0.2        |
| Oil          | 1,140.24        | 1,685.18        | 2,019.58        | 2,162.23        | 2,352.18        | 2,584.43        | 2,723.51        | 42.0       | 42.6       | 37.1       | 36.0       | 35.9       | 36.2       | 35.7       | 1.9        | 0.8        | 0.8        | 0.9        | 0.5        |
| Natural gas  | 353.71          | 435.52          | 740.44          | 781.66          | 816.15          | 843.09          | 855.13          | 13.0       | 11.0       | 13.6       | 13.0       | 12.4       | 11.8       | 11.2       | 2.4        | 0.6        | 0.4        | 0.3        | 0.1        |
| Hydrogen     | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | 0.0        | -0.8       | -2.4       |
| Fuel Ammonia | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Electricity  | 383.38          | 713.50          | 1,328.51        | 1,697.55        | 2,040.10        | 2,374.78        | 2,707.24        | 14.1       | 18.0       | 24.4       | 28.3       | 31.1       | 33.2       | 35.5       | 4.1        | 2.8        | 1.9        | 1.5        | 1.3        |
| Heat         | 15.57           | 51.75           | 159.35          | 187.33          | 184.90          | 170.71          | 145.71          | 0.6        | 1.3        | 2.9        | 3.1        | 2.8        | 2.4        | 1.9        | 7.8        | 1.8        | -0.1       | -0.8       | -1.6       |
| Others       | 366.57          | 396.80          | 460.96          | 487.66          | 496.74          | 503.57          | 511.26          | 13.5       | 10.0       | 8.5        | 8.1        | 7.6        | 7.0        | 6.7        | 0.7        | 0.6        | 0.2        | 0.1        | 0.2        |

## Power generation Output

|                                     | TWh             |                 |                  |                  |                  |                  |                  |            |            |            |            |            |            |            | AAGR(%)    |            |            |            |            |
|-------------------------------------|-----------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                     | 1990            | 2005            | 2021             | 2030             | 2040             | 2050             | 2060             | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050  | 2050-2060  |
| <b>Total</b>                        | <b>5,440.42</b> | <b>9,717.02</b> | <b>17,685.43</b> | <b>22,772.75</b> | <b>27,297.24</b> | <b>31,465.39</b> | <b>35,391.48</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.9</b> | <b>2.8</b> | <b>1.8</b> | <b>1.4</b> | <b>1.2</b> |
| Coal PP                             | 2,622.45        | 5,350.70        | 8,758.28         | 8,828.92         | 8,333.01         | 7,748.96         | 6,898.51         | 48.2       | 55.1       | 49.5       | 38.8       | 30.5       | 24.6       | 19.5       | 4.0        | 0.1        | -0.6       | -0.7       | -1.2       |
| Coal PP with biomass co-firing      | 0.00            | 0.00            | 0.00             | 61.43            | 98.24            | 141.49           | 149.66           | 9.9        | 4.1        | 0.0        | 0.3        | 0.4        | 0.4        | 0.4        | -100.0     | -          | 4.8        | 3.7        | 0.6        |
| Coal PP with fuel ammonia co-firing | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 11.6       | 15.0       | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -100.0     | -          | -          | -          | -          |
| Coal PP with CCS                    | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Oil                                 | 536.27          | 398.96          | 120.52           | 65.27            | 36.85            | 25.51            | 23.02            | 9.9        | 4.1        | 0.7        | 0.3        | 0.1        | 0.1        | 0.07       | -4.7       | -6.6       | -5.6       | -3.6       | -1.0       |
| Gas PP                              | 629.39          | 1,460.91        | 2,924.64         | 3,377.00         | 3,829.63         | 4,266.26         | 4,519.94         | 11.6       | 15.0       | 16.5       | 14.8       | 14.0       | 13.6       | 12.8       | 5.1        | 1.6        | 1.3        | 1.1        | 0.6        |
| Gas PP with hydrogen co-firing      | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Gas PP with CCS                     | 0.00            | 0.00            | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -          | -          |
| Nuclear PP                          | 872.89          | 1,332.67        | 1,495.01         | 1,798.04         | 1,832.22         | 2,027.21         | 2,247.77         | 16.0       | 13.7       | 8.5        | 7.9        | 6.7        | 6.4        | 6.4        | 1.8        | 2.1        | 0.2        | 1.0        | 1.0        |
| Solar PV                            | 20.33           | 27.53           | 757.13           | 2,777.39         | 5,063.00         | 6,976.79         | 8,920.47         | 0.4        | 0.3        | 4.3        | 12.2       | 18.5       | 22.2       | 25.2       | 12.4       | 15.5       | 6.2        | 3.3        | 2.5        |
| Wind                                | 3.10            | 31.26           | 1,166.64         | 2,697.44         | 4,429.56         | 6,156.28         | 7,880.75         | 0.1        | 0.3        | 6.6        | 11.8       | 16.2       | 19.6       | 22.3       | 21.1       | 9.8        | 5.1        | 3.3        | 2.5        |
| Hydro                               | 632.02          | 970.40          | 2,044.03         | 2,357.76         | 2,667.10         | 2,953.74         | 3,327.96         | 11.6       | 10.0       | 11.6       | 10.4       | 9.8        | 9.4        | 9.4        | 3.9        | 1.6        | 1.2        | 1.0        | 1.2        |
| Geothermal                          | 26.53           | 35.83           | 55.44            | 82.79            | 100.54           | 120.33           | 169.01           | 0.5        | 0.4        | 0.3        | 0.4        | 0.4        | 0.4        | 0.5        | 2.4        | 4.6        | 2.0        | 1.8        | 3.5        |
| Biomass and others                  | 97.43           | 108.76          | 363.74           | 726.70           | 907.09           | 1,048.83         | 1,254.39         | 1.8        | 1.1        | 2.1        | 3.2        | 3.3        | 3.3        | 3.5        | 4.3        | 8.0        | 2.2        | 1.5        | 1.8        |

