Energy Outlook and Energy-Saving Potential in East Asia 2023

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This report was prepared by the Working Group for Analysis of Energy Saving Potential in East Asia under an energy research project conducted by the Economic Research Institute for ASEAN and East Asia (ERIA) in 2021–2022. Members of the working group, representing the participating countries of the East Asia Summit region, discussed and agreed on certain key assumptions and modelling approaches to enable harmonisation of the forecasting techniques, although the techniques may differ from those normally used in each country. Therefore, the projections presented here should not be viewed as official national projections of the participating countries.

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Preface

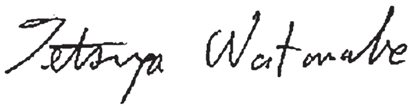
The Association of Southeast Asian Nations (ASEAN) and East Asia face tremendous challenges in the future energy landscape, including transitioning to new architectures that ensure affordable, secure, and sustainable energy access through sound policies and technologies. Despite having been hit hard by the coronavirus disease (COVID-19) pandemic, energy demand growth is expected to rebound strongly in the East Asian Summit economies once they start recovering in 2023. The report exhorts leaders to carefully weigh their decisions and energy policy measures against the potentially higher energy costs and security risks in the post–COVID-19 era.

Since the outbreak of the Russian Federation–Ukraine war on 24 February 2022, global oil and gas prices have risen sharply. Oil market sentiments and concerns could last longer if the war continues and immediate alternative sources of supplies of oil and natural gas are lacking.

Most countries have pledged net-zero emission by mid-century. However, the war could discourage switching from coal to natural gas, a low-hanging mitigation opportunity for the fossil fuel–dependent region. Fossil fuel, especially coal, could stay in the Asian energy mix in some countries longer than previously anticipated. However, decarbonisation pathways must consider the various socio-economic and political circumstances that can help countries reach carbon neutrality. Thus, the Working Group for Analysis of Energy Saving Potential in East Asia has added a low-carbon energy transition (LCET) scenario to the report. The report analyses the energy outlook and saving potential in each East Asia Summit country to predict the medium- to long-term growth (2019–2050) of energy demand and supply.

The report contributes to mitigating problems related to energy security and climate change by increasing the understanding of the potential for energy saving through a range of energy efficiency goals, action plans, and policies, and the aggressive introduction of clean fuels and technologies into the carbon neutrality scenario. The report discusses several key insights for policy development.

Promoting energy efficiency and renewable energy alone is not enough to develop sustainable energy in the East Asia Summit region. Thus, the Economic Research Institute for ASEAN and East Asia has considered including commercially available energy technologies such as carbon capture, utilisation, and storage; hydrogen; and ammonia fuels into the region's energy outlook modelling.



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Acknowledgements

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Special acknowledgement goes to Dr Han Phoumin, Dr Alloysius Joko Purwanto, Ms Clara Gillispie, and Ms Cecilya Laksmiwati Malik for their contributions to the report's technical editing. Our thanks also go to Ms Dian Lutfiana and Ms Citra Endah Nur Setyawati for their data gathering and general support to the editing team.

The study could not have been realised without the invaluable support and contribution of many people (see List of Project Members).

Special thanks go to Mr Stefan Wesiak, chief editor and publication director of ERIA, and his team of editors and publishing staff, for helping edit and prepare the report for publication.

Shigeru Kimura
Leader of the Working Group
2023

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List of Abbreviations and Acronyms

ANRE	Agency for Natural Resources and Energy
APS	alternative policy scenario
ASEAN	Association of Southeast Asian Nations
BAU	business as usual
BREE	Bureau of Resources and Energy Economics
CCS	carbon capture and storage
CCT	clean coal technology
CDM	Clean Development Mechanism
CNG	compressed natural gas
CO_2	carbon dioxide
EAS	East Asia Summit
EAS17	East Asia Summit Region plus the United States
ECTF	Energy Cooperation Task Force
EEC	energy efficiency and conservation
EMM	East Asia Summit Energy Ministers Meeting
ERIA	Economic Research Institute for ASEAN and East Asia
FiT	feed-in-tariff
GCV	gross calorific value
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
IEA	International Energy Agency
IEEJ	Institute for Energy Economics, Japan
IPCC	Intergovernmental Panel for Climate Change
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour

LCET	low-carbon energy transition
LDV	light-duty vehicles
LEAP	Long-range Energy Alternative Planning
LEDS	long-term energy demand system
LET	low-emission technologies
LPG	liquefied petroleum gas
METI	Ministry of Economy, Trade and Industry
Mtoe	million tonnes of oil equivalent (1 Mtoe = 41.868 petajoules)
Mt-C	million tonnes carbon (may be converted to million tonnes of CO_2 by multiplying by 44/12)
Mt-CO_2	metric tonne of carbon dioxide
MW	megawatts
MWh	megawatt-hour
NCV	net calorific value
NDC	nationally determined contribution
NRE	new and renewable energy
OECD	Organisation for Economic Co-operation and Development
RPS	renewable portfolio standards
SWG	sub-working group
toe	tonnes of oil equivalent
t-C	tonnes of carbon
TFEC	total final energy consumption
TPES	total primary energy supply
TWh	terawatt-hour
US$	United States dollar
WG	working group

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Executive Summary

The Economic Research Institute for ASEAN and East Asia (ERIA) has updated the East Asia Summit (EAS) Energy Outlook in 2021–2022 by revising the macro assumptions such as economic and population growth, as well as the crude oil price. The outlook incorporates more recent information on the EAS17 (the East Asia Summit Region plus the United States) member countries' energy saving potentials and energy efficiency goals, action plans, and policies, including power development plans such as renewable electricity. Most importantly, the outlook considers adding a low-carbon energy transition (LCET) scenario to analyse how countries in EAS17 can achieve carbon neutrality under different economic and social circumstances.

Although the coronavirus disease (COVID-19) pandemic has had a large impact on the EAS17 and global economies throughout 2020 to late 2022, the ASEAN region and East Asia are expected to rebound after 2023. Sustained economic growth in ASEAN and EAS17 countries is crucial to improve well-being and is expected to be positive from 2023. The post-pandemic era is anticipated to be a period of growth and energy consumption is envisaged to increase. Decades of sustained economic growth, particularly in ASEAN and India, have led to higher per capita incomes, significantly reduced poverty, and improved living standards for hundreds of millions.

Two key drivers — population and economic growth — in the EAS region are responsible for the projected increase in primary energy supply from 2019 to 2050 in all three main scenarios: business as usual (BAU), alternative policy scenario (APS), and LCET. The total primary energy supply (TPES) was 8,036 million tonnes of oil equivalent (Mtoe) in 2019, and is predicted to increase towards 2050 to 10,457 Mtoe in BAU, to 8,497 Mtoe in APS, and to 4,795 Mtoe in LCET. The average annual growth rate of TPES is 0.9% in BAU, 0.2% in APS, and 0.1% in LCET from 2019 to 2050. Energy intensity is expected to drop from 168 tonnes of oil equivalent (toe)/US$ million in 2017 to 66 toe/US$ million in 2050 in APS, and to 79 toe/US$ million in 2050 in LCET, representing 60% and 53% energy intensity reduction, respectively, in 2019–2050. Similarly, emission intensity is expected to drop from 0.70 tonnes of carbon (t-C)/toe in 2019 to 0.44 t-C/toe in APS, and to 0.16 in LCET in 2050, representing 37% and 77% emission-intensity reduction, respectively, in 2019–2050. The economy is expected to become more efficient and have a cleaner energy system, especially in LCET.

With economic growth will come increasing access to and demand for electricity and rising levels of vehicle ownership. Continued reliance on fossil fuels to meet the increase in energy demand may lead to increased greenhouse gas emissions and climate change challenges, unless low-emission technologies are used. Even if fossil fuel resources are sufficient, oil will likely be imported from other regions, and no assurance can be given that they will be secure or affordable. The region, especially ASEAN, must diversify fuel supply sources, strengthen strategic stockpiling, and enhance energy connectivity. As the EAS17 region considers energy supply security as a priority, it must implement energy efficiency and conservation measures and increase the use of domestic energy to reduce reliance on imported fossil fuels and promote the use of domestic energy sources. The ASEAN region should consider adopting regional energy networks, such as the Trans-ASEAN Gas Pipeline, with virtual pipelines of liquefied natural gas, and the ASEAN Power Grid to maintain energy supply security. Nuclear power generation is another option for securing energy supply. The region must prioritise introducing clean fuels and technologies to promote decarbonisation.

CHAPTER 1

Main Report

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1. Introduction

The Economic Research Institute for ASEAN and East Asia (ERIA) updates the energy outlook and analyses saving potential in the East Asia Summit (EAS)[1] region every 2 years. The last update was in 2019–2020. In 2020–2021, ERIA assessed the impacts of the coronavirus disease (COVID-19) pandemic on energy demand in East Asia using the updated energy outlook models in 2019–2020 and released a special report of the assessment (ERIA, 2022). Whilst highlighting the EAS economies that have been hit hard by the pandemic, the report cites the energy demand growth that is expected to rebound strongly as economies recover after 2022. The report calls the attention of EAS leaders to how energy decisions and policy measures will need to be weighed against potentially higher energy costs and security risks in the post–COVID-19 era. Since the Russian Federation–Ukraine war broke out on 24 February 2022, the fear of rising global oil and gas prices has grown. The Brent crude oil price, recorded at US$95.42 per barrel on 24 February 2022, soared to US$127.98 per barrel on 8 March 2022. The price went down to US$87 per barrel on 18 November 2022 (OilPrice.com, 2022). The gas price, indexed to the global oil price, has temporarily moved up more than the global oil price. In Asia, natural gas demand is being met by imported liquefied natural gas (LNG). On the Japan/Korea Marker (Platts), the price of LNG moved down slightly from US$32.47/million British thermal units (Mbtu) in September 2022 to US$27/Mbtu on 18 November 2022. The oil market sentiment and concerns could last longer if the war continues and no immediate alternative sources of supplies of oil and natural gas are available.

From the United Nations Climate Change Conference (COP 26) in Glasgow to COP 27 in Sharm El-Sheikh, countries have pledged net-zero emission by mid-century. However, the ongoing oil and gas price hikes due to the war could discourage fuel switching from coal to natural gas, which is a low-hanging mitigation opportunity for the fossil fuel–dependent region. Fossil fuels, especially coal, could stay in the energy mix in some Asian countries longer than previously anticipated. Decarbonisation pathways will need to consider various socio-economic and political circumstances that can help countries become carbon neutral. The Working Group for Analysis of Energy Saving Potential in East Asia has added to the report low-carbon energy transition (LCET), a carbon-neutral scenario. By analysing the energy outlook and saving potential in each EAS country, the working group predicts the medium- to long-term growth of energy demand and supply in 2019–2050. The outlook consists of two scenarios: business as usual (BAU), which considers only the existing policies and does not consider any future policy change; and the alternative policy scenario (APS). APS includes aggressive energy efficiency and conservation (EEC) and renewable energy targets until 2050. It assesses how targets can contribute to energy saving and carbon dioxide (CO_2) emission reduction in EAS17 countries. LCET will analyse the impacts of net-zero emission technologies that can help countries achieve carbon neutrality by 2050 or beyond.

[1] The EAS is an annual regional forum of leaders of, initially, 16 countries, comprising the 10 member states of the Association of Southeast Asian Nations (ASEAN) plus Australia, China, India, Japan, Republic of Korea (henceforth, Korea), and New Zealand. EAS membership expanded to 18 countries, including the Russian Federation and the US, at the Sixth EAS in 2011. ASEAN has led the forum since its establishment. EAS meetings are held after the annual ASEAN leaders' meetings. The EAS plays an important role in the regional architecture of Asia-Pacific.

Recalling the Cebu Declaration,[2] the outlook continues to shed light on the policy implications for decision-making to ensure that the region can enjoy economic growth and investment opportunities whilst averting energy security threats and environmental problems. Multiple pathways can be sought for LCET to help countries embark on the journey to carbon neutrality by 2050.

1.1. East Asia Summit

EAS17 countries vary widely in per capita income, standards of living, energy resource endowments, climate, and per capita energy consumption. They include the 10 Association of Southeast Asian Nations (ASEAN) member countries – Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam – and 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 developing. Several had a per capita gross domestic product (GDP) of less than US$1,500 (in 2015 prices)[3] in 2019, whilst some mature economies had per capita GDP of more than US$53,000. Countries with mature economies have higher per capita energy consumption than do developing countries. A large percentage of people in developing countries still meet their energy needs mainly with traditional biomass fuels.

These differences partly explain why EEC goals, action plans, and policies are assigned different priorities across countries. Developed economies may be keen to reduce energy consumption, whilst developing countries tend to emphasise economic growth and improvement of the standard of living. However, as economies grow, per capita energy consumption is expected to grow, as well.

Despite differences, EAS17 leaders agree that the EAS 'could play a significant role in community building', which could be an important cornerstone for the development of regional cooperation in the years to come (Ministry of Foreign Affairs, 2005a).

1.2. Objective and Rationale

The study aims to analyse the potential impacts of proposed additional energy-saving goals, action plans, and policies in EAS17 on energy consumption, by fuel and sector and greenhouse gas (GHG) emissions. The study provides a platform for EAS17 countries to collaborate on energy and to build capacity in energy modelling and policy development.

[2] In 2007, leaders from ASEAN Member States, Australia, China, India, Japan, the Republic of Korea (henceforth, Korea), and New Zealand adopted the Cebu Declaration, which focuses on energy security. The leaders agreed to promote energy efficiency, new renewable energy, and the clean use of coal. Japan proposed to undertake a study on energy savings and the potential of reducing CO_2 emissions. The outlook results have been reported yearly to the EAS Energy Ministers Meeting to support studies on the agreed areas of energy work streams of the East Asia Summit – Energy Cooperation Task Force.

[3] All US dollars in this document are stated at constant year 2015 values unless specified.

The study supports the Cebu Declaration (ASEAN Secretariat, 2007), which highlights several goals, including the following:

(i) improving the efficiency and environmental performance of fossil fuel use;
(ii) reducing dependence on conventional fuels through intensified EEC programmes, increased share of hydropower, expansion of renewable energy systems and biofuel production and utilisation, and, for interested parties, civilian nuclear power; and
(iii) mitigating GHG emissions through effective policies and measures, thus helping abate global climate change.

The Government of Japan asked ERIA to conduct a study on energy saving and CO_2 emission-reduction potential in East Asia. Japan is the coordinating country of the energy efficiency work stream under the Energy Cooperation Task Force. As a result, the working group was convened, representing all EAS17 countries.

2. Data and Methodology

2.1. Scenarios

Like the studies conducted annually since 2007, the study continues to examine a BAU scenario reflecting each country's current goals, action plans, and policies; and an APS, which includes additional goals, action plans, and policies reported annually to the East Asia Energy Ministers Meeting. The assumptions incorporate the latest policies and targets into the model. The APS assumptions are grouped into (i) more efficient final energy consumption (APS1), (ii) more efficient thermal power generation (APS2), (iii) higher consumption of new and renewable energy (NRE) and biofuels (APS3), and (iv) introduction or higher utilisation of nuclear energy (APS4). APS is the total of APS1 to APS4. LCET is to combine APS with additional technological options, including clean fuels such as hydrogen and ammonia and clean technology such as carbon capture and storage.

The energy models can estimate the individual impacts of the assumptions on primary energy supply and CO_2 emissions. The combination of the assumptions constitutes the assumptions of APS and LCET. The main report highlights only BAU, APS, and LCET. However, each country report will analyse all APS scenarios, from APS1 to APS4.

Detailed assumptions for each APS are follows:

(i) The assumptions in APS1 are the reduction targets in sectoral final energy consumption, assuming that more efficient technologies are utilised, and that energy-saving practices are implemented in the industrial, transport, residential, commercial, and even agricultural sectors of some countries. The scenario resulted in less primary energy and CO_2 emission in proportion to the reduction in final energy consumption.
(ii) APS2 assumes the utilisation of more efficient thermal power plant technologies in the power sector. The assumption resulted in lower primary energy supply and CO_2 emission in proportion to the efficiency improvement in generating thermal power. The most efficient coal and natural gas combined-cycle technologies are assumed to be utilised for new power plant construction.

(iii) APS3 assumes higher contributions of NRE for electricity generation and utilisation of liquid biofuels in transport, resulting in lower CO_2 emissions as NRE is considered carbon-neutral or not emitting additional CO_2 into the atmosphere. However, primary energy supply may not decrease as NRE, like biomass and geothermal energy, is assumed to have lower efficiencies than fossil fuel–fired generation when converting electricity generated from NRE sources into their primary energy equivalent.

(iv) APS4 assumes the introduction of nuclear energy or a higher contribution of nuclear energy in countries already using the energy source. The scenario would produce less CO_2 emissions as nuclear energy emits minimal CO_2. However, as the assumption of thermal efficiency when converting nuclear energy output into primary energy is only 33%, primary energy supply is not expected to be lower than in BAU.

Detailed assumptions for LCET are as follows: APS considers further fuel switch from fossil fuels to hydrogen, electricity, and biomass in transport and industry, and application of carbon capture, utilisation, and storage (CCUS) in industry production and power generation.

(i) **Fuel switching**. Coal to highly efficient combined-cycle gas turbine is considered a transitional pathway. Hydrogen will be introduced into industry by replacing coal in iron and steel production and diesel in other activities in 2035–2050 at a 100% utilisation rate. Hydrogen and ammonia, including for co-firing in power generation and boilers in industry, will be applied after 2040. Biomass will replace coal and natural gas in other activities, depending on the country's situation. Some countries will start from 2030 and continue until 2050 at a higher utilisation rate of up to 95%.

(ii) **Electric vehicles**. Electricity will be introduced into public passenger transport by replacing diesel and gasoline. Some countries are expected to introduce electric buses by 2035. Electric vehicles will be introduced into private transport by replacing diesel and gasoline in 2025–2050 at a maximum 70% utilisation rate, depending on the country's situation.

(iii) **Application of CCUS**. CCUS will be applied for cement production and power generation, including coal and natural gas, in 2040–2050, with a 100% utilisation rate.

However, EAS17 countries are diverse in speed, pace, and progress, and are at various levels of implementing EEC goals, action plans, and policies. Some countries are ahead whilst others are just getting started. A few already have significant energy-saving goals, action plans, and policies built into BAU, whilst others have only started to quantify their goals.

2.2. Data

For consistency, the historical energy data used in the analysis were changed to the energy balances of national energy statistics of EAS17 countries from the International Energy Agency (IEA). Of the ASEAN 10 countries, Cambodia, Lao PDR, and Myanmar use their national energy statistics produced by ERIA, and the other 7 use the Asia-Pacific Economic Cooperation energy database, which includes national energy data submitted by the 7 countries. ASEAN+7 countries, including China and India, use IEA energy balance tables (IEA, 2020). Socio-economic data for 17 countries were obtained from the World Bank's World Databank–World Development Indicators and Global Development Finance. Other data, such as those relating to transport, buildings, and industrial production indices, if available, were provided by the working group members from each EAS17 country. Where official data were not available, estimates were obtained from other sources or developed by the Institute of Energy Economics, Japan (IEEJ), especially international energy prices such as crude oil price.

2.3 Methodology

In 2007, the primary model used was IEEJ's world energy outlook model, which was used to prepare Asia/World Energy Outlook. Since 2008, all ASEAN 10 member countries have used their own energy models. The rest have depended on the IEEJ model but provided their own key assumptions on population and GDP growth; electric generation fuel mixes; and EEC goals, action plans, and policies. The next section describes the study's energy models.

ASEAN countries. The energy models of ASEAN countries were developed by applying the econometrics approach to forecast energy balance tables based on final energy consumption and energy input and output in the transformation sector. Final energy consumption is forecast using energy demand equations by energy, sector, and future macroeconomic assumptions. For the study, all 10 member countries used the Long-range Energy Alternative Planning software.

Other countries. IEEJ produced energy outlooks of other countries using its model, which has various explanatory variables based on exogenously specified GDP growth rates. The model projects prices for natural gas and coal based on exogenously specified oil price assumptions. Demand equations are econometrically calculated in another module using historical data, and future parameters are projected using the explanatory variables. An econometric approach means that future demand and supply will be heavily influenced by historical trends. However, the supply of energy and new technologies are treated exogenously. For electricity generation, working group members specified assumptions about the future electricity generation mix in their countries by energy source. The assumptions were used to determine the future electricity generation mix.

3. Assumptions of the Study

Growth in energy consumption and GHG emissions is driven by various socio-economic factors. In EAS17, the factors – including increasing population, sustained economic growth, increasing vehicle ownership, and increasing access to electricity – will tend to increase energy demand. Together, they create a huge growth headwind that works against efforts to limit energy consumption. Understanding the nature and size of the headwind is critical for any analysis of energy demand in the region. However, an increase in consumption of energy services is fundamental to achieve a range of socio-economic development goals.

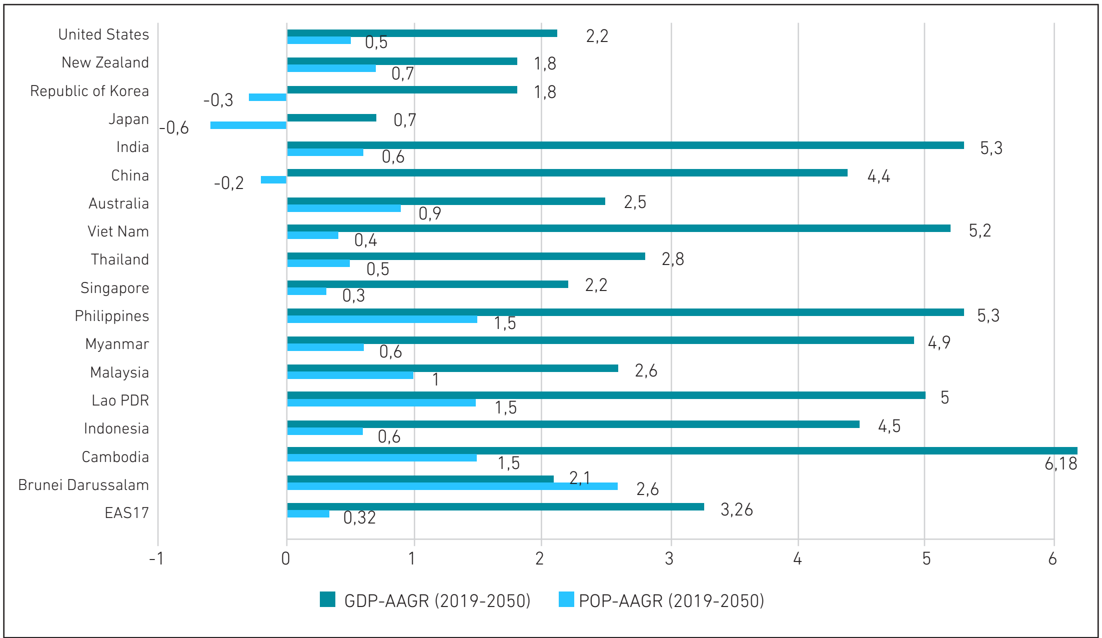
This section discusses the assumptions of key socio-economic indicators and energy policies for EAS17 until 2050.

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

The study's modelling assumption assumes that changes in population until 2050 are set exogenously. No difference in population between BAU, APS, and LCET is assumed. The EAS17 countries, except China, submitted assumed changes in population based on United Nations' population projections.

In 2019, the EAS17 total population was about 3.89 billion. It is forecast to increase at an average annual rate of about 0.4%, reaching about 4.37 billion in 2050.

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



GDP-AAGR = gross domestic product average annual growth rate, POP-AAGR = population average annual growth rate, Lao PDR = Lao People's Democratic Republic.

Source: Authors.

Brunei Darussalam, Cambodia, Lao PDR, and the Philippines are generally assumed to have the fastest average annual population growth rate, from 2.6% to 1.5% in 2019–2050 (Figure 1.1). Australia, India, Indonesia, Malaysia, New Zealand, Singapore, Thailand, Viet Nam, and the US are expected to have moderate average annual population growth rate, from 0.3% to 1.0%. Populations of China, Japan, and Korea are assumed to decline slowly throughout the projection period as they continue to age. Their average annual population growth rates are predicted to be –0.2%, –0.3%, and –0.6%, respectively.

Long-term economic growth rates are assumed to be high in the developing countries, and highest in Cambodia, India, the Philippines, Lao PDR, Indonesia, Viet Nam, and Myanmar (Figure 1.1). Economic growth in other developing countries is assumed to be rapid. Brunei Darussalam, Singapore, Malaysia, and Thailand are expected to have moderate average annual GDP annual growth rates of 2.1%–2.8% in 2019–2050. Developed EAS17 countries – the US, Japan, Republic of Korea, New Zealand, and Australia – are expected to have moderate annual GDP growth rate. Due to their large economies, China, India, and Indonesia, together with the US, are likely to see rapid growth, which will be especially significant for energy demand.

In 2019, the total GDP in EAS17 was about US$47.9 trillion in 2015 US dollar constant price and accounted for more than half of global GDP. The region's GDP is assumed to grow at an average annual rate of about 3.26% in 2019–2050, implying that, by 2050, total GDP in the region will reach about US$129.2 trillion in 2015 US dollar constant price. China is projected to have the largest real GDP, about $55 trillion (2015 US dollar constant price), by 2050, followed by the US, with about $38.6 trillion. India and Japan are projected to have the next-largest GDPs, projected at about $13.4 trillion and $5.7 trillion, respectively, in 2015 US dollar constant price, by 2050 (Table 1.1).

Table 1.1 Gross Domestic Product (2015 US$ Constant Prices) and Population in East Asia Summit 17 Countries (2019–2050)

Region	GDP (2015 US$ billion)		Population (millions)		Per Capita GDP	Per Capita GDP
	2019	2050	2019	2050	2019	2050
Brunei Darussalam	14.01	26.55	0.44	0.67	46,700	39,627
Cambodia	20.92	134.14	16.49	26.16	1,269	5,128
Indonesia	1,204	4,710	271	325	4,443	14,492
Lao PDR	18.5	82.8	7.2	11.4	2,569	7,263
Malaysia	364.7	816.6	32.0	43.9	11,397	18,601
Myanmar	74.276	327.01	54.0	65.3	1,375	5,008
Philippines	377	1,847	108.1	171.3	3,488	10,782
Singapore	348.9	683.1	5.8	6.4	60,155	106,734
Thailand	460.8	1,092.5	69.6	82.4	6,621	13,259
Viet Nam	162.19	773.93	96.5	108.9	1,681	7,107

Region	GDP (2015 US$ billion)		Population (millions)		Per Capita GDP	Per Capita GDP
	2019	2050	2019	2050	2019	2050
Australia	1,346	2,871	25.4	33.0	52,992	87,000
China	14,296	55,025	1,397.7	1,320.0	10,228	41,686
India	2,751	13,447	1,366.4	1,639.2	2,013	8,203
Japan	4,591	5,737	126.3	105.	36,350	54,482
Republic of Korea	1,638	2,611	51.7	47.3	31,682	55,200
New Zealand	201	348	5.104	6.3	39,381	55,238
United Sates	19,975	38,670	328.2	378.5	60,862	102,166
EAS17	47,843	129,203	3,961	4,370	21,953	37,175

EAS17 = East Asia Summit 17, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.

Source: Authors.

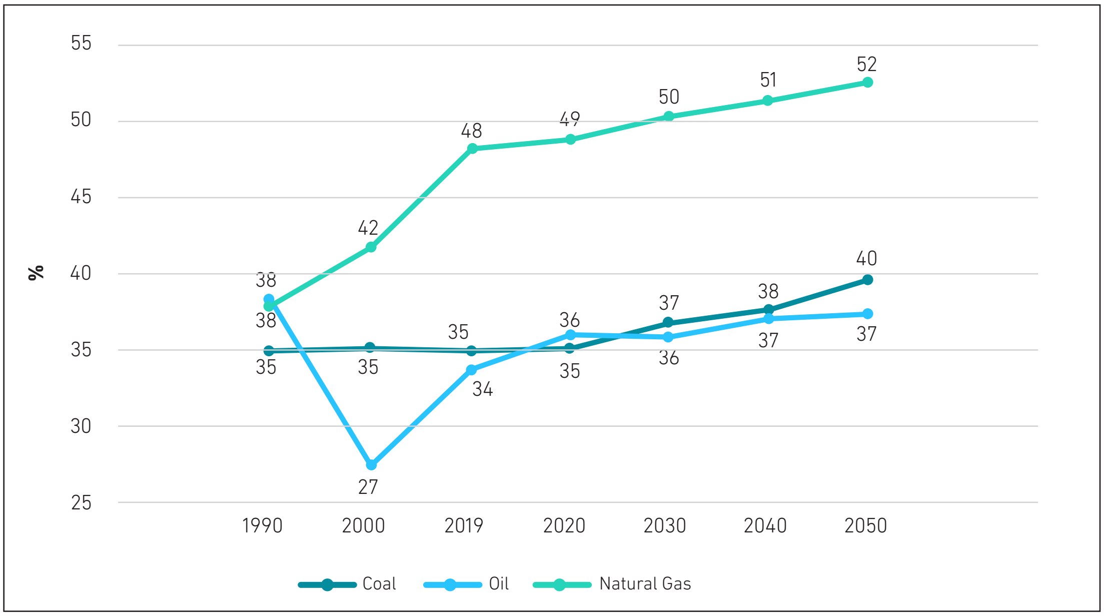
Average real per capita GDP (2015 US dollar constant price) in EAS17 is assumed to increase from about US$21,953 in 2019 to about US$37,175 in 2050. However, there are, and will continue to be, significant differences in per capita GDP amongst EAS17 countries. In 2019, per capita GDP (2015 US dollar constant price) ranged from about US$1,269 in Cambodia to over US$36,350 in Japan, the US, Singapore, and Australia. In 2050, per capita GDP is assumed to range from about US$5,127 in Cambodia to over US$102,166 in the US and Singapore.

3.2. Thermal Efficiency of Power Generation

The thermal efficiency of electricity generation reflects the amount of fuel required to generate a unit of electricity. Thermal efficiency was another exogenous assumption used in the study. Base year 2019 thermal efficiencies by fuel type (coal, gas, and oil) were derived from fossil fuel input and fuel output as electricity production. Thermal efficiencies by fuel type (coal, gas, and oil) were projected by Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam, and growth rates in thermal efficiency were derived from the projections. For the remaining countries, assumptions about the potential changes in thermal efficiency were based on IEEJ's *Asia/World Energy Outlook 2020*. As analyses start to add new fuels (hydrogen and ammonia) for thermal efficiency in LCET, data availability starts from 2020 and is projected towards 2050.

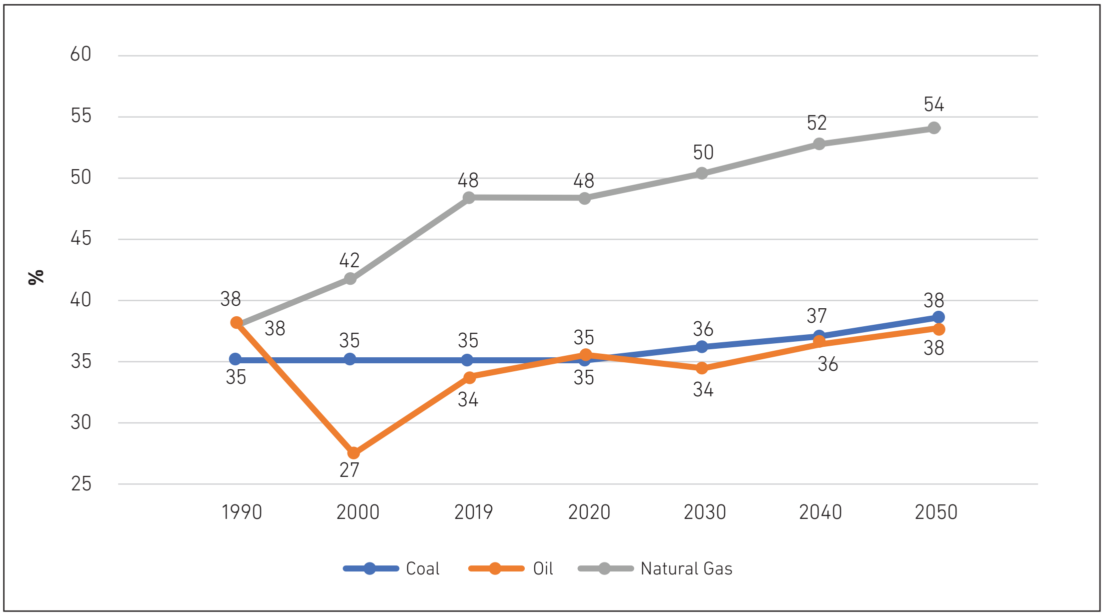
Thermal efficiencies may differ significantly amongst countries due to differences in technological availability, age, cost of technology, temperature, and cost and availability of fuel inputs. Thermal efficiencies in ASEAN and EAS7 countries are expected to improve considerably over time in BAU as more advanced-generation technologies, such as natural gas combined-cycle and supercritical coal-fired power plants, become available. In many countries, additional improvements are assumed in APS and LCET (Figures 1.2, 1.3, and 1.4).

Figure 1.2 Average East Asia Summit 17's Thermal Efficiency in the Business-as-Usual Scenario



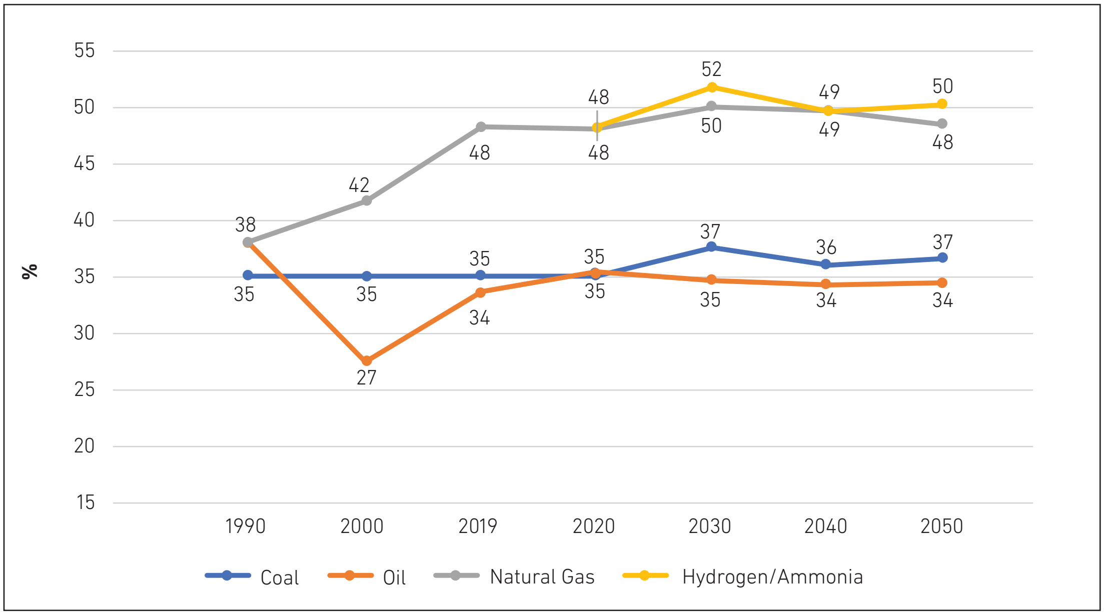
Source: Authors.

Figure 1.3 Average East Asia Summit 17's Thermal Efficiency in the Alternative Policy Scenario



Source: Authors.

Figure 1.4 Average East Asia Summit 17's Thermal Efficiency in the Low-Carbon Energy Transition Scenario



Source: Authors.

3.3. Imported Price Assumption of Oil, Coal, and Natural Gas

Table 1.2 depicts the oil price assumptions used in the modelling adopted by IEEJ from the world energy model price data of IEA (2020). In the reference scenario, crude oil prices were US$41/blue barrel (bbl) in 2020, to rise to US$80/bbl by 2030, and to US$100/bbl in 2050. The increase in the oil price in 2030 and 2050 is due to combined factors such as robust demand growth in non–Organisation for Economic Co-operation and Development countries, full economic recovery from the COVID-19 pandemic, new emerging geopolitical risks and financial factors, and oil supply constraints reflecting rising depletion rates for oil fields, amongst others.

Table 1.2 Imported Price Assumption 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

Year	Crude Oil (US$/bbl)	Coal (US$/ tonne)	Natural Gas (US$/MBtu)		
			US	Europe	Asia
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

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

Notes: 1. The constant price 2020 is used for the energy outlook of Australia, China, India, Japan, Korea, and New Zealand. However, for the outlook of ASEAN countries, we use the nominal price 2020. 2. Crude oil price assumptions start from 2020.

Source: Institute for Energy Economics, Japan (2020) oil price assumptions.

3.4. Energy-saving Goals and Other Policy Assumptions

The working group members from each country included information on the policy assumptions and targets in BAU, APS, and LCET. Since LCET assumes additional technology efficiency improvement above APS, Table 1.3 shows only the policy assumptions for APS. Some countries in EAS17 have clear targets for energy saving or any emission reduction. Table 1.3 summarises the policy assumptions in EAS17.

Table 1.3 Other Assumptions of Energy-saving Target Alignment with Nationally Determined Contributions in the Alternative Policy Scenario by East Asia Summit 17

Country	Assumptions
Australia	Energy efficiency target of 40% improvement in 2015–2030. Further reduction of GHG emissions by 43% below 2005 levels by 2050.
Brunei Darussalam	Reduction of GHG emissions by 20% relative to BAU. Reduction of total energy consumption by 63% from BAU by 2035. A 10% share of renewables in the power mix by 2035.
Cambodia	Total energy saving of 27% from BAU levels by 2030. Specific fuel efficiency target by 2050 included (coal, oil, gas, biomass industry, 10%; electricity-efficiency target, 20%). Reduce estimated total emissions by 2030 under the updated NDC scenario to about 64.6 million tCO_2eq/year (41.7%).
China	Have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. Lower CO_2 emissions per unit of GDP by over 65% from the 2005 level, increase the share of non-fossil fuels in primary energy consumption to about 25% and the forest stock volume by 6 billion cubic metres from the 2005 level, and bring total installed capacity of wind and solar energy to over 1.2 billion kW.
India	Reduce emission intensity of GDP by 33%–35% by 2030 from the 2005 level. Achieve about 40% cumulative electric power installed capacity from non-fossil fuel–based energy resources by 2030 with the help of technology transfer and low-cost international finance, including from the Green Climate Fund. Create an additional carbon sink of 2.5 to 3 $BtCO_2e$ through additional forest and tree cover by 2030.

Country	Assumptions
Indonesia	Reduce GHG emissions in 2020–2030 by 29% (unconditional) up to 41% (conditional) against 2030 BAU, an increased unconditional commitment compared with the 2010 pledge of 26%.
Japan	Reduce GHG emissions by 46% in fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target aligned with the long-term goal of achieving net-zero emission by 2050. Continue strenuous efforts to meet the lofty goal of cutting emissions by 50%.
Republic of Korea	Reduce 24.4% from 2017 total national GHG emissions (709.1 $MtCO_2eq$) by 2030. It is an absolute emission-reduction target that is more predictable and transparent than the target relative to BAU emission projections in the previous NDC. The updated target includes an increased share of domestic reduction, which is facilitated through continued mitigation efforts such as the nationwide ban on construction of new coal-fired power plants.
Lao People's Democratic Republic	Unconditionally reduce GHG emissions in 2030 by 60% compared with BAU. Reduce land use, land-use change, and forestry emissions by 1.1 $MtCO_2eq$/year by reducing deforestation, reach 13 GW of hydropower capacity (5.5 GW capacity is already operational), introduce 50,000 energy-efficient cook stoves, and build a new bus rapid transit system in Vientiane and a new railway to China. With international support (conditionally), the country could increase its forest cover to 70% of total land area, develop 1 GW of wind energy and solar energy capacity, 300 MW of biomass-fired power capacity, and reduce final energy consumption by 10% compared with BAU.
Malaysia	Reduce economy-wide carbon intensity of 45% in 2030 compared with the 2005 level; save 16% electricity by 2050 in industry, commercial, and residential sectors; save 16% of oil in final consumption by 2050; and replace 5% of diesel with biodiesel in road transport.
Myanmar	Target saving by 2050 included (transport and residential by 20%; industrial, commercial, and 'others' by 10%). Replace 8% of transport diesel with biodiesel.
New Zealand	Use the emission budget approach of the updated NDC, which is total net emissions the country will be responsible for in 2021–2030. Managing the NDC through an emission budget means that net emissions will be measured across the whole target period (2021–2030), not only by isolating emissions in a single year (2030). The provisional budget for the updated NDC is 571 $MtCO_2eq$. It represents cumulative net emissions in 2021–2030, if net emissions decline in a straight line from 2020 levels to the point-year target in 2030. The previous NDC target was to reduce net GHG emissions by 30% below gross 2005 levels by 2030.
Philippines	Commit to a projected 75% GHG emission reduction and avoidance, of which 2.71% is unconditional and 72.29% conditional, representing the goal of GHG mitigation in 2020–2030 for agriculture, waste, industry, transport, and energy. The commitment is referenced against a projected BAU cumulative economy-wide emission of 3,340.3 $MtCO_2eq$ for the same period.
Thailand	Reduce GHG emissions by 30% from the projected BAU level by 2030. The level of contribution could increase up to 40%, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity-building support. Continue vigorous efforts to meet the long-term goal of carbon neutrality by 2050 and net-zero GHG emission by 2065. Energy efficiency targets by 2050 included reduction of final energy demand in transport by 70%; residential, 10%; commercial, 40%; and industrial, 20%. Biofuels to displace 12.2% of transport energy demand.

Country	Assumptions
United States	Set an economy-wide target of reducing net GHG emissions by 50%–52% below 2005 levels by 2030. Reach 100% carbon pollution–free electricity by 2035 through multiple cost-effective technology and investment pathways, each resulting in meaningful emission reductions in this decade. Support decarbonisation of international maritime and aviation energy use through domestic action as well as through the International Maritime Organization and the International Civil Aviation Organization. Invest in new technologies to reduce emissions associated with construction, including of high-performance electrified buildings. The government will support research, development, demonstration, commercialisation, and deployment of very low- and zero-carbon industrial processes and products.
Viet Nam	Strive to achieve net-zero emission by 2050. By 2030, GHG emissions in energy will be lower by 43.5% than in BAU and emissions will not be in excess of 457 $MtCO_2eq$. By 2050, ensure that total national GHG emissions reach net zero and that GHG emissions in energy will be lower than in BAU by 91.6% and will not be in excess of 101 $MtCO_2eq$.

BAU = business as usual, $BtCO_2e$ = British thermal unit of carbon dioxide equivalent, CO_2e = carbon dioxide equivalent, GHG = greenhouse gas, kW = kilowatt, $MtCO_2eq$ = metric tonne of carbon dioxide equivalent, MW = megawatt, NDC = nationally determined contribution, tCO_2eq = tonne of carbon dioxide equivalent.

Source: United Nations Climate Change, 2022.

4. Energy Outlook for the East Asia Summit Region

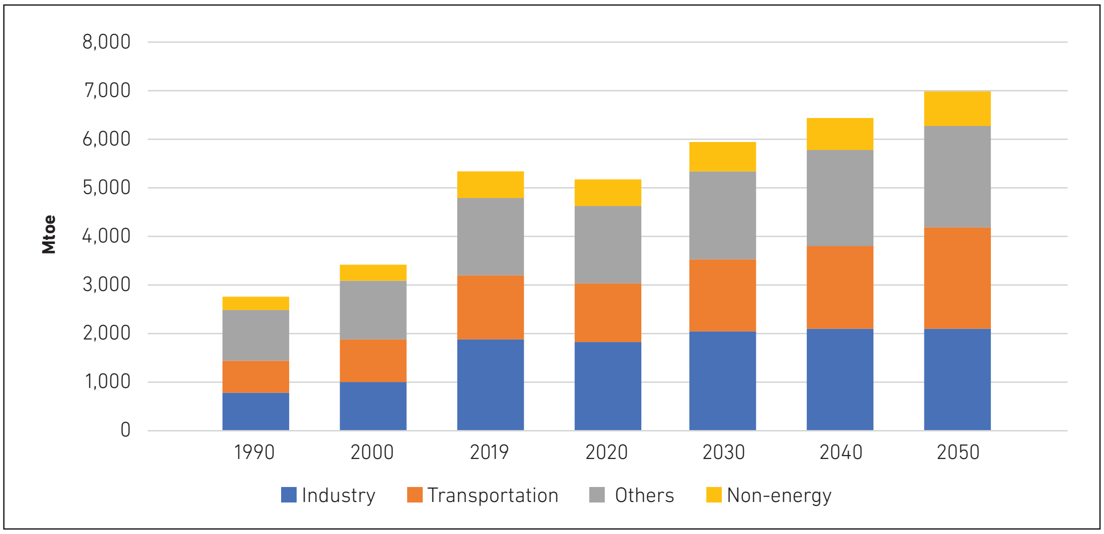
4.1. Business-as-Usual Scenario

4.1.1. Final Energy Consumption

In 2019–2050, total final energy consumption (TFEC)[4] in EAS17 is projected to grow at an average annual rate of 0.9%, reflecting the assumed 3.26% annual GDP growth and 0.32% population growth. Final energy consumption is projected to increase from 5,318 Mtoe in 2019 to 6,966 Mtoe in 2050. Transport energy demand is projected to grow by about 1.3% per year in 2019–2050, and its energy consumption share is projected to be 29.3% by 2050. Industry's annual growth rate in 2019–2050 is about 0.4% per year, but its energy consumption share is projected to be about 30.2% by 2050. Commercial and residential ('others') demand will grow by 0.9% per year, higher than that of industry, but energy consumption share is projected to be 30%, the second largest after industry. Figure 1.5 shows final energy consumption by sector under BAU in EAS17 in 1990–2050, and Figure 1.6 shows details of sector shares in final energy consumption.

[4] 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.

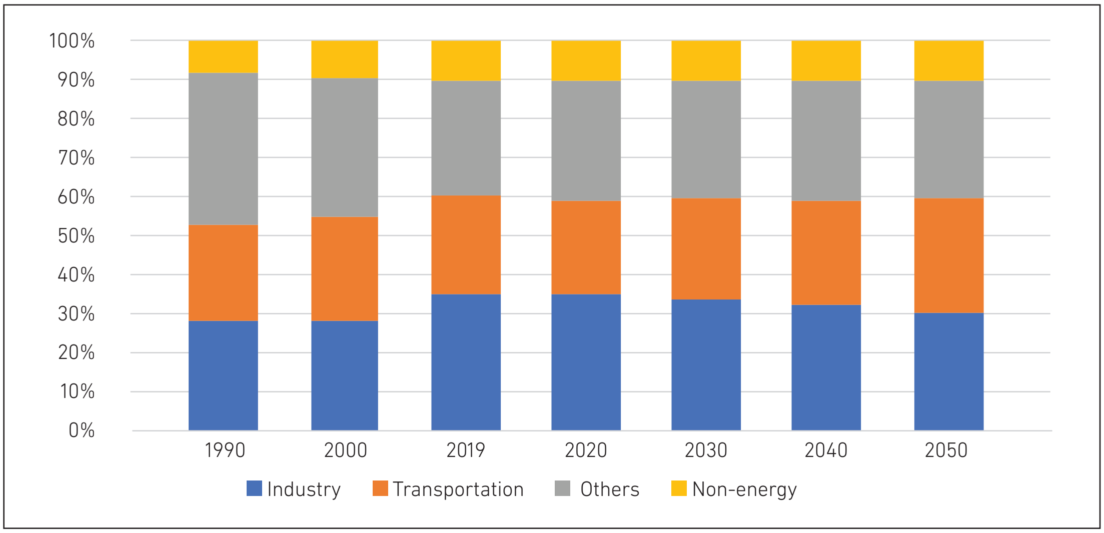
Figure 1.5. **Final Energy Consumption by Sector, Business-as-Usual Scenario (1990–2050)**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

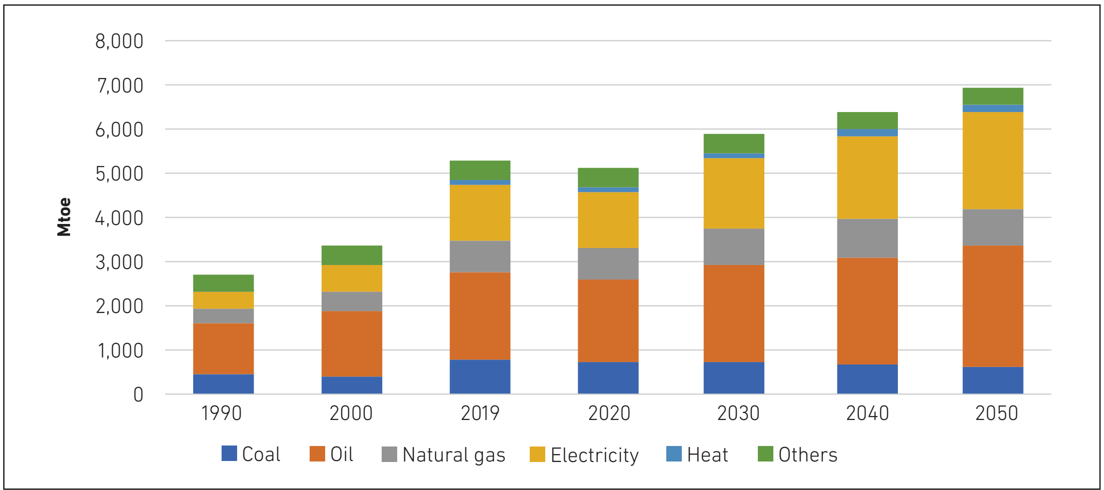
Figure 1.6 **Final Energy Consumption Share by Sector (1990–2050)**



Source: Authors.

Figure 1.7 and Figure 1.8 show final energy consumption and shares by fuel type in EAS17 under BAU in 1990–2050. By energy source, electricity and natural gas demand in BAU are projected to show the fastest growth, increasing by 1.9% and 0.7% per year, respectively, in 2019–2050, but their shares are just 31.6% and 12.5%. Although oil will retain the largest share, 38.8%, of TFEC, it is projected to grow at a lower rate of 1.0% per year in 2019–2050, reaching 2,706 Mtoe in 2050. Generally, oil share slightly increases from 37.9% in 2019 to 38.8% in 2050. Coal demand will grow at a rate of –0.6% per year on average in 2019–2050, reaching 653.45 Mtoe in 2050. The share of other fuels, such as biomass, will decline from 8.4% in 2019 to 6.0% in 2050. The slow growth is due to the gradual shift from non-commercial biomass to conventional fuels such as liquefied petroleum gas and electricity in the residential sector. Slow growth is observed in the declining share of heat energy demand, projected to drop from 2.3% in 2019 to 1.7% in 2050, in final energy consumption. One reason could be the shift from heat energy demand to more electricity consumption in final energy consumption.

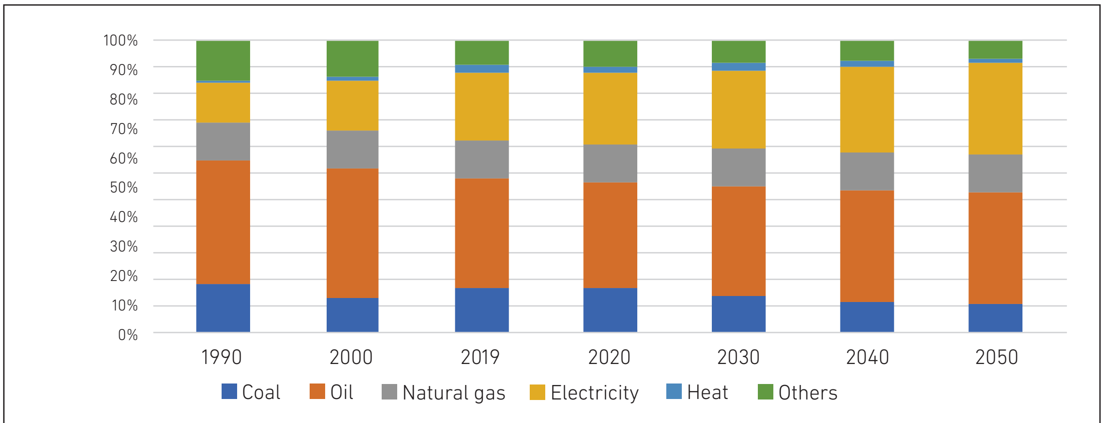
Figure 1.7 Final Energy Consumption by Fuel (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 1.8 Final Energy Consumption Share by Fuel (1990–2050)

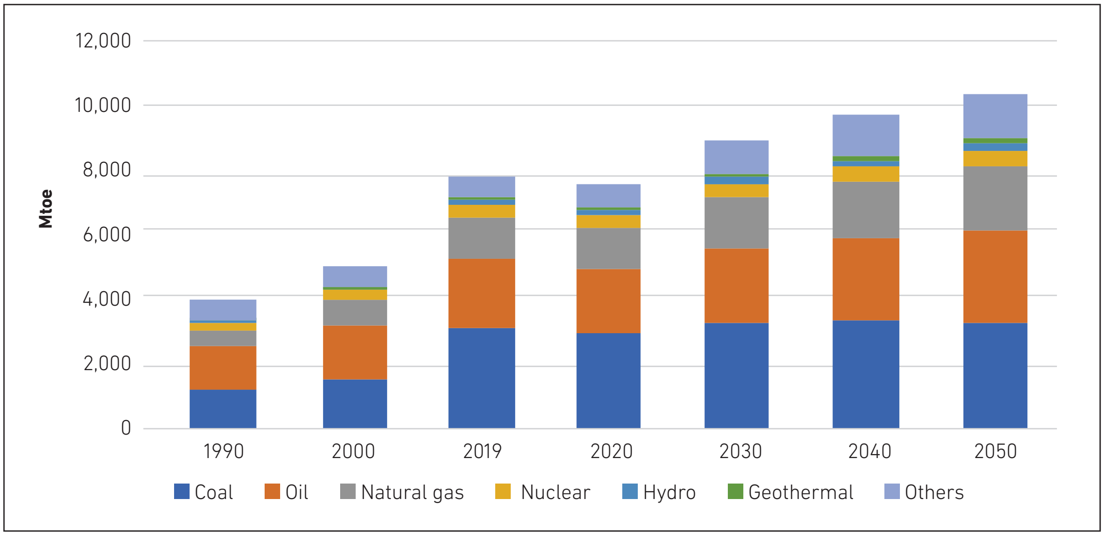


Source: Authors.

4.1.2. Primary Energy Supply

Figure 1.9 shows primary energy supply in EAS17 in 1990–2050. Primary energy supply[5] is projected to grow at a slower pace, 0.9% per year in 2019–2050, the same growth rate of final energy consumption. The EAS17 primary energy supply is projected to increase from 8,046 Mtoe in 2019 to 10,467 Mtoe in 2050. Coal will still comprise the largest share (32.5%) of primary energy supply, but its growth is expected to be slower, increasing at 0.2% per year in 2019–2050. The share of coal in total primary energy supply (TPES) is forecast to decline from 39.7% in 2019 to 32.5% in 2050.

Figure 1.9 Primary Energy Supply in East Asia Summit 17 (1990–2050)



Mtoe = million tonnes of oil equivalent.

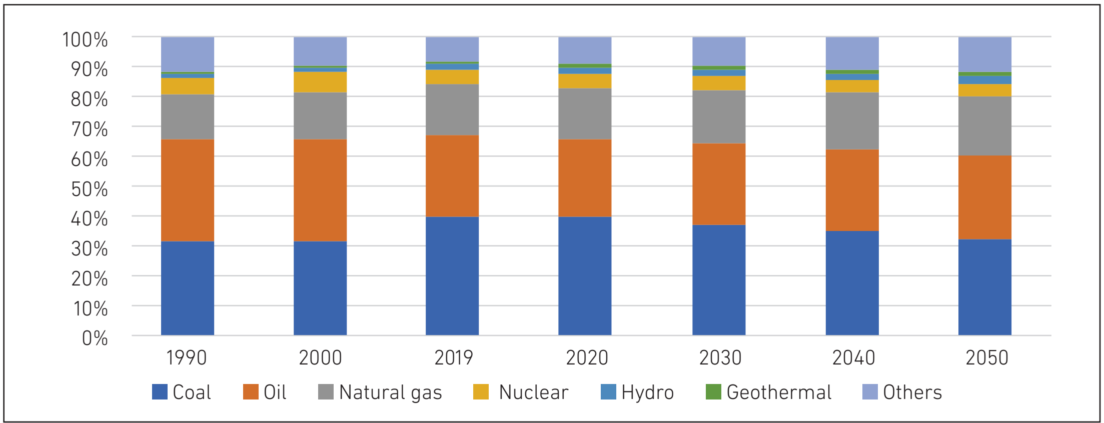
Source: Authors.

Amongst fossil sources of energy, natural gas is projected to see less moderate growth in 2019–2050, increasing at an annual average rate of 1.3%. Its share of the total will increase from 16.9% (1,360 Mtoe) in 2019 to 19.6% (2,047 Mtoe) in 2050. Nuclear energy is projected to increase at a slower rate of 0.8% per year on average in 2019–2050 and its share is projected to slightly drop from 4.7% in 2019 to 4.6% in 2050. Nuclear power generation in Japan and expansion of nuclear power generation capacity in China and India are assumed to resume. The share of hydropower is projected to slightly increase from 2.2% in 2019 to 2.3% in 2050. Geothermal energy is projected to grow at 3.3% per year in 2017–2050, which is the fastest growth rate amongst energy sources. However, its share is projected to be small, about 0.7% in 2019, increasing from 1.6% by 2050.

[5] Refers to energy in its raw form, before any transformation, most significantly the generation of electricity.

Amongst the energy sources, 'others' – solar and wind energy, and solid and liquid biofuels – will grow at 1.9% in 2019–2050. Consequently, their share will increase from 8.4% in 2019 to 11.6% in 2050. Most remarkably, wind and solar energy will see the largest average annual growth rate, 4.5%, in 2019–2050. The share of wind and solar energy in primary energy supply will increase from 1.7% in 2017 to 5.3% in 2050. Figure 1.10 shows the shares of each energy source in the total primary energy mix in 1990–2050.

Figure 1.10 Share of Primary Energy Mix by Source (1990–2050)

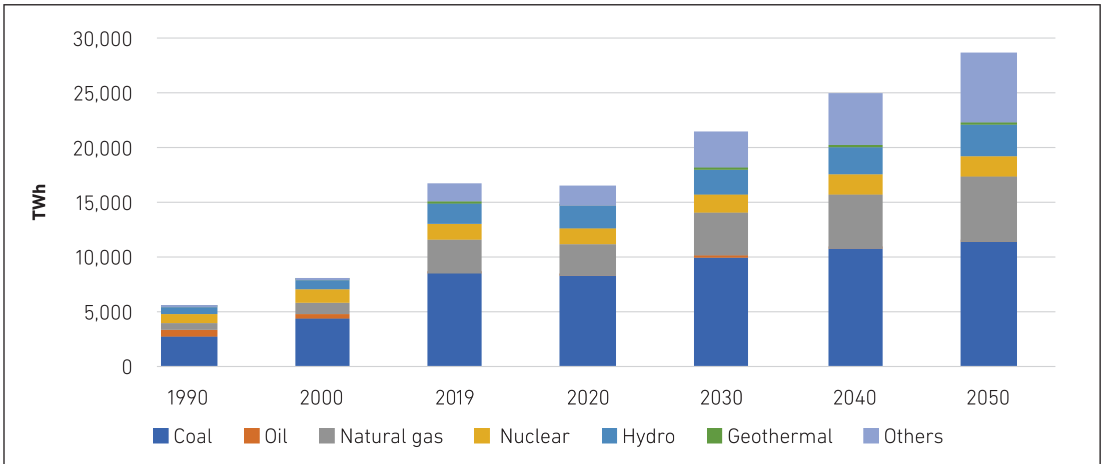


Source: Authors.

4.1.3. Power Generation in East Asia Summit 17

Figure 1.11 shows power generation output in EAS17. Total power generation is projected to grow at 1.8% (16,534 terawatt-hours [TWh]) per year on average in 2019–2050 (equivalent to 28,515 TWh). However, the growth rate in 1990–2019 was 3.9%, more than twice as high as the projected growth rate in 2019–2050.

Figure 1.11 Energy Mix of the Power Generation in East Asia Summit 17 (1990–2050)

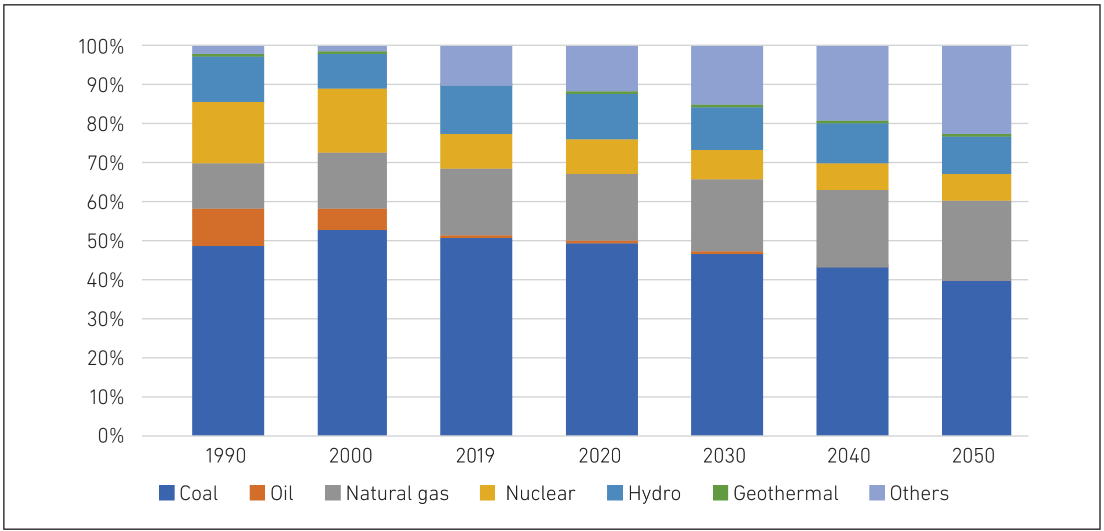


TWh = terawatt-hour.

Source: Authors.

Figure 1.12 shows the shares of each energy source in electricity generation in 1990–2050. The share of coal-fired generation is projected to continue to be the largest and will be about 39.5% in 2050, a large drop from the 50.5% share in 2019. The share of natural gas is projected to increase from 17.5% in 2019 to 20.8% in 2050. Nuclear power share (8.8% in 2019) is forecast to decrease to 6.5% in 2050. The share of geothermal power was 0.3% in 2019 and is projected to increase to 0.8% in 2050. Other sources (wind, solar, and biomass energy, amongst others) will record the highest average annual growth rate, 4.5%, in 2019–2050. The share of combined wind, solar, and biomass energy in the power mix is expected to be 22.4% in 2050, from 9.9% in 2019. The share of oil will drop from 0.7% in 2019 to 0.1% in 2050, with an average annual growth rate of –4.1% in 2019–2050 due to its higher fuel cost and limited use in power generation. The share of hydropower in the power mix is projected to decrease from 12.2% in 2019 to 9.9% in 2050. The average annual growth rate of hydropower is expected to slow down to 1.1% in 2019–2050.

Figure 1.12 **Share of Power Generation Mix in East Asia Summit 17 (1990–2050)**



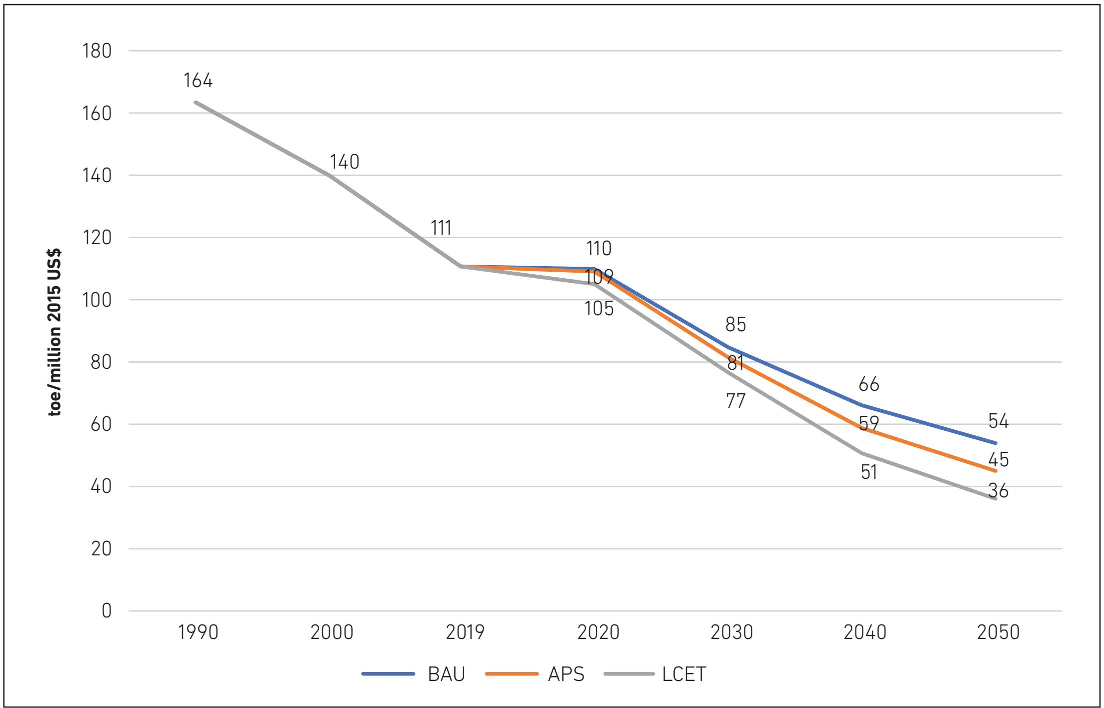
Source: Authors.

4.2. Comparison of Business-as-Usual, Alternative Policy, and Low-carbon Energy Transition Scenarios

4.2.1. Energy Indicators in East Asia Summit 17

Figure 1.13 and Figure 1.14 show the final energy intensity and primary energy intensity in 1990–2050 for BAU, APS, and LCET. The final energy intensity (toe/million 2010 US dollars) in EAS17 is projected to decline by 51.4% in BAU, 59.5% in APS, and 67.6% in LCET in 2050 from the 2019 level. The final energy intensity indicator shows how the economy becomes more efficient in using final energy consumption to produce a unit of the GDP. In general, final energy intensity has been remarkably improved, pointing to the gradual increase of energy efficiency in all final energy sectors such as industry, transport, commercial, and residential (Figure 1.13).

Figure 1.13 Final Energy Intensity – Final Energy Consumption per Unit of Gross Domestic Product (toe/million 2015 US$)



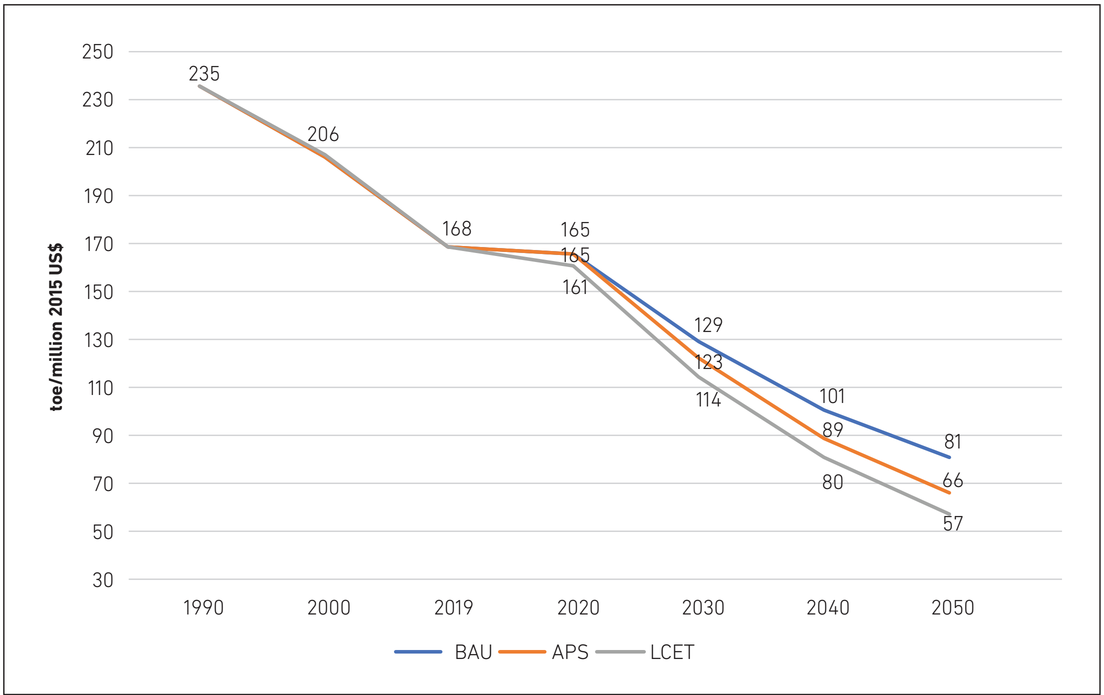
APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, toe = tonne of oil equivalent

Source: Authors.

Primary energy intensity measures the whole economy efficiency in using a unit of energy to produce a unit of GDP and shows the efficiency of transformation plus the final energy consumption sectors. Figure 1.14 shows that EAS17 is projected to see a large improvement in primary energy intensity, which is expected to decline by 51.8% in BAU, 60.7% in APS, and 66.1% in LCET in 2050 compared with the 2019 level.

The improvement in primary energy intensity is reflected in improved carbon intensity (t-C/million 2015 US dollars).

Figure 1.14 Primary Energy Intensity – Final Energy Consumption per Unit of GDP (toe/million 2015 US$)

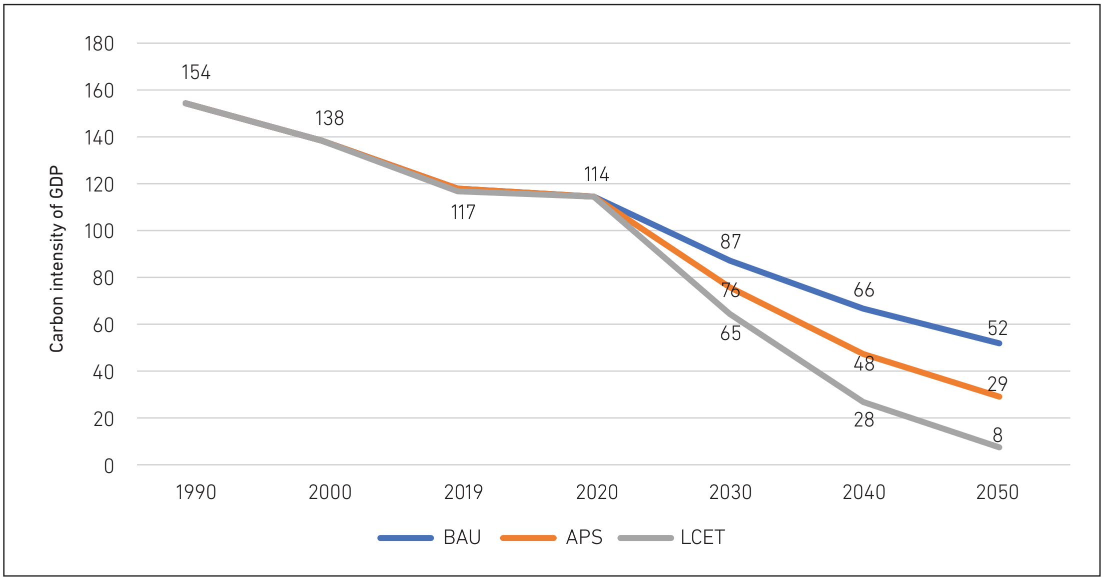


APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, toe = tonne of oil equivalent

Source: Authors.

The carbon intensity of GDP is expected to drop 55.56% in BAU, 75.2% in APS, and 93.2% in LCET in 2050 from the 2019 level (Figure 1.15). The differences of the carbon intensity of GDP between BAU, APS, and LCET in 2019–2050 reflect the fundamental shift from fossil fuels to more renewables and clean technologies.

Figure 1.15 **Carbon Intensity of Gross Domestic Product**
(t-C/million 2015 US$)

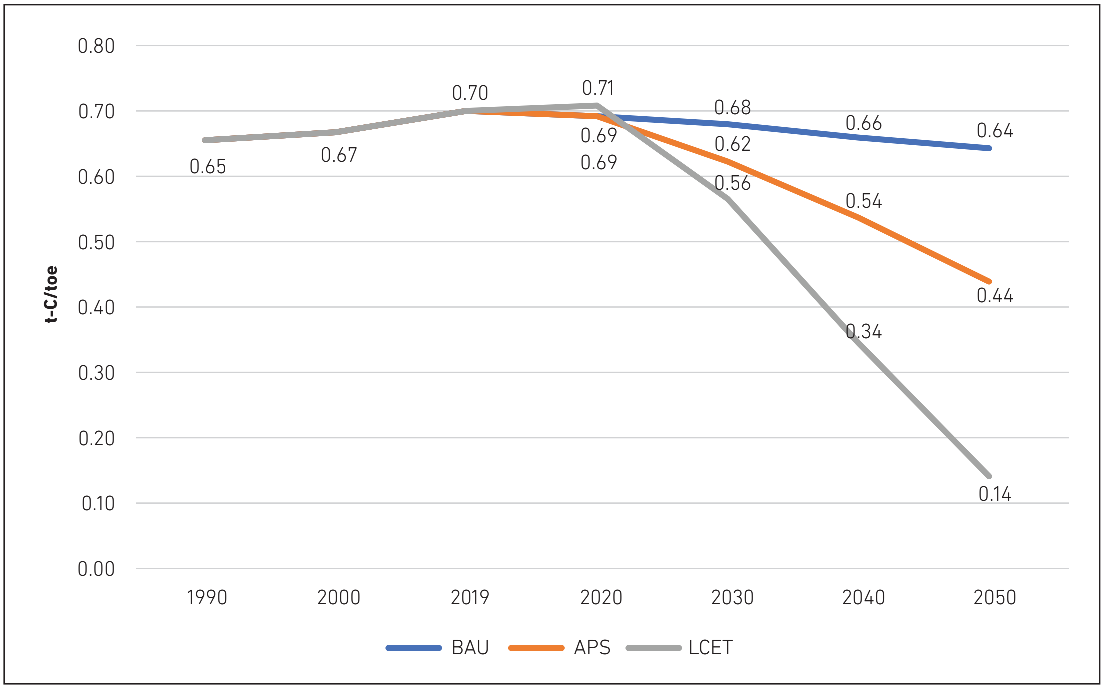


APS = alternative policy scenario, BAU = business as usual, GDP = gross domestic product, LCET= low carbon energy transition, t-C = tonne of carbon.

Source: Authors.

The carbon intensity of primary supply measures how a country or region is performing in terms of CO_2 emission per unit of energy use. If a country or region shifts to renewables and clean energy, intensity will be lower; it is an indicator of a country's energy system's shift to cleaner energy. Some countries in ASEAN, such as Lao PDR, have low final energy intensity but high primary energy intensity. In Lao PDR, the reason is its export of electricity from coal-fired power plants to neighbouring countries. Thus, primary energy intensity is crucial in evaluating the gross intensity in relation to the environment. In EAS17, the carbon intensity of primary supply is projected to decline by 8% in BAU, 37% in APS, and 78% in LCET in 2050 from the 2019 level (Figure 1.16). If the region can achieve LCET, the energy system of EAS17 will become cleaner as result of less emissions per unit of primary energy use.

Figure 1.16 Carbon Intensity of Primary Energy Supply



APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, t-C = tonnes of carbon, toe = tonnes of oil equivalent.

Source: Authors.

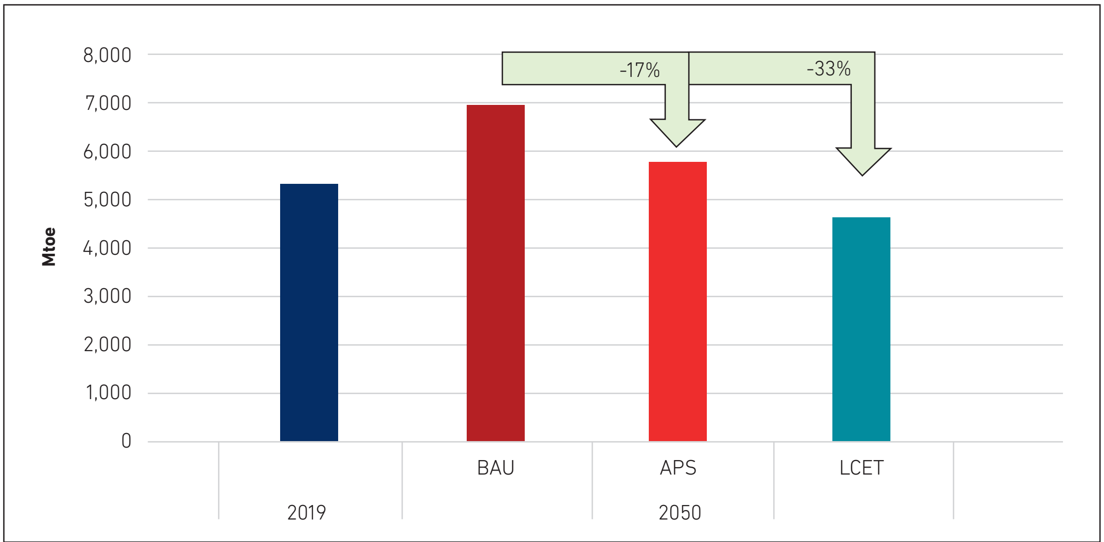
Per capita energy demand in BAU is projected to increase by 15% in 2050 compared with 2017. In APS and LCET, per capita energy demand is expected to decrease by 3.7% for APS and 20.8% for LCET in 2050 compared with 2019. The differences in per capita energy demand between BAU, APS, and LCET in 2019–2050 explain the fundamental change in terms of energy efficiency from BAU to APS to LCET. The decrease per se of per capita energy in 2050 compared with 2019 could be attributed to energy conservation as a result of energy saving and conservation awareness in EAS17, or could reflect the effective energy price that triggers demand response behaviour in EAS17. Because EAS17 comprises large economies with high per capita energy use, such as Australia, China, Japan, Korea, New Zealand, and the US, projected per capita energy demand is expected to decline as consumers reach a saturated level of energy consumption. However, if per capita energy demand for developing countries is projected, per capita energy demand is expected to rise, bringing about a more energy-intensive lifestyle as people are able to purchase vehicles, household appliances, and other energy-consuming devices as a result of greater disposable income.

4.2.2. Final Energy Consumption

TFEC in APS is projected to rise from 5,317.5 Mtoe in 2019 to 5,773.8 Mtoe. In 2050, comparing BAU and APS, the difference is 1,192 Mtoe or 17% lower in APS than in BAU. In LCET, TFEC is predicted to be about 2,321 Mtoe or 33.3%, which is lower than in BAU (Figure 1.17). TFEC in APS and LCET are expected to be lower than in BAU because of expected achievements of various energy efficiency plans and programmes, and the effective deployment of innovative technologies for the supply and demand sides.

Potential energy saving in TFEC of EAS17 (1,192 Mtoe in APS) in 2050 is almost triple ASEAN's TFEC in 2019 (447 Mtoe). In LCET, energy saving is expected to be 2,321 Mtoe or more than sixfold greater than ASEAN's TFEC in 2019. The achievement in energy saving in EAS17 is largely expected from the transport, industry, commercial, and residential sectors.

Figure 1.17 Total Final Energy Consumption, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition

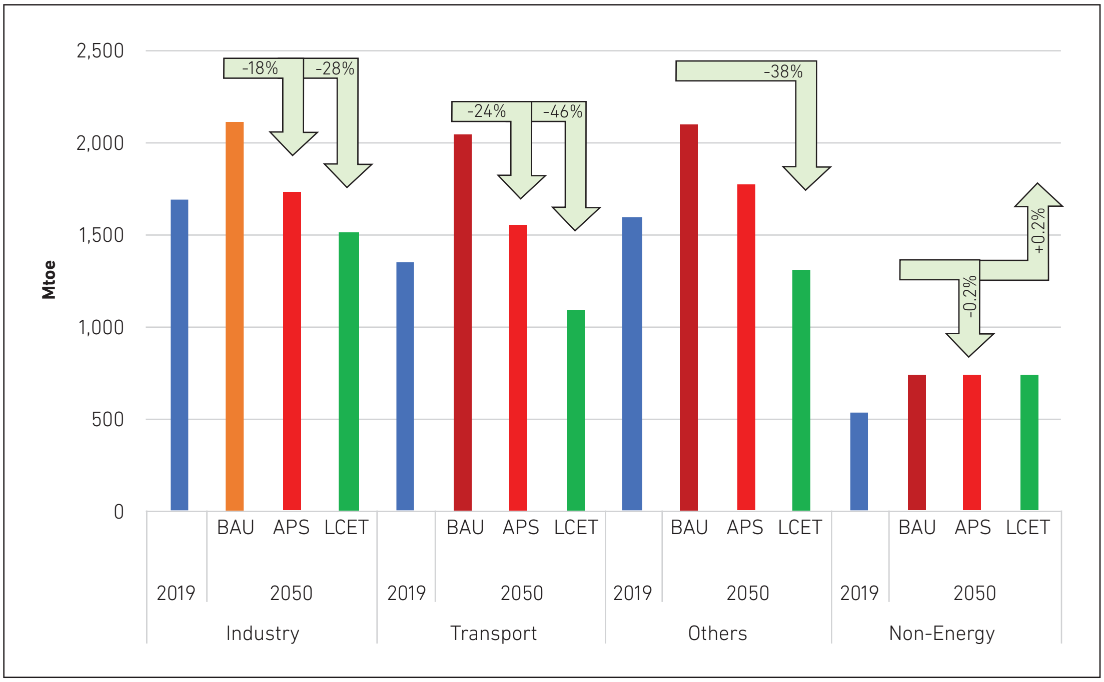


APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 1.18 shows the composition of final energy consumption by sector in BAU, APS, and LCET. TFEC in most sectors is significantly reduced in APS and LCET compared with BAU. In percentage terms, the reduction is largest in transport (24% in APS, 46% in LCET), followed by 'others' (16% in APS, 38% in LCET) and industry (18% in APS, 28% in LCET). Non-energy demand will slightly drop by 0.2% in APS compared with BAU, but will slightly increase by 0.2% in LCET compared with BAU. Hydrogen and ammonia fuel will play an important role in LCET as they are expected to be used in cogeneration with coal and natural gas.

Figure 1.18 Final Energy Consumption by Sector, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

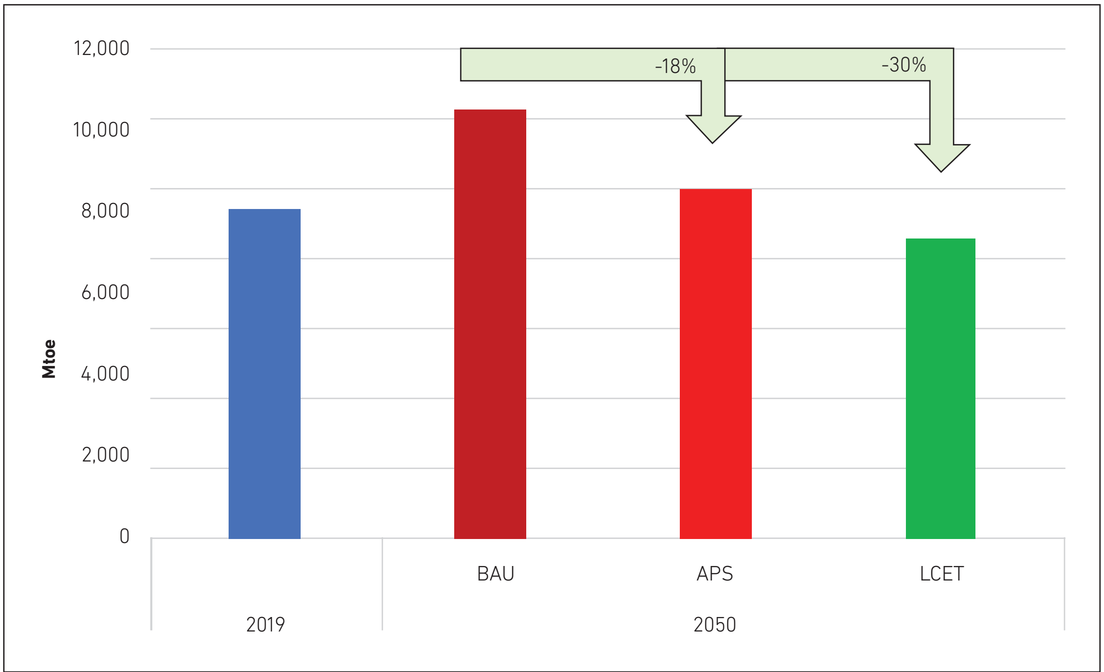
4.2.3. Primary Energy Supply

The large energy saving in LCET is due to technological innovation on the energy supply side, which is highly expected to produce more clean energy as a result of shifting from coal-fired power generation to more efficient gas-fired combined cycle, and the introduction of cogeneration of gas with hydrogen or coal with ammonia. LCET is expected to have a high share of renewables and clean technologies that will bring down emissions, as well.

Figure 1.19 shows TPES in BAU, APS, and LCET. It is projected to grow from 8,046 Mtoe in 2019 to 10,467 Mtoe in BAU, 8,558 Mtoe in APS in 2050, and 7,347 Mtoe in LCET in 2050. Total savings potential is the difference between BAU and APS, and BAU and LCET in 2050. Total savings potential in TPES is expected to be 1,909 Mtoe in APS and 3,120 Mtoe in LCET, representing an 18% and a 30% reduction from BAU to APS and from BAU to LCET, respectively, in 2050.

The energy savings potential in TPES is brought about by improvements in the transformation sector, particularly in power generation, and the final energy consumption sectors such as transport, industry, and residential and commercial, where efficiencies are expected. The large energy saving in LCET is due to technological innovation on the energy supply side. More clean energy is highly expected to be produced as a result of shifting from coal-fired power generation to more efficient gas-fired combined cycle, and the introduction of cogeneration of gas with hydrogen or coal with ammonia. LCET is expected to have a high share of renewables and clean technologies that will bring down emissions, as well.

Figure 1.19 Total Primary Energy Supply, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, Mtoe = million tonnes of oil equivalent.

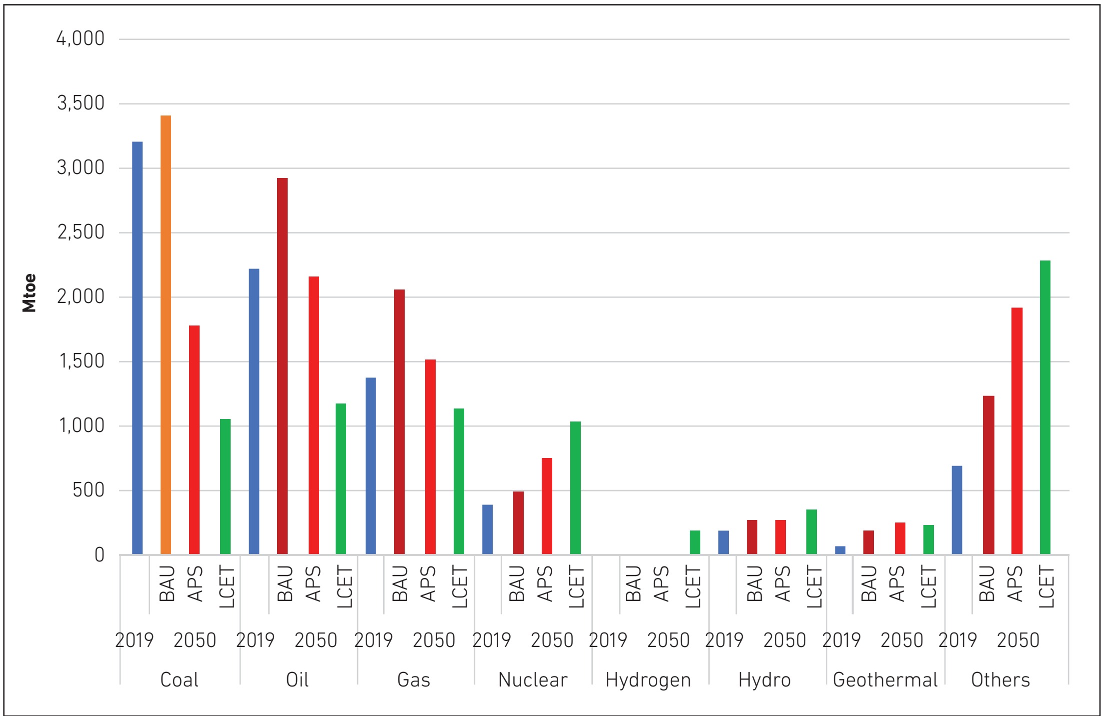
Source: Authors.

Figure 1.20 shows primary energy supply from all energy sources. New clean fuels, such as hydrogen and ammonia, are in the supply mix in LCET (Figure 1.20). Combined solar, wind, and biomass energy – 'others' – is projected to be 2,271 Mtoe, which is higher than the 2,047 Mtoe of natural gas supply in BAU (Figure 1.20).

In APS and LCET, growth in primary energy supply for fossil fuels is lower than in BAU. Growth rates in primary energy supply in APS and LCET are projected to be 0.2% and –0.3%, respectively, per year on average in 2019–2050. The rates are lower than in BAU, where the growth rate is projected to be 0.9%. In absolute terms, the largest reduction from BAU will be in coal demand, by 1,636 Mtoe or 48% in APS and by 2,364 Mtoe or 67% in LCET (Figure 1.21).

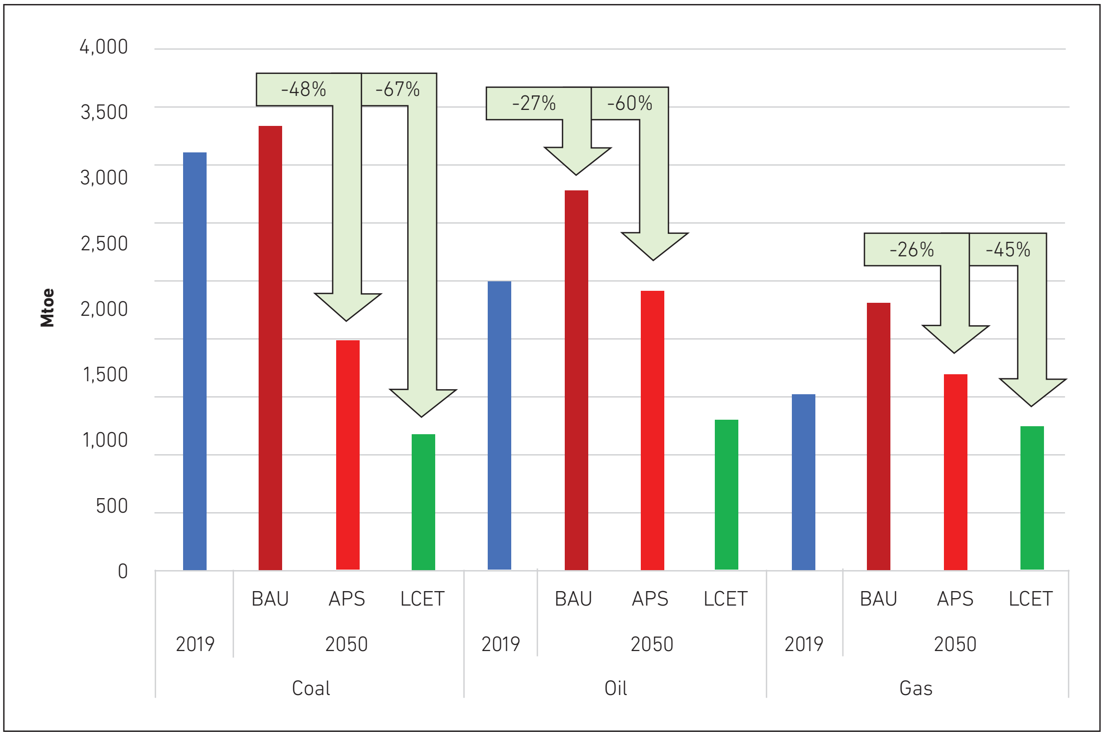
TPES of oil is expected to be lower than in BAU by 27% and 60% in APS and LCET, respectively. The large reduction of oil supply consumption from BAU to LCET is calculated, in real terms, to about 1,749 Mtoe. The reason is the large shift to electricity consumption for most sectors, especially transport, where electric vehicles are expected to be rolled out starting early 2040. The use of natural gas is expected to drop from BAU to about 26% and 45% in APS and LCET, respectively, by 2050 (Figure 1.21), even though it will remain an important fuel in 2050.

Figure 1.20 **Primary Energy Supply by All Energy Sources, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition**



APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, Mtoe = million tonnes of oil equivalent.
Source: Authors.

Figure 1.21 **Primary Energy Supply by Fossil Fuel Source, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition**



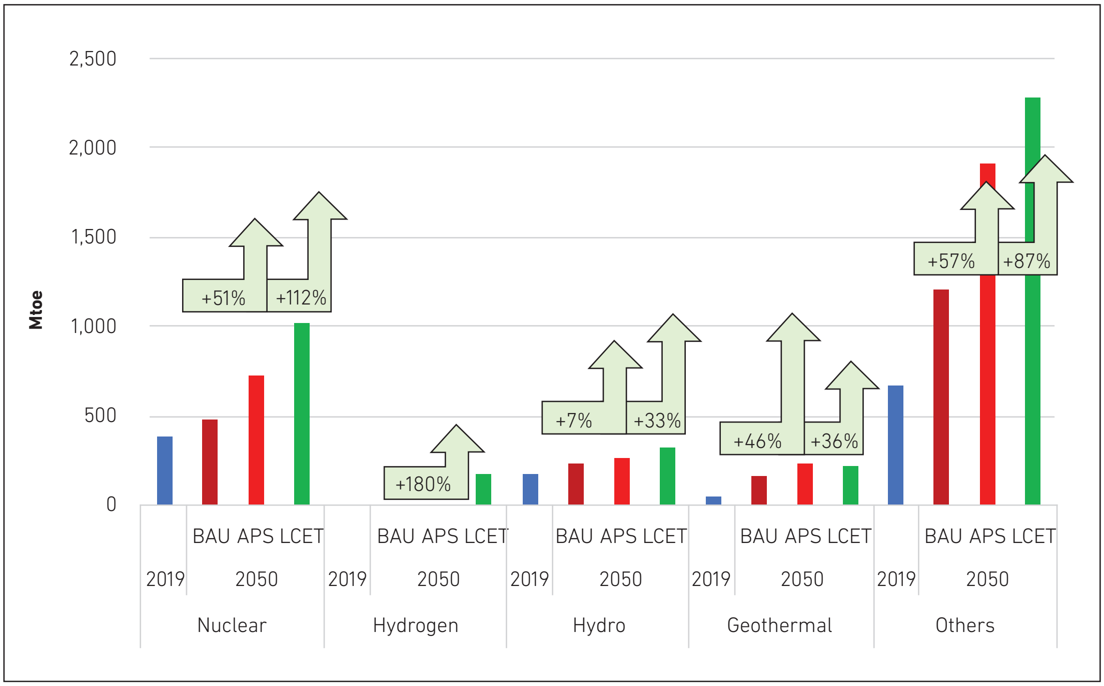
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

The introduction of renewables, such as nuclear energy, hydropower, geothermal energy, and 'others' (solar, wind, and biomass energy) is projected to increase significantly in APS and LCET (Figure 1.22). Nuclear energy is projected to increase from BAU by 51% and 112% in APS and LCET, respectively. Nuclear energy will become vital in the energy mix in East Asia. Some countries in ASEAN will keep nuclear energy as an energy option by 2050.

Hydropower has fully developed in some countries and is expected to develop in some countries where potentials are yet to be tapped. In LCET, hydropower is predicted to increase by 33% from BAU (Figure 1.22). Geothermal potential is expected to increase from BAU by 46% and 36% in APS and LCET, respectively. Geothermal potential is expected to increase greatly in APS and to slowly reduce in LCET because some geothermal fields will eventually be depleted. Amongst renewables, solar and wind energy make up the largest contribution in LCET. 'Others' (solar, wind, and biomass energy) will increase from BAU by 57% and 87% in ASP and LCET, respectively (Figure 1.22). In ASEAN, solar energy is abundant in all countries and clean energy will be a big game-changer in helping decarbonise ASEAN's energy system.

Figure 1.22 Primary Energy Supply by Clean Fuel and Renewable Sources, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET= low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Note: Hydrogen in the primary energy supply reflects imported hydrogen only and does not include domestic production for end-use. All domestic hydrogen production is secondary energy, and its feedstock, such as electricity or natural gas, has been accounted for in the transformation sector.

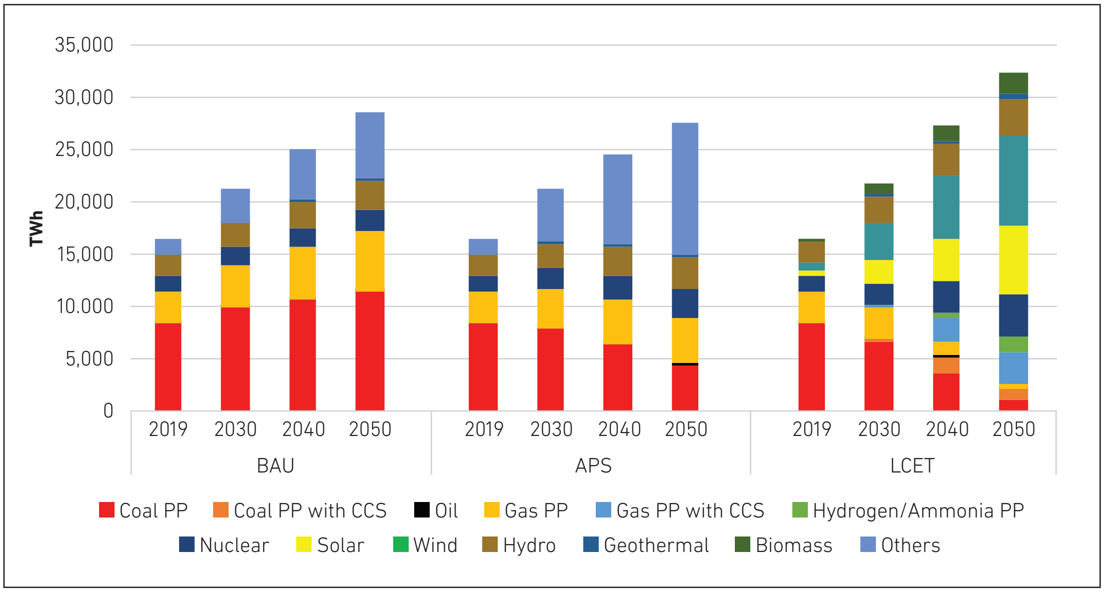
Source: Authors.

4.3. Power Generation, Business-as-Usual vs Alternative Policy vs Low-carbon Energy Transition Scenarios

In the power generation mix output, coal and natural gas are predicted to be dominant, contributing 11,268 TWh (39.5%) and 5,932 TWh (20.8%), respectively, in 2050 (Figure 1.23 and Figure 1.24). 'Others' comprise wind, solar, and biomass energy in BAU and APS. In LCET, 'others' are broken down into solar, wind, and biomass fuels. 'Others' generation output is predicted to change significantly from 6,380 TWh (22.4%) in BAU to 12,543 TWh (45.6%) in APS in 2050. In LCET, generation output from solar, wind, and biomass energy is expected to contribute about 6,752 TWh (21%) for solar energy, 8,298 TWh (25.8%) for wind energy, and 2003 TWh (6.2%) for biomass energy in the generation mix in 2050.

Hydrogen and ammonia power generation is expected to enter the generation mix by 2030, and its share will increase by 0.1% in 2030, 2% in 2040, and 4.8% in 2050 (Figure 1.24). Other clean energy, such as hydropower, geothermal, and nuclear, will play a significant role in decarbonising power generation in LCET, with shares of 11.6% for hydropower, 1% for geothermal energy, and 12.3% for nuclear energy.

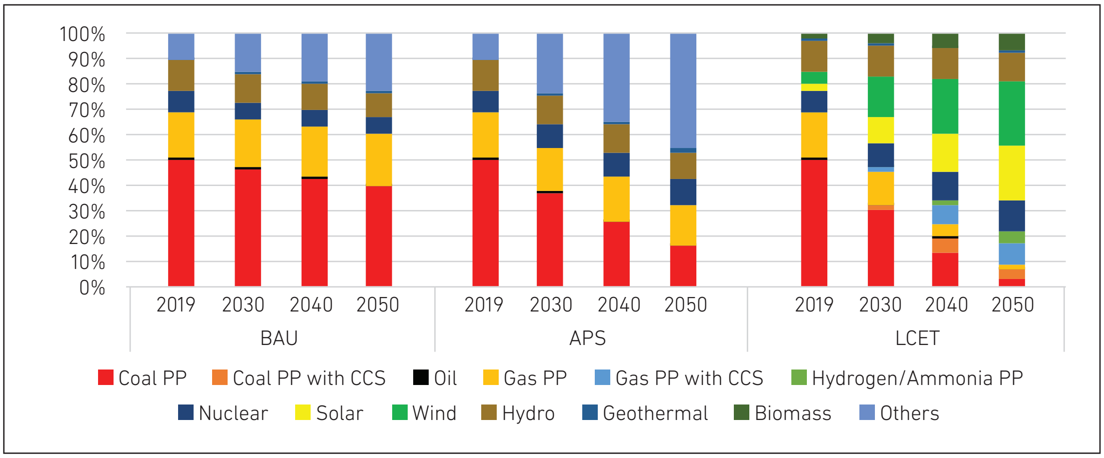
Figure 1.23 Power Generation, Business-as-Usual Scenario vs Alternative Policy Scenario vs Low-carbon Energy Transition (Terawatt-hours)



APS = alternative policy scenario, BAU = business as usual, CCS = carbon capture and storage, LCET= low carbon energy transition, PP= power plant, TWh = terawatt-hours.

Source: Authors.

Figure 1.24 Power Generation, Business-as-Usual Scenario, Alternative Policy Scenario, and Low-carbon Energy Transition (%)



APS = alternative policy scenario, BAU = business as usual, CCS = carbon capture and storage, LCET= low carbon energy transition, PP = power plant.

Source: Authors.

4.4. CO_2 Emissions from Energy Consumption

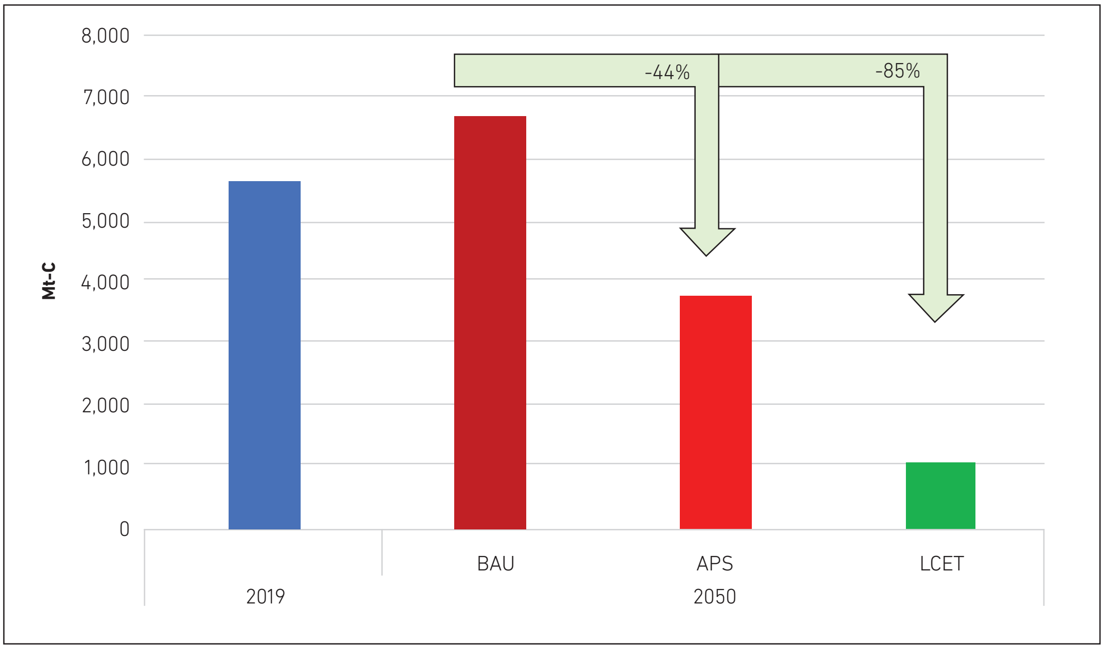
Consumption of fossil fuels such as coal, oil, and natural gas has discharged emissions largely into the atmosphere, which are the sole cause of temperature rise, causing global warming that is threatening the planet. The impacts of global warming have already been seen in sudden changes of temperatures; seawater rise; and natural catastrophic events such as severe storms, rains, landslides, and many others, which take lives and cause damage to habitats and infrastructure. During the Conference of the Parties 21 (COP 21) in December 2015, global leaders committed to reduce GHG emissions as outlined in the Paris Agreement, the first-ever universal and binding global climate deal, which was adopted by 195 countries. The agreement presents a global action plan aimed at limiting global warming to well below 2°C compared with pre-industrial levels by mid-century (2050s). The agreement pledges to further reduce emissions preferably to 1.5°C by the 2050s. The Paris Agreement represents a crucial step in bridging the gap between current policies and achieving climate neutrality before the end of the century.

LCET aims to introduce clean fuels and technologies and renewables into the entire energy system to reduce emissions in the EAS region. Figure 1.25 shows CO_2 emissions in BAU, APS, and LCET. CO_2 emissions from energy consumption in BAU are projected to drop from 6,709 million tonnes of carbon (Mt-C) in 2019 to 3,760 Mt-C in 2050 in APS, representing about 44% reduction (Figure 1.25). Emissions are expected to further drop by about 85% largely from BAU (6,709 Mt-C) to LCET (1,026 Mt-C) due to the significant improvement in energy efficiency, introduction of large share of renewables and clean fuels, and innovative technologies.

Negative emission growth is expected from BAU to APS to LCET. The average annual emission growth rate in 2019–2050 for APS is –2.1% for coal, –0.3 for oil, and –0.4% for natural gas. For combined coal, oil, and natural gas, the average annual growth rate in 2019–2050 is expected to be –1.3%. The annual emission average growth rate in LCET is expected to be –6.2% for coal, –3.9% for oil, and –5.5% for natural gas. For combined fossil fuels, the average annual growth rate is expected to be –5.3% in 2019–2050.

The CO_2 emissions in APS and LCET are lower than the 2019 emission level. In real terms, emissions in 2050 are 3,760 Mt-C in APS and 1,026 Mt-C in LCET, much lower than the 2019 emission level (5,606 Mt-C). LCET's trend of reducing emissions is partly in line with scientific evidence that such reductions are necessary to prevent severe impacts from climate change. The Intergovernmental Panel on Climate Change (2015) analysis indicates that global CO_2 emissions must fall by 45% from 2010 levels by 2030 to limit the global temperature increase to 2°C compared with pre-industrial levels. The Paris Agreement commits to 'pursuing efforts' to limit the temperature increase to 1.5°C, which, scientists suggest, will require achieving zero emission in 2030–2050. However, EAS members, including ASEAN Member States, must balance mitigating climate change with ensuring energy access and affordability. Innovative technologies such as clean coal technology, co-combustion of coal and natural gas with ammonia and hydrogen, and CCUS will play a central role in carbon sink worldwide. Some developing countries in ASEAN have significant potential for negative carbon sinks.

Figure 1.25 Total CO_2 Emissions, Business-as-Usual Scenario, Alternative Policy Scenario, and Low-carbon Energy Transition



BAU = business as usual, APS = alternative policy scenario, LCET= low carbon energy transition, Mt-C = million tonnes of carbon equivalent.

Source: Authors.

5. Conclusions and Recommendations

Despite the COVID-19 pandemic's significant impact on EAS17 and world economies from 2020 to late 2022, the ASEAN region and East Asia are expected to rebound starting in 2023. Sustained economic growth in ASEAN and all EAS17 countries is crucial for improving well-being. Economic growth is expected to be positive from 2023 onward, making the post-pandemic era an age of growth, leading to increased energy consumption. Decades of sustained economic growth, particularly in ASEAN and India, have increased per capita incomes, significantly reduced poverty rates, and improved living standards of hundreds of millions.

Two key drivers – population and economic growth in EAS – contribute to the projected increase in primary energy supply in 2019–2050 in BAU, APS, and LCET. TPES was 8,036 Mtoe in 2019 and is predicted to increase by 2050 to 10,457 Mtoe in BAU, 8,497 Mtoe in APS, and 4,795 Mtoe in LCE. The average annual growth rate of TPES is 0.9% in BAU, 0.2% in APS, and 0.1% in LCET iin 2019–2050.

Energy intensity is expected to drop from 168 toe/US$ million in 2017 to 66 toe/US$ million in 2050 for APS and 79 toe/US$ million in 2050 for LCET, representing 60% and 53% energy intensity reduction, respectively, in 2019–2050. Emission intensity is expected to drop from 0.70 t-C)/toe in 2019 to 0.44 t-C/toe, and to 0.16 in 2050, representing 37% and 77% emission intensity reduction in APS and LCET, respectively, in 2019–2050. The economy will be more efficient and a clean energy system will exist, especially in LCET.

As economic growth continues, demand for electricity will rise and vehicle ownership increase. However, unless low-emission technologies are used, reliance on fossil fuels to meet increased energy demand could lead to higher GHG emissions and climate change challenges. Even if fossil fuel resources are sufficient, the importation of oil from other regions may not be secure or affordable. Consequently, the ASEAN region is diversifying fuel supply sources, strengthening strategic stockpiling, and enhancing energy connectivity.

The Comprehensive Asia Development Plan 3.0 (CADP 3.0) emphasises that sustainability is not just a long-term concern but also an immediate response to urgent problems. Speedy energy infrastructure development, such as transmission and distribution networks and the Trans-ASEAN Gas Pipeline, including the LNG supply chain, and stable economic and demographic expansion in ASEAN will boost ASEAN and EAS energy demand. Even with higher crude oil prices, the region is expected to rely on coal, oil, and gas until 2050 under BAU. ASEAN and many developing countries need to explore a variety of options and use all available fuels and technologies to pursue their carbon neutrality goals. The outlook includes options in APS and LCET, where key innovative technologies, clean fuels, and renewables will be introduced at high levels by 2050.

Below are the key findings suggested by the results of the outlook in BAU, APS, and LCET.

5.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and CO_2 emissions in BAU, APS, and LCET, the working group identified several key findings:

(i) The TFEC of APS and LCET are expected to be lower than that of BAU due to expected achievement of various energy efficiency plans and programmes, and the effective deployment of innovative technologies for the supply and demand sides. TFEC in most sectors is significantly lower in APS and LCET than in BAU. In percentage terms, the reduction is largest in transport (24% in APS, 46% in LCET), followed by 'others' (16% in APS, 38% in LCET), and industry (18% in APS, 28% in LCET).

(ii) Total power generation is projected to grow at 1.8% per year on average, from 2019 (equivalent to 16,534 TWh) to 2050 (equivalent to 28,515 TWh) in BAU. In the power generation mix output of BAU, coal and natural gas are predicted to be dominant, contributing 11,268 TWh (39.5%) and 5,932 TWh (20.8%), respectively, in 2050. 'Others' generation output is predicted to change significantly from BAU (6,380 TWh or 22.4%) to 12,543 TWh (45.6%) in APS in 2050. In LCET, generation output from solar, wind, and biomass energy is expected to contribute about 6,752 TWh (21%), 8,298 TWh (25.8%), and 2003 TWh (6.2%), respectively, into the generation mix in 2050. Hydrogen and ammonia power generation is expected to enter the generation mix by 2030; its share will increase by 0.1% in 2030, 2% in 2040, and 4.8% in 2050 (Figure, 1-24). Other clean energy such as hydropower, geothermal energy, and nuclear energy play a significant role in decarbonising power generation in LCET, with 11.6%, 1%, and 12.3%, respectively.

(iii) Potential energy saving in TFEC of EAS17 (1,192 Mtoe in APS) in 2050 is almost triple ASEAN's TFEC in 2019 (447 Mtoe). In LCET, energy saving and technological achievement is expected to save energy (2,321 Mtoe), more than sixfold greater than ASEAN's TFEC in 2019. The achievement in energy saving in EAS17 is largely expected from the transport, industrial, commercial, and residential sectors. The total savings potential in TPES is expected to be 1,909 Mtoe in APS and 3,120 Mtoe in LCET, representing 18% and 30% reduction from BAU, respectively, in 2050. In LCET, efficiency and technological innovations are not the only factors contributing to savings. A significant increase is expected in clean energy, such as shifting from coal-fired power generation to more efficient gas-fired combined cycle, as well as the introduction of cogeneration of gas with hydrogen or coal with ammonia. LCET is projected to have a substantial share of renewables and clean technologies, further reducing emissions.

(iv) TPES of oil is expected to be lower by 27% in BAU and 60% in APS and LCET. The large reduction in oil supply consumption from BAU to LCET is calculated, in real terms, at about 1,749 Mtoe. The reason is the large shift to electricity consumption in most sectors, especially transport, where electric vehicles are expected to be rolled out by the early 2040s. Although the use of natural gas is expected to decline to about 26% in BAU and 45% in APS and LCET by 2050 (Figure 1.21), it will continue to be an important fuel source.

(v) Projected final energy intensity (toe/million 2010 US dollars) in EAS17 is expected to decline significantly by 51.4% in BAU, 59.5% in APS, and 67.6% in LCET in 2050 compared with 2019. Final energy intensity is an indicator of the economy's efficiency in using final energy consumption to produce a unit of GDP without considering efficiency in the transformation sector. In general, final energy intensity is remarkably improved, pointing to gradual enhancement in energy efficiency across all final energy sectors, such as industry, transport, commercial, and residential sectors.

(vi) The CO_2 emissions from energy consumption in BAU are projected to drop from 6,709 Mt-C in 2050 to 3,760 Mt-C in 2050 in APS, representing about 44% reduction from BAU to APS. The emissions are expected to further drop, largely from BAU (6,709 Mt-C) to LCET (1,026 Mt-C), representing about 85%, due to significant improvement in energy efficiency, introduction of a large share of renewables and clean fuels, and innovative technologies.

5.2. Policy Implications

Based on the above findings, the working group identified five major categories of policy implications aimed at enhancing action plans in specific sectors, preparing appropriate energy efficiency policies, shifting from fossil to non-fossil energy, rationalising energy pricing mechanisms, and improving energy consumption statistics. Appropriate policies will vary between countries based on their unique circumstances, policy objectives, and market structures, and not all members may agree to all recommendations. The following are the implications outlined by the working group:

(i) Energy efficiency action plans in final consumption sectors. The industry, transport, and commercial sectors will be major sources of energy savings. Several EEC action plans will need to be introduced, implemented, and accelerated in EAS17. The policies are listed by area and sector:

- Industry will need to become energy efficient. Energy service companies (ESCOs) will play a crucial role in energy savings. Some ASEAN countries will need to accelerate the introduction of ESCOs through a national energy policy that will make it compulsory for industries with large energy consumption to have energy managers and to conduct energy auditing.
- Transport greatly contributes to the growth of final energy consumption, with oil being the primary fuel source for passenger light-duty vehicles, buses, and trucks in LCET. Although a major share of passenger vehicles are expected to shift to electrification by 2050 in LCET, long-distance alternative vehicle technologies, such as battery electric vehicles and fuel cell vehicles, remain expensive, which means that oil consumption will continue until 2050. The use of biofuels in internal combustion engines and hybrid vehicles is expected to increase. The infrastructure for electric vehicles will need to be accelerated to accommodate the fast-growing market for them worldwide.
- Known as hidden fuel, energy efficiency translates as energy resources to the region as energy will be available for other economic activities and for more people. EAS17 countries are encouraged to review their regulations or to formulate effective policy on energy efficiency to define the legal and organisational basis for energy efficiency activities and create conditions to reduce energy consumption in all sectors. The policy is to promote energy efficiency as part of a country's sustainable development policy by (i) applying a system of activities and measures to improve energy efficiency, especially for end-use of energy; (ii) introducing schemes of obligations for energy savings; (iii) developing a market of energy efficiency services and encouraging provision of energy efficiency services; and (iv) introducing financial mechanisms and schemes to attain the national objective of energy efficiency. Amongst the known policies are (i) green building codes for energy-efficient buildings, (ii) standards and labelling systems, (iii) demand management systems for households and buildings that can be managed by energy managers and energy service companies, and (iv) improved thermal efficiency in power generation by constructing or replacing facilities with new and more efficient generation technologies.

(ii) Renewable energy policies. Low-carbon fuels must be increased and can be achieved by raising the share of renewables and clean fuels, such as hydrogen and nuclear energy, in the energy mix of each country. Several policies and actions will need to be considered:

- Setting targets and sharing renewables such as wind, solar, and biomass energy in the energy mix. Supportive renewable energy policies such as feed-in-tariff, renewable portfolio standard, and net metering are suggested based on the situation and evolution of the cost perspective of the renewables and clean technologies. Other supportive frameworks are needed, such as international financing of the Clean Development Mechanism (CDM)[6] and Joint Credit Mechanism (JDM)[7] for renewables and energy efficiency.
- The intermittent nature of renewable energy sources poses significant challenges to integrating renewable energy generation with existing electricity grids. Electricity storage technologies, combined with solar and wind energy, and on-site hydrogen production for curtailed renewable electricity will be highly important, although the combination cost is still high and needs the right policy and framework to drive down the cost.

[6] The CDM allows emission-reduction projects in developing countries to earn certified emission reduction credits, each equivalent to 1 tonne of CO_2.

[7] The JDM is a project-based bilateral offset crediting mechanism initiated by the Government of Japan to facilitate the diffusion of low-carbon technologies.

(iii) Power connectivity and smart grid.

- An ASEAN power pool, with proper institutions guided by regional electricity market rules and procedures, will need to be established and operated. Once up and running, it can avoid the cost of building new generation plants, more efficiently use the region's energy resources, help utilities companies balance their excess supply and demand, improve access to energy services, reduce costs of developing energy infrastructure, accelerate the development of renewable power generation capacity and integrate it into the regional grid, reduce the need for investment in power reserves to meet peak demand, and attract additional investment to the region's interconnection by signalling a price to catalyse investors. Geographical limitations, however, hinder the creation of an ASEAN power pool, making it a distant possibility. But the Mekong sub-region (Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam) could be the first potential physical power connectivity and power pool in ASEAN. Connecting the Mekong sub-region to Malaysia and Singapore is the most feasible option to explore.
- To facilitate the future power market, the electricity sector will require policy reforms, particularly deregulation of national rules and procedures to harmonise with the regional power pool's rules and procedures. Unbundling ownership in electricity market segments, non-discriminatory third-party access to transmission and distribution networks, and gradual removal of subsidies in fossil fuel–based power generation will ensure the pre-conditions for market competition and level the playing field for new technologies and renewables. To attract foreign investment to renewables and clean technologies, fiscal policy incentives such as tax holidays and reduced market barriers and regulatory burdens are essential. Other policies, such as a rebated payment system through government subsidies and guarantees, should be implemented to reduce upfront investment costs, making such investments feasible and low risk.
- The ASEAN region and East Asia can greatly benefit from investing in the smart grid system. The grid can protect, monitor, and ensure the most efficient use of energy by having an integrated technology system from the demand side and the generation side. The grid is a complex arrangement of infrastructure with functions that depend on many interconnected elements. The grid's first layer is the physical component, which covers generation, transmission, and the distribution network as well as energy storage facilities. The second layer is telecommunications, which monitor, protect, and control the grid, including wide, field, home, and local area networks. The third layer is data management, which ensures proper data mining and utilisation to facilitate grid applications. The fourth layer consists of tools and software technologies that use and process collected information from the grid to monitor, protect, and control the hard infrastructure layer, and reinforce the grid to allow integration of renewable energy.

(iv) Technological innovations. Environmental technologies will need to be considered to curb increasing CO_2 emissions:

- The development of CCUS technology will be highly important in controlling GHG emissions. With strong government leadership, continued research and development, including the CCUS value chain, will ensure the economic viability of deploying carbon capture and storage technology.
- Through electrolysis using renewable energy, hydrogen can be extracted from fossil fuels such as low-ranked coal and natural gas. However, it is still more expensive than existing fuels. Hydrogen fuel development is promising and can be commercialised. Continued research and development in fuel cells and hydrogen power generation will be important for future clean fuel use.
- The ASEAN region will need to accelerate technological cooperation and technology diffusion, including the hydrogen value chain.

(v) Energy supply security policies. Based on the Organisation for Economic Co-operation and Development's practice of strengthening energy security by increasing the oil stockpiling requirement (IEA, 2020), several measures are identified:
   - Promote regional energy connectivity, such as the Trans-ASEAN Gas Pipeline, using a virtual pipeline (LNG) including ship and road transport.
   - Diversify sources of import.
   - Strengthen energy infrastructure, including construction of LNG-receiving terminals and regasification plants.
   - Look into the strategic reserve or stockpiling requirement on public and private bases.

(vi) Appropriate transition financing technologies. ERIA's (2022) The Technology List and Perspectives for Transition Finance in Asia seeks to support smooth energy transitions in developing Asia with realistic approaches. The approaches can help many countries move to carbon neutrality whilst considering energy security, affordability, accessibility, and environmental protection.
   - Financial institutions might find the list useful as a reference point to assess potential transition technologies submitted by project developers. The list will continue to serve financial institutions until stakeholders and regulators (such as ASEAN and governments of member states) are prepared and have established their technology road maps or taxonomies, which will guide energy investment to achieve net-zero emission.
   - Although the first version of the study's list does not cover all transition technologies, it at least covers major potential transition technologies in the power sector and its upstream, which together account for more than 50% of Asia's CO_2 emissions.
   - The list provides key information about each transition technology, including six key elements, such as cost and reliability of technology, and additional considerations, such as social benefits and potential emission reductions. ASEAN countries are recommended to use the list to support their energy infrastructure financing in the medium term and transition to carbon neutrality by 2050.

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CHAPTER 2

Australia Country Report

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1. Background

Australia is the largest country in Oceania and the sixth largest in the world by total area (about 7.7 million square kilometres), with diverse geography and climate. It has six states and two territories. Its population grew at an average annual rate of 1.4%, from 17.1 million in 1990 to 25.4 million in 2019.[1]

Gross domestic product (GDP) increased at an average annual rate of 3.0%, from US$569 billion in 1990 to US$1.35 trillion in 2019 (constant 2015 US$ values), and per capita income increased from US$33,330 to US$53,080. Economic activities are focused on the eastern and south-eastern seaboard, where most of the population live. In 2019, three states generated 74% of Australia's GDP: New South Wales (with 32% of the national population), Victoria (26%), and Queensland (20%) (ABS, 2021a, 2021b).

1.1. Energy Situation

Australia has abundant, high-quality, and diverse non-renewable and renewable energy resources. Its non-renewable energy resources include fossil fuels (coal, gas, and oil) and nuclear energy fuels (uranium and, potentially, thorium). The country had 1.23 million tonnes of economically demonstrated resources of uranium, nearly one-third of the world's uranium resources, as of the end of 2020. It has a major share of the world's thorium, which could be an alternative to uranium as a nuclear fuel. It has 74.147 million tonnes or 10% of the world's recoverable black coal and 74,039 million tonnes or 23% of the world's brown coal (Senior et al., 2022). The substantial conventional and unconventional gas resources of Australia account for almost 1.3% of the world's gas resources, and it has a small share (0.1%) of the world's crude oil resources (BP, 2022). The amount of recoverable resources is expected to grow with further exploration, and to last for many more decades even if production increases.

Australia has large, widely distributed wind, solar, geothermal, hydroelectricity, ocean energy, and bioenergy resources. Wind energy technology is mature, and its uptake is growing fast. Generation capacity of solar electricity is increasing rapidly because of fast-decreasing solar technology costs. Australia has the highest solar radiation per square metre in the world. No substantial expansion of traditional hydropower will likely occur because of the dry climate and low water run-off over most of the country. Pumped hydro for electricity storage is being considered for existing hydropower installations and new sites.

Energy resources play a significant role in the country's economic prosperity. Coal and gas resources support not only domestic consumption but also significant export earnings. In 2019, Australia was the world's eighth-largest energy producer (444.8 million tonnes of oil equivalent [Mtoe]), accounting for 3.0% of global primary energy supply. It was the world's 21st-largest energy consumer, accounting for 0.9% (128.7 Mtoe) of world primary energy supply.

[1] Unless otherwise cited, all data in the report is 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.

Australia's primary energy supply is largely based on fossil fuels. In 2019, coal contributed about 32% of its primary energy supply; oil, 34%; and natural gas, 27%. Renewables contributed the remaining 7%, consisting of hydropower (1%), solar and wind energy (2%), and biomass energy and biofuels (4%).

Australia plays a prominent role in meeting increasing energy demand not only in Asia and the Pacific but also in the rest of the world. In 2019, it was the world's fourth-largest energy exporter, exporting 80% of its energy production, consisting largely of coal and liquefied natural gas. It is the world's largest exporter of metallurgical coal, the second-largest exporter of thermal coal, and a large exporter of uranium. With limited crude oil resources, it is a net importer of crude oil and petroleum products. It is increasingly reliant on imported transport fuels with the closure of two refineries in 2021.

Australia's gross electricity generation increased at an average annual rate of 1.9%, from 154 terawatt-hours (TWh) in 1990 to 264 TWh in 2019. In 2019, coal accounted for 59% of total electricity generation, followed by natural gas, 20%; hydropower, 6%; oil, 2%; and 'others' (non-hydro renewables), 14%. Coal still dominates the electricity generation mix, although its share fell from 79% in 1990 to 59% in 2019. The share of natural gas and non-hydro renewables in the generation mix increased significantly over the period.

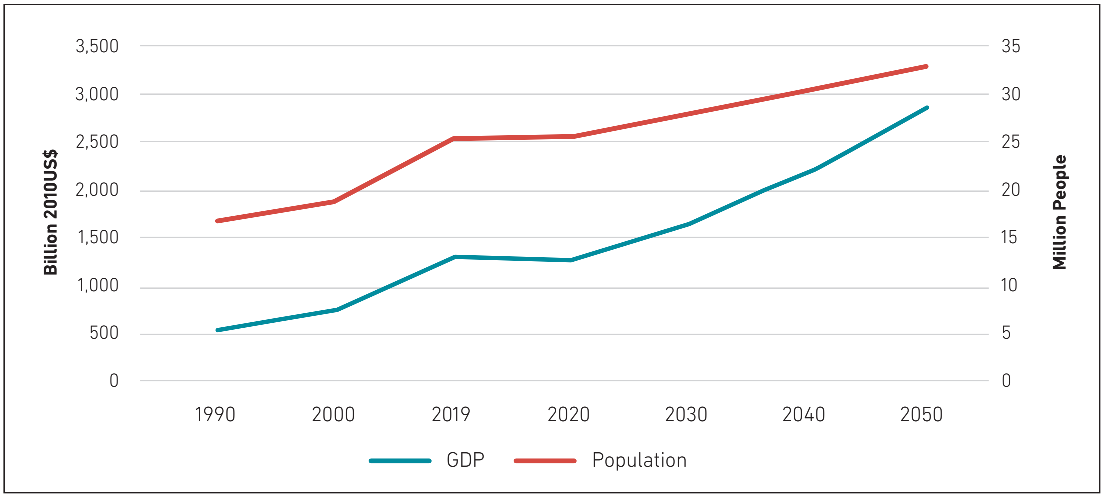
The coronavirus disease (COVID-19) pandemic and the measures taken to control its spread have had a notable impact on patterns of daily life and economic activity. In 2020, Australia went into its first recession in almost 30 years although its GDP contracted less than many other developed countries'. The pandemic impacted energy use and supply.

2. Modelling Assumptions

The study analyses long-term energy demand and supply by comparing the results from three scenario models: business as usual (BAU), alternative policy scenario (APS), and low carbon energy transition (LCET). The scenarios were developed before Australia's net-zero emission commitment.

All three scenarios apply the same GDP and population assumptions. Australia's population growth is driven primarily by its migration programme. The COVID-19 pandemic slowed the programme, impacting GDP growth. Australia's GDP is assumed to grow at an average annual rate of 2.5% over the outlook period (2019–2050), compared with average annual growth of 3.0% in 1990–2019. The population is assumed to grow at an average annual rate of 0.9% in 2019–2050, which is marginally slower than the average annual growth rate of about 1.4% in 1990–2019 (Figure 2.1).

Figure 2.1 Australia – Gross Domestic Product and Population (1990–2050)



GDP = gross domestic product.

Source: Authors.

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.

APS applies the same GDP and population assumptions as BAU. APS assumes improved efficiency of final energy consumption in end-use sectors. It will see more efficient thermal power generation and higher contribution of renewable energy to total supply with no nuclear power plants. The measures' combined effects are assumed to provide maximum energy saving over the projection period. Energy saving in industry is assumed to 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 are assumed to further save 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 applies the same GDP and population assumptions as BAU. LCET will see a further increase in thermal efficiency of power generation and greater contribution of renewable energy than in APS. LCET has no nuclear power plants and 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 comparing APS 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_2) emission reduction. LCET results provide a basis for exploring carbon neutrality pathways for the energy sector by 2050.

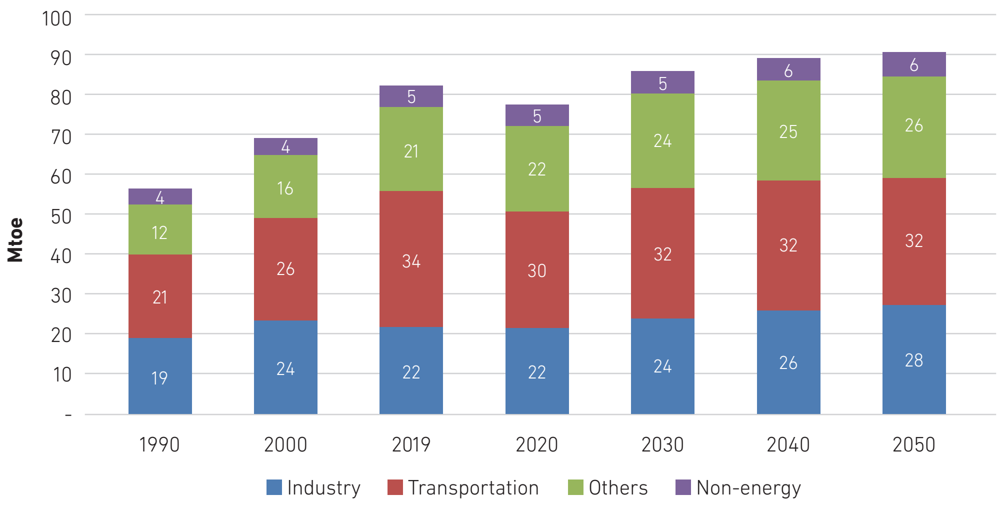
3.Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final Energy Consumption

In BAU, total final energy consumption is projected to increase from 82.3 Mtoe in 2019 to 90.8 Mtoe in 2050, about 10.2% more than in the projection period and an average annual rate of increase at 0.3%. The strongest growth is projected in industry, increasing at 0.7% per year in 2019–2050. In BAU, transport is the only sector where energy consumption is projected to decline over the projection period (0.2% per year), although it saw relatively strong growth (1.6% per year) in 1990–2019. 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 others (e.g. residential and service sectors) is anticipated to increase at 0.6% per year in 2019–2050 (Figure 2.2).

Figure 2.2 **Australia – Final Energy Consumption by Sector, Business as Usual (1990–2050)**

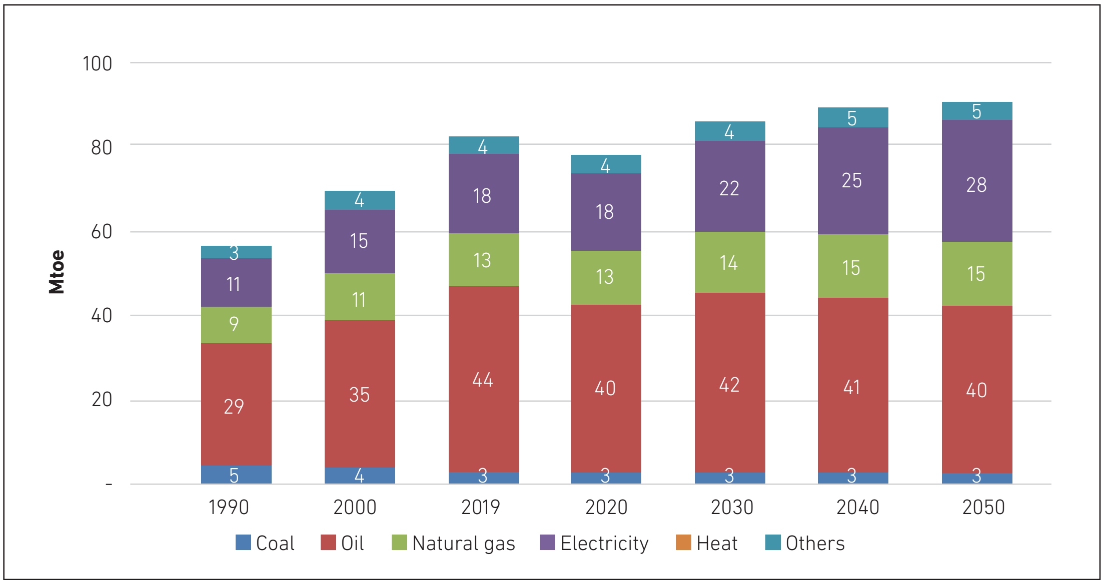


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Electricity consumption is projected to grow fastest at an average rate of 1.4% per year in 2019–2050. Natural gas consumption will increase at the second-highest rate of 0.6% per year. Petroleum product consumption is projected to increase at 0.6% per year during 2020 and 2030, but will decline after, with an average rate of 0.3% per year. Coal consumption will decline at an average rate of 0.4% per year in 2019–2050 (Figure 2.3).

Figure 2.3 Australia – Final Energy Consumption by Fuel Type, Business as Usual (1990–2050)



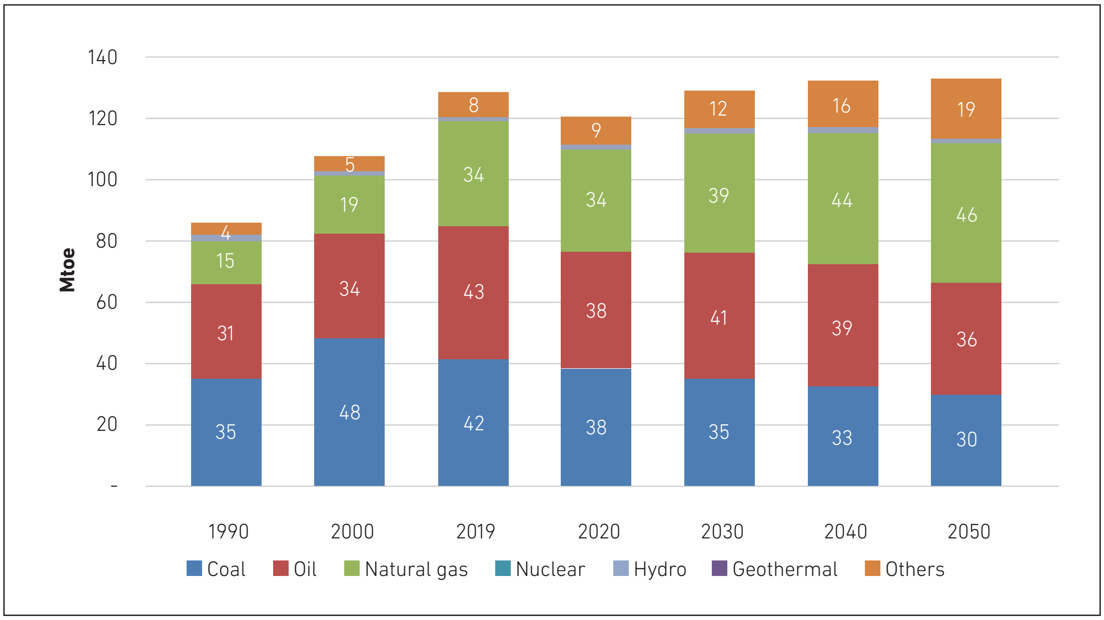
Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.1.2. Primary Energy Supply

Primary energy supply is projected to increase from 128.7 Mtoe in 2019 to 133.1 Mtoe in 2050 at an average annual rate of 0.1%, with coal consumption expected to decline at an annual average rate of 1.1% and oil consumption at 0.6%. Natural gas supply will increase at 1.0% per year in 2019–2050, where its share in the primary energy mix is expected to increase from 26.6% in 2019 to 34.5% in 2050. The overall share of fossil fuels in primary energy supply will decline from 92.6% in 2019 to 84.3% in 2050. 'Others' (including non-hydro renewables) are projected to increase by 2.8% a year over the projection period. The share of 'others' is expected to increase from 6.3% in 2019 to 14.6% in 2050, with the biggest contribution coming from solar and wind energy, followed by biofuels and biomass. Solar, wind, and ocean energy together are expected to grow at an average annual rate of 4.3% in 2019–2050 (Figure 2.4).

Figure 2.4 Australia – Primary Energy Supply by Fuel Type, Business as Usual (1990–2050)



Mtoe = million tonnes of oil equivalent.

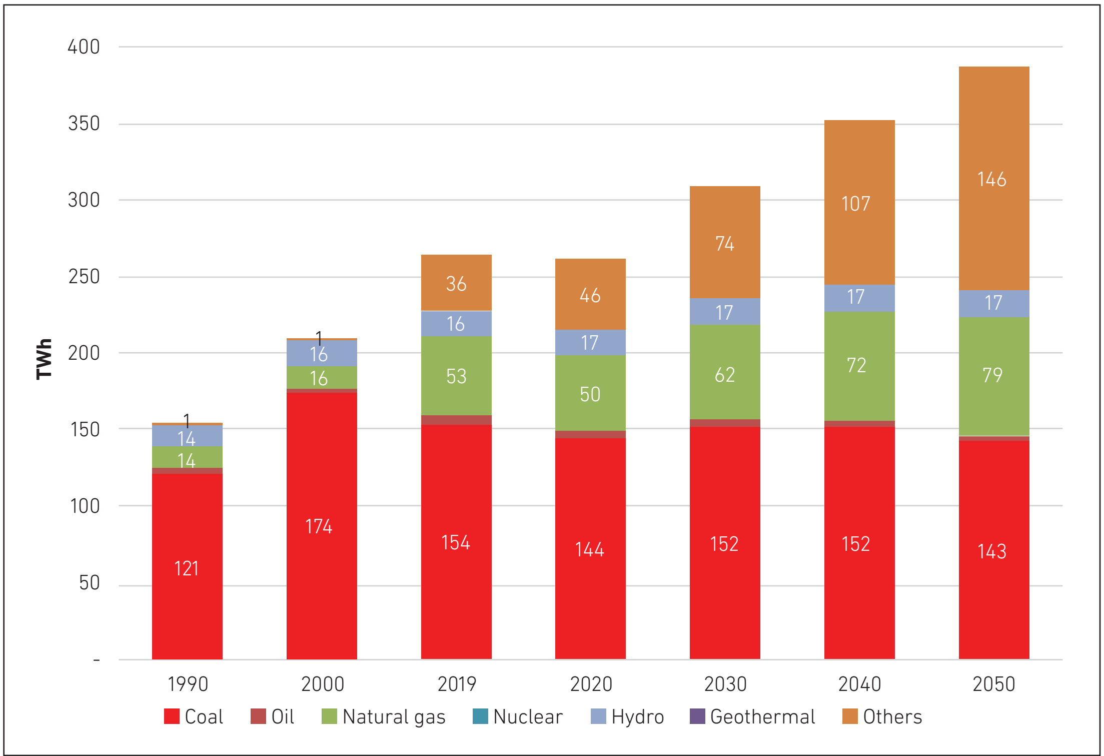
Source: Authors.

3.1.3. Power Generation

Electricity generation is projected to increase from 263.7 TWh in 2019 to 388.0 TWh in 2050 at an average rate of 1.3% per year. The share of coal in the power generation mix is projected to fall from 58.5% in 2019 to 36.9% in 2050. 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 1.9% in 2019 to 0.7% in 2050. In contrast, the share of natural gas in the generation mix will remain flat, with a slight increase from 20.0% in 2019 to 20.3% in 2050, and natural gas use in electricity generation is projected to grow at an average rate of 1.3% per year over the period.

Hydroelectricity's share in the power generation mix is expected to decline slightly from 5.9% in 2019 to 4.4% by 2050. Electricity generation from others (non-hydro renewables) is expected to grow faster, at an average rate of 4.6% per year in 2019–2050. 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 2.5 and Figure 2.6).

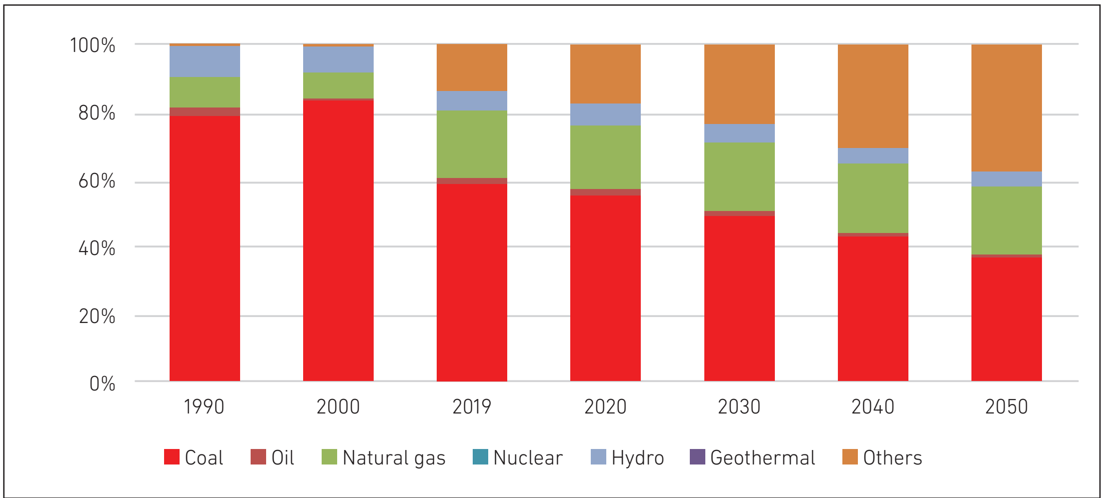
Figure 2.5 Australia – Power Generation, Business as Usual (1990–2050)



TWh = terawatt-hour.

Source: Authors.

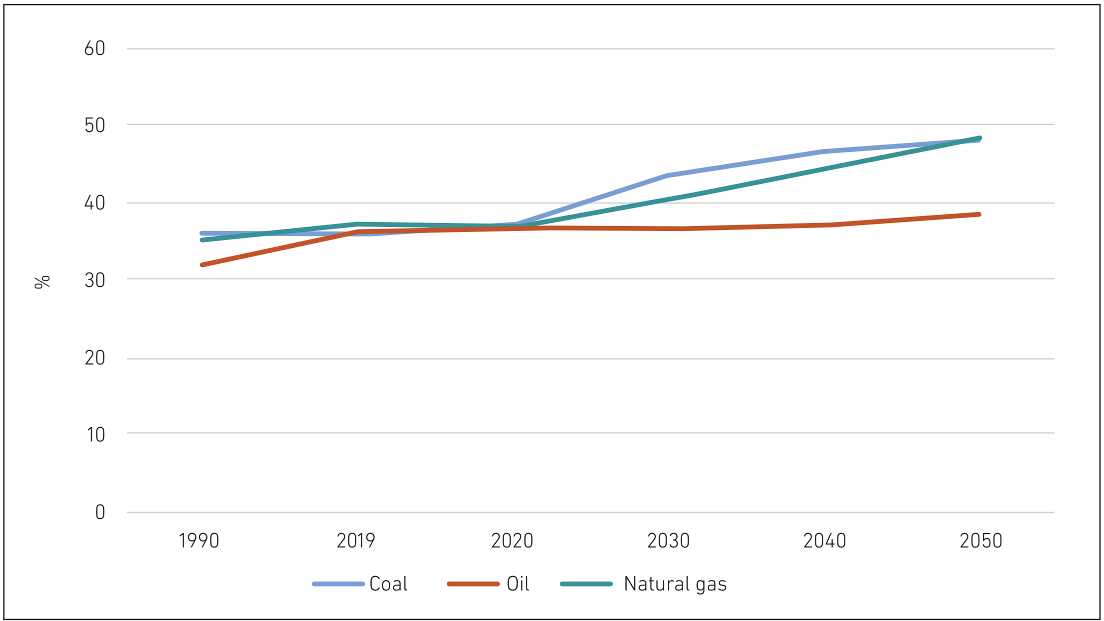
Figure 2.6 Australia – Share of Power Generation Mix, Business as Usual (1990–2050)



Source: Authors.

Thermal efficiency of power generation is projected to improve for coal-fired power plants, from 36.3% in 2019 to 48.4% in 2050. Similarly, gas power plants are expected to improve thermal efficiency, from 37.2% to 48.6%, whilst oil power plant will remain flat with a modest increase, from 36.7% to 38.6% over the outlook period under BAU (Figure 2.7).

Figure 2.7 **Australia – Thermal Efficiency of Power Generation, Business as Usual (1990–2050)**



Source: Authors.

3.1.4. Energy Indicators

Primary energy intensity (primary energy consumption per unit of GDP) and final energy intensity (final energy consumption per unit of GDP) improved by 36.9% and 38.6%, respectively, in 1990–2019. Strong GDP growth, the move to less energy-intensive industries, and energy efficiency improvement across economic sectors contributed to energy intensity improvements. Primary and final energy intensities are projected to improve by 51.5% and 48.3%, respectively, for the outlook period. Australia's CO_2 intensity decreased by 37.1% in 1990–2019. CO_2 intensity is projected to reduce by 59.3% over the outlook period. The increased share of renewable energy in the primary energy mix will reduce CO_2 emissions per unit of primary energy consumption (CO_2 per energy). CO_2 per energy is projected to decrease by 16.1%, and CO_2 per capita is projected to decrease by 33.4% for the period (Table 2.1, Figure 2.8).

Table 2.1 Australia – Energy Indicators, Business as Usual (1990–2050)

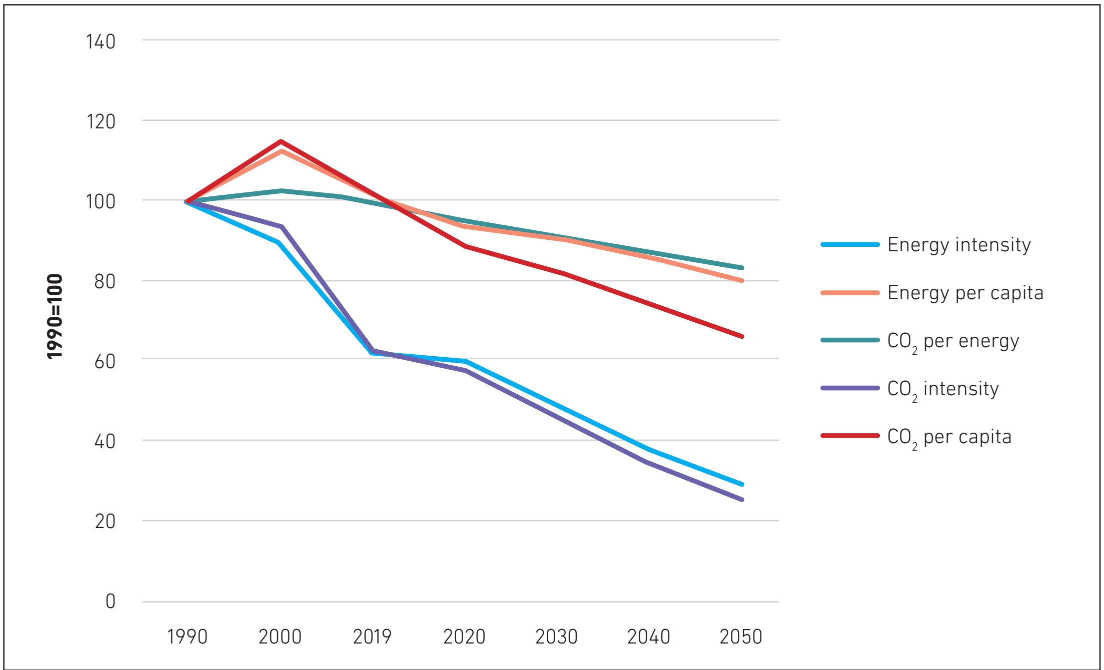
Energy Indicators	1990	2000	2019	2020	2030	2040	2050
Energy intensity[a]	151.4	137.2	95.6	92.1	76.4	59.3	46.4
Energy per capita[b]	5.0	5.6	5.1	4.7	4.6	4.3	4.0
CO_2 per energy[c]	0.81	0.83	0.81	0.77	0.74	0.71	0.68
CO_2 intensity[d]	122.7	114.4	77.1	70.8	56.4	42.0	31.4
CO_2 per capita[e]	4.1	4.7	4.1	3.6	3.4	3.1	2.7

[a] Primary energy consumption per unit of GDP (toe/million 2015 US dollars)
[b] Primary energy consumption per capita (toe/person)
[c] CO_2 emissions per unit of primary energy consumption (t-C/toe)
[d] CO_2 emissions per unit of GDP (t-C/million 2015 US dollars)
[e] CO_2 emissions per person (t-C/person)

GDP = gross domestic product, t-C = tonne of carbon, toe = tonne of oil equivalent.

Source: Authors.

Figure 2.8 Australia – Indices of Energy Indicators, Business as Usual (1990 = 100)



Source: Authors.

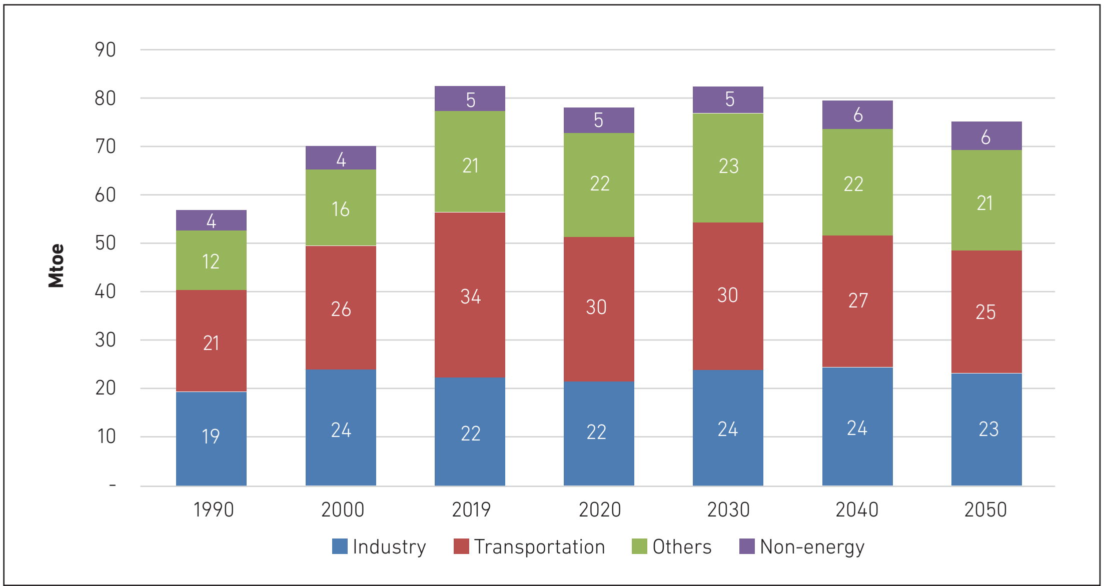
3.2. Energy Savings in Alternative Policy Scenario and CO_2 Reduction Potential

3.2.1. Final Energy Consumption

In APS, total final energy consumption is projected to decrease from 82.3 Mtoe in 2019 to 75.0 Mtoe in 2050, or by about 8.9% (0.3% per year). Consumption will decline steeply in transport, at an average rate of 1.0% per year in 2019–2050. In contrast, industry's consumption will grow at 0.2% per year, and the non-energy sector's at 0.3% per year during the same period. 'Others', mainly the residential and commercial sectors, will increase at 0.5% per year and peak in 2030, before declining to the 2019 level in 2050 (Figure 2.9).

Electricity consumption will grow at an average rate of 1.3% per year during the outlook period. Electricity's share will increase from 22.4% in 2019 to 37.0% in 2050. In contrast, oil consumption will decline at 1.2% per year and reduce oil's share from 53.4% to 40.1% during the same period. Natural gas consumption will peak in 2030 before declining nearly to the 2000 level in 2050. Coal consumption will decline at an average rate of 2.6% per year in 2019–2050, and coal's share in the final energy mix will decrease from 3.6% to 1.8% (Figure 2.10).

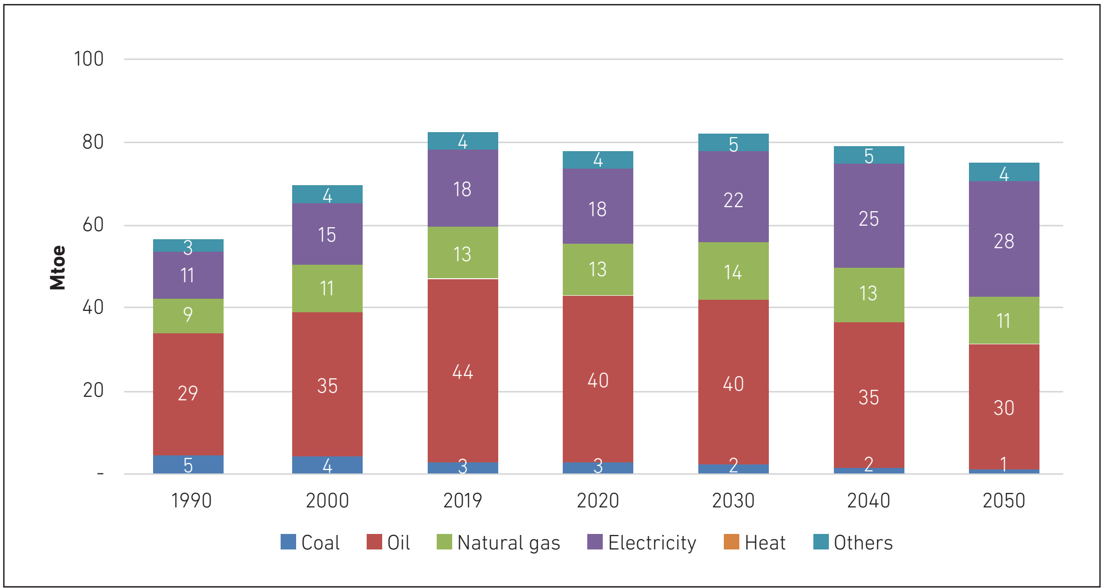
Figure 2.9 Australia – Final Energy Consumption by Sector, Alternative Policy Scenario (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.10 Australia – Final Energy Consumption by Fuel Type, Alternative Policy Scenario (1990–2050)

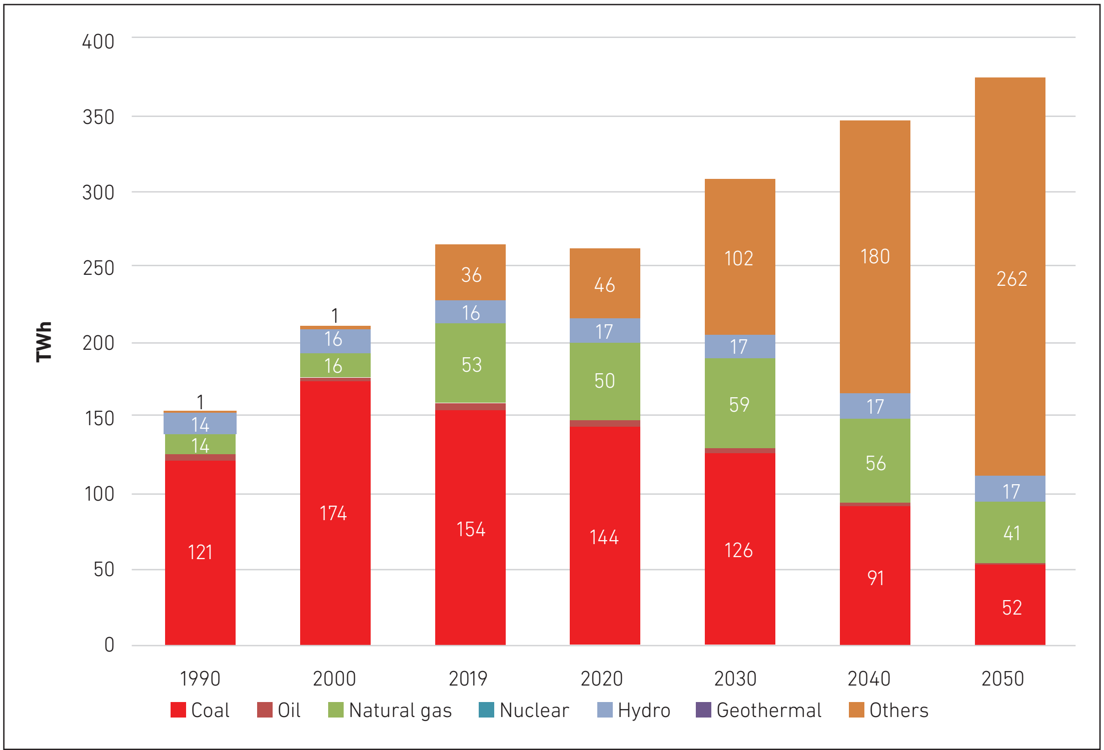


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Electricity generation is projected to increase from 263.7 TWh in 2019 to 373.6 TWh in 2050, or at an average rate of 1.1% per year. The share of fossil fuels in the power generation mix is projected to fall sharply by the end of the outlook period. Electricity generation from non-hydro renewables ('others') is expected to grow faster at an average rate of 6.6% per year in 2019–2050. In 2050, about 74.8% of power generation will come from zero-carbon sources, whilst coal will make up 14.0% of the power generation mix; natural gas, 10.9%; and oil, only 0.3% (Figure 2.11 and Figure 2.12).

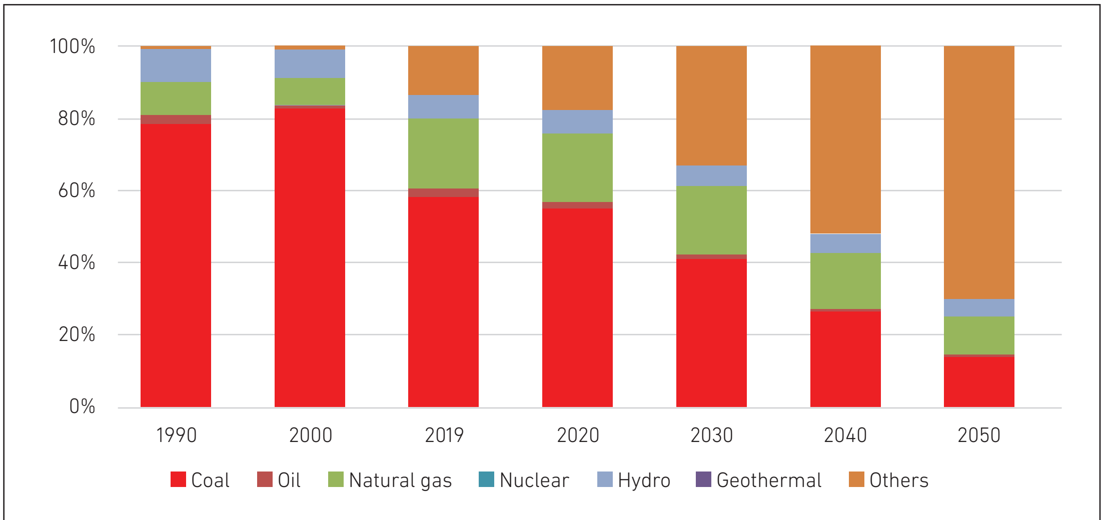
Figure 2.11 Australia – Power Generation, Alternative Policy Scenario (1990–2050)



TWh = terawatt-hour.

Source: Authors.

Figure 2.12 Australia – Share of Power Generation Mix, Alternative Policy Scenario (1990–2050)

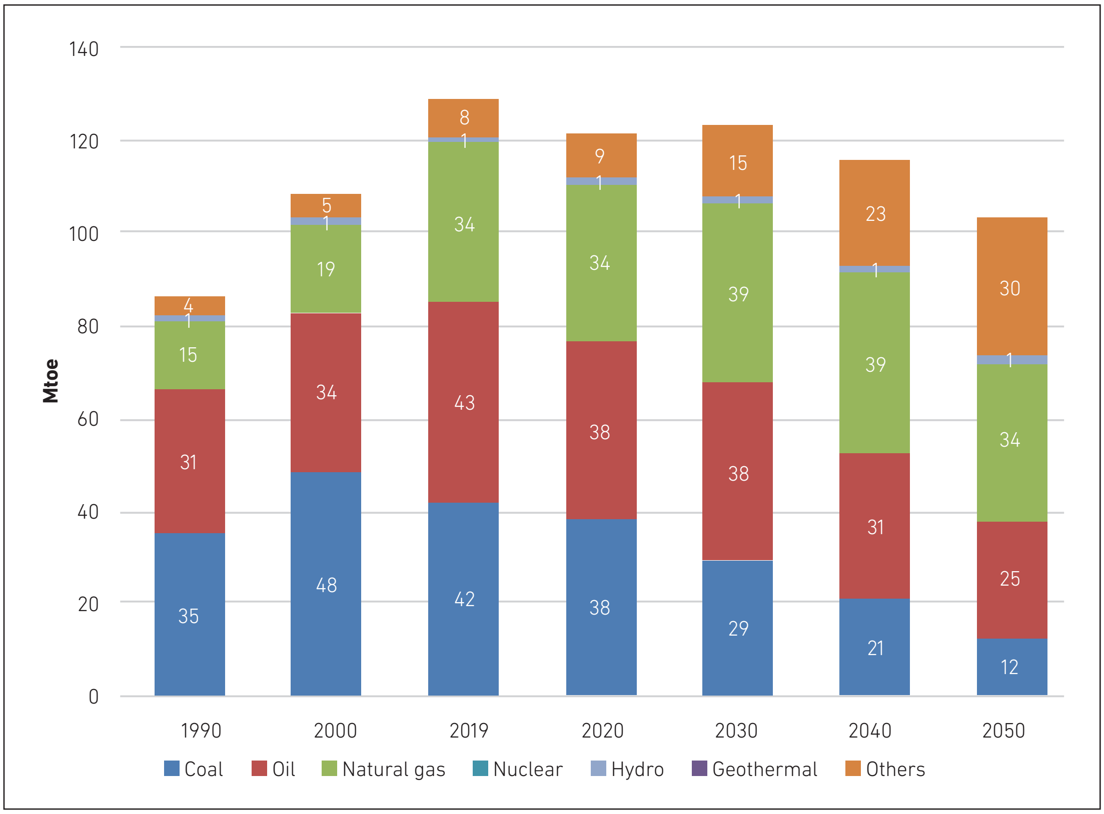


Source: Authors.

3.2.2. Primary Energy Supply

Total primary energy consumption is projected to decrease from 128.7 Mtoe in 2019 to 103.2 Mtoe in 2050, at an average rate of 0.7% per year. Coal consumption will decline sharply at 3.8% per year and oil consumption at 1.7% per year. Natural gas use will peak in 2040 before sharply declining to the 2019 level in 2050. The representation of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 69.6% in 2050. Hydropower will remain relatively flat, with a modest growth of 0.3% per year over the outlook period. In contrast, consumption of non-hydro renewables ('others') will grow rapidly at 4.3% per year during the period, supported mainly by the growth of solar and wind energy (6.3% per year) and biomass energy (1.7% per year) (Figure 2.13).

Figure 2.13 Australia – Primary Energy Supply by Fuel Type, Alternative Policy Scenario (1990–2050)



Mtoe = million tonnes of oil equivalent.

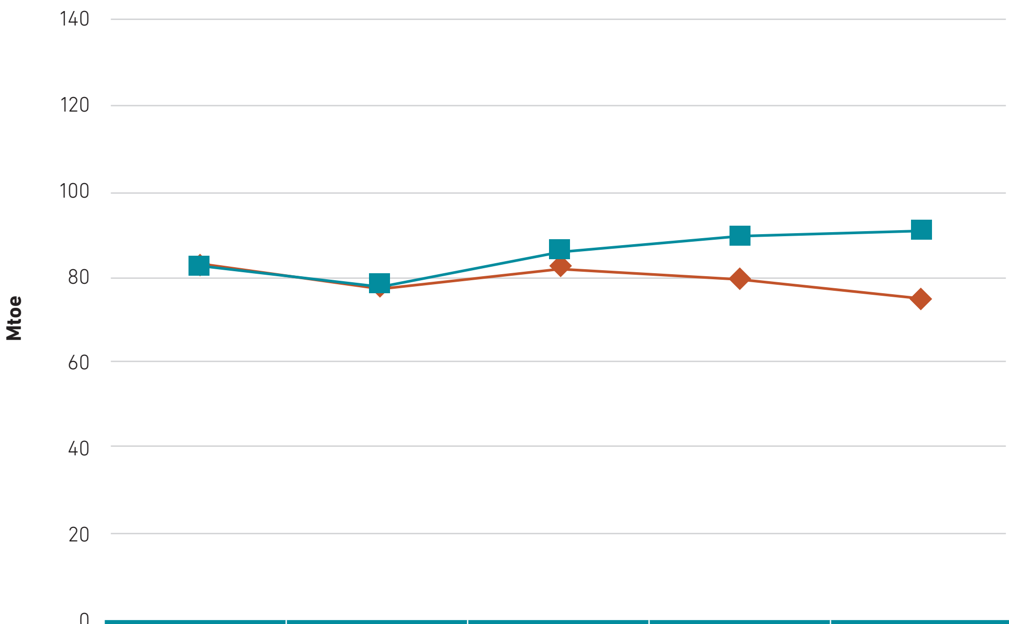
Source: Authors.

3.2.3. Projected Energy Saving

Total final energy consumption will decline from 82.3 Mtoe to 75.0 Mtoe over the outlook period, saving 15.8 Mtoe or 17.4% more energy in 2050 than in BAU (Figure 2.14).

Transport is projected to achieve the highest energy savings, 6.9 Mtoe (21.6%), followed by the residential and commercial sectors, 4.6 Mtoe (17.9%); and the industry sector, 4.3 Mtoe (15.7%) in 2050, compared with BAU. The savings reflect improvements in fuel efficiency in transport vehicles and end-use technologies (Figure 2.15).

Figure 2.14 Australia – Total Final Energy Consumption, Alternative Policy Scenario vs Business as Usual (2019–2050)



	2019	2020	2030	2040	2050
APS	82	78	82	79	75
BAU	82	78	86	89	91

APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

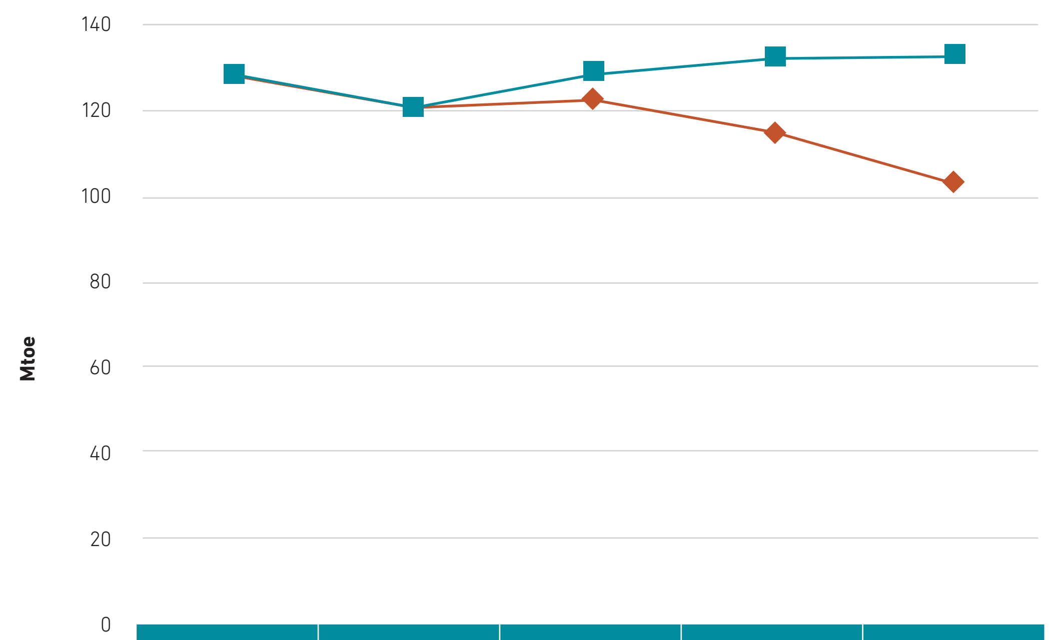
Figure 2.15 Australia – Final Energy Consumption by Sector, Alternative Policy Scenario vs. Business as Usual (2019 and 2050)

APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Total primary energy consumption will decrease by 0.7% per year from 128.7 Mtoe in 2019 to 103.2 Mtoe in 2050, for a saving of 29.9 Mtoe or 22.4% primary energy consumption in APS in 2050, compared with BAU (Figure 2.16 and Figure 2.17).

Figure 2.16 **Australia – Total Primary Energy Consumption, Alternative Policy Scenario vs Business as Usual (2019–2050)**

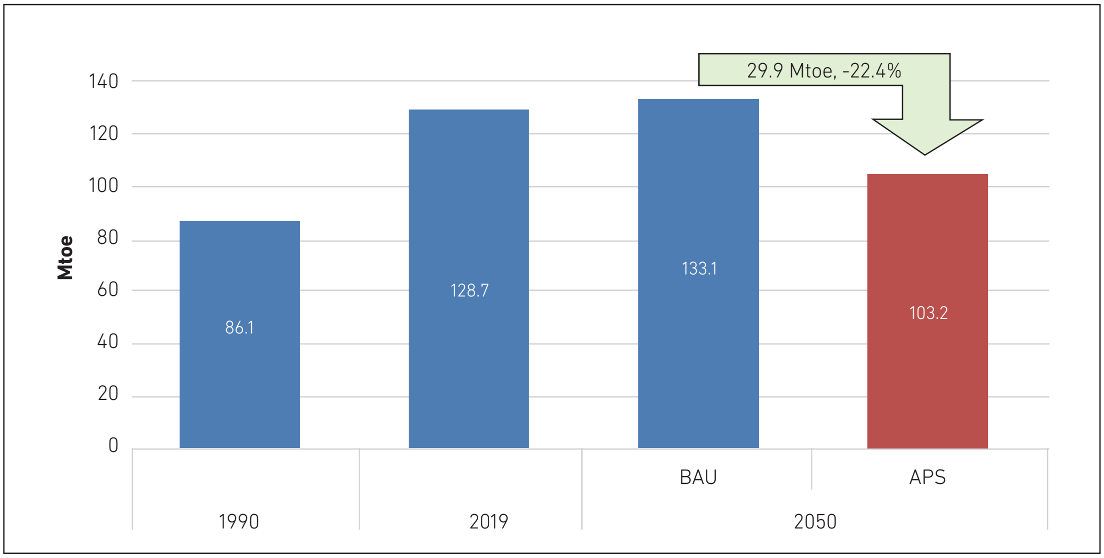


	2019	2020	2030	2040	2050
APS	129	121	123	115	103
BAU	129	121	129	133	133

APS = alternative policy scenario BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.17 Australia – Total Primary Energy Supply, Business as Usual vs Alternative Policy Scenario (2019 and 2050)

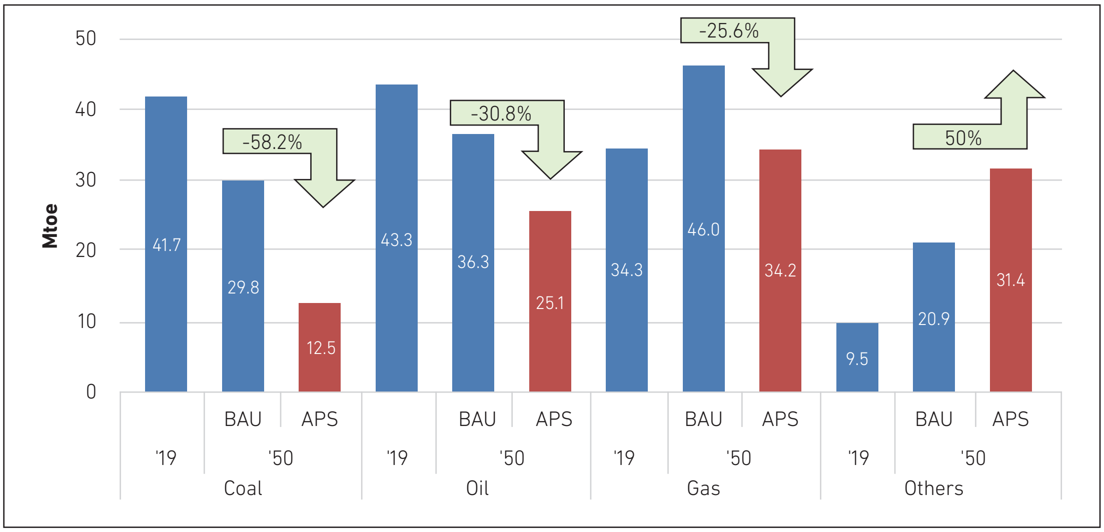


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Savings on coal in primary energy will be 17.4 Mtoe (or 58.2%) in 2050 compared with BAU. Savings on natural gas are 11.8 Mtoe (25.6%) and on oil, 11.2 Mtoe (30.8%) in 2050 compared with BAU. However, demand for renewable primary energy ('others') will increase by 10.5 Mtoe or 50.0% more in 2050 compared with BAU (Figure 2.18).

Figure 2.18 Australia – Primary Energy Supply by Fuel, Alternative Policy Scenario vs Business as Usual (2019 and 2050)



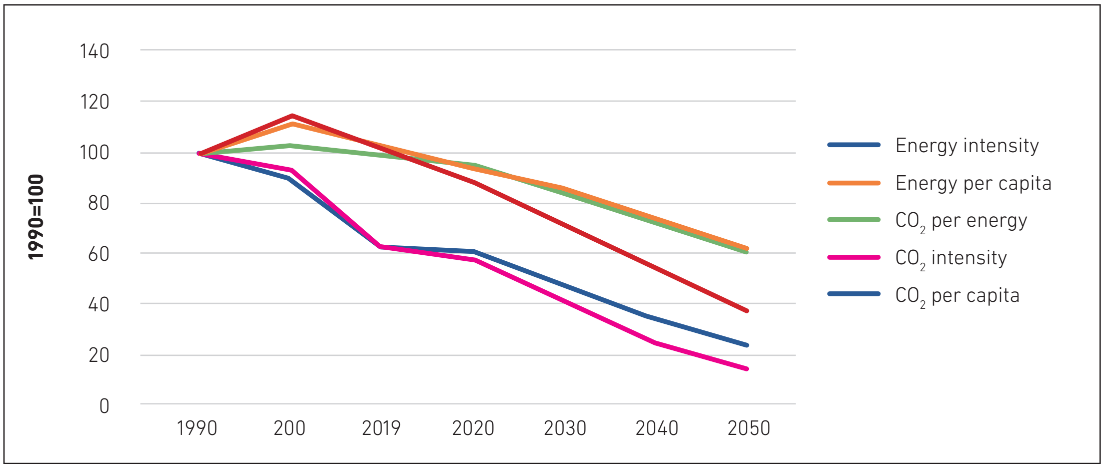
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.2.4. Energy Indicators

Primary energy intensity and final energy intensity are projected to improve by 62.4% (51.5% in BAU) and 57.3% (48.3% in BAU), respectively, in 2019–2050. The improvement implies that greater energy efficiency is achieved across economic sectors in APS than in BAU. Primary energy consumption per person will be 3.1 toe in 2050, 22.4% lower than in BAU. Greenhouse gas (GHG) emissions per person will be 1.5 t-C in 2050, 44.1% lower than in BAU. CO_2 emissions per unit of primary energy consumption in 2050 will be 27.9% less than in BAU because of the greater share of renewable energy in the primary energy mix than in BAU (Figure 2.19).

Figure 2.19 Australia – Indices of Energy Indicators, Alternative Policy Scenario (1990 = 100)

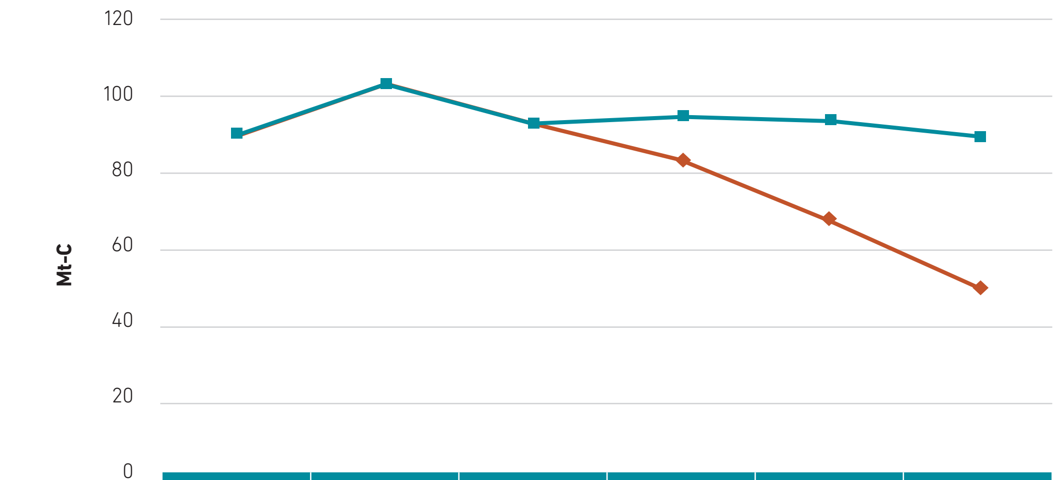


Source: Authors.

3.2.5. CO_2 Emission Reduction

CO_2 emissions from energy consumption will decline from 103.8 million tonnes of carbon (Mt-C) in 2019 to 50.4 Mt-C in 2050 or an equivalent decrease by an average rate of 2.3% per year. In 2050, emission saving is projected to be 39.7 Mt-C or 44.1% compared with BAU. The rate of emission reduction over the outlook period is faster than the declining rate of primary energy consumption in APS, reflecting the increased use of less carbon-intensive and renewable energy sources in the primary energy supply. The lower emission growth rate indicates that energy-saving options are effective in reducing CO_2 emissions. Reduced use of coal in power generation and reduced oil consumption in transport will contribute to the reduction of CO_2 emissions (Figure 2.20, Figure 2.21, and Figure 2.22)

Figure 2.20 **Australia – CO_2 Emissions Trends for Domestic Energy Use, Alternative Policy Scenario vs. Business as Usual**

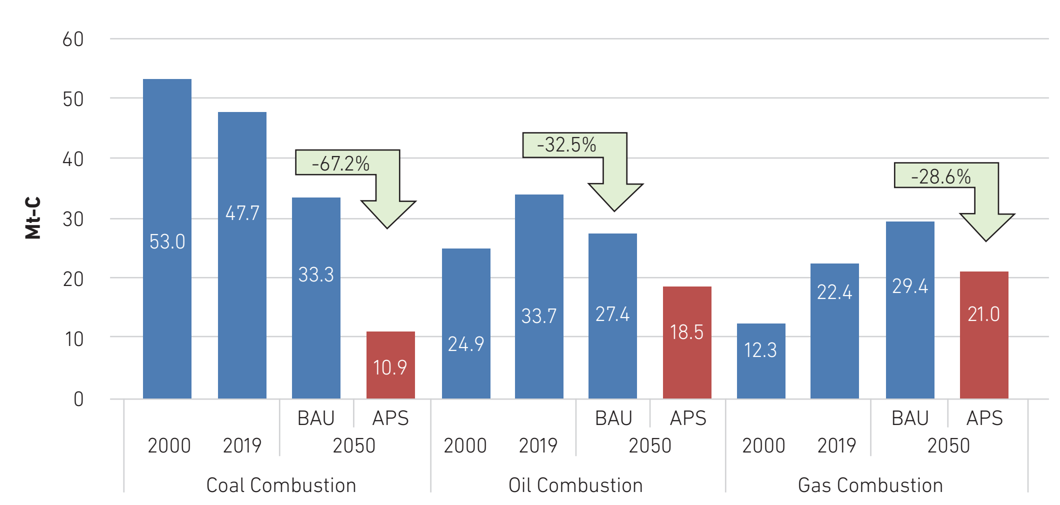


	2000	2019	2020	2030	2040	2050
APS	90.2	103.8	93.0	83.8	68.2	50.4
BAU	90.2	103.8	93.1	95.4	94.0	90.1

APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Authors.

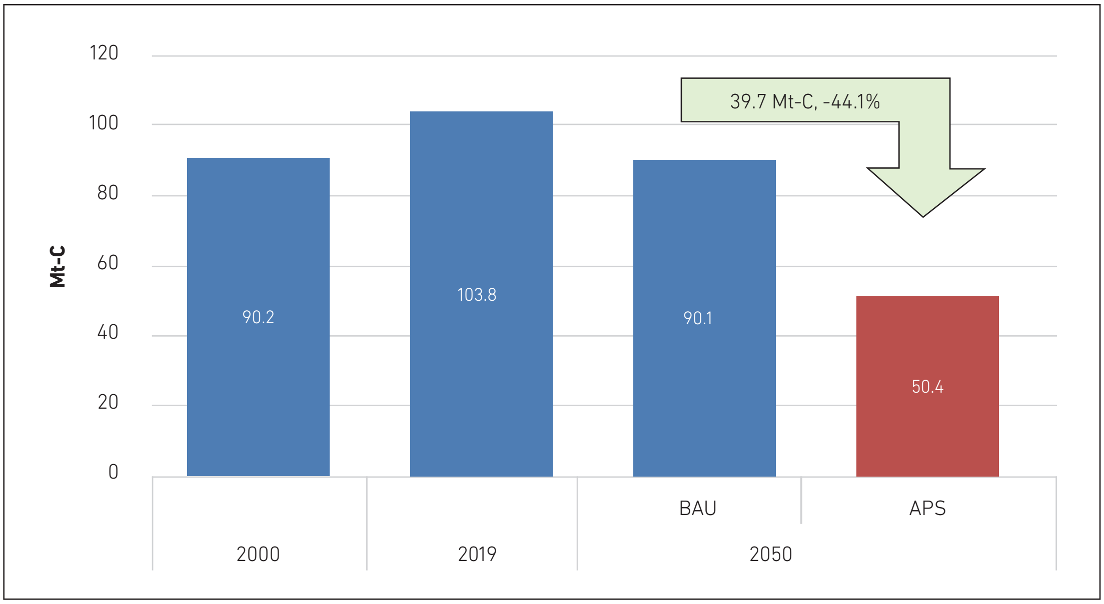
Figure 2.21 **Australia – CO_2 Emissions from Fuel Combustion, Alternative Policy Scenario vs. Business as Usual**



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Authors.

Figure 2.22 Australia – CO_2 Emissions Savings, Alternative Policy Scenario, 2050



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

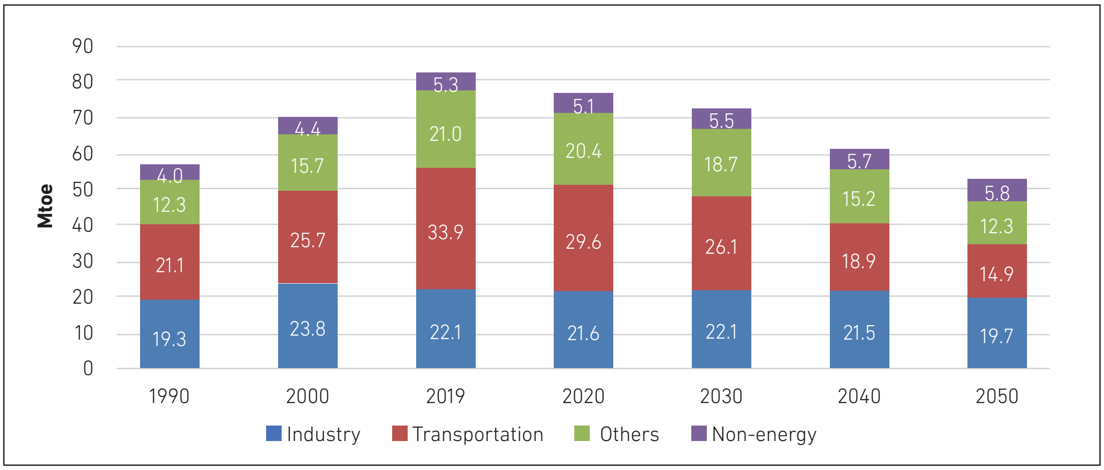
Source: Authors.

3.3. Low-Carbon Energy Transition Scenario

3.3.1. Final Energy Consumption

In LCET, total final energy consumption will decrease from 82.3 Mtoe in 2019 to 52.7 Mtoe in 2050, or by about 36.0% or an average of 1.4% per year. Transport's consumption will decline strongly (55.9%) because of efficiency improvements and other structural changes despite continued growth in vehicle ownership. Energy use in 'others', mainly residential and service sectors, will decrease at an average annual rate of 1.7%, from 21.0 Mtoe in 2019 to 12.3 Mtoe in 2050. Industry's energy use will decline by 0.4% per year during the same period but non-energy's will grow by 0.3% per year. Consumption of coal, oil, and natural gas will decline sharply, but demand for electricity and other renewables will grow. The share of hydrogen and ammonia in the final energy mix is expected to be the second highest (14.8%), behind electricity. Electricity's share will increase from 22.4% in 2019 to 57.8% in 2050 (Figure 2.23, Figure 2.24, and Figure 2.25).

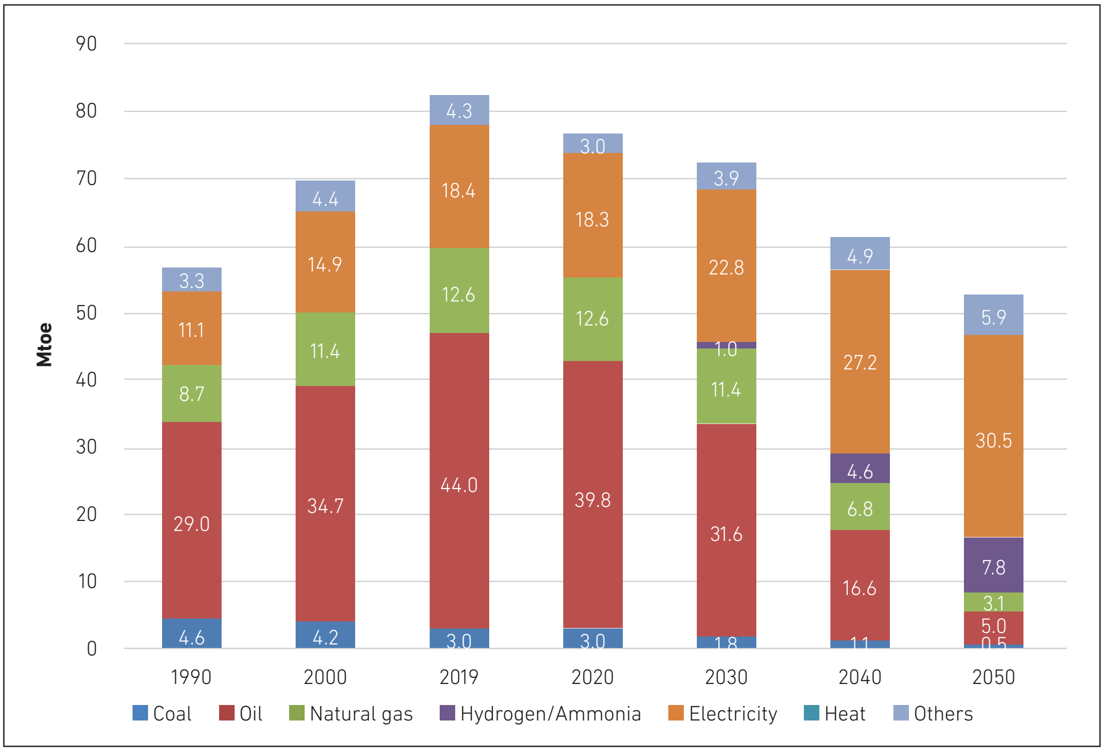
Figure 2.23 **Australia – Final Energy Consumptions by Sector, Low-Carbon Energy Transition (1990–2050)**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

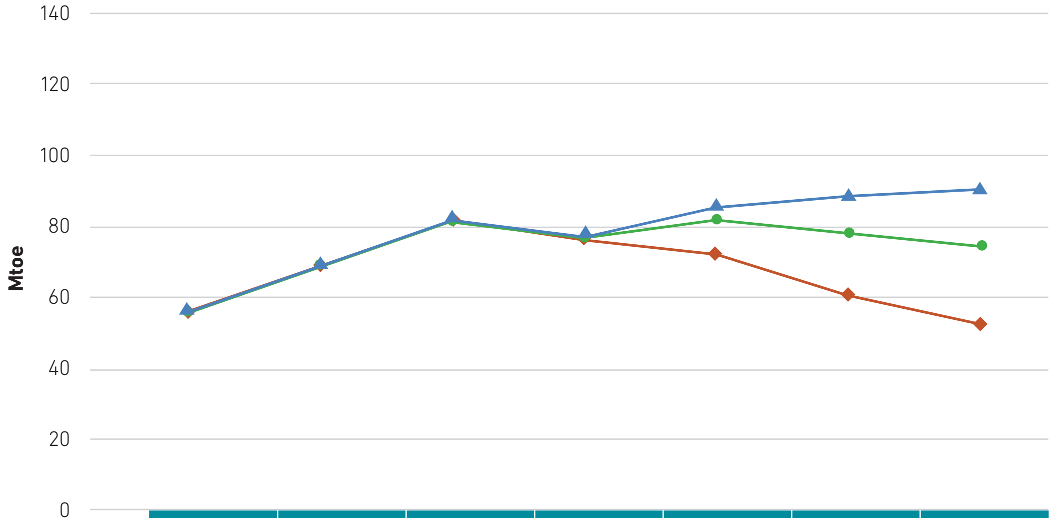
Figure 2.24 **Australia – Final Energy Consumptions by Fuel Type, Low-Carbon Energy Transition (1990–2050)**



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.25 Australia – Final Energy Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	56.7	69.6	82.3	76.7	72.4	61.3	52.7
APS	56.7	69.6	82.3	77.8	82.2	79.2	75.0
BAU	56.7	69.6	82.3	77.9	85.9	89.3	90.8

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

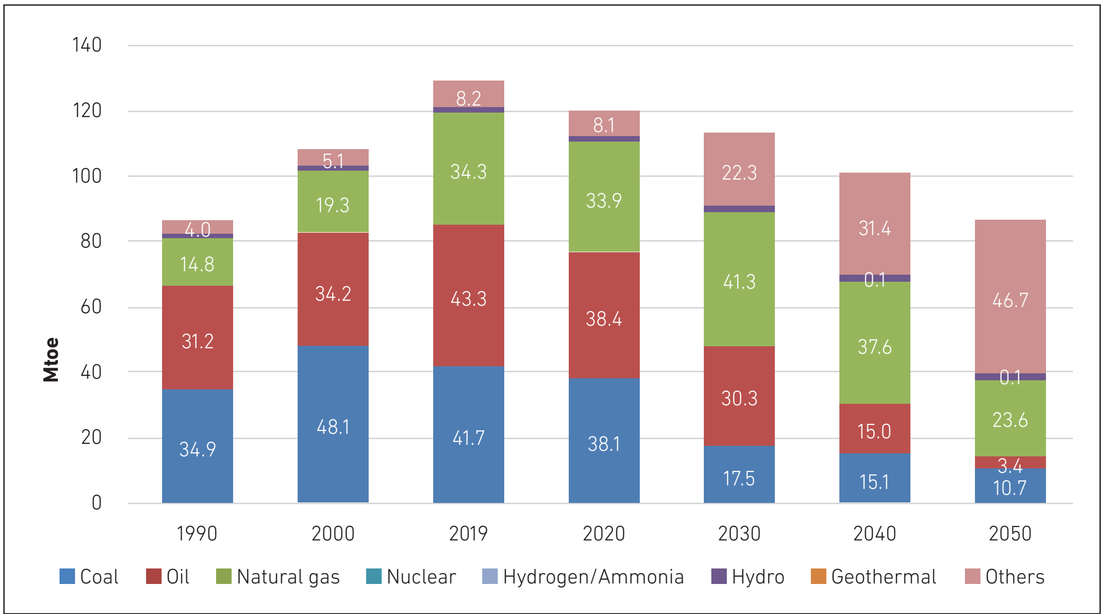
Source: Authors.

3.3.2. Primary Energy Supply

Total primary energy consumption is projected to decrease from 128.7 Mtoe in 2019 to 86.3 Mtoe in 2050, with an equivalent average rate of 1.3% per year. During the period, coal consumption will decline sharply at 4.3% per year and oil consumption at 7.9% per year. Use of natural gas will peak at 41.3 Mtoe in 2030 before declining to 23.6 Mtoe in 2050.

The share of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 43.6% in 2050. Hydropower's share will remain relatively flat with modest growth of 1.1% per year. In contrast, consumption of non-hydro renewables ('others') is projected to grow rapidly at 5.8% per year during the outlook period, supported by the growth of solar and wind energy (7.1%) and biomass (4.6%) (Figure 2.26 and Figure 2.27).