## Power generation Input

|                      | MTOE          |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |             |             |            |
|----------------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|------------|
|                      | 1990          | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040   | 2040-2050   | 2050-2060  |
| <b>Total</b>         | <b>909.93</b> | <b>1,745.26</b> | <b>2,754.89</b> | <b>3,029.77</b> | <b>3,009.98</b> | <b>2,881.61</b> | <b>2,722.88</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>3.6</b> | <b>1.1</b> | <b>-0.1</b> | <b>-0.4</b> | <b>0.0</b> |
| Coal                 | 645.53        | 1,364.29        | 2,192.36        | 2,183.73        | 2,037.75        | 1,812.11        | 1,571.62        | 70.9       | 78.2       | 79.6       | 72.1       | 67.7       | 62.9       | 57.7       | 4.0        | 0.0        | -0.7        | -1.2        | -0.8       |
| Fuel ammonia         | 0.00          | 0.00            | 0.00            | 1.21            | 2.21            | 3.65            | 4.67            | 0.0        | 0.0        | 0.0        | 0.0        | 0.1        | 0.1        | 0.2        | -          | -          | 6.2         | 5.1         | 2.5        |
| Coal (Co-firing)     | 0.00          | 1.93            | 2.75            | 4.91            | 10.16           | 12.19           | 14.22           | 0.0        | 0.1        | 0.1        | 0.2        | 0.3        | 0.4        | 0.5        | -          | 6.7        | 7.5         | 1.8         | 1.6        |
| Oil                  | 121.04        | 96.39           | 30.94           | 15.30           | 8.56            | 5.80            | 5.21            | 13.3       | 5.5        | 1.1        | 0.5        | 0.3        | 0.2        | 0.2        | -4.3       | -7.5       | -5.6        | -3.8        | -1.1       |
| Gas                  | 142.97        | 281.93          | 522.44          | 592.61          | 670.66          | 732.78          | 762.14          | 15.7       | 16.2       | 19.0       | 19.6       | 22.3       | 25.4       | 28.0       | 4.3        | 1.4        | 1.2         | 0.9         | 0.4        |
| Hydrogen             | 0.00          | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.00            | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -           | -           | -          |
| Biomass (Biomass PP) | 0.39          | 0.72            | 6.41            | 232.01          | 280.64          | 315.08          | 365.02          | 0.0        | 0.0        | 0.2        | 7.7        | 9.3        | 10.9       | 13.4       | 9.5        | 49.0       | 1.9         | 1.2         | 1.5        |