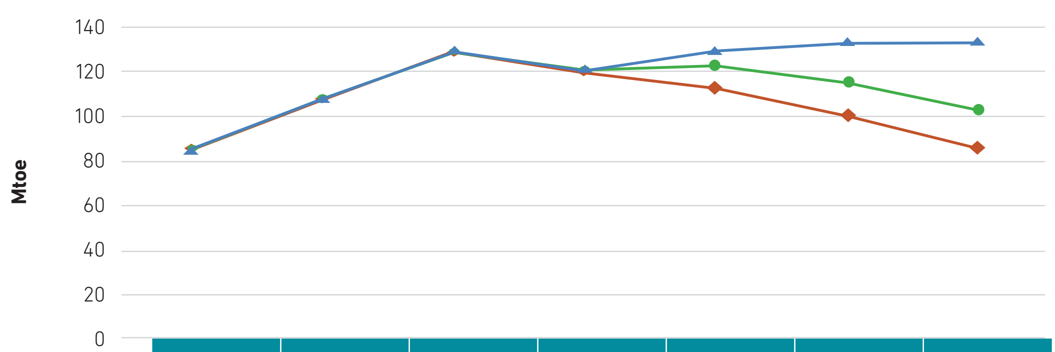
Figure 2.26 Australia – Primary Energy Supply by Fuel Type, Low-Carbon Energy Transition (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.27 Australia – Primary Energy Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	86.1	108.1	128.7	119.9	113.0	100.9	86.3
APS	86.1	108.1	128.7	121.0	123.0	115.4	103.2
BAU	86.1	108.1	128.7	121.0	129.2	132.8	133.1

APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition,

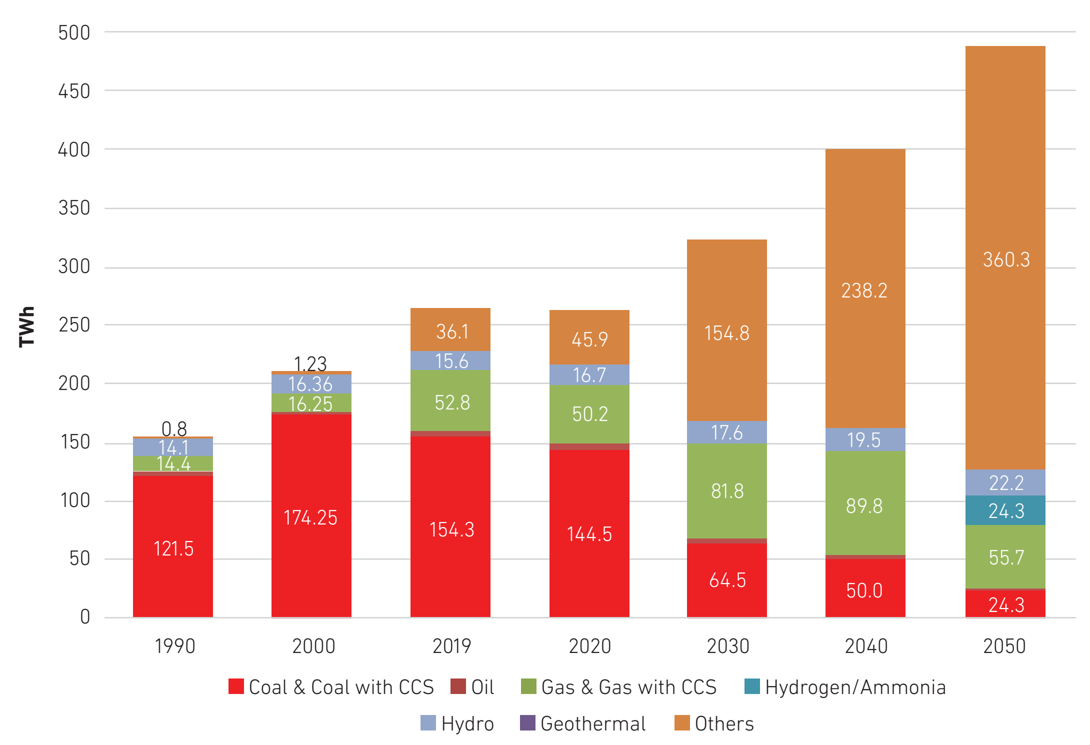
Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.3.3. Power Generation

Electricity generation will grow from 263.7 TWh in 2019 to 487.0 TWh in 2050 at an equivalent average rate of 2.0% per year. The share of fossil fuels in the power generation mix will fall sharply from 80.4% in 2019 to 16.4% in 2050, of which 11.4% will be gas power plants with CCS and 5.0% coal power plants with CCS. All inefficient coal, gas, and oil power plants will be closed by 2040. In 2050, about 83.6% of power generation will come from zero-carbon sources. Green hydrogen and ammonia will take up 5.0% in 2050; solar energy, 31.2%; wind energy, 16.0%; hydropower, 4.5%; and other renewables, 26.8% (Figure 2.28 and Figure 2.29).

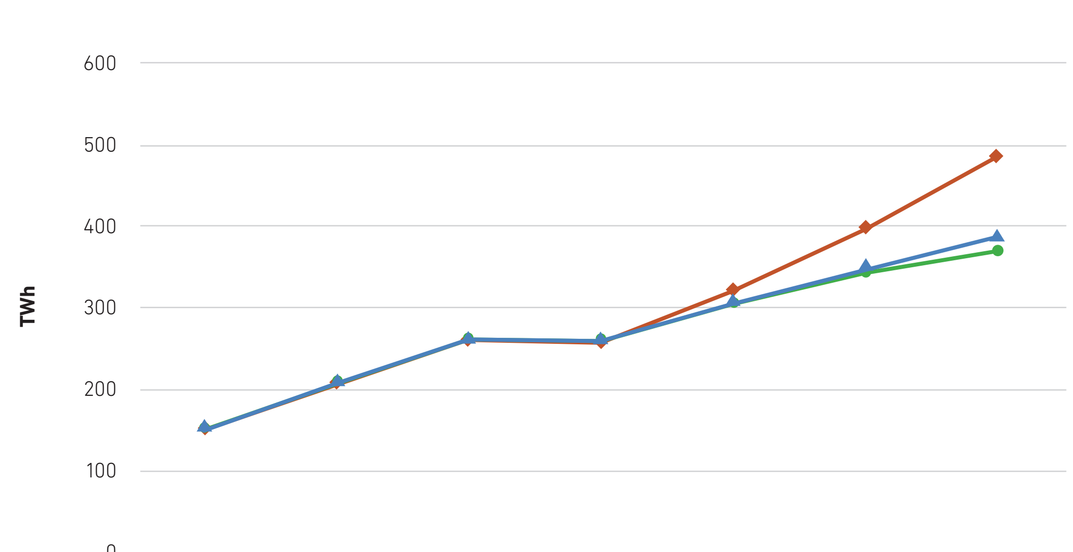
Figure 2.28 Australia – Electricity Generation by Fuel Type, Low-Carbon Energy Transition (1990–2050)



CCS = carbon capture and storage, TWh = terawatt hour.

Source: Authors.

Figure 2.29 **Australia – Electricity Generation, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)**



	1990	2000	2019	2020	2030	2040	2050
LCET	154.3	209.9	263.7	261.8	322.5	400.3	487.0
APS	154.3	209.9	263.7	261.8	307.6	345.9	373.6
BAU	154.3	209.9	263.7	261.8	309.4	352.3	388.0

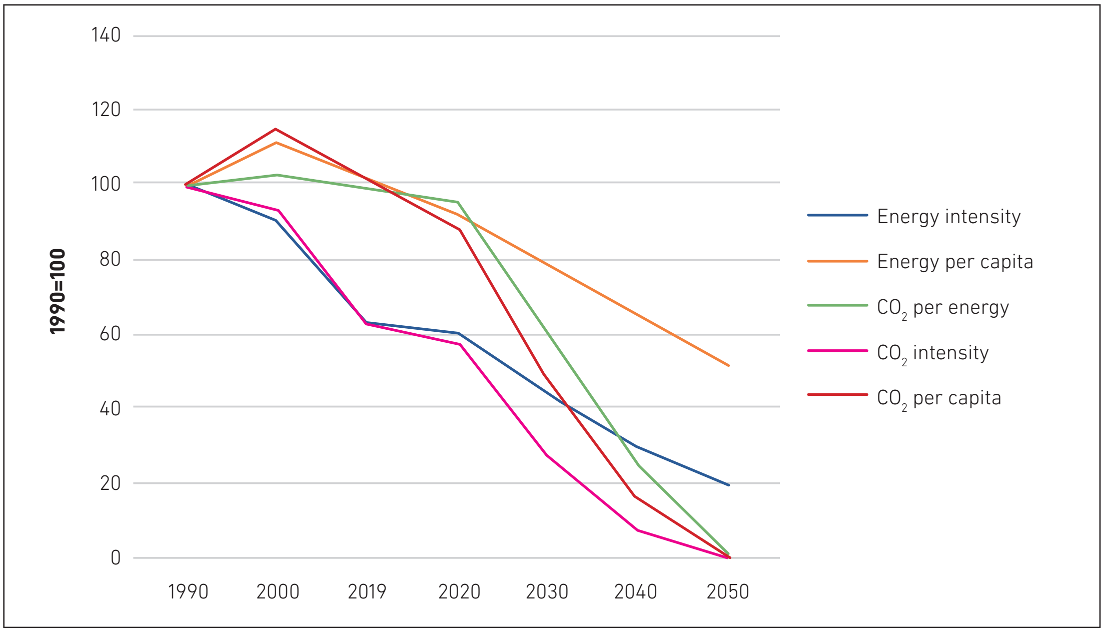
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, TWh = terawatt hour.

Source: Authors.

3.3.4. Energy Indicators

Primary energy intensity and final energy intensity are expected to improve by 68.6% (62.4% in APS and 51.5% in BAU) and 70.0% (57.3% in APS and 48.3% in BAU), respectively, in 2019–2050. LCET will achieve more energy efficiency across economic sectors than APS or BAU. Primary energy consumption per person will be 2.6 toe in 2050, 16.4% lower than in APS and 35.1% lower than in BAU. GHG emissions per person will be nearly zero (0.03 t-C) in 2050, almost 98.9% lower than in BAU, whilst CO_2 emission per unit of primary energy consumption in 2050 will be 98.3% lower under LCET than in BAU (Figure 2.30).

Figure 2.30 Australia – Indices of Energy Indicators, Low-Carbon Energy Transition (1990 = 100)



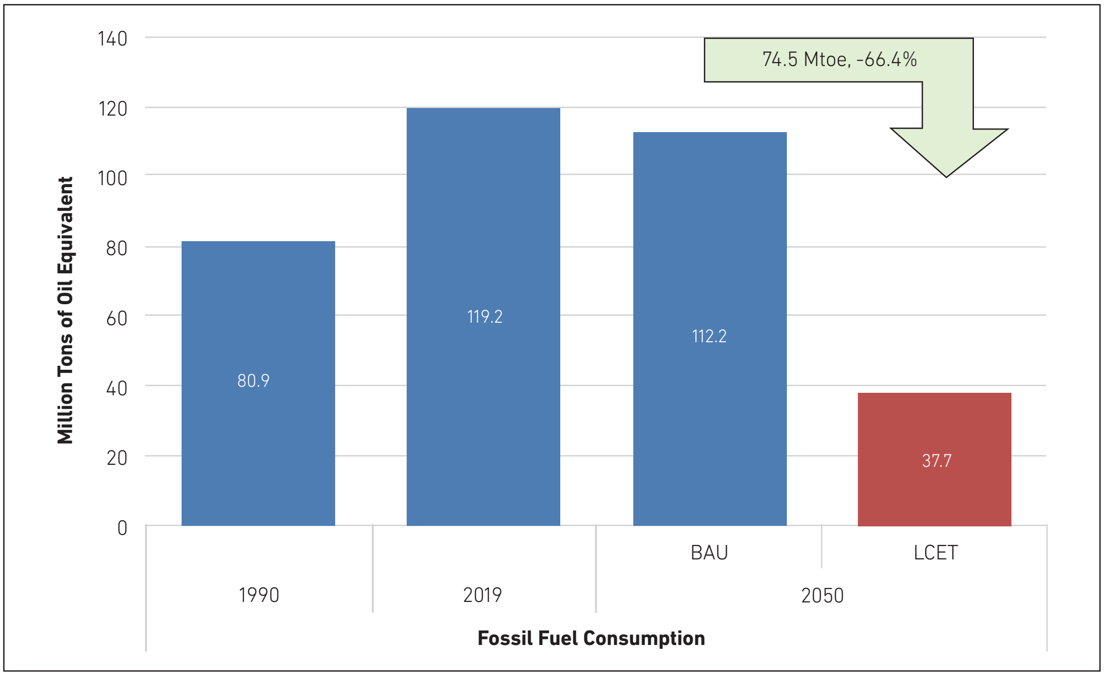
Source: Authors.

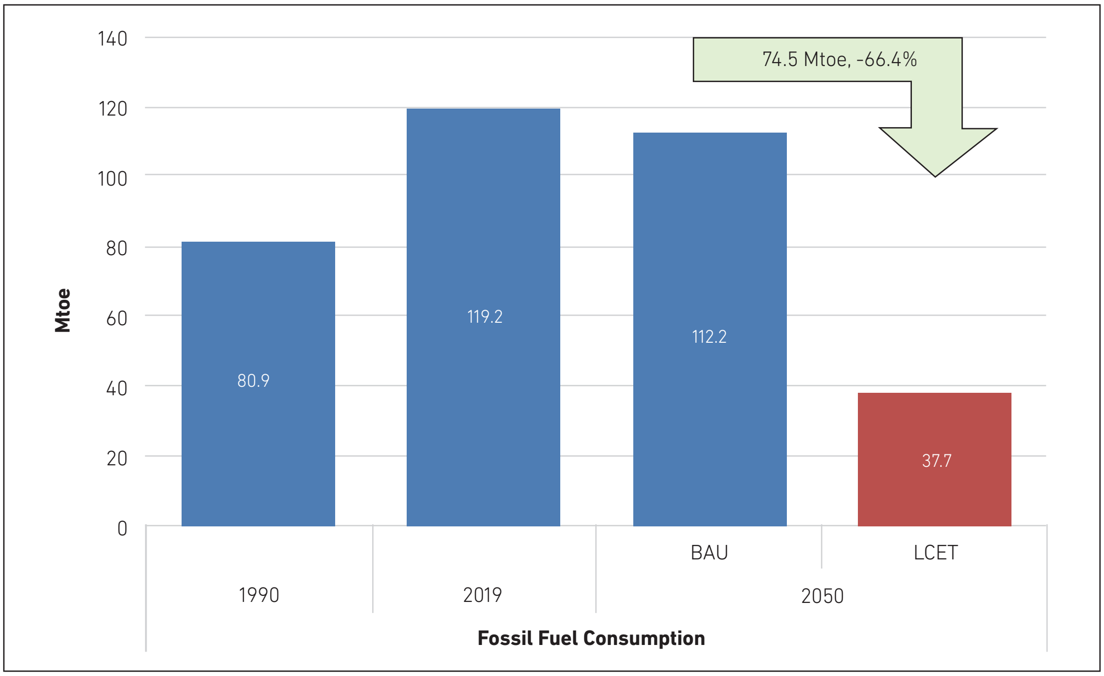
3.3.5. Saving of Fossil Fuel Consumption and CO_2 Reduction

Energy efficiency is projected to improve across economic sectors earlier and faster than in APS. Because of the greater penetration of renewables in the primary energy mix, the share of fossil fuels will fall from 92.6% in 2019 to 43.6% in 2050. Electrification of transport and adoption of electric vehicles will be faster in LCET than in APS. CCS will be implemented in coal and natural gas power plants and boilers in industry. Green hydrogen and ammonia will make up 5% of the generation mix by 2050. The share of renewables in the power generation mix will increase from 19.6% in 2019 to 83.6% by 2050. As a result, demand for fossil fuels will decline sharply at an average rate of 3.6% per year compared with a decline of 1.6% per year in APS and 0.2% per year in BAU.

Saving of fossil fuel consumption is projected at 74.5 Mtoe or 66.4% more than in BAU (Figure 2.31 and Figure 2.32).

Figure 2.31 Australia – Saving of Fossil Fuel Consumption in 2050, Low-Carbon Energy Transition

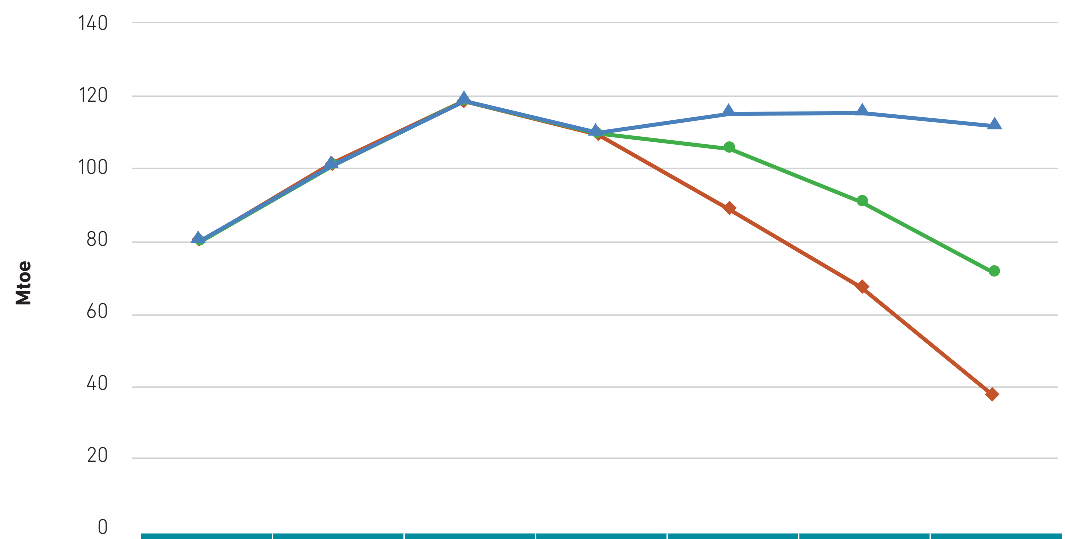




BAU = business as usual, LCET = low-carbon energy transition, million tonnes of oil equivalent.

Source: Authors.

Figure 2.32 **Australia – Fossil Fuel Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)**



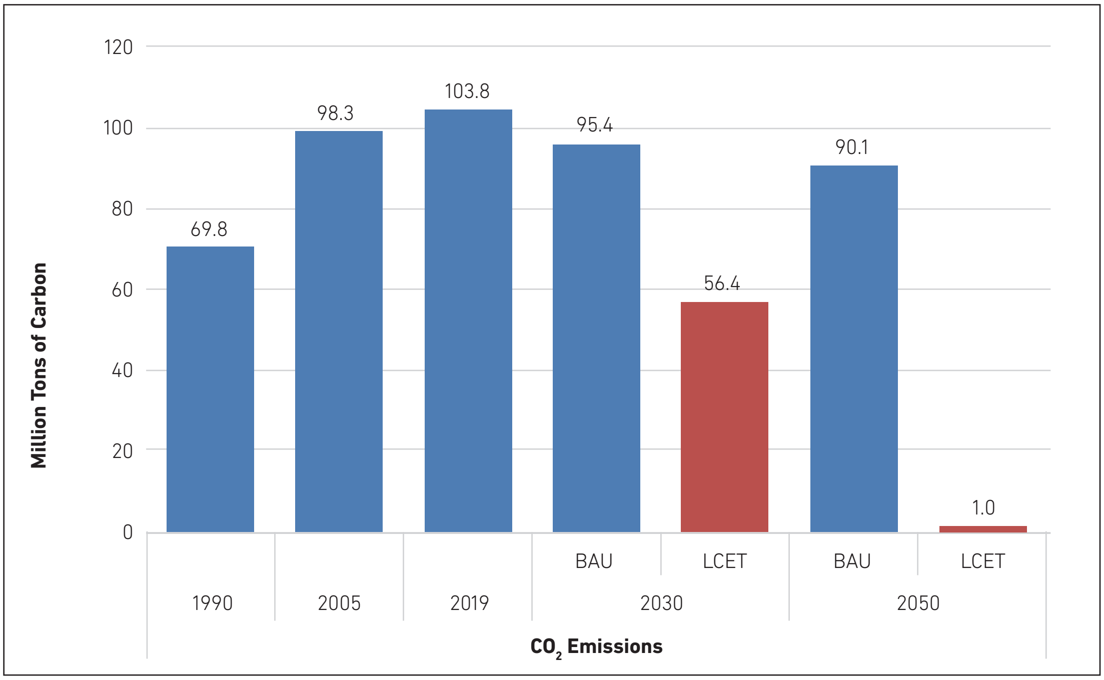
	1990	2000	2019	2020	2030	2040	2050
LCET	80.9	101.6	119.2	110.4	89.1	67.8	37.7
APS	80.9	101.6	119.2	110.4	106.3	91.4	71.8
BAU	80.9	101.6	119.2	110.4	115.5	115.7	112.2

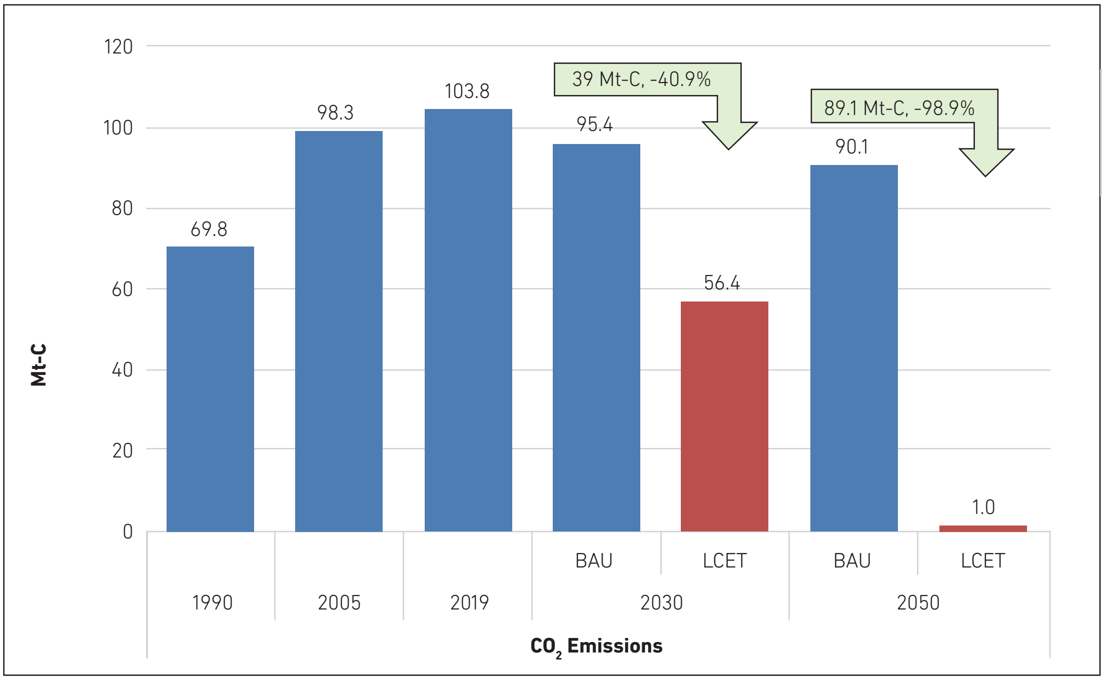
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Less fossil fuel use has a direct impact on CO_2 emission reduction. LCET was developed to analyse the decarbonisation pathway of energy in Australia. CO_2 emission reduction is projected at 39.0 Mt-C in 2030 and 89.1 Mt-C in 2050 compared with BAU. In contrast, the APS results show relatively lower CO_2 reduction for the same period (11.6 Mt-C in 2030 and 39.7 Mt-C in 2050) (Figure 2.33, Figure 2.34, and Figure 2.35).

Figure 2.33 Australia – CO_2 Reduction in 2030 and 2050, Low-Carbon Energy Transition

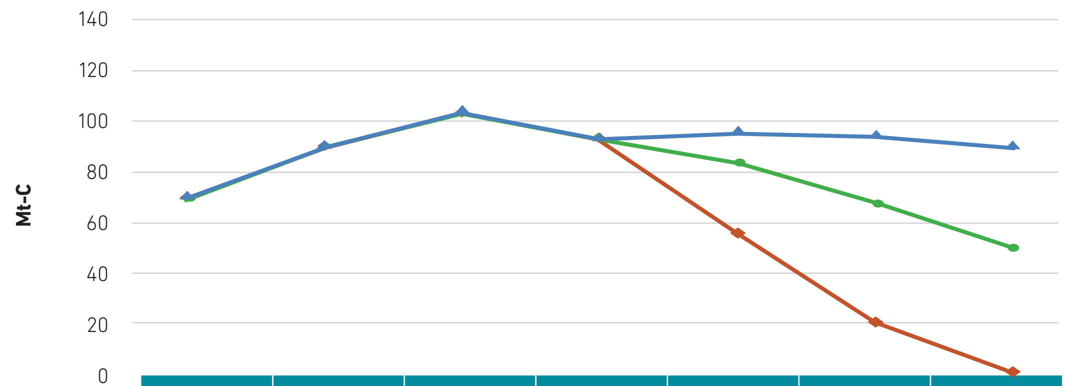




BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors.

Figure 2.34 Australia – CO_2 Emissions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)

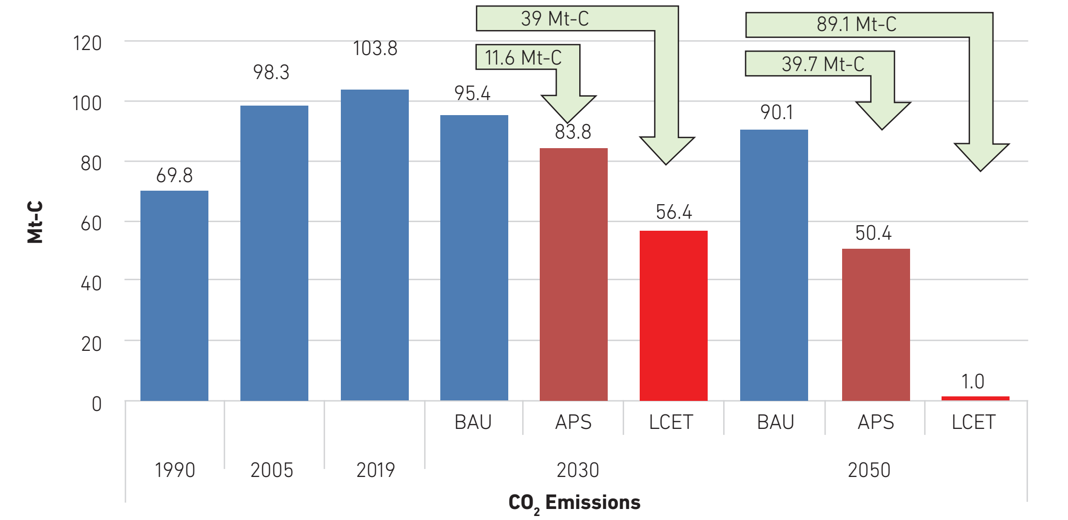


	1990	2000	2019	2020	2030	2040	2050
LCET	69.8	90.2	103.8	93.0	56.4	20.7	1.0
APS	69.8	90.2	103.8	93.0	83.8	68.2	50.4
BAU	69.8	90.2	103.8	93.1	95.4	94.0	90.1

APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors.

Figure 2.35 Australia – CO_2 Reduction in 2030 and 2050, Alternative Policy Scenario and Low-Carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors.

4. Implications and Recommendations

In APS, the dominance of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 69.6% in 2050. Coal and oil consumption will decline sharply over the outlook period. Natural gas demand will peak in 2040 before sharply declining to the 2019 level in 2050. In LCET, a large drop in the share of fossil fuels in the primary energy mix will be seen in 2050. The share of non-hydro renewables in the primary energy mix will increase from 6.3% in 2019 to 54.1% in 2050, supported by a sharp increase in wind, solar, and biomass energy in LCET.

The share of renewables in power generation will increase from 19.6% in 2019 to 83.6% in 2050 whilst the share of renewables in power generation will increase to 74.8% in 2050 in APS. Solar and wind energy penetration in the power system is faster in LCET. Implementation of CCS in coal and gas power plants starting from 2030 and application of hydrogen and ammonia in power generation by 2050 will be seen in LCET. APS does not anticipate notable application of hydrogen, ammonia, and CCS in power generation during the outlook period.

Energy consumption in transport will decline in LCET and APS, but will be much faster in LCET. Energy consumption in the residential and service sectors will decline earlier and faster in LCET than in APS, and energy efficiency will improve across economic sectors earlier and faster than in APS. In LCET, 66.4% savings of fossil fuel consumption will be achieved, and in APS, 36.0% savings will be achieved compared with BAU in 2050.

The study shows that energy-saving options are effective in reducing CO_2 emissions. In 2050, CO_2 emissions are 98.9% lower in LCET and 44.1% lower in APS than in BAU.

Australia will achieve its intended nationally determined contribution target of emission reduction in LCET but not in APS. CO_2 emissions in 2030 are 42.7% lower than the 2005 level in LCET but 14.8% lower than the 2005 level in APS. In 2050, emissions are 99.0% lower than the 2005 level in LCET but 48.8% lower than the 2005 level in APS.

The LCET results suggest that decarbonisation of the power generation system requires earlier and faster closure of inefficient fossil fuel power plants. Australia needs to implement CCS technology in existing efficient coal and gas power plants. It requires greater attention to replacing ageing electricity infrastructure and storage technologies to achieve faster growth of non-hydro renewable technologies. Using green hydrogen and ammonia fuel in power plants is critical to decarbonise the power generation system.

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

Energy efficiency improvement is about 50% faster in LCET than in APS. Improved and efficient end-use technologies must be adopted to reduce final energy consumption in end-use sectors. Transport has more opportunities for energy saving. Energy saving in industry comes from improved efficiency in large energy-intensive industries.

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CHAPTER 3

Brunei Darussalam Country Report

Ministry of Energy, Brunei Darussalam

1. Background

Brunei Darussalam is on the northwest coast of Borneo in Southeast Asia, with a northern coastline of 161 kilometres along the South China Sea on the north. With a total land area of 5,765 square kilometres, it has four districts: Brunei–Muara, Tutong, Belait, and Temburong. The capital city, Bandar Seri Begawan, is in Brunei–Muara. The climate is equatorial, with high rainfall and humidity.

Gross domestic product (GDP) in 2019 was US$13.3 billion,[1] the population 433,300, and per capita GDP US$28,900 (Department of Economic Planning and Statistics, 2022). About 55% of GDP is generated by oil and gas. Crude oil, liquefied natural gas, and methanol account for more than 90% of total exports, primarily to Asia and the Pacific.

2. Energy Policies

2.1. Supply

Brunei Darussalam continues to strengthen upstream oil and gas activities to ensure long-term energy security and sustainability of oil and gas reserves. It is developing unexplored areas, such as deepwater fields. Rejuvenation of current upstream-producing assets is a priority to enhance recovery from existing fields and maximise production. The country is focusing on developing downstream energy industries by maximising economic spin-off potential from upstream production and assets.

Brunei Darussalam aims to reduce its energy intensity by 45% in 2035 from the baseline year of 2005, in line with its regional commitment to the Asia-Pacific Economic Cooperation. It has set a target to increase the share of renewable energy in its power generation mix, particularly from solar photovoltaic (PV), to 200 megawatts (MW) by 2025 and at least 30% from renewable energy.

To support the development of renewable energy sources, the government plans to introduce renewable energy policy and regulatory frameworks that will stimulate public and private investment to develop and deploy renewable energy. Renewable energy policies, such as the net-metering programme, which is intended for small- to medium-scale solar PV with less than 1-megawatt (MW) capacity; and the renewable portfolio standard policy, which will be introduced for large-scale solar PV to ensure that a certain percentage of energy consumption is powered by renewable energy. The 200 MW target by 2025 will mostly be from large-scale ground-mounted and floating solar PV.

[1] Measured in constant 2010 values (with currency exchange rate of US$1=BN$1.3)

2.2 Demand

Brunei Darussalam has implemented several initiatives and activities to achieve 45% energy intensity reduction by 2035. Government agencies and industry are collaborating to set up initiatives that promote energy efficiency and low energy-intensive industries. The role of industries includes identifying and implementing the latest technologies that may help reduce energy usage over time, whilst adopting consumption behaviour changes that include embracing energy-efficient appliances.

Efforts to achieve the energy efficiency and conservation (EEC) target are power efficiency improvement, setting standard and introduce labelling scheme for electrical appliances, deployment of electric vehicles, expansion of EEC building guidelines, and light-emitting diode (LED)–fitting system for streetlights, amongst others, through a whole-of-nation approach. The Department of Electrical Services and the Berakas Power Company play major roles in improving power efficiency of power stations, including establishing combined-cycle turbine and co-generation power plants, whilst phasing out single-cycle power stations and carbon-intensive diesel-powered plants.

2.3. Recent Energy Developments

As Brunei Darussalam aspires for greater economic development, the government has substantially invested in downstream oil and gas industries, including, since 2010, Brunei Methanol Company, and, since late 2019, Hengyi Industries Sdn Bhd. Further development in downstream activities is expected with the scheduled operation of Brunei Fertiliser Sdn Bhd in 2021 and the completion of the second phase of Hengyi Industries' refinery and petrochemical complex, which will drive gas demand.

2.4. Brunei Darussalam's Climate Change Commitments

In 2016, Brunei Darussalam joined the collective international effort to limit the global temperature rise to below 2° Celsius above pre–Industrial Revolution levels, and committed to pursuing efforts to limit the increase to 1.5° Celsius by signing the Paris Agreement. In 2020, the country marked a milestone with the launch of the Brunei Darussalam National Climate Change Policy, paving the way for a low-carbon and climate-resilient economy. In the same year, Brunei Darussalam submitted its nationally determined contribution (NDC), a commitment to reduce by 20% its national greenhouse gas (GHG) emissions by 2030 from the business-as-usual (BAU) level. At the 26th United Nations Climate Change Conference of Parties (COP26), Brunei Darussalam expressed interest in reaching net-zero emissions by 2050, primarily through energy transition and forest preservation.

3. Modelling Assumptions

Energy demand projections up to 2050, including macroeconomic parameters such as GDP and population, are forecast using the Long-range Energy Alternatives Planning system. Historical data are sourced from the Asia-Pacific Economic Cooperation Energy Database and the World Bank's World Development Indicators for Brunei Darussalam (1990 and 2000).

3.1. Gross Domestic Product and Population

GDP and population trajectories through to 2050 will grow at an annual rate of 2.1% and 1.4%, respectively. Energy demand is expected to be driven by GDP and population, as the oil and gas sector continues to be the main economic pillar.

Table 3.1 Brunei Darussalam – Gross Domestic Product and Population Projection (2020–2050)

	Historical Data		2019–2050					
	1990	2000	2019	2020	2030	2040	2050	AAGR (%) 2019–2050
GDP (billion US$)	9.6	12.0	13.3	14.0	17.5	21.6	26.6	2.1
Population (million)	0.26	0.37	0.46	0.44	0.50	0.58	0.67	1.4

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

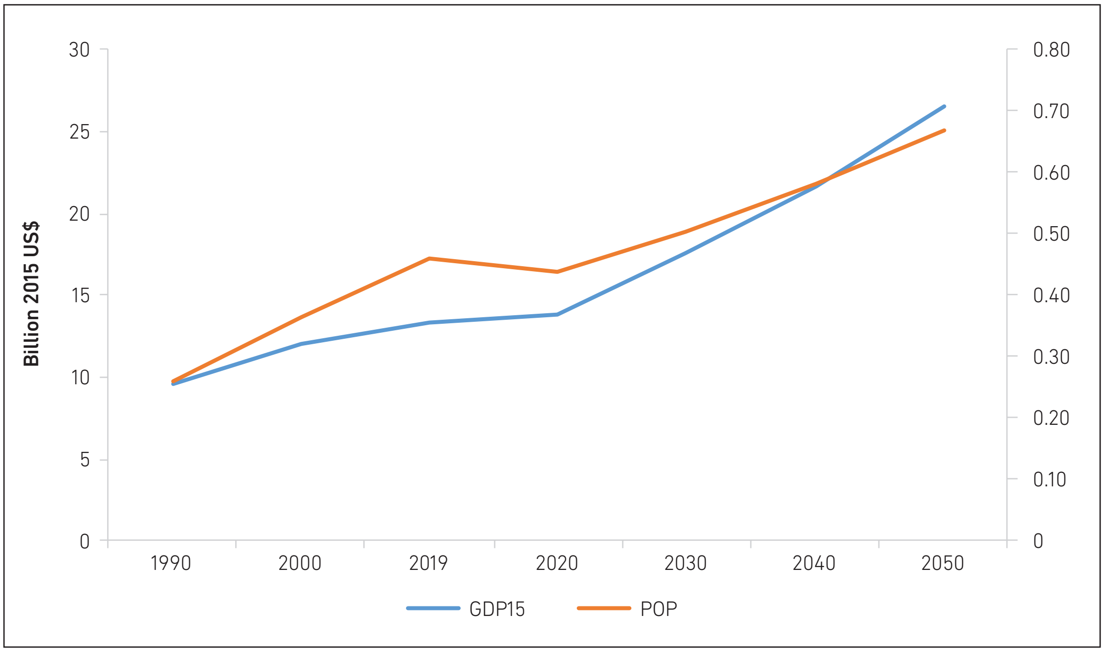
Source: Author; and World Bank, 2022. World Development Indicators for historical data.

3.2. Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition

The study examines energy savings potential and energy efficiency improvement, carbon dioxide (CO_2) emission reduction, and renewable energy development throughout the forecast period (2020–2050) through several scenarios:

i. BAU reflects current trends in energy and demand and existing energy policies. It presents a basis against which other scenarios can be compared.

Figure 3.1 Brunei Darussalam – Gross Domestic Product and Population Growth Rate, Business as Usual



GDP = gross domestic product, POP = population.

Source: Author.

ii. The alternative policy scenario (APS) analyses different possible energy initiatives:
   a. APS1. Implement and promote EEC initiatives, with 10% energy consumption reduction in 2019–2050.
   b. APS2. Increase number of energy-efficient thermal power plants, with thermal efficiency of 30% for coal-fired power plants and 48% for natural gas–powered power plants.
   c. APS3. Contribute more renewable energy to total energy supply.
   d. APS4. Omitted as the country has no nuclear energy plans.
   e. APS5. Combine APS1, APS2, and APS3.

iii. The low-carbon energy transition (LCET) scenario has the most aggressive emission-reduction initiatives and programmes. It assumes alternative pathways where the country uses new technologies, such as carbon capture, utilisation, and storage (CCUS), in new gas-fired power plants. The scenario considers high use of electric vehicles.

3.3 Energy Supply and Consumption in 2019

Oil and natural gas remain the primary sources of total primary energy supply (TPES). In 2019, natural gas contributed most of TPES, or 3.60 million tonnes of oil equivalent (Mtoe) or 79%; oil contributed 16.4%. Coal entered the mix, accounting for 4.3%, as feedstock to the new power station for downstream industry (Hengyi Phase I), which started operating in late 2019. Use of renewable energy was minimal, accounting for only 0.003% of TPES.

Total final energy consumption (TFEC) was 1.66 Mtoe in 2019. Transport accounted for the largest share (34%), followed by non-energy at 32%. 'Others' and industry contributed about 23% and 11%, respectively. Oil remains the dominant fuel, accounting for 49% of TFEC, followed by natural gas at 32.3% and electricity at 18.7%.

The two major public utilities are owned by the Department of Electrical Services and the Berakas Power Company. All public utility power plants use natural gas to fuel the electricity grid. In 2019, the installed power generation capacity of public utility power plants was 890 MW, including solar PV at 1.3 MW. Natural gas and coal were used for energy industries' self-production. Total electricity production in 2019 was 5.17 terawatt-hours (TWh).

Table 3.2 Brunei Darussalam – Energy Supply and Consumption (2019)
(Mtoe)

Supply and Consumption	Coal	Oil	Natural Gas	Electric-ity	Renew-able Energy	Total
Primary energy supplies						
Indigenous production	-	6.40	10.95	-	0.00013	17.35
Net import and others	0.19	-5.66	-7.35	-		-12.81
Total primary energy supply	**0.19**	**0.74**	**3.60**	**-**	**0.00013**	**4.54**
Final energy consumption						
Industrial sector	-	0.12	-	0.12	-	0.24
Transport	-	0.56	-	-	-	0.56
'Others' a	-	0.06	0.02	0.31	-	0.39
Non-energy	-	0.01	0.52	-	-	0.53
Total final energy consumption	**-**	**0.75**	**0.54**	**0.43**	**-**	**1.72**

Mtoe = million tonnes of oil equivalent.

a Includes the residential and commercial sectors.

Source: Author.

4. Outlook Result

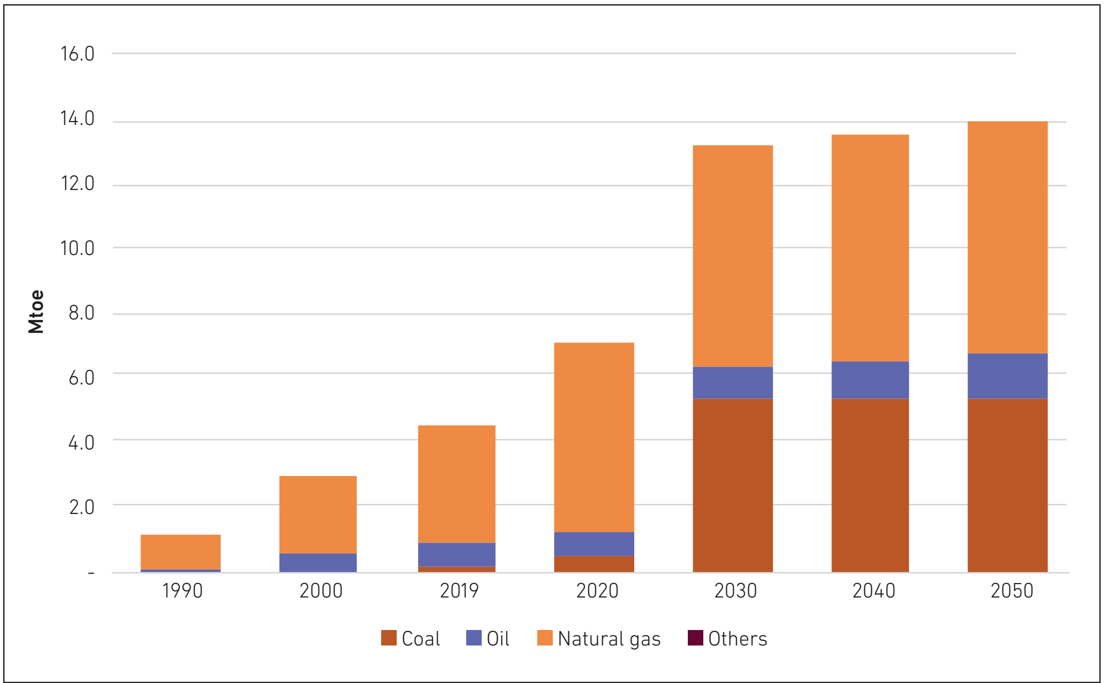
4.1. Business-as-Usual Scenario

The section describes the trends in energy production and utilisation with the current and existing policy intervention in reducing energy demand and CO_2 emissions.

4.1.1. Primary Energy Supply

TPES is projected to reach 13.92 Mtoe in 2050, increasing by 3.7% per year from 4.54 Mtoe in 2019. Historically, TPES has been dominated by natural gas, at 79.6% in 2019. However, that share is expected to decline to 51.5% in 2050, with coal entering the mix through imports for the operation of the Hengyi Industries refinery and petrochemical complexes. Crude oil imports are expected to supplement the limited domestic oil supply, as a feedstock to Hengyi's refineries.

Figure 3.2 Brunei Darussalam – Total Primary Energy Supply by Fuel, Business as Usual (1990–2050)



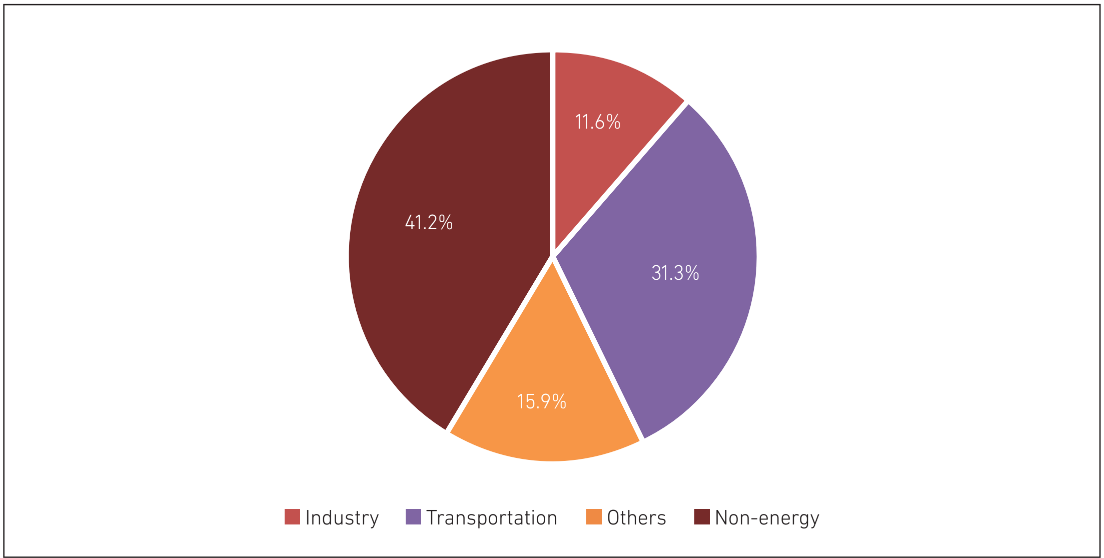
Mtoe = million tonnes of oil equivalent.

Source: Author.

4.1.2. Final Energy Consumption

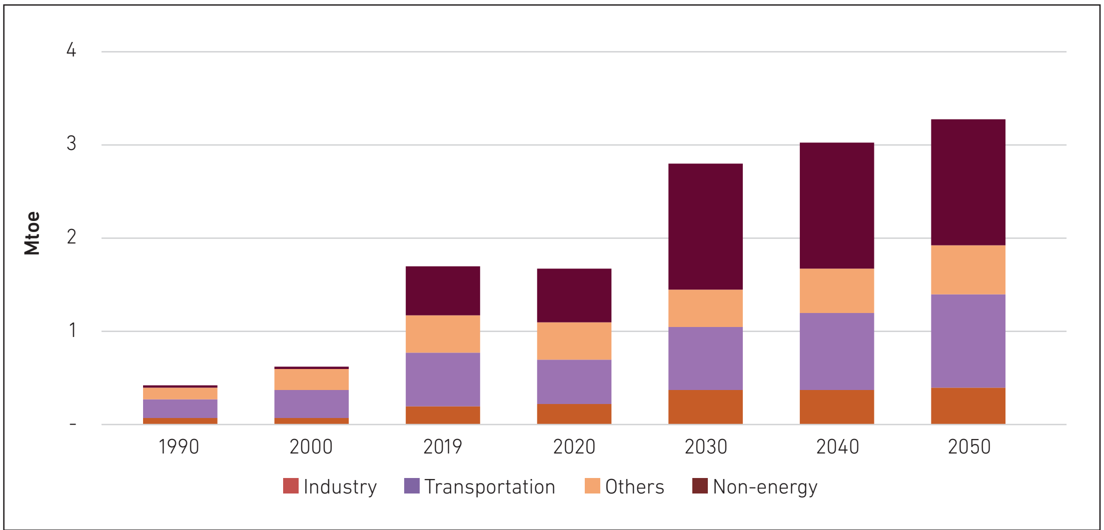
TFEC will increase by 2.1% annually to 3.2 Mtoe in 2050. The trend in TFEC is set to change as the non-energy sector is expected to contribute the largest share in 2050, at 41.2%, whilst the share of transport is expected to drop marginally from 33.8% to 31.3%, with 'others' declining from 23.3% to 15.9%.

Figure 3.3 **Brunei Darussalam – Final Energy Consumption by Sector, Business as Usual**



Source: Author.

Figure 3.4 **Brunei Darussalam – Final Energy Consumption by Sector, Business as Usual**

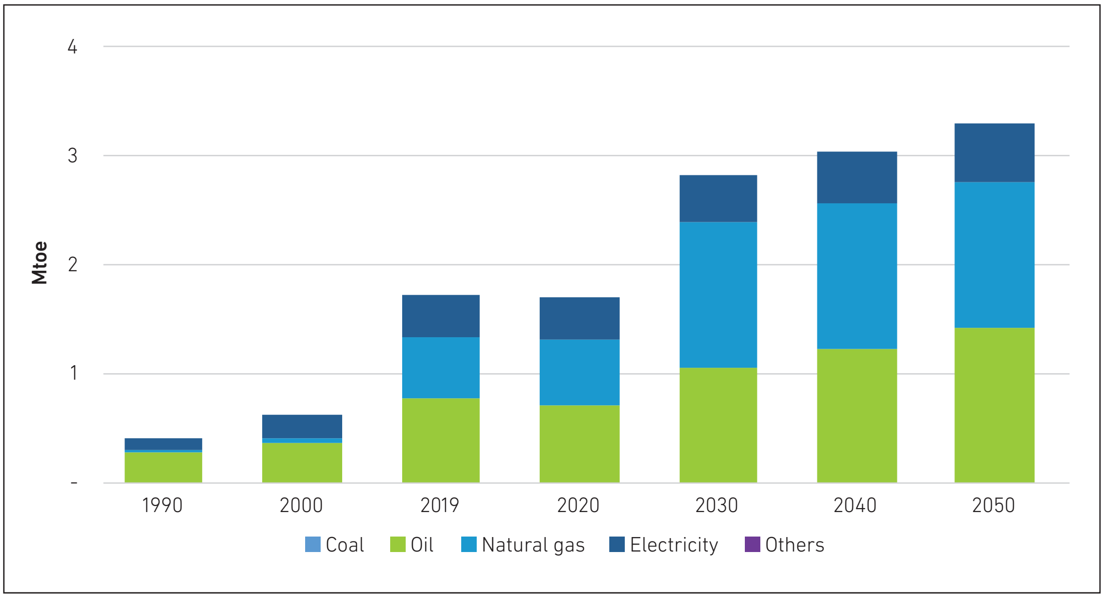


Mtoe = million tonnes of oil equivalent.

Source: Author.

Whilst oil has been the dominant fuel historically, attributed to growth in demand from transport, natural gas demand is expected to grow significantly over the outlook period. The share of natural gas will increase to 40.6% in 2050, compared with 32.6% in 2019, and the oil share will decrease from 60.1% to 43.1% in 1990–2050. The trend is driven mainly by new downstream facilities, such as the Brunei Methanol Company and the Brunei Fertiliser Industries (Figure 3.5). Demand for oil is expected to continue increasing, whilst demand for electricity is expected to increase marginally.

Figure 3.5 Brunei Darussalam – Final Energy Consumption by Fuel, Business as Usual



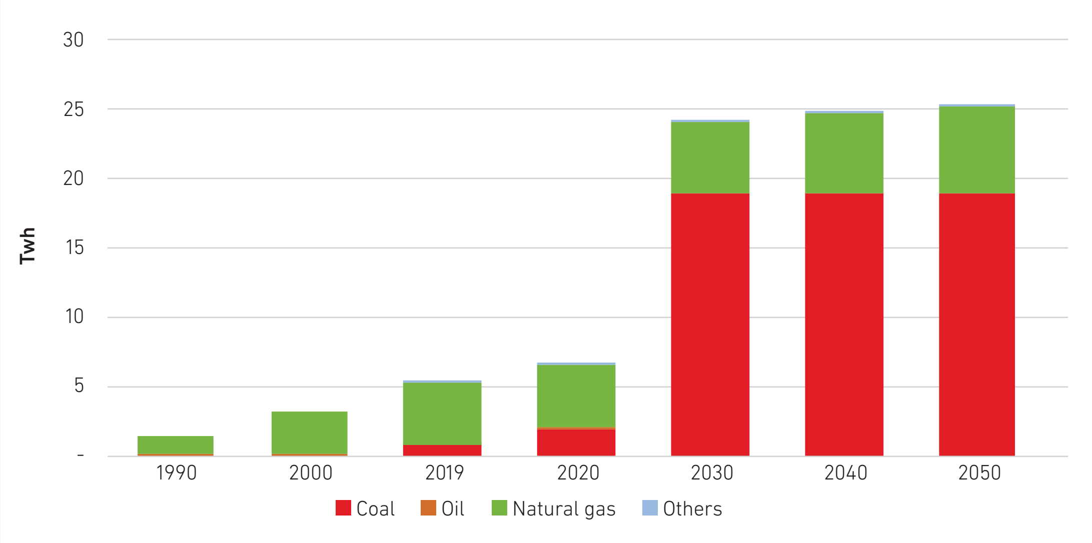
Mtoe = million tonnes of oil equivalent.

Source: Author.

4.1.3. Electricity Generation

Power generation from public utilities is dominated by natural gas whilst major downstream facilities are highly dependent on coal. The fuel mix throughout the outlook period mostly reflects changes in the power sector. Coal-fired power generation is expected to increase about 30-fold, with about 18.75 TWh of electricity generated in 2050, 6.20 TWh from natural gas and 0.033 TWh from renewable energy. Diesel power plants are expected to be phased out from 2023 onward.

Figure 3.6 Brunei Darussalam – Electricity Generation by Fuel, Business as Usual



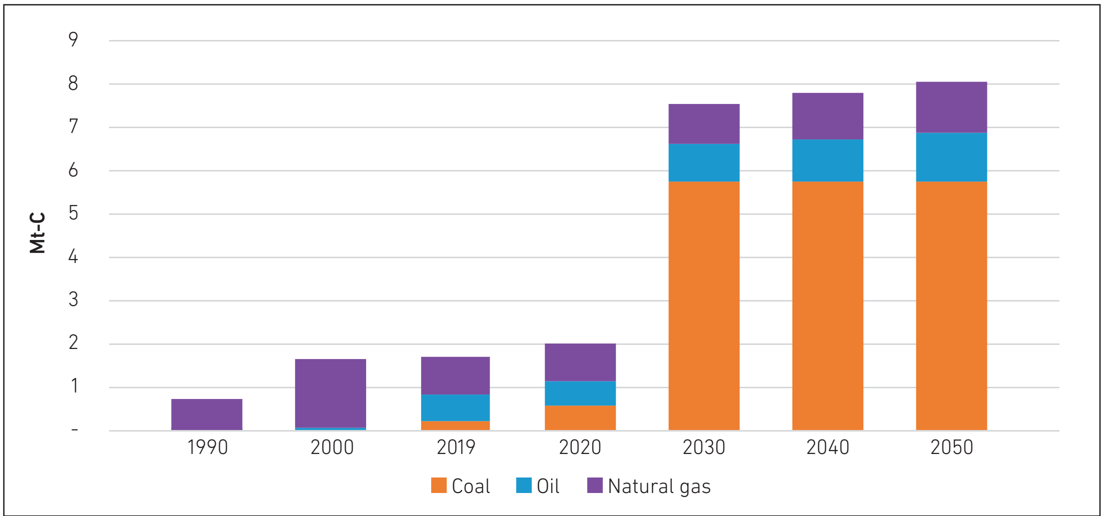
TWh = terawatt-hours.

Source: Author.

4.1.4. CO_2 Emissions

Energy-related CO_2 emissions correlate to TPES. With minimal use of renewable energy, CO_2 emissions will increase from 1.7 million tonnes of carbon (Mt-C) in 2019 to 8 Mt-C in 2050 in BAU. Coal is projected to be the largest emission source, accounting for 71.5% of total CO_2 emissions, followed by natural gas at 14.6% and oil at 13.9%.

Figure 3.7 Brunei Darussalam – Carbon Dioxide Emission by Fuel, Business as Usual



Mt-C = million tonnes of carbon.

Source: Author.

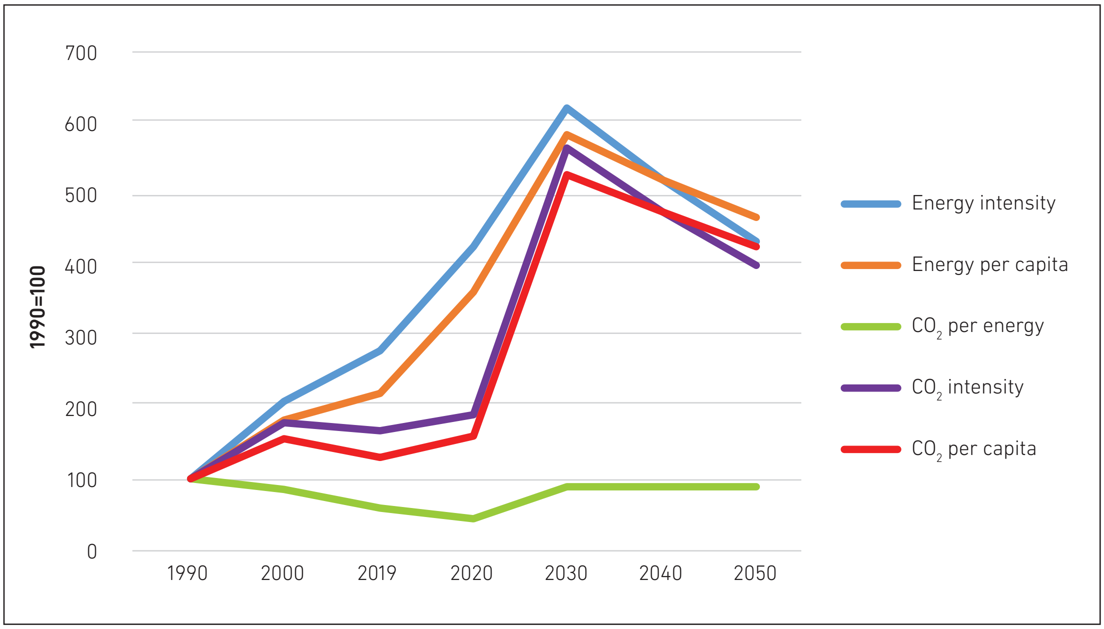
4.1.5. Energy Indicators

In 1990–2019, energy intensity showed an increasing trend. TPES doubled from 121 toe/US$ million (in constant 2010 values) to 324 toe/US$ million (in constant 2010 values) in 1990–2019. TFEC increased from 41 toe/US$ million (in constant 2010 values) to 119 toe/US$ million (in constant 2010 values) in 1990–2019. The trend is related to stable economic growth and the emergence of new power plants (Hengyi) in 2019. TPES and TFEC will increase until 2030 before they start decreasing in 2030–2050, to 524 toe/US$ million (in constant 2010 values) and 120 toe/US$ million (in constant 2010 values) in 2050, respectively. The trend is related to increased use of coal for Hengyi Phase 2 until 2030 and the phasing out of Hengyi Phase 2 after 2030.

Primary energy per capita increased from 4.5 toe/person in 1990 to 5.1 toe/person in 2019 and will continue to increase to 26.1 toe/person in 2030 but will fall to 20.9 toe/person in 2050.

CO_2 intensity reflects the increasing trend of energy intensity, from 75.1 t-C/US$ million (in constant 2010 values) in 1990 to 118 t-C/US$ million (in constant 2010 values) in 2019, then to 242.6 t-C/US$ million (in constant 2010 values) in 2030 and 299.4 t-C/US$ million (in constant 2010 values) in 2050. Per capita CO_2 significantly increased from 2.8 t-C/toe in 1990 to 5.6 t-C/toe in 2019 and will continue to increase to 11.9 t-C/toe in 2050 (Figure 3.8).

Figure 3.8 Brunei Darussalam – Energy Indicators, Business as Usual



Source: Author.

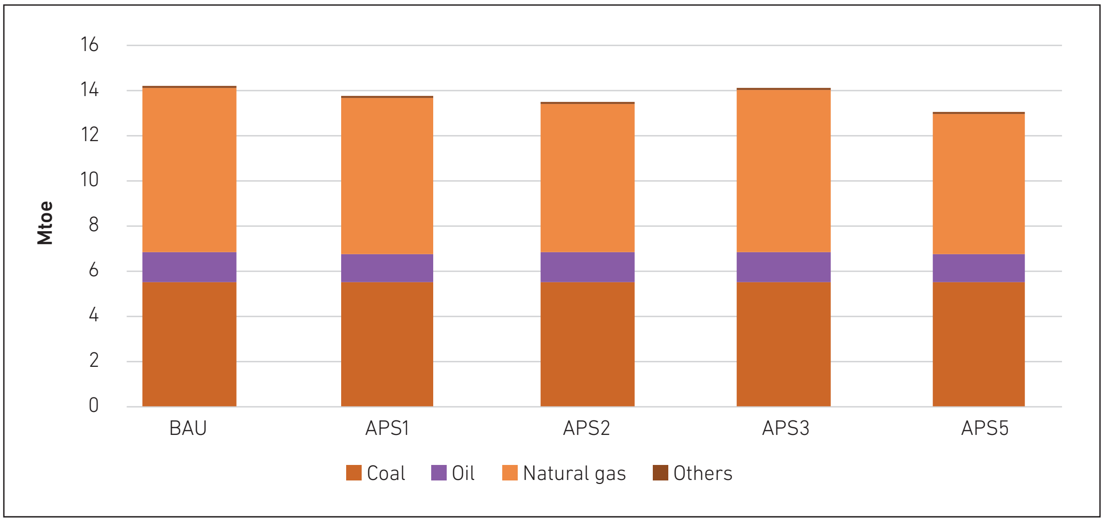
4.2. Alternative Policy Scenario

The APS was developed to estimate the energy-saving potential of Brunei Darussalam to achieve its energy intensity-reduction targets by deploying advanced technologies for energy saving and enforcing relevant initiatives.

4.2.1. Primary Energy Supply

TPES for coal remains the same in BAU and APS. Oil supply in 2050 under the APS is projected to be 10% lower than BAU as a result of implementing EEC measures. Natural gas supply in APS is also predicted to be about 10% lower than in BAU. However, renewable energy supply will increase significantly, particularly from solar PV sources.

Figure 3.9 Brunei Darussalam – Reduction of Primary Energy Supply, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, Mtoe = million tonnes of oil equivalent.

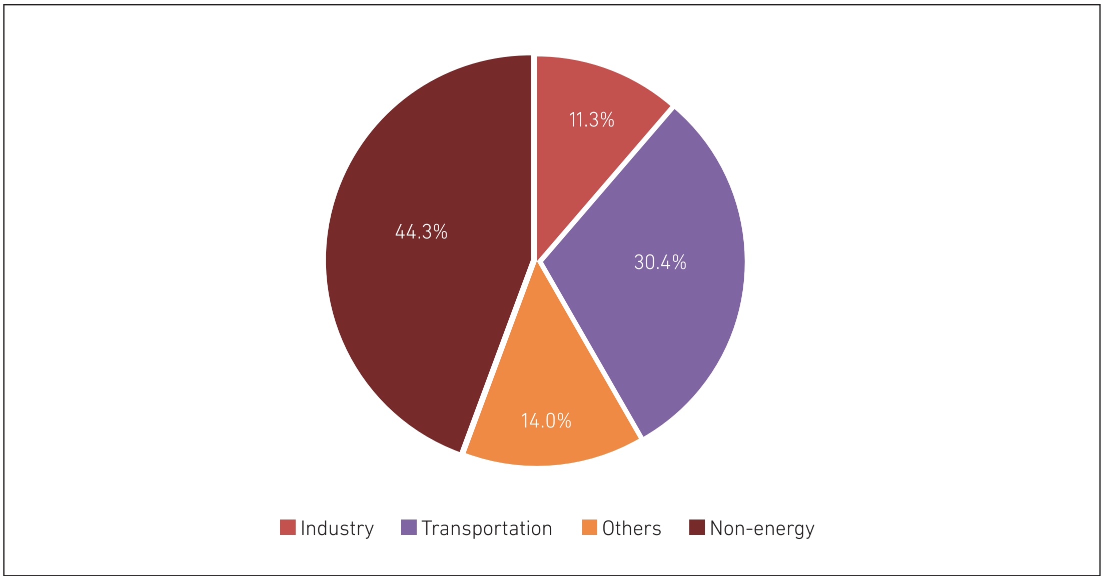
Source: Author.

The energy that could potentially be saved by implementing EEC measures and by developing renewable energy is about 1.1 Mtoe of TPES or equivalent to a reduction of 4.1% from BAU in 2050 (Figure 3.9).

4.2.2. Final Energy Consumption

Overall TFEC in 2050 will be 3 Mtoe. In 2050, 11.3% of energy demand will be required by industry, followed by 'others' at 14.0% and transport at 30.4%. Demand by the non-energy sector will be at 44.3% (Figure 3.10).

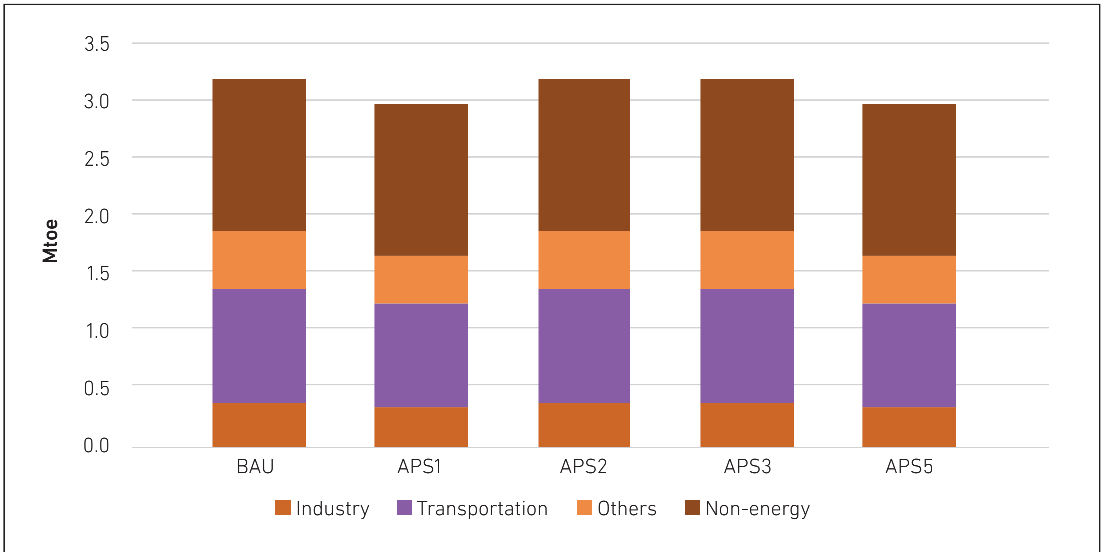
Figure 3.10 Brunei Darussalam – Final Energy Consumption Share by Sector, Alternative Policy Scenario



Source: Author.

TFEC is projected to remain the same in APS against BAU in the non-energy sector, at 1.32 Mtoe in 2050. However, TFEC will be reduced by 7% by 2050 (Figure 3.11) with EEC initiatives in place.

Figure 3.11 Brunei Darussalam – Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario

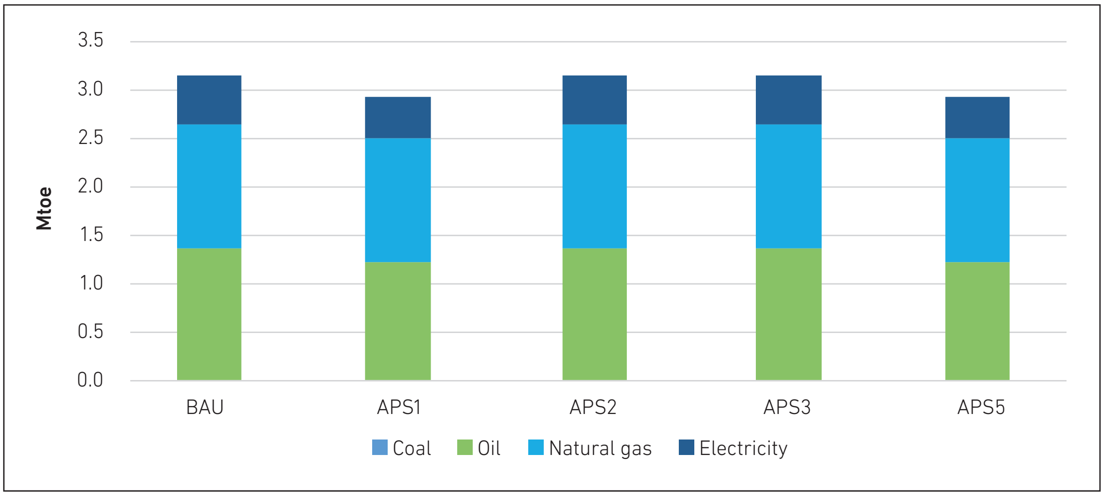


APS = alternative policy scenario, Mtoe = million tonnes of oil equivalent.

Source: Author.

TFEC is projected to remain the same in APS and BAU, at 1.3 Mtoe for natural gas in 2050. With the implementation of the EEC programme, TFEC will be reduced by about 10% or 1.24 Mtoe for oil and by about 18% for electricity (0.43 Mtoe) in 2050 in scenarios against BAU (Figure 3.12).

Figure 3.12 Brunei Darussalam – Final Energy Consumption by Fuel Type, Business as Usual and Alternative Policy Scenario



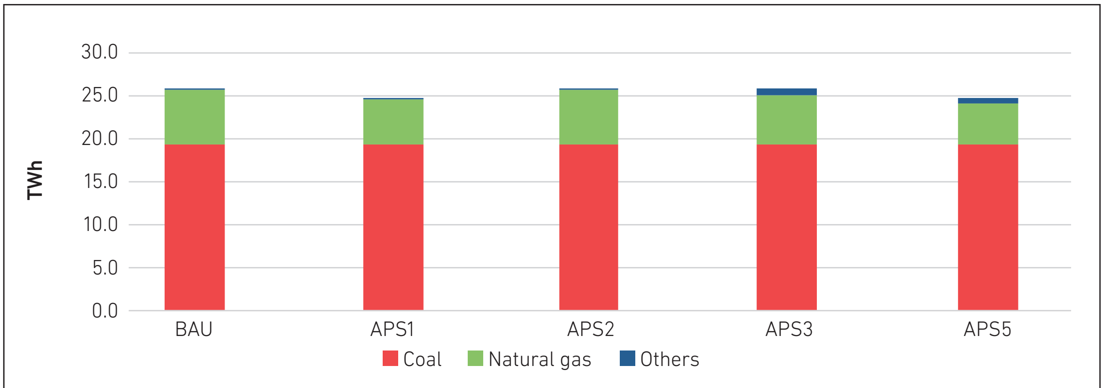
APS = alternative policy scenario, Mtoe = million tonnes of oil equivalent.

Source: Author.

4.2.3. Power Generation

Power generation is projected to decline by 4% to 23.88 TWh from 24.98 TWh in BAU owing to the increase in renewables. As coal-fired generation remains unchanged across all scenarios, the share of renewables will increase slightly in APS, 2% compared with 0.1% in BAU (Figure 3.13).

Figure 3.13 Brunei Darussalam – Power Generation, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, Mtoe = million tonnes of oil equivalent.

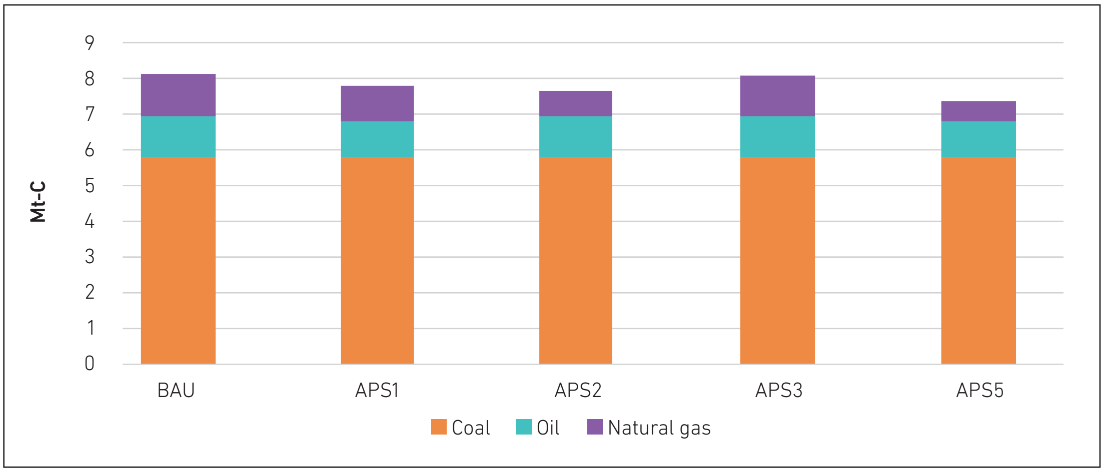
Source: Author.

4.2.4. CO_2 emissions

CO_2 emissions from coal will remain unchanged in 2050 compared with BAU (Figure 3.14), at 5.69 Mt-C. CO_2 emissions from oil against BAU in 2050 will be reduced by 10% once energy-saving initiatives are implemented.

Results of the model show a significant reduction against BAU, with a total of 0.46 Mt-C by 2050. The decrease in CO_2 is significantly attributed to more efficient power generation plants. CO_2 emissions from natural gas will remain unchanged even after the introduction of renewable energy in 2050. Improved efficiencies in power generation plants, coupled with energy-saving initiatives, will further reduce overall CO_2 emissions by 0.72 Mt-C in 2050 (Figure 3.14).

Figure 3.14 Brunei Darussalam – CO_2 Emissions in Energy Consumption, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, Mtoe = million tonnes of carbon.

Source: Author.

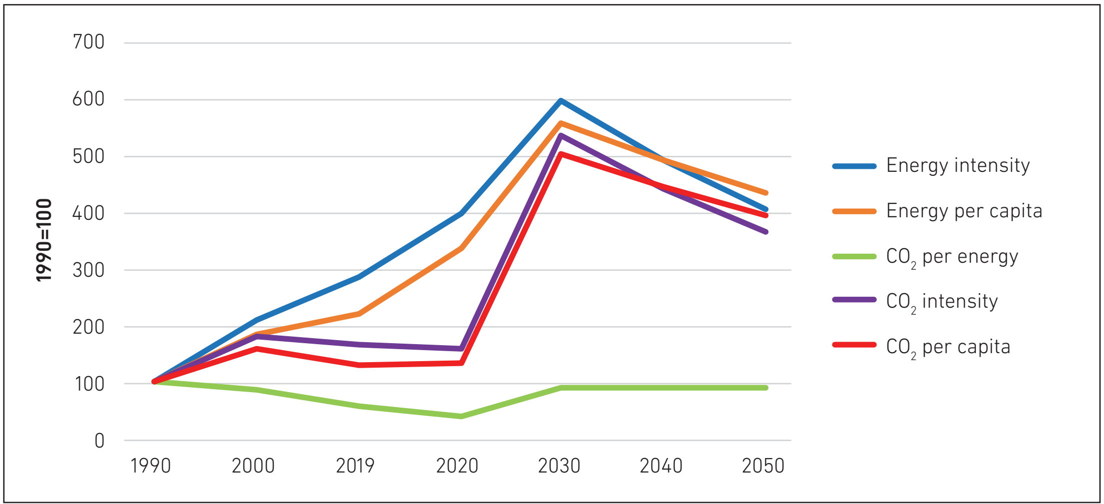
4.2.5. Energy Indicators

Energy intensity shows an increasing trend in 2019–2030 as TPES doubled from 324 toe/US$ million (in constant 2010 values) to 712 toe/US$ million (in constant 2010 values), and TFEC significantly increased from 119 toe/US$ million (in constant 2010 values) in 2019 to 152 toe/US$ million (in constant 2010 values) in 2030. The increasing trend is related to stable economic growth. TPES and TFEC will start to show a decreasing trend in 2030–2050, at 483 toe/US$ million (in constant 2010 values) and 112 toe/US$ million (in constant 2010 values) in 2050, respectively.

Primary energy per capita will increase to 24.7 toe/person in 2030 from 5.1 toe/person in 2019 and will drop to 19.2 toe/person in 2050.

CO_2 intensity will reflect the increasing trend of energy intensity, from 118 t-C/US$ million (in constant 2010 values) in 2019 to 399 t-C/US$ million (in constant 2010 values) in 2030 before dropping to 272 t-C/US$ million (in constant 2010 values) in 2050 (Figure 3.15).

Figure 3.15 Brunei Darussalam – Energy Indicators, Alternative Policy Scenario



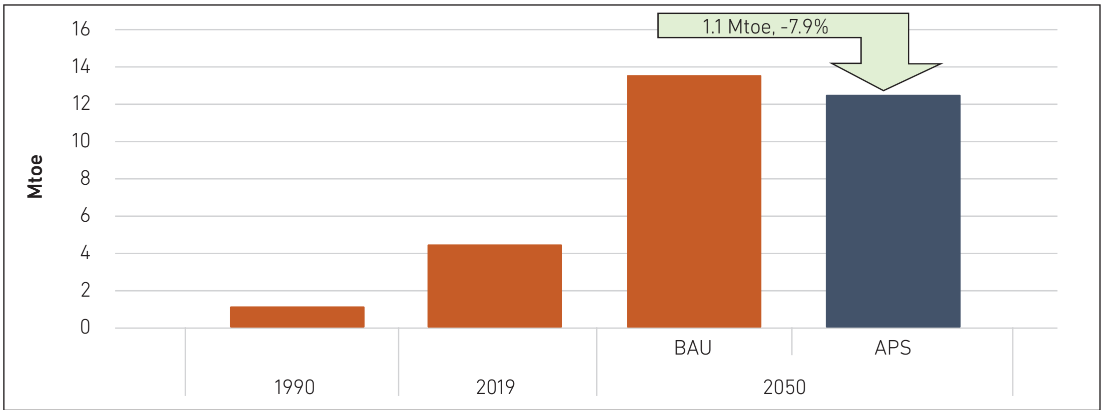
Source: Author.

4.2.5. Projected Energy Saving

4.2.5.1. Primary Energy Supply

Implementing EEC initiatives, improving thermal efficiency in power generation plants, and integrating renewables will reduce TPES by 1.1 Mtoe or 7.9% from BAU in 2050.

Figure 3.16 Brunei Darussalam – Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario



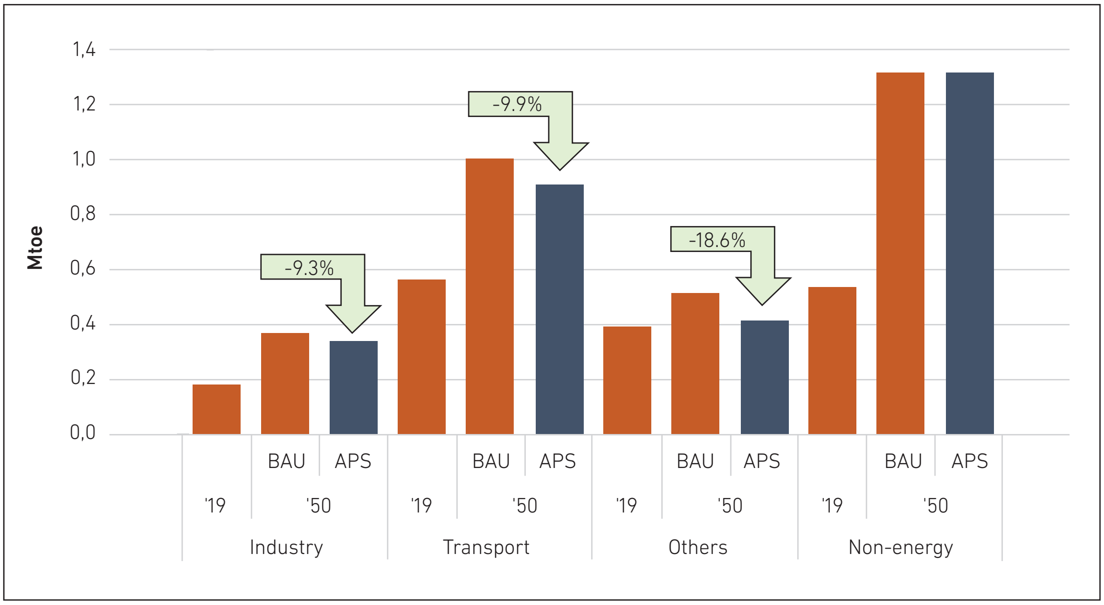
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author.

4.2.5.2. Final Energy Consumption and Primary Energy Supply

Contributions from improved fuel efficiency in transport are projected to result in the decline in TFEC in APS. TFEC in transport could decrease by 9.9% in 2050 compared with BAU. 'Others' will show significant potential reduction by 18.6% with implementation of more EEC such as standards and labelling in the residential and commercial sectors. Industry's demand will be 9.3% lower in 2050.

Figure 3.17 Brunei Darussalam – Total Final Energy Consumption by Sectors, Business as Usual and Alternative Policy Scenario

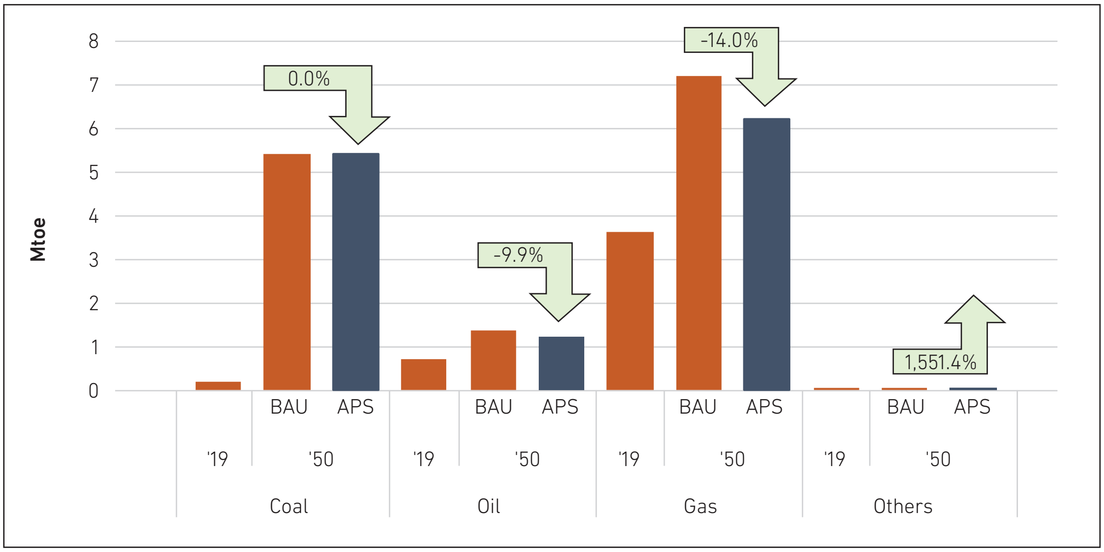


APS = alternative policy scenario, BAU= business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author.

In 2050, 0.05 Mtoe solar PVs will be deployed as part of the programme to increase renewable energy share in generating electricity. Oil consumption will reduce with improvements in fuel economy standards, with savings of 9.9% in 2050. Natural gas is projected to decline with increased efficiency in power plants, contributing to about 14% savings. Coal demand will remain consistent. Figure 3.18 is comparison of primary energy supply between BAU and APS.

Figure 3.18 Brunei Darussalam – Total Primary Energy Supply by Fuel Type, Business as Usual and Alternative Policy Scenario



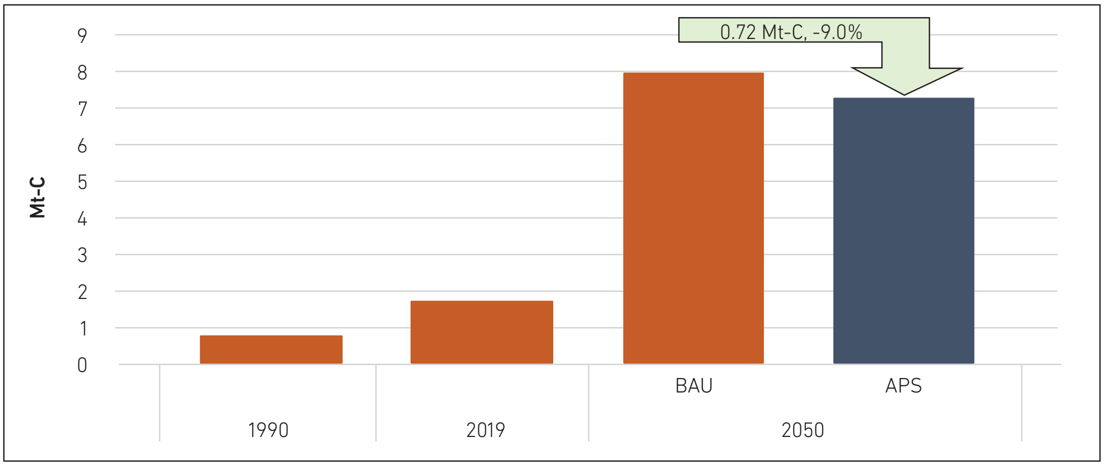
APS = alternative policy scenario, BAU= business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author.

4.2.5.3. CO_2 Emissions

Reduction of fossil fuel consumption will be the main driver of CO_2 emission reduction in 2050. The largest reduction will come from natural gas, with 50%. Overall CO_2 emissions are 9% lower in 2050 compared with BAU (Figure 3.19).

Figure 3.19 Brunei Darussalam – CO_2 Emissions, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU= business as usual, Mt-C = million tonnes of carbon.

Source: Author.

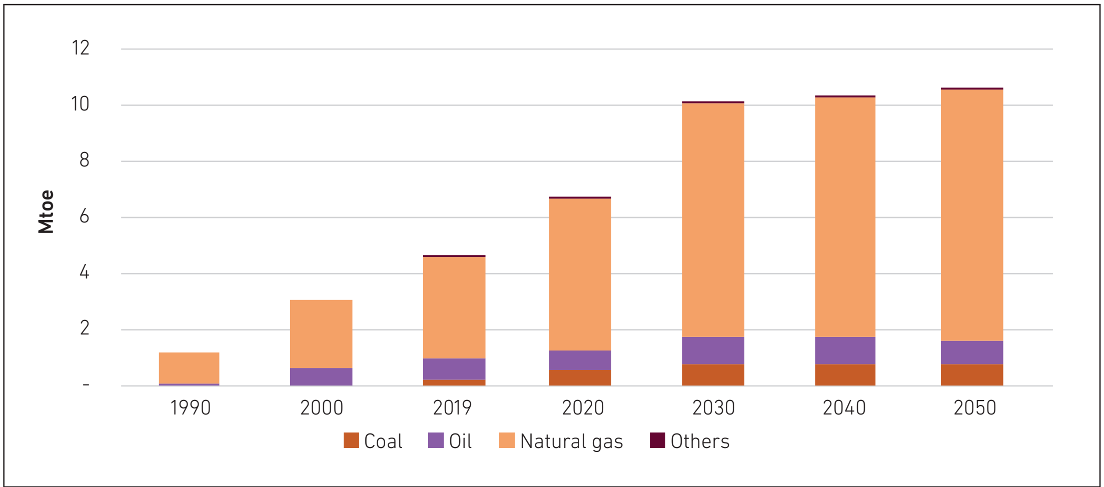
4.3. Low-carbon Energy Transition Scenario

LCET is underpinned by emission-reduction targets of Brunei Darussalam's two aspirational goals: NDC by 2030 and net-zero emission commitment by 2050. LCET explores the impact on energy supply and demand of new technologies, such CCUS, for energy own-use, particularly on natural gas, from 2040. The scenario introduces significant penetration of electric vehicles.

4.3.1. Primary Energy Supply

LCET sees a decline in TPES by 19.2% to 10.4 Mtoe compared with APS. The share of natural gas is projected to increase to 84.3% in 2050 and the shares of coal and oil to decline to 7.4% and 7.6%, respectively. The trend is assumed to be attributed to the switch from natural gas to coal in the second phase of the Hengyi petrochemical complex.

Figure 3.20 Brunei Darussalam – Total Primary Energy Supply, Low-carbon Energy Transition



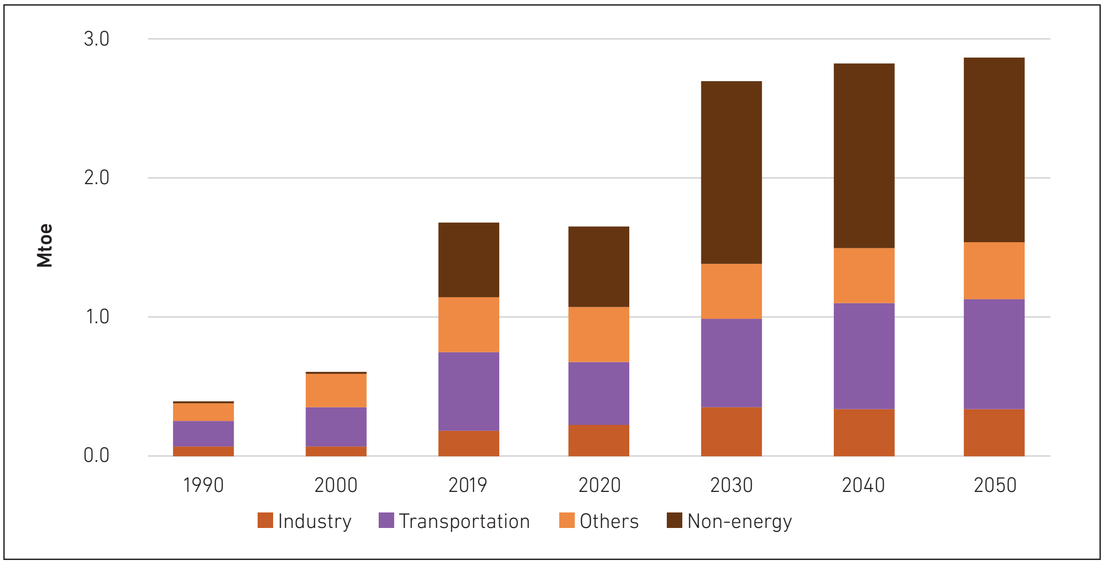
Mtoe = million tonnes of oil equivalent.

Source: Author.

4.3.2. Final Energy Consumption

The highest reduction in TFEC is expected to occur in transport: 13.6% in 2050 compared with APS. The drop is primarily the result of stricter fuel efficiency regulations and the introduction of electric vehicles. 'Others' will see further demand reductions by 1.5% if stringent EEC measures for buildings are implemented.

Figure 3.21 Brunei Darussalam – Total Final Energy Consumption by Sector, Low-carbon Energy Transition

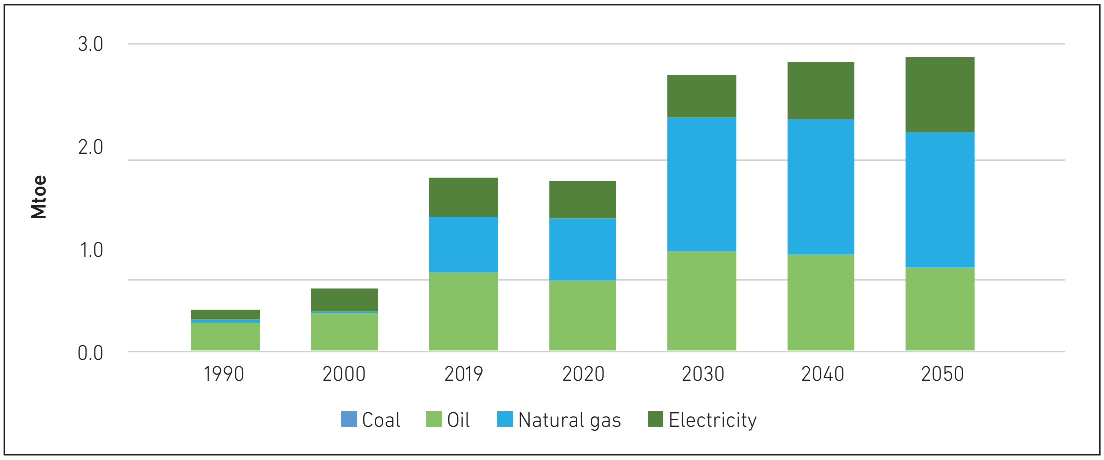


Mtoe = million tonnes of oil equivalent.

Source: Author.

In 2050, electricity's share of 25.3% will be noticeably higher in TFEC than the 14.4% share in BAU, in line with anticipated electricity demand for electric vehicles. Whilst the share of oil will decline to 28.5%, the share of natural gas is expected to increase to 46.2% as demand for natural gas will continue to surge with the expansion of downstream industry. Total TFEC is projected to drop from 3 Mtoe to 2.8 Mtoe in APS in 2050.

Figure 3.22 Brunei Darussalam – Total Final Energy Consumption by Fuel Types, Low-carbon Energy Transition



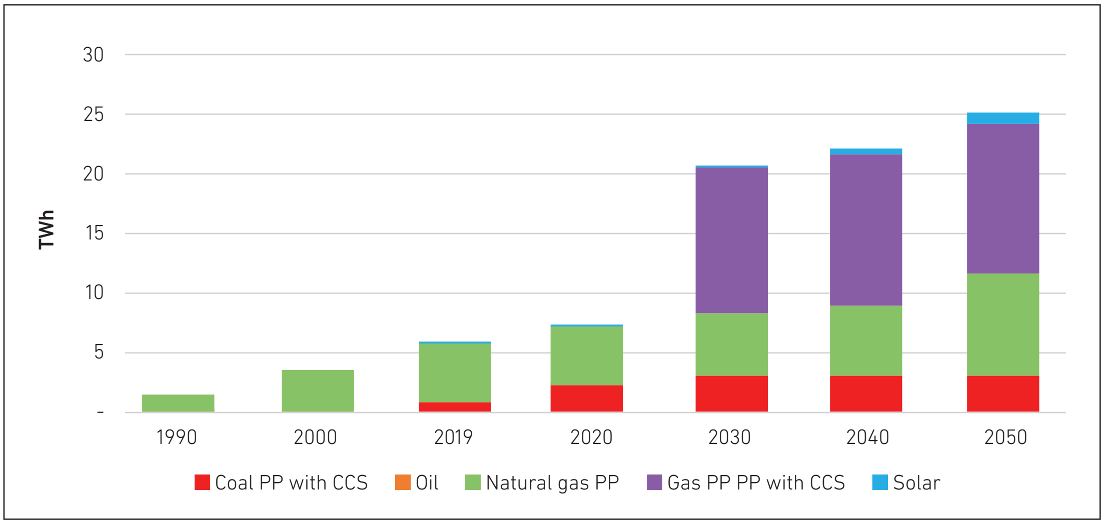
Mtoe = million tonnes of oil equivalent.

Source: Author.

4.3.3. Power Generation

Power generation is expected to remain largely from fossil fuels, with an increase of natural gas share to 81.3% compared with 14% in APS, whilst the share of coal will drop to 18.7%. It is assumed that the own use of coal to operate Hengyi Phase I is not affected in LCET and will remain the same as in BAU and APS. However, LCET will assume that Hengyi Phase II will transition to gas-fired power generation, including CCUS, from coal. The transition will result in a moderate reduction in electricity generation to 22.6 TWh in 2050 from 23.98 TWh in APS.

Figure 3.23 Brunei Darussalam – Power Generation, Low-carbon Energy Transition



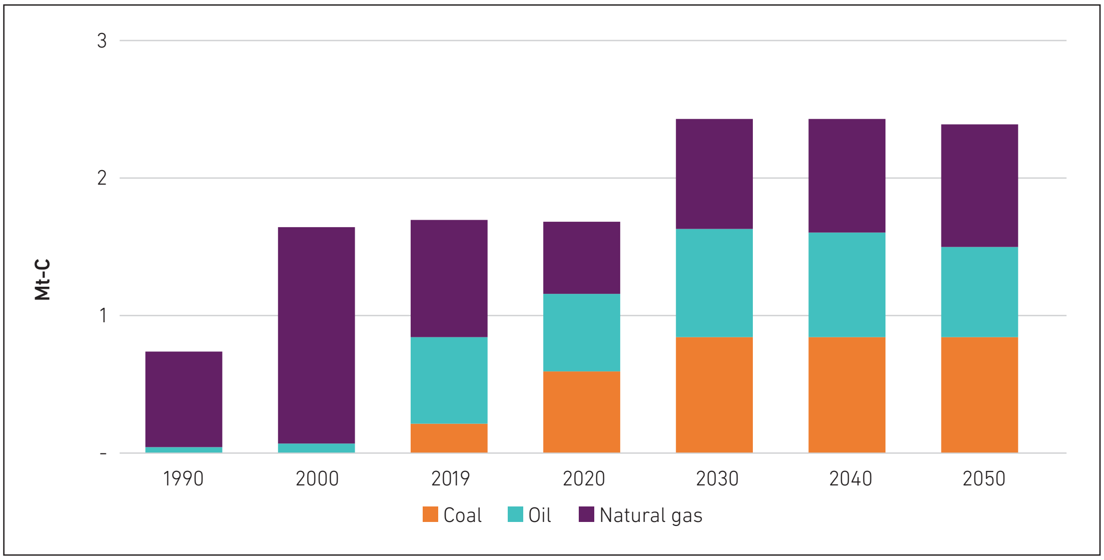
CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

Source: Author.

4.3.4. CO_2 Emissions

Total CO_2 emissions will peak in 2030 and show a declining trend of about –0.17% per year to reach 2.3 Mt-C in 2050, as less demand for oil is expected. Natural gas will become the major source of CO_2 emissions, with a 37.6% share in 2050, followed by coal with 35.2%. Oil is projected to emit the least, with 27.2%. Using a CCUS unit in natural gas power plants will reduce CO_2 emissions by 67.6% in LCET compared with APS.

Figure 3.24 Brunei Darussalam – CO_2 Emissions, Low-carbon Energy Transition



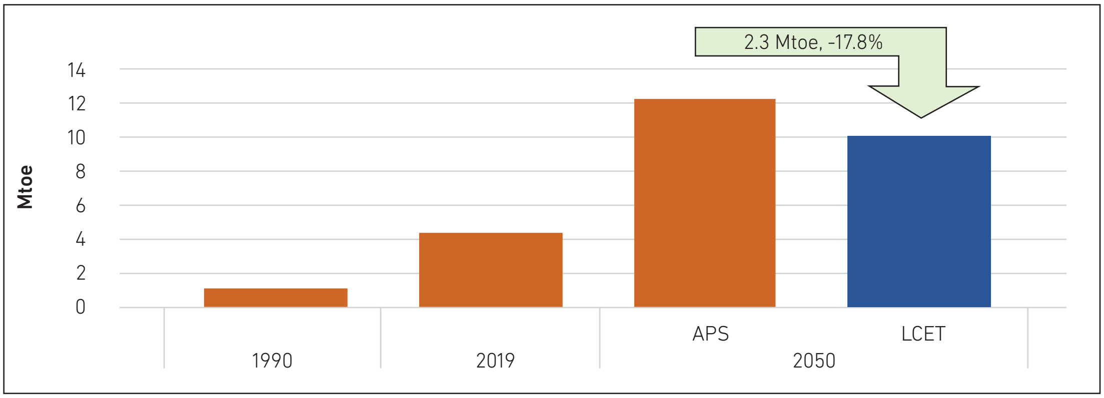
Mt-C = metric tonne of carbon.

Source: Author.

4.3.5. Saving of Fossil Fuel Consumption and CO_2 Emission Reduction

At 10.5 Mtoe in 2050, TPES in LCET is 2.3 Mtoe less than in BAU, with fuel saving of 17.8%. CO_2 emissions are expected to be 67.6% lower than in APS. Projected carbon removal of about 3.8 Mt-C and CO_2 emissions of 2.3 Mt-C in 2050 will result in a net sink of –1.5 Mt-C. Hence, the NDC and net-zero emission target is assumed to be achieved in LCET, which means that ambitious measures are required to put the economy on a sustainable energy pathway to realise net-zero emission by 2050.

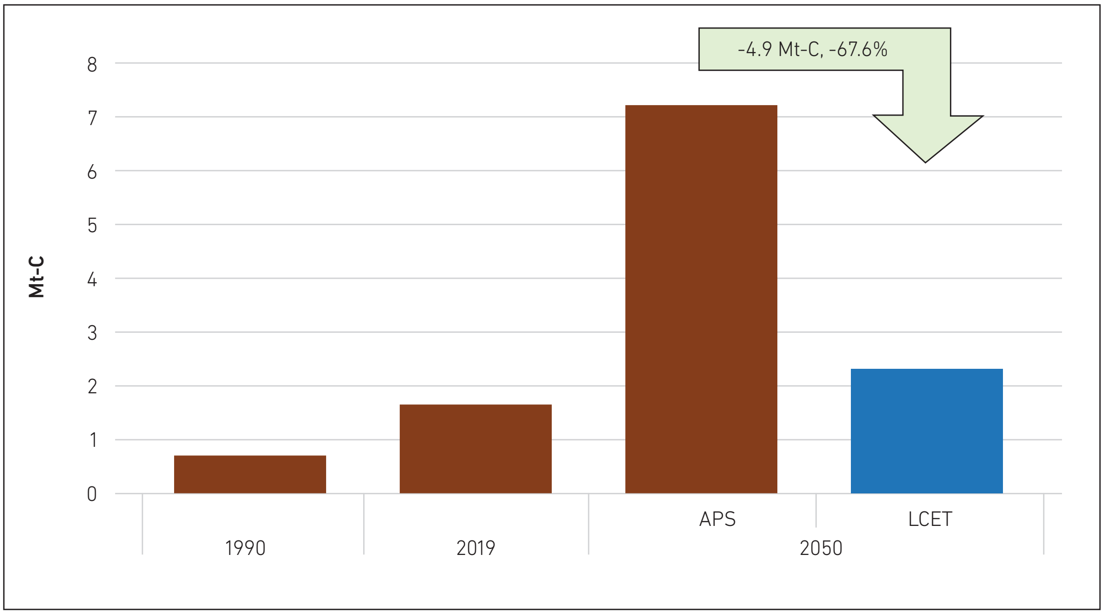
Figure 3.25 Brunei Darussalam – Saving of Fossil Fuel Consumption, Alternative Policy Scenario and Low-carbon Energy Transition



APS = alternative policy scenario, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author.

Figure 3.26 Brunei Darussalam – CO_2 Emission Reduction, Alternative Policy Scenario and Low-carbon Energy Transition



APS = alternative policy scenario, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author.

5. Key Findings

- Brunei Darussalam will remain heavily reliant on fossil fuels to meet growing energy demand in all scenarios, with increasing dependency on oil imports.
- The non-energy sector will drive energy demand as a significant volume of natural gas will be needed to expand downstream industries as the economy diversifies.
- Transport will offer the greatest savings in the net-zero emission scenario, with improved vehicle efficiency and greater use of electric vehicles.
- Although renewable energy is the fastest-growing energy source after coal, growth is considered moderate as coal will take the lead.
- Energy-related CO_2 emissions will decrease significantly in the net-zero emission scenario compared with APS. Current policies are not sufficient to meet NDC as emissions continue to rise in BAU and APS.
- The power sector must be decarbonised through CCS or higher shares of renewable energy.

6. Policy Recommendations

To increase renewable energy sources and EEC, Brunei Darussalam will continue to explore and promote low-carbon measures through several initiatives:

i) Setting sustainable energy development targets

a) The energy sector aims to reduce energy intensity by 45% in 2035 from the baseline year of 2005. Energy intensity can be reduced by improving EEC and diversifying the economy with high value-added but less energy-intensive industries.

b) The country can adopt and use renewable energy technologies that focus on increasing the total share of renewable energy to 200 MW by 2025 and to at least 70% of total capacity in the power generation mix by 2050. That could be achieved by public and private investments in the technologies. Measures include policies enabling installation and integration of renewable energy such as the net-metering programme, renewable portfolio standards, reverse bidding through public–private partnerships, improvement of grid infrastructure to allow integration of renewable energy into the grid through rooftop solar PV, and large-scale solar PV as well as floating solar PV. Other renewable energy such as wind energy and hydropower imports can be explored.

ii) Promoting energy efficiency and conservation

a) Improving supply- and demand-side efficiency

On the supply side, Brunei Darussalam is pursuing a strategy to improve efficiency of existing open-cycle gas turbines whilst more efficient combined-cycle gas turbines are being used for new capacity expansion. Reduction of electricity consumption from the user side (demand side) will enhance energy savings further by increasing public awareness.

b) Managing electricity and fuel demand

Demand management is one of the strategies to reduce the use of fossil fuels in electricity generation and transport, and can be achieved by improving energy efficiency of the stock of energy technologies and increasing the utilisation efficiency of existing and future technologies.

- **Standards and labelling order (SLO).** Rolled out in 2021, standards and labelling order for electrical appliances are regulatory frameworks that allow only efficient technologies to be used in residences and only efficient electrical appliances to be sold in the market. Regulation has started with air conditioning systems and will cover refrigerators, lighting systems, and water heaters.
- **EEC guidelines for non-residential buildings**. The guidelines aim to establish EEC standards for buildings. The EEC building guideline is mandatory for all government buildings. The Department of Energy, Prime Minister's Office, in collaboration with the Ministry of Development, is planning to make the guidelines mandatory in the commercial sector.
- **Energy management**. Brunei Darussalam is considering adopting an energy management system that is compatible with ISO 50001. Building owners will be encouraged to introduce management systems that include equipment to monitor energy consumption, such as building automation systems, demand controllers, and building energy management systems. Deploying energy managers in buildings is crucial to monitor and manage the energy efficiency of a facility or organisation by implementing conservation measures, monitoring energy consumption, assessing business decisions for sustainability, and seeking out opportunities to increase energy efficiency.

- **Tariff reforms for the residential sector**. The progressive electricity tariff structure, introduced in 2012, is a tool to ensure the efficient use of energy by providing a financial disincentive for higher energy consumption. The reform's main objective is to help low-income citizens by charging them BN$0.01/kWh for basic electricity consumption, thus promoting energy saving and avoiding energy wastage. Tariff reforms will be extended to the commercial sector to further promote EEC.

iii) Decarbonisation of the power sector

- **Hydrogen**. Hydrogen is a potential energy source that could serve as feedstock and storage; decarbonise energy, transport, and industry; and generate power. Hydrogen technologies can contribute to carbon neutrality by producing hydrogen from natural gas or methane via steam-reforming processes (grey hydrogen), fossil fuel with CCS (blue hydrogen), and renewable energy (green hydrogen).
- **Coal-to-gas switch**. Fuel switching is recommended to meet environmental or climate change challenges. Switching from coal – the largest emitter of CO_2 – to natural gas may not be a long-term answer, but it can significantly improve air quality. The emissions offset from fuel switching can support electric vehicles running on zero-carbon electricity.

iv) Decarbonisation of transport

- **Deployment of electric vehicles.** The strategy is to increase the share of electric vehicles to 100% of total annual sales by 2050. The target of electric vehicle deployment is subject to future development of electric vehicle technologies and infrastructure. Brunei Darussalam rolled out a pilot project for electrical vehicles in 2021 by providing public charging infrastructure.

v) Introduction of new technologies

- **CCS**. Capturing and storing up to 90% of CO_2 from burning fossil fuel for electricity generation and in industrial processes can reduce GHG emissions, lessen the impacts of climate change, and help achieve the net-zero emission target.

To achieve the objectives of Wawasan Brunei 2035, all economic sectors, including energy, must significantly boost their activity. Despite the growing emphasis on EEC, energy demand is expected to continue its steady ascent. Thus, the country will continue to rely on fossil fuels as its primary source of energy to meet rising domestic demand.

CHAPTER 4

Cambodia Country Report

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1. Background

The Kingdom of Cambodia is in the Lower Mekong region of Southeast Asia. The country has an area of 181,035 square kilometres and an 800-kilometre border with Thailand in the west. Lao People's Democratic Republic (Lao PDR) lies to the north and Viet Nam to the east. The landscape is dominated by lowland plains around the Mekong River and the Tonle Sap Lake. The country has about 2.5 million hectares of arable land and more than 0.5 million hectares of pastureland.

For 2 decades, until March 2020, before the coronavirus disease (COVID-19) pandemic, Cambodia's gross domestic product (GDP) growth was strong, at about 7.7% average yearly. The government's policy reforms have attracted foreign direct investment. Energy has been critical in supporting economic activities and growth. The impact of the pandemic on energy demand has prompted a rethinking of the future energy mix, including types of fuel to meet electricity demand and demand in other sectors. Cambodia has revised its Power Development Plan 2020–2030, which foresees a larger share of gas consumption in the power generation mix. Post–COVID-19 economic recovery is expected from 2022 onwards. Thus, energy demand is expected to rebound strongly, with liquefied natural gas (LNG) and other clean fuels playing a crucial role in the energy mix, especially in power generation, industrial use, transport, and commercial and residential use.

The longer historical energy data set reflects the following energy demand–supply analysis. Total final energy consumption (TFEC) grew by 6.6% per year in 2000–2010 and by 7.9% in 2010–2019. Energy demand increased rapidly after 2010. If biomass is excluded, the rate in 2000–2010 was 9.9% and 11.2% in 2020–2019. Demand for conventional energy such as oil and especially electricity increased remarkably by 17.9% per year in 2000–2019. Total primary energy supply (TPES) increased by 5.8% per year in 2000–2010 and by 8.0% per year in 2010–2019, showing the same trend as that of TFEC. Due to the significant increase in electricity demand, Cambodia rapidly increased its hydropower and coal power generation in 2010–2019. Liquefied petroleum gas (LPG), used for cooking and as transport fuel, marked a higher increase ratio in 2000–2019. However, traditional biomass has been phasing out and, as a result, TPES without biomass increased by 11.1% in 2000–2019. Cambodia is promoting energy efficiency and conservation (EEC) in accordance with the Energy Efficiency and Conservation Master Plan for Cambodia prepared by the Economic Research Institute for ASEAN and East Asia. Using the longer historical energy data set, the energy outlook business-as-usual (BAU) model has been updated based on the latest future macroeconomic assumptions, although the results are more moderate than previous ones. The growth rate of TPES in 2019–2050 is 4.4% per year compared with 5.6% in 2018–2050 due to different GDP assumptions, which are 5.8% in the revised case and 6.4% in the previous one. Data coverage is extended from 9 years to 19 years, so that the elasticity between GDP and energy consumption has improved, from 0.875 of the previous results to 0.8 of the current ones. Longer data coverage seems to provide better energy outlook results than shorter data coverage when the econometrics approach is applied.

2. Modelling Assumptions

2.1. Gross Domestic Product and Population

Based on energy demand forecast to 2050, GDP is assumed to increase at an average annual growth rate (AAGR) of 6.18% and population is projected to increase steadily at an AAGR of 1.5%, resulting in an AAGR of GDP per capita of 4.61%.

Table 4.1 Cambodia – Updated Energy Information

Year	2019	2020	2030	2040	2050	AAGR, 2019–2050
GDP (billions 2010 US$)	20.92	22.28	41.36	74.90	134.14	6.18
Population (millions)	16.49	16.73	19.42	22.54	26.16	1.5

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

Source: Author.

2.2. Electricity Generation

In BAU, LNG is expected to dominate the fuel mix in 2050, followed by hydro and solar energy. Cambodia is predicted to have total installed electricity generation capacity of 22,604.07 megawatts (MW) in 2050, mainly from LNG, with 8,700 MW; hydro energy, 6,156.7 MW; and solar energy, 4,526.8 MW.

Table 4.2 Cambodia – Installed Capacity, Business as Usual

Installed Capacity (megawatt)	2019	2020	2030	2040	2050
Coal	675.00	675.00	2,210.00	2,210.00	2,210.00
Heavy fuel oil	624.80	617.55	545.03	472.52	400.00
Hydro	1,331.70	1,331.70	1,561.70	3,156.70	6,156.70
Biomass	30.57	30.57	30.57	30.57	30.57
Solar	105.32	215.81	1,976.80	3,226.80	4,526.80
Natural gas	-	-	-	2,700.00	8,700.00
Wind	-	-	180.00	380.00	580.00
Total	2,767.39	2,893.71	6,757.95	12,176.59	22,604.07

Source: Author.

Table 4.3 Cambodia – Installed Capacity, Alternative Policy Scenario 5

Installed Capacity (megawatt)	2019	2020	2030	2040	2050
Coal	675.00	1,000.00	1,640.00	1,640.00	1,640.00
Oil	624.80	617.55	545.03	472.52	400.00
Hydro	1,331.70	2,103.00	4,727.00	6,127.00	7,127.00
Biomass	30.57	30.57	30.57	30.57	30.57
Solar	105.32	215.81	1,976.80	3,596.80	5,596.80
Natural gas	-	-	-	2,700.00	8,700.00
Wind	-	-	230.00	430.00	860.00
New biomass	-	-	450.00	650.00	1,750.00
Total	**2,767.39**	**3,966.93**	**9,599.40**	**15,646.89**	**26,104.37**

Source: Author.

Table 4.4 Cambodia – Installed Capacity, Low-carbon Energy Transition

Installed Capacity (megawatt)	2019	2020	2030	2040	2050
Coal	675.00	1,000.00	1,640.00	-	-
Oil	624.80	617.55	545.03	472.52	400.00
Hydro	1,331.70	2,103.00	4,727.00	6,127.00	9,000.00
Biomass	30.57	30.57	30.57	30.57	30.57
Solar	105.32	215.81	1,976.80	3,600.00	7,500.00
Natural gas	-	-	-	2,700.00	-
Wind	-	-	230.00	430.00	1,500.00
New biomass	-	-	450.00	650.00	2,000.00
Coal PP with CCS	-	-	-	1,640.00	3,000.00
Natural gas PP with CCS	-	-	-	5,000.00	12,000.00
Total	**2,767.39**	**3,966.93**	**9,599.40**	**20,650.09**	**35,430.57**

CCS = carbon capture and storage, LCET = low carbon energy transition, MW = megawatt, PP = power plant.

Source: Author.

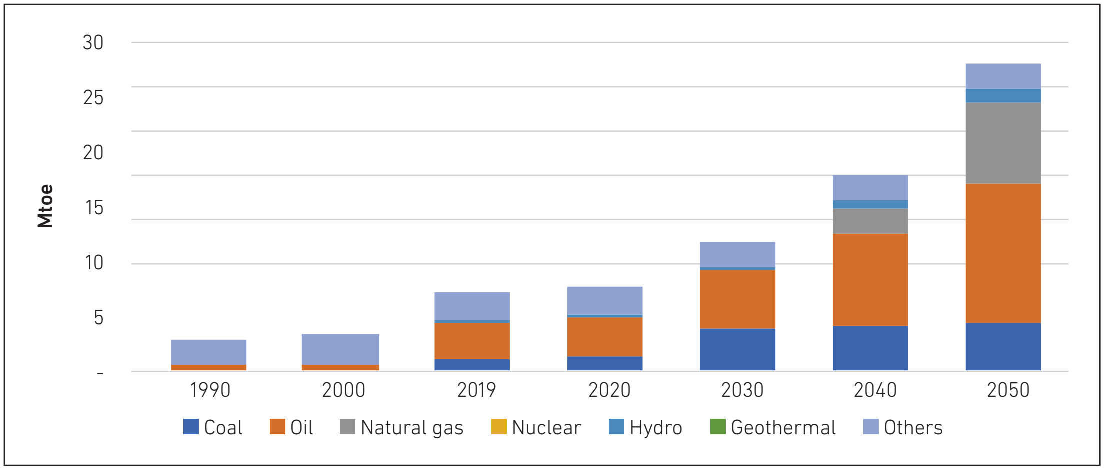
3. Outlook Results

3.1. Business-as-Usual Scenario

3.1.1. Primary Energy Supply

Total primary energy supply (TPES) will grow at an AAGR of 4.44% in 2019–2050. Primary energy supply will increase from 7.17 million tonnes of oil equivalent (Mtoe) in 2019 to 27.56 Mtoe in 2050, slightly faster than final energy demand, from 4.97 Mtoe in 2019 to 19.46 Mtoe in 2050. Amongst the major energy sources, the fastest growing is solar and wind energy, with an AAGR of 14.2% in 2019–2050, followed by oil at 4.6% and coal at 4.1%. The share of solar and wind energy is projected to increase by 14.2% in 2050 to comply with the policy on renewable energy, which promotes utilising clean energy to the maximum extent possible to help mitigate climate change. The share of LNG is projected to increase from 2.09% in 2032 to 25.8% in 2050 due to global limitations on the use of coal.

Figure 4.1 **Cambodia – Total Primary Energy Supply, Business as Usual**



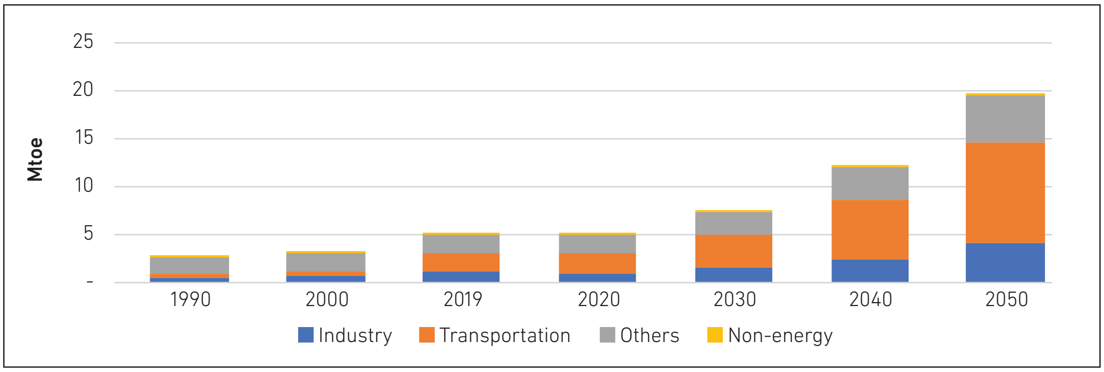
Mtoe = million tonnes of oil equivalent.

Source: Author.

3.1.2. Final Energy Consumption by Sector

Total final energy consumption (TFEC) will grow at an average annual rate of 4.51% in 2019–2050. Final energy demand by sector will increase from 4.97 Mtoe in 2019 to 19.46 Mtoe in 2050 (Figure 4.2).

Figure 4.2 Cambodia – Total Final Energy Consumption by Sector, Business as Usual



Mtoe = million tonnes of oil equivalent.

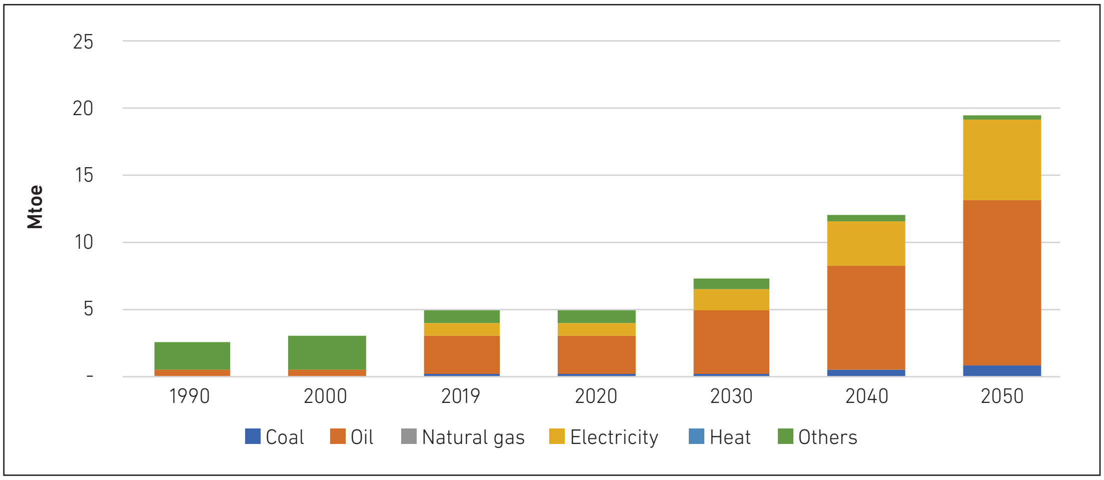
Source: Author.

Strongest growth in demand is projected in transport, which will increase fivefold at an annual average rate of 5.33% in 2019–2050, from 2.09 Mtoe to 10.46 Mtoe. Demand in industry is projected to grow 4.32 times at an annual rate of 4.85%, from 0.95 Mtoe in 2019 to 4.11 Mtoe in 2050, followed by 'others' at 3.07%, from 1.91 Mtoe in 2019 to 4.88 Mtoe in 2050.

3.1.3. Final Energy Consumption by Fuel

Electricity is projected to exhibit the fastest growth in final energy consumption, 14.7 times at 6.37% per year, from 0.88 Mtoe in 2019 to 5.96 Mtoe in 2050. Coal is projected to have the second-highest growth, 5.79% per year or 5.6 times, from 0.14 Mtoe in 2019 to 0.78 Mtoe in 2050. Oil is projected to have the third-highest growth rate, 4.79 % per year or 4.26 times, from 2.90 Mtoe in 2019 to 12.37 Mtoe in 2050 (Figure 4.3).

Figure 4.3 Cambodia – Total Final Energy Consumption by Fuel, Business as Usual



Mtoe = million tonnes of oil equivalent.

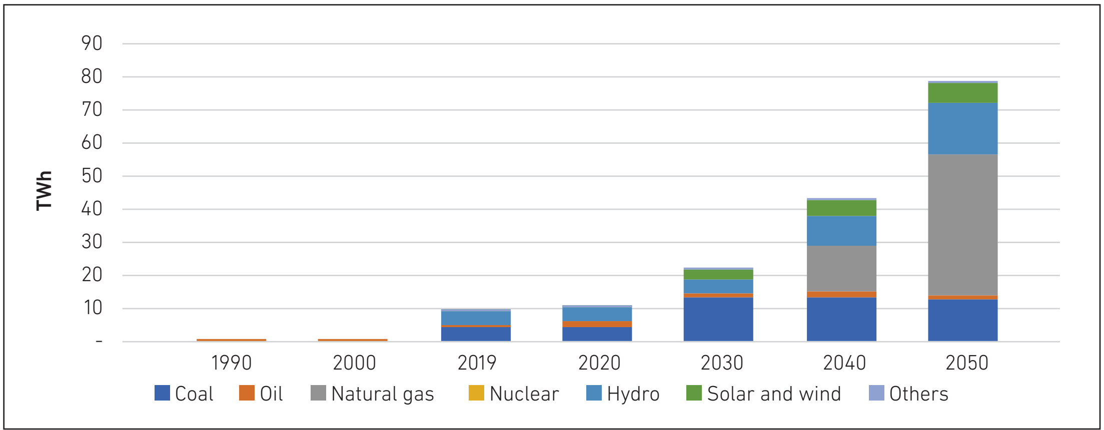
Source: Author.

3.1.4. Electricity Generation

Electricity generation is projected to increase by 7.23% per year from 9.01 terawatt-hours (TWh) in 2019 to 78.36 TWh in 2050. From 2032 to 2050, three main fuels will contribute to electricity generation: LNG, from 6.37% to 54.9%; coal, from 53.6% to 15.9%; and hydropower, from 20.52% to 19.9%.

To meet demand for electricity, power generation is projected to increase at an average rate of 7.23% in 2019–2050. The fastest growth in electricity generation will be in solar energy, by 14.34% per year; followed by coal, 3.8%; and hydropower, 4.38% (Figure 4.4). Generation from heavy fuel oil power plants will decrease by 1.44% from 2020 to 2050 due to high fuel cost.

Figure 4.4 Cambodia – Power Generation by Fuel, Business as Usual



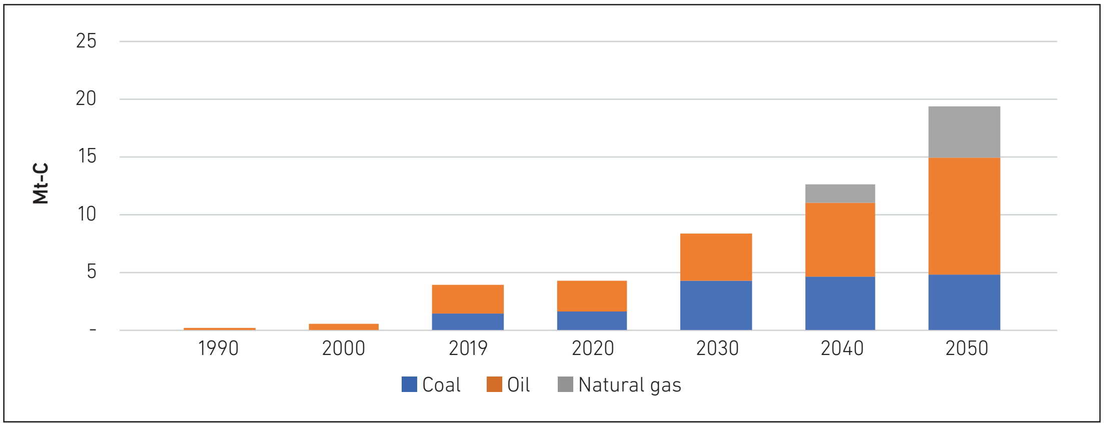
TWh = terawatt-hour.

Source: Author.

3.1.5. CO_2 Emissions

Carbon dioxide (CO_2) emissions from energy consumption are projected to increase by 5.17% per year, from 3.84 million tonnes of carbon (Mt-C) in 2019 to 19.35 Mt-C in 2050. Oil is the largest source of carbon emissions, which will increase fastest, with an AAGR of 4.63%, from 2.49 Mt-C in 2019 to 10.13 Mt-C in 2050. The second-largest source of carbon emissions is coal, with an AAGR at 4.09%, from 1.35 Mt-C in 2019 to 4.09 Mt-C in 2050 (Figure 4.5).

Figure 4.5 Cambodia – CO_2 Emissions from Energy Consumption, Business as Usual



Mt-C = million tonnes of carbon.

Source: Author.

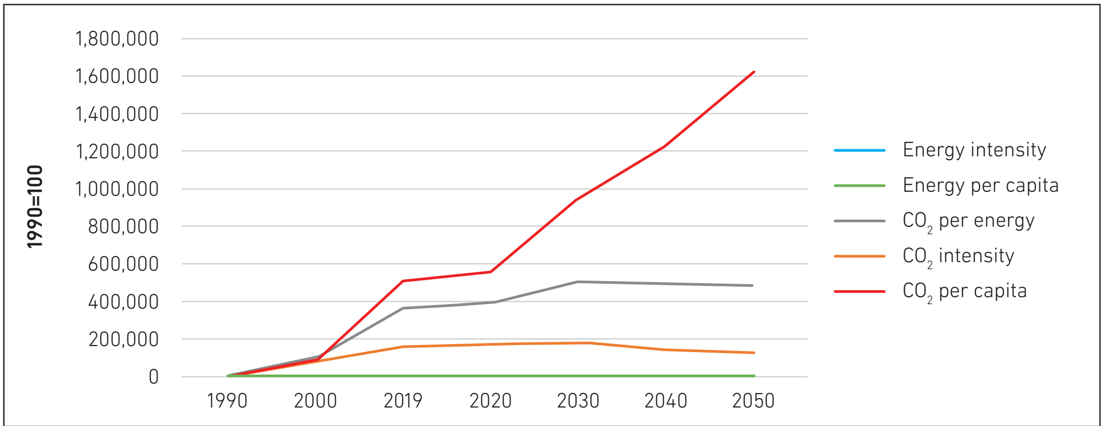
3.1.6. Energy Indicators

Primary energy intensity decreased from 775 toe/US$ million in 1990 to 343 toe/US$ million in 2019. Energy intensity will further decrease to 205 toe/US$ million in 2050, indicating that energy will be used more efficiently as a result of the implementation of an EEC programme.

Per capita primary energy increased from 0.32 toe/person in 1990 to 0.43 toe/person in 2019. Per capita energy will further increase to 1.05 toe/person in 2050, indicating that living standards will improve, which will result in increasing energy demand per capita.

Figure 4.6 shows various indicators of energy consumption.

Figure 4.6 Cambodia – Energy and CO_2 Indicators, Business as Usual



Source: Author.

CO_2 per primary energy in BAU is projected to increase from 0.54 metric tonne of carbon per tonne of oil equivalent (t-C/toe) in 2019 to 0.70 t-C/toe in 2050, implying faster growth of fossil fuels in the total energy consumption. However, CO_2 intensity increased from 108 t-C/US$ million in 1990 to 184 t-C/US$ million in 2019 and will decrease to 144 t-C/US$ million in 2050.

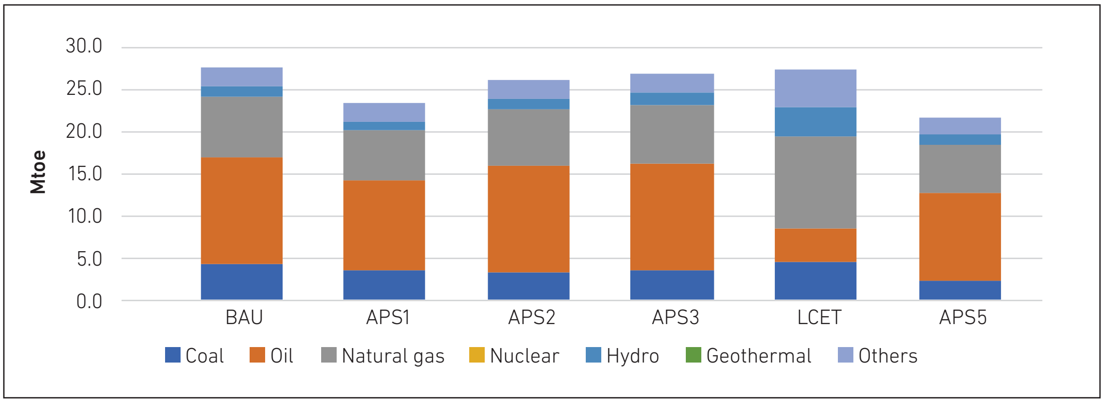
3.2. Alternative Policy Scenario

Alternative policy scenario (APS) 5 consists of three scenarios: EEC (APS1), improvement of energy efficiency in power generation (APS2), and development of renewable energy (APS3). The scenarios are individually modelled to determine the impact of each on reduction of energy consumption and CO_2 emissions. Below are the assumptions in each scenario:

- **APS1**. Focus on EEC on the demand side:
  - Energy demand is projected to increase by an AAGR of 3.9% in 2019–2050, from 4.97 Mtoe to 16.29 Mtoe, which is slower than the AAGR in BAU of 4.5%, from 4.97 Mtoe to 19.46 Mtoe.
  - Use efficient motorbikes, LPG cars, and hybrid cars for road transport.
  - Replace inefficient devices – such as those used in cooking, lighting, refrigeration, air conditioning, etc. – with efficient ones in the commercial and residential sectors.
- **APS2**. Improvement of energy efficiency in thermal power plants. Energy efficiency of LNG, coal, and fuel oil thermal power plants is assumed to stay constant at 44.6% until 2050 in BAU. In APS, it is assumed that new LNG, coal, and fuel oil thermal power plants will have thermal efficiencies of 51.7%. APS2 is projected to improve efficiency of thermal power generation to about 21% in 2019–2050.
- **APS3**. The share of renewable energy in the power generation mix is 27.66% in BAU but 31.07% in APS3 in 2050. However, in the power generation mix in 2050, the share of hydropower is 27.61%; LNG, 55.55%; coal, 11.9%; solar and wind energy, 9.45%; and biomass, 0.12%.
- **APS5 or APS**. Combine APS1, APS2, and APS3.

The assumptions in APS were analysed separately to determine the individual impacts of each in APS1, APS2, APS3, and APS5. Figure 4.7 shows the changes in primary energy supply in all scenarios. APS1 and APS5 have the largest reduction in primary energy supply in 2050 due to improvement of energy efficiency in thermal power generation and energy efficiency assumptions in APS1. In APS1, primary energy supply could be lower than in BAU by 4.2 Mtoe or 18.2%. In APS2, the reduction will be slower, amounting to 1.49 Mtoe or 5.7%.

Figure 4.7 **Cambodia – Total Primary Energy Supply, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2050)**

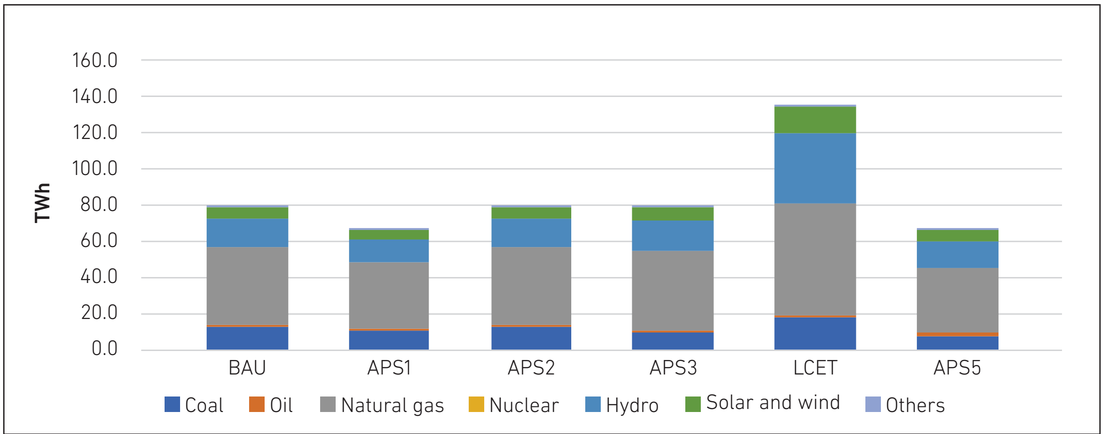


APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author.

Figure 4.8 shows total electricity generation in 2050 in all scenarios. In APS1, due to lower electricity demand, the share of fossil fuel–fired electricity generation will be 17% lower than BAU in 2050. In APS3, the share of fossil fuel generation will be 25% lower than in BAU and APS2, the share is the same as in BAU in 2050. In APS5, the reduction in the share of fossil fuel energy–based generation will be significant, at almost 38% lower than in BAU in 2050.

Figure 4.8 **Cambodia – Electricity Generation, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2050)**

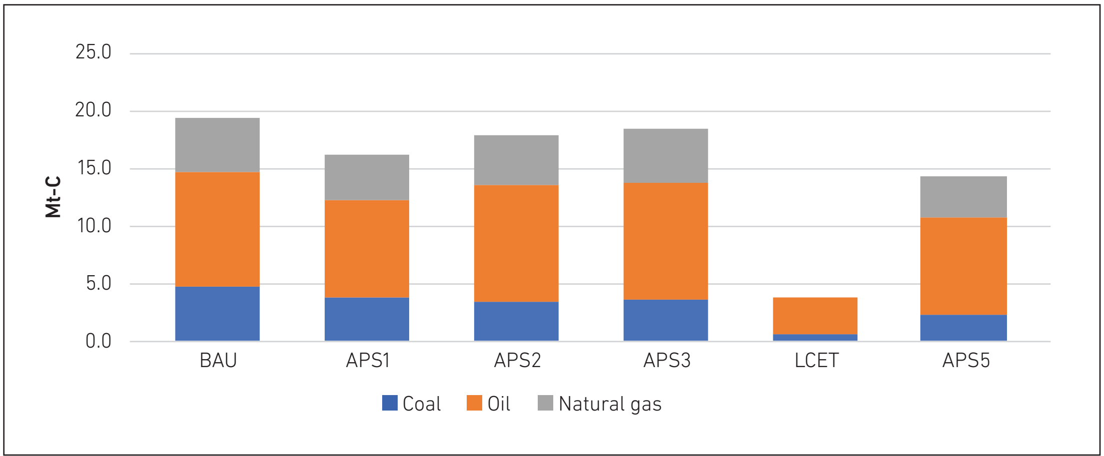


APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, TWh = terawatt-hour.

Source: Author.

Figure 4.9 compares CO_2 emission scenarios in 2050. In APS1, emissions could be lower by 19.85% than in BAU. In APS2, the installation of more efficient new power plants is projected to reduce emissions by 8.13%. In APS 3, as the result of small contributions from solar, wind, and biomass energy to power generation mix, emissions could reduce by 4.99%. All the assumptions combined (APS5) could reduce CO_2 emissions by 35.02% in 2050.

Figure 4.9 Cambodia – CO_2 Emissions, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2050)



APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author.

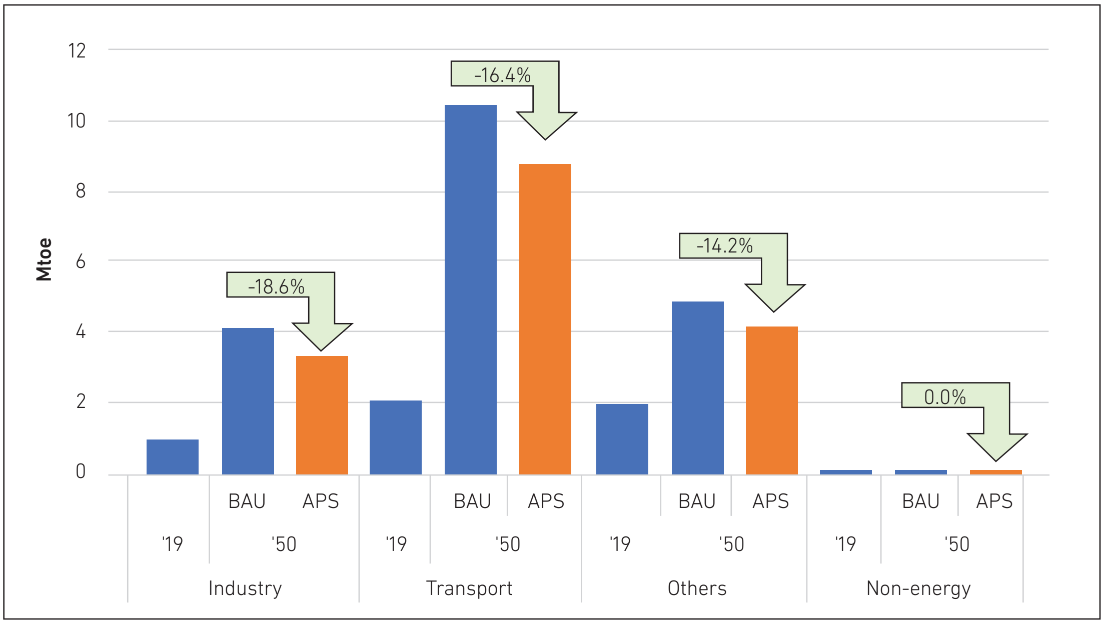
3.2.1. Final Energy Consumption in Alternative Policy Scenario 5

TFEC is 16.29 Mtoe, smaller than TFEC in BAU, which is 19.46 Mtoe by 2050. Final energy demand in APS5 is projected to decrease by 16.3% compared with BAU in 2050 as a result of EEC measures in APS1 in the industrial, transport, and residential and commercial ('others') sectors.

Final energy demand savings in APS5 amount to 3.17 Mtoe, mostly in transport (1.71 Mtoe), followed by industry (0.76 Mtoe) and 'others' (0.69 Mtoe) in 2050.

An improvement in end-user technologies and the introduction of energy management systems is expected to contribute to the slower rate of consumption growth, particularly in 'others' (residential and commercial sectors), industry, and transport (Figure 4.10).

Figure 4.10 Cambodia – Final Energy Demand by Sector, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author.

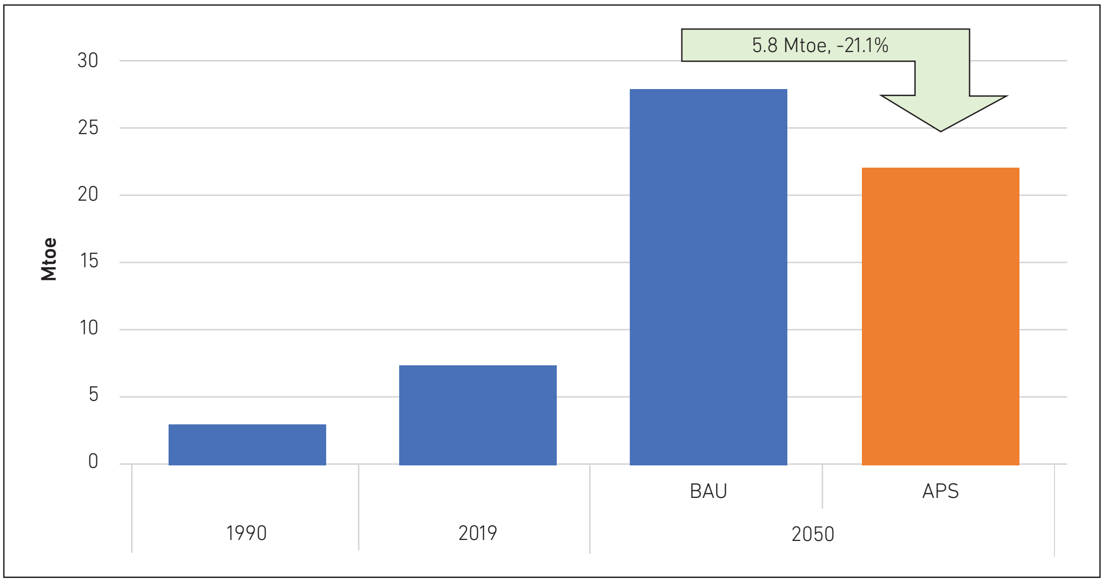
3.2.2. Primary Energy Supply in Alternative Policy Scenario 5

Primary energy supply is projected to increase by 3.6% per year, from 7.17 Mtoe in 2019 to 21.76 Mtoe in 2050. The savings could mostly be derived from EEC on the demand side and development of renewable energy technology (APS3).

Solar and wind energies are projected to grow fastest, by an annual average rate of 14.4% compared with 14.3% in BAU, followed by hydropower at 4.2% compared with 4.4% in BAU, and oil at 4% compared with 4.6% in BAU.

Total savings are equal to 5.8 Mtoe, equivalent to 2.5% of primary energy supply in 2050 (Figure 4.11).

Figure 4.11 Cambodia – Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario

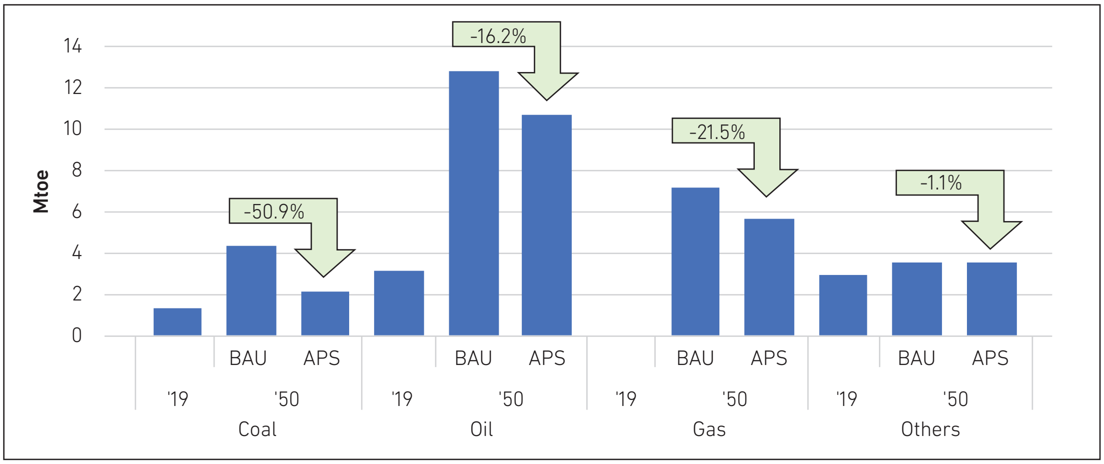


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author.

Consumption is reduced because of demand-side EEC measures (APS1), more aggressive uptake of energy efficiency in thermal power plants (APS2), and supply-side adoption of renewable energy (APS3). The energy-saving potential from coal sources will be 50.9%, followed by LNG at 21.5% and oil at 16.2% (Figure 4.12).

Figure 4.12 Cambodia – Total Primary Energy Saving Potential by Fuel, Business as Usual vs. Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

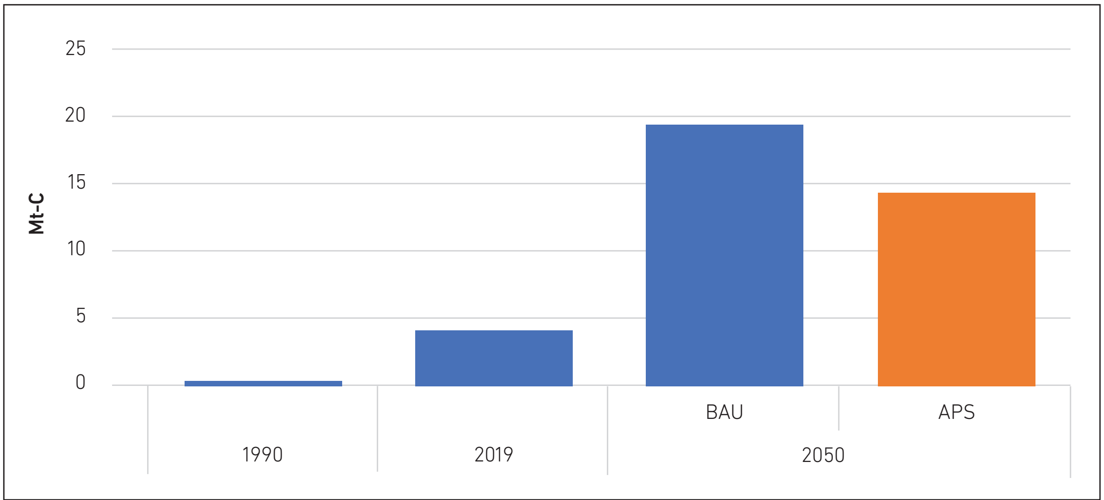
Source: Author.

3.2.3. CO_2 Emissions, Business as Usual and Alternative Policy Scenario 5

CO_2 emissions from energy consumption in BAU are projected to increase by 5.4% per year, from 3.84 Mt-C in 2019 to 19.35 Mt-C in 2050. In APS5, the annual increase in CO_2 emissions is projected to be 4.3 % per year in 2019–2050, 25.9% lower than in BAU.

CO_2 emission reduction will be mostly derived from demand-side EEC measures (APS1). Improvement of energy efficiency in thermal power plants (APS2) and development of renewable energy technologies (APS3) can contribute significantly to CO_2 reduction (Figure 4.13).

Figure 4.13 Cambodia – CO_2 Emission by Fuel, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Author.

3.3. Low-carbon Energy Transition Scenario

The low-carbon energy transition (LCET) scenario was used to assess the impact of new energy technologies – use of hydrogen and ammonia for heat and electricity generation, and carbon capture, utilisation, and storage (CCUS) – on TPES, TFEC, power generation, and CO_2 emissions. Carbon neutrality means the balance of energy-related CO_2 emissions and carbon sink by forest. Cambodia's nationally determined contribution (NDC) in 2020 for the United Nations Climate Change Conference in Glasgow (COP26) states that greenhouse gas (GHG) emissions are expected to rise by up to 90 million tonnes of carbon dioxide equivalent (tCO_2e) per year by 2030, whilst GHG emissions are expected to increase to 155 million tCO_2e per year in BAU.

Table 4.5 Cambodia – Sectoral Share and Absolute Number of Greenhouse Gas Emissions, Business as Usual (2030)

Sector	Sectoral Share (%)	GHG Emissions ($MtCO_2e$)
FOLU	49.2	76.3
Energy	22.2	34.4
Agriculture	17.5	27.1
IPPU	9.0	13.9
Waste	2.1	3.3

BAU = business as usual, FOLU = forestry and other land use, IPPU = industrial processes and product use, $MtCO_2e$ = metric tonne of carbon dioxide equivalent.

Source: Cambodia's Updated Nationally Determined Contribution 2020.

Forestry and other land use (FOLU) will mark the highest CO_2 emissions in BAU in 2030, at 49.2%, followed by energy, 22.2%; agriculture, 17.5%; and industrial processes and product use, 9.0%. The estimated emission reduction in the NDC in 2030 will be about 64.5 million tCO_2e per year, or a 41.7% reduction, of which 59.1% is from FOLU (Table 4.5 and Table 4.6). We assume about 38 $MtCO_2e$ as carbon sink by forest until 2050 (Table 4.6).

Table 4.6 Cambodia – Summary of Business-as-Usual Emissions and Nationally Determined Contribution Emission Reduction

Sector	BAU 2016 Emissions ($MtCO_2e$)	BAU 2030 Emissions ($MtCO_2e$)	NDC 2030 Scenario ($MtCO_2e$)	NDC 2030 Reduction ($MtCO_2e$)	NDC 2030 Emission Reduction
FOLU	76.3	76.3	38.2	–38.1	–50%
Energy	15.1	34.4	20.7	–13.7	–40%
Agriculture	21.2	27.1	20.9	–6.2	–23%
IPPU	9.9	13.9	8.0	–5.9	–42%
Waste	2.7	3.3	2.7	–0.6	–18%
Total	**125.2**	**155.0**	**90.5**	**–64.5**	**–42%**

BAU = business as usual, FOLU = forestry and other land use, IPPU = industrial processes and product use, $MtCO_2e$ = metric tonne of carbon dioxide equivalent, NDC = nationally determined contribution.

Source: Cambodia's Updated Nationally Determined Contribution, 2020.

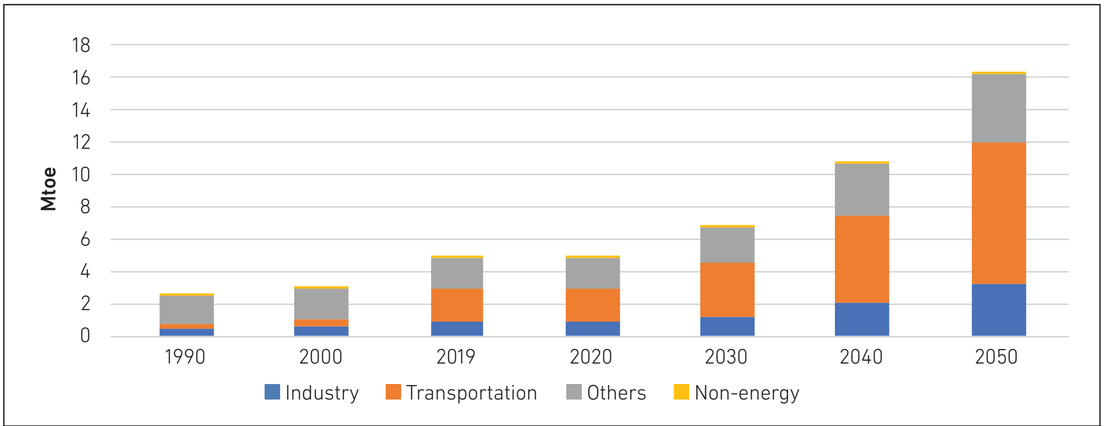
To create the LCET scenario in line with the NDC emission-reduction target, in addition to assuming carbon sink by forest until 2050, decreased oil demand is projected at 9.4% per year in industry and at 18.6% per year in transport in 2040–2050 due to electrification. New technologies are applied, such as coal power plants using clean coal technologies with CCS and natural gas power plants with CCS in 2040–2050.

3.3.1. Final Energy Consumption by Sector

Figure 4.14 illustrates final energy consumption by sector in 1990–2050. The AAGR is 3.9% per year in 1990–2050, which is the same as the AAGR of final energy consumption in APS5.

Demand growth is projected to be strongest in transport, by an annual average rate of 4.73% in 2019–2050, from 2.09 Mtoe to 8.74 Mtoe. Industry is projected to grow by an annual rate of 4.2%, from 0.95 Mtoe in 2019 to 3.35 Mtoe in 2050, followed by 'others' at 2.06%, from 1.91 Mtoe in 2019 to 4.19 Mtoe in 2050.

Figure 4.14 Cambodia – Total Final Energy Consumption by Sector, Low-carbon Energy Transition



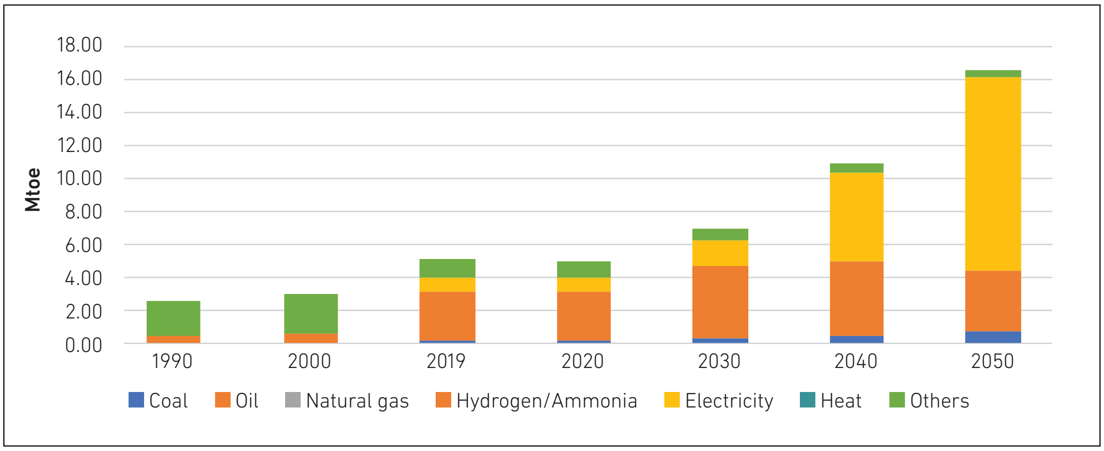
Mtoe = million tonnes of oil equivalent.

Source: Author.

3.3.2. Final Energy Consumption by Fuel

Figure 4.15 shows the highest shares of electricity demand in 2040–2050, the result of reducing oil demand in transport. The AAGR of TFEC in LECT is projected to increase by 3.9% in 2019–2050. Electricity has the main share, at 50.4% in 2040 and 71.2% in 2050, followed by oil, at 41.5% in 2040, before it drops to 22.8% in 2050.

Figure 4.15 Cambodia – Total Final Energy Consumption by Fuel, Low-carbon Energy Transition



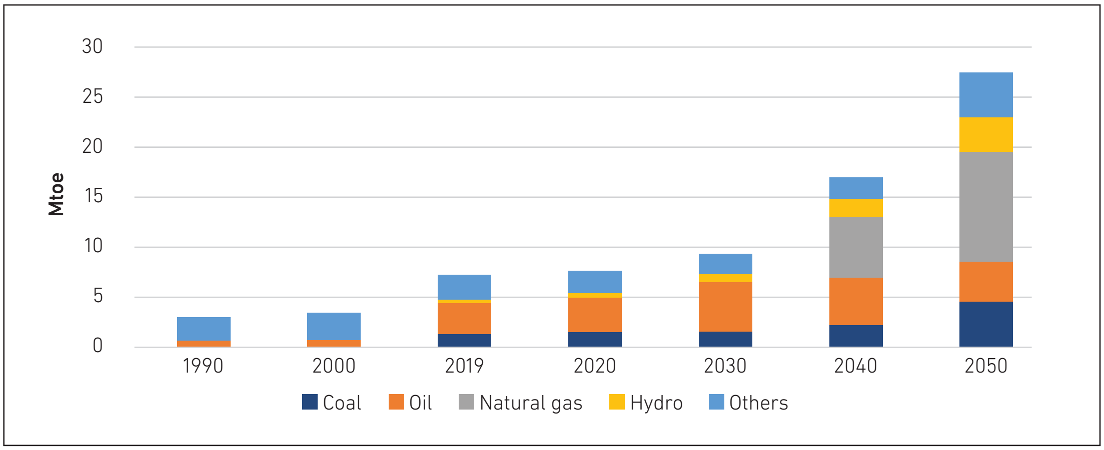
Mtoe = million tonnes of oil equivalent.

Source: Author.

3.3.3. Primary Energy Supply

In 2050, total primary energy supply will register at 27.35 Mtoe, much higher than in APS5 at 21.76 Mtoe. TPES recorded AAGR at 4.4% per year in 2019–2050 in LCET and 3.6% per year in APS5. Biomass is the only fuel that registered negative average annual growth, –1.05%, because people replaced firewood with LPG as cooking fuel in urban and rural areas.

Figure 4.16 Cambodia – Total Primary Energy Supply by Fuel, Low-carbon Energy Transition



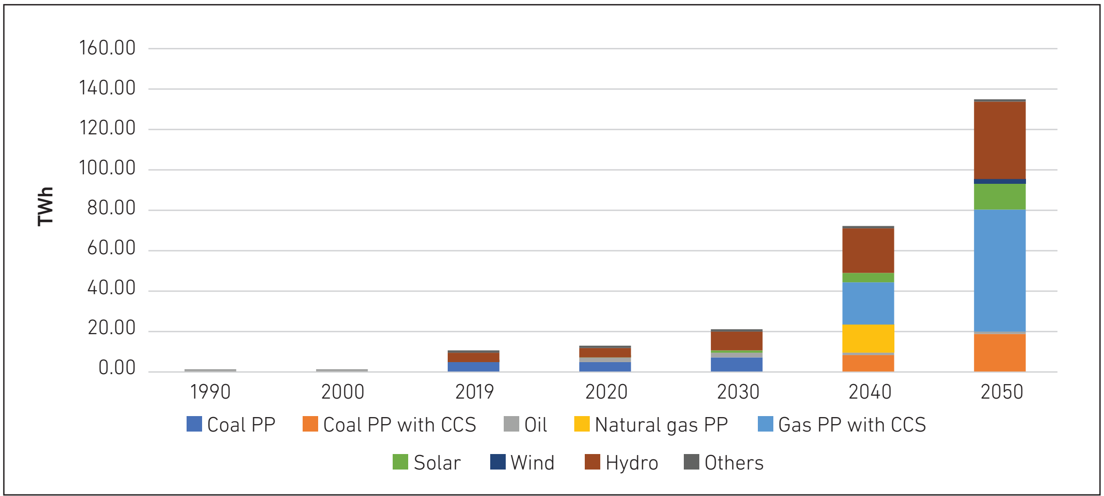
Mtoe = million tonnes of oil equivalent.

Source: Author.

3.3.4. Electricity Generation

Figure 4.17 shows total electricity generation in 2050 at 134.02 TWh, much higher than in APS5 at 65.82 TWh due to projected huge decrease in oil demand in 2040–2050. CO_2 emissions will be reduced as natural gas power plants will be the main contributor to electricity generation in 2032–2040; natural gas with CCS and coal with CCS will be the highest contributors in 2040–2050. Electricity generation is projected to have an AAGR of 9.1%, with solar energy having the highest at 16.9% in 2019–2050.

Figure 4.17 **Cambodia – Total Primary Energy Supply by Fuel, Low-carbon Energy Transition**



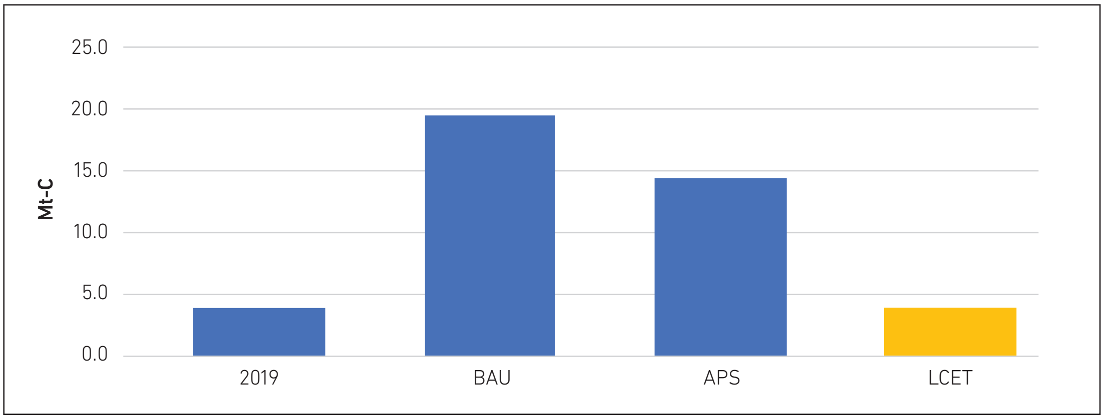
CCS = carbon capture and storage, PP = power plant, TWh = terawatt-hour.

Source: Author.

3.3.5. CO_2 Emissions

CO_2 emissions from energy consumption are projected to decrease by 3.7% per year, from 5.64 Mt-C in 2040 to 3.85 Mt-C in 2050. In APS5, the AAGR of CO_2 emissions is projected to increase by 4.3% per year in 2019–2050. CO_2 emissions in LCET will decrease by 10.5 Mt-C or about 73.2% compared with APS5 in 2050 (Figure 4.18). Carbon sink by forest is assumed to be about 38 $MtCO_2e$ or about 10 Mt-C. Applying CCS technologies, Cambodia could achieve carbon neutrality by 2050.

Figure 4.18 Cambodia – CO_2 Emission Reduction, Business as Usual, Alternative Policy Scenario 5, and Low-carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

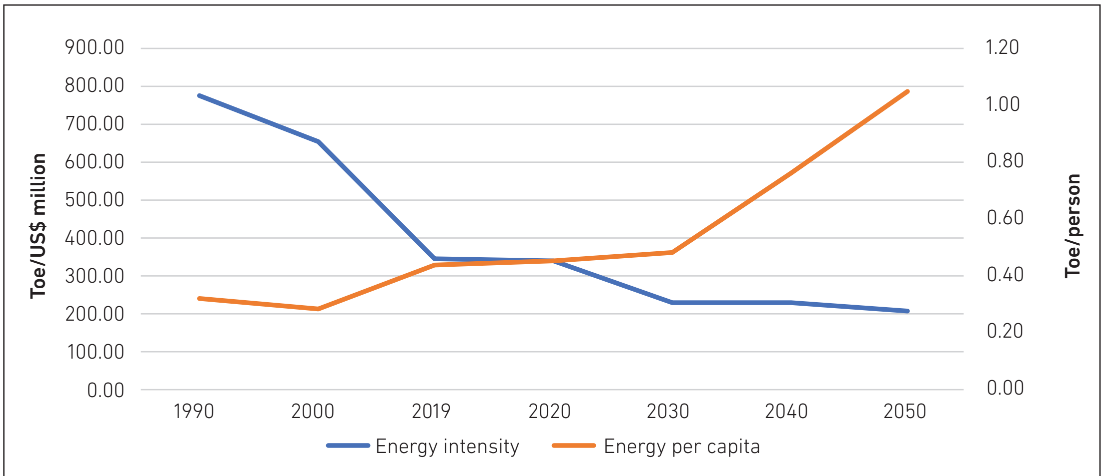
Source: Author.

3.3.6. Energy Indicators

Figure 4.19 shows that primary energy intensity decreased from 775 toe/US$ million in 1990 to 343 toe/US$ million in 2019 and will further decrease to 204 toe/US$ million in 2050. The trend indicates that energy will be used more efficiently as a result of implementation of the EEC programme and use of new technologies.

Primary energy per capita increased from 0.32 toe/person in 1990 to 0.43 toe/person in 2019 and will further increase to 1.05 toe/person in 2050, indicating that living standards are improving, resulting in increasing energy demand per capita.

Figure 4.19 Cambodia – Energy Indicator, Low-carbon Energy Transition



Source: Author.

4. Key Findings and Recommendations

The key findings are as follows:

- Energy demand is expected to continue to grow significantly, driven by robust economic growth, industrialisation, urbanisation, and population growth. EEC is reflected in APS and LCET.
- Energy intensity will further decrease until 2050 due to efficient use of energy.
- Annual growth of energy demand in transport is projected to be the highest at 5.3%, from 2.09 Mtoe in 2019 to 10.46 Mtoe in 2050 in BAU, but in LCET, the AAGR of transport sector energy demand is projected lower at 4.7% reaching only 8.74 Mtoe in 2050.
- Coal demand is increasing, with the highest annual growth rate of 5.8 % in BAU, and projected at slightly lower at 5.0% in APS5 and LCET.
- LNG power plants will be the major power generation source. LNG's share in total power generation output is increasing continually, from 6.4% in 2032 to 55% in 2050 in BAU. But in LCET, natural gas power plants will be the main power-generating source in 2032–2040. Then natural gas with CCS and coal with CCS will contribute the highest generation in 2040–2050, thereby reducing CO_2 emissions. Projected AAGR in power generation in LCET is 9.1%. Solar energy will have the highest AAGR at 16.9% in 2019–2050.
- Hydropower plants will be the second major source of power generation. Their share in total power generation output will increase continually to 46% by 2019 but drop to 20% in 2050 due to LNG's huge contribution.

To implement EEC, the following actions are recommended:

- Establish appropriate policies, including targets and road maps, to promote EEC measures. EEC targets should be for the short, medium, and long term, and focused on the building and industrial sectors. The long-term plan should be based on an assessment of energy-saving potential of all energy sectors, including the residential and commercial sectors, which have large energy-saving potential up to 2050. Some activities can promote EEC, such as (i) support for the development of professionals in the energy conservation field, who can be responsible for energy management and operation; verification and monitoring; consultancy and engineering services provision; and the planning, supervision, and promotion of the implementation of energy conservation measures; (ii) support for the development of institutional capability of agencies and organisations in the public and private sectors to be responsible for planning, supervision, and promotion of the implementation of energy conservation measures; (iii) support for the operation of energy service companies to alleviate technical and financial risks of entrepreneurs who wish to implement energy conservation measures; and (iv) energy conservation public relations and knowledge provision through educational institutions and fostering of awareness amongst the youth.
- Establish a compulsory energy standard and labelling system for electrical appliances. Annual growth of electricity demand in the residential and commercial sectors is projected to be substantial. The measure could generate energy savings.

- Prioritise the development of advanced hydro and thermal power technologies, including coal and natural gas. Hydropower and thermal power plants will be the major source of power generation up to 2050. Therefore, advanced technologies for both types of resources should be prioritised for development from project design onwards.
- Prioritise renewable energy development policies. Renewable energy is an important resource for energy independence, energy security, and GHG emission abatement. The strategy and mechanisms to support renewable energy development must be built up.
- Keep in touch with international and regional CCUS frameworks, such as the Asia CCUS Network. Monitor the development and deployment of CCUS under appropriate carbon-pricing mechanisms in Asia as conducted by Organisation for Economic Co-operation and Development countries and the network. CCS and CCUS will be important innovations in decarbonisation technologies.

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CHAPTER 5

China Country Report

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1. Background

Since 2020, the global economy, social development, and public health have been threatened by the coronavirus disease (COVID-19) pandemic. China has explored a series of policies to bring the domestic outbreak under control and to recover gradually. China's significant progress in many aspects is noteworthy, such as the victory in the critical battle against poverty, promotion of digital currency, outstanding achievements in ecological conservation, and targeting of carbon peak and carbon neutrality.

In 2021, energy production grew steadily, energy efficiency continued to improve, the energy consumption structure was optimised, and the level of electrification of end-use energy accelerated. Production of raw coal, crude oil, natural gas, and electricity rose by 4.7%, 2.4%, 8.2%, and 8.1%, respectively, on a year-on-year basis. Energy consumption per unit of gross domestic product (GDP) was reduced by 2.7% compared with that of 2020 (30% lower than in 2012). The clean energy industry grew rapidly. The proportion of clean energy consumption reached 25.3% in 2021: a remarkable achievement in the energy structure transition. Electricity consumption increased to 8,312.8 billion kilowatt-hours (KWh) or by 10.3% year on year.

The report will explore China's energy development and propose policy recommendations.

2. Macro Assumptions

China has gradually recovered from the COVID-19 pandemic. In 2021, GDP exceeded CN¥100 trillion for the second consecutive year and the economic growth rate of 8.1% was the highest in the past 10 years. Table 5-1 shows the assumptions of the average annual growth rate (AAGR) of GDP and population. Based on the estimation of the Economic Research Institute for ASEAN and East Asia (ERIA), the average AAGR of GDP is projected to be 5.3%, 4.5%, and 3.4% in 2019–2030, 2030–2040, and 2040–2050, respectively. China's GDP in 2050 is estimated to be US$44,340 billion.

Table 5.1 China – Assumptions of Annual Growth Rates of Gross Domestic Product and Population

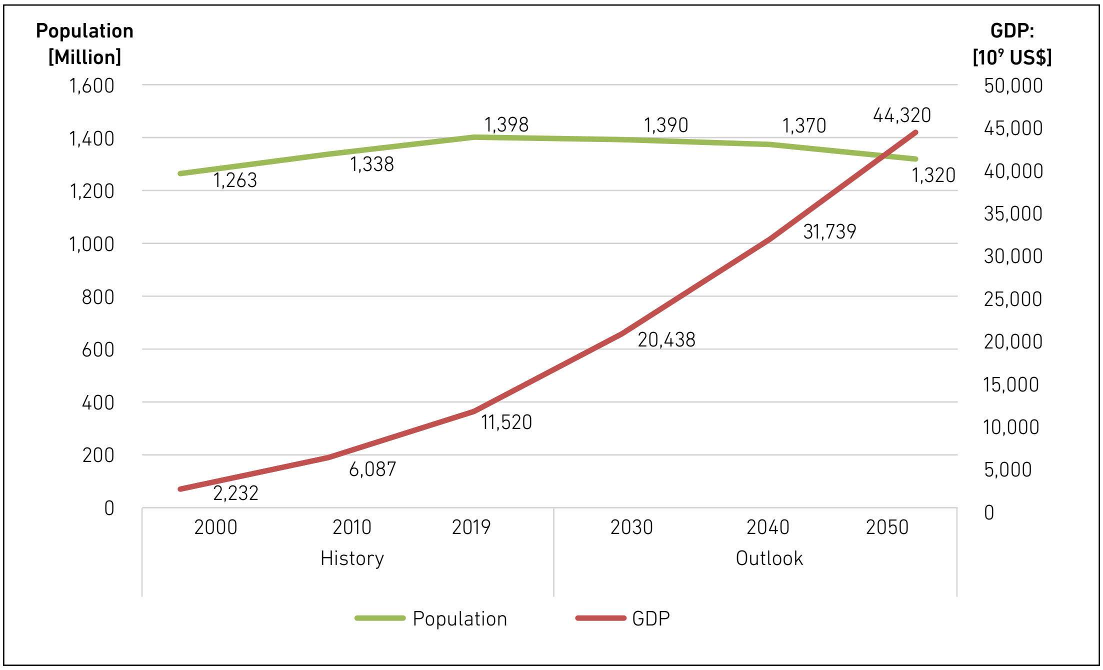
	2000–2010	2010–2019	2019–2030	2030–2040	2040–2050
GDP	10.6%	7.3%	5.3%	4.5%	3.4%
Population	0.6%	0.5%	–0.1%	–0.1%	–0.4%

GDP = gross domestic product.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.1 shows China's GDP and population assumptions. The population increased from 1.135 billion to 1.403 billion in 1990–2020, with an AAGR of about 0.7%, making China the world's most populous country. As the economy progresses, the population growth rate is expected to decrease by 0.1%, 0.1%, and 0.4% in 2019–2030, 2030–2040, and 2040–2050, respectively. By 2050, the population will be 1.320 billion. Economic development encourages people to pursue higher quality of life, leading to higher parenting costs, e.g. education, and a lower fertility rate. The continuous decrease in the number of women of child-bearing age can also explain the trend that population growth momentum has weakened.

Figure 5.1 China – Assumptions of the Average Annual Growth Rate of Gross Domestic Product and Population



GDP = gross domestic product.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

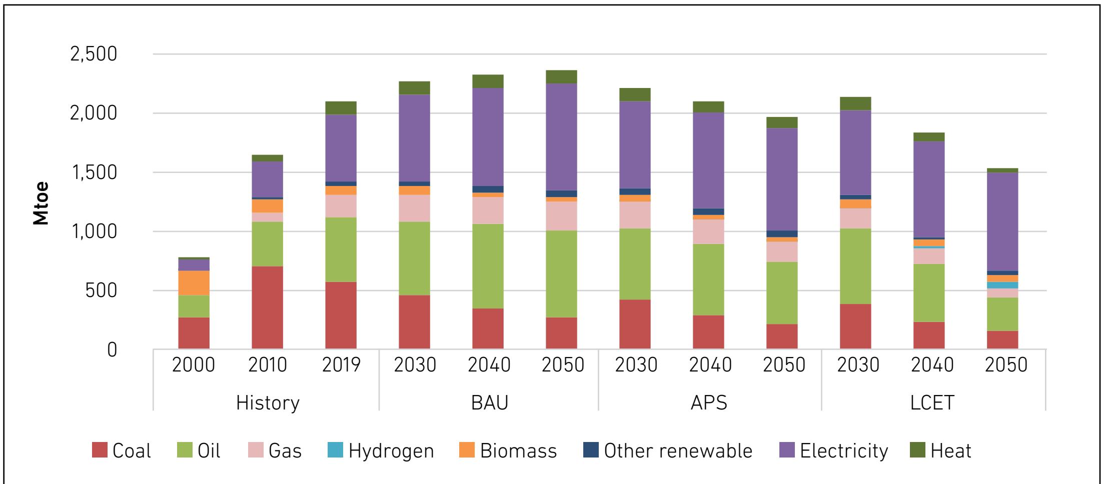
3. Outlook Results

3.1. Total Final Energy Consumption

Figure 5.2 shows total energy consumption by fuel in 2000–2019 and in 2030–2050 under different scenarios: business as usual (BAU), alternative policy scenario (APS), and low-carbon energy transition (LCET). China is the largest consumer of coal in the world (BP, 2022). Although coal accounts for a large portion of total final energy consumption, it is projected to decrease annually. In 2019–2050, China's coal consumption will decrease from 574 to 273 million tonnes of oil equivalent (Mtoe) in BAU, 206 Mtoe in APS, and 150 Mtoe in

LCET. The reason is that the government has introduced a series of policies to reduce coal consumption (Liao et al., 2019) and promote clean energy transition (Li et al., 2022). In 2050, the consumption of oil and gas is projected to reach 738 Mtoe and 239 Mtoe, respectively, in BAU; 533 Mtoe and 173 Mtoe, respectively, in APS; and 292 Mtoe and 82 Mtoe, respectively, in LCET. Oil and gas consumption will increase in BAU to meet rising energy demand. However, if the government adopts low-carbon emission technology or implements other alternative measures, oil and natural gas consumption will decrease because the government is pursuing a clean energy transition from fossil fuels to renewable energy, which is conducive to sustainable development. Consumption of biomass and heat energy is projected to reach about 29 Mtoe and 112 Mtoe, respectively, in BAU; 42 Mtoe and 86 Mtoe, respectively, in APS; and 62 Mtoe and 42 Mtoe, respectively, in LCET. Hydrogen consumption, despite being almost non-existent in BAU, is predicted to increase from 16 thousand tonnes of oil equivalent (Ktoe) to 123 Ktoe in APS, and from 13 Ktoe to 48 Ktoe in LCET in 2030–2050. Consumption of other renewable energy will increase from 48 Mtoe to 53 Mtoe in BAU in 2030–2050. However, in the other two scenarios, consumption will decrease: from 46 Mtoe to 40 Mtoe in APS and from 41 Mtoe to 23 Mtoe in LCET in 2030–2050. Electricity has long been the most important energy. The government has introduced policies to develop it, as reflected in its rapid growth rate of consumption. In 2030–2050, electricity consumption is projected to increase by 24.5% in BAU, 21.2% in APS, and 15.1% in LCET. Electricity consumption will rise from 729 Mtoe to 905 Mtoe in BAU, from 729 Mtoe to 882 Mtoe in APS, and from 722 Mtoe to 830 Mtoe in LCET, which is attributed to the attention recently paid to electricity development by the government.

Figure 5.2 China – Final Energy Consumption by Fuel, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)

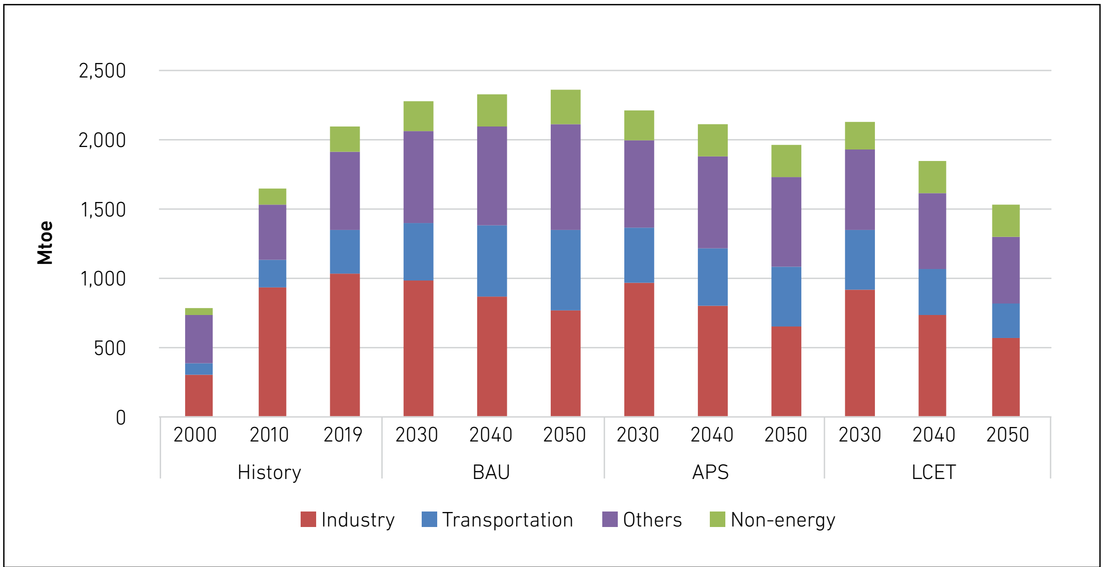


APS = alternative policy scenario, BAU = business as usual, GDP = gross domestic product, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.3 shows total final energy consumption (TFEC) by sector in 2000–2019 and 2030–2050 in different scenarios. TFEC increased by 5.2% in 2021, higher than its 2.2% growth rate in 2020 (CSY, 2021). According to ERIA, TFEC increased from 781 Mtoe to 2,093 Mtoe in 2000–2019. TFEC is projected to rise from 2,270 Mtoe to 2,350 Mtoe in 2030–2050 in BAU, from 2,201 Mtoe to 1,962 Mtoe in APS, and from 2129 Mtoe to 1529 Mtoe in LCET. Energy consumption in industry will decrease from 980 Mtoe to 761 Mtoe in 2030–2050 in BAU, decline from 964 Mtoe to 648 Mtoe in APS, and decrease from 918 Mtoe to 563 Mtoe in LCET. Since the supply-side structural reform during the 13th Five-Year Plan Period, the government has taken a series of measures to address overcapacity and adjust the industrial structure (Zhao et al., 2021). Energy consumption in industry will decrease even in BAU. Due to the effectiveness of low-carbon–emitting technologies, energy consumption in industry will decrease even more remarkably in LCET. Although its results may not be as significant as those in LCET, APS is still an effective emission-reduction strategy. In transport, energy consumption will decrease from 417 Mtoe to 248 Mtoe in LCET, but will increase from 420 Mtoe to 588 Mtoe in BAU and from 391 Mtoe to 425 Mtoe in APS. As the economy grows, an increasing number of people can afford private cars. The number of private cars rose from 6.25 million to 225.09 million in 2000–2019 (CSY, 2021). Transport energy consumption is, therefore, constantly increasing. The upward trend will continue in BAU. In APS, even if the rate of rise slows down, energy consumption will still increase. Only in LCET can the trend be inhibited. In 'others' (residential and commercial sectors), low-carbon technologies and other policies are effective in reducing energy consumption. In 2030–2050, energy consumption in 'others' will continue to increase in BAU, reach a peak, start to decline in APS, and steadily decrease in LCEP.

Figure 5.3 China – Final Energy Consumption by Sector, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)



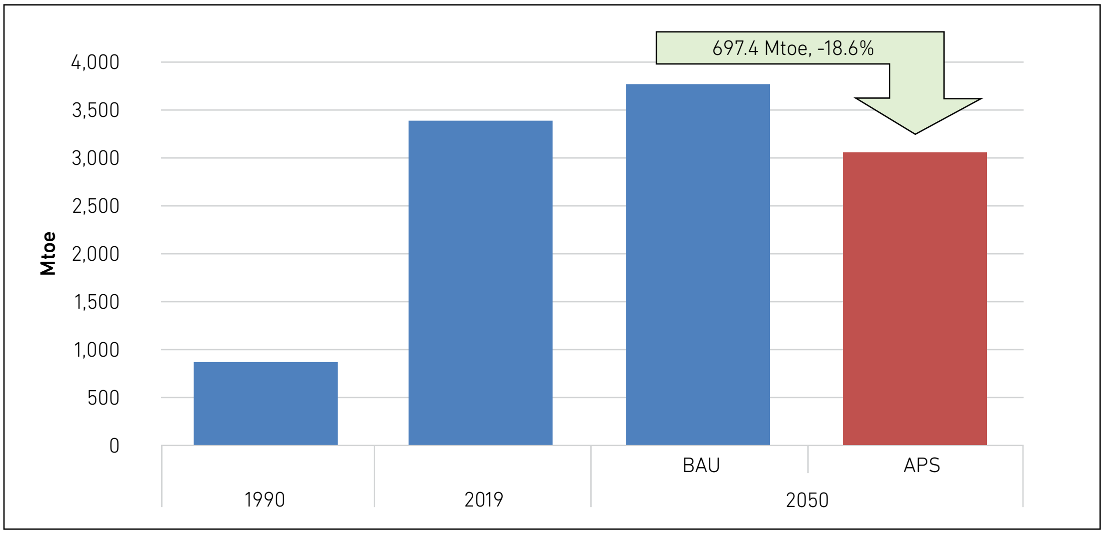
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.2. Total Primary Energy Supply

Figure 5-4 shows total primary energy supply (TPES) in 1990, 2019, and 2050. TPES increased from 873.6 Mtoe in 1990 to 3,389.3 Mtoe in 2019, for an annual growth rate of 4.8%. In BAU, energy consumption is predicted to continually increase in 2019–2050. In contrast, energy consumption is projected to be lower in 2050 than in 2019 in APS. TPES will decrease by 18.6% in APS compared with BAU, equivalent to 697.4 Mtoe.

Figure 5.4 China – Total Primary Energy Supply in 1990, 2019, and 2050

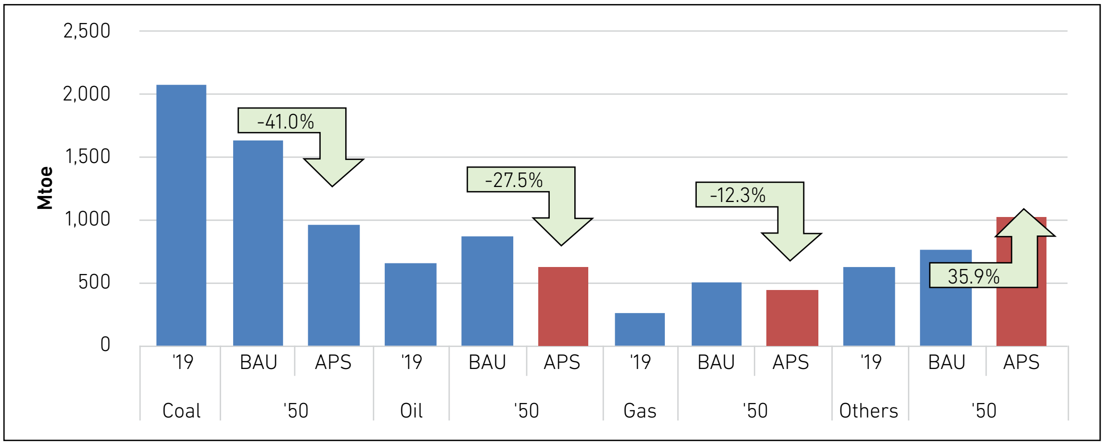


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.5 shows TPEC by fuel. Despite being the primary energy source, coal is projected to decrease in the next 30 years, even if alternative policies are not adopted. However, TPEC in APS is 41.0% lower than in BAU, suggesting that policies are significant in reducing energy consumption. For oil, TPEC in APS drops by 27.5% (239 Mtoe) more than in BAU. As natural gas is generally regarded as clean energy, its share in TPEC is expected to increase. However, APS can decrease the share of natural gas in TPEC by 12.3%. Regarding other fuels (e.g. renewable energy), their share in TPEC is estimated to improve by 35.9% because alternative policies are adopted.

Figure 5.5 China – Total Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario (2019–2050)



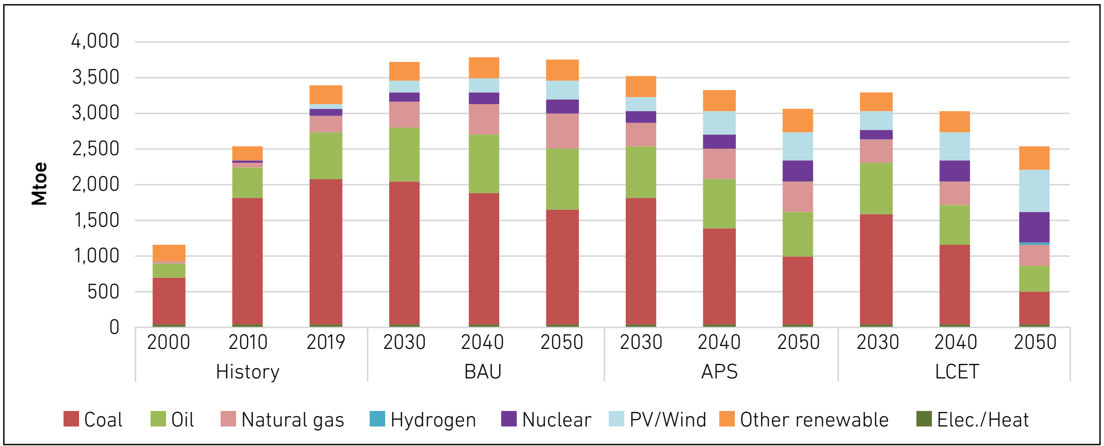
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.3. Total Primary Energy Supply

Figure 5.6 shows total primary energy supply (TPES) by source in 2000–2019 in BAU, APS, and LCET. Since 2000, coal has constituted the largest share of total primary energy and that share has been increasing. However, its growth in 2010–2019 was slower than in 2000–2010. Oil accounts for a noticeable part of primary energy supply, whilst the proportion of other energy sources, such as natural gas and renewable energy, is relatively low. In 2030–2050 in BAU, primary energy supply is projected to increase at an annual average rate of 0.1%, from 3,710 Mtoe to 3,753 Mtoe. Coal will still constitute the largest share in total primary energy, but it is projected to decrease slightly by 1.1% every year. Consequently, the share of coal in total primary energy is projected to decline from 55.2% in 2030 to 43.4% in 2050. Oil and natural gas are projected to grow at lower rates of 0.7% and 1.6% per year, respectively. Hydrogen, nuclear energy, and other renewable energy resources will increase slightly. In APS, TPES will decrease from 3,522 Mtoe to 3,056 Mtoe, by an average of 0.7% every year. Coal and oil are projected to decrease by 3.1% and 0.7%, respectively. Natural gas, hydrogen, nuclear, solar photovoltaic (PV) and wind, and other renewable energy resources are estimated to increase each year by 1.1%, 19.7%, 3.2%, 3.5%, and 0.5%, respectively. In LCET, TPES will decrease from 3,289 Mtoe to 2,452 Mtoe, by 1.3% per year. Hydrogen is projected to grow the fastest in 2030–2050, by an annual average rate of 47.7%, and nuclear and solar PV and wind energy at 5.3% and 4.5%, respectively. Fossil fuels such as coal, oil, and natural gas are predicted to decrease each year by 5.7%, 3.5%, and 0.1%, respectively.

Figure 5.6 China – Primary Energy Supply by Source, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)



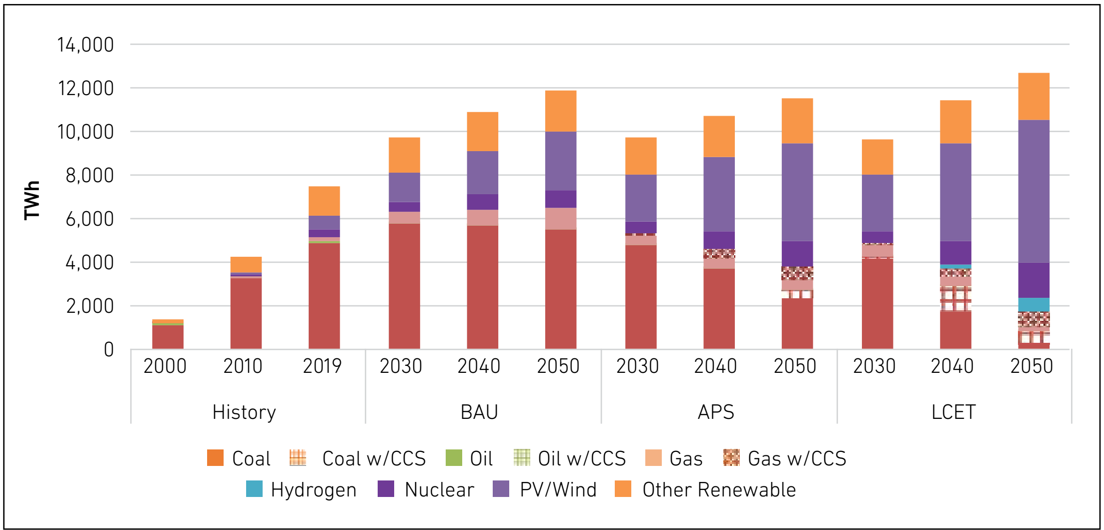
APS = alternative policy scenario, BAU = business as usual, elec. = electricity, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent, PV = photovoltaic.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.4. Power Generation

Figure 5.7 shows historical and future power generation in BAU, APS, and LCET. Power generation is projected to grow more slowly in 2030–2050 than in 2000–2019. In BAU, power generation is projected to grow at a slower pace, by 1.0% per year, from 9,702 TWh in 2030 to 11,862 TWh in 2050. The share of coal power in BAU is projected to decrease, from 58.8% to 46.1% in 2050. Conversely, the shares of natural gas and nuclear energy are projected to grow because they are clean, from 5.4% and 5.2% in 2030 to 8.7% and 6.7% in 2050, respectively. The share of oil is projected to decrease slightly. Other methods of power generation are projected to increase. In APS, total power generation will increase by 0.9% per year in 2030–2050. By 2050, total power generation output is projected to reach 11,505 TWh. The annual growth rate in 2030–2050 of all fuels in APS, except for coal-fired power, oil power, and natural gas power, is projected to grow faster than in BAU. In LCET, solar PV and wind and other renewable energy sources for power generation will grow significantly at 51.4% and 17.6%, respectively, in 2050. In contrast, coal is expected to account for only 1.2% in 2050, much lower than its 65.2% share in 2019. Coal with carbon capture and storage (CCS) and gas with CCS are expected to be 4.8% and 5.6%, respectively, in 2050.

Figure 5.7 China – Power Generation by Source, Alternative Policy Scenario, Business as Usual, and Low-carbon Energy Transition (2000–2050)

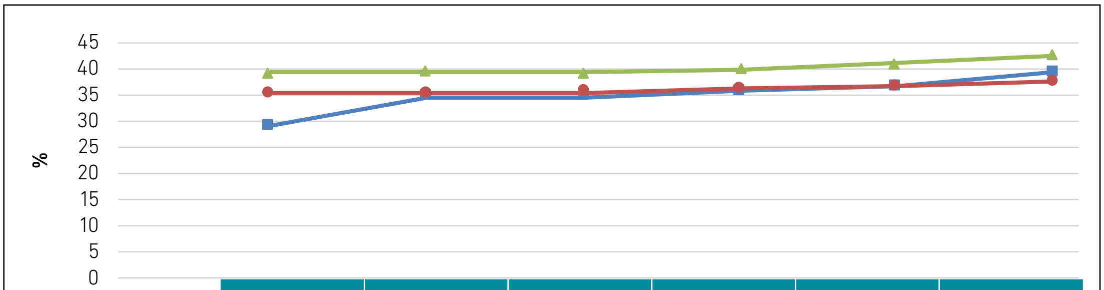


APS = alternative policy scenario, BAU = business as usual, CCS = carbon capture and storage, low-carbon energy transition, PV = photovoltaic, TWh = terawatt-hour.

Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.8 presents the thermal efficiency of coal, oil, and natural gas in 1990–2050 in BAU. The fast development of PV power generation typifies the country's preference for clean power. Thermal efficiency of fuel in BAU is projected to increase in 2020–2050. In 1990–2020, the thermal efficiency of coal, oil, and natural gas increased from 28.8%, 35.0%, and 39.0% to 34.4%, 35.4%, and 39.1%, respectively. Thermal efficiency of coal, oil, and natural gas is projected to reach 39.1%, 37.2% and 42.1%, respectively, in 2050.

Figure 5.8 China – Thermal Efficiency of Fossil Fuel, Business as Usual (1990–2050)



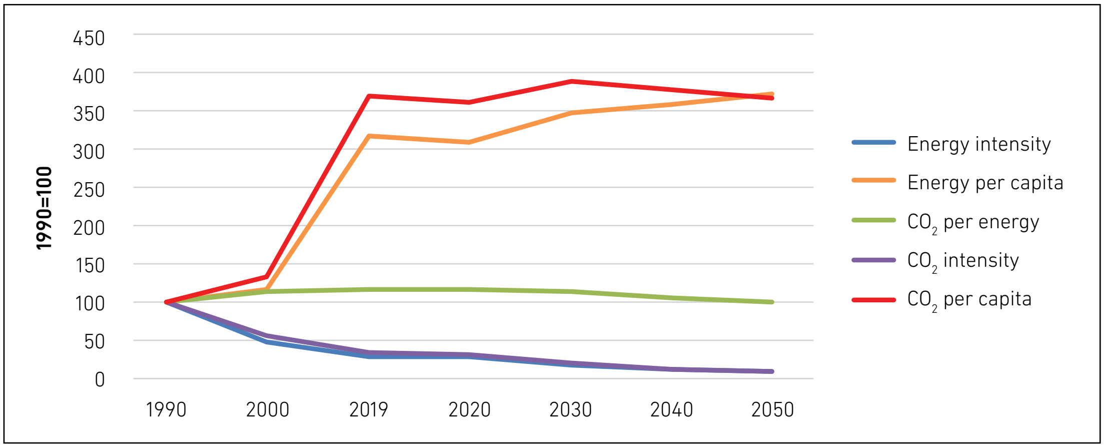
	1990	2019	2020	2030	2040	2050
Coal	28.8	34.4	34.4	35.5	36.6	39.1
Oil	35.0	35.0	35.4	36.0	36.7	37.2
Natural gas	39.0	39.3	39.1	39.7	40.9	42.1

Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.5. Energy Indicators

Figure 5.9 shows the energy indicators in BAU. Energy intensity dropped remarkably because of energy efficiency efforts. In 2050, energy intensity is projected to drop to about 8% of that in 1990. Carbon dioxide (CO_2) intensity similarly is expected to decrease by 7.9% in 2050 compared with 1990. With improved living standards, energy per capita in BAU is projected to reach 369.5% of that in 1990. CO_2 per capita is expected to gradually peak in 2030 at 388% of that in 1990. CO_2 per energy is relatively stable in 1990–2050.