## Thermal Efficiency

|         | %       |         |       |      |      |      |      |  |  |  |  |  |  |  | AAGR(%)   |           |           |           |           |           |
|---------|---------|---------|-------|------|------|------|------|--|--|--|--|--|--|--|-----------|-----------|-----------|-----------|-----------|-----------|
|         | 1990    | 2005    | 2021  | 2030 | 2040 | 2050 | 2060 |  |  |  |  |  |  |  | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total   | 36.7    | 36.1    | 38.0  | 37.1 | 37.7 | 39.5 | 40.6 |  |  |  |  |  |  |  | 0.1       | -0.3      | 0.2       | 0.5       | 0.3       | 0.2       |
| Coal    | 34.9    | 33.7    | 34.3  | 34.9 | 35.4 | 37.1 | 38.1 |  |  |  |  |  |  |  | -0.1      | 0.2       | 0.1       | 0.5       | 0.3       | 0.3       |
| Oil     | 38.1    | 35.6    | 33.5  | 36.7 | 37.0 | 37.8 | 38.0 |  |  |  |  |  |  |  | -0.4      | 1.0       | 0.1       | 0.2       | 0.0       | 0.3       |
| Gas     | 37.9    | 44.6    | 48.1  | 49.0 | 49.1 | 50.1 | 51.0 |  |  |  |  |  |  |  | 0.8       | 0.2       | 0.0       | 0.2       | 0.2       | 0.1       |
| Biomass | 2.148.6 | 1.291.9 | 488.0 | 26.9 | 27.8 | 28.6 | 29.6 |  |  |  |  |  |  |  | -4.7      | -27.5     | 0.3       | 0.3       | 0.3       | -6.9      |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                 |                 |                 |                 |                 |                 |            |            |            |            |            |            |            | AAGR(%)    |            |            |             |             |            |
|--------------|--------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|------------|
|              | 1990               | 2005            | 2021            | 2030            | 2040            | 2050            | 2060            | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030  | 2030-2040  | 2040-2050   | 2050-2060   | 2021-2060  |
| <b>Total</b> | <b>9,359.7</b>     | <b>14,962.5</b> | <b>20,869.6</b> | <b>21,371.5</b> | <b>21,295.2</b> | <b>21,167.1</b> | <b>20,615.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.6</b> | <b>0.3</b> | <b>0.0</b> | <b>-0.1</b> | <b>-0.3</b> | <b>0.0</b> |
| Coal         | 4,693.65           | 8,686.40        | 12,730.83       | 12,489.59       | 11,695.97       | 10,753.26       | 9,838.55        | 50.1       | 58.1       | 61.0       | 58.4       | 54.9       | 50.8       | 47.7       | 3.3        | -0.2       | -0.7       | -0.8        | -0.9        | -0.7       |
| Oil          | 3,354.69           | 4,512.83        | 5,060.44        | 5,500.51        | 5,992.53        | 6,648.93        | 6,989.24        | 35.8       | 30.2       | 24.2       | 25.7       | 28.1       | 31.4       | 33.9       | 1.3        | 0.9        | 0.9        | 1.0         | 0.5         | 0.8        |
| Gas          | 1,311.33           | 1,763.28        | 3,078.30        | 3,381.38        | 3,606.66        | 3,764.90        | 3,788.04        | 14.0       | 11.8       | 14.8       | 15.8       | 16.9       | 17.8       | 18.4       | 2.8        | 1.0        | 0.6        | 0.4         | 0.1         | 0.5        |
| CCS/DAC (-)  |                    |                 |                 |                 |                 |                 |                 | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -          | -          | -           | -           | -          |

## Energy and economic Indicators

|                                                                                           |           |           |           |           |           |            |            | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990      | 2005      | 2021      | 2030      | 2040      | 2050       | 2060       | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 16,680.96 | 28,947.24 | 49,904.86 | 65,156.88 | 89,683.35 | 120,286.42 | 154,508.46 | 3.6       | 3.0       | 3.25      | 2.98      | 2.5       | 2.9       |
| Population (millions of people)                                                           | 2,879.86  | 3,511.56  | 4,030.61  | 4,188.63  | 4,305.14  | 4,343.30   | 4,299.62   | 1.1       | 0.4       | 0.3       | 0.1       | -0.1      | 0.2       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 5.8       | 8.2       | 12.4      | 15.6      | 20.8      | 27.7       | 35.9       | 2.5       | 2.6       | 3.0       | 2.9       | 2.6       | 2.8       |
| Primary energy consumption per capita (toe/person)                                        | 1.4       | 1.7       | 2.1       | 2.2       | 2.2       | 2.4        | 2.5        | 1.3       | 0.6       | 0.3       | 0.5       | 0.6       | 0.5       |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 235       | 203       | 166       | 140       | 108       | 85         | 69         | -1.1      | -1.9      | -2.6      | -2.4      | -2.0      | -2.2      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 163       | 137       | 109       | 92        | 73        | 60         | 50         | -1.3      | -1.8      | -2.3      | -2.0      | -1.8      | -2.0      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 561       | 517       | 418       | 328       | 237       | 176        | 133        | -0.9      | -2.7      | -3.2      | -3.0      | -2.7      | -2.9      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.39      | 2.55      | 2.52      | 2.35      | 2.20      | 2.07       | 1.93       | 0.2       | -0.8      | -0.6      | -0.6      | -0.7      | -0.7      |
| Automobile ownership volume (millions of vehicles)                                        | -         | -         | -         | -         | -         | -          | -          | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -         | -         | -         | -         | -         | -          | -          | -         | -         | -         | -         | -         | -         |