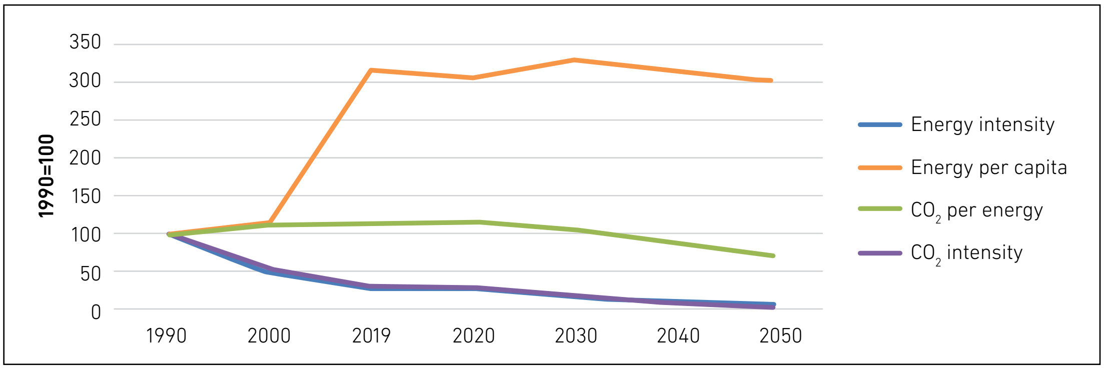
Figure 5.9 China – Energy Indicators, Business as Usual (1990–2050)



Source: Economic Research Institute for ASEAN and East Asia, 2020.

Figure 5.10 shows the energy indicators in APS in 1990–2050. Compared with energy intensity in BAU, energy intensity in APS is projected to decrease faster in 1990–2050. CO_2 intensity is expected to decrease to 4.5% of that in 1990 (7.9% in BAU), and energy intensity to drop to 6.5% (8% in BAU) of that in 1990. Similarly, energy per capita is projected to decrease to about 300.8% of that in 1990 (369.5% in BAU), and CO_2 per energy is estimated to decline to 68.3% of that in 1990 (98.7% in BAU).

Figure 5.10 China – Energy Indicators, Alternative Policy Scenario (1990–2050)

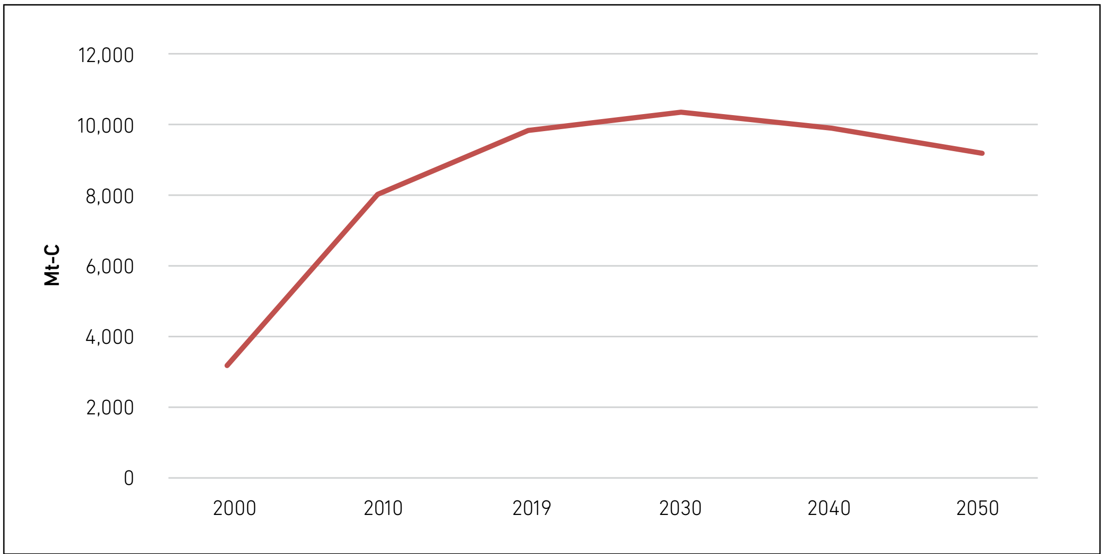


Source: Economic Research Institute for ASEAN and East Asia, 2020.

3.6. CO_2 Emissions

Figure 5.11 shows CO_2 emissions in 2000–2050. In 2019–2030, they are projected to slowly increase, with an annual growth rate of 0.4%, and peak in 2030 in BAU, equivalent to 10,365 metric tonnes (Mt). China aims to achieve peak carbon by 2030, as reflected in the prediction results. However, China's carbon peak still faces challenges. Traditional industries with high input, high energy consumption, high pollution still account for a relatively high proportion. The manufacturing industry of a considerable scale is still in the middle and low end of the international industrial chain, with large consumption of high-carbon fuels and low added value of products. Chinese government has promoted a series of policies in an effort to reduce carbon emissions. In 2030-2050, CO_2 emissions are expected to decrease from 10,365 Mt to 9,250 Mt, or by 0.57% annually. Besides, China is striving to be carbon neutral by 2060.

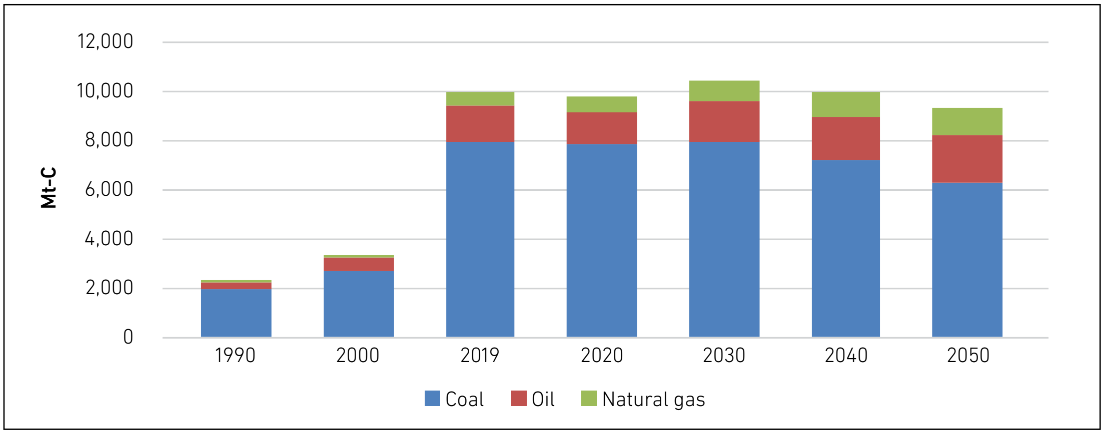
Figure 5.11 China – CO_2 Emissions, Business as Usual (2000–2050)



Source: Economic Research Institute for ASEAN and East Asia, 2021.

Figure 5.12 shows CO_2 emissions from fossil fuels in BAU. A high-carbon energy source, coal contributes the most to CO_2 emissions. In 1990–2019, CO_2 emissions caused by burning fossil fuels increased from 2,180 Mt to 9,882 Mt, whilst emissions from coal accounted for more than 80%. In BAU, even though coal is still the largest contributor to CO_2 emissions, the proportion of emissions from coal is predicted to drop from 80.5% to 67.4%. Oil contributed 11.9%–13.6% in 1990–2020 and is expected to increase by 15.9%–20.4% in 2030–2050. Regarding natural gas – the cleanest amongst the three fossil fuels – the proportion of CO_2 emissions grew by 0.8%–5.9% in 1990–2020 and is projected to reach 12.2% in 2050.

Figure 5.12 China – CO_2 Emissions by Fossil Fuel, Business as Usual Scenario (1990–2050)



Mt-C = metric tonne of carbon dioxide.

Source: Economic Research Institute for ASEAN and East Asia, 2021.

4. Implications and Policy Recommendations

As the world's largest energy consumer and largest CO_2 emitter, China faces great pressure to improve energy efficiency and reduce CO_2. In recent years, the government has made great efforts and set ambitious targets to deal with climate change. In 2021, it published China's Achievements, New Goals and New Measures for Nationally Determined Contributions, and China's Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy, indicating its determination to achieve peak CO_2 emissions around 2030 and to make best efforts to peak early. The main findings follow.

First, TFEC is projected to increase in BAU and decrease in APS and LCET in 2030–2050. Coal is projected to decrease annually and electricity to increase rapidly. Other new energy, such as hydrogen, will increase in APS and LCET. Energy consumption by industry is estimated to decrease annually in all scenarios. Transport energy consumption will continually increase in BAU and APS and decrease in LCET.

Second, TPEC in 2050 is predicted to be higher than in 2019 in BAU and to be lower than in 2019 in APS. TPEC will be lower in APS than in BAU for coal, oil, and natural gas, but higher for other fuels in APS than in BAU. TPES in 2050 is projected to be lower than in 2019 in APS. Coal will still constitute the largest share but is projected to decrease slightly every year. In APS and LCET, hydrogen, nuclear, solar PV and wind, and other renewable energy will increase.

Third, power generation is projected to grow slower in 2030–2050 than in 2000–2019. The share of coal power is projected to be 46.1% in BAU and 1.2% in LCET in 2050. The generation source is transitioning to cleaner fuels, such as hydrogen, nuclear, and solar PV and wind. The thermal efficiency of coal, oil, and natural gas will continually increase in 2019–2050.

Fourth, CO_2 emission trends are different in the three scenarios. In BAU, they will grow slowly in 2019–2030, peak in 2030, and decrease slightly in 2030–2050. In APS and LCET, they will decrease in 2019–2050; LCET is more effective in reducing CO_2 emissions. Those from fossil fuels will continually decline in 2020–2050.

Given the current energy outlook, three policy recommendations are put forward.

First, explore the paths of CO_2 reduction and design specific development plans. To better deal with climate change, consider different scenarios to analyse the corresponding energy consumption and emissions. For instance, society is ageing and small families are more prevalent. Policies or businesses associated with time-use and consumption patterns shape energy demand and CO_2 emissions. Considering regions' heterogeneity, regional plans should be different from the national plan. The governance mechanism is regionally decentralised authoritarian, where the central government determines the performance appraisal of local officials. Sometimes, emission-reduction goals may negatively affect economic growth. Since regional competition can produce positive effects on environmental governance, a regional competition mechanism may be introduced when setting emission-reduction goals.

Second, emphasise low-carbon–emitting technologies since they significantly reduce carbon reduction in industries, especially traditional ones. The iron and steel industry must accelerate the deployment of small-ball sintering, low-temperature sintering, electric arc furnace steelmaking, and CCS technology. The chemical industry should focus on lightweight raw materials, advanced coal gasification technology, low-carbon hydrogen production, and CO_2 utilisation technology. Buildings should improve their heating and cooling efficiency, increase their electrification level, and develop distributed energy. In transport, railways and waterways should be given priority and electric and hydrogen-fuel vehicles promoted.

Finally, introduce policies to promote energy transition. Despite the wide use of clean energy in urban areas, many rural households still depend on traditional energy. Rural household energy transition projects, such as the Clean Winter Plan in northern China, are important to promote energy transition. Since low-income residents still have difficulty affording the high cost of transition, the government should subsidise them.

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CHAPTER 6

India Country Report

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1. Background

The world's second-most populous country, with a population of over 1.39 billion, India sits on a land mass of about 3.1 million square kilometres, the seventh-largest country by area (The World Bank, 2021). It is in South Asia and home to arguably the biggest democracy globally. India shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the northeast; and Bangladesh and Myanmar to the east. The Indian Ocean bounds it in the south, the Arabian Sea in the southwest, and the Bay of Bengal in the southeast. India's topography is vast and varied, comprising a wide range of weather conditions. Referencing the Köppen system, the country has six climatic subtypes. Its climate is arid desert in the west, alpine tundra and glaciers in the north, and humid tropical regions supporting rainforests in the southwest and the island territories. Many regions have starkly different microclimates.

India is a leading global economic force. Its economy was nominally worth US$9.3 trillion in 2021 (World Bank, 2022b). It is the fifth largest by market exchange rate and the third largest by purchasing power parity (PPP), at over US$11 trillion (International Monetary Fund, 2022). With its average annual gross domestic product (GDP) growth rate of 8.7% for 2021–2022, India is one of the fastest-growing economies. However, it ranks 142nd for nominal world GDP per capita and 128th for GDP per capita at PPP (The World Bank, 2022a). Despite economic growth in recent decades, India continues to face socio-economic challenges such as poverty and access to modern energy.

Energy consumption has more than doubled since 2000, propelled upwards by a growing population – soon to be the world's largest – and a period of rapid economic growth. Near-universal household access to electricity was achieved in 2019, which means that over 900 million citizens have gained an electrical connection in less than 2 decades (IEA, 2021). Total energy consumption per capita remains about 0.7 tonne of oil equivalent (toe) (2021), half the Asian average (Enerdata, 2022). Despite continued growth, India is still at a comparatively low human development index level of 0.645 in 2019 and a global rank of 131 (UNDP, 2020). It continues to have a large underserved yet aspiring population, indicating that development is the most critical priority. The country faces increasing challenges in meeting growing commercial energy demand sustainably. The concern assumes even greater significance in the context of volatility in global fuel prices and growing global pressure to reduce greenhouse gas (GHG) emissions. Ensuring rapid economic growth and enhancing access to energy and infrastructure in an environmentally sustainable manner with limited resources makes it a complex challenge for India's planners and decision-makers to ensure sustainability and a better living standard.[1]

[1] The chapter is based on Institute of Energy Economics, Japan model and assumptions.

2. Modelling Assumptions

There is a marked increase in GDP, from US$2.75 trillion (in constant 2015 values) in 2019 to about US$13.45 trillion (in constant 2015 values) in 2050, equivalent to 5.3% average annual growth rate. The population is assumed to grow at an average annual rate of 0.6%, from about 1.37 billion in 2019 to about 1.64 billion in 2050. In the business-as-usual (BAU) scenario, the share of coal in the electricity generation mix slightly decreases over time but remains the dominant source of electricity generation over the modelling timeframe. The shares of hydropower and oil are expected to decrease in the energy mix by 2050, with nuclear power plants and 'others' (renewables) set to increase across the modelling timeframe.

Per the alternative policy scenario (APS), India seeks to attain substantial energy-saving goals by deploying renewable energy power generation and implementing energy efficiency programmes in end-use sectors. Ensuring energy saving in the industry involves improving the efficiency of small plants and highly energy-intensive industries. Efficient end-use technologies and energy management systems can ensure significant savings in the residential and commercial sectors. Improvement in the vehicle fuel economy and effective traffic management is important to increase efficiency in transport.

In the low-carbon energy transition (LCET) scenario, India is expected to achieve its net-zero emission target by 2070. Notable efforts are being made to raise non-fossil fuel energy capacity to 500 gigawatts (GW) and reduce carbon intensity to below 45% by 2030. In addition to energy efficiency programmes in APS, the country deploys significant carbon capture and storage (CCS) technology as well as carbon sequestration through sinks (such as forestry) to significantly lower CO_2 emissions.

3. Outlook Results

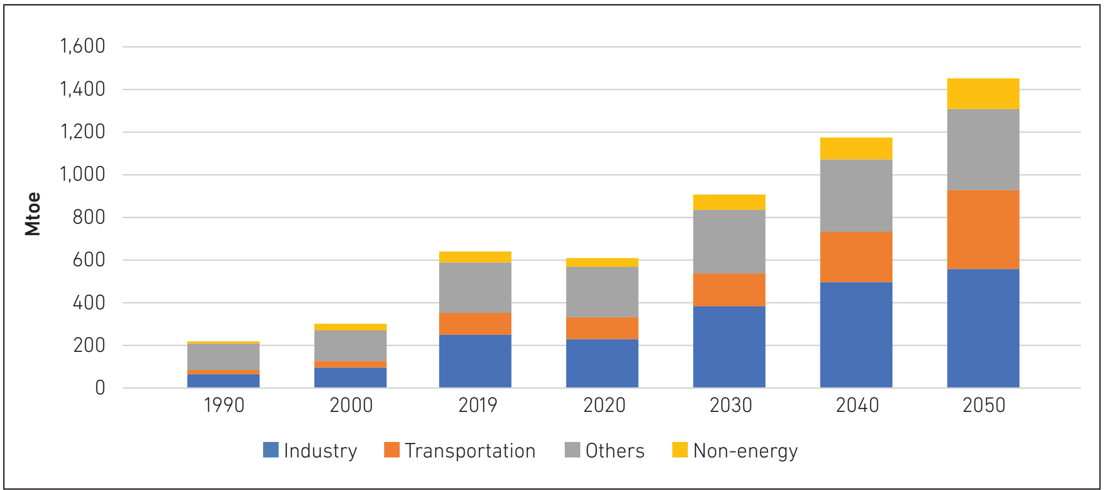
3.1. Business-as-Usual Scenario

The section describes the current trend of energy production and utilisation based on existing policies, devoid of any other policy intervention, to reduce energy demand or CO_2 emissions.

3.1.1. Final Energy Consumption

BAU assumes strong economic growth and a rising population, resulting in significant projected increase in India's total final energy consumption (TFEC) at an average rate of 2.7% per year, from about 630 million tonnes of oil equivalent (Mtoe) in 2019 to about 1,442 Mtoe in 2050 (Figure 6.1). Projections indicate that the transport end-use sector exhibits marked growth, increasing at an average of 4.1% per year in 2019–2050. The non-energy and industry sectors increase at a projected yearly average rate of 3.3% and 2.7%, respectively. The large share of non-commercial energy in the final energy consumption mixes will result in a modest growth rate of 'others', including the residential and commercial sectors, by a projected 1.7% per year. Consequently, the energy consumption of commercial and residential sectors in 'others' will increase in value but decrease in share, from about 231 Mtoe (37%) in 2019 to 386 Mtoe (27%) in 2050. Industry is expected to have the highest share of energy demand by 2050, despite its decrease in share from 38% in 2019 to 37% in 2050. Driven by the growing population's high demand for mobility, the share of transport is projected to increase in value and share, from about 17% (105 Mtoe) to 25% (363 Mtoe). The share of the non-energy sector is projected to increase from about 8% (51 Mtoe) to 10% (139 Mtoe).

Figure 6.1 Total Final Energy Consumption by Sector, Business as Usual (1990–2050)

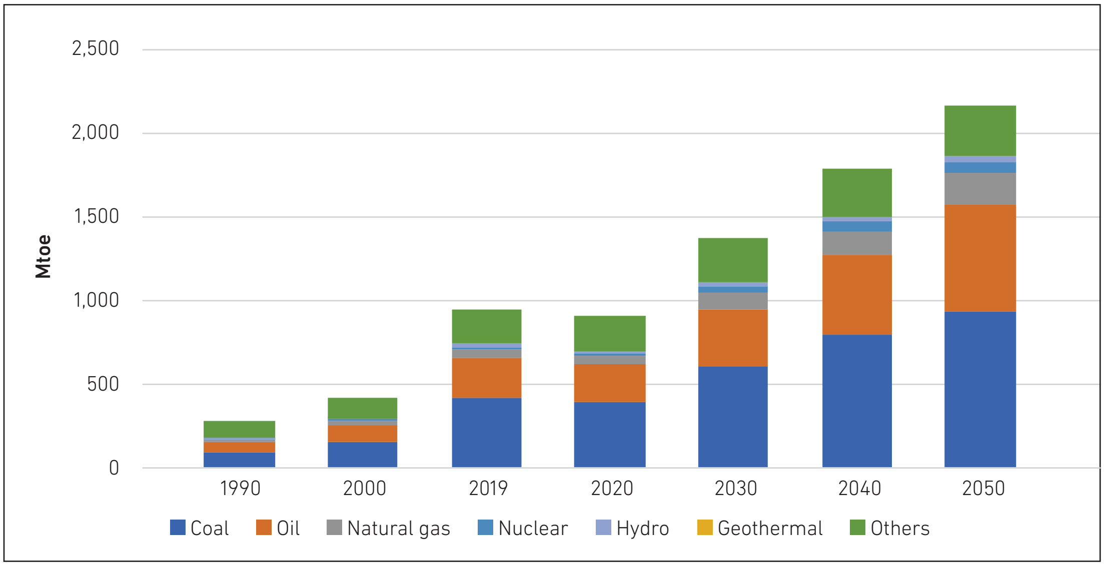


Source: Authors.

3.1.2. Primary Energy Supply

Energy projections indicate an increase in primary energy supply by an average annual rate of 2.6%, reaching 2,166 Mtoe in 2050 from 938 Mtoe in 2019 (Figure 6.2). With power generation being the major driving force, the consumption of coal is projected to grow by 2.6% per year, from about 418 Mtoe in 2019 to 934 Mtoe in 2050, accounting for the largest share of primary energy supply (43%) in 2050 against 45% in 2019. The supply of oil is projected to increase in value and share due to rapid motorisation; supply will increase at an annual average growth rate of 3.3%, resulting in an increase in value and share from 235 Mtoe (25%) in 2019 to 637 Mtoe (29%) in 2050, representing the second-largest share in the primary energy supply mix. Increasing at a projected 4.1% per year, the share of natural gas will increase by about 3%, from 6% in 2019 to 9% in 2050. In 'others', the share of non-commercial biomass declines significantly from 94% in 2019 to 73% in 2050, resulting in an annual average growth rate (AAGR) of 0.5% per year. Solar photovoltaic (PV) and wind power are expected to increase in value and share, accounting for about 3.8% in 2050 from 1.2% in 2019. Figure 6.2 depicts the projected primary energy supply in 1990–2050.

Figure 6.2 India – Total Primary Energy Supply, Business as Usual (1990–2050)



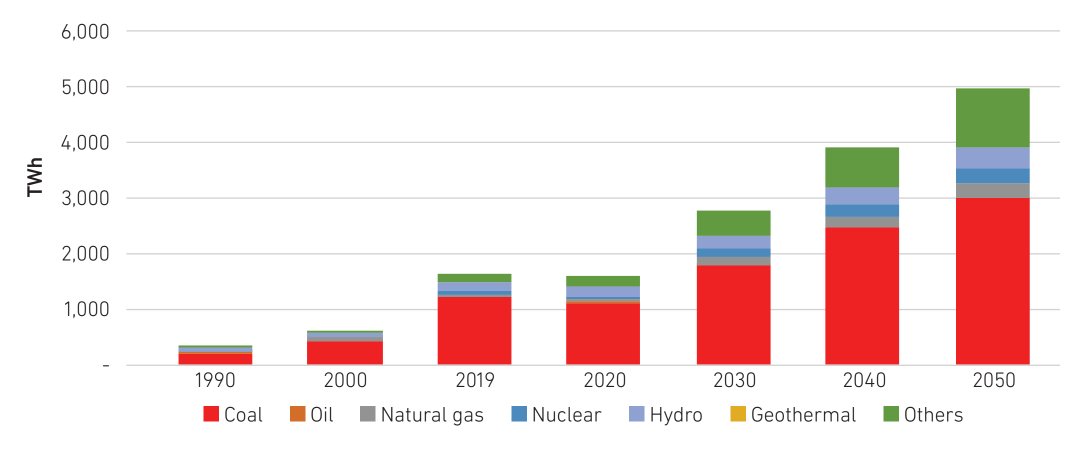
Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.1.3. Power Generation

Power generation stood at 1,623 terawatt-hours (TWh) in 2019. It is projected to increase by 3.7% per year, reaching 4,937 TWh in 2050 (Figure 6.3). Irrespective of its decreased share in power generation output, from 72% in 2019 to 60% in 2050, coal will continue to dominate the power generation mix. The transition to low-carbon fuels will see the share of renewables and alternative energy sources increase over the modelling timeframe. Hydropower will account for the second-largest share in 2050, with about 8% of total energy output, declining from 10% in 2019. In contrast, the share of nuclear energy will increase from about 3% to 5%, at an AAGR of 5.6% per year for the same period. The share of natural gas will reach about 5% by 2050, a slight increase from its 4% value in 2019, equivalent to an average growth rate of 4.7%. The value and share of 'others', comprising wind and solar power, will significantly increase from 202 Mtoe (9.4%) in 2019 to 1,047 Mtoe (21%) in 2050, averaging annual growth of 6.7% a year. Figure 6.3 illustrates the projected power generation output in 1990–2050.

Figure 6.3 India – Electricity Generation, Business as Usual (1990–2050)



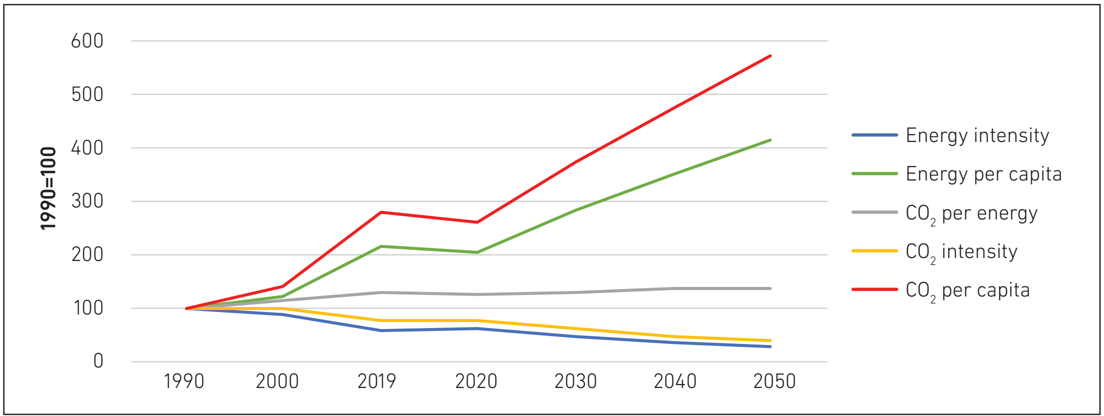
TWh = terawatt-hour.

Source: Authors.

3.1.4. Energy Indicators

Based on the socio-economic data projections and energy estimates, Figure 6.4 depicts the changes in various projected energy indicators in 1990 –2050. Owing to the adoption of more energy-conservative measures and more efficient energy technologies, energy intensity will decrease from 590 toe/US$ million (in constant 2015 values) in 2019 to 161 toe/US$ million (in constant 2015 values) in 2050 – an indication of the primary energy supply per unit of GDP – at an average annual growth of –2.4%. Conversely, energy per capita will grow at 2.1% per year, increasing in value from 0.7 toe/person in 2019 to 1.3 toe/person in 2050, indicating marked improvements in energy access across the population. Due to the introduction of renewable energy technology into the energy mix, a significant decrease in CO_2 intensity is observed, to 421 tonnes of carbon (t-C)/US$ million (in constant 2015 values) in 2050, from 840 t-C/US$ million (in constant 2015 values) in 2019, reflecting a notable decrease in CO_2 emissions per unit of GDP, resulting in annual average growth rate of –2.2%. A slight increase in CO_2 emissions per unit of primary energy supply is projected, from about 2.5 t-C/toe in 2019 to 2.6 t-C/toe in 2050, equivalent to an AAGR of 0.2%. Consequently, CO_2 emissions per capita will increase from roughly 1.7 metric tonnes of carbon (Mt-C)/million people in 2019 to 3.5 Mt-C/million people in 2050, corresponding to a growth rate of 2.3% per year, owing to increased CO_2 emissions on the basis of current policies and national energy framework.

Figure 6.4 India – Energy Indicators, Business as Usual (1990–2050)



Source: Authors.

3.2. Alternative Policy Scenario and Low-Carbon Energy Transition

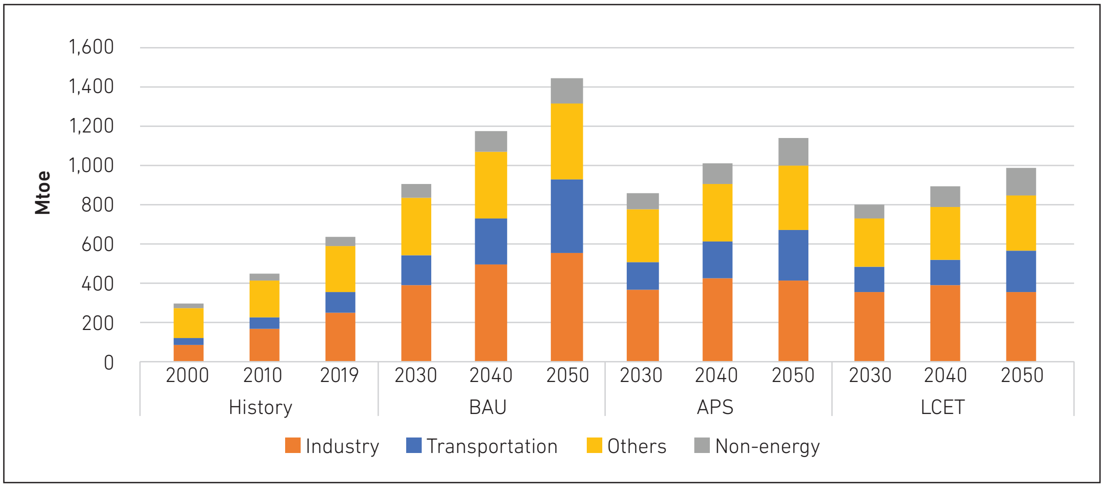
3.2.1. Final Energy Consumption

TFEC in APS and LCET is expected to be lower, reflecting robust energy-saving targets, improvements in end-use technology, and the introduction of more efficient energy management systems. In APS, TFEC will reach 1,132 Mtoe in 2050, decreasing by 22% (311 Mtoe) relative to BAU (Figure 6.5). TFEC in LCET is projected at 979 Mtoe in 2050, a 32% (464 Mtoe) decrease compared with BAU for the same period.

In APS, savings in energy consumption are estimated at 145 Mtoe in industry, 105 Mtoe in transport, and 60 Mtoe in 'others' in 2050, equivalent to 26%, 29%, and 16% consumption savings, respectively. For the non-energy end-use sector, no change in TFEC is observed under either scenario as energy projection values remain unchanged.

In LCET, TFEC is projected to decrease by significantly more than in BAU, decreasing by 34% and corresponding to energy savings of 464 Mtoe in 2050. Industry, transport, and 'others' will decrease by 199 Mtoe, 157 Mtoe, and 107 Mtoe, respectively, in 2050, corresponding to energy savings of 36%, 43%, and 28%, respectively. The non-energy sector will reach 139 Mtoe in LCET in 2050.

Figure 6.5 India – Total Final Energy Consumption, Alternative Policy Scenario and Low-carbon Energy Transition (2000–2050)



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

Source: Authors.

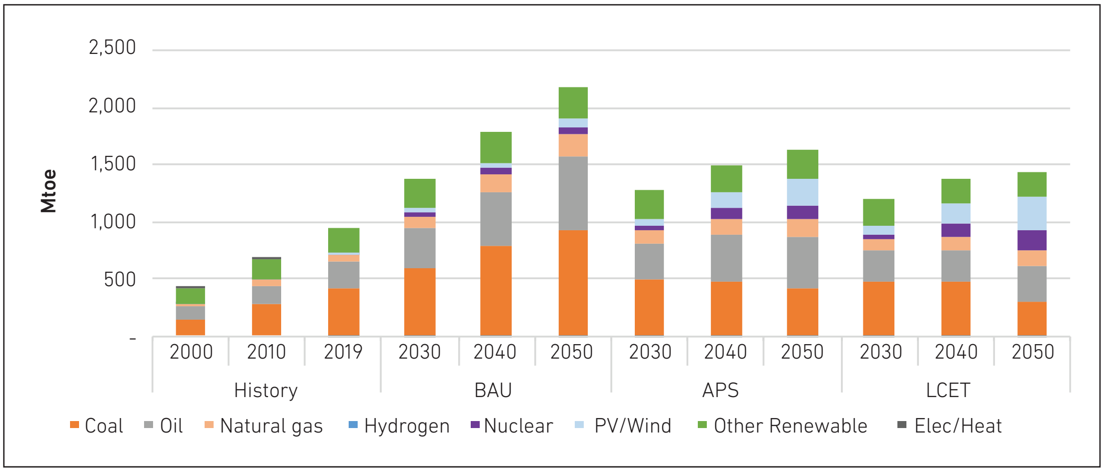
3.2.2. Primary Energy Supply

In APS, primary energy supply is projected to grow at a slower pace, increasing at an average annual growth rate of 1.8% and reaching 1,624 Mtoe in 2050, a 25% (542 Mtoe) supply savings relative to BAU (Figure 6.6). It will increase by an average of 1.4% per year, reaching 1,430 Mtoe in LCET in 2050, equivalent to 34% (737 Mtoe) energy savings. The observed decreases in consumption can be attributed to a more robust approach to adopting and utilising more efficient low-carbon technologies and the visible incorporation of strong energy-saving targets.

'Others' will account for the second-largest share of TPES in APS and the largest share in LCET, increasing at 2.5% and 2.6% per year, respectively, in 2019–2050. Their overall share will increase, accounting for 27% and 31% in APS and LCET, respectively, by 2050. The share of biomass is observed to decrease to 43% in APS and 37% in LCET. Conversely, the consumption of solar and wind energy will increase in value and share, accounting for 63% and 52%, respectively, of TPES in 2050, at growth rates of 10.9% and 10.1% per year in APS and LCET, respectively. Nuclear energy and hydropower will see notable growth, increasing by 7.9% and 3.1%, respectively, per year in APS, with 9.2% and 3.7% increase, respectively, in LCET.

A significant decrease is projected in the share of coal in APS and LCET. By 2050, coal will account for 26% and 22% share in the primary energy supply, equivalent to growth rates of 0.1% and –0.1%, in APS and LCET, respectively, from a 45% share in 2019. The growth rate of oil is expected to be lower in BAU, increasing at about 2.1% and 0.8% per year for APS and LCET, respectively. The AAGR of natural gas is projected at roughly 3.2% in APS (9% of TPES) and 2.95% in LCET (10% of TPES). Consumption of fossil fuels such as coal and natural gas will be mitigated owing to energy efficiency measures. Figure 6.6 shows projected primary energy supply for APS and LCET in 1990–2050.

Figure 6.6 India – Total Primary Energy Supply, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2000–2050)



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

Source: Authors.

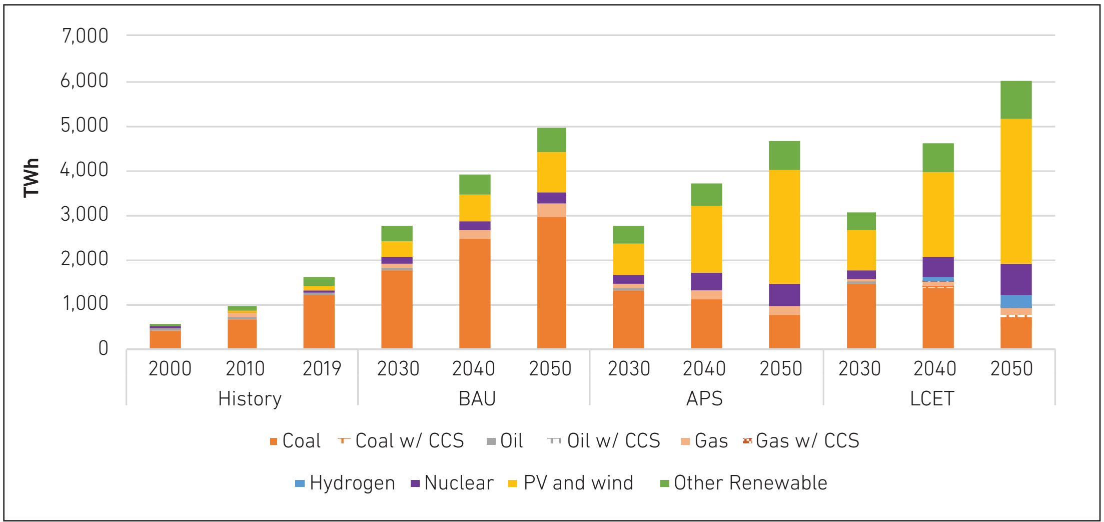
3.2.3. Power Generation

In APS, power generation output will decrease by 6%, an energy saving of 280 TWh in 2050 (Figure 6.7). 'Others', mainly solar PV and wind power, will account for the largest share (60%) in the power generation mix, increasing by 1,732 TWh (165%) at an AAGR of 9.8% within the same period. Nuclear energy and hydropower are expected to increase by 98% (243 TWh) and 11% (44 TWh), respectively, in 2050 because of the integration of renewable energy technologies and alternative fuels into the power generation mix, with a resultant decline in the use of fossil fuels.

Coal-based power is projected to decrease by about 75%, saving 2,222 TWh in energy by 2050, reflected in its growth rate of –1.5% per year. Demand for oil and natural gas in power generation will decrease subsequently; oil consumption will become obsolete whilst natural gas power generation will decrease by 29% (77 TWh) in 2050.

The scenario is different in LCET. Total power generation output is expected to increase by 21% due to the increased share of renewables and the introduction of CCS technology into the electricity mix. Coal-based power generation is projected to decrease by 77%, saving 2,278 TWh in energy in 2050. Oil will be phased out of the electricity mix, with natural gas–based generation decreasing by 35%, corresponding to saving of 94.33 TWh. Demand for nuclear energy and hydropower is expected to increase by 189% and 34%, respectively, with demand for 'others' increasing at an average growth rate of 11.3% per year. The introduction of CCS technology into coal-, gas-, and hydrogen and ammonia–fuelled power plants will significantly reduce CO_2 emissions in power generation output.

Figure 6.7 India – Power Generation Output, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2000–2050)



APS = alternative policy scenario, BAU = business as usual, CCS = carbon capture and storage, LCET = low-carbon energy transition, PV = photovoltaic, TWh = terawatt-hour.

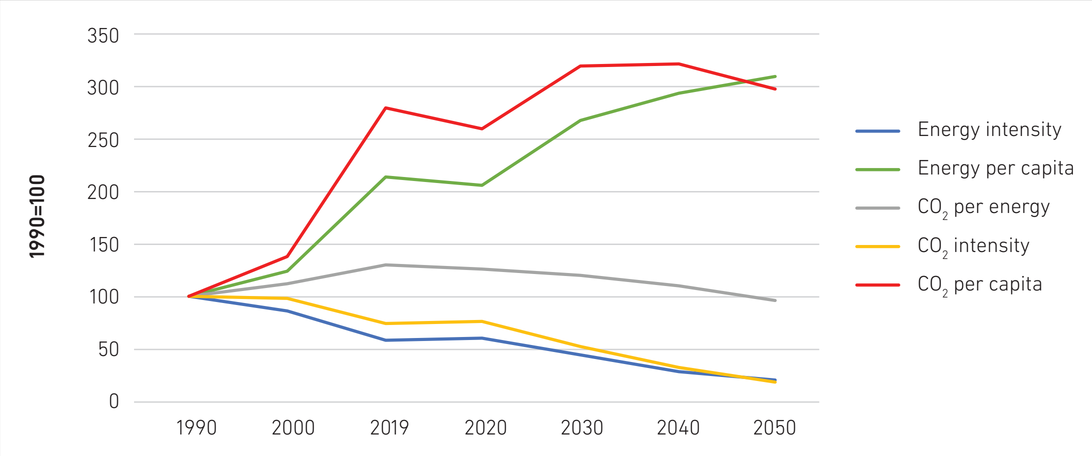
Source: Authors.

3.2.4. Energy Indicators

Due to the vigorous implementation of energy-saving technologies and targets, energy intensity – defined as primary energy supply per unit of GDP – is projected to decrease by 25% (55 toe/US$ million in constant 2015 values) and 34% (40 toe/US$ million in constant 2015 values), in APS and LCET, respectively, in 2050 (Figure 6.8 and Figure 6.9), with individual growth rates of –3.3% and –3.7% per year. CO_2 intensity is expected to decrease by 48% (202 t-C/US$ million in 2015 constant values) and 69% (292 t-C/Us$ million in constant 2015 values) in APS and LCET, respectively, because of significant reductions in CO_2 emissions resulting from the projected decrease in consumption of coal in industrial power plants. The transition from consumption of oil products (mainly gasoline and diesel) in transport and notable reductions in natural gas consumption are expected to considerably lower CO_2 emissions.

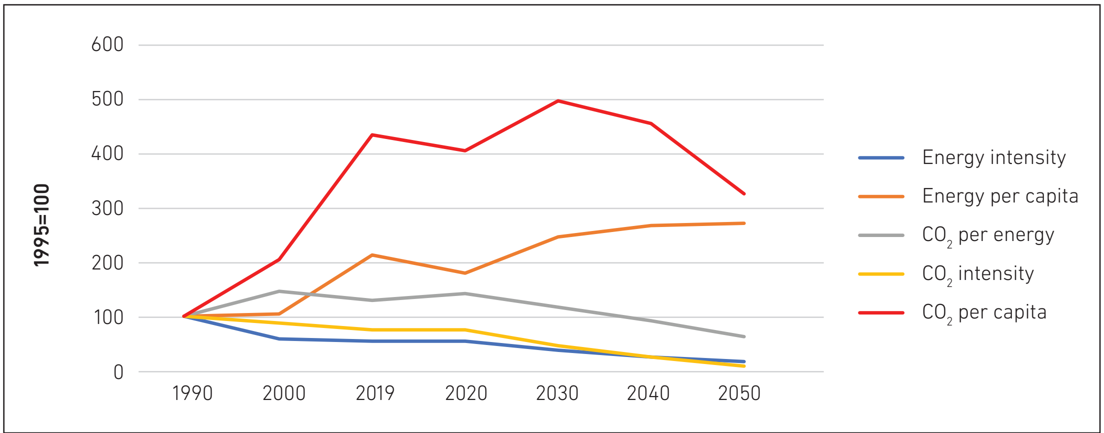
In APS, CO_2 emissions per unit of primary energy supply will reach 1.81 t-C/toe in 2050, decreasing by 31% relative to BAU. In LCET, CO_2 emissions per unit of primary energy supply will decrease to 1.21 t-C/toe in the same year, a 54% decrease compared with BAU.

Figure 6.8 India – Energy Indicators, Alternative Policy Scenario (1990–2050)



Source: Authors.

Figure 6.9 India – Energy Indicators, Low-carbon Energy Transition (1990–2050)



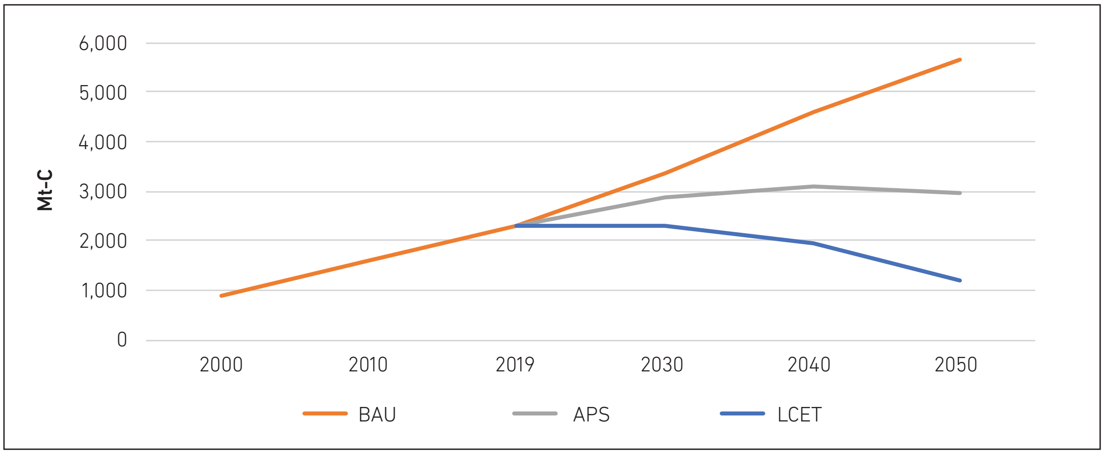
Source: Authors.

3.2.5. Saving of Fossil Fuel Consumption and CO_2 Reduction

In BAU, CO_2 emissions from energy consumption are expected to increase by 2.9% per year, reaching 5,658 million tonnes of carbon (Mt-C) in 2050. Coal is the highest emitter of CO_2, accounting for 65% of total emissions, with oil and natural gas each contributing 30% and 5%, respectively. BAU is still marked by the presence of fossil fuels in its energy mix, with negligible effort to implement energy-saving initiatives. However, the case is different in APS and LCET.

By 2050, overall CO_2 emissions in APS and LCET will be 2,946 and 1,730 Mt-C, respectively, equivalent to 48% (2,712 Mt-C) and 69% (3,928 Mt-C) reductions, respectively, compared with BAU (Figure 6.10). The reasons are reduced demand for coal, oil, and natural gas in power generation output, the introduction of more alternative fuel options into end-use subsectors, and robust energy-saving goals (Figure 6.10).

Figure 6.10 India – CO_2 Emissions, Business as Usual, Alternative Policy Scenario, and Low-carbon Energy Transition (2000–2050)



APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = metric tonne of carbon.

Source: Authors.

4. Implications and Policy Recommendations

Achieving net-zero emissions requires significantly lowering CO_2 emissions and fostering a swift transition to renewable energy. Pathways to help achieve the targets include the following:

- Developing policies that promote the massive expansion of renewables, strengthen the electricity grid to enhance flexibility, and develop storage technologies.
- Deployment of a substantial amount of carbon-removal projects using CCS technology and encouragement of massive investment in afforestation to sink carbon. The measures will aid in significantly lowering CO_2 emissions by capturing residual emissions from fossil-fuel–generated power plants and hard-to-abate industries, such as cement, and offset emissions from fast-growing sectors.
- Raising the share of hydrogen from its nascent stage today and deploying it mainly as a fuel substitute for heavy-duty transport and industrial applications.
- Considerably improving energy efficiency through robust investment in urban and industrial energy infrastructure, power plants, factories, appliances, and cars to significantly lower energy intensity.
- Transitioning from fossil fuel–generated power output in the electricity mix, primarily from coal, to renewable energy sources such as wind power, solar PV, and hydropower and other alternative energy sources such as nuclear energy and hydrogen.
- Implementing policies that favour the adoption of electric vehicle technology to phase out oil consumption in transport. The measure will serve to not only lower CO_2 emissions and energy intensity but also create significant opportunities for local and foreign investors.

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CHAPTER 7

Indonesia Country Report

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1. Background

Indonesia covers an area of 1,913,000 square kilometres, with a population that increased by an average of 1.4% per year—from 178.6 million in 1990 to 270.6 million people in 2019 (World Development Indicators, 2021).

Gross domestic product (GDP) was $1,204.5 billion (constant 2010 United States [US] dollars) in 2019, an average increase of 4.3% per year from 1990. The service sector is a major contributor to GDP (44.7%), followed by industry (38.5%), agriculture (12.8%), and other activities (4.1%). In 2019, GDP per capita was about $3,877 (constant 2010 US$), whilst in 1990 it was only $1,488 (constant 2010 US$).

Indonesia is richly endowed with natural resources. Its vast oil and gas reserves made it a significant player in the international oil and gas industry. Reserves, however, continue to deplete as the scale of oil and gas exploration is small and the success rate of exploration is low. The oil and gas investment climate has not been conducive and the use of enhanced oil recovery technology to boost oil production is not yet optimal. As of January 2019, proven reserves of crude oil were 2.48 billion barrels, whilst those of natural gas were 49.7 trillion cubic feet (Center for Data and Information Technology-Pusdatin, 2019). Indonesia exports coal and had about 36.3 billion tonnes of proven coal reserves by the end of 2019.

Non-fossil energy resources include hydro, geothermal, biomass, and other renewable sources such as solar and wind. Estimated hydro potential is about 95 gigawatts (GW), whilst estimated geothermal potential is 23.9 GW. In total, renewable energy potential is about 3,643 GW for power plants, of which only 0.3% or 11.6 GW have been utilised. The use of new and renewable energy (NRE) for power plants is low due to high production cost, which makes competing with coal power plants difficult. The lack of renewable energy power plant components and the difficulty of obtaining low-interest financing have also slowed renewable energy development.

2. Modelling Assumptions

Real GDP growth was 5.02% in 2019 but decreased to -2.07% in 2020 due to the corona virus disease (COVID-19) pandemic. In 2021, GDP growth slightly increased to 3.8% (Central Bank of Indonesia, 2021), in line with the decline in Covid cases and an increase in vaccines. Expected real GDP growth for 2022 was 5.2%. The National Energy Policy (KEN) of 2014 estimated an average annual growth rate of 8.00% from 2017 to 2025, which would slow to 7.25% in 2035 and 6.50% in 2050. Since current real GDP growth is slower than what the KEN expected, this study estimates that real GDP will grow by an average of 4.8% per year from 2019 to 2050. This rate is in line with the long-term vision of about 5% per year for Indonesia to become a high-income economy by 2045. The population growth assumption is 0.8% per year from 2017 to 2050. The business as usual (BAU) scenario and the five alternative policy scenarios (APSs) are similar to those in the previous ERIA reports on the analysis of energy saving potential in East Asia; the latest one was in 2019. The APSs reflect additional likely policy interventions such as energy efficiency and conservation (EEC) targets and action plans, efficiency improvement in power generation plants, more aggressive adoption of renewable energy, and introduction of nuclear energy. Below are the five APSs:

(i) APS1. More efficient final energy consumption, with energy-saving targets by sector. Article 9b of the KEN states that energy elasticity (with regard to GDP) will be less than 1 in 2025 and that final energy intensity will be reduced by 1% per year up to 2025. These targets are considered for this year's study.
(ii) APS2. More efficient thermal power generation, significant improvement of existing coal power plants, introduction of cleaner coal technologies, and more-efficient natural gas combined-cycle technologies.
(iii) APS3. Higher contribution of NRE and biofuels, higher penetration of NRE for electricity generation, and utilisation of liquid biofuels in transport. The scenario assumes that article 9f of the KEN will be fulfilled, i.e. NRE share reaches 23% by 2025 and 31% by 2050, and the share of liquid biofuels in road transport is 30% from 2020 onwards.
(iv) APS4. Introduction or higher utilisation of nuclear energy. The assumption was that nuclear energy would be used after 2045, but it is now the last option. The existing plan has been delayed, but the study still assumes that 1,000-megawatt nuclear power plants will be constructed by 2045.
(v) APS5. The combination of APS1 to APS4. The APS5 results are represented as the APS.

In addition to the 5 APS, this year we formulated the Low Carbon Energy Transition (LCET) scenario. In this scenario, fossil fuel consumption in the industry, transport, and commercial sectors will be replace with hydrogen. For transport sector, a shift from Internal Combustion Engine (ICE) vehicles to Battery Electric Vehicles (BEVs) is necessary decarbonize the emission in transportation sector. Additionally, transitioning from coal-based power generation to a combination of gas and renewable energy, using Carbon Capture Storage (CCS) for coal and gas power, is vital.

3. Outlook Result

3.1. Business-as-Usual Scenario

3.1.1. Final Energy Consumption

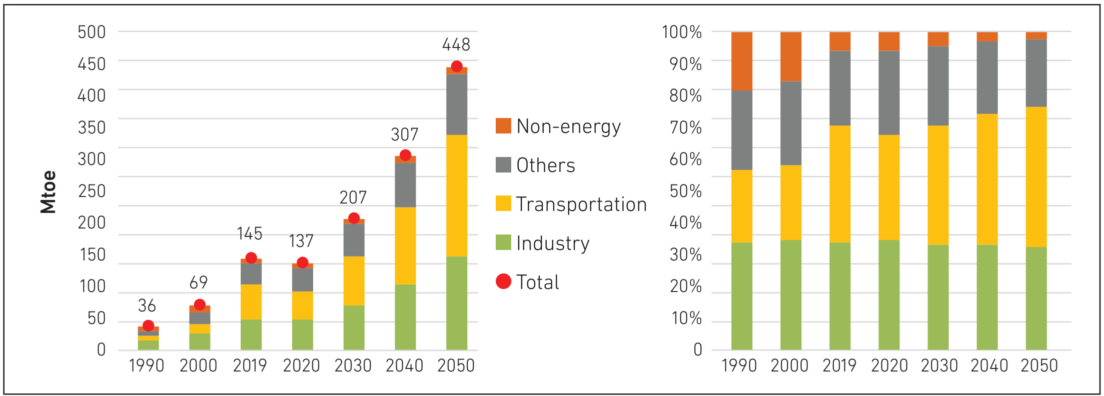
Total final energy consumption (TFEC) increased by an average of 4.9% per year from 1990 to 2019, from 36.43 million tonnes of oil equivalent (Mtoe) to 144.78 Mtoe. Given the assumed economic and population growth, TFEC will continue growth slowly, by 3.7% per year from 2019 to 2050 under BAU.

a. Final Energy Consumption by Sector

Growth in total final energy consumption is mainly due to the rapid increase of energy consumed by transport and industry. Transport is still heavily dependent on oil. Transport's final energy consumption grew at an average of 6.7% per year in 1990–2019. Growth is expected to continue until 2050 under BAU but only by 4.3% per year. Transport's share in TFEC increased from about 22.6% in 1990 to 36.9% in 2019. The share will continue to increase to 45.9% in 2050. Industry's final energy consumption grew more slowly than transport sector in 1990–2019 (4.8% per year) and will continue decrease in 2019–2050 (3.6%). Industry had the highest share in TFEC in 1990–2005, but in 2019–2050 transport had the highest share. In 2050, the share of transport sector in TFEC is expected to be about 43.5%, while the share of industry is estimated to remain the same from 1990 to 2050 at 33%.

The final energy consumption of 'others' (mainly the residential and commercial sectors) grew by an average of 4.6% per year in 1990–2019 and is projected to slow to an average of 3.4% per year in 2019–2050. The share of 'others' in TFEC in 1990 was about 25.2% and is expected to decrease to 21.6% in 2050. The combined share of oil and alternative fuels for transport will contribute to the increase of transport's share in TFEC. Figure 7.1 shows TEFC by sector for 1990–2050.

Figure 7.1 Final Energy Consumption by Sector, 2019–2050
(Mtoe)



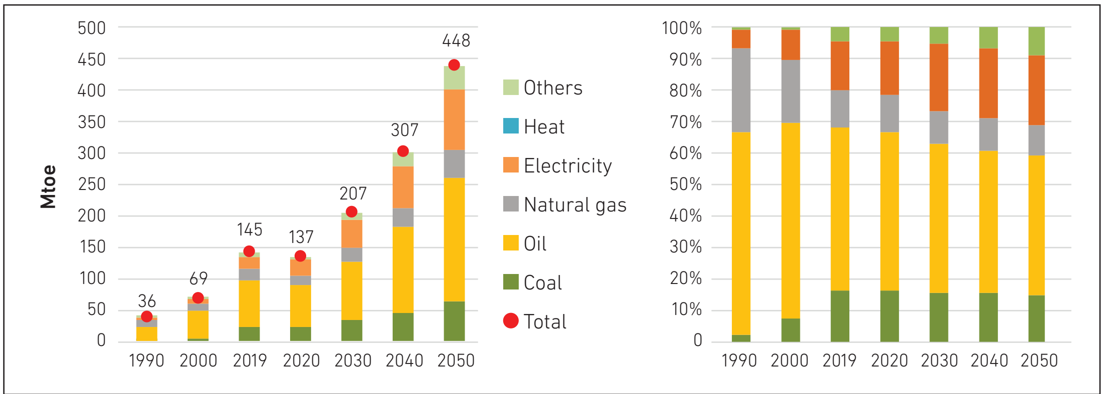
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

b. Final Energy Consumption by Fuel Type

Coal grew the fastest in 1990–2019 because in this period the cement and metal industries as major consumers started to expand rapidly. Total coal demand increased from 0.82 Mtoe in 1990 to 23.4 Mtoe in 2019, growing by an average of 12.3% per year. Electricity, increased significantly by an average of 8.1% per year, due to the significant increase in industry and residential consumption, from 2.4 Mtoe in 1990 to 22.5 Mtoe in 2019. Natural gas grew an average of 1.9% and oil by an average of 4.1% in 1990–2019. Demand for all fuels will continue to increase. While oil will still play a major role in final energy consumption, more alternative fuels will be consumed by end-use sectors (Figure 7.2). The share of oil is expected to be about 44.9% in 2050, slightly lower than its share in 2019 (52.3%). The remaining share will be composed of coal (14.9%), natural gas (9.9%), electricity (22.3%), and others (86.2%)

Figure 7.2 Final Energy Consumption by Fuel, 1990–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent

Source: Author's calculations.

3.1.2. Primary Energy Supply

Total primary energy supply (TPES) grew by about 3.7% per year, from 79 Mtoe in 1990 to 229 Mtoe in 2019. The fastest-growing fuels in 1990–2019 were coal and geothermal. Coal supply grew by an average of 11.5% per year, whilst geothermal grew by an average 9.1% per year. Oil supply increased more slowly, by 4% per year, whilst gas had the slowest growth rate at 0.8% per year during the same period.

Under BAU, TPES is projected to increase by an average of 3.5% per year, reaching 664 Mtoe in 2050. The biggest growth in 2050 will come from solar and wind at about 10.2%, driven by the development of renewable energy power generation, including solar rooftops on commercial and residential buildings. Geothermal energy is projected to grow by 4.4% per year until 2050. Hydro, including mini and micro hydro, will also increase from 2019 to 2050, but at a slower rate than geothermal, at 4.3% per year.

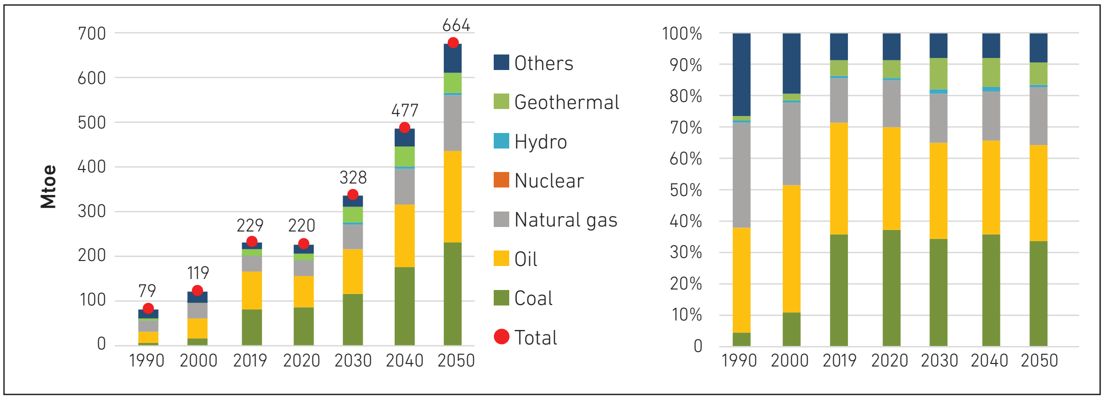
Natural gas is projected to increase an average 4.4% per year in 2019–2050. Oil is projected to increase by an average of 3% per year and coal an average of 3.3% per year.

The BAU model assumes no uptake of nuclear energy. As a result, renewable energy will be significant in the primary energy supply mix as the uptake of cleaner fuels increases. Other renewable energy resources include solar, wind, biofuels, and biomass

Oil constituted the largest share in TPES at about 33.8% in 1990 and 35.9% in 2019. The share of natural gas in the total mix decreased from 33.2% in 1990 to 14.2% in 2019. Coal's share in TPES increased from about 4.3% in 1990 to 35.5% in 2019. Geothermal share decreased from 1.2% to 5.3% in 1990–2019.

In 2050, the oil's share in TPES is projected to decrease from 35.9% to 30.6%. Coal's share will decrease slightly from 35.5% in 2019 to 33.9% in 2050. The share of natural gas will increase to 18.4% in 2050 from 14.2% in 2019. Hydro's share in TPES will increase from 0.7% in 2019 to 0.9% in 2050. Same with hydro, the geothermal share will increase from 5.3% to 7.1%. The share of 'others will reach 9.1% in 2050 from 8.4% in 2019 (Figure 7.3).

Figure 7.3 Primary Energy Supply, 1990–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent

Source: Author's calculatios.

3.1.3. Power Generation

Power generation output increased by an average of 7.8% per year, from about 33.1 terawatt hour (TWh) in 1990 to 293.8 TWh in 2019. In 1990, most generation output was still from oil-based plants (37.2%), followed by coal power plant (29.5%). As coal became more available and government policy was to move away from oil for power generation, coal's share in the generation mix increased significantly to 59.4% in 2019. Coal power generation reached 174.5 TWh in 2019, increasing rapidly by 10.5% per year.

Natural gas became more important with the expansion of gas turbine and combined cycle capacity. The share of natural gas, however, was lower than that of coal (21.2% in 2019), although electricity generation from natural gas increased at the fastest pace, by 10.5% per year, reaching 62.3 TWh in 2019.

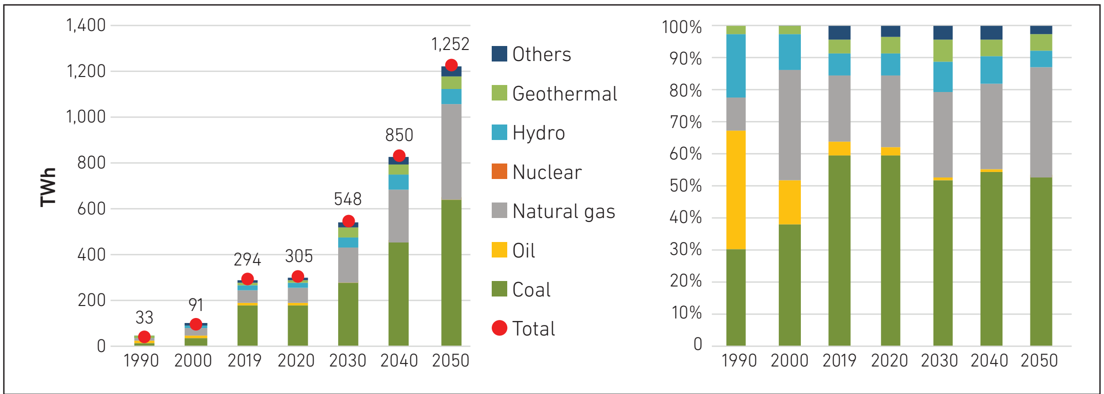
Under BAU, power generation is projected to reach 1252 TWh by 2050, increasing by an average of 4.8% per year (Figure 7.4). Hydropower and geothermal generation are growing, by 4.3% and 4.4%, respectively. Generation from 'others' will grow, but slower than hydropower and geothermal by an average of 4% per year.

Power generation from natural gas will continue to increase at an average rate of 6.4% per year, whilst coal-based power generation will grow by an average of 4.3% per year. The BAU scenario does not include nuclear plants.

The share of coal will remain dominant in total power generation and is expected to continue to increase about 51.8% in 2050. While the share of natural gas will increase to 34.5% by 2050, oil will continue to decline to 0.1% by 2050. The assumption is that oil-based plants (diesel plants) will be replaced with natural gas or renewable sources except where substitution is not feasible especially in remote area.

The total share of renewable energy in the generation mix will reach 13.5% by 2050, with hydropower at 5.8%, geothermal at 4.3%, and other renewables at 3.4%.

Figure 7.4 Power Generation by Type of Fuel, 1990–2050
(TWh)



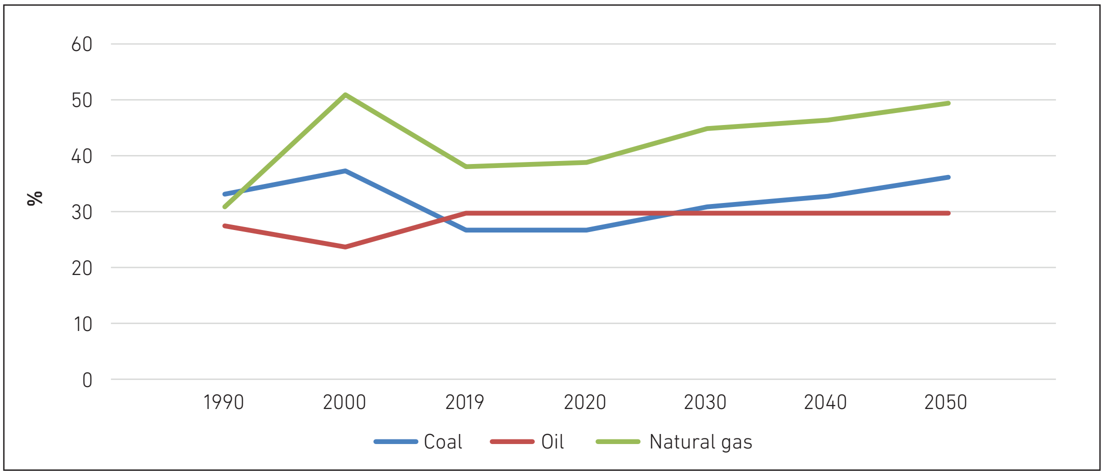
TWh = terrawatt hour.

Source: Author's calculations.

The average thermal efficiency of power plants based on fossil fuel was about 28.2% in 2019. Under BAU, coal and natural gas power plants are assumed to become more efficient, causing thermal efficiency of fossil fuel plants to increase to 39% by 2050. The thermal efficiency of coal-fired power plants will increase from 26% in 2019 to 35% in 2050, whilst that of natural gas will increase from 37% to 48%. Oil will remain at 29% in 2019–2050 (Figure 7.5).

Figure 7.5 Thermal Efficiency, Business as Usual, 1990–2050

(%)



Source: Author's calculations.

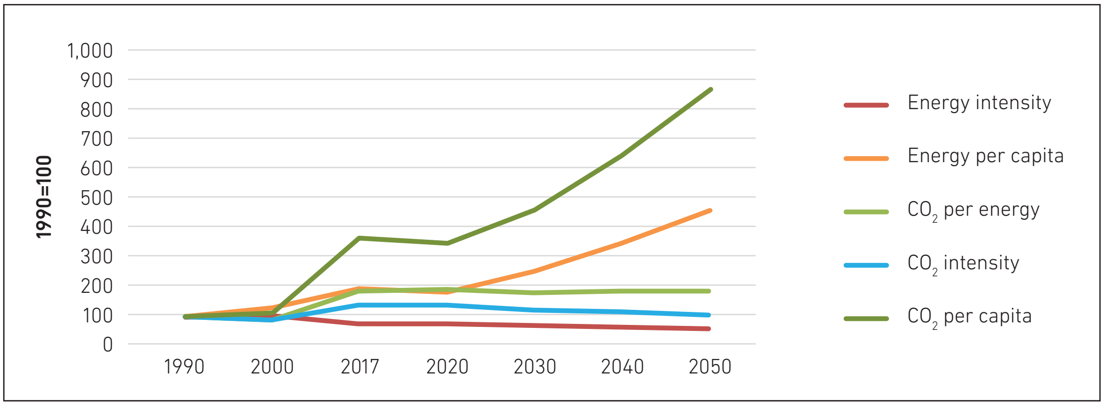
3.1.4. Energy Indicators

Primary energy intensity is measured as the ratio of total primary energy supply (TPES) and GDP, which is the unit consumption of primary energy per $1 million (2010 USD constant). Primary energy intensity has been declining since 1990, reaching 189.9 tonnes of oil equivalent (toe) in 2019. Final energy intensity (TFEC/GDP) started declining after 2000, reaching 120 toe per $1 million (2010 USD constant). These figures indicate that energy producers and consumers have started to use energy effectively by implementing energy conservation measures and using more efficient energy technologies.

In 2019–2050 primary energy intensity under BAU is projected to decline at an average rate of 0.9% per year during, while final energy intensity will decline at an average rate of 0.8% per year (Figure 7.6). Primary energy intensity in 2050 will be about 140.9 toe/$1 million (2010 USD constant), whilst final energy intensity will be 95.2 toe/$1 million (2010 USD constant). Per-capita energy consumption, measured as the ratio of total primary energy supply to the total population, increased from 0.4 in 1990 to 0.8 in 2019, indicating that energy access is improving. In 2015, the electrification ratio was about 88.3% and reached 98.9% by 2019 (Ministry of Energy and Mineral Resources, 2019). The government expected that all households would have access to electricity by 2020.

Under BAU, energy consumption per capita will continue to increase and reach 2.1 toe per person in 2050, which is lower than the KEN target of 3.2 toe in 2050. Under BAU, the elasticity of final energy consumption with regard to GDP in 2019–2050 will reach 0.8. Elasticity below 1 indicates that growth in final energy consumption will be slower than growth in GDP in 2019–2050.

Figure 7.6 Energy Intensity and Other Energy Indicators, 1990–2050



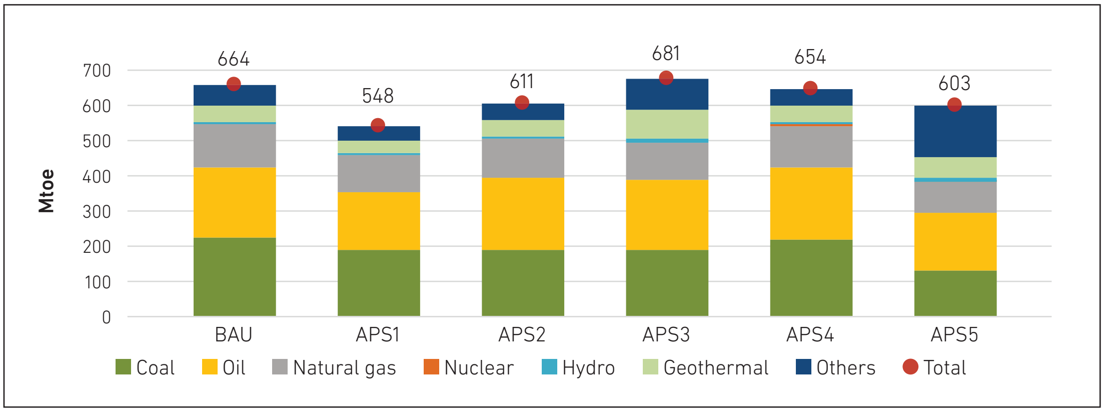
CO_2 = carbon dioxide.

Source: Author's calculations.

3.2. Potential for Energy Savings and Reduction of Carbon Dioxide Emission

The assumptions in APS1 to APS5 were analyzed separately to determine their individual impacts. Figure 7.7 shows the changes in TPES under all scenarios.

Figure 7.7 Comparison of Scenarios' Total Primary Energy Supply by 2050
(Mtoe)



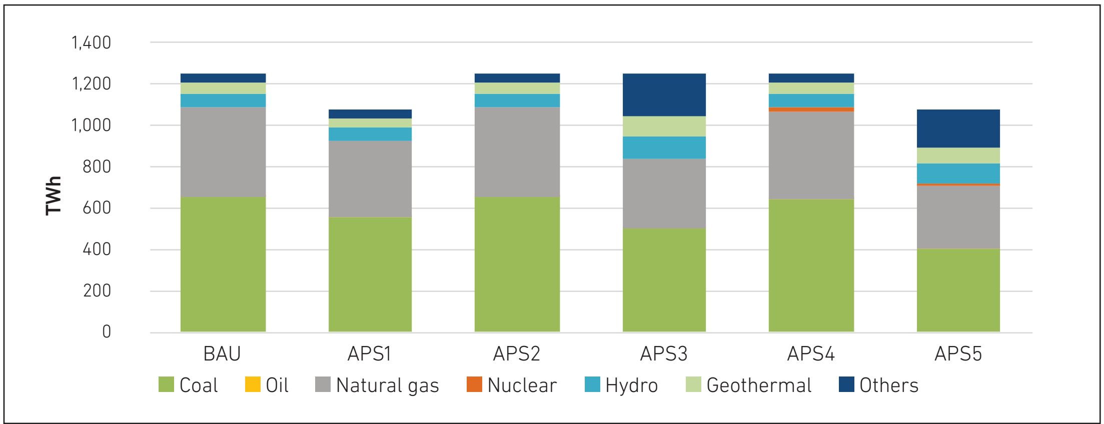
APS = alternative policy scenarios; BAU = business as usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

APS1 and APS5 have the largest decreases in primary energy supply by 2050 due to demand side energy efficiency, reducing BAU TPES by up to 17.5% (116.3 Mtoe) and 9.1% (60.7 Mtoe) respectively. APS2's higher efficiency in thermal electricity generation results in a 7.9% (52.7 Mtoe) TPES reduction from BAU. Without efficiency measures in the final sector, it has less impact than APS1. The reduction is due to more efficient power generation, whilst some conventional plants cease operation after reaching the end of their technical life. APS3 sees a slight TPES increase of 2.5% from BAU as more renewable energy is used to generate power and more biofuels are consumed in transport. The introduction of nuclear power generation in 2045 under APS4 only increases TPES from BAU by 1.5% (9.7 Mtoe) in 2050. Though nuclear plants would reduce the consumption of fossil fuels (coal, oil, gas) in generating power, they are slightly less efficient than fossil fuel plants, resulting in no savings from BAU.

Total electricity generation in 2050 under all scenarios is shown in Figure 7.8. In APS1, lower electricity demand results in less electricity production. Since the difference between APS1 and BAU is the amount generated, the generation mix is the same. Fossil fuel generation still dominates, at 86%, whilst renewable energy (hydro, geothermal, others) generation accounts for 14%.

Figure 7.8 Comparison of Scenarios' Electricity Generation by 2050
(TWh)



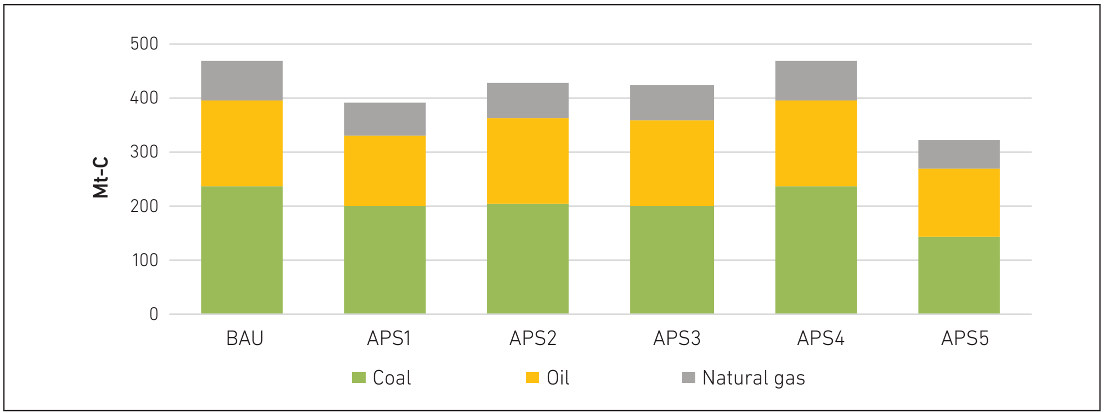
APS = alternative policy scenarios; BAU = business as usual; TWh = terrawatt hour.

Source: Author's calculations.

Under APS2 and BAU, the share of fossil fuel-fired generation will be the same since the differences lie only in the fuel efficiency of fossil fuel power plants. Under APS3, which assumes more renewable energy, the share of fossil fuel-fired generation will be reduced to 67%. Under APS4, nuclear energy will slightly reduce the fossil fuel share to 85%. With APS5, the share of fossil fuel-based generation will be significantly reduced to 20.5%

Under APS1, carbon dioxide (CO_2) emissions could be reduced 77.5 million tonnes of carbon (Mt-C) or about 16% in 2050 (Figure 7.9). Under APS2, the installation of more-efficient power plants could reduce emissions by 41 Mt-C (9%). More renewable energy could reduce emissions by 46.5 Mt-C(10%), whilst nuclear energy could reduce them by 2.7 Mt-C(1%). APS5 could reduce emissions by 150 Mt-C 32% in 2050.

Figure 7.9 **Comparison of Scenarios' Carbon Dioxide Emissions by 2050**
(Mt-C)



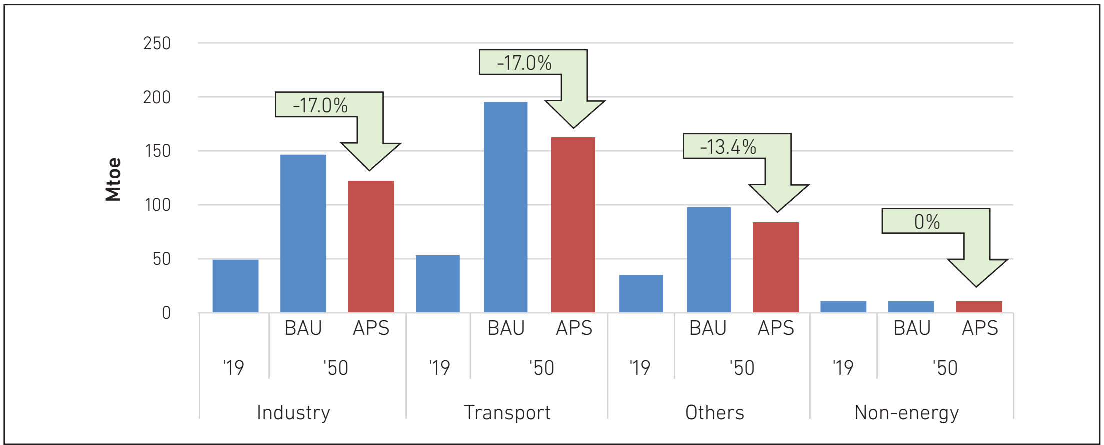
APS = alternative policy scenarios; BAU = business as usual; Mt-C = Million Ton Carbon.

Source: Author's calculations.

3.2.1. Final Energy Consumption

TFEC is expected to increase at a slower rate under APS, averaging 3.4% annually from 144.8 Mtoe in 2019 to 377.3 Mtoe in 2050. This is due to the government's energy efficiency and conservation (EEC) program, which will result in slower growth across all sectors, particularly in transport. Transport energy demand is expected to increase by 4.1% annually, compared to 4.7% under BAU. Figure 7.10. shows TFEC by sector in 2019 and 2050 for both scenarios. The APS assumes savings of 25 Mtoe in industry, 33 Mtoe in transport, and 13 Mtoe in the residential and commercial ('others') sectors by 2050.

Figure 7.10 **Final Energy Consumption by Sector, Business as Usual, and Alternative Policy Scenario**
(Mtoe)



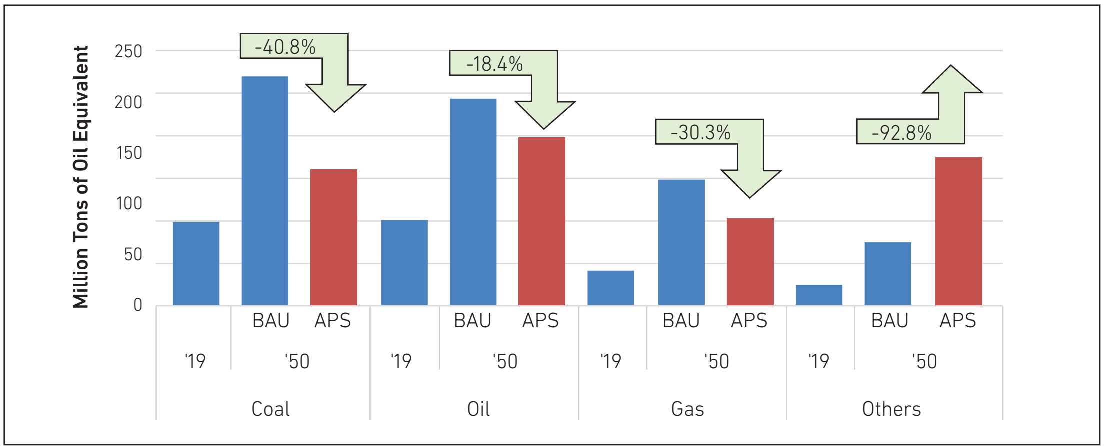
APS = alternative policy scenarios; BAU = business as usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.2.2. Primary Energy Supply

TPES is projected to increase by 3% annually to reach 541 Mtoe in 2050 under APS, reflecting energy efficiency and conservation measures on the demand side, as well as more-efficient technology for power generation on the supply side. Under the APS, Indonesia is expected to save almost 91.7 Mtoe on coal, about 37.3 Mtoe on oil, and 37.1 Mtoe on natural gas by 2050. Additionally, TPES under APS for other resources (new and renewable resources, nuclear, and 'others') is 53.4 Mtoe higher than under BAU in 2050. See Figure 7.11.

Figure 7.11 Primary Energy Supply by Source, Business as Usual, and Alternative Policy Scenario, 2019–2050
(Mtoe)



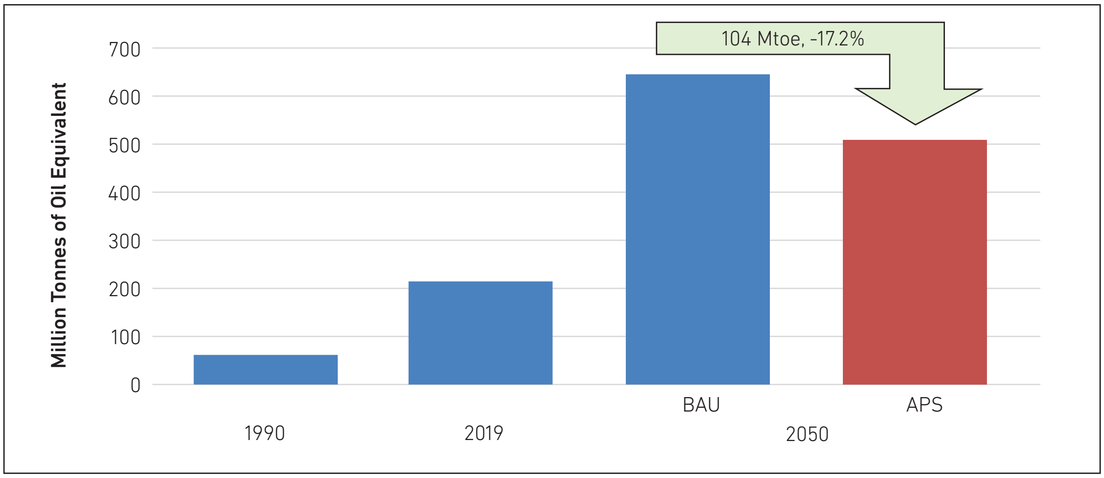
APS = alternative policy scenarios; BAU = business as usual.

Source: Author's calculations.

3.2.3. Projected Energy Savings

Total energy savings—the difference between TPES under BAU and APS is 104 Mtoe in 2050, almost half than TPES in 2019, which was about 221 Mtoe. The difference is achieved by implementing EEC and achieving renewable energy targets, improving power plant efficiency, and introducing nuclear energy.

Figure 7.12 **Total Primary Energy Supply, BAU and APS, 1990–2050**
(Mtoe)



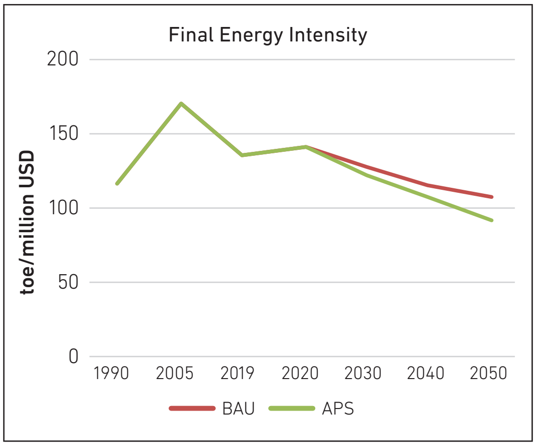
APS = alternative policy scenarios; BAU = business as usual; Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

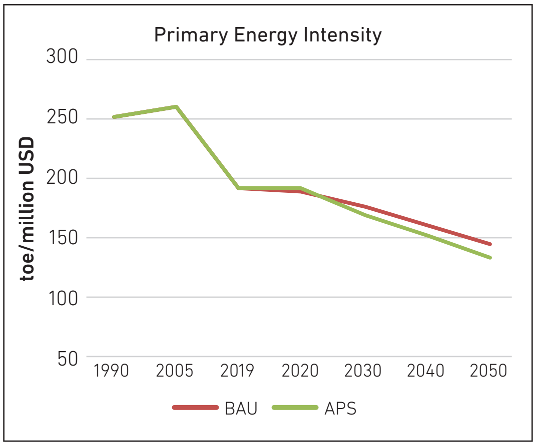
3.2.4. Energy Intensity

The National Energy Policy (KEN) targets an annual reduction of 1% in final energy intensity up to 2025. Under BAU, final energy intensity will decline by an average of 0.8% per year in 2019–2050. Achieving sector EEC targets under APS will hasten the decline of final energy intensity to 1.3% per year over the projection period.

Primary energy intensity will be reduced by more than 1.1% per year under BAU and by 1.7% per year under APS if the EEC sector targets are achieved. See Figure 7.13.

Figure 7.13 **Energy Intensity, 1990–2050**





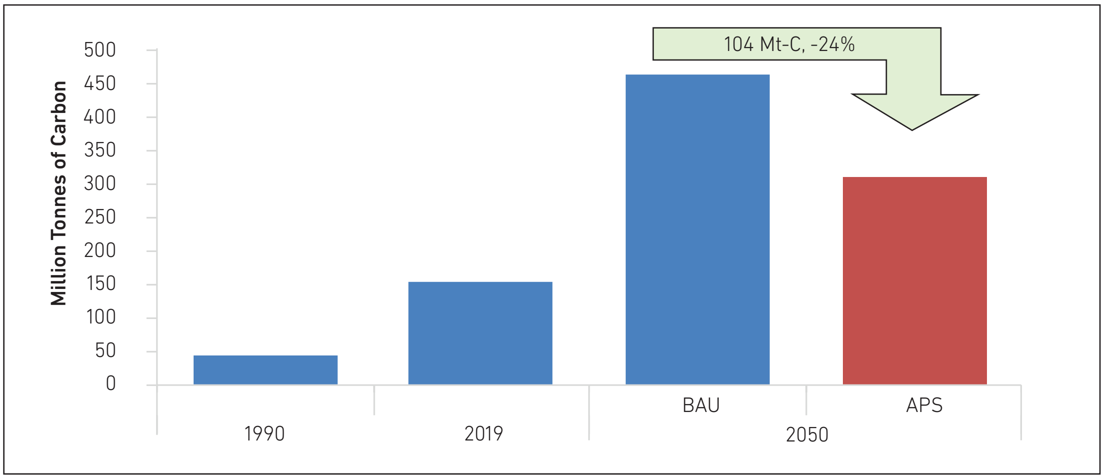
APS = alternative policy scenarios; BAU = business as usual; toe = tonnes of oil equivalent.
Source: Author's calculations.

3.2.5. Carbon Dioxide Emission Reduction

Under BAU, Carbon dioxide emissions from energy consumption are projected to increase by an average of 3.8% per year. This is equivalent to about 163.6 million tonnes carbon (Mt-C) (Figure 7.14). The increase is driven by the increasing use of carbon-intensive fuels, particularly coal for power generation and industry and oil for transport.

Figure 7.14 Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenarios, 1990, 2019, and 2050

(Mt-C)



APS = alternative policy scenarios; BAU = business as usual; Mt-C = million tonnes of carbon.

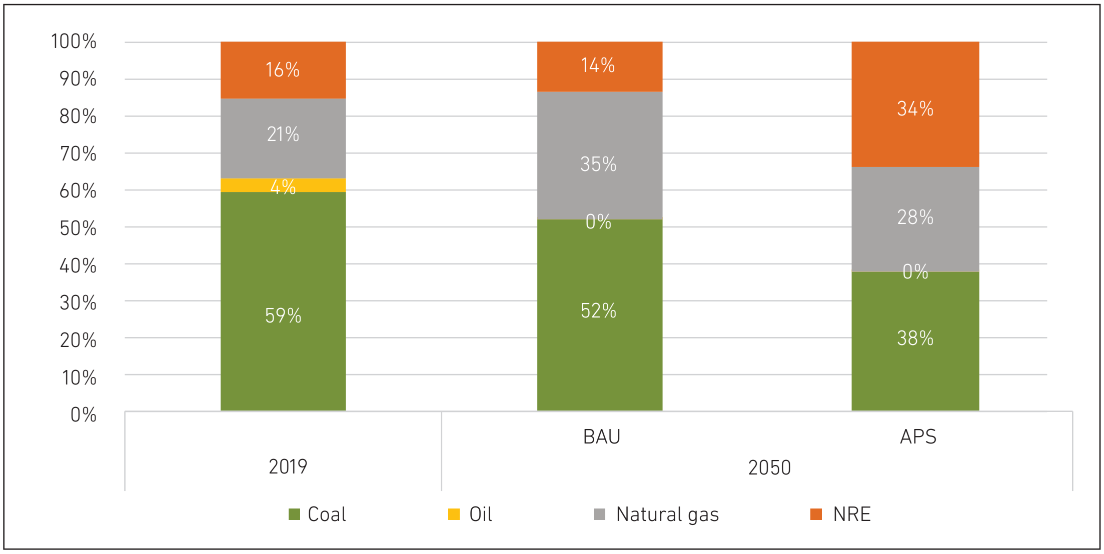
Source: Author's calculations.

With the onset of greater energy conservation, higher efficiency, elevated renewable targets, and the inclusion of nuclear energy in 2045, CO_2 emissions in 2050 under APS are expected to be 31.9% lower than under BAU. The government has committed to reduce CO_2 emissions in 2030 by 29% without international assistance and by 41% with international assistance. This study's CO_2 emission reduction result is lower than the committed target of 29%, indicating that the combined target and action plan under APS will not be sufficient and must be more aggressive. Compared to oil and gas, replacing coal, which is mainly used in the power sector, reduces the most CO_2 emission. Increasing the share of new and renewable energy (NRE) as outlined in the KEN will significantly reduce the use of coal. Despite the introduction of alternatives, oil remains the dominant fuel source in transport.

Figure 7.15 displays the share of each energy source used to generate electricity in 2050. Coal-based power plant electricity production grows slower than NRE- and gas-based power plants in both BAU and APS. Solar- and biomass-based power generation exhibit the fastest growth rates.

Figure 7.15 Power Generation Mix, BAU and APS, 2019 and 2050

(%)



APS = alternative policy scenarios; BAU = business as usual; NRE = new and renewable energy.

Source: Author's calculations.

3.3. Low Carbon Energy Transition Scenario (Carbon Neutral)

The Low Carbon Energy Transition (LCET) is a new scenario in Outlook Energy Saving Potential (OESP) 2022 that was created to achieve net zero emission. Through the Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050 published by the Ministry of Environment and Forestry, Indonesia aims to reduce greenhouse gas (GHG) emissions to 540 million tonnes of carbon dioxide equivalent (Mt-Co_2e) by 2050 and Indonesia sets the emission peaking target of national GHG emissions in 2030. Target emissions in 2050 can be achieved through the net sink of the forest and land-use sector. Carbon neutrality should be achieved by reducing emissions in Energy, Waste, and Industrial Processes and Product Use (IPPU) sector. To reach this goal, forestry must continue efforts to increase the amount of carbon absorbed by forests to achieve and maintain net sink, even after 2030. Second, significant changes in the energy sector are needed. This includes increasing the use of renewable energy sources, improving energy efficiency, reducing coal consumption, and implementing carbon capture and storage (CCS) and carbon capture, utilization, and storage (CCUS).

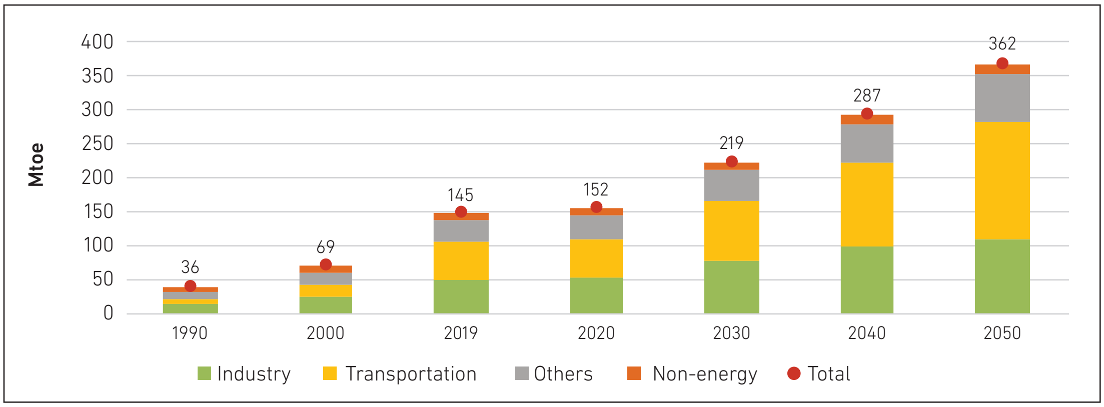
To achieve net zero emission in 2060, the LCET scenario requires substituting fossil fuel with hydrogen, especially in industry and transport, increasing the use of electronic vehicles (EVs) and biofuel for road transport, applying CCS and CCUS in power generation, and optimising renewable energy sources—including nuclear—in power generation.

Starting in 2035, new hydrogen fuel will replace fossil fuel in industry and road transport. Hydrogen, EVs, and biofuel (biodiesel and bioethanol) will replace In road transport, gasoline and diesel oil. The power generation will achieve decarbonisation by implementing CCS/CCUS technology in coal and gas power generation from 2040. Nuclear generation also will introduce in 2040. In addition Renewable power generation will be increase sharply start 2030 (hydro, geothermal, biomass, solar, wind, municipal solid waste and ocean)

3.3.1. Final Energy Consumption

Final energy consumption in the LCET scenario is projected to increase by an average annual growth rate of 3% from 2019–2050. By 2050, the final energy consumption will reach about 362 Mtoe. This amount will be 4% lower than in the APS5 due to the slow growth of final energy consumption in the industrial sector.

Figure 7.16 Final Energy Consumption by Sector, Low Carbon Energy Transition Scenario 1990–2050
(Mtoe)

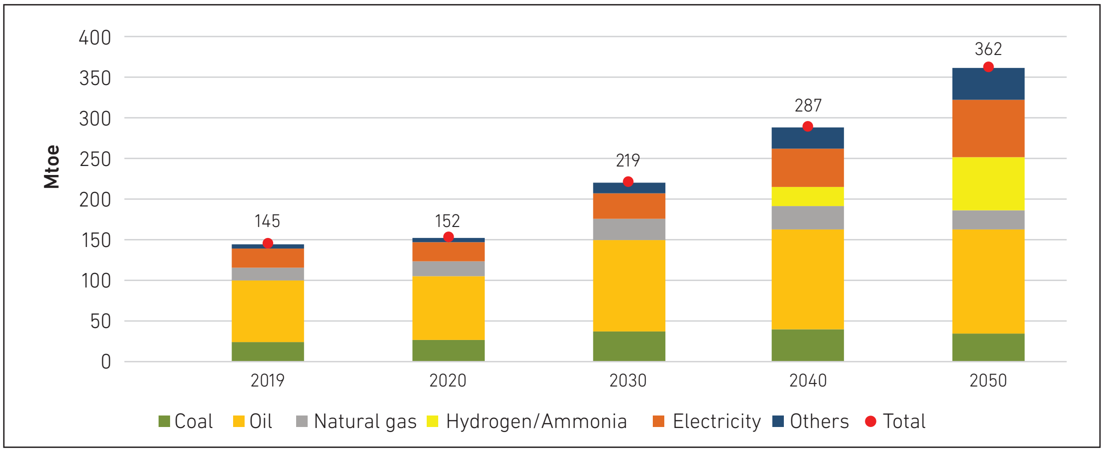


Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 7.17 shows the final energy consumption by fuel. In 2050, share of fossil fuel consumption in the LECT scenario (coal, oil, and natural gas) will only be 51% of the final energy consumption. The TFEC in LCET is about 68% lower than in APS5. In terms of fuel, share, oil consumption will decrease from 51% in 2019 to 36% in 2050. In the case of coal, the share will decrease from 17% to 9 % over same period, while natural gas will also decrease from 10% to 7%. In LCET, substituting fuel oil with hydrogen, increasing biofuel and electricity in transport sector, and using hydrogen in industry will greatly reduce the use of coal, oil, and gas in the future. Hydrogen consumption is expected to reach about 24.7 Mtoe in 2040 and increase to 64 Mtoe in 2050 (18%).For electricity, it was 22.5 Mtoe in 2019, and is expected to increase to 72 Mtoe in 2050, while (biofuel) increase will reach 40 Mtoe in 2050.

Figure 7.17 Final Energy Consumption by Fuel, Low Carbon Energy Transition Scenario, 2019 – 2050 (Mtoe)



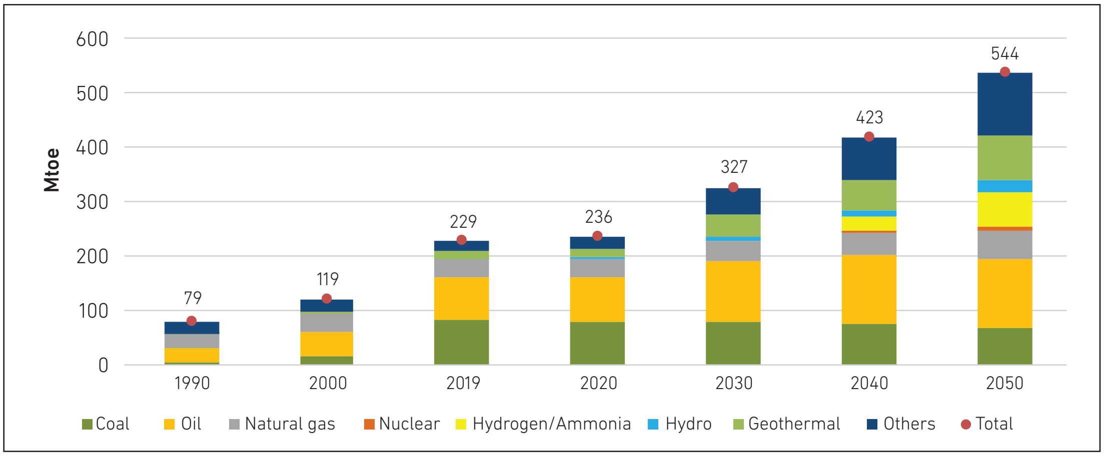
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.3.2. Primary Energy Supply

The TPES of LCET is projected to reach 544 Mtoe in 2050 (Figure 7.18). Compared to the TPES in APS5 (603 Mtoe), TPES of LCET will be lower 10%. Although TPES in LCET is lower than APS5, the share of renewable energy for LCET will reach 54.2%, higher than APS5 (36.3%). This higher share of renewable energy in TPES of LECT is in line with the government plan to increase renewable generation (geothermal 15%, biomass 12.4%, hydro 4% and nuclear 1.5%.

Figure 7.18 Primary Energy Supply by Fuel, Low Carbon Energy Transition Scenario 1990–2050 (Mtoe)



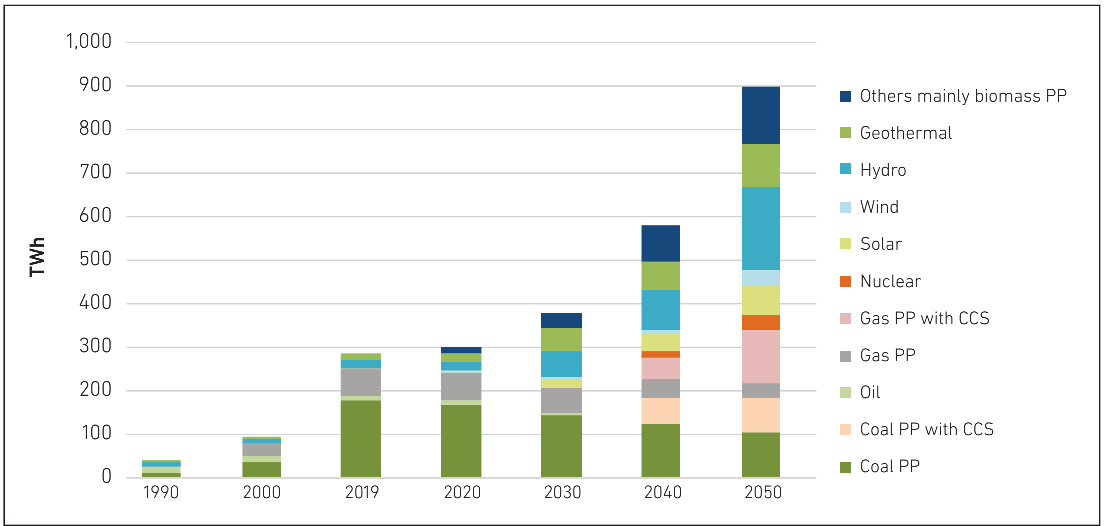
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.3.3. Power Generation

In 2050, under the LCET scenario, the total electricity generation displayed in Figure 7.19 is 896.3 TWh, which is lower than the APS5 total of approximately 1071 TWh. By 2050, the share of coal power plants is about 19.9%, followed by gas at 17.9%, and oil at only 0.1%. Renewable energy would reach 62% (hydro at 21.5%, biomass 14.7%, geothermal 10.8%, solar 7.6%, wind 4.1%, and nuclear 3.4%) by 2050. Coal power plants are major emitters of CO_2. The government has decided to phase out coal power plants except for those that use clean coal technology. Under LCET, the assumption is that CCS/CCUS technology will be combined with not only coal power plants but also gas power plants to achieve net zero emission in 2060.

Figure 7.19 Electricity Generation by Fuel, Low Carbon Energy Transition Scenario 1990–2050
(TWh)



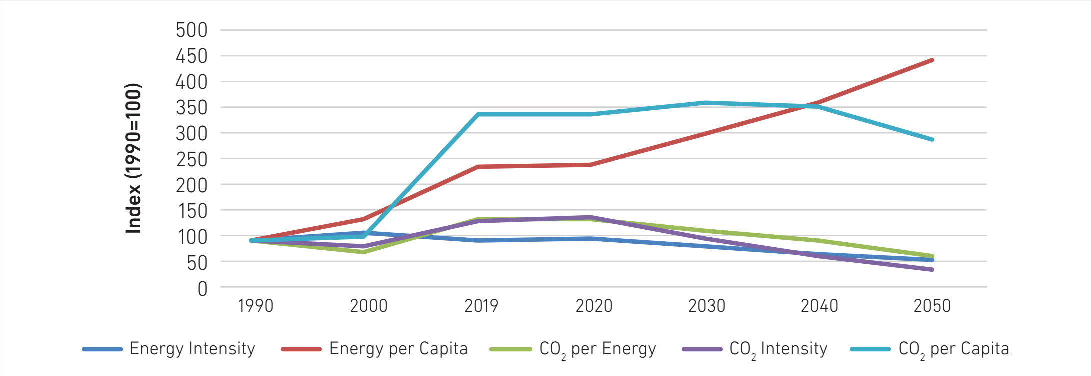
CCS = carbon capture and storage; PP = power plant; TWh = terrawatt hour.

Source: Author's calculations.

3.3.4. Energy Indicators

Figure 7.20 shows that only energy per capita increases from 1990–2050. Beginning in 2030, CO_2 emission per capita decreases, in line with the use of renewable energy in all sectors, including power generation.

Figure 7.20 **Energy Indicator Index, Low Carbon Energy Transition Scenario 1990–2050**



CO_2 = carbon dioxide.

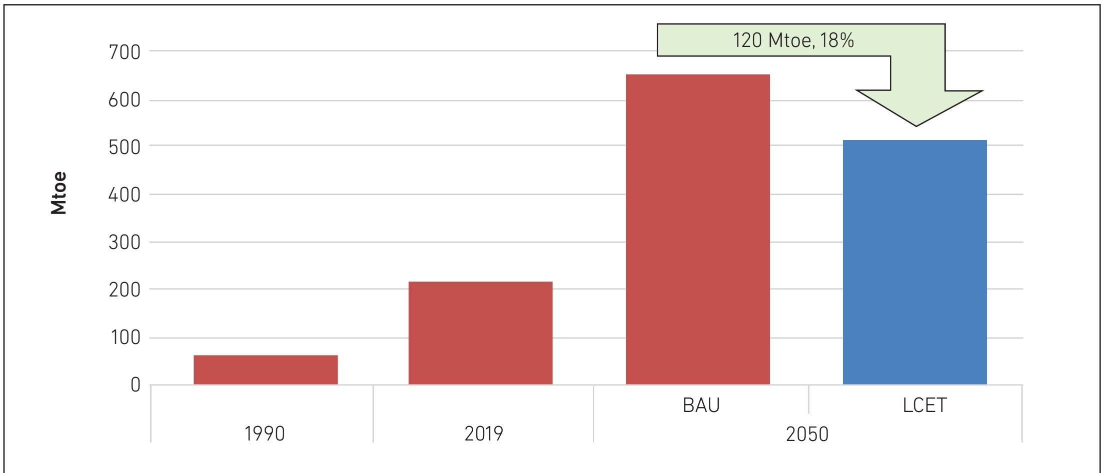
Source: Author's calculations.

3.3.5. Energy Saving Potential

The LCET scenario presents a potential savings in total primary energy supply of 120 Mtoe (18%) compared to BAU scenario if all initiatives under the LCET scenario are implemented.

Figure 7.21 **Primary Energy Supply, BAU and Low Carbon Energy Transition Scenarios 1990, 2019, and 2050**

(Mtoe)



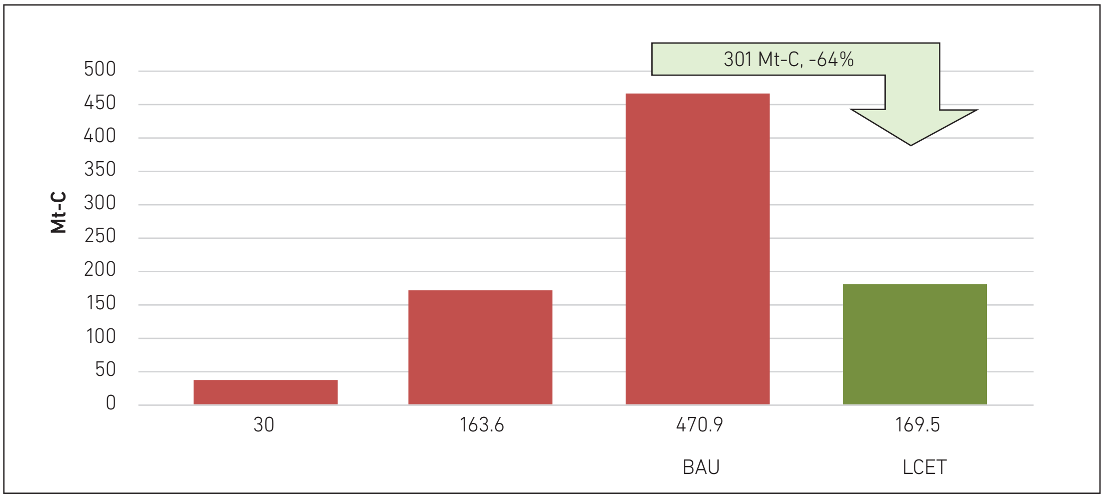
BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

In 2050, total CO_2 emission under the LCET scenario is 169.5 Mt-C, while in BAU scenario at 470.9 Mt-C. There is emissions reduction in LECT Scenario about 301 Mt-C or 64% compare BAU. Furthermore, total CO_2 emission in 2050 under LCET scenario only 5.8 Mt-C higher than total emission in 2019.

Figure 7.22 CO_2 Emission Reduction, BAU and Low Carbon Energy Transition Scenarios 1990, 2019, and 2050

(Mt-C)



BAU = business as usual; LCET = low carbon energy transition; Mt-C = million tonnes of carbon.

Source: Author's calculations.

4. Implications and Policy Recommendations

Economic recovery due to the impact of Covid-19 is still a concern for all countries, including Indonesia. The energy sector also experienced a decline in final energy consumption, including electricity consumption. As a result, an electricity surplus makes it difficult to include new and renewable energy in the electricity grid system.

However, Indonesia has committed to reducing its emissions to achieve zero emission by 2060. Efforts to reduce emissions in power generation and final energy use must be encouraged in all sectors.

Currently, electricity supply in Indonesia is mostly from coal. Reducing emissions must, therefore, be focused on transforming it to renewable energy generation, including solar, wind, biomass, municipal solid waste, and nuclear. However, to meet the electricity demand in 2050, CCS technology must be used to generate additional fossil fuel (coal and gas).

To reduce energy usage in transportation, industry, and other sectors, the energy efficiency policies for equipment used must be improved. For electrical appliances, regulations must mandate energy efficiency labels and minimum energy performance standards (MEPS) for appliances such as refrigerators, rice cookers, washing machines, and water pumps should be regulated. Currently, only compact fluorescent lamps (CFL) and air conditioning are regulated.

To reduce emissions in transportation, the use of electric vehicles on a large scale must be increased. Currently, while there is an appeal for the use of EV cars, especially for office cars, EV is now being used by several taxis (motorcycles and cars). However, the number of EVs is insignificant compared to conventional vehicles. Policies have been put in place to encourage EV use such as reduced purchase tax and lower interest rates, additional free power at home, and reduced import taxes for producers. Despite this, stronger efforts are needed to make EVs more affordable. Reducing emissions in transportation can also be done through the use of biofuels, such as B30 (30% of biofuel and 70% of diesel), which is being tested for the implementation of the B40 (40% of biofuel and 60% of diesel).

As the use of solar photovoltaic technology and electric cars increases, so does the need for batteries as electricity storage. A domestic battery industry must be developed to increase growth in the industrial sector.

Meeting the challenges posed by the need to develop clean energy, especially CCS technology, requires costly investments. For Indonesia to achieve its emission reduction target, policy support from the government must provide and coordination between ministries are critical.

In 2050, carbon emissions will be 169.5 million carbon ton or around 594 . With the expected carbon net sink by forestry at 540 million CO_2 ton, the current LCET-CN will not achieve carbon neutrality by 2050. However, Indonesia is targeting carbon neutrality by 2060, giving the country more time to utilise low carbon energy technologies such as hydrogen/ammonia and CCS/CCUS to meet its goal.

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CHAPTER 8

Japan

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1. Introduction

In October 2020, the Government of Japan declared its goal to be carbon neutral by 2050. Then in 2021, the government updated its Nationally Determined Contribution (NDC) for 2030 to 46% below 2013 greenhouse gas (GHG) emissions. The government previously declared an emission target of just 26% below 2013, and the target has gotten a far more ambitious one. The 6th Strategic Energy Plan, which was approved by the cabinet the same year as the NDC update, outlines these quantitative targets and the actions to be taken in each energy sector to reach carbon neutrality by 2050 and NDC by 2030 (Ministry of Economy, 2021a).

While Japan works toward carbon neutrality, the current energy mix in the country heavily depends on fossil fuels. In 2020, fossil fuels made up 85% of the primary energy supply (Ministry of Economy, 2021b). Power generation is a relatively decarbonised sector, yet generation from coal, oil, and natural gas covers 74% of total power generation. Japan has to substitute these fossil fuel demands or capture and storage the emissions from fossil fuels in order to neutralise the GHG emission.

To consider energy supply and demand in Japan, this report presents a business-as-usual (BAU) scenario, in which similar energy policies are currently taken; an alternative policy scenario (APS) scenario, which considers more powerful measures for climate issues (these two are forecast scenarios); and an LCET scenario, a backcast scenario for carbon neutrality. This scenario analysis will show the difference between Japan's carbon neutrality and the forecast scenarios and summarise the challenges to achieving it.

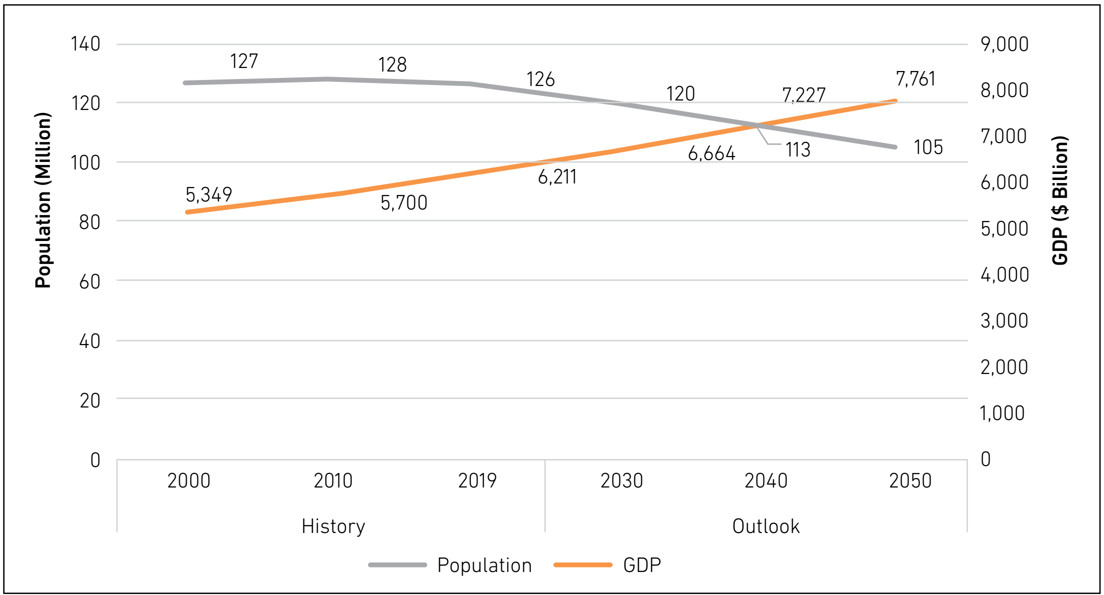
2. Modelling Assumptions

2.1. Macro-Economy

Recently, gross domestic product (GDP) in Japan has continued a moderate and steady growth, at 1.0% per year between 2010 and 2019. On the other hand, in 2020, GDP declined 4.8% from the previous year due to the economic damage from the coronavirus disease (COVID-19) pandemic. In this outlook, the economy is projected to restart a slow and steady growth so that its GDP is assumed to have an average annual growth rate (AAGR) of 0.8% from 2021 to 2050.

Population in Japan peaked around 2010 and has been declining since then. In the outlook period, population will decline by about 0.6% per year due to a low birth rate. Consequently, population is projected to decline from 126 million in 2020 to 105 million in 2050. Figure 8-1 shows the assumptions of GDP and population in this outlook.

Figure 8.1 Population and Gross Domestic Product Prospect



GDP = gross domestic product.

Sources:

1. International Monetary Fund, 2021.
2. United Nations Population Division, 2019.

In this outlook, energy supply and demand are projected in three scenarios. First, the BAU scenario incorporates the expected effects of past tends and extends the energy and environmental policies and technologies to date. In the APS scenario, intensive reduction measures for carbon dioxide (CO_2) emissions are expected based on social opportunities and acceptability. Energy conservation will accelerate from current trends, and fuel substitution and renewable energy will be introduced within techno-economic limits. In Japan, several nuclear power plants have been suspended since the Great East Japan Earthquake happened in 2011. This scenario considers the restart of nuclear power plants that are confirmed safe and which have been operating within 60 years.

Additionally, the LCET scenario is a backcasting scenario that assumes carbon neutrality in 2050. In the scenario, necessary efforts to achieve it will be made (regardless of the economy). Since Japan has a very limited carbon capture storage (CCS) potential, it is hardly considered in the BAU and the APS scenarios. However, the LCET scenario assumes CCS penetration into existing thermal power plants and industrial processes due to the need for carbon neutrality.

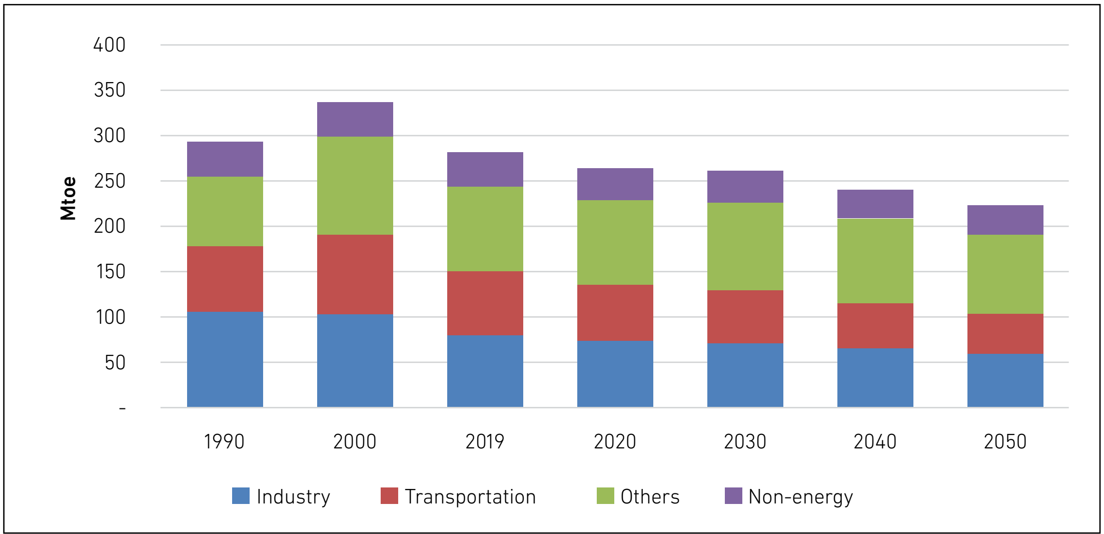
3. Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final Energy Consumption

Japan's total final energy consumption (TFEC) will continue to decline through 2050 (Figure 8.2). Transportation sector demand will especially decrease at an AAGR of 1.5% from 2019 to 2050 mainly due to the vehicle shift from conventional gasoline vehicles to gasoline hybrid vehicles and electric vehicles, improving fuel economy. Industry sector demand will also decline at an AAGR of 0.9% during the same period because of the industrial structure change and further energy conservation along with existing policies.

Figure 8.2 Final Energy Consumption by Sector, Business-as-Usual, 1990–2050
(Mtoe)

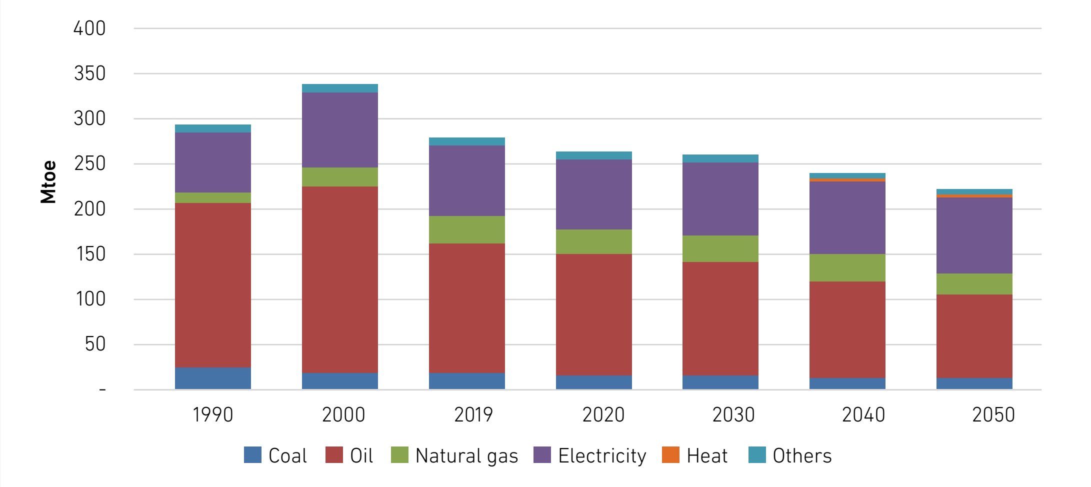


Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

In terms of the TFEC by source, coal and oil consumption will decrease at an AAGR of 1.5% and 1.4%, respectively, due to reduced demand from the transportation and industry sectors (Figure 8.3). In contrast, electricity demand will increase at an AAGR of 0.7% due to further electrification on the demand side.

Figure 8.3 Final Energy Consumption by Source, Business-as-Usual, 1990–2050
(Mtoe)



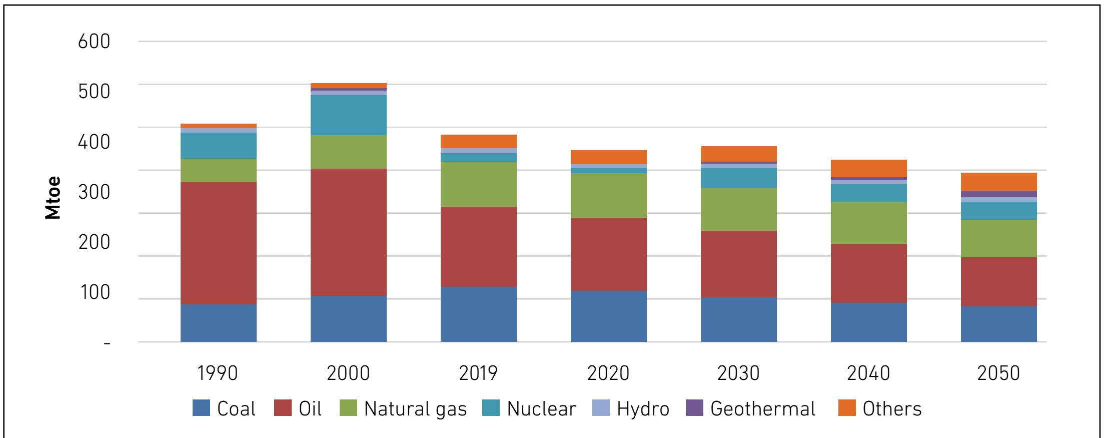
Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

3.1.2. Primary Energy Supply

Because of energy conservation led by existing policies, total primary energy supply (TPES) will decline at an AAGR of 0.6% through 2050 (Figure 8.4). Oil, coal, and natural gas will decrease at an AAGR of 1.5%, 1.4% and 0.6%, respectively, due to the decline in fossil-fuel use in the TFEC and the power sector. On the contrary, renewables like solar photovoltaics (PV), wind, and geothermal will increase since the power sector particularly utilises more renewables according to existing policies.

Figure 8.4 Primary Energy Supply, Business-as-Usual, 1990–2050
(Mtoe)



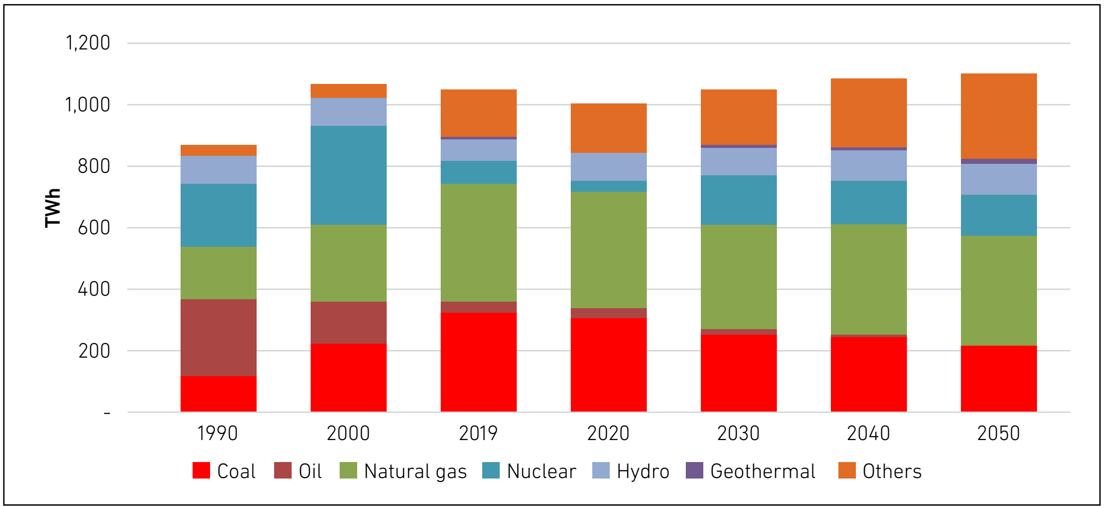
Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

3.1.3. Power Generation

Total power generation dropped in 2020 due to the COVID-19 pandemic but would increase again through 2050 (Figure 8.5). While fossil-fuel fired power generation will decrease, renewables such as solar PV, wind and geothermal and nuclear will increase along with existing policies. In the BAU scenario, over 45% of power generation will come from non-fossil fuels in 2050.

Figure 8.5 Power Generation, Business-as-Usual, 1990–2050
(TWh)



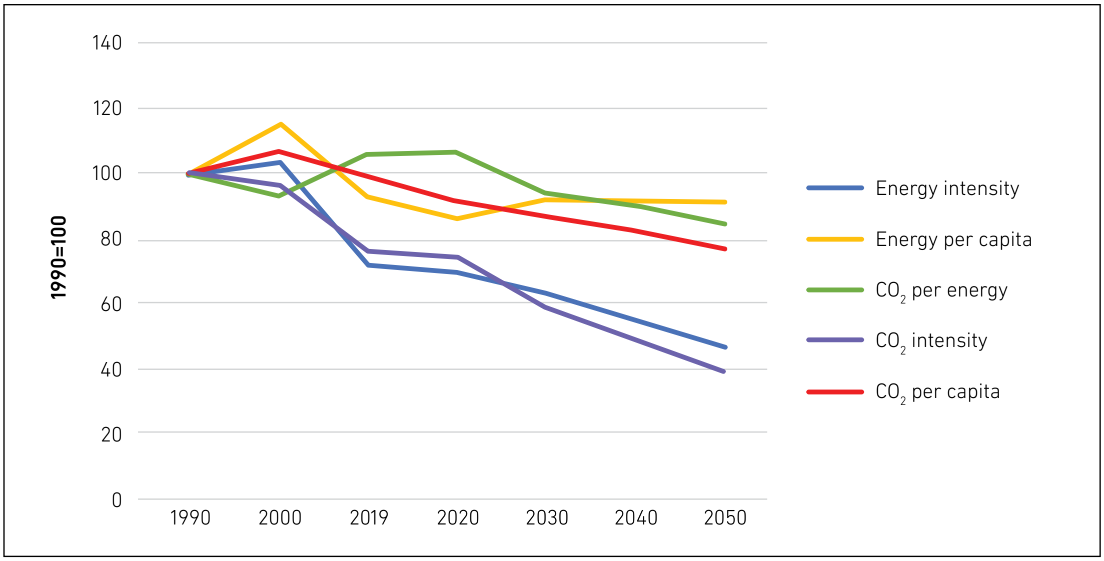
TWh = terawatt-hour.

Source: Authors' calculation.

3.1.4. Energy Indicators

Energy intensity, or primary energy supply per GDP, and CO_2 per energy will decline at an AAGR of -1.4% and -0.7%, respectively (Figure 8.6). As a result, CO_2 intensity will decrease at an AAGR of -2.1% through 2050.

Figure 8.6 Indices of Energy and Carbon Dioxide Intensities, Energy Per Capita, and Carbonisation Rate, Business-as-Usual, 1990–2050



CO_2 = carbon dioxide.

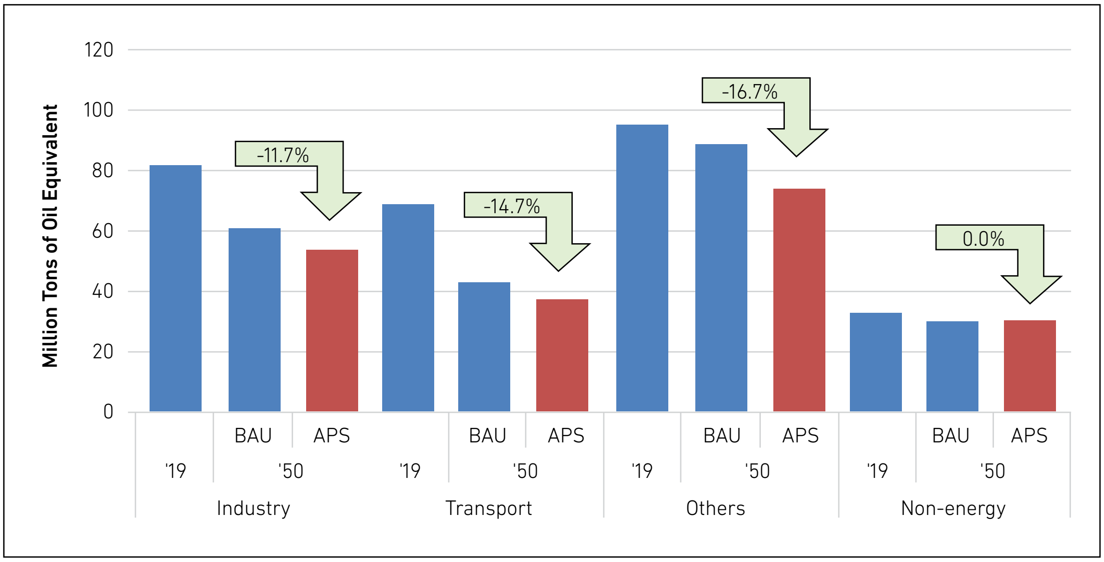
Source: Authors' calculation.

3.2. Energy Saving and Carbon Dioxide Reduction Potential, Alternative Policy Scenario

3.2.1. Final Energy Consumption

The total final energy consumption (TFEC) for the APS scenario will decrease by 12.7% in 2050 from the BAU level (Figure 8.7). For the APS in 2050, demands will decrease by 16.7% for the 'Others' sector, which includes residential and commercial; 14.7% for transport; and 11.7% for industry from the BAU levels in 2050. In the APS, energy conservation will proceed more aggressively than the BAU with powerful policies for climate issues.

Figure 8.7 Total Energy Consumption, Business-as-Usual and Alternative Policy Scenario, 2019 and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual.

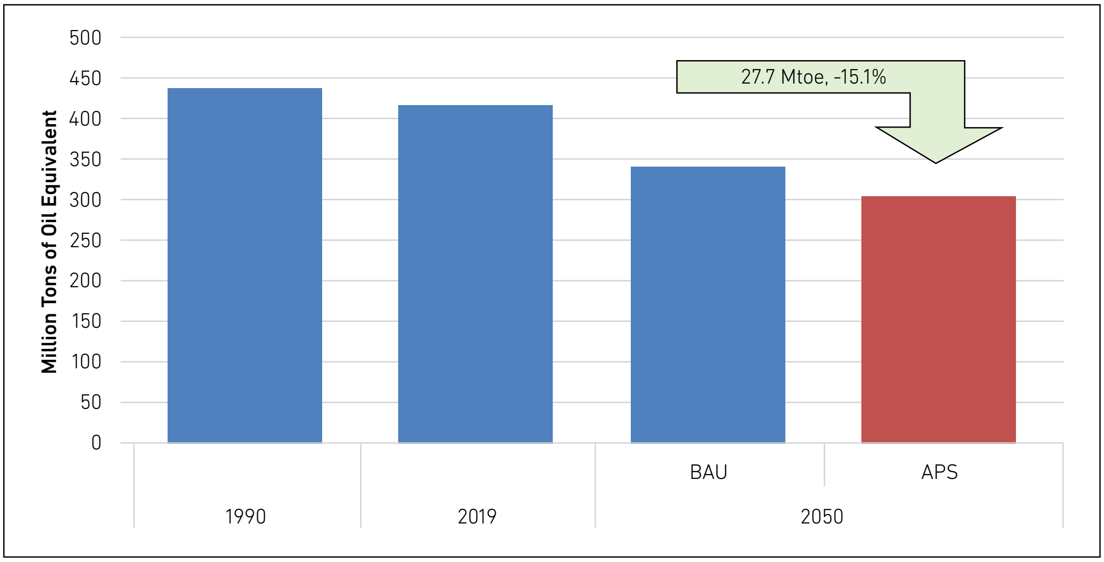
Source: Authors' calculation.

3.2.2. Primary Energy Supply

The total primary energy supply (TPES) for the APS scenario would decrease by 15.1% in 2050 from the BAU level, mainly due to energy conservation in final energy consumption and efficiency improvement in the power sector (Figure 8.8).

Figure 8.8 Total Primary Enregy Supply, Business-as-Usual and Alternative Policy Scenario, 1990, 2019, and 2050

(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

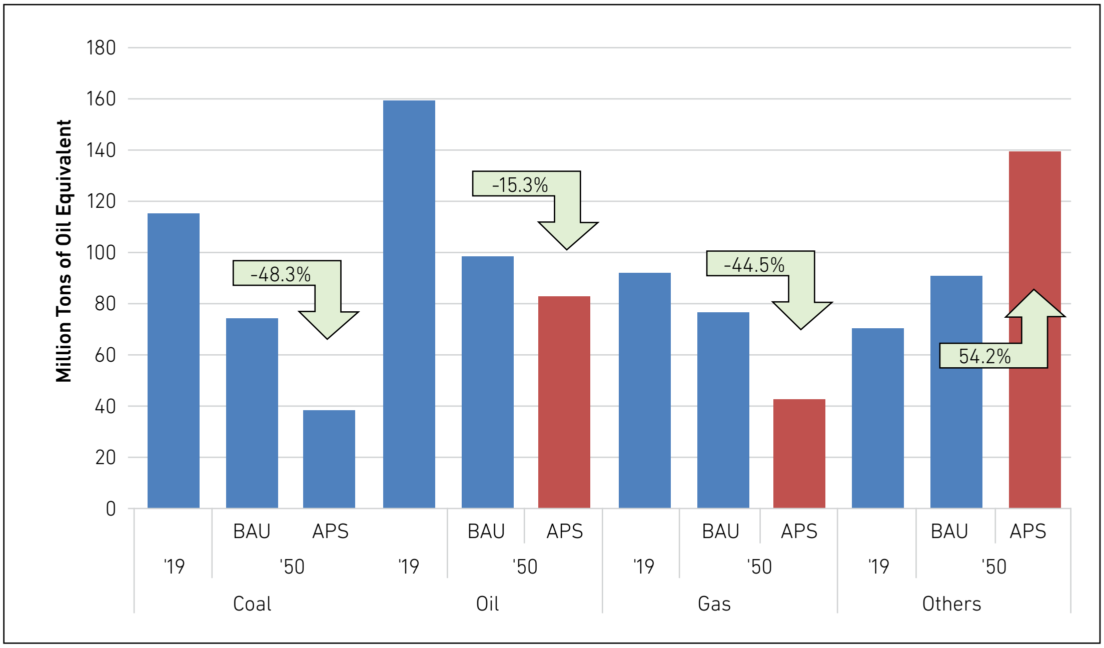
Source: Authors' calculation.

3.2.3. Projected Energy Saving

Fossil fuel consumption for the APS in 2050 will considerably decrease from BAU levels, while other energy sources, such as renewables, will increase (Figure 8.9). The APS scenario in 2050 sees a 48.3% reduction in coal demand from the BAU level, followed by 44.5% in natural gas and 15.3% in oil. In contrast, the APS will increase other energy sources including renewables by 54.2% from the BAU level. In the APS, energy sources will shift to more non-fossil fuels with more energy conservation than the BAU.

Figure 8.9 Primary Energy Supply by Source, Business-as-Usual and Alternative Policy Scenario, 2019, and 2050

(Mtoe)



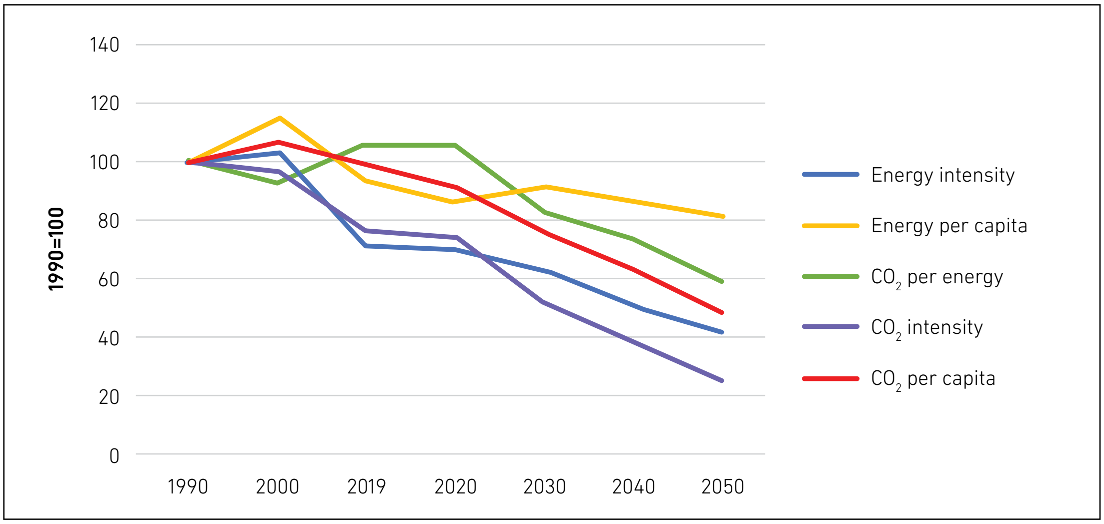
APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

3.2.4. Energy Indicators

In the APS, energy intensity will decrease by an AAGR of 1.7%, while CO_2 per energy demand will decrease at an AAGR 1.9% (Figure 8.10). Compared to the BAU, the decreasing rate of CO_2 per energy demand will be remarkable due to more non-fossil fuel diffusion. As a result, CO_2 intensity, which is CO_2 emission per GDP, will drop at an AAGR of 3.5% from 2019 to 2050. Reflecting on the 24% improvement of CO_2 intensity from 1990 to 2019, the 67% improvement from 2019 to 2050 would be extraordinary.

Figure 8.10 Indices of Energy and Carbon Dioxide Intensities, Energy Per Capita, and Carbonisation Rate, Business-as-Usual, 1990–2050



CO_2 = carbon dioxide.

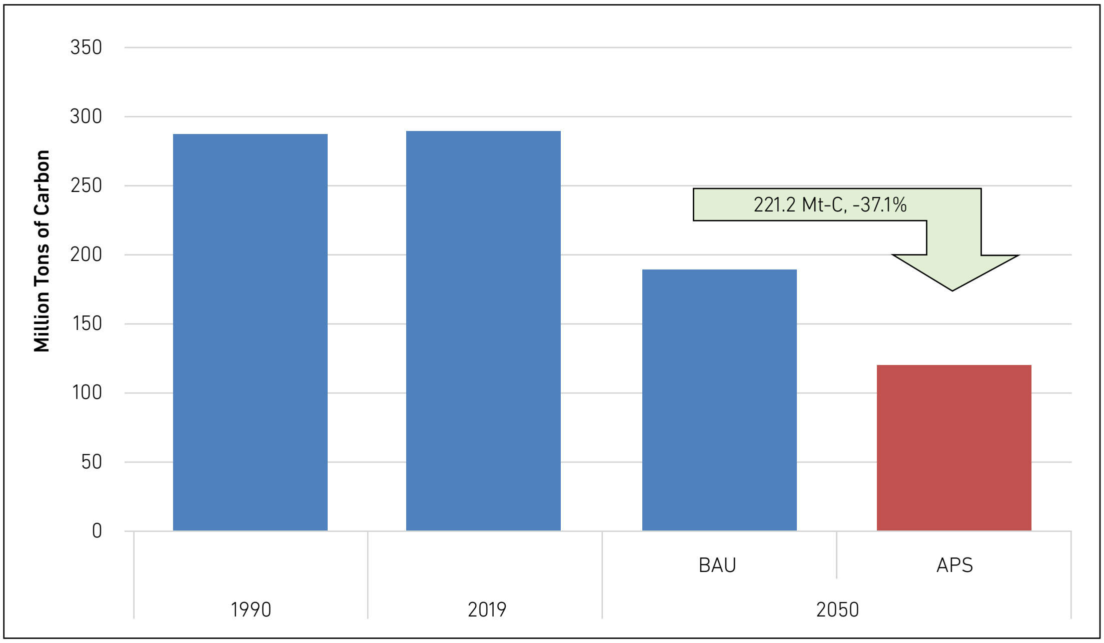
Source: Authors' calculation.

3.2.5. Carbon Dioxide Emission Reduction

The CO_2 emission reduction rate for the APS will be 37.1% from the BAU level in 2050 (Figure 8.11). The total CO_2 emission will be 435 Mt-C in 2050, which is only 41% of the 2019 emission level. Still, the APS will not achieve net-zero emissions by 2050, which is the new national target of Japan.

Figure 8.11 Carbon Dioxide Emissions from Fossil Fuel Combustion, Business-as-Usual and Alternative Policy, 1990, 2019, and 2050

(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, Mt-C = million tonnes of carbon.

Source: Authors' calculation.

3.3. Low Carbon Energy Transition Scenario, Carbon Neutral

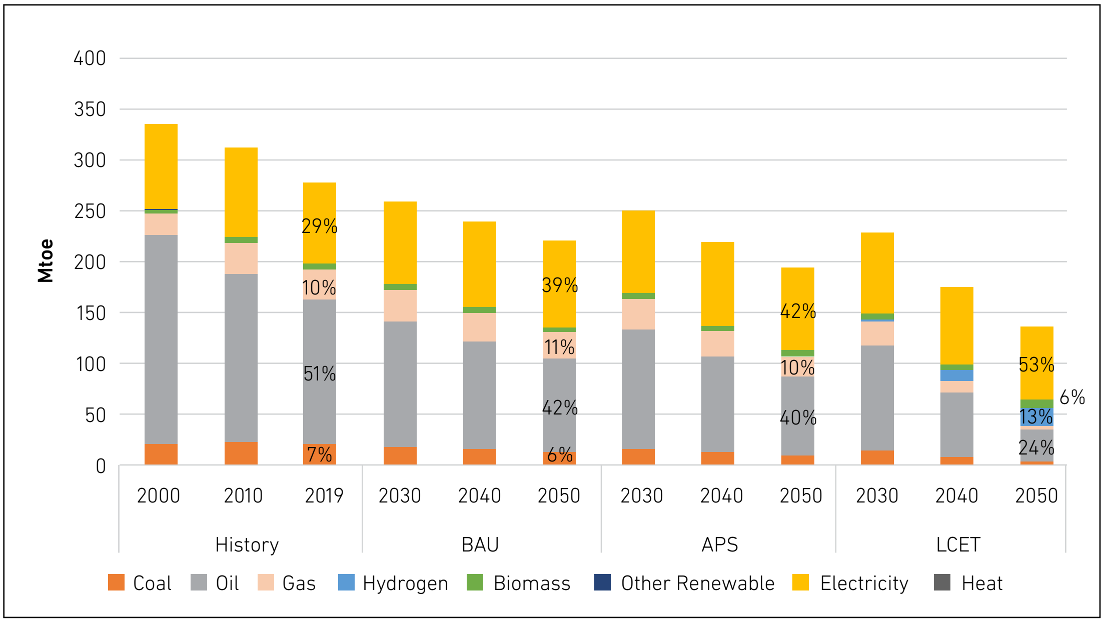
In this section, the results of the LCET scenario will be described compared to the BAU and the APS scenarios.

3.3.1. Final Energy Consumption

In the LCET, the TFEC will decline approximately 2.5 times faster than the BAU, falling to 136 Mtoe in 2050, or 61% of the BAU level (Figure 8.12). To achieve carbon neutrality, significant energy transition from fossil fuels to electricity and hydrogen is necessary. Fossil-fuel share will decrease drastically, from 69% of energy in 2019 to 28% in 2050. The share of electricity will increase from 29% in 2019 to 53% in 2050.

Figure 8.12 **Final Energy Consumption by Source, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology Scenarios, 2000–2050**

(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy Technology, Mtoe = million tonnes of oil equivalent.

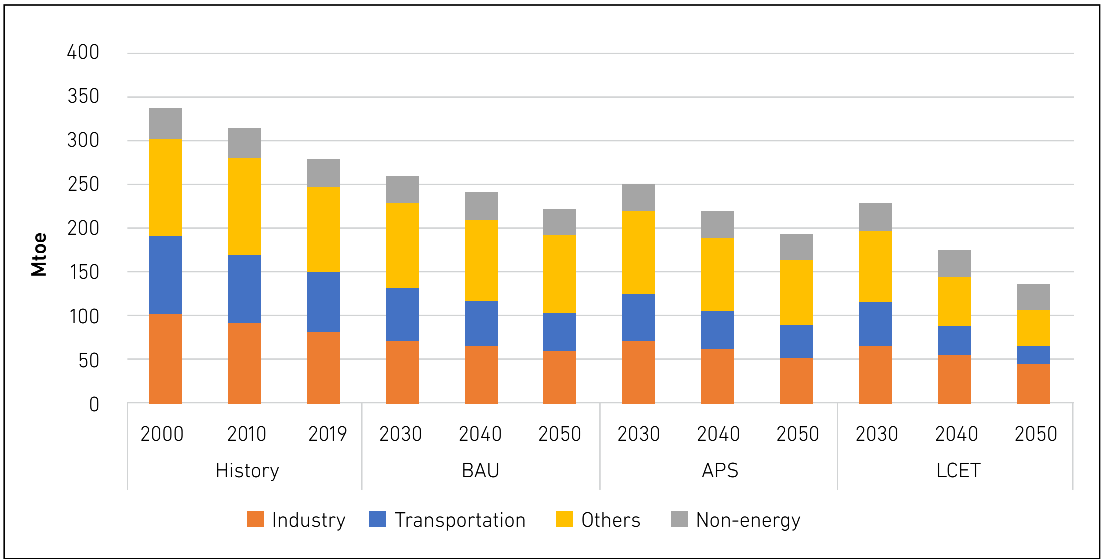
Source: Authors' calculation.

In transport and the 'Other' sector, demands will be shrink due to intensive energy conservation efforts and electrification, which will boost energy efficiency (Figure 8.13 and Table 8.1). Meanwhile, decline will be limited in industry. In this sector, it will be difficult to substitute all of fossil-fuel demand to electricity or hydrogen, due to the need for high-temperature heat sources and lock-in effect of existing machinery.[1] Instead, carbon capture and storage (CCS) would be implemented to reduce CO_2 emissions.

[1] A *lock-in effect* refers to a situation where fossil fuel consuming facilities that have already been built will continue to emit CO_2 in the future.

Figure 8.13 Final Energy Consumption by Sector, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology Scenarios, 2000–2050

(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy Transition, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

Table 8.1 Change in Final Energy Consumption by Sector, 2019 to 2050

	BAU	APS	LCET
Industry	-25%	-34%	-44%
Transport	-38%	-47%	-69%
Others	-7%	-23%	-59%
Total	**-21%**	**-31%**	**-51%**

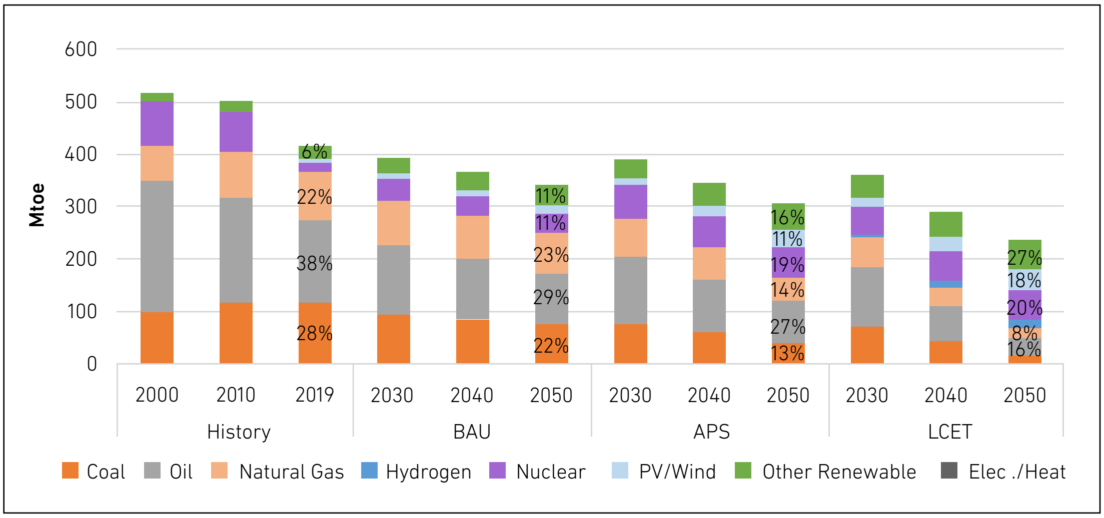
APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy Technology.

Source: Authors' calculation.

3.3.2. Primary Energy Supply

In the LCET scenario, primary energy supply will decline as significantly as final energy demand declines. The primary supply in 2050 is projected to be 226 Mtoe, 67% of the BAU level (Figure 8.14). In addition, the share of fossil fuels, which accounted for 88% of primary energy supply in Japan 2019, will shrink to 32% in 2050. Nevertheless, even in such a progressively decarbonised scenario, demands for fossil fuels will not disappear, and efforts for a stable supply in fossil fuels will remain as one of the key energy policies in Japan.

Figure 8.14 Primary Energy Supply, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology Scenarios, 2000–2050



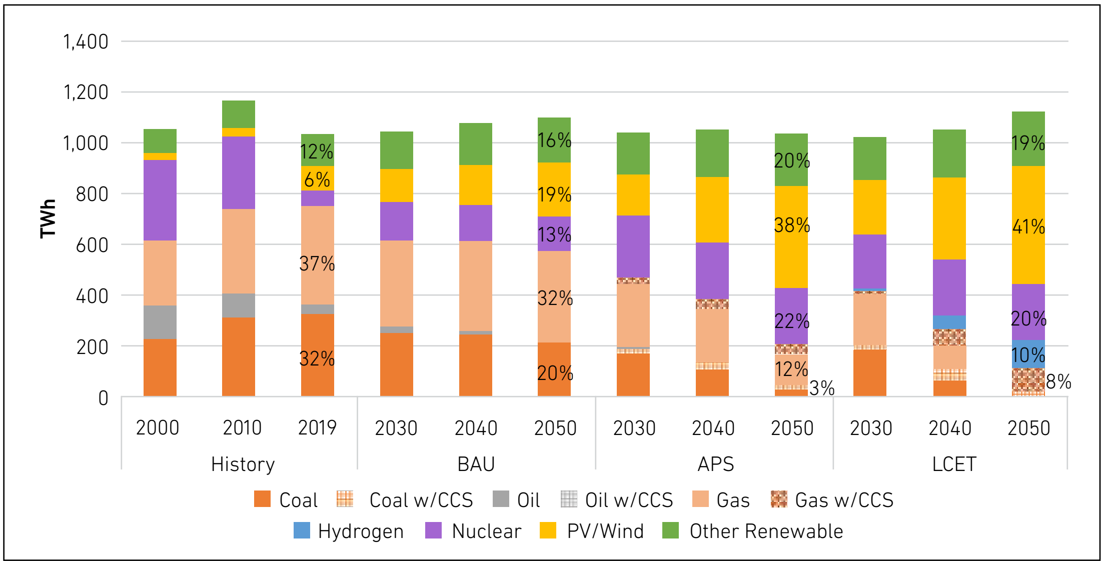
APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy. Technology, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

3.3.3. Power Generation

Power generation for the LCET scenario in 2050 is projected to be 1,136 TWh. Due to the rapid progress of electrification and demand for green hydrogen, the generation for the LCET in 2050 will be larger than those in the other two scenarios (Figure 8.15). The share of solar PV and wind power would be 41%. Since output from these variable renewable energies is unstable, backup storages and expansion of the grid will be necessary. Other renewables (hydro, geothermal, and biomass) will account for 19%. Nuclear energy covers 20% of total generation. The remaining 20% is thermal power, of which another 10% is hydrogen and 10% is coal and natural gas with CCS.

Figure 8.15 Power Generation, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology Scenarios, 2000–2050



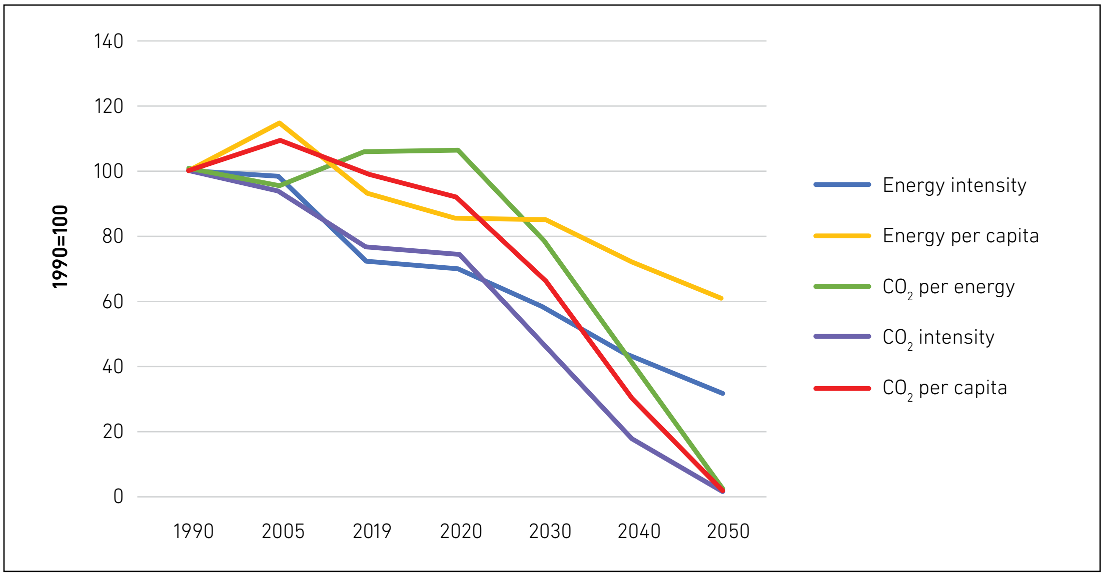
APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy Technology, TWh = terawatt-hour.

Source: Authors' calculation.

3.3.4. Energy Indicators

In the LCET scenario described so far, the energy indicators will improve at a faster pace compared to BAU (Figure 8.16). Between 1990 and 2019, energy intensity improved at the pace of 1.1% per year. In this scenario, electrification and other efficiency improvements are expected to play a significant role, contributing to the energy intensity improvement by 2.5% per year between 2020 and 2050, leading to about a half of the 2019 level.

Figure 8.16 **Indices of Energy and Carbon Dioxide Intensities, Energy Per Capita, and Carbonisation Rate, Low Carbon Energy Technology, 1990–2050**



CO_2 = carbon dioxide.

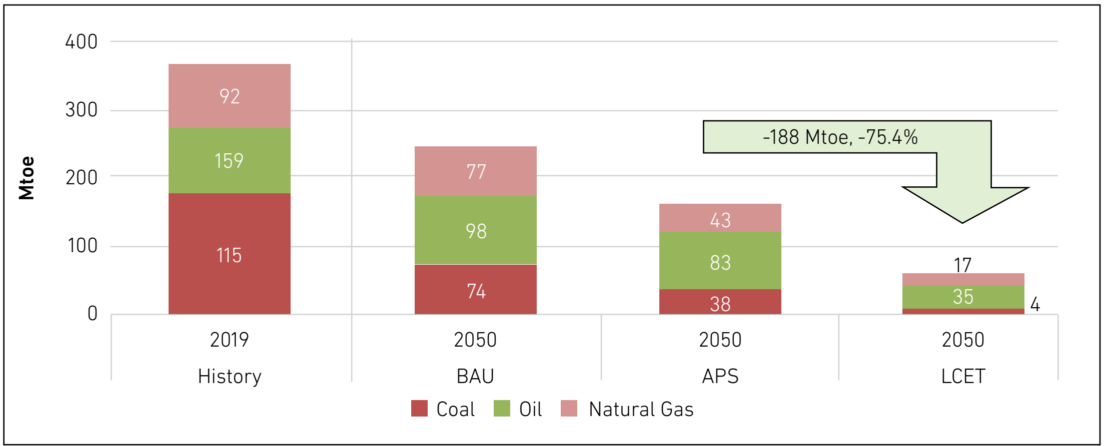
Source: Authors' calculation.

3.3.5. Saving on Fossil Fuel Consumption and Carbon Dioxide Reduction

In the LCET scenario, fossil-fuel consumption will be about 25% of the BAU scenario, which will reduce consumption by 188 Mtoe (Figure 8.17). Amongst fossil fuels, other energy sources in industry and power sectors mostly replaced coal, with demand of only 4 Mtoe in 2050. On the other hand, oil demand will linger relatively even in 2050, which is used mainly in industry and non-energy sectors.

Figure 8.17 Fossil-Fuel Reduction in Primary Energy Supply, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology, 2019 and 2050

(Mtoe)



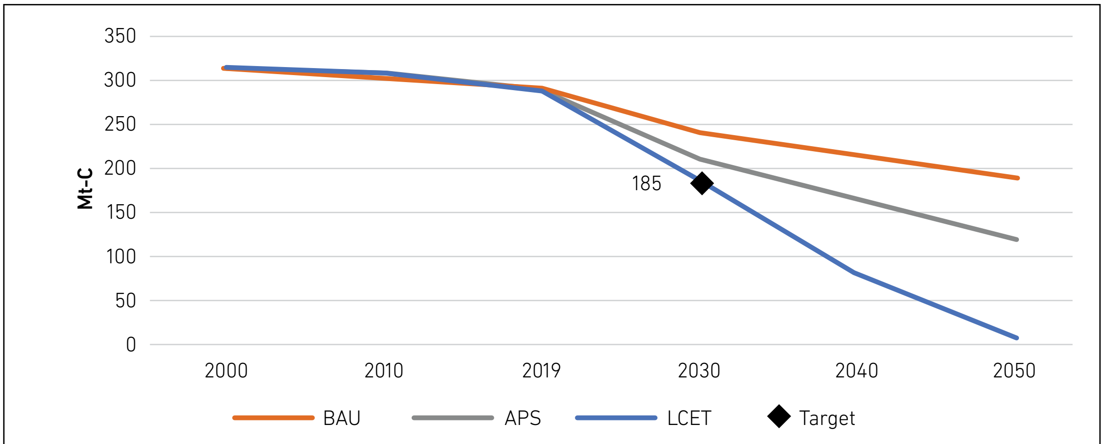
APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

When the BAU, the APS, and the LECT scenarios are compared for CO_2 emissions, the BAU shows a decline along with the historical trends, the APS scenario shows a faster decline than the trend, while the LCET shows even faster reductions than the APS (Figure 8.18). Japan's new NDC target of energy-related CO_2 emissions for 2030 is 185 Mt-C (a 45% reduction from the 2013 level, which is the base volume). The LCET scenario will be consistent with the NDC target.

Figure 8.18 Carbon Dioxide Emissions from Fossil Fuel Combustion, Business-as-Usual, Alternative Policy Scenario, and Low Carbon Energy Technology, 2000–2050

(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, LCET = Low Carbon Energy Technology, Mt-C = million tonnes of carbon.

Source: Authors' calculation.

4. Implications and Policy Recommendations

According to Japan's net-zero policy, energy demand and CO_2 emissions can be reduced. However, the net zero emission will not materialise in the BAU and the APS scenarios. In the BAU, CO_2 emissions in 2050 are 65% of 2019 levels. The APS assumes faster energy efficiency improvements than the trend due to the progress in restarting nuclear power plants and massive introduction of renewable energy, reducing CO_2 emission to 41% of the 2019 level. Although they are decent improvements, the results are still far from carbon neutral. They show that carbon neutrality requires further CO_2 reduction efforts than assumed in the forecast scenarios, such as the BAU and the APS scenarios. In contrast, the LCET scenario will complement this concern, which is a back-casting scenario that assumes carbon neutrality in 2050, as defined.

Nonetheless, CO_2 reduction is not the only focal point of energy policy. The "3E+S" (Environment, Energy Security, Economic Efficiency + Safety) is a fundamental principle in Japan's energy policy. While the LCET is a scenario that pursues environment, the scenario shows some challenges in terms of the two remaining E's – energy security and economic efficiency.

Energy Security

While fossil fuel will be reduced to 32% of the primary supply in the LCET scenario, it would remain a necessary energy source. It is essential to continue efforts to ensure its stable supply, from upstream investments to downstream infrastructure maintenance.

Though electricity and hydrogen will be largely deployed to replace fossil fuels, challenges for energy security for these energies are also inevitable. Stable electricity must be supplied in greater quantities than at present and without CO_2 emissions. In the LCET scenario, the amount of power generation in 2050 is about 8% greater than today. The Government of Japan has set renewable energy as its main power source. It is essential to develop the dispatchable capacity and adjust the capability for output fluctuation of renewables. Currently, investment in thermal power generation to provide this adjustment is difficult due to volatile wholesale electricity prices and decarbonisation policies. However, policy efforts must continue to ensure sufficient capacity through 2050 and in the interim.

Hydrogen is expected to be supplied mainly through water electrolysis and imports in Japan because of scarce fossil-fuel resources. It is necessary to build good relationships with countries that supply hydrogen and to form an international market, in the same way we currently do for a stable supply of fossil fuels. Despite these challenges, efforts toward carbon neutrality will increase the energy self-sufficiency rate. It will improve from 15% in 2020 to 65% in 2050 under the LCET scenario.

Economic Efficiency

Energy costs are also a significant issue. Although the costs of solar PV and wind power, which accounts for a significant share of electricity, is declining, additional costs will arise for investments in batteries to regulate their output, transmission lines to power generation facilities, and so on. As the share of variable renewable energies increases, the cost per kWh itself increases cumulatively. Therefore, it is necessary to utilise other power sources such as nuclear, hydrogen, and fossil fuels with CCS to reduce costs, rather than relying too heavily on renewable energy.

Carbon neutral is exceedingly difficult to achieve with a combination of existing and mature technologies, and the LCET scenario incorporates developing technologies such as CCS and hydrogen. Financial and technical supports from the government for these technologies are significant. In addition, in the transition period, around 2040, current technologies and facilities will be mixed with these developing technologies including hydrogen and CCS. It is essential to replace existing technologies with the new technologies prudently so that stable energy supply will not be compromised.

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CHAPTER 9

Republic of Korea Country Report

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1. Background

The Republic of Korea (henceforth Korea) is in the southern half of the Korean Peninsula and shares a 238-kilometre border with North Korea. It occupies 100,188 square kilometres and includes 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 2019, Korea has a population of 51,709,097 million, 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 economic crisis in 2008. However, in the aftermath of the global financial crisis of 2007–2008, growth has slowed down. Manufacturing, particularly electronic products, passenger vehicles, and petrochemicals, dominates the Korean economy.

Korea has no domestic oil resources and has produced only a small amount of anthracite coal, but imports most of its coal, which is bituminous coal. Korea must import nearly all its needed energy and is the fifth-largest oil importer and the second-largest importer of liquefied natural gas (LNG) in the world. The total primary energy supply in 2019 was 280.2 million tonnes of oil equivalent (Mtoe), increasing by 3.9% a year since 1990. Though oil and coal dominate the primary energy supply, nuclear power and LNG also supply a significant share of the country's primary energy. The strongest growth occurred in natural gas (10.5% per year), followed by others such as renewable energy (6.9% per year), coal (4.0% per year), and nuclear (3.6% per year). Oil has increased relatively slower at 2.6% per year.

Total final energy consumption in 2019 was 181.9 Mtoe, increasing at an average annual rate of 3.6% from that in 1990. The industry sector accounted for 25.9% of final energy consumption in 2019, followed by non-energy (29.0%) and transportation (20.1%). While consumption of coal has gradually decreased, natural gas in the final energy consumption rapidly grew at a rate of 12.7% per year between 1990 and 2019. With oil, though it has increased in volume, its share in the final energy consumption has continued to shrink.

In 2019, electric power generation in Korea amounted to 578.0-terawatt hour (TWh), with coal providing nearly half of the country's electricity, followed by natural gas at 25.3% and nuclear power also at 25.3%. Total electricity consumption grew at an average annual growth rate (AAGR) of 6.0% between 1990 and 2019. When broken down by fuel, coal increased at an annual rate of 9.5%, natural gas at 9.8%, and nuclear at 3.6% between 1990 and 2019. Over the same period, oil had a negative annual growth rate of -2.4% while hydro had -2.8%. Meanwhile, other energy sources such as new and renewable energy (NRE) rapidly grew at an annual rate of 42.3%.

Since the 1990s, the Government of Korea has established six Basic Plans for Rational Energy Use in a row, which are being revised every 5 years and contain various policy tools and programmes developed and implemented under the auspices of the Ministry of Trade, Industry, and Energy (MOTIE). The government announced several energy savings measures to encourage the public to conserve energy. As part of the measures, they launched voluntary energy conservation campaigns to reduce heating and fuel consumption. The government urged energy-intensive industries to enhance the energy efficiency of their products.

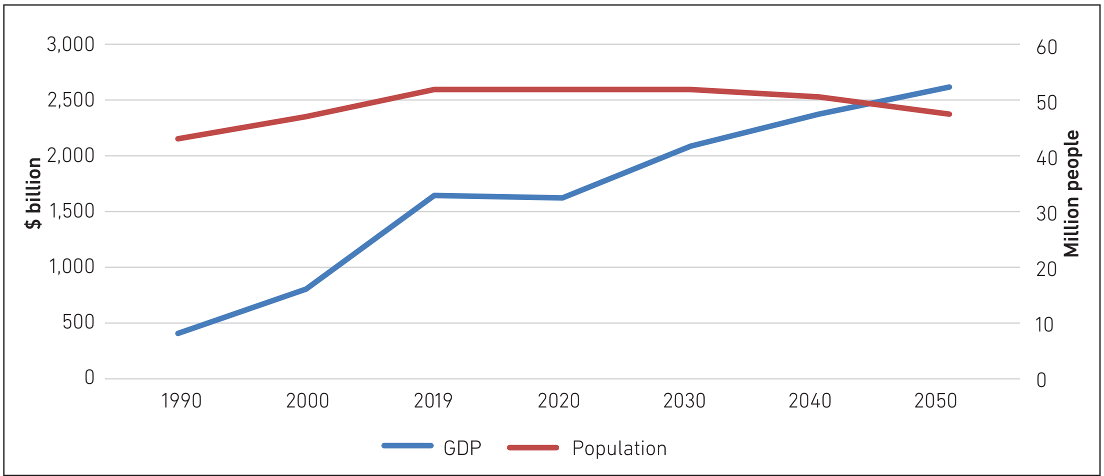
In addition, MOTIE and the Board of Audit and Inspection of Korea formed a task force to examine hundreds of public and private organisations to measure their progress in implementing voluntary energy saving plans.

'The Sixth Basic Plan for Rational Energy Use (2020–2024)' encompasses various key policy tools and programmes to attain the country's energy savings target. Amongst them are voluntary agreements, energy audits, energy service companies, appliance labelling and standards, fuel economy, and public transit and mode shifting. These policy tools will continue to play important roles in energy savings.

2. Modelling Assumptions

Korea's gross domestic product (GDP) grew at an average annual rate of 5% between 1990 and 2019. In this report, the country's GDP is assumed to grow at an AAGR of 1.5% from 2019 to 2050. Despite the recent global economic slowdown, the Korean economy is still in good shape, and its economic growth is expected to recover to 2.5% per year from 2020 to 2030, slowing down to 1.1% per year in 2030 to 2050.

Figure 9.1 Assumptions for GDP and Population, 1990–2050



GDP = gross domestic product.

Note: This figure uses 2010 US$.

Source: Author.

Korea is expected to continue to rely heavily on coal and nuclear energy for power generation to meet the baseload. Gas-fired power generation is projected to increase in 2019–2050, while oil-fired generation is projected to decline. Hydro power generation is projected to remain relatively stable. Also projected is a strong growth in electricity generation from wind power and solar photovoltaics, driven by renewable portfolio standards, which were launched in January 2012. A larger uptake of renewable energy is expected thanks to the recently announced RE 3020 and the Energy Transition policy.

Implementing energy efficiency improvement programmes in all energy sectors can help Korea achieve its energy-saving goals. In the industry sector, energy saving is expected from the expansion of voluntary agreements, the highly efficient equipment programme, and the development of alternative energy and improvements in efficient technologies. The transport sector aims to save energy by enhancing the efficiency of the logistics system, expanding public transport, and improving the fuel economy of vehicles. In the residential and commercial ('others') sector, the minimum energy efficiency standards programme is projected to induce huge savings in addition to 'e-Standby Korea 2010.'[1]

3. Outlook Results

3.1. Final Energy Consumption

Korea's final energy consumption grew 3.6% per year, from 64.9 Mtoe in 1990 to 181.9 Mtoe in 2019.[2] The non-energy sector had the highest growth rate during this period at 7.4% per year, followed by the transportation sector with 3.2%. Energy consumption in the residential/commercial/public ('others') sector grew at a relatively slow pace of 2.2% per year. Oil was the most consumed product, with a share of 67.3% in 1990, declining to 53.8% in 2019. The share of coal in the final energy consumption declined by 13.7 percentage points between 1990 and 2019, whereas the share of electricity nearly doubled, becoming the second-largest consumed product.

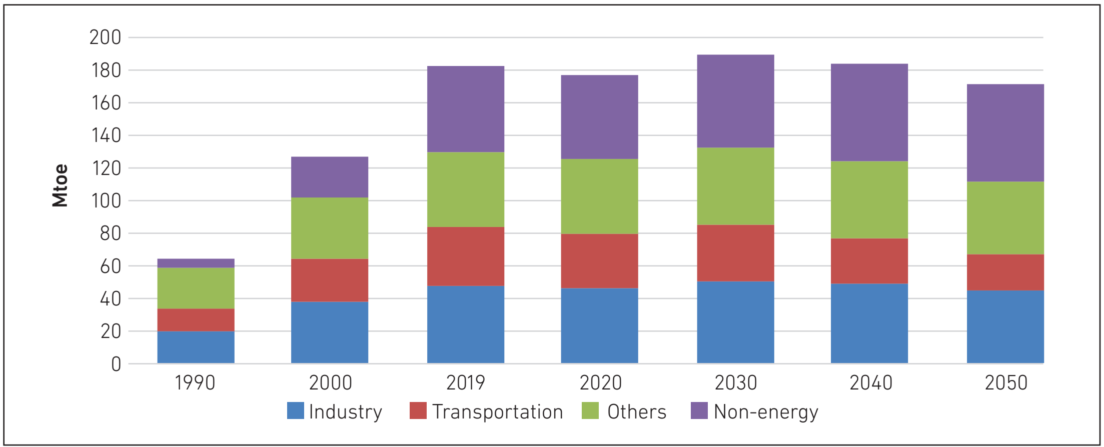
3.1.1. Business-As-Usual Scenario

With an assumption of low economic and population growth, final energy consumption in Korea is projected to reach 170.9 Mtoe in 2050, increasing at a negative average rate of -0.2% a year between 2019 and 2050 under the Business-As-Usual scenario (BAU). This is largely due to the negative growth in energy consumption in the transportation sector, which is projected to decrease at an AAGR of -1.7% between 2019 and 2050. The growth in final energy consumption is expected to be led by industry at 0.9% and non-energy at 0.8% until 2030. Then, all sectors except for the non-energy sector are projected to slow down, showing negative AAGRs. The non-energy sector will take the lead at an AAGR of 0.4% thereafter up to 2050. See Figure 9.2.

1 The Korea Energy Agency introduced the 'E-Standby Korea' programme which urges the manufacturers to minimise standby power and select sleep mode during the standby. It is a voluntary agreement.

2 Energy consumption is calculated based on the net calorific values as converted by The Institute of Energy Economics, Japan from original data submitted by the Republic of Korea.

Figure 9.2 **Final Energy Consumption by Sector, Business-as-Usual, 1990–2050**
(Mtoe)

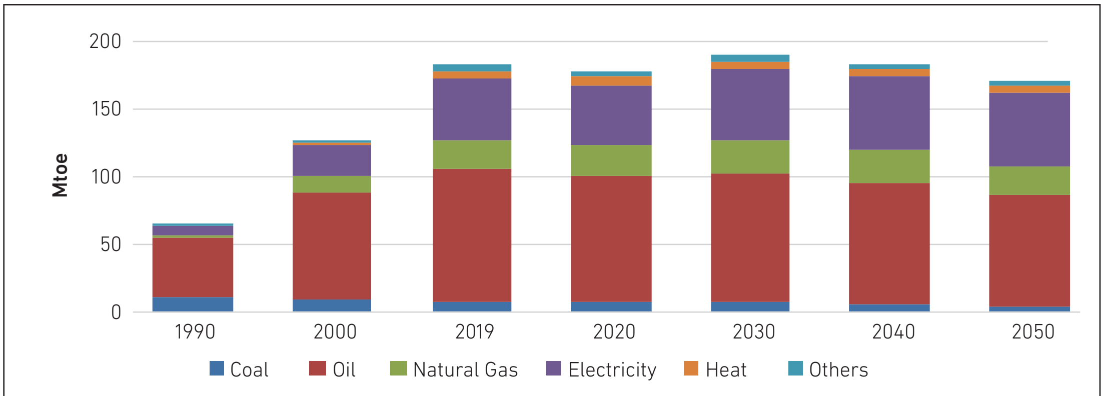


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is expected to be patterned after energy consumption by sector as shown in the Figures 9-3 and 9-4. The AAGR shows -1.7% for coal, -0.6% for oil, -0.1% for natural gas, 0.6% for electricity, and -0.5% for heat between 2019 and 2050. Coal and oil consumptions are expected to decrease, showing a negative growth rate. Heat energy consumption is expected to follow the same pattern because of the expected decrease in population and the changing lifestyle towards using more electricity for heating. The case of oil is more telling because of the decreasing energy consumption in the transport sector caused by an increasing deployment of electrical vehicles. Other energy types, including NRE, in addition to natural gas, will increase as clean and green energy will considerably contribute to reduced CO_2 emissions.

Figure 9.3 **Final Energy Consumption by Source, Business-as-Usual, 1990–2050**
(Mtoe)

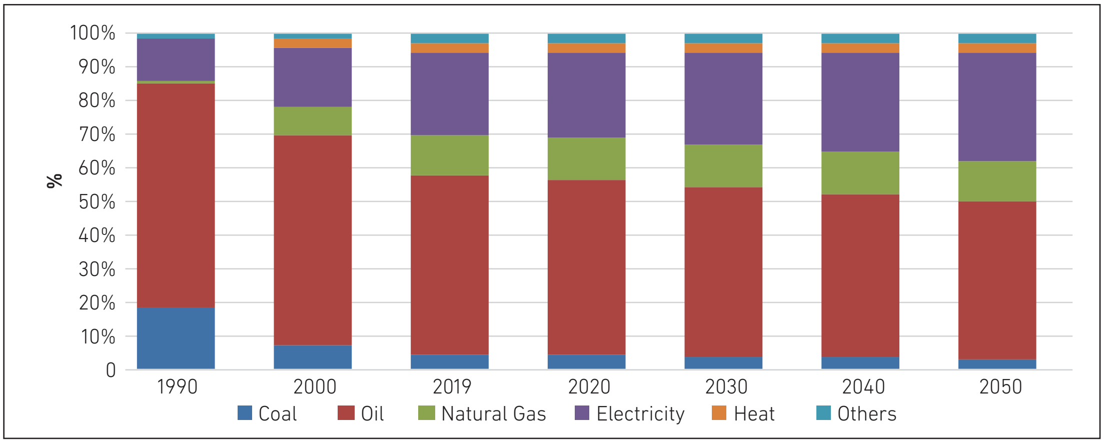


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 9.4 Shares in the Final Energy Consumption by Source, Business-as-Usual 1990–2050

(%)



Source: Author's calculation.

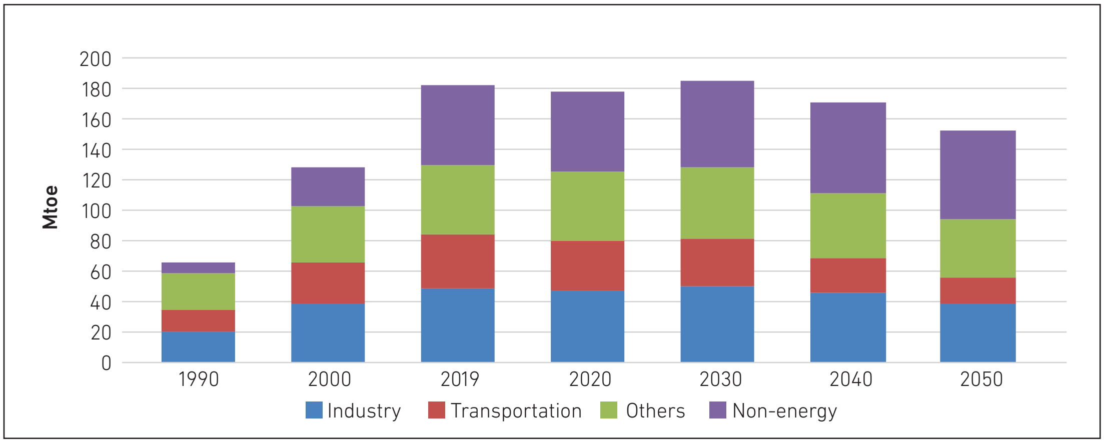
3.1.2. Alternative Policy Scenarios

This section discusses the alternative scenario developed based on the combination of policy options: (i) improved efficiency of final energy demand, (ii) more efficient thermal power generation, (iii) higher contribution of renewable energy to total supply, (iv) contribution of nuclear energy to total supply.

The total final energy demand in the alternative policy scenario (APS) is to be reduced to 152.6 Mtoe, decreased by 29.3 Mtoe or 16.1% from 183.2 Mtoe in 2019 at a negative AAGR of -0.6%. Figure 9.5 shows the final energy demand by sector in APS. The transportation sector shows the fastest decreasing rate at -2.6% per year, followed by the industry sector at -0.7% per year. The share of final energy demand by sector shows a structural change from 2019. The share of transportation is forecasted to decrease, while the share of industry and other sectors will slowly increase at first and decrease later. The share of non-energy sector will increase at a faster speed, reaching 39.2% in 2050.

Figure 9.5 Final Energy Consumption by Sector, Alternative Policy Scenario, 1990–2050

(Mtoe)

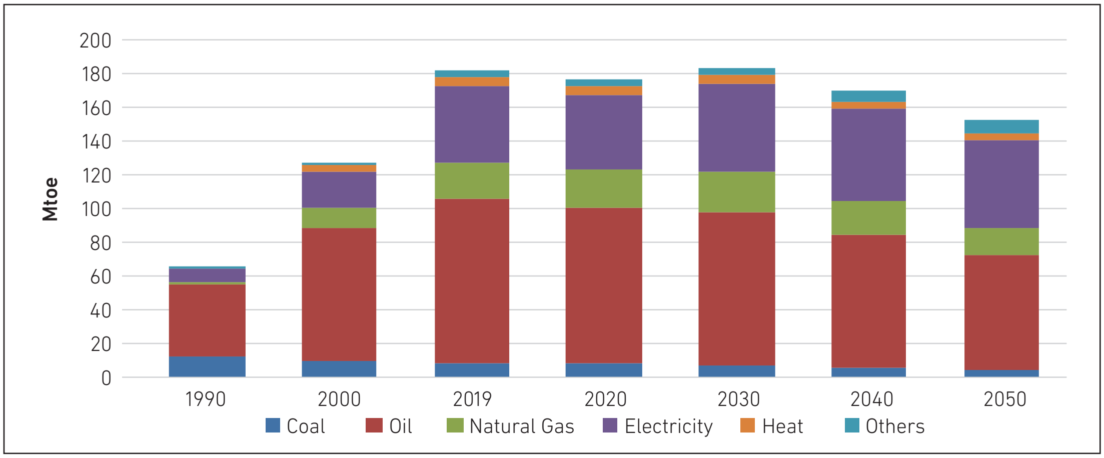


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy demand by source is shown in Figure 9.6. Oil will continue to be a dominant energy, accounting for 45.4% of its share, followed by electricity, 34.7% and natural gas, 10.0%. Coal will be marginalised at a share of 2.1% as a minor energy source for industrial, residential, and commercial use.

Figure 9.6 Final Energy Consumption by Energy, Alternative Policy Scenario, 1990–2050



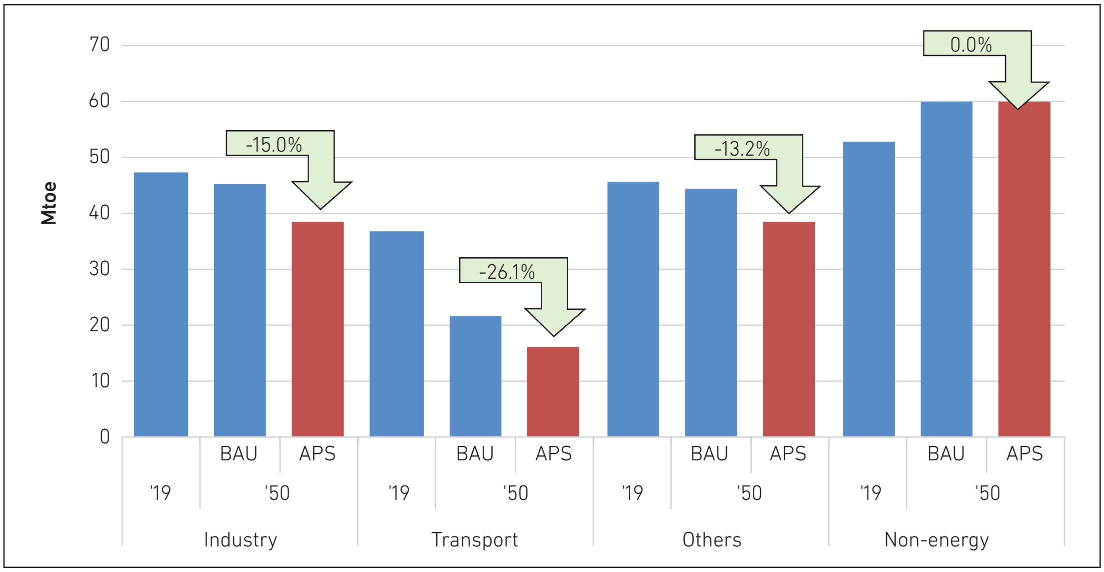
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 9.7 shows the final energy consumption by sector in BAU vs APS in 2050. In BAU, energy demand is projected to decrease by 6.1% from 2019 to 2050 in which transportation sector will lead its negative growth. In APS, 18.3 Mtoe (10.7%) will be saved from BAU in 2050, most of which will come from transport and industry. Reduction rates will be -26.0% for transport sector, -15.0% for industry sector, and -13.2% for others sector, whereas almost no change will take place in the non-energy sector.

Figure 9.7 Final Energy Consumption by Sector, Business-as-Usual vs Alternative Policy Scenario, 2019 and 2050

(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual.

Source: Author's calculation.

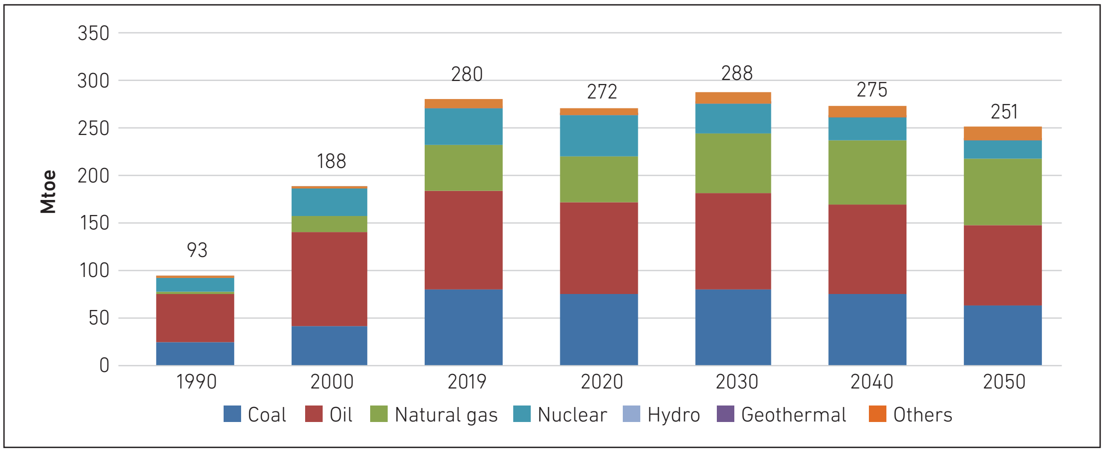
3.2. Primary Energy Demand

Primary energy demand in Korea increased at an AAGR of 4.2%, from 92.9 Mtoe in 1990 to 280.2 Mtoe in 2019. Amongst the major energy sources, natural gas grew the fastest at an average annual rate of 10.5%. The next was coal (4.0%), followed by nuclear (3.6%), and oil (2.6%). Other energy sources, mainly renewable energy such as solar, wind, biomass, and ocean energy, have rapidly grown at a rate of 8.7% over the same period. This shows that the government has been successfully implementing its 'Low Carbon Green Growth' and 'Energy New Industry' policies initiated by previous administrations.

3.2.1. Business-As-Usual Scenario

In BAU, primary energy demand in Korea is projected to decrease at an AAGR of -0.4%, from 280.2 Mtoe in 2019 to 251.2 Mtoe in 2050 as shown in the Figure 9.8. Consumption of all energy sources are projected to decrease except for natural gas and hydro. While consumption of nuclear shows the fastest decreasing rate of -2.4% per year, followed by coal (-0.8%), oil (-0.6%), and geothermal (-0.4%), over the period 2019–2050. Other energy sources, mainly renewable energy sources show a positive AAGR of 1.8%, wherein solar, wind, and ocean together show an AAGR of 4.5%.

Figure 9.8 Primary Energy Supply by Energy, Business-as-Usual, 1990–2050



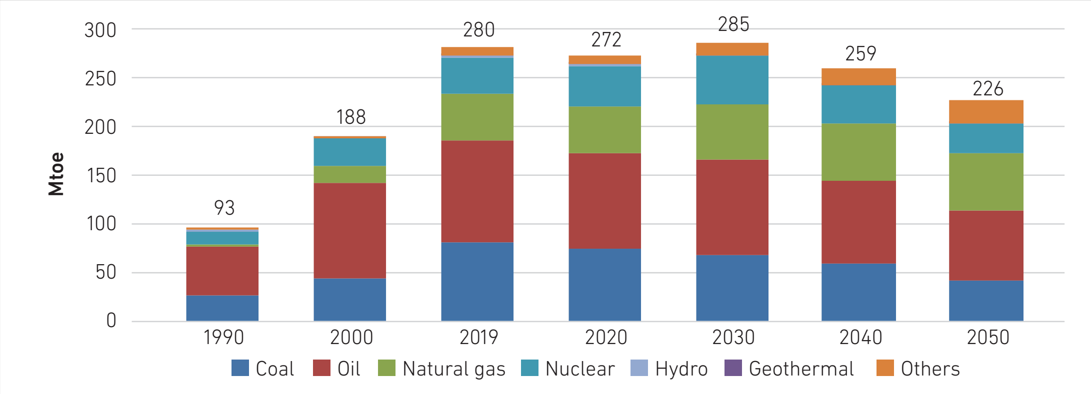
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.2. Alternative Policy Scenario

In APS, primary energy supply is projected to decrease at an AAGR of -0.7% per year, from 280.2 Mtoe in 2019 to 226.1 Mtoe in 2050. Consumption of fossil fuels, such as coal, oil, and nuclear will gradually decrease in 2017–2050, whereas that of clean energy such as hydro and others (NRE) will increase by 0.8%, 3.4% per year, respectively, over the projection period (Figure 9.9). Aggressive implementation of energy efficiency and conservation measures on the demand side, along with a larger uptake of renewable energy on the supply side, will be the major contributors to reduced nuclear and fossil fuel consumption.

Figure 9.9 Total Primary Energy Supply, Alternative Policy Scenario, 2019–2050



Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.3. Projected Energy Savings

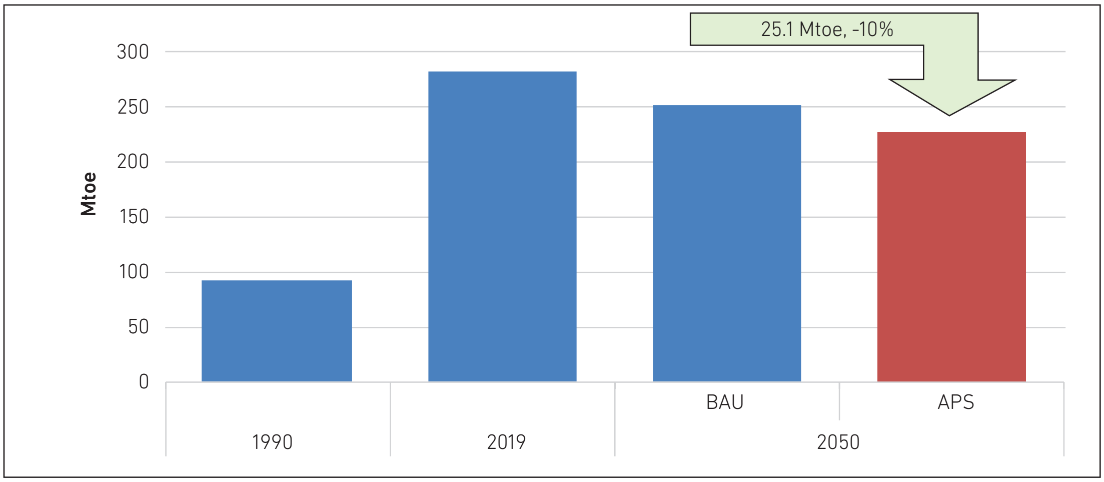
Major energy policy approaches to reduce energy demand in Korea are as follows:

1. Switch to demand-oriented energy policy and prioritise energy pricing and taxation reforms. Introduce market mechanisms that share information on the full cost of energy production and consumption to encourage rational energy use.
2. Accelerate the shift from energy-intensive industries to knowledge-based, service, and green industries that consume clean energies.
3. Apply energy efficiency standards and codes to product design, production process, and system design and construction (e.g. factories, buildings, plants). The government should develop and implement a cost-effective action plan with specific milestones and strategies to achieve these policy goals.

The above-mentioned energy savings targets, action plans, and policy tools results in a difference of 25.1 Mtoe (10%) between primary energy supply in BAU and the APS in 2050 (Figure 9.10).

Figure 9.10 Total Primary Energy Supply, Business-as-Usual and Alternative Policy Scenario, 2017 and 2050

(Mtoe)



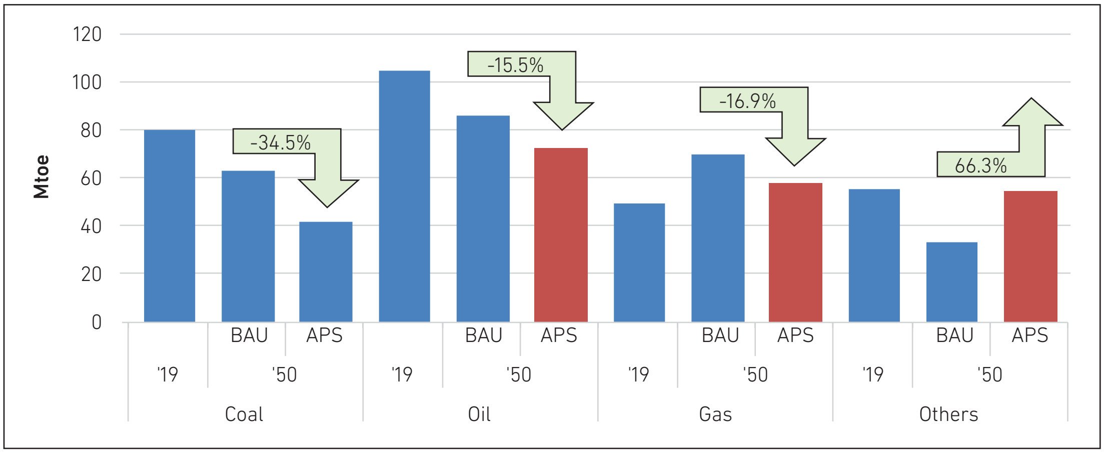
APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 9.11 shows the energy saving potential by energy source. Amongst energy sources, coal has the largest reduction in energy demand (-34.5%), followed by natural gas (-16.9%) and oil (-15.5%). In contrast, other energy sources, such as nuclear and renewable energy, will increase by 66.3% compared to the BAU scenario. Renewable energy will be the primary driver of growth.

Figure 9.11 Primary Energy Supply by Source, Business-as-Usual vs. Alternative Policy Scenario, 2019 and 2050

(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

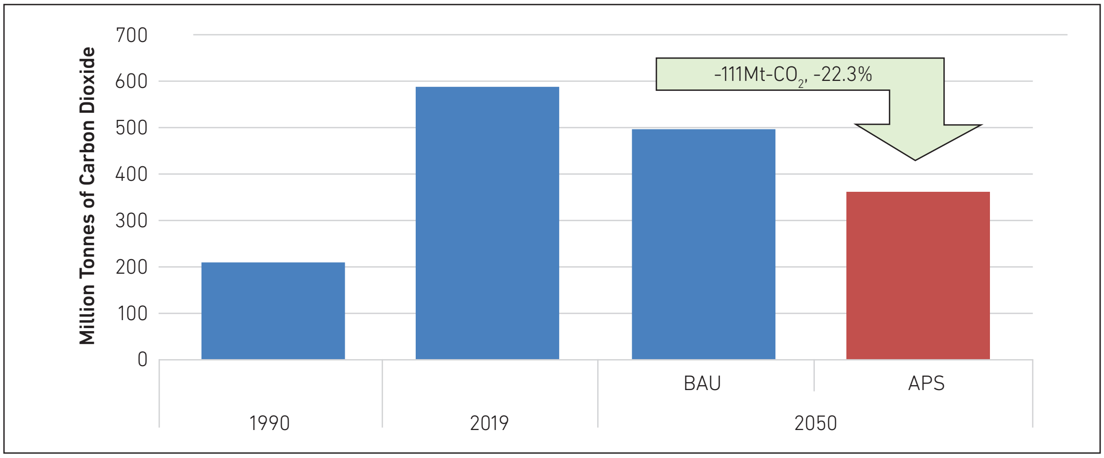
3.3. Carbon Dioxide Emissions from Energy Consumption

Carbon dioxide (CO_2) emissions from energy consumption are projected to decrease at an AAGR of -0.5%, from 586.7 million tonnes of CO_2 (Mt-C) in 2019 to 497.0 Mt-C in 2050 based on BAU. Such a growth rate is slower than that in primary energy supply. This indicates that Korea will use less carbon-intensive fuels—such as nuclear, natural gas, and renewable energy—and employing more energy-efficient green technologies.

In the APS, CO_2 emissions are projected to decline at an AAGR of -1.5% between 2019 and 2050. The difference in CO_2 emissions between BAU and the APS is 111 Mt-C or -22.3% (Figure 9.12). To attain such an ambitious target, the government must develop and implement cost-effective and consensus-based action plans to save energy and reduce CO_2 emissions.

Figure 9.12 Carbon Dioxide Emission from Energy Consumption, Business-as-Usual vs. Alternative Policy Scenario, 2019 and 2050

(Mt-C)



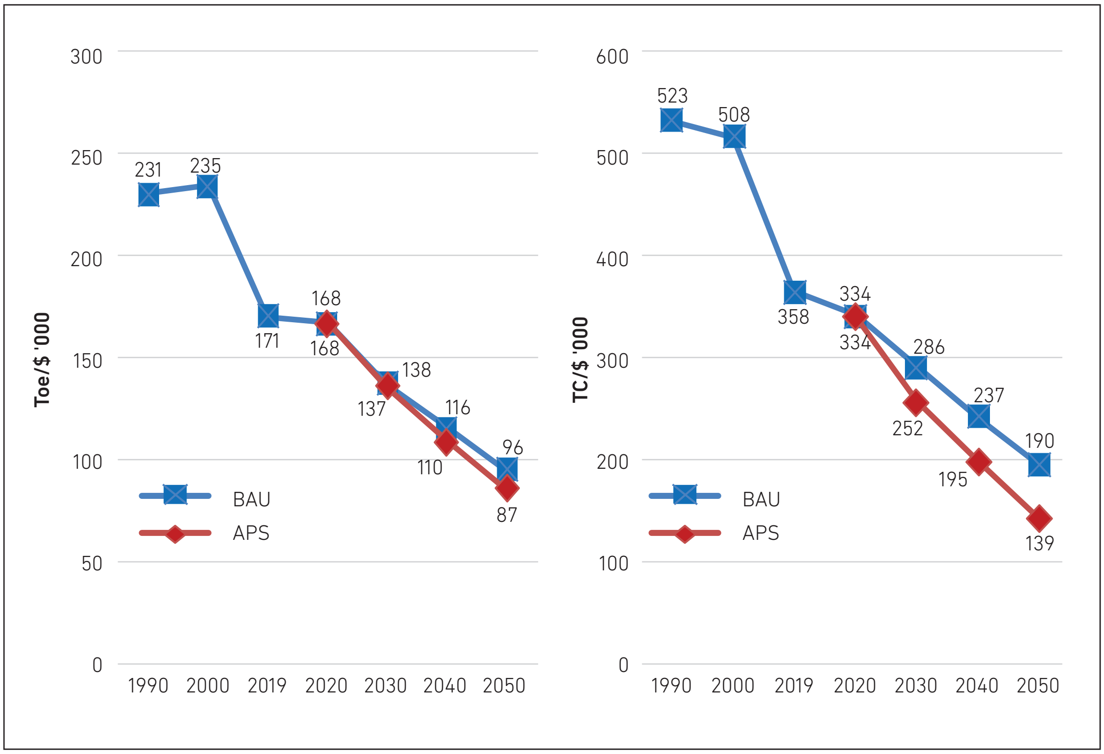
APS = alternative policy scenario; BAU = business-as-usual; Mt-C = million tonnes of carbon dioxide.

Source: Author's calculation.

3.4. Energy and Carbon Intensity

As a result of energy savings, the energy intensity of GDP is projected to improve (Figure 9.13). In BAU, energy consumption per unit of GDP (toe/million 2015 US$) is projected to be reduced from 171 to 96, showing a 43.9% improvement between 2019 and 2050. In the APS, it was accelerated by 49.1%. Energy intensity in the APS is 9.4% below that in BAU. This is due to a reduction in primary energy supply and the aggressive introduction of low-carbon energy sources and energy efficiency technologies. Carbon intensity, which refers to CO2 emissions per unit of GDP (measured in t-C/million 2015 US$), is a more important measure of progress than energy intensity and is projected to improve in both BAU and the APS. This is due to a reduction in primary energy supply and the aggressive introduction of low-carbon energy sources and energy efficiency technologies. The outlook shows that carbon intensity is expected to decrease from existing levels of 358 to 190 (43.1%) for BAU and 139 (58.4%) under the APS. Carbon intensity levels in the APS are 26.8% lower relative to those in BAU.

Figure 9.13 Energy and Carbon Intensities, 1990–2050



Toe = tonnes of oil equivalent; TC = tonnes of carbon dioxide.

Source: Author's calculation.

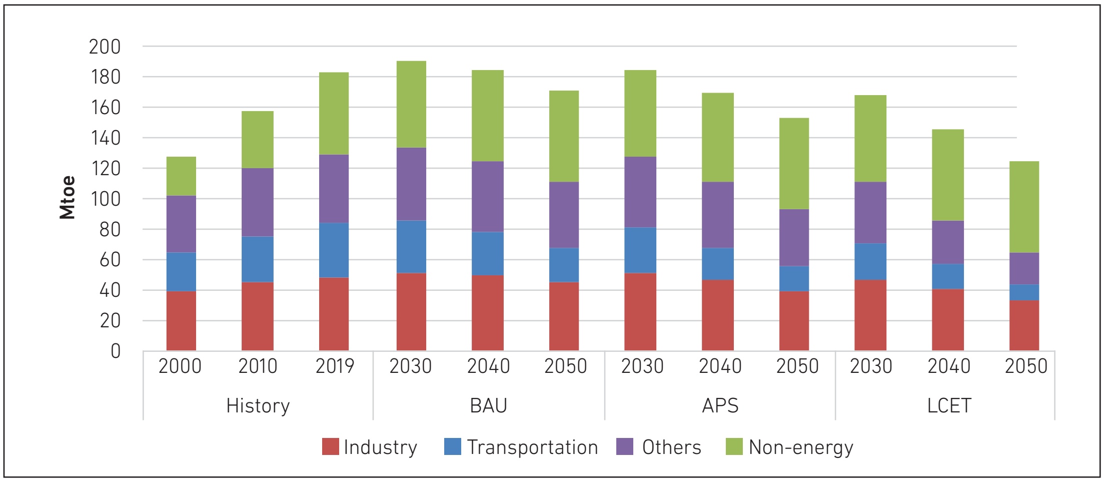
4. Low Carbon Energy Transition Scenario

This section delves into the Low Carbon Energy Transition (LCET) scenario, which has gained significant global momentum as countries embrace Energy Transition and Carbon Neutrality. With the government spearheading these initiatives through the implementation of the Energy Transition Policy and Carbon Neutral Strategy, and the launch of the Green New Deal, the LCET scenario provides a timely and effective approach to achieving these goals.

4.1. Final Energy Consumption

Final energy consumption in the LCET scenario is projected to decrease from 181.9 Mtoe in 2019 to 123.9 Mtoe in 2050 at an AAGR of -1.2%, which is significantly higher than that of the APS with -0.6%. Figures 9-14 and 9-15 compare final energy consumption between BAU, APS, and LCET scenarios. Figure 9.14 shows that final energy consumption will decrease faster compared to the APS due to reduction in energy consumption in industry and transport, while 'others' remain similar to the APS.

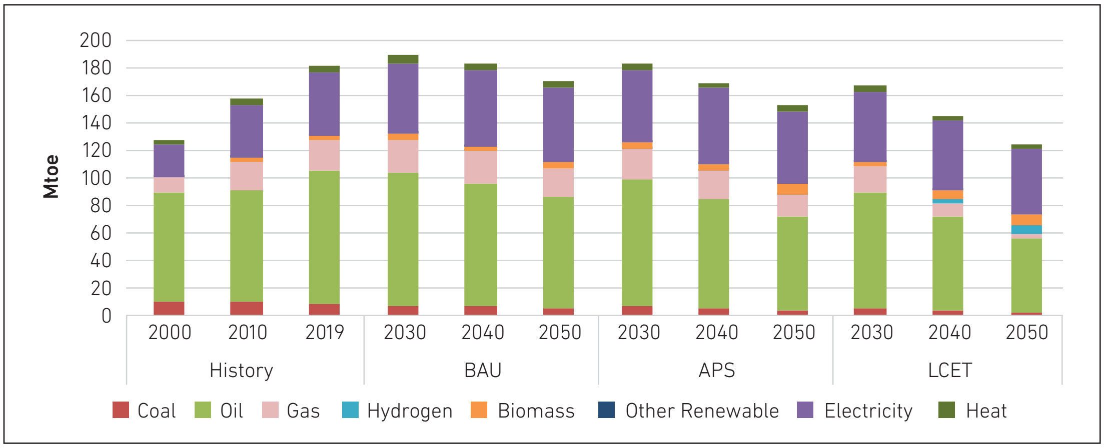
Figure 9.14 Final Energy Consumption by Sector, Business-as-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050
(Mtoe)



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

The difference in energy consumption by energy source between the APS and LCET scenario is due to a reduction in fossil fuel such as coal and natural gas. Another important factor is the use of hydrogen, which will be accelerated by the rapidly emerging hydrogen economy as a core element in a transition to a sustainable energy system in the future. According to the LCET scenario, a 5.6% share of hydrogen is projected for 2050 (Figure 9.15).

Figure 9.15 Final Energy Consumption by Source, Business-as-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050
(Mtoe)

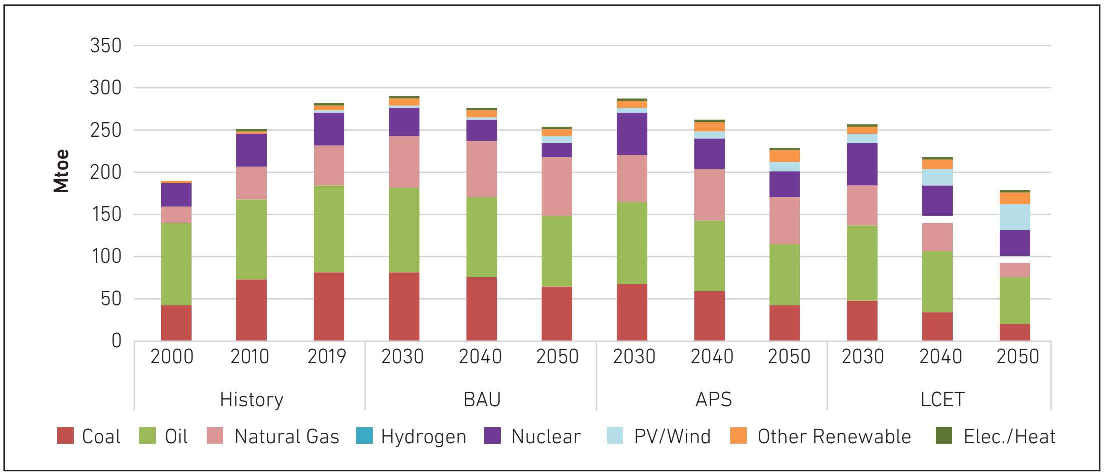


APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.
Source: Author's calculation.

4.2. Primary Energy Supply

Primary energy supply will decrease from 280.2 Mtoe in 2019 to 175.3 Mtoe in 2050 with a negative AAGR of -1.5%, higher than -0.7% in the APS (Figure 9.16). This difference is led by the reduction in the use of fossil fuels like coal, oil, and natural gases, and the increase in the use of solar photovoltaics (PVs) and wind. This shift has been driven by government policy on carbon-free and green energy adoption, as part of its Carbon Neutral Strategy for energy transition. In addition, the hydrogen economy is emerging as a key element of sustainable energy systems, as highlighted in the energy consumption data. As projected in the LCET scenario, hydrogen is expected to comprise about 4.9% of the primary energy supply.

Figure 9.16 Primary Energy Supply by Source, Business-as-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050
(Mtoe)

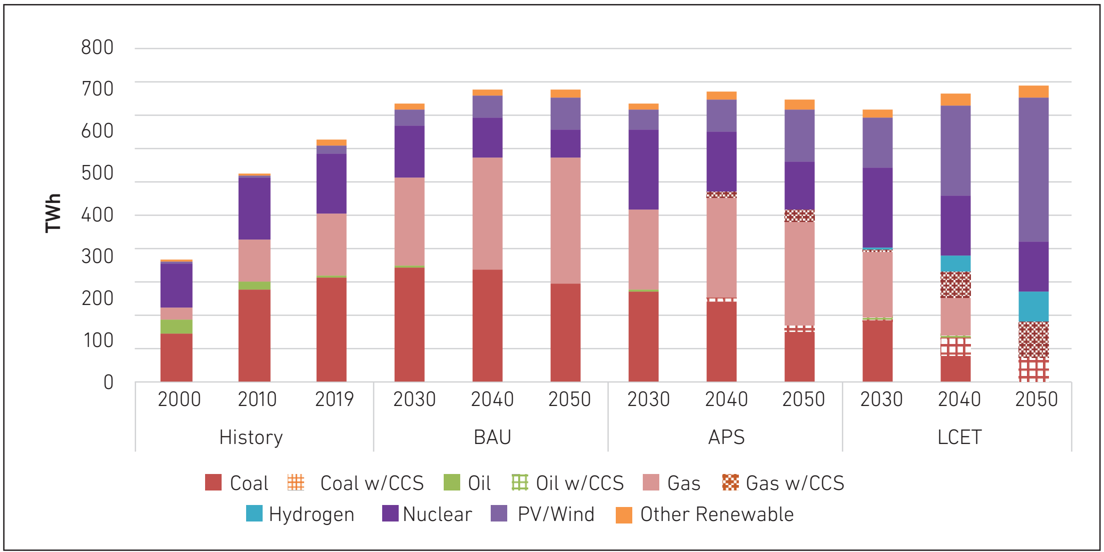


APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent, PV = photovoltaic.
Source: Author's calculation.

4.3. Power Generation

As shown in Figure 9.17, electric power generation in the LCET scenario is projected to increase from 578,034 gigawatt hours (GWh) in 2019 to 708,280 GWh in 2050, which is not much different from 674,584 GWh in the APS, a difference of only 4.8%. However, fuel mix in the power generation show has a quite different story. In general, it is predicted that clean and carbon-free energy sources, such as solar PVs and wind, will experience a rapid increase in the LCET scenario. In contrast, traditional energy sources such as coal, oil, and gas will continue to serve as major energy sources in the APS. However, in the case of fossil fuels with carbon capture and storage (CCS) implementation, they will overwhelmingly dominate the LCET scenario. In the APS, approximately 10% of coal and gas is combusted with CCS. The fuel mix is expected to include hydrogen, making up approximately 10% of the total, but there will be no hydrogen introduced in the APS. Other fuels, including nuclear and other renewables, are expected to hold similar shares in the fuel mix.

Figure 9.17 **Power Generation, Business-as-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050**
(TWh)



APS = alternative policy scenario; BAU = business-as-usual; CCS = carbon capture storage; LCET = low carbon energy transition; PV = photovoltaic; TWh = terawatt hour.

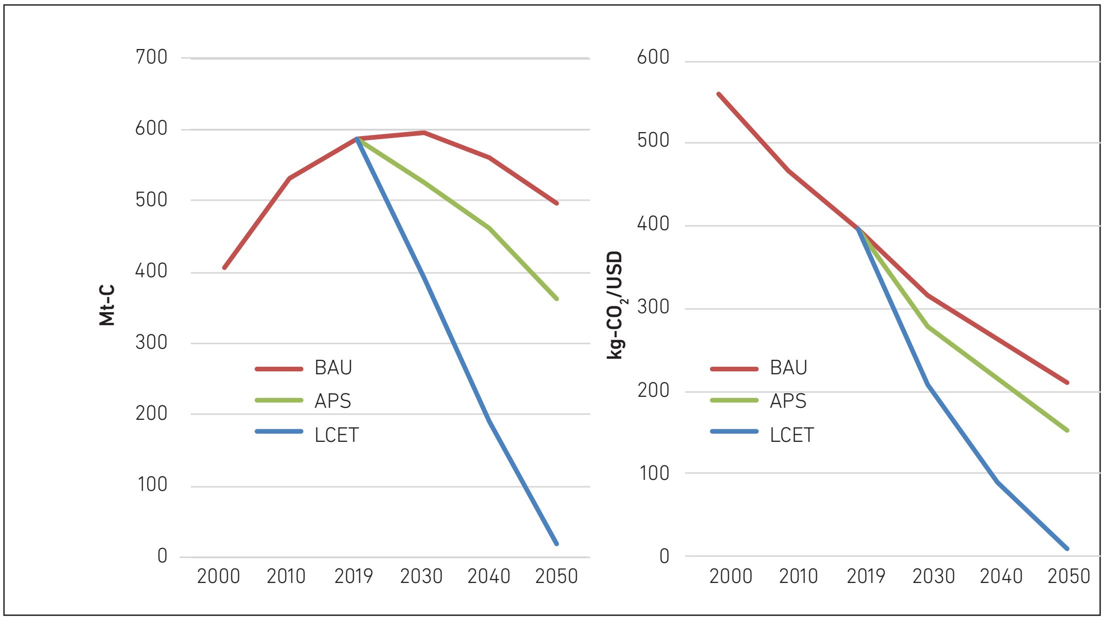
Source: Author's calculation.

4.4. Carbon Dioxide Reduction and Carbon Intensity

In the LCET scenario, CO_2 emissions are projected to decline at an AAGR of -10.5% from 586.7 Mt-C in 2019 and 18.8 Mt-C in 2050. The difference in CO_2 emissions between BAU and LCET scenarios is 96%, which shows the need for tremendous efforts to attain such an ambitious target. To address this challenge, it is critical for the Government of Korea to establish and enact widespread, cost-efficient, and collaborative strategies aimed at significantly reducing CO_2 emissions throughout the nation.

The projected reduction in CO_2 emissions will result in an improved carbon intensity of GDP, as depicted in Figure 9.18. Carbon intensity is also projected to improve in both BAU and the APS, mainly due to the reduction in primary energy supply in terms of energy intensity. This is achieved through the introduction of low-carbon energy sources and technologies and energy-efficient technologies. Accordingly, carbon intensity, as represented by CO_2 emissions per unit of GDP (t-C/million 2015 US$), is expected to decrease from 396 down to 210 in BAU, 153 in the APS, and 8 in the LCET scenario. This represents reductions of 47.0% for BAU, 61.4% for the APS, and 98.0% for the LCET scenario, with the latter exhibiting carbon intensity that is 96.2% lower than BAU and 98.0% lower than the APS.

Figure 9.18 Carbon Dioxide Reduction and Carbon Intensity, Business-as-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition.

Source: Author's calculation.

5. Implications and Policy Recommendations

Due to an absence of affordable domestic energy resources, Korea imports most of its energy needs (93% in 2020) for economic growth. Thus, energy security has been a top priority on its policy agenda, with a focus on maintaining stable energy supply to sustain economic growth. However, at the turn of the 21st century, the government shifted its energy policy towards a more sustainable, efficient, and energy-saving approach, which comprehensively outlined in the First (2009), the Second (2014), and most recently, the Third (2019) Energy Basic Plan.

In the 1990s, while Korea experienced a rapid increase in energy consumption, its GDP was not growing as fast as it was driven by energy-intensive industries, such as the petrochemical, steel, and cement industries. Since 1997, the contribution of these industries to GDP has gradually declined, resulting in reduced energy intensity. However, the shift to a less energy-intensive industrial structure takes time, indicating that energy-intensive industries will prevail in the short to medium term. However, in the long term, Korea will need to transform into a less energy-intensive industrial structure.

The Second National Energy Basic Plan released in 2014 was the first full-scale energy basic plan with a workable target and an action plan. The policy approach outlined by the plan involved a complete transformation of the industrial structure, shifting it from a focus on supply to a focus on meeting demand. Its basic policy direction comprises six major agendas, with an emphasis on energy policy driven by demand as the top priority. Other five key agendas include constructing dispersed power sources, integrating environmental and safety objectives, strengthening energy security and stable energy supply, and implementing an energy policy supported by its people.

Another policy agenda prioritises the environment by aiming to reduce GHG emissions to address global climate change. The government announced an ambitious goal of decreasing GHG emissions by 37% from BAU (850.6 Mt-C) by 2030 across all economic sectors. Of the overall goal of 37%, domestic activities will meet 25.7%, while the remaining 11.3%, will be attained through carbon trading in the international market. It is a response to and a fulfilment of its international responsibility for the new climate regime established as a follow-up action to the Paris Agreement in December 2015.

In the past 30 years, the government has been mostly concerned with energy security, energy efficiency, and environmental preservation. To address the energy security challenge, the government has taken steps to encourage the import of foreign resources and promote the development of renewable energy sources. The improvement of energy efficiency has been addressed through programmes that receive support from a series of the Five-Year Basic Plan of Rational Energy Use. Offices of the Ministry of Environment have approached the environmental issue caused by consumption of fossil and nuclear energy. Now is the time for Korea to synergise its previous efforts in policy tools and programmes by coordinating with ministries clearly specified in the Third National Energy Basic Plan.

In 2017, the new government led by President Moon Jae-In proposed reforms to the current energy policy, announcing a new energy policy direction, 'Energy Transition', which has completely shaken up the existing national energy policy. Energy Transition rests on two major energy policy agendas: (i) gradual reduction of nuclear power plants and coal-fired plants ('de-nuclearisation' and 'de-coalisation' policies), and (ii) expansion of renewable energy with the share of renewable electricity raised up to 20% by 2030 (Renewable Energy 2030). These policy agendas will be reflected in subsequent energy plans: the 8th Electricity Demand and Supply Basic Plan (completed and announced) and the 3rd National Energy Master Plan (under way).

The basic spirit of the Energy Transition was fully reflected in the Third Energy Basic Plan, which establishes a national energy blueprint up to the year 2040. The Third National Energy Basic Plan builds on the idea of a sustainable energy system stipulated in the First and the Second Energy Basic Plans, while also focusing on the innovative transition of the overall energy system from supply side to demand side. In this context, the Third Energy Basic Plan sets the goal to achieve sustainable growth and enhance the quality of life through energy transition.

The Third Energy Basic Plan proposes two strategic goals. The first is the transition of energy supply, consumption, and industry. The second is to establish the foundation for energy transition. Under these two strategic goals, 5 basic policy directions are suggested: (i) Innovation in the Energy Consumption Structure, (ii) Transition towards a Safe and Green Energy Mix, (iii) Expansion of Distributed & Participatory Systems, (iv) Global Competitiveness of the Energy Industry, (v) Better Infrastructure and Market Systems for Energy Transition.

If successfully implemented, Energy Transition will result in a complete turnaround from traditional energy based on coal and nuclear power to a sustainable energy system based on renewable energy and gas-fired power generation. This change in energy mix does not signify the end of the nuclear industry in Korea. Recent polling suggests that the public is marginally in favour of continued investment in nuclear power. In 2017, five nuclear reactor units were being constructed. Keeping nuclear power in the energy mix, along with a larger uptake of renewable energy, will give Korea more options to meet its Paris Agreement targets, which were set by nationally determined contributions (NDC).

The impacts and implications of reform in the energy mix remain to be seen. Such reform calls for a vast amount of investment in rebuilding infrastructure, hardware, and software, along with an institutional arrangement. It also entails a change not only in the energy sector but also in the cultural, political, and social domains. Having successfully gone through energy transitions in the past, the government is highly confident to move forward with the current policy goals to transform into a less energy-intensive, greener economic structure and implement major policy agendas and their corresponding policy tools and programmes. Nationwide campaigns could transform the Korean economy to be less energy-intensive and greener. This would lead to reduced CO_2 emissions and position Korea as one of the global leading nations in terms of low-carbon green growth.

CHAPTER 10

The Lao People's Democratic Republic Country Report

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1. Background

1.1. Socioeconomic Situation

The Lao People's Democratic Republic (Lao PDR) is the only landlocked country in the Association of Southeast Asian Nations (ASEAN). Located in the centre of the Indochina Peninsula, it borders five countries: China in the north, Viet Nam in the east, Cambodia in the south, and Thailand and Myanmar in the west. Lao PDR has a total area of 236,800 square kilometres (km^2), about 70% of which is covered by mountains, and a population of 7.1 million as of 2019. The average population density is 30 persons per km^2. Lao PDR comprises 18 provinces, with Vientiane as the capital.

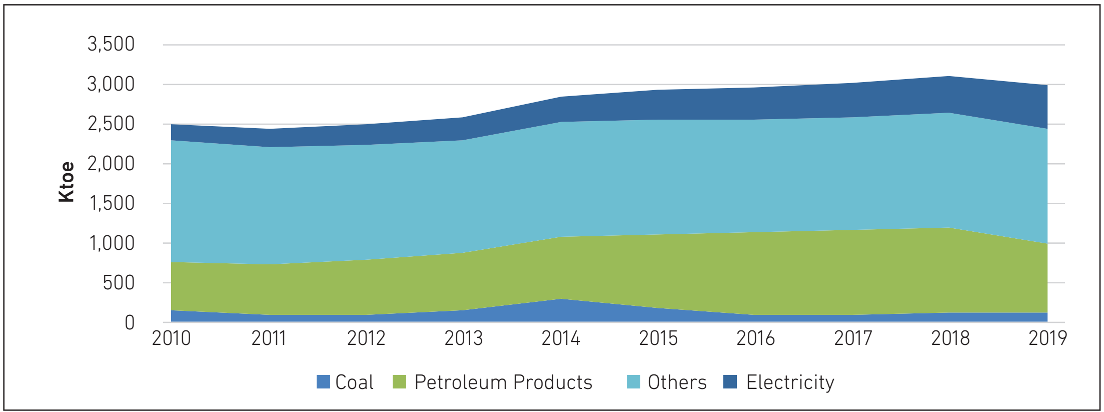
Since 1986, when Lao PDR changed its economic policy to an open-door policy, the economy has progressed and expanded rapidly. The gross domestic product (GDP) in 2019 increased by 5.2% from the previous year, to $18,492 million in 2015 constant prices, bringing per capita income to $2,579 (World Development Indicators, 2022). The economy has been changing gradually from agriculture-oriented activities to a wider range of activities, such as services and industry. For example, in 2019, services accounted for 42.3% of GDP, while agriculture only accounted for 15.2%. Industry accounted for 31.4%, and its share is expected to expand in the coming years due to large investments in the mineral and hydropower sectors.

1.2. Energy Supply-Demand Situation

Lao PDR is relatively well-endowed with renewable energy resources, especially hydropower and biomass. Recently, hydropower resources have been developed intensively to meet the electricity requirements of the country, as well as that of neighbouring countries. Every year, Lao PDR receives a significant number of hard currencies from those power exports. This is widely considered to be one of the driving forces that boosts socioeconomic development and energy security in the country.

Lao PDR's total final energy consumption (TFEC) grew by 2.1% from 2010 to 2019 (Figure 10.1). Electricity grew the fastest at 11.7% per year, followed by petroleum products at 3.8%. Biomass consumption, which has the highest share of the TFEC, decreased at an average rate of 0.7% per year. A small amount of coal consumption was noted in the industry sector.

Figure 10.1 **Total Final Energy Consumption by Fuel Type**
(Ktoe)



Ktoe = kilotonne of oil equivalent.

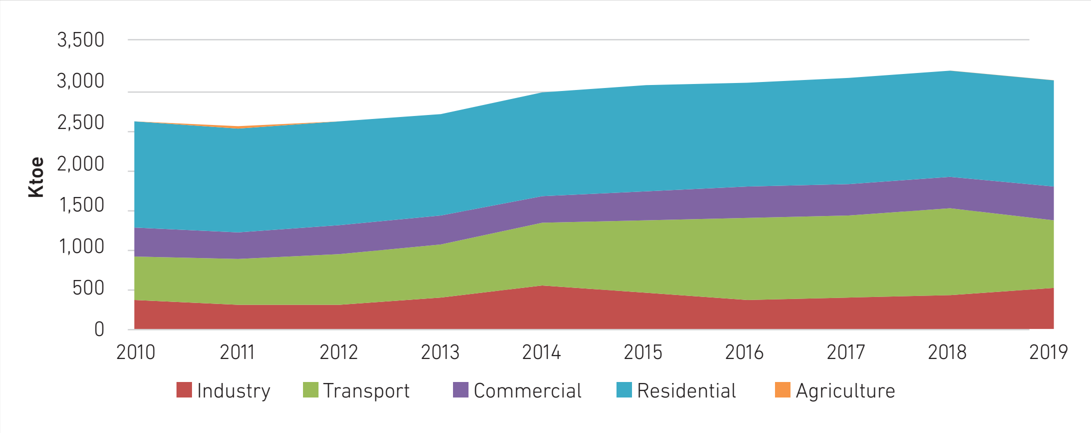
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table Collection Historical. 14 December.

The industry and commercial sectors consume biomass, but at a lower rate than the residential sector, which dominates the country's consumption. Although the residential sector is the biggest user of biomass, its share declined from 51% in 2010 to 41% in 2019. This shift is due to the adoption of liquefied petroleum gas (LPG), the use of efficient biomass stoves in rural areas, and the increased use of electricity equipment in urban areas.

The transport energy consumption had the second largest share (27%) in the TFEC, it decreased from 43% in 2018 to 27% in 2019. However, from 2019 onward, the energy consumption in transport sector started to increase slowly due to the completion and operation of the high-speed rail Lao–China. Further, the increase in road sector energy consumption was mainly driven by the rapid growth in the number of motor vehicles.

Industry accounted for around 17% of the TFEC with an average annual growth rate of 3.6% from 2010–2019, while the commercial sector accounted for around 13% of TFEC with an average annual growth rate of 2% (Figure 10.2).

Figure 10.2 Total Final Energy Consumption by Sector



Ktoe = kilotonne of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table Collection Historical. 14 December.

In 2019, Lao PDR's total primary energy supply (TPES) was 5.9 million tonnes of oil equivalent (Mtoe), and the energy mix consisted of hydropower, oil, coal, solar and biomass. As there were many power plants in Lao PDR generating electricity for export in 2019, the export figure reached 25,048 gigawatt-hours (GWh) or equivalent to 2.15 Mtoe. This amounted to more than half of all electricity consumed in the country and 77% of total hydropower generation.

Biomass was the most consumed energy type in the country but has decreased annually. People who lack access to modern energy use biomass as a main source for cooking, heating, and many other activities because it is abundant and free of charge. In 2019, 1.62 Mtoe of biomass was used, representing 18.4% of the TPES. Consumption of oil products ranked second highest after biomass, and the majority of the country's oil product demands are met through imports from Thailand and Viet Nam. In 2019, Lao PDR's share of oil consumption was 29%. The country imported 0.92 Mtoe of oil products to supply the demand for the transport sector and others. In the same year, Lao PDR consumed 4.5 Mtoe of coal, mainly in thermal power plants such as the Hongsa Thermal Power Plant, the country's first and largest coal power plant, which began operating in 2015. Thus, coal demand increased sharply from 2015 onwards.

Due to its geographic advantages, including its many rivers, Lao PDR is rich in hydropower resources. According to the Mekong River Commission Study in 1995, Lao PDR's potential hydropower resources total 26,000 megawatts (MW). However, as of 2020, only 9,985.9 MW or 38.4% of its total potential had been realised. In 2020, Lao PDR produced around 52,217.8 GWh of electricity, of which 72% (equivalent to 37,596.8 GWh) was exported to Thailand, Viet Nam, and Cambodia; the rest was consumed domestically (Department of Energy Policy and Planning, 2020).Power exports are projected to increase sharply because the Government of Lao PDR has committed, through a revised memorandum of understanding, to export 10,500 MW to Thailand and 5,000 MW to Viet Nam. There are also plans to export 6000 MW to Cambodia; 600 MW to Myanmar; 300 MW to Malaysia; and 100 MW to Singapore. Exported power is mainly generated from hydropower. However, the

Hongsa plant has 1,878 MW of installed capacity to generate electricity for export and has exported 95% of its generated electricity since 2015.

The power sector plays a major role in the energy sector as well as in the country's economy as it generates a significant amount of national revenue. Although this revenue is insignificant in the short to medium term, it will increase in the long term because the government plans to assume ownership of private power plants. The electrification rate in Lao PDR was 94.3% in 2020 (Electric De Laos, 2020), and the government is striving to raise this to 98% by 2025. This plan is part of the government's strategy to eradicate poverty in the country. Considering the increasing demand for electricity in Lao PDR and power generation for export, balancing domestic supply with exports is an issue that must be addressed to ensure the electricity supply in the future.

1.3. Energy Policies

Since the Ministry of Energy and Mines was established in 2006, energy infrastructure and legislation has been newly developed and expanded. Energy policy has gained much public attention and support. It has gradually evolved from power sector policy to broader energy policies supporting the development of a sustainable and environmentally friendly energy sector. Close cooperation amongst ASEAN members can be credited for this improvement.

Although Lao PDR is landlocked, it is located in the middle of the Mekong subregion and is surrounded by three large economies – China, Thailand, and Viet Nam – and two medium economies – Myanmar and Cambodia. As a result, Lao PDR can position itself as a land-linked country and leverage the advantages thereof. The energy policies exchanged on the energy cooperation platform of ASEAN+3 (China, Japan, and the Republic of Korea) indicate that the substantial energy demands of these countries can drive energy trade and facilitate power integration across the region, thereby enhancing energy security and promoting sustainable development. Building on its longstanding history of trading electricity with Thailand, Lao PDR has now expanded its policy to other neighboring countries to strengthen regional energy cooperation. Specifically, Lao PDR intends to augment power exports to the aforementioned neighboring countries mentioned above.

According to the National Power Development Strategy, 2022–2030 and the Ninth Five-Year Energy and Mines Development Plan 5, 2021–2025, the Ministry of Energy and Mines has set the following goals for the power sector:

(i) Increase power supply efficiency by 75 % for hydropower, 14 % for thermal power plants, and 11 % for renewable energy; and meet the domestic demand and export target.
(ii) Develop transmission lines for domestic power supply and for export.
(iii) Improve distribution and services.
(iv) Expand the electrification rate to 98 % in rural areas by 2025.
(v) Promote green energy usage in the transport sector by increasing the number of electric vehicles to 15 % of all cars in the country by 2025.
(vi) Promote energy savings and conservation by reducing energy consumption by 10 % by 2030.

2. Modelling Assumptions

This study aims to forecast energy supply and demand in Lao PDR from 2020 to 2050 and to determine the country's potential for energy savings and carbon dioxide (CO_2) emission reduction, improved energy efficiency, and feasible renewable development if Lao PDR uses or implements certain alternative policy scenarios (APSs). Therefore, this study considers five scenarios: Business as Usual (BAU), APSs (APS1, APS2, APS3, APS4[1] and APS5) described below.

(i) BAU Scenario is calculated based on the assumed growth of GDP, population, and oil prices.

(ii) APS1, Lao PDR will implement energy saving and conservation programmes, reducing energy consumption by 10% during the study period (2020–2030) and 10% from 2030 to 2050.

(iii) APS2, Lao PDR will make thermal power generation more efficient, increasing thermal efficiency by 30% by 2030 and 32% by 2050.

(iv) APS3 involves a higher contribution of renewable energy to the total supply.

(v) APS5, combines APS1, APS2, and APS3 into a single scenario.

Table 10.1 Assumption of Annual Average Growth of Gross Domestic Product and Population

Projection period	GDP growth	Population growth
2019–2020	0.5%	1.5%
2020–2030	3.9%	
2030–2050	5.7%	

GDP = gross domestic product.

Source: World Bank, World Development Indicators.

[1] The APS 4, which promotes nuclear power generation, is omitted because there is no nuclear power plan.

3. Outlook Results

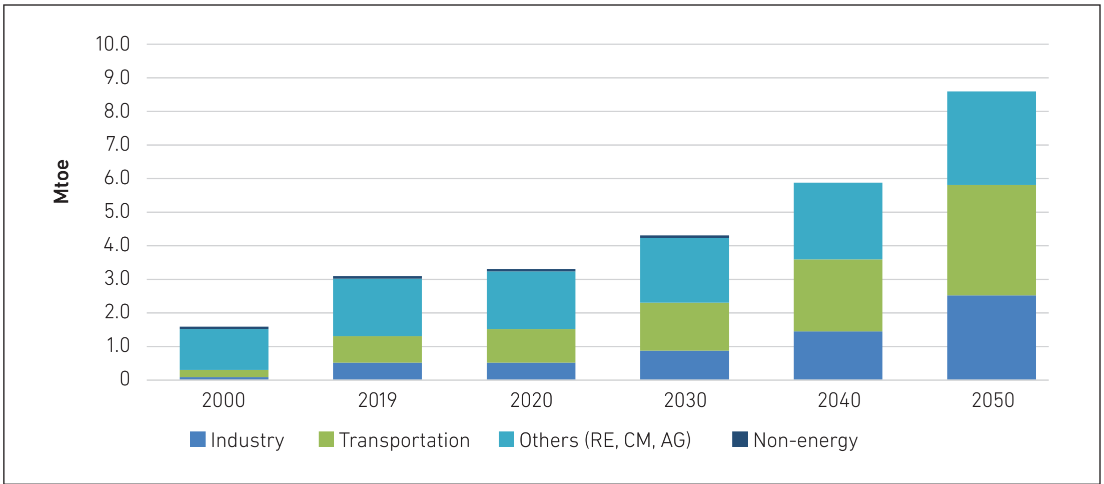
3.1. Business-As-Usual Scenario

3.1.1. Final Energy Consumption

In Lao PDR, the final energy mix comprises coal, oil, electricity, and 'others'. The country's TFEC increased from 1.51 Mtoe in 2000 to 3 Mtoe in 2019, an average annual growth rate (AAGR) of 3.7%. This growth will continue at a rate of 8.2% in 2019–2020, 2.6% in 2020–2030, 3.4% in 2030–2040, and 3.8% in 2040–2050. From 2019 to 2050, this growth will increase at a constant rate of 3.5% per year.

With respect to final energy consumption by sector, like other Southeast Asian countries, the four main sectors in Lao PDR are industry, transport, others, and non-energy. 'Others' covers subsectors such as residential, agriculture, services, and commerce. During 2000–2019, the industry sector grew the fastest, at a rate of 10% per year, followed by the transport sector at 6.2% per year, and the 'others' sector at 1.9% per year. Industry's high growth rate is expected to continue from 2019–2050 at 5.4% per year (Figure 10.3 and Figure 10.4).

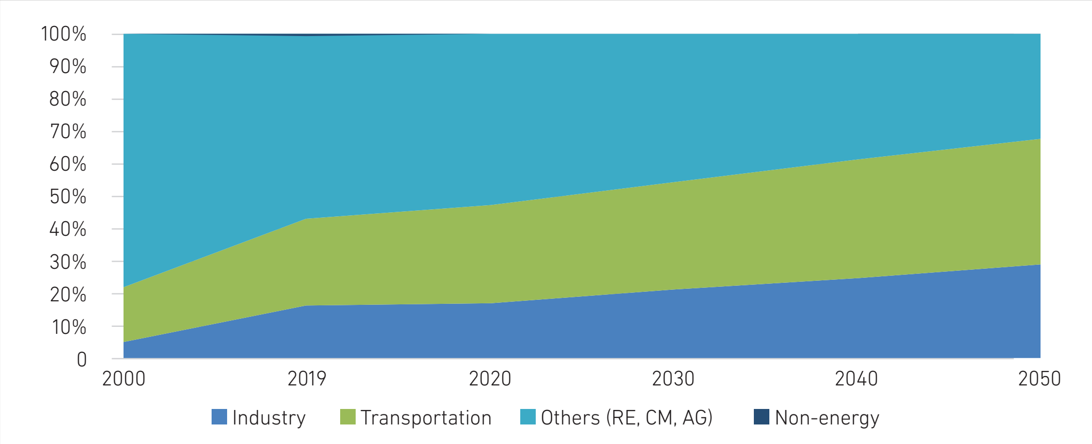
Figure 10.3 Final Energy Consumption by Sector, 2000–2050
(Mtoe)



AG = agriculture, CM = commerce, Mtoe = million tonnes of oil equivalent, RE = residential.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

Figure 10.4 Sectors' Share in Final Energy Consumption
(%)

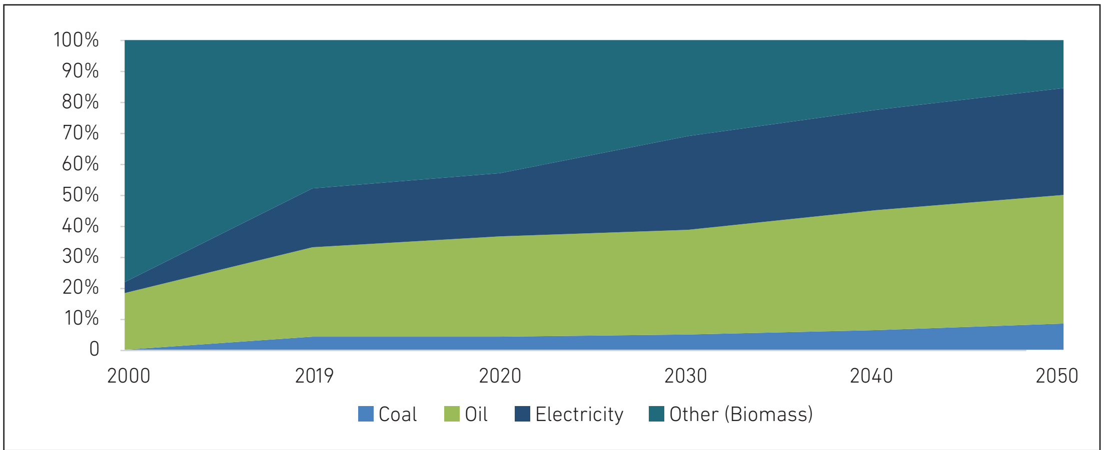


AG = agriculture, CM = commerce, RE = residential.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

In terms of energy types, 'others' (biomass, consisting of wood and charcoal, and solar) was the most frequently used in 2019, reaching 1.43 Mtoe, representing 47.6% of the TFEC (Figure 10.6). This is expected to decrease to 15.7% by 2050. Oil will become dominant in 2030–2050 and electricity will come second during 2040–2050. 'Others' (including biomass) is expected to be dominant until 2028 due to the reliance of rural Lao people on wood for cooking (Figure 10.5). Although less convenient, wood remains cost-effective compared to other energy options. However, biomass consumption is expected to decline slightly after 2028 as LPG and electric equipment replace it.

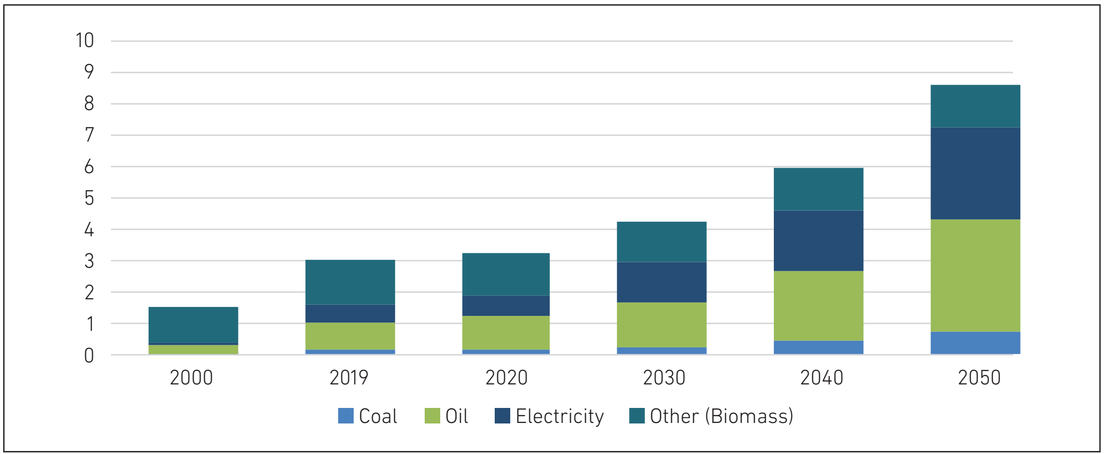
Figure 10.5 Fuels' Share of Total Final Energy Consumption
(%)



Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

Figure 10.6 Final Energy Consumption by Fuel Type

(Mtoe)



Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result ¬(Lao PDR_Template_BAU_APS_LCET August 2022).

Oil is an important energy source for Lao PDR because the entire transport sector depends on it. Oil prices directly affect the country's socioeconomic development, especially the cost of living and doing business in the country. However, unlike electricity and coal, oil is not produced domestically, and Lao PDR must import it from Thailand or Viet Nam. This keeps the country dependent on its neighbours. In this regard, it is necessary to observe and monitor this trend closely. Due to their reliance on imports, Lao PDR is expected to face an oil shortage with increased prices in mid-2022 amidst the global economic situation. In 2019, the country consumed 0.863 Mtoe of oil. While this is a decrease from 2018, demand is projected to increase from 0.863 Mtoe in 2019 to 3.56 Mtoe in 2050 (an AAGR of 4.7%), making it the third highest share relative to coal, electricity, and biomass during this period.

3.1.2. Primary Energy Supply

Lao PDR's energy primarily comes from coal, oil, hydropower, and 'others' (including biomass, solar, and electricity for export). Lao PDR's total primary energy supply (TPES) increased from 1.62 Mtoe in 2000 to 6.3 Mtoe in 2019, an AAGR of 7.4%. This growth is expected to decrease steadily at a rate of 0.1% per year from 2019–2020. The TPES growth rate is projected to decrease steadily at a slower rate of 3.7% per year from 2019–2050.

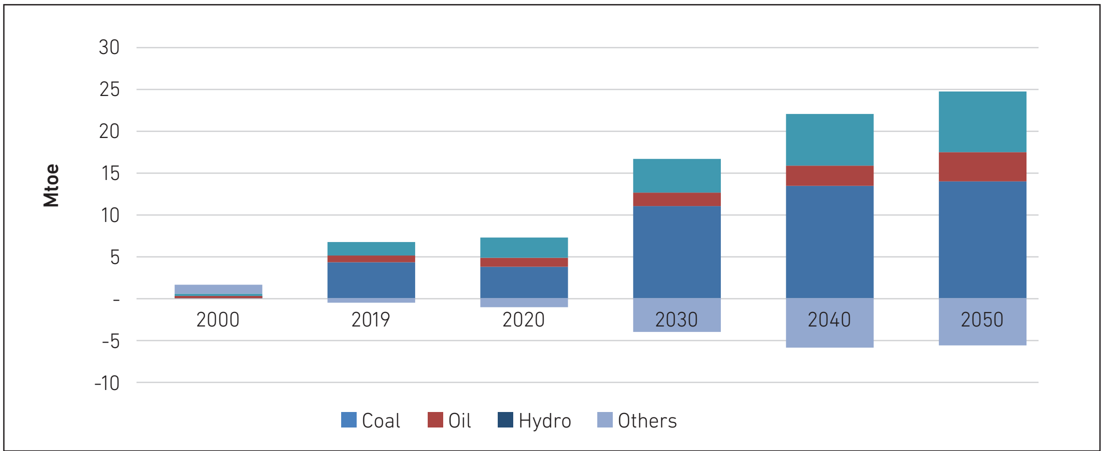
In 2019, coal was the most frequently used energy at 4.27 Mtoe, followed by hydropower at 1.73 Mtoe and biomass at 1.68 Mtoe. The Hongsa Plant is driving the high rate of coal consumption. Further, there are plans to construct coal power plants for exporting, which is expected to increase by 3.9% from 2019 to 2050. Therefore, coal's share of the TPES is projected to increase from 67.7% in 2019 to 73.3% in 2050.

Hydropower generated 1.73 Mtoe (27.5% of the TFES) in 2019 and is expected to generate 7.23 Mtoe (37.7% of the TFES) in 2050. It is forecasted to grow at an AAGR of 4.7 % from 2019 to 2050 because Lao PDR has been developing hydropower projects intensively to meet increasing domestic and export demands.

Biomass is frequently used in Lao PDR because it is a cheap fuel for cooking and is therefore the primary fuel used by rural people. The amount of biomass used has increased from 1.26 Mtoe in 2000 to 1.68 Mtoe in 2019 and is projected to increase to 1.96 Mtoe by 2050. Similar to projections regarding the share of biomass in the final energy mix, biomass as a share of primary energy is also estimated to increase by 0.5% during 2019-2050.

Oil is also experiencing high growth in Lao PDR because many people can now afford to buy private cars, significantly raising the number of vehicles. As of 2019, Lao PDR did not produce crude oil. All oil products are imported. There are 11 oil import and export companies and 12 oil distribution companies authorised within Lao PDR. In 2000, 0.27 Mtoe of oil was used, accounting for 16.8% of the TPES. This increased to 0.86 Mtoe (13.7 % of the TPES) in 2019, an AAGR of 6.3%, during 2000–2019. From 2019 to 2050, oil consumption is projected to grow at an AAGR of 4.7%, while oil will account for 18.6% of the TPES in 2050.

Figure 10.7 Primary Energy Supply
(Mtoe)



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

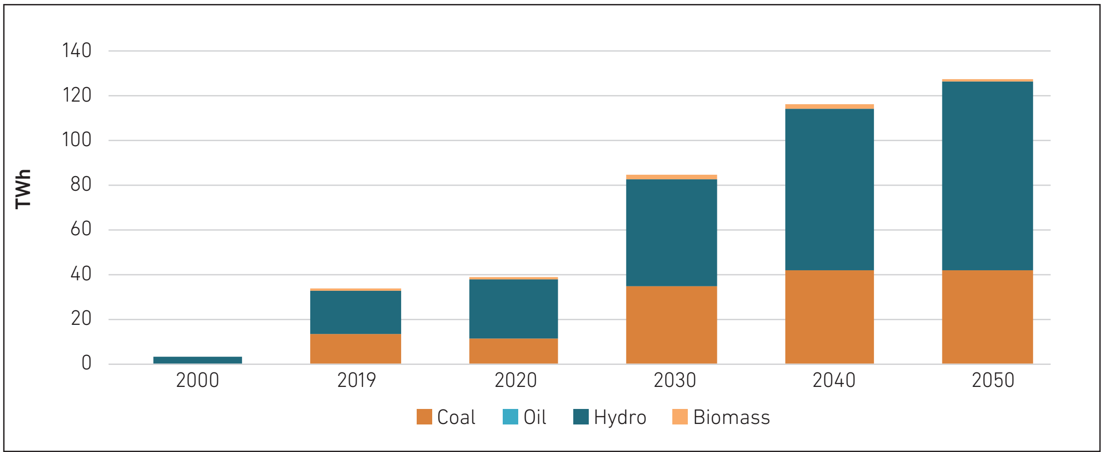
3.1.3. Power Generation

The history of power generation in Lao PDR can be divided into two periods: (i) 1970–2015, when all power was generated from hydropower sources and (ii) after 2015, when the Hongsa Coal Fired Power Plant began operating.

In 1990, Lao PDR only produced 0.82 terawatt hours (TWh) of electricity; this increased to 3.51 TWh in 2000 and 20.14 TWh in 2019. This is forecasted to increase to 84 TWh by 2050. Power generation outputs are also estimated to rise dramatically from 2019 to 2050, at an AAGR of 4.6%. The inauguration of the first thermal power plant in 2015 changed the power generation mix in Lao PDR (see Figure 10.8 for 2019 data).

In 2019, hydropower accounted for 59.7% of total generation and the Hongsa Plant accounted for 38.4%, with the remaining 0.2% coming from solar and biomass. Hydropower is forecasted to continue to dominate Lao PDR's power sector, accounting for 62.1% of total generation by 2050, while the Hongsa Plant's share is projected at 30.9%.

Figure 10.8 Electricity Generation 2050
(TWh)



Hydro = hydropower, TWh = terawatt-hour.

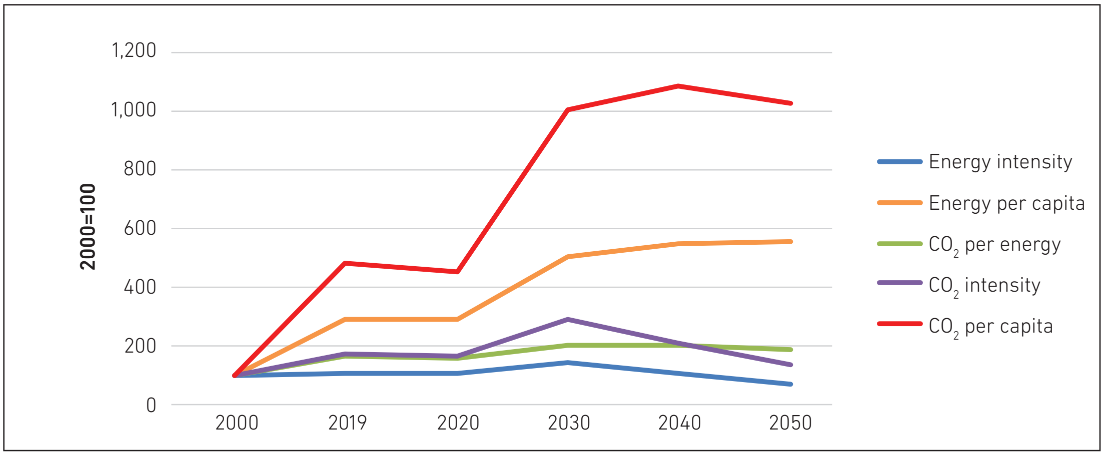
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.1.4. Energy Indicators

Lao PDR's primary energy intensity (TPES/GDP) increased from 325 tonnes of oil equivalent per million dollars (toe/$ million) to 341 toe/$ million in 2019 because of steadily increasing coal consumption by the Hongsa Plant; this is expected to decline to 137 toe/$ million by 2050.[2] The final energy intensity is projected to decline further to 85 toe/$ million by 2050. This indicates that energy consumers are implementing energy efficiency and conservation programmes.

[2] All United States dollars in this report are in constant 2010 values unless specified.

Figure 10.9 Energy Intensity and Other Energy Indicators (2000 = 100)



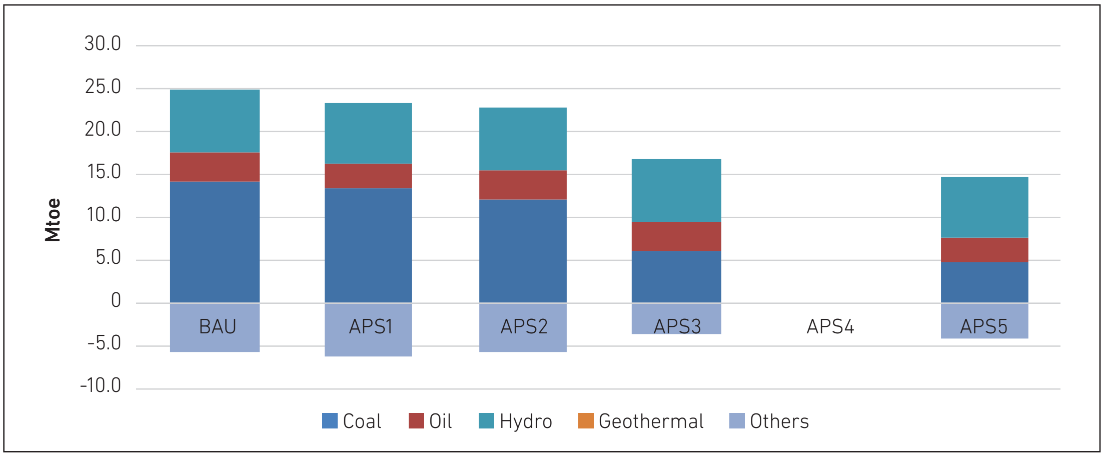
CO_2 = carbon dioxide.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.2. Energy Saving and Carbon Dioxide Reduction Potential (Alternative Policy Scenario)

As outlined above, this study considers four APSs with respect to Lao PDR's energy saving and CO_2 reduction potential: energy efficiency and conservation (APS 1), improved efficiency of the thermal power generation plant (APS 2), development of renewable energy (APS 3), and a combination of APSs 1, 2, and 3 (APS 5). Under these four APSs, various changes can be observed as shown in Figure 10.10. Under APS 1 the TPES decreases by 2.15 Mtoe (from 19.1 Mtoe to 17 Mtoe) compared with BAU. Under APS 2, more efficient thermal power generation reduces the TPES by 2 Mtoe. Under APS 3, replacing coal power generation with wind, solar will decrease the TPES from 19.1 Mtoe under BAU to 13.3 Mtoe. APS 5 combines the total reductions projected for APSs 1, 2, and 3. These reductions in the TPES mainly come from the targeted energy savings of 10%, followed by replacing coal power generation with renewable energy and improving the efficiency of thermal power generation.

Figure 10.10 Comparison of Scenarios, Total Primary Energy Supply, 2050
(Mtoe)

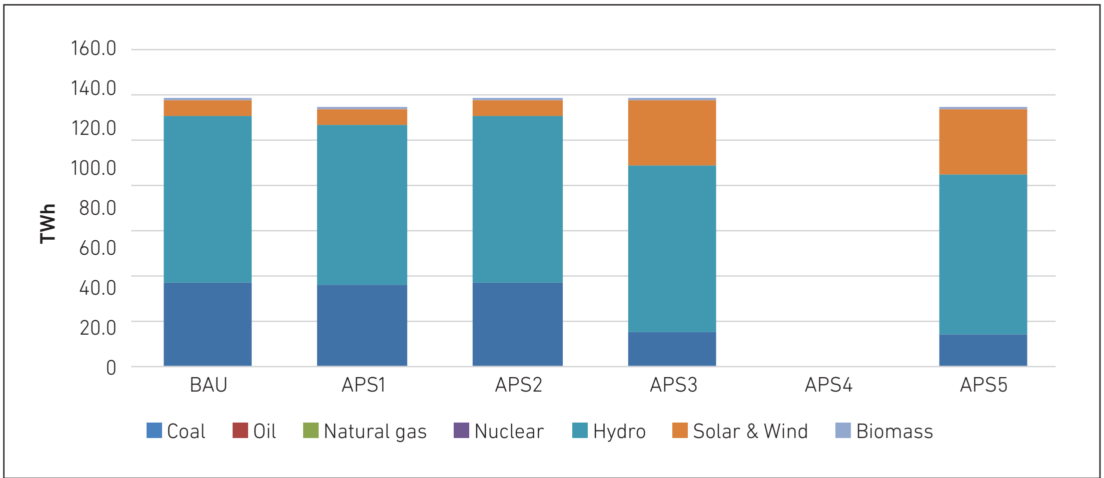


APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

For electricity generation in the APS5 scenario (Figure 10.11), generation from hydropower is the largest (80.98 TWh), followed by solar and wind (32.26 TWh), coal (15.95 TWh), and biomass (1.38 TWh).

Figure 10.11 Comparison of Scenarios for Electricity Generation, 2050
(TWh)



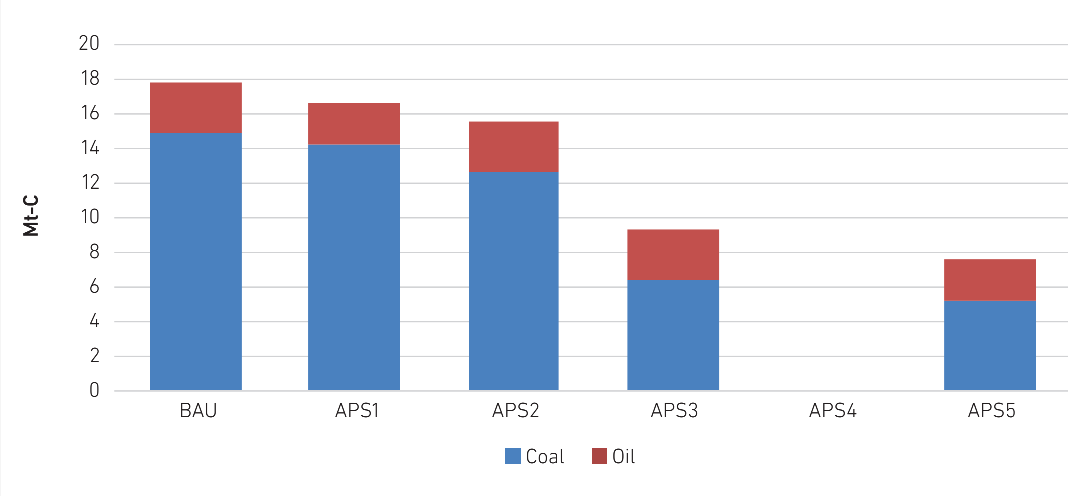
APS = alternative policy scenario, BAU = business-as-usual, Hydro = hydropower, TWh = terawatt-hour.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

Comparing projected levels of CO_2 emissions across these five scenarios reveals that APS 5 will eliminate 8.5 million tonnes of carbon (Mt-C), followed by APS 2 at 2.2 Mt-C, and APS 1 at 1.2 Mt-C. In total, this study projects that APS 5 will reduce total CO_2 emissions by 10.3 Mt-C, from 17.8 Mt-C of BAU to 7.51 Mt-C by 2050 (Figure 10.12).

Figure 10.12 Comparison of Scenarios, 2050

(Mt-C)



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

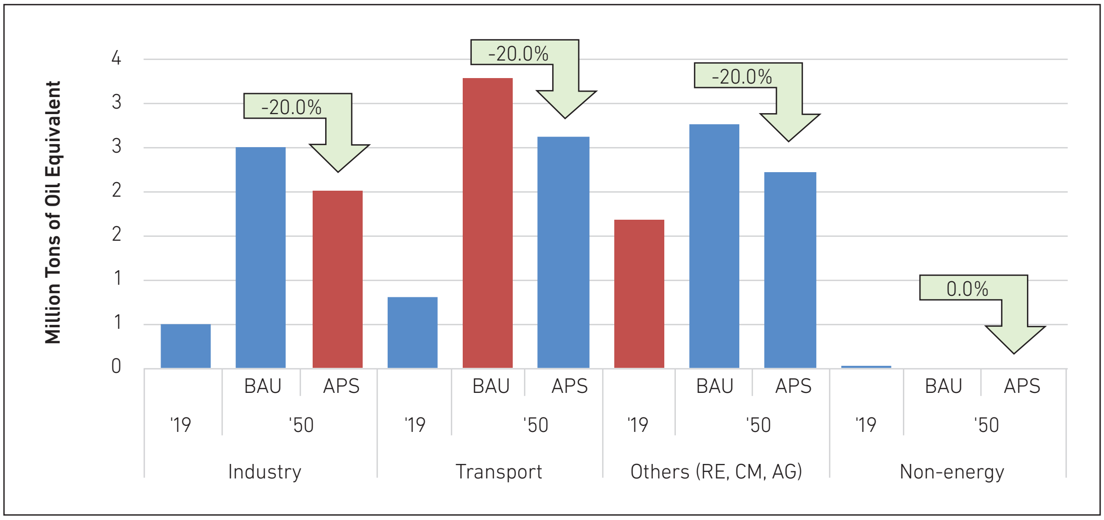
With respect to trends of final energy consumption under BAU and in the APSs in each sector, the model yields that in APS 1, final energy consumption is expected to increase from 3 Mtoe in 2019 to 6.86 Mtoe in 2050. Under BAU, from 2019 to 2030, the 'other' sector will be the largest consumer in 2030, consuming 1.93 Mtoe, or 45.8% of the TFEC energy, increasing to the second largest by 2050 with a consumption of 2.78 Mtoe (32.4%). Transport is the second largest consumer in 2030 with 1.38 Mtoe (32.8%) but is projected become the largest consumer by 2050 with 3.29 Mtoe (38.3%). The industry sector will show the highest increase in energy consumption, with a growth rate of 5.4% from 2019 to 2050, making it the third largest consumer by 2050.

The APS 1 is expected to realise energy savings of 10% of the TFEC by 2030 and another 10% by 2050, with all sector consumption decreasing by 10% compared to BAU. In APS 2, under which the efficiency of thermal power generation will improve, the results are still the same as under BAU, and final energy consumption is not affected. In APS 3, replacing coal with solar and wind will reduce primary consumption of fossil fuels and increase the use of renewable energy. Therefore, this scenario does not affect final energy consumption, which remains the same as in BAU.

Although APS 5 is a combination of APSs 1, 2, and 3, its effect is the same as that of APS 1, that is, each sector's final consumption reduced by 10 % in 2030 and expected increase of energy saving reduction of 20% in 2050.

The final energy consumption by sector (Figure 10.13) shows that a significant reduction in energy consumption of about 20% from BAU to APS is expected for industry, transport, and others.

Figure 10.13 Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario 5
(Mtoe)



AG = agriculture; APS = alternative policy scenario; BAU = business as usual; CM = commerce; Mtoe = million tonnes of oil equivalent; RE = residential.

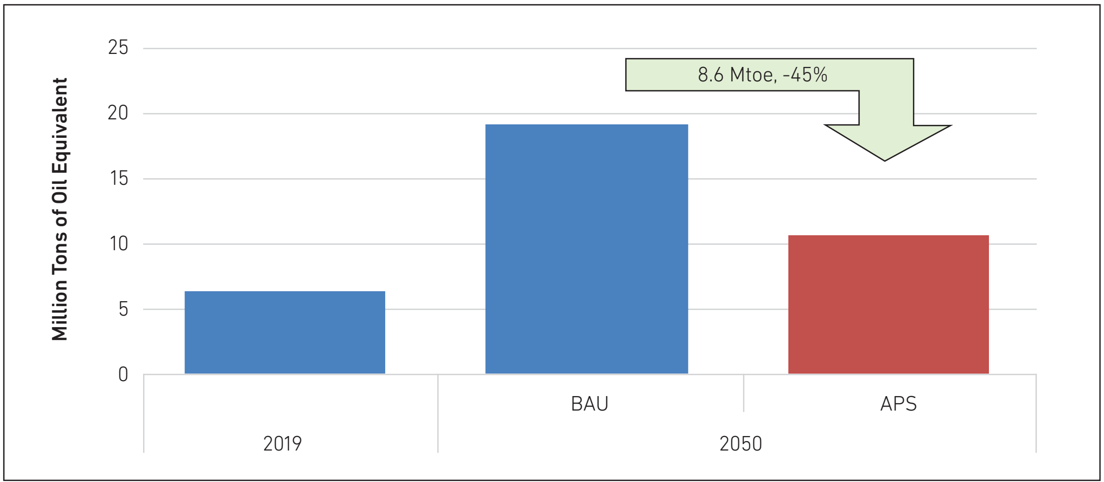
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.2.1. Projected Energy Savings

By 2050, primary energy is expected to decrease by 8.61 Mtoe or 45% from BAU to the APS 5 level (Figure 10.14). This decrease in the TPES is due to the 20% reduction in energy consumption as well as the shift to renewable electricity such as solar photovoltaics from 2019 to 2050.

Figure 10.14 Total Primary Energy Demand, Business as Usual and Alternative Policy Scenario 5

(Mtoe)



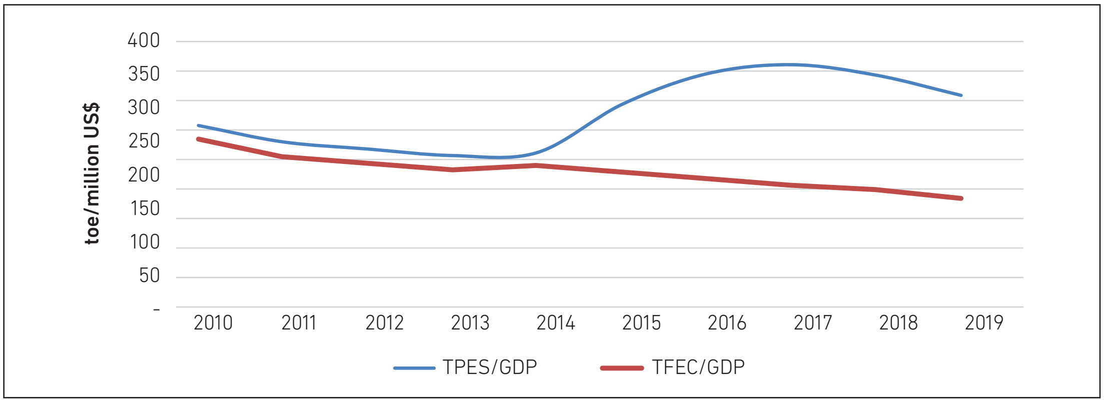
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.2.2. Energy Intensity

Energy intensity is defined as the TPES divided by GDP. Figure 10.15 below shows that growth decreased to 3.9% from 2010 to 2014, increased to 16.2% through 2017, and decreased again to 6.5% from 2017 to 2019. This indicates that energy intensity increased from 273 toe/$ million in 2010 to 318 toe/$ million in 2019 as a result of the Hongsa Power Plant beginning operations in 2015. Coal consumption also increased rapidly due to its lower thermal efficiency (less than 30%). On the other hand, the final energy consumption intensity (TFEC/GDP) showed a declining trend due to the decreased use of biomass from 251.3 toe/$ million to 163 toe/$ million during the same period.

Figure 10.15 **Energy Intensity, 2010–2019**
(toe/million US$)

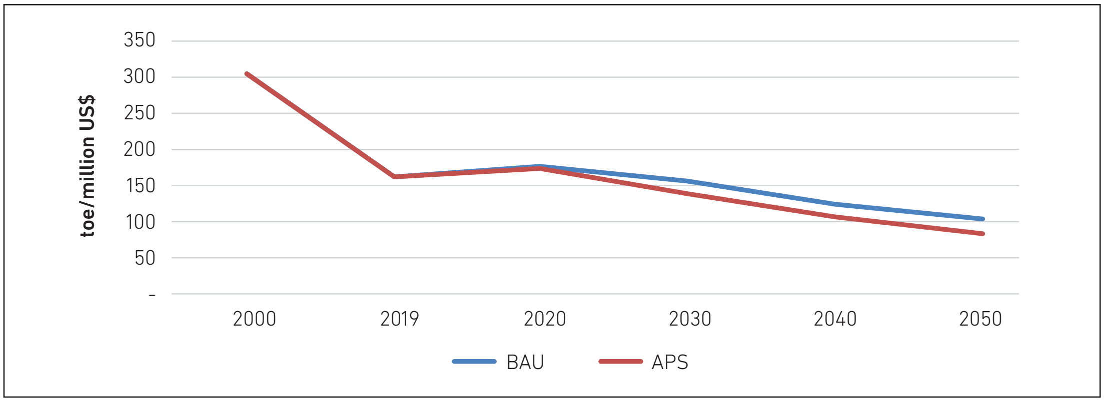


GDP = gross domestic product, toe = tonnes of oil equivalent, TFEC = total final energy consumption, TPES = total primary energy supply.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table Collection Historical. 14 August.

As Lao PDR endeavours to promote sustainable development and make its economy more efficient and competitive, final and primary energy intensities is significantly reduced. The final energy intensity is projected to decrease from 162 toe/million US$ in 2019 to 104 toe/million US$ by 2050. As Figure 10.16 shows, the final energy intensity in APS 5 is less than under BAU due to the implementation of the energy savings in APS 1.

Figure 10.16 **Final Energy Intensity, Business as Usual and Alternative Policy Scenario 5**
(toe/million US$)

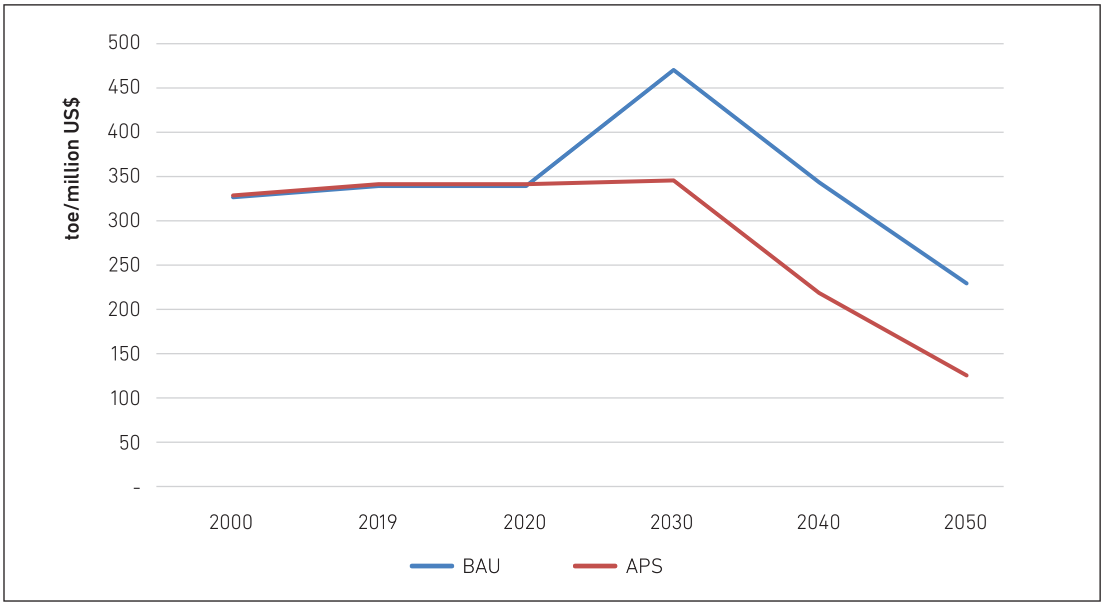


APS = alternative policy scenario, BAU = business as usual, toe = tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

The primary energy intensity is also expected to decline from 341 toe/million US$ in 2019 to 231 toe/million US$ by 2050. As shown in Figure 10.17, in APS 5 the primary energy intensity is expected to decline more than 37 % from BAU, from 341 toe/million US$ to 127 toe/million US$ by 2050 due to energy savings, improved efficiency of thermal power generation, and the replacement of coal power generation with solar and wind. Therefore, the primary energy intensity will improve in the future.

Figure 10.17 Primary Energy Intensity — Business as Usual and Alternative Policy Scenario 5
(toe/million US$)



APS = alternative policy scenario, BAU = business as usual, toe = tonnes of oil equivalent.

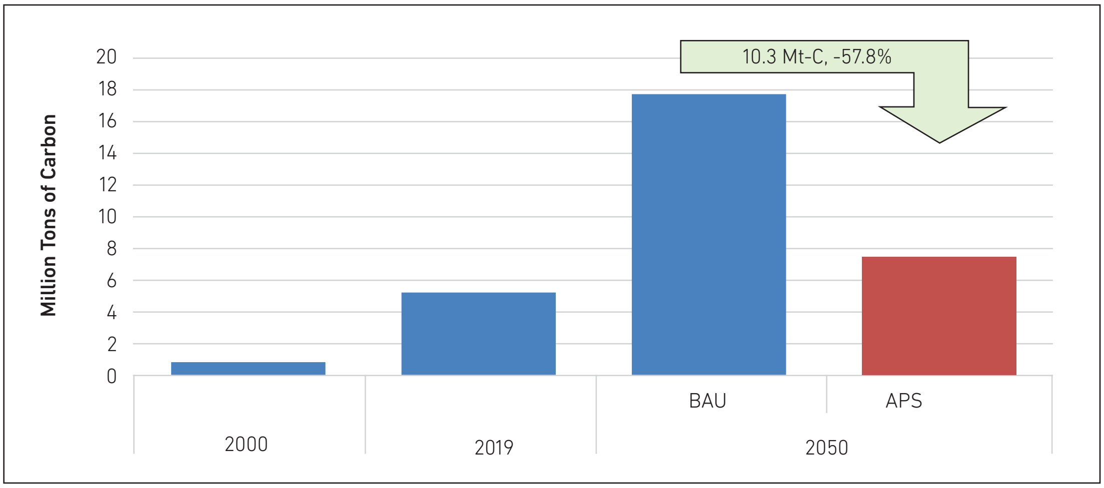
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.2.3. Carbon Dioxide Emissions from Energy Consumption

Carbon dioxide emissions from energy consumption are projected to decrease by 57.8% from 17.8 Mt-C under BAU to 7.5 Mt-C in APS 5 due to the implementation of APSs 1, 2, and 3. By 2050, it is expected that APS 1 will reduce CO_2 emissions by around 1.2 Mt-C or 7% from BAU, APS 2 by 2.2 Mt-C or 12%, and APS 3 by 8.5 Mt-C or 48%.

Figure 10.18 **Carbon Dioxide Emissions from Energy Combustion, Business as Usual vs Alternative Policy Scenario 5**

(Mt-C)



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.3. Low Carbon Energy Transition Scenario (Carbon Neutral)

Low Carbon Energy Transition (LCET) Scenario aims to see the impact of clean fuel, renewables, and new technologies to support energy transition towards carbon neutrality. A concept of carbon neutral was formalised to observe how economies can achieve environmentally sustainable development. Based on the National Determined Contribution (NDC) and Biennial Update Report (BUR) of the Department of Climate Change, Ministry of Natural Resources and Environment, the Land Use, land use Change & Forestry (LULUCF) had the capacity to remove around 13,000 kt-CO_2e (thousand tonnes of carbon dioxide equivalent) in 2014. Table 10.2 shows the potential removals of LULUCF under the LCET scenario from 2020 until 2050.

Table 10.2 **Potential Removals, Land Use Change & Forestry, Low Carbon Energy Transition Scenario, 2020–2050**

Year	Removals (Mt-CO_2e)	Removals (Mt-CO_2e.)
2020	5.32	1.45
2030	20.80	5.68
2040	18.38	5.02
2050	7.20	1.97

Mt-CO_2e = million tonnes of carbon dioxide equivalent.

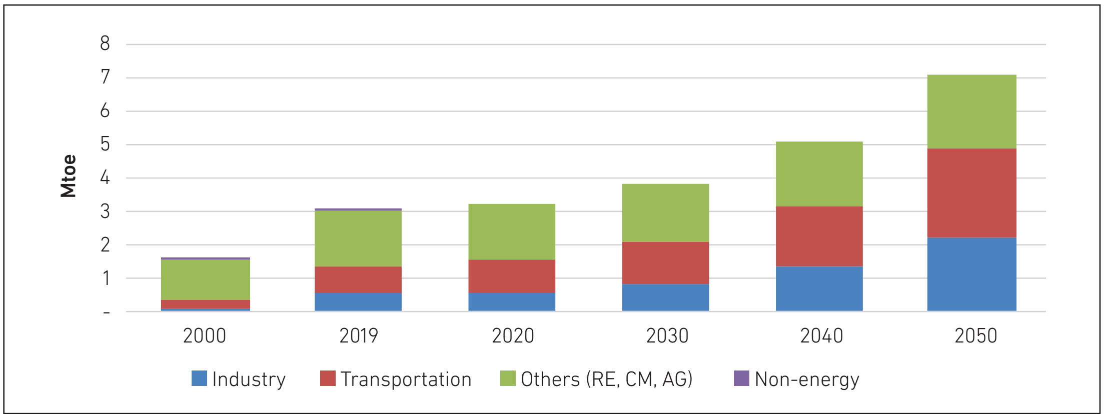
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

Lao PDR aims to reduce CO_2 emissions and meet both domestic and export demands through power development. The LCET scenario considered the exiting APS scenario and add other options including the increase of hydropower development to meet full hydro's install capacity potential; the fuel switching from coal to natural gas and any substitution from fossil fuel to clean fuel and hydrogen or ammonia.

3.3.1. Final Energy Consumption by Sector

For the final energy consumption, transportation is expected to have the largest energy consumption (2.6 Mtoe), followed by industry (2.2 Mtoe), and Others (2.2 Mtoe) in 2050. (Figure 10.19).

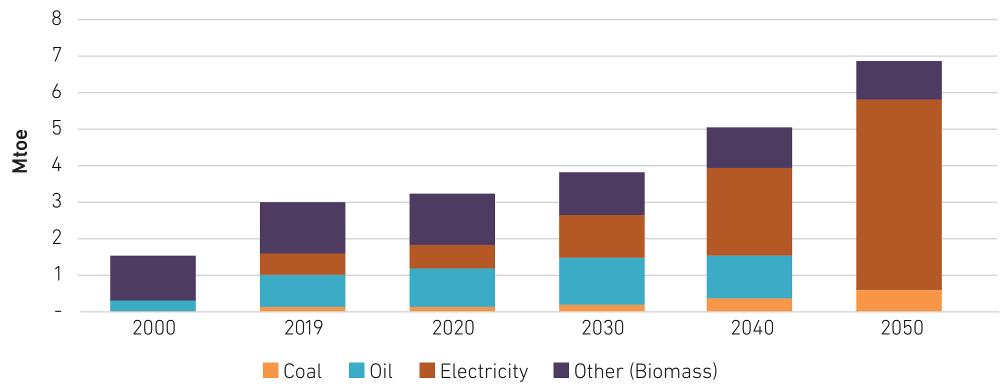
Figure 10.19 Final Energy Consumption by Sector, Low Carbon Energy Transition Scenario, 2000–2050
(Mtoe)



AG = agriculture; CM = commerce; LCET = low carbon energy transition scenario; Mtoe = million tonnes of oil equivalent; RE = residential.
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

Electricity is predicted to be the largest energy source, contributing 5.19 Mtoe (73.6%) in the final energy consumption by 2050 (Figure 10.20). The annual growth rate of electricity during 2019–2050 is estimated to be 7.4%. In terms of energy types, 'others' (biomass, consisting of wood and charcoal), solar, and wind are included in this energy type in this scenario, consuming 1.08 Mtoe (15.3%), making it the second largest energy source by 2050. Coal will remain in the energy mix in BAU as the country has already committed to providing electricity from coal to neighbouring countries, as well as for domestic use in the dry season. Coal is predicted to contribute 0.58 Mtoe (8.3%), making it the third largest energy source by 2050. In 2030, oil consumption will be 1.30 Mtoe, making it dominant in 2030. However, it will reduce to 0.01 Mtoe (0.1%) by 2050.

Figure 10.20 **Final Energy Consumption by Fuel, Low Carbon Energy Transition Scenario, 2000–2050**
(Mtoe)



LCET = low carbon energy transition scenario, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_ Template_BAU_APS_LCET August 2022).

3.3.2. Primary Energy Supply

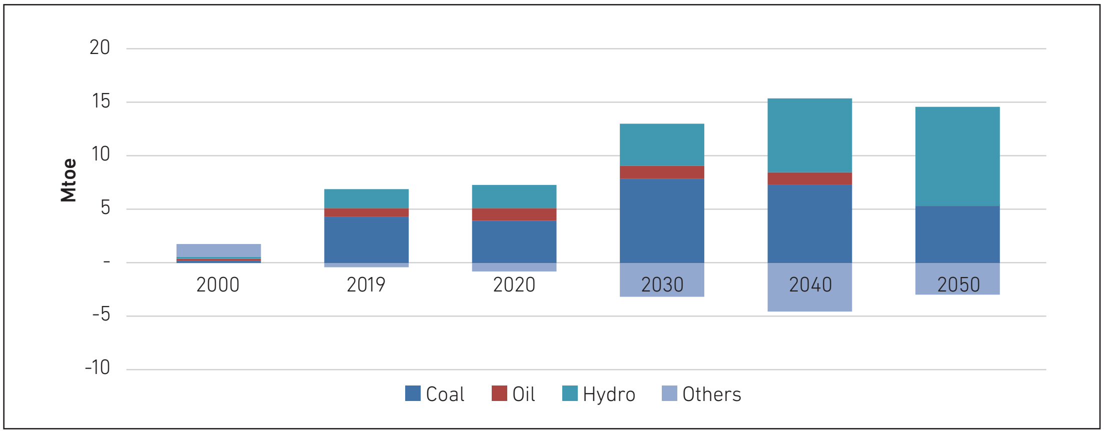
Total primary energy supply consists of coal, oil, hydropower, and 'others' (including biomass, solar, wind, and electricity for export) and will increase from 6.3 Mtoe in 2019 to 11.38 Mtoe in 2050, an AAGR of 1.9 % per year. This growth is expected to decrease at an annual rate of 0.3% from 2019 to 2020 and increase again at an annual rate of 4.4% from 2020 to 2030.

Coal was the most frequently used energy at 4.27 Mtoe (67.7%) in 2019, followed by hydropower at 1.73 Mtoe (27.5%) and others (biomass) at 1.68 Mtoe. In 2050, coal still remains dominant as it increases to 5.20 Mtoe. The share of coal will decrease from 67.7% in 2019 to 45.7% in 2050 due to the share of other sources of power production.

Hydropower is expected to generate 9.20 Mtoe (80.8% of the TFES) in 2050. It is forecasted to grow at an AAGR of 5.5% from 2019 to 2050 because Lao PDR has been developing hydropower projects intensively to meet increasing domestic demand and export more to its neighbours according to their commitment and cooperation.

In terms of 'others', biomass remains the same under BAU and LCET scenarios. It is projected to increase from 1.68 Mtoe in 2019 to 1.72 Mtoe in 2050. Similar to projections regarding the share of biomass in the final energy mix, biomass as a share of primary energy is also estimated to increase by 0.1% during 2019–2050. The share of solar in the TPES is minimal in 2018. Wind is expected to increase to 1.22 Mtoe (12.6%) in 2030 and 2.29 Mtoe (26.2%) in 2050. Wind is forecasted to grow at an AAGR of 22.4% from 2019 to 2050. Oil consumption is projected to be 0.86 Mtoe (13.7 % of the TPES) in 2019, and to 0.01 Mtoe (0.1%) in 2050, an average decrease rate of 14% during 2019–2050.

Figure 10.21 **Primary Energy Supply by Fuel, Low Carbon Energy Transition Scenario, 2000–2050**
(Mtoe)



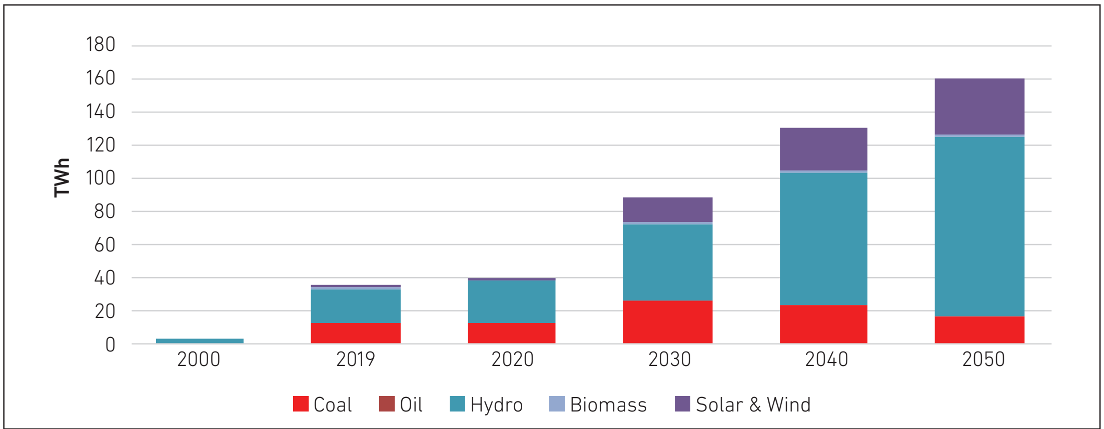
LCET = low carbon energy transition scenario, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_ Template_BAU_APS_LCET August 2022).

3.3.3. Power Generation

In 2019, power generation was at 33.75 TWh. It is forecasted to increase to 160.41 TWh by 2050, at an AAGR of 5.2%. The inauguration of the first thermal power plant in 2015 changed the power generation mix in Lao PDR (see Figure 10.22 for data from 2019). In 2050, hydropower will account for 66.7% of total generation and the thermal power plant will account for 10.7%, with the remaining coming from solar (14.9%), wind (6.8%), and biomass (0.9%).

Figure 10.22 **Electricity Generation by Fuel, Low Carbon Energy Transition Scenario, 2000–2050**
(TWh)



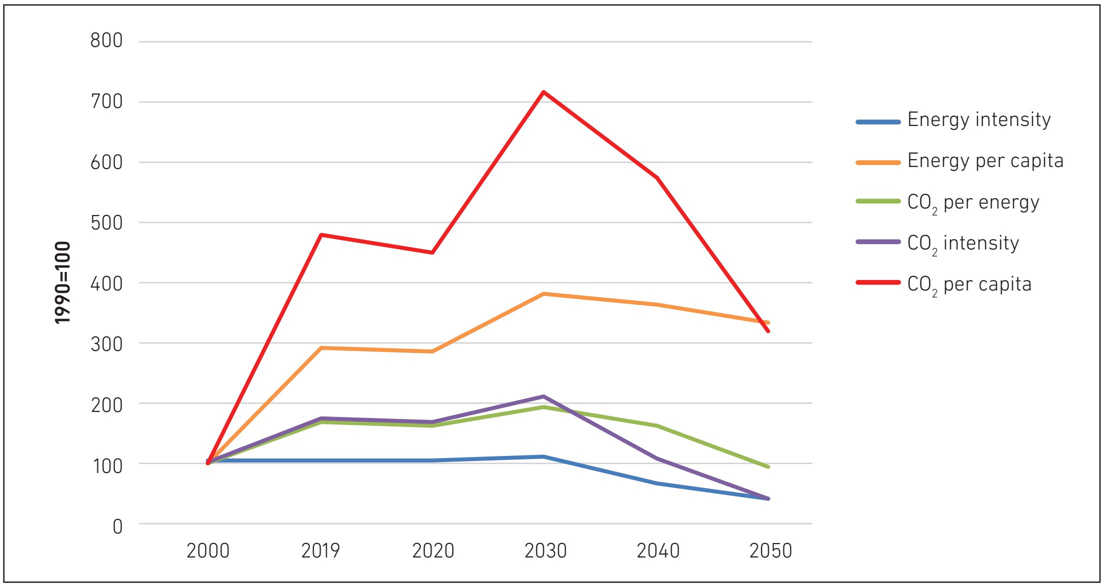
LCET = low carbon energy transition scenario, TWh = terawatt-hour.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_ Template_BAU_APS_LCET August 2022).

3.3.4. Energy Indicators

The primary energy intensity (TPES/GDP) is projected to decrease from 341 tonnes of oil equivalent per million dollars (toe/million US$)[3] in 2019 to 137 toe/million US$ in 2050 because of steadily decreasing oil consumption, as well as increasing renewable energy and hydrogen. The final energy intensity is projected to decline further to 85 toe/million US$ by 2050 (Figure 10.23).

Figure 10.23 Energy Indicators, Low Carbon Energy Transition Scenario, 2000–2050



CO_2 = carbon dioxide.

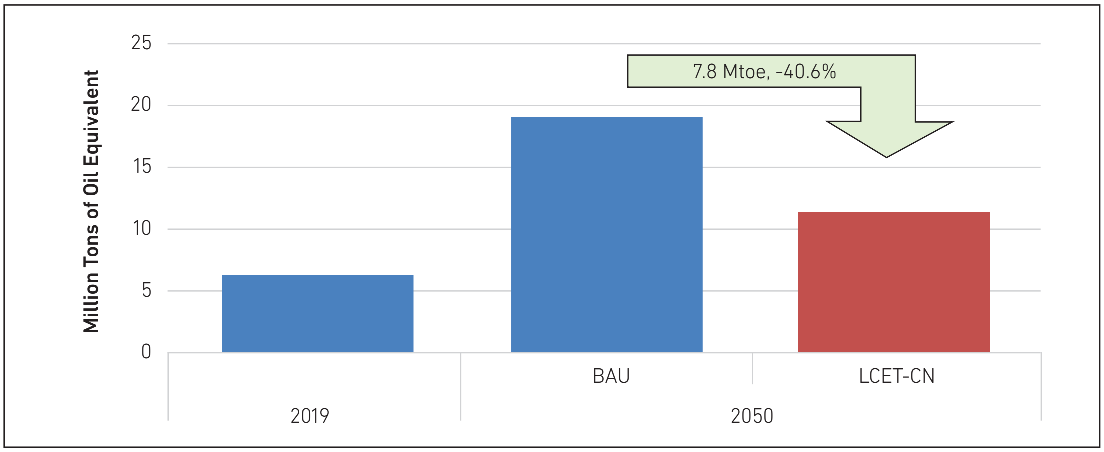
Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

3.3.5. Fossil Fuel Consumption Savings and Carbon Dioxide Reduction

By 2050, primary energy is expected to decrease by 7.8 Mtoe or 40.6% from BAU to the LCET (Figure 10.24). This decrease in the TPES is due to the 10% reduction in energy consumption as well as the shift to renewable electricity such as solar photovoltaics from 2018 to 2050, wind from 2030-2050.

[3] All United States dollars in this report are in constant 2010 values unless specified.

Figure 10.24 Primary Energy Supply, Business-as-Usual and Low Carbon Energy Transition Scenarios, 2019 and 2050
(Mtoe)

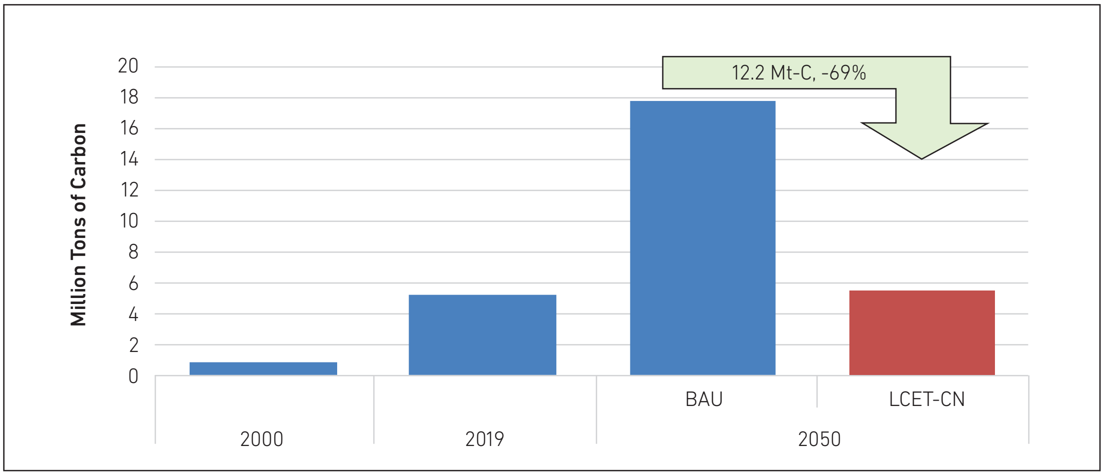


LCET = low carbon energy transition scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_ Template_BAU_APS_LCET August 2022).

The CO_2 emissions from energy consumption are projected to decrease by 69% from 17.8 Mt-C under BAU to 7.5 Mt-C in LCET due to the implementation of APSs 1, 2, and 3 and fuel switching by 2050 (Figure 10.25).

Figure 10.25 Carbon Dioxide Emission Reduction, Business-as-Usual and Low Carbon Energy Transition Scenarios, 2000, 2019 and 2050
(Mt-C)



LCET = low carbon energy transition scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning, Lao PDR Energy Outlook Result (Lao PDR_Template_BAU_APS_LCET August 2022).

4. Implications and Policy Recommendations

The purpose of LCET is to highlight energy efficiency and conservation, with a specific focus on achieving a 10% reduction in the TFEC. It seeks to explore ways to improve the efficiency of thermal power generation, promote the use of renewable energy sources, and decrease reliance on fossil fuels in the primary energy supply.

To reduce energy consumption for both TPES and TFEC and at the same time to reduce CO_2 emissions to meet NDC targets, Lao PDR will need to accelerate the share of renewable energy, especially the share of hydropower. The policy must also introduce more efficient technologies to reduce the TFEC by 20% by 2050. In order to reduce CO_2 emissions, Lao PDR may need to consider shifting from fossil fuel to electricity for all sector as much as possible. As these programmes are critical in reducing energy consumption, they should be proposed as an energy policy.

To conserve energy, the industry sector should take the lead by installing energy management systems; developing and implementing their own energy reduction plans; collaborating with the government to maintain energy security; and routinely conducting seminars on energy-efficient strategies. The transport sector should promote the use of public transportation in big cities and launch awareness campaigns about it. Other sectors should also help raise public understanding of energy conservation and follow energy management practices in building construction. In addition, more studies on how GDP rates correlate with energy consumption should be carried out, and the quality of energy statistics should be improved accordingly. Finally, the government should consider implementing the following actions:

(i) Promote and implement energy efficiency and conservation programmes in all sectors.
(ii) Establish a fund to support energy efficiency and conservation programmes and energy service companies.
(iii) Promote clean coal technology to improve the efficiency of thermal power generation and reduce CO_2 emissions.
(iv) Include the findings of this study in Lao PDR's energy policy and plan.
(v) Promote electric vehicles, which can reduce oil imports as well as CO_2 emissions.
(vi) Reform the electricity tariff regime to encourage more energy efficiency and conservation activities.
(vii) Increase the share of coal thermal power generation in the power generation mix by using local coal and clean coal technology to ensure a stable supply of electricity.
(viii) Promote a power generation mix of 67% hydropower, 11% thermal power, and 22% other sources (such as solar, wind, and biomass) from 2030 to 2050. Compared to the power generation mix of the National Power Development Strategy (NPDS). Hydropower still has the potential to be developed to meet the 75% target share. Coal is below the target at 14% of the share in the National Power Development Strategy (NPDS), but it is good for Lao PDR because it reduces CO_2 emissions. Other sources (solar, wind, and other forms of energy sources) have surpassed their target at 11% due to fuel switching. It's significant for Lao PDR to include these in the policy to be the pathway for investors to obtain financial guarantees from the bank for investment and the development of renewable energy.
(ix) Carry out the feasibility study in detail on the integration of hydropower with renewable energy sources (solar, wind, and biomass) to understand the impact of high penetration of renewables into the power system.
(x) Promote and expand power interconnection capacity and power trade through system-to-system transmission within ASEAN.

Reference

Department of Energy Policy and Planning (2020), *Summary of Power Generation Project of Lao PDR*. Vientiane: Department of Energy Policy and Planning.

CHAPTER 11

Malaysia Country Report

Zaharin Zulkifli
Energy Commission of Malaysia

1. Background

Malaysia has two (2) main areas separated by the South China Sea, namely Peninsular Malaysia (bordered with Thailand in the north and Singapore in the south) and West Malaysia (the northern part of Borneo Island, which is bordered with Indonesia in the South and Brunei in the North). Malaysia is located close to the equatorial line, with the Latitude of 1o and 7o North and Longitudes of 100o and 119o East Malaysia. The land area of Malaysia covers 330,534 square kilometres.

As of 1 January 2019, Malaysia's crude oil reserve stood at 4.675 billion barrels. Sarawak constituted about 36% and the rest lies in Sabah and Peninsular Malaysia at 32% each. The ratio of current reserves over production in 2019 showed that Malaysia can sustain its crude oil production, including condensates, for the next 21 years.

As of 1 January 2019, total natural gas reserves were 79.168 trillion standard cubic feet (Tscf), of which 58% are found in Sarawak, 27% in Peninsular Malaysia, and the other 15% in Sabah. Total associated gas reserves stood at 9.901 Tscf, while non-associated gas reserves stood at 69.267 Tscf in 2019. Natural gas could be sustained for another 32 years.

The latest reserve of coal in Malaysia as of 2019 was 1.918 million tonnes. Of the total amount, about 80% is found in Sarawak, 19% in Sabah, and only 1% in Peninsular Malaysia. In Sarawak, coal is produced from the areas of Merit-Pila, Silantek, and Mukah Balingian.

2. Modelling Assumptions

Gross domestic product (GDP) is commonly used as a basic assumption in energy modelling to project energy demand. Malaysia's energy demand has correlated with GDP growth, as its economy depends on energy-intensive industries, such as manufacturing. Since energy demand increases in tandem with the country's economic growth, information on future GDP growth is key in projecting its energy demand. Future GDP growth data by sector can be obtained from the Economic Planning Unit (EPU) office.

Malaysia's GDP in 2020 dropped by 5.54% from 2019 due to the coronavirus disease (COVID-19) pandemic. In this modelling assumption, GDP will grow by 3.44% per year from 2020 until 2030. This growth illustrates the economic recovery programme carried out by the Government of Malaysia to stimulate the economy. Following a similar trend, the total GDP will continue to grow at 2.89% per year from 2030 to 2040 and 2.43% per year from 2040 to 2050. Table 11.1 shows details of the GDP assumption growth rates.

Table 11.1 Assumptions, Gross Domestic Product Annual Growth Rate

(%)

Parameter	ID Name	Growth Rates (%)			
		2019–2020	2020–2030	2030–2040	2040–2050
GDP (constant 2015 US$)	GDP	-5.54	3.44	2.89	2.43
Industry (including construction), value added (constant 2015 US$)	INGDP	-6.46	4.12	2.35	2.09
Services, value added (constant 2015 US$)	CSGDP	-5.39	3.33	3.27	2.67
Agriculture, forestry, and fishing, value added (constant 2015 US$)	AGGDP	-2.46	1.25	1.96	1.74
Manufacturing, value added (constant 2015 US$)	MGGDP	-2.69	5.63	2.57	2.30

AGGDP = Agriculture GDP; CSGDP = Services GDP; GDP = gross domestic product; INGDP = Industrial GDP; MGGDP = Manufacturing GDP.

Source: Author's estimation based on World Bank data.

Population growth is also a parameter used with GDP as the main driver for energy demand growth for the future. In Malaysia's case, the information of population projection is based on the data published by Department of Statistics Malaysia (DOSM). The population Projections (Revision), Malaysia, 2010–2040 presents the data revised population projections at the Malaysian level for the years 2010-2040 based on recent changes in birth, death, and migration components. Method used to project the population in this publication is according to guidelines from Manual III: Methods for Population Projections by Sex and Age, United Nations (1956), and Manual VIII: Methods for Projections of Urban and Rural Population, United Nations (1974). As shown in Table 11.2, the projected growth of the Malaysian population is 1.28% per year in 2021–2025, 1.09% per year in 2026–2030, 0.92% per year during 2031–2035, and 0.79% per year in 2036–2040.

Table 11.2 Assumptions, Population Annual Growth Rates

Parameter	ID Name	Growth Rates (%)					
		2018–2019	2019–2020	2021–2025	2026–2030	2031–2035	2036–2040
Population	POP	1.41	1.37	1.28	1.09	0.92	0.79

Source: Author's estimation based on Department of Statistics of Malaysia (DOSM) data.

3. Outlook Results

3.1. Business-as-Usual Scenario

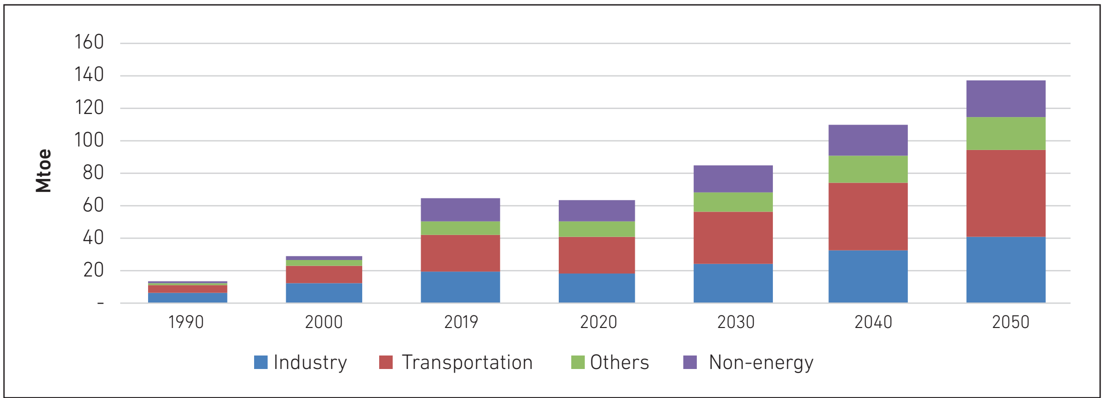
The business-as-usual (BAU) scenario is based on previous energy consumption data provided by the Energy Statistics and Training Office (ESTO) of the Asia Pacific Energy Research Centre (APERC). The set of data from 1980 until 2019 is in the unit of kilo tonnes of oil equivalent (ktoe). By using Microfit, a software for determining the demand equations, the regression analysis was conducted using GDP and population parameters as the main driver. In addition to GDP and population, energy prices, provided by the Institute of Energy Economic of Japan (IEEJ) were also used as parameters. The BAU scenario does not include any intervention elements such as mitigation to reduce energy or carbon emissions. It is only derived from historical trends correlated with GDP and population growths. Using the LEAP software, energy, and carbon emissions under the BAU scenario were projected until 2050.

3.1.1. Final Energy Consumption

Under the BAU scenario, the final energy consumption for Malaysia is expected to increase at 2.5% per year from 2019 until 2050. During this period, transport will lead the growth at 2.9% per year, followed by the 'others' sector at 2.6% per year, industry at 2.5% per year, and non-energy sector at 1.8% per year. Overall, the total final energy consumption will register at 137.74 Mtoe in 2050 under the BAU scenario.

In terms of the share, transport will have the largest share with 39.0% in 2050. It was followed by the industry sector at 29.5%, non-energy at 17.0%, and 'others' sector at 14.5%. As shown in Figure 11.1, in 2020, the total final energy consumption experienced a downward trend at -0.5% from 2019. This was due to lower consumption of energy, especially by the industry sector. Industry recorded a decrease of -5.5% in 2020 compared to 2019.

Figure 11.1 Final Energy Consumption by Sector, Business-as-Usual, 1990–2050
(Mtoe)



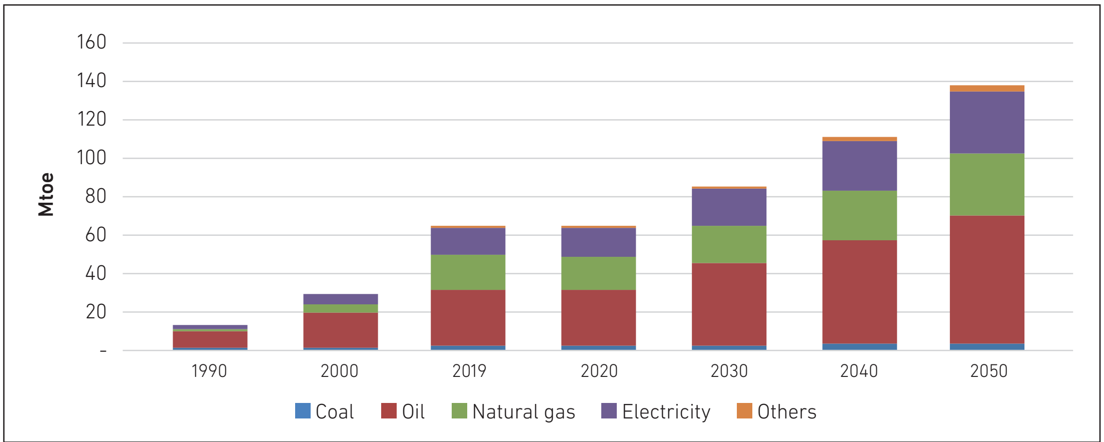
APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The average annual growth rate of total final energy consumption (TFEC) from 1990 until 2050 is lower than the GDP, which is at 2.6% per year. This shows that even under the BAU scenario, Malaysia can potentially be an efficient economy in terms of energy elasticity. The country can achieve higher savings by maintaining and enhancing current energy efficiency initiatives.

Figure 11.2 shows the final energy consumption by fuel under the BAU scenario from 1990 until 2050. In 2050, oil will still dominate the share at 47.9% as the majority of transport will use oil as the major fuel for the sector. Natural gas and electricity each have a 23.8% share in 2050 as electricity will grow by 2.9% per year compared to natural gas at 1.8% per year. Coal used mainly by cement manufacturers will be at 2.5% share from the total final energy consumption. 'Others' fuel (i.e. biodiesel) will constitute a 2.1% share in 2050.

Figure 11.2 Final Energy Consumption by Fuel, Business-as-Usual, 1990–2050
(Mtoe)



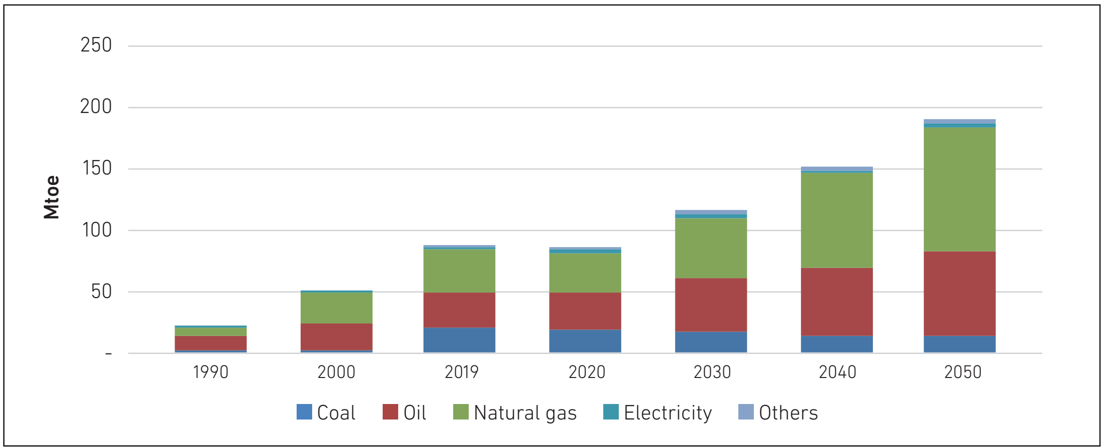
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.1.2. Primary Energy Supply

Under the BAU scenario, the total primary energy supply (TPES) is expected to increase at 2.6% per year from 2019 until 2050. Figure 11.3 shows that, in 2050, the TPES will register at 190.50 Mtoe, more than double from 2019, which was at 86.36 Mtoe. In 2050, natural gas will cover about 53.4% of TPES with an average annual growth rate of 3.6% per year. Interestingly, the share of coal will be shrinking to 7.3% in 2050 compared to its share in 2019 at 22.5%. This was due to the government policy that stated that it will no longer build coal-fired power plants as the value of coal imports will have a sizeable impact, especially on the environment and national expenditure. Government and stakeholders understood that coal generation causes the emission of greenhouse gases which contributes to climate change. The second largest share of TPES in 2050 is oil at 35.6%. In the BAU scenario, the share of oil will remain dominant in 2050 as it is most convenient fuel that can used directly by the end user.

Figure 11.3 **Total Primary Energy Supply by Fuel, Business-as-Usual, 1990–2050**
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Since the introduction of the Biofuel Policy in 2006, fuel in the 'others' category, particularly biofuel or biodiesel, has increased significantly on TPES. This is because a higher blending of biodiesel has been observed. The Biofuel Industry Act 2007 was developed to make sure that the development of biodiesel in the country remains competitive and attractive. As a result, the share of biodiesel is expected to increase at 5.0% per year from 2019 until 2050. Under the BAU scenario, the projected share until 2050 is not much different expect for coal. The rest of energy sources will maintain their respective shares at their current rate.

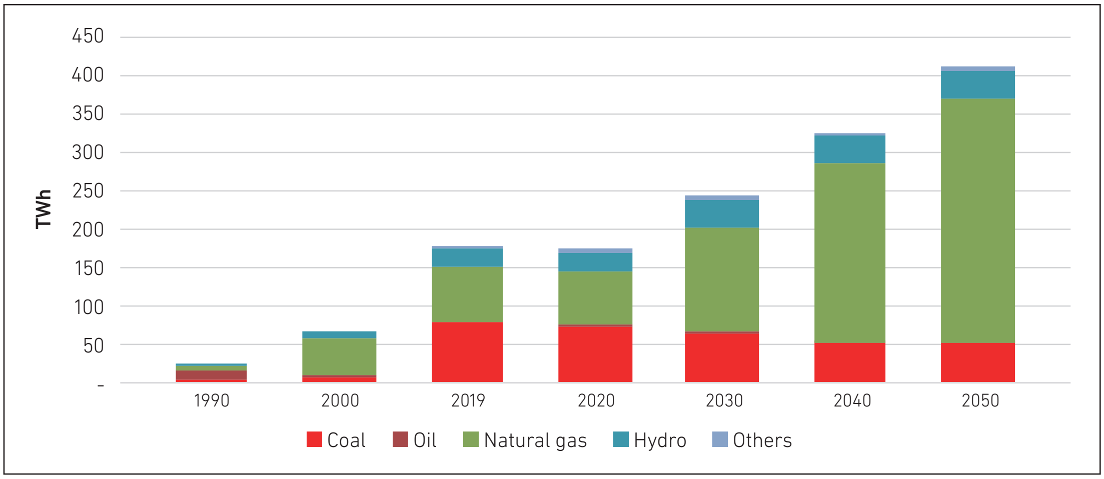
3.1.3. Power Generation

Total installed capacity in Malaysia for 2019 was 36,121 megawatts (MW). Natural gas and coal dominate the chart, making up three-quarters of the total installed capacity in Malaysia. Renewable energy (RE)capacity totalled 21.5%, with a 2.3% increase in energy capacity from 2018. This is a good indication that the national target of 31% RE by 2025 is achievable.

From 2019 to 2050, electricity generation is expected to grow at average annual rate of 2.7%. This growth is underpinned by a higher annual growth rate of 4.9% for natural gas. Further, with the government's new policy not to build new coal power plants, Malaysia is shifting to natural gas as a major fuel. In 2050, the share of electricity coming from natural gas plants will be at 77.7%, almost double from 40.5% in 2019. The share of electricity generation from coal plants will only be 11-9% in 2050, as compared to 42.8% in 2019.

Figure 11.4 shows that, in 2020, there was a 2.4% decrease in electricity generation from 2019. As expected, lower GDP growth affected the demand in 2020 with the onslaught of the COVID-19 global pandemic.

Figure 11.4 Electricity Generation by Fuel, Business-as-Usual, 1990–2050
(TWh)



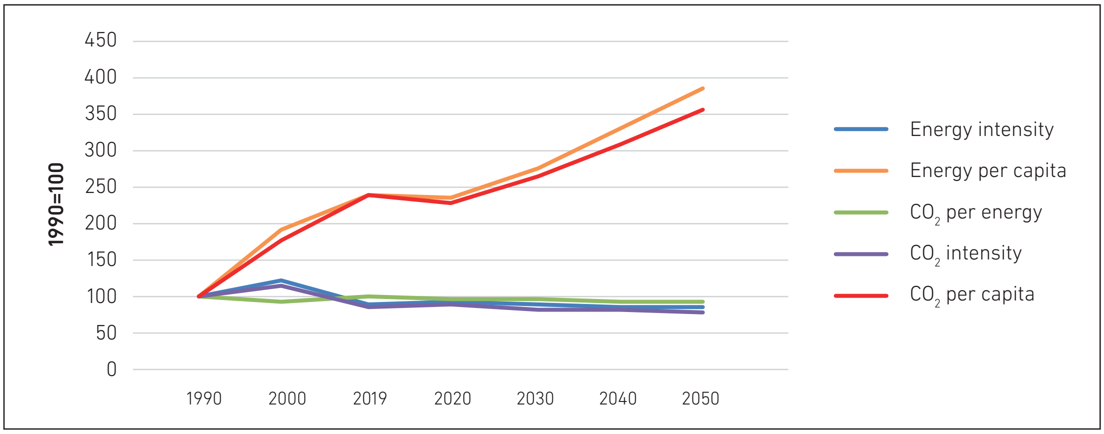
TWh = terawatt hour.

Source: Author's calculations.

3.1.4. Energy Indicators

Figure 11.5 shows the selected energy indicators under the BAU scenario. Only energy per capita and carbon dioxide (CO_2) emission per capita registered an upward trend until 2050. The CO2 emission intensity recorded a downward trend at average annual growth rate of 0.3% from 2019 until 2050.

Figure 11.5 Energy Indicators, Business-as-Usual, 1990–2050



CO_2 = carbon dioxide.

Source: Author's calculations.

3.2 Energy Saving and Carbon Dioxide Reduction Potential, Alternative Policy Scenario

Under APS1, Malaysia has initiatives to enhance demand-side management and energy efficiency, primarily focused on the electricity sector through the National Energy Efficiency Action Plan (NEEAP). The NEEAP targets an 8% electrical efficiency savings over a 10-year period between 2016–2025 through energy efficiency labelling, minimum efficiency performance standards (MEPS), energy audits and energy management, promotion of co-generation, and energy efficient buildings. These initiatives are supported by various enablers, including the Energy Audit Conditional Grant (EACG), which supports voluntary energy audits by industry players and the introduction of Registered Electrical Energy Manager (REEM) in the 2010s. By using the saving of 8% for electricity, the same amount was applied to all types of fuels, including coal, natural gas, and petroleum products until 2050. As for APS2, higher performance of power plants in generating electricity compared to their input fuels will be expected to increase by 2050.

Higher contribution of renewable energy is under APS3. In Malaysia, RE contribution was mainly for the power and transport sectors. The RE contribution for power sector was taken from Power Development Plan (PDP) 2020. The potential capacity of RE capacity was derived from various RE programmes currently being implemented in Malaysia, including Large Scale Solar (LSS), Feed in Tariff (FiT), Net Energy Metering (NEM), and Self Consumption Generators (Selco). For transport, Malaysia has a biodiesel programme that already being implemented. The B30 biodiesel programme will be implemented by 2030. Table 11.3 shows the respective scenarios in addressing all mitigation measures.

Table 11.3 Energy Saving and Carbon Dioxide Reduction, Alternative Policy Scenario

APS1	Improved Efficiency of Final Energy Demand
APS2	More Efficient Thermal Power Generation
APS3	Higher Contribution of Renewable Energy to Total Supply
APS4	Contribution of Nuclear Energy to Total Supply (not applied in Malaysia)
APS5	Combined Effects of APS1, APS2, APS3, APS4 and APS5

APS = alternative policy scenarios.

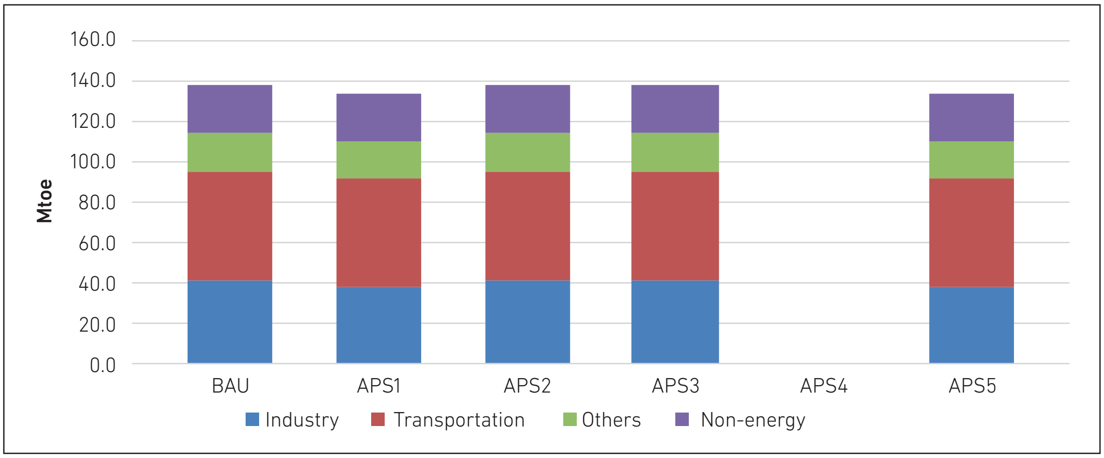
Source: Author's assumptions.

3.2.1. Final Energy Consumption

In 2050, the total final energy consumption for APS1 is at 132.89 Mtoe compared to BAU, APS2, and APS3 at 137.74 Mtoe each as shown in Figure 11.6. The reduction of energy consumption was observed for industry and others sector, while transportation and non-energy sector remained at the same level for all scenarios. The implementation of various energy efficiency initiatives under NEEAP has the potential savings of 8% compared to BAU scenario.

Figure 11.6 Final Energy Consumption by Sector, Business-as-Usual and Alternative Policy Scenario, 2050

(Mtoe)



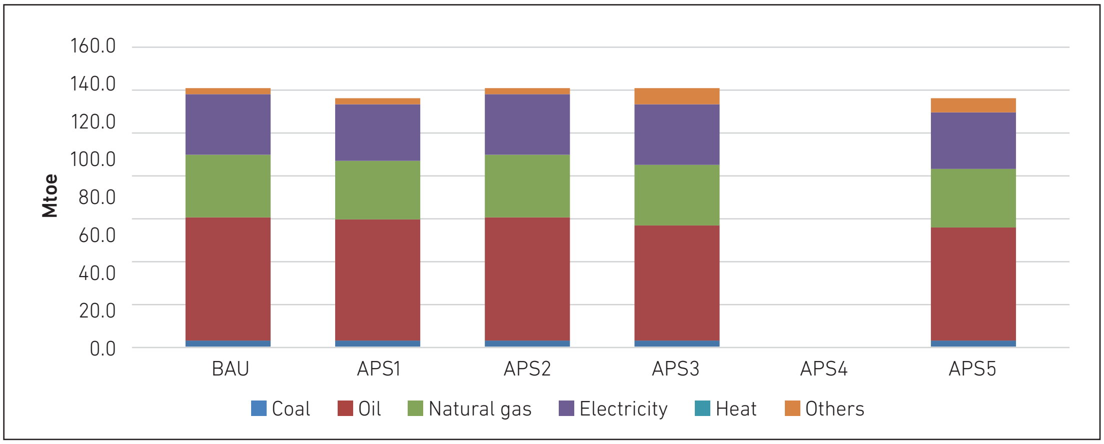
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 11.7 shows the final energy consumption by fuels for BAU and APS in 2050. Under APS1, the total final energy consumption is much lower than all scenarios for all types of fuels. This was due to the early assumption that all types of fuels will have similar savings potential of 8% compared to the BAU scenario. While for APS5, the 'others' fuel (i.e. biofuel) is expected to increase in 2050 as an alternative for fuel switching from oil to biofuel.. The implementation of biodiesel programmes will maintain the level of usage due to the shift from diesel to biodiesel.

Figure 11.7 Final Energy Consumption by Fuels, Business-as-Usual and Alternative Policy Scenario, 2050

(Mtoe)



APS = alternative policy scenarios; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

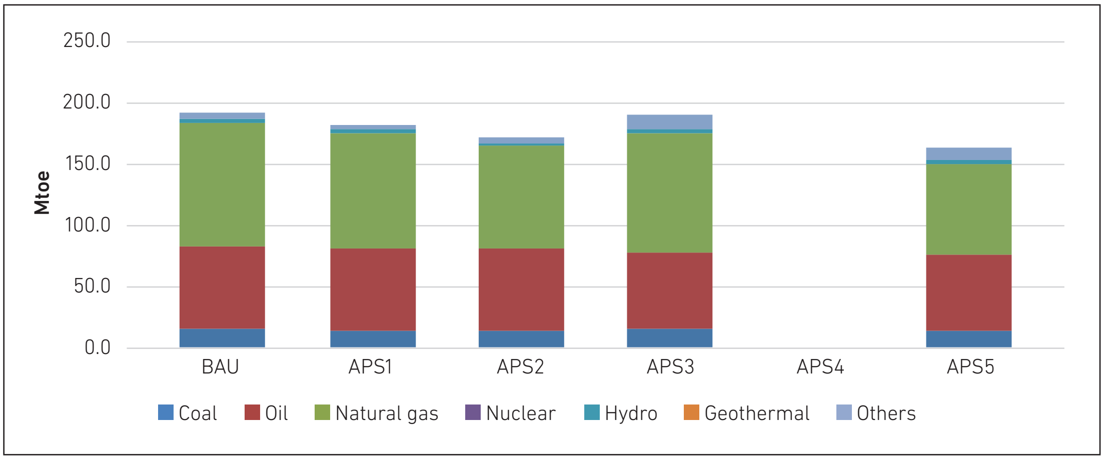
Source: Author's calculations.

3.2.2. Primary Energy Supply

As seen in Figure 11.8, all scenarios registered different total primary energy supplies in 2050. Under APS2, the total primary energy supply was 170.7 Mtoe in 2050, amongst the lowest compared to BAU, APS3, and APS1 scenarios. This indicates that by implementing more efficient power plants, it may produce a great amount of savings. However, this mitigation option requires a high amount of investment.

The energy efficiency measures implemented under APS1 registered a total primary energy supply of 181.2 Mtoe in 2050. Energy savings can be observed from the supply of coal, oil, and natural gas due to energy efficiency measures. The least energy saving scenario is APS3, where renewable energy programmes that promote the utilisation of Solar Photovoltaic (PV), Biogas, Biomass and Hydro, namely Self Consumption (SELCO), Net Energy Metering (NEM), Large Scale Solar (LSS), and Feed-in Tariff (FiT) are being implemented.

Figure 11.8 Primary Energy Supply by Fuels, Business-as-Usual and Alternative Policy Scenario, 2050



APS = alternative policy scenarios; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

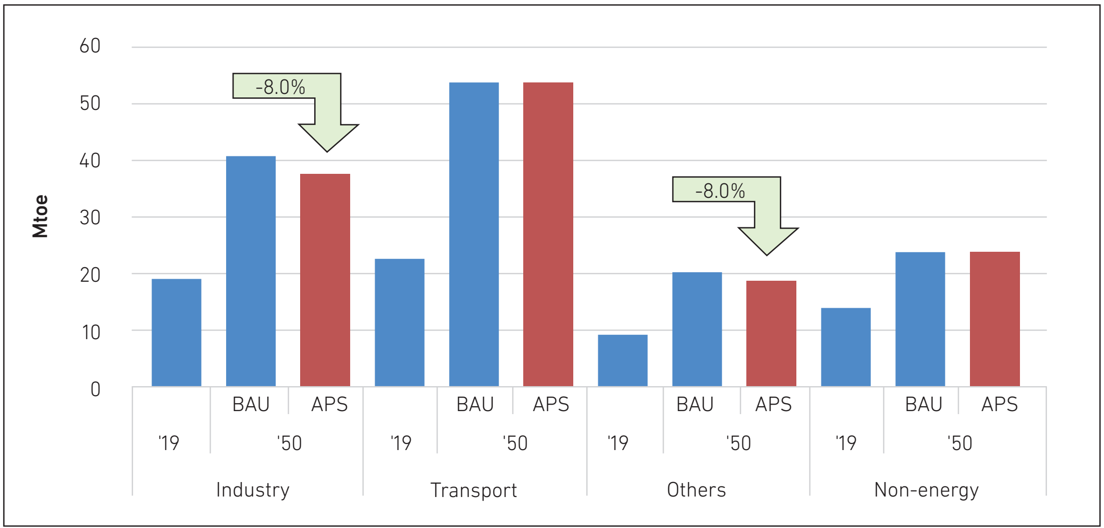
Source: Author's calculations.

3.2.3. Projected Energy Saving

Figure 11.9 shows the Final Energy Consumption by sectors for BAU and APSs in 2019 and 2050. The potential savings from industry and others sector is at 8%. The results are consistent with the assumption under APS1. The average annual growth rate for APSs is much lower at 2.4% per year compared to the BAU scenario at 2.5% per year. In 2050, the final energy consumption under APS is registered at 132.89 Mtoe, while it is at 137.74 Mtoe in the BAU scenario.

Figure 11.9 Final Energy Consumption by Sector, Business-as-Usual and Alternative Policy Scenario, 2019 and 2050

(Mtoe)



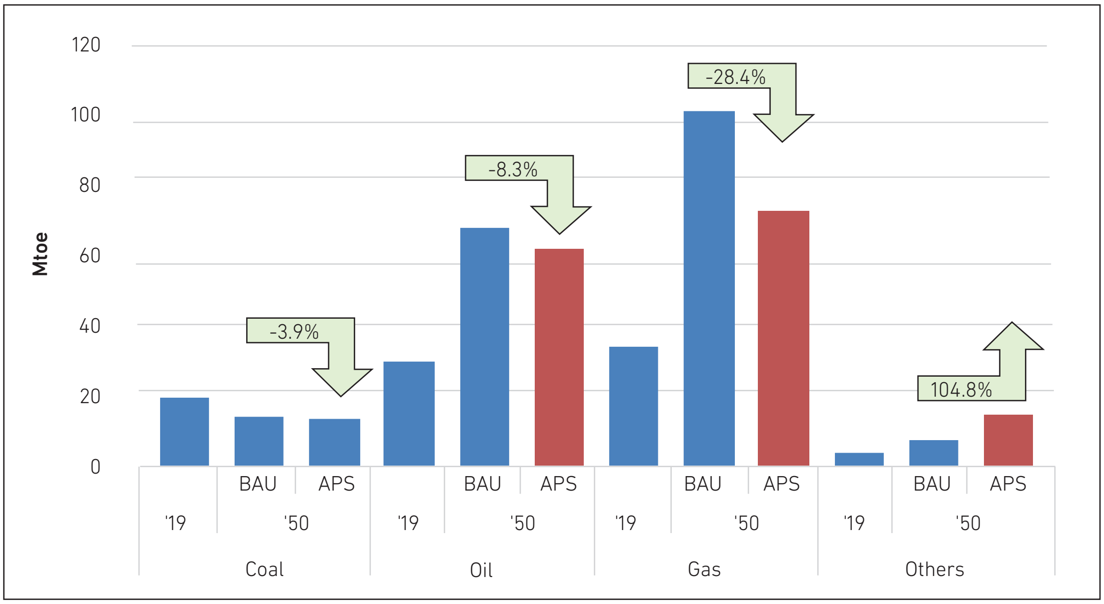
APS = alternative policy scenarios; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 11.10 illustrates the primary energy supply by source for BAU and APSs. In 2050, coal is expected to have a lower primary energy supply of 3.9% under the APSs than under BAU scenario. This was due to improved efficiency of coal usage in the industry sector and higher efficiency of coal power plants. Oil will register a total savings of 8.3% in APSs due to the shift from diesel to biodiesel and better energy efficiency measures adopted by the end user.

Figure 11.10 **Primary Energy Supply by Source, Business-as-Usual and Alternative Policy Scenario, 1990 and 2050**

(Mtoe)



APS = alternative policy scenarios; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

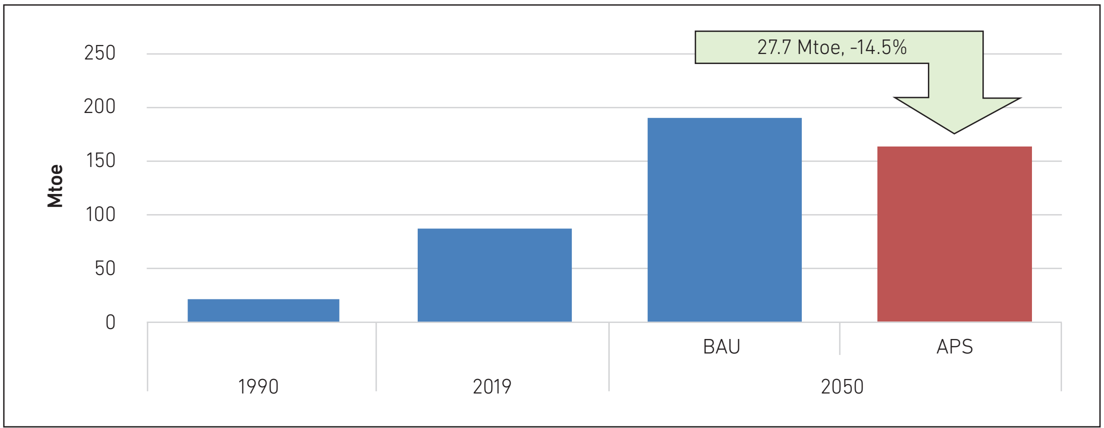
Source: Author's calculations.

Natural gas supply is expected to produce savings of 28.4% in APSs due to power plants with improved technology. This savings was also due to better energy efficiency measures conducted in the manufacturing sector. The implementation of the biodiesel programme can be illustrated through the 104.8% increase of fuel in the 'Others' category in the APS scenario compared to BAU. The growth showed that how big the impact of biodiesel programme utilisation in Malaysia.

As stated in Figure 11.11, the total primary energy supply for APSs in 2050 is at 162.8 Mtoe, a savings of 27.7 Mtoe from BAU scenario, which is at 190.5 Mtoe. The savings of 14.5% was achieved due to better efficiency from demand side management programme and higher efficiency of natural gas and coal power plants.

Figure 11.11 Total Primary Energy Supply, Business-as-Usual and Alternative Policy Scenario, 1990 and 2050

(Mtoe)



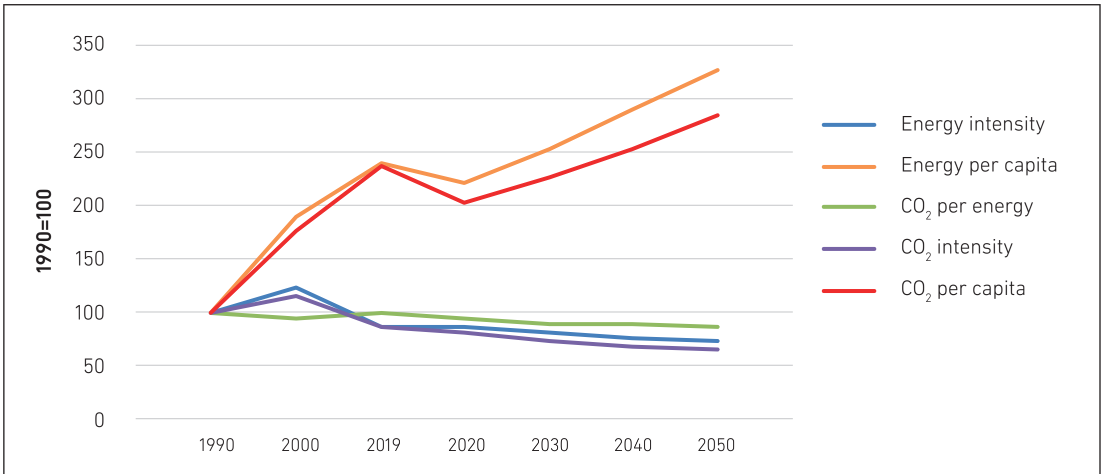
APS = alternative policy scenarios; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.2.4. Energy Indicators

Under the APS scenario, the projected energy intensity is expected to decrease at an average annual growth rate of 0.6% from 2019 until 2050. However, the energy per capita will expand to 1.0% per year during the same period. The CO_2 emission per energy will decrease by 0.4% per year, while CO_2 emission per capita will grow at 0.6% per year. The CO_2 emission intensity will be expected to decrease by 1.0% from 2019 until 2050, registering at 115 t-C/million 2015 US Dollars.

Figure 11.12 Energy Indicators, Alternative Policy Scenario, 1990–2050



CO_2 = carbon dioxide.

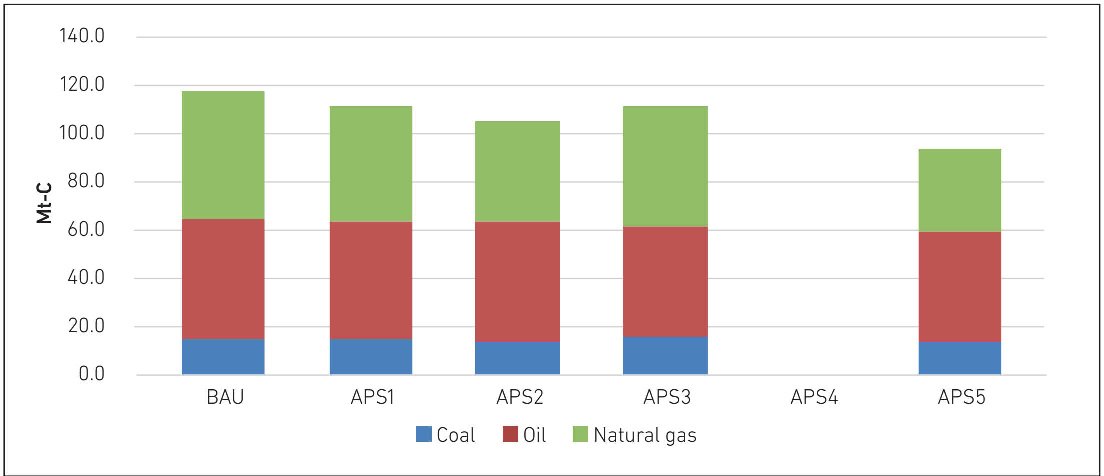
Source: Author's calculations.

3.2.5. Carbon Dioxide Emission Reduction

Figure 11.13 shows that APS5 registered the lowest CO_2 emission at 94.15 Mt-C, followed by APS2 at 104.85 Mt-C, APS3 at 111-28 Mt-C, APS1 at 111-63 Mt-C, and BAU scenario at 117.89 Mt-C. This indicates that if all scenarios are combined and implemented, the biggest potential savings in terms of CO_2 emissions can be generated.

Figure 11.13 Carbon Dioxide Emissions Reduction by Fuel, Business-as-Usual and Alternative Policy Scenario, 1990 and 2050

(Mt-C)



APS = alternative policy scenarios, BAU = business-as-usual, Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

3.3. Low Carbon Energy Transition Scenario (Carbon Neutral)

The low-carbon energy transition (LCET) scenario was created to see the impact of energy supply and consumption and carbon emission if new technologies are introduced or fuel switching is implemented. A concept of carbon neutrality was formalised to observe how economies can move forward with development while conserving the environment.

Based on the Third National Communication (NC3) Report, in 2030 the projected Land Use, Land-Use Change and Forestry (LULUCF) Removals of greenhouse gas emissions under the BAU scenario are as follows: 254,962 Gg CO_2 equivalent (Gg CO_2 eq) for 2020; 250,841 Gg CO_2 eq for 2025; and 246,649 Gg CO_2 eq for 2030. While under the Third Biennial Update Report (BUR3) report, Malaysia's LULUCF Removals in 2016 totalled 259,146 Gg CO_2 eq. By applying the existing LULUCF data, the projected LULUCF removals until 2050 was projected. Figure 11.4 shows the potential removals of LULUCF under the LCET scenario from 1994 until 2050.

Table 11.4 Potential Removals of LULUCF, Low Carbon Energy Transition Scenario, 1994–2050

	Removals (Million MT CO_2 eq.)	Removals (Million MT C eq.)
1994	211-84	57.82
2000	235.24	64.20
2005	233.92	63.84
2011	242.59	66.21
2014	267.15	72.91
2016	259.15	70.72
2020	254.96	69.58
2025	250.84	68.46
2030	246.65	67.31
2040	238.47	65.08
2050	230.57	62.93

$MtCO_2e$. = million tonnes of carbon dioxide equivalent, Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

The LCET scenario encompasses several initiatives, one of which involves incorporating CCUS technology in industries rely on natural gas and coal for combustion activities. It is projected that from 2041 until 2050, these industries will adopt CCUS technology at a utilisation rate of 50% in the market. Furthermore, from 2041 to 2050, road transport will shift from gasoline to new hydrogen fuel with a 50% utilisation rate.

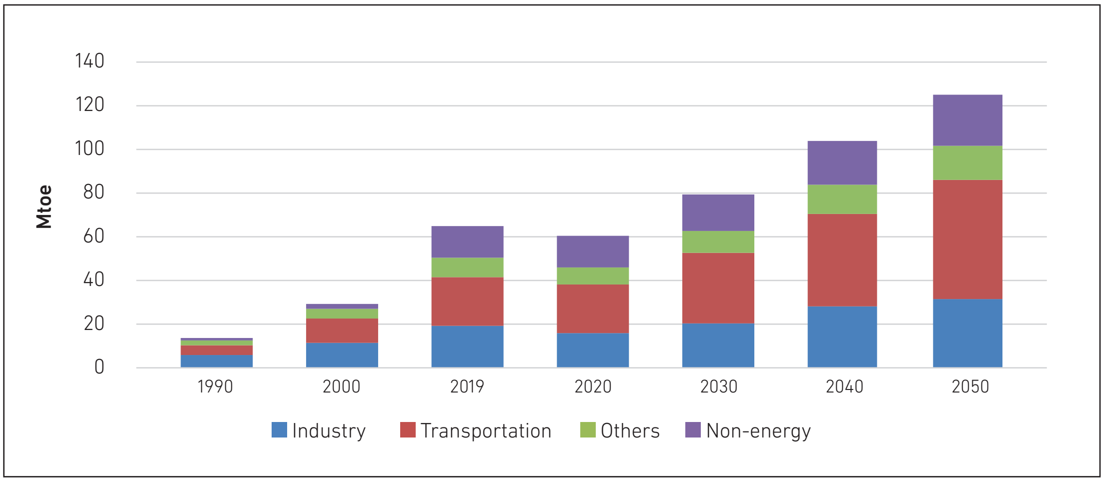
For demand side management, higher savings of Energy Efficiency at a rate of 16% from 2041 to 2050 is expected, especially for residential and commercial sectors. As for the power sector, the capacity of RE, which includes small hydro, biomass, biogas, and municipal solid waste will double compared to APS3 from 2041 until 2050. From 2041 until 2050, the power sector plans to implement the CCUS technology for coal and natural gas power plants operating at a 50% utilisation rate.

3.3.1. Final Energy Consumption by Sector

Figure 11.14 illustrates the final energy consumption by sector from 1990 until 2050 under the LCET scenario. The average annual growth rate is at 2.2% per year from 1990 until 2050. Lower final energy consumption in 2050 compared to APS5 scenario was due to greater savings of energy were expected under the residential and commercial sector.

Figure 11.14 **Final Energy Consumption by Sector, Low Carbon Energy Transition Scenario 1990–2050**

(Mtoe)



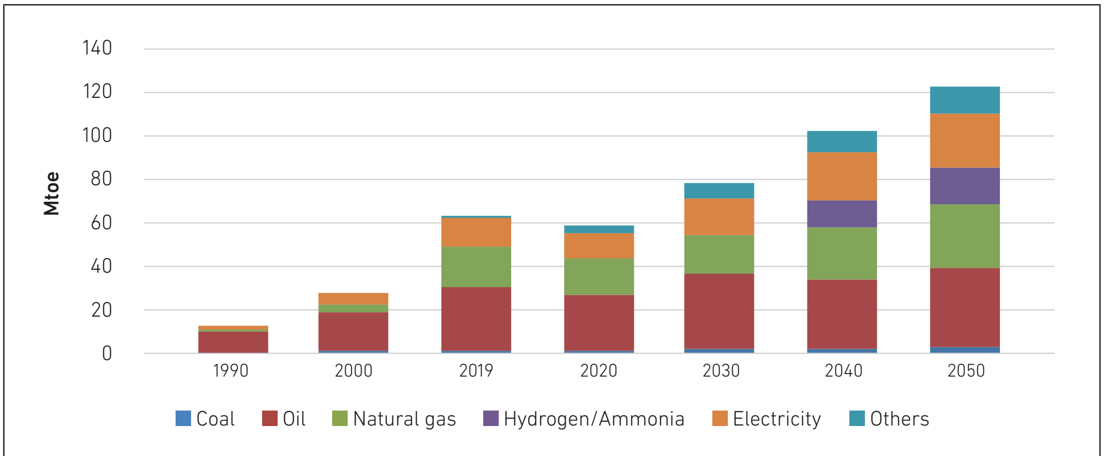
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The introduction of hydrogen fuel for transport from 2041 onwards impacts the consumption of gasoline. As a result, in 2050, there is a consumption of hydrogen at 16.63 Mtoe. The average annual growth rate of oil will reduce to 0.8% per year from 2019 to 2050, compared to 2.4% per year under the APS5. The final energy consumption by fuel under the LCET scenario is shown in Figure 11.15.

Figure 11.15 **Final Energy Consumption by Fuel, Low Carbon Energy Transition Scenario 1990–2050**

(Mtoe)



Mtoe = million tonnes of oil equivalent.

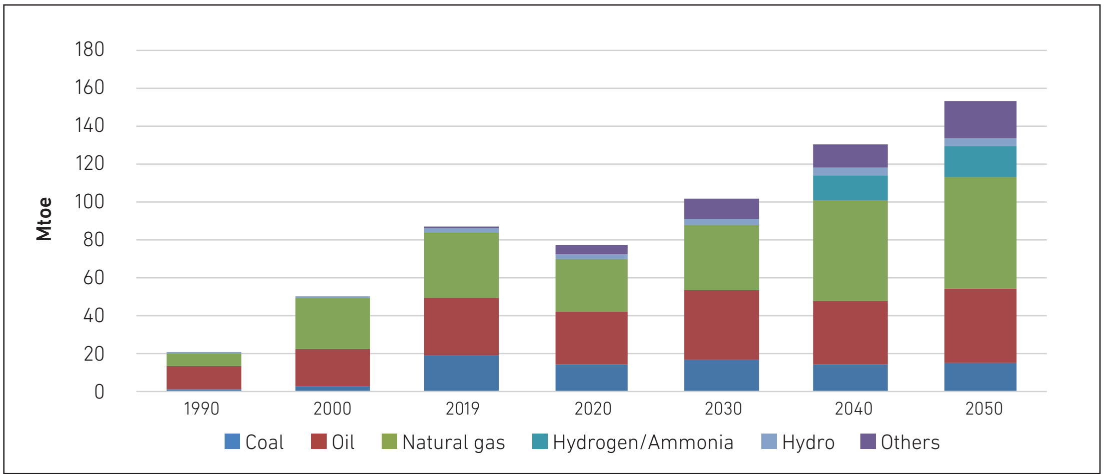
Source: Author's calculations.

3.3.2. Primary Energy Supply

In 2050, the total primary energy supply (TPES) under the LCET scenario registered at 152.54 Mtoe, much lower compared 162.84 Mtoe under the APS5. In terms of average annual growth rate, TPES was recorded at 1.9% per year from 2019 to 2050, while it was 2.1% per year under the APS5. Due to the government's decision to not incorporate any new coal plants into the system, coal is the only fuel with a negative average annual growth rate (-0.8%). Interestingly, by doubling renewable energy capacity in the power sector starting in 2041, other fuels will have a higher growth rate in TPES.

Figure 11.16 Primary Energy Supply by Fuel, Low Carbon Energy Transition Scenario 1990–2050

(Mtoe)



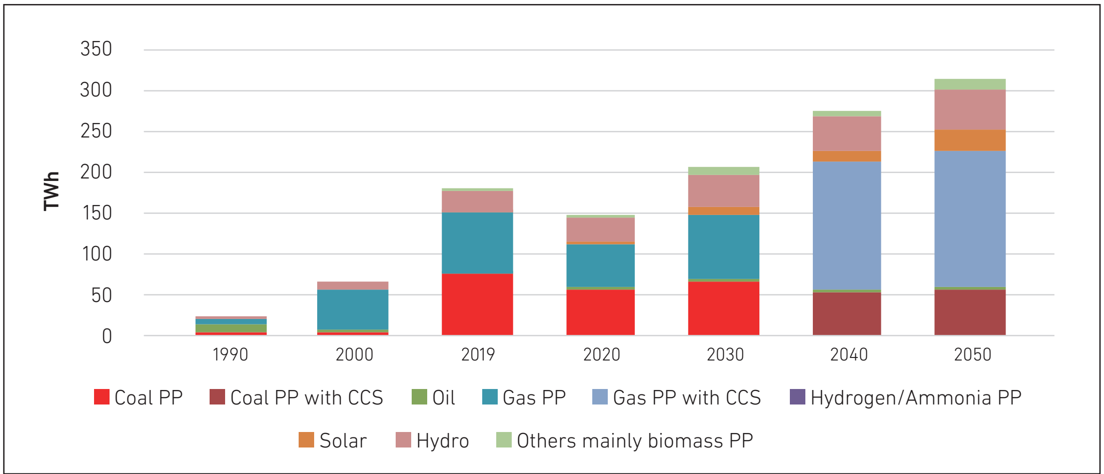
Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.3.3. Power Generation

From the Figure 11.17 shows the total electricity generation under LCET scenario in 2050 at 314.95 TWh compared to 379.80 TWh under the APS5 scenario. The reduction of electricity consumption due to EE initiatives has resulted the lower generation of electricity by 2050. By 2050, natural gas power plant will constitute 53.4% of share followed by coal at 18.2%, hydro at 14.7%, solar at 8.4%, biomass at 4.7% and oil at 0.7%.

Figure 11.17 **Electricity Generation by Fuel, Low Carbon Energy Transition Scenario 1990–2050**
(TWh)



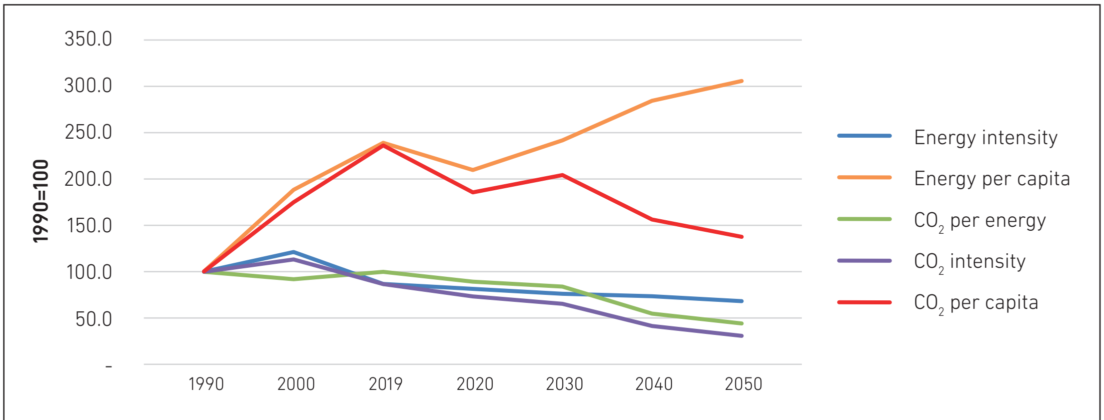
CCS = carbon capture and storage, PP = powerplant, TWh = terawatt hour.

Source: Author's calculations.

3.3.4. Energy Indicators

Figure 11.18 shows that only energy per capita registered a positive trend compared to all other energy indicators. The CO_2 emission per capita showed a downward trend from 2019 to 2050 at -1.8% per year. Energy intensity also showed a similar trend at -0.5% per year, while CO_2 emission intensity was marked at -3.4% per year.

Figure 11.18 **Energy Indicators, Low Carbon Energy Transition Scenario, 1990–2050**



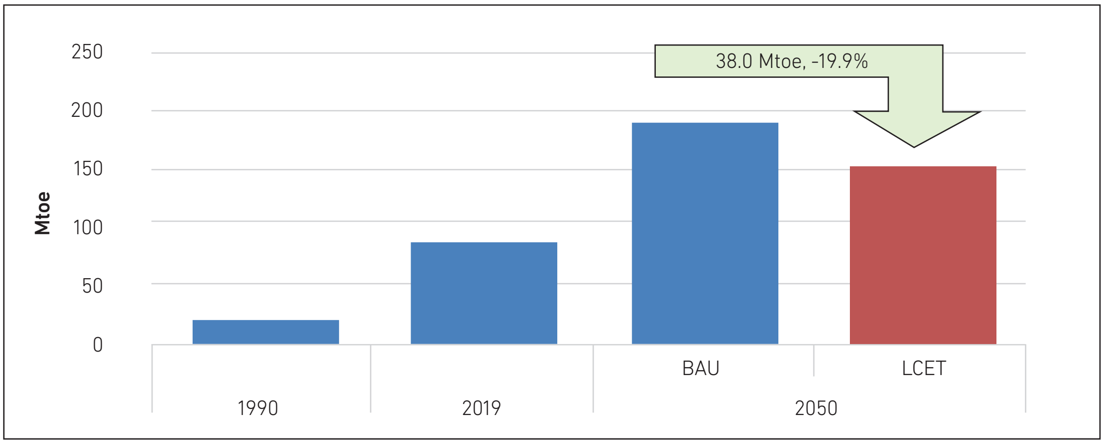
CO_2 = carbon dioxide.

Source: Author's calculations.

3.3.5. Fossil Fuel Consumption Savings and Carbon Dioxide Reduction

Figure 11.19 shows the potential savings of total primary energy supply in the LCET scenario at 38.0 Mtoe when compared to BAU. This potential savings of -19.9% would be met if all initiatives under the LCET scenario are implemented.

Figure 11.19 Primary Energy Supply, Business-as-Usual and Low Carbon Energy Transition Scenarios, 1990, 2019 and 2050
(Mtoe)

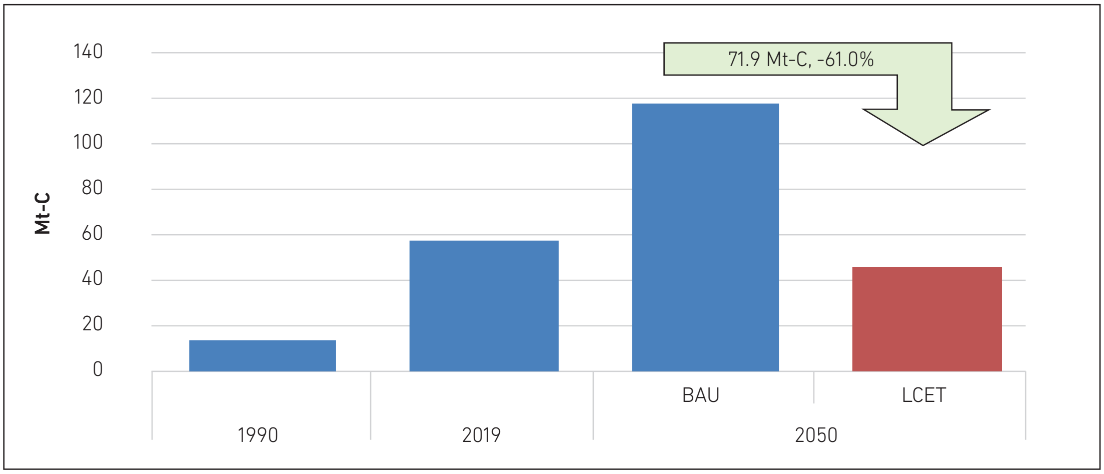


APS = alternative policy scenarios, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

The total CO_2 emission in 2050 under the LCET scenario was at 46.0 Mt-C, while it was 117.9 Mt-C under BAU. This reduction is about 71.9 Mt-C or 61.0% when comparing BAU and LCET scenarios. Further, the rate of total CO_2 emission in 2050 under the LCET scenario is lower than the total CO_2 emission registered in 2019 (see Figure 11.20).

Figure 11.20 Carbon Dioxide Emission Reduction, Business-as-Usual and Low Carbon Energy Transition Scenarios, 1990, 2019, and 2050

(Mt-C)



APS = alternative policy scenarios; BAU = business-as-usual; Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

4. Implications and Policy Recommendations

As countries around the world work to rebuild their economies after the COVID-19 pandemic, the environmental conservation and climate change mitigation are taking center stage. While each country's approach may differ based on each country's unique economic structures and strategic plans, many have pledged to combat climate change by targeting carbon neutrality or net zero. New technologies and alternative fuels are being explored worldwide. However, the adoption of new technologies will require significant investments, long-term partnerships, and secure funding. It is essential for each country to prioritise and strategise their approach to combating climate change from an early stage. By implementing a well-crafted roadmap, economies can effectively address this complex problem, with the support of more advanced economies.

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CHAPTER 12

Myanmar Country Report

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1. Background

1.1. Country Profile

Myanmar is the largest country in the mainland of Southeast Asia. Its territorial area covers 676,577 square kilometres and shares a border of 5,858 kilometres (km) with Bangladesh and India to the northwest, China to the northeast, and Thailand to the southeast. Approximately 48% of the total land area is covered with forest, and most of the land area is used for agriculture. Myanmar had a population of 54 million in 2021 with an average annual growth rate of 0.9% from the 1990 to 2019.

Myanmar is geographically located at the tip of the Southeast Asia Peninsula and has three distinct seasons. It enjoys three to four months of heavy monsoon and abundant sunshine all year round, which makes it ideal for accumulating water resource for hydropower and agriculture. Its topographic features include numerous rivers, mountain ranges, and sedimentary basins where mineral deposits and energy resources have abundantly accumulated. The delta regions where the two major rivers enter the Bay of Bengal and the 2,832 km coastal strip along the southern part are good areas for the development of marine ecosystems and are an abundant source for marine products and chemicals.

Myanmar is endowed with rich natural resources used for the production of commercial energy. The current available sources of energy found in Myanmar are crude oil, natural gas, hydroelectricity, biomass, and coal. Besides these, wind, solar, geothermal, bioethanol, biodiesel, and biogas are the potential energy sources found in Myanmar.

Myanmar's proven energy reserves in 2017 comprised of 94 million barrels of oil, 4.552 trillion cubic feet of gas, and over 500 million metric tons of coal. The country is a net exporter of energy, exporting substantial amounts of natural gas and coal to neighbouring countries. However, it imports around 90% of its total oil requirements.

1.2. Socio-Economic Status

The population of Myanmar grew at 1.0% per year between 1990 and 2019 to 54 million in 2021. Myanmar's gross domestic product (GDP) was $74.28 billion (constant 2010 US$) in 2019, and its GDP per capita grew from around $200 in 1990 to $1,370 in 2019. With the objectives of enhancing economic development in Myanmar, five-year short-term plans have been formulated and implemented from 1992 to 2013. The first plan (1992–1995) achieved a 7.5% annual growth rate; the second (1996–2000), 8.5%; the third (2001–2005), 12,8%; and the fourth plan (2006–2010), 12%. The last five-year plan (2011–2016) has been formulated to achieve an average annual GDP growth rate of 7.0%.

1.3. Energy Consumption, Base Year

Myanmar's total primary energy supply was 20.48 million tons of oil equivalent (Mtoe) in 2019. Natural gas is mainly used for electricity generation and in industry. In 2019, Myanmar had 6034 megawatts (MW) of installed generation capacity and produced almost 23.19 terawatt-hours (TWh) of electricity. During the same year, thermal (coal, natural gas, and oil) and hydro, accounted for 57% and 43%. of total electricity generation, respectively.

Table 12.1 Installed Capacity and Power Generation by Fuel Type, 2019–2020

No.	Type of Fuel	2019–2020	
		Installed (MW)	Generation (GWh)
1	Hydro	3,262.37	10,032.27
2	Gas + Steam	2,495.70	12,275.4
3	Coal	120.00	692.96
4	Diesel	117.00	136.11
5	Solar	40.00	56.12
	Total	**6,034.33**	**23,190.93**

GWh = gigawatt-hour; MW = megawatt.

Source: Myanmar Ministry of Electric Power, 2020.

2. Modelling Assumptions

2.1. Gross Domestic Product and Population Growth

In this report, Myanmar's GDP is expected to grow at an average annual rate of around 4.9% from 2019 to 2050, slowing from 8.0% from 1990–2019. Population is assumed to increase by about 0.6% per year from 2019 to 2050 (Ministry of Labour, Immigration and Population, 2020).

2.2. Energy Consumption and Electricity Generation

Hydro and natural gas dominated electricity generation in Myanmar. Other fuels such as oil and coal also contributed to the country's generation mix, but at less than 13% in 1990. The Government of Myanmar plans to increase the share of natural gas, coal, hydro, and other renewables in the total generation mix and decrease oil share. The government also plans to export electricity to neighbouring countries such as Thailand and China from its hydro power plants.

As shown in Table 12.2, the Power Resource Balance scenario (Scenario 3) has the lowest installed capacity at 23,594 MW by 2030, with hydro share at 38%, coal 33%, gas 20%, and renewables (solar, wind, etc.) at 8%.

Table 12.2 Installed Capacity and Power Supply in Scenarios, 2030

No	Scenario 1 (Domestic Energy Consumption)			Scenario 2 (Least Cost)		Scenario 3 (Power Resources Balance)	
	Energy Resources	Installed Capacity		Installed Capacity		Installed Capacity	
		MW	%	MW	%	MW	%
1	Hydro(large)	12,147	42	12,147	43	1,412	6
2	Hydro (Small & 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	Renewable	2,000	7	2,000	7	2,000	8
	Total	**28,784**		**28,552**		**23,594**	

MW = megawatt.

Source: Myanmar Energy Master Plan, 2015.

The Myanmar Energy Master Plan, 2015 outlined installed capacities for three power demand scenarios in 2030 (Table 12.2). Scenario 3 is the power resource balance, which requires an increased share of hydropower and natural gas supply for power generation.

2.3. Energy and Climate Change Environmental Policies

Through intensive exploration and development activities, Myanmar's energy policy strives to maintain the status of energy independence by increasing indigenous production of available primary energy resources. The policy also addresses electric power as the main driving power source for economic development and the need to generate and distribute in terms of volume, density, and reliability. Myanmar's energy policy aims to increase the use of its abundant water resources for hydropower development to reduce the need for fossil fuel power generation. Energy efficiency management can reduce energy consumption to minimise harmful environmental impacts.

Based on 2018 data, Myanmar emits the least greenhouse gases (GHG) in the world, emitting only 0.61 tons of carbon dioxide equivalent per person ($CO2e$/person). Myanmar's total emission reductions contributions to the NDC are 244 million tonnes of $CO2$ emissions equivalent ($tCO2e$) unconditionally, and a total of 413 million $tCO2e$, subject to conditions of international finance and technical support by 2030, which is a significant commitment to global climate change efforts based on its national circumstances.

Myanmar will continue to mainstream climate change into short, medium, and long-term national development plans and policies. This includes state and regional development plans and policies under the guidance of the Myanmar Sustainable Development Plan, 2018–2030, which is aligned with the 2030 Sustainable Development Goals (SDG). In addition, the National Environmental Policy, 2019; Myanmar Climate Change Policy, 2019; Myanmar Climate Change Strategy, 2018–2030; and Myanmar Climate Change Master Plan, 2018–2030 were endorsed in 2019. Myanmar needs cross-cutting support to improve the implementation of climate change actions across an array of sectors, broadly defined as Policy, Institutions, Finance, Capacity, Technology and Partnerships. The Climate Change Strategy and Master Plan prioritises six sectors pertaining to adaptation, mitigation, and cross cutting issues. To facilitate the implementation of this plan, Myanmar will use the Green Climate Fund (GCF) Readiness Programme. This support will aid in the development of the Strategies for Natural Resources Management and the Urban Low-Emissions and Climate Resilient Development plans.

The National Environmental Conservation and Climate Change Central Committee (NECCCCC) led by the vice president provides oversight on all environmental and climate change activities.

2.4. The National Efficiency Policies

According to the *National Energy Efficiency & Conservation Policy, Strategy and Roadmap of Myanmar* by the Asian Development Bank in 2015, Myanmar aims to achieve 20% energy savings in the electricity sector between 2020 and 2030. Specifically, the targets include a 12% reduction in 2020 and a 16% reduction by 2025.

For the industry sector, energy savings is set for 5.34% in 2020, 5.31% in 2025, and 6.63% in 2030. Savings targets for commercial sectors are 1.99% in 2020, 2.98% in 2025, and 3.98 in 2030 . Savings in the residential sector is set for 0.68% in 2020, 1.02 % in 2025, and 1.36 in 2030. All other sectors collectively have targets set at t 0.68% in 2020, 1.02% in 2025 and 1.36% in 2030.

For the residential sector, approaches include the following:

(i) Introduction of energy efficiency performance standards and labelling for appliances, testing and certification facilities for appliances, and incentives for energy-efficient equipment
(ii) Phasing out inefficient appliances from the market
(iii) Promotion of efficient biomass cook stoves
(iv) Increasing consumer awareness of benefits in liquefied petroleum gas (LPG) for cooking and the introduction of energy efficient labelling for LPG cook stoves
(v) Regular EE awareness campaigns in national media

For the commercial sector, the following approaches include the following:

(i) Energy audits
(ii) Energy serformance standards for appliances
(iii) Incorporation of energy efficiency in new building design, energy building codes and refurbishments
(iv) Preparation of energy efficiency guidelines for commercial buildings.

2.5. Intended National Determined Contribution and National Determined Contribution

Mitigation actions and policies in the energy sector

1. Energy: 30% renewable energy in rural electrification via mini hydropower, biomass, solar, wind, and solar mini-grid technologies.
2. Clean cooking and heating: Distribute approximately 260,000 energy-efficient cooking stoves between 2016 and 2031.
3. Renewable energy (hydropower): 9.4 GW hydro-electric generation by 2030.
4. Energy efficiency: 20% electricity-saving potential based on the total forecasted electricity consumption for 2030.
5. Renewable energy: 12% of national energy mix (generation) by 2030, which includes greater than 2000 megawatts of renewable energy such as small and mini-hydro, biomass (Rice Husk & Municipal Solid Waste, year), wind, and solar.
6. Reduction of Deforestation: Myanmar has set a conditional target to reduce deforestation by 50% by the 2030, resulting in a cumulative emissions reduction of 256.5 million tCo2e over the period 2021–2030.

2.6. Alternative Policy Scenarios

In the previous studies, two scenarios were formulated to analyse the impact of policy interventions on the energy sector: (i) the Business-as-Usual scenario (BAU), which serves as the reference case to project energy demand and carbon dioxide (CO2) emission, and (ii) the Alternative Policy Scenario (APSs) to evaluate the impacts of policy interventions in the development and use of energy resources in the country. The APS can include policies to increase energy efficiency and conservation targets, expedite the penetration of new and renewable energy, and introduce cleaner technology including the option for a nuclear power plant. In order to further understand the impact of individual policy interventions, this year's study was formulated as follows.

1) APS1: Improved energy efficiency of final energy consumption
2) APS2: Higher efficiency of thermal electricity generation
3) APS3: Higher contribution of new and renewable energy (NRE), wherein NRE for electricity generation and biofuels in the transport sector are assumed
4) APS4: Introduction or higher contribution of nuclear energy
5) APS5: Combined impact of scenarios APS1 to APS4
6) Low Carbon Energy Transition (LCET): Increased hydro and natural gas meet net zero emission.

In the case of Myanmar, there is no existing plan to introduce nuclear energy for power generation. As such, the APS4 was not considered in the analysis. Thus, APS5 would only consist of APS1, APS2, and APS3.The APS3 includes more renewable energy in the power generation mix of Myanmar. For APS3, the additional installed capacity for coal-based and gas-based power plants for 2030 is replaced by renewable energy capacity, which includes a hydro plant. LCET includes hydrogen fuel in industry and the use of electric vehicles in transport.

3. Outlook Result

3.1. Business-as-Usual Scenario

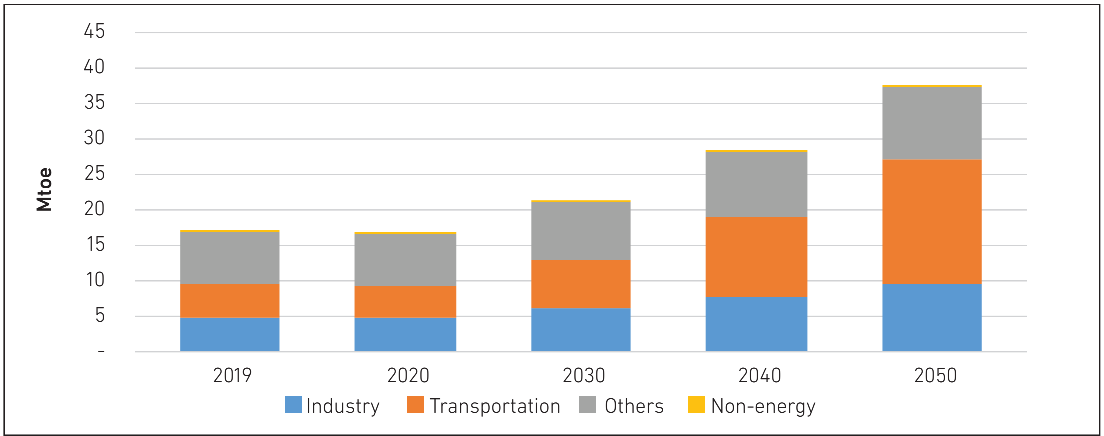
3.1.1. Final Energy Consumption

The total final energy consumption in Myanmar increased by about 2.1% per year, from 9.4 million tonnes of oil equivalent (Mtoe) in 1990 to 17.4 Mtoe in 2019. Industry was the fastest growing sector with an average annual growth of 9.1% during1990–2019. Consequently, the share of this sector in the total energy demand increased from around 4.2% in 1990 to almost 28.6% in 2019. Transport was the second fastest growing sector with an average annual growth rate of 8.5% over the same period. Its share in the total energy demand increased from 47% in 1990 to 26.9% in 2019.

The 'Others' sector, which comprised of the commercial and residential sectors, was the major contributor to the total final energy consumption. Its share declined from 90.2% in 1990 to 44.2% in 2019. This indicates that annual growth rate for demand within this sector (0.3%) was slower than in industry and transport.

Figure 12.1 shows the Final energy consumption by sector from 2019 to 2050 under the BAU scenario. Using the socio-economic assumptions stated above, the Final energy consumption in Myanmar is projected to grow at an annual rate of 2.6% under the BAU scenario, reaching 38.28 Mtoe in 2050. While Final energy consumption for transport grows fastest during 2019–2050, its growth rate is lower than the 1990–2019 period. The Final energy consumption from transport will increase at an average rate of 4.4% per year, while the demand from industry will grow at 2.2% per year. The Final energy consumption from the 'Others' sector (mainly residential and commercial) is projected to grow at an annual average rate of 0.4%, higher than in 1990–2019.

Figure 12.1 Final Energy Consumption by Sector, Business-As-Usual, 2019–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

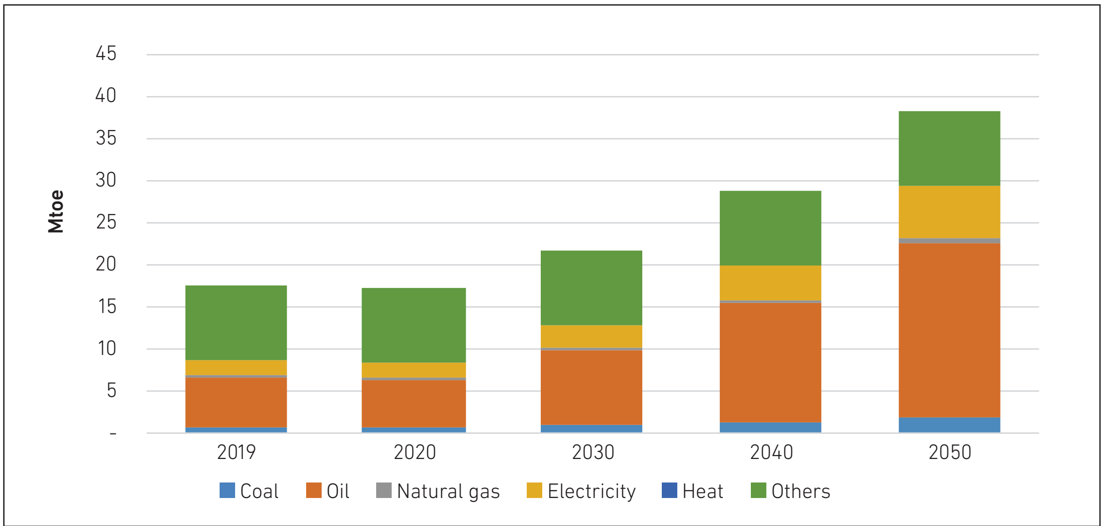
Source: Study outcome.

Under the BAU scenario, transport, industry, and non-energy will continue to grow, resulting in an increase in their shares of total final energy consumption. Meanwhile, the 'Others' sector share will decline. In 2050, share from transport is projected to increase to 47.1%, while industry would reach 25.7%. The 'Others' would decline to around 27.1% from 2019's 44.2%.

By fuel type, 'Others', which pertains mostly to biomass, was the most consumed fuel in 1990 with a share of 89.2% in the total final energy consumption of the country. In 2019, its share decreased to 51.4% due to the higher growth of other fuels, while demand for natural gas increased from 0.23 Mtoe. Coal demand grew the fastest at an average rate of 9.1% per year during 1990–2019.

Under the BAU scenario, the share of other fuels will decline to 23.4% in 2050, indicating that its future use will grow slower than the other fuels. In contrast, oil share will continue to increase and will reach 54.2% in 2050 from 33.0% in 2019, with an average growth of 4.2% per year. This is due to the rapid increase of transport activities during 2019–2050. Figure 12.2 shows the final energy consumption by fuel type from 2019 to 2050 under the BAU scenario.

Figure 12.2 Final Energy Consumption by Fuel, Business-As-Usual, 2019–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Source: Study outcome.

Coal is projected to have an average annual growth rate of 3.2% during 2019–2050, still slower than oil (4.2%). Electricity demand will still grow the fastest at an average annual growth rate of 4.4% per year during the same period. Its share will increase from 9.6% in 2019 to 16.5% in 2050.

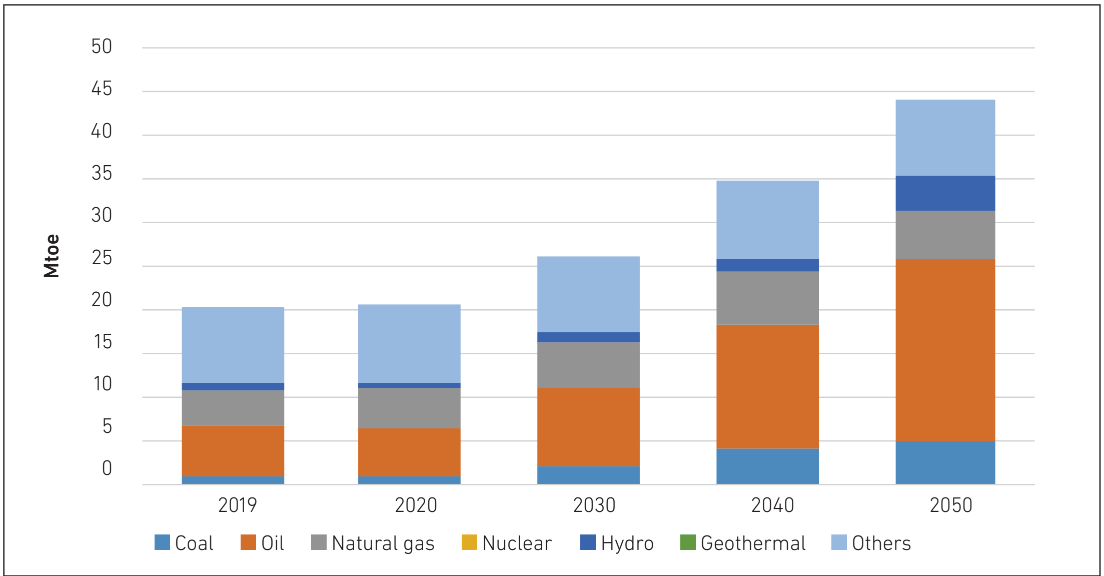
3.1.2. Primary Energy Supply

From 1990 to 2019, primary energy supply in Myanmar grew at an average annual rate of 2.3% from 10.68 Mtoe to 20.48 Mtoe. Amongst the major energy sources, hydro and oil grew the fastest with average annual growth rates of 7.7% and 7.4% respectively. Natural gas consumption grew at an average annual rate of 5.9%, and coal consumption increased at 9.2% per year on average. 'Others', such as biomass, dominated the primary energy supply mix in 2019 with a share of 43.7%. The next largest shares amongst the major fuels over the same period were oil (28.2%) and natural gas (19.7%)

In the BAU scenario, Myanmar's primary energy is projected to increase at an annual average rate of 2.5% per year to 44.17 Mtoe in 2019–2050. Hydro and natural gas are expected to grow at average annual rates of 4.9% and 1.1%, respectively. Coal will grow the fastest at 5.8% from 2019–2050, while oil will grow at 4.2% per year.

In 2050, while the share of oil in the total primary energy mix will increase to 47.4%, hydro will increase to 8.6%. Coal share will also increase from 4.2% in 2019 to 11.2% in 2050. Natural gas shares will increase to 12.8%. Notably, the share of biomass will decrease from 43.7% in 2019 to 20% in 2050 due to the shift from biomass use to LPG. From 43.7% in 2019, its share will decline to 20% in 2050. See Figure 12.3.

Figure 12.3 Final Energy Consumption by Source, Business-As-Usual, 2019–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

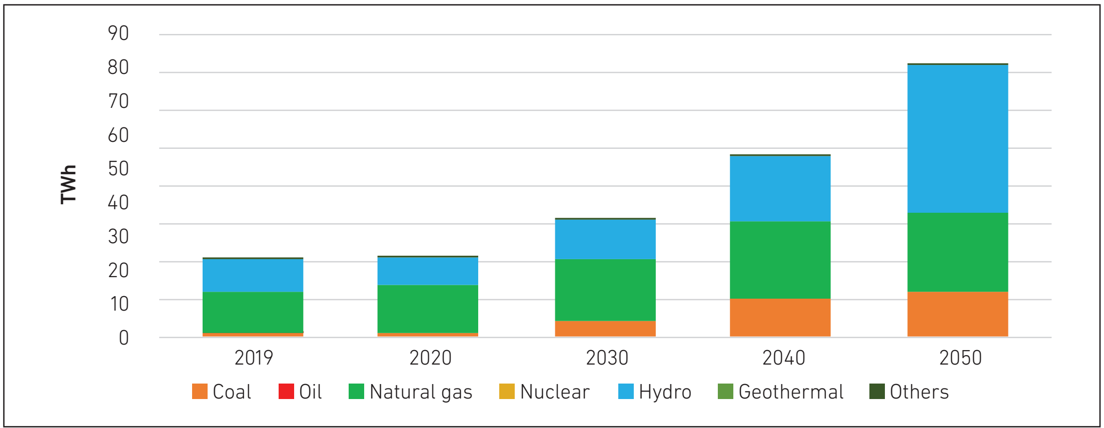
Source: Author's calculations.

3.1.3. Power Generation

Hydro and natural gas dominated the power sector fuel mix in Myanmar. In 2019, the share of hydro in the power generation mix reached 43.5%, while the natural gas share was 53.2%. The remaining fuel (coal and oil) accounted for only 3.0% of the total generation mix. During 2019, the share of hydro supply was less than natural gas. This was because of the flexibility in the natural gas power generation in Myanmar.

Under the BAU scenario, oil-based power plants will cease operation by 2030. While both hydro and natural gas would maintain shares in the power sector mix in 2050, the share would change to 5.7% from hydro-based power plants and to 28.9% from natural gas. The remaining fuels would have a more significant role in the future. The share of coal-based power generation in the total fuel mix would increase to 16.4% in 2050, becoming the dominant power generation sector while other renewable shares (solar, wind and biomass) would reach 4%. Total electricity generation from the different power plants will grow at an average annual rate of 4.1% during 2019–2050, with power plants based on natural gas growing at an average annual rate of 2.1%. Hydro power generation will increase, but at a slower average rate of 4.9%.

Figure 12.4 Power Generation Mix, Business-As-Usual, 2019–2050
(TWh)



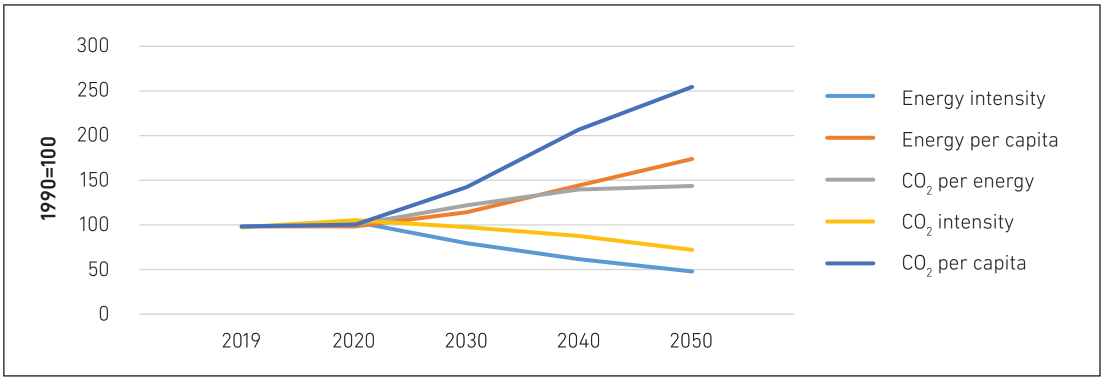
TWh = terawatt hour.

Source: Author's calculations.

3.1.4. Energy Intensity, Energy per Capita, and Energy Elasticity

Myanmar's primary energy intensity (TPES/GDP) has been declining since 1990. In 2019, primary energy intensity was 275.69 tonnes of oil equivalent per million 2010 US$ (toe/million 2010 US$), lower than what it was in 1990, which was 133 toe/million 2010 US$. It is projected that the intensity will continue to decrease to 135.07 toe/million 2010 US$ by 2050 an average rate of 22.3% per year. Energy consumption per capita grew from 0.3 toe in 1990 to 0.38 toe in 2019 and will increase to 0.68 by 2050, at an average annual growth rate of 1.9%. The CO_2 intensity was 140 tonnes of carbon per million 2010 US$ (t-C/million 2010 US$) in 1990 and decreased to 110 t-C/million 2010 US$ in 2019. It is projected that the CO_2 intensity will continue to decrease to 80 t-C/million 2010 US$ in 2050. See Figure 12.5.

Figure 12.5 Energy Intensity, CO_2 Intensity and Energy per Capita, 2019–2050



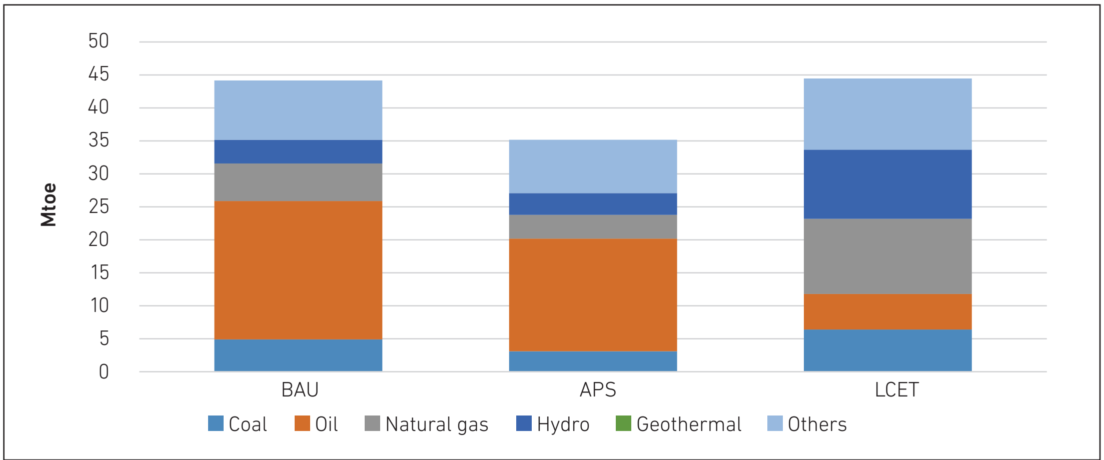
CO_2 = carbon dioxide.

Source: Study outcome.

3.2. Energy Savings Potential, Alternative Policy Scenario

The alternative policy scenario (APS) was analysed separately to determine the individual impacts of the policy interventions. The combination of all these policy interventions was further analysed in the APS. Figure 12.6 shows the changes in total primary energy supply in all the scenarios.

Figure 12.6 Comparison of Scenario to Total Primary Energy Supply (Mtoe)



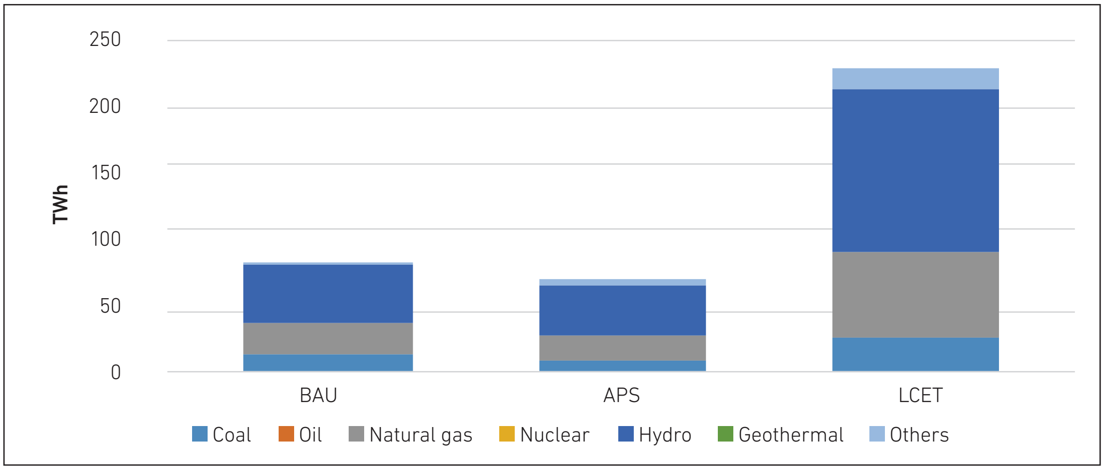
APS = alternative policy scenario, BAU = business-as-usual, LECT = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

In Figure 12.6 above, the APS has the largest reduction in total primary energy supply due to the implementation of the energy efficiency and conservation (EEC) action plans, improvement of thermal efficiency of fossil fueled power plants, and higher penetration of new and renewable energy in the country's supply mix. The average annual growth rate of the primary energy supply under the APS will be around 2% over the projection period. In 2050, the reduction of primary energy supply in APS as compared to the BAU, will be 31.67 Mtoe. The implementation of energy efficiency targets and its master plan alone will impact total primary energy supply. Achieving higher efficiency in the thermal power generation of coal and natural gas will reduce the use of hydro, coal, and natural gas. The higher penetration of new and renewable energy will increase the consumption of renewable energy such as solar, wind, and biomass.

The electricity demand would reach 81.00 TWh in 2050 under the BAU scenario. Under the APS scenario, the electricity demand would decrease by 12% as compared to the BAU scenario. As a result, the electricity demand in the APS scenario would only be 69.1 TWh in 2050. This reduction would come from natural gas, coal, and hydro power plants, with the highest reduction from coal power plants at 13.29 Mtoe in BAU and 7.72Mtoe in APS. The electricity saving of 12% has been assumed to continue to 2050 as no additional target is available after 2050. Figure 12.7 shows the total electricity generation in 2050 in all scenarios.

Figure 12.7 Comparison of Scenario of Electricity Generation
(TWh)

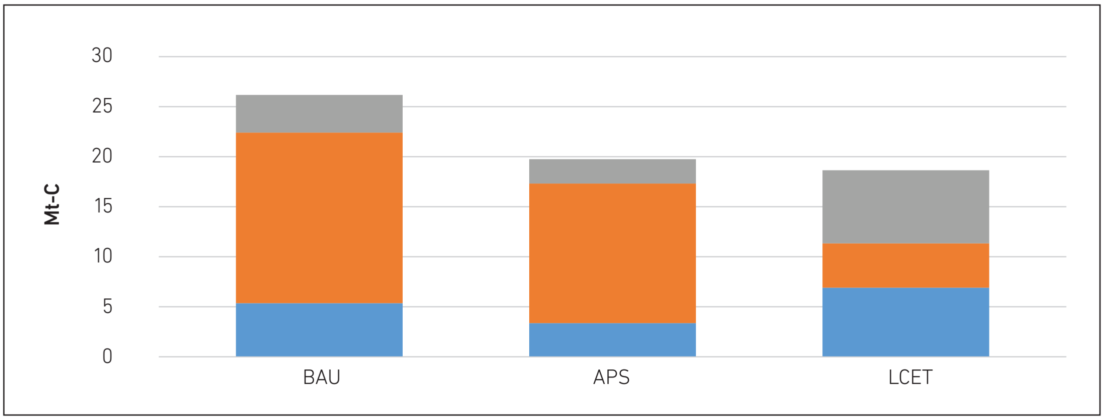


APS = alternative policy scenario; BAU = business-as-usual; LECT = low carbon energy transition; TWh = terawatt hour.

Source: Author's calculations.

In terms of reducing CO_2 emissions, energy efficiency assumptions in the APS is expected to reduce the most emissions by about 19.7 million metric tons of carbon (Mt-C) or 40% lower than the BAU. The decrease in CO_2 indicates that the energy-saving goals; action plans and policies in the promotion of programs; switch to less carbon intensive technologies, which will be effective in reducing CO_2 emissions. Figure 12.8 shows the projected CO_2 emissions in 2050 in all scenarios.

Figure 12.8 Comparison of Scenario of Carbon Dioxide Emission
(Mt-C)



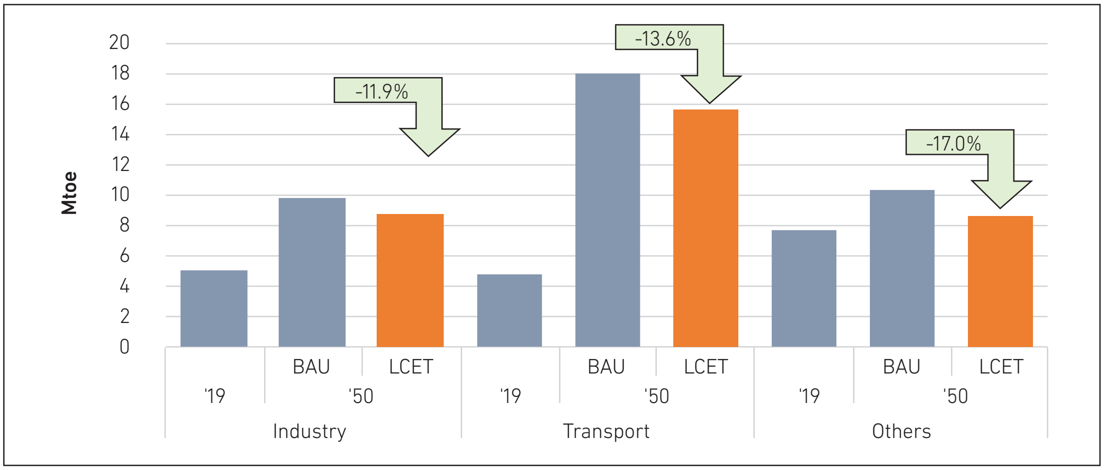
APS = alternative policy scenario, BAU = business-as-usual, LECT = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author's calculations.

3.2.1. Final Energy Consumption

In the LCET, the growth in final energy consumption is projected at a lower average annual rate of 2.1% as compared to the 2.6% annual growth in the BAU. The reason for the slower growth rate is the result of technological improvement in manufacturing process and the reduction of final energy consumption of electricity (Figure 12.9).

Figure 12.9 : Final Energy Consumption by Sector, Business-as-Usual and Low Carbon Energy Transition
(Mtoe)



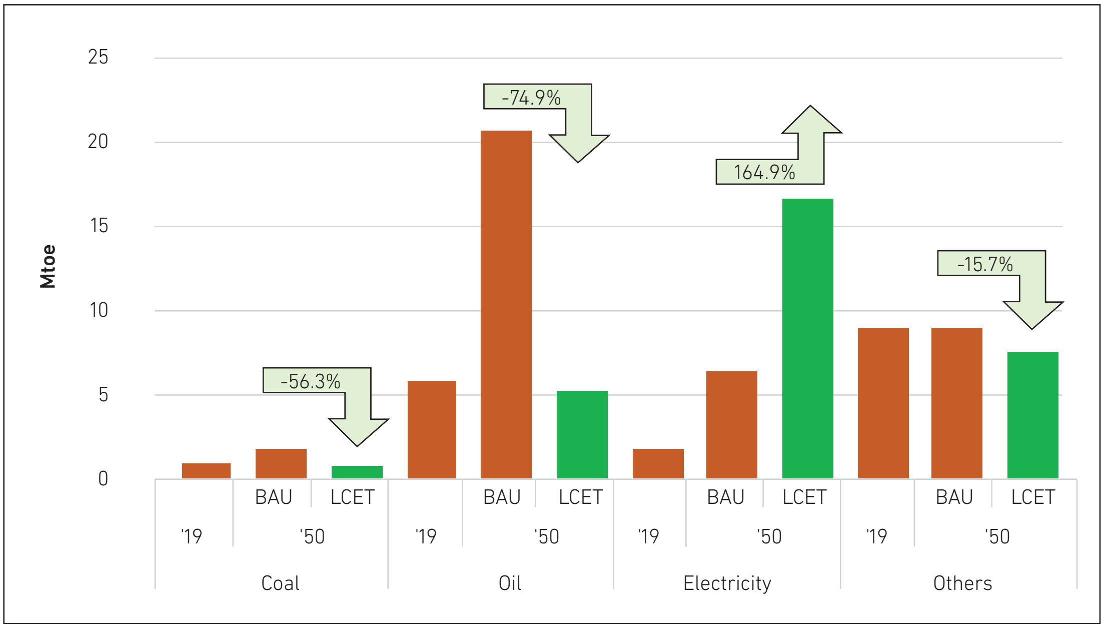
BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

3.2.2. Primary Energy Supply

In the LCET, Myanmar's primary energy supply is projected to increase by the same amount as in the BAU scenario. Between 2019 and 2050, hydro will grow the fastest at 8.4% per year, followed by coal at 6.8% per year. Natural gas is expected to grow at 3.4% per year. Oil is expected to decrease at an average annual rate of 0.2% over the same period. Figure 12.10 shows the primary energy supply by source in 2050 under the BAU and LCET.

Figure 12.10 Final Energy Consumption by Source, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050
(Mtoe)

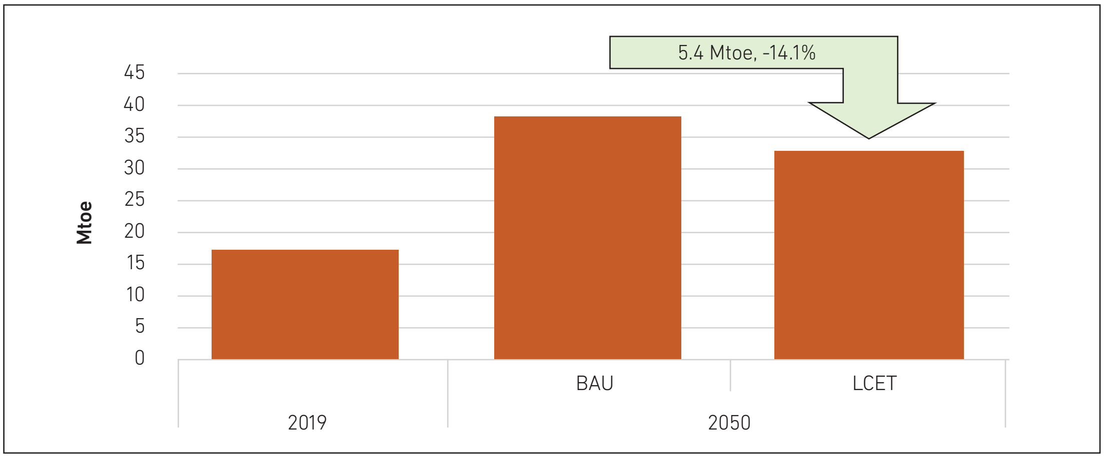


BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.
Source: Author's calculations.