# EAS17 [LCET]

## Primary energy consumption

|                                | MTOE     |          |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |  |
|--------------------------------|----------|----------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                                | 1990     | 2005     | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                          | 3,915.77 | 5,862.16 | 8,273.32 | 8,422.45 | 7,803.47 | 7,011.99 | 6,895.51 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 2.4       | 0.2       | -0.8      | -1.1      | -0.2      | -0.5      |  |
| Coal                           | 1,233.31 | 2,213.00 | 3,365.34 | 2,946.13 | 2,036.42 | 984.84   | 629.57   | 31.5 | 37.8 | 40.7 | 35.0 | 26.1 | 14.0 | 9.1  | 3.3       | -1.5      | -3.6      | -7.0      | -4.4      | -4.2      |  |
| Oil                            | 1,353.86 | 1,915.21 | 2,143.18 | 1,894.34 | 1,437.68 | 1,068.54 | 874.71   | 34.6 | 32.7 | 25.9 | 22.5 | 18.4 | 15.2 | 12.7 | 1.5       | -1.4      | -2.7      | -2.9      | -2.0      | -2.3      |  |
| Natural gas                    | 569.03   | 797.96   | 1,381.72 | 1,402.79 | 1,175.83 | 720.92   | 659.59   | 14.5 | 13.6 | 16.7 | 16.7 | 15.1 | 10.3 | 9.6  | 2.9       | 0.2       | -1.7      | -4.8      | -0.9      | -1.9      |  |
| Hydrogen                       | 0.00     | 0.00     | 0.00     | 5.76     | 34.52    | 95.19    | 116.56   | 0.0  | 0.0  | 0.0  | 0.1  | 0.4  | 1.4  | 1.7  | -         | -         | 19.6      | 10.7      | 2.0       | -         |  |
| Fuel Ammonia                   | 0.00     | 0.00     | 0.00     | 0.07     | 0.05     | 0.73     | 1.44     | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -         | -         | -3.3      | 30.4      | 7.1       | -         |  |
| Nuclear                        | 227.44   | 347.24   | 389.54   | 571.88   | 823.04   | 1,072.35 | 1,157.14 | 5.8  | 5.9  | 4.7  | 6.8  | 10.5 | 15.3 | 16.8 | 1.8       | 4.4       | 3.7       | 2.7       | 0.8       | 2.8       |  |
| Hydro                          | 54.75    | 83.16    | 175.75   | 212.43   | 253.80   | 303.28   | 355.26   | 1.4  | 1.4  | 2.1  | 2.5  | 3.3  | 4.3  | 5.2  | 3.8       | 2.1       | 1.8       | 1.8       | 1.6       | 1.8       |  |
| Geothermal                     | 22.87    | 30.01    | 62.13    | 101.62   | 153.02   | 167.80   | 162.51   | 0.6  | 0.5  | 0.8  | 1.2  | 2.0  | 2.4  | 2.4  | 3.3       | 5.6       | 4.2       | 0.9       | -0.3      | 2.5       |  |
| Others                         | 454.50   | 475.57   | 755.65   | 1,287.44 | 1,889.11 | 2,598.34 | 2,938.72 | 11.6 | 8.1  | 9.1  | 15.3 | 24.2 | 37.1 | 42.6 | 1.7       | 6.1       | 3.9       | 3.2       | 1.2       | 3.5       |  |
| Biomass                        | 451.52   | 444.35   | 483.03   | 523.75   | 473.97   | 540.19   | 567.33   | 11.5 | 7.6  | 5.8  | 6.2  | 6.1  | 7.7  | 8.2  | 0.2       | 0.9       | -1.0      | 1.3       | 0.5       | 0.4       |  |
| Solar, Wind, Ocean             | 1.73     | 8.08     | 196.29   | 645.18   | 1,223.93 | 1,866.10 | 2,130.88 | 0.0  | 0.1  | 2.4  | 7.7  | 15.7 | 26.6 | 30.9 | 16.5      | 14.1      | 6.6       | 4.3       | 1.3       | 6.3       |  |
| Biofuels                       | 0.80     | 17.93    | 69.96    | 111.40   | 179.94   | 173.44   | 222.15   | 0.0  | 0.3  | 0.8  | 1.3  | 2.3  | 2.5  | 3.2  | 15.5      | 5.3       | 4.9       | -0.4      | 2.5       | 3.0       |  |
| Electricity (Import or Export) | 0.45     | 5.20     | 6.38     | 7.10     | 11.27    | 18.61    | 18.36    | 0.0  | 0.1  | 0.08 | 0.08 | 0.1  | 0.3  | 0.3  | 8.9       | 1.2       | 4.7       | 5.1       | -0.1      | 2.7       |  |