In Myanmar, transport energy consumption is projected based on the energy requirements of major sectors (industry, transport, agriculture, and households). The choice of fuel type is determined by available supply, since energy demands must be met mainly by domestic sources.

Future savings in energy could be due to savings in primary energy supply in the residential, commercial, transportation, and industrial sectors. In this regard, Myanmar implemented a range of energy efficiency and conservation goals and action plans that target energy savings in all sectors. These will yield estimated savings of 5.4 Mtoe by 2050 in the LCET, relative to BAU, which is equivalent to 14.1% savings in the primary energy supply by 2050 under BAU. The LETC scenario includes the use of hydrogen fuel in industry and electric vehicles in transport.

Figure 12.11 **Final Energy Consumption by Source, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050**
(Mtoe)



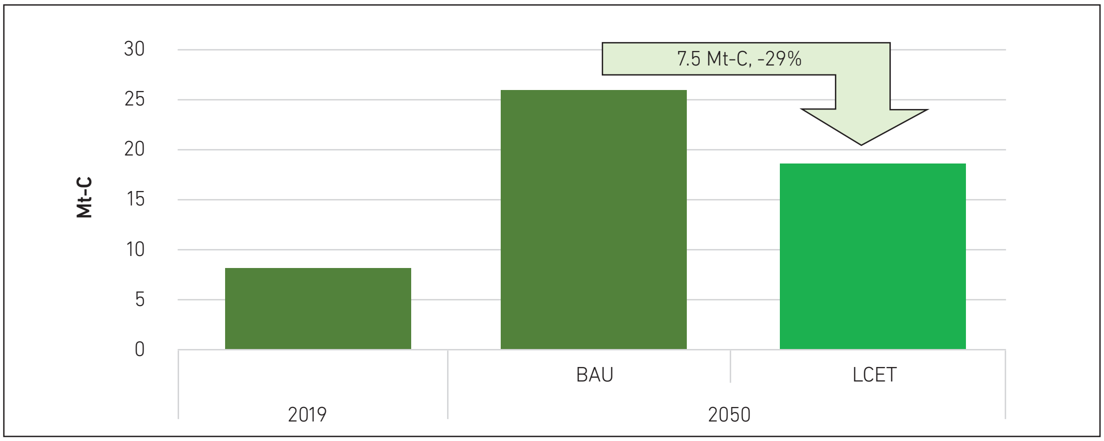
BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.

Source: Study outcome.

3.2.3. Carbon Dioxide Reduction Potential

In the LCET scenario, CO_2 emission from energy consumption is expected to reach about 7.5 million tons of carbon (Mt-C) in 2050, which is about 29% below the BAU level (Figure 12.12). The total CO_2 emission under the BAU in 2050 will be 26 Mt-C. Under the LCET, CO_2 emission will be around 18 Mt-C in 2050. Compared to BAU, this is a 28.43 Mt-C (29%) reduction of CO_2 emission.

Figure 12.12 **Final Energy Consumption by Source, Business-As-Usual and Low and Low Carbon Energy Transition, 2019 and 2050**
(Mt-C)



BAU = business-as-usual; LCET = low carbon energy transition; Mt-C = million tonnes of carbon.

Source: Study outcome.

4. Conclusion and Policy Implications

The Myanmar energy demand supply situation indicates that power generation mix must shift to more coal and hydropower, continued use of biomass, natural gas consumption, and appropriate increase of renewable energy such as solar PV and wind power generation. If Myanmar seeks an affordable energy supply, it will need to shift to more coal, hydropower, and biomass, with coal playing a key role in the future. In the LCET scenario, all sectors are expected to save energy as a result of the improving energy efficiency and the introduction of clean technologies.

Achieving early, partial, and deep decarbonisation of fossil power generation requires multiple phases. Financial institutions, policymakers, and the business community, should be informed about which technologies are suitable for financial arrangements, present potential business opportunities during the decarbonisation process, and are relevant for a fair and organised transition.

CHAPTER 13

New Zealand Country Report

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1. Background

New Zealand is an island country in the southwestern Pacific Ocean, about 1,500 kilometres (km) east of Australia. It consists of two large islands, the North Island and South Island, and several smaller ones, of which Stewart Island is the largest. The population was about 5.1 million on 31 March 2022 (Statistics New Zealand, 2022). Although it has some light and heavy industry, foreign trade heavily depends on agriculture, tourism, forestry, and fishing. In 2020, New Zealand had a nominal gross domestic product (GDP) of about $194.7 billion in United States dollars, (constant 2015 US dollars [US$]) or about $38,000 per capita.

This chapter shows the progress of net zero emissions by comparing several scenarios: business-as-usual (BAU), alternate policy scenario (APS), and the low carbon energy transition (LCET) scenario until 2050.

New Zealand possesses significant indigenous energy resources, including hydropower, geothermal, wind, natural gas, and coal. New Zealand is self-sufficient in natural gas and electricity and is a net exporter of coal. New Zealand has locally produced crude oil, which is exported because of its high quality. Therefore, it has high value on the international market. In 2020, New Zealand's production of oil – excluding liquefied petroleum gas (LPG) – was 7.9 million barrels, of which 93% was exported. In 2020, New Zealand imported 28 million barrels of crude oil – compared to 38 million barrels of crude oil in 2019 – to meet its oil demand. The largest amount of crude oil that New Zealand imported in 2020 came from the Middle East, with the rest coming from Russia, Asia, and the United States of America.

In 2020, the amount of crude oil and feedstocks taken in by Refinery NZ was 73% lower than 2019. Specifically, it dropped from 41.6 million barrels in 2019 to 30.4 million barrels in 2020. Additionally, the refinery output decreased from 41.3 million barrels in 2019 to 29.6 million barrels in 2020. These reductions were caused by multiple factors, including low refining margins, the effects of COVID-19, New Zealand's transition to low-carbon transport fuels, and high cost of operating in New Zealand. Due to these challenges, Refinery NZ conducted an 18-month Strategic Review, which involved engaging with various stakeholders, such as customers and the government. Based on this review, Refinery NZ decided to stop refinery operations in 2022 and instead transition to import terminal operations. As of April 2022, Refinery NZ changed its name Channel Infrastructure and is now operating as an import terminal from Marsden Point (Channel Infrastructure NZ Limited, 2021).

As of 1 January 2022, total oil and condensate reserves (2P) were 58.6 million barrels and natural gas reserves were 51.5 billion cubic metres. National in-ground resources of all coal are estimated over 15 billion tonnes, of which 80% of this is lignite in the South Island (Ministry of Business, 2021).

With the impacts of the coronavirus disease (COVID-19) pandemic, New Zealand's total primary energy supply (TPES) decreased by 3.4% from 20.5 million tonnes of oil equivalent (Mtoe) in 2019 to 19.8 Mtoe in 2020. By share, oil represented the largest source at about 29.9%, followed by geothermal energy at 27.5%, and natural gas at 18.7%. The rest of the primary energy supply came from hydropower at 10.9%, coal at 6.0%, biomass with 5.9%, and a smaller percentage of other renewables such as wind, solar photovoltaics, and biofuels.

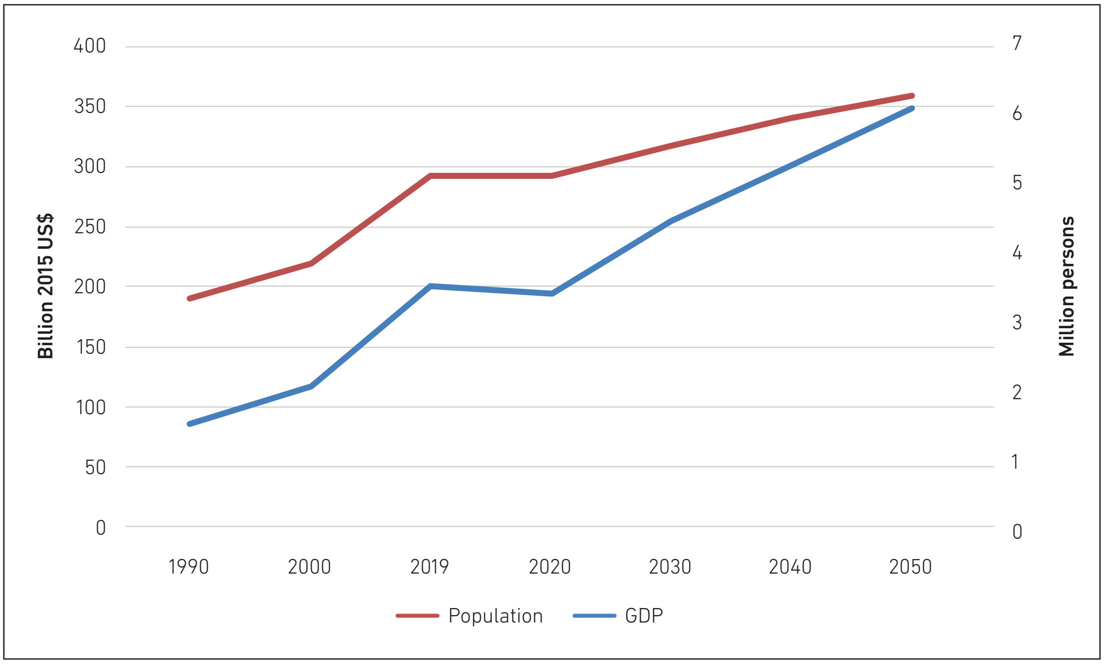
Final energy consumption was about 14.1 Mtoe in 2020. By share, the transport sector was the largest at around 33.9% because New Zealand depends heavily on private road vehicles, road freight, and air transport. The industrial sector was the second largest with about 30.9%, followed by the agricultural, residential, and commercial sectors, with 24.6% altogether. The non-energy sector consumed the remaining 10.7%.

In 2020, the total gross power generation output was about 44.3 terawatt-hours (TWh), of which hydropower accounted for about 56.8% (the most utilised source), followed by geothermal with about 21.3%, natural gas with about 10.8%, coal with 3.7%, and other renewables with 7.4%. Oil, a minor source in electricity generation, is only used for peaking and emergency supply.

2. Modelling Assumptions

This outlook assumes that New Zealand's GDP will grow at an average rate of 1.8% per year between 2019 and 2050, and its population will increase by an average rate of 0.7% per year from 5.1 million in 2019 to 6.3 million by 2050 (Figure 13.1).

Figure 13.1 Gross Domestic Product and Population, 1990–2050
(Billion 2015 US$ per Million Persons)



GDP = gross domestic product.

Source: Author's calculations.

3. Outlook Results

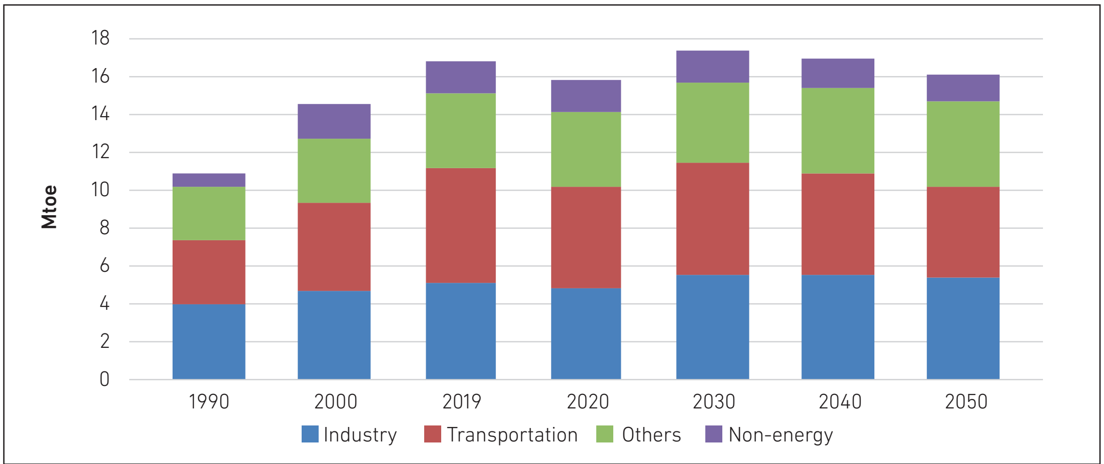
3.1. Business-as-Usual Scenario

3.1.1. Final Energy Consumption

New Zealand's final energy consumption grew by 1.5% per year from 9.8 Mtoe in 1990 to 15.0 Mtoe in 2019. The business-as-usual (BAU) scenario projects a decrease in final energy consumption from 2019 to 2050 at an average rate of 0.2% per year, resulting in a decrease of 0.7 Mtoe. Transport energy consumption is projected to decrease by 1.1 Mtoe at an average rate of 0.7% per year, while the non-energy sector is predicted to decrease by 0.3 Mtoe also at an average rate of 0.7% during 2019–2050. However, the 'others' sector (agricultural, residential, and commercial) is projected to increase by 0.5 Mtoe at an average rate of 0.4% per year, and the industry sector is also projected to increase by 0.2 Mtoe at an average growth rate of 0.2% per year (Figure 13.2).

Figure 13.2 Final Energy Consumption by Sector, Business-As-Usual, 1990–2050

(Mtoe)



BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

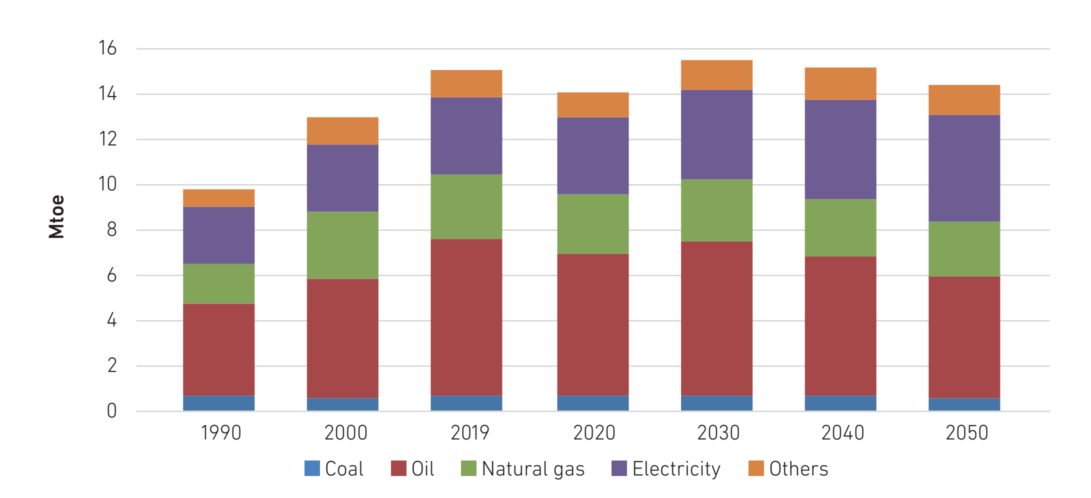
Note: 'Others' includes agricultural, residential, and commercial sectors.

Source: Author's calculations.

By source, in 2019–2050, final electricity demand will increase by 1.4 Mtoe at an average rate of 1.1% per year and final demand of other renewable energy, including geothermal, solar, biogas, and woody biomass used for direct-use heat applications, will increase slightly at an average rate of 0.1% per year. In 2050, final oil, natural gas, and coal demand will decrease by 1.6 Mtoe at an average rate of 0.8% per year, 0.4 Mtoe at an average rate of 0.5% per year, and 0.1 Mtoe at an average rate of 0.6% per year respectively (Figure 13.3).

Figure 13.3 **Final Energy Consumption by Source, Business-As-Usual, 1990–2050**

(Mtoe)



BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Note: 'Others' include geothermal, solar, biogas, and woody biomass.

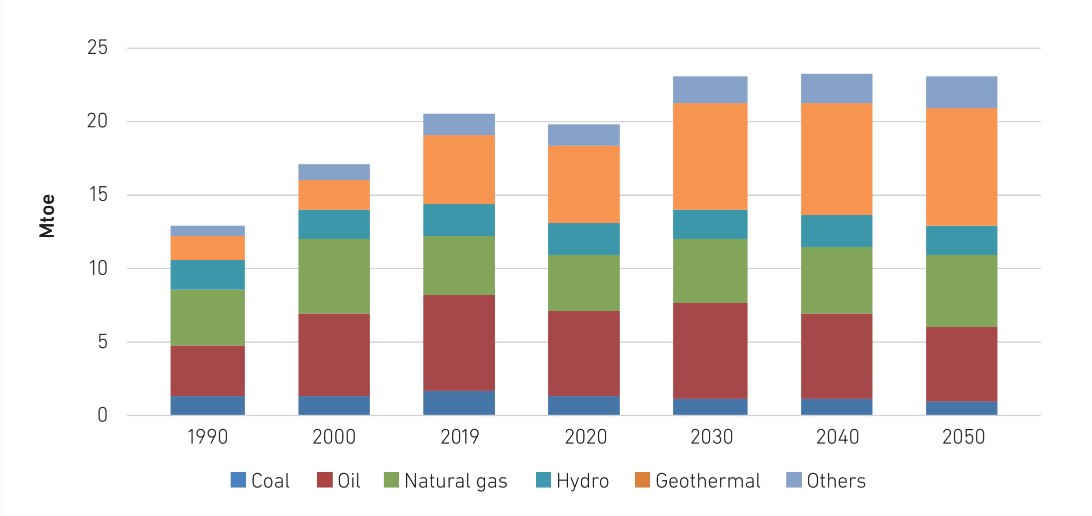
Source: Author's calculations.

3.1.2. Primary Energy Supply

Total Primary energy supply (TPES) in New Zealand grew at an average rate of 1.6% per year from 12.8 Mtoe in 1990 to 20.5 Mtoe in 2019. Geothermal and oil grew faster in 1990–2019. Geothermal share in TPES increased from 11.6% in 1990 to 22.8% in 2019, and oil's share in TPES increased from 27.3% to 32.6%. 'Other' energy sources, which include biomass, solar, wind, liquid biofuels, and biogas, increased their shares slightly from 6.2% to 7.0%. In 1990–2019, the share of natural gas decreased from 30.1% to 19.5%, hydro from 15.5% to 10.7%, and coal from 9.2% to 7.3%.

Under the BAU scenario, New Zealand's primary energy supply will grow at an average rate of 0.4% per year from 20.5 Mtoe in 1990 to 23.0 Mtoe in 2050. Geothermal energy is projected to contribute the most to the incremental growth of the primary energy supply between 2019 and 2050 and will account for 34.9% of the TPES in 2050. 'Others' primary energy will grow at an average rate of 1.4% per year, mainly reflecting the expected growth in wind power; and the share of 'Others' will account for 9.4% of the TPES in 2050. In contrast, coal will decrease slightly by an average rate of 1.7% and will account for 3.8% of TPES. Oil will decrease slightly, at an average rate of 0.9% and will account for 22.1% of the TPES. Hydropower for electricity generation will decrease at an average rate of 0.3% per year and will account for the remaining 8.6% of the TPES (Figure 13.4).

Figure 13.4 **Primary Energy Supply by Source, Business-as-Usual, 1990–2050**
(Mtoe)



BAU = business-as-usual; Hydro = hydropower; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes biomass, solar, wind, liquid biofuels, and biogas.

Source: Author's calculations.

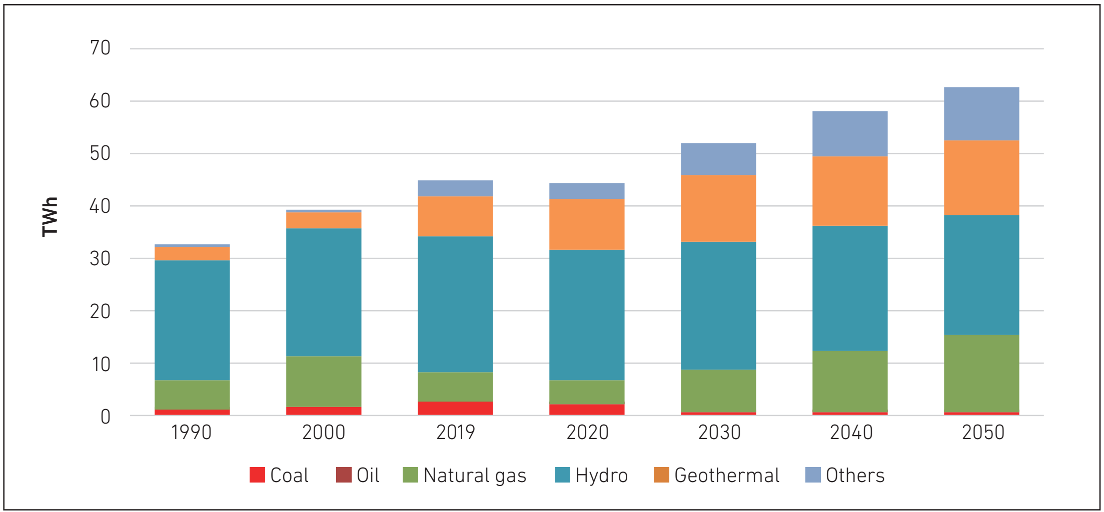
3.1.3. Power Generation

Under the BAU scenario, generation from renewable sources is projected to increase as new capacities for geothermal and wind will increase in the future. In 2020, some additional capacities of the Ngawha OEC4 geothermal plant and Waipipi wind farm have added to the market. Several companies made announcements on new plants to support a greater renewable generation mix. When these plants are complete, these plants will add 347 megawatts (MW) to the renewable electricity market (Ministry of Business, 2021).

Hydropower is projected to decrease slightly at an average rate of 0.3% per year from 2019 to 2050. Generation from natural gas-based plants is projected to increase slightly, at an average rate of 3.0% per year. Geothermal power generation will increase at an average rate of 1.8% per year and wind generation will continue to grow and account for 16.4% share of New Zealand's electricity by 2050 (6.8% share in 2019). In contrast, coal power generation will decrease at an average rate of 5.0% per year (Figure 13.5).

The thermal efficiency of gas- and oil-fired power plants may not increase so much in the future because there are no plans for new, large fossil fuel-based plants. Moreover, Genesis Energy – New Zealand's largest energy company – has decommissioned its coal-fired power plants by 2023.

Figure 13.5 **Power Generation by Source, Business-as-Usual**
(TWh)



BAU = business-as-usual; Hydro = hydropower; TWh = terawatt-hour.

Note: 'Others' includes biomass, solar, wind, and biogas.

Source: Author's calculations.

The Government of New Zealand implemented an emissions trading scheme in 2010. The New Zealand Emissions trading scheme (NZ ETS) helps reduce greenhouse gas emissions in New Zealand. The purpose of the NZ ETS is to help New Zealand meet its international obligations under the Paris Agreement and its 2050 target and emissions budgets (Ministry for the Environment, 2022).

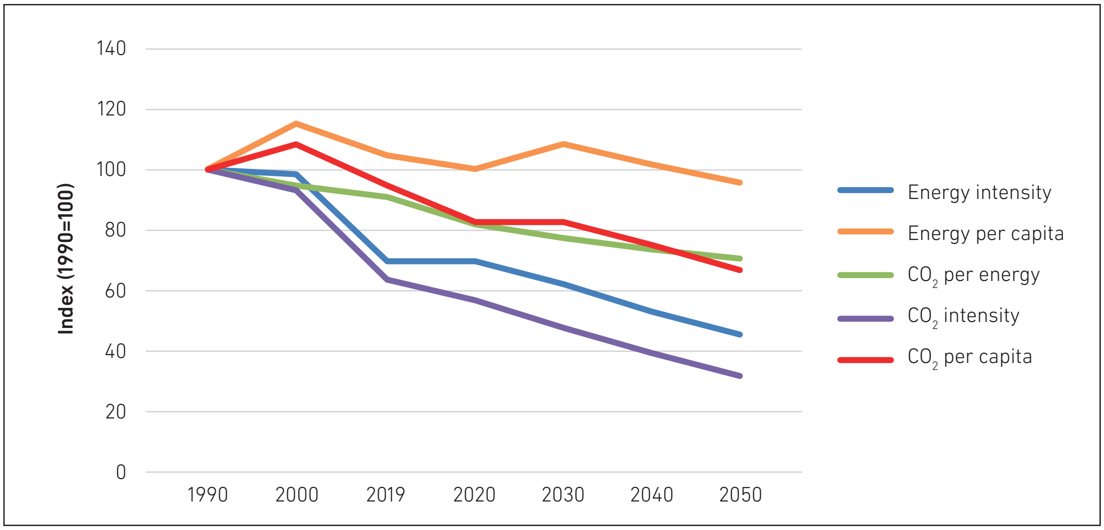
Through its Energy and Energy Efficiency and Conservation Strategies, New Zealand also set a target for 90% of electricity to be generated from renewable sources by 2025 (Ministry of Economic Development, 2011). The government also maintains a range of programmes to promote energy efficiency at home, work, and in transport, as well as the development and deployment of sustainable energy technologies.

3.1.4. Energy Indicators

Primary energy intensity is calculated as the ratio of TPES over GDP, which is the unit consumption of primary energy per million US dollars (constant 2015 US$). The lower growth of the primary energy supply relative to GDP growth will cause lower energy intensity in the future. From 102 tonnes of oil equivalent per million US dollars (toe/US$ million) in 2019, energy intensity will improve to 66 toe/ US$ million in 2050. Primary energy supply per capita will decrease from 4.0 toe per person in 2019 to 3.7 toe per person in 2050.

Carbon dioxide (CO_2) intensity – defined as the ratio of emissions over GDP – is projected to drop by an average rate of 2.2% per year in 2019–2050. Under the BAU scenario, all energy and CO_2 emissions indicators are projected to have similar declining trends (Figure 13.6).

Figure 13.6 Energy Indicators, Business-as-Usual, 1990–2050



CO_2= carbon dioxide.

Source: Author's calculations.

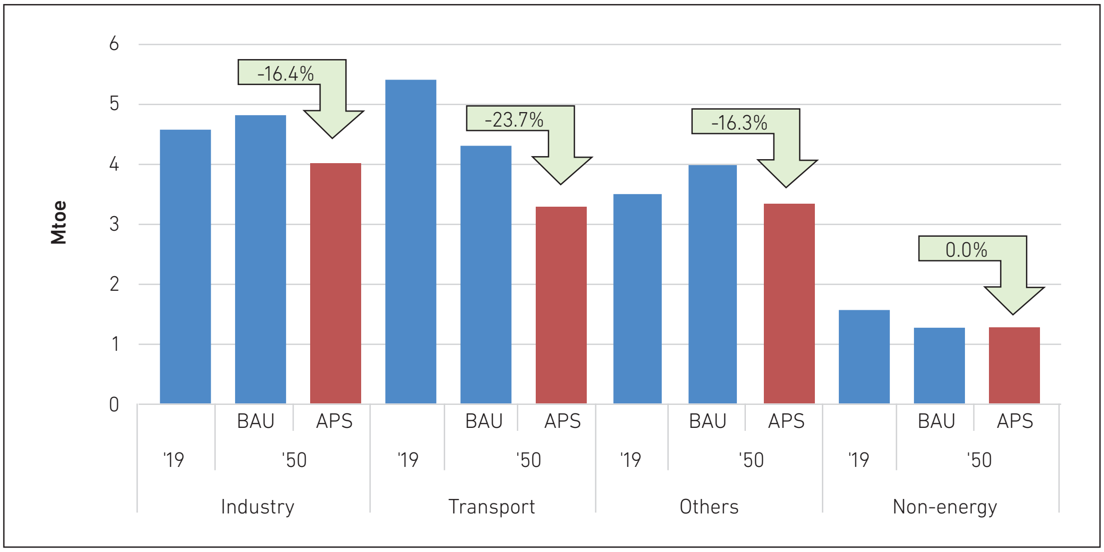
3.2. Energy Saving and Carbon Dioxide Reduction Potential - Alternative Policy Scenario

3.2.1. Final Energy Consumption

The APS predicts the final energy consumption will decrease by an average rate of 0.8% per year in 2019–2050. When compared with the BAU scenario, the transport sector is expected to experience the most significant decline in energy use, with a reduction 23.7% in 2050 due to the shift to more energy-efficient vehicles electric vehicles. The industrial sector is expected to see a decrease by 16.4%, while the 'others' sector, including agricultural, residential, and commercial activities, is predicted to decrease by 16.3%. This reduction is attributed to the use of highly efficient appliances, heat pumps, and compact fluorescent lamp and light-emitting diode light bulbs in the residential and commercial sectors (Ministry of Business, 2019). The non-energy sector is projected to remain unchanged compared to the BAU scenario in 2050. Figure 13.7 shows the final energy consumption in 2019 and 2050 under both the BAU and APS.

Figure 13.7 Final Energy Consumption by Sector, Business-as-Usual and Alternative Policy Scenario, 2019 and 2050

(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

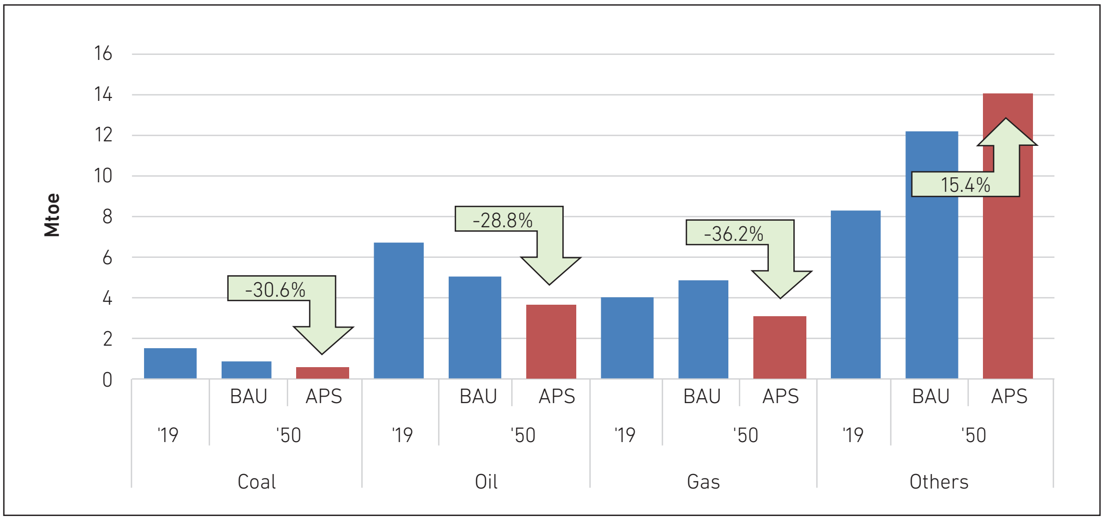
Note: 'Others' includes agricultural, residential, and commercial sectors.

Source: Author's calculation.

3.2.2. Primary Energy Supply

According to projections for the APS, the primary energy supply is projected to grow at a lower rate of 0.1% per year in 2019–2050. In 2050, in comparison to the BAU scenario, the use of gas for primary energy in 2050 is expected to decrease by 36.2%, coal by 30.6%, and oil 28.8%. Primary energy categorised as 'Others', which includes renewable sources such as biomass, solar, wind, liquid biofuels, biogas, hydropower, and geothermal, is expected to grow by 15.4% in 2050, compared to the BAU scenario. Figure 13.8 shows the primary energy supply by source under the BAU scenario and APS.

Figure 13.8 Primary Energy Supply by Source, Business-as-Usual and Alternative Policy Scenario, 2019 and 2050
(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

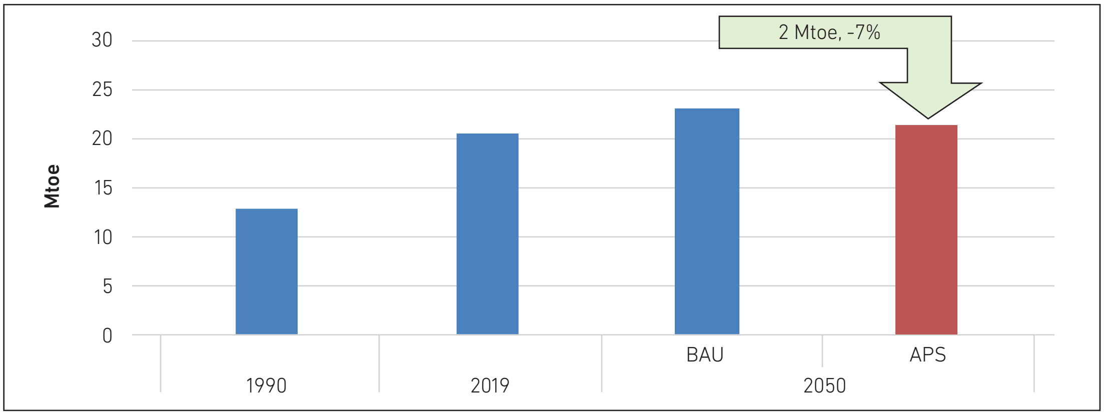
Note: 'Others' includes biomass, solar, wind, liquid biofuels, biogas, hydropower, and geothermal.

Source: Author's calculations.

3.2.3. Projected Energy Savings

In the APS, the primary energy supply is projected to save about 2.0 Mtoe or 7.0% less than under BAU scenario in 2050 (Figure 13.9).

Figure 13.9 Total Primary Energy Supply, Comparison of 2050 Business-as-Usual and Alternative Policy Scenarios to 1990 and 2019
(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The savings in primary energy are due to the adoption of more efficient vehicles, particularly electric ones, in transport. Additionally, with improved insulation, increased use of more efficient appliances, and a shift from incandescent bulbs to compact fluorescent lamp and light-emitting diode light bulbs in the residential and commercial sectors.

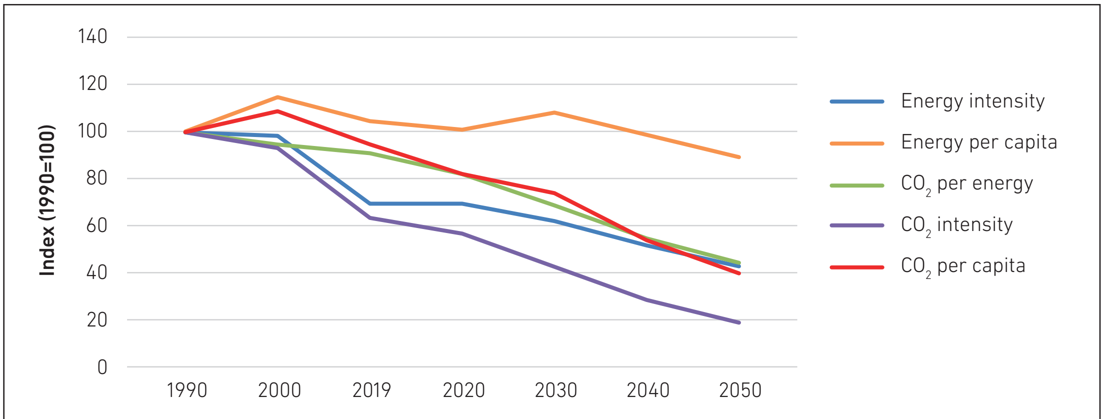
3.2.4. Energy Indicators

Under the APS, primary energy intensity is projected to decline at an average rate of 1.6% per year in 2019–2050. From 1990 to 2019, primary energy intensity declined and was 102 toe/US$ million in 2019. Primary energy intensity will improve to 62 toe/US$ million in 2050 compared with 2019.

Under the APS, a 3.9% annual average reduction in CO_2 intensity is projected from 2019 to 2050. In the BAU scenario, CO_2 intensity will reach 82 toe/US$ million in 2050, while the APS predicts CO_2 intensity will reach 48 toe/US$ million. This represents a 41% reduction in CO_2 intensity compared to the BAU scenario, which equals 34 toe/US$ million.

All energy and CO_2 emission indicators are expected to decline similarly, as shown in Figure 13.10, which displays their trends from 1990 to 2050 under APS.

Figure 13.10 **Energy Indicators, Alternative Policy Scenario, 1990–2050**



CO_2= carbon dioxide.

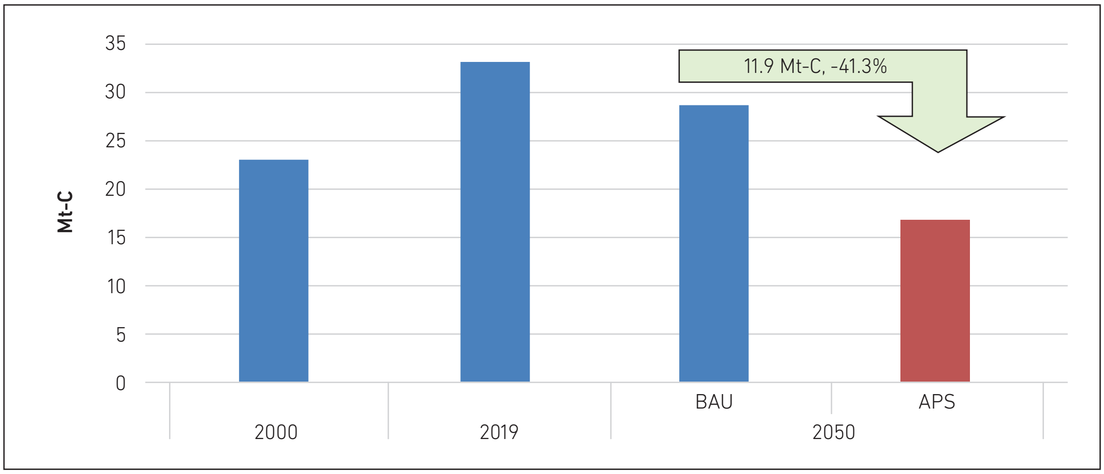
Source: Author's calculations.

3.2.5. Carbon Dioxide Emission Reduction

Under the BAU scenario, CO_2 emissions will decrease from 33.2 million tonnes of carbon dioxide (Mt-C) in 2019 to 28.7 Mt-C in 2050. Compared to the BAU scenario, the APS would result in a reduction of 41.3% in CO_2emissions, reaching 16.8 Mt-CO_2 in 2050. This decrease in emissions reflects the switch to renewable energy in electricity generation and the switch to electric vehicles in transport. Figure 13.11 provides a comparison in CO_2 emissions from fossil fuel combustion between the BAU scenario and APS in 2050 and levels recorded for 1990 and 2019.

Figure 13.11 Carbon Dioxide Emissions from Fossil Fuel Combustion, Comparison of 2050 Business-as-Usual and Alternative Policy Scenario to 1990 and 2019

(Mt-C)



APS = alternative policy scenario; BAU = business-as-usual; CO_2 = carbon dioxide; Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

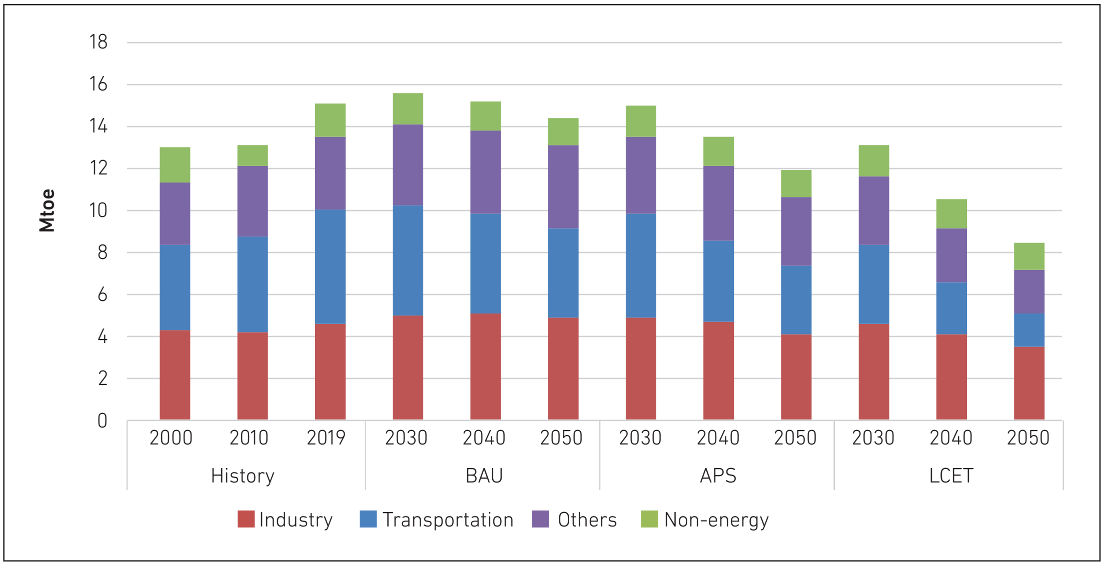
3.3. Low Carbon Energy Transition Scenario – Carbon Neutral

3.3.1. Final Energy Consumption

In the LCET scenario, the average annual decrease rate of TFEC will be 1.9% from 15.0 Mtoe in 2019 to 8.4 Mtoe in 2050. Throughout this period, TFEC will remain lower than in the LCET than in the BAU scenario (decreases 42% in LCET compared to BAU) and APS (decreases 30% in LCET compared to APS). The highest reduction in energy consumption will occur in transport, which will decrease by 70% between 2019 and 2050. The 'Others' sector, which includes agricultural, residential, and commercial, will decrease by 40%, industrial sector by 26%, and non-energy sector by 19% in 2050.

In 2050, the transport in the LCET is expected to decrease by 62% compared to BAU and 51% compared to APS. The 'others' category (agricultural, residential, and commercial) will decrease by 47% in BAU and 37% in APS, while industry is projected to decrease by 29% in BAU and 15% in APS. LCET's non-energy sector in TFEC is projected to remain unchanged, as shown in Figure 13.12.

Figure 13.12 **Final Energy Consumption by Sector, Low Carbon Energy Transition Scenario, 2000–2050**
(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes agricultural, residential, and commercial sectors.

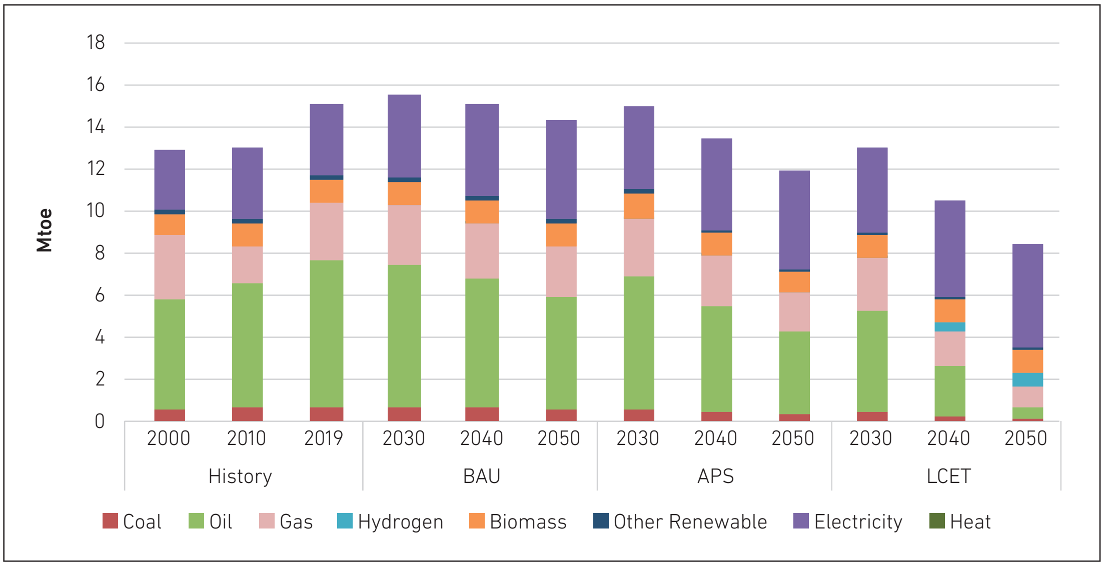
Source: Author's calculations.

From 2019 to 2050, in the LCET scenario, TFEC reduction will come from oil at 0.6 Mtoe (92% decrease), coal at 0.1 Mtoe (85% decrease), gas at 0.9 Mtoe (65% decrease), and other renewable sources (geothermal, solar, and biogas) at 0.08 Mtoe (59% decrease). In the same period, electricity demand is projected to increase by 45% and biomass by 3.9%. Hydrogen demand is projected to increase from 0.2% in 2030 to 8.2% in 2050.

There will be a substantial reduction in oil consumption by 89% compared to the BAU scenario and 86% compared to the APS in 2050. Coal consumption will also decline significantly, with a decrease of 82% compared to BAU and 66% compared to APS. In addition, natural gas will decrease by 59% and other renewable consumption by 57% compared to BAU, and by 49% and 43% respectively compared to APS (Figure 13.13).

Figure 13.13 Final Energy Consumption by Source, Low Carbon Energy Transition Scenario, 2000–2050

(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent.

Note: 'Other Renewable' includes geothermal, solar, and biogas.

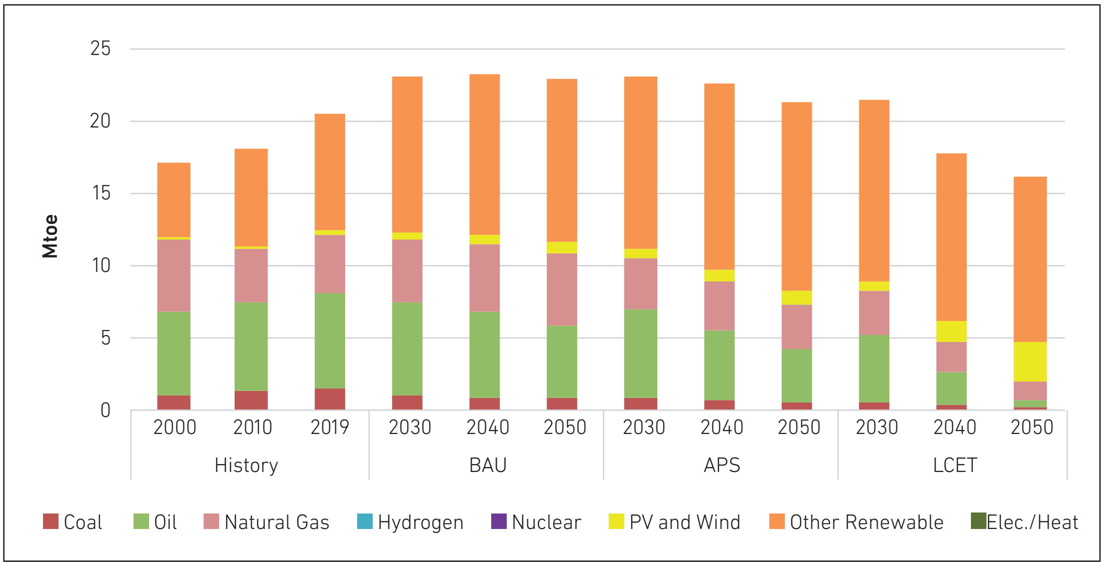
Source: Author's calculations.

3.3.2. Primary Energy Supply

In the LCET scenario, primary energy supply will decrease by an average rate of 0.8% per year from 2019–2050. In comparison, the increase in BAU is 0.4% and 0.1% per year in APS. Oil will decrease rapidly each year by 8.2% in the LCET scenario, by 0.9% in BAU and by 2.0% per year in APS. Coal will also decrease by 6.8% in LCET, by 1.7% in BAU, and by 2.9% per year in APS. Natural gas is projected to decrease by 3.6% per year, while other renewable sources, which include hydro, geothermal, biomass, solar, liquid biofuels, and biogas, are projected to increase by an average rate of 1.1% per year in 2019–2050 (Figure 13.14).

Figure 13.14 Primary Energy Supply by Source, Low Carbon Energy Transition Scenario, 2000–2050

(Mtoe)



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mtoe = million tonnes of oil equivalent; PV = photovoltaics.

Note: 'Other renewable' includes hydro, geothermal, biomass, solar, liquid biofuels, and biogas.

Source: Author's calculations.

3.3.3. Power Generation

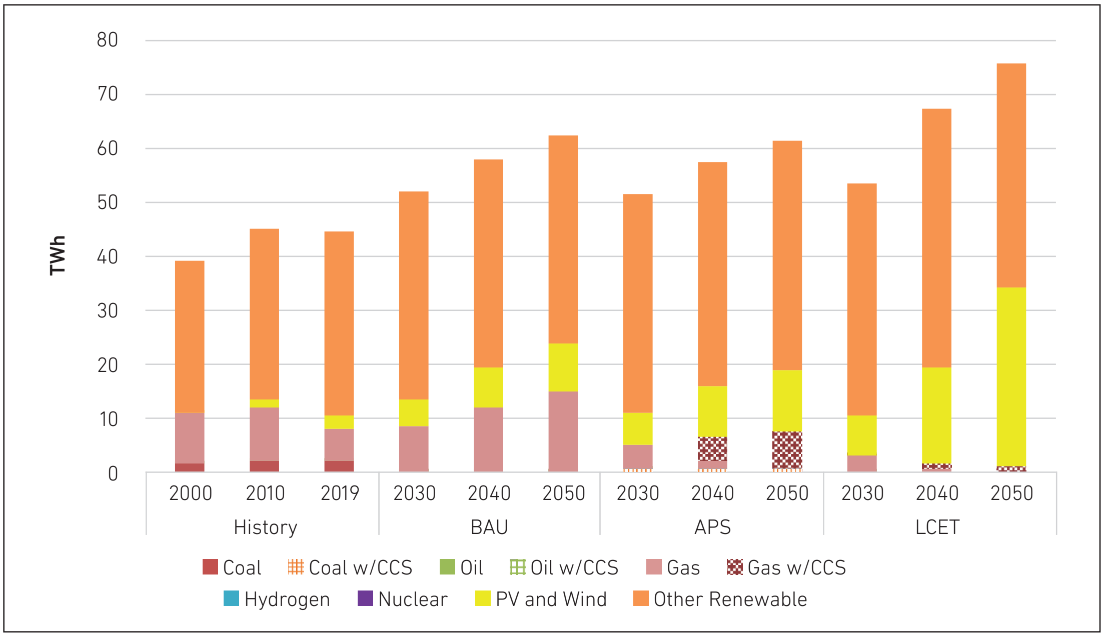
Figure 13.15 shows both the history of power generation in BAU, APS, and LCET scenarios for 2000–2019 and outlook in 2030–2050. All scenarios are projected to increase in power generation from 2030 to 2050. In the LCET scenario, power generation is projected to grow significantly at 69.1% in 2019–2050. In comparison to the LCET scenario, power generation increases only by 39.4% in the BAU and by 37.0% in the APS.

Under the LCET, power generation is projected to increase at an average rate of 1.7% per year, from 32.3 TWh in 2019 to 75.8 TWh in 2050. The share of other renewable sources is projected to fall from 76.4% in 2019 to 54.5% in 2050, but solar photovoltaics (PV) and wind are projected to grow from 5.4% in 2019 to 44.0% in 2050. The percentage of gas and coal will decrease significantly. Specifically, the share of gas, which was 13.1% in 2019, and the share of coal, which was 5.1% in 2019 are both expected to decline to 0.0% in 2050.

The APS projects that carbon capture and storage (CCS) will be used to generate 11.4% of the total power generated from gas and 1.0% of the total power generated from coal by 2050. The share of total power generated from gas that will utilise CCS under the LCET, accounts for 1.5% in 2050.

Figure 13.15 **Power Generation, Business-As-Usual, Alternative Policy Scenario and Low Carbon Energy Transition Scenarios, 2000–2050**

(TWh)



APS = alternative policy scenario; BAU = business-as-usual; CCS = Carbon capture and storage; LCET = low carbon energy transition; PV = photovoltaics; TWh = terawatt-hour.

Note: 'Other renewable' includes hydro, geothermal, biomass, solar, and biogas.

Source: Author's calculations.

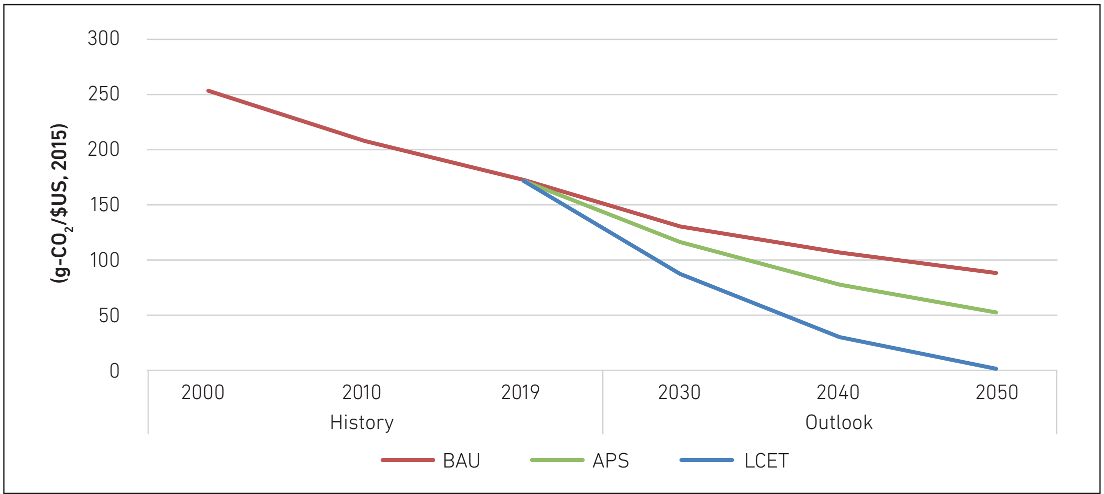
3.3.4. Energy Indicators

The ratio of emissions to GDP is used to measure CO_2 intensity, expressed as the unit of CO_2 emission per US dollar (g-CO_2/US$) at a constant 2015 US$ rate. Figure 13.16 shows CO_2 intensity in the BAU, APS and LCET scenarios from 2020 to 2050. The projections indicate that CO_2 intensity in all three scenarios will exhibit a declining trend from 2019 to 2050. Specifically, the LCET scenario anticipates a 15.7% average yearly reduction in CO_2 intensity in 2019–2050, which will result in net zero emissions in 2050. The Government of New Zealand has committed to reaching this target, along with a 24%–47% reduction in biogenic methane emissions by 2050.

In the APS, CO_2 intensity will improve from 173 g-CO_2/US$ in 2019 to 51 g-CO_2/US$ in 2050. This is faster than in the BAU scenario wherein it will reach 86 g-CO_2/US$ in 2050.

Figure 13.16 Energy Indicators, Business-as-usual, Alternative Policy Scenario and Low Carbon Energy Transition Scenario, 2020–2050

($g-CO_2$/$US, 2015)



APS = alternative policy scenario; BAU = business-as-usual; $g-CO_2$ = gram of carbon dioxide; LCET = low carbon energy transition.

Source: Author's calculations.

3.3.5. Saving of Fossil Fuel Consumption and Carbon Dioxide Reduction

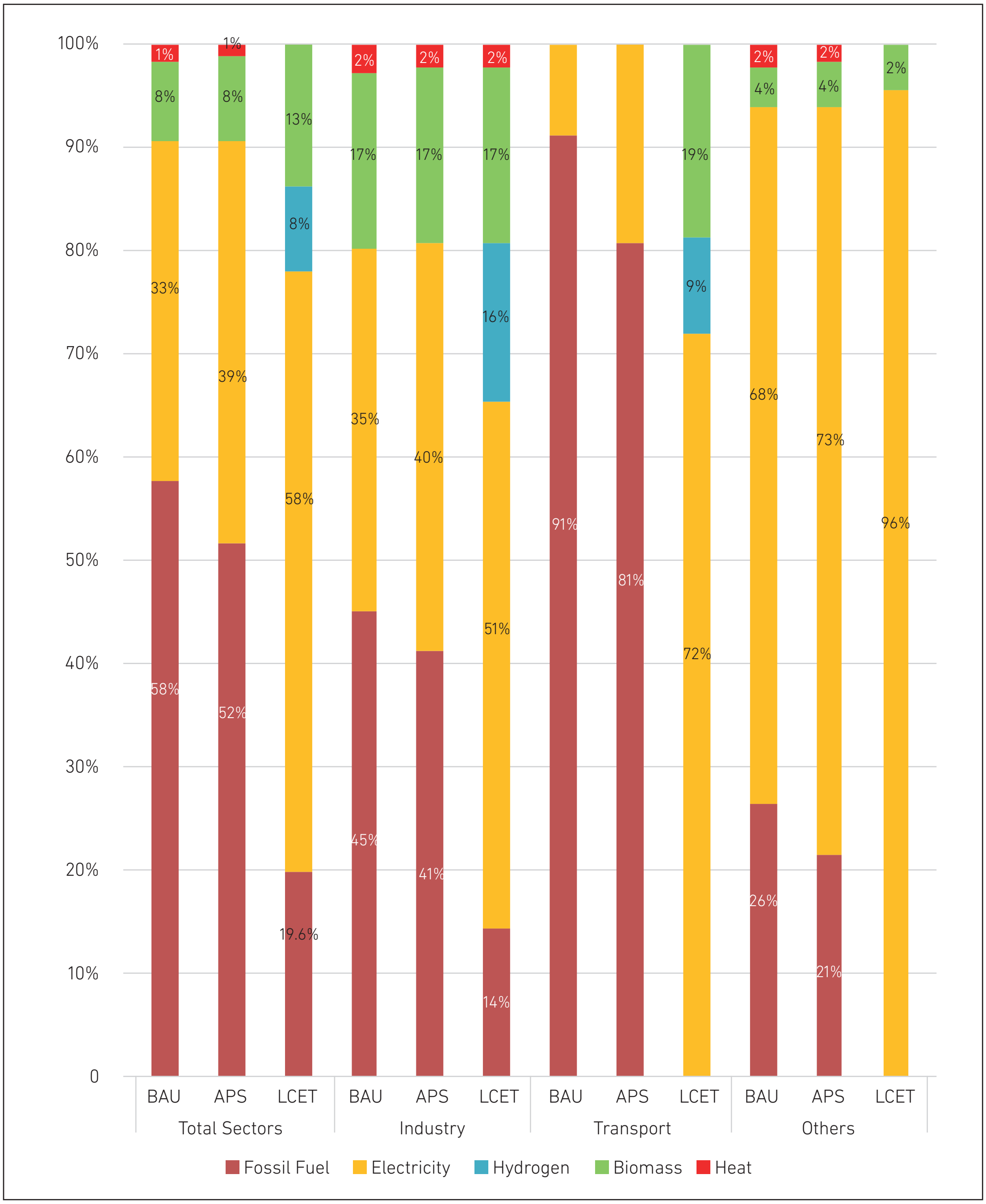
a. Saving of Fossil Fuel Consumption

Figure 13.17 shows the distribution of TFEC across sectors and sources in the BAU, APS, and LCET scenarios in 2050. The LCET scenario shows that fossil fuel consumption's share in TFEC is merely 20%, which is lower than its share in BAU (58%) and APS (52%) scenarios. In terms of sectors, the LCET scenario demonstrates a substantial potential for electrification in the 'others' category (96%), which includes agricultural, residential, and commercial sectors; transport (72%); and industry (51%) in TFEC. This electrification potential can help in reducing energy consumption and decarbonising the economy by 2050.

Under the LCET scenario, an increased share of hydrogen in the TFEC used for industry (16%) and transport (9%) in 2050 will also contribute to decarbonisation.

Figure 13.17 Savings of Fossil Fuel Consumption and Carbon Dioxide Reduction, 2050

(%)



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition.

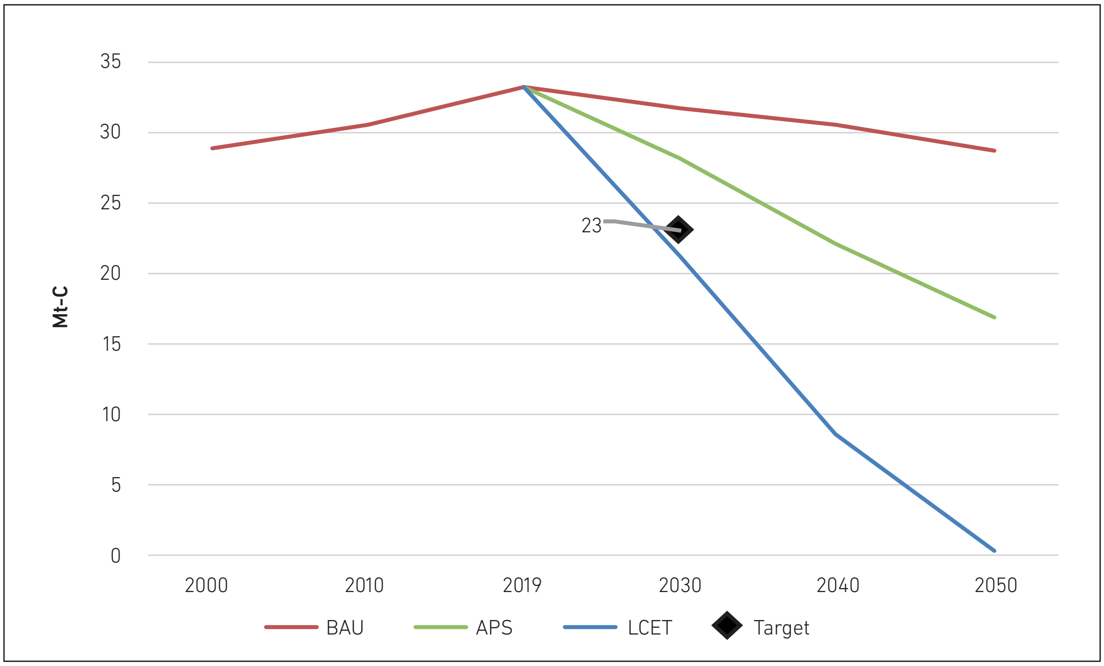
Note: 'Others' includes agricultural, residential, and commercial sectors.

Source: Author's calculations.

b. Carbon Dioxide Reduction

From 2019 to 2050, CO_2 emissions are expected to decline the BAU, APS, AND LCET scenarios are expected to decline. The LCET scenario projects a yearly reduction of 15.7% in CO_2 emissions from energy demand, leading to a decline from 33. 2 Mt-CO_2 in 2019 to around 0.2 Mt-CO_2 in 2050. Figure 13.18 shows the history of CO_2 emissions during 2000–2019 and outlook for 2030–2050 in the three scenarios, with a target to reduce CO_2 emissions by 30% in 2030 from 2005 levels.

Figure 13.18 Carbon Dioxide Reduction, 2020–2050
(Mt-C)



APS = alternative policy scenario; BAU = business-as-usual; LCET = low carbon energy transition; Mt-C = million tonnes of carbon dioxide.
Source: Author's calculations.

4. Implications and Policy Recommendations

Although New Zealand's primary energy intensity (energy per dollar of GDP) in the BAU scenario has been declining from 147 toe/US$ million in 1990 to 66 toe/US$ million in 2050, energy use continues to grow steadily due to factors such as economic growth, population growth, and increasing numbers of private road vehicles. However, in 2011, New Zealand set ambitious goals to generate 90% of its electricity from renewable sources by 2025 and reduce greenhouse gas emissions by 30% in 2005–2030 and 50% in 1990–2050. As of 2021, New Zealand was generating about 82% of its electricity from renewable sources, with solar generation up 28%, wind up 15%, and biomass up 2%, contributing to this increase (Ministry of Business, 2022). In contrast, non-renewable sources such gas fell 21.5%, despite a historically high coal consumption during that year.

The LCET scenario predicts a decline in the growth rate of the TFEC by 1.9% per year in 2019–2050. This rate of decline is faster than under APS (0.8%) and BAU (0.2%). By 2030–2050, New Zealand's CO_2 emissions are expected to be significantly lower in the LCET scenario than in 1990. However, 2019–2050, CO_2 emissions are projected to decrease only slightly in by 0.5% per year in BAU and 2.2% in APS. In the LCET scenario, CO_2 emissions are projected to reach net zero by 2050, with a yearly reduction of 15.7% in 2019–2050. The adoption of hydrogen in heavy vehicles and its use for electricity system support and export will further aid in decarbonisation (Castalia Limited, 2022). The LCET scenario forecasts the share of hydrogen in the TFEC to increase from 0.2% in 2030 to 8.2% in 2050.

The government has committed to reaching net-zero emissions of long-lived gases by 2050 and reducing biogenic (plant and animal) methane emissions by 24%–47% by 2050. In January 2021, the Climate Change Commission (CCC) provided preliminary recommendations to the government and outlined the policy direction necessary to meet the targets. Following this, the commission presented its recommendations to the Minister of Climate Change, and in June 2021, it was submitted to Parliament for consideration (Climate Change Commission, 2021).

In May 2022, the CCC was granted additional funding to help the government in making decisions about achieving Aotearoa New Zealand's emissions reduction goals and adapting to the effects of climate change (Climate Change Commission, 2022).

In July 2022, the Minister of Climate Change released regarding updates to the unit limits and price control settings for the New Zealand Emissions Trading Scheme (NZ ETS) over the next five years. Per this advice, '[t]he unit limits aim to cap the emissions allowed by the scheme, in line with the country's emissions reduction targets. The price control settings are guardrails to provide stability to the NZ ETS, while also enabling it to operate as an effective tool to reward low emissions choices' (Climate Change Commission, 2022).

The Commission's advice is now entering a new phase, which involves monitoring Aotearoa New Zealand's progress on reducing its emissions and on adapting for climate change.

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CHAPTER 14

Philippines Country Report

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1. Background

1.1 Socio-Economic

The Republic of the Philippines (the Philippines) is an archipelagic country in Southeast Asia. It comprises 7,641 islands. It is in the western Pacific Ocean and composed of three main geographical archipelago or divisions: Luzon, Visayas, and Mindanao. The country's capital, the National Capital Region (NCR) – commonly known as Metro Manila or Manila – is in Luzon. In 2019, the country's economic output grew by 6.1%, this is 0.2% lower than the 2018 level of 6.3%. The main drivers of growth for the fourth quarter (Q4) of 2019 were trade and repair of motor vehicles, motorcycles, personal and household goods; manufacturing; and construction.[1] Services accounted for 60.4% of the total gross domestic product (GDP). The industrial sector accounted for 30.4%. Agriculture, forestry, and fishing accounted 9.2% of the total GDP. Regionally, the NCR registered the largest share in the economic output at 32.1%.

Amongst the major economic sectors, services posted the fastest growth in Q4 2019 with 7.9% while industry grew by 5.4%. Agriculture, hunting, forestry, and fishing registered a growth of 1.5%.

The country's population was projected to reach 108.7 million by the end of 2019, while the GDP growth rate was 4.8% and final consumption expenditure grew by 3.9% in 2019.

1.2. Policy

The economic growth of the country heavily relies on its energy sector, which is why the Philippine Department of Energy (DOE) places great emphasis on consumer-oriented policies, reliable energy supply, and environmental sustainability. During the Duterte Administration, the DOE set forth a set of strategic directions and energy agenda aimed to attain the development goals as envisioned in the *Ambisyon* 2040, the blueprint of a long-term, collective vision and aspirations of Filipino people. These goals are supported by national economic strategies that aim to create opportunities for inclusive growth.

The DOE has established eight "Energy Sector Strategic Directions": (1) ensure energy security; (2) expand of energy access; (3) promote of a low carbon future; (4) strengthen of partnership and collaboration between private sector and government agencies on energy-related issues; (5) implement, monitor, and integrate sector and technology roadmaps and action plans; (6) advocate the passage of DOE's legislative agenda; (7) strengthen consumer welfare and protection; and (8) foster international relations and partnerships.

[1] Gross domestic product posts 6.4% growth in the fourth quarter of 2019. Philippine Statistics Authority, https://psa.gov.ph/content/gdp. Accessed on 31 August 2022.

The Philippine Energy Plan (PEP) 2020–2040 aims to attain a clean energy future that is sustainable and energy resilient. The direction set under the recent PEP includes the aggressive Renewable Energy (RE) and Energy Efficiency and Conservation (EEC) institutionalisation programmes; the moratorium on new coal power projects; a mechanism allowing foreign ownership on large-scale geothermal projects under financial and technical assistance agreement (FTAA); the resumption of indigenous oil and gas exploration; the introduction of liquified natural gas (LNG) portfolio; establishment of strategic petroleum reserves; and exploration of hydrogen's potential. The PEP policies aim to unify the planned transition and transformation under its Clean Energy Scenario (CES). They encompass ambitious plans, strategies, and benchmarks for renewable energy, natural gas, alternative fuels, and energy-efficient technologies.

The following policies represent important achievements aligned with the strategic directives:

- In 2019, President Rodrigo R. Duterte signed Executive Order (EO) No. 30 to create an Energy Investment and Coordinating Council (EICC) with the priority task of streamlining the permitting and approval procedures for Energy Projects deemed of "National Significance". This was accomplished by harmonising rules and regulations of all government agencies involved with obtaining permits and regulatory approvals.
- Passage of RA No. 11234 – or the Energy Virtual One-Stop Shop (EVOSS) Act – signed 08 March 2019. The EVOSS is an online system that allows the coordinated submission and synchronous processing of all required data and information. It provides a single decision-making portal for actions on applications for permits and/or certification necessary for, or related to, an application of a proponent for new power generation, transmission, or distribution projects.
- The Philippine Downstream Natural Gas Regulation (PDNGR) was issued in 2019 to establish the rules and regulations that govern the downstream natural gas industry. It encompasses provisions that enable gas-fired power plants to continue operating in the absence of natural gas supply from Malampaya, the country's indigenous natural gas resource. This is in line to transform the country into a regional LNG trading transhipment hub.
- The issuance of Department Circular No. DC2018-01-0001, titled the 'Adoption of Resiliency Planning and Program in the Energy Industry to Mitigate Adverse Effects Brought About by Disasters', has facilitated the mainstreaming of the Resiliency Planning and Program. The policy paves the way for the inclusion of disaster risk and reduction programmes in energy project planning and investments, as well as the adoption of both engineering and non-engineering mechanisms on existing energy infrastructure. These measures ensure continuous delivery of energy services to consumers.
- In 2019, the Energy Efficiency and Conservation Act, or RA No. 11285, was enacted to promote the efficient use of energy in the country. The law seeks to accomplish this goal by establishing policy mechanisms and standards across various sectors.
- R.A. No. 11697, or the Electric Vehicles Industry Development Act (EVIDA), was passed to decrease the transport sector's reliance on imported fuel to safeguard the country's energy security and independence. The law provides a conducive environment for the development of electric vehicles, which includes options for micro mobility as an attractive and feasible mode of transportation, to reduce dependence on fossil fuels.

- The power sector has adopted and integrated pertinent policies, such as the Renewable Portfolio Standard (RPS) for On-Grid Areas. This standard seeks to produce a specific portion of the electricity demand from eligible renewable energy sources to develop indigenous and environment friendly energy sources. The goal is to attain the ambitious target of 35% share in the generation mix by 2030.
- In response to the country's future energy demands, Department of Energy issued Department Order No. DO2016-01-0013 entitled "Creating the Nuclear Energy Program Implementing Organization (NEPIO) in the Department of Energy". The NEPIO is responsible for proposing a national policy on nuclear energy. On July 24, 2020, President Rodrigo R. Duterte issued Executive Order (EO) No. 116 entitled "Directing a Study for the Adoption of a National Position on a Nuclear Energy Program, Constituting a Nuclear Energy Program Inter-Agency Committee, and For Other Purposes". This policy expands the involvement of other government agencies that would establish the country's policy on nuclear energy and determine its feasibility as a long-term option for power generation.
- Another milestone for the energy sector is the issuance of EO No. 164, which was signed by President Rodrigo Duterte on 28 February 2022. The EO seeks to adopt a national position on energy that considers economic, political, social, and environmental issues related to nuclear power development.

The power sector implements a 25.0% reserve requirement to meet the peaking requirement of the Luzon, Visayas and Mindanao grid. In addition, efforts to develop and promote indigenous energy, such as renewable energy and hydrocarbon fuels (oil, gas, and coal), and the use of clean and smart technologies, has been on the priority list to augment the country's long-term energy needs.

Below are some highlights of the Philippine energy sector's plans and programmes:

The National Renewable Energy Program 2020–2040

The Renewable Energy Act of 2008, also known as RA No. 9513, supports the policy and programme framework to encourage the use of renewable energy resources and technologies. On 14 June 2011, the Government of the Philippines unveiled the National Renewable Energy Program (NREP), also called the "Green Energy Roadmap," as part of the DOE's Energy Reform Agenda. The NREP outlines the policy and programme framework to promote the use of renewable energy and establish a roadmap to achieve the market penetration targets of each renewable. The updated renewable energy roadmap aims to increase the installed renewable energy capacity target of 15,304 megawatt (MW) by 2030 to at least 20,000 MW by 2040. In June 2022, the 2020–2040 NREP, which was the first update of the NREP was signed. It aligned the renewable energy targets with the country's long-term vision known as the "AmBisyon Natin 2040" and reinforced the on a whole-of-nation approach to achieve the renewable energy goals and leverage its positive socio-economic benefits.

Implementation of Biofuels Blending as Mandated by the "Biofuels Act of 2006"

The aim of the Biofuels Act of 2006 is to utilise the local agricultural resources of the country as potential raw materials for biofuel production. This aims to support the country's goal of energy security while also augmenting earnings of farmers, generating employment opportunities in rural areas, and reducing greenhouse gas (GHG) emissions.

Since May 2007, a mandatory 1.0% biodiesel blend has been required in all diesel fuel sold in the country. In February 2009, the blending requirement was voluntarily increased to 2.0%. Using E10 (10%) bioethanol blend, which is supplied by most gasoline retailers, has proliferated in the country. The DOE and the National Biofuels Board (NBB) are currently revisiting and reassessing the blending requirement, considering the availability of feedstock, to ensure compliance with the Biofuels Law and facilitate the scheduled blending of biofuels.

Intensification of Electricity Access through Household Electrification

Energy access is a key to poverty alleviation. In the Philippines, providing electricity is now focused on providing electricity at the household level. Starting 2017, the total potential households being adopted for the Total Electrification Program (TEP) is 22,984,971. The data is based on the 2015 Census of Population (POPCEN2015) of the Philippine Statistical Authority (PSA).

As of 2019, household electrification level reached 92.9%, with approximately 23.2 million households having access to electricity.[2] Meanwhile, there were still around 1.6 million households that remained unserved based on data from the distribution utilities during the same year. In terms of grid-level electrification, Luzon had the highest electrification at 97.8%, followed by Visayas at 93.9%, and Mindanao at 80.0% in 2019. Further, there are various grid and off-grid programs in the Household Electrification Development Plan (HEDP) that aim to provide electricity to all targeted and identified households accessible to the grid by 2022, thus contributing to 100% electrification.

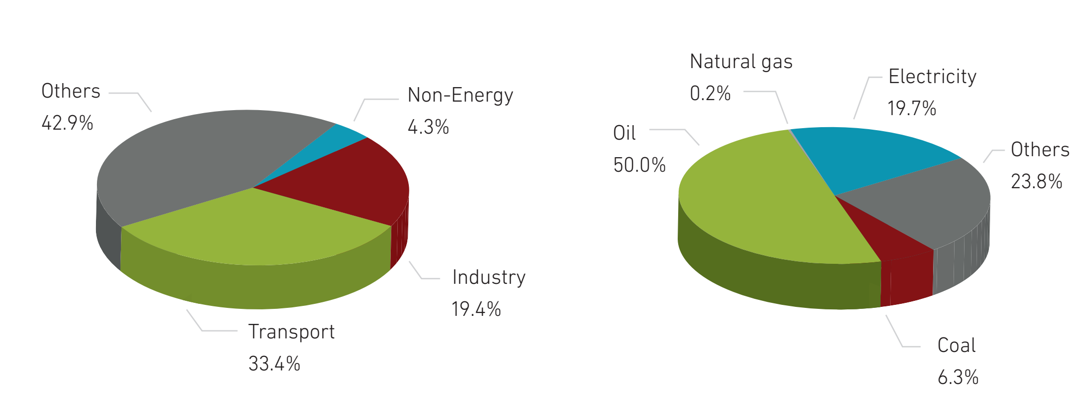
1.3. Energy Supply-Demand

In terms of demand, the country's total final energy consumption in 2019 was recorded at 37.9 million tonnes of oil equivalent (Mtoe). Amongst the fuels, oil comprised the largest share with 50.0% (18.9 Mtoe), which can be attributed to the fuel demand by the transport sector. Electricity, which is consumed in all sectors, accounts for the second most used fuel in the country, accounting for 19.7% (7.5 Mtoe). Other fuels (biomass and biofuels) accounted for 23.8% of the total energy demand. Biomass (7.3 Mtoe), which comprised 80.0% of the other fuels and 19.7% share of the total demand, was mainly consumed in households.

According to Figure 14.1, when energy usage is analysed by sector, transport has been the largest consumer, representing 33.4% of the total demand. Industry, in contrast, accounted for approximately 19.4%. Meanwhile, the combined total of the 'Other' sector – comprised of residential, commercial and agriculture, forestry and fishery (AFF) – accounted for the 42.9% of the total energy demand.

[2] Potential households (HH) minus unserved HH divided by potential HH.

Figure 14.1 **Total Final Energy Consumption, Fuel and Sector Shares, 2019**
%

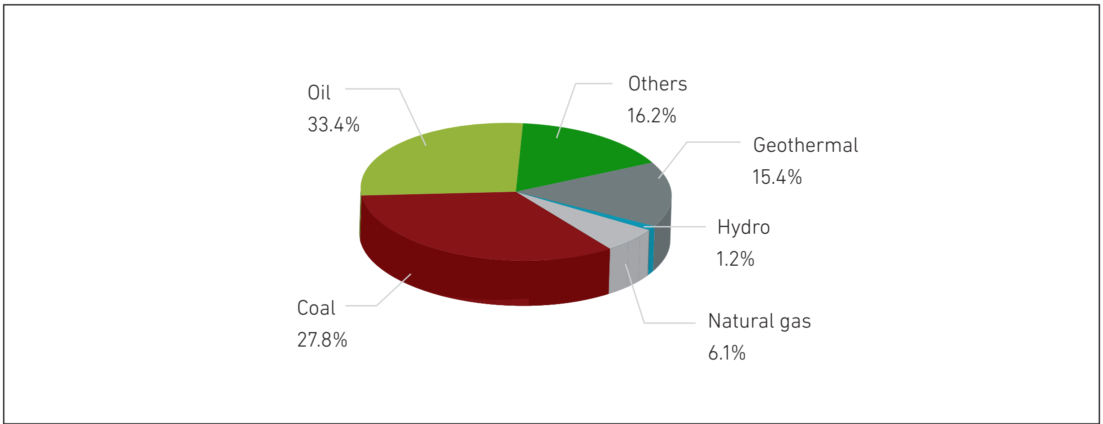


Note: 'Others' includes residential, commercial, and agriculture, forestry and fishery.

Source: Department of Energy, 2019.

The country's total primary energy supply in 2019 reached 60.0 Mtoe (Department of Energy [DOE], 2019). Oil continued to be the major source of supply, which accounted for 33.4% in the total energy supply, followed by coal at 27.8% and geothermal at 15.4%. Meanwhile, the share of indigenous production to the total supply, known as energy self-sufficiency, reached 51.6% (Figure 14.2).

Figure 14.2 **Total Primary Energy Supply Mix, Fuel Shares, 2019**
%



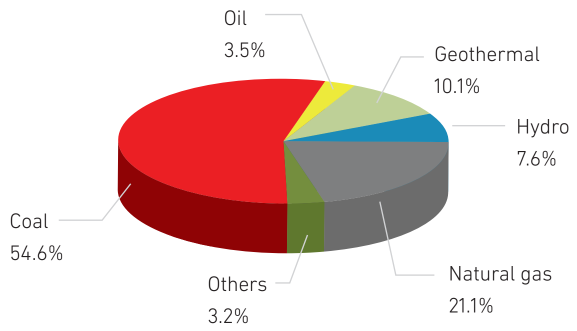
Note: 'Others' include biomass, solar, wind, bioethanol and biodiesel.

Source: Department of Energy, 2019.

Meanwhile, the country's total electricity generation in 2019 reached 106.4 terawatt-hours (TWh). Coal-fired power plants remained as the major source for power generation with total installed capacity of 10,417 MW during the period. Coal contributed 54.6% or 57.9 TWh in the total power generation mix of the country. Meanwhile, natural gas-fired power plants accounted for 21.1% or 23.4 TWh in the power mix. The country's natural gas power plants have a combined installed capacity of 3,286 MW. the combined share of renewable energy in the total power generation mix was registered at 20.8% during the period (Figure 14.3).

Figure 14.3 Total Power Generation Mix, Fuel Shares, 2019

%



Note: 'Others' include biomass, solar and wind.

Source: 2019 EBT, DOE – Philippines.

2. Modelling Assumptions

In energy modelling, gross domestic product (GDP) is the most common parameter for forecasting energy demand growth. In the model, GDP is projected to grow at an annual rate of around 5.3% for 2019–2050. Population is another crucial factor that affects energy demand, and it is expected to grow at a yearly rate of 1.5% during the same period. The population count of 109.0 million is based on the 2020 census of population and housing and was declared official by President Rodrigo Duterte through Proclamation No. 1179 dated 06 July 2021.

Due to the impact of the coronavirus disease (COVID-19) pandemic, the country's GDP experienced a negative growth of 9.5% in 2020 compared to its 2019 level. Meanwhile, an annual GDP growth rate of 6.9% is assumed for 2020–2030, incorporating the government's economic recovery programme to stimulate growth. Following a positive economic outlook, the total GDP is projected to grow at an annual rate of 5.4% for from 2030 to 2040 and 5.0% per year from 2040 to 2050. Table 14.1 provides a breakdown of the GDP growth rate assumptions.

Table 14.1 The Assumptions of GDP Annual Growth Rates, 2019–2050

Parameter	ID Name	Growth Rates (%)				
		2019–2020	2020–2030	2030–2040	2040–2050	2019–2050
GDP (constant 2010 US$)	GDP10	-9.5	6.9	5.4	5.0	5.3

GDP = gross domestic product.

Source: Authors assumption.

Population growth is a significant factor, along with GDP, for energy demand growth. Table 14.2 provides the assumed population growth.

Table 14.2 The assumptions of Population Annual Growth Rates, 2019–2020 and 2020–2050 (%)

Parameter	ID Name	Growth Rates (%)	
		2019–2020	2020–2050
Population	POP	1.4	1.5

Source: Based on author's calculation.

3. Outlook Results

3.1. Business-as-Usual Scenario

The BAU scenario serves as the baseline case for forecasting the energy demand and carbon dioxide (CO_2) emission of the energy sector. It incorporates the energy sector's existing energy policies, plans, and programmes, which are being implemented and will be pursued within the forecast period.

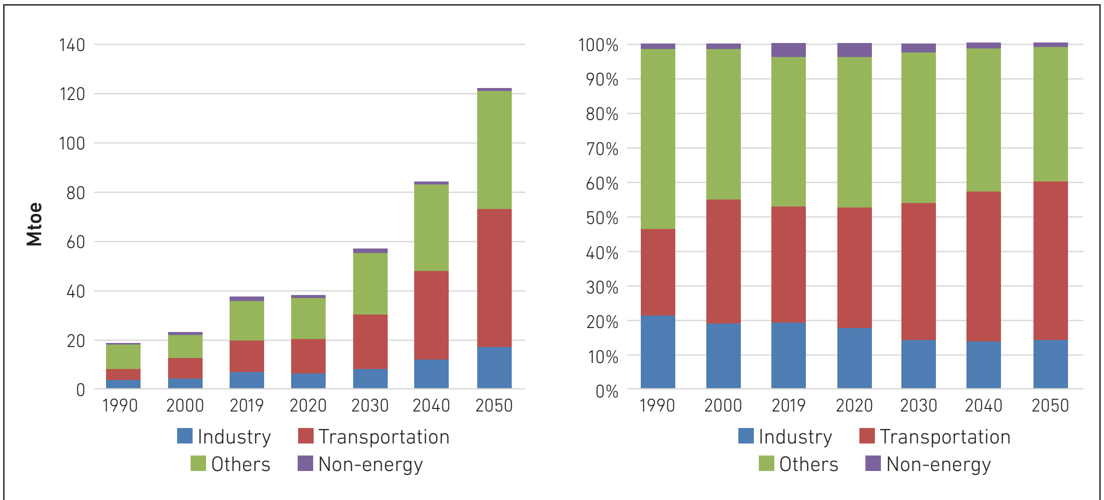
3.1.1. Total Final Energy Demand

a. Total Final Energy Demand by Sector

From 1990 to 2019, the Philippine witnessed a growth in final energy demand from 19.0 Mtoe in 1990 to 37.9 Mtoe, with an average annual growth rate of about 2.4%. During this period, energy demand in the transport sector grew the fastest at an average annual rate of 3.5%, followed by the industry sector at 2.0%. Other sectors – consisting of residential; commercial; and agriculture, forestry and fishery (AFF) – which had the largest share of 51.6% in 1990, saw a decline in their contribution to the total final energy demand mix, dropping to 42.9% due to its slow annual growth rate at an average of 1.8% during 1990–2019.

Over the planning period from 2019 to 2050, the business-as-usual scenario projects an annual average growth rate of 3.8% in final energy demand. By the end of 2050, the transport sector is expected to become the most energy-intensive, increasing its share from 24.6% in 2019 to 45.5%. It is expected to grow at an average rate of 4.9% per year. Industry will grow at an average annual rate of 2.9%, thanks to government initiatives aimed to boost the manufacturing sector. Meanwhile, the combined demand from the other sectors will contribute a substantial share of 38.6% in the total final energy demand by 2050, with an expected average growth rate of 3.1% per year (Figure 14.4). The ongoing growth of the commercial sector, coupled with the enhancement of services and the business environment, as well as the government's modernisation programmes in the agriculture sector, are the reasons behind this trend.

Figure 14.4 Total Final Energy Consumption, Sector, Business-as-Usual, 1990–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' include commercial, residential, and agriculture, forestry and fishing.

Source: 1990-2019 data (2019 EBT. DOE – Philippines; 2020-2050 data (Author's calculation).

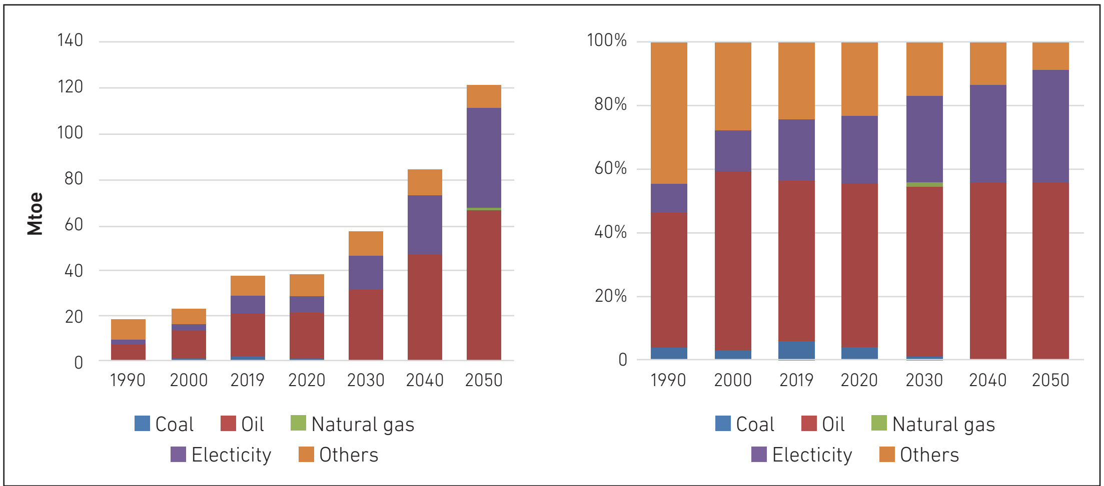
b. Total Final Energy Demand by Fuel

Throughout the planning period, petroleum products remain the most extensively consumed fuel due to their high demand in transport. In 2019, oil demand held about 50.0% of the total demand mix. Projections show a notable surge in oil demand of up to 4.7% by the end of 2030. However, this growth rate slightly decreases to 3.8% by 2050 due to the adoption of energy efficiency and conservation measures, the use of more efficient technology, and fuel switching in the end-use sector.

Electricity, which had a 19.7% share of 19.7% in the demand mix in 2019, is expected to grow at an annual rate of 5.9% and reach 35.8% in 2050. Electricity demand will expand five times from 7.5 Mtoe in 2019 to 43.7 Mtoe in 2050 due to the increased demand from all sectors such as (1) expansion of the mass and light railway systems in the transport sector; (2) households switching from liquified petroleum gas (LPG) to electricity for cooking; (3) a resurgence of the manufacturing sub-sector driving growth in industrial; and (4) increased activity in the modernisation in the agricultural sector.

According to projections, there will be a decrease in demand for coal by 0.4% and other fuels such as biomass and other renewable energy by 0.2%. This decline is due to a shift towards different sources in both the industrial sector, particularly in energy-intensive manufacturing subsectors like cement, as well as in households. Recently, biomass fuels have been increasingly used as an alternate for coal in industry, while LPG and electricity have been adopted as alternate fuels in residential settings (Figure 14.5).

Figure 14.5 Total Final Energy Demand by Fuel, Business-as-Usual, 1990–2050



Mtoe = million tonnes of oil equivalent.

Note: 'Others' include biomass, bioethanol, biodiesel.

Source: 1990-2019 data (2019 EBT, DOE – Philippines); 2020-2050 data (Author's calculation).

3.1.2. Total Primary Energy Supply by Energy

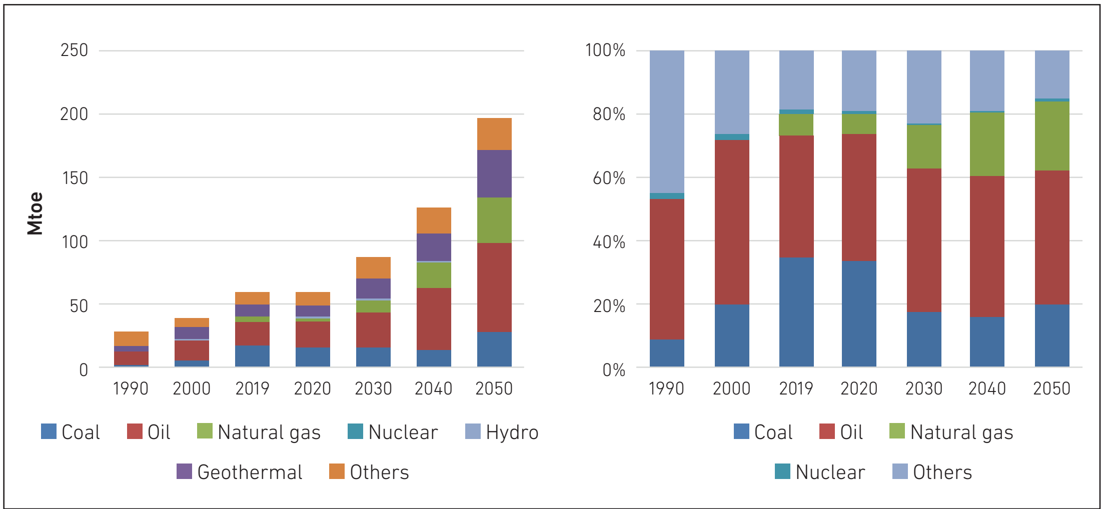
Primary energy supply in the Philippines grew from 28.7 Mtoe in 1990 to 59.7 Mtoe in 2019 at an annual average rate of 2.6%. Amongst the major energy sources, coal grew the fastest at 8.6% per year as the country embarked on an aggressive investment in baseload power plants to stabilise the country's electricity supply. Geothermal, oil, and hydro each registered average increases of 2.3%, 2.1% and 1.0%, respectively. On the other hand, primary energy supply of other fuels went down by 0.5% per year.

For 2019 to 2050, the country's primary energy supply is expected to increase threefold, from its 59.7 Mtoe in 2019 to 197.0 Mtoe in 2050, with an average growth rate of 3.9% per year. Oil will account for the largest share of the country's total energy supply, increasing from 33.4% in 2019 to 35.2% in 2050. This increase is necessary to meet the growing demands of the economic sectors, particularly transport. However, oil supply is predicted to peak in 2030 at an annual rate of 4.8% and will display a slower growth rate of 3.7% at the end of the review period. The slower growth is due to the penetration of alternative fuels, such as biofuels and electricity, and improvements in the transport sector efficiencies and mileage.

For the period 2019 up to 2050, natural gas is expected to grow at an annual average rate of 4.1%. Natural gas is mainly used for power generation. The expected growth is in line with the government programme being pushed for the development of a liquefied natural gas (LNG) Hub in the country to secure future supply of natural gas.

Major renewable energy supply from geothermal and hydro will grow at an average rate of 4.6% and 1.8%, respectively. By 2050, the combined consumption of other fuels, including biomass, solar, wind and ocean technologies, is expected to reach 12.7%, growing at an annual rate of 3.1% throughout the planning period (Figure 14.6).

Figure 14.6 Total Primary Energy Supply by Energy, Business-as-Usual, 1990–2050



Mtoe = million tonnes of oil equivalent.

Note: 'Others' include biomass, bioethanol and biodiesel.

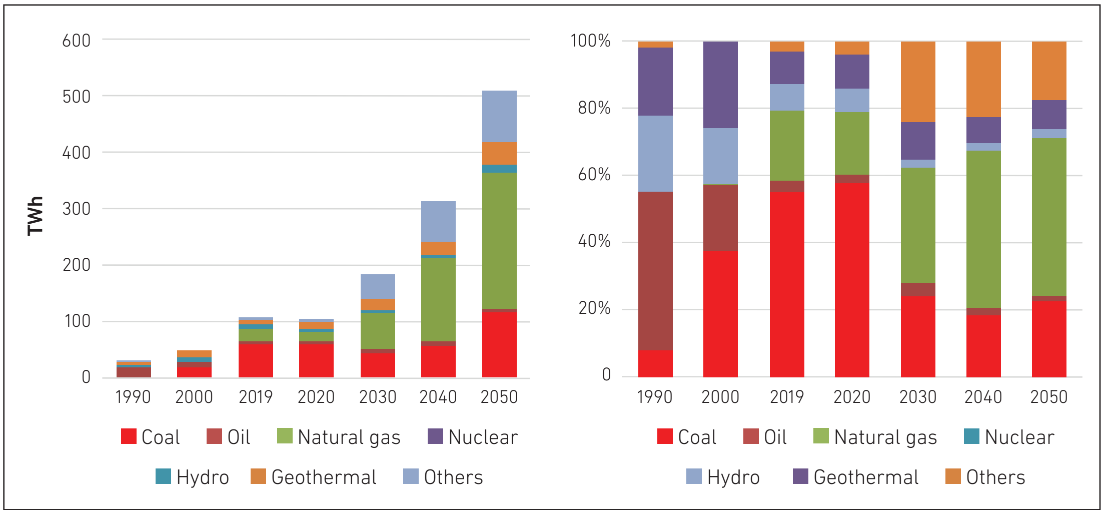
Source: 1990-2019 data (2019 EBT. DOE – Philippines; 2020-2050 data (Author's calculation).

3.1.3. Power Generation

In 2019, the total power generation reached 106.0 TWh, which was four times the country's level of 26.3 TWh in 1990. The total power generation output is projected to rise by 5.2% yearly and reach 508.9 TWh by 2050. Coal, which accounts for 54.6% of the power generation mix in 2019, would decrease its share to 22.2% in 2050 due to the coal moratorium imposed by the government in 2020. As cleaner fuel is increasingly used for power generation and coal is replaced, natural gas-fired power plants are expected to comprise 47.6% of the power generation mix.

Renewable energy sources, which include hydro, geothermal, wind, solar, and biomass are expected to contribute an aggregate share of 20.8% in 2019 up to 29.0% in 2050 (Figure 14.7).

Figure 14.7 Power Generation, Business-as-Usual, 1990–2050
(TWh)



TWh = terawatt-hour.

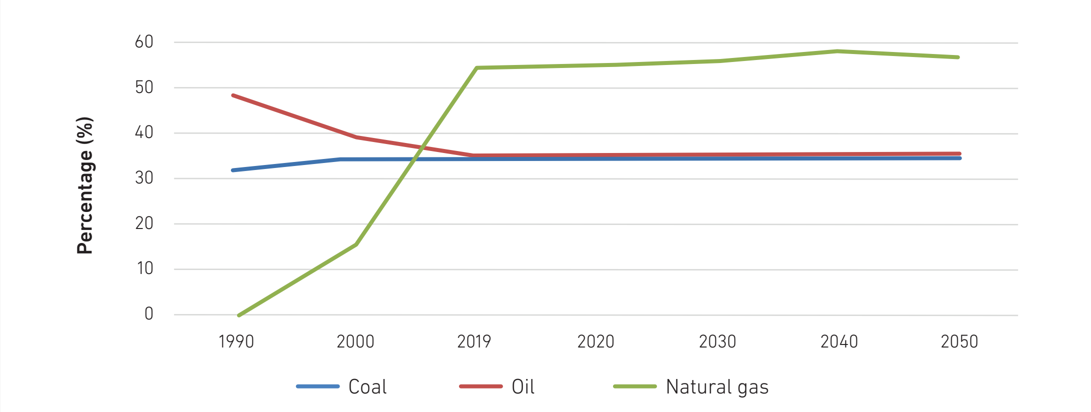
Note: 'Others' include biomass, solar and wind.

Source: 1990-2019 data (2019 EBT. DOE – Philippines; 2020-2050 data (Author's calculation).

According to projections, the thermal efficiencies of coal and oil will remain constant throughout the planning period under the BAU scenario. Coal thermal efficiency is expected to remain at 35.0%, while oil power plant efficiency is projected to remain around 36.0%. In contrast, the efficiency of natural gas power plants is expected to range from 55. 0% to 58.0% due to new capacity additions expected within the period being studied (Figure 14.8).

Figure 14.8 Thermal Efficiency, Business-as-Usual, 1990–2050

(%)

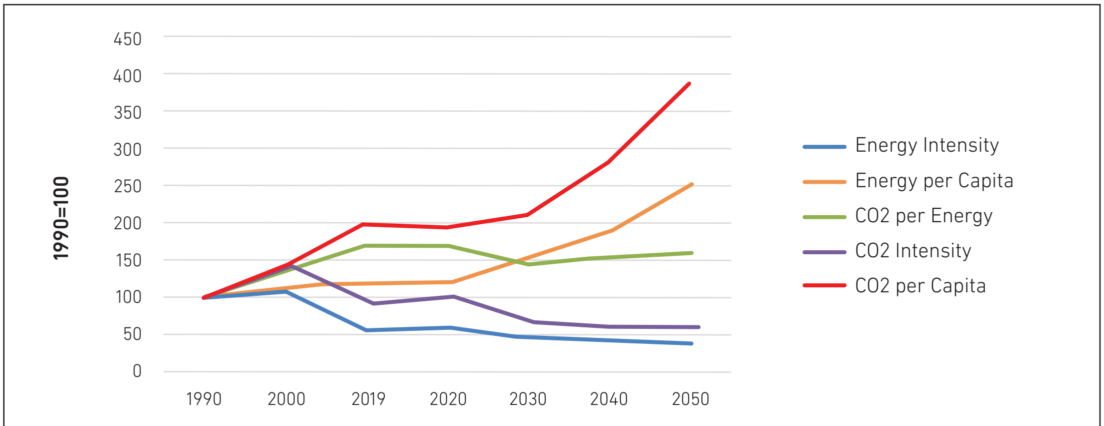


Source: 1990-2019 data (2019 EBT. DOE – Philippines; 2020-2050 data (Author's assumption).

3.1.4. Energy Indicators

Under the BAU, the energy intensity of the country is expected to decrease at a rate of 1.3% for 2019–2050. Energy intensity is defined as the ratio of total primary energy to GDP. This significant reduction in energy intensity is attributed to the government's efforts to promote energy conservation and efficiency in the various sectors of the economy. However, the energy per capita is expected to increase from 0.6 tonnes of oil per person (toe/person) in 2019 to 1.2 toe/person in 2050 due to improvements in living standards and income levels. Additionally, CO_2 per capita is expected to decrease from 0.3 tonnes of carbon per toe (t-C/toe) to 0.6 t-C/toe due to increasing demand for energy resulting from the improved standard of living (Figure 14.9).

Figure 14.9 Energy Indicators, Business-as-Usual, 1990–2050



CO_2 = carbon dioxide.

Source: Author's calculations.

Amongst the energy indicators, CO_2 energy per capita, energy per capita, and CO_2 per energy registered an increasing trend due to improvements in standard of living. Meanwhile, energy intensity and CO_2 intensity decrease over time due to the adoption of energy conservation measures, energy efficiency improvements, and a gradual shift from fossil fuels to clean energy sources, particularly renewables.

3.2. Alternative Policy Scenario

The study developed five (5) alternative policy scenarios to assess the energy savings potential of the country in addition to the business-as-usual (BAU) scenario. The assumptions in the alternative policy scenario (APS) were analysed separately to determine the individual impacts of each assumption to BAU. Table 14.3 describes the policy scenarios adopted for the study.

Table 14.3 Alternative Policy Scenarios

APS1	Improved Efficiency of Final Energy Demand
APS2	More Efficient Thermal Power Generation (coal, oil and natural gas)
APS3	Higher Contribution of Renewable Energy to Total Supply
APS4	Contribution of Nuclear Energy to Total Supply (not applied in the Philippines)
APS5 or APS	Combined Effects of APS1, APS2, APS3, and APS4

APS = alternative policy scenario.

Source: Author's assumptions.

The alternative policy scenario (APS) 1 assessed the potential impact of policy interventions in promoting the use of eco-friendly and efficient technologies in future energy consumption, as well as the corresponding reduction in CO_2 emissions. The scenario assumed a 5.0% energy savings in oil and electricity demand until 2050 through a range of measures, including intensified energy utilisation management programmes across all economic sectors. The adoption of more energy-efficient electrical appliances in residential and commercial sectors is also anticipated to result in savings. Energy labelling and rating for major electrical appliances will help consumers in choosing more efficient products, while the Information and Education Campaign (IEC) Program of the DOE will contribute to the country; energy-saving goals.

The APS2 assessed the effect of a more efficient thermal power generation, particularly for future coal and natural gas power plant technologies. In this scenario, higher efficiency was adopted for coal and natural gas. Under the BAU, the process efficiency of coal power plant was 35% while natural gas was 55%. Under the APS2, process efficiency of coal and natural gas was improved to 37% and 62%, respectively.

The APS3 evaluated the combined impact of renewable energy and alternative fuels on the total energy supply. The model integrated the targets outlined in the National Renewable Energy Program (NREP), which is part of the government's efforts to ensure energy security, protect the environment, and promote green technology. The NREP serves as a framework for the developing country's renewable energy resources, attracting investments in the renewable energy sector, advancing technology, and driving the adoption of renewable energy at the national and local levels. It establishes interim targets for the delivery of renewable energy within the timeframe. The scenario also incorporates the continued use of alternative fuels, such as biofuels, under the Biofuels Law of 2006.

3.2.1. Total Primary Energy Supply by Energy

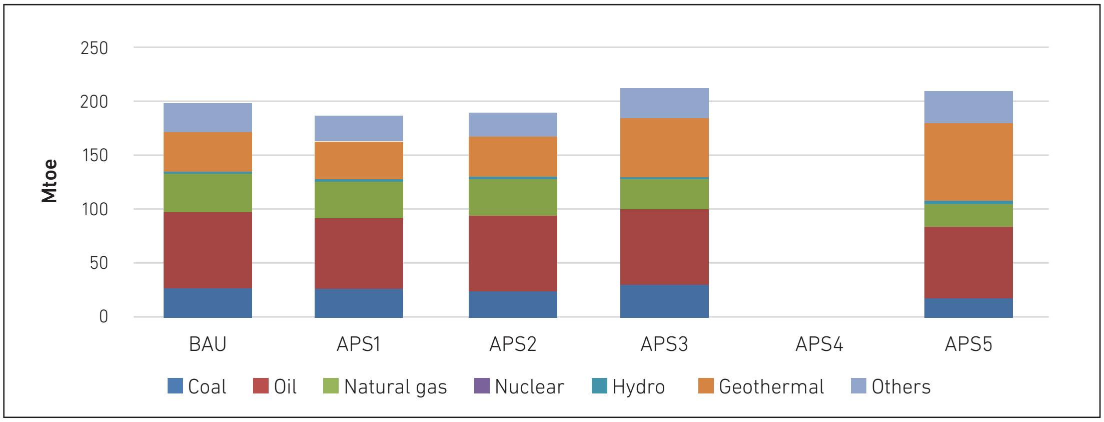
Figure 14.10 shows the changes in total primary energy supply in all the scenarios. APS1, which assumes improved efficiency of final energy demand, is projected to increase at a rate of 3.8% per year and reach 187.2 Mtoe by 2050. Compared to the BAU, APS1 shows a reduction of 5.0% or 9.8 Mtoe, which can be attributed to the projected savings from various measures to be implemented in the energy sector. These measures include intensified energy utilisation management programmes in the commercial and industrial sectors, power plants, and distribution utilities; the continued use of alternative fuels and technologies; and other measures developed with the implementation of RA No. 11285, also known as the Energy Efficiency and Conservation Act.

The total primary energy supply of APS2 is expected to reach 189.1 Mtoe by 2050, with a 4.0% or 7.9 Mtoe decrease compared to the BAU scenario. This suggests that enhancing the thermal efficiency of fossil fuel-based power plants can lead to notable energy savings.

The APS3 will result in a higher total primary energy supply of 212.1 Mtoe, which is 7.7 Mtoe more than the BAU scenario. This increase is due to the increased utilisation of geothermal, hydropower, and other renewable energy in power generation. While renewable energy sources, such as geothermal and hydropower, have lower efficiencies than fossil fuels, resulting in higher fuel input, the adoption of these cleaner sources increases total primary energy supply. During the planning period, the average annual growth rate of geothermal energy will grow at an average rate of 4.6%, resulting in an increase from 9.2 Mtoe in 2019 to 37.3 Mtoe in 2050. Additionally, the aggregate generation output from other renewable energy sources, such as solar, wind, and ocean, is expected to increase at an average rate of 2.8% per year.

When all the APS scenarios are combined (APS5), the country's total primary energy supply is projected to reach 208.0 Mtoe in 2050, with an annual average growth rate of 4.1%. The increase in supply under APS3, due to the lower efficiencies of renewables compared to fossil-based fuels, will offset the combined reduction of APS1 to APS2. This highlights the effectiveness of combining improved efficiency in energy demand and thermal power generation. Further, a higher contribution of renewable energy in the supply mix will increase TPES and decrease carbon emissions, which is beneficial to the environment (Figure 14.10).

Figure 14.10 Comparison of Total Primary Energy Supply by Energy, 2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

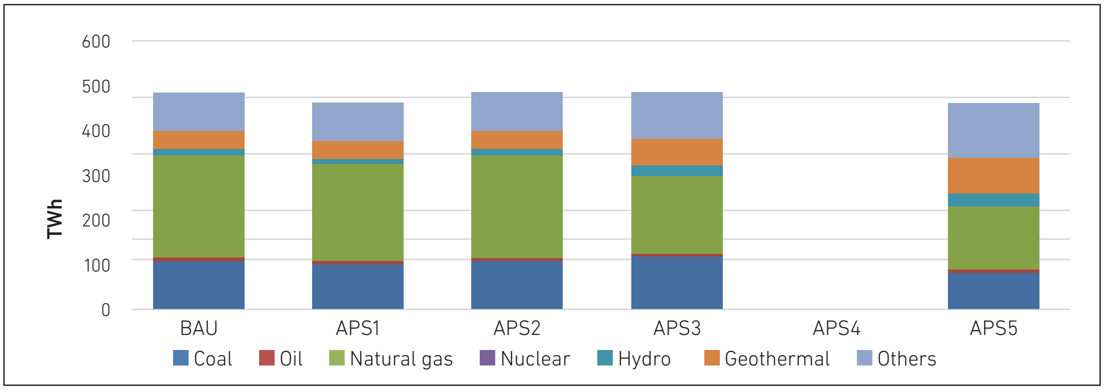
Source: Author's calculation.

3.2.2. Total Electricity Generation

Figure 14.11 shows the total electricity generation in 2050 in all scenarios. Under the APS1, total generation output is projected at 483.4 TWh. This is 5.0% lower than the BAU due to efficiency measures imposed on the different end-use sectors. As a result, all fuels registered reduced generation output compared to the BAU scenario.

The annual average growth rate in APS 1 would increase by 5.0%. Natural gas is expected to grow the fastest at 7.8% average per year, with a 4.6% reduction in output compared to BAU. The total fuel input decreased significantly by 4.7% from the BAU level of 36.1 Mtoe, largely due to reduced electricity consumption.

Figure 14.11 Scenario Comparison, Electricity Generation, 2050
(TWh)



APS = alternative policy scenario, BAU = business-as-usual, TWh = terawatt-hour.

Note: 'Others' include biomass, solar and wind.

Source: Author's calculation.

Two scenarios, APS2 and APS3, yield the same total generation output of 508.9 Mtoe. Under APS2, there is no difference in power generation output compared to the BAU. However, the higher thermal efficiencies of the fossil fuel plants lead to a reduction in fuel input by 8.5%. The combined input of fossil-based fuel (coal, oil, and natural gas) only requires 60.2 Mtoe input in APS2 compared to 65.7 Mtoe in the BAU. In the case of adding new coal capacity, the process efficiency increases from 36.0% to 43.0%.

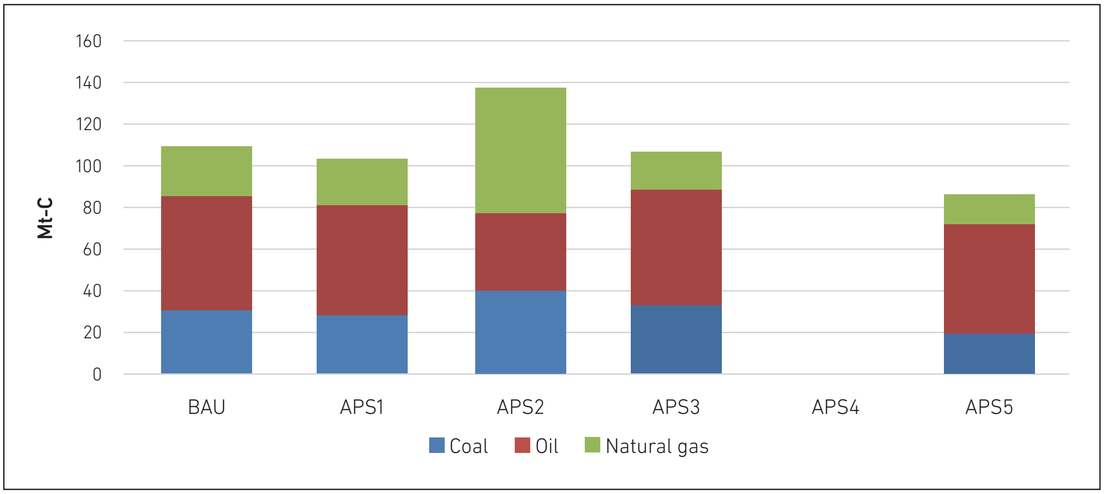
On the other hand, APS3 will have a greater share of generation from renewable energy technologies. Geothermal energy is expected to increase by 47.5% compared to the BAU, with an annual average growth rate of 5.9%. Therefore, it is recommended that the government continue to explore and utilise the country's geothermal potential.

While APS5's total generation output is equal to that of APS1 for 2050 at 483.4 TWh, the aggregate power output from coal and oil will decrease by 25.4% from the BAU from 121.1 TWh to 90.4 TWh under APS5.

3.2.3. Total Carbon Dioxide Emission, 2050

The implementation of energy efficiency measures, or APS1, will lead to a 5.4% decrease in CO_2 emissions in 2050 compared to the BAU level of 109.2 million tonnes of carbon (Mt-C). The decrease in CO_2 indicates that the energy saving goals, action plans, and policies in the promotion of energy efficiency and conservation programme will have a substantial impact in reducing CO_2 emissions (Figure 14.12).

Figure 14.12 Scenario Comparison, Carbon Dioxide
(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, Mt-C = Million Tonnes of Carbon.

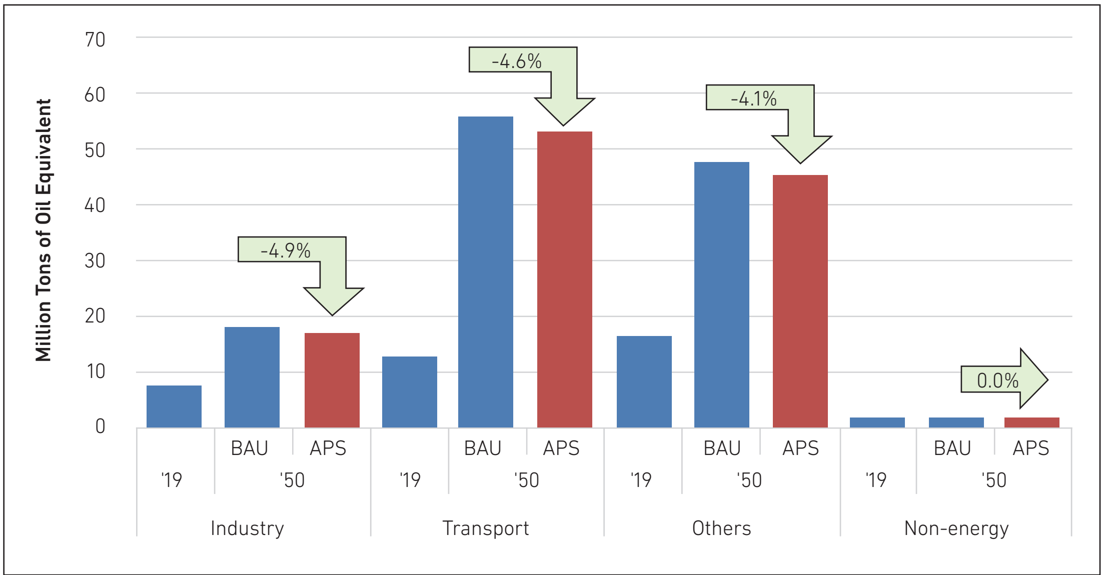
Source: Author's calculation.

By improving the thermal efficiency under APS2, the total CO_2 emissions will decrease by 4.7% compared to the BAU. Similarly, increasing the share of renewable energy technology under APS3 will lead to a reduction of 2.2%. If all assumptions in APS1, APS2, and APS3 are combined, the aggregate reduction of CO2 emissions from the BAU scenario will be 20.9%.

3.2.4. Energy Saving Potential

Figure 14.13 shows the total final energy consumption by sector in 2050 under both the BAU and APS5. The implementation of energy efficiency measures in APS5 will result in a 4.4% reduction in total final energy consumption, decreasing from 122.0 Mtoe in BAU to 116.9 Mtoe in APS5. A reduction of 4.9% can be observed from industry because of technological advancements and more efficient systems and practices. Similarly, a 4.6% reduction is expected in transport, which can be attributed to the use of mass transport systems, improved transportation network and highways, increased use of electric vehicles, and higher biofuel blends. Energy demand from other sectors (residential, commercial, and AFF) will also decrease from 47.0 Mtoe in the BAU to 45.0 Mtoe in APS5, decreasing at an annual rate of 4.1%. The decrease is due to the aggressive implementation of the energy labelling programme, energy efficiency solutions for commercial infrastructures, and technology improvements.

Figure 14.13 Final Energy Consumption, Business-as-Usual vs Alternative Policy Scenario, 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes commercial, residential, and agriculture, forestry and fishery.

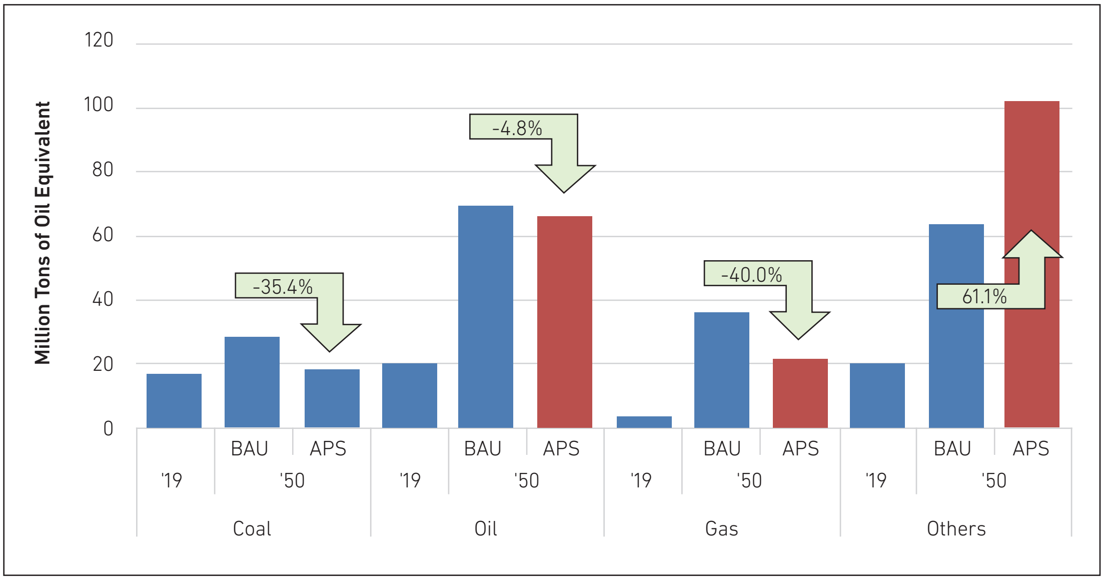
Source: Author's calculation.

Figure 14.14 illustrates a comparison of total primary energy supply by fuel between the BAU and APS in 2050. It is projected that primary energy supply will increase by 5.6% from 197.0 Mtoe to 208.0 Mtoe by end of 2050. The growth is due to the expected increase of renewables for power generation, which is included in the category of 'Others'. The efficiency of renewables, especially geothermal at 10%, is lower compared to fossil-based fuels like coal, which has an efficiency of 35.0%. The 'Others' category is expected to increase from 63.5 Mtoe to 102.2 Mtoe in 2050 due to the aggressive implementation of policy mechanisms under Renewable Energy Act of 2008. By 2050, the share of renewables under APS5 is would reach 54.3% by 2040 and 50.0% by the end of the study period. The result is consistent with the PEP 2020–2040, which targeted a 50% share for power generation by 2040. Meanwhile, coal consumption is expected to further decline from 28.0 Mtoe in the BAU to 18.1 Mtoe in the APS5, as an effect of increasing renewable energy for power generation and the use of other fuels in the end-use sector. Similarly, natural gas consumption is expected to decrease by 4.3% compared to the BAU due to the increasing share of renewable energy for power generation.

Figure 14.14 shows the comparison of total primary energy supply in 2050 between BAU and APS5. The combined effect of energy efficiency measures and higher thermal power plant efficiency was negated by the increase of renewables for power generation. This is because the efficiency of other renewable energy resources is much lower than fossil-based plants, such as natural gas and coal. As a result, the total primary energy supply is expected to rise by 5.6% in 2050 compared to the BAU level of 197.0 Mtoe.

Figure 14.14 Total Primary Energy Supply Comparison, Fuel, Business-as-Usual vs Alternative Policy Scenario, 2050

(Mtoe)



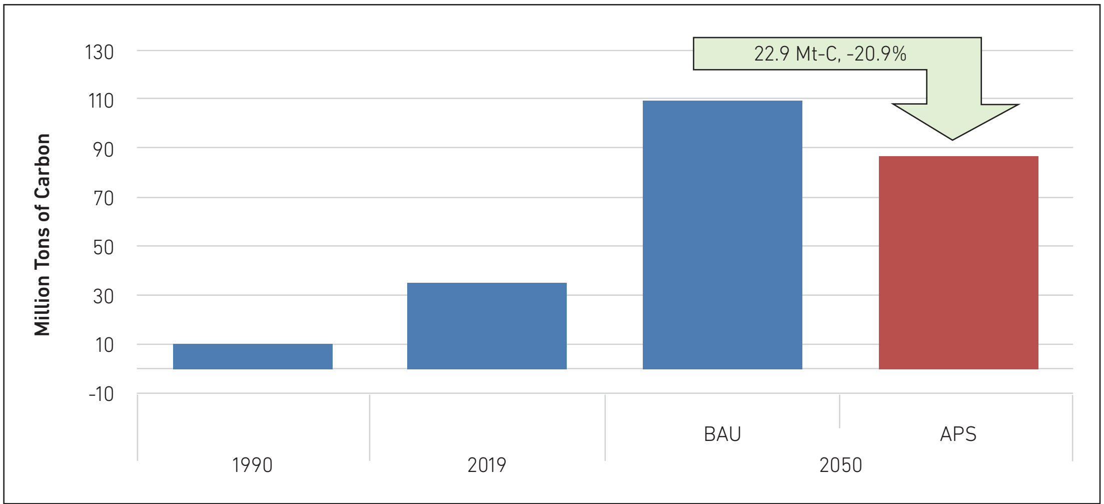
APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' include geothermal, hydro, biomass, bioethanol, and biodiesel.

Source: Author's calculation.

Figure 14.15 compares CO_2 emissions in 2050 between BAU and APS5. The implementation of energy efficiency measures, higher thermal power plant efficiency, increased use of renewable energy for power generation resulted in a significant reduction of 22.9 Mt-C or 20.9% reduction in the CO_2 emissions in APS5 compared to the BAU level. The result shows that the combined strategies under the scenarios will help the energy sector to achieve its goal of reducing emission levels in line with the Nationally Determined Contribution targets.

Figure 14.15 Carbon Dioxide Emission Comparison, Business-as-Usual vs Alternative Policy Scenario, 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.3. Low Carbon Energy Transition Scenario, Carbon Neutral

A new scenario called low carbon energy transition (LCET) scenario was created to assess the impact of new technologies on energy supply, consumption, and emissions reduction. A concept of achieving carbon neutrality was introduced to analyse how economies can integrate technology advancements, energy sources, activities, and behaviour to reach this goal. Currently, the Philippines has no net zero emission target unlike other ASEAN countries such as Malaysia and Indonesia. To establish a net zero target, more aggressive goals were adopted, including the use of new and emerging technology and fuels that are projected to form part of the global energy mix in the future.

In developing the scenario, several measures were considered in the model, including the use of carbon capture utilisation and storage (CCUS) from 2040 to 2050 to reach 55.0% efficiency in natural gas plants and 45.0% efficiency in coal power plants. Additionally, hydrogen fuel will replace diesel in road transport starting in 2040, with a 5.0% share targeted in 2050. The scenario also includes a higher penetration rate of electric vehicles at 20.0% in transport by 2050. Bioethanol and biodiesel blends are projected to be at 20% by 2050. Energy savings on oil and electricity are also targeted to increase to 20% by the end of 2050. The energy savings is applied in the industrial, commercial, and residential sectors. In terms of power generation, the share of renewable energy is targeted to reach a 60% by 2050. Due to the new developments under the nuclear power programme of the government, the model also assumed a 1000 MW nuclear power plant as part of the power generation mix starting in 2035. The government sees nuclear power as a potential part of the country's energy mix in the future, as demonstrated by their initiatives under EO No. 116, which calls for a study on the adoption of a national position on nuclear energy programmes. Additionally, EO No. 164 seeks to adopt a national position that will consider economic, political, social, and environmental factors related to nuclear power development. The model also considered fuel switching in the industrial and residential sectors as follows:

¤ Biomass for Coal in the industrial Sector (5% by 2050)

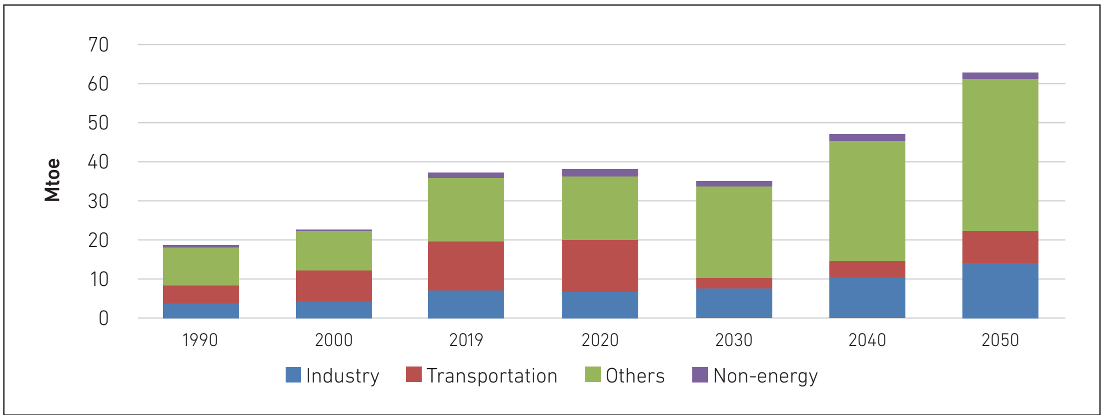
¤ Electricity for LPG in the residential sector (at least 5% by 2050)

3.3.1. Final Energy Consumption Sector

Figure 14.16 illustrates the final energy consumption by sector from 1990 until 2050 under the LCET scenario. The average annual growth rate from 1990 to 2019 is 2.4%. Compared to APS5, the final energy consumption in 2050 is much lower under LCET, reaching 63.9 Mtoe. For the period 2019 to 2050, the annual average growth rate of final energy consumption is expected to slow down from 2019 to 2050, with a rate of 1.7% due to the combined assumption used in the model.

Figure 14.16 Final Energy Consumption by Sector, Low Carbon Energy Transition Scenario, 1990–2050

(Mtoe)



Mtoe = million tonnes of oil equivalent.

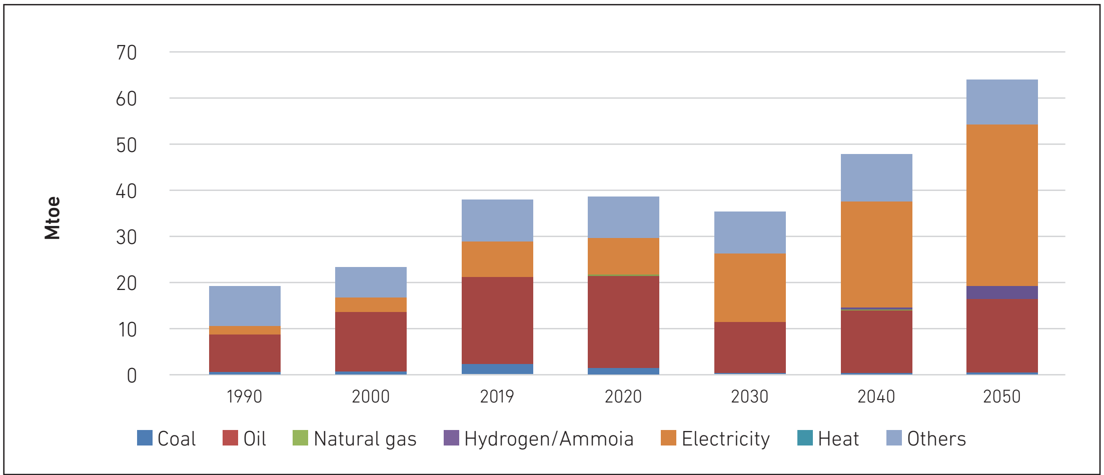
Note: 'Others' include commercial, residential, and agriculture, forestry and fishery.

Source: Author's calculations.

Introducing hydrogen fuel for transport sector from 2040 onwards would impact the consumption of diesel. In 2050, hydrogen is seen to reach 2.7 Mtoe, with an average annual growth rate of 22.8% from 2040 to 2050. Meanwhile, oil will reduce to 0.5% per year from 2019 until 2050, compared to an average annual growth rate of 4.0% under the APS5 scenario. The final energy consumption by fuel under the LCET scenario is shown in Figure 14.17.

Figure 14.17 Final Energy Consumption by Fuel, Low Carbon Energy Transition Scenario,1990–2050

(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' include biomass, bioethanol, and biodiesel.

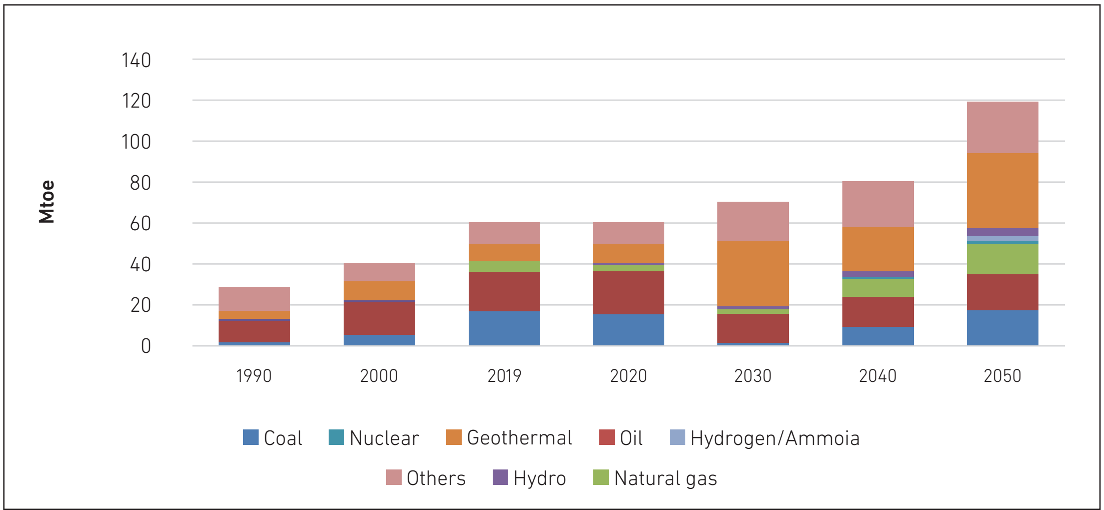
Source: Author's calculations.

3.3.2. Primary Energy Supply

The LCET scenario projects a total primary energy supply of 119.1 Mtoe in 2050 in Table 14.18, much lower than the APS5 scenario's 197.0 Mtoe. The average annual growth rate of the total primary energy supply is 3.9% from 2019 to 2050 under the BAU, higher than 2.2% under the APS5. Only oil shows a negative average annual growth with –0.4% due to the combined initiatives identified in the LCET scenario. The government's decision not to construct any new coal plants into the system results in a 0.2% annual growth rate for coal. The combined share of hydropower, geothermal, and other renewable sources (such as solar, wind, biofuels, and others) is expected to make up 55.0% of the total supply mix, as the study assumed 60.0% share of renewables for power generation.

Figure 14.18 **Primary Energy Supply by Fuel, Low Carbon Energy Transition Scenario, 1990–2050**

(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' include biomass, bioethanol, and biodiesel.

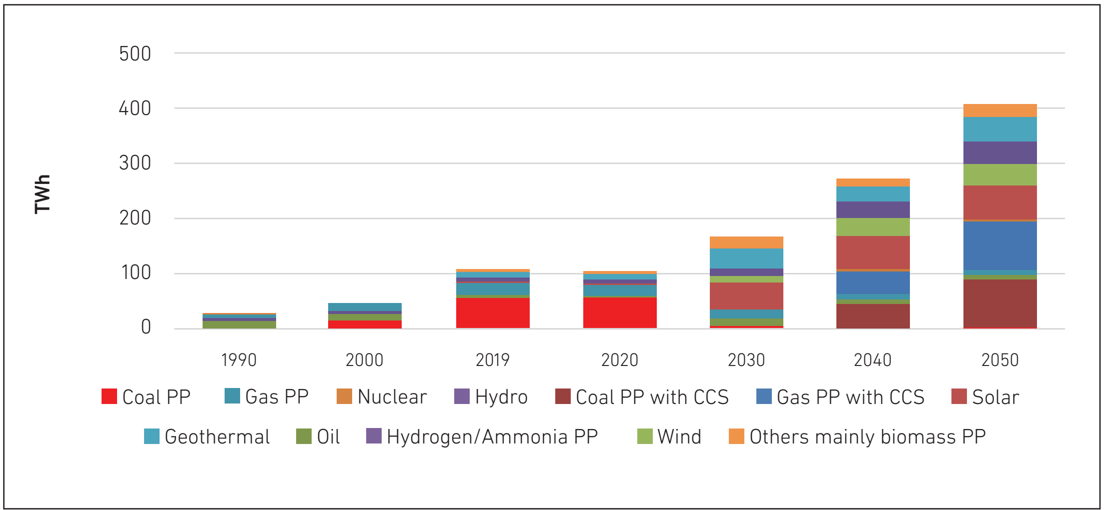
Source: Author's calculations.

3.3.3. Power Generation

Figure 14.19 shows the total electricity generation in 2050 under the LCET scenario will grow to 408.0 TWh compared to 483.4 TWh under the APS5 scenario. Reduced electricity consumption due to energy efficiency initiatives leads to lower electricity generation by 2050. By the end of the study period, natural gas power plants, which include natural gas with CCUS, will constitute 23.6%; followed by coal, which includes coal with CCUS, at 22%; solar at 15.3%; geothermal at 10.5%; hydro at 10.3%; wind at 9.6%; biomass at 6.0%; and oil at 1.9%. Meanwhile, nuclear is seen to contribute a share of 0.9% in 2050.

Figure 14.19 Electricity Generation by Fuel, Low Carbon Energy Transition Scenario, 1990–2050

(TWh)



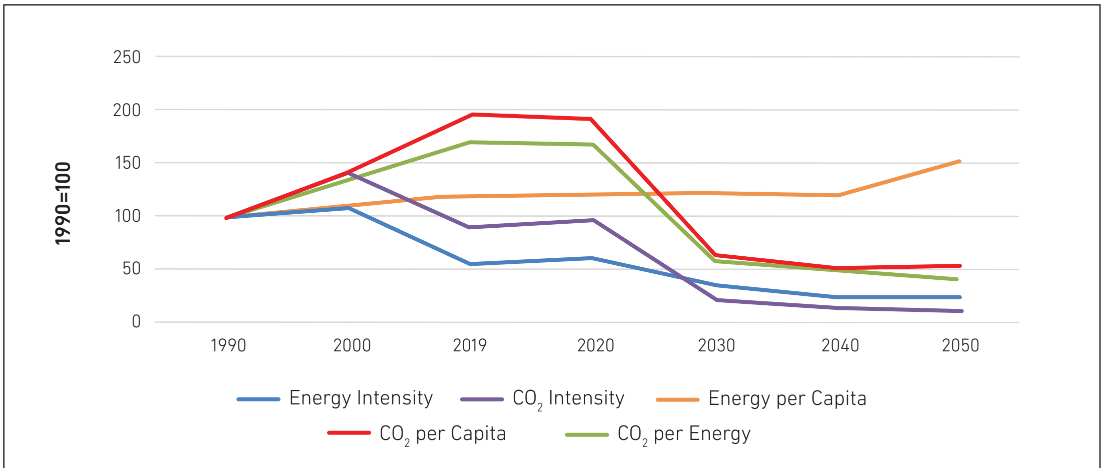
CCS = Carbon Capture Storage, PP = power plant, TWh = terawatt-hour.

Source: Author's calculations.

3.3.4. Energy Indicators

Figure 14.20 demonstrates that amongst all energy indicators, only energy per capita exhibits a positive trend. The increase is mainly driven by it the rising energy demand due to an improvement living standards. Emission per capita showed a downward trend at -4.1% per year from 2019 to 2050. Energy intensity also showed a similar trend decreasing at -3.4% per year, while CO_2 emissions intensity marked at -7.5% per year.

Figure 14.20 Energy Indicators, Low Carbon Energy Transition Scenario, 1990–2050



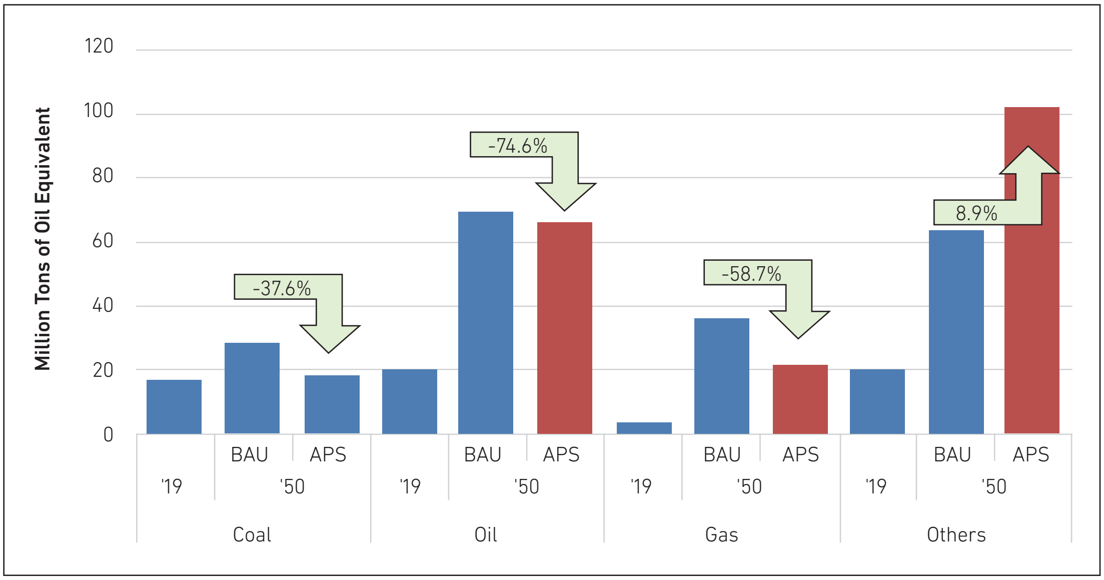
CO_2 = carbon dioxide.

Source: Author's calculations.

3.3.5. Saving of Fossil Fuel Consumption and CO_2 Reduction

Figure 14.21 shows the potential reduction in total primary energy supply under the LCET scenario, which amounts to 77.9 Mtoe, as compared to the BAU scenario. This potential savings of 39.5% could be achievable if all the initiatives under the LCET scenario are implemented.

Figure 14.21 Primary Energy Supply, Business-as-Usual and Low Carbon Energy Transition Scenarios, 1990, 2019, and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

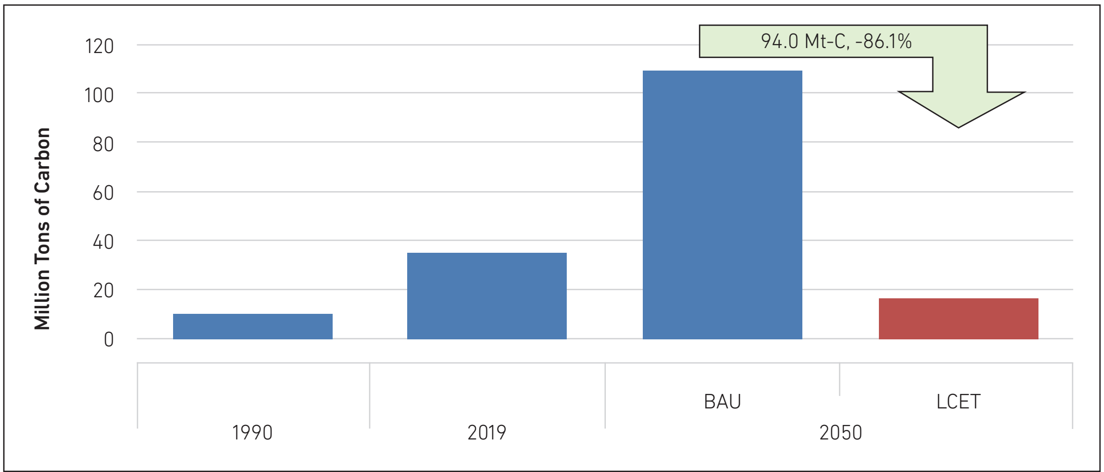
Note: 'Others' include geothermal, hydro, solar, wind and biomass.

Source: Author's calculations.

Figure 14.22 shows the LCET scenario predicts a decrease in total CO_2 emissions by 2.7% to reach 15.2 Mt-C compared to 109.2 Mt-C in the BAU scenario in 2050. This reduction is about 94.0 Mt-C or 86.1% less than the BAU scenario. Based on the results of the study, the country will not achieve net carbon neutrality by 2050, given the combined assumptions used. More aggressive targets should be established to achieve a net-zero carbon future.

Figure 14.22 : Carbon Dioxide Emission Reduction, Business-as-Usual and Low Carbon Energy Transition Scenarios, 1990, 2019, and 2050

(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual.

Source: Author's calculations.

4. Implications and Policy Recommendations

Based on the results of this study, the Philippines can attain its target of increasing renewable energy share, given the available resources in the country. However, achieving the 50% renewable energy share in power generation by the end of 2050 has its various issues and challenges. Significant issues and challenges were revealed in the 1,090 renewable energy service contracts (RESCs) awarded from 2009 to 2019, which had the potential to generate about 36,735 MW of installed capacity and could have exceeded the NREP, 2011–2030 target of 15,304 MW by 2030. These issues and challenges include (1) delayed implementation of renewable energy policy mechanisms; (2) complex permitting process; (3) grid interconnection issues; (4) renewable energy resource development; (5) limited access to financing; and (6) exposure to climate related risks.

This study suggests the implementation of energy efficiency and conservation (EE&C) standards and measures as one key area for achieving significant energy in the country. The government must intensify its promotion of EE&C measures with specific targets and strategies to achieve energy efficiency while still meeting the future energy demand required for economic growth. Based on the projections in the BAU, the final energy demand is expected to triple from 36.7 Mtoe in 2019 to 116.1 Mtoe by 2050. This indicates the significant energy demand of a developing nation like the Philippines, for which the present government has established an ambitious objective for the economy outlined in the Ambisyon 2040 plan. Oil will continue to have the largest share in the final energy demand on the demand side, accounting for almost half of the demand mix by the end of the planning period. However, implementing energy efficiency and conservation programmes, as well as developing alternative fuels and technologies, can result in higher energy savings potential for oil demand. According to the model's results, the share of oil in total demand ranges between 40% to 50% indifferent scenarios. One policy recommendation is for the government to focus on the promotion of alternative fuels, such as bioethanol and biodiesel, in transport to displace the use of oil in the sector. The passing of Electric Vehicle Industry Development Act (EVIDA) will address challenges in promoting electric vehicles as an alternative fuel, and aggressive implementation of the law should be pursued. To increase the market penetration of electric vehicles, necessary infrastructure such as charging stations should be established.

As the energy requirement is expected to increase, the energy sector must develop an energy supply plan to meet the country's growing energy needs. The study suggests an optimal energy mix that can be adopted based on different APS scenarios. In the Philippines, coal, which has been a major power source in the past decades, is expected to decline further due to the increasing demand for environmentally friendly fuel sources. According to the results of APS2, improving thermal efficiency of fossil-based fuels has the potential to save energy by about 8.5% in terms of fuel input compared to the BAU scenario. This improvement led to a substantial reduction in CO2 emissions of 5.2 Mt-C or about 4.7%. Therefore, it is recommended to improve the thermal efficiencies of fossil fuel-based power plants, even though the initial investments and costs may be high. This would lead to lower production requirements and emissions in the long-term, which would benefit the energy sector. However, before implementing this policy, further investigation is necessary. Since the power sector is a deregulated industry and driven by private sector investments, the government may need to develop a policy solution to encourage investments in highly efficient technologies in the future.

The APS3 demonstrates that the government's commitment to the Renewable Energy Act of 2008, which aims to increase the use of clean and efficient alternative fuels such as geothermal, hydro, solar, wind, biomass, and other emerging renewable energy technologies, can lead to a strategy for energy security through greater reliance on indigenous resources. To ensure continued progress, policy mechanisms such as Feed-in Tariff (FIT), Renewable Portfolio Standards (RPS) for On-grid and Off-grid, Renewable Energy Market, Green Energy Option Program (GEOP), and Green Energy Auction Program (GEAP) are already in place. The government should further promote the use of renewable energy not only for power generation but also for end-use sectors. Additionally, future policy mechanisms should be established to ensure an increased share of renewable energy in the power generation mix.

The COVID-19 pandemic has prompted economies worldwide to rebuild their economic structures, taking into account energy security, affordability, and environmental sustainability. Many economies have committed to combat climate change by setting targets for carbon neutrality or net zero emissions. The emergence of new technologies, such as CCUS and alternative fuels like hydrogen, is now a global trend. Each economy should explore these new technologies and consider them as a long-term option. However, implementing new technologies requires significant investment. Long-term partnerships and secure funding are essential for successful investment. Moreover, the private sector drives the country's power sector, so policies must be developed to encourage private sector investment in new technologies to realise the government's plans for a low carbon future or a transition to environment-friendly technologies. There are various options available to reduce energy carbon emissions both on the demand and supply side. To be able to achieve carbon neutrality, local and foreign funding support is also needed.

In the Philippines, the energy sector has developed plans for a low carbon future, as reflected in the 2020–2040 PEP. However, the country has yet to establish a net-zero scenario, unlike other ASEAN nations like Malaysia, which has a net-zero target by 2050, and Indonesia with a net-zero target by 2060 or sooner. To prepare for the future, the Philippines should start strategising, beginning with a comprehensive study of advantages and disadvantages of the potential new technologies. These strategies must align with the energy sector's objectives of providing secure, environmentally friendly, and affordable energy. Each adopted strategy should have a roadmap developed for its implementation.

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CHAPTER 15

Singapore Country Report

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1. Introduction

In February 2020, Singapore officially released its enhanced Nationally Determined Contribution (NDC) and Long-Term Low-Emissions Development Strategy (LEDS) (NCCS, 2020a). Both development and climate strategies would be submitted to the United Nations Framework Convention on Climate Change (UNFCCC). According to Singapore's new enhanced NDC, the country further aims to peak its national emissions at 65 million tonnes of Carbon Dioxide equivalent ($MtCO_2e$) around 2030, which is projected to be consistent with Singapore's existing 2030 NDC. In addition, Singapore's energy intensity target under its existing NDC, which aims to achieve a 36% reduction in Emissions Intensity (EI) from 2005 level by 2030. To further facilitate climate change mitigation and sustainable development, Singapore has addressed its long-term development strategy in the LEDS for the post-2030 period. Specifically, Singapore aims to halve its national emissions from its peak (i.e. 65 $MtCO_2e$ around 2030 as addressed in the enhanced NDC) to 33 $MtCO_2e$ by 2050, to achieve net zero emissions as soon as viable in the second half of the century. To support Singapore's low-emissions development, rigorous analysis is needed, which will inform policymaking in this field by providing quantitative benchmarking information (Su and Ang, 2020; Su, Ang, and Li, 2017).

The analysis was conducted in partnership with the Economic Research Institute for ASEAN and East Asia (ERIA), which involved contributing to the creation of ERIA's flagship research publication titled "Energy Outlook and Energy Saving Potential in East Asia 2020" (ERIA, 2021). Singapore's energy outlook model and scenario analysis were completed by using the Low Emissions Analysis Platform (LEAP) software. The latest 2020 edition of Singapore's energy outlook was completed prior to the coronavirus disease (COVID-19) pandemic by using 2017 as the base year. However, the COVID-19 pandemic led to lots of economic and social impacts on Singapore. These impacts are closely associated with changes in energy demand and supply. In addition, Singapore's enhanced NDC and LEDS are not covered in the 2020 edition of Singapore's energy outlook.

Therefore, it is crucial to update the business-as-usual (BAU) scenario and the alternative policy scenario (APS) of Singapore's LEAP model in the current edition of the energy outlook to incorporate the new macroeconomic conditions during the COVID-19 pandemic. More importantly, this report seeks to explore the scenario that can generate the climate targets and dynamics of emissions as projected by Singapore's Long-Term Low-Emissions Development Strategy (LEDS). In developing the LEDS scenario, this project will take into account specific technological development. This will include Singapore's recent plan of phasing out coal power plants by 2050 and the application of emerging low carbon technologies, such as carbon capture and storage (CCS) in the power and industrial sectors.

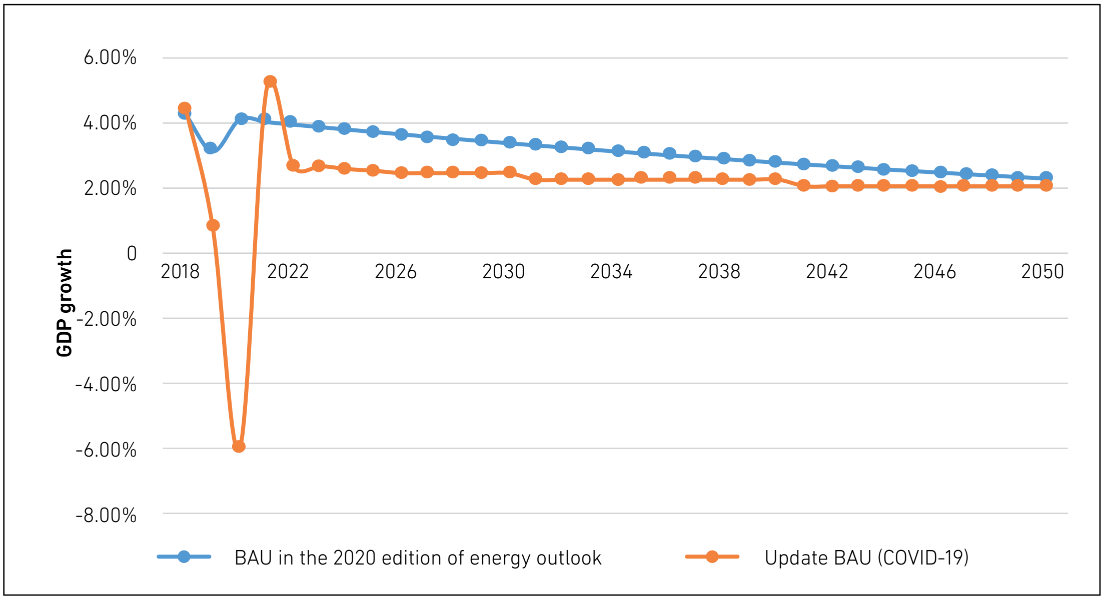
2. Major Model Assumptions

This section introduces the major model assumptions regarding the BAU, APS, and LEDS scenarios used in this project. The LEAP model used in this report draws on Singapore's LEAP model presented in ERIA's Energy Outlook and Energy Saving Potential in East Asia 2020 (ERIA, 2021). However, the model has been updated to meet the specific requirements of this project, as detailed in Sections 2.1–2.3. The rest of the model settings are consistent with the 2020 edition of Singapore's LEAP model.

2.1. Business-as-Usual

As compared to the 2020 edition of Singapore's LEAP model, the key change is the annual GDP growth rate assumption. As shown in Figure 15-1, the BAU GDP growth in this project (i.e. updated BAU) considers the impacts of the COVID-19 pandemic and presents much higher levels of fluctuations during 2018–2023. However, in the long run, the trend of the updated GDP growth converges to the GDP growth in the 2020 edition of Singapore's LEAP model.

Figure 15.1 Comparison of Gross Domestic Product Growth Assumption, 2018–2050
(%)



BAU = business-as-usual, COVID-19 = coronavirus disease, GDP = gross domestic product.

Source: Author's calculations.

Table 15.1 presents a detailed comparison of annual GDP growth rates, highlighting a significant difference since 2019 in the updated BAU, which is 0.7%. The most critical difference is found in 2020, where the impact of the COVID-19 pandemic resulted in a projected decrease of about 6% in Singapore's annual GDP growth, whereas the 2020 edition estimated a 4% growth under the BAU. This project assumes a sharp increase of 5% in GDP growth in 2021. However, due to COVID-19, the expected GDP growth for the upcoming years is lower than the figures projected in the 2020 edition. Specifically, the projected GDP growth for 20222 is 2.6% in 2022 and 2% in the long term (2040–2050), while the 2020 edition predicted 3.9% and 2.5% in the long run.

Table 15.1 Assumptions of Annual Gross Domestic Product Growth Rates

(%)

	2018	2019	2020	2021	2022	2023	2023–2030	2030–2040	2040–2050
Updated BAU (COVID-19)	4.4%	0.7%	-6.0%	5.0%	2.6%	2.6%	2.4%	2.2%	2.0%
BAU in the 2020 edition of energy outlook	4.2%	3.1%	4.0%	4.0%	3.9%	3.8%	3.5%	3.0%	2.5%

BAU = Business-as-usual, COVID-19 = coronavirus disease, GDP = Gross Domestic Product.

Source: Author's estimations.

The other major change in BAU in this project pertains to the forecasted contribution of solar photovoltaic (PV) technology to power generation in the long term. In March 2020, the National Climate Change Secretariat (NCCS) of Singapore released a new solar PV technological roadmap for Singapore (NCCS, 2020b). According the NCCS, under the updated BAU, the share of solar PVs in Singapore's generation mix is projected to be 1.8% in 2030 and 3.4% in 2050.

2.2. Alternative Policy Scenario

In this project, the APS is primarily developed based on the APS in the 2020 edition of Singapore's LEAP model, with several minor changes. In addition, the APS in this project is adapted to the updated annual GDP growth assumptions in the BAU scenario.

According to the solar PV technological roadmap released by NCCS, given the application of more advanced technologies and better policy support, the share of solar PVs in Singapore's generation mix is projected to be 4.5% in 2030 and 7.4% (NCCS, 2020b). Both values are higher than the projections in BAU. The more ambitious shares of solar PVs in the generation mix are used in the APS scenario.

In APS, higher levels of thermal efficiency are assumed for natural gas power plants and conventional thermal power plants. For natural gas power plants, the thermal efficiency is projected to grow from 56.6% in 2019 to 65% in 2050, whereas the efficiency is 58% in 2050 under BAU scenario. For conventional thermal power plants, the efficiency is assumed to increase from 22.0% in 2019 to 48% in 2050, whereas the efficiency is assumed to grow to 45% in 2050 under BAU scenario.

The APS scenario also considers the energy efficiency improvement in industrial, commercial, and residential sectors. The electricity consumption in industrial, commercial, and residential sectors is assumed to drop by 10% by 2030 due to energy efficiency improvement.

2.3. Long-Term Low-Emissions Development Strategy

The LEDS scenario in this project is primarily developed by using the APS scenario, while several major changes have been implemented.

First, in this project, the LEDS scenario considers the phasing out of coal power plants in power generation. In the BAU and APS scenarios, coal power plants account for about 1.19% in generation mix in 2019. However, in the LEDS scenario, the share of coal power plants will gradually decrease to 0 in generation mix by 2050. This is in line with the policy target released by NCCS in November 2021 (NCCS, 2021). In the industrial sector, however, coal will still account for a small share of consumption.

Second, as compared to the BAU and APS scenarios, a critical difference is that Carbon Capture and Storage (CCS) is introduced to the LEDS scenario. This includes the applications of CCS in power generation and the industrial sector. Specifically, a new power generation technology, namely, natural gas power plants with CCS, will be introduced to the power sector over the period 2030–2050. Such new power plants are used to replace the existing natural gas power plants without CCS. By 2050, all natural gas power plants without CCS will be replaced by those with CCS, with a goal to reduce the share of natural gas power plants without CCS to 0 by 2050. This study assumes a 90% $CO2$ capture rate for CCS technology, resulting in power plants with CCS having a grid emission factor of 10% compared to those without CCS. However, power plants with CCS will experience a 15% loss in thermal efficiency. This is consistent with the Annual Technology Baseline 2021 developed by the National Renewable Energy Laboratory (NREL) of the US (NREL, 2021). In industrial sector, the application of CCS technology will be extended to natural gas and refinery gas over the period 2030–2050. By 2050, all industrial processes that use these gases will be retrofitted with CCS technology, reducing their emission factors to 10% of those without CCS, based on the assumed 90% $CO2$ capture rate. Additionally, the LEDS scenario assumes biomass in the power sector will phase out by 2050.

Third, electricity consumption in industrial sector is projected to increase by 20% by 2050 due to the application of CCS. In the LEDS scenario, the energy efficiency improvements in the commercial and residential sectors are the same as those projected in the APS scenario, with a 10% drop in electricity consumption by 2050.

Finally, electricity is expected to replace the consumption of natural gas and liquefied petroleum gas (LPG) in the residential sector by 2050. In road transport, electric vehicles (EVs) would replace gasoline vehicles by 2040 (LTA, 2023). However, diesel vehicles are not expected to be replaced by EVs.

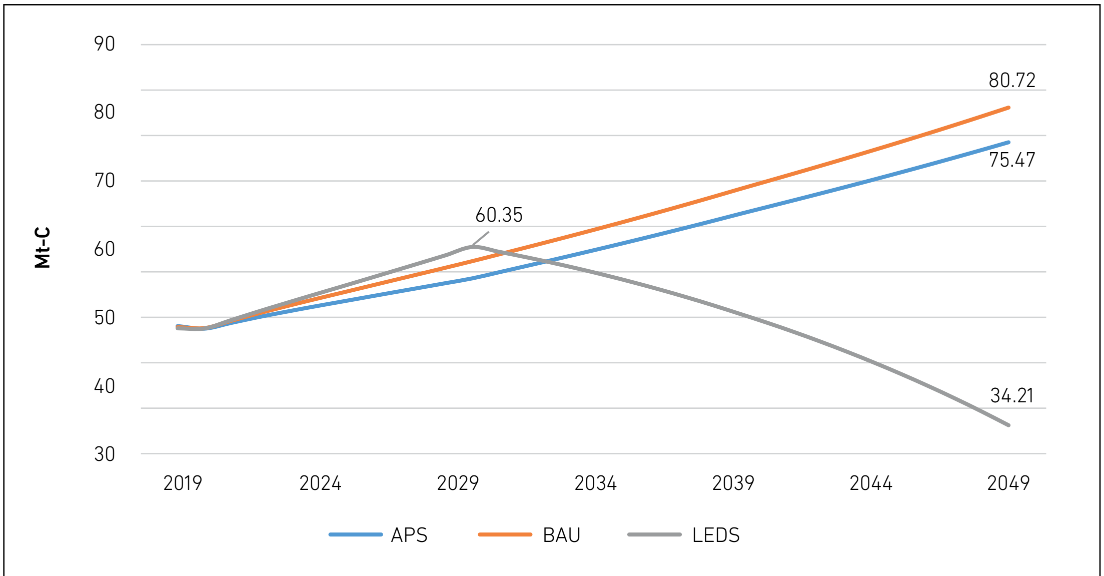
3. Model Results

This section presents the key results of this project, comparing the BAU, APS, and LEDS scenarios. Section 3.1 presents the dynamics of CO_2 emissions at the country level over 2019–2050. Section 3.2 shows the generation mix by scenario. Section 3.3 discusses total primary energy supply, followed by final energy demand in Section 3.4.

3.1. Carbon Dioxide Emissions, 2019–2050

This section reports the country's CO_2 emissions by scenario. Figure 15.2 illustrates that the emissions from BAU and the APS continue to grow over time, increasing from 48.42 $MtCO_2$ in 2019 to 80.72 $MtCO_2$ and 75.47 $MtCO_2$ in 2050, respectively. Across all model years, the emissions peak in 2050 for both BAU and the APS would continue to increase as the energy demand grows after 2050. As expected, CO_2 emissions in the APS are lower than those in the BAU scenario, due to a higher share of solar PV in generation mix, improvement in power plant thermal efficiency, and energy efficiency improvement in industrial, commercial, and residential sectors.

Figure 15.2 Carbon Dioxide Emissions by Scenario, 2019–2050
(Mt-C)



APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

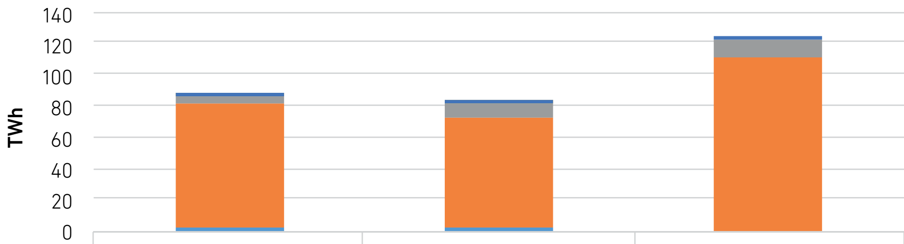
The emissions trend for the LEDS scenario significantly differs from the other two scenarios, as it initially increases to a higher level than the other two scenarios and reaches peak emissions at 60.35 $MtCO_2$ in 2030. This aligns with Singapore's enhanced NDC target of peaking at around 65 $MtCO_2$ in 2030. From 2030 and onwards, the CO_2 emissions under the LEDS scenario start to decline to 34.21 $MtCO_2$ in 2050, which is slightly above Singapore's LEDS target of 33 $MtCO_2$ in 2050. This is because, in Singapore's LEDS, more emerging low-carbon technologies have been considered, such as hydrogen and CCS, whereas in the current analysis in this report, hydrogen is not included. In addition, according to Singapore's NDC, the 2005 level of emission intensity was 0.176 kilogram of carbon dioxide/Singapore Dollar ($kgCO_2$/SGD). In the current analysis, the emissions intensity under the LEDS scenario in 2030 is 0.097 $kgCO_2$/SGD. This indicates a reduction of 44.7% in emissions intensity from the 2005 level. This means the LEDS scenario would exceed Singapore's enhanced NDC target of a 36% reduction in emissions intensity from the 2005 level.

3.2. Power Generation Mix

Figure 15.3 below presents the generation mix in the power sector in 2050. The LEDS scenario generates the most electricity, followed by BAU. The APS generates the lowest level of electricity. Regarding the generation mix, a major difference is that coal and biomass power plants phase out in the LEDS scenario, in which renewables generate the most electricity amongst all scenarios at 11.62 TWh. The LEDS scenario also results in a decrease in electricity generated from oil products. Amongst all scenarios, natural gas still contributes the most in power generation mix, i.e. 109.49 TWh in the LEDS scenario, 79.75 TWh in the BAU scenario and 71.6 TWh in APS scenario.

Figure 15.3 Power Generation Mix by Scenario, 2050

(TWh)



	BAU	APS	LEDS
Oil Products	2.03	2.77	0.54
Biomass	0.42	0.40	-
Renewables	5.35	8.46	11.62
Natural gas	79.75	71.60	109.49
Coal	1.06	1.01	-

Coal Natural gas Renewable Biomass Oil Products

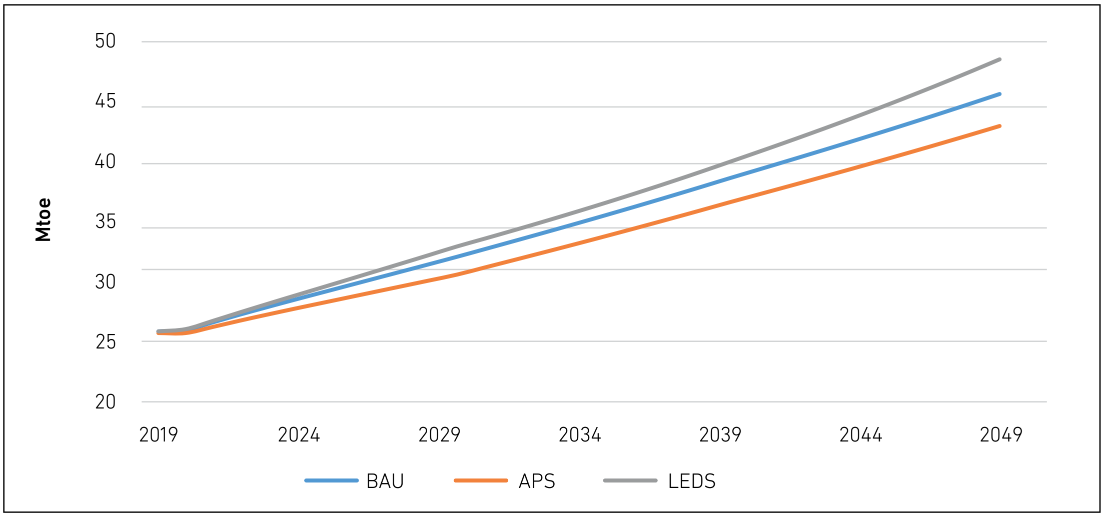
APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, TWh = terawatt-hour.

Source: Author's calculations.

3.3. Total Primary Energy Supply

This section presents the results regarding the total primary energy supply (TPES). Figure 15.4 shows the trends of TPES by scenario over the period 2019–2050. The three curves have similar trends. Amongst all scenarios, the LEDS is the scenario that produces the most TPES, which is followed by the BAU scenario and APS scenario. This is consistent with the results reported in Section 3.2.

Figure 15.4 Total Primary Energy Supply by Scenario, 2019–2050
(Mtoe)



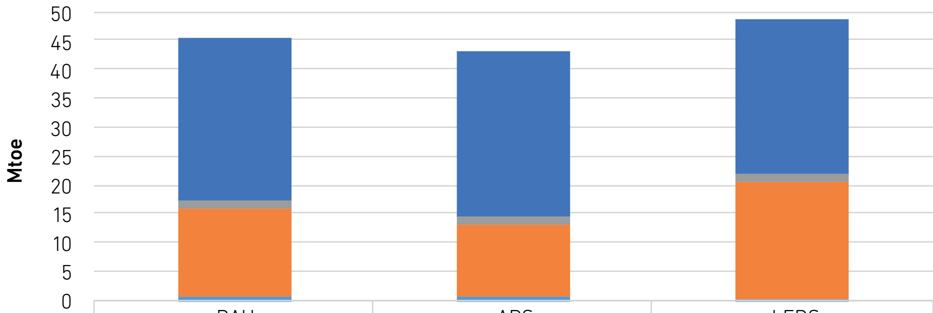
APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 15.5 illustrates the energy structure in TPES by scenario in 2050. Amongst all energy sources, oil is the largest contributor, followed by natural gas. Notably, the LEDS scenario has a lower level of oil consumption, but a higher level of natural gas, biomass, and renewables compared to the other two scenarios. Further, coal still accounts for a small share in industrial consumption under the LEDS scenario.

Figure 15.5 Total Primary Energy Supply, Fuel by Scenario, 2050

(Mtoe)



	BAU	APS	LEDS
Oil	28.20	28.38	26.72
Biomass	0.12	0.11	0.00
Renewables	1.45	1.08	1.42
Natural gas	15.05	12.70	20.21
Coal	0.63	0.61	0.18

Coal Natural gas Renewable Biomass Oil

APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, Mtoe = million tonnes of oil equivalent.

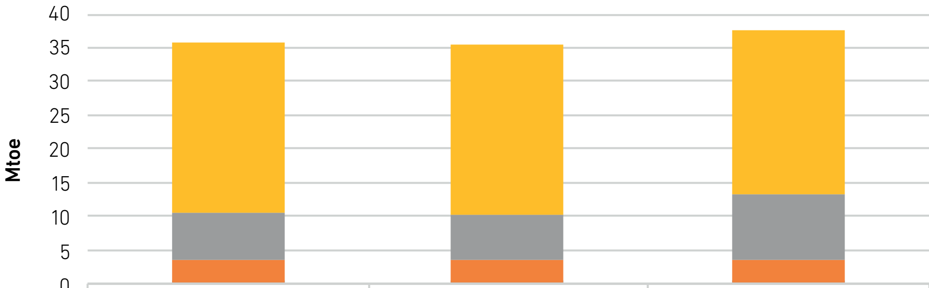
Source: Author's calculations.

3.4. Final Energy Demand

The following results relate to the final energy demand. Figure 15.6 shows the energy consumption structure by energy source and scenario in 2050. Oil products account for the highest share in final energy demand across all scenarios, followed by electricity. However, the electricity consumption is the highest in the LEDS scenario compared to any of the other two scenarios.

Figure 15.6 Final Energy Demand, Fuel by Scenario, 2050

(Mtoe)



	BAU	APS	LEDS
Oil Products	25.16	25.16	24.21
Electricity	7.18	6.83	9.86
Natural gas	3.23	3.23	3.17
Coal	0.18	0.18	0.18

Coal Natural gas Electricity Oil Products

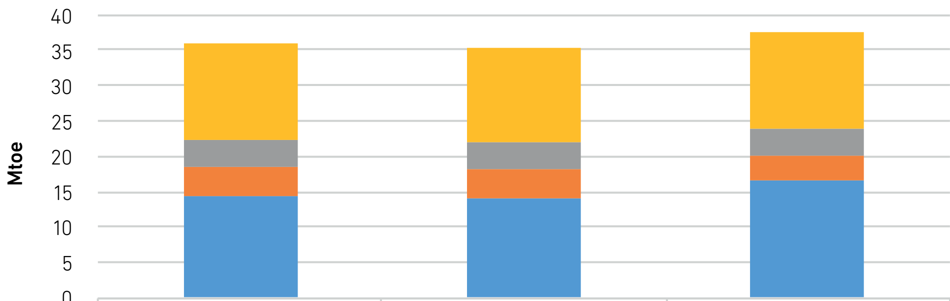
APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 15.7 further presents the energy consumption structure by sector and scenario in 2050. Across all sectors, the non-energy sector consumes the most energy, followed by the industrial sector. In particular, the industrial sector under the LEDS scenario consumes more energy than that in any of the other two scenarios.

Figure 15.7 Final Energy Demand, Sector and Scenario, 2050

(Mtoe)



	BAU	APS	LEDS
Non Energy	13.50	13.50	13.50
Others	3.90	3.71	3.71
Transport	4.09	4.09	3.60
Industry	14.27	14.10	16.62

Industry Transport Others Non Energy

APS = alternate policy scenario, BAU = business-as-usual, LEDS = Long-Term Low-Emissions Development Strategy, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

4. Conclusions

To achieve sustainable development in the long run, Singapore has set enhanced targets for 2030 and post-2030 periods. The COVID-19 pandemic led to substantial socio-economic changes worldwide, which is perceived to affect energy supply and demand, as well as emissions. The pathways to such targets require rigorous research. Based on the LEAP modelling platform, this project updates Singapore's energy outlook model by incorporating the new macroeconomic circumstances due to COVID-19 and policy changes. This project seeks to explore a scenario that aligns with Singapore's enhanced NDC and LEDS objectives. To do so, an updated BAU, APS, and LEDS scenarios have been developed.

The projected CO_2 emissions for Singapore under BAU and the APS show an increase until the final model year. Under these two scenarios, Singapore's enhanced NDC targets for reducing emissions intensity can be met, but the LEDS targets for peak emissions and emissions in 2050 cannot be achieved. In contrast, the LEDS scenario, which considers a higher share of solar energy and CCS technology, presents a different emissions trajectory. Under LEDS scenario, Singapore's emissions are projected to peak at 60.35 $MtCO_2$ in 2030 and then gradually decline to 34.21 $MtCO_2$ in 2050, achieving both the enhanced NDC and peak emissions targets. The modelled emissions in 2050 are slightly higher than the LEDS policy target of 35 MtCO2. However, in addition to CCS technology, the LEDS policy design considers a wider range of low-carbon emerging technologies, such as hydrogen applications, more diversified energy mix (e.g. energy imports), and policy tools such as carbon tax (Li and Su, 2017; Boey and Su, 2014), which are not considered in the current analysis. With the inclusion of these alternatives, Singapore's emissions target in 2050 would be viable.

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CHAPTER 16

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 up north, and highlands in the northeast. Its gross domestic product (GDP) in 2019 was around $460.8 billion (in constant 2015 US$). In 2019, the population was 69.6 million and income per capita was around $6,620.

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 133.1 million tonnes of oil equivalent (Mtoe) in 2019. Oil accounted for the largest share at around 30.8%, followed by natural gas at 29.7%, and coal at 13.9%. 'Others', which includes the commercial and residential sectors, accounted for the remaining 25.6%. In 2019, net imports of energy accounted for 56% of the TPES. Due to very 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 2019, 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 (GW) of installed electricity generation capacity. In 2019, power generation was about 201.8 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, while the remaining portion was made up of geothermal, solar, small hydro, and biomass.

2. Modelling Assumptions

The annual GDP growth rate from 1990 to 2019 was a moderate 4.2% per year. For 2019–2050, an average GDP growth rate of 2.8% per year is assumed for Thailand. Population growth is also projected to be quite slow at around 0.5% per year between 2019 and 2050, which is comparable to average growth of about 0.5% per year between 1990 and 2019.

Efficiency programmes in all sectors are expected to help Thailand achieve its energy-saving goals. The industrial 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-emission vehicles (ZEV) 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_2 emissions are also expected to be achieved through the increased adoption of more energy-efficient technologies. In particular, in the APS, renewable energy sources are expected to help reduce CO_2 emissions from electricity generation. Gasohol and biodiesel as oil alternatives are also expected to help curb CO_2 emissions from transportation. To achieve carbon neutrality by 2050, around 120 million tonnes of carbon dioxide (Mt-C) emissions will be able to offset the carbon sink in Thailand. This means that the energy sector is allocated a carbon emission quota of 100 Mt-C, out of the total quota.

3. Outlook Results

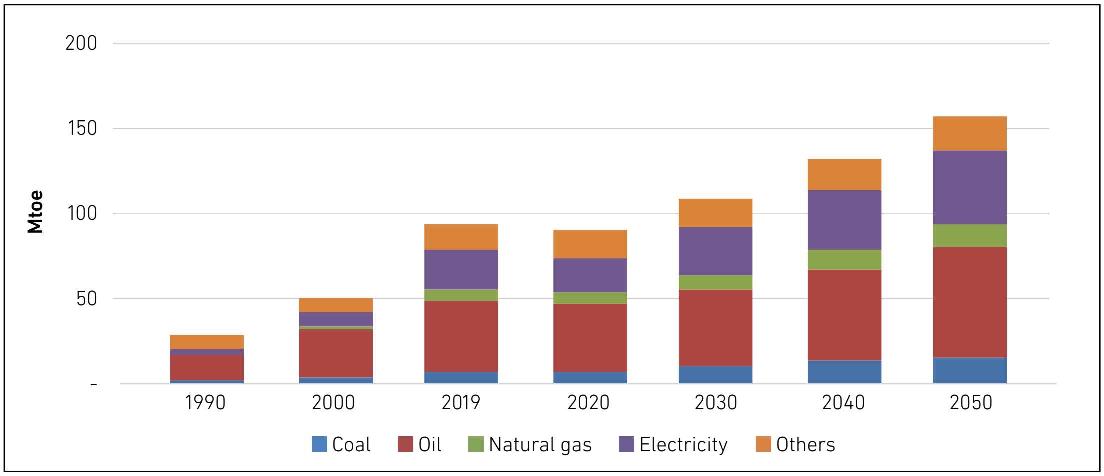
3.1. Business-as-Usual Scenario

3.1.1. Final Energy Consumption

Between 1990 and 2019, Thailand's final energy consumption grew at an average rate of 4.2% per year from 28.9 Mtoe in 1990 to 93.9 Mtoe in 2019 (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 1.7% per year between 2019 and 2050.

Oil has been the dominant fuel in Thailand's final energy consumption, accounting for 40.7 Mtoe, or a 43.4% share, in 2019. Electricity was the second-largest energy fuel, accounting for 22.7 Mtoe, or a 24.1% share, in 2019. Oil is expected to remain the largest final energy source throughout the projection period. Its share is expected to rise continuously from the 2019 to 40.9% in 2050. In 2050, the share of electricity in final energy consumption will be 27.5%, while coal will be 8.8%.

Figure 16.1 Final Energy Consumption by Fuel, Business-as-Usual
(Mtoe)



BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

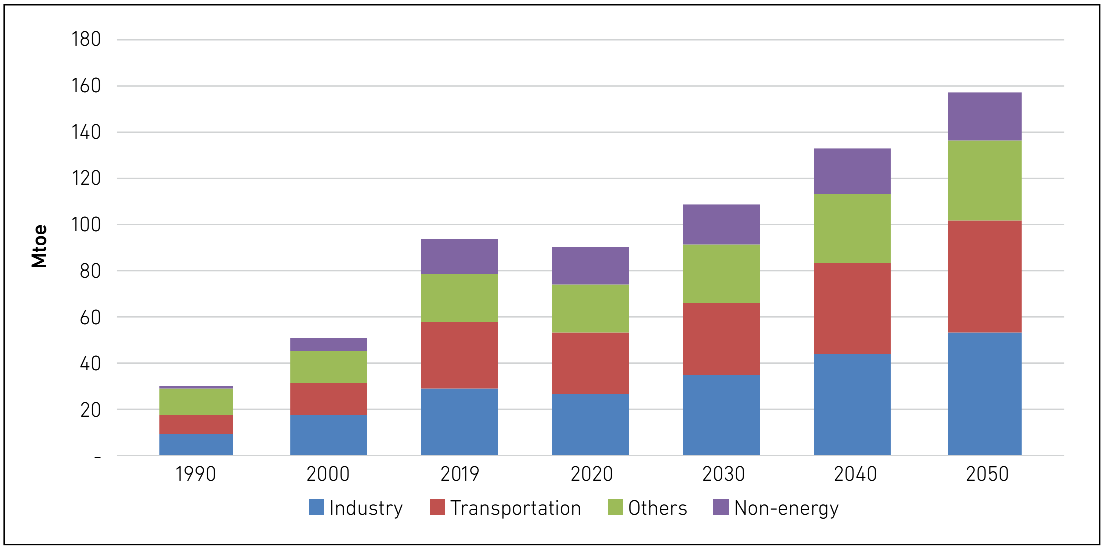
Source: Author's calculation.

In 1990, the share of industrial sector for Thailand's total final energy consumption was 30.%, equal to 8.7 Mtoe (Figure 16.2). The sector's demand grew by an average rate of 4.2% a year between 1990 and 2019, increasing its share to 30.6% (equivalent to 28.7 Mtoe) in 2019, making it the largest consuming sector. It is projected to remain the largest consumer, accounting for 33.6% (equivalent to 52.7 Mtoe) in 2050. In contrast, the 'Others' sector (mainly residential and commercial) will account for the smallest proportion of final energy consumption in 2050, at 21.8%, compared to its 37.3% share in 1990.

3.1.2. Primary Energy Supply

Primary energy supply grew at an average annual rate of 4.0% from 42.6 Mtoe in 1990 to 133.1 Mtoe in 2019, 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 world economic crisis in 2008. In 2019, the major sources of primary energy were oil with a 30.8% (41.0 Mtoe) share; natural gas with 24.0% (39.6 Mtoe); and coal with12.3% (18.5 Mtoe).

Figure 16.2 **Final Energy Consumption by Sector, Business-as-Usual**
(Mtoe)



BAU = business-as-usual scenario; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes commercial and residential sectors.

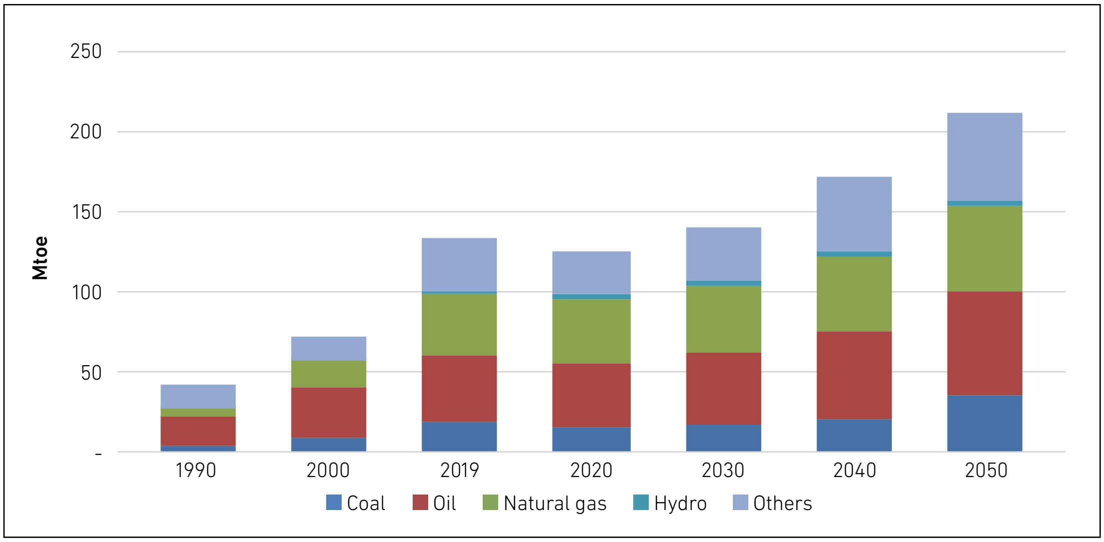
Source: Author's calculation.

Although oil remained the largest source between 1990 and 2019, its share in primary energy supply decreased from 42.8% in 1990 to 30.8% in 2019. Natural gas, which is mainly consumed in the power generation sector, became an important source of energy with its share in primary supply increasing from 11.9% in 1990 to 29.7% in 2019. The share of hydropower remained small at 1.0% in 1990 to 1.3% in 2019.

In the business-as-usual (BAU) scenario, primary energy supply is projected to grow by an average of 1.5% per year from 2019 to 2050, reaching 211.3 Mtoe in 2050 (Figure 16.3). The highest average annual growth rate is expected in coal (2.1%), with consumption projected to reach 35.2 Mtoe in 2050. Oil will follow at an annual average growth rate of 1.7%, reaching 64.4 Mtoe in 2050. Natural gas is projected to increase at an average rate of 1.0% per year. The share of oil will be almost the same around 30.5% in 2050, while the shares of coal and natural gas will be around 16.7% and 25.8%, respectively. Biomass is expected to grow at an average rate of 1.1% per year between 2019 and 2050.

The share of biomass in the total primary energy consumption will decline somewhat from 16.2% in 2019 to 14.2% in 2050.

Figure 16.3 Primary Energy Supply by Fuel, Business-as-Usual
(Mtoe)



BAU = Business-as-Usual; Mtoe = million tonnes of oil equivalent.

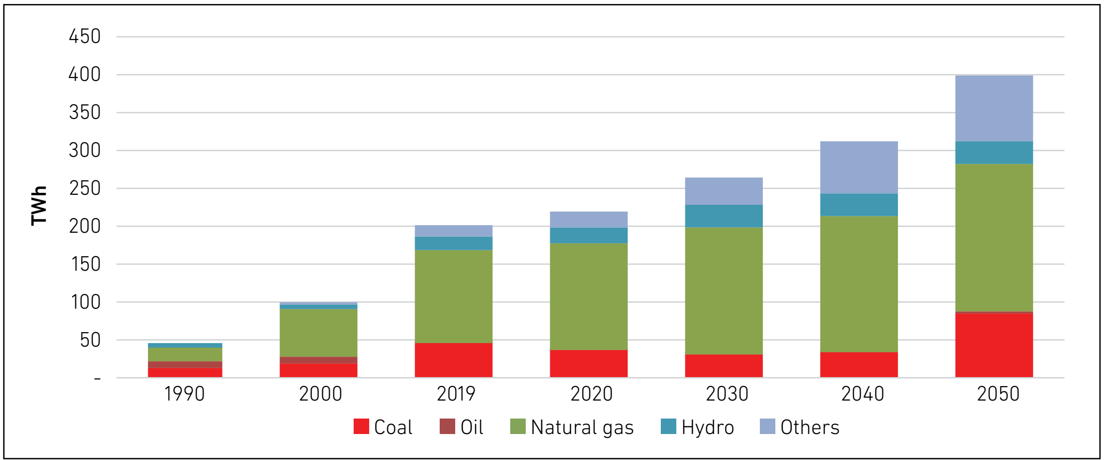
Source: Author's calculation.

3.1.3. Power Generation

In 1990, the total power generation was 44.2 TWh. It reached 201.8 TWh in 2019, with an average growth rate of 5.4% 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 6.9% per year from 17.8 TWh (40.2% share) in 1990 to 121.4 TWh (60.2% share) in 2019. Coal had the second largest share at 25.0% in 1990 but dropped to 22.4% in 2019. Oil was the least used fuel in power generation, with only 0.4 TWh in 2019.

In the BAU scenario, power generation is expected to grow at around 2.2% per year from 2019 to 2050 and will reach 400.7 TWh in 2050. In 2050, natural gas will remain the dominant fuel used in power generation with the highest share of 49.5% or 198.2 TWh. Coal will remain the second largest source of power generation, with a share of 21.2% or a level of 85.1 TWh in 2050. Power generation from hydro will increase by 1.2% per year from 20.4 TWh in 2019 to 29.9 TWh in 2050.

Figure 16.4 Power Generation by Fuel, Business-as-Usual
(TWh)

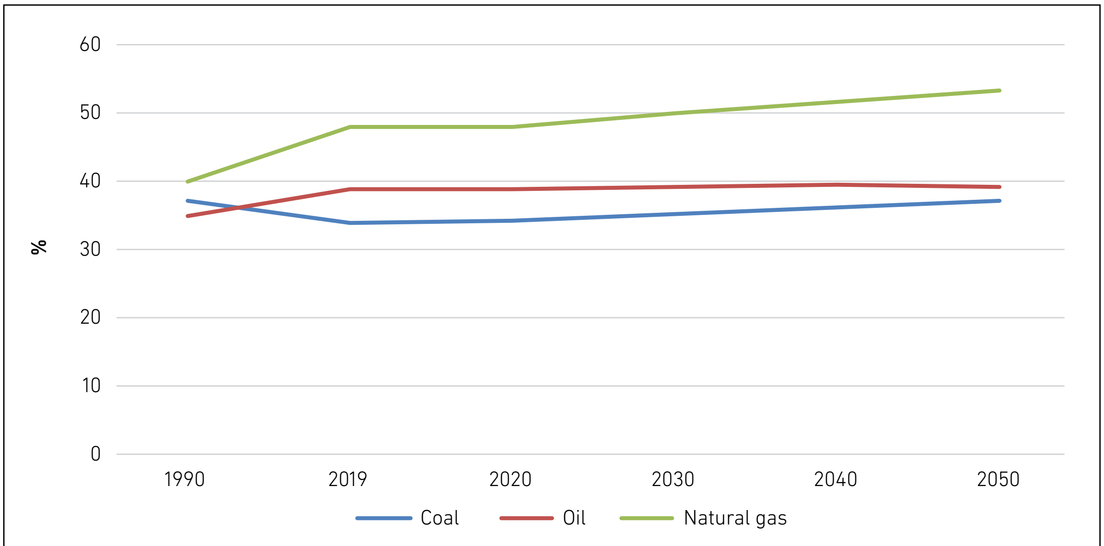


BAU = business-as-usual scenario; TWh = terawatt-hour.

Source: Author's calculation.

Out of all energy sources, natural gas has shown the greatest improvement in thermal efficiency. Its efficiency increased from 40% in 1990 to almost 48% in 2019 and is expected to reach 53.4% in 2050. In contrast, coal's thermal efficiency declined by almost 3.3% from 1990 to 2019 but is expected to improve to 37.3% over the study period (Figure 16.5).

Figure 16.5 Thermal Efficiency by Fuel, Business-As-Usual, 1990–2050
(%)



BAU = business-as-usual scenario.

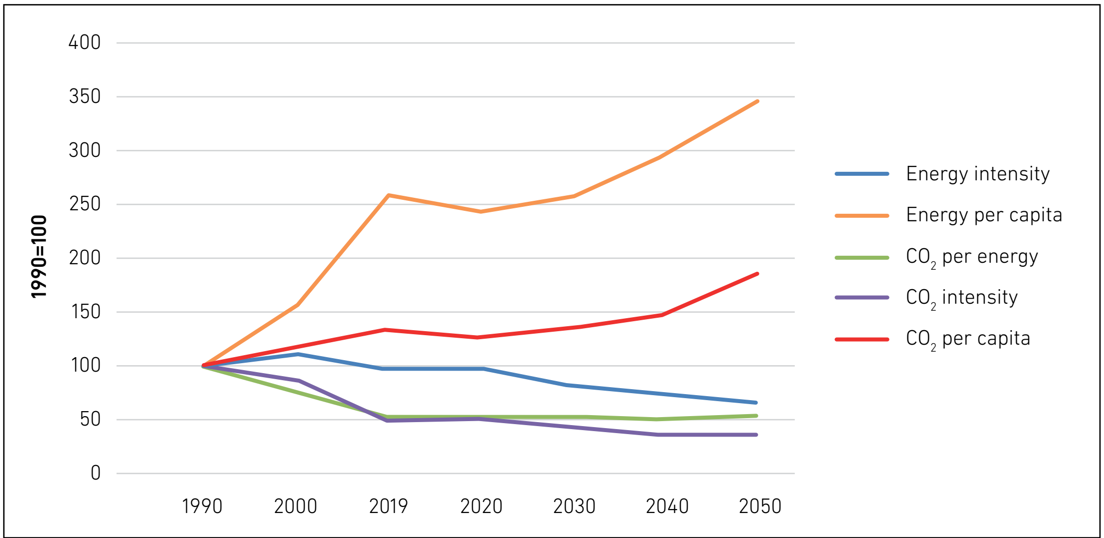
Source: Author's calculation.

3.1.4. Energy Indicators

Energy indicators are shown in Figure 16.6. Energy intensity in 2019 was 289 tonnes of oil equivalent per million 2015 US$ (toe/million 2015 US$). In the BAU, energy intensity is projected to decline and reach 193 toe/million in 2050, calculated in 2015 US$. Energy per capita will increase from almost 1.9 toe per person in 2019 to 2.6 toe per person in 2050.

Energy elasticity between 1990 and 2017 was 1.0, which indicates that energy demand rose at the same rate as economic output. In BAU, energy elasticity is projected at 0.61 between 2019 and 2050, which indicates that energy demand will grow at a slower rate than economic output.

Figure 16.6 Energy Indicators, 1990–2050



CO_2 = carbon dioxide.

Source: Author's calculation.

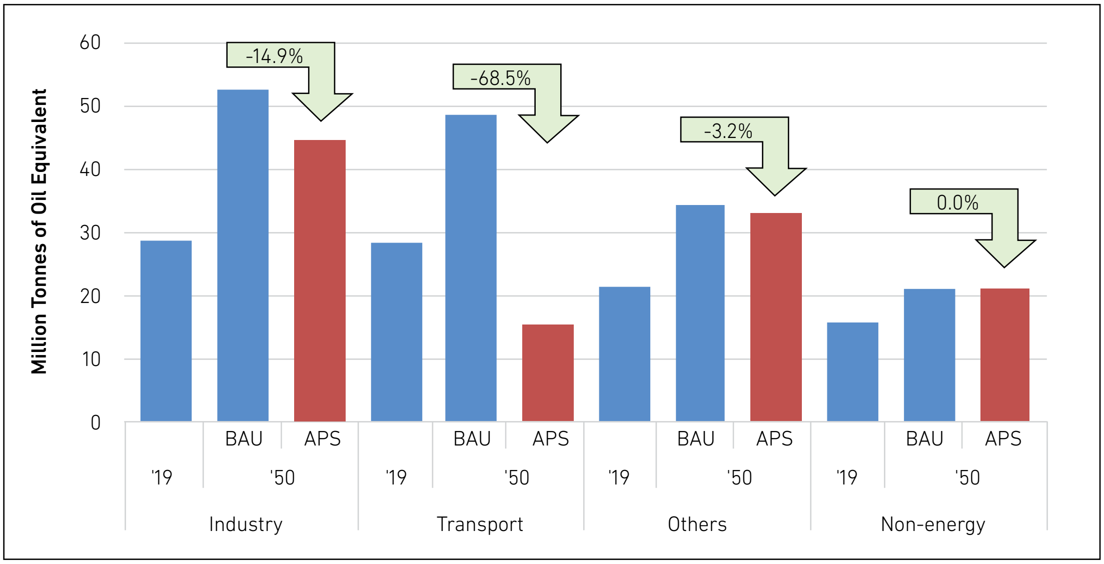
3.2. Energy Savings and Carbon Dioxide Reduction Potential

3.2.1. Final Energy Consumption

In the APS, final energy consumption is projected to grow by 0.6% per year, from 93.9 Mtoe in 2019 to 114.4 Mtoe in 2050. This is 27.1% lower than in the BAU. The majority of energy savings will be achieved through energy efficiency improvement programmes implemented in industry (14.9%) and transport (68.5%). Improvements will also be achieved in 'Other' sectors (3.2%), as shown in Figure 16.7.

Figure 16.7 Final Energy Consumption by Sector, Business-as-Usual and Alternative Policy Scenario, 2019–2050

(Mtoe)



APS = Alternative Policy Scenario; BAU = Business-as-Usual scenario; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes commercial and resident sectors.

Source: Author's calculation.

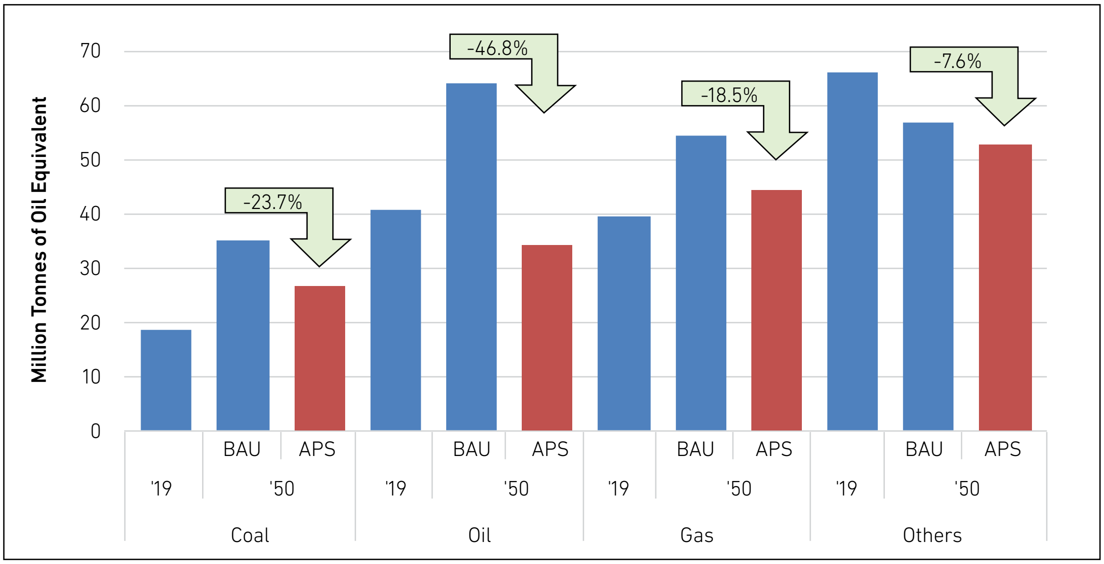
3.2.2. Primary Energy Supply

In the APS, growth in primary energy supply is projected to be much slower than in BAU, increasing at 0.6% per year (compared with 1.5% in the BAU) to reach 158.5 Mtoe in 2050. Primary APS energy supply is expected to be about 25.0% lower than the BAU in 2050, which is an energy savings of about 52.8 Mtoe.

Coal and oil are projected to increase at slower annual average rates of 1.2% and -0.6%, respectively (compared to 2.1% and 1.5% in the BAU). Natural gas use is projected to increase at an annual average rate of 0.4% (compared to 1.0% in the BAU) from 39.6 Mtoe in 2019 to 44.4 Mtoe in 2050. The lower growth rates compared to the BAU are mainly achieved through energy efficiency and conservation measures on the demand side. 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 Alternative Policy Scenario, 2019–2050**

(Mtoe)



APS = Alternative Policy Scenario; BAU = Business-as-Usual scenario; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

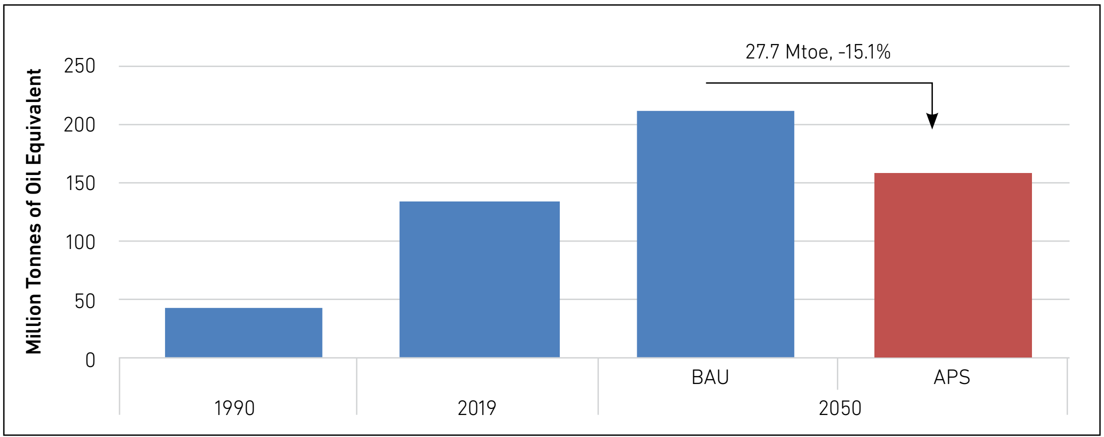
3.2.3. Projected Energy Savings

The difference between primary energy supply in BAU and the APS in 2050 is 52.8 Mtoe (Figure 16.9). This represents the energy savings that could be achieved if efficiency, conservation goals, and action plans were implemented. Oil will contribute the largest energy savings at 30.1 Mtoe, followed by natural gas at 10.1 Mtoe. Energy savings from coal will reach 8.3 Mtoe in 2050, but the contribution of non-fossil energy sources will also be 4.3 Mtoe lower than in the BAU.

In the final energy consumption, savings in the APS compared with the BAU in 2050 will reach 42.4 Mtoe. The largest savings are expected in the transport sector, at 33.5 Mtoe. The industry sector is expected to reach 7.9 Mtoe in energy savings, while sectors in the 'Other' category are expected to save a combined total of 1.1 Mtoe.

Figure 16.9 Total Primary Energy Supply, Business-as-Usual and Alternative Policy Scenario, 1990, 2019 and 2050

(Mtoe)



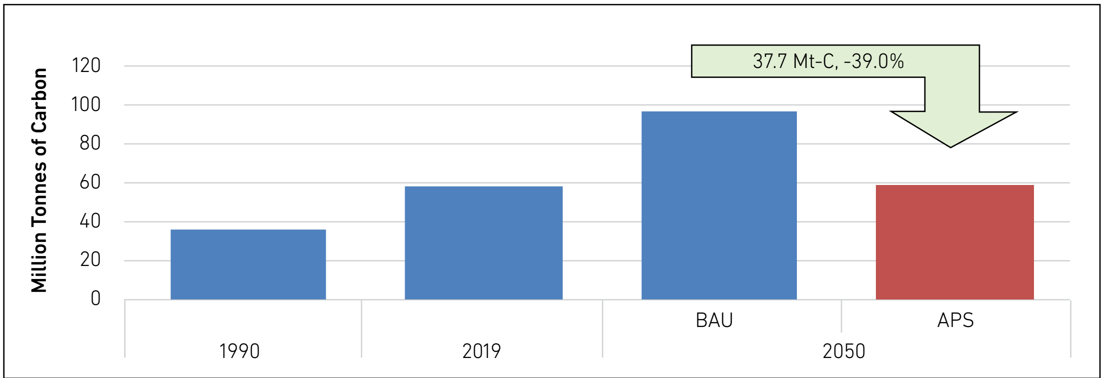
APS = Alternative Policy Scenario; BAU = Business-as-Usual; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.4. Carbon Dioxide Emissions

Carbon dioxide emissions from energy consumption are projected to increase by an average of 1.6% per year, from 58.4 Mt-C in 2019 to 96.5 Mt-C in 2050 under the BAU. Under the APS, the average annual growth in CO_2emissions from 2019 to 2050 is projected to be only 0.02%, with an emissions level of 58.8 Mt-C in 2050. The difference in CO_2 emissions between BAU and the APS is 37. Mt-C, or 39.1%. This reduction in CO_2emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans (Figure 16.10).

Figure 16.10 Carbon Dioxide Emissions from Energy Consumption, Business-as-Usual and Alternative Policy Scenario, 1990, 2019 and 2050



APS = Alternative Policy Scenario; BAU = Business-as-Usual scenario; CO_2 = carbon dioxide; Mt-C = million tonnes of carbon.

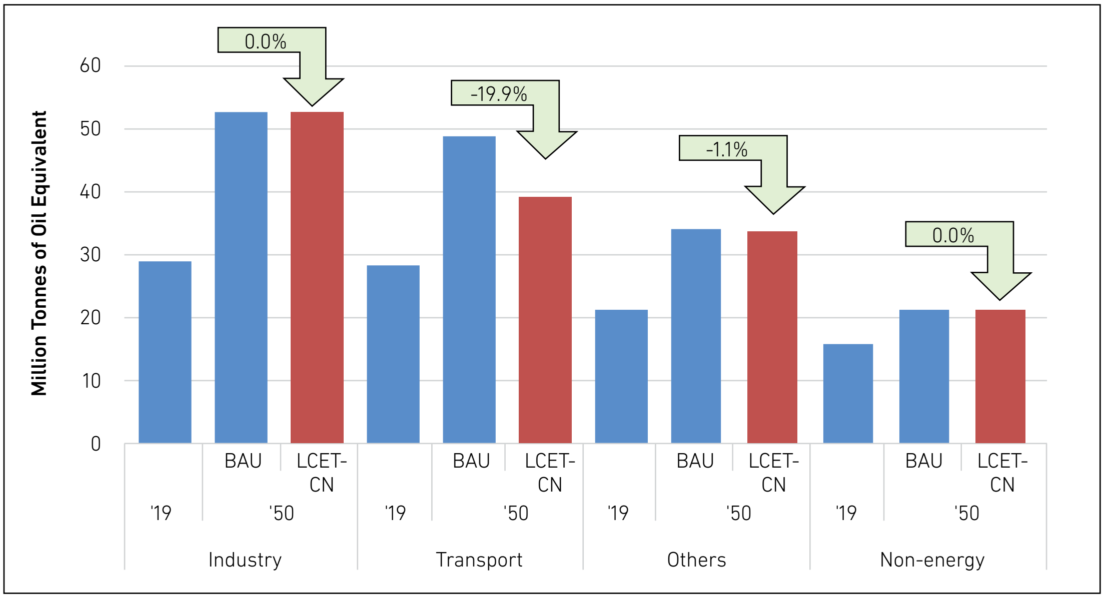
Source: Author's calculation.

3.3. Low Carbon Energy Transition Scenario

3.3.1. Final Energy Consumption Sector

In the LCET, final energy consumption is projected to grow by 1.4% per year, from 93.9 Mtoe in 2019 to 146.7 Mtoe in 2050. This is less than 1.0% lower than in the BAU. Electric vehicles, energy efficiency in road transport, and travel mode switching (behavior changes) probably drive consumption in transport down. For the BAU, the share of final energy consumption is 19.9% for transport sector and 1.1% for 'Others' sector (Figure 16.11).

Figure 16.11 Final Energy Consumption by Sector, Business-as-Usual and Low Carbon Energy Transition Scenario
(Mtoe)



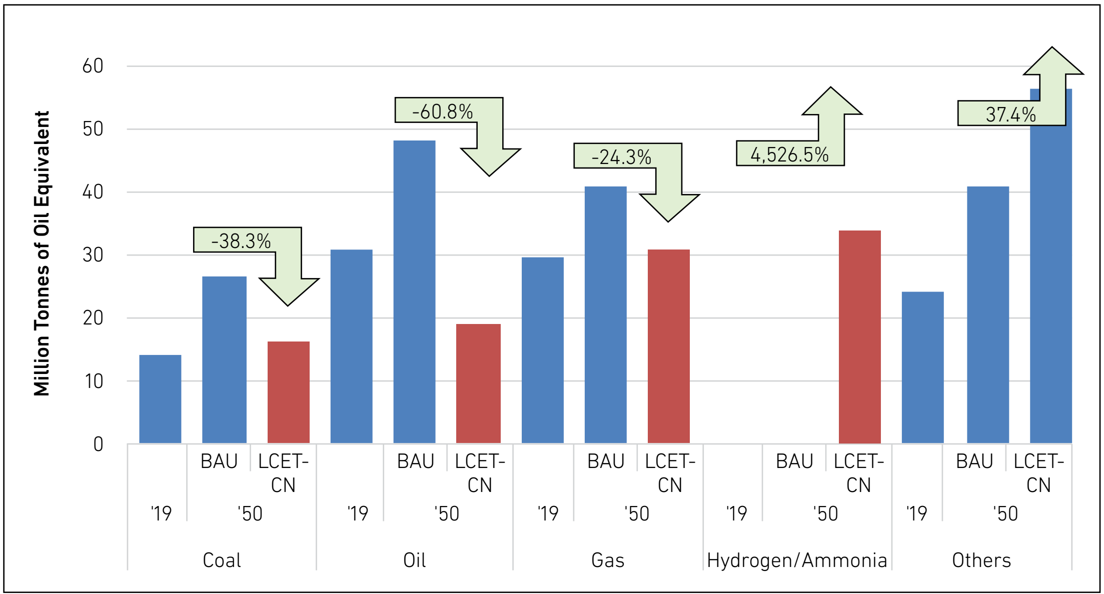
BAU = Business-as-Usual scenario; LCET-CN = Low Carbon Energy Transition Scenario; Mtoe = million tonnes of oil equivalent.
Note: 'Others' includes commercial and residential sectors.
Source: Author's calculation.

3.3.2. Primary Energy Supply

The growth rate of primary energy supply in the LCET scenario is projected to be the same as that in the BAU, increasing at 1.5% annually and reaching 186.6 Mtoe in 2050. However, primary LCET energy supply has a different fuel mix from BAU.

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 by 38.3%, 60.8%, and 24.3% respectively. However, they are expected to increase in the 'Others' category by 37.4% and hydrogen/ammonia (from 0 Mtoe in 2019 to 45.3 Mtoe). The differences in the projections between the two scenarios are shown in Figure 16.12.

Figure 16.12 Primary Energy Supply by Source, Business-as-Usual and Low Carbon Energy Transition Scenario
(Mtoe)



BAU = Business-as-Usual scenario; LCET = Low Carbon Energy Transition Scenario; Mtoe = million tonnes of oil equivalent.
Source: Author's calculation.

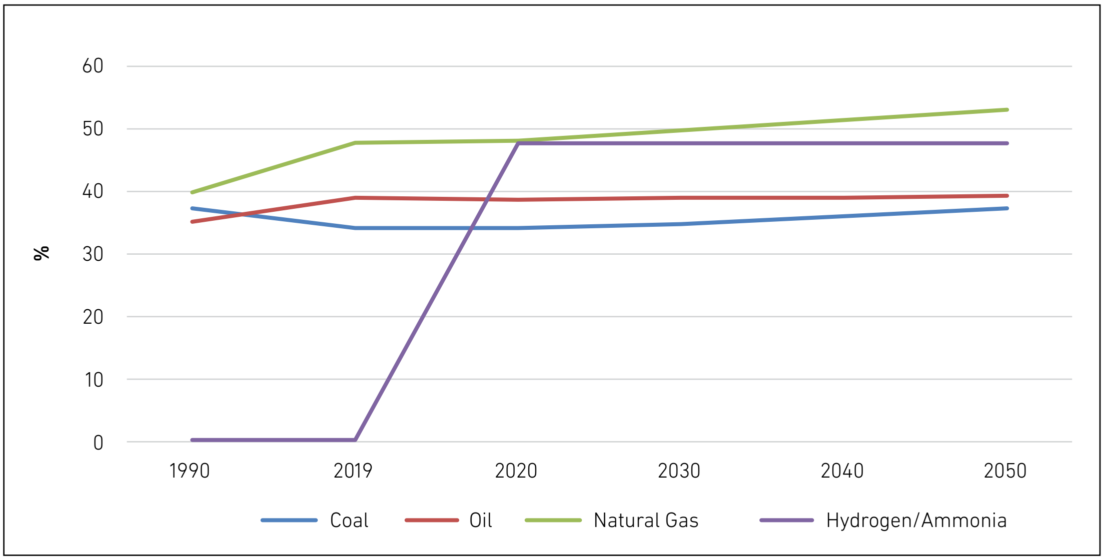
3.3.3. Energy Indicators

Figures 16-13 and 16-14 show the thermal efficiency and energy indicators respectively. Energy intensity reached 289 toe/million in 2019, calculated in 2015 US$. In the LCET, energy intensity is projected to decline by -1.3% per year to reach 193 toe/million in 2050, calculated in 2015 US dollars. Energy per capita will increase from almost 1.9 toe per person in 2019 to 2.6 toe per person in 2050.

In the LCET, energy elasticity is projected at 0.50 between 2019 and 2050, compared to 0.61 in BAU.

Figure 16.13 Thermal Efficiency by Fuel, Low Carbon Energy Transition

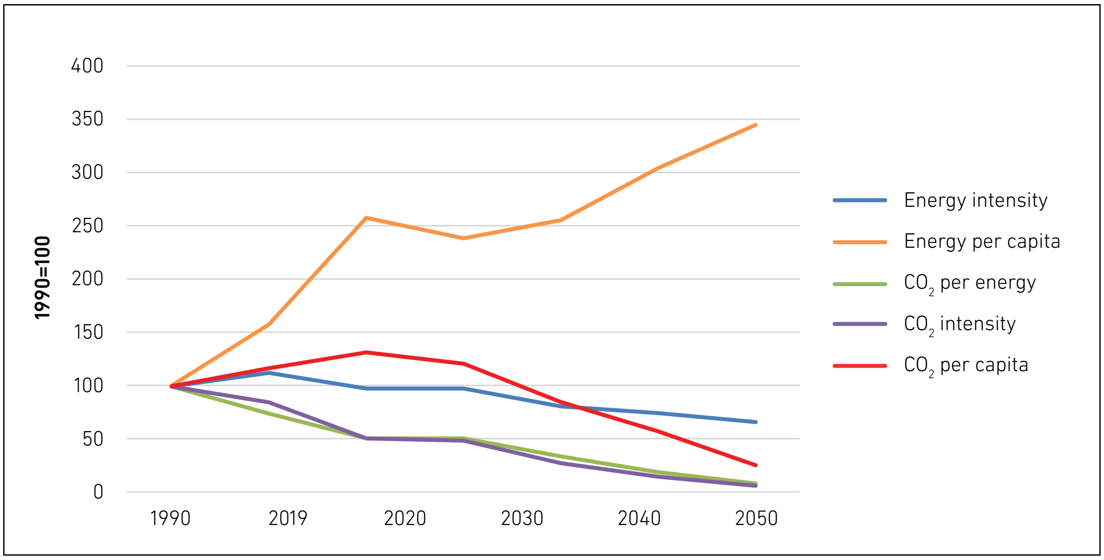
(%)



LCET = low carbon energy transition.

Source: Author's calculation.

Figure 16.14 Energy Indicators, Low Carbon Energy Transition



CO_2 = carbon dioxide.

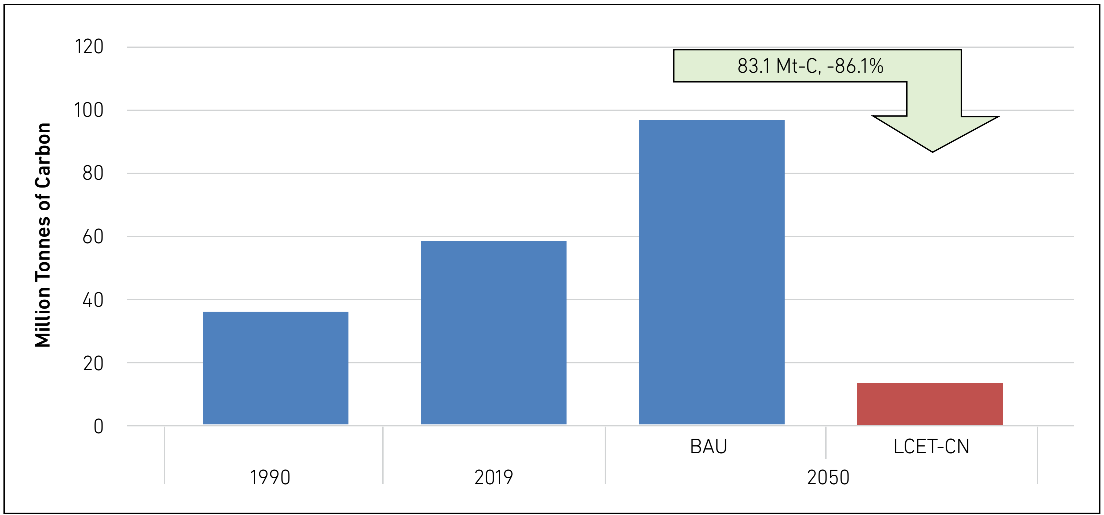
Source: Author's calculation.

3.3.4. Carbon Dioxide Emission Reduction

Under the LCET, the average annual growth in CO_2 emissions from 2019 to 2050 is projected to be -4.6%, with an emissions level of 13.5 Mt-C in 2050. The difference in CO_2 emissions between the BAU and the LCET is 83.1 Mt-C, or 86.1%. This can achieve carbon neutrality, which is less than the offset capability in Thailand in 2050 of 27 Mt-C. This reduction in CO_2 emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans, CCS (carbon capture and storage) in industry, and in power generation for coal and natural gas (Figure 16.15).

Figure 16.15 Carbon Dioxide Emissions from Energy Consumption, Business-as-Usual and Low Carbon Energy Transition

(Mt-C)



BAU = business-as-usual; CO_2 = carbon dioxide; LCET = low carbon energy transition; Mt-C = million tonnes of carbon.

Source: Author's calculation.

4. Implications and Policy Recommendations

In Thailand, solely focusing emissions from energy sources would not be a sufficient to achieve the carbon neutrality target, as the BAU scenario falls significantly short of this goal. It means that there is a need to reshape the current energy consumption patterns to be more environmentally sustainable in the distant future.

APS can cut down some amount of energy consumption with energy conservation programmes and replace the high CO_2 emission of fossil fuels with renewable energy in government programmes. This can help ease CO_2 emission from energy by approximately 39% lower than in BAU. However, it is probably inadequate in terms of carbon neutral.

To set the criteria, Thailand estimates the carbon sinks in 2050 around 120 Mt-C in total, and the quota of carbon sink from the energy sector is set around 100 Mt-C. To achieve carbon neutral (CO_2 emission against the offset), the LCET scenario requires a greater focus on clean energy compared to current government programmes. This involves the introduction of new energy and technology, such as hydrogen/ammonia and CCS (carbon capture and storage) on fossil fuels such as coal and natural gas. However, the extensive use of hydrogen and CCS technologies may result in an estimated13.5 Mt-C, which is significantly lower than the carbon neutrality target of 27 Mt-C.

The three scenarios presented represent extremes, ranging from inaction under the BAU to high reliance on alternative fuels and energy efficiency (APS) to full adoption of pure clean energy (LCET). While policymakers may consider more moderate options, the optimal approach likely lies somewhere in between these extremes. While the LCET scenario does not address cost, it is essential to ensure that energy solutions are both affordable, environmentally friendly, and sustainable. Therefore, a balanced approach incorporating elements of both APS and LCET is necessary for optimal results.

CHAPTER 17

Viet Nam Country Report

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1. Background

Viet Nam is a developing country in Southeast Asia. The total land area is 331,100 square kilometres, 50% of which is in productive use. In 2019, Viet Nam's population was 96.5 million, which represents an average annual increase of 1.3% (or 30.5 million) from its 1990 level of 66.0 million.

Viet Nam's gross domestic product (GDP) increased at an average annual rate of 6.1%, from $29.5 billion in 1990 to $162.2 billion in 2019 (constant 2010 US$). The commercial sector contributes the most to Viet Nam's GDP (38.7%), followed by the industry sector (36.2%), agriculture (13.6%), and other activities (11.5%). In 2019, GDP per capita was $1,681.

1.1. Energy Situation

Viet Nam possesses considerable indigenous energy resources. It has 3.39 billion tonnes of proven recoverable reserves of coal, 460 million cubic meters (m3) of crude oil reserves, and 610 billion m^3 of gas reserves.

In 2019, Viet Nam produced 47.16 million tonnes of coal, 10.2 billion m^3 of natural gas, and 13.09 million tonnes of crude oil. Almost all crude oil production is used for the oil refinery and the remaining part is exported. Coal is mainly used in the industry sector, while natural gas is largely used to generate electricity.

The country had around 55.1gigawatts (GW) of installed generating capacity and produced over 230terawatt hours (TWh) of electricity in 2019. The main share of electricity generation comes from thermal sources (coal, natural gas, and oil), accounting for 69.6% of total generation; the remaining is hydro at 24.3% and others at around 6.1%.

The rural electrification programme has been implemented over the past few years. According to reports by Viet Nam Electricity (EVN), by the end of 2019, 100% of communes and 99.25% of households had access to electricity from the national grid, higher than most countries with the same GDP in the region and in the world.

Viet Nam has a high potential for renewable energy, such as small-scale hydropower, biomass energy, wind energy, and solar energy, which can be utilised to meet the national energy demand and the need for electricity in remote areas.

1.2. Targets on Greenhouse Gas Emission Reduction and Energy Development

1.2.1. Mitigation Targets and Related Legal Documents

Viet Nam has committed to develop and implement strong emissions reduction measures to achieve net-zero emissions by 2050 with its own resources, along with the cooperation and support from the international community.

The Government of Viet Nam recently implemented a series of strategies and policies in the energy sector to fulfil their commitment of increasing the share of renewable energy sources in power generation, enhancing energy efficiency, and promoting fuel switching to reduce greenhouse gas (GHG) emissions. The targets for reducing GHG emissions, conserving energy, promoting fuel switching, and advancing renewable energy development, as outlined in legal documents, are summarised in Table 17.1.

Table 17.1 Mitigation Targets and Related Legal Documents

Legal Document	Mitigation Targets and Actions
The National Climate Change Strategy, Vision to 2050	Targets: Viet Nam will strive to achieve net zero emissions by 2050. • By 2030: GHG emission in the energy sector decreases by 43.5% from BAU and emissions does not exceed 457 MTCO_2e. • By 2050: Total national GHG emission reaches net-zero, GHG emission in energy sector reduces by 91.6% from BAU, and emissions does not exceed 101 million tonnes of CO_2equivalent.
MOIT's Action Plan for implementing the Viet Nam's commitments at COP26	• Strengthen implementation of energy efficiency measures by improving Minimum Energy Performance Standards (MEPS) • Phase out the use of fossil fuels in energy sector • Apply CCUS in industry fields such as cement, steel, and chemical industries. • Develop renewable energy projects such as solar PV, wind power, hydropower, hydrogen, CCUS, and energy storage technologies. • Promote electrification and energy efficiencies in residential, transport sectors.
Action Plan on Green Energy Transition GHG emission Reduction in Transport Sector	Target: Develop a green transport system towards net-zero emissions by 2050. • By 2030: Promote energy efficiency and encourage the switch to electricity and green energy in fields where technologies, institutions, and resources are available to fulfil the country's commitments in its NDC. • By 2050: Prioritise the development of sustainable modes of transport and achieve zero emissions by transitioning all transportation means, equipment, and infrastructure to use electricity and green energy.

BAU = business as usual; CCUS = carbon capture, utilisation, and storage; GHG = greenhouse gas; MOIT = Ministry of Industry and Trade; MtCO_2e = million tonnes of carbon dioxide equivalent; NDC = Nationally Determined Contribution.

Source : Authors, compiled from various sources.

1.2.2. Energy Development

A reliable power supply is an important requirement for an emerging economy in Viet Nam. By the end of 2019, the total installed capacity of the power generation system of Viet Nam was around 55.1 GW (Viet Nam Electricity, 2021), an increase of 11.9% over 2018 (Viet Nam Electricity, 2018). Coal takes the largest share of 35.8% in total installed capacity, followed by hydropower with 31.4%, and natural gas with 13.5%. According to the Final Draft Power Development Plan VIII, renewable power plants will mainly contribute to the essential capacity expansion, accounting for 29.6% by 2030 and 53.9% by 2050; followed by coal thermal power plants with 25.8% by 2030 and 7.6% by 2050; natural gas with 22.6% by 2030 and 9.7% by 2050; hydro with 18.6% by 2030 and 5.5% by 2050; and others with 3.48% by 2030 and 23.3% by 2050.

To diversify its imported fuel sources beyond coal, Viet Nam is planning to rely on liquefied natural gas (LNG) as a major import fuel in the upcoming years. According to the Viet Nam Gas Industry Development Master Plan for the period up to 2035, the import of LNG should have started by 2021, with demand expected to increase to around 5 million tonnes by 2025, 10 million tonnes by 2030, and 15 million tonnes by 2035. Viet Nam plans to establish three or four LNG import terminal systems between 2021 and 2025, with each depot having an estimated capacity of 1–3 million tonnes per year. Additionally, the country intends to construct five or six more LNG import terminals between 2026 and 2035, each with an estimated capacity of around 3 million tonnes per year. These LNG terminal systems will mostly be in southern Viet Nam to cater to domestic power plants and industrial buyers.

In addition to the Dung Quat refinery, Viet Nam's second oil refinery at Nghi Son, with a capacity of 10 million tonnes per year, started operations in 2019. As a result, it can meet around 80% of the country's total current petroleum demand. Moreover, other oil refinery projects are being prepared for investment in the period 2025–2030 to achieve the total capacity of around 30 million tonnes a year by 2030.

2. Modelling Assumptions

In this outlook, Viet Nam's GDP would grow at an average annual rate of 5.2% from 2019 to 2050. Growth is projected to be lower in the first outlook period, increasing at 2.9% per year between 2019 and 2020 due to the impacts of the corona virus disease (COVID-19) pandemic. For the remaining periods, the country's economic growth will be slightly moderate at an annual rate of 6.2% for 2020–2030, 5.2% for 2030–2040, and 4.2% for2040–2050. Population growth is projected to increase at a much slower rate, increasing by 0.4% per year between 2019 and 2050.

The projected thermal efficiencies per fuel (coal, gas, and oil) in Viet Nam's power generation sector were based on the International Energy Agency's estimates for future power plant technologies. According to the forecasts, thermal efficiency is expected to increase considerably over time in the alternative policy scenarios (APSs) as more advanced generation technologies, such as natural gas combined cycles and supercritical coal plants, become available.

The main sources of electricity generation in Viet Nam are coal, hydro, and natural gas power plants.The share of electricity generated from natural gas and coal-fired power plants is projected to increase considerably in 2017–2030, whereas the electricity generated from hydro power plants will decline. This is due to the limited development of hydropower sources since its potential is almost fully exploited. However, the share of coal-fired power plants is strongly reduced after 2030 and renewable energy sources (such as wind power and solar photovoltaics) will be the important alternative sources. Viet Nam is expected to increase its imports of electricity, particularly from the Lao People's Democratic Republic and China.

The energy sector is the primary source of GHG emissions in Viet Nam, accounting for approximately 65% of the country's total emission by 2016 (Ministry of Natural Resources and Environment [MONRE], 2020). To help achieve carbon neutrality by 2050, the energy sector intends to take significant mitigation actions. These include improving energy efficiency, promoting electrification and shifting to hydrogen, halting the installation of new coal power plants from 2030, developing renewable technologies, and utilizing Carbon Capture Utilisation and Storage (CCUS).

Based on the analysis presented above, the alternative policy scenario (APS) and low carbon energy transition (LCET) scenario are proposed as follows:

APS: Implementation of the energy efficiency and conservation (EEC) measures on the demand side (APS1); improvement of energy efficiency in power generation (APS2); and development of renewables sources (APS3).

(i) APS1: Promote EEC activities in all sectors.
This is assuming that the promotion of EEC activities will result in energy reductions from business-as-usual (BAU) levels with around 5% in 2025, 10% in 2030, and 18% in 2050.

(ii) APS2: Improve energy efficiency in thermal power plants.
It is assumed that the efficiency of coal thermal power plants will increase to 48% from 35% (in BAU) by 2050, while natural gas with combined cycle gas turbines technology will increase to 60% from 55% (in BAU) by 2050.

(iii) APS3: Develop renewable technologies.
Installed electricity-generating capacity from renewables is assumed to reach 264,468megawatts (MW) in 2050, with solar contributing 120,603 MW; wind, 130,550 MW; small hydro, 7,300 MW; and biomass, 6,015 MW.

LCET: Under the LCET, further implementation of fuel switch from fossil fuels to hydrogen, electricity, and biomass in transport and industry activities as well as application of CCUS in cement production and power generation.

(i) Fuel Switch:
In the industry sector: Starting 2035 until 2050, hydrogen will be introduced in the industry sector by replacing coal in iron and steel production and replacing diesel in other activities, reaching100% utilisation rate. In the same period, biomass will replace coal and natural gas in other activities, reaching a 95% and 90% utilisation rate, respectively.

In the transport sector: Starting 2035 until 2050, hydrogen will be introduced in freight transport, replacing diesel and residual fuel oil, reaching 100% utilisation rate. Similarly, public passenger transport will shift to electricity from diesel and gasoline, reaching a100% utilisation rate. Electric vehicles will also be introduced in the private transport, replacing diesel and gasoline starting 2025 until 2050, reaching a70% utilisation rate.

(ii) Application of CCUS: CCUS will be applied for cement production and power generation including coal and natural gas from 2041 until 2050 with the utilisation rate of 100%.

LCET is combining APS with fuel switch and CCUS.

3. Outlook Results

3.1. Business-as-Usual Scenario

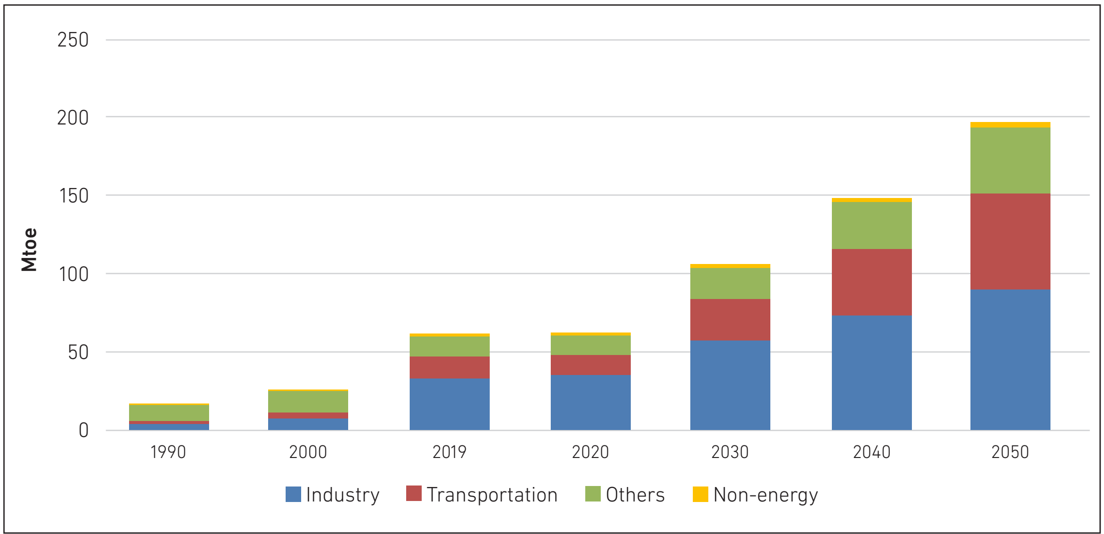
3.1.1. Total Final Energy Consumption

Viet Nam's total final energy consumption (TFEC) in 2019 was 61.3 million tonnes of oil equivalent (Mtoe), which has increased at 4.7% per year, 3.8 times more than its 1990 level of 16.1 Mtoe. On a per sector basis, the fastest growth occurred in the transport sector (8.3% per year), followed by the industry sector (7.1%), and the residential/commercial ('others') sector (0.9% per year). Non-energy use is expected to grow at 13.9% per year.

For 2019–2050, the TFEC is projected to increase at an average rate of 3.8% per year under the BAU scenario. The increase is driven by strong economic growth, which is assumed to be at an average annual growth rate of 5.2%, and the rising population with an average annual growth rate of 0.4%. On a per sector basis, the transport sector is expected to exhibit the strongest growth in energy consumption, with an annual increase of 4.9%. This is followed by the residential/commercial ('others') sector with an annual growth of 3.9% and the industry sector with 3.3%. Non-energy use is expected to grow at 2.8% per year. Figure 17.1 shows the final energy consumption by sectors from 1990 to 2050.

Figure 17.1 Final Energy Consumption by Sector, Business-As-Usual, 1990–2050

(Mtoe)



BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

Source: Author's calculations.

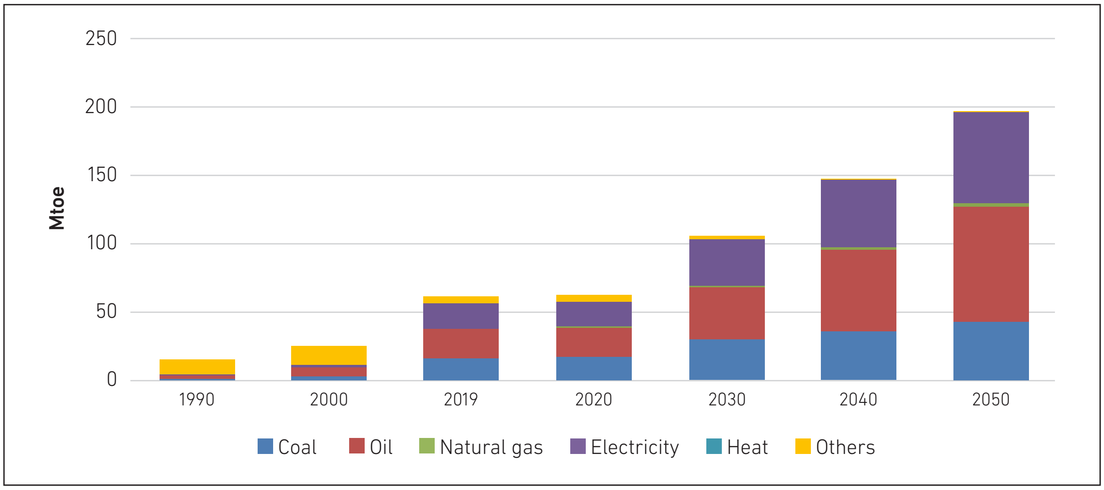
The residential/commercial ('others') sector was the primary source of the country's energy consumption in 1990, accounting for around 63%. This was mainly due to the use of biomass fuel used for residential cooking. This share decreased to 21.1% by 2019 due to the growing economy, which led to the substitution of biomass fuels with more efficient commercial fuels. Economic growth is expected to continue improving the standard of living, thus increasing the transition from biomass to modern fuels such as LPG.

During 2019–2050, the industry sector is expected to remain the largest consumer of energy in Viet Nam. However, its share of energy consumption will increase from 54.0% in 2019 to 56.2% in 2020, before slightly declining to 45.8% in 2050. Meanwhile, the transport sector will become the second-largest consumer, with its share increasing slowly from 22.9% in 2019 to 31.3% in 2050.

In 1990, other fuels – mainly biomass – had the highest consumption rate, accounting for 73.9% of the TFEC. However, this share decreased dramatically to 8.3% in 2019. Oil was the second most consumed product, making up 14.5% of the TFEC in 1990 and increasing to 34.7% in 2019. Coal consumption increased from 8.3% in 1990 to 26.7% in 2019. Electricity had a small share of 3.3% in 1990 but increased to 29.4% in 2019. On a per fuel basis under BAU, natural gas is projected to exhibit the fastest growth in final energy consumption, increasing at 5.0% per year between 2019 and 2050. Oil is projected to have the second-highest growth rate of 4.6% per year, followed by electricity with 4.3% and coal with3.1%. Other fuels (mainly biomass) are projected to decrease at an annual rate of 6.5% due to the transition from biomass to modern fuels.

In 2019, oil products held the largest share of energy at 34.7%. This share is projected to increase to 43.1% in 2050. The second-largest share of demand is electricity, which is projected to increase from 29.4% in 2019 to 33.6% in 2050. By 2050, coal will decrease from 26.7% in 2019 to 21.7% in 2050, while other fuels (mainly biomass) will decrease from 8.3% in 2019 to 0.3% in 2050. However, natural gas is expected to rise from 0.9% in 2019 to 1.2% in 2050. See Figure 17.2.

Figure 17.2 Final Energy Consumption by Sector, Business-As-Usual, 1990–2050
(Mtoe)



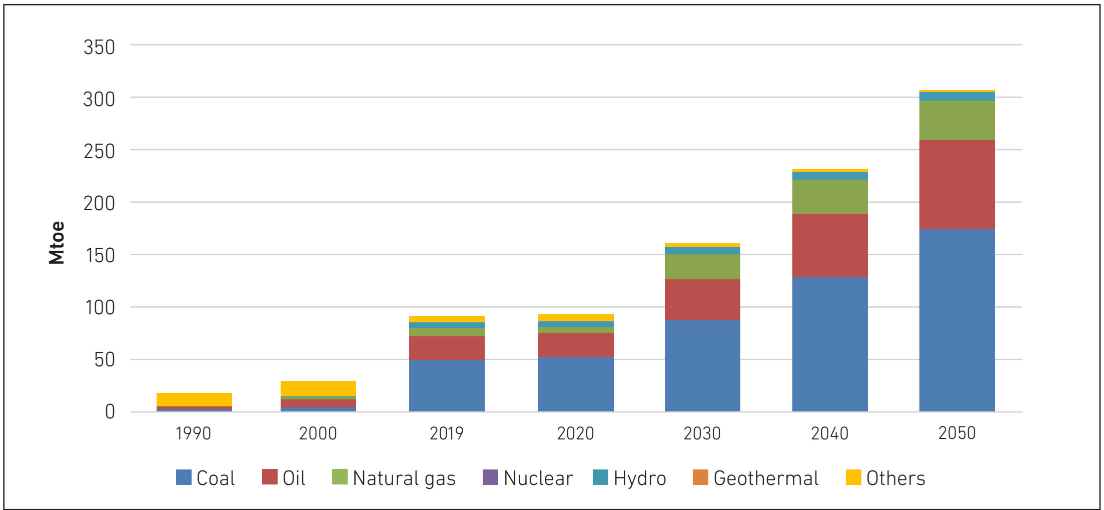
BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.
Note: 'Others' is mainly biomass.
Source: Author's calculations.

3.1.2. Total Primary Energy Supply

The total primary energy supply (TPES) of Viet Nam grew at a higher rate than the TFEC. It increased by 5.8% per year, from 17.9 Mtoe in 1990 to 91.4 Mtoe in 2019. Also, between 1990 to 2019, natural gas consumption grew at an average annual rate of 31.3%; coal at 11.3%; hydropower at 9.2%; and oil at 7.5%.

In the BAU scenario, Viet Nam's TPES is projected to increase at an annual rate of 4.0%, or 3.4 times, from 91.4 Mtoe in 2019 to 307.4 Mtoe in 2050. The fastest growth is expected in natural gas, increasing at an annual average rate of 5.1% between 2019 and 2050, followed by oil at 4.5%, coal at 4.1%, and hydro at 1.0%. Meanwhile, other fuels (mainly biomass) will decrease at 3.5% per year. Figure 17.3 shows the primary energy supply by source in for 1990–2050.

Figure 17.3 **Primary Energy Supply, Business-As-Usual, 1990–2050**
(Mtoe)



BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' is mainly biomass.

Source: Author's calculations.

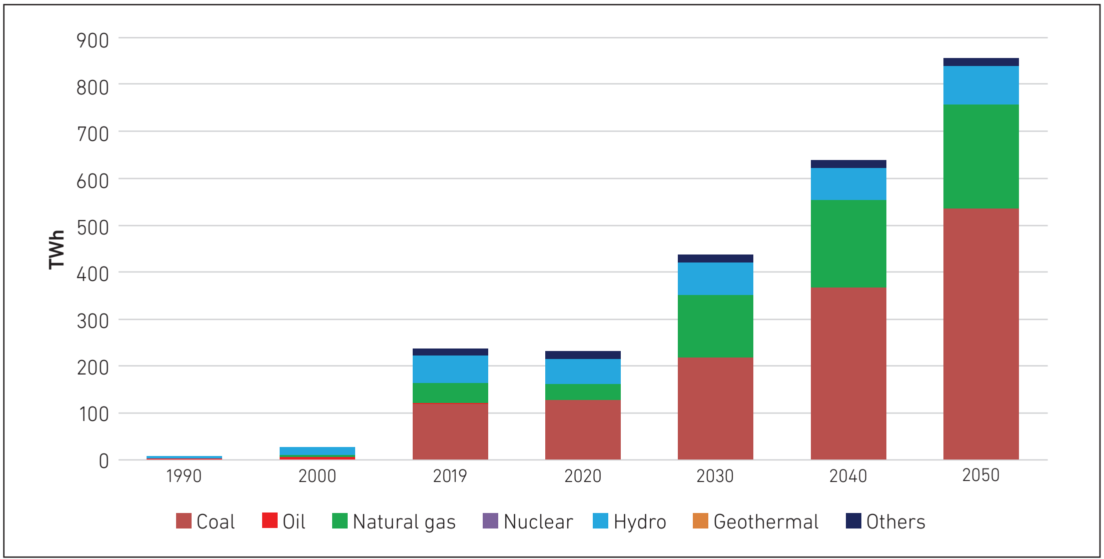
In 2019, coal accounted for the largest share of TPES at 54.2% and is expected to increase slightly to 56.7% in 2050. From 2019 to 2050, oil is projected to increase from 23.9% to 27.7%, while natural gas would increase from 8.9% to 12.2%. This growth is due to the projected decline of hydro from 6.5% in 2019 to 2.7% in 2050 and other sources from 6.5% in 2019 to 0.6% in 2050.

3.1.3. Power Generation

Power generation output increased at 12.1% per year, or 27.3 times, from 8.7 TWh in 1990 to 236.9 TWh in 2019. The fastest growth occurred in natural gas power generation (35.8% per year), followed by coal (15.2%), hydro power (8.5%), and oil power (1.7%).

Under the BAU scenario, power generation is projected to increase by an average of 4.2% per year, or 3.6 times between 2017 and 2050, to meet electricity demand. Natural gas power generation is projected to experience the highest growth rate of 5.5% per year, followed by coal (4.9%), hydro (1.1%), and others, which includes biomass, wind, solar and imported electricity (0.8%). Figure 17.4 shows the power generation output by type of fuel under the BAU scenario from 1990 to 2050.

Figure 17.4 **Power Generation by Type of Fuel, Business-As-Usual, 1990–2050**
(TWh)



BAU = business-as-usual, TWh = terawatt-hour.

Note: 'Others' includes biomass, wind, solar, and imported electricity.

Source: Author's calculations.

By the end of 2019, most of the country's power came from coal, which comprised about 50.7% of the total power generation mix. The share of hydro power generation was around 24.3%, while the rest were from natural gas (18.0%), oil (0.9%), and 'others' (around 6.1%).

From 2020 to 2050, coal is projected to remain the primary fuel for power generation under the BAU scenario. Its share is expected to grow from the largest share of 55.2% in 2020 to the largest share of 62.7% in 2050. Natural gas is anticipated to be the second largest fuel, with its share increasing from 14.5% in 2020to 25.8% in 2050. The share of hydro in the total power generation will decline from 22.4% in 2020 to 9.4% in 2050.

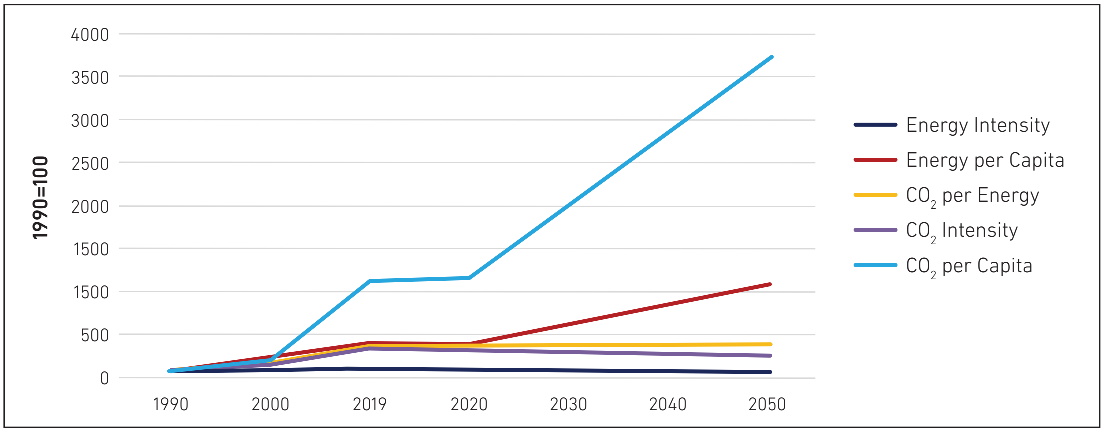
3.1.4. Energy Indicators

From 1990 to 2019, Viet Nam experienced a decline in energy intensity. The country's primary energy intensity decreased from 606 tonnes of oil equivalent (toe) per million 2010 US dollar (2010 US$) in 1990to 564 toe/million 2010 US$ in 2019. Final energy intensity decreased from 545 toe/million 2010 US$ to 378 toe/million 2010 US$. This trend was due to the growing use of modern energy sources such as oil and electricity, which complemented the use of biomass. As the economy continues to grow steadily, the use of biomass will be phased out due to its inefficiency. The final energy intensity is projected to follow a decreasing trend under the BAU scenario, dropping from 378 toe/million 2010 US$ in 2019 to 254 toe/million 2010 US$ by 2050. This indicates that energy will be used more efficiently for the country's economic development.

Meanwhile, primary energy per capita increased from 0.27 toe per person (toe/person) in 1990 to 0.95 toe/person in 2019.It will continue to increase to 2.82 toe/person in 2050. This shows that as the income of people increases in the future, it will lead to improved living standards and a shift in the industrial structure from primary to secondary and service industries, resulting in a rise in primary energy supply per capita.

The carbon dioxide (CO_2) intensity increased from 160 tonnes of carbon (t-C)/million 2010 US$ in 2019 to 484 t-C/million 2010 US$ in 2019. The CO_2 per energy increased from 0.26 t-C/toe in 1990 to 0.86 t-C/toe in 2019. In the BAU scenario, CO_2 intensity will slightly decline to 375 t-C/million 2010 US$ in 2050, while CO_2 per energy will slightly increase at around 0.95 t-C/toe in 2050. Moreover, CO_2 per capita will significantly increase due to energy demand rising faster than population growth (Figure 17.5).

Figure 17.5 Energy Indicators, 1990–2050



CO_2 = carbon dioxide.

Source: Author's calculations.

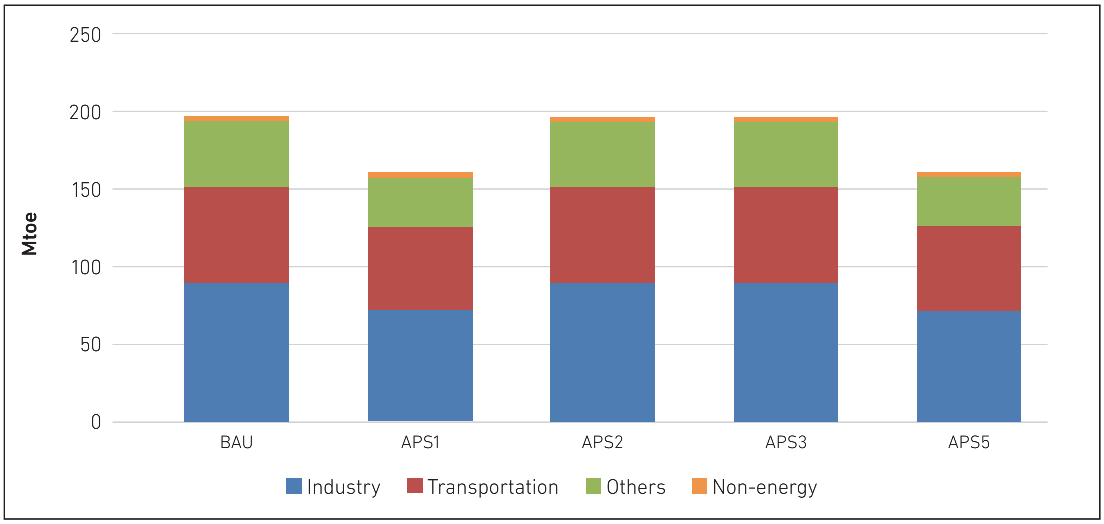
3.2. Energy Savings and Carbon Dioxide Reduction Potential in Alternative Policy Scenarios

3.2.1. Total Final Energy Consumption

In the Alternative Policy Scenarios (APSs), the TFEC is projected to increase at a slower rate of 3.2% per year (compared to 3.8% in BAU), from 61.3 Mtoe in 2019 to 160.9 Mtoe in 2050 because of EEC measures (APS1) implemented in the industry, transport, and 'others' (residential and commercial) sectors. On the other hand, APS2 and APS3 do not include EEC measures on the demand side and are comparable to the BAU scenario. Since APS5 combines all APSs, it will be similar to APS1. Figure 17.6 presents the TFEC by sector in the BAU scenario and APSs in 2050.

Figure 17.6 Total Final Energy Consumption by Sector in Business-as-Usual and Alternative Policy Scenario

(Mtoe)



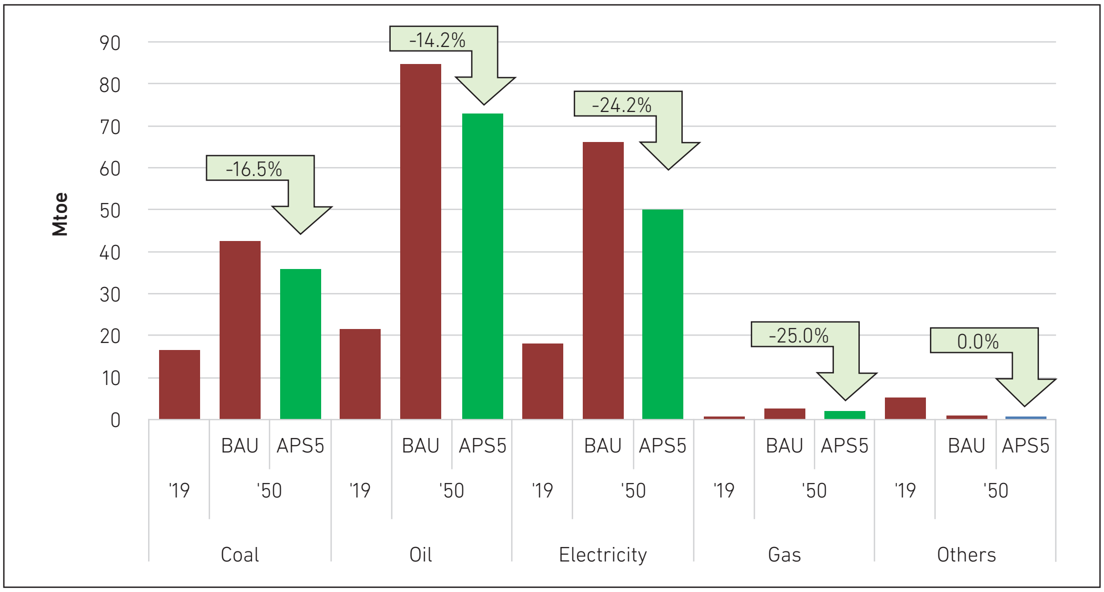
APS = alternative policy scenario, BAU = business-as-usual.

Note: 'Others' includes residential and commercial sectors.

Source: Author's calculations.

Under APS5, the highest average annual growth rate is projected for natural gas and oil at 4.0%, compared with 5.0% for natural gas and 4.6% for oil in the BAU scenario. This is followed by electricity with 3.4%, coal with 2.5%, and others with -6.5%, compared with 4.3%, 3.1% and -6.5% in BAU, respectively, over the same period. However, energy savings potential comes mainly from electricity due to energy efficiency in the industry, residential, and commercial sectors, resulting in savings of 16.0 Mtoe in 2050, which is a 24.2% decrease from the BAU scenario. This is followed by oil with energy savings of 12.0 Mtoe (14.2% decrease from BAU in 2050), coal with 7.0 Mtoe (16.2% decrease), and natural gas with 0.6 Mtoe (25% decrease). The TFEC by fuel in the BAU scenario and APSs are presented in Figure 17.7 below.

Figure 17.7 **Total Final Energy Consumption by Fuel, Business-as-Usual and Alternative Policy Scenario5, 2017 and 2050**
(Mtoe)



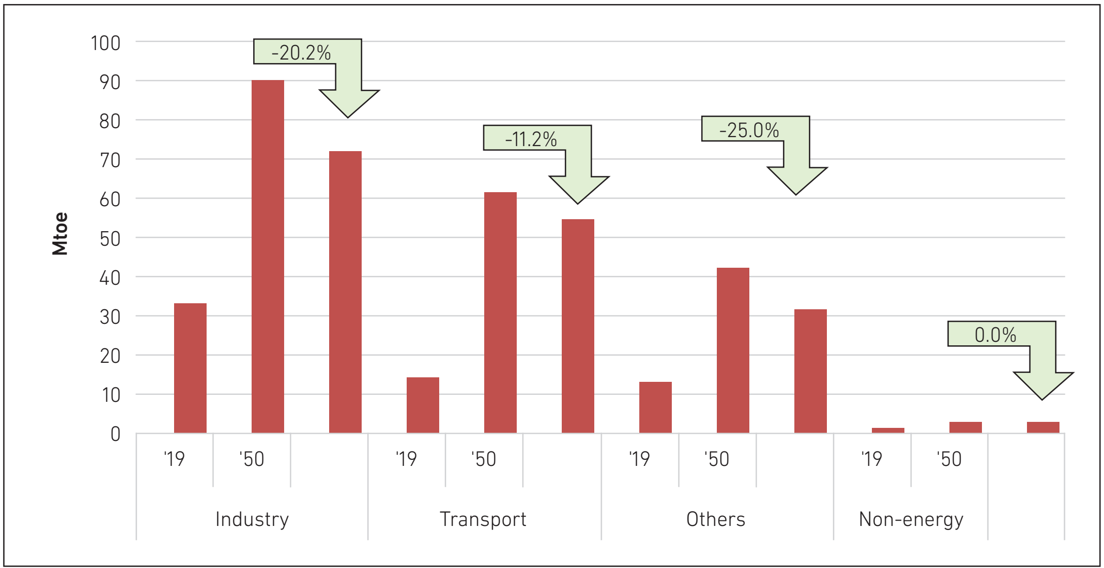
APS = alternative policy scenario, BAU = Business-As-Usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The bulk of the demand-side savings is expected to occur in the industry sector with 18.2 Mtoe (equivalent to 20.2% reduction), followed by the 'others' sector with 10.5 Mtoe (equivalent to 25.0% reduction) and the transport sector with 6.9 Mtoe (equivalent to 11.2% reduction).

Improving end-use technologies and introducing EEC measures would contribute to the slower rate of consumption growth, particularly in the industry, transport, and 'others' (residential and commercial) sectors. See Figure 17.8.

Figure 17.8 Final Energy Consumption by Sector, Business-as-Usual and Alternative Policy Scenario 5, 2017 and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' refers to commercial and residential sectors.

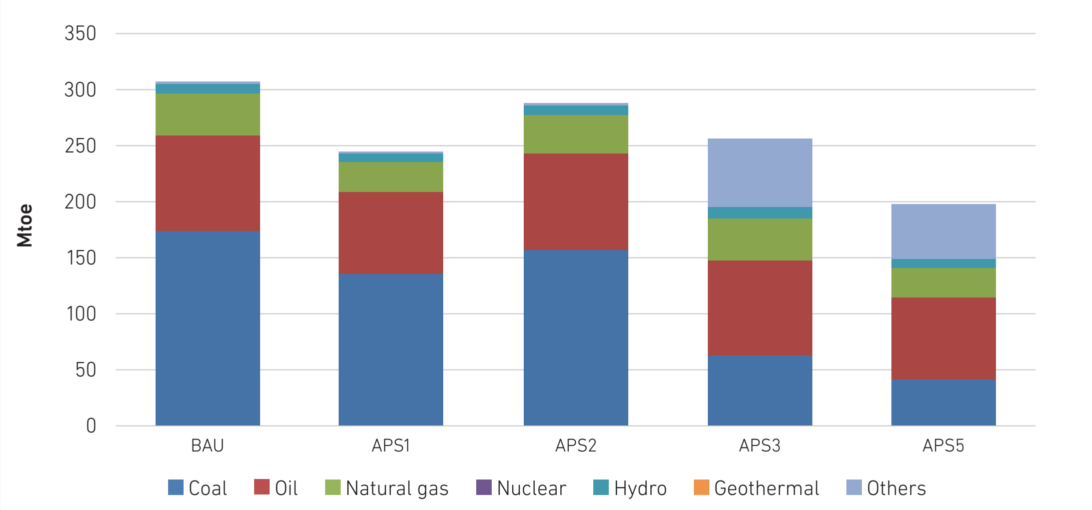
Source: Author's calculations.

3.2.2. Total Primary Energy Supply

In APS5, the TPES is projected to increase at a slower rate of 2.5% per year, from 91.4 Mtoe in 2019 to 198.4 Mtoe in 2050. Other fuels (mostly solar and wind) are projected to grow at the highest average annual rate of 7.1% compared with -3.5% in the BAU scenario. This is followed by natural gas and oil (4.0%) and hydro (0.8%), compared with 5.1%, 4.5% and 1.0% in BAU, respectively, over the same period.

The consumption growth rate is projected to be slower in the APSs compared to BAU, with coal consumption decreasing by 0.6%. This decrease is due to the use of substitute renewable technologies in power generation (APS3) and the implementation of EEC measures on the demand side (APS1), and the more aggressive adoption of energy efficiency in thermal power plants (APS2). The TPES by fuel in the BAU scenario and APS5 are presented in Figure 17.9.

Figure 17.9 **Total Primary Energy Supply by Fuel in Business-as-Usual and Alternative Policy Scenarios**
(Mtoe)

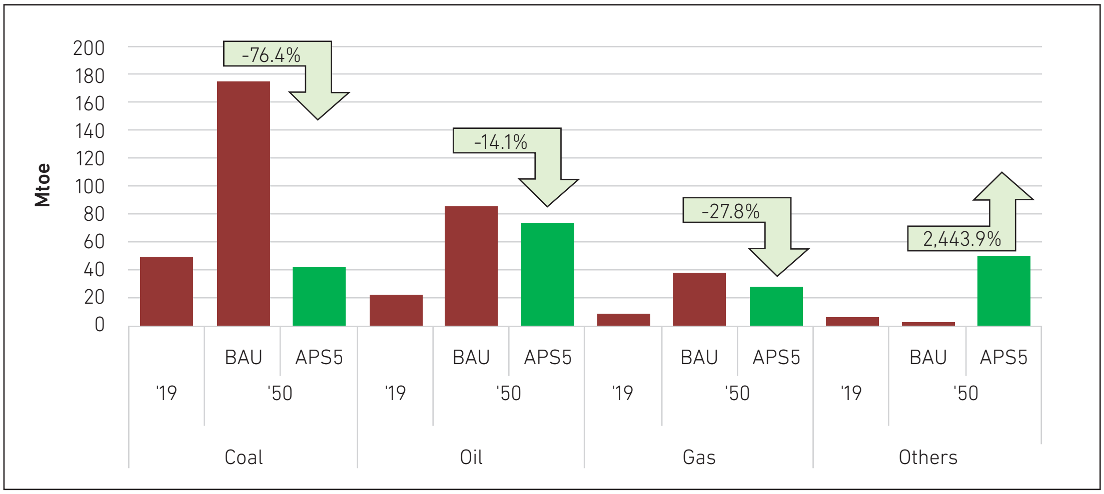


APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Coal has the highest energy savings potential with 76.4%, followed by natural gas (27.8%) and oil (14.1%). Figure 17.10 shows the primary energy savings potential by fuel in the BAU scenario and APS.

Figure 17.10 **Primary Energy Saving Potential by Fuel, Business-As-Usual and Alternative Policy Scenario 5, 2017 and 2050**
(Mtoe)

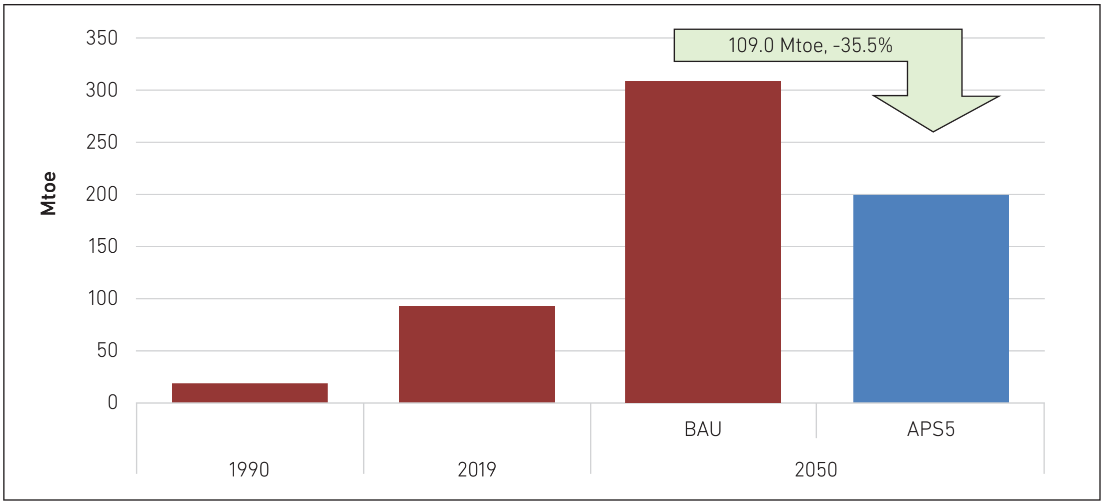


APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The total energy savings achieved in the APS5 compared to the BAU scenario is 109.0 Mtoe, which is equivalent to 35.5% of Viet Nam's TPES in 2050 (Figure 17.11). These energy savings can be attained through the demand-side EEC measures, greater enhancements on the efficiency of thermal power plants, and increased use of renewable energy resources.

Figure 17.11 Evolution of Primary Energy Supply, Business-As-Usual and Alternative Policy Scenario 5, 1990, 2019, and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

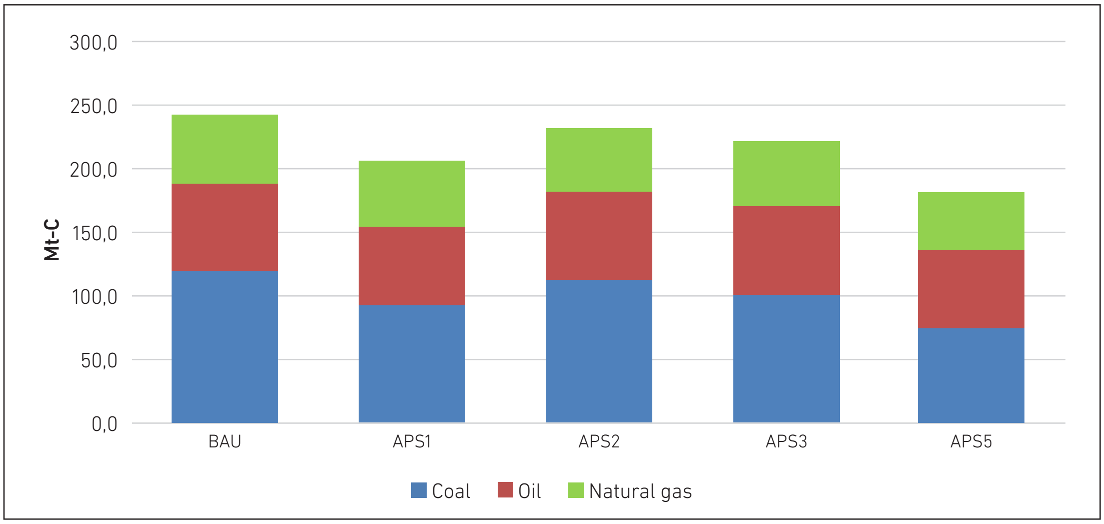
3.2.3. Carbon Dioxide Reduction Potential

The CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 4.3% per year from 78.5 million tonnes of carbon (Mt-C) in 2019 to 290.5 Mt-C in 2050. Meanwhile, under the APSs, the annual increase in CO_2 emissions between 2019 and 2050 is projected to be 1.6% yearly, which is 2.7% points lower than BAU.

Reduced CO_2 emissions are mostly derived from EEC measures on the demand side (APS1). Improvement of energy efficiency in thermal power plants (APS2) and development of renewable technologies (APS3) also contributed significantly to CO_2 reduction (Figure 17.12).

Figure 17.12 Carbon Dioxide Emissions by Fuel, Business-As-Usual and Alternative Policy Scenarios

(Mt-C)



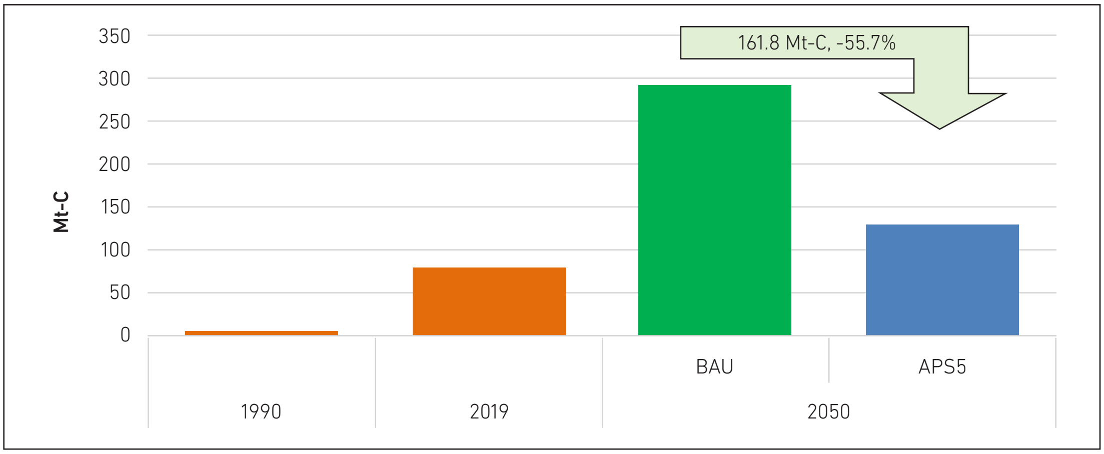
APS = alternative policy scenario, BAU = business-as-usual, Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

Improvement in CO_2 emissions under the APSs will be lower than under BAU by 161.8 Mt-C, equal to 55.7% reduction in 2050. This shows that the energy saving goals and action plans of Viet Nam are very effective in reducing CO_2 emissions (see Figure 17.13).

Figure 17.13 Evolution of Carbon Dioxide Emissions, Business-as-Usual and Alternative Policy Scenario 5, 1990, 2019, and 2050

(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual; Mt-C = million tonnes of carbon.

Source: Author's calculations.

3.3. Energy Savings and Carbon Dioxide Reduction Potential in Low Carbon Energy Transition Scenario

This section introduces a new LCET scenario, which builds upon APS5, to assess the effects of LCET on energy supply, consumption, and carbon emissions. The scenario incorporates additional mitigation measures, such as CCUS technology and new hydrogen fuel. The concept of carbon neutralityis a state of net-zero emissions, where the amount of CO_2 emitted is balanced by its removal, often through carbon offsetting by forests.

The calculation of projected land use, land use change, and forestry (LULUCF) Removals under the GHG mitigation scenario was based on available data. Special emphasis was placed on enhancing the capacity of GHG absorption to facilitate progress towards achieving net zero emissions by 2050. Table 17.2 shows the GHG emission reductions in the carbon neutral scenario compared with the BAU.

Table 17.2 Potential Removals of Land Us, Land Use Change, And Forestry in Low Carbon Energy Transition Scenario, 2014–2050

	2014	2020	2025	2030	2035	2040	2045	2050
BAU	-37.5	-35.4	-37.9	-49.2	-52.2	-55.5	-58.1	-60.2
Carbon Neutral	-37.5	-45.9	-65.6	-95.3	-112.4	-134.0	-149.6	-185.2

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

Source: The National Climate Change Strategy, 2022.

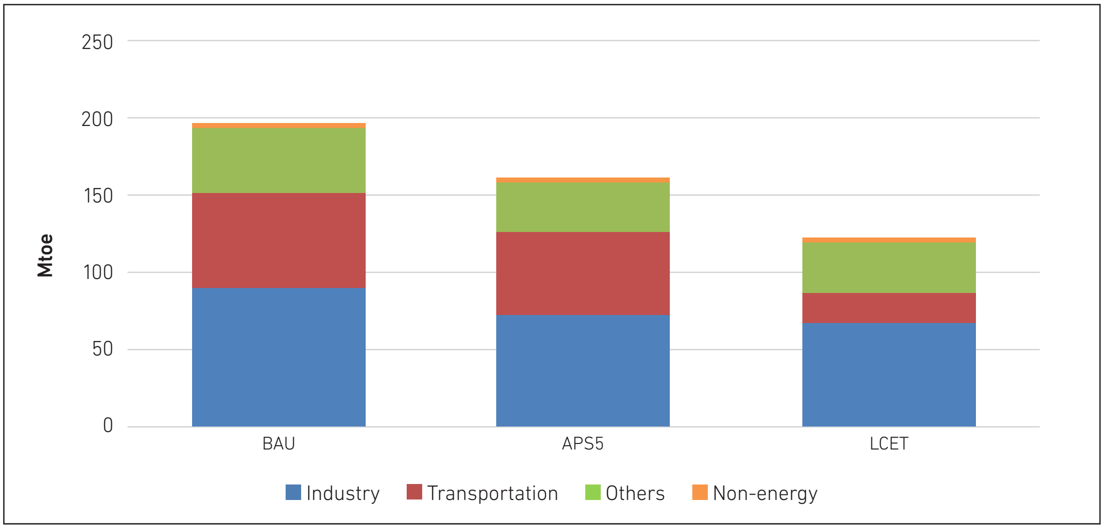
According to the National Climate Change Strategy of 2022, achievingnet zero emissions by 2050 requires a restriction on the emissions of the energy sector, which must not exceed 101 $MTCO_2e$ (or 27.5 Mt-C). The remaining 84.2 MT-CO_2e provides the allowance for offsetting CO_2 in other sectors such as agriculture (56.4 $MTCO_2e$), waste (7.8 $MTCO_2e$), and industry processes (20 $MTCO_2e$).

3.3.1. Total Final Energy Consumption

In the LCET scenario, the TFEC is projected to increase at a slower rate of 2.2% per year from 61.3 Mtoe in 2019 to 121.9 Mtoe in 2050. The main reason for the lower final energy consumption in 2050, compared to the BAU scenario (196.6 Mtoe) and APS5 (160.9 Mtoe), was the greater expected energy savings in the industry, residential, and commercial sectors. In addition, the transport sector is expected to switch from oil products to electricity and hydrogen, further contributing to the reduction in final energy consumption. The TFEC by sector in the BAU, APS5, and LCET scenarios by 2050 is presented in Figure 17.14.

Figure 17.14 **Total Final Energy Consumption by Sector, Business-as-Usual, Alternative Policy Scenario5, and Low Carbon Energy Transition**

(Mtoe)



APS5 = alternative policy scenario 5, BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

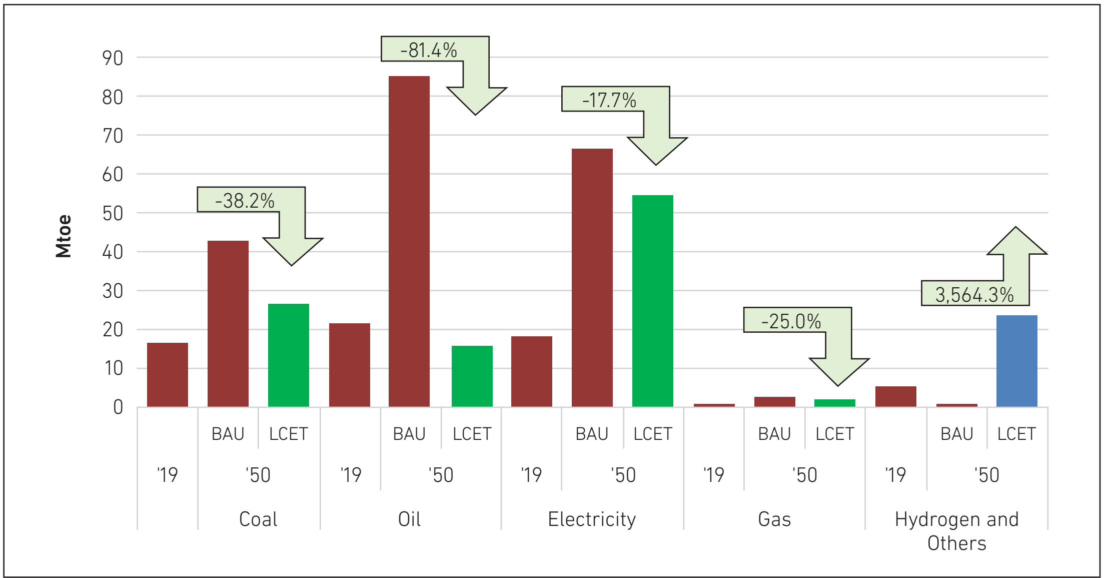
Source: Author's calculations.

Under the LCET, introducing electricity and hydrogen fuel for transport from 2035 onwards impacts the consumption of oil products. The average annual growth rate of oil reduces to 1.0% per year from the 2019 level until 2050. This is in contrast to the higher annual growth rate of 4.6% under BAU and 4.0% under the APS5 scenario.

As a result, fuel switching in transport leads to significant energy savings potential, mainly from oil products. In 2050, these savings would amount to 69.0 Mtoe, which is an 81.4% decrease from the BAU scenario. Additionally, when compared to the BAU scenario in 2050, there are savings in coal with 16.3 Mtoe (38.2%), electricity with 11.7 Mtoe (17.7%), and natural gas 0.6 Mtoe (25.0%).

The final energy consumption by fuel under the LCET scenario is shown in Figure 17.15.

Figure 17.15 Total Final Energy Consumption by Fuel, Business-as-Usual and Low Carbon Energy Transition, 2019–2050
(Mtoe)



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

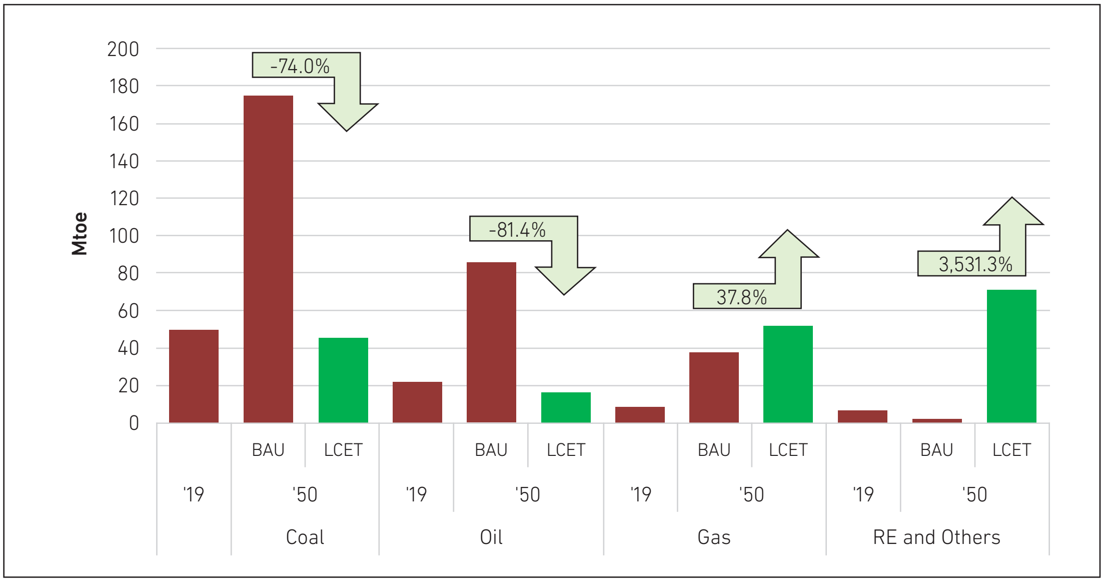
Source: Author's calculations.

3.3.2. Primary Energy Supply

In 2050, the total primary energy supply under the LCET scenario is194.7 Mtoe, which is lower from the BAU scenario's 307.4 Mtoe. The largest energy savings potential is observed in oil, with a reduction of 81.4%, followed by coal with 74.0%. This decrease in primary energy supply is due to the shift towards cleaner energy sources such as natural gas and renewable energy. The primary energy savings potential by fuel in the BAU and LCET scenarios are presented in Figure 17.16.

Figure 17.16 Primary Energy Supply by Fuel, Low Carbon Energy Transition Scenario, 2019–2050

(Mtoe)



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

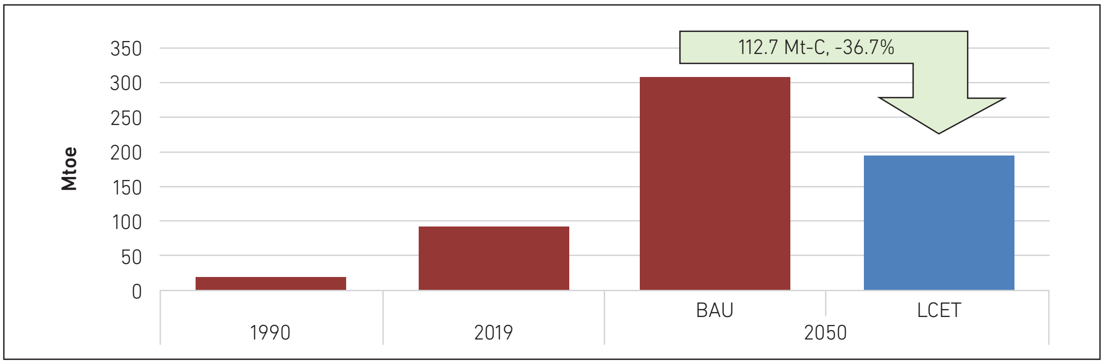
Note: 'Others' includes biomass, wind, solar and imported electricity.

Source: Author's calculations.

The difference between the TPES in the LCET and BAU scenarios is total energy savings, amounting to 112.7 Mtoe, which is equivalent to 36.7% of Viet Nam's TPES in 2050 (Figure 17.17). This energy savings could be achieved from demand-side EEC efforts, improved thermal power plant efficiency, fuel switching, and increased reliance on renewable resources.

Figure 17.17 Evolution of Primary Energy Supply, Business-as-Usual and Low Carbon Energy Transition, 1990, 2019, and 2050

(Mtoe)



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

Source: Author's calculations.

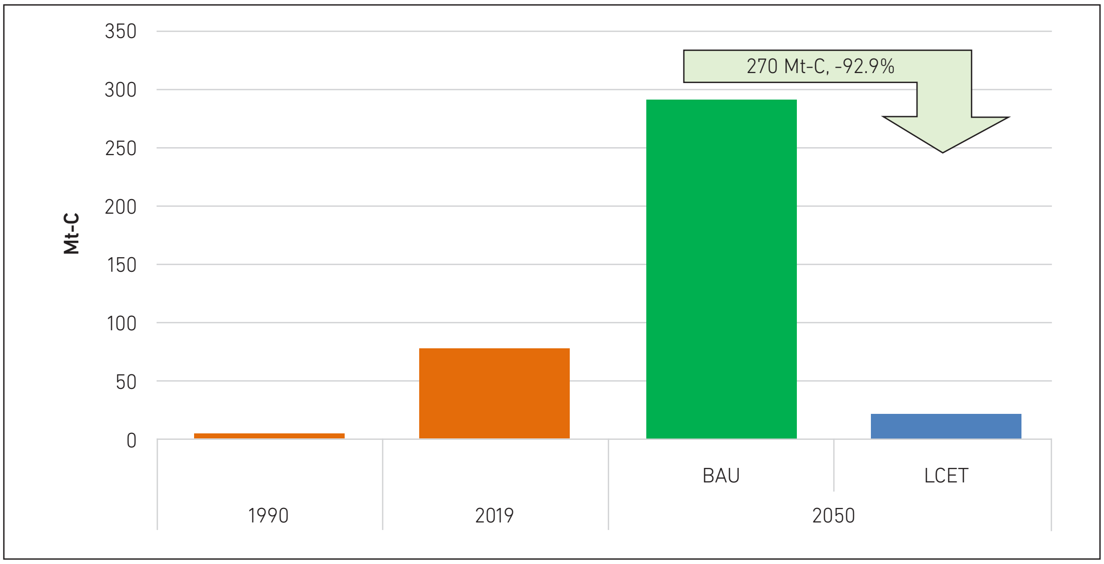
3.3.3. Carbon Dioxide Reduction Potential

The total CO_2 emission under the LCET scenario is projected to decrease by 4.2% per year from 78.5 million tonnes of carbon (Mt-C) in 2019 to 20.5 Mt-C in 2050, which is lower than CO_2 emissions in 2019 at 58.0 Mt-C. In 2050, CO_2 emission in the BAU scenarios was projected at 290.5 Mt-C, thus the reduction in LCET scenario, compared to BAU, is about 270.0 Mt-C or 92.9%(see Figure 17.18). Based on the calculation results, it is evident that Viet Nam has the potential to achieve carbon neutrality by 2050. The LCET (Low Carbon Energy Transition) scenario has been shown to achieve a carbon emission reduction of 20.5 Mt-C, which is lower than the estimated potential carbon sink capacity of forests, amounting to 27.5 Mt-C until 2050. These findings indicate that Viet Nam can effectively offset its carbon emissions through forest preservation and other measures, paving the way for carbon neutrality by 2050.

The LCET scenario includes significant use of variable renewable energy, such as solar PV and wind. It also integrates new energy technologies, such as hydrogen from wind power generation and CCS applied to coal and gas power plants. Implementing ambitious EEC measures will be crucial for reducing CO_2 emissions across various sectors. There are lots of challenge ahead of Viet Nam, but if the country could tackle these challenges, the LCET scenario suggests it can achieve carbon neutrality by 2050.

Figure 17.18 Evolution of Carbon Dioxide Emissions, Business-As-Usual and Low Carbon Energy Transition, 1990, 2019, and 2050

(Mt-C)



BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon dioxide.

Source: Author's calculations.

4. Implications and Policy Recommendations

To achieve the goal of net zero emissions by 2050, Viet Nam must reduce its reliance on fossil fuel quickly – especially coal-fired power – and switch to renewable energy sources and low greenhouse gas emissions technologies such as CCUS and hydrogen. However, while the cost of solar and wind energy has been decreasing rapidly, their reliability depends on the weather and time of day. Further, CCUS and hydrogen technologies are still in their early stages and require substantial financial investments. Therefore, promoting EEC measures is essential for Viet Nam in the coming years to reduce overall energy consumption, especially in using fossil fuel. The Government of Viet Nam should support the implementation of practical EEC action plans by setting up policies, such as mandatory regulations and incentivising measures.

Coal thermal power plants play a significant role in meeting Viet Nam's growing electricity demand. However, because of the goal of achieving net-zero emissions, the country is transitioning from coal to natural gas for power generation and exploring options for natural gas or LNG imports. The development of transparent markets in Asia will surely enhance Viet Nam's LNG supply security.

The demand for petroleum products in Viet Nam will increase in the coming years. While Viet Nam is a net exporter of crude oil, it relies on petroleum product imports due to limited oil refinery capacity for domestic needs. Efforts will be made to expand its refinery capacity, but petroleum product imports will still be necessary until 2040. To reduce dependence on energy imports, Vie Nam is implementing policies focused on fuel switching from oil to electricity and hydrogen, especially for road transport.

As renewable energy sources will expand rapidly in the coming years, ensuring a safe and stable electricity supply system is crucial for Viet Nam. Therefore, it is necessary to develop a well-balanced power generation portfolio that maximises the use of hydropower resources, prioritise the development of wind and solar power while ensuring safety at reasonable prices, and develops natural gas power as an important source of power supply.

Viet Nam's priorities in developing the national energy system also include establishing a robust financial mechanism, mobilising investment capital for power sector development, and expediting the implementation of a competitive power generation market.

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CHAPTER 18

United States Country Report*

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* Unless otherwise cited, all data in this report can be attributed to IEEJ's economic modelling results for the United States, which are included in full as an appendix to this publication.

1. Introduction

The United States (US) is the fourth largest country in the world by total area and the third largest by population. Since 2010, the country's population has grown by an average of about 2.3 million people per year, reaching approximately 332.4 million people in 2021 (US Census Bureau, 2022a & 2022b) with over 80% living in urban areas (US Census Bureau, 2010 & World Bank, 2022a).

The US is the world's first or second largest economy (depending on the metric), with a gross domestic product (GDP) of $23 trillion and per capita income of $70,480 as of 2021 (World Bank, 2022b & World Bank, 2022c). By sector of origin, roughly 80% of the US GDP can be linked to services, while around 18% is linked to industry including construction (World Bank, 2022d, and World Bank, 2022e).Agriculture, forestry, and fishing collectively make up just 1% (World Bank, 2022f).More broadly, international trade also plays a crucial role in the overall strength and health of its economy, with data from the World Bank suggesting that roughly one quarter of the US GDP is linked to trade (World Bank, 2022g).

1.1. Energy Situation

The United States is the world's second largest consumer of energy (first, on a per capita basis) but its consumption growth rate has slowed significantly in recent years. In 1990, its final energy consumption was 1,293.54 million tonnes of oil equivalent (Mtoe). Over the following decade, consumption increased by nearly 20% (reaching 1,546.28 Mtoe in 2000), and then grew by less than 3% over the next two decades (reaching 1,588.48 Mtoe in 2019).

In terms of how the US might meet its demand for energy, the country has long had abundant and diverse resources. This includes ample reserves of fossil fuels, such as coal, oil, and natural gas, as well as significant potential for geothermal, wind, and solar energy. Until recently, much of this energy potential was deemed impractical or uneconomical, with coal dominating domestic energy production until the early 2000s. However, advancements in technology, declining production costs, and favorable conditions for development and investment have sparked a surge of interest in the domestic production of oil, natural gas, and renewable energy sources like wind and solar energy. Consequently, the country's natural gas and crude oil have both doubled since 2005 (US Energy Information Administration, 2022a). Meanwhile, in the past 10 years alone, wind power capacity in the US has more than doubled, while solar power capacity has increased twenty-fold (US Energy Information Administration, 2022b).

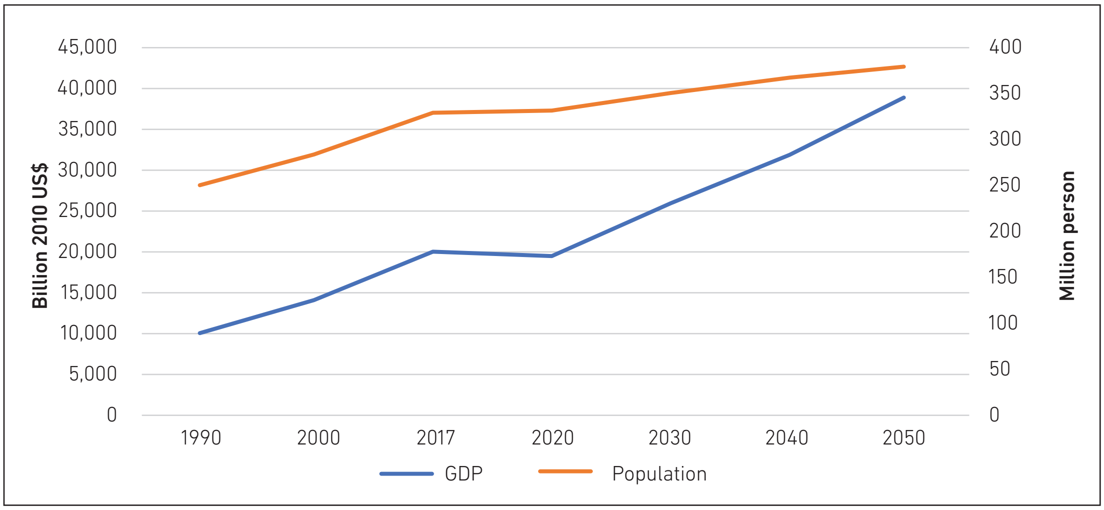
These developments have had at least two ripple effects on US energy outlooks. First, they have accelerated the ongoing shift towards cleaner consumption patterns, as there is now a wider range of available lower- and zero-carbon supply options. In 2014, natural gas surpassed coal as the single largest share of US power generation and, since then, has further increased its share. Consumption of wind and solar has also continued to hit new record highs (US Energy Information Administration, 2022c & 2022d, and Clara. G, 2022). Collectively, these shifts have also had an additional effect of offsetting expected growth in US carbon dioxide emissions. Despite the rise in total final energy consumption since 1990, US CO_2 emissions in 2019 were only 0.3 million tonne of carbon (Mt-C)2 higher than levels in 1990 (i.e., 4,743.6 Mt-C vs. 4,743.3 Mt-C).

The second major impact of these shifts is in reshaping the country's expected outlook for trade in energy. Increased oil and natural gas production has not only reduced the need for imports from Canada and other countries but also bolstered the country's potential to serve as an important global energy supplier. As of 2021, the US has already exported substantial volumes of liquefied natural gas (LNG) to Japan, Taiwan, India, South Korea (henceforth, Korea), and China (US Energy Information Administration, 2022e). Reduced domestic coal demand led to increased focus on exporting coal, with India, Japan, and South Korea amongst the top export markets for US coal (US Energy Information Administration, 2022f). While these trends offer potential for US energy production to enhance regional energy security and trade balances, several factors may limit interest in otherwise available US supplies and technologies. This includes potential bottlenecks in energy export and import infrastructure, as well as intense competition between the US and other economies for global market share amidst growing climate change concerns.

2. Modelling Assumptions

Over this study's outlook period of 2019–2050, GDP and population counts are projected to grow, though at markedly different rates, resulting in a trend of an overall rising per capita GDP (Figure 18.1). While 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 0.5% per year, the population growth rate for the outlook period is still at a notably slower pace than the 0.9% per year of the 1990–2019 period.

Figure 18.1 **Gross Domestic Product and Population, 1990–2050**



GDP = gross domestic product.

Source: Authors' calculation, 2022.

Between 1990 and 2019, the GDP grew at an average annual rate of 2.5%. Despite significant disruption during the 2007–2008 global economic crisis and the 2020–2021 coronavirus (COVID-19) crisis, the US economy has managed to maintain steady growth, albeit at a relatively modest pace. As of this writing, it also appears to have recovered at a national-level from the downturns brought on by the disruptions in regular travel and business patterns during the COVID-19 pandemic. Hence, despite ongoing uncertainty around near-term economic outlooks, this model projects that US GDP growth rates will re-stabilise over the outlook period at an annual average growth rate of 2.2%. This estimate aligns with anticipated progress in efficiency, productivity, and modest yet steady population growth. It also assumes that the US will maintain its leadership in innovation in emerging fields alongside continued global market recovery.

With these conditions in mind, this study estimates the energy saving and CO_2 emission reduction potential by comparing the results of a Business-as-Usual (BAU) Scenario with the cumulative impact of several Alternative Policy Scenarios (APS). In the BAU scenario, longstanding market trends are expected to persist. This includes a decline in coal and nuclear energy due to unfavourable economic and social license in the US compared to non-hydro renewables and natural gas. Coal, in particular, is expected to decline significantly due to the competitiveness of alternative generation options and the retirement of a number of older, less efficient coal-fired plants. Despite increasing use of alternative fuel and the adoption electric vehicles, the US transport is anticipated to continue relying heavily on oil. This is partly due to limited means and incentives for large-scale switching compared with the tools available within the power sector.

The APS, in contrast, assumes the full implementation and realisation of ongoing policy efforts, including improved energy efficiency of final energy demand; thermal power generation; nuclear energy as a source of baseload power generation; and higher contribution from renewable energy in total supply. The analysis is based on national and state laws and policies in place as of 2021. Importantly, this cut-off date means that the potential impacts of the United States' Inflation Reduction Act, which was signed into law in August 2022, are not covered by APS scenario findings.

Finally, and new to this year's report, is the inclusion of a 'carbon neutral', or low carbon energy transition (LCET) scenario, which models what shifts, if any, might enable a country to reach net-zero CO_2 emissions on an annual basis by 2050. In the United States, these shifts involve implementing new incentives, tools, and approaches that prioritize decarbonization more aggressively than those in APS. However, these measures are still technically feasible and potentially socially acceptable. For example, this could mean setting more ambitious deadlines for phasing out combustion engines without suggesting the elimination of all motorized vehicles. The United States' *Pathways to Net-Zero Greenhouse Gas Emissions by 2050* and executive orders by the Biden administration on decarbonisation provide the foundation for scenario modelling in this context. These efforts focus on reducing greenhouse gas emissions in power, transport, and industry. However, in some cases, divergences in the findings of these official reviews and this report do occur. Such differences can arise from variations in methodologies, such as assumptions about economic conditions and technological advancements between 2019 and 2050.

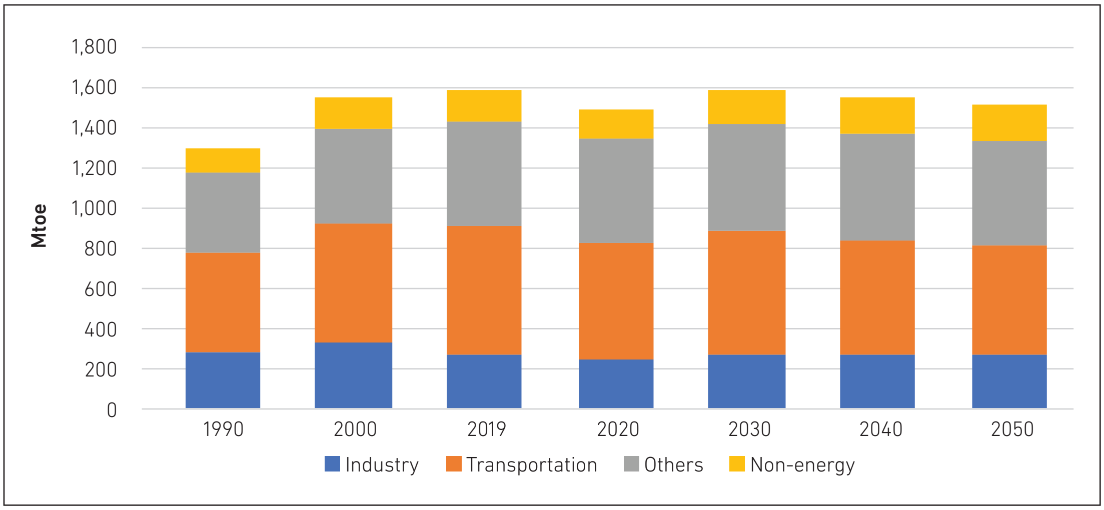
3. Outlook Results

3.1. Business-as-Usual Scenario

3.1.1. Final Energy Consumption

Under the BAU scenario, total final energy consumption is anticipated to decline slightly between 2019 and 2050 at an average annual rate of decrease of 0.2% (Figure 18.2). Transport is a key driver of this decline, as otherwise expected, growth linked to a modest rise in vehicle ownership and utilisation is more than offset by increased switching to cleaner, more efficient vehicles as well as other structural changes within the sector. However, an otherwise steeper decline in overall US energy consumption is offset by consumption increases in other sectors. Non-energy sector consumption, for example, is expected to see an average annual growth of 0.5%. Meanwhile, both industry and others are expected to see relatively flat growth during the outlook period.

Figure 18.2 Final Energy Consumption by Sector, Business-As-Usual
(Mtoe)



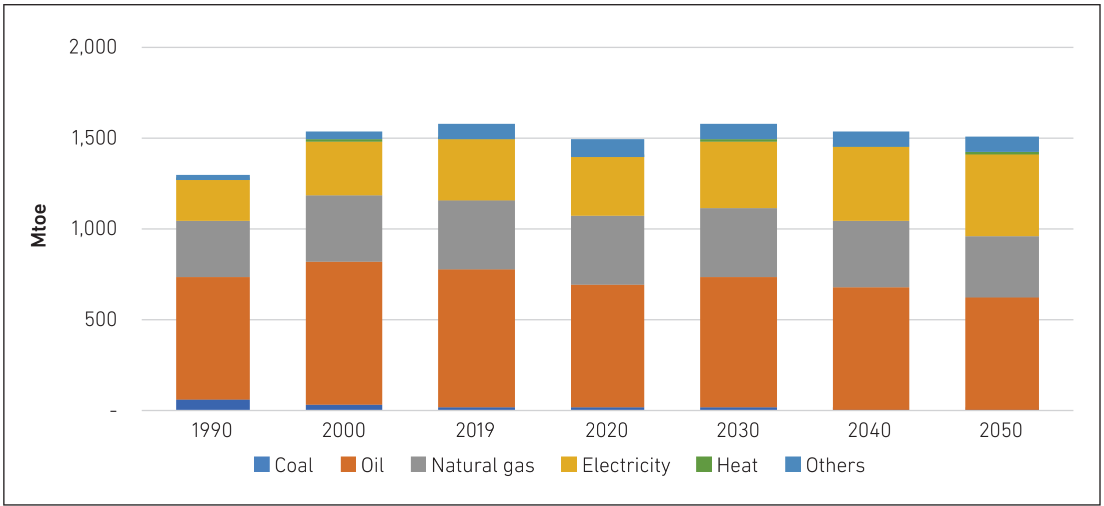
Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

In this context, oil consumption declines and, by 2050, is anticipated to fall to 616.91 Mtoe (roughly 10% below levels in 1990). Coal consumption also consistently declines throughout the entire 2019–2050 period. In contrast, electricity consumption grows from 329.32 Mtoe in 2019 to 448.68 Mtoe in 2050 (Figure 18.3). which (amongst other things) reflects headwinds in newly This growth is influence by factors such as the electrification of various sectors of the US economy, including transport and industry. Natural gas consumption also increases overall but may reach its peak and subsequently decline after the 2030s. This is due to increased competition from other energy sources in various end-use sectors.

Figure 18.3 Final Energy Consumption by Fuel Under Business-As-Usual
(Mtoe)



Mtoe = million tonnes of oil equivalent.

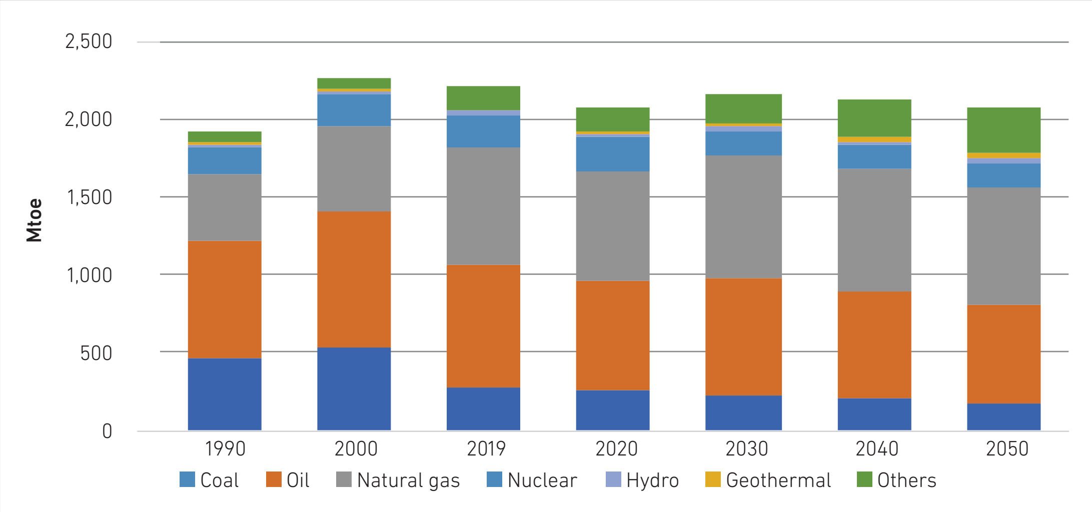
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

3.1.2. Primary Energy Supply

Under BAU, total primary energy supply is anticipated to decline from 2,212.75 Mtoe in 2019 to 2,082.97 Mtoe in 2050, with an average annual rate of decrease of 0.2%. Coal consumption is anticipated to decline at a rate of 1.6% during this period, while nuclear declines by 1.1%. In contrast, non-hydropower renewables experience the largest growth in consumption at 4.8%, followed by geothermal at 4.6% (Figure 18.4).

Figure 18.4 Primary Energy Supply Under Business-As-Usual



Mtoe = million tonnes of oil equivalent.

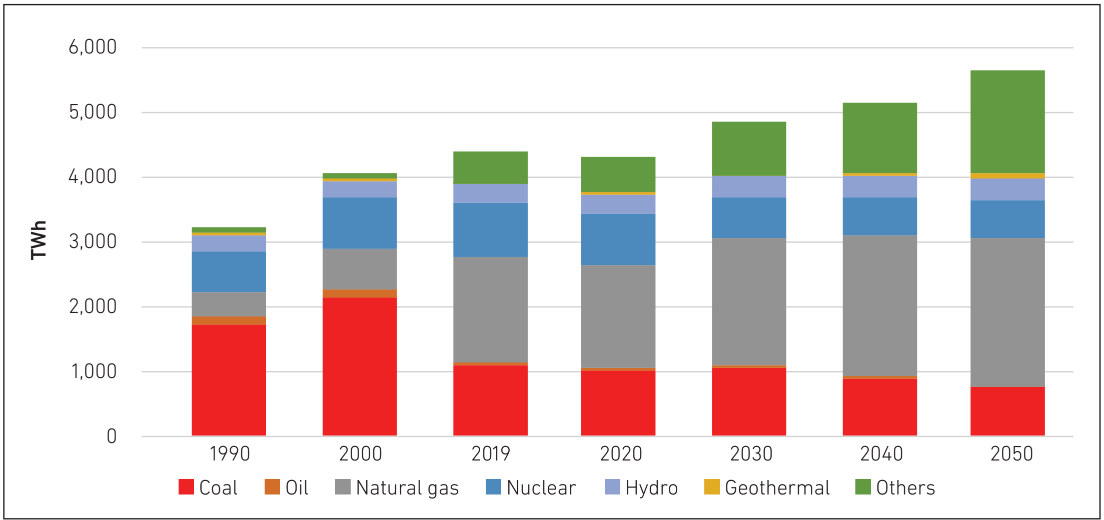
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

3.1.3. Power Generation

Under the BAU scenario, electricity generation in the United States, increases over the outlook period, though at a modestly slower pace than the previous 25 years. Generation output increases from 4,370.99 terawatt hour (TWh) to 5,634.40 TWh between 2019 and 2050, for an average annual growth rate of 0.8% (Figure 18.5). The retirement of older, less efficient coal-fired plants, technological advancements promoting more efficient consumption, and broader market and policy forces that drive input switching all contribute to shaping this outlook. In line with this, coal declines steadily at 1.3% a year and accounts for only 12.7% of all US power generation by 2050 (down from 24.5% in 2019). Meanwhile, natural gas gains in relative competitiveness and, by 2050, represents 41.1% of the overall mix. Even so, the largest average annual growth rates are seen in non-hydro renewables, most prominently solar and wind. When combined with shares for nuclear and hydro, these growth rates suggest that by 2050, roughly 46% of power generation output may come from zero-carbon energy sources.

Figure 18.5 **Power Generation Under Business-As-Usual**
(TWh)



TWh = terawatt hour.

Note: 'Others' includes residential and commercial sectors.

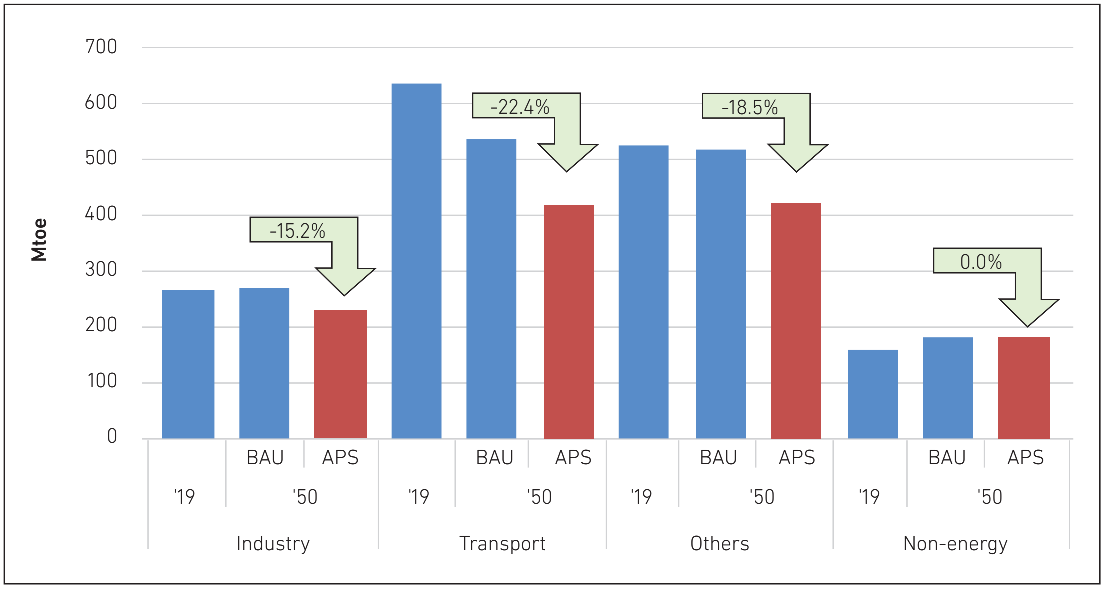
Source: Authors' calculation.

3.2. Alternative Policy Scenarios

3.2.1. Final Energy Consumption

Under the APS, this study projects that an even more dramatic decline in total final energy consumption will occur in the US. To that end, under the APS, such consumption declines from 1,588.48 Mtoe to 1,251.43 Mtoe during 2019–2050. When compared with the BAU, this shows an energy savings of roughly 258 Mtoe or 17.1% during the outlook period. Transportation saves 120 Mtoe (22.4%); industry, 41 Mtoe (15.2%); and residential and commercial (others), 96 Mtoe (18.5%) (Figure 18.6). Meanwhile, contrary to expectations under BAU, both industry and residential and commercial sectors experience a decline in overall consumption.

Figure 18.6 **Final Energy Consumption by Sector, Business-As-Usual vs. Alternative Policy Scenario**
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual; Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes residential and commercial sectors.

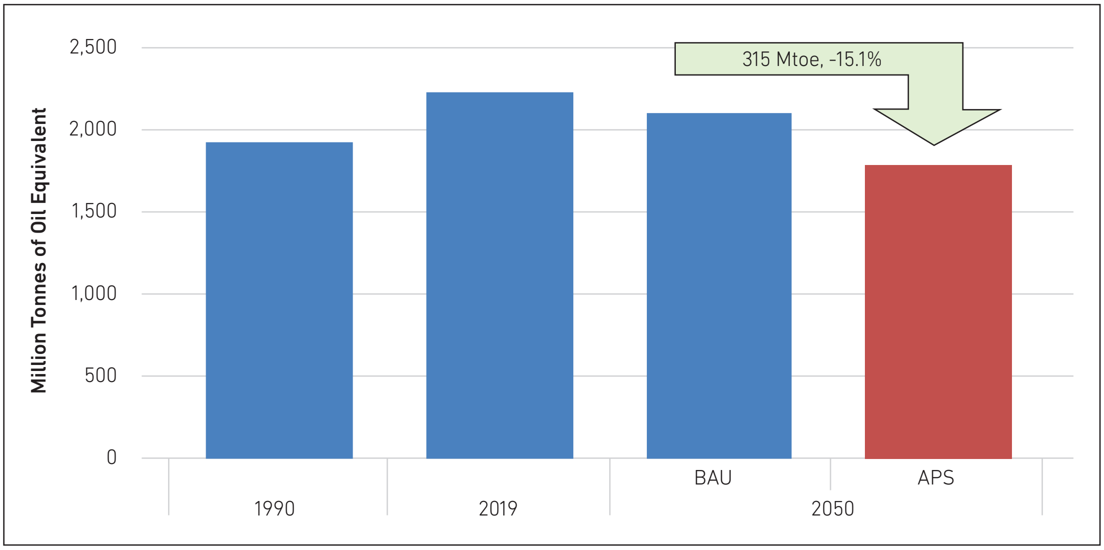
Source: Authors' calculation.

These declines are not evenly distributed across fuel type. While coal, oil, and natural gas all realise even faster rates of decline over the outlook period under the APS, the difference between the APS and BAU is sharpest for natural gas. Meanwhile, electricity consumption grows – and, indeed, is modestly higher than in BAU – given factors such as an increased uptake in electric vehicles.

3.2.2. Primary Energy Supply

Under APS, the United States' primary energy supply is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,767.98 Mtoe in 2050 (Figure 18.7). This implies that in 2050, primary energy supply under APS will be around 315 Mtoe or 15.1% lower than BAU.

Figure 18.7 Primary Energy Supply in Business-As-Usual vs. Alternative Policy Scenario
(Mtoe)

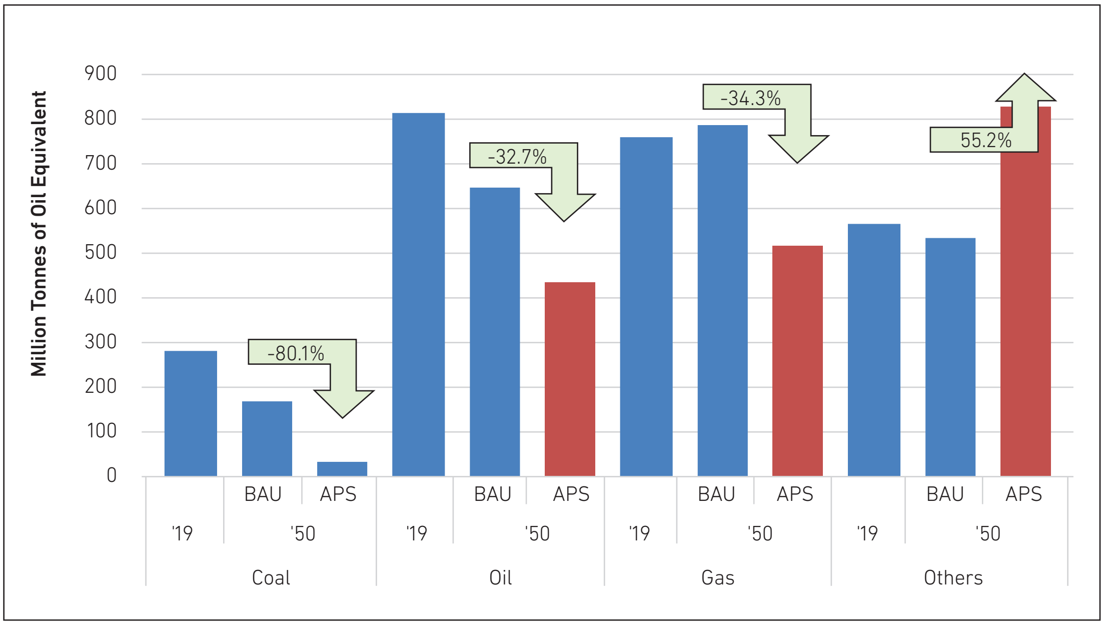


APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Authors' calculation.

Primary energy supply in APS is declines for coal to 32.80 Mtoe. This represents a total energy savings of 132.4 Mtoe (or 80.1%) in 2050 compared with BAU. Oil consumption also declines compared to BAU, with a potential savings of 206.6 Mtoe (or 32.7%) by 2050, while natural gas sees an even more pronounced decline at 263.0 (or 34.3%). In contrast, the combined demand for all others increases by about 286.98 Mtoe (55.2%) compared to BAU in 2050 (Figure 18.8).

Figure 18.8 **Total Primary Energy Supply by Fuel, Business-As-Usual vs. Alternative Policy Scenario, 2019 and 2050**
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

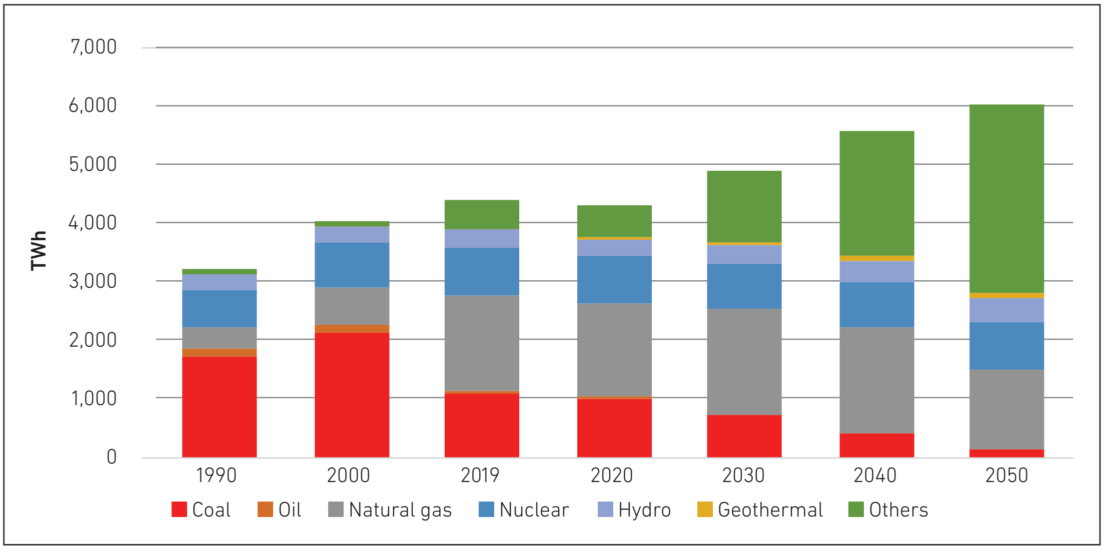
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

3.2.3. Power Generation

In line with rising demand for electricity, power generation under the APS rises to 5,997.37 TWh in 2050, an increase of 362.97 (or 6.4%) over BAU in that same year (Figure 18.9). Yet, this modest increase belies larger changes in the US power mix that occur in this scenario. Critical in this context is that the expectation is for the complete implementation of existing US policies that support more aggressive transition to wind, solar, and geothermal sources through 2050, as well as the country's ability to maintain nuclear energy output at roughly 2019 levels. As a result, zero-carbon energy sources come to account for roughly 75.6% of US electricity generation by 2050. Consequentially, in contrast to BAU, zero-carbon generation replaces both coal- and gas-fired power, such that output from natural gas in 2050 is 960.74 TWh less under APS when compared with BAU for the same year. Even so, at 22.5% of total US power generation output, natural gas still represents a significant share of the power mix in 2050.

Figure 18.9 Power Generation Under Alternative Policy Scenario, 1990–2050
(TWh)



TWh = terawatt hour.

Note: 'Others' includes residential and commercial sectors.

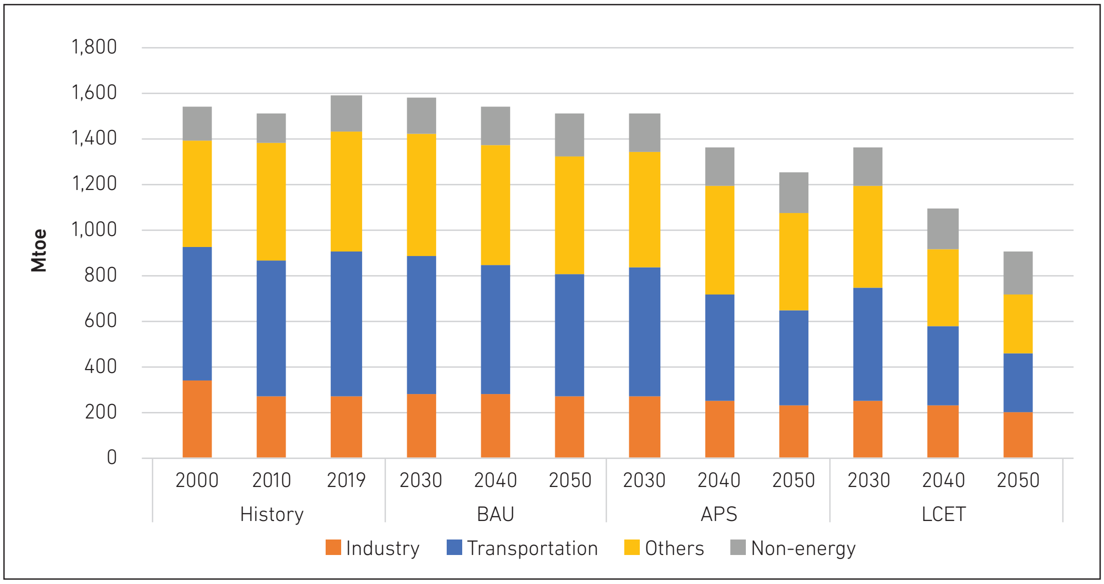
Source: Authors' calculation.

3.3. Low Carbon Energy Transition Scenario

3.3.1. Final Energy Consumption

Under the LCET scenario, final energy consumption falls from 1,588.48 Mtoe to 901.25 Mtoe during 2019–2050. This suggests that in 2050, there is an additional 350.18 Mtoe (or 28%) savings compared to the APS. Residential and commercial ('others') sectors is now 163 Mtoe (38.5%) lower than the APS, while transport also realises an additional savings of 152 Mtoe (36.5%). Although the savings under the LCET relative to the APS is less pronounced for industry, it is nonetheless notable at an additional decline of 35 Mtoe (15.3%) (Figure 18.10).

Figure 18.10 **Final Energy Consumption by Sector in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050**
(Mtoe)



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

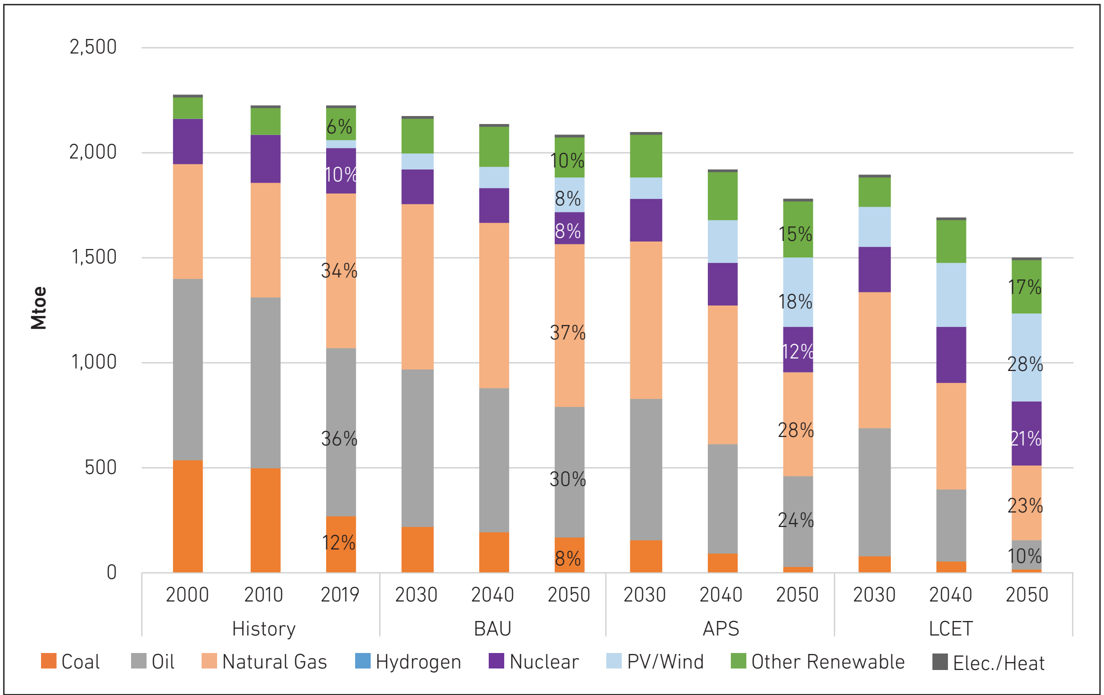
Note: 'Others' includes residential and commercial sectors.

Source: Authors' calculation.

3.3.2. Primary Energy Supply

Under the LCET, the United States' primary energy supply is anticipated to decrease from 2,212.75 Mtoe in 2019 to 1,499.98 Mtoe in 2050. This implies that in 2050, under LCET savings of primary energy supply will be around 268 Mtoe (15% lower) compared with APS (Figure 18-11). As part of this, primary energy supply for coal declines to 18.96 Mtoe. This represents an additional energy saving of 13.84 Mtoe (or 42%) in 2050 over the already dramatic decline in APS. Oil consumption is also anticipated to decline compared to APS, with a potential saving of 281.46 Mtoe (or 66%) by 2050, while natural gas declines by 158.78 Mtoe (or 32%). Meanwhile, demand for all others is anticipated to increase in both absolute terms and relative to APS, with hydrogen/ammonia also playing a growing role.

Figure 18.11 Primary Energy Supply in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent, PV = photovoltaic.

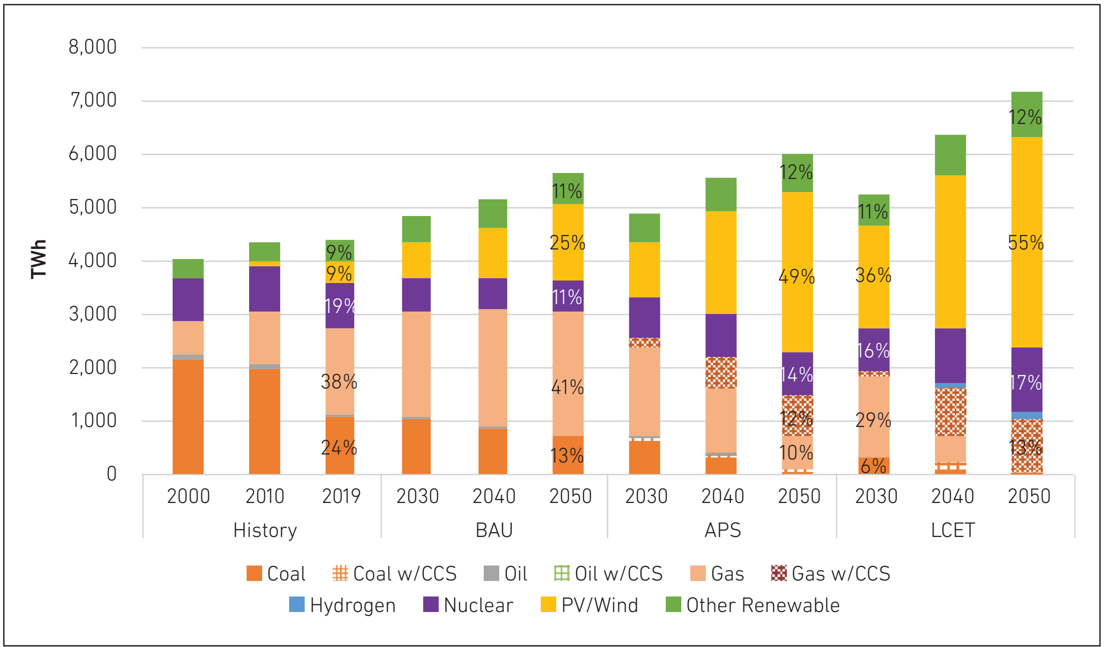
Source: Authors' calculation.

3.3.3. Power Generation

The LCET expects even greater progress in electrifying the US economy and an aggressive expansion infrastructure to meet the increased demand. As a result, this scenario sees a significant increase in power generation output, exceeding the APS by 1,176.6 TWh, accounting for nearly 20% of the difference (Figure 18.12).

Figure 18.12 Power Generation in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000, 2010, and 2019

(TWh)



APS = alternative policy scenario, BAU = business-as-usual, CCS = carbon capture and storage, LCET = low carbon energy transition, PV = photovoltaic, TWh = terawatt hour.

Source: Authors' calculation.

Under the LCET scenario, a key assumption is that market and policy breakthroughs will make technologies that support the decarbonisation of coal and natural gas more attractive. By 2050, all coal and natural gas are expected to be paired with CCS. However, non-fossil sources remain highly competitive, capturing an even larger share of total power generation output in 2050 compared to the APS. Notably, there is significant growth in wind and solar power and an increase in nuclear power generation due to anticipated technological advancements and new construction. Meanwhile, the collective impact of these various trends leads to a scenario where virtually all US power generation output is fully decarbonised in 2050.

3.4. Carbon Dioxide Emissions

All scenarios in this report project that US CO_2 emissions will decline during the outlook period, although at markedly different rates. Under BAU, CO2 emissions from energy consumption declines at an annual average rate of 0.7%, from 4,743.6 Mt-C in 2019 to 3,826.6 Mt-C in 2050. This decline is a result of reduced energy consumption overall and ongoing shifts in the US power sector. Specifically, there have been decreases in coal consumption and increases in the consumption of non-fossil sources. However, a decline in nuclear energy generation offsets what might otherwise be even steeper reductions in the power sector.

In the APS, CO_2 emissions decrease at an average annual rate of 3% from 4,743.6 Mt-C in 2017 to 1,838.6 Mt-C in 2050. Emissions savings in the APS are thus 51.95% compared to the BAU in 2050. The most dramatic shifts between BAU and the APS are due to absolute reductions in emissions from natural gas (by 836.7 Mt-C), though significant reductions are also seen with coal at 577.9 Mt-C and oil at 573.3 Mt-C. However, persistent uncertainties in investments and progress towards improving aging grid infrastructure, which is necessary to effectively integrate variable renewable energy sources, are likely to pose challenges in achieving new zero-carbon generation capacity online in ways that maximise potential energy savings and CO_2 reductions.

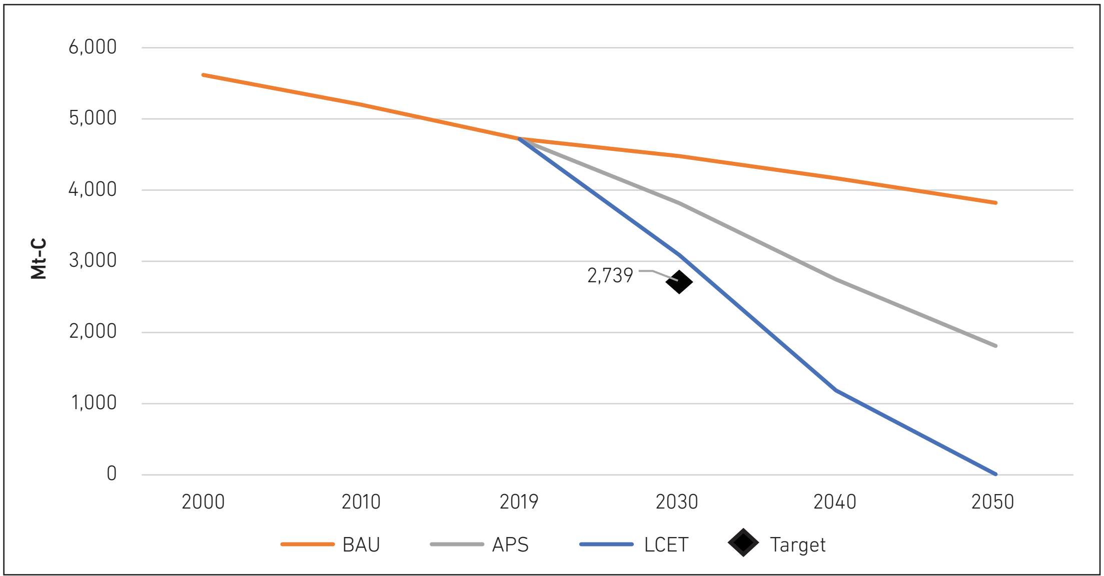
In the LCET, CO_2 emissions are anticipated to decrease at an average annual rate of 15.4%, which is five times faster than in the APS and roughly 22 times faster than BAU. However, the rate of decrease does not ensure that the energy system is truly "carbon neutral" by 2050, as roughly 26.2 Mt-C is still emitted annually in this scenario. Key to this picture is substantial emissions that persist from natural gas, which make up roughly 75% of the remaining emissions, as well as emissions from coal. Despite expectations for continued oil consumption in the United States, emissions from oil do reach zero by mid-century in this scenario. This suggests the enormous potential of various tools to support cleaner consumption of this fossil fuel when well-aligned with other decarbonisation efforts.

The United States pledged in its revised Intended National Determined Contribution submission to reduce its greenhouse gas emissions by 50%–52% from 2005 levels by 2030 and reach "net-zero" emissions by 2050.[1] The modelling suggests that the US is making encouraging progress in taming its emissions and, under the APS, could be poised to see even more rapid decline in the future. However, even under the APS more robust action may be necessary to meet the 2030 targets, let alone the goals for mid-century (Figure 18.13). Meanwhile, while the LCET scenario suggests ways that the country might be able to close the gap with its 2030 targets, it nonetheless falls slightly short of guaranteeing that the United States will fully decarbonise its energy system by 2050. Consequentially, even this more aggressive approach suggests that more work remains to be done.

[1] For more on this, see US Department of State and the United States Executive Office of the President, 'The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050,' Washington, D.C, November 2021, https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf (accessed September 1, 2022).

Figure 18.13 Carbon Dioxide Emission Trends in Business-As-Usual, Alternative Policy Scenario, Low Carbon Energy Transition, 2000–2050

(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors' calculation.

4. Implications

- While natural gas will remain the single greatest share of the US electricity generation mix over the period to 2050 under BAU, non-hydro renewables such as wind and solar are anticipated to experience the largest growth rates. Further, under the APS and LCET scenarios, zero-carbon sources surpass natural gas as the single greatest share of the US electricity generation mix. Yet, to sustain this shift, it is crucial to increase focus on addressing aging infrastructure and advancing new breakthroughs in storage technologies.
- All scenarios recognise the importance of strengthening the transport sector as a critical opportunity to save energy. This involves not only accelerating the deployment of electric vehicles but also greater attention to fuel efficiency and cleaner consumption technologies. Hydrogen, too, has a potentially prominent role to play.
- Even amidst the changes above, oil and natural gas represent a sizeable share of the United States' energy mix in both BAU and the APS and are still relatively prominent under the LCET. Achieving "net-zero" by 2050 requires radical decarbonisation of their consumption, alongside the transition to renewable and alternative energy sources. Taking the lead in these efforts could also bolster the long-term competitiveness of US fossil fuel exports and contribute to Asia's energy and environmental security goals.
- As referenced above, during the final stages of this report, the United States passed the 2022 Inflation Reduction Act, which incorporates new resources for advancing various clean energy technologies and addressing other concerns mentioned previously. While the specific impacts of this policy on US energy outlooks is a subject for future editions of this study, a key question for the United States now is how to enhance its coordination with allies and partners in operationalising this legislation. This includes how to best address concerns raised by Asian economies regarding its potential impact on their own industries and energy-saving strategies. Such collaboration could create new opportunities to accelerate US emission reductions and yield greater regional benefits.

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ANNEX 1

Energy Outlook Results of the Association of Southeast Asian Nations

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1. Background

According to the World Bank World Development Indicators database (The World Bank, 2023), the 10 member states of the Association of Southeast Asian Nations (ASEAN) reached a total gross domestic product (GDP) of around $3.06 trillion in 2021.[1] During the period of mobility restrictions imposed by the coronavirus (COVID-19) pandemic the region, like other parts of the world, witnessed a growth of 3.2% compared to the total GDP of approximately $2.96 trillion in 2021. Due to the pandemic the total GDP decreased by 3.62% from the 2019 GDP of $3.08 trillion. Before the pandemic, the growth rates were 4.48% for 2018¬–2019 and 5.21% for 2017–2018.

By 2021, Southeast Asia was then the world's 5th largest economy, only behind the United States ($20.53 trillion), China ($15.80 trillion), Japan ($4.43 trillion), and Germany ($3.56 trillion). The International Monetary Fund (2022) estimated that ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand), GDP growth rates would increase to 5.0% for 2021–2022, 4.7% for 2022–2023, and 5.1% for 2023–2024.

The total GDP of the 10 ASEAN member states is projected to rise from around $3.04 trillion in 2019 to around $10.49 trillion in 2050, which is an average annual growth rate (AAGR) of around 4.1%. At the same time, the total ASEAN population will increase with an AAGR of 0.8%, from around 661 million in 2019 to around 841 million in 2050. Further, GDP per capita is projected to increase from around $4,606 in 2019 to $12,471 in 2050, an AAGR of around 3.3%.

In this chapter, we present the energy outlook for the aggregated results of ASEAN members. We begin by discussing the results of business-as-usual (BAU), followed by the results of the outcomes of the fifth alternative policy scenario (APS). The APS focuses on enhancing energy efficiency and conservation (EEC) amongst end users, as well as expanding the use of renewable energy sources. Finally, we examine the outlook results of the low carbon energy transition scenario (LCET). In the LCET, ASEAN members aim to achieve their respective carbon neutrality targets by the 2050 or 2060 (depending on the country). This will be accomplished through the implementation of low-carbon technologies such as carbon capture utilisation and storage (CCUS) and/or carbon capture and sequestration (CCS), as well as the adoption of new energy sources and carriers, such as hydrogen and ammonia in conjunction with gas-fired and coal-fired power plants.

The LCET scenario includes fuel switching from fossil fuels to hydrogen, electricity, and biomass in transport and industry activities, as well as the application of CCUS/CCS in industry production and power generation. In the LCET scenario, fuel switching from coal to highly efficient combined cycle gas turbine (CCGT) is considered a transitional pathway. From 2035 to 2050, hydrogen will not only replace coal in iron and steel production but also diesel in other activities, reaching a 100% utilisation rate. The application of hydrogen and ammonia, including co-firing in power generation and boilers in industry, will be implemented after 2040. Biomass will also be used to replace coal and natural gas various activities, with the timing and utilisation

[1] This report uses constant 2015 United States dollars.

rate varying by country, with some countries starting as early as 2030 and reaching up to 95% utilisation rate of up to 95% by 2050. Finally, electricity will replace and diesel in public transport, with some countries expected to adopt electric buses by 2035. Electric vehicles will also be introduced in private transport gradually replacing diesel and gasoline from 2025 to 2050, with a maximum utilisation rate of 70% depending on each country's situation.

In both the APS and LCET scenario, we show the progress of final energy demand, primary energy supply, power generation sector, and several energy indicators that reflect the region's advancements in improved energy, reduced energy intensity, and carbon emissions.

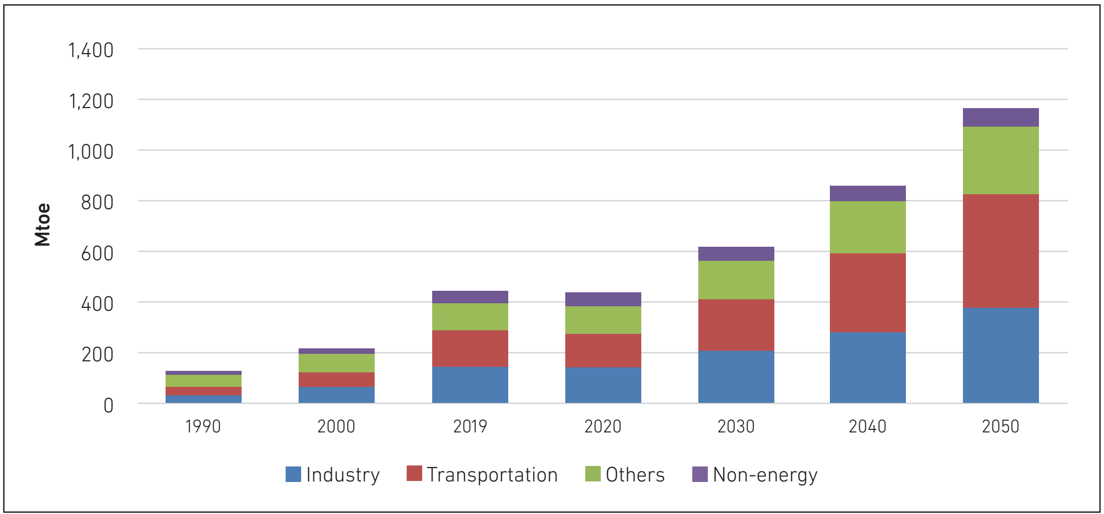
2. Outlook Results

2.1. Business-As-Usual

2.1.1. Final Energy Demand

ASEANS's final energy demand grew at an annual rate of 4.3% from 130 million tonnes of oil equivalent (Mtoe) in 1990 to 448 Mtoe in 2019. During this period, the 'others' sector (residential and commercial) dominated energy consumption, increasing from 53 Mtoe in 1990 to 108 Mtoe in 2019, with an AAGR of 2.5%. This transport sector followed with an AAGR of around 5.4%, and the industry sector with an AAGR of 5.0%. In 2019, the industry sector accounted for the largest share of energy consumption at around 150 Mtoe (34%), followed closely by the 'others' sector at 142 Mtoe (32%), and the 'others' sector at 108 Mtoe (24%). Around 11% of the region's total energy in 2019 was used for non-energy purposes, especially as feedstock for petrochemical production.

Figure A.1 **Final Energy Demand by Sector, Business-As-Usual, 1990–2050**
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers subsectors such as residential, agriculture, services, and commerce.

Source: Author's compilation.

Under BAU, final energy demand is projected to grow by 3.1% per year from 2019 to 2050. The fastest AAGR is expected to occur in the transport sector (3.8%), whilst the industry will grow at 3.0% and the 'others' sectors at 2.9%. Demand is projected to grow at an AAGR of 1.4% in the non-energy sectors. The slow growth in the 'others' sector will be caused by the shift from traditional biomass use, especially in the residential sector, to other commercial and more efficient energy sources, such as oil and electricity.

Transport will account for the highest share of total final energy demand in ASEAN, followed by the industry sector and the 'others' sector. By 2050, the transportation sector's share of energy use is expected to reach nearly 39%, while that of industry is projected to reach 33% and that of the 'others' sector nearly 23%.

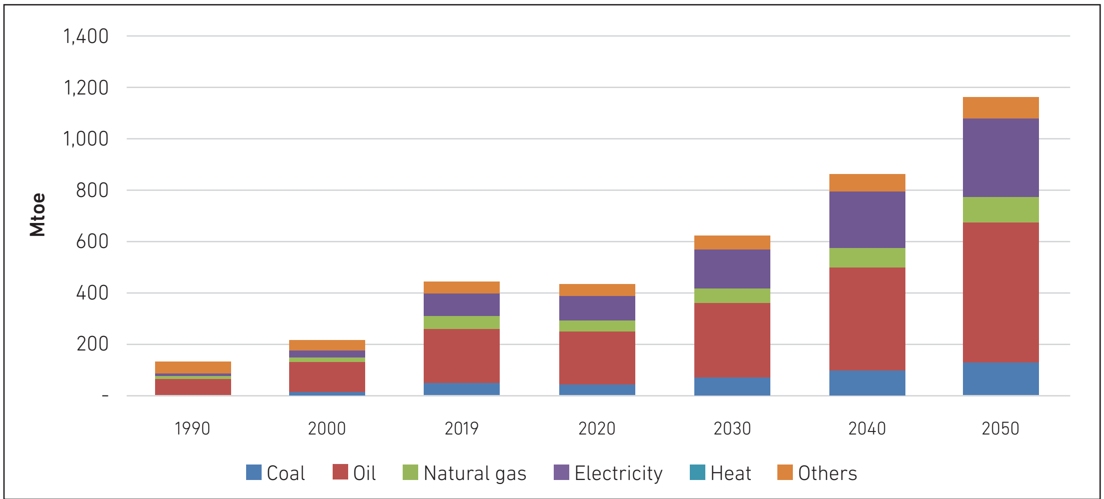
By fuel type, coal experienced the fastest growth from 1990 to 2019, at an AAGR of 8.6%, mainly driven by the rapidly expanding industry sector. In the same period, electricity grew by 7.6% per year and natural gas by 5.0%. Demand for oil grew by 4.2% per year, while demand for 'other' sources, mostly traditional biomass, grew by 0.7% per year.

Oil held the largest fuel share with 63.37 Mtoe (49% share) in 1990. By 2019, its share only slightly decreased to 47% (210 Mtoe). In 2019, oil remained the primary fuel , with the highest share, followed by electricity (21%), coal (12%), others (11%), and natural gas (10%).

Under BAU, the demand for all fuels between 2019 and 2050 expands, but at a slower AAGR. Electricity will grow the fastest at 4.0% per year, followed by oil and coal (each at around 3.0%), natural gas (2.5%), and others (2%).

With a share of around 47% in 2050, oil is still expected to play a major role in ASEAN's final energy demand. From 1990 to 2019, the share of oil increased from 40% to around 45%. Under BAU, oil's share of the final energy demand is expected to remain constant at around 46%–47% during 2020–2050. Meanwhile, the share of electricity in the final energy demand will increase to around 21% starting in 2020, before it rises further to 26.5% by 2050. Figure A.2 shows the final energy demand by fuel.

Figure A.2 Final Energy Demand by Fuel, Business-As-Usual, 1990–2050
(Mtoe)



Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solid and liquid biofuels.

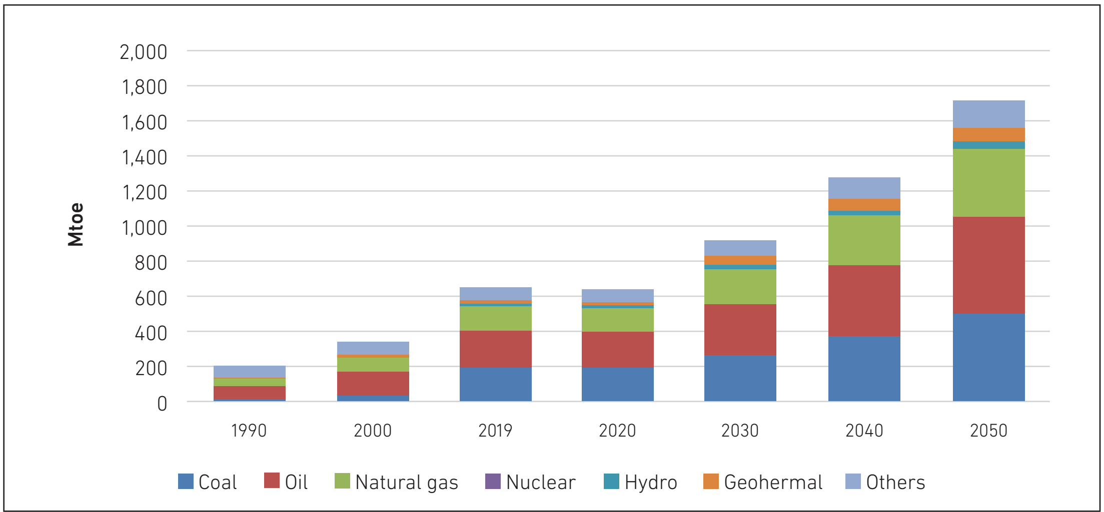
Source: Author's compilation.

2.1.2. Primary Energy Supply

Total primary energy supply grew by 4.0% per year, from 211 Mtoe in 1990 to 661 Mtoe in 2019. The ASEAN region's dominant source of energy in 1990 was oil, which accounted for almost 38% of the total primary energy supply (TPES); and oil consumption increased from nearly 80 Mtoe in 1990 to 218.5 Mtoe in 2019, an AAGR of 3.5%. The second dominant source of commercial energy in 1990 was "Others" (sources of energy) mostly composed of traditional biomass. Consumption of traditional biomass decreased from nearly 71 Mtoe in 1990 (34% of the TPES) to 62 Mtoe in 2019 (12% of the TPES), an AAGR of -0.4%. The fastest growing energy source is coal, the consumption of which increased from 13 Mtoe in 1990 to 192 Mtoe in 2019, an AAGR of 9.9%. This fast growth rate of coal consumption was followed in the second place by hydropower consumption that increased at an AAGR of 6.6% and geothermal at an AAGR of 4.7% during 2019–2020.

As shown in Figure A.3, total primary energy supply under BAU is projected to grow by 3.1% per year between 2019 and 2050. Of the energy sources, solar, wind, solid, and liquid biofuels altogether are expected to grow the fastest at 6.1% per year, followed by biofuels at 5.3% and geothermal at 4.5%. Natural gas is expected to increase at an AAGR of 3.5%, followed by coal at an AAGR of 3.2%, oil (3.0%) and hydropower (2.5%). By 2050, oil is expected to be the dominant energy source, accounting for around 32% of the TPES, followed by coal with 29% and natural gas with 22.5%. Hydropower's share is expected to remain limited to 2%, whilst geothermal' s share will reach almost 5%. 'Others' (energy sources) will account for around 9% by 2050 as this share is expected to grow by 2.2% during 2019–2050.

Figure A.3 Primary Energy Supply, Business-As-Usual, 1990–2050
(Mtoe)



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solar, wind, and solid and liquid biofuels.

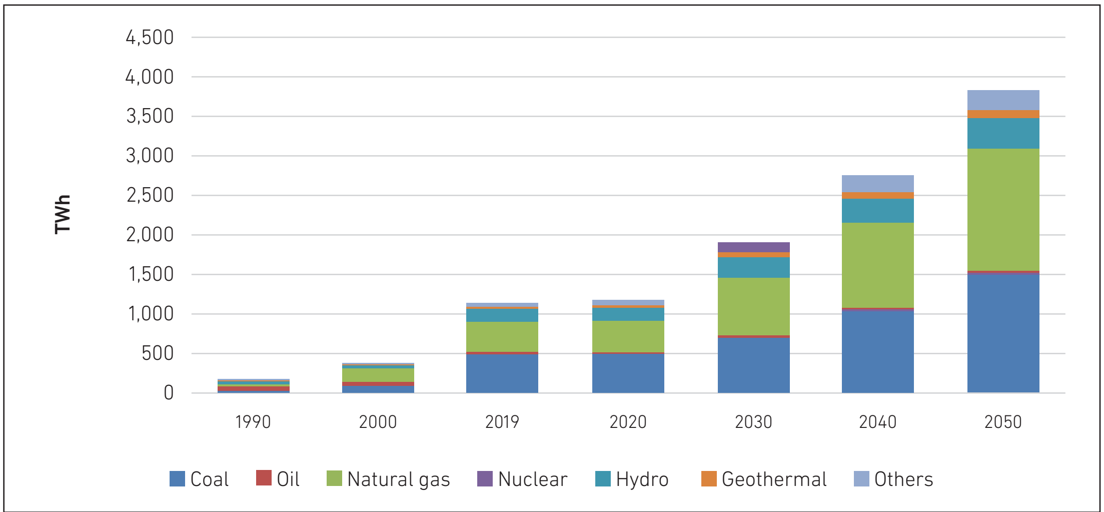
Source: Author's compilation.

2.1.3. Power Generation

Electricity generation grew by 7.1% per year from 155 TWh in 1990 to 1143 TWh in 2019. The power generation mix has changed significantly since 1990, with a shift from oil to natural gas and coal. In 1990, natural gas and coal accounted for 18% each, around 28.5 TWh and 28 TWh, respectively of electricity generation in ASEAN. However, in 2019, natural gas supplied 34% (403 TWh) of the region's electricity and coal supplied 43% (493 TWh). Hydropower's share dropped from 18% (28 Mtoe) in 1990 to 14.5% (166 TWh) in 2019, while the fuel oil's share for thermal power generation dropped from 41% (63.5 TWh) in 1990 to only 2% (19 TWh) in 2017. Other energy sources, including biomass and solar, accounted for only a small proportion of the mix, increasing from nearly zero in 1990 to around 4.5% in 2019.

Under BAU, power generation is projected to increase at 4% per year from 2019 to 2050, reaching 3,832 TWh (Figure A.4). Natural gas is expected to have the largest share of the power generation mix, with 41% of the total energy output in power generation by 2050, followed by coal (40%) and hydropower (10%). Generation from other energy sources, comprising of biomass and solar power, will see the fastest growth at an AAGR of almost 5.5%.

Figure A.4 Electricity Generation, Business-As-Usual, 1990–2050
(TWh)



Hydro = hydropower, TWh = terawatt-hour.

Note: 'Others' covers wind, solar, and biomass sources.

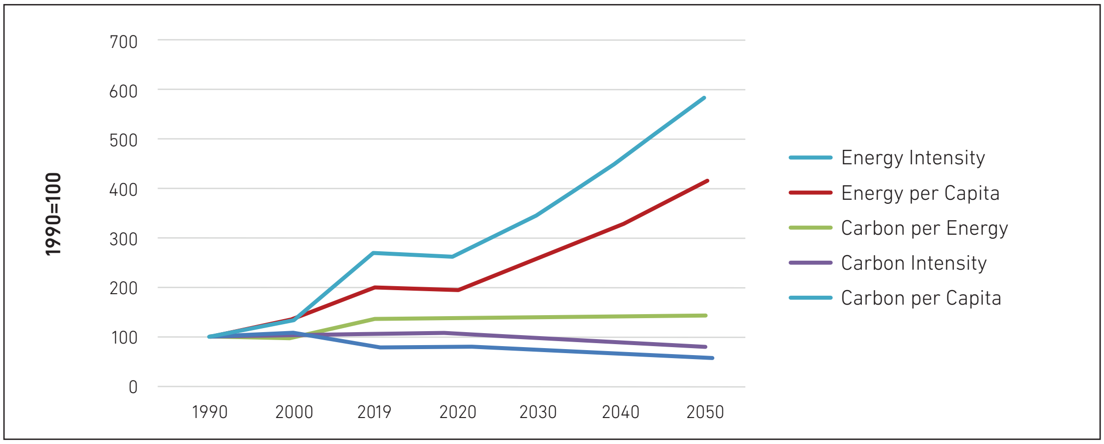
Source: Author's compilation.

The average thermal efficiency of fossil-fueled power plants in ASEAN improved from around 33% in 1990 to 35% in 2019, mainly due to more natural gas-fired power plants (especially combined cycle gas turbines) in operation. Under BAU, the thermal efficiency of fossil plants is expected to improve to around 41% by 2050. Specifically, by fuel, natural gas plants are expected to achieve a thermal efficiency of 49% in 2050, while oil and gas plants will reach 35% thermal efficiency.

2.1.4. Energy Indicators

As shown in Figure A.5, primary energy intensity, which is the ratio of primary energy supply to GDP, is expected to decrease. Energy intensity will continue to decrease as the total primary energy supply grows more slowly than the economy. The intensity of CO_2, defined as CO_2 emissions per unit of GDP, is projected to see a similar declining trend compared to energy intensity. Energy and carbon emission per capita will increase because of rapid industrialisation, lifestyle changes toward a more energy-intensive way of life, and slow population growth relative to the growth of fossil fuel demand.

Figure A.5 Energy Indicators, Business-As-Usual, 1990–2050



Source: Author's compilation.

2.2 Energy Saving and Carbon Emission Reduction Potential, Alternative Policy Scenario

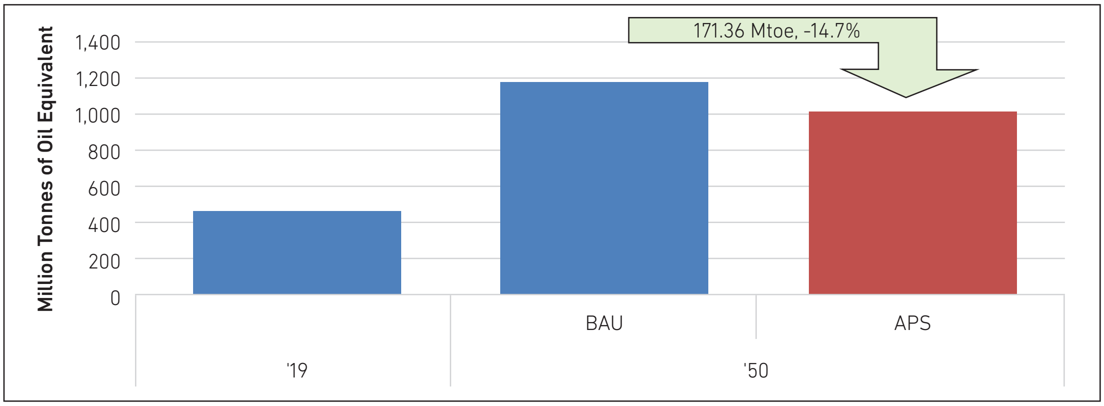
The APS applies the same GDP and population assumptions as the BAU. However, the APS incorporates improvements in the efficiency of final energy consumption in various end-use sectors. It also includes more efficient thermal power generation and a higher share of renewable energy in the total supply, with no nuclear power plants. By comparing the APS results with BAU, this section offers a foundation for assessing the effects of promoting energy efficiency and increasing the use of renewable energy in ASEAN. The aim is to determine the potential for energy savings and CO_2 emissions reductions within the region.

2.2.1. Final Energy Demand

Final energy demand under the APS is projected to increase by an AAGR of 2.6% from 2019 to 2050, slower than under BAU (3.1%). As shown in Figure A.6, by 2050, the total final energy demand in the APS should reach around 996 Mtoe, nearly 15% lower than under BAU. Between 2019 and 2050, the transport sector is expected to grow at an AAGR of 3.1%, followed by the industry and other sectors both at 2.5%. The AAGR of the non-energy sector is forecasted to be 1.4%, similar to BAU.

Figure A.6: Total Final Energy Demand in 2050, Business-As-Usual and Alternative Policy Scenario, 1990 and 2050

(Mtoe)



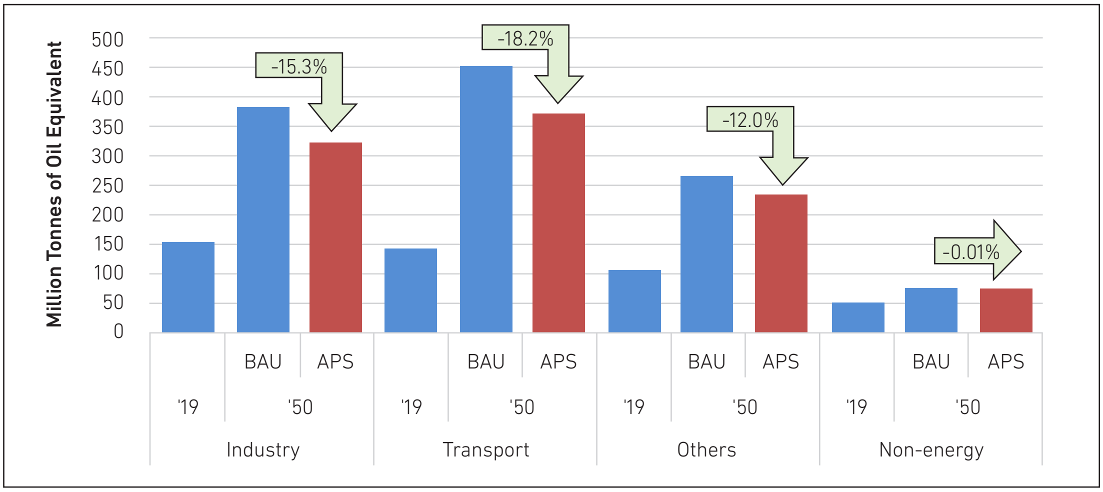
APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's compilation.

In the APS, the transport sector is expected to see the greatest decrease in energy consumption. Figure A.7 shows that, by 2050, the transport sector's energy consumption would decrease by over 18% in the APS, relative to BAU. Further, the industry sector is expected to have 15.3% lower energy consumption by 2050 in the APS, while the consumption in the 'other' sector would be 12% lower than under BAU.

Figure A.7 Total Final Energy Demand by Sector in 2050, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050

(Mtoe)



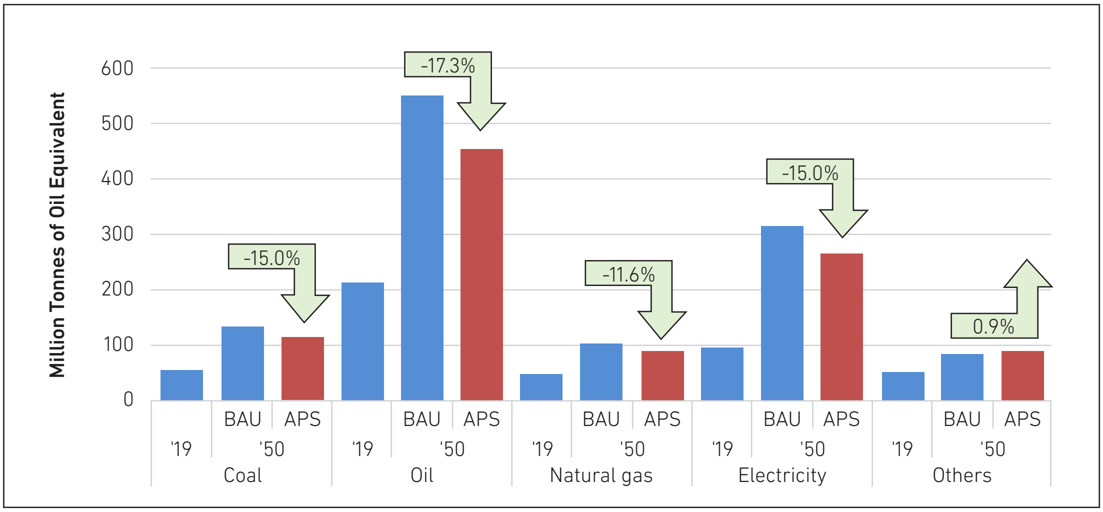
APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' covers solid and liquid biofuels.

Source: Author's compilation.

In terms of fuel type, the APS is expected to reduce oil consumption by over 17%, natural gas by over 11%, and electricity consumption by 15.7% by 2050, relative to BAU (Figure A.8). Additionally, coal demand in the APS would be 15% lower than under BAU, while consumption of 'Others' (other fuel types) would be 0.9% higher.

Figure A.8 Total Final Energy Demand by Fuel, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

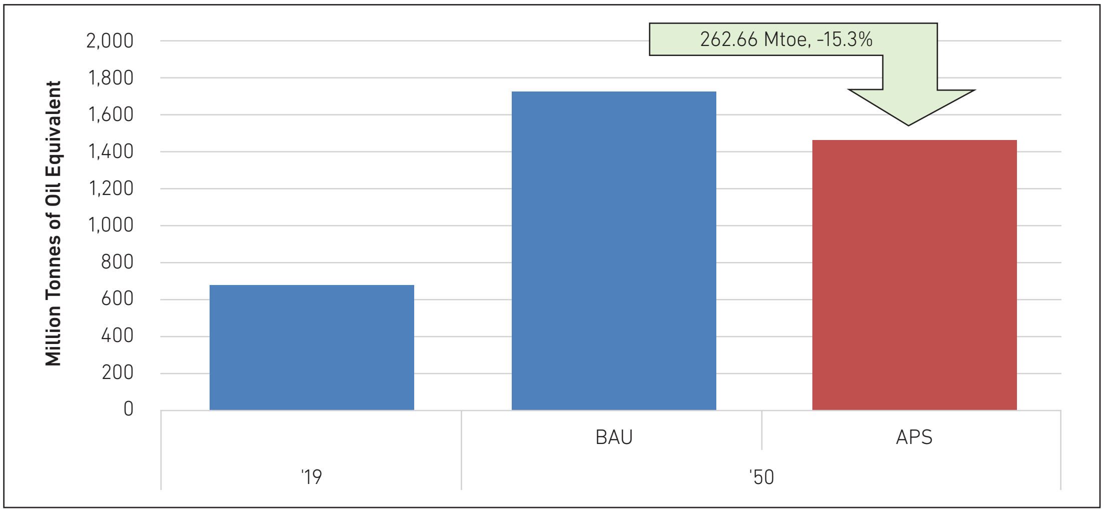
Note: 'Others' covers solid and liquid biofuels.

Source: Author's compilation from individual Association of Southeast Asian Nations member states' results.

2.2.2. Primary Energy Supply

In 2050, the APS would decrease the TPES by around 263 Mtoe, or over 15% compared to BAU (Figure A.9). Most of this reduction will come from coal at 254 Mtoe, indicating a drop of around 50% compared to BAU (Figure A.10). Natural gas consumption would decrease by 27.5%, while oil consumption would decrease by over 17%. In contrast, the APS has a notable increase in geothermal power generation as well as solar, wind, and biomass energy sources, surpassing the levels expected under BAU. Biofuel consumption will remain relatively constant. Altogether, this scenario indicates an over 86% increase in the consumption of 'others', encompassing biomass, solar, wind, ocean, biofuel, and electricity. Additionally, around 4 Mtoe of hydrogen will also appear by 2050 in the APS.

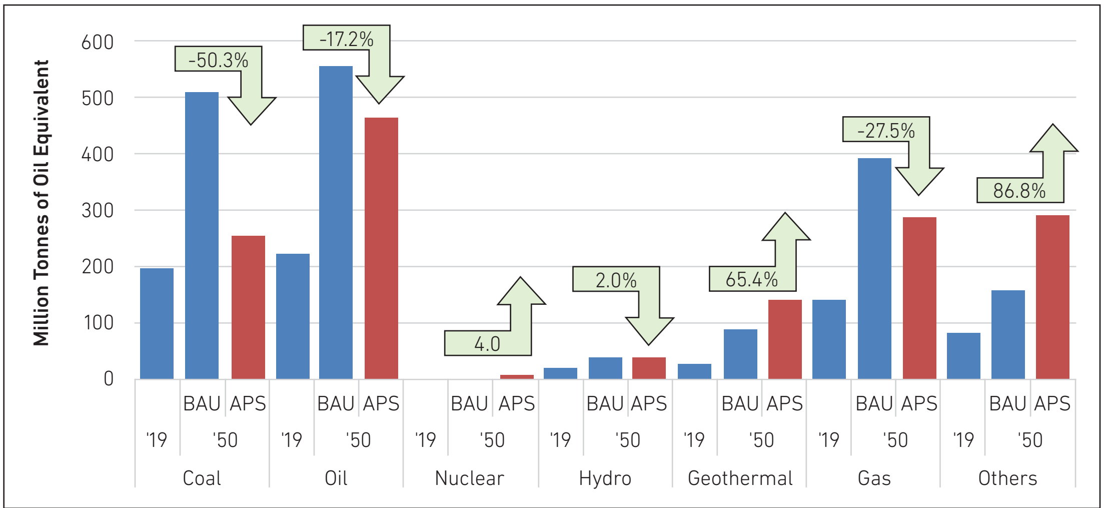
Figure A.9 Total Primary Energy Supply, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Source: Author's compilation.

Figure A.10 Total Primary Energy Supply by Fuel, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050
(Mtoe)



APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' 'covers solar, wind, and solid and liquid biofuels.

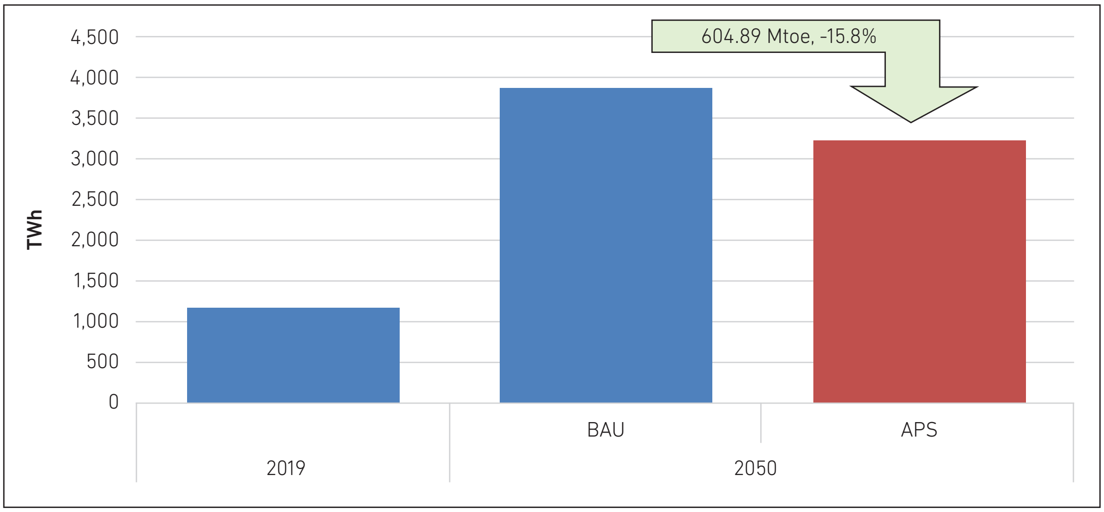
Source: Author's compilation.

2.2.3. Power Generation

In the APS, electricity generation in 2050 decreased by around 605 TWh (nearly 16%) from BAU (Figure A.11). As shown in the Figure A.12, by 2050, the APS policy measures would reduce coal-fired electricity production by over 54% and gas-fired electricity production by 22% compared to BAU. Additionally, the use of 'other' energy sources (mainly solar) to generate electricity in the APS would almost triple to 734 TWh from 251 TWh under BAU. Geothermal power generation is anticipated to increase by nearly 75% from BAU to the APS. Moreover, the APS envisions that nuclear plants will contribute to the generation of a little over 15 TWh of electricity by 2050, while no nuclear based power generation is expected under BAU.

Figure A.11 Electricity Generation, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050

(TWh)

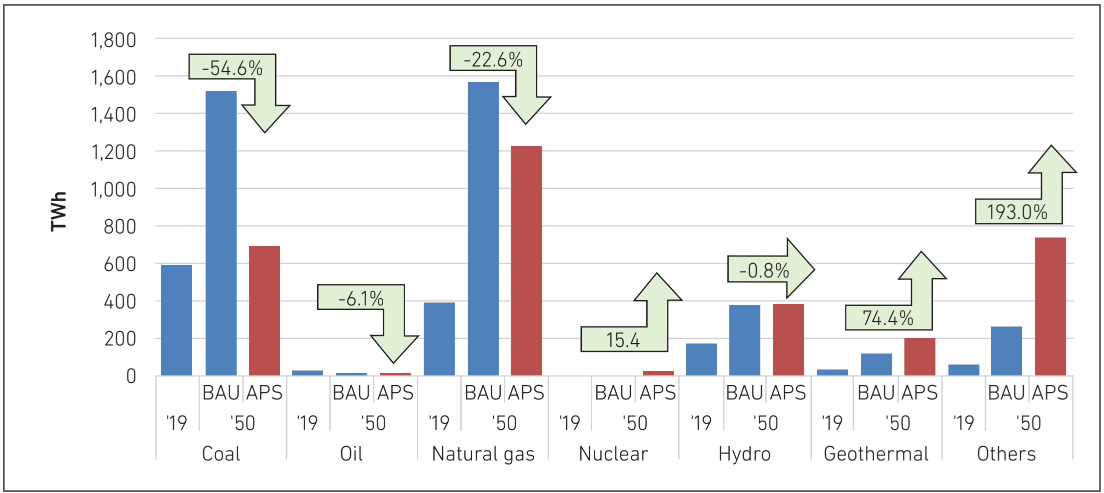


APS = alternative policy scenario, BAU = business-as-usual, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

Source: Author's compilation.

Figure A.12 **Electricity Generation by Source, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050**

(TWh)



APS = alternative policy scenario, BAU = business-as-usual, Hydro = hydropower, TWh = terawatt hour.

Note: 'Others' covers wind, solar, and biomass sources.

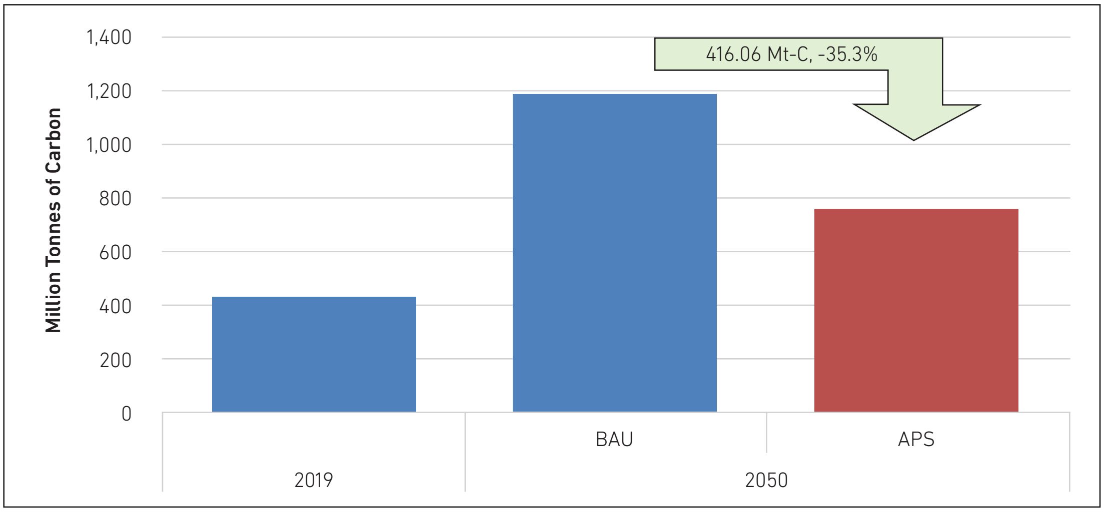
Source: Author's compilation.

2.2.4. Carbon Emission Reduction Potential

Under BAU, carbon emissions from energy demand are projected to increase at an AAGR of 3.3%. This would lead to an increase from 425 million tonnes of carbon equivalent (Mt-C) in 2019 to around 1177 Mt-C in 2050 (Figure A.13). During the same period, in the APS, emissions would grow at an AAGR of 1.9% to 761 Mt-C by 2050. Therefore, the APS demonstrates a potential for reducing CO_2 emissions by approximately 416 Mt-C by 2050, a decrease of over 35% compared to BAU.

Figure A.13 Carbon Emissions from Energy Consumption, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050

(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, Mt-C = million tonnes of carbon.

Source: Authors' compilation.

2.3. Energy Saving and Carbon Emission Reduction Potential, Low Carbon energy Transition Scenario

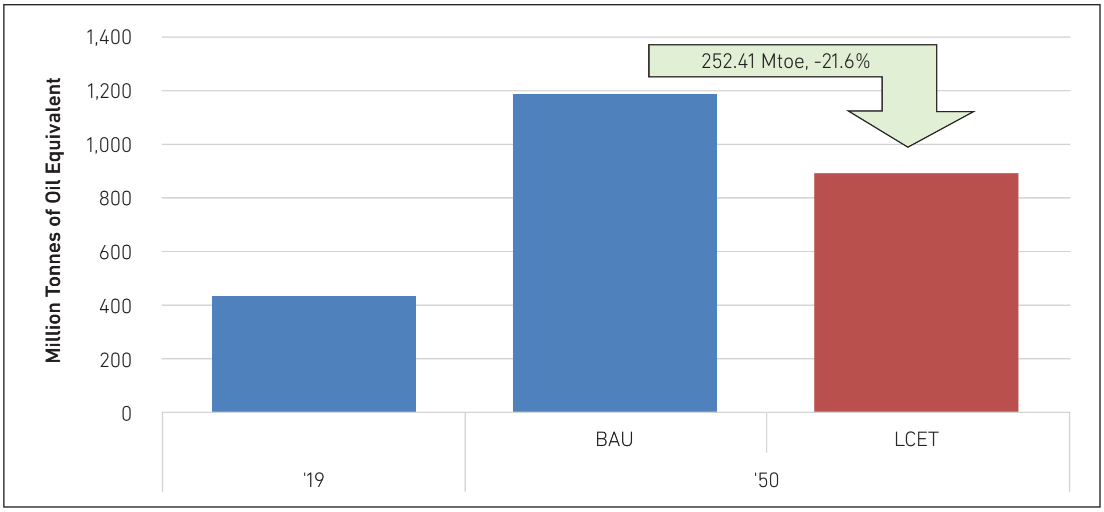
In the low carbon energy transition (LCET) scenario, the assumptions regarding GDP and population are consistent with those of the BAU and the APS. However, the LCET scenario assumes that each ASEAN member state will achieve carbon neutrality by either 2050 or 2060, depending on their individual commitments and pledges.

This section serves as a foundation for evaluating the impacts of integrating low carbon technologies and new energy resources and carriers in ASEAN. By comparing the results of the LCET scenario with BAU, it allows for the assessment of the impacts achieved by implementing these measures in addition to the assumptions made for improving final users' energy consumption and expanding the share of renewable energy sources, as already considered in the APS.

2.3.1. Final Energy Demand

Final energy demand under the LCET is projected to increase by an AAGR of 2.3% from 2019 to 2050, slower than under BAU (3.1%) and APS (2.6%). As shown in Figure A.14, by 2050, the total final energy demand in the LCET should reach around 915 Mtoe, nearly 22% lower than under BAU. Between 2019 and 2050, the transportation sector is expected to grow at an AAGR of 2.7%, followed by the industry with 2.3% and other sectors at 2.2%. The AAGR of the non-energy sector is forecast to be 1.5%, almost like BAU (1.4%).

Figure A.14 Total Final Energy Demand, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050
(Mtoe)

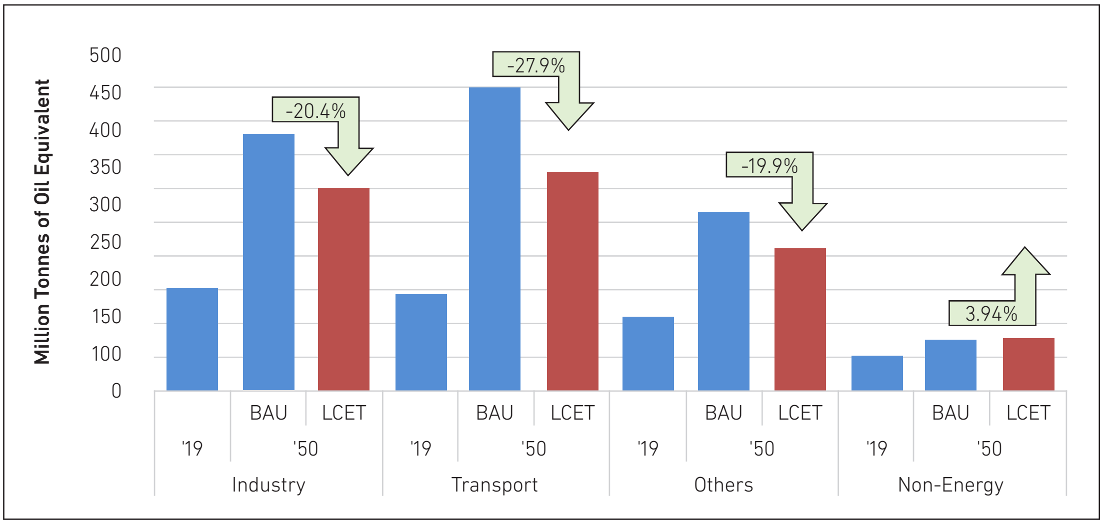


BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Author's compilation.

In the LCET scenario, the transport sector is expected to see the greatest decrease in energy use by 27% relative to BAU as shown in the Figure A.15. Similarly, by 2050, the energy consumption of the industry and 'Others' sectors should be around 20% lower each in the LCET compared to BAU.

Figure A.15 Total Final Energy Demand by Sector, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050
(Mtoe)



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

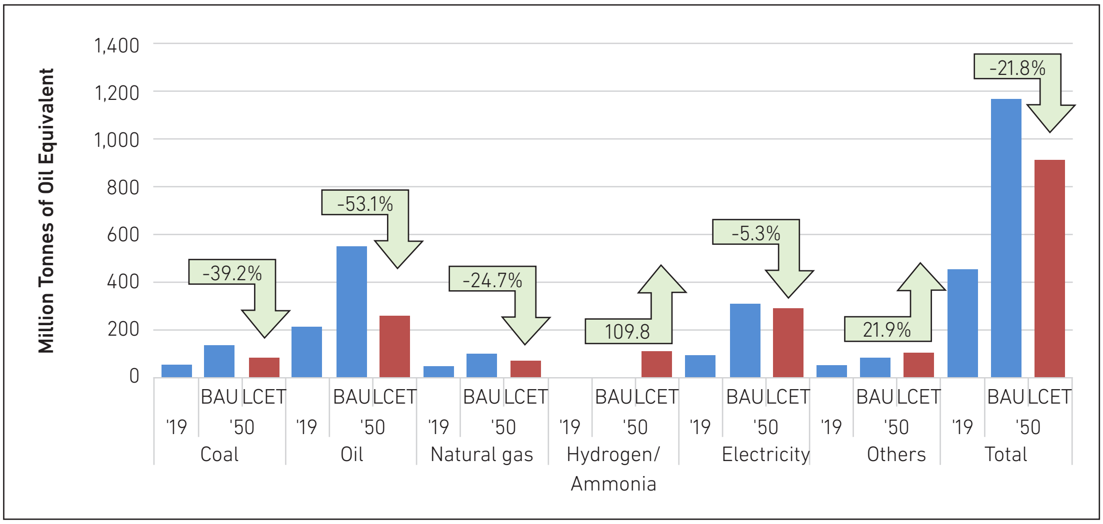
Note: 'Others' covers subsectors such as residential, agriculture, services, and commerce.

Source: Author's compilation.

By 2050, the LCET scenario is expected to achieve substantial reductions in fuel consumption compared to BAU. Specifically, in the LCET scenario, oil consumption is expected to decrease by over 53%, coal consumption by 29%, natural gas consumption by almost 25%, and electricity consumption by over 5% (Figure A.16). In the LCET scenario, the consumption of 'Others' (other fuel types) is expected to increase by nearly 22% compared to BAU. Finally, hydrogen and ammonia will be used for co-firing in gas-fired and coal-fired power plants by 2040. As a result, the total final demand for hydrogen and ammonia combined is projected to reach around 110 Mtoe by 2050 within this scenario.

Figure A.16 Total Final Energy Demand by Fuel, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050

(Mtoe)



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

Note: 'Others' covers solid and liquid biofuels.

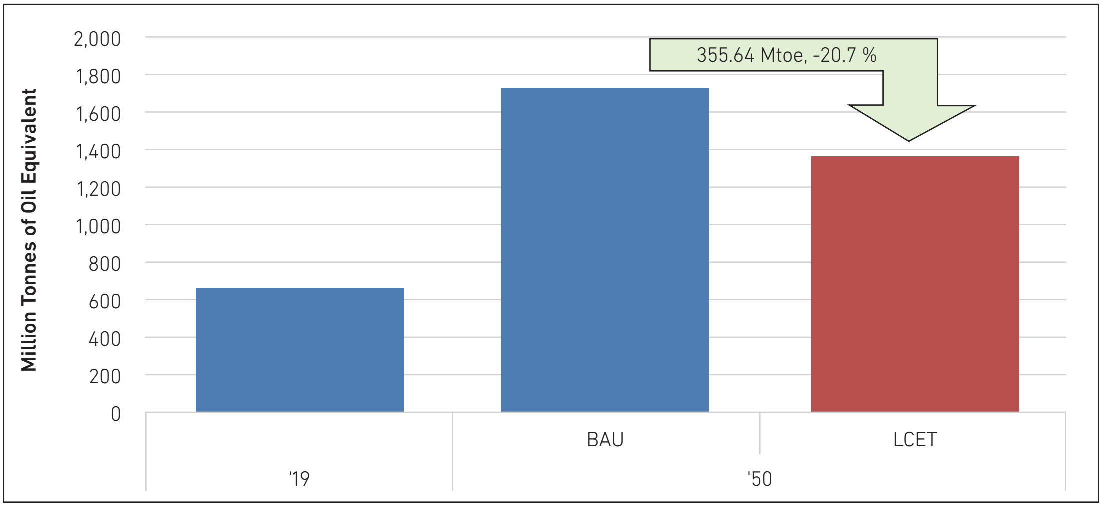
Source: Author's compilation from individual Association of Southeast Asian Nations member states' results.

2.3.2. Primary Energy Supply

In 2050, relative to BAU, measures in the LCET scenario would decrease the total primary energy supply (TPES) by around 355 Mtoe, or around 20% (Figure A.17). Most of this reduction will come from coal at 320 Mtoe, a drop of around 63% from BAU (Figure A.18). Natural gas would decrease by 30%, and oil consumption would decrease by over 53%. In the LCET scenario, geothermal power generation will increase by 43% compared to BAU. Other fuels' consumption such as solar, wind, ocean, and biomass would more than double, from 154 Mtoe in BAU to 321.

Figure A.17 Total Primary Energy Supply, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050

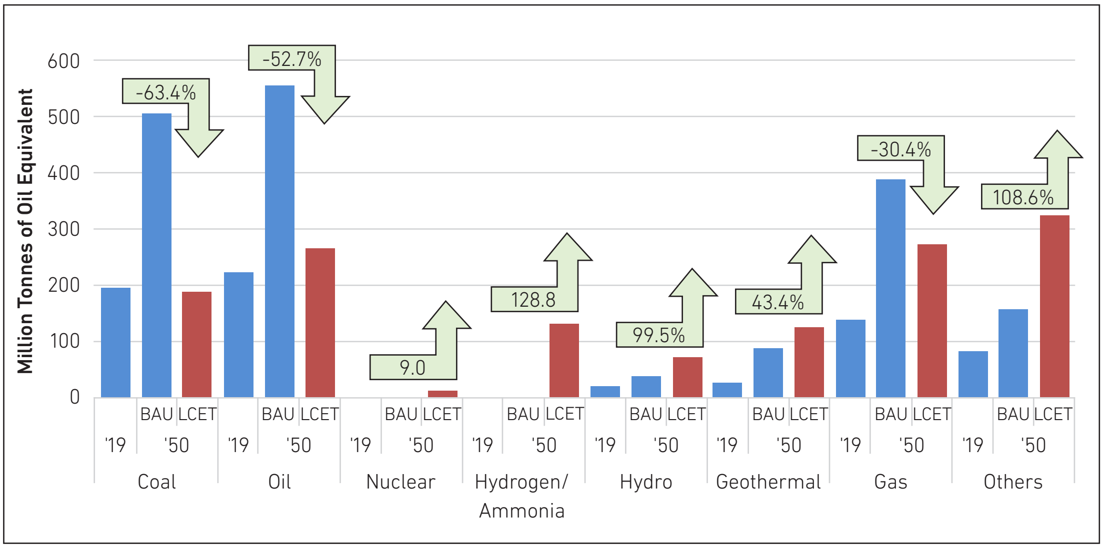
(Mtoe)



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

Source: Author's compilation.

Figure A.18 Total Primary Energy Supply by Fuel, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050



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

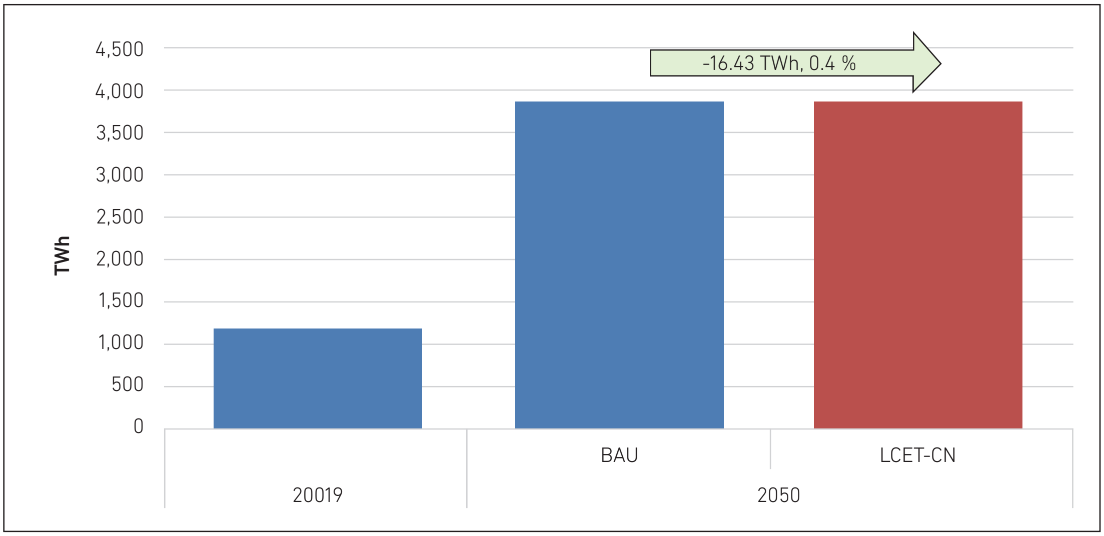
Note: 'Others' covers solar, wind, and solid and liquid biofuels.

Source: Author's compilation.

2.3.3. Power Generation

In the LCET scenario, electricity generation in 2050 would reach around 3,848 TWh, which is only a 0.4% (16 TWh) increase from 3,832 TWh in BAU (Figure A.19). Strong electrification measures in transport are amongst the most important factors that boost power generation in the LCET scenario.

Figure A.19 Electricity Generation, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050
(TWh)



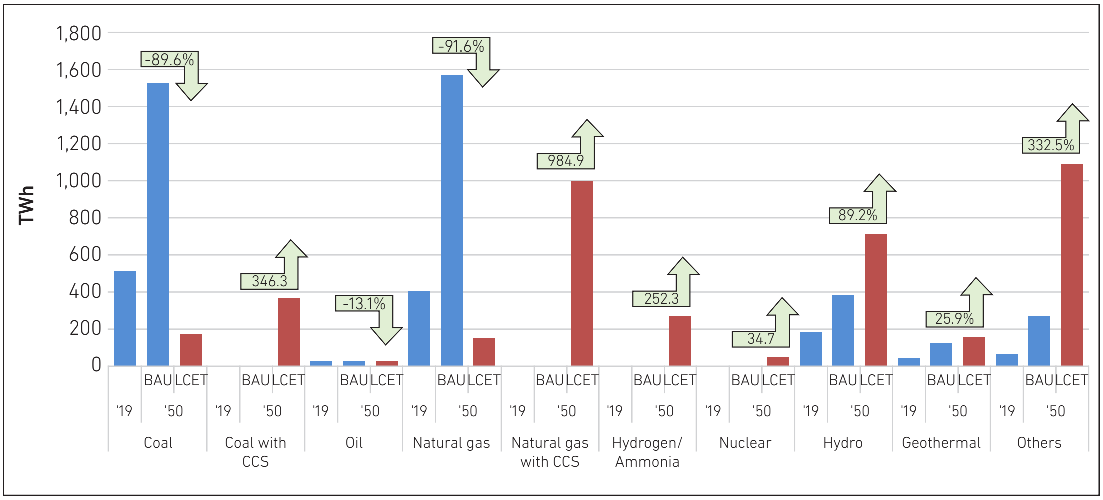
BAU = business-as-usual, LCET = low carbon energy transition, Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.
Source: Author's compilation.

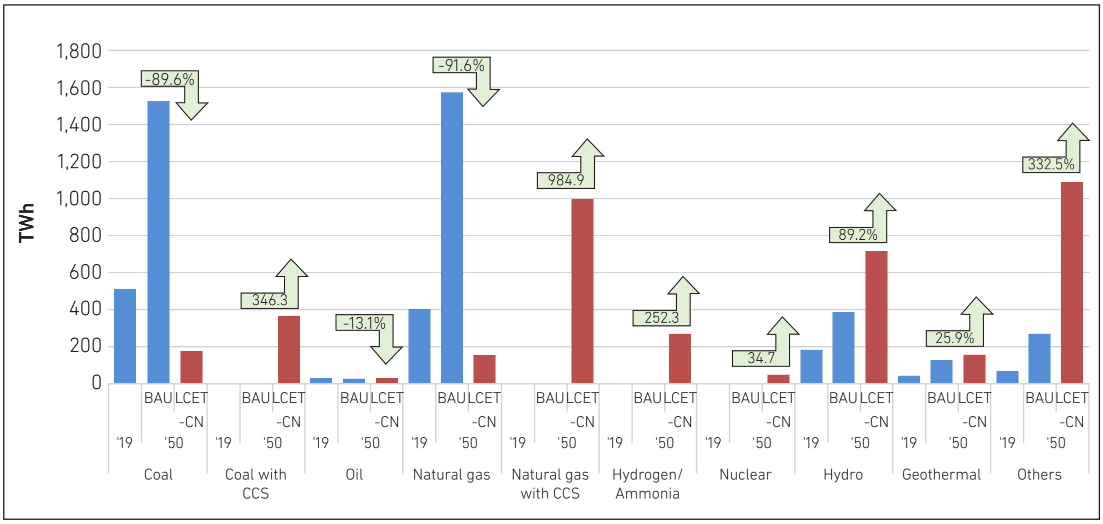
As shown in Figure A.20, by 2050, the policy measures in the LCET should reduce the production of coal-fired electricity by nearly 90% (1,360 TWh) and that of gas-fired electricity production by almost 92% (1,433 TWh) from BAU. Use of 'other' energy sources (mainly solar) to generate electricity in the APS would almost triple to 734 TWh from 251 TWh under BAU. In LCET, coal-fired power production combined with carbon capture and sequestration (CCS) is assumed to appear by 2030 and by 2050 and reach 346 TWh of electricity production. Gas-fired power production combined with CCS is assumed to enter the market by 2019. By 2050, this combination produces 985 TWh of power. The gradual utilisation of hydrogen and/or ammonia in co-firing, specifically with natural gas and coal in power generation, is assumed to appear gradually by 2020. By 2050, it is anticipated that the total electricity produced through this method would reach around 252 TWh. Nuclear power plants are assumed to start power production by 2040 in this LCET scenario. By 2050, the total power produced would reach 35 TWh. Also, by 2050, electricity generated by hydro power plants in the LCET scenario would increase by 89% compared to BAU, whilst that of geothermal plants would increase by nearly 26% from BAU to the LCET.

Finally, power generation in 2050 from other sources, i.e. solar, wind, and biomass, would increase by 4.3 times from 251 TWh in BAU to 1084 TWh in the LCET scenario.

Figure A.20 Electricity Generation by Source, Business-As-Usual and Low Carbon Energy Transition, 2019 and 2050

(TWh)





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

Note: 'Others' covers wind, solar, and biomass sources.

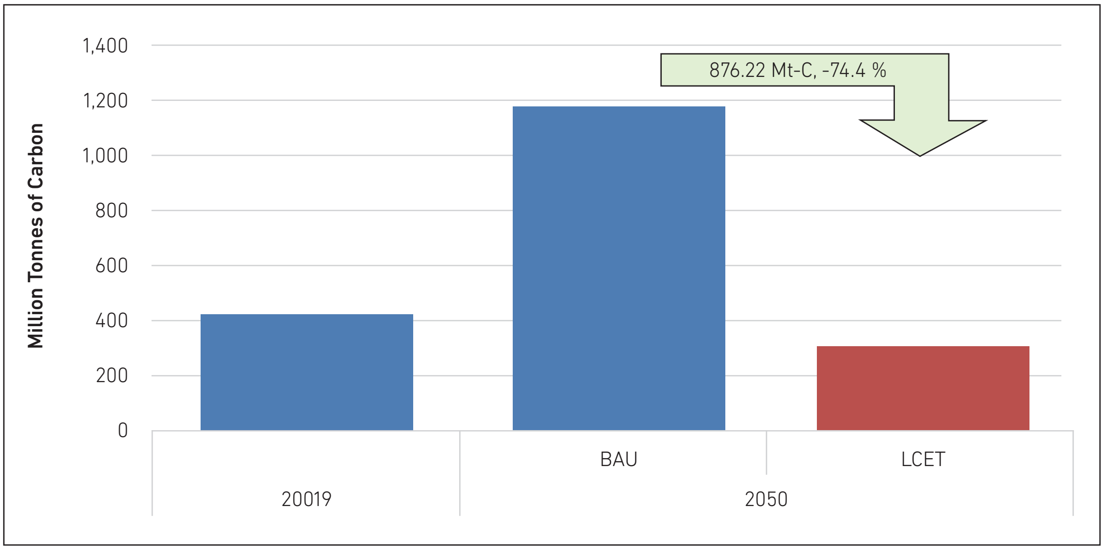
Source: Author's compilation.

2.3.4. Carbon Reduction Potential

Under BAU, carbon emissions from energy demand are projected to increase at an AAGR of 3.3%, from 425 million tonnes of carbon (Mt-C) in 2019 to around 1,177 Mt-C in 2050 (Figure A.21). During the same period, in the LCET, emissions would decrease by 1.1% to 301 Mt-C by 2050. In other words, CO_2 emissions in the LCET scenario in 2050 (301 Mt-C) are around 29% less than 2019' CO_2 emissions (425 Mt-C).

The LCET scenario has the potential to significantly reduce CO_2 emissions, leading to a savings of around 876 Mt-C by 2050. This represents a decrease of over 74% compared to BAU. The emissions reduction achieved in the LCET scenario of 876 Mt-C by 2050 is more than double the amount saved in the APS, which is 416 Mt-C.

Figure A.21 Carbon Emissions from Energy Consumption, Business-As-Usual and Alternative Policy Scenario, 2019 and 2050
(Mt-C)



APS = alternative policy scenario, BAU = business-as-usual, LCET = low carbon energy transition, Mt-C = million tonnes of carbon.

Source: Author's compilation.

3. Implications and Policy Recommendations

At least five main conclusions can be derived based on the outlook results. First, energy consumption in ASEAN, in BAU is projected to increase continuously as a result of stable economic growth up to 2050. Second, individual governments of ASEAN member states have been implementing diversified sector measures to promote and advocate the adoption of clean energy technologies and sources, as well as emissions reduction. If, by implementing those measures, member states could accomplish their energy efficiency and renewable energy penetration targets over the next 3 decades, as in the APS scenario, then ASEAN as a region would reduce energy consumption and carbon emissions significantly. Third, achieving carbon neutrality in member states would require not only aggressive implementation of energy efficiency and conservation (EEC) and the expansion of renewable energy (RE), but also the implementation of new low carbon technologies. These technologies include such as CCUS/CCS in power generation and industry, high efficiency combined cycle gas turbines (CCGT), and the introduction of new energy carriers and sources such as hydrogen and ammonia for co-firing in natural gas and/or coal fired power plants and various industries.