## Final energy demand

|              | MTOE     |          |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|--------------|----------|----------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|              | 1990     | 2005     | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total        | 2,722.77 | 3,964.18 | 5,456.57 | 5,446.51 | 5,120.97 | 4,743.38 | 4,550.52 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 2.3       | 0.0       | -0.6      | -0.8      | -0.4      | -0.5      |
| Industry     | 764.85   | 1,259.05 | 1,957.07 | 2,034.22 | 1,895.54 | 1,598.06 | 1,286.84 | 28.1 | 31.8 | 35.9 | 37.3 | 37.0 | 33.7 | 28.3 | 3.1       | 0.4       | -0.7      | -1.7      | -2.1      | -1.1      |
| Transport    | 680.59   | 1,020.24 | 1,312.08 | 1,278.40 | 1,131.97 | 1,065.30 | 1,146.76 | 25.0 | 25.7 | 24.0 | 23.5 | 22.1 | 22.5 | 25.2 | 2.1       | -0.3      | -1.2      | -0.6      | 0.7       | -0.3      |
| Others       | 1,046.92 | 1,312.71 | 1,627.59 | 1,522.65 | 1,424.26 | 1,340.36 | 1,350.38 | 38.5 | 33.1 | 29.8 | 28.0 | 27.8 | 28.3 | 29.7 | 1.4       | -0.7      | -0.7      | -0.6      | 0.1       | -0.5      |
| Non-energy   | 230.41   | 372.18   | 559.84   | 611.25   | 669.21   | 739.67   | 766.54   | 8.5  | 9.4  | 10.3 | 11.2 | 13.1 | 15.6 | 16.8 | 2.9       | 1.0       | 0.9       | 1.0       | 0.4       | 0.8       |
| Total        | 2,722.76 | 3,964.18 | 5,456.57 | 5,446.51 | 5,120.97 | 4,743.37 | 4,550.53 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 2.3       | 0.0       | -0.6      | -0.8      | -0.4      | -0.5      |
| Coal         | 454.03   | 670.95   | 733.26   | 588.17   | 472.24   | 319.88   | 199.95   | 16.7 | 16.9 | 13.4 | 10.8 | 9.2  | 6.7  | 4.4  | 1.6       | -2.4      | -2.2      | -3.8      | -4.6      | -3.3      |
| Oil          | 1,140.74 | 1,686.62 | 2,023.76 | 1,798.98 | 1,368.55 | 1,031.91 | 855.04   | 41.9 | 42.5 | 37.1 | 33.0 | 26.7 | 21.8 | 18.8 | 1.9       | -1.3      | -2.7      | -2.8      | -1.9      | -2.2      |
| Natural gas  | 353.94   | 435.82   | 740.67   | 629.60   | 463.42   | 317.88   | 272.89   | 13.0 | 11.0 | 13.6 | 11.6 | 9.0  | 6.7  | 6.0  | 2.4       | -1.8      | -3.0      | -3.7      | -1.5      | -2.5      |
| Hydrogen     | 0.00     | 0.00     | 0.00     | 12.01    | 73.82    | 137.46   | 152.51   | 0.0  | 0.0  | 0.0  | 0.2  | 1.4  | 2.9  | 3.4  | -         | -         | 19.9      | 6.4       | 1.0       | -         |
| Fuel Ammonia | 0.00     | 0.00     | 0.00     | 0.42     | 94.99    | 149.03   | 159.00   | 0.0  | 0.0  | 0.0  | 0.0  | 1.9  | 3.1  | 3.5  | -         | -         | 72.0      | 4.6       | 0.7       | -         |
| Electricity  | 383.53   | 713.87   | 1,330.08 | 1,816.37 | 2,139.48 | 2,372.56 | 2,530.66 | 14.1 | 18.0 | 24.4 | 33.3 | 41.8 | 50.0 | 55.6 | 4.1       | 3.5       | 1.7       | 1.0       | 0.6       | 1.7       |
| Heat         | 15.57    | 51.75    | 159.35   | 156.65   | 117.07   | 71.04    | 21.57    | 0.6  | 1.3  | 2.9  | 2.9  | 2.3  | 1.5  | 0.5  | 7.8       | -0.2      | -2.9      | -4.9      | -11.2     | -5.0      |
| Others       | 374.96   | 405.18   | 469.45   | 444.32   | 391.40   | 343.61   | 358.91   | 13.8 | 10.2 | 8.6  | 8.2  | 7.6  | 7.2  | 7.9  | 0.7       | -0.6      | -1.3      | -1.3      | 0.4       | -0.7      |