Electrification in the different final sectors is the key measure considered in the LCET scenario, including mobility. In mobility, for example, the use of diesel and gasoline fuel in public transport will be replaced by electric power. It is expected that by 2035, some countries will completely run their buses on electricity. Between 2025 and 2050, private passenger transport modes will undergo a process of electrification with some countries be reaching the share of 70% of electric vehicles amongst their private modes.

The successful implementation of low carbon-fuel switching technology, energy sources, and carriers, as in the LCET scenario, would lead to a level of carbon emissions in 2050 lower than the level of carbon emissions in 2019.

Fourth, at the regional level, ASEAN must put forward more initiatives and programmes, to improve energy efficiency and boost renewable energy share by speeding up regional collaboration and international cooperation.

Fifth, energy efficiency promotion measures in transport fuel and electricity generation will be essential. The affordable and stable use of renewable energy will also be crucial. To promote the use of renewable energy, the parallel use of affordable natural gas will be key. A liquefied natural gas hub in Asia is one option to secure a stable and affordable natural gas supply for ASEAN.

As the fifth largest economy in the world currently, ASEAN plays an important role in terms of energy consumption and greenhouse gas emissions. Continuously monitoring and observing energy savings and emissions reductions at the ASEAN level, along with regular updates to the regional energy outlook, as presented in this chapter, are therefore crucial.

References

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ANNEX 2

Results Summary Tables

Australia BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**86,14**	**108,11**	**128,74**	**121,00**	**129,15**	**132,82**	**133,09**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-6,0**	**0,7**	**0,3**	**0,0**	**0,1**
Coal	34,89	48,15	41,66	38,13	34,97	32,61	29,83	40,5	44,5	32,4	31,5	27,1	24,6	22,4	0,6	-8,5	-0,9	-0,7	-0,9	-1,1
Oil	31,20	34,15	43,30	38,41	41,15	39,28	36,34	36,2	31,6	33,6	31,7	31,9	29,6	27,3	1,1	-11,3	0,7	-0,5	-0,8	-0,6
Natural gas	14,79	19,27	34,28	33,85	39,43	43,81	45,98	17,2	17,8	26,6	28,0	30,5	33,0	34,5	2,9	-1,3	1,5	1,1	0,5	1,0
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	1,41	1,34	1,43	1,44	1,45	1,46	1,4	1,3	1,0	1,2	1,1	1,1	1,1	0,3	6,8	0,1	0,1	0,1	0,3
Geothermal	0,00	0,00	0,00	0,00	0,02	0,04	0,05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	22,3	5,2	2,4	-
Others	4,04	5,13	8,16	9,18	12,14	15,62	19,42	4,7	4,7	6,3	7,6	9,4	11,8	14,6	2,5	12,5	2,8	2,6	2,2	2,8
Biomass	3,96	5,04	4,94	5,22	5,95	6,72	7,38	4,6	4,7	3,8	4,3	4,6	5,1	5,5	0,8	5,7	1,3	1,2	0,9	1,3
Solar, Wind, Ocean	0,08	0,09	3,22	3,95	6,19	8,90	12,04	0,1	0,1	2,5	3,3	4,8	6,7	9,0	13,5	22,9	4,6	3,7	3,1	4,3
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**56,66**	**69,58**	**82,34**	**77,89**	**85,91**	**89,29**	**90,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-5,4**	**1,0**	**0,4**	**0,2**	**0,3**
Industry	19,32	23,79	22,15	21,60	24,29	26,40	27,53	34,1	34,2	26,9	27,7	28,3	29,6	30,3	0,5	-2,4	1,2	0,8	0,4	0,7
Transportation	21,11	25,66	33,86	29,56	32,40	32,20	31,77	37,3	36,9	41,1	38,0	37,7	36,1	35,0	1,6	-12,7	0,9	-0,1	-0,1	-0,2
Others	12,27	15,71	21,04	21,58	23,77	25,00	25,62	21,7	22,6	25,6	27,7	27,7	28,0	28,2	1,9	2,6	1,0	0,5	0,2	0,6
Non-energy	3,95	4,43	5,30	5,14	5,45	5,70	5,84	7,0	6,4	6,4	6,6	6,3	6,4	6,4	1,0	-2,9	0,6	0,4	0,2	0,3
Total	**56,66**	**69,58**	**82,34**	**77,89**	**85,91**	**89,29**	**90,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-5,4**	**1,0**	**0,4**	**0,2**	**0,3**
Coal	4,56	4,20	3,00	3,02	2,93	2,81	2,64	8,0	6,0	3,6	3,9	3,4	3,1	2,9	-1,4	0,7	-0,3	-0,4	-0,6	-0,4
Oil	29,00	34,72	44,01	39,81	42,32	41,49	39,87	51,2	49,9	53,4	51,1	49,3	46,5	43,9	1,4	-9,5	0,6	-0,2	-0,4	-0,3
Natural gas	8,66	11,39	12,61	12,54	14,32	15,09	15,22	15,3	16,4	15,3	16,1	16,7	16,9	16,8	1,3	-0,5	1,3	0,5	0,1	0,6
Electricity	11,11	14,85	18,45	18,32	21,89	25,36	28,48	19,6	21,3	22,4	23,5	25,5	28,4	31,4	1,8	-0,7	1,8	1,5	1,2	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	4,42	4,27	4,19	4,45	4,56	4,55	5,9	6,4	5,2	5,4	5,2	5,1	5,0	0,9	-2,0	0,6	0,2	0,0	0,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**154,29**	**209,86**	**263,66**	**261,76**	**309,44**	**352,32**	**388,04**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,9**	**-0,7**	**1,7**	**1,3**	**1,0**	**1,3**
Coal	121,48	174,25	154,30	144,48	152,43	151,95	143,15	78,7	83,0	58,5	55,2	49,3	43,1	36,9	0,8	-6,4	0,5	0,0	-0,6	-0,2
Oil	3,55	1,78	4,92	4,56	4,24	3,60	2,75	2,3	0,9	1,9	1,7	1,4	1,0	0,7	1,1	-7,4	-0,7	-1,6	-2,6	-1,9
Natural gas	14,36	16,25	52,78	50,27	62,45	72,47	78,78	9,3	7,7	20,0	19,2	20,2	20,6	20,3	4,6	-4,8	2,2	1,5	0,8	1,3
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	14,15	16,36	15,60	16,66	16,77	16,88	16,99	9,2	7,8	5,9	6,4	5,4	4,8	4,4	0,3	6,8	0,1	0,1	0,1	0,3
Geothermal	0,00	0,00	0,00	0,00	0,03	0,05	0,06	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	22,3	5,2	2,4	-
Others	0,75	1,23	36,06	45,80	73,53	107,37	146,30	0,5	0,6	13,7	17,5	23,8	30,5	37,7	14,3	27,0	4,8	3,9	3,1	4,6

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,34**	**45,77**	**49,94**	**45,77**	**44,27**	**42,77**	**39,99**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-8,4**	**-0,3**	**-0,3**	**-0,7**	**-0,7**
Coal	28,92	41,19	36,58	33,10	30,05	27,90	25,43	86,8	90,0	73,2	72,3	67,9	65,2	63,6	0,8	-9,5	-1,0	-0,7	-0,9	-1,2
Oil	0,95	0,53	1,15	1,06	0,99	0,83	0,61	2,8	1,1	2,3	2,3	2,2	1,9	1,5	0,7	-8,5	-0,7	-1,7	-3,0	-2,0
Natural gas	3,47	4,06	12,21	11,62	13,23	14,04	13,95	10,4	8,9	24,4	25,4	29,9	32,8	34,9	4,4	-4,8	1,3	0,6	-0,1	0,4

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,0**	**36,1**	**36,5**	**37,4**	**42,6**	**45,9**	**48,3**								**0,1**	**2,6**	**1,3**	**0,7**	**0,5**	**0,9**
Coal	36,1	36,4	36,3	37,5	43,6	46,8	48,4								0,0	3,5	1,5	0,7	0,3	0,9
Oil	32,3	29,2	36,7	37,1	36,9	37,4	38,6								0,4	1,2	-0,1	0,1	0,3	0,2
Natural gas	35,6	34,4	37,2	37,2	40,6	44,4	48,6								0,2	0,1	0,9	0,9	0,9	0,9

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**69,8**	**90,2**	**103,8**	**93,1**	**95,4**	**94,0**	**90,1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-10,4**	**0,2**	**-0,1**	**-0,4**	**-0,5**
Coal	37,9	53,0	47,7	42,6	39,0	36,4	33,3	54,3	58,7	45,9	45,7	40,9	38,7	37,0	0,8	-10,7	-0,9	-0,7	-0,9	-1,1
Oil	22,7	24,9	33,7	28,9	31,3	29,7	27,4	32,5	27,6	32,5	31,1	32,8	31,6	30,4	1,4	-14,2	0,8	-0,5	-0,8	-0,7
Natural gas	9,2	12,3	22,4	21,6	25,1	27,9	29,4	13,2	13,7	21,6	23,2	26,3	29,7	32,6	3,1	-3,7	1,5	1,1	0,5	0,9

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	569	788	1.346	1.314	1.690	2.238	2.871	3,0	-2,4	2,5	2,8	2,5	2,5
Population (millions of people)	17,1	19,2	25,4	25,7	28,4	30,8	33,0	1,4	1,2	1,0	0,8	0,7	0,9
GDP per capita (thousands of 2015 USD/person)	33,33	41,15	53,08	51,20	59,60	72,75	86,93	1,6	-3,5	1,5	2,0	1,8	1,6
Primary energy consumption per capita (toe/person)	5,05	5,64	5,08	4,71	4,55	4,32	4,03	0,0	-7,1	-0,3	-0,5	-0,7	-0,7
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	151	137	96	92	76	59	46	-1,6	-3,7	-1,8	-2,5	-2,4	-2,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	100	88	61	59	51	40	32	-1,7	-3,1	-1,5	-2,4	-2,3	-2,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	123	114	77	71	56	42	31	-1,6	-8,2	-2,2	-2,9	-2,9	-2,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,81	0,83	0,81	0,77	0,74	0,71	0,68	0,0	-4,6	-0,4	-0,4	-0,5	-0,6
Automobile ownership volume (millions of vehicles)	9,8	12,3	18,9	19,0	21,4	24,3	27,1	2,3	0,5	1,2		2,4	1,2
Automobile ownership volume per capita (vehicles per person)	0,573	0,642	0,746	0,741	0,756	0,789	0,820	0,9	-0,7	0,2		0,8	0,3

Australia APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**86,14**	**108,11**	**128,74**	**121,04**	**122,99**	**115,37**	**103,23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-6,0**	**0,2**	**-0,6**	**-1,1**	**-0,7**
Coal	34,89	48,15	41,66	38,06	29,25	20,69	12,48	40,5	44,5	32,4	31,4	23,8	17,9	12,1	0,6	-8,6	-2,6	-3,4	-4,9	-3,8
Oil	31,20	34,15	43,30	38,41	38,13	31,40	25,15	36,2	31,6	33,6	31,7	31,0	27,2	24,4	1,1	-11,3	-0,1	-1,9	-2,2	-1,7
Natural gas	14,79	19,27	34,28	33,89	38,88	39,27	34,21	17,2	17,8	26,6	28,0	31,6	34,0	33,1	2,9	-1,2	1,4	0,1	-1,4	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	1,41	1,34	1,43	1,44	1,45	1,46	1,4	1,3	1,0	1,2	1,2	1,3	1,4	0,3	6,8	0,1	0,1	0,1	0,3
Geothermal	0,00	0,00	0,00	0,00	0,03	0,05	0,06	0,0	0,0	0,0	0,0	0,0	0,0	0,1	-	-	25,9	4,5	1,8	-
Others	4,04	5,13	8,16	9,25	15,25	22,51	29,88	4,7	4,7	6,3	7,6	12,4	19,5	28,9	2,5	13,4	5,1	4,0	2,9	4,3
Biomass	3,96	5,04	4,94	5,30	6,77	7,69	8,24	4,6	4,7	3,8	4,4	5,5	6,7	8,0	0,8	7,2	2,5	1,3	0,7	1,7
Solar, Wind, Ocean	0,08	0,09	3,22	3,95	8,48	14,82	21,64	0,1	0,1	2,5	3,3	6,9	12,8	21,0	13,5	22,9	7,9	5,7	3,9	6,3
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**56,66**	**69,58**	**82,34**	**77,85**	**82,24**	**79,20**	**74,99**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-5,5**	**0,6**	**-0,4**	**-0,5**	**-0,3**
Industry	19,32	23,79	22,15	21,60	23,84	24,32	23,20	34,1	34,2	26,9	27,8	29,0	30,7	30,9	0,5	-2,4	1,0	0,2	-0,5	0,2
Transportation	21,11	25,66	33,86	29,56	30,30	27,04	24,91	37,3	36,9	41,1	38,0	36,8	34,1	33,2	1,6	-12,7	0,2	-1,1	-0,8	-1,0
Others	12,27	15,71	21,04	21,54	22,64	22,14	21,04	21,7	22,6	25,6	27,7	27,5	28,0	28,1	1,9	2,4	0,5	-0,2	-0,5	0,0
Non-energy	3,95	4,43	5,30	5,14	5,45	5,70	5,84	7,0	6,4	6,4	6,6	6,6	7,2	7,8	1,0	-2,9	0,6	0,4	0,2	0,3
Total	**56,66**	**69,58**	**82,34**	**77,85**	**82,24**	**79,20**	**74,99**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-5,5**	**0,6**	**-0,4**	**-0,5**	**-0,3**
Coal	4,56	4,20	3,00	2,99	2,11	1,70	1,33	8,0	6,0	3,6	3,8	2,6	2,1	1,8	-1,4	-0,3	-3,5	-2,1	-2,4	-2,6
Oil	29,00	34,72	44,01	39,81	39,86	34,81	30,07	51,2	49,9	53,4	51,1	48,5	44,0	40,1	1,4	-9,5	0,0	-1,3	-1,5	-1,2
Natural gas	8,66	11,39	12,61	12,56	13,90	13,09	11,44	15,3	16,4	15,3	16,1	16,9	16,5	15,3	1,3	-0,5	1,0	-0,6	-1,3	-0,3
Electricity	11,11	14,85	18,45	18,30	21,72	25,02	27,72	19,6	21,3	22,4	23,5	26,4	31,6	37,0	1,8	-0,8	1,7	1,4	1,0	1,3
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	4,42	4,27	4,19	4,65	4,59	4,43	5,9	6,4	5,2	5,4	5,7	5,8	5,9	0,9	-1,9	1,0	-0,1	-0,4	0,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,31**	**3,16**	**5,17**	**6,42**	**23,80**	**24,43**	**24,98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**24,0**	**14,0**	**0,3**	**0,2**	**5,2**
Coal			0,67	1,91	18,75	18,75	18,75	0	0	13	30	79	77	75	-	184,1	25,6	0,0	0,0	11,3
Oil	0,01	0,02	0,05	0,05	0,00	0,00	0,00	1	1	1	1	0	0	0	5,2	-3,2	-100,0	-	-	-100,0
Natural gas	1,29	3,14	4,45	4,46	5,01	5,64	6,20	99	99	86	69	21	23	25	4,4	0,1	1,2	1,2	0,9	1,1
Nuclear								0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro								0	0	0	0	0	0	0	-	-	-	-	-	-
Geothermal								0	0	0	0	0	0	0	-	-	-	-	-	-
Others			0,002	0,002	0,034	0,030	0,033	0	0	0	0	0	0	0	-	4,9	35,6	-1,2	0,9	10,4

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,34**	**45,77**	**49,94**	**45,72**	**38,61**	**29,09**	**17,62**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-8,5**	**-1,7**	**-2,8**	**-4,9**	**-3,3**
Coal	28,92	41,19	36,58	33,07	25,20	17,16	9,48	86,8	90,0	73,2	72,3	65,3	59,0	53,8	0,8	-9,6	-2,7	-3,8	-5,8	-4,3
Oil	0,95	0,53	1,15	1,05	0,85	0,54	0,25	2,8	1,1	2,3	2,3	2,2	1,9	1,4	0,7	-8,6	-2,1	-4,4	-7,3	-4,8
Natural gas	3,47	4,06	12,21	11,60	12,56	11,38	7,89	10,4	8,9	24,4	25,4	32,5	39,1	44,8	4,4	-5,0	0,8	-1,0	-3,6	-1,4

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,0**	**36,1**	**36,5**	**37,4**	**42,0**	**44,1**	**45,9**								**0,1**	**2,5**	**1,2**	**0,5**	**0,4**	**0,7**
Coal	36,1	36,4	36,3	37,5	43,1	45,7	47,5								0,0	3,4	1,4	0,6	0,4	0,9
Oil	32,3	29,2	36,7	37,1	36,6	36,9	38,1								0,4	1,2	-0,1	0,1	0,3	0,1
Natural gas	35,6	34,4	37,2	37,2	40,3	42,0	44,3								0,2	0,1	0,8	0,4	0,5	0,6

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**69,8**	**90,2**	**103,8**	**93,0**	**83,8**	**68,2**	**50,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-10,4**	**-1,0**	**-2,0**	**-3,0**	**-2,3**
Coal	37,9	53,0	47,7	42,5	30,6	20,5	10,9	54,3	58,7	45,9	45,7	36,5	30,1	21,7	0,8	-10,9	-3,2	-3,9	-6,1	-4,6
Oil	22,7	24,9	33,7	28,9	28,9	23,4	18,5	32,5	27,6	32,5	31,1	34,4	34,3	36,7	1,4	-14,2	0,0	-2,1	-2,3	-1,9
Natural gas	9,2	12,3	22,4	21,6	24,3	24,2	21,0	13,2	13,7	21,6	23,2	29,0	35,5	41,6	3,1	-3,6	1,2	0,0	-1,4	-0,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	569	788	1.346	1.314	1.690	2.238	2.871	3,0	-2,4	2,5	2,8	2,5	2,5
Population (millions of people)	17	19	25	26	28	31	33	1,4	1,2	1,0	0,8	0,7	0,9
GDP per capita (thousands of 2015 USD/person)	33,33	41,15	53,08	51,20	59,60	72,75	86,93	1,6	-3,5	1,5	2,0	1,8	1,6
Primary energy consumption per capita (toe/person)	5,05	5,64	5,08	4,72	4,34	3,75	3,13	0,0	-7,1	-0,8	-1,4	-1,8	-1,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	151	137	96	92	73	52	36	-1,6	-3,7	-2,3	-3,4	-3,5	-3,1
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	100	88	61	59	49	35	26	-1,7	-3,1	-1,9	-3,1	-3,0	-2,7
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	123	114	77	71	50	30	18	-1,6	-8,2	-3,5	-4,8	-5,4	-4,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,81	0,83	0,81	0,77	0,68	0,59	0,49	0,0	-4,7	-1,2	-1,4	-1,9	-1,6
Automobile ownership volume (millions of vehicles)	10	12	19	19	21	24	27	2,3	0,5	1,2	2,5	2,4	1,2
Automobile ownership volume per capita (vehicles per person)	0,573	0,642	0,746	0,741	0,756	0,789	0,820	0,9	-0,7	0,2	0,6	0,8	0,3

Australia LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**86,14**	**106,23**	**128,74**	**119,88**	**112,97**	**100,86**	**86,34**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-6,9**	**-0,6**	**-1,1**	**-1,5**	**-1,3**
Coal	34,89	48,15	41,66	38,06	17,54	15,13	10,66	40,5	45,3	32,4	31,8	15,5	15,0	12,4	0,6	-8,6	-7,5	-1,5	-3,4	-4,3
Oil	31,20	34,15	43,30	38,41	30,32	15,03	3,39	36,2	32,2	33,6	32,0	26,8	14,9	3,9	1,1	-11,3	-2,3	-6,8	-13,8	-7,9
Natural gas	14,79	19,27	34,28	33,89	41,29	37,60	23,60	17,2	18,1	26,6	28,3	36,5	37,3	27,3	2,9	-1,2	2,0	-0,9	-4,5	-1,2
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	-	-	-	-	-	-
Hydrogen/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	-	-	40,6	-100,0	-	-
Hydro	1,22	1,41	1,34	1,43	1,51	1,68	1,90	1,4	1,3	1,0	1,2	1,3	1,7	2,2	0,3	6,8	0,5	1,1	1,3	1,1
Geothermal	0,00	0,00	0,00	0,00	0,03	0,06	0,08	0,0	0,0	0,0	0,0	0,0	0,1	0,1	-	-	26,3	5,6	3,0	-
Others	4,04	3,25	8,16	8,08	22,28	31,37	46,70	4,7	3,1	6,3	6,7	19,7	31,1	54,1	2,5	-0,9	10,7	3,5	4,1	5,8
Biomass	3,96	3,16	4,94	4,13	10,59	13,05	19,71	4,6	3,0	3,8	3,4	9,4	12,9	22,8	0,8	-16,4	9,9	2,1	4,2	4,6
Solar, Wind, Ocean	0,08	0,09	3,22	3,95	11,69	18,32	26,99	0,1	0,1	2,5	3,3	10,3	18,2	31,3	13,5	22,9	11,5	4,6	4,0	7,1
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**56,66**	**67,70**	**82,34**	**76,68**	**72,40**	**61,29**	**52,72**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-6,9**	**-0,6**	**-1,7**	**-1,5**	**-1,4**
Industry	19,32	23,79	22,15	21,60	22,08	21,52	19,66	34,1	35,1	26,9	28,2	30,5	35,1	37,3	0,5	-2,4	0,2	-0,3	-0,9	-0,4
Transportation	21,11	25,66	33,86	29,56	26,13	18,91	14,94	37,3	37,9	41,1	38,5	36,1	30,8	28,3	1,6	-12,7	-1,2	-3,2	-2,3	-2,6
Others	12,27	13,83	21,04	20,37	18,74	15,16	12,28	21,7	20,4	25,6	26,6	25,9	24,7	23,3	1,9	-3,2	-0,8	-2,1	-2,1	-1,7
Non-energy	3,95	4,43	5,30	5,14	5,45	5,70	5,84	7,0	6,5	6,4	6,7	7,5	9,3	11,1	1,0	-2,9	0,6	0,4	0,2	0,3
Total	**56,66**	**67,70**	**82,34**	**76,68**	**72,40**	**61,29**	**52,72**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-6,9**	**-0,6**	**-1,7**	**-1,5**	**-1,4**
Coal	4,56	4,20	3,00	2,99	1,80	1,14	0,49	8,0	6,2	3,6	3,9	2,5	1,9	0,9	-1,4	-0,3	-4,9	-4,5	-8,0	-5,7
Oil	29,00	34,72	44,01	39,81	31,60	16,60	4,97	51,2	51,3	53,4	51,9	43,6	27,1	9,4	1,4	-9,5	-2,3	-6,2	-11,4	-6,8
Natural gas	8,66	11,39	12,61	12,56	11,36	6,84	3,13	15,3	16,8	15,3	16,4	15,7	11,2	5,9	1,3	-0,5	-1,0	-4,9	-7,5	-4,4
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,00	4,62	7,81	0,0	0,0	0,0	0,0	1,4	7,5	14,8	-	-	189,0	16,5	5,4	-
Electricity	11,11	14,85	18,45	18,30	22,77	27,20	30,46	19,6	21,9	22,4	23,9	31,4	44,4	57,8	1,8	-0,8	2,2	1,8	1,1	1,6
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	2,54	4,27	3,03	3,87	4,89	5,86	5,9	3,8	5,2	3,9	5,4	8,0	11,1	0,9	-29,2	2,5	2,3	1,8	1,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**154,29**	**209,86**	**263,66**	**261,44**	**322,45**	**400,32**	**486,96**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,9**	**-0,8**	**2,1**	**2,2**	**2,0**	**2,0**
Coal PP	121,48	174,25	154,30	144,24	41,92	16,26	0,00	78,7	83,0	58,5	55,2	13,0	4,1	0,0	0,8	-6,5	-11,6	-9,0	-100,0	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	22,57	33,78	24,35	0,0	0,0	0,0	0,0	7,0	8,4	5,0	-	-	-	4,1	-3,2	-
Oil	3,55	1,78	4,92	4,55	3,80	2,69	0,00	2,3	0,9	1,9	1,7	1,2	0,7	0,0	1,1	-7,6	-1,8	-3,4	-100,0	-100,0
Gas PP	14,36	16,25	52,78	50,19	53,15	29,18	0,00	9,3	7,7	20,0	19,2	16,5	7,3	0,0	4,6	-4,9	0,6	-5,8	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	28,62	60,61	55,67	0,0	0,0	0,0	0,0	8,9	15,1	11,4	-	-	-	7,8	-0,8	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	0,00	24,35	0,0	0,0	0,0	0,0	0,0	0,0	5,0	-	-	-	-	-	-
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	-	-	-	-	-	-
Solar	0,00	0,00	14,85	16,36	64,14	103,68	152,04	0,0	0,0	5,6	6,3	19,9	25,9	31,2	-	10,2	14,6	4,9	3,9	7,8
Wind	0,00	0,00	17,71	24,74	68,00	106,35	159,38	0,0	0,0	6,7	9,5	21,1	26,6	32,7	-	39,7	10,6	4,6	4,1	7,3
Hydro	14,15	16,36	15,60	16,66	17,58	19,54	22,15	9,2	7,8	5,9	6,4	5,5	4,9	4,5	0,3	6,8	0,5	1,1	1,3	1,1
Geothermal	0,00	0,00	0,00	0,00	0,04	0,07	0,09	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	26,5	5,6	3,0	-
Others	0,75	1,23	3,50	4,71	22,64	28,16	48,93	0,5	0,6	1,3	1,8	7,0	7,0	10,0	5,5	34,5	17,0	2,2	5,7	8,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,34**	**45,77**	**49,94**	**45,72**	**32,39**	**31,22**	**22,15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-8,5**	**-3,4**	**-0,4**	**-3,4**	**-2,6**
Coal	28,92	41,19	36,58	33,07	13,26	10,30	5,08	86,8	90,0	73,2	72,3	40,9	33,0	22,9	0,8	-9,6	-8,7	-2,5	-6,8	-6,2
Oil	0,95	0,53	1,15	1,05	0,94	0,71	0,00	2,8	1,1	2,3	2,3	2,9	2,3	0,0	0,7	-8,6	-1,1	-2,8	-100,0	-100,0
Gas	3,47	4,06	12,21	11,60	18,19	20,21	12,44	10,4	8,9	24,4	25,4	56,1	64,7	56,2	4,4	-5,0	4,6	1,1	-4,7	0,1
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	0,00	4,62	0,0	0,0	0,0	0,0	0,0	0,0	20,9	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,0**	**36,1**	**36,5**	**37,4**	**39,8**	**39,3**	**40,5**								**0,1**	**2,5**	**0,6**	**-0,1**	**0,3**	**0,3**
Coal	36,1	36,4	36,3	37,5	41,8	41,8	41,2								0,0	3,4	1,1	0,0	-0,1	0,4
Oil	32,3	29,2	36,7	37,1	34,7	32,7	-								0,4	1,2	-0,7	-0,6	-	-
Gas	35,6	34,4	37,2	37,2	38,7	38,2	38,5								0,2	0,1	0,4	-0,1	0,1	0,1
Hydrogen/Ammonia	-	-	-	-	-	-	45,3								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**69,8**	**90,2**	**103,8**	**93,0**	**56,4**	**20,7**	**1,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,4**	**-10,4**	**-4,9**	**-9,5**	**-26,2**	**-13,9**
Coal	37,9	53,0	47,7	42,5	13,9	5,3	0,4	54,3	58,7	45,9	45,7	24,6	25,5	42,3	0,8	-10,9	-10,6	-9,2	-22,3	-14,1
Oil	22,7	24,9	33,7	28,9	21,1	5,9	0,0	32,5	27,6	32,5	31,1	37,4	28,3	0,0	1,4	-14,2	-3,1	-12,0	-100,0	-100,0
Natural gas	9,2	12,3	22,4	21,6	21,4	9,6	0,6	13,2	13,7	21,6	23,2	37,9	46,2	57,7	3,1	-3,6	-0,1	-7,7	-24,5	-11,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	569	788	1.346	1.314	1.690	2.238	2.871	3,0	-2,4	2,5	2,8	2,5	2,5
Population (millions of people)	17	19	25	26	28	31	33	1,4	1,2	1,0	0,8	0,7	0,9
GDP per capita (thousands of 2015 USD/person)	33,33	41,15	53,08	51,20	59,60	72,75	86,93	1,6	-3,5	1,5	2,0	1,8	1,6
Primary energy consumption per capita (toe/person)	5,05	0,16	5,08	4,67	3,98	3,28	2,61	0,0	-8,0	-1,6	-1,9	-2,2	-2,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	151	4	96	91	67	45	30	-1,6	-4,6	-3,1	-3,9	-4,0	-3,7
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	100	44	61	58	43	27	18	-1,7	-4,6	-3,0	-4,4	-3,9	-3,8
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	123	114	77	71	33	9	0	-1,6	-8,2	-7,2	-12,0	-28,0	-16,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,81	28,58	0,81	0,78	0,50	0,21	0,01	0,0	-3,8	-4,3	-8,5	-25,0	-12,8
Automobile ownership volume (millions of vehicles)	10	12	19	19	21	24	27	2,3	0,5	1,2	1,2	2,4	1,2
Automobile ownership volume per capita (vehicles per person)	0,573	0,642	0,746	0,741	0,756	0,789	0,820	0,9	-0,7	0,2	0,4	0,8	0,3

Brunei BAU

Primary energy consumption

	Mtoe															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,16**	**3,02**	**4,54**	**7,11**	**13,16**	**13,54**	**13,92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**56,7**	**6,4**	**0,3**	**0,3**	**3,7**
Coal	0,00	0,00	0,19	0,55	5,38	5,38	5,38	0,0	0,0	4,3	7,7	40,9	39,7	38,6	-	184,1	25,6	0,0	0,0	11,3
Oil	0,08	0,62	0,74	0,69	1,01	1,18	1,38	7,2	20,4	16,4	9,7	7,7	8,7	9,9	7,8	-7,1	3,9	1,6	1,5	2,0
Natural gas	1,07	2,41	3,60	5,87	6,77	6,98	7,16	92,8	79,6	79,4	82,6	51,4	51,5	51,5	4,3	63,0	1,4	0,3	0,3	2,2
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	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	4,9	35,6	-1,2	0,9	10,4
Biomass								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Solar, Wind, Ocean			0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	4,9	35,6	-1,2	0,9	10,4
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity								0,0	0,0	0,00	0,00	0,0	0,0	0,0	-	-	-	-	-	-

Final energy demand

	Mtoe															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,72**	**2,95**	**3,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,1**	**5,2**	**0,8**	**0,8**	**2,1**
Industry	0,06	0,07	0,18	0,22	0,34	0,36	0,37	15,6	11,8	11,0	13,4	12,6	12,3	11,6	3,8	20,1	4,6	0,5	0,2	2,3
Transportation	0,19	0,28	0,56	0,45	0,66	0,82	1,00	49,0	47,0	33,8	27,6	24,3	27,7	31,3	3,7	-19,2	3,9	2,1	2,1	1,9
Others	0,12	0,23	0,39	0,39	0,41	0,45	0,51	31,2	38,3	23,3	23,6	14,9	15,4	15,9	4,0	0,3	0,5	1,1	1,1	0,9
Non-energy	0,02	0,02	0,53	0,58	1,31	1,31	1,32	4,3	2,9	31,9	35,4	48,1	44,6	41,2	12,6	9,7	8,5	0,0	0,0	3,0
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,72**	**2,95**	**3,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,1**	**5,2**	**0,8**	**0,8**	**2,1**
Coal								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil	0,26	0,36	0,75	0,68	1,01	1,18	1,38	66,8	60,1	45,2	41,1	37,1	40,1	43,1	3,7	-9,9	4,1	1,6	1,5	2,0
Natural gas	0,03	0,03	0,54	0,59	1,30	1,30	1,30	7,6	4,3	32,6	35,9	47,7	44,1	40,6	10,5	9,1	8,2	0,0	0,0	2,9
Electricity	0,10	0,21	0,37	0,38	0,41	0,46	0,52	25,6	35,6	22,3	22,9	15,2	15,7	16,2	4,6	1,7	0,9	1,1	1,2	1,1
Heat								-	-	-	-	-	-	-	-	-	-	-	-	-
Others								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Power generation Output

	TWh															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,31**	**3,16**	**5,17**	**6,42**	**23,80**	**24,43**	**24,98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**24,0**	**14,0**	**0,3**	**0,2**	**5,2**
Coal			0,67	1,91	18,75	18,75	18,75	0	0	13	30	79	77	75	-	184,1	25,6	0,0	0,0	11,3
Oil	0,01	0,02	0,05	0,05	0,00	0,00	0,00	1	1	1	1	0	0	0	5,2	-3,2	-100,0	-	-	-100,0
Natural gas	1,29	3,14	4,45	4,46	5,01	5,64	6,20	99	99	86	69	21	23	25	4,4	0,1	1,2	1,2	0,9	1,1
Nuclear								0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro								0	0	0	0	0	0	0	-	-	-	-	-	-
Geothermal								0	0	0	0	0	0	0	-	-	-	-	-	-
Others			0,002	0,002	0,034	0,030	0,033	0	0	0	0	0	0	0	-	4,9	35,6	-1,2	0,9	10,4

Power generation Input

	Mtoe															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,48**	**0,86**	**1,52**	**1,87**	**6,85**	**7,04**	**7,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**23,5**	**13,8**	**0,3**	**0,2**	**5,2**
Coal			0,19	0,55	5,38	5,38	5,38	0,0	0,0	12,7	29,3	78,5	76,4	74,7	-	184,1	25,6	0,0	0,0	11,3
Oil	0,00	0,01	0,014	0,013	0,00	0,00	0,00	0,6	0,6	0,9	0,7	0,0	0,0	0,0	5,6	-7,1	-100,0	-	-	-100,0
Natural gas	3,47	4,06	12,21	11,62	13,23	14,04	13,95	10,4	8,9	24,4	25,4	29,9	32,8	34,9	4,4	-4,8	1,3	0,6	-0,1	0,4

Thermal Efficiency

	%															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,3**	**31,6**	**29,3**	**29,5**	**29,8**	**29,8**	**29,8**								**0,8**	**0,5**	**0,1**	**0,0**	**0,0**	**0,1**
Coal	-	-	30	30	30	30	30								-	0,0	0,0	0,0	0,0	0,0
Oil	33,2	33,2	30	31	-	-	-								-0,3	4,3	-	-	-	-
Natural gas	23,3	31,6	29	29	29	29	29								0,8	0,0	0,0	0,0	0,0	0,0

CO_2 emissions

	Mt-C															AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,72**	**1,60**	**1,67**	**1,98**	**7,44**	**7,69**	**7,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,9**	**18,9**	**14,2**	**0,3**	**0,3**	**5,2**
Coal	0,00	0,00	0,20	0,58	5,69	5,69	5,69	0,0	0,0	12,3	29,3	76,4	73,9	71,5	-	184,1	25,6	0,0	0,0	11,3
Oil	0,03	0,06	0,61	0,55	0,81	0,95	1,10	4,2	3,9	36,9	27,9	10,9	12,3	13,9	11,0	-9,9	3,9	1,5	1,5	1,9
Natural gas	0,69	1,54	0,85	0,85	0,94	1,06	1,16	95,8	96,1	50,9	42,8	12,6	13,8	14,6	0,7	0,0	1,0	1,2	0,9	1,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9,59	11,97	14,01	13,78	17,52	21,57	26,55	1,3	-1,6	2,43	2,10	2,1	2,1
Population (millions of people)	0,26	0,37	0,30	0,44	0,51	0,58	0,67	0,5	46,3	1,4	1,4	1,4	2,6
GDP per capita (thousands of 2015 USD/person)	37,1	32,8	46,7	31,4	34,7	37,2	39,8	0,8	-32,8	1,0	0,7	0,7	-0,5
Primary energy consumption per capita (toe/person)	4,5	8,3	15,1	16,2	26,1	23,3	20,9	4,3	7,1	4,9	-1,1	-1,1	1,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	121	253	324	516	751	628	524	3,5	59,3	3,8	-1,8	-1,8	1,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	41	50	119	119	155	137	120	3,7	0,5	2,7	-1,3	-1,2	0,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	75	134	119	144	425	357	299	1,6	20,8	11,4	-1,7	-1,7	3,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,53	0,37	0,28	0,57	0,57	0,57	-1,8	-24,1	7,3	0,0	0,0	1,4
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Brunei APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,16**	**3,02**	**4,54**	**6,59**	**12,48**	**12,67**	**12,85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**45,3**	**6,6**	**0,2**	**0,1**	**3,4**
Coal	0,00	0,00	0,19	0,55	5,38	5,38	5,38	0,0	0,0	4,3	8,3	43,1	42,4	41,8	-	184,1	25,6	0,0	0,0	11,3
Oil	0,08	0,62	0,74	0,69	0,98	1,10	1,24	7,2	20,4	16,4	10,4	7,8	8,7	9,7	7,8	-7,4	3,6	1,2	1,2	1,7
Natural gas	1,07	2,41	3,60	5,36	6,11	6,17	6,21	92,8	79,6	79,4	81,3	49,0	48,7	48,3	4,3	48,7	1,3	0,1	0,1	1,8
Nuclear	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					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Geothermal	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	0,02	0,02	0,02	0,0	0,0	0,0	0,0	0,1	0,2	0,2	-	4,8	61,7	2,2	0,2	17,8
Biomass	0,00	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	0,00	0,02	0,02	0,02	0,0	0,0	0,0	0,0	0,1	0,2	0,2	-	4,8	61,7	2,2	0,2	17,8
Biofuels	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,66**	**2,81**	**2,97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,4**	**5,0**	**0,5**	**0,5**	**1,9**
Industry	0,06	0,07	0,18	0,22	0,33	0,34	0,34	15,6	11,8	11,0	13,4	12,5	12,0	11,3	3,8	19,7	4,3	0,2	-0,1	2,0
Transportation	0,19	0,28	0,56	0,45	0,64	0,76	0,90	49,0	47,0	33,8	27,6	24,0	27,1	30,4	3,7	-19,5	3,5	1,8	1,7	1,5
Others	0,12	0,23	0,39	0,39	0,38	0,40	0,41	31,2	38,3	23,3	23,6	14,3	14,2	14,0	4,0	-0,3	-0,1	0,5	0,4	0,2
Non-energy	0,02	0,02	0,53	0,58	1,31	1,31	1,32	4,3	2,9	31,9	35,5	49,2	46,7	44,3	12,6	9,7	8,5	0,0	0,0	3,0
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,66**	**2,81**	**2,97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,4**	**5,0**	**0,5**	**0,5**	**1,9**
Coal	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil	0,26	0,36	0,75	0,67	0,98	1,10	1,24	66,8	60,1	45,2	41,1	36,6	39,2	41,9	3,7	-10,2	3,8	1,2	1,2	1,6
Natural gas	0,03	0,03	0,54	0,59	1,30	1,30	1,30	7,6	4,3	32,6	36,0	48,8	46,2	43,8	10,5	9,1	8,2	0,0	0,0	2,9
Electricity	0,10	0,21	0,37	0,37	0,39	0,41	0,43	25,6	35,6	22,3	22,9	14,6	14,5	14,4	4,6	1,2	0,4	0,5	0,4	0,5
Heat	0,00	0,00	0,00					-	-	-	-	-	-	-	-	-	-	-	-	-
Others	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,31**	**3,16**	**5,17**	**6,41**	**23,52**	**23,76**	**23,88**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**23,9**	**13,9**	**0,1**	**0,0**	**5,1**
Coal	0,00	0,00	0,67	1,91	18,75	18,75	18,75	0	0	13	30	80	79	79	-	184,1	25,6	0,0	0,0	11,3
Oil	0,01	0,02	0,05	0,05	0,00	0,00	0,00	1	1	1	1	0	0	0	5,2	-3,3	-100,0	-	-	-100,0
Natural gas	1,29	3,14	4,45	4,45	4,56	4,76	4,87	99	99	86	69	19	20	20	4,4	0,0	0,3	0,4	0,2	0,3
Nuclear	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Geothermal	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Others	0,00	0,00	0,002	0,002	0,198	0,245	0,250	0	0	0	0	1	1	1	-	4,8	61,7	2,2	0,2	17,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,48**	**0,86**	**1,52**	**1,36**	**6,19**	**6,23**	**6,25**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**-10,5**	**16,4**	**0,1**	**0,0**	**4,7**
Coal	0,00	0,00	0,19	0,55	5,38	5,38	5,38	0,0	0,0	12,7	40,4	86,8	86,3	86,0	-	184,1	25,6	0,0	0,0	11,3
Oil	0,00	0,01	0,014	0,013	0,00	0,00	0,00	0,6	0,6	0,9	1,0	0,0	0,0	0,0	5,6	-7,1	-100,0	-	-	-100,0
Natural gas	0,48	0,85	1,31	0,80	0,82	0,85	0,87	99,4	99,4	86,4	58,7	13,2	13,7	14,0	3,5	-39,2	0,3	0,4	0,2	-1,3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,3**	**31,6**	**29,3**	**40,6**	**32,4**	**32,5**	**32,5**								**0,8**	**38,4**	**-2,2**	**0,0**	**0,0**	**0,3**
Coal	-	-	30,0	30	30	30	30								-	0,0	0,0	0,0	0,0	0,0
Oil	33,2	33,2	30,0	31	-	-	-								-0,3	4,1	-	-	-	-
Natural gas	23,3	31,6	29,2	48	48	48	48								0,8	64,4	0,0	0,0	0,0	1,6

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,72**	**1,60**	**1,67**	**1,7**	**7,0**	**7,1**	**7,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,9**	**-0,9**	**15,5**	**0,2**	**0,2**	**4,9**
Coal	0,00	0,00	0,20	0,6	5,7	5,7	5,7	0,0	0,0	12,3	35,1	81,3	79,9	78,6	-	184,1	25,6	0,0	0,0	11,3
Oil	0,03	0,06	0,61	0,6	0,8	0,9	1,0	4,2	3,9	36,9	33,4	11,2	12,4	13,7	11,0	-10,2	3,6	1,2	1,2	1,6
Natural gas	0,69	1,54	0,85	0,5	0,5	0,5	0,6	95,8	96,1	50,9	31,5	7,4	7,6	7,7	0,7	-38,7	0,0	0,4	0,2	-1,3

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9,59	11,97	14,01	13,78	17,52	21,57	26,55	1,3	-1,6	2,43	2,10	2,1	2,1
Population (millions of people)	0,26	0,37	0,30	0,44	0,51	0,58	0,67	0,5	46,3	1,4	1,4	1,4	2,6
GDP per capita (thousands of 2015 USD/person)	37,1	32,8	46,7	31,4	34,7	37,2	39,8	0,8	-32,8	1,0	0,7	0,7	-0,5
Primary energy consumption per capita (toe/person)	4,5	8,3	15,1	15,0	24,7	21,8	19,3	4,3	-0,7	5,1	-1,2	-1,2	0,8
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	121	253	324	478	712	587	484	3,5	47,7	4,1	-1,9	-1,9	1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	41	50	119	119	152	130	112	3,7	0,2	2,5	-1,5	-1,5	-0,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	75	134	119	120	399	330	272	1,6	0,7	12,8	-1,9	-1,9	2,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,53	0,37	0,25	0,56	0,56	0,56	-1,8	-31,8	8,4	0,0	0,0	1,4
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Brunei LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,16**	**3,02**	**4,54**	**6,59**	**10,00**	**10,20**	**10,54**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**45,3**	**4,3**	**0,2**	**0,3**	**2,8**
Coal	0,00	0,00	0,19	0,55	0,78	0,78	0,78	0,0	0,0	4,3	8,3	7,8	7,6	7,4	-	184,1	3,6	0,0	0,0	4,6
Oil	0,08	0,62	0,74	0,69	0,95	0,93	0,80	7,2	20,4	16,4	10,4	9,5	9,1	7,6	7,8	-7,5	3,3	-0,3	-1,4	0,3
Natural gas	1,07	2,41	3,60	5,36	8,25	8,46	8,89	92,8	79,6	79,4	81,3	82,5	82,9	84,3	4,3	48,8	4,4	0,2	0,5	3,0
Nuclear	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia	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					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Geothermal	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	0,02	0,03	0,08	0,0	0,0	0,0	0,0	0,2	0,3	0,7	-	4,8	63,5	5,5	8,7	22,7
Biomass	0,00	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	0,00	0,02	0,03	0,08	0,0	0,0	0,0	0,0	0,2	0,3	0,7	-	4,8	63,5	5,5	8,7	22,7
Biofuels	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,67**	**2,79**	**2,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,4**	**5,0**	**0,4**	**0,2**	**1,7**
Industry	0,06	0,07	0,18	0,22	0,34	0,34	0,33	15,6	11,8	11,0	13,3	12,8	12,1	11,6	3,8	19,4	4,6	-0,1	-0,3	1,9
Transportation	0,19	0,28	0,56	0,45	0,64	0,74	0,78	49,0	47,0	33,8	27,6	24,0	26,6	27,5	3,7	-19,3	3,5	1,5	0,5	1,1
Others	0,12	0,23	0,39	0,39	0,38	0,39	0,41	31,2	38,3	23,3	23,5	14,2	14,1	14,4	4,0	-0,3	-0,2	0,4	0,3	0,2
Non-energy	0,02	0,02	0,53	0,58	1,31	1,31	1,32	4,3	2,9	31,9	35,5	49,1	47,1	46,5	12,6	9,7	8,5	0,0	0,0	3,0
Total	**0,39**	**0,60**	**1,66**	**1,64**	**2,65**	**2,77**	**2,82**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-1,4**	**4,9**	**0,4**	**0,2**	**1,7**
Coal	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil	0,26	0,36	0,75	0,67	0,95	0,93	0,80	66,8	60,1	45,2	41,1	35,8	33,4	28,5	3,7	-10,3	3,5	-0,3	-1,4	0,2
Natural gas	0,03	0,03	0,54	0,59	1,30	1,30	1,30	7,6	4,3	32,6	36,0	49,0	46,9	46,2	10,5	9,1	8,2	0,0	0,0	2,9
Hydrogen/Ammonia								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,10	0,21	0,37	0,38	0,40	0,55	0,71	25,6	35,6	22,3	22,9	15,2	19,7	25,3	4,6	1,4	0,7	3,1	2,7	2,1
Heat	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					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,31**	**3,16**	**5,18**	**6,41**	**19,35**	**20,58**	**23,33**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**23,9**	**11,7**	**0,6**	**1,3**	**5,0**
Coal PP	0,00	0,00	0,67	1,91	2,72	2,72	2,72	0	0	13	30	14	13	12	-	184,1	3,6	0,0	0,0	4,6
Coal PP with CCS								0	0	0	0	0	0	0	-	-	-	-	-	-
Oil	0,01	0,02	0,05	0,05				1	1	1	1	0	0	0	5,2	-3,5	-100,0	-	-	-100,0
Gas PP	1,29	3,14	4,45	4,45	16,41	17,03	19,35	99	99	86	69	85	83	83	4,4	0,1	13,9	0,4	1,3	4,9
Gas PP PP with CCS						0,45	0,39	0	0	0	0	0	2	2	-	-	-	-	-1,4	-
Hydrogen/Ammonia PP								0	0	0	0	0	0	0	-	-	-	-	-	-
Nuclear	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Solar	0,00	0,00	0,002	0,002	0,22	0,38	0,87	0	0	0	0	1	2	4	-	-19,0	63,5	5,5	8,7	21,7
Wind	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Geothermal	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-	-	-	-	-
Others	0,00	0,00	0,00					0	0	0	0	0	0	0	-	-100,0	-	-	-	-100,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,48**	**0,86**	**1,52**	**1,36**	**3,72**	**3,75**	**4,18**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**-10,5**	**10,6**	**0,1**	**1,1**	**3,3**
Coal	0,00	0,00	0,19	0,55	0,78	0,78	0,78	0,0	0,0	12,7	40,4	21,0	20,8	18,7	-	184,1	3,6	0,0	0,0	4,6
Oil	0,00	0,01	0,014	0,013	0,00	0,00	0,00	0,6	0,6	0,9	1,0	0,0	0,0	0,0	5,6	-7,1	-100,0	-	-	-100,0
Gas	0,48	0,85	1,31	0,80	2,94	2,97	3,40	99,4	99,4	86,4	58,7	79,0	79,2	81,3	3,5	-39,2	13,9	0,1	1,3	3,1
Hydrogen/Ammonia	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,3**	**31,6**	**29,3**	**40,6**	**44,2**	**45,3**	**45,4**								**0,8**	**38,5**	**0,9**	**0,2**	**0,0**	**1,4**
Coal	-	-	30,0	30	30	30	30								-	0,0	0,0	0,0	0,0	0,0
Oil	33,2	33,2	30,1	31	-	-	-								-0,3	3,9	-	-	-	-
Gas	23,3	31,6	29,2	48	48	51	50								0,8	64,4	0,0	0,5	-0,1	1,7
Hydrogen/Ammonia	-	-	-	-	-	-	45,3								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,72**	**1,60**	**1,67**	**1,6**	**3,5**	**3,5**	**3,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,9**	**-0,9**	**7,7**	**0,0**	**0,5**	**2,6**
Coal	0,00	0,00	0,20	0,6	0,8	0,8	0,8	0,0	0,0	12,3	35,2	23,8	23,8	22,7	-	184,1	3,6	0,0	0,0	4,6
Oil	0,03	0,06	0,61	0,6	0,8	0,7	0,6	4,2	3,9	36,9	33,4	22,0	21,3	17,5	11,0	-10,3	3,3	-0,3	-1,5	0,1
Natural gas	0,69	1,54	0,85	0,5	1,9	1,9	2,2	95,8	96,1	50,9	31,5	54,2	54,9	59,8	0,7	-38,7	13,8	0,1	1,3	3,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9,59	11,97	14,01	13,78	17,52	21,57	26,55	1,3	-1,6	2,43	2,10	2,1	2,1
Population (millions of people)	0,26	0,37	0,30	0,44	0,51	0,58	0,67	0,5	46,3	1,4	1,4	1,4	2,6
GDP per capita (thousands of 2015 USD/person)	37,1	32,8	46,7	31,4	34,7	37,2	39,8	0,8	-32,8	1,0	0,7	0,7	-0,5
Primary energy consumption per capita (toe/person)	4,5	8,3	15,1	15,0	19,8	17,6	15,8	4,3	-0,7	2,8	-1,2	-1,1	0,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	121	253	324	478	571	473	397	3,5	47,7	1,8	-1,9	-1,7	0,7
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	41	50	-	-	-	-	-	-	-	-	-	-	-
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	75	134	119	120	198	161	137	1,6	0,7	5,2	-2,1	-1,6	0,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,53	0,37	0,25	0,35	0,34	0,34	-1,8	-31,8	3,3	-0,2	0,1	-0,2
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Cambodia BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,84**	**3,42**	**7,17**	**7,51**	**11,54**	**17,62**	**27,56**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,25**	**4,81**	**4,38**	**4,33**	**4,58**	**4,44**
Coal	0,00	0,00	1,23	1,36	3,87	4,17	4,27	0,0	0,0	17,2	18,1	33,6	23,7	15,5	-	10,2	11,1	0,8	0,2	4,1
Oil	0,51	0,70	3,11	3,44	5,11	8,15	12,69	18,0	20,5	43,4	45,8	44,3	46,3	46,1	6,4	10,7	4,0	4,8	4,5	4,6
Natural gas	0,00	0,00	-	-	-	2,37	7,12	0,0	0,0	0,0	0,0	0,0	13,4	25,8	-	-	-	-	11,6	-
Nuclear	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,00	0,00	0,36	0,34	0,36	0,74	1,35	0,0	0,0	5,0	4,5	3,1	4,2	4,9	-	-6,0	0,6	7,6	6,2	4,4
Geothermal	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	2,33	2,72	2,47	2,38	2,20	2,19	2,14	82,0	79,5	34,5	31,7	19,1	12,4	7,7	0,2	-3,8	-0,8	0,0	-0,2	-0,5
Biomass	2,33	2,72	2,25	2,28	1,96	1,75	1,63	82,0	79,5	31,4	30,4	17,0	10,0	5,9	-0,1	1,3	-1,5	-1,1	-0,8	-1,0
Solar, Wind, Ocean	0,00	0,00	0,01	0,03	0,24	0,41	0,51	0,0	0,0	0,1	0,4	2,1	2,3	1,8	-	248,9	23,8	5,6	2,2	14,3
Biofuels	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,00	0,00	0,21	0,07	0,01	0,02	0,00	0,0	0,0	2,93	0,89	0,0	0,1	0,0	-	-68,1	-22,8	16,8	-95,3	-65,2

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,54**	**2,95**	**4,97**	**4,94**	**7,22**	**11,93**	**19,46**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,33**	**-0,60**	**3,88**	**5,15**	**5,02**	**4,51**
Industry	0,44	0,61	0,95	0,93	1,39	2,38	4,11	17,2	20,7	19,1	18,9	19,2	20,0	21,1	2,7	-1,5	4,0	5,6	5,6	4,8
Transportation	0,38	0,43	2,09	2,11	3,48	6,15	10,46	15,0	14,6	42,1	42,8	48,2	51,5	53,7	6,0	1,2	5,1	5,8	5,5	5,3
Others	1,72	1,90	1,91	1,87	2,34	3,39	4,88	67,5	64,4	38,6	38,0	32,4	28,4	25,1	0,4	-2,1	2,2	3,8	3,7	3,1
Non-energy	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,3	0,3	0,3	0,3	0,2	0,1	0,1	2,2	0,0	0,0	0,0	0,0	0,0
Total	**2,54**	**2,95**	**4,97**	**4,94**	**7,22**	**11,93**	**19,46**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-0,6**	**3,9**	**5,1**	**5,0**	**4,5**
Coal	0,00	0,00	0,1	0,1	0,2	0,4	0,8	0,0	0,0	2,8	2,7	3,2	3,7	4,0	-	-3,5	5,9	6,4	6,0	5,8
Oil	0,44	0,54	2,9	2,9	4,7	7,8	12,4	17,3	18,1	58,4	59,7	64,7	65,1	63,6	6,7	1,6	4,7	5,2	4,8	4,8
Natural gas	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,01	0,03	0,9	0,8	1,6	3,2	6,0	0,4	1,0	17,7	17,2	22,6	27,2	30,6	16,3	-3,4	6,8	7,1	6,3	6,4
Heat	0,00	0,00						-	-	-	-	-	-	-	-	-	-	-	-	-
Others	2,09	2,39	1,1	1,0	0,7	0,5	0,4	82,3	80,8	21,2	20,5	9,5	4,0	1,8	-2,3	-4,0	-3,8	-3,5	-3,0	-3,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,20**	**0,45**	**9,01**	**10,49**	**21,60**	**42,53**	**78,36**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**14,1**	**16,5**	**7,5**	**7,0**	**6,3**	**7,2**
Coal	0,00	0,00	3,92	4,39	13,03	13,39	12,49	0	0	44	42	60	31	16	-	11,9	11,5	0,3	-0,7	3,8
Oil	0,20	0,45	0,75	1,79	1,58	1,37	1,16	100	100	8	17	7	3	1	4,7	136,8	-1,2	-1,4	-1,7	1,4
Natural gas	0,00	0,00	-	-	-	14,31	43,03	0	0	0	0	0	34	55	-	-	-	-	11,6	-
Nuclear	0,00	0,00						0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	0,00	0,00	4,15	3,90	4,14	8,60	15,66	0	0	46	37	19	20	19,99	-	-6,0	0,6	7,6	6,2	4,4
Geothermal	0,00	0,00	0,1	0,3	2,8	4,8	5,9	0	0	1	3	13	11	7,55	-	248,9	23,8	5,6	2,2	14,3
Others	0,00	0,00	0,09	0,10	0,10	0,10	0,10	0	0	1	1	0	0	0,12	-	5,9	0,0	0,0	0,0	0,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,10**	**0,86**	**1,30**	**1,72**	**4,08**	**6,48**	**10,92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,3**	**32,0**	**9,0**	**4,8**	**5,4**	**7,1**
Coal	0,00	0,00	1,09	1,23	3,64	3,74	3,49	0,0	0,0	83,9	71,2	89,2	57,6	31,9	-	11,9	11,5	0,3	-0,7	3,8
Oil	0,10	0,86	0,21	0,50	0,44	0,38	0,32	100,0	100,0	16,1	28,8	10,8	5,9	2,9	2,6	136,8	-1,2	-1,4	-1,7	1,4
Natural gas	0,00	0,00	-	-	-	2,37	7,12	0,0	0,0	0,0	0,0	0,0	36,5	65,1	-	-	-	-	11,6	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**17,2**	**4,5**	**30,8**	**30,8**	**30,8**	**38,6**	**44,6**								**2,0**	**0,0**	**0,0**	**2,3**	**1,5**	**1,2**
Coal	-	-	31	31	31	31	31								-	0,0	0,0	0,0	0,0	0,0
Oil	17,2	4,5	31	31	31	31	31								2,0	0,0	0,0	0,0	0,0	0,0
Natural gas	-	-	-	-	-	52	52								-	-	-	-	0,0	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,50**	**3,84**	**4,26**	**8,33**	**12,58**	**19,35**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**37,1**	**11,0**	**6,9**	**4,2**	**4,4**	**5,4**
Coal	0,00	0,00	1,35	1,49	4,25	4,58	4,69	0,0	0,0	35,2	35,0	51,1	36,4	24,2	-	10,2	11,1	0,8	0,2	4,1
Oil	0,00	0,50	2,49	2,77	4,08	6,49	10,13	100,0	100,0	64,8	65,0	48,9	51,6	52,3	35,0	11,4	3,9	4,8	4,6	4,6
Natural gas	0,00	0,00	-	-	-	1,51	4,54	0,0	0,0	0,0	0,0	0,0	12,0	23,4	-	-	-	-	11,6	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3,66	5,24	20,92	22,28	41,36	74,90	134,14	6,20	6,50	6,38	6,12	6,00	6,18
Population (millions of people)	8,97	12,16	16,49	16,73	19,42	22,54	26,16	2,12	1,50	1,50	1,50	1,50	1,50
GDP per capita (thousands of 2015 USD/person)	0,41	0,43	1,27	1,33	2,13	3,32	5,13	3,99	4,93	4,81	4,55	4,43	4,61
Primary energy consumption per capita (toe/person)	0,32	0,28	0,43	0,45	0,59	0,78	1,05	1,11	3,26	2,84	2,78	3,03	2,90
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	775	653	343	337	279	235	205	-2,78	-1,59	-1,88	-1,69	-1,34	-1,64
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	695	563	237	222	175	159	145	-3,64	-6,67	-2,35	-0,92	-0,93	-1,57
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	0	95	184	191	201	168	144	29,07	4,20	0,52	-1,80	-1,51	-0,77
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,00	0,15	0,54	0,57	0,72	0,71	0,70	32,76	5,89	2,44	-0,11	-0,17	0,88
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Cambodia APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,84**	**3,42**	**7,17**	**7,54**	**9,34**	**14,29**	**21,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,2**	**5,2**	**2,2**	**4,3**	**4,3**	**3,6**
Coal	0,00	0,00	1,23	1,43	1,56	1,87	2,10	0,0	0,0	17,2	18,9	16,7	13,1	9,6	-	16,0	0,9	1,8	1,2	1,7
Oil	0,51	0,70	3,11	3,43	4,88	7,35	10,63	18,0	20,5	43,4	45,5	52,2	51,4	48,9	6,4	10,3	3,6	4,2	3,8	4,0
Natural gas	0,00	0,00	-	-	-	1,85	5,59	0,0	0,0	0,0	0,0	0,0	13,0	25,7	-	-	-	-	11,7	-
Nuclear	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,00	0,00	0,36	0,38	0,78	1,12	1,29	0,0	0,0	5,0	5,0	8,4	7,9	5,9	-	6,1	7,5	3,7	1,4	4,2
Geothermal	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	2,33	2,72	2,47	2,30	2,13	2,09	2,15	82,0	79,5	34,5	30,6	22,7	14,7	9,9	0,2	-6,8	-0,8	-0,1	0,3	-0,5
Biomass	2,33	2,72	2,25	2,28	1,96	1,75	1,63	82,0	79,5	31,4	30,3	21,0	12,3	7,5	-0,1	1,3	-1,5	-1,1	-0,8	-1,0
Solar, Wind, Ocean	0,00	0,00	0,01	0,02	0,17	0,34	0,52	0,0	0,0	0,1	0,3	1,8	2,4	2,4	-	149,3	23,7	7,3	4,4	14,4
Biofuels	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,00	0,00	0,21	-	0,00	-	0,00	0,0	0,0	2,93	0,00	0,0	0,0	0,0	-	-100,0	-	-100,0	-	-65,4

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,54**	**2,95**	**4,97**	**4,91**	**6,83**	**10,67**	**16,29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-1,1**	**3,4**	**4,6**	**4,3**	**3,9**
Industry	0,44	0,61	0,95	0,9	1,3	2,1	3,3	17,2	20,7	19,1	18,9	19,0	19,6	20,5	2,7	-2,0	3,4	4,9	4,8	4,2
Transportation	0,38	0,43	2,09	2,1	3,3	5,5	8,7	15,0	14,6	42,1	42,8	48,1	51,3	53,7	6,0	0,6	4,6	5,3	4,8	4,7
Others	1,72	1,90	1,91	1,9	2,2	3,1	4,2	67,5	64,4	38,6	38,0	32,7	29,0	25,7	0,4	-2,4	1,8	3,3	3,1	2,6
Non-energy	0,01	0,01	0,01	0,0	0,0	0,0	0,0	0,3	0,3	0,3	0,3	0,2	0,1	0,1	2,2	0,0	0,0	0,0	0,0	0,0
Total	**2,54**	**2,95**	**4,97**	**4,91**	**6,83**	**10,67**	**16,29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-1,1**	**3,4**	**4,6**	**4,3**	**3,9**
Coal	0,00	0,00	0,14	0,1	0,2	0,4	0,6	0,0	0,0	2,8	2,7	3,3	3,6	3,8	-	-3,9	5,4	5,6	5,1	5,0
Oil	0,44	0,54	2,90	2,9	4,4	7,0	10,3	17,3	18,1	58,4	59,7	65,0	65,3	63,3	6,7	1,2	4,2	4,6	4,0	4,2
Natural gas	0,00	0,00	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,01	0,03	0,88	0,8	1,5	2,8	5,0	0,4	1,0	17,7	17,1	21,8	26,6	30,7	16,3	-4,4	5,9	6,7	5,8	5,8
Heat	0,00	0,00	0,00					-	-	-	-	-	-	-	-	-	-	-	-	-
Others	2,09	2,39	1,05	1,0	0,7	0,5	0,4	82,3	80,8	21,2	20,6	10,0	4,5	2,2	-2,3	-4,0	-3,8	-3,5	-3,0	-3,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,20**	**0,45**	**9,01**	**11,16**	**19,71**	**37,46**	**65,82**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**14,1**	**23,9**	**5,9**	**6,6**	**5,8**	**6,6**
Coal	0,00	0,00	3,92	4,65	7,00	7,78	7,70	0	0	44	42	36	21	12	-	18,5	4,2	1,1	-0,1	2,2
Oil	0,20	0,45	0,75	1,79	1,58	1,37	1,16	100	100	8	16	8	4	2	4,7	136,8	-1,2	-1,4	-1,7	1,4
Natural gas	0,00	0,00	-	-	-	11,20	35,74	0	0	0	0	0	30	54	-	-	-	-	12,3	-
Nuclear	0,00	0,00						0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	0,00	0,00	4,15	4,40	9,08	13,07	15,06	0	0	46	39	46	35	23	-	6,1	7,5	3,7	1,4	4,2
Geothermal	0,00	0,00	0,09	0,2	2,0	3,9	6,1	0	0	1	2	10	11	9	-	149,3	23,7	7,3	4,4	14,4
Others	0,00	0,00	0,09	0,10	0,10	0,10	0,10	0	0	1	1	0	0	0	-	5,9	0,0	0,0	0,0	0,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,10**	**0,86**	**1,30**	**1,79**	**1,78**	**3,72**	**7,38**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,3**	**37,5**	**-0,1**	**7,7**	**7,1**	**5,7**
Coal	0,00	0,00	1,09	1,30	1,34	1,49	1,47	0,0	0,0	83,9	72,3	75,3	40,0	19,9	-	18,5	0,3	1,1	-0,1	1,0
Oil	0,10	0,86	0,21	0,50	0,44	0,38	0,32	100,0	100,0	16,1	27,7	24,7	10,2	4,4	2,6	136,8	-1,2	-1,4	-1,7	1,4
Natural gas	0,00	0,00	-	-	-	1,85	5,59	0,0	0,0	0,0	0,0	0,0	49,8	75,7	-	-	-	-	11,7	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**17,2**	**4,5**	**30,8**	**30,8**	**41,5**	**47,1**	**52,0**								**2,0**	**0,0**	**3,0**	**1,3**	**1,0**	**1,7**
Coal	-	-	30,8	31	45	45	45								-	0,0	3,9	0,0	0,0	1,2
Oil	17,2	4,5	30,9	31	31	31	31								2,0	0,0	0,0	0,0	0,0	0,0
Natural gas	-	-	-	-	-	52	55								-	-	-	-	0,6	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,50**	**3,84**	**4,33**	**5,60**	**9,08**	**14,33**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**37,1**	**12,7**	**2,6**	**4,9**	**4,7**	**4,3**
Coal	0,00	0,00	1,35	1,57	1,71	2,05	2,30	0,0	0,0	35,2	36,2	30,6	22,6	16,1	-	16,0	0,9	1,8	1,2	1,7
Oil	0,00	0,50	2,49	2,76	3,89	5,84	8,47	100,0	100,0	64,8	63,8	69,4	64,4	59,1	35,0	11,0	3,5	4,2	3,8	4,0
Natural gas	0,00	0,00	-	-	-	1,18	3,56	0,0	0,0	0,0	0,0	0,0	13,0	24,8	-	-	-	-	11,7	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3,66	5,24	20,92	22,28	41,36	74,90	134,14	6,2	6,5	6,38	6,12	6,0	6,2
Population (millions of people)	8,97	12,16	16,49	16,73	19,42	22,54	26,16	2,1	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	0,4	0,4	1,3	1,3	2,1	3,3	5,1	4,0	4,9	4,8	4,6	4,4	4,6
Primary energy consumption per capita (toe/person)	0,3	0,3	0,4	0,5	0,5	0,6	0,8	1,1	3,6	0,7	2,8	2,8	2,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	775	653	343	338	226	191	162	-2,8	-1,2	-4,0	-1,7	-1,6	-2,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	695	563	237	221	165	142	121	-3,6	-7,1	-2,8	-1,5	-1,6	-2,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	0	95	184	194	135	121	107	29,1	5,9	-3,5	-1,1	-1,3	-1,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,00	0,15	0,54	0,57	0,60	0,64	0,66	32,8	7,2	0,4	0,6	0,4	0,7
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Cambodia LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,84**	**3,42**	**7,17**	**7,54**	**9,34**	**17,04**	**27,35**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,2**	**5,2**	**2,2**	**6,2**	**4,8**	**4,4**
Coal	0,00	0,00	1,23	1,43	1,56	2,14	4,49	0,0	0,0	17,2	18,9	16,7	12,6	16,4	-	16,0	0,9	3,2	7,7	4,3
Oil	0,51	0,70	3,11	3,43	4,88	4,81	4,03	18,0	20,5	43,4	45,5	52,2	28,2	14,7	6,4	10,3	3,6	-0,1	-1,7	0,8
Natural gas	0,00	0,00	-	-	-	6,06	11,02	0,0	0,0	0,0	0,0	0,0	35,5	40,3	-	-	-	-	6,2	-
Nuclear	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,00	0,00	0,36	0,38	0,78	1,88	3,31	0,0	0,0	5,0	5,0	8,4	11,0	12,1	-	6,1	7,5	9,2	5,8	7,4
Geothermal	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	2,33	2,72	2,47	2,30	2,13	2,16	4,50	82,0	79,5	34,5	30,6	22,7	12,7	16,5	0,2	-6,8	-0,8	0,2	7,6	2,0
Biomass	2,33	2,72	2,25	2,28	1,96	1,75	1,63	82,0	79,5	31,4	30,3	21,0	10,3	5,9	-0,1	1,3	-1,5	-1,1	-0,8	-1,05
Solar, Wind, Ocean	0,00	0,00	0,01	0,02	0,17	0,41	1,27	0,0	0,0	0,1	0,3	1,8	2,4	4,7	-	149,3	23,7	9,3	12,1	17,8
Biofuels	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,00	0,00	0,21	-	0,00	0,00	1,60	0,0	0,0	2,93	0,00	0,0	0,0	5,9	-	-100,0	-	38,3	3.329,1	6,8

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,54**	**2,95**	**4,97**	**4,91**	**6,83**	**10,67**	**16,29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-1,1**	**3,4**	**4,6**	**4,3**	**3,9**
Industry	0,44	0,61	0,95	0,93	1,30	2,09	3,35	17,2	20,7	19,1	18,9	19,0	19,6	20,5	2,7	-2,0	3,4	4,9	4,8	4,2
Transportation	0,38	0,43	2,09	2,10	3,28	5,48	8,74	15,0	14,6	42,1	42,8	48,1	51,3	53,7	6,0	0,6	4,6	5,3	4,8	4,73
Others	1,72	1,90	1,91	1,87	2,24	3,09	4,19	67,5	64,4	38,6	38,0	32,7	29,0	25,7	0,4	-2,4	1,8	3,3	3,1	2,6
Non-energy	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,3	0,3	0,3	0,3	0,2	0,1	0,1	2,2	0,0	0,0	0,0	0,0	0,0
Total	**2,54**	**2,95**	**4,97**	**4,91**	**6,83**	**10,67**	**16,29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-1,1**	**3,4**	**4,6**	**4,3**	**3,9**
Coal	0,00	0,00	0,14	0,13	0,22	0,38	0,63	0,0	0,0	2,8	2,7	3,3	3,6	3,8	-	-3,9	5,4	5,6	5,1	5,0
Oil	0,44	0,54	2,90	2,93	4,44	4,43	3,71	17,3	18,1	58,4	59,7	65,0	41,5	22,8	6,7	1,2	4,2	0,0	-1,8	0,8
Natural gas	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,01	0,03	0,88	0,84	1,49	5,38	11,60	0,4	1,0	17,7	17,1	21,8	50,4	71,2	16,3	-4,4	5,9	13,7	8,0	8,7
Heat	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	2,09	2,39	1,05	1,01	0,68	0,48	0,35	82,4	80,8	21,2	20,6	10,0	4,5	2,2	-2,3	-4,0	-3,8	-3,5	-3,0	-3,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,40**	**1,31**	**9,01**	**11,16**	**19,71**	**71,05**	**134,02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**11,4**	**23,9**	**5,9**	**13,7**	**6,6**	**9,1**
Coal PP	0,20	0,86	3,92	4,65	7,00	-	-	50	66	44	42	36	0	0	10,8	18,5	4,2	-100,0	-	-100,0
Coal PP with CCS	0,00	0,00	-	-	-	8,18	17,95	0	0	0	0	0	12	13	-	-	-	-	8,2	-
Oil	0,20	0,45	0,75	1,79	1,58	1,37	1,16	50	34	8	16	8	2	1	4,7	136,8	-1,2	-1,4	-1,7	1,4
Gas PP	0,00	0,00	-	-	-	13,47	-	10	14	0	0	0	19	0	-	-	-	-	-100,0	-
Gas PP PP with CCS	0,00	0,00	-	-	-	21,37	61,54	0	0	0	0	0	30	46	-	-	-	-	11,2	-
Hydrogen/Ammonia PP								0	0	0	0	0	0	0	-	-	-	-	-	-
Nuclear	0,00	0,00						0	0	0	0	0	0	0	-	-	-	-	-	-
Solar	0,00	0,00	0,09	0,23	1,95	4,75	11,86	0	0	1	2	10	7	9	-	149,3	23,7	9,3	9,6	16,9
Wind	0,00	0,00	-	-	0,00	0,00	2,96	0	0	0	0	0	0	2	-	-	-	-1,4	3.334,8	-
Hydro	0,00	0,00	4,15	4,40	9,08	21,83	38,46	0	0	46	39	46	31	29	-	6,1	7,5	9,2	5,8	7,4
Geothermal	0,00	0,00						0	0	0	0	0	0	0	-	-	-	-	-	-
Others	0,00	0,00	0,09	0,10	0,10	0,10	0,10	0	0	1	1	0	0	0	-	5,9	0,0	0,0	0,0	0,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,10**	**0,86**	**1,30**	**1,79**	**1,78**	**8,19**	**15,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,3**	**37,5**	**-0,1**	**16,5**	**6,4**	**8,2**
Coal	0,00	0,00	1,09	1,30	1,34	1,76	3,86	0,0	0,0	83,9	72,3	75,3	21,5	25,4	-	18,5	0,3	2,8	8,2	4,1
Oil	0,10	0,86	0,21	0,50	0,44	0,38	0,32	100,0	100,0	16,1	27,7	24,7	4,6	2,1	2,6	136,8	-1,2	-1,4	-1,7	1,4
Gas	0,00	0,00	-	-	-	6,06	11,02	0,0	0,0	0,0	0,0	0,0	73,9	72,5	-	-	-	-	6,2	-
Hydrogen/Ammonia	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**34,4**	**13,1**	**30,8**	**30,8**	**41,5**	**24,2**	**10,8**								**-0,4**	**0,0**	**3,0**	**-5,3**	**-7,7**	**-3,3**
Coal	-	-	30,8	31	45	40	40								-	0,0	3,9	-1,2	0,0	0,8
Oil	17,2	4,5	30,9	31	31	31	31								2,0	0,0	0,0	0,0	0,0	0,0
Gas	-	-	-	-	-	49	48								-	-	-	-	-0,3	-
Hydrogen/Ammonia	-	-	-	-	-	-	45,3								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,50**	**3,84**	**4,33**	**5,60**	**5,64**	**3,85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**37,1**	**12,7**	**2,6**	**0,1**	**-3,7**	**0,01**
Coal	0,00	0,00	1,35	1,57	1,71	0,42	0,69	0,0	0,0	35,2	36,2	30,6	7,5	17,9	-	16,0	0,9	-13,1	5,1	-2,2
Oil	0,00	0,50	2,49	2,76	3,89	3,80	3,16	100,0	100,0	64,8	63,8	69,4	67,4	82,1	35,0	11,0	3,5	-0,2	-1,8	0,8
Natural gas	0,00	0,00	-	-	-	1,42	-	0,0	0,0	0,0	0,0	0,0	25,2	0,0	-	-	-	-	-100,0	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3,66	5,24	20,92	22,28	41,36	74,90	134,14	6,2	6,5	6,38	6,12	6,0	6,2
Population (millions of people)	8,97	12,16	16,49	16,73	19,42	22,54	26,16	2,1	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	0,4	0,4	1,3	1,3	2,1	3,3	5,1	4,0	4,9	4,8	4,6	4,4	4,6
Primary energy consumption per capita (toe/person)	0,3	0,3	0,4	0,5	0,5	0,8	1,0	1,1	3,6	0,7	4,6	3,3	2,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	775	653	343	338	226	228	204	-2,8	-1,2	-4,0	0,1	-1,1	-1,7
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	695	563	237	221	165	142	121	-3,6	-7,1	-2,8	-1,5	-1,6	-2,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	0	95	184	194	135	75	29	29,1	5,9	-3,5	-5,7	-9,2	-5,8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,00	0,15	0,54	0,57	0,60	0,33	0,14	32,8	7,2	0,4	-5,8	-8,2	-4,2
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

China BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**873,64**	**1.129,87**	**3.389,30**	**3.314,16**	**3.710,17**	**3.773,17**	**3.753,37**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**-2,2**	**1,1**	**0,2**	**-0,1**	**0,3**
Coal	530,52	664,72	2.071,57	2.017,92	2.049,34	1.856,57	1.629,11	60,7	58,8	61,1	60,9	55,2	49,2	43,4	4,8	-2,6	0,2	-1,0	-1,3	-0,8
Oil	118,79	220,81	648,03	605,03	751,79	827,50	867,80	13,6	19,5	19,1	18,3	20,3	21,9	23,1	6,0	-6,6	2,2	1,0	0,5	0,9
Natural gas	12,80	20,76	248,18	258,13	369,38	439,02	504,01	1,5	1,8	7,3	7,8	10,0	11,6	13,4	10,8	4,0	3,6	1,7	1,4	2,3
Nuclear	0,00	4,36	90,77	95,43	131,05	169,81	207,64	0,0	0,4	2,7	2,9	3,5	4,5	5,5	-	5,1	3,2	2,6	2,0	2,7
Hydro	10,90	19,12	109,42	104,60	122,85	132,82	137,30	1,2	1,7	3,2	3,2	3,3	3,5	3,7	8,3	-4,4	1,6	0,8	0,3	0,7
Geothermal	0,00	1,66	18,72	19,51	21,47	22,69	23,33	0,0	0,1	0,6	0,6	0,6	0,6	0,6	-	4,2	1,0	0,6	0,3	0,7
Others	200,64	198,44	202,62	213,54	264,29	324,75	384,18	23,0	17,6	6,0	6,4	7,1	8,6	10,2	0,0	5,4	2,2	2,1	1,7	2,1
Biomass	200,45	198,17	126,57	124,77	121,38	119,51	123,90	22,9	17,5	3,7	3,8	3,3	3,2	3,3	-1,6	-1,4	-0,3	-0,2	0,4	-0,1
Solar, Wind, Ocean	0,03	0,99	77,49	90,21	144,35	206,68	261,73	0,0	0,1	2,3	2,7	3,9	5,5	7,0	30,7	16,4	4,8	3,7	2,4	4,0
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	0,16	-0,72	-1,44	-1,44	-1,44	-1,44	-1,44	0,0	-0,1	0,0	0,0	0,0	0,0	0,0	-207,9	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**657,59**	**781,19**	**2.093,08**	**2.067,56**	**2.270,03**	**2.321,91**	**2.349,67**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-1,2**	**0,9**	**0,2**	**0,1**	**0,4**
Industry	233,85	301,63	1.024,37	1.026,86	980,18	861,34	761,18	35,6	38,6	48,9	49,7	43,2	37,1	32,4	5,2	0,2	-0,5	-1,3	-1,2	-1,0
Transportation	30,20	83,64	323,55	286,62	420,19	508,33	588,00	4,6	10,7	15,5	13,9	18,5	21,9	25,0	8,5	-11,4	3,9	1,9	1,5	1,9
Others	350,68	338,37	567,04	575,79	656,92	717,84	758,60	53,3	43,3	27,1	27,8	28,9	30,9	32,3	1,7	1,5	1,3	0,9	0,6	0,9
Non-energy	42,86	57,55	178,13	178,30	212,73	234,40	241,89	6,5	7,4	8,5	8,6	9,4	10,1	10,3	5,0	0,1	1,8	1,0	0,3	1,0
Total	**657,59**	**781,19**	**2.093,08**	**2.067,56**	**2.270,03**	**2.321,91**	**2.349,67**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-1,2**	**0,9**	**0,2**	**0,1**	**0,4**
Coal	311,40	274,47	574,20	569,21	451,19	351,26	272,88	47,4	35,1	27,4	27,5	19,9	15,1	11,6	2,1	-0,9	-2,3	-2,5	-2,5	-2,4
Oil	84,60	180,37	542,50	507,61	635,52	702,45	737,75	12,9	23,1	25,9	24,6	28,0	30,3	31,4	6,6	-6,4	2,3	1,0	0,5	1,0
Natural gas	8,87	12,38	178,96	183,56	223,61	234,25	238,82	1,3	1,6	8,6	8,9	9,9	10,1	10,2	10,9	2,6	2,0	0,5	0,2	0,9
Electricity	39,03	89,13	560,86	567,85	727,67	823,76	905,68	5,9	11,4	26,8	27,5	32,1	35,5	38,5	9,6	1,2	2,5	1,2	1,0	1,6
Heat	13,21	25,50	111,33	114,78	120,75	117,83	111,55	2,0	3,3	5,3	5,6	5,3	5,1	4,7	7,6	3,1	0,5	-0,2	-0,5	0,0
Others	200,48	199,35	125,24	124,55	111,29	92,37	82,98	30,5	25,5	6,0	6,0	4,9	4,0	3,5	-1,6	-0,5	-1,1	-1,8	-1,1	-1,3

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**621,27**	**1.355,74**	**7.472,18**	**7.565,91**	**9.701,83**	**10.898,57**	**11.861,57**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,0**	**1,3**	**2,5**	**1,2**	**0,9**	**1,5**
Coal	441,34	1.060,37	4.875,58	4.850,15	5.709,18	5.622,76	5.465,17	71,0	78,2	65,2	64,1	58,8	51,6	46,1	8,6	-0,5	1,6	-0,2	-0,3	0,4
Oil	50,37	47,27	10,53	10,29	9,80	7,18	4,37	8,1	3,5	0,1	0,1	0,1	0,1	0,0	-5,3	-2,3	-0,5	-3,1	-4,9	-2,8
Natural gas	2,77	5,77	212,76	231,73	519,66	775,64	1.033,14	0,4	0,4	2,8	3,1	5,4	7,1	8,7	16,1	8,9	8,4	4,1	2,9	5,2
Nuclear	0,00	16,74	348,36	366,25	502,96	651,72	796,92	0,0	1,2	4,7	4,8	5,2	6,0	6,7	-	5,1	3,2	2,6	2,0	2,7
Hydro	126,72	222,41	1.272,54	1.216,50	1.428,80	1.544,72	1.596,75	20,4	16,4	17,0	16,1	14,7	14,2	13,5	8,3	-4,4	1,6	0,8	0,3	0,7
Geothermal	0,06	0,11	0,13	0,17	0,34	0,45	0,51	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8	35,8	7,0	3,1	1,3	4,7
Others	0,011	3,07	752,28	890,83	1.531,10	2.296,10	2.964,71	0,0	0,2	10,1	11,8	15,8	21,1	25,0	46,8	18,4	5,6	4,1	2,6	4,5

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**144,73**	**297,16**	**1.268,86**	**1.265,49**	**1.498,91**	**1.486,79**	**1.413,26**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**-0,3**	**1,7**	**-0,1**	**-0,5**	**0,3**
Coal	131,74	284,28	1.219,77	1.212,09	1.384,01	1.322,11	1.201,30	91,0	95,7	96,1	95,8	92,3	88,9	85,0	8,0	-0,6	1,3	-0,5	-1,0	0,0
Oil	12,37	11,61	2,59	2,50	2,34	1,68	1,01	8,5	3,9	0,2	0,2	0,2	0,1	0,1	-5,3	-3,4	-0,6	-3,3	-5,0	-3,0
Natural gas	0,61	1,27	46,50	50,90	112,56	163,00	210,96	0,4	0,4	3,7	4,0	7,5	11,0	14,9	16,1	9,5	8,3	3,8	2,6	5,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29,4**	**32,2**	**34,6**	**34,6**	**35,8**	**37,1**	**39,6**								**0,6**	**0,1**	**0,3**	**0,3**	**0,7**	**0,4**
Coal	28,8	32,1	34,4	34,4	35,5	36,6	39,1								0,6	0,1	0,3	0,3	0,7	0,4
Oil	35,0	35,0	35,0	35,4	36,0	36,7	37,2								0,0	1,2	0,2	0,2	0,1	0,2
Natural gas	39,0	39,0	39,3	39,1	39,7	40,9	42,1								0,0	-0,5	0,1	0,3	0,3	0,2

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**594,8**	**867,7**	**2.695,1**	**2.637,4**	**2.826,7**	**2.702,7**	**2.522,8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,3**	**-2,1**	**0,7**	**-0,4**	**-0,7**	**-0,2**
Coal	519,4	718,3	2.159,3	2.122,1	2.152,6	1.943,3	1.699,8	87,3	82,8	80,1	80,5	76,2	71,9	67,4	5,0	-1,7	0,1	-1,0	-1,3	-0,8
Oil	70,5	139,1	386,8	358,6	448,7	491,1	513,9	11,9	16,0	14,4	13,6	15,9	18,2	20,4	6,0	-7,3	2,3	0,9	0,5	0,9
Natural gas	4,9	10,3	149,0	156,7	225,4	268,4	309,0	0,8	1,2	5,5	5,9	8,0	9,9	12,2	12,5	5,2	3,7	1,8	1,4	2,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	1.027	2.770	14.296	14.599	25.363	39.387	55.025	9,5	2,1	5,7	4,5	3,4	4,4
Population (millions of people)	1.135,2	1.262,6	1.397,7	1.403,1	1.390,0	1.370,0	1.320,0	0,7	0,4	-0,1	-0,1	-0,4	-0,2
GDP per capita (thousands of 2015 USD/person)	0,91	2,19	10,23	10,40	18,25	28,75	41,69	8,7	1,7	5,8	4,7	3,8	4,6
Primary energy consumption per capita (toe/person)	0,77	0,89	2,42	2,36	2,67	2,75	2,84	4,0	-2,6	1,2	0,3	0,3	0,5
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	850	408	237	227	146	96	68	-4,3	-4,2	-4,3	-4,1	-3,3	-3,9
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	640	282	146	142	90	59	43	-5,0	-3,3	-4,5	-4,1	-3,2	-3,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	579	313	189	181	111	69	46	-3,8	-4,2	-4,7	-4,7	-4,0	-4,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,77	0,80	0,80	0,76	0,72	0,67	0,5	0,1	-0,4	-0,6	-0,6	-0,5
Automobile ownership volume (millions of vehicles)	5,3	15,7	247,7	261,7	386,0	574,4	824,2	14,2	5,6	4,0		7,9	4,0
Automobile ownership volume per capita (vehicles per person)	0,005	0,012	0,177	0,186	0,278	0,419	0,624	13,4	5,2	4,1		8,4	4,1

China APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**873,64**	**1.129,87**	**3.389,30**	**3.313,06**	**3.522,49**	**3.328,92**	**3.055,99**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**-2,2**	**0,6**	**-0,6**	**-0,9**	**-0,3**
Coal	530,52	664,72	2.071,57	2.016,40	1.801,72	1.368,10	961,84	60,7	58,8	61,1	60,9	51,1	41,1	31,5	4,8	-2,7	-1,1	-2,7	-3,5	-2,4
Oil	118,79	220,81	648,03	605,24	718,19	698,33	628,99	13,6	19,5	19,1	18,3	20,4	21,0	20,6	6,0	-6,6	1,7	-0,3	-1,0	-0,1
Natural gas	12,80	20,76	248,18	258,52	356,28	425,80	442,26	1,5	1,8	7,3	7,8	10,1	12,8	14,5	10,8	4,2	3,3	1,8	0,4	1,9
Nuclear	0,00	4,36	90,77	95,43	155,20	222,09	291,59	0,0	0,4	2,7	2,9	4,4	6,7	9,5	-	5,1	5,0	3,6	2,8	3,8
Hydro	10,90	19,12	109,42	104,60	126,73	138,57	143,88	1,2	1,7	3,2	3,2	3,6	4,2	4,7	8,3	-4,4	1,9	0,9	0,4	0,9
Geothermal	0,00	1,66	18,72	19,52	20,53	19,34	17,41	0,0	0,1	0,6	0,6	0,6	0,6	0,6	-	4,3	0,5	-0,6	-1,0	-0,2
Others	200,64	198,44	202,62	213,35	343,84	456,70	570,02	23,0	17,6	6,0	6,4	9,8	13,7	18,7	0,0	5,3	4,9	2,9	2,2	3,4
Biomass	200,45	198,17	126,57	124,57	133,94	136,93	149,51	22,9	17,5	3,7	3,8	3,8	4,1	4,9	-1,6	-1,6	0,7	0,2	0,9	0,5
Solar, Wind, Ocean	0,03	0,99	77,49	90,22	211,34	321,20	421,91	0,0	0,1	2,3	2,7	6,0	9,6	13,8	30,7	16,4	8,9	4,3	2,8	5,6
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	0,16	-0,72	-1,44	-1,44	-1,44	-1,44	-1,44	0,0	-0,1	0,0	0,0	0,0	0,0	0,0	-207,9	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**657,59**	**781,19**	**2.093,08**	**2.067,41**	**2.201,36**	**2.100,29**	**1.961,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-1,2**	**0,6**	**-0,5**	**-0,7**	**-0,2**
Industry	233,85	301,63	1.024,37	1.026,86	964,15	799,17	647,96	35,6	38,6	48,9	49,7	43,8	38,1	33,0	5,2	0,2	-0,6	-1,9	-2,1	-1,5
Transportation	30,20	83,64	323,55	286,58	391,42	415,10	425,15	4,6	10,7	15,5	13,9	17,8	19,8	21,7	8,5	-11,4	3,2	0,6	0,2	0,9
Others	350,68	338,37	567,04	575,69	633,83	653,01	648,39	53,3	43,3	27,1	27,8	28,8	31,1	33,1	1,7	1,5	1,0	0,3	-0,1	0,4
Non-energy	42,86	57,55	178,13	178,30	211,96	233,02	240,32	6,5	7,4	8,5	8,6	9,6	11,1	12,2	5,0	0,1	1,7	1,0	0,3	1,0
Total	**657,59**	**781,19**	**2.093,08**	**2.067,41**	**2.201,36**	**2.100,29**	**1.961,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-1,2**	**0,6**	**-0,5**	**-0,7**	**-0,2**
Coal	311,40	274,47	574,20	568,63	422,04	298,49	206,93	47,4	35,1	27,4	27,5	19,2	14,2	10,5	2,1	-1,0	-2,9	-3,4	-3,6	-3,2
Oil	84,60	180,37	542,50	507,81	606,98	591,55	532,69	12,9	23,1	25,9	24,6	27,6	28,2	27,2	6,6	-6,4	1,8	-0,3	-1,0	-0,1
Natural gas	8,87	12,38	178,96	183,76	216,51	200,16	173,24	1,3	1,6	8,6	8,9	9,8	9,5	8,8	10,9	2,7	1,7	-0,8	-1,4	-0,1
Electricity	39,03	89,13	560,86	567,82	727,58	813,74	881,52	5,9	11,4	26,8	27,5	33,1	38,7	44,9	9,6	1,2	2,5	1,1	0,8	1,5
Heat	13,21	25,50	111,33	114,83	117,33	103,93	85,83	2,0	3,3	5,3	5,6	5,3	4,9	4,4	7,6	3,1	0,2	-1,2	-1,9	-0,8
Others	200,48	199,35	125,24	124,58	110,92	92,42	81,62	30,5	25,5	6,0	6,0	5,0	4,4	4,2	-1,6	-0,5	-1,2	-1,8	-1,2	-1,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**621,27**	**1.355,74**	**7.472,18**	**7.566,90**	**9.695,77**	**10.730,55**	**11.504,68**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,0**	**1,3**	**2,5**	**1,0**	**0,7**	**1,4**
Coal	441,34	1.060,37	4.875,58	4.851,10	4.761,22	3.704,27	2.693,99	71,0	78,2	65,2	64,1	49,1	34,5	23,4	8,6	-0,5	-0,2	-2,5	-3,1	-1,9
Oil	50,37	47,27	10,53	10,29	8,26	5,08	2,48	8,1	3,5	0,1	0,1	0,1	0,0	0,0	-5,3	-2,3	-2,2	-4,7	-6,9	-4,6
Natural gas	2,77	5,77	212,76	231,77	498,12	855,63	1.084,63	0,4	0,4	2,8	3,1	5,1	8,0	9,4	16,1	8,9	8,0	5,6	2,4	5,4
Nuclear	0,00	16,74	348,36	366,25	595,65	852,35	1.119,09	0,0	1,2	4,7	4,8	6,1	7,9	9,7	-	5,1	5,0	3,6	2,8	3,8
Hydro	126,72	222,41	1.272,54	1.216,50	1.473,88	1.611,54	1.673,33	20,4	16,4	17,0	16,1	15,2	15,0	14,5	8,3	-4,4	1,9	0,9	0,4	0,9
Geothermal	0,06	0,11	0,13	0,17	0,44	0,59	0,76	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8	35,8	9,9	3,1	2,5	6,0
Others	0,011	3,07	752,28	890,83	2.358,21	3.701,09	4.930,39	0,0	0,2	10,1	11,8	24,3	34,5	42,9	46,8	18,4	10,2	4,6	2,9	6,3

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**144,73**	**297,16**	**1.268,86**	**1.265,57**	**1.283,37**	**1.077,51**	**836,29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**-0,3**	**0,1**	**-1,7**	**-2,5**	**-1,3**
Coal	131,74	284,28	1.219,77	1.211,94	1.174,44	902,21	620,23	91,0	95,7	96,1	95,8	91,5	83,7	74,2	8,0	-0,6	-0,3	-2,6	-3,7	-2,2
Oil	12,37	11,61	2,59	2,50	1,99	1,20	0,58	8,5	3,9	0,2	0,2	0,2	0,1	0,1	-5,3	-3,4	-2,3	-4,9	-7,1	-4,7
Natural gas	0,61	1,27	46,50	51,14	106,94	174,10	215,49	0,4	0,4	3,7	4,0	8,3	16,2	25,8	16,1	10,0	7,7	5,0	2,2	5,1

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29,4**	**32,2**	**34,6**	**34,6**	**35,3**	**36,4**	**38,9**	**0,6**	**0,1**	**0,2**	**0,3**	**0,7**	**0,4**
Coal	28,8	32,1	34,4	34,4	34,9	35,3	37,4	0,6	0,1	0,1	0,1	0,6	0,3
Oil	35,0	35,0	35,0	35,4	35,8	36,5	37,1	0,0	1,2	0,1	0,2	0,2	0,2
Natural gas	39,0	39,0	39,3	39,0	40,1	42,3	43,3	0,0	-0,9	0,3	0,5	0,2	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**594,8**	**867,7**	**2.695,1**	**2.636,2**	**2.514,4**	**2.019,8**	**1.421,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,3**	**-2,2**	**-0,5**	**-2,2**	**-3,5**	**-2,0**
Coal	519,4	718,3	2.159,3	2.120,5	1.887,1	1.420,8	895,6	87,3	82,8	80,1	80,4	75,1	70,3	63,0	5,0	-1,8	-1,2	-2,8	-4,5	-2,8
Oil	70,5	139,1	386,8	358,7	421,9	393,2	337,0	11,9	16,0	14,4	13,6	16,8	19,5	23,7	6,0	-7,3	1,6	-0,7	-1,5	-0,4
Natural gas	4,9	10,3	149,0	157,0	205,4	205,8	189,0	0,8	1,2	5,5	6,0	8,2	10,2	13,3	12,5	5,3	2,7	0,0	-0,8	0,8

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	1.027	2.770	14.296	14.599	25.363	39.387	55.025	9,5	2,1	5,7	4,5	3,4	4,4
Population (millions of people)	1.135	1.263	1.398	1.403	1.390	1.370	1.320	0,7	0,4	-0,1	-0,1	-0,4	-0,2
GDP per capita (thousands of 2015 USD/person)	0,91	2,19	10,23	10,40	18,25	28,75	41,69	8,7	1,7	5,8	4,7	3,8	4,6
Primary energy consumption per capita (toe/person)	0,77	0,89	2,42	2,36	2,53	2,43	2,32	4,0	-2,6	0,7	-0,4	-0,5	-0,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	850	408	237	227	139	85	56	-4,3	-4,3	-4,8	-4,8	-4,1	-4,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	640	282	146	142	87	53	36	-5,0	-3,3	-4,8	-4,8	-3,9	-4,5
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	579	313	189	181	99	51	26	-3,8	-4,2	-5,8	-6,4	-6,6	-6,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,77	0,80	0,80	0,71	0,61	0,47	0,5	0,1	-1,1	-1,6	-2,6	-1,7
Automobile ownership volume (millions of vehicles)	5	16	248	262	386	574	824	14,2	5,6	4,0	8,2	7,9	4,0
Automobile ownership volume per capita (vehicles per person)	0,005	0,012	0,177	0,186	0,278	0,419	0,624	13,4	5,2	4,1	8,4	8,4	4,1

China LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**873,64**	**1.129,87**	**3.389,30**	**3.215,47**	**3.288,56**	**3.032,51**	**2.542,23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,8**	**-5,1**	**0,2**	**-0,8**	**-1,7**	**-0,9**
Coal	530,52	664,72	2.071,57	2.016,40	1.557,89	1.131,75	479,60	60,7	58,8	61,1	62,7	47,4	37,3	18,9	4,8	-2,7	-2,5	-3,1	-8,2	-4,6
Oil	118,79	220,81	648,03	605,24	744,43	568,79	364,49	13,6	19,5	19,1	18,8	22,6	18,8	14,3	6,0	-6,6	2,1	-2,7	-4,4	-1,8
Natural gas	12,80	20,76	248,18	258,52	316,83	327,88	309,62	1,5	1,8	7,3	8,0	9,6	10,8	12,2	10,8	4,2	2,1	0,3	-0,6	0,7
Nuclear	0,00	4,36	90,77	95,43	153,92	284,24	430,56	0,0	0,4	2,7	3,0	4,7	9,4	16,9	-	5,1	4,9	6,3	4,2	5,2
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,01	17,81	25,74	0,0	0,0	0,0	0,0	0,0	0,6	1,0	-	-	-	110,1	3,7	-
Hydro	10,90	19,12	109,42	104,60	125,69	147,17	158,97	1,2	1,7	3,2	3,3	3,8	4,9	6,3	8,3	-4,4	1,9	1,6	0,8	1,2
Geothermal	0,00	1,66	18,72	0,47	18,10	13,52	7,73	0,0	0,1	0,6	0,0	0,6	0,4	0,3	-	-97,5	44,2	-2,9	-5,4	-2,8
Others	200,64	198,44	202,62	134,82	371,69	541,35	765,53	23,0	17,6	6,0	4,2	11,3	17,9	30,1	0,0	-33,5	10,7	3,8	3,5	4,4
Biomass	200,45	198,17	126,57	46,03	128,41	137,31	181,18	22,9	17,5	3,7	1,4	3,9	4,5	7,1	-1,6	-63,6	10,8	0,7	2,8	1,2
Solar, Wind, Ocean	0,03	0,99	77,49	90,22	244,72	405,48	585,80	0,0	0,1	2,3	2,8	7,4	13,4	23,0	30,7	16,4	10,5	5,2	3,7	6,7
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	0,16	-0,72	-1,44	-1,44	-1,44	-1,44	-1,44	0,0	-0,1	0,0	0,0	0,0	0,0	-0,1	-207,9	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**657,59**	**781,19**	**2.093,08**	**1.969,83**	**2.129,09**	**1.836,67**	**1.529,05**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-5,9**	**0,8**	**-1,5**	**-1,8**	**-1,0**
Industry	233,85	301,63	1.024,37	1.026,86	918,24	726,52	563,45	35,6	38,6	48,9	52,1	43,1	39,6	36,8	5,2	0,2	-1,1	-2,3	-2,5	-1,9
Transportation	30,20	83,64	323,55	286,58	417,41	330,81	248,33	4,6	10,7	15,5	14,5	19,6	18,0	16,2	8,5	-11,4	3,8	-2,3	-2,8	-0,8
Others	350,68	338,37	567,04	478,10	581,48	546,32	476,96	53,3	43,3	27,1	24,3	27,3	29,7	31,2	1,7	-15,7	2,0	-0,6	-1,3	-0,6
Non-energy	42,86	57,55	178,13	178,30	211,96	233,02	240,32	6,5	7,4	8,5	9,1	10,0	12,7	15,7	5,0	0,1	1,7	1,0	0,3	1,0
Total	**657,59**	**781,19**	**2.093,08**	**1.969,83**	**2.129,09**	**1.836,67**	**1.529,05**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-5,9**	**0,8**	**-1,5**	**-1,8**	**-1,0**
Coal	311,40	274,47	574,20	568,63	378,65	242,42	149,66	47,4	35,1	27,4	28,9	17,8	13,2	9,8	2,1	-1,0	-4,0	-4,4	-4,7	-4,2
Oil	84,60	180,37	542,50	507,81	645,76	480,95	292,11	12,9	23,1	25,9	25,8	30,3	26,2	19,1	6,6	-6,4	2,4	-2,9	-4,9	-2,0
Natural gas	8,87	12,38	178,96	183,76	173,08	128,67	82,18	1,3	1,6	8,6	9,3	8,1	7,0	5,4	10,9	2,7	-0,6	-2,9	-4,4	-2,5
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,01	25,94	48,16	0,0	0,0	0,0	0,0	0,0	1,4	3,1	-	-	-	113,4	6,4	-
Electricity	39,03	89,13	560,86	567,82	721,56	807,31	830,18	5,9	11,4	26,8	28,8	33,9	44,0	54,3	9,6	1,2	2,4	1,1	0,3	1,3
Heat	13,21	25,50	111,33	114,83	108,65	74,07	41,48	2,0	3,3	5,3	5,8	5,1	4,0	2,7	7,6	3,1	-0,6	-3,8	-5,6	-3,1
Others	200,48	199,35	125,24	26,99	101,38	77,32	85,28	30,5	25,5	6,0	1,4	4,8	4,2	5,6	-1,6	-78,4	14,1	-2,7	1,0	-1,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**621,27**	**1.355,74**	**7.472,18**	**7.566,90**	**9.615,96**	**1.1396,84**	**1.2711,09**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,0**	**1,3**	**2,4**	**1,7**	**1,1**	**1,7**
Coal PP	441,34	1.060,37	4.875,58	4.851,10	4.113,99	1.713,15	152,53	71,0	78,2	65,2	64,1	42,8	15,0	1,2	8,6	-0,5	-1,6	-8,4	-21,5	-10,6
Coal PP with CCS	0,00	0,00	0,00	0,00	127,24	1.142,10	610,13	0,0	0,0	0,0	0,0	1,3	10,0	4,8	-	-	-	24,5	-6,1	-
Oil	50,37	47,27	10,53	10,29	8,19	5,39	2,74	8,1	3,5	0,1	0,1	0,1	0,0	0,0	-5,3	-2,3	-2,3	-4,1	-6,5	-4,2
Gas PP	2,77	5,77	212,76	231,77	528,01	458,23	177,24	0,4	0,4	2,8	3,1	5,5	4,0	1,4	16,1	8,9	8,6	-1,4	-9,1	-0,6
Gas PP PP with CCS	0,00	0,00	0,00	0,00	16,33	305,49	708,96	0,0	0,0	0,0	0,0	0,2	2,7	5,6	-	-	-	34,0	8,8	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	227,94	635,55	0,0	0,0	0,0	0,0	0,0	2,0	5,0	-	-	-	-	10,8	-
Nuclear	0,00	16,74	348,36	366,25	590,74	1.090,87	1.652,44	0,0	1,2	4,7	4,8	6,1	9,6	13,0	-	5,1	4,9	6,3	4,2	5,2
Solar	0,00	0,02	224,00	256,57	684,93	1.273,82	2.065,19	0,0	0,0	3,0	3,4	7,1	11,2	16,2	49,3	14,5	10,3	6,4	5,0	7,4
Wind	0,00	0,62	406,03	509,91	1.875,92	3.159,70	4.423,00	0,0	0,0	5,4	6,7	19,5	27,7	34,8	52,4	25,6	13,9	5,4	3,4	8,0
Hydro	126,72	222,41	1.272,54	1.216,50	1.461,75	1.711,60	1.848,80	20,4	16,4	17,0	16,1	15,2	15,0	14,5	8,3	-4,4	1,9	1,6	0,8	1,2
Geothermal	0,06	0,11	0,13	0,17	0,43	0,63	0,84	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8	35,8	9,8	3,9	2,9	6,3
Others	0,01	2,43	122,25	124,35	208,42	307,92	433,66	0,0	0,2	1,6	1,6	2,2	2,7	3,4	40,0	1,7	5,3	4,0	3,5	4,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**144,73**	**297,16**	**1.268,86**	**1.265,57**	**1.114,08**	**938,44**	**521,69**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**-0,3**	**-1,3**	**-1,7**	**-5,7**	**-2,8**
Coal	131,74	284,28	1.219,77	1.211,94	997,46	728,71	200,54	91,0	95,7	96,1	95,8	89,5	77,7	38,4	8,0	-0,6	-1,9	-3,1	-12,1	-5,7
Oil	12,37	11,61	2,59	2,50	1,93	1,38	0,77	8,5	3,9	0,2	0,2	0,2	0,1	0,1	-5,3	-3,4	-2,5	-3,3	-5,7	-3,8
Gas	0,61	1,27	46,50	51,14	114,69	163,03	196,96	0,4	0,4	3,7	4,0	10,3	17,4	37,8	16,1	10,0	8,4	3,6	1,9	4,8
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	45,31	123,42	0,0	0,0	0,0	0,0	0,0	4,8	23,7	-	-	-	-	10,5	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29,4**	**32,2**	**34,6**	**34,6**	**37,0**	**35,3**	**37,7**								**0,6**	**0,1**	**0,7**	**-0,5**	**0,7**	**0,3**
Coal	28,8	32,1	34,4	34,4	36,6	33,7	32,7								0,6	0,1	0,6	-0,8	-0,3	-0,2
Oil	35,0	35,0	35,0	35,4	36,5	33,5	30,8								0,0	1,2	0,3	-0,9	-0,9	-0,4
Gas	39,0	39,0	39,3	39,0	40,8	40,3	38,7								0,0	-0,9	0,5	-0,1	-0,4	-0,1
Hydrogen/Ammonia	-	-	-	-	-	43,3	44,3								-	-	-	-	0,2	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**594,8**	**867,7**	**2.695,1**	**2.636,2**	**2.224,5**	**1.220,7**	**371,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,3**	**-2,2**	**-1,7**	**-5,8**	**-11,2**	**-6,2**
Coal	519,4	718,3	2.159,3	2.120,5	1.592,9	783,3	180,8	87,3	82,8	80,1	80,4	71,6	64,2	48,7	5,0	-1,8	-2,8	-6,9	-13,6	-7,7
Oil	70,5	139,1	386,8	358,7	441,5	288,6	120,6	11,9	16,0	14,4	13,6	19,8	23,6	32,5	6,0	-7,3	2,1	-4,2	-8,4	-3,7
Natural gas	4,9	10,3	149,0	157,0	190,0	148,9	69,8	0,8	1,2	5,5	6,0	8,5	12,2	18,8	12,5	5,3	1,9	-2,4	-7,3	-2,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	1.027	2.770	14.296	14.599	25.363	39.387	55.025	9,5	2,1	5,7	4,5	3,4	4,4
Population (millions of people)	1.135	1.263	1.398	1.403	1.390	1.370	1.320	0,7	0,4	-0,1	-0,1	-0,4	-0,2
GDP per capita (thousands of 2015 USD/person)	0,91	2,19	10,23	10,40	18,25	28,75	41,69	8,7	1,7	5,8	4,7	3,8	4,6
Primary energy consumption per capita (toe/person)	0,77	0,89	2,42	2,29	2,37	2,21	1,93	4,0	-5,5	0,3	-0,7	-1,4	-0,7
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	850	408	237	220	130	77	46	-4,3	-7,1	-5,2	-5,1	-5,0	-5,1
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	640	282	146	135	84	47	28	-5,0	-7,8	-4,6	-5,7	-5,0	-5,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	579	313	189	181	88	31	7	-3,8	-4,2	-7,0	-9,9	-14,1	-10,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,77	0,80	0,82	0,68	0,40	0,15	0,5	3,1	-1,9	-5,1	-9,6	-5,3
Automobile ownership volume (millions of vehicles)	5	16	248	262	386	574	824	14,2	5,6	4,0	4,1	7,9	4,0
Automobile ownership volume per capita (vehicles per person)	0,005	0,012	0,177	0,186	0,278	0,419	0,624	13,4	5,2	4,1	4,2	8,4	4,1

India BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**937,94**	**907,48**	**1.368,14**	**1.779,93**	**2.166,96**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-3,2**	**4,2**	**2,7**	**2,0**	**2,7**	**-0,1**	**0,3**
Coal	417,86	388,27	597,59	790,27	933,91	33,1	34,9	44,6	42,8	43,7	44,4	43,1	5,3	-7,1	4,4	2,8	1,7	2,6	-1,3	-0,8
Oil	235,48	223,17	343,29	474,48	636,67	21,8	26,8	25,1	24,6	25,1	26,7	29,4	4,8	-5,2	4,4	3,3	3,0	3,3	0,5	0,9
Natural gas	55,49	53,99	98,22	148,32	191,92	3,8	5,5	5,9	5,9	7,2	8,3	8,9	5,9	-2,7	6,2	4,2	2,6	4,1	1,4	2,3
Nuclear	12,11	11,21	40,91	51,00	64,86	0,6	1,1	1,3	1,2	3,0	2,9	3,0	7,2	-7,4	13,8	2,2	2,4	5,6	2,0	2,7
Hydro	14,82	13,83	20,60	27,51	34,56	2,2	1,5	1,6	1,5	1,5	1,5	1,6	3,1	-6,7	4,1	2,9	2,3	2,8	0,3	0,7
Geothermal	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	0,3	0,7
Others	202,18	217,01	267,54	288,34	305,05	38,6	30,2	21,6	23,9	19,6	16,2	14,1	2,2	7,3	2,1	0,8	0,6	1,3	1,7	2,1
Biomass	191,03	203,40	233,47	233,89	223,59	38,5	30,1	20,4	22,4	17,1	13,1	10,3	2,0	6,5	1,4	0,0	-0,4	0,5	0,4	-0,1
Solar, Wind, Ocean	11,47	13,92	34,39	54,77	81,77	0,0	0,0	1,2	1,5	2,5	3,1	3,8	27,3	21,4	9,5	4,8	4,1	6,5	2,4	4,0
Biofuels	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	0,04	-0,32	-0,32	-0,32	-0,32	-0,1	0,0	0,0	0,0	0,0	0,0	0,0	-194,7	-916,7	0,0	0,0	0,0	-207,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**629,81**	**606,60**	**899,38**	**1.166,55**	**1.442,30**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-3,7**	**4,0**	**2,6**	**2,1**	**2,7**	**0,1**	**0,4**
Industry	242,58	224,81	380,67	488,75	554,82	27,5	29,2	38,5	37,1	42,3	41,9	38,5	5,0	-7,3	5,4	2,5	1,3	2,7	-1,2	-1,0
Transportation	105,03	98,27	154,61	236,74	362,50	9,6	11,0	16,7	16,2	17,2	20,3	25,1	5,8	-6,4	4,6	4,4	4,4	4,1	1,5	1,9
Others	230,83	235,17	288,73	335,53	386,12	56,7	50,6	36,7	38,8	32,1	28,8	26,8	2,2	1,9	2,1	1,5	1,4	1,7	0,6	0,9
Non-energy	51,37	48,34	75,37	105,53	138,86	6,2	9,2	8,2	8,0	8,4	9,0	9,6	4,8	-5,9	4,5	3,4	2,8	3,3	0,3	1,0
Total	**629,81**	**606,60**	**899,38**	**1.166,55**	**1.442,30**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-3,7**	**4,0**	**2,6**	**2,1**	**2,7**	**0,1**	**0,4**
Coal	106,87	97,81	150,88	189,46	220,37	17,8	11,4	17,0	16,1	16,8	16,2	15,3	3,6	-8,5	4,4	2,3	1,5	2,4	-2,5	-2,4
Oil	207,95	197,66	310,16	434,38	585,93	23,3	32,6	33,0	32,6	34,5	37,2	40,6	5,0	-4,9	4,6	3,4	3,0	3,4	0,5	1,0
Natural gas	34,33	33,19	64,91	96,55	125,79	2,8	4,0	5,5	5,5	7,2	8,3	8,7	6,1	-3,3	6,9	4,1	2,7	4,3	0,2	0,9
Electricity	112,74	109,54	190,85	276,05	363,42	8,5	10,9	17,9	18,1	21,2	23,7	25,2	6,5	-2,8	5,7	3,8	2,8	3,8	1,0	1,6
Heat	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	-0,5	0,0
Others	167,92	168,39	182,58	170,11	146,79	47,6	41,1	26,7	27,8	20,3	14,6	10,2	1,7	0,3	0,8	-0,7	-1,5	-0,4	-1,1	-1,3

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**289.47**	**561.06**	**1,623.69**	**1,571.95**	**2,755.99**	**3,879.04**	**4,937.53**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.1**	**-3.2**	**5.8**	**3.5**	**2.4**	**3.7**
Coal	189.15	386.52	1,180.77	1,098.23	1,775.19	2,454.56	2,968.58	65.3	68.9	72.7	69.9	64.4	63.3	60.1	6.5	-7.0	4.9	3.3	1.9	3.0
Oil	12.54	25.31	6.00	5.31	4.29	0.00	0.00	4.3	4.5	0.4	0.3	0.2	0.0	0.0	-2.5	-11.4	-2.1	-100.0	-	-100.0
Natural gas	9.96	55.96	64.94	61.64	119.85	194.15	270.47	3.4	10.0	4.0	3.9	4.3	5.0	5.5	6.7	-5.1	6.9	4.9	3.4	4.7
Nuclear	6.14	16.90	46.47	43.03	156.99	195.74	248.91	2.1	3.0	2.9	2.7	5.7	5.0	5.0	7.2	-7.4	13.8	2.2	2.4	5.6
Hydro	71.66	74.46	172.40	160.80	239.61	319.99	401.98	24.8	13.3	10.6	10.2	8.7	8.2	8.1	3.1	-6.7	4.1	2.9	2.3	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	0.03202	1.90	153.11	202.94	460.06	714.59	1,047.58	0.0	0.3	9.4	12.9	16.7	18.4	21.2	33.9	32.5	8.5	4.5	3.9	6.4

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**301,17**	**280,02**	**425,45**	**565,45**	**660,80**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,9**	**-7,0**	**4,3**	**2,9**	**1,6**	**2,6**	**-0,5**	**0,3**
Coal	284,52	265,01	402,08	532,99	617,93	85,1	85,0	94,5	94,6	94,5	94,3	93,5	6,3	-6,9	4,3	2,9	1,5	2,5	-1,0	0,0
Oil	2,96	2,06	1,71	0,00	0,00	8,8	7,4	1,0	0,7	0,4	0,0	0,0	-1,8	-30,3	-1,9	-100,0	-	-100,0	-5,0	-3,0
Natural gas	13,69	12,95	21,67	32,46	42,86	6,1	7,6	4,5	4,6	5,1	5,7	6,5	4,9	-5,4	5,3	4,1	2,8	3,7	2,6	5,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,7**	**35,8**	**38,4**	**40,3**	**42,2**	**37,1**	**39,6**								**0,4**	**0,1**	**0,7**	**0,5**	**0,5**	**0,5**
Coal	35,7	35,6	38,0	39,6	41,3	36,6	39,1								0,2	-0,1	0,6	0,4	0,4	0,5
Oil	17,4	22,2	21,6	-	-	36,7	37,2								-0,7	27,2	-0,3	-	-	-
Natural gas	40,8	40,9	47,6	51,4	54,3	40,9	42,1								1,7	0,4	1,5	0,8	0,5	0,9

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**630,0**	**589,5**	**922,9**	**1.249,4**	**1.543,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,2**	**-6,4**	**4,6**	**3,1**	**2,1**	**2,9**	**-0,7**	**-0,2**
Coal	440,3	408,6	633,4	840,4	994,9	67,6	64,2	69,9	69,3	68,6	67,3	64,5	5,3	-7,2	4,5	2,9	1,7	2,7	-1,3	-0,8
Oil	167,6	159,3	247,9	344,4	466,1	30,0	31,8	26,6	27,0	26,9	27,6	30,2	4,8	-4,9	4,5	3,3	3,1	3,4	0,5	0,9
Natural gas	22,1	21,5	41,7	64,6	81,9	2,4	4,0	3,5	3,6	4,5	5,2	5,3	6,5	-2,8	6,8	4,5	2,4	4,3	1,4	2,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	475	817	2.751	2.531	4.978	8.513	13.447	6,2	-8,0	7,0	5,5	4,7	5,3
Population (millions of people)	873,3	1.056,6	1.366,4	1.380,0	1.503,6	1.592,7	1.639,2	1,6	1,0	0,9	0,6	0,3	0,6
GDP per capita (thousands of 2015 USD/person)	0,54	0,77	2,01	1,83	3,31	5,35	8,20	4,6	-8,9	6,1	4,9	4,4	4,6
Primary energy consumption per capita (toe/person)	0,32	0,40	0,69	0,66	0,91	1,12	1,32	2,7	-4,2	3,3	2,1	1,7	2,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	590	511	341	359	275	209	161	-1,9	5,2	-2,6	-2,7	-2,6	-2,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	453	355	229	240	181	137	107	-2,3	4,7	-2,8	-2,7	-2,4	-2,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	304	297	229	233	185	147	115	-1,0	1,7	-2,3	-2,3	-2,4	-2,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,52	0,58	0,67	0,65	0,67	0,70	0,71	0,9	-3,3	0,4	0,4	0,1	0,2
Automobile ownership volume (millions of vehicles)	4,3	9,4	54,3	56,2	120,0	245,0	489,1	9,1	3,7	7,9		15,1	7,4
Automobile ownership volume per capita (vehicles per person)	0,005	0,009	0,040	0,041	0,080	0,154	0,298	7,4	2,6	7,0		14,1	6,7

India APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**280,23**	**417,88**	**937,94**	**907,43**	**1.283,38**	**1.491,72**	**1.624,62**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-3,3**	**3,5**	**1,5**	**0,9**	**1,8**
Coal	92,70	145,92	417,86	387,66	490,33	481,93	426,84	33,1	34,9	44,6	42,7	38,2	32,3	26,3	5,3	-7,2	2,4	-0,2	-1,2	0,1
Oil	61,10	111,99	235,48	223,23	325,83	401,83	446,59	21,8	26,8	25,1	24,6	25,4	26,9	27,5	4,8	-5,2	3,9	2,1	1,1	2,1
Natural gas	10,57	23,07	55,49	54,68	104,04	136,24	147,25	3,8	5,5	5,9	6,0	8,1	9,1	9,1	5,9	-1,4	6,6	2,7	0,8	3,2
Nuclear	1,60	4,40	12,11	11,21	49,48	94,89	128,10	0,6	1,1	1,3	1,2	3,9	6,4	7,9	7,2	-7,4	16,0	6,7	3,0	7,9
Hydro	6,16	6,40	14,82	13,83	21,92	30,05	38,34	2,2	1,5	1,6	1,5	1,7	2,0	2,4	3,1	-6,7	4,7	3,2	2,5	3,1
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	126,09	202,18	216,81	291,78	346,77	437,49	38,6	30,2	21,6	23,9	22,7	23,2	26,9	2,2	7,2	3,0	1,7	2,4	2,5
Biomass	107,97	125,80	191,03	203,21	228,60	213,07	210,77	38,5	30,1	20,4	22,4	17,8	14,3	13,0	2,0	6,4	1,2	-0,7	-0,1	0,3
Solar, Wind, Ocean	0,01	0,18	11,47	13,92	63,50	134,01	227,03	0,0	0,0	1,2	1,5	4,9	9,0	14,0	27,3	21,4	16,4	7,8	5,4	10,1
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	-0,19	0,00	0,04	0,04	0,03	0,03	0,03	-0,1	0,0	0,0	0,0	0,0	0,0	0,0	-194,7	-7,4	-0,4	-0,5	-1,8	-1,1

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**215,04**	**290,03**	**629,81**	**606,52**	**851,82**	**1.010,47**	**1.131,77**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-3,7**	**3,5**	**1,7**	**1,1**	**1,9**
Industry	59,05	84,68	242,58	224,81	366,62	418,17	409,34	27,5	29,2	38,5	37,1	43,0	41,4	36,2	5,0	-7,3	5,0	1,3	-0,2	1,7
Transportation	20,75	31,92	105,03	98,27	140,93	191,17	257,85	9,6	11,0	16,7	16,2	16,5	18,9	22,8	5,8	-6,4	3,7	3,1	3,0	2,9
Others	121,96	146,64	230,83	235,10	268,90	295,60	325,72	56,7	50,6	36,7	38,8	31,6	29,3	28,8	2,2	1,8	1,4	1,0	1,0	1,1
Non-energy	13,28	26,80	51,37	48,34	75,37	105,53	138,86	6,2	9,2	8,2	8,0	8,8	10,4	12,3	4,8	-5,9	4,5	3,4	2,8	3,3
Total	**215,04**	**290,03**	**629,81**	**606,52**	**851,82**	**1.010,47**	**1.131,77**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-3,7**	**3,5**	**1,7**	**1,1**	**1,9**
Coal	38,24	33,15	106,87	97,71	140,51	158,17	162,85	17,8	11,4	17,0	16,1	16,5	15,7	14,4	3,6	-8,6	3,7	1,2	0,3	1,4
Oil	50,17	94,47	207,95	197,70	293,84	366,36	408,07	23,3	32,6	33,0	32,6	34,5	36,3	36,1	5,0	-4,9	4,0	2,2	1,1	2,2
Natural gas	6,09	11,70	34,33	33,21	63,18	85,55	100,38	2,8	4,0	5,5	5,5	7,4	8,5	8,9	6,1	-3,3	6,6	3,1	1,6	3,5
Electricity	18,21	31,61	112,74	109,52	190,82	269,42	353,11	8,5	10,9	17,9	18,1	22,4	26,7	31,2	6,5	-2,9	5,7	3,5	2,7	3,8
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	119,11	167,92	168,39	163,47	130,97	107,35	47,6	41,1	26,7	27,8	19,2	13,0	9,5	1,7	0,3	-0,3	-2,2	-2,0	-1,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**289,47**	**561,06**	**1.623,69**	**1.572,93**	**2.743,92**	**3.703,24**	**4.657,05**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,1**	**-3,1**	**5,7**	**3,0**	**2,3**	**3,5**
Coal	189,15	386,52	1.180,77	1.096,71	1.315,85	1.112,34	746,50	65,3	68,9	72,7	69,7	48,0	30,0	16,0	6,5	-7,1	1,8	-1,7	-3,9	-1,5
Oil	12,54	25,31	6,00	5,38	3,19	0,00	0,00	4,3	4,5	0,4	0,3	0,1	0,0	0,0	-2,5	-10,3	-5,1	-100,0	-	-100,0
Natural gas	9,96	55,96	64,94	64,07	155,37	206,97	193,37	3,4	10,0	4,0	4,1	5,7	5,6	4,2	6,7	-1,3	9,3	2,9	-0,7	3,6
Nuclear	6,14	16,90	46,47	43,03	189,90	364,19	491,64	2,1	3,0	2,9	2,7	6,9	9,8	10,6	7,2	-7,4	16,0	6,7	3,0	7,9
Hydro	71,66	74,46	172,40	160,80	254,89	349,46	445,92	24,8	13,3	10,6	10,2	9,3	9,4	9,6	3,1	-6,7	4,7	3,2	2,5	3,1
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	0,032	1,90	153,11	202,94	824,73	1.670,28	2.779,62	0,0	0,3	9,4	12,9	30,1	45,1	59,7	33,9	32,5	15,1	7,3	5,2	9,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**56,84**	**121,39**	**301,17**	**280,17**	**335,64**	**293,87**	**206,65**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,9**	**-7,0**	**1,8**	**-1,3**	**-3,5**	**-1,2**
Coal	48,37	103,17	284,52	264,62	306,62	260,07	176,80	85,1	85,0	94,5	94,5	91,4	88,5	85,6	6,3	-7,0	1,5	-1,6	-3,8	-1,5
Oil	5,01	8,96	2,96	2,09	1,66	0,00	0,00	8,8	7,4	1,0	0,7	0,5	0,0	0,0	-1,8	-29,5	-2,2	-100,0	-	-100,0
Natural gas	3,46	9,26	13,69	13,46	27,36	33,80	29,85	6,1	7,6	4,5	4,8	8,2	11,5	14,4	4,9	-1,7	7,3	2,1	-1,2	2,5

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**32,0**	**33,1**	**35,7**	**35,8**	**37,8**	**38,6**	**39,1**	**0,4**	**0,1**	**0,5**	**0,2**	**0,1**	**0,3**
Coal	33,6	32,2	35,7	35,6	36,9	36,8	36,3	0,2	-0,1	0,3	0,0	-0,1	0,1
Oil	21,5	24,3	17,4	22,2	16,5	-	-	-0,7	27,2	-2,9	-	-	-
Natural gas	24,7	52,0	40,8	40,9	48,8	52,7	55,7	1,7	0,4	1,8	0,8	0,6	1,0

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**144,6**	**242,8**	**630,0**	**589,3**	**790,6**	**843,4**	**803,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,2**	**-6,5**	**3,0**	**0,6**	**-0,5**	**0,8**
Coal	97,7	155,9	440,3	408,0	514,4	505,5	444,9	67,6	64,2	69,9	69,2	65,1	59,9	55,4	5,3	-7,3	2,3	-0,2	-1,3	0,0
Oil	43,3	77,2	167,6	159,4	231,0	280,5	302,9	30,0	31,8	26,6	27,0	29,2	33,3	37,7	4,8	-4,9	3,8	2,0	0,8	1,9
Natural gas	3,5	9,8	22,1	21,9	45,1	57,4	55,7	2,4	4,0	3,5	3,7	5,7	6,8	6,9	6,5	-0,8	7,5	2,4	-0,3	3,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	475	817	2.751	2.531	4.978	8.513	13.447	6,2	-8,0	7,0	5,5	4,7	5,3
Population (millions of people)	873	1.057	1.366	1.380	1.504	1.593	1.639	1,6	1,0	0,9	0,6	0,3	0,6
GDP per capita (thousands of 2015 USD/person)	0,54	0,77	2,01	1,83	3,31	5,35	8,20	4,6	-8,9	6,1	4,9	4,4	4,6
Primary energy consumption per capita (toe/person)	0,32	0,40	0,69	0,66	0,85	0,94	0,99	2,7	-4,2	2,6	0,9	0,6	1,2
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	590	511	341	359	258	175	121	-1,9	5,2	-3,2	-3,8	-3,6	-3,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	453	355	229	240	171	119	84	-2,3	4,7	-3,3	-3,6	-3,4	-3,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	304	297	229	233	159	99	60	-1,0	1,7	-3,8	-4,6	-4,9	-4,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,52	0,58	0,67	0,65	0,62	0,57	0,49	0,9	-3,3	-0,5	-0,9	-1,3	-1,0
Automobile ownership volume (millions of vehicles)	4	9	54	56	120	245	489	9,1	3,7	7,9	15,9	15,1	7,4
Automobile ownership volume per capita (vehicles per person)	0,005	0,009	0,040	0,041	0,080	0,154	0,298	7,4	2,6	7,0	14,2	14,1	6,7

India LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**280,23**	**417,88**	**937,94**	**800,55**	**1.200,74**	**1.366,23**	**1.430,00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-14,6**	**4,1**	**1,3**	**0,5**	**1,4**
Coal	92,70	145,92	417,86	387,66	475,62	477,80	310,26	33,1	34,9	44,6	48,4	39,6	35,0	21,7	5,3	-7,2	2,1	0,0	-4,2	-1,0
Oil	61,10	111,99	235,48	223,23	281,88	278,01	300,41	21,8	26,8	25,1	27,9	23,5	20,3	21,0	4,8	-5,2	2,4	-0,1	0,8	0,8
Natural gas	10,57	23,07	55,49	54,68	81,47	113,57	136,12	3,8	5,5	5,9	6,8	6,8	8,3	9,5	5,9	-1,4	4,1	3,4	1,8	2,9
Nuclear	1,60	4,40	12,11	11,21	55,41	113,38	187,33	0,6	1,1	1,3	1,4	4,6	8,3	13,1	7,2	-7,4	17,3	7,4	5,1	9,2
Hydrogen/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	-	-	-	16,4	10,0	-
Hydro	6,16	6,40	14,82	13,83	23,68	35,52	46,36	2,2	1,5	1,6	1,7	2,0	2,6	3,2	3,1	-6,7	5,5	4,1	2,7	3,7
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	108,09	126,09	202,18	109,93	282,67	347,94	449,52	38,6	30,2	21,6	13,7	23,5	25,5	31,4	2,2	-45,6	9,9	2,1	2,6	2,6
Biomass	107,97	125,80	191,03	96,32	202,46	179,05	164,91	38,5	30,1	20,4	12,0	16,9	13,1	11,5	2,0	-49,6	7,7	-1,2	-0,8	-0,5
Solar, Wind, Ocean	0,01	0,18	11,47	13,92	80,52	169,21	284,92	0,0	0,0	1,2	1,7	6,7	12,4	19,9	27,3	21,4	19,2	7,7	5,3	10,9
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	-0,19	0,00	0,04	0,04	0,03	0,03	0,03	-0,1	0,0	0,0	0,0	0,0	0,0	0,0	-194,7	-7,4	-0,4	-0,5	-1,8	-1,1

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**215,04**	**290,03**	**629,81**	**499,64**	**794,37**	**887,37**	**978,70**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-20,7**	**4,7**	**1,1**	**1,0**	**1,4**
Industry	59,05	84,68	242,58	224,81	349,17	380,15	355,95	27,5	29,2	38,5	45,0	44,0	42,8	36,4	5,0	-7,3	4,5	0,9	-0,7	1,2
Transportation	20,75	31,92	105,03	98,27	124,61	136,35	205,17	9,6	11,0	16,7	19,7	15,7	15,4	21,0	5,8	-6,4	2,4	0,9	4,2	2,2
Others	121,96	146,64	230,83	128,22	245,23	265,34	278,73	56,7	50,6	36,7	25,7	30,9	29,9	28,5	2,2	-44,5	6,7	0,8	0,5	0,6
Non-energy	13,28	26,80	51,37	48,34	75,37	105,53	138,86	6,2	9,2	8,2	9,7	9,5	11,9	14,2	4,8	-5,9	4,5	3,4	2,8	3,3
Total	**215,04**	**290,03**	**629,81**	**499,64**	**794,37**	**887,37**	**978,70**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,8**	**-20,7**	**4,7**	**1,1**	**1,0**	**1,4**
Coal	38,24	33,15	106,87	97,71	114,24	102,48	72,24	17,8	11,4	17,0	19,6	14,4	11,5	7,4	3,6	-8,6	1,6	-1,1	-3,4	-1,3
Oil	50,17	94,47	207,95	197,70	255,58	257,70	285,48	23,3	32,6	33,0	39,6	32,2	29,0	29,2	5,0	-4,9	2,6	0,1	1,0	1,0
Natural gas	6,09	11,70	34,33	33,21	57,56	66,29	72,62	2,8	4,0	5,5	6,6	7,2	7,5	7,4	6,1	-3,3	5,7	1,4	0,9	2,4
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,05	24,57	44,78	0,0	0,0	0,0	0,0	0,1	2,8	4,6	-	-	-	37,1	6,2	-
Electricity	18,21	31,61	112,74	109,52	213,50	322,49	415,82	8,5	10,9	17,9	21,9	26,9	36,3	42,5	6,5	-2,9	6,9	4,2	2,6	4,3
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	119,11	167,92	61,51	152,44	113,84	87,76	47,6	41,1	26,7	12,3	19,2	12,8	9,0	1,7	-63,4	9,5	-2,9	-2,6	-2,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**289,47**	**561,06**	**1.623,69**	**1.572,93**	**3.072,64**	**4.599,75**	**5.991,13**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,1**	**-3,1**	**6,9**	**4,1**	**2,7**	**4,3**
Coal PP	189,15	386,52	1.180,77	1.096,71	1.473,49	1.351,31	690,18	65,3	68,9	72,7	69,7	48,0	29,4	11,5	6,5	-7,1	3,0	-0,9	-6,5	-1,7
Coal PP with CCS	0,00	0,00	0,00	0,00	0,00	27,58	28,76	0,0	0,0	0,0	0,0	0,0	0,6	0,5	-	-	-	-	0,4	-
Oil	12,54	25,31	6,00	5,38	3,57	0,00	0,00	4,3	4,5	0,4	0,3	0,1	0,0	0,0	-2,5	-10,3	-4,0	-65,8	10,0	-28,3
Gas PP	9,96	55,96	64,94	64,07	71,74	101,34	176,14	3,4	10,0	4,0	4,1	2,3	2,2	2,9	6,7	-1,3	1,1	3,5	5,7	3,3
Gas PP PP with CCS	0,00	0,00	0,00	0,00	0,00	1,02	3,59	0,0	0,0	0,0	0,0	0,0	0,0	0,1	-	-	-	-	13,4	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	137,99	299,56	0,0	0,0	0,0	0,0	0,0	3,0	5,0	-	-	-	-	8,1	-
Nuclear	6,14	16,90	46,47	43,03	212,65	435,16	718,94	2,1	3,0	2,9	2,7	6,9	9,5	12,0	7,2	-7,4	17,3	7,4	5,1	9,2
Solar	0,00	0,00	50,56	75,85	502,08	1.101,08	1.868,35	0,0	0,0	3,1	4,8	16,3	23,9	31,2	-	50,0	20,8	8,2	5,4	12,3
Wind	0,03	1,68	69,95	71,80	395,12	803,92	1.339,28	0,0	0,3	4,3	4,6	12,9	17,5	22,4	30,4	2,6	18,6	7,4	5,2	10,0
Hydro	71,66	74,46	172,40	160,80	275,37	413,10	539,20	24,8	13,3	10,6	10,2	9,0	9,0	9,0	3,1	-6,7	5,5	4,1	2,7	3,7
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	0,21	32,60	55,29	138,63	227,25	327,14	0,0	0,0	2,0	3,5	4,5	4,9	5,5	64,8	69,6	9,6	5,1	3,7	7,7

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**56,84**	**121,39**	**301,17**	**280,17**	**339,84**	**345,88**	**235,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,9**	**-7,0**	**1,9**	**0,2**	**-3,8**	**-0,8**
Coal	48,37	103,17	284,52	264,62	325,70	307,34	163,07	85,1	85,0	94,5	94,5	95,8	88,9	69,1	6,3	-7,0	2,1	-0,6	-6,1	-1,8
Oil	5,01	8,96	2,96	2,09	1,76	0,00	0,00	8,8	7,4	1,0	0,7	0,5	0,0	0,0	-1,8	-29,5	-1,7	-65,8	10,0	-28,3
Gas	3,46	9,26	13,69	13,46	12,38	16,43	27,33	6,1	7,6	4,5	4,8	3,6	4,7	11,6	4,9	-1,7	-0,8	2,9	5,2	2,3
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	22,11	45,42	0,0	0,0	0,0	0,0	0,0	6,4	19,3	-	-	-	-	7,5	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**32,0**	**33,1**	**35,7**	**35,8**	**39,2**	**40,3**	**43,7**								**0,4**	**0,1**	**0,9**	**0,3**	**0,8**	**0,7**
Coal	33,6	32,2	35,7	35,6	38,9	38,6	37,9								0,2	-0,1	0,9	-0,1	-0,2	0,2
Oil	21,5	24,3	17,4	22,2	17,5	17,5	17,5								-0,7	27,2	-2,4	0,0	0,0	0,0
Gas	24,7	52,0	40,8	40,9	49,8	53,6	56,6								1,7	0,4	2,0	0,7	0,5	1,1
Hydrogen/Ammonia	-	-	-	-	-	53,7	56,7								-	-	-	-	0,6	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**144,6**	**242,8**	**630,0**	**589,3**	**632,9**	**536,8**	**335,1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,2**	**-6,5**	**0,7**	**-1,6**	**-4,6**	**-2,0**
Coal	97,7	155,9	440,3	408,0	435,6	371,0	188,4	67,6	64,2	69,9	69,2	68,8	69,1	56,2	5,3	-7,3	0,7	-1,6	-6,6	-2,7
Oil	43,3	77,2	167,6	159,4	170,6	143,3	127,1	30,0	31,8	26,6	27,0	27,0	26,7	37,9	4,8	-4,9	0,7	-1,7	-1,2	-0,9
Natural gas	3,5	9,8	22,1	21,9	26,7	22,6	19,6	2,4	4,0	3,5	3,7	4,2	4,2	5,8	6,5	-0,8	2,0	-1,7	-1,4	-0,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	475	817	2.751	2.531	4.978	8.513	13.447	6,2	-8,0	7,0	5,5	4,7	5,3
Population (millions of people)	873	1.057	1.366	1.380	1.504	1.593	1.639	1,6	1,0	0,9	0,6	0,3	0,6
GDP per capita (thousands of 2015 USD/person)	0,54	0,77	2,01	1,83	3,31	5,35	8,20	4,6	-8,9	6,1	4,9	4,4	4,6
Primary energy consumption per capita (toe/person)	0,32	0,40	0,69	0,58	0,80	0,86	0,87	2,7	-15,5	3,2	0,7	0,2	0,8
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	590	511	341	316	241	160	106	-1,9	-7,2	-2,7	-4,0	-4,0	-3,7
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	453	355	229	197	160	104	73	-2,3	-13,8	-2,1	-4,2	-3,5	-3,6
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	304	297	229	233	127	63	25	-1,0	1,7	-5,9	-6,8	-8,9	-6,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,52	0,58	0,67	0,74	0,53	0,39	0,23	0,9	9,6	-3,3	-2,9	-5,0	-3,3
Automobile ownership volume (millions of vehicles)	4	9	54	56	120	245	489	9,1	3,7	7,9	7,4	15,1	7,4
Automobile ownership volume per capita (vehicles per person)	0,005	0,009	0,040	0,041	0,080	0,154	0,298	7,4	2,6	7,0	6,8	14,1	6,7

Indonesia BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**78,7**	**119,1**	**228,7**	**220,0**	**328,5**	**477,2**	**663,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**-3,8**	**4,1**	**3,8**	**3,4**	**3,5**
Coal	3,4	13,1	81,2	82,5	113,1	170,7	225,0	4,3	11,0	35,5	37,5	34,4	35,8	33,9	11,5	1,6	3,2	4,2	2,8	3,3
Oil	26,6	48,1	82,1	71,4	100,2	142,2	202,9	33,8	40,4	35,9	32,5	30,5	29,8	30,6	4,0	-13,0	3,4	3,6	3,6	3,0
Natural gas	26,2	31,8	32,5	33,2	52,9	76,8	122,4	33,2	26,7	14,2	15,1	16,1	16,1	18,4	0,8	2,2	4,8	3,8	4,8	4,4
Nuclear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydro	0,6	0,9	1,7	1,9	4,5	5,7	6,2	0,7	0,7	0,7	0,9	1,4	1,2	0,9	3,9	12,7	9,0	2,5	0,8	4,3
Geothermal	1,0	2,3	12,1	12,7	33,1	43,2	46,6	1,2	1,9	5,3	5,8	10,1	9,0	7,0	9,1	4,3	10,1	2,7	0,8	4,4
Others	21,0	23,0	19,1	18,3	24,7	38,6	60,7	26,7	19,3	8,4	8,3	7,5	8,1	9,1	-0,3	-20,6	3,1	4,5	4,6	3,8
Biomass	21,0	23,0	13,0	13,0	13,7	17,4	23,0	26,7	19,3	5,7	5,9	4,2	3,6	3,5	-1,6	-	0,6	2,4	2,8	1,9
Solar, Wind, Ocean	-	0,0	0,1	0,1	0,5	0,9	1,0	-	0,0	0,0	0,0	0,2	0,2	0,2	-	8,0	24,5	6,5	1,0	10,2
Biofuels	-	-	6,1	5,2	10,5	20,2	36,7	-	-	2,7	2,4	3,2	4,2	5,5	-	-14,2	7,2	6,8	6,1	6,0
Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,4**	**69,4**	**144,8**	**136,8**	**207,5**	**307,3**	**448,2**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**4,9**	**5,9**	**4,1**	**3,9**	**3,7**	**4,0**
Industry	12,4	23,9	48,6	47,3	69,3	101,8	145,9	34,0	39,2	33,6	33,8	35,2	35,0	34,1	4,8	6,7	4,5	3,8	3,4	4,0
Transportation	8,2	16,3	53,4	44,7	77,3	124,9	195,1	22,6	26,6	36,9	35,7	39,4	43,1	45,9	6,7	2,6	5,1	4,8	4,4	4,7
Others	9,2	18,6	34,0	36,1	51,6	70,7	96,9	25,2	23,4	23,5	24,5	20,8	18,4	17,3	4,6	10,5	2,4	2,6	3,0	2,9
Non-energy	6,6	10,6	8,7	8,7	9,3	9,8	10,3	18,2	10,8	6,0	5,9	4,6	3,5	2,8	1,0	3,9	1,5	1,1	1,3	1,4
Total	**36**	**69**	**145**	**137**	**207**	**307**	**448**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**5,9**	**4,1**	**3,9**	**3,7**	**4,0**
Coal	0,8	5,1	23,4	22,8	33,0	47,3	65,6	2,2	10,6	16,2	16,8	17,4	17,6	17,4	12,3	9,9	4,4	4,0	3,6	4,2
Oil	23,6	43,7	76,0	68,7	97,8	140,2	201,4	64,8	57,8	52,5	51,8	51,1	51,4	51,8	4,1	4,4	3,9	3,9	3,8	3,9
Natural gas	9,6	13,8	16,6	16,1	22,3	31,4	44,3	26,4	21,1	11,4	12,0	12,6	11,4	10,1	1,9	10,7	4,6	2,9	2,4	3,5
Electricity	2,4	6,8	22,5	23,8	43,8	68,0	100,1	6,5	10,6	15,6	15,2	13,4	12,5	12,1	8,1	3,3	2,8	3,2	3,3	3,1
Heat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Others	0,0	0,0	6,2	5,4	10,6	20,4	36,8	0,0	0,0	4,3	4,3	5,6	7,1	8,7	31,7	5,6	6,9	6,4	5,8	6,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33**	**91**	**294**	**305**	**548**	**850**	**1.252**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**1,5**	**2,6**	**3,2**	**3,3**	**3,0**
Coal	9,8	34,0	174,5	180,6	279,4	459,2	648,8	29,5	40,6	59,5	59,2	51,0	54,0	50,1	10,5	1,1	1,1	3,8	2,6	2,4
Oil	12,3	12,5	10,6	6,2	4,7	3,4	1,8	37,2	13,6	3,6	2,0	0,9	0,4	0,1	-0,5	-43,1	-5,9	-4,3	-11,2	-8,6
Natural gas	3,4	31,9	62,3	68,6	149,1	233,1	432,1	10,3	32,2	21,3	22,5	27,2	27,4	33,3	10,5	7,6	4,5	3,3	5,4	4,5
Nuclear	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	6,5	10,0	19,5	21,9	52,2	66,6	72,3	19,6	8,4	6,6	7,2	9,5	7,8	7,1	3,9	10,0	5,5	1,2	2,3	3,2
Geothermal	1,1	2,6	14,1	14,7	38,5	50,2	54,2	3,4	5,2	4,8	4,8	7,0	5,9	5,3	9,1	1,9	6,5	1,4	2,2	3,3
Others	-	0,0	12,8	12,7	23,8	37,5	42,8	0,0	0,0	4,2	4,2	4,3	4,4	4,2	-	2,2	3,0	3,4	2,8	3,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**7**	**18**	**75**	**77**	**111**	**169**	**237**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8,2**	**0,0**	**0,3**	**3,0**	**2,6**	**1,9**
Coal	2,6	8,1	57,7	59,7	80,1	123,4	159,4	34,4	53,4	76,6	77,4	72,2	73,1	66,8	11,3	1,0	-0,4	3,1	1,6	1,4
Oil	4,0	4,7	3,1	1,8	1,4	1,0	0,5	52,8	24,1	4,2	2,4	1,3	0,6	0,1	-0,8	-43,1	-5,9	-4,3	-11,2	-8,6
Natural gas	1,0	5,6	14,5	15,6	29,4	44,5	77,4	12,8	22,5	19,2	20,2	26,5	26,3	33,1	9,8	5,4	3,1	2,9	4,9	3,7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29**	**34**	**28**	**28**	**34**	**35**	**39**								**-0,1**	**0,8**	**1,7**	**0,5**	**1,0**	**1,0**
Coal	32,3	36,3	26,0	26,0	30,0	32,0	35,0								-0,7	0,0	1,4	0,6	0,9	1,0
Oil	26,5	22,9	29,0	29,0	29,0	29,0	29,0								0,3	-	-	-	-	-
Natural gas	30,2	49,2	37,0	37,8	43,6	45,1	48,0								0,7	2,1	1,4	0,3	0,4	0,8

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**30**	**38**	**164**	**158**	**226**	**336**	**471**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**3,8**	**2,7**	**3,7**	**3,3**	**3,2**
Coal	3,7	14,4	85,9	87,3	119,7	180,7	238,1	11,0	32,9	52,5	52,4	46,0	45,2	42,2	10,8	3,6	1,3	3,5	2,5	2,5
Oil	9,2	3,1	60,1	53,0	75,8	109,3	157,8	59,5	40,9	36,7	36,3	41,2	42,7	45,2	3,2	2,7	4,0	4,0	3,9	3,9
Natural gas	16,8	20,3	17,7	18,1	30,7	45,9	75,0	29,4	26,2	10,8	11,2	12,9	12,1	12,6	1,4	8,1	4,1	3,0	3,7	3,7

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	309,8	453,4	1.204,5	1.171,9	1.898,0	3.033,2	4.710,5	4,8	-2,7	4,9	4,8	4,5	4,5
Population (millions of people)	178,6	208,9	270,6	272,8	294,8	312,4	325,1	1,4	0,8	0,8	0,6	0,4	0,6
GDP per capita (thousands of 2015 USD/person)	1,7	2,2	4,5	4,3	6,4	9,7	14,5	3,3	-3,5	4,1	4,2	4,1	3,9
Primary energy consumption per capita (toe/person)	0,4	0,6	0,8	0,8	1,1	1,5	2,0	2,3	-4,6	3,3	3,2	2,9	2,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	254,0	262,7	189,9	187,7	173,1	157,3	140,9	-1,0	-1,2	-0,8	-0,9	-1,1	-1,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	117,6	153,0	120,2	116,7	109,3	101,3	95,2	0,1	-2,9	-0,7	-0,8	-0,6	-0,8
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	96,0	83,4	135,9	135,2	119,2	110,7	100,0	1,2	-0,5	-1,3	-0,7	-1,0	-1,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,4	0,3	0,7	0,7	0,7	0,7	0,7	2,2	0,7	-0,5	0,2	0,1	-0,0
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Indonesia APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**78,7**	**119,1**	**228,7**	**222,2**	**314,2**	**448,2**	**603,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**-2,9**	**3,5**	**3,6**	**3,0**	**3,18**
Coal	3,4	13,1	81,2	82,0	107,4	120,6	133,3	4,3	11,0	35,5	36,9	34,2	26,9	22,1	11,5	1,0	2,7	1,2	1,0	1,61
Oil	26,6	48,1	82,1	71,1	94,9	128,8	165,7	33,8	40,4	35,9	32,0	30,2	28,7	27,5	4,0	-13,5	2,9	3,1	2,6	2,29
Natural gas	26,2	31,8	32,5	32,4	45,0	62,9	85,2	33,2	26,7	14,2	14,6	14,3	14,0	14,1	0,8	-0,5	3,4	3,4	3,1	3,16
Nuclear	-	-	0,0	0,0	0,0	0,0	4,0	0,0	0,0	0,0	0,0	0,0	0,0	0,7	-	-	-	-	-	-
Hydro	0,6	0,9	1,7	2,0	3,8	5,0	8,3	0,7	0,7	0,7	0,9	1,2	1,1	1,4	3,9	17,1	6,9	2,7	5,3	5,31
Geothermal	1,0	2,3	12,1	13,8	29,4	46,1	62,6	1,2	1,9	5,3	6,2	9,4	10,3	10,4	9,1	14,2	7,8	4,6	3,1	5,43
Others	21,0	23,0	19,1	20,9	33,6	85,0	144,1	26,7	19,3	8,4	9,4	10,7	19,0	23,9	-0,3	9,4	4,8	9,7	5,4	6,73
Biomass	21,0	23,0	13,0	15,6	20,8	59,8	101,4	26,7	19,3	5,7	7,0	6,6	13,3	16,8	-1,6	20,0	2,9	11,1	5,4	6,85
Solar, Wind, Ocean	-	0,0	0,1	0,1	1,5	2,7	7,5	0,0	0,0	0,0	0,0	0,5	0,6	1,2	-	63,5	33,4	6,1	10,6	17,39
Biofuels	-	-	6,1	5,2	11,3	22,4	35,2	0,0	0,0	2,7	2,4	3,6	5,0	5,8	-	-13,6	7,9	7,1	4,6	5,83
Electricity	-	-	-	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,43**	**69,39**	**144,78**	**135,92**	**198,05**	**282,06**	**377,28**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**5,2**	**3,7**	**3,5**	**2,8**	**3,4**
Industry	12	24	49	47	65	92	121	34,0	39,2	33,6	33,8	34,8	34,2	33,5	4,8	5,9	4,0	3,3	2,6	3,4
Transportation	8	16	53	44	74	117	162	22,6	26,6	36,9	35,8	39,6	43,7	45,2	6,7	1,9	4,7	4,5	3,2	4,1
Others	9	19	34	36	49	64	84	25,2	23,4	23,5	24,5	20,8	18,3	18,1	4,6	9,8	2,0	2,2	2,7	2,5
Non-energy	7	11	9	9	9	10	10	18,2	10,8	6,0	5,9	4,8	3,8	3,3	1,0	3,9	1,5	1,1	1,3	1,4
Total	**36,43**	**69,39**	**144,78**	**135,92**	**198,05**	**282,06**	**377,28**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**5,2**	**3,7**	**3,5**	**2,8**	**3,4**
Coal	0,82	5,05	23,44	22,60	31,09	42,60	54,43	2,2	10,6	16,2	16,8	17,2	17,2	17,1	12,3	9,0	3,9	3,5	2,8	3,6
Oil	23,60	43,68	76,01	68,21	92,80	126,90	164,41	64,8	57,8	52,5	51,7	50,8	50,7	50,7	4,1	3,7	3,5	3,5	2,8	3,3
Natural gas	9,62	13,85	16,57	16,04	21,20	28,66	37,48	26,4	21,1	11,4	12,0	12,5	11,3	10,2	1,9	10,0	4,2	2,4	1,8	3,0
Electricity	2,38	6,81	22,53	23,68	41,57	61,34	85,66	6,5	10,6	15,6	15,2	13,3	12,4	12,2	8,1	2,7	2,3	2,7	2,7	2,6
Heat	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,00	0,00	6,22	5,40	11,40	22,56	35,30	0,0	0,0	4,3	4,3	6,2	8,5	9,8	31,7	6,3	7,4	6,8	4,4	6,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33**	**91**	**294**	**303**	**520**	**767**	**1.071**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**0,8**	**2,1**	**2,7**	**2,7**	**2,5**
Coal	9,77	34,00	174,49	179,61	276,06	364,45	403,14	29,5	40,6	59,5	59,4	52,4	49,0	42,3	10,5	0,5	0,9	2,0	1,2	1,3
Oil	12,32	12,50	10,59	6,41	3,99	2,98	0,81	37,2	13,6	3,6	2,1	0,8	0,4	0,1	-0,5	-40,8	-7,9	-3,6	-12,0	-9,2
Natural gas	3,40	31,93	62,32	64,02	124,21	199,18	303,04	10,3	32,2	21,3	21,2	23,6	26,8	31,8	10,5	0,3	3,2	4,0	4,5	3,8
Nuclear	-	-	-	-	-	-	15,42	0,0	0,0	0,0	0,0	0,0	0,0	2,5	-	-	-	-	-	-
Hydro	6,49	10,02	19,48	22,80	44,51	58,04	97,58	19,6	8,4	6,6	7,5	8,5	7,8	6,8	3,9	14,4	3,3	1,9	1,4	2,6
Geothermal	1,13	2,65	14,10	16,10	34,24	53,58	73,18	3,4	5,2	4,8	5,3	6,5	7,2	7,7	9,1	11,5	4,2	3,8	3,4	4,0
Others	-	0,01	12,78	13,60	36,73	88,73	177,91	0,0	0,0	4,2	4,5	8,2	8,7	8,9	-	9,1	8,5	3,3	2,9	5,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8**	**18**	**75**	**76**	**100**	**112**	**127**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8,2**	**-1,2**	**-0,7**	**0,5**	**1,1**	**0,3**
Coal	2,60	8,07	57,72	59,41	76,31	77,96	79,35	34,4	53,4	76,6	78,0	76,2	70,1	61,9	11,3	0,5	-0,9	-0,3	-0,1	-0,4
Oil	3,99	4,69	3,14	1,93	1,18	0,88	0,24	52,8	24,1	4,2	2,5	1,2	0,8	0,2	-0,8	-39,8	-8,0	-3,6	-12,0	-9,2
Natural gas	0,97	5,58	14,49	14,85	22,64	33,25	47,38	12,8	22,5	19,2	19,5	22,6	29,1	37,9	9,8	0,1	0,8	3,1	3,8	2,5

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29**	**34**	**28**	**28**	**35**	**43**	**49**								**-0,1**	**-0,1**	**2,1**	**2,1**	**1,3**	**1,8**
Coal	32	36	26	26	31	40	44								-0,7	0,0	1,8	2,3	1,4	1,8
Oil	27	23	29	29	29	29	29								0,3	-1,7	0,2	0,0	0,0	0,0
Natural gas	30	49	37	37	47	52	55								0,7	0,2	2,4	0,9	0,7	1,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**30**	**38**	**164**	**157**	**211**	**263**	**321**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**2,9**	**2,0**	**2,5**	**2,3**	**2,3**
Coal	4	14	86	87	114	128	142	11,0	32,9	52,5	52,6	46,4	41,7	38,4	10,8	3,0	0,8	1,4	1,4	1,3
Oil	9	3	60	53	72	98	128	59,5	40,9	36,7	36,4	41,8	46,1	48,9	3,2	2,1	3,4	3,6	2,9	3,3
Natural gas	17	20	18	18	26	37	51	29,4	26,2	10,8	11,0	11,8	12,2	12,6	1,4	4,9	2,8	2,8	2,6	2,8

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	310	453	1.204	1.172	1.898	3.033	4.710	4,8	-2,7	4,9	4,8	4,5	4,5
Population (millions of people)	179	209	271	273	295	312	325	1,4	0,8	0,8	0,6	0,4	0,6
GDP per capita (thousands of 2015 USD/person)	1,7	2,2	4,5	4,3	6,4	9,7	14,5	3,3	-3,5	4,1	4,2	4,1	3,9
Primary energy consumption per capita (toe/person)	0,4	0,6	0,8	0,8	1,1	1,4	1,9	2,3	-3,6	2,7	3,0	2,6	2,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	254	263	190	190	166	148	128	-1,0	-0,2	-1,3	-1,1	-1,4	-1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	118	153	120	116	104	93	80	0,1	-3,5	-1,1	-1,1	-1,5	-1,3
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	96	83	136	134	111	87	68	1,2	-1,3	-1,9	-2,4	-2,4	-2,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,38	0,32	0,72	0,71	0,67	0,59	0,53	2,2	-1,1	-0,5	-1,3	-1,0	-1,0
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Indonesia LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**78,7**	**119,1**	**228,7**	**236,4**	**326,7**	**422,8**	**543,6**	**100,0**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**3,4**	**3,3**	**2,6**	**2,5**	**2,8**
Coal	3,4	13,1	81,2	80,8	78,0	76,2	67,7	4,3	11,0	35,5	34,2	23,9	18,0	12,5	11,5	-0,5	-0,3	-0,2	-1,2	-0,6
Oil	26,6	48,1	82,1	81,8	113,4	127,3	129,6	33,8	40,4	35,9	34,6	34,7	30,1	23,8	4,0	-0,5	3,3	1,2	0,2	1,5
Natural gas	26,2	31,8	32,5	35,2	40,0	43,3	51,7	33,2	26,7	14,2	14,9	12,3	10,2	9,5	0,8	8,3	1,3	0,8	1,8	1,5
Nuclear	-					4,0	8,0	-	-	-	-	-	1,0	1,5	-	-	-	-	7,2	-
Hydrogen/Ammonia			-	-	-	24,7	64,2	-	-	-	-	-	5,8	11,8	-	-	-	-	10,0	-
Hydro	0,6	0,9	1,7	2,1	5,1	10,6	21,9	0,7	0,7	0,7	0,9	1,6	2,5	4,0	3,9	22,5	9,6	7,5	7,6	8,6
Geothermal	1,0	2,3	12,1	14,5	43,6	57,0	83,6	1,2	1,9	5,3	6,1	13,3	13,5	15,4	9,1	19,4	11,6	2,7	3,9	6,4
Others	21,0	23,0	19,1	22,2	46,6	79,8	117,0	26,7	19,3	8,4	9,4	14,3	18,9	21,5	-0,3	15,8	7,7	5,5	3,9	6,0
Biomass	21,0	23,0	13,0	15,6	31,2	49,4	67,6	26,7	19,3	5,7	6,6	9,6	11,7	12,4	-1,6	20,0	7,2	4,7	3,2	5,5
Solar, Wind, Ocean	-	0,0	0,1	0,1	2,0	4,5	9,5	-	0,0	0,0	0,0	0,6	1,1	1,8	-	71,1	36,7	8,2	7,9	18,3
Biofuels	-	-	6,1	6,5	13,4	25,9	39,8	-	-	2,7	2,7	4,1	6,1	7,3	-	6,4	7,6	6,8	4,4	6,3
Electricity															-	-	-	-	-	-

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**36,4**	**69,4**	**144,8**	**152,3**	**219,3**	**286,9**	**361,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**5,2**	**3,7**	**2,7**	**2,3**	**3,0**
Industry	12,4	23,9	48,6	51,5	75,9	97,8	105,1	34,0	39,2	33,6	33,8	34,6	34,1	29,1	4,8	5,9	4,0	2,6	0,7	2,5
Transportation	8,2	16,3	53,4	54,5	87,5	121,5	172,3	22,6	26,6	36,9	35,8	39,9	42,4	47,6	6,7	1,9	4,8	3,3	3,6	3,9
Others	9,2	18,6	34,0	37,3	45,4	55,9	71,0	25,2	23,4	23,5	24,5	20,7	19,5	19,6	4,6	9,8	2,0	2,1	2,4	2,4
Non-energy	6,6	10,6	8,7	9,1	10,5	11,7	13,3	18,2	10,8	6,0	5,9	4,8	4,1	3,7	1,0	3,9	1,5	1,1	1,3	1,4
Total	**36,4**	**69,4**	**144,8**	**152,3**	**219,3**	**286,9**	**361,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**5,2**	**3,7**	**2,7**	**2,3**	**3,0**
Coal	0,8	5,1	23,4	25,6	37,5	37,8	33,2	2,2	10,6	16,2	16,8	17,1	13,2	9,2	12,3	9,0	3,9	0,1	-1,3	1,1
Oil	23,6	43,7	76,0	78,8	110,8	125,2	128,3	64,8	57,8	52,5	51,7	50,5	43,6	35,5	4,1	3,7	3,5	1,2	0,2	1,7
Natural gas	9,6	13,8	16,6	18,2	27,4	26,6	24,0	26,4	21,1	11,4	12,0	12,5	9,3	6,6	1,9	10,0	4,2	-0,3	-1,0	1,2
Hydrogen/Ammonia			-	-	-	24,7	64,2	0,0	0,0	0,0	0,0	0,0	8,6	17,7				-	10,0	-
Electricity	2,4	6,8	22,5	23,1	30,0	46,6	72,1	6,5	10,6	15,6	15,2	13,7	16,2	19,9	8,1	2,6	2,7	4,5	4,5	3,8
Heat	-	-						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	6,2	6,6	13,5	26,1	40,0	0,0	0,0	4,3	4,3	6,2	9,1	11,0	31,7	6,3	7,4	6,8	4,4	6,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,1**	**91,1**	**293,2**	**295,5**	**375,7**	**579,2**	**896,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,8**	**0,8**	**2,4**	**4,4**	**4,5**	**3,7**
Coal PP	9,8	34,0	174,5	166,9	142,6	123,3	103,7	29,5	40,6	59,5	56,5	38,0	21,3	12	10,5	-4,4	-1,6	-1,4	-1,7	-1,7
Coal PP with CCS						55,3	74,1	0,0	0,0	0,0	0,0	0,0	9,5	8						
Oil	12,3	12,5	10,6	6,7	5,4	3,7	0,9	37,2	13,6	3,6	2,3	1,4	0,6	0	-0,5	-36,6	-2,2	-3,7	-12,9	-7,6
Gas PP	3,4	31,9	62,3	67,0	58,9	42,3	37,0	10,3	32,2	21,3	22,7	15,7	7,3	4	10,5	7,5	-1,3	-3,3	-1,3	-1,7
Gas PP PP with CCS						49,1	123,5	0,0	0,0	0,0	0,0	0,0	8,5	14						
Hydrogen/Ammonia PP																				
Nuclear						15,4	30,8	0,0	0,0	0,0	0,0	0,0	2,7	3	-	-	-	-	7,2	-
Solar			0,1	0,5	17,4	36,8	67,9	0,0	0,0	0,0	0,2	4,6	6,4	8						
Wind			0,5	0,6	6,1	12,3	37,0	0,0	0,0	0,2	0,2	1,6	2,1	4						
Hydro	6,5	10,0	19,5	23,9	59,8	92,1	192,6	19,6	8,4	6,6	8,1	15,9	15,9	21	3,9	22,5	9,6	4,4	7,7	7,7
Geothermal	1,1	2,6	14,1	16,8	50,6	66,3	97,2	3,4	5,2	4,8	5,7	13,5	11,4	11	9,1	19,4	11,6	2,7	3,9	6,4
Others			11,6	13,2	34,8	82,6	131,5	0,0	0,0	3,9	4,5	9,3	14,3	15	-	14,1	10,2	9,0	4,8	8,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,10**	**0,86**	**1,30**	**1,79**	**1,78**	**8,19**	**15,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9,3**	**37,5**	**-0,1**	**16,5**	**6,4**	**8,2**
Coal	0,00	0,00	1,09	1,30	1,34	1,76	3,86	0,0	0,0	83,9	72,3	75,3	21,5	25,4	-	18,5	0,3	2,8	8,2	4,1
Oil	0,10	0,86	0,21	0,50	0,44	0,38	0,32	100,0	100,0	16,1	27,7	24,7	4,6	2,1	2,6	136,8	-1,2	-1,4	-1,7	1,4
Gas	0,00	0,00	-	-	-	6,06	11,02	0,0	0,0	0,0	0,0	0,0	73,9	72,5	-	-	-	-	6,2	-
Hydrogen/Ammonia	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29,0**	**36,8**	**28,2**	**28,4**	**33,3**	**42,6**	**47,2**								**-0,1**	**0,7**	**1,6**	**2,5**	**1,0**	**1,7**
Coal	32,3	36,3	26,0	26,0	30,3	40,0	44,3								-0,7	0,0	1,5	-0,9	-0,7	0,0
Oil	26,5	22,9	29,0	28,5	29,0	29,0	29,0								0,3	-1,7	0,2	0,0	0,0	0,0
Gas	30,2	49,2	37,0	37,1	44,2	23,2	11,8													
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**29,7**	**37,8**	**163,6**	**166,1**	**190,9**	**197,3**	**169,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**1,5**	**1,4**	**0,3**	**-1,5**	**0,1**
Coal	3,7	14,4	85,9	85,5	82,5	78,9	56,6	11,0	32,9	52,5	51,5	43,2	40,0	33,4	10,8	-0,5	-0,3	-0,4	-3,3	-1,3
Oil	9,2	3,1	60,1	61,4	86,7	95,5	96,9	59,5	40,9	36,7	37,0	45,4	48,4	57,2	3,2	2,3	3,5	1,0	0,2	1,6
Natural gas	16,8	20,3	17,7	19,2	21,7	23,0	16,0	29,4	26,2	10,8	11,6	11,4	11,6	9,4	1,4	8,7	1,2	0,6	-3,6	-0,3

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	309,8	453,4	1.204,5	1.171,9	1.898,0	3.033,2	4.710,5	4,8	-2,7	4,9	4,8	4,5	4,5
Population (millions of people)	178,6	208,9	270,6	272,8	294,8	312,4	325,1	1,4	0,8	0,8	0,6	0,4	0,6
GDP per capita (thousands of 2015 USD/person)	1,7	2,2	4,5	4,3	6,4	9,7	14,49	3,3	-3,5	4,1	4,2	4,1	3,9
Primary energy consumption per capita (toe/person)	0,4	0,6	0,8	0,9	1,1	1,4	1,67	2,3	2,5	2,5	2,0	2,1	2,2
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	254,0	262,7	189,9	201,7	172,1	139,4	115	-1,0	6,2	-1,6	-2,1	-1,9	-1,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	117,6	153,0	120,2	130,0	115,5	94,6	77	0,1	8,1	-1,2	-2,0	-2,1	-1,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	96,0	83,4	135,9	141,7	100,6	65,1	36	1,2	4,3	-3,4	-4,3	-5,8	-4,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,4	0,3	0,7	0,7	0,6	0,5	0,31	2,2	-1,8	-1,8	-2,2	-4,0	-2,6
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Japan BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**437,33**	**516,14**	**415,31**	**384,29**	**392,35**	**365,63**	**339,75**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,2**	**-7,5**	**0,2**	**-0,7**	**-0,7**	**-0,6**
Coal	77,14	97,28	115,36	105,54	92,07	83,74	73,77	17,6	18,8	27,8	27,5	23,5	22,9	21,7	1,4	-8,5	-1,4	-0,9	-1,3	-1,4
Oil	248,79	253,09	159,34	146,00	135,43	115,79	98,35	56,9	49,0	38,4	38,0	34,5	31,7	28,9	-1,5	-8,4	-0,7	-1,6	-1,6	-1,5
Natural gas	44,12	65,63	92,08	89,54	84,41	82,40	76,66	10,1	12,7	22,2	23,3	21,5	22,5	22,6	2,6	-2,8	-0,6	-0,2	-0,7	-0,6
Nuclear	52,70	83,91	16,62	10,10	40,96	36,76	36,66	12,1	16,3	4,0	2,6	10,4	10,1	10,8	-3,9	-39,2	15,0	-1,1	0,0	2,6
Hydro	7,56	7,23	6,84	7,21	7,82	8,11	8,19	1,7	1,4	1,6	1,9	2,0	2,2	2,4	-0,3	5,3	0,8	0,4	0,1	0,6
Geothermal	1,58	3,10	2,56	2,90	5,29	8,43	10,86	0,4	0,6	0,6	0,8	1,3	2,3	3,2	1,7	13,0	6,2	4,8	2,6	4,8
Others	5,44	5,90	22,50	23,00	26,38	30,40	35,26	1,2	1,1	5,4	6,0	6,7	8,3	10,4	5,0	2,2	1,4	1,4	1,5	1,5
Biomass	4,22	5,05	15,73	15,57	17,26	18,46	19,09	1,0	1,0	3,8	4,1	4,4	5,0	5,6	4,6	-1,0	1,0	0,7	0,3	0,6
Solar, Wind, Ocean	1,22	0,85	6,77	7,43	9,12	11,95	16,17	0,3	0,2	1,6	1,9	2,3	3,3	4,8	6,1	9,7	2,1	2,7	3,1	2,8
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**291,36**	**336,08**	**279,11**	**262,00**	**259,52**	**240,29**	**221,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-6,1**	**-0,1**	**-0,8**	**-0,8**	**-0,7**
Industry	107,87	103,41	81,40	74,21	72,58	66,58	60,65	37,0	30,8	29,2	28,3	28,0	27,7	27,3	-1,0	-8,8	-0,2	-0,9	-0,9	-0,9
Transportation	71,91	88,99	69,33	61,26	59,12	50,14	42,97	24,7	26,5	24,8	23,4	22,8	20,9	19,4	-0,1	-11,6	-0,4	-1,6	-1,5	-1,5
Others	78,17	107,80	95,26	94,99	96,22	92,68	88,26	26,8	32,1	34,1	36,3	37,1	38,6	39,8	0,7	-0,3	0,1	-0,4	-0,5	-0,2
Non-energy	33,41	35,87	33,11	31,54	31,61	30,89	30,01	11,5	10,7	11,9	12,0	12,2	12,9	13,5	0,0	-4,7	0,0	-0,2	-0,3	-0,3
Total	**291,36**	**336,08**	**279,11**	**262,00**	**259,52**	**240,29**	**221,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-6,1**	**-0,1**	**-0,8**	**-0,8**	**-0,7**
Coal	27,08	20,89	20,78	18,32	17,19	14,99	13,06	9,3	6,2	7,4	7,0	6,6	6,2	5,9	-0,9	-11,8	-0,6	-1,4	-1,4	-1,5
Oil	180,96	205,57	142,67	131,82	124,25	107,18	92,38	62,1	61,2	51,1	50,3	47,9	44,6	41,6	-0,8	-7,6	-0,6	-1,5	-1,5	-1,4
Natural gas	13,61	21,32	28,86	28,59	30,57	28,03	24,87	4,7	6,3	10,3	10,9	11,8	11,7	11,2	2,6	-1,0	0,7	-0,9	-1,2	-0,5
Electricity	65,76	83,64	79,76	76,48	80,62	83,64	85,62	22,6	24,9	28,6	29,2	31,1	34,8	38,6	0,7	-4,1	0,5	0,4	0,2	0,2
Heat	0,20	0,54	0,54	0,55	0,54	0,48	0,40	0,1	0,2	0,2	0,2	0,2	0,2	0,2	3,5	0,5	-0,1	-1,2	-1,8	-1,0
Others	3,75	4,11	6,48	6,24	6,35	5,97	5,57	1,3	1,2	2,3	2,4	2,4	2,5	2,5	1,9	-3,8	0,2	-0,6	-0,7	-0,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**861,54**	**1.055,05**	**1.037,32**	**994,73**	**1.045,63**	**1.079,79**	**1.099,60**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,6**	**-4,1**	**0,5**	**0,3**	**0,2**	**0,2**
Coal	124,71	228,20	329,22	314,61	257,45	246,97	220,80	14,5	21,6	31,7	31,6	24,6	22,9	20,1	3,4	-4,4	-2,0	-0,4	-1,1	-1,3
Oil	249,53	133,16	36,12	33,54	19,11	9,63	0,12	29,0	12,6	3,5	3,4	1,8	0,9	0,0	-6,4	-7,1	-5,5	-6,6	-35,5	-16,8
Natural gas	167,69	254,56	385,49	372,25	337,68	358,44	354,11	19,5	24,1	37,2	37,4	32,3	33,2	32,2	2,9	-3,4	-1,0	0,6	-0,1	-0,3
Nuclear	202,27	322,05	63,78	38,75	157,21	141,09	140,70	23,5	30,5	6,1	3,9	15,0	13,1	12,8	-3,9	-39,2	15,0	-1,1	0,0	2,6
Hydro	87,90	84,05	79,60	83,85	90,98	94,29	95,31	10,2	8,0	7,7	8,4	8,7	8,7	8,7	-0,3	5,3	0,8	0,4	0,1	0,6
Geothermal	1,74	3,35	2,83	3,22	6,01	9,69	12,54	0,2	0,3	0,3	0,3	0,6	0,9	1,1	1,7	13,7	6,4	4,9	2,6	4,9
Others	27,69	29,68	140,28	148,50	177,20	219,68	276,02	3,2	2,8	13,5	14,9	16,9	20,3	25,1	5,8	5,9	1,8	2,2	2,3	2,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**113,32**	**122,67**	**141,75**	**133,74**	**110,28**	**103,93**	**92,17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,8**	**-5,7**	**-1,9**	**-0,6**	**-1,2**	**-1,4**
Coal	27,03	46,66	69,32	65,54	52,29	47,35	40,25	23,8	38,0	48,9	49,0	47,4	45,6	43,7	3,3	-5,5	-2,2	-1,0	-1,6	-1,7
Oil	52,73	28,45	8,96	7,03	4,13	2,14	0,03	46,5	23,2	6,3	5,3	3,7	2,1	0,0	-5,9	-21,6	-5,2	-6,4	-35,4	-17,1
Natural gas	33,56	47,57	63,47	61,17	53,86	54,45	51,90	29,6	38,8	44,8	45,7	48,8	52,4	56,3	2,2	-3,6	-1,3	0,1	-0,5	-0,6

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,1**	**43,2**	**45,6**	**46,3**	**47,9**	**50,9**	**53,7**								**0,4**	**1,7**	**0,3**	**0,6**	**0,5**	**0,5**
Coal	39,7	42,1	40,8	41,3	42,3	44,9	47,2								0,1	1,1	0,3	0,6	0,5	0,5
Oil	40,7	40,3	34,7	41,1	39,8	38,8	38,2								-0,6	18,4	-0,3	-0,3	-0,1	0,3
Natural gas	43,0	46,0	52,2	52,3	53,9	56,6	58,7								0,7	0,2	0,3	0,5	0,4	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**286,2**	**314,1**	**288,9**	**267,6**	**241,6**	**216,1**	**188,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-7,4**	**-1,0**	**-1,1**	**-1,4**	**-1,4**
Coal	79,1	98,1	111,7	111,8	97,7	89,1	78,7	27,6	31,2	38,7	41,8	40,4	41,2	41,8	1,2	0,1	-1,3	-0,9	-1,2	-1,1
Oil	179,1	175,2	120,9	97,4	88,7	73,1	59,3	62,6	55,8	41,9	36,4	36,7	33,8	31,5	-1,3	-19,5	-0,9	-1,9	-2,1	-2,3
Natural gas	28,0	40,7	56,3	58,4	55,1	54,0	50,4	9,8	13,0	19,5	21,8	22,8	25,0	26,7	2,4	3,7	-0,6	-0,2	-0,7	-0,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3.477	3.954	4.591	4.371	4.926	5.342	5.737	1,0	-4,8	1,2	0,8	0,7	0,7
Population (millions of people)	123,5	126,8	126,3	125,9	120,2	112,8	105,3	0,1	-0,3	-0,5	-0,6	-0,7	-0,6
GDP per capita (thousands of 2015 USD/person)	28,15	31,17	36,36	34,72	40,99	47,35	54,48	0,9	-4,5	1,7	1,5	1,4	1,3
Primary energy consumption per capita (toe/person)	3,54	4,07	3,29	3,05	3,26	3,24	3,23	-0,3	-7,2	0,7	-0,1	0,0	-0,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	126	131	90	88	80	68	59	-1,1	-2,8	-1,0	-1,5	-1,4	-1,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	84	85	61	60	53	45	39	-1,1	-1,4	-1,3	-1,6	-1,5	-1,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	82	79	63	61	49	40	33	-0,9	-2,7	-2,2	-1,9	-2,1	-2,1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,61	0,70	0,70	0,62	0,59	0,55	0,2	0,1	-1,2	-0,4	-0,6	-0,7
Automobile ownership volume (millions of vehicles)	57,7	72,4	78,1	78,0	76,0	72,0	67,6	1,0	0,0	-0,3		-1,2	-0,5
Automobile ownership volume per capita (vehicles per person)	0,467	0,571	0,618	0,620	0,632	0,638	0,642	1,0	0,3	0,2		0,1	0,1

Japan APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**437,33**	**516,14**	**415,31**	**384,68**	**388,56**	**344,20**	**304,25**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,2**	**-7,4**	**0,1**	**-1,2**	**-1,2**	**-1,0**
Coal	77,14	97,28	115,36	105,31	76,27	58,77	38,15	17,6	18,8	27,8	27,4	19,6	17,1	12,5	1,4	-8,7	-3,2	-2,6	-4,2	-3,5
Oil	248,79	253,09	159,34	145,94	127,21	102,07	83,27	56,9	49,0	38,4	37,9	32,7	29,7	27,4	-1,5	-8,4	-1,4	-2,2	-2,0	-2,1
Natural gas	44,12	65,63	92,08	89,42	73,30	61,99	42,52	10,1	12,7	22,2	23,2	18,9	18,0	14,0	2,6	-2,9	-2,0	-1,7	-3,7	-2,5
Nuclear	52,70	83,91	16,62	10,10	64,46	58,61	58,45	12,1	16,3	4,0	2,6	16,6	17,0	19,2	-3,9	-39,2	20,4	-0,9	0,0	4,1
Hydro	7,56	7,23	6,84	7,21	7,88	8,19	8,28	1,7	1,4	1,6	1,9	2,0	2,4	2,7	-0,3	5,3	0,9	0,4	0,1	0,6
Geothermal	1,58	3,10	2,56	2,89	6,52	10,87	15,65	0,4	0,6	0,6	0,8	1,7	3,2	5,1	1,7	13,0	8,5	5,2	3,7	6,0
Others	5,44	5,90	22,50	23,80	32,92	43,71	57,92	1,2	1,1	5,4	6,2	8,5	12,7	19,0	5,0	5,8	3,3	2,9	2,9	3,1
Biomass	4,22	5,05	15,73	16,37	20,78	23,35	25,29	1,0	1,0	3,8	4,3	5,3	6,8	8,3	4,6	4,1	2,4	1,2	0,8	1,5
Solar, Wind, Ocean	1,22	0,85	6,77	7,43	12,14	20,36	32,63	0,3	0,2	1,6	1,9	3,1	5,9	10,7	6,1	9,7	5,0	5,3	4,8	5,2
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**291,36**	**336,08**	**279,11**	**261,76**	**250,23**	**219,49**	**193,71**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-6,2**	**-0,4**	**-1,3**	**-1,2**	**-1,2**
Industry	107,87	103,41	81,40	74,21	71,50	62,62	53,57	37,0	30,8	29,2	28,4	28,6	28,5	27,7	-1,0	-8,8	-0,4	-1,3	-1,5	-1,3
Transportation	71,91	88,99	69,33	61,25	54,57	42,77	36,65	24,7	26,5	24,8	23,4	21,8	19,5	18,9	-0,1	-11,7	-1,1	-2,4	-1,5	-2,0
Others	78,17	107,80	95,26	94,76	92,56	83,21	73,48	26,8	32,1	34,1	36,2	37,0	37,9	37,9	0,7	-0,5	-0,2	-1,1	-1,2	-0,8
Non-energy	33,41	35,87	33,11	31,54	31,61	30,89	30,01	11,5	10,7	11,9	12,1	12,6	14,1	15,5	0,0	-4,7	0,0	-0,2	-0,3	-0,3
Total	**291,36**	**336,08**	**279,11**	**261,76**	**250,23**	**219,49**	**193,71**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-6,2**	**-0,4**	**-1,3**	**-1,2**	**-1,2**
Coal	27,08	20,89	20,78	18,28	15,44	12,11	9,39	9,3	6,2	7,4	7,0	6,2	5,5	4,8	-0,9	-12,0	-1,7	-2,4	-2,5	-2,5
Oil	180,96	205,57	142,67	131,77	118,34	94,77	77,93	62,1	61,2	51,1	50,3	47,3	43,2	40,2	-0,8	-7,6	-1,1	-2,2	-1,9	-1,9
Natural gas	13,61	21,32	28,86	28,55	29,39	24,30	18,73	4,7	6,3	10,3	10,9	11,7	11,1	9,7	2,6	-1,1	0,3	-1,9	-2,6	-1,4
Electricity	65,76	83,64	79,76	76,38	80,31	81,86	80,95	22,6	24,9	28,6	29,2	32,1	37,3	41,8	0,7	-4,2	0,5	0,2	-0,1	0,0
Heat	0,20	0,54	0,54	0,54	0,51	0,40	0,29	0,1	0,2	0,2	0,2	0,2	0,2	0,1	3,5	0,1	-0,6	-2,3	-3,4	-2,0
Others	3,75	4,11	6,48	6,23	6,24	6,04	6,42	1,3	1,2	2,3	2,4	2,5	2,8	3,3	1,9	-3,9	0,0	-0,3	0,6	0,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**861,54**	**1.055,05**	**1.037,32**	**993,46**	**1.041,24**	**1.054,61**	**1.036,21**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,6**	**-4,2**	**0,5**	**0,1**	**-0,2**	**0,0**
Coal	124,71	228,20	329,22	314,06	187,34	131,78	46,84	14,5	21,6	31,7	31,6	18,0	12,5	4,5	3,4	-4,6	-5,0	-3,5	-9,8	-6,1
Oil	249,53	133,16	36,12	33,48	9,91	6,04	0,04	29,0	12,6	3,5	3,4	1,0	0,6	0,0	-6,4	-7,3	-11,5	-4,8	-38,9	-19,5
Natural gas	167,69	254,56	385,49	371,59	272,11	248,00	162,26	19,5	24,1	37,2	37,4	26,1	23,5	15,7	2,9	-3,6	-3,1	-0,9	-4,2	-2,8
Nuclear	202,27	322,05	63,78	38,75	247,38	224,93	224,32	23,5	30,5	6,1	3,9	23,8	21,3	21,6	-3,9	-39,2	20,4	-0,9	0,0	4,1
Hydro	87,90	84,05	79,60	83,85	91,63	95,21	96,30	10,2	8,0	7,7	8,4	8,8	9,0	9,3	-0,3	5,3	0,9	0,4	0,1	0,6
Geothermal	1,74	3,35	2,83	3,22	7,46	12,54	18,14	0,2	0,3	0,3	0,3	0,7	1,2	1,8	1,7	13,7	8,8	5,3	3,8	6,2
Others	27,69	29,68	140,28	148,50	225,42	336,11	488,30	3,2	2,8	13,5	14,9	21,6	31,9	47,1	5,8	5,9	4,3	4,1	3,8	4,1

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**113,32**	**122,67**	**141,75**	**133,54**	**84,71**	**65,03**	**33,01**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,8**	**-5,8**	**-4,4**	**-2,6**	**-6,6**	**-4,6**
Coal	27,03	46,66	69,32	65,43	38,72	26,07	9,37	23,8	38,0	48,9	49,0	45,7	40,1	28,4	3,3	-5,6	-5,1	-3,9	-9,7	-6,3
Oil	52,73	28,45	8,96	7,01	2,11	1,33	0,01	46,5	23,2	6,3	5,3	2,5	2,0	0,0	-5,9	-21,7	-11,3	-4,5	-38,8	-19,8
Natural gas	33,56	47,57	63,47	61,10	43,88	37,63	23,63	29,6	38,8	44,8	45,8	51,8	57,9	71,6	2,2	-3,7	-3,3	-1,5	-4,5	-3,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,1**	**43,2**	**45,6**	**46,3**	**47,7**	**51,0**	**54,5**								**0,4**	**1,7**	**0,3**	**0,7**	**0,7**	**0,6**
Coal	39,7	42,1	40,8	41,3	41,6	43,5	43,0								0,1	1,1	0,1	0,4	-0,1	0,2
Oil	40,7	40,3	34,7	41,1	40,3	39,0	38,4								-0,6	18,4	-0,2	-0,3	-0,1	0,3
Natural gas	43,0	46,0	52,2	52,3	53,3	56,7	59,1								0,7	0,1	0,2	0,6	0,4	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**286,2**	**314,1**	**288,9**	**267,2**	**211,3**	**166,3**	**118,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-7,5**	**-2,3**	**-2,4**	**-3,3**	**-2,8**
Coal	79,1	98,1	111,7	111,6	80,1	61,9	40,7	27,6	31,2	38,7	41,8	37,9	37,2	34,3	1,2	-0,1	-3,3	-2,5	-4,1	-3,2
Oil	179,1	175,2	120,9	97,3	84,0	65,3	51,7	62,6	55,8	41,9	36,4	39,8	39,3	43,6	-1,3	-19,5	-1,5	-2,5	-2,3	-2,7
Natural gas	28,0	40,7	56,3	58,3	47,2	39,1	26,1	9,8	13,0	19,5	21,8	22,3	23,5	22,0	2,4	3,6	-2,1	-1,9	-4,0	-2,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3.477	3.954	4.591	4.371	4.926	5.342	5.737	1,0	-4,8	1,2	0,8	0,7	0,7
Population (millions of people)	124	127	126	126	120	113	105	0,1	-0,3	-0,5	-0,6	-0,7	-0,6
GDP per capita (thousands of 2015 USD/person)	28,15	31,17	36,36	34,72	40,99	47,35	54,48	0,9	-4,5	1,7	1,5	1,4	1,3
Primary energy consumption per capita (toe/person)	3,54	4,07	3,29	3,06	3,23	3,05	2,89	-0,3	-7,1	0,6	-0,6	-0,5	-0,4
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	126	131	90	88	79	64	53	-1,1	-2,7	-1,1	-2,0	-1,9	-1,7
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	84	85	61	60	51	41	34	-1,1	-1,5	-1,6	-2,1	-1,9	-1,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	82	79	63	61	43	31	21	-0,9	-2,8	-3,5	-3,2	-4,0	-3,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,61	0,70	0,69	0,54	0,48	0,39	0,2	-0,1	-2,4	-1,2	-2,1	-1,9
Automobile ownership volume (millions of vehicles)	58	72	78	78	76	72	68	1,0	0,0	-0,3	-0,8	-1,2	-0,5
Automobile ownership volume per capita (vehicles per person)	0,467	0,571	0,618	0,620	0,632	0,638	0,642	1,0	0,3	0,2	0,3	0,1	0,1

Japan LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**437,33**	**516,14**	**415,31**	**382,48**	**359,89**	**289,47**	**235,81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,2**	**-7,9**	**-0,6**	**-2,2**	**-2,0**	**-1,8**
Coal	77,14	97,28	115,36	105,31	71,04	42,13	14,04	17,6	18,8	27,8	27,5	19,7	14,6	6,0	1,4	-8,7	-3,9	-5,1	-10,4	-6,6
Oil	248,79	253,09	159,34	145,94	112,57	69,06	35,17	56,9	49,0	38,4	38,2	31,3	23,9	14,9	-1,5	-8,4	-2,6	-4,8	-6,5	-4,8
Natural gas	44,12	65,63	92,08	89,42	57,81	34,33	17,02	10,1	12,7	22,2	23,4	16,1	11,9	7,2	2,6	-2,9	-4,3	-5,1	-6,8	-5,3
Nuclear	52,70	83,91	16,62	10,10	56,05	56,20	58,59	12,1	16,3	4,0	2,6	15,6	19,4	24,8	-3,9	-39,2	18,7	0,0	0,4	4,1
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	3,06	13,73	17,23	0,0	0,0	0,0	0,0	0,9	4,7	7,3	-	-	355,0	16,2	2,3	-
Hydro	7,56	7,23	6,84	7,21	7,75	8,17	8,98	1,7	1,4	1,6	1,9	2,2	2,8	3,8	-0,3	5,3	0,7	0,5	1,0	0,9
Geothermal	1,58	3,10	2,56	2,77	17,70	18,12	19,33	0,4	0,6	0,6	0,7	4,9	6,3	8,2	1,7	8,1	20,4	0,2	0,6	6,7
Others	5,44	5,90	22,50	21,73	33,91	47,74	65,44	1,2	1,1	5,4	5,7	9,4	16,5	27,8	5,0	-3,4	4,6	3,5	3,2	3,5
Biomass	4,22	5,05	15,73	14,30	17,51	21,85	27,94	1,0	1,0	3,8	3,7	4,9	7,5	11,8	4,6	-9,0	2,0	2,2	2,5	1,9
Solar, Wind, Ocean	1,22	0,85	6,77	7,43	16,40	25,89	37,50	0,3	0,2	1,6	1,9	4,6	8,9	15,9	6,1	9,7	8,2	4,7	3,8	5,7
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**291,36**	**336,08**	**279,11**	**259,56**	**228,16**	**175,17**	**136,18**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-7,0**	**-1,3**	**-2,6**	**-2,5**	**-2,3**
Industry	107,87	103,41	81,40	74,21	66,21	55,42	45,40	37,0	30,8	29,2	28,6	29,0	31,6	33,3	-1,0	-8,8	-1,1	-1,8	-2,0	-1,9
Transportation	71,91	88,99	69,33	61,25	49,69	34,10	21,52	24,7	26,5	24,8	23,6	21,8	19,5	15,8	-0,1	-11,7	-2,1	-3,7	-4,5	-3,7
Others	78,17	107,80	95,26	92,56	80,66	54,76	39,25	26,8	32,1	34,1	35,7	35,4	31,3	28,8	0,7	-2,8	-1,4	-3,8	-3,3	-2,8
Non-energy	33,41	35,87	33,11	31,54	31,61	30,89	30,01	11,5	10,7	11,9	12,2	13,9	17,6	22,0	0,0	-4,7	0,0	-0,2	-0,3	-0,3
Total	**291,36**	**336,08**	**279,11**	**259,56**	**228,16**	**175,17**	**136,18**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0,1**	**-7,0**	**-1,3**	**-2,6**	**-2,5**	**-2,3**
Coal	27,08	20,89	20,78	18,28	13,36	7,27	2,99	9,3	6,2	7,4	7,0	5,9	4,2	2,2	-0,9	-12,0	-3,1	-5,9	-8,5	-6,1
Oil	180,96	205,57	142,67	131,77	104,61	63,73	32,31	62,1	61,2	51,1	50,8	45,8	36,4	23,7	-0,8	-7,6	-2,3	-4,8	-6,6	-4,7
Natural gas	13,61	21,32	28,86	28,55	24,12	10,60	2,47	4,7	6,3	10,3	11,0	10,6	6,0	1,8	2,6	-1,1	-1,7	-7,9	-13,6	-7,6
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,44	10,98	18,36	0,0	0,0	0,0	0,0	0,6	6,3	13,5	-	-	105,1	22,5	5,3	-
Electricity	65,76	83,64	79,76	76,38	79,01	76,04	71,67	22,6	24,9	28,6	29,4	34,6	43,4	52,6	0,7	-4,2	0,3	-0,4	-0,6	-0,3
Heat	0,20	0,54	0,54	0,54	0,41	0,14	0,00	0,1	0,2	0,2	0,2	0,2	0,1	0,0	3,5	0,1	-2,9	-10,0	-100,0	-100,0
Others	3,75	4,11	6,48	4,03	5,22	6,41	8,38	1,3	1,2	2,3	1,6	2,3	3,7	6,2	1,9	-37,8	2,6	2,1	2,7	0,8

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**861,54**	**1.055,05**	**1.037,32**	**993,46**	**1.024,30**	**1.052,15**	**1.124,33**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,6**	**-4,2**	**0,3**	**0,3**	**0,7**	**0,3**
Coal PP	124,71	228,20	329,22	314,06	188,78	66,29	0,00	14,5	21,6	31,7	31,6	18,4	6,3	0,0	3,4	-4,6	-5,0	-9,9	-100,0	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	5,84	44,19	22,49	0,0	0,0	0,0	0,0	0,6	4,2	2,0	-	-	-	22,4	-6,5	-
Oil	249,53	133,16	36,12	33,48	10,24	5,26	0,00	29,0	12,6	3,5	3,4	1,0	0,5	0,0	-6,4	-7,3	-11,2	-6,4	-100,0	-100,0
Gas PP	167,69	254,56	385,49	371,59	205,67	90,71	0,00	19,5	24,1	37,2	37,4	20,1	8,6	0,0	2,9	-3,6	-5,7	-7,9	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	6,36	60,47	89,95	0,0	0,0	0,0	0,0	0,6	5,7	8,0	-	-	-	25,3	4,0	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	10,24	57,87	112,43	0,0	0,0	0,0	0,0	1,0	5,5	10,0	-	-	-	18,9	6,9	-
Nuclear	202,27	322,05	63,78	38,75	215,10	215,69	224,87	23,5	30,5	6,1	3,9	21,0	20,5	20,0	-3,9	-39,2	18,7	0,0	0,4	4,1
Solar	0,07	0,36	68,95	75,65	153,01	188,60	210,31	0,0	0,0	6,6	7,6	14,9	17,9	18,7	27,0	9,7	7,3	2,1	1,1	3,7
Wind	0,00	0,11	7,67	8,58	36,22	111,72	225,42	0,0	0,0	0,7	0,9	3,5	10,6	20,0	-	11,8	15,5	11,9	7,3	11,5
Hydro	87,90	84,05	79,60	83,85	90,14	94,99	104,49	10,2	8,0	7,7	8,4	8,8	9,0	9,3	-0,3	5,3	0,7	0,5	1,0	0,9
Geothermal	1,74	3,35	2,83	3,22	20,49	21,04	22,49	0,2	0,3	0,3	0,3	2,0	2,0	2,0	1,7	13,7	20,3	0,3	0,7	6,9
Others	27,62	29,21	63,66	64,27	82,20	95,33	111,88	3,2	2,8	6,1	6,5	8,0	9,1	10,0	2,9	1,0	2,5	1,5	1,6	1,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**113,32**	**122,67**	**141,75**	**133,54**	**76,12**	**56,34**	**35,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,8**	**-5,8**	**-5,5**	**-3,0**	**-4,4**	**-4,3**
Coal	27,03	46,66	69,32	65,43	38,64	22,73	5,26	23,8	38,0	48,9	49,0	50,8	40,3	14,6	3,3	-5,6	-5,1	-5,2	-13,6	-8,0
Oil	52,73	28,45	8,96	7,01	2,15	1,19	0,00	46,5	23,2	6,3	5,3	2,8	2,1	0,0	-5,9	-21,7	-11,2	-5,7	-100,0	-100,0
Gas	33,56	47,57	63,47	61,10	33,71	23,79	14,60	29,6	38,8	44,8	45,8	44,3	42,2	40,6	2,2	-3,7	-5,8	-3,4	-4,8	-4,6
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,62	8,63	16,10	0,0	0,0	0,0	0,0	2,1	15,3	44,8	-	-	-	18,2	6,4	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,1**	**43,2**	**45,6**	**46,3**	**48,3**	**49,6**	**53,8**								**0,4**	**1,7**	**0,4**	**0,3**	**0,8**	**0,5**
Coal	39,7	42,1	40,8	41,3	43,3	41,8	36,8								0,1	1,1	0,5	-0,4	-1,3	-0,3
Oil	40,7	40,3	34,7	41,1	41,1	38,0	-								-0,6	18,4	0,0	-0,8	-	-
Gas	43,0	46,0	52,2	52,3	54,1	54,6	53,0								0,7	0,1	0,3	0,1	-0,3	0,0
Hydrogen/Ammonia	-	-	-	-	54,3	57,7	60,1								-	-	-	0,6	0,4	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**286,2**	**314,1**	**288,9**	**267,2**	**184,6**	**77,8**	**5,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-7,5**	**-3,6**	**-8,3**	**-23,7**	**-12,1**
Coal	79,1	98,1	111,7	111,6	75,9	32,3	3,6	27,6	31,2	38,7	41,8	41,1	41,5	68,6	1,2	-0,1	-3,8	-8,2	-19,8	-10,5
Oil	179,1	175,2	120,9	97,3	70,8	30,7	1,6	62,6	55,8	41,9	36,4	38,4	39,5	30,2	-1,3	-19,5	-3,1	-8,0	-25,7	-13,1
Natural gas	28,0	40,7	56,3	58,3	37,9	14,8	0,1	9,8	13,0	19,5	21,8	20,5	19,0	1,3	2,4	3,6	-4,2	-9,0	-41,9	-19,6