## Power generation Output

|                                     | TWh      |          |           |           |           |           |           |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |
|-------------------------------------|----------|----------|-----------|-----------|-----------|-----------|-----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                     | 1990     | 2005     | 2021      | 2030      | 2040      | 2050      | 2060      | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| Total                               | 5,440.42 | 9,717.02 | 17,685.43 | 24,349.09 | 29,136.07 | 33,924.09 | 37,291.39 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.9       | 3.6       | 1.8       | 1.5       | 1.0       | 1.9       |
| Coal PP                             | 2,622.45 | 5,350.70 | 8,758.27  | 6,891.92  | 3,205.27  | 920.48    | 706.50    | 48.2 | 55.1 | 49.5 | 28.3 | 11.0 | 2.7  | 1.9  | 4.0       | -2.6      | -7.4      | -11.7     | -2.6      | -6.3      |
| Coal PP with biomass co-firing      | 0.00     | 0.00     | 0.00      | 47.20     | 180.62    | 237.86    | 315.05    | 9.9  | 4.1  | 0.0  | 0.2  | 0.6  | 0.7  | 0.8  | -100.0    | -         | 14.4      | 2.8       | 2.9       | -         |
| Coal PP with fuel ammonia co-firing | 0.00     | 0.00     | 0.00      | 35.69     | 180.95    | 153.26    | 193.26    | 11.6 | 15.0 | 0.0  | 0.1  | 0.6  | 0.5  | 0.5  | -100.0    | -         | 17.6      | -1.6      | 2.3       | -         |
| Coal PP with CCS                    | 0.00     | 0.00     | 0.00      | 1,245.71  | 1,521.57  | 644.18    | 404.30    | 0.0  | 0.0  | 0.0  | 5.1  | 5.2  | 1.9  | 1.1  | -         | -         | 2.0       | -8.2      | -4.6      | -         |
| Oil PP                              | 536.27   | 398.96   | 120.52    | 59.59     | 35.08     | 8.94      | 8.40      | 9.9  | 4.1  | 0.7  | 0.2  | 0.1  | 0.0  | 0.0  | -4.7      | -7.5      | -5.2      | -12.8     | -0.6      | -6.6      |
| Gas PP                              | 629.39   | 1,460.91 | 2,924.64  | 3,214.32  | 1,870.83  | 729.04    | 566.90    | 11.6 | 15.0 | 16.5 | 13.2 | 6.4  | 2.1  | 1.5  | 5.1       | 1.1       | -5.3      | -9.0      | -2.5      | -4.1      |
| Gas PP with hydrogen co-firing      | 0.00     | 0.00     | 0.00      | 15.67     | 296.48    | 1,142.30  | 1,728.41  | 0.0  | 0.0  | 0.0  | 0.1  | 1.0  | 3.4  | 4.6  | -         | -         | 34.2      | 14.4      | 4.2       | -         |
| Gas PP with CCS                     | 0.00     | 0.00     | 0.00      | 372.67    | 1,364.13  | 1,123.85  | 1,063.96  | 0.0  | 0.0  | 0.0  | 1.5  | 4.7  | 3.3  | 2.9  | -         | -         | 13.9      | -1.9      | -0.5      | -         |
| Nuclear PP                          | 872.89   | 1,332.67 | 1,495.01  | 2,193.21  | 3,158.73  | 4,115.56  | 4,440.95  | 16.0 | 13.7 | 8.5  | 9.0  | 10.8 | 12.1 | 11.9 | 1.8       | 4.4       | 3.7       | 2.7       | 0.8       | 2.8       |
| Solar PV                            | 20.33    | 27.66    | 757.13    | 3,893.38  | 8,083.18  | 12,784.66 | 14,628.50 | 0.4  | 0.3  | 4.3  | 16.0 | 27.7 | 37.7 | 39.2 | 12.4      | 20.0      | 7.6       | 4.7       | 1.4       | 7.9       |
| Wind                                | 3.10     | 31.13    | 1,166.64  | 3,050.37  | 5,078.02  | 7,103.48  | 7,914.28  | 0.1  | 0.3  | 6.6  | 12.5 | 17.4 | 20.9 | 21.2 | 21.1      | 11.3      | 5.2       | 3.4       | 1.1       | 5.0       |
| Hydro                               | 632.02   | 970.40   | 2,044.03  | 2,470.60  | 2,935.66  | 3,433.72  | 3,677.76  | 11.6 | 10.0 | 11.6 | 10.1 | 10.1 | 10.1 | 9.9  | 3.9       | 2.1       | 1.7       | 1.6       | 0.7       | 1.5       |
| Geothermal                          | 26.53    | 35.83    | 55.44     | 105.91    | 169.95    | 196.98    | 208.72    | 0.5  | 0.4  | 0.3  | 0.4  | 0.6  | 0.6  | 0.6  | 2.4       | 7.5       | 4.8       | 1.5       | 0.6       | 3.5       |
| Biomass and others                  | 97.43    | 108.76   | 363.74    | 752.86    | 1,055.61  | 1,329.77  | 1,434.38  | 1.8  | 1.1  | 2.1  | 3.1  | 3.6  | 3.9  | 3.8  | 4.3       | 8.4       | 3.4       | 2.3       | 0.8       | 3.6       |

## Power generation Input

|                      | MTOE   |          |          |          |          |          |          |      |      |      |      |      |      |      | AAGR(%)   |           |           |           |           |           |  |
|----------------------|--------|----------|----------|----------|----------|----------|----------|------|------|------|------|------|------|------|-----------|-----------|-----------|-----------|-----------|-----------|--|
|                      | 1990   | 2005     | 2021     | 2030     | 2040     | 2050     | 2060     | 1990 | 2005 | 2021 | 2030 | 2040 | 2050 | 2060 | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |  |
| Total                | 909.93 | 1,745.26 | 2,754.85 | 2,889.33 | 2,238.31 | 1,332.32 | 1,271.11 | 100  | 100  | 100  | 100  | 100  | 100  | 100  | 3.6       | 0.5       | -2.5      | -5.1      | -0.5      | -2.0      |  |
| Coal                 | 645.53 | 1,364.29 | 2,192.36 | 2,004.78 | 1,248.53 | 417.14   | 256.49   | 70.9 | 78.2 | 79.6 | 69.4 | 55.8 | 31.3 | 20.2 | 4.0       | -1.0      | -4.6      | -10.4     | -4.7      | -5.4      |  |
| Fuel ammonia         | 0.00   | 0.00     | 0.00     | 2.62     | 50.59    | 53.65    | 87.40    | 0.0  | 0.0  | 0.0  | 0.1  | 2.3  | 4.0  | 6.9  | -         | -         | 34.4      | 0.6       | 5.0       | -         |  |
| Biomass (Co-firing)  | 0.00   | 1.93     | 2.75     | 6.14     | 27.98    | 54.38    | 80.84    | 0.0  | 0.1  | 0.1  | 0.2  | 1.2  | 4.1  | 6.4  | -         | 9.4       | 16.4      | 6.9       | 4.0       | 9.1       |  |
| Oil                  | 121.04 | 96.39    | 30.94    | 14.43    | 8.96     | 2.17     | 2.04     | 13.3 | 5.5  | 1.1  | 0.5  | 0.4  | 0.2  | 0.2  | -4.3      | -8.1      | -4.7      | -13.2     | -0.6      | -6.7      |  |
| Gas                  | 142.97 | 281.93   | 522.44   | 635.14   | 590.06   | 305.73   | 265.03   | 15.7 | 16.2 | 19.0 | 22.0 | 26.4 | 22.9 | 20.9 | 4.3       | 2.2       | -0.7      | -6.4      | -1.4      | -1.7      |  |
| Hydrogen             | 0.00   | 0.00     | 0.00     | 3.61     | 48.28    | 178.20   | 257.21   | 0.0  | 0.0  | 0.0  | 0.1  | 2.2  | 13.4 | 20.2 | -         | -         | 29.6      | 14.0      | 3.7       | -         |  |
| Biomass (Biomass PP) | 0.39   | 0.72     | 6.37     | 22.61    | 263.92   | 321.05   | 322.12   | 0.0  | 0.0  | 0.2  | 7.7  | 11.8 | 24.1 | 25.3 | 9.4       | 48.4      | 1.7       | 2.0       | 0.0       | 10.6      |  |

## CO<sub>2</sub> emissions

|              | Mt-CO <sub>2</sub> |                 |                 |                 |                 |                |                |            |            |            |            |            |            |            | AAGR(%)    |             |             |             |             |             |
|--------------|--------------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|
|              | 1990               | 2005            | 2021            | 2030            | 2040            | 2050           | 2060           | 1990       | 2005       | 2021       | 2030       | 2040       | 2050       | 2060       | 1990-2021  | 2021-2030   | 2030-2040   | 2040-2050   | 2050-2060   | 2021-2060   |
| <b>Total</b> | <b>9,359.7</b>     | <b>14,962.5</b> | <b>20,869.6</b> | <b>17,257.0</b> | <b>10,552.5</b> | <b>4,627.5</b> | <b>2,969.8</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>100</b> | <b>2.6</b> | <b>-2.1</b> | <b>-4.8</b> | <b>-7.9</b> | <b>-4.3</b> | <b>-4.9</b> |
| Coal         | 4,693.65           | 8,686.40        | 12,730.83       | 10,006.22       | 6,045.76        | 2,476.31       | 1,508.39       | 50.1       | 58.1       | 61.0       | 58.0       | 57.3       | 53.5       | 50.8       | 3.3        | -2.6        | -4.9        | -8.5        | -4.8        | -5.3        |
| Oil          | 3,354.69           | 4,512.83        | 5,061.81        | 4,335.22        | 2,827.75        | 1,593.10       | 1,037.75       | 35.8       | 30.2       | 24.3       | 25.1       | 26.8       | 34.4       | 34.9       | 1.3        | -1.7        | -4.2        | -5.6        | -4.2        | -4.0        |
| Gas          | 1,311.33           | 1,763.28        | 3,076.93        | 2,915.54        | 1,678.97        | 558.05         | 423.67         | 14.0       | 11.8       | 14.7       | 16.9       | 15.9       | 12.1       | 14.3       | 2.8        | -0.6        | -5.4        | -10.4       | -2.7        | -5.0        |
| CCS/DAC (-)  |                    |                 |                 |                 |                 |                |                | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | 0.0        | -          | -           | -           | -           | -           | -           |

## Energy and economic Indicators

|                                                                                           |           |           |           |           |           |            |            | AAGR(%)   |           |           |           |           |           |
|-------------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                                           | 1990      | 2005      | 2021      | 2030      | 2040      | 2050       | 2060       | 1990-2021 | 2021-2030 | 2030-2040 | 2040-2050 | 2050-2060 | 2021-2060 |
| GDP (billions of 2015 US dollars)                                                         | 16,680.96 | 28,947.24 | 49,904.86 | 65,156.88 | 89,683.35 | 120,286.42 | 154,508.46 | 3.6       | 3.0       | 3.25      | 2.98      | 2.5       | 2.9       |
| Population (millions of people)                                                           | 2,879.86  | 3,511.56  | 4,030.61  | 4,188.63  | 4,305.14  | 4,343.30   | 4,299.62   | 1.1       | 0.4       | 0.3       | 0.1       | -0.1      | 0.2       |
| GDP per capita (thoAUSnds of 2015 USD/person)                                             | 5.8       | 8.2       | 12.4      | 15.6      | 20.8      | 27.7       | 35.9       | 2.5       | 2.6       | 3.0       | 2.9       | 2.6       | 2.8       |
| Primary energy consumption per capita (toe/person)                                        | 1.4       | 1.7       | 2.1       | 2.0       | 1.8       | 1.6        | 1.6        | 1.3       | -0.2      | -1.0      | -1.2      | -0.1      | -0.6      |
| Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)                  | 235       | 203       | 166       | 129       | 87        | 58         | 45         | -1.1      | -2.7      | -3.9      | -3.9      | -2.6      | -3.3      |
| Final energy consumption per unit of GDP (toe/million 2015 US Dollars)                    | 163       | 137       | 109       | 84        | 57        | 39         | 29         | -1.3      | -2.9      | -3.7      | -3.6      | -2.9      | -3.3      |
| CO <sub>2</sub> emissions per unit of GDP (t-CO <sub>2</sub> /million 2015 US Dollars)    | 561       | 517       | 418       | 265       | 118       | 38         | 19         | -0.9      | -4.9      | -7.8      | -10.6     | -6.7      | -7.6      |
| CO <sub>2</sub> emissions per unit of primary energy consumption (t-CO <sub>2</sub> /toe) | 2.39      | 2.55      | 2.52      | 2.05      | 1.35      | 0.66       | 0.43       | 0.2       | -2.3      | -4.1      | -6.9      | -4.2      | -4.4      |
| Automobile ownership volume (millions of vehicles)                                        | -         | -         | -         | -         | -         | -          | -          | -         | -         | -         | -         | -         | -         |
| Automobile ownership volume per capita (vehicles per person)                              | -         | -         | -         | -         | -         | -          | -          | -         | -         | -         | -         | -         | -         |