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	3.477	3.954	4.591	4.371	4.926	5.342	5.737	1,0	-4,8	1,2	0,8	0,7	0,7
Population (millions of people)	124	127	126	126	120	113	105	0,1	-0,3	-0,5	-0,6	-0,7	-0,6
GDP per capita (thousands of 2015 USD/person)	28,15	31,17	36,36	34,72	40,99	47,35	54,48	0,9	-4,5	1,7	1,5	1,4	1,3
Primary energy consumption per capita (toe/person)	3,54	4,07	3,29	3,04	2,99	2,57	2,24	-0,3	-7,6	-0,1	-1,5	-1,4	-1,2
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	126	131	90	88	73	54	41	-1,1	-3,3	-1,8	-2,9	-2,7	-2,5
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	84	85	61	59	46	33	24	-1,1	-2,3	-2,5	-3,4	-3,2	-3,0
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	82	79	63	61	37	15	1	-0,9	-2,8	-4,8	-9,0	-24,2	-12,8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,61	0,70	0,70	0,51	0,27	0,02	0,2	0,4	-3,0	-6,3	-22,1	-10,5
Automobile ownership volume (millions of vehicles)	58	72	78	78	76	72	68	1,0	0,0	-0,3	-0,5	-1,2	-0,5
Automobile ownership volume per capita (vehicles per person)	0,467	0,571	0,618	0,620	0,632	0,638	0,642	1,0	0,3	0,2	0,1	0,1	0,1

Korea BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**92,91**	**188,16**	**280,19**	**272,09**	**287,52**	**274,66**	**251,15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-2,9**	**0,6**	**-0,5**	**-0,9**	**-0,4**
Coal	25,38	41,95	80,04	74,17	80,30	74,56	62,89	27,3	22,3	28,6	27,3	27,9	27,1	25,0	4,0	-7,3	0,8	-0,7	-1,7	-0,8
Oil	49,73	99,04	104,43	98,83	101,93	94,59	85,80	53,5	52,6	37,3	36,3	35,5	34,4	34,2	2,6	-5,4	0,3	-0,7	-1,0	-0,6
Natural gas	2,73	17,01	48,87	48,08	61,69	67,40	69,76	2,9	9,0	17,4	17,7	21,5	24,5	27,8	10,5	-1,6	2,5	0,9	0,3	1,2
Nuclear	13,78	28,39	38,02	41,74	32,63	25,28	17,80	14,8	15,1	13,6	15,3	11,3	9,2	7,1	3,6	9,8	-2,4	-2,5	-3,4	-2,4
Hydro	0,55	0,34	0,24	0,31	0,31	0,31	0,31	0,6	0,2	0,1	0,1	0,1	0,1	0,1	-2,8	27,4	0,0	0,0	0,0	0,8
Geothermal	0,00	0,00	0,22	0,23	0,25	0,23	0,20	0,0	0,0	0,1	0,1	0,1	0,1	0,1	-	1,0	1,1	-0,8	-1,4	-0,4
Others	0,74	1,42	8,36	8,75	10,42	12,30	14,38	0,8	0,8	3,0	3,2	3,6	4,5	5,7	8,7	4,6	1,8	1,7	1,6	1,8
Biomass	0,73	1,38	6,68	6,80	7,52	7,93	8,03	0,8	0,7	2,4	2,5	2,6	2,9	3,2	7,9	1,8	1,0	0,5	0,1	0,6
Solar, Wind, Ocean	0,01	0,04	1,63	1,89	2,85	4,32	6,30	0,0	0,0	0,6	0,7	1,0	1,6	2,5	19,2	16,3	4,2	4,3	3,8	4,5
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**64,91**	**127,11**	**181,93**	**177,44**	**189,65**	**183,56**	**170,85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-2,5**	**0,7**	**-0,3**	**-0,7**	**-0,2**
Industry	19,26	38,47	47,19	46,60	50,88	49,10	45,18	29,7	30,3	25,9	26,3	26,8	26,8	26,4	3,1	-1,2	0,9	-0,4	-0,8	-0,1
Transportation	14,57	26,27	36,65	32,72	34,03	28,24	21,65	22,5	20,7	20,1	18,4	17,9	15,4	12,7	3,2	-10,7	0,4	-1,8	-2,6	-1,7
Others	24,35	37,34	45,41	45,54	47,91	46,86	44,20	37,5	29,4	25,0	25,7	25,3	25,5	25,9	2,2	0,3	0,5	-0,2	-0,6	-0,1
Non-energy	6,73	25,03	52,68	52,59	56,83	59,35	59,82	10,4	19,7	29,0	29,6	30,0	32,3	35,0	7,4	-0,2	0,8	0,4	0,1	0,4
Total	**64,91**	**127,11**	**181,93**	**177,44**	**189,65**	**183,56**	**170,85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-2,5**	**0,7**	**-0,3**	**-0,7**	**-0,2**
Coal	11,72	9,07	7,92	7,59	6,84	5,82	4,71	18,1	7,1	4,4	4,3	3,6	3,2	2,8	-1,3	-4,1	-1,0	-1,6	-2,1	-1,7
Oil	43,66	79,88	97,50	93,19	96,15	89,83	81,03	67,3	62,8	53,6	52,5	50,7	48,9	47,4	2,8	-4,4	0,3	-0,7	-1,0	-0,6
Natural gas	0,67	10,93	21,79	22,16	24,60	23,29	20,97	1,0	8,6	12,0	12,5	13,0	12,7	12,3	12,7	1,7	1,1	-0,5	-1,0	-0,1
Electricity	8,12	22,62	45,04	44,73	51,95	54,74	54,70	12,5	17,8	24,8	25,2	27,4	29,8	32,0	6,1	-0,7	1,5	0,5	0,0	0,6
Heat	0,00	3,29	5,50	5,52	5,59	5,26	4,78	0,0	2,6	3,0	3,1	2,9	2,9	2,8	-	0,5	0,1	-0,6	-1,0	-0,5
Others	0,74	1,32	4,18	4,25	4,52	4,62	4,66	1,1	1,0	2,3	2,4	2,4	2,5	2,7	6,2	1,8	0,6	0,2	0,1	0,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**105,37**	**288,53**	**578,03**	**573,84**	**666,33**	**701,07**	**699,11**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,0**	**-0,7**	**1,5**	**0,5**	**0,0**	**0,6**
Coal	17,66	111,40	246,07	228,87	272,34	267,74	234,48	16,8	38,6	42,6	39,9	40,9	38,2	33,5	9,5	-7,0	1,8	-0,2	-1,3	-0,2
Oil	18,86	34,58	9,30	8,28	5,00	0,00	0,00	17,9	12,0	1,6	1,4	0,8	0,0	0,0	-2,4	-11,0	-4,9	-100,0	-	-100,0
Natural gas	9,60	29,46	146,09	139,50	213,47	267,20	303,40	9,1	10,2	25,3	24,3	32,0	38,1	43,4	9,8	-4,5	4,3	2,3	1,3	2,4
Nuclear	52,89	108,96	145,91	160,18	125,21	97,02	68,30	50,2	37,8	25,2	27,9	18,8	13,8	9,8	3,6	9,8	-2,4	-2,5	-3,4	-2,4
Hydro	6,36	4,01	2,79	3,56	3,56	3,56	3,56	6,0	1,4	0,5	0,6	0,5	0,5	0,5	-2,8	27,4	0,0	0,0	0,0	0,8
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	0,001	0,12	27,87	33,45	46,74	65,56	89,38	0,0	0,0	4,8	5,8	7,0	9,4	12,8	42,3	20,0	3,4	3,4	3,1	3,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,52**	**40,44**	**84,04**	**78,17**	**95,31**	**97,43**	**93,03**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**-7,0**	**2,0**	**0,2**	**-0,5**	**0,3**
Coal	5,98	27,06	56,76	52,56	59,18	55,42	46,34	47,7	66,9	67,5	67,2	62,1	56,9	49,8	8,1	-7,4	1,2	-0,7	-1,8	-0,7
Oil	4,51	7,63	2,42	1,90	1,16	0,00	0,00	36,0	18,9	2,9	2,4	1,2	0,0	0,0	-2,1	-21,5	-4,8	-100,0	-	-100,0
Natural gas	2,04	5,76	24,86	23,71	34,97	42,01	46,69	16,3	14,2	29,6	30,3	36,7	43,1	50,2	9,0	-4,6	4,0	1,8	1,1	2,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**37,3**	**41,1**	**41,4**	**44,3**	**47,2**	**49,7**								**0,9**	**0,9**	**0,7**	**0,6**	**0,5**	**0,6**
Coal	25,4	35,4	37,3	37,4	39,6	41,5	43,5								1,3	0,5	0,6	0,5	0,5	0,5
Oil	35,9	39,0	33,1	37,5	37,1	-	-								-0,3	13,4	-0,1	-	-	-
Natural gas	40,5	44,0	50,5	50,6	52,5	54,7	55,9								0,8	0,1	0,4	0,4	0,2	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**57,4**	**110,8**	**160,0**	**147,9**	**162,3**	**152,8**	**135,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-7,6**	**0,9**	**-0,6**	**-1,2**	**-0,5**
Coal	24,8	43,5	85,8	79,0	85,3	79,3	67,2	43,3	39,2	53,6	53,4	52,5	51,9	49,6	4,4	-7,9	0,8	-0,7	-1,6	-0,8
Oil	30,9	56,4	41,4	36,9	36,1	28,7	21,7	53,9	50,9	25,9	24,9	22,2	18,8	16,0	1,0	-11,0	-0,2	-2,3	-2,7	-2,1
Natural gas	1,7	11,0	32,8	32,0	41,0	44,9	46,7	2,9	9,9	20,5	21,7	25,2	29,3	34,4	10,8	-2,2	2,5	0,9	0,4	1,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	402	801	1.638	1.622	2.083	2.364	2.611	5,0	-1,0	2,5	1,3	1,0	1,5
Population (millions of people)	42,9	47,0	51,7	51,8	51,6	50,3	47,3	0,6	0,1	0,0	-0,3	-0,6	-0,3
GDP per capita (thousands of 2015 USD/person)	9,39	17,03	31,68	31,34	40,35	47,03	55,23	4,3	-1,1	2,6	1,5	1,6	1,8
Primary energy consumption per capita (toe/person)	2,17	4,00	5,42	5,26	5,57	5,47	5,31	3,2	-3,0	0,6	-0,2	-0,3	-0,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	231	235	171	168	138	116	96	-1,0	-1,9	-1,9	-1,7	-1,9	-1,8
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	161	159	111	109	91	78	65	-1,3	-1,5	-1,8	-1,6	-1,7	-1,7
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	143	138	98	91	78	65	52	-1,3	-6,6	-1,6	-1,8	-2,2	-2,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,59	0,57	0,54	0,56	0,56	0,54	-0,3	-4,8	0,4	-0,1	-0,3	-0,2
Automobile ownership volume (millions of vehicles)	3,4	12,1	23,6	23,6	25,4	23,9	20,7	6,9	0,1	0,7		-2,0	-0,4
Automobile ownership volume per capita (vehicles per person)	0,079	0,257	0,457	0,457	0,491	0,475	0,439	6,2	0,0	0,7		-1,1	-0,1

Korea APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**92,91**	**188,16**	**280,19**	**272,00**	**285,12**	**258,89**	**226,09**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-2,9**	**0,5**	**-1,0**	**-1,3**	**-0,7**
Coal	25,38	41,95	80,04	74,04	67,84	58,85	41,23	27,3	22,3	28,6	27,2	23,8	22,7	18,2	4,0	-7,5	-0,9	-1,4	-3,5	-2,1
Oil	49,73	99,04	104,43	98,82	97,56	84,19	72,52	53,5	52,6	37,3	36,3	34,2	32,5	32,1	2,6	-5,4	-0,1	-1,5	-1,5	-1,2
Natural gas	2,73	17,01	48,87	48,04	56,82	60,41	57,98	2,9	9,0	17,4	17,7	19,9	23,3	25,6	10,5	-1,7	1,7	0,6	-0,4	0,6
Nuclear	13,78	28,39	38,02	41,74	49,89	37,92	30,40	14,8	15,1	13,6	15,3	17,5	14,6	13,4	3,6	9,8	1,8	-2,7	-2,2	-0,7
Hydro	0,55	0,34	0,24	0,31	0,31	0,31	0,31	0,6	0,2	0,1	0,1	0,1	0,1	0,1	-2,8	27,4	0,0	0,0	0,0	0,8
Geothermal	0,00	0,00	0,22	0,23	0,24	0,19	0,14	0,0	0,0	0,1	0,1	0,1	0,1	0,1	-	0,8	0,5	-2,0	-2,9	-1,4
Others	0,74	1,42	8,36	8,83	12,46	17,02	23,51	0,8	0,8	3,0	3,2	4,4	6,6	10,4	8,7	5,6	3,5	3,2	3,3	3,4
Biomass	0,73	1,38	6,68	6,88	8,52	10,42	13,16	0,8	0,7	2,4	2,5	3,0	4,0	5,8	7,9	3,0	2,2	2,0	2,4	2,2
Solar, Wind, Ocean	0,01	0,04	1,63	1,89	3,89	6,54	10,31	0,0	0,0	0,6	0,7	1,4	2,5	4,6	19,2	16,3	7,5	5,3	4,7	6,1
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**64,91**	**127,11**	**181,93**	**177,37**	**184,05**	**169,80**	**152,63**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-2,5**	**0,4**	**-0,8**	**-1,1**	**-0,6**
Industry	19,26	38,47	47,19	46,60	49,95	45,38	38,43	29,7	30,3	25,9	26,3	27,1	26,7	25,2	3,1	-1,2	0,7	-1,0	-1,6	-0,7
Transportation	14,57	26,27	36,65	32,71	31,02	22,15	16,02	22,5	20,7	20,1	18,4	16,9	13,0	10,5	3,2	-10,8	-0,5	-3,3	-3,2	-2,6
Others	24,35	37,34	45,41	45,46	46,24	42,92	38,36	37,5	29,4	25,0	25,6	25,1	25,3	25,1	2,2	0,1	0,2	-0,7	-1,1	-0,5
Non-energy	6,73	25,03	52,68	52,59	56,83	59,35	59,82	10,4	19,7	29,0	29,6	30,9	35,0	39,2	7,4	-0,2	0,8	0,4	0,1	0,4
Total	**64,91**	**127,11**	**181,93**	**177,37**	**184,05**	**169,80**	**152,63**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-2,5**	**0,4**	**-0,8**	**-1,1**	**-0,6**
Coal	11,72	9,07	7,92	7,56	5,91	4,47	3,17	18,1	7,1	4,4	4,3	3,2	2,6	2,1	-1,3	-4,5	-2,4	-2,7	-3,4	-2,9
Oil	43,66	79,88	97,50	93,19	92,34	80,41	69,34	67,3	62,8	53,6	52,5	50,2	47,4	45,4	2,8	-4,4	-0,1	-1,4	-1,5	-1,1
Natural gas	0,67	10,93	21,79	22,14	23,36	19,64	15,26	1,0	8,6	12,0	12,5	12,7	11,6	10,0	12,7	1,6	0,5	-1,7	-2,5	-1,1
Electricity	8,12	22,62	45,04	44,70	52,13	54,59	52,94	12,5	17,8	24,8	25,2	28,3	32,1	34,7	6,1	-0,7	1,5	0,5	-0,3	0,5
Heat	0,00	3,29	5,50	5,52	5,36	4,57	3,67	0,0	2,6	3,0	3,1	2,9	2,7	2,4	-	0,4	-0,3	-1,6	-2,2	-1,3
Others	0,74	1,32	4,18	4,25	4,94	6,12	8,25	1,1	1,0	2,3	2,4	2,7	3,6	5,4	6,2	1,8	1,5	2,2	3,0	2,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**105,37**	**288,53**	**578,03**	**573,56**	**668,34**	**697,87**	**674,58**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,0**	**-0,8**	**1,5**	**0,4**	**-0,3**	**0,5**
Coal	17,66	111,40	246,07	228,70	216,42	199,65	134,11	16,8	38,6	42,6	39,9	32,4	28,6	19,9	9,5	-7,1	-0,6	-0,8	-3,9	-1,9
Oil	18,86	34,58	9,30	8,28	4,20	0,00	0,00	17,9	12,0	1,6	1,4	0,6	0,0	0,0	-2,4	-11,0	-6,5	-100,0	-	-100,0
Natural gas	9,60	29,46	146,09	139,39	191,70	253,59	277,36	9,1	10,2	25,3	24,3	28,7	36,3	41,1	9,8	-4,6	3,2	2,8	0,9	2,1
Nuclear	52,89	108,96	145,91	160,18	191,49	145,53	116,68	50,2	37,8	25,2	27,9	28,7	20,9	17,3	3,6	9,8	1,8	-2,7	-2,2	-0,7
Hydro	6,36	4,01	2,79	3,56	3,56	3,56	3,56	6,0	1,4	0,5	0,6	0,5	0,5	0,5	-2,8	27,4	0,0	0,0	0,0	0,8
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	0,001	0,12	27,87	33,45	60,97	95,55	142,88	0,0	0,0	4,8	5,8	9,1	13,7	21,2	42,3	20,0	6,2	4,6	4,1	5,4

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,52**	**40,44**	**84,04**	**78,10**	**80,35**	**80,36**	**67,63**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**-7,1**	**0,3**	**0,0**	**-1,7**	**-0,7**
Coal	5,98	27,06	56,76	52,52	48,04	41,68	26,99	47,7	66,9	67,5	67,2	59,8	51,9	39,9	8,1	-7,5	-0,9	-1,4	-4,3	-2,4
Oil	4,51	7,63	2,42	1,90	0,97	0,00	0,00	36,0	18,9	2,9	2,4	1,2	0,0	0,0	-2,1	-21,6	-6,5	-100,0	-	-100,0
Natural gas	2,04	5,76	24,86	23,69	31,35	38,68	40,64	16,3	14,2	29,6	30,3	39,0	48,1	60,1	9,0	-4,7	2,8	2,1	0,5	1,6

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**37,3**	**41,1**	**41,4**	**44,1**	**48,5**	**52,3**								**0,9**	**0,9**	**0,6**	**0,9**	**0,8**	**0,8**
Coal	25,4	35,4	37,3	37,5	38,7	41,2	42,7								1,3	0,5	0,3	0,6	0,4	0,4
Oil	35,9	39,0	33,1	37,5	37,2	-	-								-0,3	13,4	-0,1	-	-	-
Natural gas	40,5	44,0	50,5	50,6	52,6	56,4	58,7								0,8	0,1	0,4	0,7	0,4	0,5

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**57,4**	**110,8**	**160,0**	**147,8**	**143,3**	**125,6**	**98,8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-7,7**	**-0,3**	**-1,3**	**-2,4**	**-1,5**
Coal	24,8	43,5	85,8	78,9	72,6	62,9	44,6	43,3	39,2	53,6	53,4	50,6	50,1	45,2	4,4	-8,1	-0,8	-1,4	-3,4	-2,1
Oil	30,9	56,4	41,4	36,9	32,8	22,3	15,2	53,9	50,9	25,9	25,0	22,9	17,8	15,4	1,0	-11,0	-1,2	-3,8	-3,8	-3,2
Natural gas	1,7	11,0	32,8	32,0	37,9	40,4	38,9	2,9	9,9	20,5	21,7	26,4	32,2	39,4	10,8	-2,3	1,7	0,6	-0,4	0,6

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	402	801	1.638	1.622	2.083	2.364	2.611	5,0	-1,0	2,5	1,3	1,0	1,5
Population (millions of people)	43	47	52	52	52	50	47	0,6	0,1	0,0	-0,3	-0,6	-0,3
GDP per capita (thousands of 2015 USD/person)	9,39	17,03	31,68	31,34	40,35	47,03	55,23	4,3	-1,1	2,6	1,5	1,6	1,8
Primary energy consumption per capita (toe/person)	2,17	4,00	5,42	5,26	5,52	5,15	4,78	3,2	-3,0	0,5	-0,7	-0,7	-0,4
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	231	235	171	168	137	110	87	-1,0	-1,9	-2,0	-2,2	-2,3	-2,2
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	161	159	111	109	88	72	58	-1,3	-1,5	-2,1	-2,0	-2,0	-2,0
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	143	138	98	91	69	53	38	-1,3	-6,7	-2,8	-2,5	-3,3	-3,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,59	0,57	0,54	0,50	0,49	0,44	-0,3	-4,9	-0,8	-0,4	-1,0	-0,9
Automobile ownership volume (millions of vehicles)	3	12	24	24	25	24	21	6,9	0,1	0,7	0,1	-2,0	-0,4
Automobile ownership volume per capita (vehicles per person)	0,079	0,257	0,457	0,457	0,491	0,475	0,439	6,2	0,0	0,7	0,4	-1,1	-0,1

Korea LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**92,91**	**187,94**	**280,19**	**270,85**	**253,19**	**215,84**	**175,30**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-3,3**	**-0,7**	**-1,6**	**-2,1**	**-1,5**
Coal	25,38	41,95	80,04	74,04	48,20	33,51	18,03	27,3	22,3	28,6	27,3	19,0	15,5	10,3	4,0	-7,5	-4,2	-3,6	-6,0	-4,7
Oil	49,73	99,04	104,43	98,82	88,75	72,87	57,52	53,5	52,7	37,3	36,5	35,1	33,8	32,8	2,6	-5,4	-1,1	-2,0	-2,3	-1,9
Natural gas	2,73	17,01	48,87	48,04	46,72	34,44	16,41	2,9	9,1	17,4	17,7	18,5	16,0	9,4	10,5	-1,7	-0,3	-3,0	-7,1	-3,5
Nuclear	13,78	28,39	38,02	41,74	50,24	37,55	31,92	14,8	15,1	13,6	15,4	19,8	17,4	18,2	3,6	9,8	1,9	-2,9	-1,6	-0,6
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,75	7,03	8,58	0,0	0,0	0,0	0,0	0,7	3,3	4,9	-	-	453,9	14,9	2,0	-
Hydro	0,55	0,34	0,24	0,31	0,30	0,30	0,32	0,6	0,2	0,1	0,1	0,1	0,1	0,2	-2,8	27,4	-0,3	0,2	0,6	0,9
Geothermal	0,00	0,00	0,22	0,00	0,19	0,07	0,00	0,0	0,0	0,1	0,0	0,1	0,0	0,0	-	-98,0	45,6	-8,9	-29,2	-13,7
Others	0,74	1,20	8,36	7,91	17,04	30,07	42,52	0,8	0,6	3,0	2,9	6,7	13,9	24,3	8,7	-5,4	8,0	5,8	3,5	5,4
Biomass	0,73	1,16	6,68	5,96	7,16	12,11	13,17	0,8	0,6	2,4	2,2	2,8	5,6	7,5	7,9	-10,7	1,9	5,4	0,8	2,2
Solar, Wind, Ocean	0,01	0,04	1,63	1,89	9,83	17,90	29,29	0,0	0,0	0,6	0,7	3,9	8,3	16,7	19,2	16,3	17,9	6,2	5,0	9,8
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**64,91**	**126,89**	**181,93**	**176,22**	**167,62**	**145,10**	**123,86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-3,1**	**-0,5**	**-1,4**	**-1,6**	**-1,2**
Industry	19,26	38,47	47,19	46,60	46,25	40,16	32,57	29,7	30,3	25,9	26,4	27,6	27,7	26,3	3,1	-1,2	-0,1	-1,4	-2,1	-1,2
Transportation	14,57	26,27	36,65	32,71	24,10	16,53	10,64	22,5	20,7	20,1	18,6	14,4	11,4	8,6	3,2	-10,8	-3,0	-3,7	-4,3	-3,9
Others	24,35	37,12	45,41	44,32	40,43	29,05	20,84	37,5	29,3	25,0	25,1	24,1	20,0	16,8	2,2	-2,4	-0,9	-3,2	-3,3	-2,5
Non-energy	6,73	25,03	52,68	52,59	56,83	59,35	59,82	10,4	19,7	29,0	29,8	33,9	40,9	48,3	7,4	-0,2	0,8	0,4	0,1	0,4
Total	**64,91**	**126,89**	**181,93**	**176,22**	**167,62**	**145,10**	**123,86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-3,1**	**-0,5**	**-1,4**	**-1,6**	**-1,2**
Coal	11,72	9,07	7,92	7,56	5,12	2,80	1,11	18,1	7,1	4,4	4,3	3,1	1,9	0,9	-1,3	-4,5	-3,8	-5,9	-8,8	-6,1
Oil	43,66	79,88	97,50	93,19	84,17	69,46	55,54	67,3	63,0	53,6	52,9	50,2	47,9	44,8	2,8	-4,4	-1,0	-1,9	-2,2	-1,8
Natural gas	0,67	10,93	21,79	22,14	18,49	8,62	1,87	1,0	8,6	12,0	12,6	11,0	5,9	1,5	12,7	1,6	-1,8	-7,4	-14,2	-7,6
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,71	4,34	6,95	0,0	0,0	0,0	0,0	0,4	3,0	5,6	-	-	172,6	19,9	4,8	-
Electricity	8,12	22,62	45,04	44,70	50,72	51,52	48,57	12,5	17,8	24,8	25,4	30,3	35,5	39,2	6,1	-0,7	1,3	0,2	-0,6	0,2
Heat	0,00	3,29	5,50	5,52	4,68	3,12	1,94	0,0	2,6	3,0	3,1	2,8	2,1	1,6	-	0,4	-1,6	-4,0	-4,6	-3,3
Others	0,74	1,10	4,18	3,11	3,72	5,25	7,88	1,1	0,9	2,3	1,8	2,2	3,6	6,4	6,2	-25,6	1,8	3,5	4,1	2,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**105,37**	**288,53**	**578,03**	**573,56**	**650,31**	**691,14**	**708,28**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,0**	**-0,8**	**1,3**	**0,6**	**0,2**	**0,7**
Coal PP	17,66	111,40	246,07	228,70	141,93	63,24	0,00	16,8	38,6	42,6	39,9	21,8	9,2	0,0	9,5	-7,1	-4,7	-7,8	-100,0	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	4,39	42,16	56,66	0,0	0,0	0,0	0,0	0,7	6,1	8,0	-	-	-	25,4	3,0	-
Oil	18,86	34,58	9,30	8,28	4,09	2,17	0,00	17,9	12,0	1,6	1,4	0,6	0,3	0,0	-2,4	-11,0	-6,8	-6,1	-	-165,7
Gas PP	9,60	29,46	146,09	139,39	158,98	93,54	0,00	9,1	10,2	25,3	24,3	24,4	13,5	0,0	9,8	-4,6	1,3	-5,2	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	4,92	62,36	85,47	0,0	0,0	0,0	0,0	0,8	9,0	12,1	-	-	-	28,9	3,2	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	6,50	38,01	70,83	0,0	0,0	0,0	0,0	1,0	5,5	10,0	-	-	-	19,3	6,4	-
Nuclear	52,89	108,96	145,91	160,18	192,83	144,13	122,50	50,2	37,8	25,2	27,9	29,7	20,9	17,3	3,6	9,8	1,9	-2,9	-1,6	-0,6
Solar	0,00	0,00	13,00	17,63	84,79	149,39	232,44	0,0	0,0	2,2	3,1	13,0	21,6	32,8	38,6	35,6	17,0	5,8	4,5	9,7
Wind	0,00	0,00	2,68	2,92	19,42	42,10	76,56	0,0	0,0	0,5	0,5	3,0	6,1	10,8	-	8,9	20,9	8,0	6,2	11,4
Hydro	6,36	4,01	2,79	3,56	3,46	3,52	3,73	6,0	1,4	0,5	0,6	0,5	0,5	0,5	-2,8	27,4	-0,3	0,2	0,6	0,9
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	0,00	0,12	12,19	12,90	29,00	50,52	60,09	0,0	0,0	2,1	2,2	4,5	7,3	8,5	-	5,9	8,4	5,7	1,7	5,3

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,52**	**40,44**	**84,04**	**78,10**	**59,50**	**53,83**	**37,50**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**-7,1**	**-2,7**	**-1,0**	**-3,6**	**-2,6**
Coal	5,98	27,06	56,76	52,52	31,11	22,93	13,33	47,7	66,9	67,5	67,2	52,3	42,6	35,5	8,1	-7,5	-5,1	-3,0	-5,3	-4,6
Oil	4,51	7,63	2,42	1,90	0,93	0,54	0,00	36,0	18,9	2,9	2,4	1,6	1,0	0,0	-2,1	-21,6	-6,9	-5,3	-	-165,8
Gas	2,04	5,76	24,86	23,69	26,42	24,67	13,96	16,3	14,2	29,6	30,3	44,4	45,8	37,2	9,0	-4,7	1,1	-0,7	-5,5	-1,8
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	1,04	5,70	10,20	0,0	0,0	0,0	0,0	1,8	10,6	27,2	-	-	-	18,5	6,0	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**37,3**	**41,1**	**41,4**	**46,4**	**48,2**	**48,8**								**0,9**	**0,9**	**1,1**	**0,4**	**0,1**	**0,6**
Coal	25,4	35,4	37,3	37,5	40,4	39,5	36,6								1,3	0,5	0,8	-0,2	-0,8	-0,1
Oil	35,9	39,0	33,1	37,5	38,0	34,9	30,9								-0,3	13,4	0,1	-0,8	-1,2	-0,2
Gas	40,5	44,0	50,5	50,6	53,4	54,4	52,6								0,8	0,1	0,5	0,2	-0,3	0,1
Hydrogen/Ammonia	-	-	-	-	53,6	57,4	59,7								-	-	-	0,7	0,4	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**57,4**	**110,8**	**160,0**	**147,8**	**106,7**	**52,1**	**5,1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**-7,7**	**-3,2**	**-6,9**	**-20,7**	**-10,5**
Coal	24,8	43,5	85,8	78,9	50,3	25,0	3,3	43,3	39,2	53,6	53,4	47,2	47,9	65,0	4,4	-8,1	-4,4	-6,8	-18,2	-9,9
Oil	30,9	56,4	41,4	36,9	25,8	12,0	1,4	53,9	50,9	25,9	25,0	24,2	23,1	26,7	1,0	-11,0	-3,5	-7,4	-19,5	-10,4
Natural gas	1,7	11,0	32,8	32,0	30,6	15,1	0,4	2,9	9,9	20,5	21,7	28,6	29,0	8,4	10,8	-2,3	-0,5	-6,8	-30,0	-13,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	402	801	1.638	1.622	2.083	2.364	2.611	5,0	-1,0	2,5	1,3	1,0	1,5
Population (millions of people)	43	47	52	52	52	50	47	0,6	0,1	0,0	-0,3	-0,6	-0,3
GDP per capita (thousands of 2015 USD/person)	9,39	17,03	31,68	31,34	40,35	47,03	55,23	4,3	-1,1	2,6	1,5	1,6	1,8
Primary energy consumption per capita (toe/person)	2,17	4,00	5,42	5,23	4,90	4,30	3,71	3,2	-3,4	-0,6	-1,3	-1,5	-1,2
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	231	235	171	167	122	91	67	-1,0	-2,4	-3,1	-2,8	-3,0	-3,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	161	159	111	109	80	61	47	-1,3	-2,2	-3,0	-2,7	-2,5	-2,7
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	143	138	98	91	51	22	2	-1,3	-6,7	-5,6	-8,1	-21,5	-11,8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,62	0,59	0,57	0,55	0,42	0,24	0,03	-0,3	-4,5	-2,6	-5,4	-19,0	-9,1
Automobile ownership volume (millions of vehicles)	3	12	24	24	25	24	21	6,9	0,1	0,7	-0,6	-2,0	-0,4
Automobile ownership volume per capita (vehicles per person)	0,079	0,257	0,457	0,457	0,491	0,475	0,439	6,2	0,0	0,7	-0,3	-1,1	-0,1

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Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**1,62**	**6,30**	**6,29**	**12,78**	**15,59**	**18,57**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**7,4**	**-0,1**	**7,3**	**2,0**	**1,8**	**3,6**
Coal		0,01	4,27	3,93	11,13	12,69	13,29	0,0	0,6	67,7	62,4	87,1	81,4	71,5	38,2	-7,9	11,0	1,3	0,5	3,7
Oil		0,27	0,86	1,04	1,43	2,27	3,56	0,0	16,8	13,7	16,6	11,2	14,5	19,2	6,3	20,9	3,2	4,7	4,6	4,7
Natural gas								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		0,30	1,73	2,24	4,18	5,82	6,82	0,0	18,7	27,5	35,6	32,7	37,4	36,7	9,6	29,4	6,4	3,4	1,6	4,5
Geothermal		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,04	-0,56	-0,92	-3,96	-5,20	-5,09	0,0	64,0	-8,9	-14,6	-31,0	-33,3	-27,4	-196,8	64,0	15,7	2,8	-0,2	7,4
Biomass		1,26	1,68	1,62	1,82	1,88	1,93	0,0	77,9	26,7	25,8	14,2	12,1	10,4	1,5	-3,4	1,1	0,4	0,2	0,4
Solar, Wind, Ocean			0,01	0,01	0,44	0,64	0,65	0,0	0,0	0,1	0,1	3,5	4,1	3,5	-	15,5	52,3	3,8	0,2	16,5
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		-0,22	-2,25	-2,55	-6,22	-7,72	-7,67	0,0	-13,9	-35,7	-40,5	-48,6	-49,5	-41,3	12,9	13,5	9,3	2,2	-0,1	4,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**1,51**	**3,00**	**3,24**	**4,21**	**5,90**	**8,58**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**8,2**	**2,6**	**3,4**	**3,8**	**3,5**
Industry		0,08	0,50	0,55	0,90	1,48	2,52	0,0	5,4	16,7	17,1	21,4	25,2	29,3	10,0	10,9	5,0	5,1	5,4	5,4
Transportation		0,25	0,80	0,98	1,38	2,14	3,29	0,0	16,8	26,8	30,4	32,8	36,2	38,3	6,2	22,4	3,4	4,5	4,4	4,6
Others		1,17	1,69	1,70	1,93	2,28	2,78	0,0	77,7	56,5	52,5	45,8	38,6	32,4	1,9	0,6	1,3	1,7	2,0	1,6
Non-energy		0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,1	0,0	0,0	0,0	0,0		-18,7	-4,0	-100,0	-	-100,0
Total	**0,00**	**1,51**	**3,00**	**3,24**	**4,21**	**5,90**	**8,58**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**8,2**	**2,6**	**3,4**	**3,8**	**3,5**
Coal		0,01	0,14	0,14	0,22	0,40	0,73	0,0	0,6	4,6	4,4	5,2	6,8	8,5	-	2,8	4,4	6,3	6,1	5,5
Oil		0,27	0,86	1,04	1,43	2,27	3,56	0,0	17,9	28,8	32,2	34,1	38,4	41,5	-	20,9	3,2	4,7	4,6	4,7
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		0,06	0,57	0,66	1,26	1,92	2,94	0,0	3,6	19,0	20,5	29,9	32,5	34,3	-	16,8	6,6	4,3	4,4	5,4
Heat		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,17	1,43	1,39	1,29	1,32	1,35	0,0	77,8	47,6	42,9	30,8	22,3	15,7	-	-2,5	-0,7	0,2	0,2	-0,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**3,51**	**33,75**	**38,56**	**89,16**	**115,06**	**127,70**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**14,2**	**8,7**	**2,6**	**1,0**	**4,4**
Coal			12,96	11,88	34,25	38,59	39,44	0,0	0,0	38,4	30,8	38,4	33,5	30,9	-	-8,3	11,2	1,2	0,2	3,7
Oil								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Natural gas								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		3,51	20,14	26,06	48,56	67,74	79,33	0,0	100,0	59,7	67,6	54,5	58,9	62,1	-	29,4	6,4	3,4	1,6	4,5
Geothermal			0,07	0,08	5,13	7,42	7,58	0,0	0,0	0,2	0,2	5,8	6,4	5,9	-	15,5	52,3	3,8	0,2	16,5
Others			0,59	0,54	1,22	1,32	1,35	0,0	0,0	1,7	1,4	1,4	1,1	1,1	-	-8,6	8,5	0,8	0,2	2,7

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,00**	**4,13**	**3,78**	**10,91**	**12,29**	**12,56**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**-**	**-8,3**	**11,2**	**1,2**	**0,2**	**3,7**
Coal			4,13	3,78	10,91	12,29	12,56	0,0	0,0	100,0	100,0	100,0	100,0	100,0	-	-8,3	11,2	1,2	0,2	3,7
Oil								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**-**	**-**	**27,0**	**27,0**	**27,0**	**27,0**	**27,0**								**-**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
Coal	-	-	27,0	27,0	27,0	27,0	27,0								-	0,0	0,0	0,0	0,0	0,0
Oil	-	-	-	-	-	-	-								-	-	-	-	-	-
Natural gas	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,0**	**0,8**	**5,2**	**5,0**	**13,0**	**15,3**	**17,0**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-4,0**	**10,0**	**1,7**	**1,1**	**3,9**
Coal			4,5	4,2	11,8	13,4	14,1	0,0	0,0	86,4	82,8	90,9	87,8	82,7	-	-7,9	11,0	1,3	0,5	3,7
Oil		0,8	0,7	0,9	1,2	1,9	2,9	0,0	100,0	13,6	17,2	9,1	12,2	17,3	-	21,0	3,3	4,7	4,6	4,7
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)		5,0	18,5	18,6	27,3	47,6	82,8	-	0,5	3,9	5,7	5,7	5,0
Population (millions of people)		5,3	7,2	7,3	8,4	9,8	11,4	-	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	-	0,93	2,58	2,55	3,24	4,86	7,28	-	-1,0	2,4	4,1	4,1	3,4
Primary energy consumption per capita (toe/person)	-	0,30	0,88	0,86	1,51	1,59	1,63	-	-1,6	5,8	0,5	0,3	2,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	325	341	338	468	328	224	-	-0,6	3,3	-3,5	-3,7	-1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	303	162	174	154	124	104	-	7,6	-1,2	-2,1	-1,8	-1,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	-	163	283	270	474	322	205	-	-4,5	5,8	-3,8	-4,4	-1,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	-	0,50	0,83	0,80	1,01	0,98	0,92	-	-3,9	2,4	-0,3	-0,7	0,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Lao PDR APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**1,62**	**6,297**	**6,25**	**9,40**	**10,39**	**11,0**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-0,7**	**4,2**	**1,0**	**0,6**	**1,8**
Coal		0,01	4,27	3,92	7,38	7,08	5,62	0,0	0,6	67,7	62,7	78,5	68,1	51,0	-	-8,1	6,5	-0,4	-2,3	0,9
Oil		0,27	0,86	1,03	1,29	1,93	2,85	0,0	16,8	13,7	16,5	13,7	18,5	25,9	-	19,8	2,3	4,1	4,0	3,9
Natural gas								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		0,30	1,73	2,24	4,10	5,64	6,44	0,0	18,7	27,5	35,8	43,6	54,3	58,5	-	29,2	6,2	3,3	1,3	4,3
Geothermal		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,04	-0,56	-0,94	-3,37	-4,26	-3,90	0,0	64,0	-8,9	-15,0	-35,9	-40,9	-35,4	-	66,8	13,7	2,4	-0,9	6,4
Biomass		1,26	1,68	1,61	1,68	1,67	1,63	0,0	77,9	26,7	25,7	17,9	16,1	14,8	-	-4,2	0,4	-0,1	-0,3	-0,1
Solar, Wind, Ocean			0,01	0,01	1,17	1,81	2,22	0,0	0,0	0,1	0,1	12,4	17,5	20,1	-	15,4	67,9	4,5	2,0	21,2
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		-0,22	-2,25	-2,55	-6,22	-7,74	-7,74	0,0	-13,9	-35,7	-40,8	-66,1	-74,4	-70,2	-	13,6	9,3	2,2	0,0	4,1

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**1,51**	**3,00**	**3,21**	**3,79**	**5,02**	**6,86**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**7,2**	**1,7**	**2,9**	**3,2**	**2,7**
Industry		0,08	0,50	0,55	0,81	1,26	2,01	0,0	5,4	16,7	17,1	21,4	25,2	29,3	-	9,8	4,0	4,5	4,8	4,6
Transportation		0,25	0,80	0,97	1,24	1,82	2,63	0,0	16,8	26,8	30,4	32,8	36,2	38,3	-	21,3	2,4	3,9	3,8	3,9
Others		1,17	1,69	1,69	1,73	1,94	2,22	0,0	77,7	56,5	52,5	45,8	38,6	32,4	-	-0,3	0,3	1,1	1,4	0,9
Non-energy		0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,1	0,0	0,0	0,0	0,0	-	-18,7	-4,0	-100,0	-	-100,0
Total	**0,00**	**1,51**	**3,00**	**3,21**	**3,79**	**5,02**	**6,86**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**7,2**	**1,7**	**2,9**	**3,2**	**2,7**
Coal		0,01	0,14	0,14	0,20	0,34	0,58	0,0	0,6	4,6	4,4	5,2	6,8	8,5	-	1,8	3,4	5,7	5,5	4,7
Oil		0,27	0,86	1,03	1,29	1,93	2,85	0,0	17,9	28,8	32,2	34,1	38,4	41,5	-	19,8	2,3	4,1	4,0	3,9
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		0,06	0,57	0,66	1,13	1,63	2,35	0,0	3,6	19,0	20,5	29,9	32,5	34,3	-	15,7	5,6	3,7	3,8	4,7
Heat		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,17	1,43	1,38	1,16	1,12	1,08	0,0	77,8	47,6	42,9	30,8	22,3	15,7	-	-3,4	-1,7	-0,4	-0,4	-0,9

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**3,51**	**33,75**	**38,51**	**87,47**	**111,52**	**120,77**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**14,1**	**8,5**	**2,5**	**0,8**	**4,2**
Coal			12,96	11,87	25,06	23,52	18,74	0,0	0,0	38,4	30,8	28,7	21,1	15,5	-	-8,4	7,8	-0,6	-2,2	1,2
Oil								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Natural gas								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		3,51	20,14	26,03	47,64	65,62	74,96	0,0	100,0	59,7	67,6	54,5	58,8	62,1	-	29,2	6,2	3,3	1,3	4,3
Geothermal			0,07	0,08	13,58	21,11	25,80	0,0	0,0	0,2	0,2	15,5	18,9	21,4	-	15,4	67,9	4,5	2,0	21,2
Others			0,59	0,54	1,19	1,28	1,27	0,0	0,0	1,7	1,4	1,4	1,1	1,1	-	-8,7	8,3	0,7	0,0	2,5

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,00**	**4,13**	**3,78**	**7,18**	**6,74**	**5,04**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**-**	**-8,4**	**6,6**	**-0,6**	**-2,9**	**0,6**
Coal			4,13	3,78	7,18	6,74	5,04	0,0	0,0	100,0	100,0	100,0	100,0	100,0	-	-8,4	6,6	-0,6	-2,9	0,6
Oil								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**-**	**-**	**27,0**	**27,0**	**30,0**	**30,0**	**32,0**								**-**	**0,0**	**1,1**	**0,0**	**0,6**	**0,5**
Coal	-	-	27,0	27,0	30,0	30,0	32,0								-	0,0	1,1	0,0	0,6	0,5
Oil	-	-	-	-	-	-	-								-	-	-	-	-	-
Natural gas	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,0**	**0,8**	**5,2**	**5,0**	**8,9**	**9,1**	**8,3**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-4,3**	**5,9**	**0,2**	**-0,9**	**1,5**
Coal			4,5	4,2	7,8	7,5	5,9	0,0	0,0	86,4	83,0	88,0	82,5	71,6	-	-8,1	6,5	-0,4	-2,3	0,9
Oil		0,8	0,7	0,9	1,1	1,6	2,4	0,0	100,0	13,6	17,0	12,0	17,5	28,4	-	19,9	2,3	4,1	4,0	3,9
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)		5,0	18,5	18,6	27,3	47,6	82,8	-	0,5	3,9	5,7	5,7	5,0
Population (millions of people)		5,3	7,2	7,3	8,4	9,8	11,4	-	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	-	0,93	2,58	2,55	3,24	4,86	7,28	-	-1,0	2,4	4,1	4,1	3,4
Primary energy consumption per capita (toe/person)	-	0,30	0,88	0,86	1,11	1,06	0,97	-	-2,1	2,6	-0,5	-0,9	0,3
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	325	341	337	344	219	133	-	-1,2	0,2	-4,4	-4,8	-3,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	303	162	173	139	105	83	-	6,6	-2,2	-2,7	-2,4	-2,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	-	163	283	269	325	191	100	-	-4,7	1,9	-5,2	-6,2	-3,3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	-	0,50	0,83	0,80	0,94	0,87	0,75	-	-3,6	1,7	-0,8	-1,5	-0,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Lao PDR LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**2,65**	**5,74**	**4,99**	**5,99**	**5,98**	**9,04**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-12,9**	**1,8**	**0,0**	**4,2**	**1,5**
Coal		0,01	4,27	3,77	7,56	7,13	5,69	0,0	0,3	74,4	75,6	126,3	119,2	63,0	-	-11,5	7,2	-0,6	-2,2	0,9
Oil		0,27	0,86	0,88	1,10	1,04	0,01	0,0	10,2	15,0	17,7	18,4	17,4	0,1	-	2,3	2,3	-0,6	-38,4	-14,0
Natural gas								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	-	-	-	-	-	-
Hydrogen/Ammonia				0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	-0,1	0,0	0,0						
Hydro		0,30	1,73	2,23	3,93	6,27	9,28	0,0	11,4	30,2	44,7	65,7	104,8	102,7	-	28,8	5,8	4,8	4,0	5,6
Geothermal		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,04	-0,56	-0,95	-3,30	-4,23	-2,97	0,0	39,0	-9,8	-18,9	-55,2	-70,7	-32,9	-	68,4	13,3	2,5	-3,5	5,5
Biomass		1,26	1,68	1,61	1,70	1,67	1,70	0,0	47,5	29,3	32,2	28,4	28,0	18,8	-	-4,2	0,5	-0,1	0,1	0,0
Solar, Wind, Ocean			0,01	0,01	1,21	1,83	2,51	0,0	0,0	0,1	0,1	20,3	30,6	27,7	-	15,0	68,6	4,2	3,2	21,7
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		-0,22	-2,25	-2,56	-6,22	-7,74	-7,17	0,0	-8,5	-39,2	-51,3	-103,8	-129,3	-79,4	-	14,0	9,3	2,2	-0,8	3,8

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**1,51**	**3,00**	**2,92**	**3,5**	**4,72**	**6,86**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-2,4**	**1,8**	**3,1**	**3,8**	**2,7**
Industry		0,08	0,50	0,41	0,71	1,26	2,01	-	5,4	16,7	14,1	20,4	26,6	29,3	-	-17,2	5,6	5,9	4,8	4,6
Transportation		0,25	0,80	0,82	1,05	1,53	2,63	-	16,8	26,8	28,2	30,0	32,4	38,3	-	2,5	2,4	3,8	5,6	3,9
Others		1,17	1,69	1,69	1,73	1,94	2,22	-	77,7	56,5	57,7	49,6	41,0	32,3	-	-0,3	0,3	1,1	1,4	0,9
Non-energy		0,00	0,00	0,00	0,00	0,00	0,00	-	0,0	0,1	0,0	0,0	0,0	0,0	-	-100,0	-	-	-	-100,0
Total	**0,00**	**1,56**	**3,00**	**2,92**	**3,5**	**4,15**	**4,64**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-2,4**	**1,8**	**1,7**	**1,1**	**1,4**
Coal		0,01	0,14	0,01	0,09	0,32	0,00	-	0,6	4,6	0,2	2,6	7,8	0,0	-	-96,0	32,6	13,4	-100,0	-100,0
Oil		0,27	0,86	0,88	1,10	1,04	0,01	-	17,3	28,8	30,2	31,6	25,0	0,2	-	2,3	2,3	-0,6	-38,4	-14,0
Natural gas								-	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia		0,06		0,00	0,00	0,04	1,20	-	3,5	0,0	0,0	0,0	1,0	25,9						
Electricity		0,06	0,57	0,66	1,13	1,63	2,35	-	3,5	19,0	22,5	32,4	39,2	50,7	-	15,7	5,6	3,7	3,8	4,7
Heat		0,00						-	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,17	1,43	1,38	1,16	1,12	1,08	-	75,1	47,6	47,1	33,3	27,0	23,2	-	-3,4	-1,7	-0,4	-0,4	-0,9

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,00**	**33,75**	**38,39**	**87,1**	**119,32**	**159,68**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**-**	**13,7**	**8,5**	**3,2**	**3,0**	**5,1**
Coal PP			12,96	11,83	26,06	23,76	21,18	-	-	38,4	30,8	29,9	19,9	13,3	-	-8,7	8,2	-0,9	-1,1	1,6
Coal PP with CCS								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Gas PP								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Gas PP PP with CCS								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia PP								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Nuclear								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Solar			0,07	0,08	8,06	12,65	18,61	-	-	0,2	0,2	9,2	10,6	11,7	-	15,0	59,4	4,6	3,9	20,0
Wind			0,00	0,00	6,06	8,67	10,55	-	-	0,0	0,0	7,0	7,3	6,6	-	-	-	3,6	2,0	-
Hydro			20,14	25,95	45,73	72,95	107,90	-	-	59,7	67,6	52,5	61,1	67,6	-	28,8	5,8	4,8	4,0	5,6
Geothermal								-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others			0,59	0,54	1,24	1,29	1,44	-	-	1,7	1,4	1,4	1,1	0,9	-	-9,0	8,8	0,4	1,1	2,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,00**	**4,13**	**3,77**	**7,47**	**6,81**	**5,69**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**-19,2**	**-8,7**	**7,1**	**-0,9**	**-1,8**	**1,0**
Coal	-	-	4,13	3,77	7,47	6,81	5,69	-	-	100,0	100,0	100,0	100,0	100,0	-	-8,7	7,1	-0,9	-1,8	1,0
Oil	-	-						-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Gas	-	-						-	-	0,0	0,0	0,0	0,0	0,0						
Hydrogen/Ammonia	-	-						-	-	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**-**	**-**	**27,0**	**27,0**	**30,0**	**30,0**	**32,0**								**-**	**0,0**	**1,1**	**0,0**	**0,6**	**0,5**
Coal	-	-	27,00	27,00	30,01	30,01	32,01								-	0,0	1,1	0,0	0,6	0,5
Oil	-	-	-	-	-	-	-								-	-	-	-	-	-
Gas	-	-	-	-	-	-	-													
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,00**	**0,81**	**5,23**	**4,72**	**8,92**	**8,06**	**2,78**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**-9,7**	**6,6**	**-1,0**	**-10,1**	**-2,0**
Coal			4,52	3,99	8,00	7,20	2,77	0,0	0,0	86,4	84,6	89,8	89,4	99,8	-	-11,5	7,2	-1,1	-9,1	-1,6
Oil		0,81	0,71	0,73	0,91	0,86	0,01	0,0	100,0	13,6	15,4	10,2	10,6	0,2	-	2,1	2,3	-0,6	-38,4	-13,9
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)		5,0	18,5	18,6	27,3	47,6	82,8	-	0,5	3,9	5,7	5,7	5,0
Population (millions of people)		5,3	7,2	7,3	8,4	9,8	11,4	-	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	-	0,93	2,58	2,55	3,24	4,86	7,28	-	-1,0	2,4	4,1	4,1	3,4
Primary energy consumption per capita (toe/person)	-	0,50	0,80	0,69	0,71	0,61	0,79	-	-14,2	0,3	-1,5	2,7	0,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	533	310	269	219	126	109	-	-13,4	-2,0	-5,4	-1,4	-3,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	-	2	162	157	128	87	56	-	-2,9	-2,0	-3,8	-4,3	-3,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	-	163	283	254	326	169	34	-	-10,1	2,5	-6,3	-14,9	-6,6
CO_2 emissions per unit of primary energy consumption (t-C/toe)	-	0,31	0,91	0,95	1,49	1,35	0,31	-	3,7	4,6	-1,0	-13,7	-3,4
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Malaysia BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**20,40**	**49,70**	**86,36**	**85,70**	**115,18**	**151,51**	**190,50**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-0,8**	**3,0**	**2,8**	**2,3**	**2,6**
Coal	1,33	2,49	19,43	18,26	17,18	13,46	13,97	6,5	5,0	22,5	21,3	14,9	8,9	7,3	9,7	-6,0	-0,6	-2,4	0,4	-1,1
Oil	11,93	20,24	29,95	30,90	43,89	55,76	67,78	58,5	40,7	34,7	36,1	38,1	36,8	35,6	3,2	3,2	3,6	2,4	2,0	2,7
Natural gas	6,80	26,37	34,18	32,36	48,92	76,34	101,67	33,3	53,1	39,6	37,8	42,5	50,4	53,4	5,7	-5,3	4,2	4,6	2,9	3,6
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	0,60	2,26	2,27	3,04	3,10	3,10	1,7	1,2	2,6	2,6	2,6	2,0	1,6	6,7	0,0	3,0	0,2	0,0	1,0
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	0,00	0,00	0,52	1,91	2,15	2,85	3,98	0,0	0,0	0,6	2,2	1,9	1,9	2,1	-	264,2	1,2	2,8	3,4	6,8
Biomass	0,00	0,00	0,31	0,86	0,85	0,85	0,86	0,0	0,0	0,4	1,0	0,7	0,6	0,4	-	175,3	0,0	0,0	0,1	3,3
Solar, Wind, Ocean	0,00	0,00	0,13	0,15	0,15	0,15	0,15	0,0	0,0	0,1	0,2	0,1	0,1	0,1	-	19,6	0,0	0,0	0,0	0,6
Biofuels	0,00	0,00	0,65	0,68	1,11	1,81	2,94	0,0	0,0	0,8	0,8	1,0	1,2	1,5	-	4,6	5,0	5,0	5,0	5,0
Electricity	0,00	0,00	-0,56	0,23	0,04	0,04	0,04	0,0	0,0	-0,7	0,3	0,0	0,0	0,0	-	-140,2	-16,4	0,0	0,0	-191,7

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,62**	**28,44**	**63,87**	**63,54**	**84,44**	**110,50**	**137,74**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**-0,5**	**2,9**	**2,7**	**2,2**	**2,5**
Industry	5,28	11,41	18,92	17,89	23,39	32,20	40,66	41,8	40,1	29,6	28,1	27,7	29,1	29,5	4,5	-5,5	2,7	3,2	2,4	2,5
Transportation	4,88	10,81	22,40	22,53	32,09	42,35	53,70	38,7	38,0	35,1	35,5	38,0	38,3	39,0	5,4	0,6	3,6	2,8	2,4	2,9
Others	1,62	3,97	8,93	9,26	12,46	16,30	19,96	12,9	14,0	14,0	14,6	14,8	14,8	14,5	6,1	3,7	3,0	2,7	2,0	2,6
Non-energy	0,84	2,25	13,63	13,87	16,50	19,65	23,42	6,6	7,9	21,3	21,8	19,5	17,8	17,0	10,1	1,7	1,8	1,8	1,8	1,8
Total	**12,62**	**28,44**	**63,87**	**63,54**	**84,44**	**110,50**	**137,74**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**-0,5**	**2,9**	**2,7**	**2,2**	**2,5**
Coal	0,51	0,99	1,71	1,77	2,50	2,96	3,45	4,1	3,5	2,7	2,8	3,0	2,7	2,5	4,2	4,0	3,5	1,7	1,5	2,3
Oil	9,32	18,32	29,23	29,66	42,07	53,94	65,91	73,9	64,4	45,8	46,7	49,8	48,8	47,9	4,0	1,5	3,6	2,5	2,0	2,7
Natural gas	1,07	3,86	18,65	17,40	19,50	25,89	32,72	8,5	13,6	29,2	27,4	23,1	23,4	23,8	10,4	-6,7	1,1	2,9	2,4	1,8
Electricity	1,72	5,26	13,65	14,02	19,27	25,91	32,72	13,6	18,5	21,4	22,1	22,8	23,4	23,8	7,4	2,8	3,2	3,0	2,4	2,9
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	0,65	0,68	1,11	1,81	2,94	0,0	0,0	1,0	1,1	1,3	1,6	2,1	-	5,0	5,0	5,0	5,0	5,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,01**	**64,81**	**178,49**	**174,22**	**242,69**	**326,64**	**412,77**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,3**	**-2,4**	**3,4**	**3,0**	**2,4**	**2,7**
Coal	3,00	4,57	76,41	71,08	63,84	49,19	49,29	13,0	7,1	42,8	40,8	26,3	15,1	11,9	11,8	-7,0	-1,1	-2,6	0,0	-1,4
Oil	11,00	2,94	1,01	2,38	1,85	1,88	1,88	47,8	4,5	0,6	1,4	0,8	0,6	0,5	-7,9	135,7	-2,5	0,2	0,0	2,0
Natural gas	5,02	50,31	72,28	69,59	136,87	234,72	320,75	21,8	77,6	40,5	39,9	56,4	71,9	77,7	9,6	-3,7	7,0	5,5	3,2	4,9
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	3,99	6,99	26,20	26,34	35,30	36,02	36,02	17,3	10,8	14,7	15,1	14,5	11,0	8,7	6,7	0,6	3,0	0,2	0,0	1,0
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	0,00	0,00	2,60	4,83	4,83	4,83	4,83	0,0	0,0	1,5	2,8	2,0	1,5	1,2	-	86,1	0,0	0,0	0,0	2,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,16**	**14,31**	**33,53**	**32,07**	**44,59**	**61,44**	**79,96**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,7**	**-4,4**	**3,4**	**3,3**	**2,7**	**2,8**
Coal	0,81	1,50	17,73	16,49	14,68	10,50	10,52	15,7	10,4	52,9	51,4	32,9	17,1	13,2	11,2	-7,0	-1,2	-3,3	0,0	-1,7
Oil	2,99	0,78	0,26	0,62	0,48	0,49	0,49	57,9	5,5	0,8	1,9	1,1	0,8	0,6	-8,0	135,7	-2,5	0,2	0,0	2,0
Natural gas	1,36	12,04	15,54	14,96	29,42	50,46	68,95	26,4	84,1	46,3	46,6	66,0	82,1	86,2	8,8	-3,7	7,0	5,5	3,2	4,9

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**34,7**	**38,4**	**38,4**	**39,1**	**40,0**	**40,0**	**0,7**	**-0,1**	**0,2**	**0,2**	**0,0**	**0,1**
Coal	31,7	26,3	37,1	37,1	37,4	40,3	40,3	0,5	0,0	0,1	0,8	0,0	0,3
Oil	31,6	32,2	33,0	33,0	33,0	33,0	33,0	0,1	0,0	0,0	0,0	0,0	0,0
Natural gas	31,7	36,0	40,0	40,0	40,0	40,0	40,0	0,8	0,0	0,0	0,0	0,0	0,0

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**13,6**	**30,7**	**57,3**	**55,4**	**73,0**	**94,0**	**117,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-3,4**	**2,8**	**2,6**	**2,3**	**2,4**
Coal	1,4	2,6	20,7	19,4	18,3	14,3	14,9	10,3	8,5	36,1	35,1	25,0	15,2	12,6	9,7	-6,0	-0,6	-2,4	0,4	-1,1
Oil	10,3	15,7	21,7	22,3	31,9	41,0	50,0	75,7	51,1	37,9	40,3	43,7	43,6	42,4	2,6	2,8	3,6	2,5	2,0	2,7
Natural gas	1,9	12,4	14,9	13,6	22,9	38,8	53,0	14,0	40,4	26,0	24,6	31,3	41,2	45,0	7,4	-8,6	5,3	5,4	3,2	4,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	74,6	148,3	364,7	344,5	483,1	642,3	816,6	5,6	-5,5	3,4	2,9	2,4	2,6
Population (millions of people)	18,0	23,2	32,0	32,4	36,8	40,6	43,9	2,0	1,4	1,3	1,0	0,8	1,0
GDP per capita (thousands of 2015 USD/person)	4,14	6,39	11,41	10,64	13,11	15,82	18,59	3,6	-6,8	2,1	1,9	1,6	1,6
Primary energy consumption per capita (toe/person)	1,13	2,14	2,70	2,65	3,13	3,73	4,34	3,0	-2,1	1,7	1,8	1,5	1,5
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	273	335	237	249	238	236	233	-0,5	5,1	-0,4	-0,1	-0,1	0,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	169	192	175	184	175	172	169	0,1	5,3	-0,5	-0,2	-0,2	-0,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	182	207	157	161	151	146	144	-0,5	2,3	-0,6	-0,3	-0,1	-0,3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,67	0,62	0,66	0,65	0,63	0,62	0,62	0,0	-2,6	-0,2	-0,2	0,0	-0,2
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Malaysia APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**20,40**	**49,70**	**86,36**	**80,96**	**105,14**	**133,45**	**162,84**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,5**	**-2,1**	**2,6**	**2,4**	**2,0**	**1,9**
Coal	1,33	2,49	19,43	16,06	17,93	13,56	13,42	6,5	5,0	22,5	19,8	17,1	10,2	8,2	10,5	-6,2	1,1	-2,8	-0,1	-1,1
Oil	11,93	20,24	29,95	29,04	40,18	51,09	62,16	58,5	40,7	34,7	35,9	38,2	38,3	38,2	3,5	-1,0	3,3	2,4	2,0	2,2
Natural gas	6,80	26,37	34,18	29,89	36,38	56,20	72,77	33,3	53,1	39,6	36,9	34,6	42,1	44,7	6,2	-4,4	2,0	4,4	2,6	2,3
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	0,60	2,26	2,40	3,45	3,51	3,51	1,7	1,2	2,6	3,0	3,3	2,6	2,2	7,2	1,9	3,7	0,2	0,0	1,3
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	-	-	-	-	-	-
Others	0,00	0,00	0,52	3,57	7,20	9,08	10,99	0,0	0,0	0,6	4,4	6,8	6,8	6,7	-	89,4	7,3	2,3	1,9	9,7
Biomass	0,00	0,00	0,31	1,05	1,94	2,05	2,05	0,0	0,0	0,4	1,3	1,8	1,5	1,3	-	49,8	6,4	0,6	0,0	5,9
Solar, Wind, Ocean	0,00	0,00	0,13	0,23	0,91	1,14	1,14	0,0	0,0	0,1	0,3	0,9	0,9	0,7	-	22,6	14,6	2,3	0,0	6,9
Biofuels	0,00	0,00	0,65	2,07	4,24	5,77	7,76	0,0	0,0	0,8	2,6	4,0	4,3	4,8	-	47,0	7,5	3,1	3,0	7,8
Electricity	0,00	0,00	-0,56	0,23	0,12	0,13	0,04	0,0	0,0	-0,7	0,3	0,1	0,1	0,0	-	-173,8	-6,2	0,8	-11,6	-192,1

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,62**	**28,44**	**63,87**	**61,37**	**81,58**	**106,62**	**132,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,2**	**-1,3**	**2,9**	**2,7**	**2,2**	**2,2**
Industry	5,28	11,41	18,92	16,46	21,52	29,62	37,41	41,8	40,1	29,6	26,8	26,4	27,8	28,2	4,8	-4,5	2,7	3,2	2,4	2,1
Transportation	4,88	10,81	22,40	22,53	32,09	42,35	53,70	38,7	38,0	35,1	36,7	39,3	39,7	40,4	5,8	0,2	3,6	2,8	2,4	2,7
Others	1,62	3,97	8,93	8,52	11,47	15,00	18,37	12,9	14,0	14,0	13,9	14,1	14,1	13,8	6,5	-1,6	3,0	2,7	2,0	2,2
Non-energy	0,84	2,25	13,63	13,87	16,50	19,65	23,42	6,6	7,9	21,3	22,6	20,2	18,4	17,6	10,9	0,6	1,8	1,8	1,8	1,7
Total	**12,62**	**28,44**	**63,87**	**61,37**	**81,58**	**106,62**	**132,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,2**	**-1,3**	**2,9**	**2,7**	**2,2**	**2,2**
Coal	0,51	0,99	1,71	1,63	2,30	2,72	3,17	4,1	3,5	2,7	2,7	2,8	2,6	2,4	4,6	-1,5	3,5	1,7	1,5	1,9
Oil	9,32	18,32	29,23	27,87	38,31	49,22	60,25	73,9	64,4	45,8	45,4	47,0	46,2	45,3	4,3	-1,6	3,2	2,5	2,0	2,2
Natural gas	1,07	3,86	18,65	16,90	18,99	25,07	31,59	8,5	13,6	29,2	27,5	23,3	23,5	23,8	11,2	-3,2	1,2	2,8	2,3	1,6
Electricity	1,72	5,26	13,65	12,90	17,73	23,84	30,11	13,6	18,5	21,4	21,0	21,7	22,4	22,7	8,0	-1,8	3,2	3,0	2,4	2,4
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	0,00	0,00	0,65	2,07	4,24	5,77	7,76	0,0	0,0	1,0	3,4	5,2	5,4	5,8	-	47,2	7,5	3,1	3,0	7,8

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,01**	**64,81**	**178,49**	**160,08**	**222,11**	**300,08**	**379,80**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,9**	**-3,6**	**3,3**	**3,1**	**2,4**	**2,3**
Coal	3,00	4,57	76,41	62,46	71,65	53,58	52,30	13,0	7,1	42,8	39,0	32,3	17,9	13,8	12,7	-6,5	1,4	-2,9	-0,2	-1,1
Oil	11,00	2,94	1,01	2,09	2,08	2,05	2,00	47,8	4,5	0,6	1,3	0,9	0,7	0,5	-8,5	27,5	-0,1	-0,1	-0,2	2,1
Natural gas	5,02	50,31	72,28	61,16	92,54	184,55	265,60	21,8	77,6	40,5	38,2	41,7	61,5	69,9	10,4	-5,4	4,2	7,1	3,7	4,0
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	3,99	6,99	26,20	27,91	38,33	39,26	39,26	17,3	10,8	14,7	17,4	17,3	13,1	10,3	7,2	2,1	3,2	0,2	0,0	1,2
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	0,00	2,60	6,46	17,51	20,64	20,64	0,0	0,0	1,5	4,0	7,9	6,9	5,4	-	35,5	10,5	1,7	0,0	6,5

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,16**	**14,31**	**33,53**	**27,97**	**33,56**	**42,51**	**51,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,2**	**-5,9**	**1,8**	**2,4**	**2,0**	**1,3**
Coal	0,81	1,50	17,73	14,43	15,63	10,84	10,24	15,7	10,4	52,9	51,6	46,6	25,5	19,7	12,1	-6,6	0,8	-3,6	-0,6	-1,6
Oil	2,99	0,78	0,26	0,55	0,54	0,54	0,53	57,9	5,5	0,8	1,9	1,6	1,3	1,0	-8,6	27,5	-0,2	0,1	-0,3	2,1
Natural gas	1,36	12,04	15,54	12,99	17,39	31,13	41,18	26,4	84,1	46,3	46,4	51,8	73,2	79,3	9,4	-5,8	3,0	6,0	2,8	3,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**34,7**	**38,4**	**38,7**	**42,6**	**48,6**	**53,0**								**0,7**	**0,2**	**1,0**	**1,3**	**0,9**	**1,0**
Coal	31,7	26,3	37,1	37,2	39,4	42,5	43,9								0,6	0,1	0,6	0,8	0,3	0,5
Oil	31,6	32,2	33,0	33,0	33,3	32,6	32,6								0,2	0,0	0,1	-0,2	0,0	0,0
Natural gas	31,7	36,0	40,0	40,5	45,8	51,0	55,5								0,9	0,4	1,2	1,1	0,8	1,0

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**13,6**	**30,7**	**57,3**	**49,9**	**62,7**	**77,4**	**94,1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,5**	**-4,5**	**2,3**	**2,1**	**2,0**	**1,5**
Coal	1,4	2,6	20,7	17,1	19,1	14,4	14,3	10,3	8,5	36,1	34,3	30,4	18,6	15,2	10,5	-6,2	1,1	-2,8	-0,1	-1,1
Oil	10,3	15,7	21,7	20,7	28,8	37,1	45,3	75,7	51,1	37,9	41,6	45,9	47,9	48,1	2,8	-1,5	3,3	2,6	2,0	2,3
Natural gas	1,9	12,4	14,9	12,1	14,9	25,9	34,6	14,0	40,4	26,0	24,2	23,7	33,5	36,7	7,9	-6,9	2,1	5,7	2,9	2,6

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	75	148	365	344	483	642	817	6,1	-1,9	3,4	2,9	2,4	2,5
Population (millions of people)	18	23	32	32	37	41	44	2,1	0,5	1,3	1,0	0,8	1,0
GDP per capita (thousands of 2015 USD/person)	4,14	6,39	11,41	10,64	13,11	15,82	18,59	3,8	-2,3	2,1	1,9	1,6	1,5
Primary energy consumption per capita (toe/person)	1,13	2,14	2,70	2,50	2,85	3,29	3,71	3,3	-2,6	1,3	1,4	1,2	1,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	273	335	237	235	218	208	199	-0,5	-0,3	-0,8	-0,5	-0,4	-0,5
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	169	192	175	178	169	166	163	0,1	0,6	-0,5	-0,2	-0,2	-0,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	182	207	157	145	130	120	115	-0,5	-2,7	-1,1	-0,7	-0,4	-0,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,67	0,62	0,66	0,62	0,60	0,58	0,58	0,0	-2,4	-0,3	-0,3	0,0	-0,4
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Malaysia LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**20,40**	**49,70**	**86,36**	**77,17**	**101,34**	**130,42**	**152,54**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-10,6**	**2,8**	**2,6**	**1,6**	**1,9**
Coal	1,33	2,49	19,43	14,47	16,88	14,06	14,98	6,5	5,0	22,5	18,7	16,7	10,8	9,8	9,7	-25,6	1,6	-1,8	0,6	-0,8
Oil	11,93	20,24	29,95	27,22	36,44	33,36	39,21	58,5	40,7	34,7	35,3	36,0	25,6	25,7	3,2	-9,1	3,0	-0,9	1,6	0,9
Natural gas	6,80	26,37	34,18	28,14	34,32	53,39	58,41	33,3	53,1	39,6	36,5	33,9	40,9	38,3	5,7	-17,7	2,0	4,5	0,9	1,7
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	-	-	-	-	-	-
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	13,07	16,63	0,0	0,0	0,0	0,0	0,0	10,0	10,9	-	-	-	-	2,4	-
Hydro	0,34	0,60	2,26	2,39	3,45	3,51	3,97	1,7	1,2	2,6	3,1	3,4	2,7	2,6	6,7	5,7	3,7	0,2	1,2	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	0,00	0,52	4,95	10,25	13,03	19,36	0,0	0,0	0,6	6,4	10,1	10,0	12,7	-	843,7	7,5	2,4	4,0	12,3
Biomass	0,00	0,00	0,31	1,05	1,93	2,05	4,10	0,0	0,0	0,4	1,4	1,9	1,6	2,7	-	236,2	6,4	0,6	7,2	8,7
Solar, Wind, Ocean	0,00	0,00	0,13	0,23	0,91	1,14	2,28	0,0	0,0	0,1	0,3	0,9	0,9	1,5	-	84,2	14,6	2,3	7,2	9,8
Biofuels	0,00	0,00	0,65	3,45	7,37	9,73	12,59	0,0	0,0	0,8	4,5	7,3	7,5	8,3	-	431,0	7,9	2,8	2,6	10,0
Electricity	0,00	0,00	-0,56	0,23	0,04	0,11	0,40	0,0	0,0	-0,7	0,3	0,0	0,1	0,3	-	-140,2	-16,4	11,6	13,4	-198,9

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,62**	**28,44**	**63,87**	**59,37**	**78,94**	**103,05**	**123,97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**-7,0**	**2,9**	**2,7**	**1,9**	**2,2**
Industry	5,28	11,41	18,92	15,14	19,80	27,25	31,42	41,8	40,1	29,6	25,5	25,1	26,4	25,3	4,5	-20,0	2,7	3,2	1,4	1,6
Transportation	4,88	10,81	22,40	22,53	32,09	42,35	53,70	38,7	38,0	35,1	37,9	40,6	41,1	43,3	5,4	0,6	3,6	2,8	2,4	2,9
Others	1,62	3,97	8,93	7,84	10,55	13,80	15,43	12,9	14,0	14,0	13,2	13,4	13,4	12,4	6,1	-12,2	3,0	2,7	1,1	1,8
Non-energy	0,84	2,25	13,63	13,87	16,50	19,65	23,42	6,6	7,9	21,3	23,4	20,9	19,1	18,9	10,1	1,7	1,8	1,8	1,8	1,8
Total	**12,62**	**28,44**	**63,87**	**59,37**	**78,94**	**103,05**	**123,97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**-7,0**	**2,9**	**2,7**	**1,9**	**2,2**
Coal	0,51	0,99	1,71	1,50	2,12	2,51	2,67	4,1	3,5	2,7	2,5	2,7	2,4	2,2	4,2	-12,0	3,5	1,7	0,6	1,5
Oil	9,32	18,32	29,23	26,11	34,61	31,49	37,27	73,9	64,4	45,8	44,0	43,8	30,6	30,1	4,0	-10,7	2,9	-0,9	1,7	0,8
Natural gas	1,07	3,86	18,65	16,44	18,53	24,31	29,51	8,5	13,6	29,2	27,7	23,5	23,6	23,8	10,4	-11,9	1,2	2,8	2,0	1,5
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	13,07	16,63	0,0	0,0	0,0	0,0	0,0	12,7	13,4						
Electricity	1,72	5,26	13,65	11,88	16,32	21,94	25,31	13,6	18,5	21,4	20,0	20,7	21,3	20,4	7,4	-13,0	3,2	3,0	1,4	2,0
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	0,65	3,45	7,37	9,73	12,59	0,0	0,0	1,0	5,8	9,3	9,4	10,2	-	432,6	7,9	2,8	2,6	10,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**23,01**	**64,81**	**178,63**	**147,07**	**205,40**	**275,62**	**314,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,3**	**-17,7**	**3,4**	**3,0**	**1,3**	**1,8**
Coal PP	3,00	4,57	76,41	56,04	65,88	0,00	0,00	13,0	7,1	42,8	38,1	32,1	0,0	0,0	11,8	-26,7	1,6	-100,0	-	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	0,00	53,92	57,28	0,0	0,0	0,0	0,0	0,0	19,6	18,2	-	-	-	-	0,6	-
Oil	11,00	2,94	1,01	1,88	1,91	2,06	2,19	47,8	4,5	0,6	1,3	0,9	0,7	0,7	-7,9	85,9	0,2	0,8	0,6	2,5
Gas PP	5,02	50,31	72,28	54,87	79,99	0,00	0,00	21,8	77,6	40,5	37,3	38,9	0,0	0,0	9,6	-24,1	3,8	-100,0	-	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	0,00	158,18	168,03	0,0	0,0	0,0	0,0	0,0	57,4	53,4	-	-	-	-	0,6	-
Hydrogen/Ammonia 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	-	-	-	-	-	-
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	-	-	-	-	-	-
Solar	0,00	0,00	1,46	2,69	10,54	13,26	26,51	0,0	0,0	0,8	1,8	5,1	4,8	8,4	-	84,2	14,6	2,3	7,2	9,8
Wind	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	3,99	6,99	26,34	27,83	40,10	40,83	46,18	17,3	10,8	14,7	18,9	19,5	14,8	14,7	6,7	5,7	3,7	0,2	1,2	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	0,00	1,13	3,77	6,98	7,38	14,77	0,0	0,0	0,6	2,6	3,4	2,7	4,7	-	234,1	6,4	0,6	7,2	8,7

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,16**	**14,31**	**33,53**	**25,16**	**31,05**	**41,17**	**41,78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,7**	**-25,0**	**2,1**	**2,9**	**0,1**	**0,7**
Coal	0,81	1,50	17,73	12,96	14,76	11,56	12,31	15,7	10,4	52,9	51,5	47,5	28,1	29,5	11,2	-26,9	1,3	-2,4	0,6	-1,2
Oil	2,99	0,78	0,26	0,49	0,50	0,54	0,57	57,9	5,5	0,8	1,9	1,6	1,3	1,4	-8,0	85,9	0,2	0,8	0,6	2,5
Gas	1,36	12,04	15,54	11,70	15,79	29,08	28,90	26,4	84,1	46,3	46,5	50,9	70,6	69,2	8,8	-24,7	3,0	6,3	-0,1	2,0
Hydrogen/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	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,7**	**34,7**	**38,4**	**38,6**	**40,9**	**44,7**	**46,8**								**0,7**	**0,4**	**0,6**	**0,9**	**0,5**	**0,6**
Coal	31,73	26,29	37,07	37,17	38,38	0,00	0,00								0,5	0,3	0,3	-100,0	-	-100,0
Oil	31,65	32,24	33,01	33,01	33,01	33,01	33,01								0,1	0,0	0,0	0,0	0,0	0,0
Gas	31,74	35,95	40,01	40,33	43,56	46,78	50,01								0,8	0,8	0,8	0,7	0,7	0,7
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**13,6**	**30,7**	**57,3**	**45,5**	**57,1**	**47,9**	**46,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,1**	**-20,5**	**2,3**	**-1,7**	**-0,4**	**-0,7**
Coal	1,4	2,6	20,7	15,4	18,0	10,0	8,0	10,3	8,5	36,1	33,8	31,4	20,8	17,4	9,7	-25,6	1,6	-5,7	-2,2	-3,0
Oil	10,3	15,7	21,7	19,2	25,6	21,8	25,2	75,7	51,1	37,9	42,2	44,9	45,5	54,8	2,6	-11,4	2,9	-1,6	1,5	0,5
Natural gas	1,9	12,4	14,9	10,9	13,5	16,1	12,8	14,0	40,4	26,0	24,0	23,7	33,7	27,8	7,4	-26,7	2,2	1,8	-2,3	-0,5

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	74,6	148,3	364,7	344,5	483,1	642,3	816,6	5,6	-5,5	3,4	2,9	2,4	2,6
Population (millions of people)	18,0	23,2	32,0	32,4	36,8	40,6	43,9	2,0	1,4	1,3	1,0	0,8	1,0
GDP per capita (thousands of 2015 USD/person)	4,14	6,39	11,41	10,64	13,11	15,82	18,59	3,6	-6,8	2,1	1,9	1,6	1,6
Primary energy consumption per capita (toe/person)	1,13	2,14	2,70	2,38	2,75	3,21	3,47	3,0	-11,9	1,4	1,6	0,8	0,8
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	273	335	237	224	210	203	187	-0,5	-5,4	-0,7	-0,3	-0,8	-0,8
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	169	192	175	172	163	160	152	0,1	-1,6	-0,5	-0,2	-0,6	-0,5
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	182	207	157	132	118	75	56	-0,5	-15,8	-1,1	-4,5	-2,8	-3,3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,67	0,62	0,66	0,59	0,56	0,37	0,30	0,0	-11,0	-0,5	-4,2	-2,0	-2,5
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Myanmar BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,7**	**11,1**	**20,48**	**20,59**	**26,22**	**34,85**	**44,17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**0,6**	**2,4**	**2,9**	**2,4**	**2,5**
Coal	0,07	0,06	0,85	0,87	2,18	4,21	4,96	0,6	0,5	4,2	4,2	8,3	12,1	11,2	9,2	1,7	9,6	6,8	1,6	5,8
Oil	0,73	1,79	5,78	5,60	8,94	14,17	20,93	6,8	16,1	28,2	27,2	34,1	40,7	47,4	7,4	-3,2	4,8	4,7	4,0	4,2
Natural gas	0,76	1,35	4,03	4,60	5,30	5,98	5,64	7,1	12,2	19,7	22,3	20,2	17,2	12,8	5,9	14,0	1,4	1,2	-0,6	1,1
Nuclear	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,10	0,16	0,86	0,73	0,99	1,67	3,81	0,9	1,4	4,2	3,5	3,8	4,8	8,6	7,7	-15,5	3,1	5,3	8,6	4,9
Geothermal	0,00	0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	9,02	7,73	8,95	8,80	8,81	8,82	8,83	84,5	69,7	43,7	42,7	33,6	25,3	20,0	0,0	-1,7	0,0	0,0	0,0	0,0
Biomass	9,02	7,73	8,94	8,91	8,92	8,93	8,94	84,5	69,7	43,7	43	34,0	25,6	20,2	0,0	-0,4	0,0	0,0	0,0	0,0
Solar, Wind, Ocean			0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	264,9	-2,7	-2,1	-1,2	2,2
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity			0,01	-0,11	-0,11	-0,11	-0,11	0,0	0,0	0,1	-0,5	-0,4	-0,3	-0,2	-	-1.069,1	0,0	0,0	0,0	-207,6

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,4**	**9,9**	**17,4**	**17,1**	**21,7**	**28,8**	**38,278**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**2,4**	**2,9**	**2,9**	**2,6**
Industry	0,4	3,3	4,98	5,01	6,12	7,92	9,82	4,2	32,7	28,6	29,2	28,3	27,5	25,7	9,1	0,5	2,0	2,6	2,2	2,2
Transportation	0,4	0,9	4,68	4,46	7,10	11,51	18,02	4,7	9,4	26,9	26,0	32,8	39,9	47,1	8,5	-4,6	4,7	5,0	4,6	4,4
Others	8,5	5,8	7,69	7,63	8,40	9,33	10,36	90,2	57,9	44,2	44,5	38,8	32,4	27,1	-0,3	-0,8	1,0	1,1	1,0	1,0
Non-energy	0,1	0,0	0,04	0,04	0,05	0,06	0,07	1,0	0,0	0,2	0,2	0,2	0,2	0,2	-3,1	4,6	2,2	2,3	2,4	2,4
Total	**9,4**	**9,9**	**17,4**	**17,1**	**21,7**	**28,8**	**38,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**2,4**	**2,9**	**2,9**	**2,6**
Coal	0,1	0,1	0,63	0,63	0,85	1,22	1,69	0,5	0,6	3,6	3,7	3,9	4,2	4,4	9,1	0,1	3,0	3,7	3,3	3,2
Oil	0,6	1,6	5,73	5,56	8,85	14,03	20,75	6,3	16,1	33,0	32,5	40,8	48,7	54,2	8,2	-2,9	4,7	4,7	4,0	4,2
Natural gas	0,2	0,4	0,41	0,41	0,45	0,52	0,59	2,4	4,0	2,4	2,4	2,1	1,8	1,5	2,0	0,0	1,0	1,3	1,3	1,1
Electricity	0,2	0,3	1,67	1,62	2,59	4,11	6,31	1,6	2,8	9,6	9,5	12,0	14,3	16,5	8,7	-3,1	4,8	4,7	4,4	4,4
Heat	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	8,4	7,6	8,94	8,91	8,92	8,93	8,94	89,2	76,4	51,4	52,0	41,2	31,0	23,4	0,2	-0,4	0,0	0,0	0,0	0,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,5**	**5,2**	**23,08**	**23,61**	**34,79**	**53,84**	**81,004**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8,0**	**2,3**	**4,0**	**4,5**	**4,2**	**4,1**
Coal	0,0	0,0	0,69	0,74	4,63	11,28	13,29	1,6	0,8	3,0	3,2	13,3	20,9	16,4	10,3	7,4	20,1	9,3	1,7	10,0
Oil	0,3	0,0	0,07	0,00	0,00	0,00	0,00	10,9	0,8	0,3	0,0	0,0	0,0	0,0	-4,6	-100,0	-	-	-	-100,0
Natural gas	1,0	3,2	12,27	14,36	18,60	23,14	23,41	39,3	61,8	53,2	60,8	53,5	43,0	28,9	9,1	17,0	2,6	2,2	0,1	2,1
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	1,2	1,9	10,03	8,48	11,54	19,40	44,29	48,2	36,6	43,5	35,9	33,2	36,0	54,7	7,6	-15,5	3,1	5,3	8,6	4,9
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	0,01	0,03	0,03	0,02	0,02	0,0	0,0	0,0	0,1	0,1	0,0	0,0	-	264,9	-2,7	-2,1	-1,2	2,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,5**	**0,8**	**3,8**	**4,4**	**6,2**	**8,4**	**8,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,3**	**14,6**	**3,4**	**3,2**	**-0,2**	**2,5**
Coal	0,0	0,0	0,22	0,23	1,33	2,99	3,26	2,4	1,4	5,7	5,3	21,6	35,4	39,3	10,5	6,4	19,0	8,4	0,9	9,1
Oil	0,1	0,0	0,02	0,00	0,00	0,00	0,00	12,0	1,2	0,5	0,0	0,0	0,0	0,0	-4,0	-100,0	-	-	-	-100,0
Natural gas	0,4	0,8	3,60	4,17	4,84	5,45	5,04	85,7	97,4	93,8	94,7	78,4	64,6	60,7	7,6	15,7	1,5	1,2	-0,8	1,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**21,9**	**33,8**	**29,2**	**29,5**	**32,4**	**35,1**	**38,0**								**1,0**	**1,1**	**0,9**	**0,8**	**0,8**	**0,9**
Coal	28,7	28,7	27,1	27,4	29,9	32,5	35,0								-0,2	0,9	0,9	0,8	0,8	0,8
Oil	38,7	34,4	31,9	-	-	-	-								-0,7	-	-	-	-	-
Natural gas	31,7	36,0	40,0	40,0	40,0	40,0	40,0								1,4	1,1	1,1	1,0	0,9	1,0

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,2**	**2,2**	**8,2**	**8,4**	**13,0**	**19,9**	**26,00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**2,8**	**4,5**	**4,4**	**2,7**	**3,8**
Coal	0,1	0,1	0,9	0,9	2,3	4,5	5,27	8,3	3,2	11,1	11,0	17,8	22,5	20,3	7,9	1,7	9,6	6,8	1,6	5,8
Oil	0,6	1,3	4,7	4,6	7,3	11,6	17,13	50,0	58,1	57,5	54,2	56,2	58,4	65,9	7,4	-3,2	4,8	4,8	3,9	4,3
Natural gas	0,5	0,9	2,6	2,9	3,4	3,8	3,59	41,7	38,7	31,4	34,8	26,0	19,1	13,8	5,8	14,1	1,5	1,2	-0,6	1,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	8,0	16,0	74,27	69,89	117,69	200,76	327,01	8,0	-5,9	5,3	5,5	5,0	4,9
Population (millions of people)	41,3	46,7	54,0	54,6	58,9	62,2	65,3	0,9	1,0	0,8	0,5	0,5	0,6
GDP per capita (thousands of 2015 USD/person)	0,19	0,34	1,37	1,28	2,0	3,2	5,0	7,0	-6,8	4,5	4,9	4,5	4,3
Primary energy consumption per capita (toe/person)	0,26	0,24	0,38	0,38	0,44	0,56	0,68	1,3	-0,4	1,7	2,3	1,9	1,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.335	693	276	295	223	174	135	-5,3	6,9	-2,8	-2,5	-2,5	-2,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.174	621	234	245	184	144	117	-5,4	4,7	-2,8	-2,5	-2,0	-2,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	150	139	110	120	111	99	80	-1,1	9,2	-0,8	-1,1	-2,2	-1,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,11	0,20	0,40	0,41	0,50	0,57	0,59	4,5	2,2	2,0	1,4	0,3	1,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Myanmar APS

Primary energy consumption

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,7**	**11,1**	**20,48**	**20,49**	**23,82**	**29,57**	**35,24**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**0,1**	**1,5**	**2,2**	**1,8**	**1,8**
Coal	0,1	0,1	0,85	0,80	1,57	2,96	3,23	0,6	0,5	4,2	3,9	6,6	10,0	9,2	9,2	-6,3	7,0	6,6	0,9	4,4
Oil	0,7	1,8	5,78	5,60	8,16	12,21	16,97	6,8	16,1	28,2	27,3	34,2	41,3	48,2	7,4	-3,2	3,8	4,1	3,3	3,5
Natural gas	0,8	1,4	4,03	4,55	4,46	4,43	3,77	7,1	12,2	19,7	22,2	18,7	15,0	10,7	5,9	12,9	-0,2	-0,1	-1,6	-0,2
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,1	0,2	0,86	0,73	0,93	1,48	3,19	0,9	1,4	4,2	3,6	3,9	5,0	9,0	7,7	-15,5	2,4	4,7	8,0	4,3
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	9,0	7,7	8,95	8,82	8,71	8,49	8,09	84,5	69,7	43,7	43,0	36,6	28,7	23,0	0,0	-1,5	-0,1	-0,2	-0,5	-0,3
Biomass	9,0	7,7	8,94	8,91	8,66	8,37	7,88	84,5	69,7	43,7	43,5	36,4	28,3	22,4	0,0	-0,4	-0,3	-0,3	-0,6	-0,4
Solar, Wind, Ocean			0,00	0,02	0,16	0,24	0,32	0,0	0,0	0,0	0,1	0,7	0,8	0,9	-	2.545,6	21,9	4,2	3,0	21,2
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity			0,01	-0,11	-0,11	-0,11	-0,11	0,0	0,0	0,1	-0,5	-0,5	-0,4	-0,3	-	-1.069,1	0,0	0,0	0,0	-207,6

Final energy demand

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,4**	**9,9**	**17,39**	**17,14**	**20,28**	**25,44**	**31,675**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**1,7**	**2,3**	**2,2**	**2,0**
Industry	0,4	3,3	4,98	5,01	5,82	7,12	8,60	4,2	32,7	28,6	29,2	28,7	28,0	27,1	9,1	0,5	1,5	2,0	1,9	1,8
Transportation	0,4	0,9	4,68	4,46	6,39	9,78	14,42	4,7	9,4	26,9	26,0	31,5	38,5	45,5	8,5	-4,6	3,7	4,4	4,0	3,7
Others	8,5	5,8	7,69	7,63	8,03	8,48	8,60	90,2	57,9	44,2	44,5	39,6	33,3	27,1	-0,3	-0,8	0,5	0,5	0,1	0,4
Non-energy	0,1	0,0	0,04	0,04	0,05	0,05	0,07	1,0	0,0	0,2	0,2	0,2	0,2	0,2	-3,1	4,6	2,1	1,8	2,0	2,0
Total	**9,4**	**9,9**	**17,4**	**17,1**	**20,3**	**25,4**	**31,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**1,7**	**2,3**	**2,2**	**2,0**
Coal	0,1	0,1	0,63	0,63	0,81	1,10	1,48	0,5	0,6	3,6	3,7	4,0	4,3	4,7	9,1	0,1	2,4	3,2	3,0	2,8
Oil	0,6	1,6	5,73	5,56	8,07	12,08	16,79	6,3	16,1	33,0	32,5	39,8	47,5	53,0	8,2	-2,9	3,8	4,1	3,3	3,5
Natural gas	0,2	0,4	0,41	0,41	0,42	0,45	0,50	2,4	4,0	2,4	2,4	2,1	1,8	1,6	2,0	0,0	0,2	0,8	0,9	0,6
Electricity	0,2	0,3	1,67	1,62	2,47	3,71	5,37	1,6	2,8	9,6	9,5	12,2	14,6	16,9	8,7	-3,1	4,3	4,2	3,8	3,8
Heat	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	8,4	7,6	8,94	8,91	8,52	8,10	7,54	89,2	76,4	51,4	52,0	42,0	31,8	23,8	0,2	-0,4	-0,4	-0,5	-0,7	-0,5

Power generation Output

	TWh							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,5**	**5,2**	**23,1**	**23,6**	**33,2**	**48,7**	**69,120**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8,0**	**2,3**	**3,5**	**3,9**	**3,6**	**3,6**
Coal	0,0	0,0	0,69	0,53	2,75	7,46	7,72	1,6	0,8	3,0	2,2	8,3	15,3	11,2	10,3	-23,9	18,0	10,5	0,3	8,1
Oil	0,3	0,0	0,07	0,00	0,00	0,00	0,00	10,9	0,8	0,3	0,0	0,0	0,0	0,0	-4,6	-100,0	-	-	-	-100,0
Natural gas	1,0	3,2	12,27	14,36	17,39	20,47	19,58	39,3	61,8	53,2	60,8	52,4	42,0	28,3	9,1	17,0	1,9	1,6	-0,4	1,5
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	1,2	1,9	10,03	8,48	10,79	17,16	37,04	48,2	36,6	43,5	35,9	32,5	35,2	53,6	7,6	-15,5	2,4	4,7	8,0	4,3
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	0,01	0,25	2,28	3,63	4,78	0,0	0,0	0,0	1,1	6,9	7,4	6,9	-	2.545,6	24,7	4,7	2,8	22,2

Power generation Input

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,5**	**0,8**	**3,8**	**4,3**	**4,8**	**5,8**	**5,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,3**	**11,6**	**1,1**	**2,0**	**-1,5**	**0,9**
Coal	0,0	0,0	0,2	0,2	0,8	1,9	1,746	2,4	1,4	5,7	3,9	15,9	31,9	34,9	10,5	-24,8	16,6	9,3	-0,6	6,9
Oil	0,1	0,0	0,0	0,0	0,0	0,0	0,000	12,0	1,2	0,5	0,0	0,0	0,0	0,0	-4,0	-100,0	-	-	-	-100,0
Natural gas	0,4	0,8	3,6	4,1	4,0	4,0	3,261	85,7	97,4	93,8	96,1	84,1	68,1	65,1	7,6	14,4	-0,2	-0,2	-1,9	-0,3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**21,9**	**33,8**	**29,2**	**29,9**	**36,1**	**41,2**	**46,9**								**1,0**	**2,3**	**1,9**	**1,3**	**1,3**	**1,5**
Coal	28,7	28,7	27,1	27,5	31,0	34,5	38,0								-0,2	1,3	1,2	1,1	1,0	1,1
Oil	38,7	34,4	31,9	-	-	-	-								-0,7	-	-	-	-	-
Natural gas	19,4	33,9	29,3	30,0	37,1	44,4	51,6								1,4	2,3	2,2	1,8	1,5	1,8

CO_2 emissions

	Mt-C							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,2**	**2,2**	**8,2**	**8,3**	**11,2**	**16,0**	**19,70**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**1,5**	**3,0**	**3,6**	**2,1**	**2,9**
Coal	0,1	0,1	0,9	0,9	1,7	3,2	3,43	8,3	3,2	11,1	10,3	14,9	19,7	17,4	7,9	-6,3	7,0	6,5	0,9	4,4
Oil	0,6	1,3	4,7	4,6	6,7	10,0	13,87	50,0	58,1	57,5	54,9	59,7	62,7	70,4	7,4	-3,2	3,9	4,2	3,3	3,5
Natural gas	0,5	0,9	2,6	2,9	2,8	2,8	2,40	41,7	38,7	31,4	34,9	25,4	17,6	12,2	5,8	12,9	-0,2	-0,1	-1,6	-0,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	8,0	16,0	74,3	69,9	117,7	200,8	327,0	8,0	-5,9	5,3	5,5	5,0	4,9
Population (millions of people)	41,3	46,7	54,0	54,6	58,9	62,2	65,3	0,9	1,0	0,8	0,5	0,5	0,6
GDP per capita (thousands of 2015 USD/person)	0,19	0,34	1,37	1,28	2,0	3,2	5,0	7,0	-6,8	4,5	4,9	4,5	4,3
Primary energy consumption per capita (toe/person)	0,26	0,24	0,38	0,38	0,40	0,48	0,54	1,3	-0,9	0,7	1,6	1,3	1,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.335	693	276	293	202	147	108	-5,3	6,4	-3,6	-3,1	-3,1	-3,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.174	621	234	245	172	127	97	-5,4	4,7	-3,5	-3,0	-2,7	-2,8
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	150	139	110	119	95	80	60	-1,1	7,9	-2,2	-1,7	-2,8	-1,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,11	0,20	0,40	0,41	0,47	0,54	0,56	4,5	1,4	1,5	1,4	0,3	1,1
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Myanmar LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,7**	**11,1**	**20,48**	**20,49**	**23,82**	**33,82**	**44,51**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**0,1**	**1,5**	**3,6**	**2,8**	**2,5**
Coal	0,1	0,1	0,9	0,8	1,6	4,6	6,5	0,6	0,5	4,2	3,9	6,6	13,5	14,6	9,2	-6,3	7,0	11,2	3,6	6,8
Oil	0,7	1,8	5,8	5,6	8,2	9,1	5,4	6,8	16,1	28,2	27,3	34,2	27,0	12,1	7,4	-3,2	3,8	1,1	-5,1	-0,2
Natural gas	0,8	1,4	4,0	4,5	4,5	8,3	11,3	7,1	12,2	19,7	22,2	18,7	24,4	25,3	5,9	12,9	-0,2	6,4	3,2	3,4
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/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	-	-	-	-	-	-
Hydro	0,1	0,2	0,9	0,7	0,9	2,9	10,5	0,9	1,4	4,2	3,6	3,9	8,6	23,6	7,7	-15,5	2,4	12,1	13,7	8,4
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	9,0	7,7	9,0	8,8	8,7	9,0	10,8	84,5	69,7	43,7	43,0	36,6	26,6	24,3	0,0	-1,5	-0,1	0,3	1,9	0,6
Biomass	9,0	7,7	8,9	8,9	8,7	8,6	8,7	84,5	69,7	43,7	43,5	36,4	25,5	19,5	0,0	-0,4	-0,3	0,0	0,0	-0,1
Solar, Wind, Ocean			0,0	0,0	0,2	0,5	1,0	0,0	0,0	0,0	0,1	0,7	1,4	2,3	-	2.546	21,9	11,5	8,5	26,0
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity			0,0	-0,1	-0,1	-0,1	1,1	0,0	0,0	0,1	-0,5	-0,5	-0,3	2,5	-	-1.069	0,0	0,0	-	16,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,4**	**9,9**	**17,39**	**17,14**	**20,28**	**25,75**	**32,88**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**1,7**	**2,4**	**2,5**	**2,1**
Industry	0,4	3,3	4,98	5,01	5,82	7,14	8,65	4,2	32,7	28,6	29,2	28,7	27,7	26,3	9,1	0,5	1,5	2,1	1,9	1,8
Transportation	0,4	0,9	4,68	4,46	6,39	10,07	15,56	4,7	9,4	26,9	26,0	31,5	39,1	47,3	8,5	-4,6	3,7	4,7	4,4	4,0
Others	8,5	5,8	7,69	7,63	8,03	8,48	8,60	90,2	57,9	44,2	44,5	39,6	32,9	26,1	-0,3	-0,8	0,5	0,5	0,1	0,4
Non-energy	0,1	0,0	0,04	0,04	0,05	0,05	0,07	1,0	0,0	0,2	0,2	0,2	0,2	0,2	-3,1	4,6	2,1	1,8	2,0	2,0
Total	**9,4**	**9,9**	**17,39**	**17,14**	**20,28**	**25,75**	**32,878**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,1**	**-1,4**	**1,7**	**2,4**	**2,5**	**2,1**
Coal	0,1	0,1	0,63	0,63	0,81	0,89	0,74	0,5	0,6	3,6	3,7	4,0	3,5	2,2	9,1	0,1	2,4	1,1	-1,9	0,5
Oil	0,6	1,6	5,73	5,56	8,07	8,99	5,21	6,3	16,1	33,0	32,5	39,8	34,9	15,8	8,2	-2,9	3,8	1,1	-5,3	-0,3
Natural gas	0,2	0,4	0,41	0,41	0,42	0,45	0,50	2,4	4,0	2,4	2,4	2,1	1,8	1,5	2,0	0,0	0,2	0,8	0,9	0,6
Hydrogen/Ammonia	0,0	0,0	0,00	0,00	0,00	0,75	2,18	0,0	2,8	0,0	0,0	0,0	2,9	6,6		-	-	-	11,2	-
Electricity	0,2	0,3	1,67	1,62	2,47	6,56	16,71	1,6	0,0	9,6	9,5	12,2	25,5	50,8	8,7	-3,1	4,3	10,2	9,8	7,7
Heat	0,0	0,0						0,0	76,4	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	8,4	7,6	8,94	8,91	8,52	8,10	7,54	89,2	0,0	51,4	52,0	42,0	31,4	22,9	0,2	-0,4	-0,4	-0,5	-0,7	-0,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,5**	**5,2**	**23,08**	**23,61**	**33,22**	**95,75**	**228,193**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8,0**	**2,3**	**3,5**	**11,2**	**9,1**	**7,7**
Coal PP	0,0	0,0	0,69	0,53	2,75	14,67	25,48	1,6	0,0	3,0	2,2	8,3	15,3	11,2	10,3	-23,9	18,0	18,2	5,7	12,3
Coal PP with CCS								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil	0,3	0,0	0,07	0,00	0,00	0,00	0,00	10,9	0,0	0,3	0,0	0,0	0,0	0,0	-4,6	-100,0	-	-	-	-100,0
Gas PP	1,0	3,2	12,27	14,36	17,39	40,23	64,63	39,3	0,0	53,2	60,8	52,4	42,0	28,3	9,1	17,0	1,9	8,7	4,9	5,5
Gas PP PP with CCS								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydrogen/Ammonia PP								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	-	-	-	-	-	-
Solar	0,0		0,01	0,18	1,26	3,75	6,57	0,0	0,0	0,0	0,8	3,8	3,9	2,9	-	1.785,4	21,5	11,6	5,8	23,5
Wind	0,0		0,00	0,07	0,56	1,63	5,54	0,0	0,0	0,0	0,3	1,7	1,7	2,4	-	-	22,8	11,2	13,0	-
Hydro	1,2	1,9	10,03	8,48	10,79	33,73	122,30	48,2	0,0	43,5	35,9	32,5	35,2	53,6	7,6	-15,5	2,4	12,1	13,7	8,4
Geothermal	0,0							0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0		0,00	0,00	0,46	1,74	3,67	0,0	0,0	0,0	0,0	1,4	1,8	1,6	-	-	-	14,2	7,7	-

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**0,5**	**0,8**	**3,8**	**4,3**	**4,8**	**11,4**	**16,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,3**	**11,6**	**1,1**	**9,1**	**3,7**	**4,8**
Coal	0,0	0,0	0,22	0,17	0,76	3,66	5,765	2,4	1,4	5,7	3,9	15,9	31,9	34,9	10,5	-24,8	16,6	16,9	4,7	11,1
Oil	0,1	0,0	0,02	0,00	0,00	0,00	0,00	12,0	1,2	0,5	0,0	0,0	0,0	0,0	-4,0	-100,0	-	-	-	-100,0
Gas	0,4	0,8	3,60	4,12	4,03	7,79	10,765	85,7	97,4	93,8	96,1	84,1	68,1	65,1	7,6	14,4	-0,2	6,8	3,3	3,6
Hydrogen/Ammonia	0,0	0,0	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**21,9**	**33,8**	**29,2**	**29,9**	**36,1**	**41,2**	**46,9**								**1,0**	**2,3**	**1,9**	**1,3**	**1,3**	**1,5**
Coal	28,67	28,67	27,10	27,46	30,97	34,49	38,01								-0,2	1,3	1,2	1,1	1,0	1,1
Oil	38,70	31,13	31,91	-	-	-	-								-0,7	-	-	-	-	-
Gas	19,40	33,86	29,31	29,97	37,11	44,42	51,63								1,4	2,3	2,2	1,8	1,5	1,8
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,2**	**2,2**	**8,2**	**8,3**	**11,2**	**17,6**	**18,49**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,8**	**1,5**	**3,0**	**4,6**	**0,5**	**2,7**
Coal	0,1	0,1	0,91	0,85	1,67	4,84	6,92	8,3	3,2	11,1	10,3	14,9	27,5	37,4	7,9	-6,3	7,0	11,2	3,6	6,8
Oil	0,6	1,3	4,70	4,56	6,68	7,51	4,38	50,0	58,1	57,5	54,9	59,7	42,6	23,7	7,4	-3,2	3,9	1,2	-5,2	-0,2
Natural gas	0,5	0,9	2,56	2,90	2,84	5,26	7,19	41,7	38,7	31,4	34,9	25,4	29,9	38,9	5,8	12,9	-0,2	6,4	3,2	3,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	8,0	16,0	74,27	69,90	117,69	200,76	327,01	8,0	-5,9	5,3	5,5	5,0	4,9
Population (millions of people)	41,30	46,70	54,05	54,59	58,95	62,21	65,26	0,9	1,0	0,8	0,5	0,5	0,6
GDP per capita (thousands of 2015 USD/person)	0,19	0,34	1,37	1,28	2,0	3,2	5,0	7,0	-6,8	4,5	4,9	4,5	4,3
Primary energy consumption per capita (toe/person)	0,26	0,24	0,38	0,38	0,40	0,54	0,68	1,3	-0,9	0,7	3,0	2,3	1,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.335	693	276	293	202	168	136	-5,3	6,4	-3,6	-1,8	-2,1	-2,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	1.174	621	234	245	172	128	101	-5,4	4,7	-3,5	-2,9	-2,4	-2,7
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	150	139	110	119	95	88	57	-1,1	7,9	-2,2	-0,8	-4,3	-2,1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,11	0,20	0,40	0,41	0,47	0,52	0,42	4,5	1,4	1,5	1,0	-2,2	0,1
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

New Zealand BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,85**	**17,13**	**20,48**	**19,79**	**23,11**	**23,28**	**23,02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,6**	**-3,4**	**1,6**	**0,1**	**-0,1**	**0,4**
Coal	1,18	1,11	1,50	1,19	1,00	0,95	0,87	9,2	6,5	7,3	6,0	4,3	4,1	3,79	0,8	-20,8	-1,8	-0,5	-0,8	-1,7
Oil	3,51	5,71	6,67	5,91	6,50	5,85	5,07	27,3	33,3	32,6	29,9	28,1	25,1	22,05	2,2	-11,5	1,0	-1,0	-1,4	-0,9
Natural gas	3,87	5,06	4,00	3,69	4,36	4,68	4,87	30,1	29,5	19,5	18,7	18,9	20,1	21,18	0,1	-7,7	1,7	0,7	0,4	0,6
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	0,00	-	-	-	-	-	-
Hydro	1,99	2,10	2,20	2,16	2,10	2,04	1,98	15,5	12,3	10,7	10,9	9,1	8,8	8,62	0,3	-1,6	-0,3	-0,3	-0,3	-0,3
Geothermal	1,49	1,96	4,67	5,45	7,33	7,71	8,04	11,6	11,4	22,8	27,5	31,7	33,1	34,93	4,0	16,6	3,0	0,5	0,4	1,8
Others	0,80	1,20	1,43	1,39	1,82	2,05	2,17	6,2	7,0	7,0	7,0	7,9	8,8	9,43	2,0	-3,0	2,7	1,2	0,6	1,4
Biomass	0,76	1,14	1,18	1,16	1,38	1,43	1,40	5,9	6,7	5,8	5,9	6,0	6,1	6,1	1,6	-2,0	1,7	0,3	-0,2	0,5
Solar, Wind, Ocean	0,04	0,05	0,25	0,23	0,44	0,62	0,77	0,3	0,3	1,2	1,1	1,9	2,7	3,3	6,1	-7,9	6,8	3,6	2,1	3,7
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,76**	**12,95**	**15,04**	**14,09**	**15,52**	**15,10**	**14,35**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-6,3**	**1,0**	**-0,3**	**-0,5**	**-0,2**
Industry	3,62	4,24	4,56	4,35	4,96	4,99	4,80	37,1	32,7	30,3	30,9	32,0	33,0	33,4	0,8	-4,7	1,3	0,1	-0,4	0,2
Transportation	2,96	4,06	5,41	4,77	5,24	4,79	4,31	30,3	31,4	36,0	33,9	33,8	31,7	30,0	2,1	-11,8	1,0	-0,9	-1,1	-0,7
Others	2,56	3,01	3,50	3,47	3,82	3,93	3,97	26,3	23,2	23,2	24,6	24,6	26,0	27,7	1,1	-0,9	1,0	0,3	0,1	0,4
Non-energy	0,62	1,64	1,57	1,50	1,50	1,39	1,27	6,3	12,7	10,5	10,7	9,7	9,2	8,9	3,3	-4,3	0,0	-0,7	-0,9	-0,7
Total	**9,76**	**12,95**	**15,04**	**14,09**	**15,52**	**15,10**	**14,35**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-6,3**	**1,0**	**-0,3**	**-0,5**	**-0,2**
Coal	0,67	0,50	0,66	0,64	0,66	0,61	0,55	6,9	3,9	4,4	4,6	4,3	4,0	3,8	-0,1	-2,4	0,3	-0,8	-1,1	-0,6
Oil	4,03	5,31	6,94	6,21	6,77	6,13	5,37	41,3	41,0	46,2	44,1	43,6	40,6	37,4	1,9	-10,5	0,9	-1,0	-1,3	-0,8
Natural gas	1,80	3,01	2,82	2,71	2,81	2,63	2,39	18,4	23,3	18,8	19,3	18,1	17,4	16,6	1,6	-4,0	0,4	-0,7	-1,0	-0,5
Electricity	2,45	2,94	3,37	3,34	3,92	4,37	4,75	25,1	22,7	22,4	23,7	25,3	29,0	33,1	1,1	-1,1	1,6	1,1	0,8	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	0,81	1,19	1,24	1,18	1,36	1,36	1,29	8,3	9,2	8,2	8,4	8,8	9,0	9,0	1,5	-4,6	1,5	0,0	-0,5	0,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**32,26**	**39,25**	**44,81**	**44,34**	**51,92**	**57,71**	**62,49**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,1**	**1,6**	**1,1**	**0,8**	**1,1**
Coal	0,66	1,55	2,27	1,63	0,44	0,46	0,46	2,1	3,9	5,1	3,7	0,9	0,8	0,7	4,3	-28,1	-12,2	0,4	-0,1	-5,0
Oil	0,01	0,00	0,00	0,00	0,00	0,01	0,01	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-2,9	-21,0	3,0	3,4	2,3	2,0
Natural gas	5,71	9,57	5,88	4,81	8,22	11,61	14,62	17,7	24,4	13,1	10,8	15,8	20,1	23,4	0,1	-18,2	5,5	3,5	2,3	3,0
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	23,18	24,43	25,57	25,16	24,47	23,78	23,09	71,9	62,3	57,1	56,7	47,1	41,2	36,9	0,3	-1,6	-0,3	-0,3	-0,3	-0,3
Geothermal	2,13	2,92	8,04	9,46	12,78	13,47	14,09	6,6	7,4	17,9	21,3	24,6	23,3	22,6	4,7	17,6	3,1	0,5	0,5	1,8
Others	0,57	0,78	3,05	3,28	6,01	8,39	10,23	1,8	2,0	6,8	7,4	11,6	14,5	16,4	6,0	7,8	6,2	3,4	2,0	4,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,41**	**2,28**	**1,61**	**1,23**	**1,55**	**2,05**	**2,49**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-24,0**	**2,4**	**2,8**	**1,9**	**1,4**
Coal	0,17	0,38	0,55	0,36	0,12	0,13	0,13	11,9	16,7	33,9	29,1	7,8	6,1	5,0	4,1	-34,8	-10,2	0,3	-0,1	-4,6
Oil	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,4	0,0	0,1	0,1	0,1	0,1	0,1	-6,3	11,0	0,2	2,6	1,5	1,7
Natural gas	1,24	1,90	1,07	0,87	1,43	1,93	2,36	87,7	83,3	66,1	70,8	92,1	93,8	94,9	-0,5	-18,6	5,1	3,0	2,1	2,6

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**38,8**	**41,9**	**43,5**	**45,2**	**48,0**	**50,6**	**52,1**								**0,4**	**4,0**	**0,6**	**0,5**	**0,3**	**0,6**
Coal	33,9	34,9	35,7	39,3	31,3	31,4	31,5								0,2	10,2	-2,3	0,0	0,0	-0,4
Oil	13,8	-	39,3	27,9	37,0	39,9	42,9								3,7	-28,8	2,9	0,7	0,7	0,3
Natural gas	39,6	43,4	47,4	47,6	49,4	51,8	53,2								0,6	0,4	0,4	0,5	0,3	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**6,3**	**7,9**	**9,0**	**7,9**	**8,6**	**8,3**	**7,8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-12,7**	**0,9**	**-0,4**	**-0,6**	**-0,5**
Coal	1,3	1,2	1,7	1,4	1,1	1,1	1,0	20,6	14,8	18,8	17,1	13,1	12,9	12,7	1,0	-20,6	-1,8	-0,5	-0,8	-1,7
Oil	2,7	4,4	5,4	4,8	5,2	4,7	4,1	42,8	55,8	59,7	60,4	60,7	56,4	51,8	2,4	-11,7	0,9	-1,1	-1,5	-0,9
Natural gas	2,3	2,3	1,9	1,8	2,3	2,6	2,8	36,6	29,4	21,5	22,5	26,3	30,7	35,5	-0,6	-8,7	2,5	1,2	0,8	1,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	88	119	201	194,7	255	300	348	2,9	-3,0	2,7	1,6	1,5	1,8
Population (millions of people)	3,3	3,9	5,104	5,122	5,6	6,0	6,3	1,5	0,4	0,8	0,7	0,5	0,7
GDP per capita (thousands of 2015 USD/person)	26,29	30,73	39,33	38,01	45,95	50,35	55,44	1,4	-3,4	1,9	0,9	1,0	1,1
Primary energy consumption per capita (toe/person)	3,86	4,44	4,01	3,86	4,16	3,91	3,67	0,1	-3,7	0,7	-0,6	-0,6	-0,3
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	147	144	102	102	91	78	66	-1,2	-0,4	-1,1	-1,5	-1,6	-1,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	111	109	75	72	61	50	41	-1,4	-3,4	-1,7	-1,9	-2,0	-1,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	72	66	45	41	34	28	22	-1,6	-10,0	-1,8	-1,9	-2,1	-2,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,46	0,44	0,40	0,37	0,36	0,34	-0,3	-9,7	-0,7	-0,4	-0,5	-0,8
Automobile ownership volume (millions of vehicles)	1,792	2,595	4,141	4,191	4,729	5,066	5,355	2,9	1,2	1,2		1,3	0,8
Automobile ownership volume per capita (vehicles per person)	0,538	0,673	0,811	0,818	0,852	0,851	0,854	1,4	0,8	0,4		0,0	0,2

New Zealand APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,85**	**17,13**	**20,48**	**19,80**	**23,16**	**22,61**	**21,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,6**	**-3,3**	**1,6**	**-0,2**	**-0,5**	**0,1**
Coal	1,18	1,11	1,50	1,18	0,82	0,71	0,61	9,2	6,5	7,3	6,0	3,5	3,2	2,8	0,8	-21,2	-3,6	-1,4	-1,6	-2,9
Oil	3,51	5,71	6,67	5,91	6,13	4,76	3,61	27,3	33,3	32,6	29,9	26,5	21,1	16,9	2,2	-11,4	0,4	-2,5	-2,7	-2,0
Natural gas	3,87	5,06	4,00	3,69	3,66	3,49	3,11	30,1	29,5	19,5	18,7	15,8	15,4	14,5	0,1	-7,7	-0,1	-0,5	-1,2	-0,8
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	2,10	2,20	2,16	2,10	2,04	1,98	15,5	12,3	10,7	10,9	9,1	9,0	9,3	0,3	-1,6	-0,3	-0,3	-0,3	-0,3
Geothermal	1,49	1,96	4,67	5,45	8,47	9,38	9,73	11,6	11,4	22,8	27,5	36,6	41,5	45,5	4,0	16,6	4,5	1,0	0,4	2,4
Others	0,80	1,20	1,43	1,40	1,98	2,22	2,36	6,2	7,0	7,0	7,0	8,6	9,8	11,0	2,0	-2,5	3,6	1,1	0,6	1,6
Biomass	0,76	1,14	1,18	1,17	1,44	1,44	1,36	5,9	6,7	5,8	5,9	6,2	6,4	6,3	1,6	-1,3	2,1	0,0	-0,6	0,4
Solar, Wind, Ocean	0,04	0,05	0,25	0,23	0,54	0,78	1,00	0,3	0,3	1,2	1,1	2,4	3,4	4,7	6,1	-7,9	9,2	3,6	2,6	4,6
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,76**	**12,95**	**15,04**	**14,08**	**14,93**	**13,44**	**11,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-6,3**	**0,6**	**-1,0**	**-1,2**	**-0,8**
Industry	3,62	4,24	4,56	4,35	4,87	4,57	4,01	37,1	32,7	30,3	30,9	32,6	34,0	33,7	0,8	-4,7	1,1	-0,6	-1,3	-0,4
Transportation	2,96	4,06	5,41	4,77	4,90	3,94	3,29	30,3	31,4	36,0	33,9	32,8	29,4	27,7	2,1	-11,8	0,3	-2,1	-1,8	-1,6
Others	2,56	3,01	3,50	3,46	3,66	3,53	3,32	26,3	23,2	23,2	24,6	24,5	26,2	27,9	1,1	-0,9	0,6	-0,4	-0,6	-0,2
Non-energy	0,62	1,64	1,57	1,50	1,50	1,39	1,27	6,3	12,7	10,5	10,7	10,0	10,4	10,7	3,3	-4,3	0,0	-0,7	-0,9	-0,7
Total	**9,76**	**12,95**	**15,04**	**14,08**	**14,93**	**13,44**	**11,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-6,3**	**0,6**	**-1,0**	**-1,2**	**-0,8**
Coal	0,67	0,50	0,66	0,64	0,49	0,39	0,30	6,9	3,9	4,4	4,5	3,3	2,9	2,5	-0,1	-3,4	-2,5	-2,3	-2,7	-2,6
Oil	4,03	5,31	6,94	6,22	6,41	5,07	3,96	41,3	41,0	46,2	44,1	43,0	37,7	33,3	1,9	-10,5	0,3	-2,3	-2,5	-1,8
Natural gas	1,80	3,01	2,82	2,71	2,74	2,36	1,92	18,4	23,3	18,8	19,3	18,4	17,5	16,1	1,6	-3,9	0,1	-1,5	-2,0	-1,2
Electricity	2,45	2,94	3,37	3,34	3,91	4,34	4,63	25,1	22,7	22,4	23,7	26,2	32,3	39,0	1,1	-1,1	1,6	1,1	0,6	1,0
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	0,81	1,19	1,24	1,18	1,37	1,27	1,09	8,3	9,2	8,2	8,4	9,2	9,5	9,1	1,5	-4,5	1,5	-0,7	-1,6	-0,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**32,26**	**39,25**	**44,81**	**44,33**	**51,73**	**57,62**	**61,38**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,1**	**1,6**	**1,1**	**0,6**	**1,0**
Coal	0,66	1,55	2,27	1,63	0,57	0,56	0,64	2,1	3,9	5,1	3,7	1,1	1,0	1,0	4,3	-28,3	-9,9	-0,2	1,3	-4,0
Oil	0,01	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	-2,9	-21,1	-2,5	2,6	-100,0	-100,0
Natural gas	5,71	9,57	5,88	4,80	4,43	6,26	6,98	17,7	24,4	13,1	10,8	8,6	10,9	11,4	0,1	-18,4	-0,8	3,5	1,1	0,6
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	23,18	24,43	25,57	25,16	24,47	23,78	23,09	71,9	62,3	57,1	56,8	47,3	41,3	37,6	0,3	-1,6	-0,3	-0,3	-0,3	-0,3
Geothermal	2,13	2,92	8,04	9,46	14,83	16,52	17,21	6,6	7,4	17,9	21,3	28,7	28,7	28,0	4,7	17,6	4,6	1,1	0,4	2,5
Others	0,57	0,78	3,05	3,28	7,43	10,50	13,47	1,8	2,0	6,8	7,4	14,4	18,2	21,9	6,0	7,8	8,5	3,5	2,5	4,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,41**	**2,28**	**1,61**	**1,22**	**0,91**	**1,13**	**1,19**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-24,1**	**-3,0**	**2,3**	**0,5**	**-1,0**
Coal	0,17	0,38	0,55	0,36	0,12	0,13	0,12	11,9	16,7	33,9	29,2	13,5	11,1	10,5	4,1	-34,5	-10,2	0,3	-0,1	-4,7
Oil	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,4	0,0	0,1	0,1	0,1	0,1	0,0	-6,3	10,8	-5,2	1,8	-100,0	-100,0
Natural gas	1,24	1,90	1,07	0,87	0,78	1,01	1,06	87,7	83,3	66,1	70,7	86,4	88,9	89,5	-0,5	-18,7	-1,0	2,6	0,5	0,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**38,8**	**41,9**	**43,5**	**45,1**	**47,5**	**51,7**	**55,1**								**0,4**	**3,8**	**0,5**	**0,8**	**0,6**	**0,8**
Coal	33,9	34,9	35,7	39,1	40,1	38,5	44,2								0,2	9,6	0,2	-0,4	1,4	0,7
Oil	13,8	-	39,3	27,9	37,0	39,8	-								3,7	-28,8	2,8	0,7	-	-
Natural gas	39,6	43,4	47,4	47,6	48,7	53,4	56,4								0,6	0,4	0,2	0,9	0,6	0,6

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**6,3**	**7,9**	**9,0**	**7,9**	**7,7**	**6,0**	**4,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-12,8**	**-0,3**	**-2,4**	**-2,6**	**-2,2**
Coal	1,3	1,2	1,7	1,3	0,8	0,7	0,6	20,6	14,8	18,8	17,0	10,5	11,7	13,0	1,0	-21,0	-5,0	-1,4	-1,6	-3,3
Oil	2,7	4,4	5,4	4,8	5,0	3,9	3,0	42,8	55,8	59,7	60,5	65,6	65,6	65,8	2,4	-11,7	0,5	-2,4	-2,6	-1,9
Natural gas	2,3	2,3	1,9	1,8	1,8	1,4	1,0	36,6	29,4	21,5	22,5	23,9	22,7	21,3	-0,6	-8,7	0,4	-2,9	-3,3	-2,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	88	119	201	195	255	300	348	2,9	-3,0	2,7	1,6	1,5	1,8
Population (millions of people)	3,330	3,858	5,104	5,122	5,551	5,950	6,274	1,5	0,4	0,8	0,7	0,5	0,7
GDP per capita (thousands of 2015 USD/person)	26,29	30,73	39,33	38,01	45,95	50,35	55,44	1,4	-3,4	1,9	0,9	1,0	1,1
Primary energy consumption per capita (toe/person)	3,86	4,44	4,01	3,86	4,17	3,80	3,41	0,1	-3,7	0,8	-0,9	-1,1	-0,5
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	147	144	102	102	91	75	62	-1,2	-0,4	-1,1	-1,8	-2,0	-1,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	111	109	75	72	59	45	34	-1,4	-3,4	-2,1	-2,6	-2,7	-2,5
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	72	66	45	41	30	20	13	-1,6	-10,1	-2,9	-4,0	-4,1	-3,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,46	0,44	0,40	0,33	0,27	0,21	-0,3	-9,8	-1,8	-2,2	-2,1	-2,3
Automobile ownership volume (millions of vehicles)	1,792	2,595	4,141	4,191	4,729	5,066	5,355	2,9	1,2	1,2	1,9	1,3	0,8
Automobile ownership volume per capita (vehicles per person)	0,538	0,673	0,811	0,818	0,852	0,851	0,854	1,4	0,8	0,4	0,4	0,0	0,2

New Zealand LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**12,85**	**17,13**	**20,48**	**19,52**	**21,54**	**17,76**	**16,17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,6**	**-4,7**	**1,0**	**-1,9**	**-0,9**	**-0,8**
Coal	1,18	1,11	1,50	1,18	0,60	0,38	0,17	9,2	6,5	7,3	6,1	2,8	2,1	1,0	0,8	-21,2	-6,6	-4,5	-7,8	-6,8
Oil	3,51	5,71	6,67	5,91	4,62	2,22	0,47	27,3	33,3	32,6	30,3	21,4	12,5	2,9	2,2	-11,4	-2,4	-7,1	-14,4	-8,2
Natural gas	3,87	5,06	4,00	3,69	3,13	2,16	1,30	30,1	29,5	19,5	18,9	14,5	12,1	8,1	0,1	-7,7	-1,6	-3,7	-4,9	-3,6
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	-	-	-	-	-	-
Hydrogen/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	-	-	25,7	6,8	-100,0	-
Hydro	1,99	2,10	2,20	2,16	2,17	2,82	2,15	15,5	12,3	10,7	11,1	10,1	15,9	13,3	0,3	-1,6	0,0	2,7	-2,7	-0,1
Geothermal	1,49	1,96	4,67	5,38	8,73	7,01	7,47	11,6	11,4	22,8	27,6	40,5	39,5	46,2	4,0	15,1	5,0	-2,2	0,6	1,5
Others	0,80	1,20	1,43	1,19	2,30	3,18	4,61	6,2	7,0	7,0	6,1	10,7	17,9	28,5	2,0	-17,1	6,8	3,3	3,8	3,8
Biomass	0,76	1,14	1,18	0,96	1,67	1,66	1,75	5,9	6,7	5,8	4,9	7,7	9,4	10,8	1,6	-19,1	5,7	0,0	0,5	1,3
Solar, Wind, Ocean	0,04	0,05	0,25	0,23	0,63	1,52	2,86	0,3	0,3	1,2	1,2	2,9	8,5	17,7	6,1	-7,9	10,8	9,1	6,5	8,2
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**9,76**	**12,95**	**15,04**	**13,80**	**13,02**	**10,52**	**8,38**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-8,2**	**-0,6**	**-2,1**	**-2,2**	**-1,9**
Industry	3,62	4,24	4,56	4,35	4,51	4,05	3,40	37,1	32,7	30,3	31,5	34,6	38,5	40,5	0,8	-4,7	0,4	-1,1	-1,7	-0,9
Transportation	2,96	4,06	5,41	4,77	3,82	2,48	1,62	30,3	31,4	36,0	34,5	29,3	23,6	19,3	2,1	-11,8	-2,2	-4,2	-4,2	-3,8
Others	2,56	3,01	3,50	3,18	3,20	2,60	2,10	26,3	23,2	23,2	23,1	24,6	24,7	25,0	1,1	-9,0	0,1	-2,1	-2,1	-1,6
Non-energy	0,62	1,64	1,57	1,50	1,50	1,39	1,27	6,3	12,7	10,5	10,9	11,5	13,3	15,2	3,3	-4,3	0,0	-0,7	-0,9	-0,7
Total	**9,76**	**12,95**	**15,04**	**13,80**	**13,02**	**10,52**	**8,38**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,5**	**-8,2**	**-0,6**	**-2,1**	**-2,2**	**-1,9**
Coal	0,67	0,50	0,66	0,64	0,42	0,25	0,10	6,9	3,9	4,4	4,6	3,2	2,4	1,2	-0,1	-3,4	-4,1	-5,2	-8,6	-5,9
Oil	4,03	5,31	6,94	6,22	4,86	2,39	0,56	41,3	41,0	46,2	45,0	37,3	22,7	6,7	1,9	-10,5	-2,4	-6,8	-13,4	-7,8
Natural gas	1,80	3,01	2,82	2,71	2,46	1,63	0,98	18,4	23,3	18,8	19,7	18,9	15,5	11,7	1,6	-3,9	-1,0	-4,0	-5,0	-3,4
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,03	0,42	0,69	0,0	0,0	0,0	0,0	0,2	4,0	8,2	-	-	107,4	29,1	5,1	-
Electricity	2,45	2,94	3,37	3,34	4,01	4,61	4,89	25,1	22,7	22,4	24,2	30,8	43,9	58,4	1,1	-1,1	1,9	1,4	0,6	1,2
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	0,81	1,19	1,24	0,90	1,24	1,22	1,16	8,3	9,2	8,2	6,5	9,5	11,6	13,8	1,5	-27,1	3,2	-0,2	-0,5	-0,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**32,26**	**39,25**	**44,81**	**44,33**	**53,53**	**67,24**	**75,80**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,1**	**1,9**	**2,3**	**1,2**	**1,7**
Coal PP	0,66	1,55	2,27	1,63	0,00	0,00	0,00	2,1	3,9	5,1	3,7	0,0	0,0	0,0	4,3	-28,3	-100,0	-	-	-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	0,01	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	-2,9	-21,1	0,6	-0,2	-0,3	-0,7
Gas PP	5,71	9,57	5,88	4,80	3,00	0,57	0,00	17,7	24,4	13,1	10,8	5,6	0,8	0,0	0,1	-18,4	-4,6	-15,3	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	0,16	1,36	1,14	0,0	0,0	0,0	0,0	0,3	2,0	1,5	-	-	-	24,1	-1,8	-
Hydrogen/Ammonia 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	-	-	-	-	-	-
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	-	-	-	-	-	-
Solar	0,00	0,00	0,13	0,16	1,15	3,57	7,46	0,0	0,0	0,3	0,4	2,2	5,3	9,8	-	22,0	22,2	12,0	7,7	14,0
Wind	0,00	0,12	2,25	2,37	6,12	14,04	25,75	0,0	0,3	5,0	5,4	11,4	20,9	34,0	-	5,3	9,9	8,7	6,3	8,2
Hydro	23,18	24,43	25,57	25,16	25,18	32,77	25,01	71,9	62,3	57,1	56,8	47,0	48,7	33,0	0,3	-1,6	0,0	2,7	-2,7	-0,1
Geothermal	2,13	2,92	8,04	9,46	15,34	12,36	13,26	6,6	7,4	17,9	21,3	28,7	18,4	17,5	4,7	17,6	5,0	-2,1	0,7	1,6
Others	0,57	0,65	0,66	0,75	2,57	2,56	3,17	1,8	1,7	1,5	1,7	4,8	3,8	4,2	0,5	13,4	13,1	0,0	2,1	5,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,41**	**2,28**	**1,61**	**1,22**	**0,55**	**0,34**	**0,20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-24,1**	**-7,7**	**-4,8**	**-5,3**	**-6,6**
Coal	0,17	0,38	0,55	0,36	0,00	0,00	0,00	11,9	16,7	33,9	29,2	0,0	0,0	0,0	4,1	-34,5	-100,0	-	-	-100,0
Oil	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,4	0,0	0,1	0,1	0,1	0,2	0,4	-6,3	10,8	-2,3	-0,2	0,8	-0,2
Gas	1,24	1,90	1,07	0,87	0,55	0,34	0,19	87,7	83,3	66,1	70,7	99,9	99,8	99,6	-0,5	-18,7	-4,4	-4,8	-5,4	-5,3
Hydrogen/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	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**38,8**	**41,9**	**43,5**	**45,1**	**49,3**	**49,2**	**50,3**								**0,4**	**3,8**	**0,9**	**0,0**	**0,2**	**0,5**
Coal	33,9	34,9	35,7	39,1	-	-	-								0,2	9,6	-	-	-	-
Oil	13,8	-	39,3	27,9	37,5	37,5	33,6								3,7	-28,8	3,0	0,0	-1,1	-0,5
Gas	39,6	43,4	47,4	47,6	49,3	49,3	50,4								0,6	0,4	0,3	0,0	0,2	0,2
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**6,3**	**7,9**	**9,0**	**7,9**	**5,8**	**2,3**	**0,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,3**	**-12,8**	**-3,1**	**-8,7**	**-32,5**	**-15,7**
Coal	1,3	1,2	1,7	1,3	0,7	0,3	0,0	20,6	14,8	18,8	17,0	11,8	14,4	83,2	1,0	-21,0	-6,5	-6,9	-19,6	-11,6
Oil	2,7	4,4	5,4	4,8	3,6	1,5	0,0	42,8	55,8	59,7	60,5	63,2	64,6	0,0	2,4	-11,7	-2,7	-8,5	-100,0	-100,0
Natural gas	2,3	2,3	1,9	1,8	1,4	0,5	0,0	36,6	29,4	21,5	22,5	24,9	21,0	16,8	-0,6	-8,7	-2,1	-10,3	-34,0	-16,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	88	119	201	195	255	300	348	2,9	-3,0	2,7	1,6	1,5	1,8
Population (millions of people)	3,330	3,858	5,104	5,122	5,551	5,950	6,274	1,5	0,4	0,8	0,7	0,5	0,7
GDP per capita (thousands of 2015 USD/person)	26,29	30,73	39,33	38,01	45,95	50,35	55,44	1,4	-3,4	1,9	0,9	1,0	1,1
Primary energy consumption per capita (toe/person)	3,86	4,44	4,01	3,81	3,88	2,99	2,58	0,1	-5,1	0,2	-2,6	-1,5	-1,4
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	147	144	102	100	84	59	47	-1,2	-1,8	-1,7	-3,5	-2,4	-2,5
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	111	109	75	71	51	35	24	-1,4	-5,4	-3,2	-3,7	-3,7	-3,6
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	72	66	45	41	23	8	0	-1,6	-10,1	-5,7	-10,2	-33,5	-17,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,46	0,44	0,40	0,27	0,13	0,00	-0,3	-8,5	-4,0	-6,9	-31,9	-15,1
Automobile ownership volume (millions of vehicles)	1,792	2,595	4,141	4,191	4,729	5,066	5,355	2,9	1,2	1,2	0,7	1,3	0,8
Automobile ownership volume per capita (vehicles per person)	0,538	0,673	0,811	0,818	0,852	0,851	0,854	1,4	0,8	0,4	0,0	0,0	0,2

Philippines BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,71**	**40,0**	**59,7**	**59,3**	**87,2**	**126,4**	**197,1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,6**	**-0,7**	**3,9**	**3,8**	**4,5**	**3,9**
Coal	1,53	5,2	16,6	15,9	10,8	13,9	28,0	5,3	12,9	27,8	26,9	12,3	11,0	14,2	8,6	-3,9	-3,8	2,6	7,3	1,7
Oil	10,84	16,1	20,0	20,6	33,0	48,4	69,5	37,8	40,1	33,5	34,7	37,8	38,3	35,3	2,1	2,9	4,8	3,9	3,7	4,1
Natural gas	0,00	0,0	3,6	3,2	9,9	21,6	36,2	0,0	0,0	6,0	5,4	11,3	17,1	18,4	-	-10,8	12,0	8,1	5,3	7,8
Nuclear	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	0,0	-	-	-	-	-	-
Hydro	0,52	0,7	0,7	0,6	0,4	0,6	1,2	1,8	1,7	1,2	1,0	0,5	0,5	0,6	1,0	-10,4	-3,7	3,2	7,6	1,8
Geothermal	5	10,0	9,2	9,2	16,7	21,5	37,3	16,4	25,0	15,4	15,6	19,2	17,0	18,9	2,3	0,6	6,1	2,6	5,6	4,6
Others	11,12	8,1	9,7	9,7	16,5	20,4	25,0	38,7	20,3	16,2	16,4	18,9	16,1	12,7	-0,5	0,5	5,4	2,1	2,0	3,1
Biomass	11,12	8,1	8,9	9,0	12,6	14,2	17,8	38,7	20,3	15,0	15,2	14,5	11,3	9,1	-0,7	0,4	3,5	1,2	2,3	2,3
Solar, Wind, Ocean	0,00	0,0	0,2	0,2	3,1	5,1	5,7	0,0	0,0	0,3	0,3	3,5	4,0	2,9	-	4,9	31,1	5,1	1,2	11,5
Biofuels	0,00	0,0	0,5	0,5	0,8	1,1	1,4	0,0	0,0	0,9	0,9	0,9	0,9	0,7	-	0,2	3,8	3,3	2,9	3,2
Electricity	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	0,0	-	-	-	-	-	-

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**19,02**	**23,2**	**37,9**	**38,7**	**57,4**	**84,8**	**122,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,4**	**1,9**	**4,0**	**4,0**	**3,7**	**3,8**
Industry	4,13	4,5	7,4	7,0	8,4	12,1	17,8	21,7	19,5	19,4	18,1	14,6	14,3	14,6	2,0	-5,1	1,8	3,8	3,9	2,9
Transportation	4,69	8,3	12,7	13,3	22,6	36,2	55,6	24,6	35,8	33,4	34,5	39,5	42,7	45,5	3,5	5,2	5,4	4,8	4,4	4,9
Others	9,82	10,0	16,3	16,7	24,7	34,8	47,3	51,6	42,9	42,9	43,3	43,1	41,1	38,6	1,8	2,6	4,0	3,5	3,1	3,5
Non-energy	0,39	0,4	1,6	1,6	1,6	1,6	1,6	2,0	1,7	4,3	4,2	2,8	1,9	1,3	5,0	0,0	0,0	-0,2	-0,1	-0,1
Total	**19,02**	**23,20**	**37,94**	**38,66**	**57,35**	**84,75**	**122,28**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,4**	**1,9**	**4,0**	**4,0**	**3,7**	**3,8**
Coal	0,70	0,8	2,4	1,6	0,3	0,3	0,3	3,7	3,6	6,3	4,3	0,6	0,4	0,2	4,3	-30,5	-15,2	-0,3	-0,4	-6,5
Oil	8,08	12,8	19,0	19,9	31,1	46,5	67,4	42,5	55,3	50,0	51,4	54,2	54,9	55,1	3,0	4,7	4,6	4,1	3,8	4,2
Natural gas	0,00	0,0	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,2	0,2	0,1	0,1	0,1	-	0,4	0,8	0,8	0,8	0,8
Electricity	1,82	3,1	7,5	8,1	15,8	26,9	43,8	9,6	13,6	19,7	20,9	27,5	31,7	35,8	5,0	7,9	6,9	5,4	5,0	5,9
Heat	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	0,0	-	-	-	-	-	-
Others	8,42	6,4	9,0	9,0	10,1	11,0	10,8	44,3	27,5	23,8	23,3	17,6	13,0	8,8	0,2	-0,5	1,1	0,9	-0,2	0,6

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**26,3**	**45,3**	**106,0**	**101,8**	**183,8**	**312,4**	**508,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**-4,0**	**6,1**	**5,4**	**5,0**	**5,2**
Coal	1,93	16,7	57,9	58,2	42,8	55,5	112,9	7,3	36,8	54,6	57,2	23,3	17,8	22,2	12,4	0,5	-3,0	2,6	7,4	2,2
Oil	12,43	9,2	3,7	2,5	7,4	7,6	8,3	47,2	20,3	3,5	2,4	4,0	2,4	1,6	-4,1	-34,1	11,7	0,2	0,9	2,6
Natural gas	0,00	0,0	22,4	19,5	64,0	146,3	240,2	0,0	0,0	21,1	19,2	34,8	46,8	47,2	-	-12,8	12,6	8,6	5,1	8,0
Nuclear	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	0,0	-	-	-	-	-	-
Hydro	6,06	7,8	8,0	7,2	4,9	6,7	14,0	23,0	17,2	7,6	7,1	2,7	2,2	2,8	1,0	-10,4	-3,7	3,2	7,6	1,8
Geothermal	5	11,6	10,7	10,8	19,4	25,0	43,3	20,8	25,7	10,1	10,6	10,6	8,0	8,5	2,3	0,6	6,1	2,6	5,6	4,6
Others	0	0,0	3,3	3,7	45,2	71,2	90,2	1,6	0,0	3,2	3,6	24,6	22,8	17,7	7,3	9,8	28,5	4,7	2,4	11,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,69**	**6,1**	**18,6**	**17,9**	**22,0**	**36,9**	**65,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,9**	**-3,7**	**2,1**	**5,3**	**5,9**	**4,2**
Coal	0,51	4,1	14,2	14,3	10,5	13,6	27,7	18,9	67,5	76,4	79,7	47,4	36,8	42,1	12,2	0,5	-3,1	2,6	7,4	2,2
Oil	2,18	2,0	0,9	0,6	1,8	1,8	2,0	81,1	32,4	4,8	3,3	8,1	4,9	3,0	-3,0	-34,1	11,6	0,2	0,9	2,6
Natural gas	0,00	0,0	3,5	3,0	9,8	21,5	36,1	0,0	0,1	18,8	17,0	44,5	58,3	54,9	-	-12,8	12,4	8,2	5,3	7,8

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**45,9**	**36,5**	**39**	**38**	**45**	**49**	**47**								**-0,6**	**-0,9**	**1,5**	**0,9**	**-0,3**	**0,6**
Coal	33	34,8	35	35	35	35	35								0,2	0,0	0,0	0,0	0,0	0,0
Oil	49	40,0	36	36	36	36	36								-1,1	0,0	0,1	0,0	0,0	0,0
Natural gas	-	16,2	55	55	56	58	57								-	0,0	0,2	0,4	-0,2	0,1

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,2**	**18,3**	**35,3**	**34,8**	**43,7**	**67,3**	**109,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**-1,5**	**2,3**	**4,4**	**5,0**	**3,7**
Coal	1,4	5,2	17,9	17,2	11,7	15,1	30,4	13,4	28,7	50,7	49,5	26,7	22,4	27,9	9,3	-4,0	-3,8	2,6	7,3	1,7
Oil	8,8	13,1	15,1	15,6	25,7	38,4	55,6	86,6	71,3	42,8	44,8	58,9	57,0	50,9	1,9	3,0	5,2	4,1	3,8	4,3
Natural gas	0,0	0,0	2,3	2,0	6,3	13,9	23,2	0,0	0,0	6,5	5,7	14,5	20,6	21,2	-	-12,6	12,3	8,1	5,3	7,8

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	94,5	125,3	377	341	667	1.134	1.847	4,9	-9,5	6,9	5,4	5,0	5,3
Population (millions of people)	61,9	78,0	108,1	109,6	127,2	147,6	171,3	1,9	1,4	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	1,5	1,6	3,5	3,1	5,2	7,7	10,8	2,9	-10,7	5,4	3,9	3,4	3,7
Primary energy consumption per capita (toe/person)	0,5	0,5	0,6	0,5	0,7	0,9	1,2	0,6	-2,0	2,4	2,2	3,0	2,4
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	304	319	158	174	131	112	107	-2,2	9,7	-2,8	-1,6	-0,4	-1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	201	185	101	113	86	75	66	-2,4	12,6	-2,7	-1,4	-1,2	-1,3
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	108	146	94	102	66	59	59	-0,5	8,8	-4,3	-1,0	0,0	-1,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,35	0,46	0,59	0,59	0,50	0,53	0,55	1,8	-0,8	-1,6	0,6	0,4	-0,2
Automobile ownership volume (millions of vehicles)								-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Philippines APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,71**	**40,0**	**59,7**	**59,3**	**87,2**	**136,2**	**210,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,6**	**-0,7**	**3,9**	**4,6**	**4,5**	**4,2**
Coal	1,53	5,2	16,6	15,9	6,4	11,0	19,3	5,3	12,9	27,8	26,9	7,3	8,1	9,2	8,6	-3,9	-8,7	5,6	5,8	0,5
Oil	10,84	16,1	20,0	20,6	31,4	46,1	66,2	37,8	40,1	33,5	34,7	36,0	33,8	31,4	2,1	2,9	4,3	3,9	3,7	3,9
Natural gas	0,00	0,0	3,6	3,2	7,5	12,5	23,0	0,0	0,0	6,0	5,4	8,5	9,2	10,9	-	-10,8	8,9	5,3	6,3	6,2
Nuclear	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	0,0	-	-	-	-	-	-
Hydro	0,52	0,7	0,7	0,6	0,8	1,6	2,9	1,8	1,7	1,2	1,0	1,0	1,2	1,4	1,0	-10,4	3,1	6,6	6,1	4,7
Geothermal	5	10,0	9,2	9,2	25,8	45,0	76,3	16,4	25,0	15,4	15,6	29,6	33,0	36,2	2,3	0,6	10,8	5,7	5,4	7,1
Others	11,12	8,1	9,7	9,7	15,3	20,0	23,1	38,7	20,3	16,2	16,4	17,6	14,7	10,9	-0,5	0,5	4,6	2,7	1,4	2,8
Biomass	11,12	8,1	8,9	9,0	11,0	12,9	14,3	38,7	20,3	15,0	15,2	12,7	9,4	6,8	-0,7	0,4	2,1	1,5	1,1	1,5
Solar, Wind, Ocean	0,00	0,0	0,2	0,2	3,5	6,1	7,4	0,0	0,0	0,3	0,3	4,0	4,5	3,5	-	4,9	32,8	5,6	1,9	12,4
Biofuels	0,00	0,0	0,5	0,5	0,8	1,0	1,4	0,0	0,0	0,9	0,9	0,9	0,8	0,7	-	0,2	3,4	3,3	2,9	3,1
Electricity	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	0,0	-	-	-	-	-	-

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**19,02**	**23,2**	**37,9**	**38,7**	**55,1**	**81,2**	**116,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,4**	**1,9**	**3,6**	**4,0**	**3,7**	**3,7**
Industry	4,13	4,5	7,4	7,0	8,0	11,6	17,0	21,7	19,5	19,4	18,1	14,5	14,3	14,5	2,0	-5,1	1,4	3,8	3,9	2,7
Transportation	4,69	8,3	12,7	13,3	21,6	34,5	53,0	24,6	35,8	33,4	34,5	39,2	42,5	45,4	3,5	5,2	4,9	4,8	4,4	4,7
Others	9,82	10,0	16,3	16,7	23,9	33,5	45,3	51,6	42,9	42,9	43,3	43,4	41,3	38,8	1,8	2,6	3,6	3,4	3,1	3,4
Non-energy	0,39	0,4	1,6	1,6	1,6	1,6	1,6	2,0	1,7	4,3	4,2	2,9	1,9	1,3	5,0	0,0	0,0	-0,2	-0,1	-0,1
Total	**19,02**	**23,20**	**37,94**	**38,66**	**55,12**	**81,20**	**116,87**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,4**	**1,9**	**3,6**	**4,0**	**3,7**	**3,7**
Coal	0,70	0,8	2,4	1,6	0,3	0,3	0,3	3,7	3,6	6,3	4,3	0,6	0,4	0,2	4,3	-30,5	-15,2	-0,7	-0,5	-6,7
Oil	8,08	12,8	19,0	19,9	29,7	44,4	64,3	42,5	55,3	50,0	51,4	53,8	54,6	55,0	3,0	4,7	4,1	4,1	3,8	4,0
Natural gas	0,00	0,0	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,2	0,2	0,1	0,1	0,1	-	0,4	0,8	0,8	0,8	0,8
Electricity	1,82	3,1	7,5	8,1	15,0	25,5	41,6	9,6	13,6	19,7	20,9	27,2	31,4	35,6	5,0	7,9	6,4	5,4	5,0	5,7
Heat	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	0,0	-	-	-	-	-	-
Others	8,42	6,4	9,0	9,0	10,1	11,0	10,7	44,3	27,5	23,8	23,3	18,3	13,5	9,1	0,2	-0,5	1,1	0,8	-0,3	0,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**26,3**	**45,3**	**106,0**	**101,8**	**174,6**	**296,8**	**483,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**-4,0**	**5,5**	**5,4**	**5,0**	**5,0**
Coal	1,93	16,7	57,9	58,2	28,6	50,1	88,7	7,3	36,8	54,6	57,2	16,4	16,9	18,4	12,4	0,5	-6,9	5,8	5,9	1,4
Oil	12,43	9,2	3,7	2,5	7,0	6,9	7,6	47,2	20,3	3,5	2,4	4,0	2,3	1,6	-4,1	-34,1	11,0	-0,1	1,0	2,3
Natural gas	0,00	0,0	22,4	19,5	51,9	87,2	160,4	0,0	0,0	21,1	19,2	29,7	29,4	33,2	-	-12,8	10,3	5,3	6,3	6,6
Nuclear	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	0,0	-	-	-	-	-	-
Hydro	6,06	7,8	8,0	7,2	9,7	18,4	33,1	23,0	17,2	7,6	7,1	5,6	6,2	6,9	1,0	-10,4	3,1	6,6	6,1	4,7
Geothermal	5	11,6	10,7	10,8	30,0	52,3	88,7	20,8	25,7	10,1	10,6	17,2	17,6	18,3	2,3	0,6	10,8	5,7	5,4	7,1
Others	0	0,0	3,3	3,7	47,4	81,8	104,9	1,6	0,0	3,2	3,6	27,2	27,6	21,7	7,3	9,8	29,2	5,6	2,5	11,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,69**	**6,1**	**18,6**	**17,9**	**15,1**	**24,8**	**43,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,9**	**-3,7**	**-1,7**	**5,1**	**5,8**	**2,8**
Coal	0,51	4,1	14,2	14,3	6,1	10,7	19,0	18,9	67,5	76,4	79,7	40,3	43,2	43,5	12,2	0,5	-8,2	5,8	5,9	0,9
Oil	2,18	2,0	0,9	0,6	1,6	1,6	1,8	81,1	32,4	4,8	3,3	10,7	6,5	4,1	-3,0	-34,1	10,6	-0,1	1,0	2,2
Natural gas	0,00	0,0	3,5	3,0	7,4	12,5	22,9	0,0	0,1	18,8	17,0	48,9	50,3	52,5	-	-12,8	9,3	5,4	6,3	6,3

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**45,9**	**36,5**	**39**	**38**	**50**	**50**	**51**	**-0,6**	**-0,9**	**2,6**	**0,1**	**0,1**	**0,9**
Coal	33	34,8	35	35	40	40	40	0,2	0,0	1,4	0,0	0,0	0,4
Oil	49	40,0	36	36	37	37	37	-1,1	0,0	0,3	0,0	0,0	0,1
Natural gas	-	16,2	55	55	60	60	60	-	0,0	0,9	0,0	0,0	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,2**	**18,3**	**35,3**	**34,8**	**36,1**	**56,4**	**88,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**-1,5**	**0,4**	**4,6**	**4,6**	**3,0**
Coal	1,4	5,2	17,9	17,2	6,9	11,9	21,0	13,4	28,7	50,7	49,5	19,1	21,1	23,7	9,3	-4,0	-8,8	5,7	5,8	0,5
Oil	8,8	13,1	15,1	15,6	24,4	36,4	52,9	86,6	71,3	42,8	44,8	67,7	64,6	59,7	1,9	3,0	4,6	4,1	3,8	4,1
Natural gas	0,0	0,0	2,3	2,0	4,8	8,0	14,8	0,0	0,0	6,5	5,7	13,2	14,2	16,6	-	-12,6	9,1	5,3	6,3	6,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	94,5	125,3	376,8	341,0	666,9	1.133,7	1.846,7	4,9	(9,5)	6,9	5,4	5,0	5,3
Population (millions of people)	61,9	78,0	108,1	109,6	127,2	147,6	171,3	1,9	1,4	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	1,5	1,6	3,5	3,1	5,2	7,7	10,8	2,9	-10,7	5,4	3,9	3,4	3,7
Primary energy consumption per capita (toe/person)	0,5	0,5	0,6	0,5	0,7	0,9	1,2	0,6	-2,0	2,4	3,0	2,9	2,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	304	319	158	174	131	120	114	-2,2	9,7	-2,8	-0,8	-0,5	-1,1
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	201	185	101	113	83	72	63	-2,4	12,6	-3,1	-1,4	-1,2	-1,5
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	108	146	94	102	54	50	48	-0,5	8,8	-6,1	-0,8	-0,4	-2,1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,35	0,46	0,59	0,59	0,41	0,41	0,42	1,8	-0,8	-3,4	0,0	0,2	-1,1
Automobile ownership volume (millions of vehicles)								-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Philippines LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,7**	**40,0**	**59,72**	**59,32**	**67,21**	**78,91**	**119,03**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,6**	**-0,7**	**1,3**	**1,6**	**4,2**	**2,2**
Coal	1,5	5,2	16,59	15,94	1,62	9,33	17,45	5,3	12,9	27,8	26,9	2,4	11,8	14,7	8,6	-3,9	-20,4	19,1	6,5	0,2
Oil	10,8	16,1	19,93	20,49	13,86	15,18	17,66	37,8	40,1	33,4	34,5	20,6	19,2	14,8	2,1	2,8	-3,8	0,9	1,5	-0,4
Natural gas	0,0	0,0	3,63	3,29	2,39	8,05	14,92	0,0	0,0	6,1	5,5	3,6	10,2	12,5	-	-9,3	-3,1	12,9	6,4	4,7
Nuclear	0,0	0,0	0,00	0,00	0,00	0,91	1,00	0,0	0,0	0,0	0,0	0,0	1,2	0,8	-	-	-	-	1,0	-
Hydrogen/Ammonia	0,0	0,0	0,00	0,00	0,00	0,35	2,74	0,0	0,0	0,0	0,0	0,0	0,4	2,3	-	-	-	-	22,8	-
Hydro	0,5	0,7	0,69	0,62	1,35	2,80	3,60	1,8	1,7	1,2	1,0	2,0	3,5	3,0	1,0	-10,4	8,2	7,5	2,6	5,5
Geothermal	4,7	10,0	9,19	9,25	31,49	21,89	36,67	16,4	25,0	15,4	15,6	46,8	27,7	30,8	2,3	0,6	13,0	-3,6	5,3	4,6
Others	11,1	8,1	9,69	9,74	16,50	20,40	24,98	38,7	20,3	16,2	16,4	24,5	25,9	21,0	-0,5	0,5	5,4	2,1	2,0	3,1
Biomass	11,1	8,1	8,95	8,99	12,63	14,24	17,85	38,7	20,3	15,0	15,1	18,8	18,0	15,0	-0,7	0,4	3,5	1,2	2,3	2,3
Solar, Wind, Ocean	0,0	0,0	0,20	0,21	3,08	5,08	5,69	0,0	0,0	0,3	0,3	4,6	6,4	4,8	-	4,9	31,1	5,1	1,2	11,5
Biofuels	0,0	0,0	0,54	0,54	0,79	1,09	1,44	0,0	0,0	0,9	0,9	1,2	1,4	1,2	-	0,2	3,8	3,3	2,9	3,2
Electricity	0,0	0,0	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1990**	**2000**	**2019**	**2020**	**2030**	**2040**	**2050**	**1990**	**2000**	**2019**	**2020**	**2030**	**2040**	**2050**	**2019**	**2020**	**2030**	**2040**	**2050**	**2050**
Industry	19,02	23,20	37,94	38,66	35,78	47,91	63,92	100	100	100	100	100	100	100	2,4	1,9	-0,8	3,0	2,9	1,7
Transportation	4,13	4,53	7,37	7,00	7,91	10,69	14,48	21,7	19,5	19,4	18,1	22,1	22,3	22,7	2,0	-5,1	1,2	3,1	3,1	2,2
Others	4,69	8,30	12,67	13,32	2,62	4,29	8,41	24,6	35,8	33,4	34,5	7,3	8,9	13,2	3,5	5,2	-15,0	5,1	7,0	-1,3
Non-energy	9,82	9,96	16,29	16,72	23,65	31,35	39,46	51,6	42,9	42,9	43,3	66,1	65,4	61,7	1,8	2,6	3,5	2,9	2,3	2,9
Total	**19,02**	**23,20**	**37,94**	**38,66**	**35,78**	**47,91**	**63,92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,4**	**1,9**	**-0,8**	**3,0**	**2,9**	**1,7**
Coal	0,70	0,84	2,37	1,65	0,30	0,28	0,25	3,7	3,6	6,3	4,3	0,9	0,6	0,4	4,3	-30,5	-15,5	-0,9	-1,1	-7,0
Oil	8,08	12,83	18,97	19,86	11,18	13,74	16,18	42,5	55,3	50,0	51,4	31,2	28,7	25,3	3,0	4,7	-5,6	2,1	1,6	-0,5
Natural gas	0,00	0,00	0,06	0,06	0,07	0,07	0,08	0,0	0,0	0,2	0,2	0,2	0,2	0,1	-	0,4	0,8	0,8	0,8	0,8
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	0,35	2,74	0,0	0,0	0,0	0,0	0,0	0,7	4,3	-	-	-	-	22,8	-
Electricity	1,82	3,14	7,49	8,08	14,81	23,36	35,08	9,6	13,6	19,7	20,9	41,4	48,8	54,9	5,0	7,9	6,2	4,7	4,2	5,1
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	8,42	6,39	9,05	9,00	9,43	10,11	9,59	44,3	27,5	23,8	23,3	26,3	21,1	15,0	0,2	-0,5	0,5	0,7	-0,5	0,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**26,33**	**45,31**	**106,04**	**101,76**	**165,63**	**271,62**	**407,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,9**	**-4,0**	**5,0**	**5,1**	**4,2**	**4,4**
Coal PP	1,93	16,66	57,89	58,18	6,59	3,72	4,09	7,3	36,8	54,6	57,2	4,0	1,4	1,0	12,4	0,5	-19,6	-5,6	1,0	-8,2
Coal PP with CCS	0,00	0,00	0,00	0,00	0,00	43,46	85,72													
Oil	12,43	9,19	3,75	2,47	12,53	7,07	7,78	47,2	20,3	3,5	2,4	7,6	2,6	1,9	-4,0	-34,1	17,6	-5,6	1,0	2,4
Gas PP	0,00	0,02	22,35	19,50	16,77	9,46	10,41	0,0	0,0	21,1	19,2	10,1	3,5	2,6	-	-12,8	-1,5	-5,6	1,0	-2,4
Gas PP PP with CCS	0,00	0,02	0,00	0,00	0,00	42,64	85,72													
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	0,00	0,00													
Nuclear	0,00	0,00	0,00	0,00	0,00	3,50	3,85	0,0	0,0	0,0	0,0	0,0	1,3	0,9	-	-	-	-	1,0	-
Solar	0,00	0,00	1,25	1,37	47,05	58,70	62,30													
Wind	0,00	0,00	1,04	1,03	11,72	31,41	38,97													
Hydro	6,06	7,80	8,03	7,19	15,75	32,53	41,89	23,0	17,2	7,6	7,1	9,5	12,0	10,3	1,0	-10,4	8,2	7,5	2,6	5,5
Geothermal	5,47	11,63	10,69	10,76	36,62	25,46	42,65	20,8	25,7	10,1	10,6	22,1	9,4	10,5	2,3	0,6	13,0	-3,6	5,3	4,6
Others	0,43	0,00	1,04	1,26	18,59	13,69	24,58	1,6	0,0	1,0	1,2	11,2	5,0	6,0	3,1	21,2	30,9	-3,0	6,0	10,7

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2,69**	**6,09**	**18,62**	**17,93**	**6,56**	**18,67**	**33,85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6,9**	**-3,7**	**-9,6**	**11,0**	**6,1**	**1,9**
Coal	0,51	4,11	14,22	14,29	1,32	9,05	17,20	18,9	67,5	76,4	79,7	20,1	48,5	50,8	12,2	0,5	-21,2	21,2	6,6	0,6
Oil	2,18	1,97	0,90	0,59	2,91	1,64	1,81	81,1	32,4	4,8	3,3	44,4	8,8	5,3	-3,0	-34,1	17,2	-5,6	1,0	2,3
Gas	0,00	0,01	3,49	3,05	2,33	7,98	14,84													
Hydrogen/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	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**45,9**	**36,5**	**38,8**	**38,4**	**47,1**	**49,0**	**49,2**								**-0,6**	**-0,9**	**2,0**	**0,4**	**0,0**	**0,8**
Coal	32,74	34,85	35,01	35,01	42,97	3,53	2,05								0,2	0,0	2,1	-22,1	-5,3	-8,8
Oil	49,01	40,04	35,82	35,82	37,01	37,01	37,01								-1,1	0,0	0,3	0,0	0,0	0,1
Gas	-	32,49	55,01	55,01	62,01	56,16	55,69													
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**10,2**	**18,3**	**35,3**	**34,8**	**13,4**	**13,0**	**15,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**-1,5**	**-9,1**	**-0,2**	**1,5**	**-2,7**
Coal	1,4	5,2	17,9	17,2	1,7	1,1	1,1	13,4	28,7	50,7	49,5	12,7	8,1	7,4	9,3	-4,0	-20,7	-4,7	0,7	-8,5
Oil	8,8	13,1	15,1	15,6	10,1	11,1	13,1	86,6	71,3	42,8	44,8	75,8	85,1	86,1	1,9	3,0	-4,2	0,9	1,7	-0,5
Natural gas	0,0	0,0	2,3	2,0	1,5	0,9	1,0	0,0	0,0	6,5	5,7	11,5	6,8	6,4	-	-12,6	-2,6	-5,3	1,0	-2,7

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	94,5	125,3	376,8	341,0	666,9	1.133,7	1.846,7	4,9	-9,5	6,9	5,4	5,0	5,3
Population (millions of people)	61,9	78,0	108,1	109,6	127,2	147,6	171,3	1,9	1,4	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2015 USD/person)	1,53	1,61	3,49	3,11	5,24	7,68	10,78	2,9	-10,7	5,4	3,9	3,4	3,7
Primary energy consumption per capita (toe/person)	0,46	0,51	0,55	0,54	0,53	0,53	0,69	0,6	-2,0	-0,2	0,1	2,7	0,7
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	304	319	158	174	101	70	64	-2,2	9,8	-5,3	-3,6	-0,8	-2,9
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	201	185	101	113	54	42	35	-2,4	12,6	-7,2	-2,4	-2,0	-3,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	108	146	94	102	20	12	8	-0,5	8,8	-15,0	-5,4	-3,3	-7,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,35	0,46	0,59	0,59	0,20	0,17	0,13	1,8	-0,9	-10,2	-1,8	-2,6	-4,8
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Singapore BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,38**	**13,89**	**23,51**	**23,63**	**29,54**	**35,87**	**42,81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**0,5**	**2,3**	**2,0**	**1,8**	**2,0**
Coal	0,02	0,00	0,46	0,46	0,51	0,57	0,63	0,2	0,0	2,0	2,0	1,7	1,6	1,5	11,4	0,2	1,0	1,1	1,1	1,0
Oil	8,23	12,46	13,12	13,18	17,19	21,26	25,55	98,2	89,7	55,8	55,8	58,2	59,3	59,7	1,6	0,5	2,7	2,1	1,9	2,2
Natural gas	0,06	1,23	9,21	9,26	10,88	12,80	15,05	0,7	8,9	39,2	39,2	36,8	35,7	35,2	19,0	0,5	1,6	1,6	1,6	1,6
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	0,07	0,20	0,71	0,73	0,96	1,24	1,57	0,8	1,4	3,0	3,1	3,2	3,4	3,7	8,3	1,6	2,8	2,6	2,4	2,6
Biomass	0,07	0,20	0,07	0,07	0,09	0,10	0,12	0,8	1,4	0,3	0,3	0,3	0,3	0,3	0,2	0,3	1,6	1,6	1,6	1,6
Solar, Wind, Ocean	0,00	0,00	0,64	0,65	0,87	1,13	1,45	0,0	0,0	2,7	2,8	2,9	3,2	3,4	-	1,7	2,9	2,7	2,5	2,7
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,01**	**8,31**	**18,95**	**19,07**	**24,24**	**29,72**	**35,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,6**	**2,4**	**2,1**	**1,9**	**2,1**
Industry	0,61	2,18	6,84	6,80	8,94	11,38	14,27	12,2	26,2	36,1	35,7	36,9	38,3	39,9	8,7	-0,5	2,8	2,5	2,3	2,4
Transportation	1,36	1,75	2,51	2,46	3,09	3,57	4,09	27,1	21,1	13,2	12,9	12,8	12,0	11,4	2,1	-1,7	2,3	1,4	1,4	1,6
Others	1,13	1,65	2,71	2,69	2,97	3,40	3,90	22,6	19,9	14,3	14,1	12,3	11,5	10,9	3,1	-0,8	1,0	1,4	1,4	1,2
Non-energy	1,91	2,72	6,89	7,11	9,24	11,37	13,50	38,1	32,8	36,4	37,3	38,1	38,2	37,8	4,5	3,1	2,7	2,1	1,7	2,2
Total	**5,01**	**8,31**	**18,95**	**19,07**	**24,24**	**29,72**	**35,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,6**	**2,4**	**2,1**	**1,9**	**2,1**
Coal	0,02	0,00	0,18	0,18	0,18	0,18	0,18	0,4	0,0	1,0	1,0	0,8	0,6	0,5	8,0	0,0	0,0	0,0	0,0	0,0
Oil	3,81	5,86	13,03	13,09	17,01	20,98	25,16	76,0	70,5	68,8	68,7	70,2	70,6	70,4	4,3	0,5	2,7	2,1	1,8	2,1
Natural gas	0,06	0,11	1,29	1,33	1,79	2,41	3,23	1,2	1,3	6,8	7,0	7,4	8,1	9,0	11,2	3,1	3,0	3,0	3,0	3,0
Electricity	1,12	2,35	4,45	4,46	5,25	6,15	7,18	22,4	28,2	23,5	23,4	21,6	20,7	20,1	4,9	0,3	1,6	1,6	1,6	1,6
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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**15,71**	**31,67**	**54,87**	**55,04**	**64,72**	**75,92**	**88,61**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**0,3**	**1,6**	**1,6**	**1,6**	**1,6**
Coal	0,00	0,00	0,65	0,66	0,77	0,91	1,06	0,0	0,0	1,2	1,2	1,2	1,2	1,2	-	0,3	1,6	1,6	1,6	1,6
Oil	15,54	25,32	0,22	0,25	0,62	1,23	2,03	98,9	79,9	0,4	0,5	1,0	1,6	2,3	-13,7	14,3	9,6	7,1	5,1	7,5
Natural gas	0,00	5,86	52,14	52,21	60,35	69,56	79,75	0,0	18,5	95,0	94,9	93,2	91,6	90,0	-	0,1	1,5	1,4	1,4	1,4
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	0,17	0,49	1,86	1,92	2,98	4,22	5,77	1,1	1,5	3,4	3,5	4,6	5,6	6,5	8,6	3,6	4,5	3,5	3,2	3,7

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,42**	**7,72**	**8,29**	**8,30**	**9,60**	**11,06**	**12,66**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,2**	**0,2**	**1,5**	**1,4**	**1,4**	**1,4**
Coal	0,00	0,00	0,28	0,28	0,33	0,39	0,45	0,0	0,0	3,4	3,4	3,4	3,5	3,6	-	0,3	1,6	1,6	1,6	1,6
Oil	4,42	6,60	0,09	0,09	0,18	0,28	0,39	100,0	85,5	1,0	1,1	1,9	2,6	3,1	-12,7	10,6	6,5	4,7	3,2	5,0
Natural gas	0,00	1,12	7,92	7,93	9,09	10,39	11,82	0,0	14,5	95,6	95,5	94,7	94,0	93,4	-	0,1	1,4	1,3	1,3	1,3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**30,2**	**34,7**	**55,0**	**55,0**	**55,3**	**55,7**	**56,3**								**2,1**	**0,0**	**0,1**	**0,1**	**0,1**	**0,1**
Coal	-	-	20,2	20,2	20,2	20,2	20,2								-	0,0	0,0	0,0	0,0	0,0
Oil	30,2	33,0	22,0	22,7	30,1	37,6	45,0								-1,1	3,4	2,9	2,2	1,8	2,3
Natural gas	-	45,0	56,6	56,6	57,1	57,6	58,0								-	0,1	0,1	0,1	0,1	0,1

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**7,9**	**11,4**	**13,2**	**13,2**	**15,9**	**18,8**	**22,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,8**	**-0,3**	**1,9**	**1,7**	**1,6**	**1,7**
Coal	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-
Oil	7,8	10,6	7,3	7,2	8,9	10,6	12,4	99,2	93,1	55,3	55,0	56,0	56,3	56,2	-0,2	-0,9	2,1	1,7	1,6	1,7
Natural gas	0,0	0,8	5,9	5,9	7,0	8,2	9,6	0,5	6,9	44,7	45,0	44,0	43,7	43,8	18,8	0,5	1,6	1,6	1,6	1,6

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	70,9	140,5	348,9	330,1	450,8	560,4	683,1	5,7	-5,4	3,2	2,2	2,0	2,2
Population (millions of people)	3,0	4,0	5,8	5,9	6,3	6,4	6,4	2,2	0,8	0,7	0,3	-0,1	0,3
GDP per capita (thousands of 2015 USD/person)	23,26	34,88	60,11	56,42	71,98	86,94	106,61	3,3	-6,1	2,5	1,9	2,1	1,9
Primary energy consumption per capita (toe/person)	2,75	3,45	4,05	4,04	4,72	5,56	6,68	1,3	-0,3	1,6	1,7	1,8	1,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	118	99	67	72	66	64	63	-1,9	6,3	-0,9	-0,2	-0,2	-0,2
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	71	59	54	58	54	53	52	-0,9	6,3	-0,7	-0,1	-0,1	-0,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	111	81	38	40	35	33	32	-3,6	5,4	-1,3	-0,5	-0,4	-0,5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,94	0,82	0,56	0,56	0,54	0,52	0,51	-1,8	-0,8	-0,4	-0,3	-0,2	-0,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Singapore APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,38**	**13,89**	**23,51**	**23,52**	**28,29**	**33,99**	**40,17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**0,1**	**1,9**	**1,9**	**1,7**	**1,7**
Coal	0,02	0,00	0,46	0,46	0,50	0,55	0,61	0,2	0,0	2,0	2,0	1,8	1,6	1,5	11,4	-0,1	0,7	1,0	1,1	0,9
Oil	8,23	12,46	13,12	13,17	17,02	21,24	25,66	98,2	89,7	55,8	56,0	60,1	62,5	63,9	1,6	0,4	2,6	2,2	1,9	2,2
Natural gas	0,06	1,23	9,21	9,18	9,93	11,20	12,70	0,7	8,9	39,2	39,0	35,1	33,0	31,6	19,0	-0,4	0,8	1,2	1,3	1,0
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	0,07	0,20	0,71	0,71	0,85	1,00	1,20	0,8	1,4	3,0	3,0	3,0	2,9	3,0	8,3	-0,1	1,8	1,6	1,8	1,7
Biomass	0,07	0,20	0,07	0,07	0,08	0,10	0,11	0,8	1,4	0,3	0,3	0,3	0,3	0,3	0,2	-0,1	1,2	1,6	1,6	1,4
Solar, Wind, Ocean	0,00	0,00	0,64	0,64	0,77	0,90	1,08	0,0	0,0	2,7	2,7	2,7	2,6	2,7	-	-0,1	1,9	1,6	1,9	1,7
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,01**	**8,31**	**18,95**	**19,05**	**23,98**	**29,42**	**35,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,5**	**2,3**	**2,1**	**1,9**	**2,0**
Industry	0,61	2,18	6,84	6,80	8,82	11,24	14,10	12,2	26,2	36,1	35,7	36,8	38,2	39,8	8,7	-0,7	2,6	2,5	2,3	2,4
Transportation	1,36	1,75	2,51	2,46	3,09	3,57	4,09	27,1	21,1	13,2	12,9	12,9	12,1	11,5	2,1	-1,7	2,3	1,4	1,4	1,6
Others	1,13	1,65	2,71	2,68	2,83	3,24	3,71	22,6	19,9	14,3	14,1	11,8	11,0	10,5	3,1	-1,2	0,5	1,4	1,4	1,0
Non-energy	1,91	2,72	6,89	7,11	9,24	11,37	13,50	38,1	32,8	36,4	37,3	38,5	38,6	38,1	4,5	3,1	2,7	2,1	1,7	2,2
Total	**5,01**	**8,31**	**18,95**	**19,05**	**23,98**	**29,42**	**35,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,5**	**2,3**	**2,1**	**1,9**	**2,0**
Coal	0,02	0,00	0,18	0,18	0,18	0,18	0,18	0,4	0,0	1,0	1,0	0,8	0,6	0,5	8,0	0,0	0,0	0,0	0,0	0,0
Oil	3,81	5,86	13,03	13,09	17,01	20,98	25,16	76,0	70,5	68,8	68,7	70,9	71,3	71,1	4,3	0,5	2,7	2,1	1,8	2,1
Natural gas	0,06	0,11	1,29	1,33	1,79	2,41	3,23	1,2	1,3	6,8	7,0	7,5	8,2	9,1	11,2	3,1	3,0	3,0	3,0	3,0
Electricity	1,12	2,35	4,45	4,44	4,99	5,85	6,83	22,4	28,2	23,5	23,3	20,8	19,9	19,3	4,9	-0,1	1,2	1,6	1,6	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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**15,71**	**31,67**	**54,87**	**54,81**	**61,60**	**72,21**	**84,24**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**-0,1**	**1,2**	**1,6**	**1,6**	**1,4**
Coal	0,00	0,00	0,65	0,65	0,74	0,86	1,01	0,0	0,0	1,2	1,2	1,2	1,2	1,2	-	-0,1	1,2	1,6	1,6	1,4
Oil	15,54	25,32	0,22	0,20	0,02	1,20	2,77	98,9	79,9	0,4	0,4	0,0	1,7	3,3	-13,7	-7,2	-19,5	48,4	8,7	8,5
Natural gas	0,00	5,86	52,14	51,90	56,34	63,71	71,60	0,0	18,5	95,0	94,7	91,5	88,2	85,0	-	-0,5	0,8	1,2	1,2	1,0
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	0,17	0,49	1,86	2,05	4,50	6,43	8,86	1,1	1,5	3,4	3,7	7,3	8,9	10,5	8,6	10,4	8,2	3,6	3,2	5,2

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,42**	**7,72**	**8,29**	**8,21**	**8,45**	**9,42**	**10,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,2**	**-1,0**	**0,3**	**1,1**	**1,0**	**0,7**
Coal	0,00	0,00	0,28	0,28	0,31	0,37	0,43	0,0	0,0	3,4	3,4	3,7	3,9	4,1	-	-0,1	1,2	1,6	1,6	1,4
Oil	4,42	6,60	0,09	0,08	0,01	0,26	0,50	100,0	85,5	1,0	0,9	0,1	2,8	4,8	-12,7	-10,7	-22,0	44,9	6,6	5,8
Natural gas	0,00	1,12	7,92	7,85	8,13	8,80	9,47	0,0	14,5	95,6	95,7	96,2	93,3	91,1	-	-0,9	0,4	0,8	0,7	0,6

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**30,2**	**34,7**	**55,0**	**55,3**	**58,1**	**60,0**	**62,4**								**2,1**	**0,5**	**0,5**	**0,3**	**0,4**	**0,4**
Coal	-	-	20,2	20,2	20,2	20,2	20,2								-	0,0	0,0	0,0	0,0	0,0
Oil	30,2	33,0	22,0	22,8	31,2	39,6	48,0								-1,1	3,8	3,2	2,4	1,9	2,6
Natural gas	-	45,0	56,6	56,9	59,6	62,3	65,0								-	0,5	0,5	0,4	0,4	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**7,9**	**11,4**	**13,2**	**13,1**	**15,1**	**17,7**	**20,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,8**	**-0,8**	**1,4**	**1,6**	**1,5**	**1,4**
Coal	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-
Oil	7,8	10,6	7,3	7,2	8,8	10,5	12,4	99,2	93,1	55,3	55,1	57,9	59,5	60,5	-0,2	-1,1	2,0	1,9	1,7	1,7
Natural gas	0,0	0,8	5,9	5,9	6,4	7,2	8,1	0,5	6,9	44,7	44,9	42,1	40,5	39,5	18,8	-0,4	0,8	1,2	1,3	1,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	70,9	140,5	348,9	330,1	450,8	560,4	683,1	5,7	-5,4	3,2	2,2	2,0	2,2
Population (millions of people)	3,0	4,0	5,8	5,9	6,3	6,4	6,4	2,2	0,8	0,7	0,3	-0,1	0,3
GDP per capita (thousands of 2015 USD/person)	23,26	34,88	60,11	56,42	71,98	86,94	106,61	3,3	-6,1	2,5	1,9	2,1	1,9
Primary energy consumption per capita (toe/person)	2,75	3,45	4,05	4,02	4,52	5,27	6,27	1,3	-0,7	1,2	1,6	1,7	1,4
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	118	99	67	71	63	61	59	-1,9	5,8	-1,3	-0,3	-0,3	-0,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	71	59	54	58	53	53	52	-0,9	6,2	-0,8	-0,1	-0,1	-0,2
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	111	81	38	40	34	32	30	-3,6	4,9	-1,7	-0,6	-0,5	-0,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,94	0,82	0,56	0,56	0,53	0,52	0,51	-1,8	-0,8	-0,4	-0,3	-0,2	-0,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Singapore LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,38**	**13,89**	**23,51**	**23,67**	**30,17**	**37,32**	**46,12**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,6**	**0,7**	**2,5**	**2,2**	**2,1**	**2,2**
Coal	0,02	0,00	0,46	0,49	0,18	0,18	0,18	0,2	0,0	2,0	2,1	0,6	0,5	0,4	11,4	6,2	-9,4	0,0	0,0	-2,9
Oil	8,23	12,46	13,12	13,19	17,25	20,48	24,31	98,2	89,7	55,8	55,7	57,2	54,9	52,7	1,6	0,6	2,7	1,7	1,7	2,0
Natural gas	0,06	1,23	9,21	9,31	11,81	15,54	20,21	0,7	8,9	39,2	39,3	39,2	41,6	43,8	19,0	1,0	2,4	2,8	2,7	2,6
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	-	-	-	-	-	-
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	0,00	0,00													
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	0,07	0,20	0,71	0,68	0,91	1,12	1,42	0,8	1,4	3,0	2,9	3,0	3,0	3,1	8,3	-4,9	3,0	2,0	2,4	2,2
Biomass	0,07	0,20	0,07	0,03	0,00	0,00	0,00	0,8	1,4	0,3	0,1	0,0	0,0	0,0	0,2	-55,9	-100,0	-	-	-100,0
Solar, Wind, Ocean	0,00	0,00	0,64	0,65	0,91	1,12	1,42	0,0	0,0	2,7	2,7	3,0	3,0	3,1	-	1,0	3,5	2,0	2,4	2,6
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	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5,01**	**8,31**	**18,95**	**19,08**	**24,76**	**30,53**	**37,43**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,7**	**2,6**	**2,1**	**2,1**	**2,2**
Industry	0,61	2,18	6,84	6,82	9,43	12,59	16,62	12,2	26,2	36,1	35,8	38,1	41,2	44,4	8,7	-0,3	3,3	2,9	2,8	2,9
Transportation	1,36	1,75	2,51	2,44	2,84	3,07	3,60	27,1	21,1	13,2	12,8	11,5	10,1	9,6	2,1	-2,6	1,5	0,8	1,6	1,2
Others	1,13	1,65	2,71	2,71	3,26	3,49	3,71	22,6	19,9	14,3	14,2	13,1	11,4	9,9	3,1	0,0	1,8	0,7	0,6	1,0
Non-energy	1,91	2,72	6,89	7,11	9,24	11,37	13,50	38,1	32,8	36,4	37,2	37,3	37,2	36,1	4,5	3,1	2,7	2,1	1,7	2,2
Total	**5,01**	**8,31**	**18,95**	**19,08**	**24,76**	**30,53**	**37,43**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**0,7**	**2,6**	**2,1**	**2,1**	**2,2**
Coal	0,02	0,00	0,18	0,18	0,18	0,18	0,18	0,4	0,0	1,0	1,0	0,7	0,6	0,5	8,0	0,0	0,0	0,0	0,0	0,0
Oil	3,81	5,86	13,03	13,05	16,54	20,08	24,21	76,0	70,5	68,8	68,4	66,8	65,8	64,7	4,3	0,1	2,4	2,0	1,9	2,0
Natural gas	0,06	0,11	1,29	1,33	1,77	2,36	3,17	1,2	1,3	6,8	7,0	7,2	7,7	8,5	11,2	2,9	2,9	2,9	3,0	2,9
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	0,00	0,00								-100,0	-	-	-	-	-
Electricity	1,12	2,35	4,45	4,52	6,27	7,90	9,86	0,0	28,2	23,5	23,7	25,3	25,9	26,3	-	1,7	3,3	2,3	2,2	2,6
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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**15,71**	**31,67**	**54,87**	**55,80**	**77,29**	**97,47**	**121,66**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,4**	**1,7**	**3,3**	**2,3**	**2,2**	**2,6**
Coal PP	0,00	0,00	0,65	0,72	0,00	0,00	0,00	0,0	0,0	1,2	1,3	0,0	0,0	0,0	-	10,3	-100,0	-	-	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	0,00	0,00	0,00													
Oil	15,54	25,32	0,22	0,38	2,59	1,85	0,54	98,9	79,9	0,4	0,7	3,3	1,9	0,4	-13,7	75,6	21,0	-3,3	-11,6	3,0
Gas PP	0,00	5,86	52,14	52,77	69,56	43,86	0,00	0,0	18,5	95,0	94,6	90,0	45,0	0,0	-	1,2	2,8	-4,5	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	0,00	43,86	109,49								-					
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	0,00	0,00								-					
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	-	-	-	-	-	-
Solar	0,17	0,00	0,41	0,61	3,48	5,80	9,00													
Wind	0,00	0,00	0,00	0,00	0,00	0,00	0,00													
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	0,00	0,49	1,44	1,32	1,67	2,10	2,62	0,0	1,5	2,6	2,4	2,2	2,2	2,2	-	-8,7	2,4	2,3	2,2	1,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,42**	**7,72**	**8,29**	**8,43**	**10,75**	**13,58**	**17,14**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,2**	**1,8**	**2,5**	**2,4**	**2,4**	**2,4**
Coal	0,00	0,00	0,28	0,31	0,00	0,00	0,00	0,0	0,0	3,4	3,6	0,0	0,0	0,0	-	10,3	-100,0	-	-	-100,0
Oil	4,42	6,60	0,09	0,14	0,71	0,40	0,10	100,0	85,5	1,0	1,7	6,6	3,0	0,6	-12,7	69,1	17,3	-5,6	-13,2	0,4
Gas	0,00	1,12	7,92	7,98	10,04	13,18	17,04													
Hydrogen/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	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**30,2**	**34,7**	**55,0**	**54,9**	**57,7**	**56,7**	**55,2**								**2,1**	**-0,1**	**0,5**	**-0,2**	**-0,3**	**0,0**
Coal	-	-	20,18	20,18	-	-	-								-	0,0	-	-	-	-
Oil	30,24	32,99	21,96	22,80	31,20	39,61	48,01								-1,1	3,8	3,2	2,4	1,9	2,6
Gas	-	45,00	56,59	56,86	59,58	57,24	55,26													
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**7,9**	**11,4**	**13,2**	**13,2**	**16,5**	**13,8**	**9,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,8**	**0,0**	**2,2**	**-1,8**	**-3,8**	**-1,1**
Coal	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-
Oil	7,8	10,6	7,3	7,2	8,9	8,6	7,9	99,2	93,1	55,3	54,8	54,0	62,1	85,1	-0,2	-0,9	2,1	-0,4	-0,8	0,3
Natural gas	0,0	0,8	5,9	6,0	7,6	5,2	1,4	0,5	6,9	44,7	45,2	46,0	37,9	14,9	18,8	1,0	2,4	-3,7	-12,4	-4,5

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	70,9	140,5	348,9	330,1	450,8	560,4	683,1	5,7	-5,4	3,2	2,2	2,0	2,2
Population (millions of people)	3,0	4,0	5,8	5,9	6,3	6,4	6,4	2,2	0,8	0,7	0,3	-0,1	0,3
GDP per capita (thousands of 2015 USD/person)	23,26	34,88	60,11	56,42	71,98	86,94	106,61	3,3	-6,1	2,5	1,9	2,1	1,9
Primary energy consumption per capita (toe/person)	2,75	3,45	4,05	4,05	4,82	5,79	7,20	1,3	-0,1	1,8	1,9	2,2	1,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	118	99	67	72	67	67	68	-1,9	6,4	-0,7	0,0	0,1	0,0
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	71	59	54	58	55	54	55	-0,9	6,4	-0,5	-0,1	0,1	0,0
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	111	81	38	40	37	25	14	-3,6	5,7	-0,9	-3,9	-5,7	-3,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,94	0,82	0,56	0,56	0,55	0,37	0,20	-1,8	-0,7	-0,2	-3,8	-5,8	-3,2
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Thailand BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,94**	**72,27**	**133,10**	**124,91**	**140,86**	**171,94**	**211,31**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-6,2**	**1,2**	**2,0**	**2,1**	**1,5**
Coal	3,82	7,67	18,50	15,31	16,76	20,19	35,21	9,1	10,6	13,9	12,3	11,9	11,7	16,7	5,6	-17,2	0,9	1,9	5,7	2,1
Oil	17,96	31,88	40,97	40,14	45,49	54,31	64,39	42,8	44,1	30,8	32,1	32,3	31,6	30,5	2,9	-2,0	1,3	1,8	1,7	1,5
Natural gas	4,99	17,36	39,59	40,52	42,03	48,03	54,49	11,9	24,0	29,7	32,4	29,8	27,9	25,8	7,4	2,3	0,4	1,3	1,3	1,0
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	0,43	0,52	1,75	1,81	2,48	2,55	2,57	1,0	0,7	1,3	1,5	1,8	1,5	1,2	5,0	3,5	3,2	0,3	0,1	1,2
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	14,74	14,83	32,28	27,13	34,11	46,87	54,64	35,1	20,5	24,3	21,7	24,2	27,3	25,9	2,7	-15,9	2,3	3,2	1,5	1,7
Biomass	14,69	14,59	21,60	19,07	19,62	25,03	29,93	35,0	20,2	16,2	15,3	13,9	14,6	14,2	1,3	-11,7	0,3	2,5	1,8	1,1
Solar, Wind, Ocean	0,00	0,00	0,96	1,33	2,99	4,93	5,57	0,0	0,0	0,7	1,1	2,1	2,9	2,6	-	38,2	8,4	5,1	1,2	5,8
Biofuels	0,00	0,00	2,36	2,05	3,41	4,90	6,41	0,0	0,0	1,8	1,6	2,4	2,9	3,0	-	-13,3	5,3	3,7	2,7	3,3
Electricity	0,05	0,24	7,35	4,68	8,09	12,00	12,74	0,1	0,3	5,5	3,7	5,7	7,0	6,0	18,5	-36,3	5,6	4,0	0,6	1,8

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,87**	**50,57**	**93,90**	**89,93**	**108,74**	**132,20**	**156,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-4,2**	**1,9**	**2,0**	**1,7**	**1,7**
Industry	8,65	16,72	28,73	26,99	35,04	43,74	52,70	30,0	33,1	30,6	30,0	32,2	33,1	33,6	4,2	-6,1	2,6	2,2	1,9	2,0
Transportation	9,01	14,61	28,36	26,50	31,18	39,61	48,87	31,2	28,9	30,2	29,5	28,7	30,0	31,2	4,0	-6,6	1,6	2,4	2,1	1,8
Others	10,78	13,62	21,15	20,90	25,22	29,70	34,17	37,3	26,9	22,5	23,2	23,2	22,5	21,8	2,4	-1,2	1,9	1,6	1,4	1,6
Non-energy	0,43	5,63	15,66	15,55	17,29	19,16	21,10	1,5	11,1	16,7	17,3	15,9	14,5	13,5	13,2	-0,7	1,1	1,0	1,0	1,0
Total	**28,87**	**50,57**	**93,90**	**89,93**	**108,74**	**132,20**	**156,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-4,2**	**1,9**	**2,0**	**1,7**	**1,7**
Coal	1,31	3,54	7,06	6,43	9,34	12,45	15,60	4,5	7,0	7,5	7,2	8,6	9,4	9,9	6,0	-9,0	3,8	2,9	2,3	2,6
Oil	14,93	28,77	40,71	39,85	45,24	54,10	64,08	51,7	56,9	43,4	44,3	41,6	40,9	40,9	3,5	-2,1	1,3	1,8	1,7	1,5
Natural gas	0,14	1,11	7,48	6,48	8,68	11,25	13,75	0,5	2,2	8,0	7,2	8,0	8,5	8,8	14,8	-13,4	3,0	2,6	2,0	2,0
Electricity	3,30	7,56	22,65	21,49	28,38	35,75	43,20	11,4	15,0	24,1	23,9	26,1	27,0	27,5	6,9	-5,1	2,8	2,3	1,9	2,1
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	0,00	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	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**44,18**	**95,98**	**201,79**	**217,88**	**264,82**	**312,99**	**400,74**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,4**	**8,0**	**2,0**	**1,7**	**2,5**	**2,2**
Coal	11,05	17,77	45,22	35,27	30,31	32,57	85,08	25,0	18,5	22,4	16,2	11,4	10,4	21,2	5,0	-22,0	-1,5	0,7	10,1	2,1
Oil	10,38	10,03	0,36	0,46	0,28	0,16	0,63	23,5	10,4	0,2	0,2	0,1	0,0	0,2	-11,0	27,0	-4,8	-5,6	14,9	1,8
Natural gas	17,77	61,64	121,38	141,21	168,43	181,15	198,21	40,2	64,2	60,2	64,8	63,6	57,9	49,5	6,9	16,3	1,8	0,7	0,9	1,6
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	4,98	6,03	20,35	21,08	28,82	29,63	29,87	11,3	6,3	10,1	9,7	10,9	9,5	7,5	5,0	3,6	3,2	0,3	0,1	1,2
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	0,51	14,48	19,87	36,99	69,48	86,95	0,0	0,5	7,2	9,1	14,0	22,2	21,7	-	37,2	6,4	6,5	2,3	6,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,92**	**19,24**	**33,29**	**34,22**	**36,52**	**37,93**	**51,67**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,6**	**2,8**	**0,7**	**0,4**	**3,1**	**1,4**
Coal	2,55	4,16	11,44	8,88	7,42	7,73	19,61	28,6	21,6	34,4	26,0	20,3	20,4	38,0	5,3	-22,3	-1,8	0,4	9,8	1,8
Oil	2,55	2,34	0,08	0,10	0,06	0,03	0,14	28,6	12,2	0,2	0,3	0,2	0,1	0,3	-11,3	27,8	-4,9	-5,7	15,0	1,8
Natural gas	3,82	12,73	21,77	25,24	29,04	30,16	31,92	42,9	66,2	65,4	73,8	79,5	79,5	61,8	6,2	15,9	1,4	0,4	0,6	1,2

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,8**	**40,0**	**43,1**	**44,5**	**46,9**	**48,5**	**47,3**								**0,5**	**3,1**	**0,5**	**0,3**	**-0,3**	**0,3**
Coal	37,3	36,7	34,0	34,1	35,1	36,2	37,3								-0,3	0,4	0,3	0,3	0,3	0,3
Oil	35,0	36,8	39,1	38,8	39,3	39,5	39,4								0,4	-0,6	0,1	0,0	0,0	0,0
Natural gas	40,0	41,6	47,9	48,1	49,9	51,6	53,4								0,6	0,4	0,4	0,3	0,3	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,9**	**46,2**	**58,4**	**56,5**	**63,1**	**73,0**	**96,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,7**	**-3,1**	**1,1**	**1,5**	**2,8**	**1,6**
Coal	10,2	12,6	13,1	10,3	9,4	10,5	23,9	28,5	27,3	22,5	18,2	14,9	14,4	24,8	0,9	-21,8	-0,8	1,1	8,5	2,0
Oil	12,2	19,5	28,0	27,4	31,1	37,5	44,9	34,0	42,2	47,9	48,5	49,2	51,3	46,5	2,9	-1,9	1,2	1,9	1,8	1,5
Natural gas	13,5	14,1	17,3	18,8	22,6	25,0	27,7	37,5	30,5	29,6	33,3	35,9	34,2	28,7	0,9	9,1	1,9	1,0	1,0	1,5

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	141,6	217,7	460,8	432,9	581,9	797,3	1.092,5	4,2	-6,0	3,0	3,2	3,2	2,8
Population (millions of people)	56,6	61,9	69,6	70,0	73,9	78,1	82,4	0,7	0,5	0,5	0,5	0,5	0,5
GDP per capita (thousands of 2015 USD/person)	2,50	3,52	6,62	6,18	7,87	10,22	13,26	3,4	-6,5	2,4	2,6	2,6	2,3
Primary energy consumption per capita (toe/person)	0,74	1,17	1,91	1,78	1,91	2,20	2,56	3,3	-6,7	0,7	1,5	1,5	1,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	296	332	289	289	242	216	193	-0,1	-0,1	-1,7	-1,1	-1,1	-1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	204	232	204	208	187	166	144	0,0	1,9	-1,1	-1,2	-1,4	-1,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	253	212	127	131	108	92	88	-2,4	3,1	-1,8	-1,7	-0,4	-1,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,86	0,64	0,44	0,45	0,45	0,42	0,46	-2,3	3,2	-0,1	-0,5	0,7	0,1
Automobile ownership volume (millions of vehicles)	7,52	20,75	40,71	42,30	62,02	90,92	133,29	6,0	3,9	3,9	3,9	8,0	3,9
Automobile ownership volume per capita (vehicles per person)	0,133	0,335	0,585	0,604	0,839	1,165	1,617	5,2	3,3	3,3	3,3	6,8	3,3

Thailand APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,94**	**72,27**	**133,10**	**114,82**	**116,01**	**130,45**	**158,45**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-13,7**	**0,1**	**1,2**	**2,0**	**0,6**
Coal	3,82	7,67	18,50	14,12	15,25	18,64	26,88	9,1	10,6	13,9	12,3	13,1	14,3	17,0	5,6	-23,7	0,8	2,0	3,7	1,2
Oil	17,96	31,88	40,97	35,68	31,65	29,87	34,28	42,8	44,1	30,8	31,1	27,3	22,9	21,6	2,9	-12,9	-1,2	-0,6	1,4	-0,6
Natural gas	4,99	17,36	39,59	37,89	34,99	40,05	44,42	11,9	24,0	29,7	33,0	30,2	30,7	28,0	7,4	-4,3	-0,8	1,4	1,0	0,4
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	0,43	0,52	1,75	1,75	1,12	0,75	0,76	1,0	0,7	1,3	1,5	1,0	0,6	0,5	5,0	-0,1	-4,4	-4,0	0,2	-2,6
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	0,0	-	-	-	-	-	-
Others	14,74	14,83	32,28	25,38	33,00	41,16	52,11	35,1	20,5	24,3	22,1	28,4	31,5	32,9	2,7	-21,4	2,7	2,2	2,4	1,6
Biomass	14,69	14,59	21,60	18,02	21,31	24,75	30,20	35,0	20,2	16,2	15,7	18,4	19,0	19,1	1,3	-16,6	1,7	1,5	2,0	1,1
Solar, Wind, Ocean	0,00	0,00	0,96	1,37	3,34	5,65	9,09	0,0	0,0	0,7	1,2	2,9	4,3	5,7	-	42,0	9,3	5,4	4,9	7,5
Biofuels	0,00	0,00	2,36	1,69	1,75	1,49	1,94	0,0	0,0	1,8	1,5	1,5	1,1	1,2	-	-28,5	0,4	-1,6	2,7	-0,6
Electricity	0,05	0,24	7,35	4,30	6,60	9,27	10,87	0,1	0,3	5,5	3,7	5,7	7,1	6,9	18,5	-41,5	4,4	3,5	1,6	1,3

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,87**	**50,57**	**93,90**	**82,92**	**87,74**	**96,30**	**114,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-11,7**	**0,6**	**0,9**	**1,7**	**0,6**
Industry	8,65	16,72	28,73	25,31	30,77	37,24	44,84	30,0	33,1	30,6	30,5	35,1	38,7	39,2	4,2	-11,9	2,0	1,9	1,9	1,4
Transportation	9,01	14,61	28,36	21,97	16,38	12,60	15,41	31,2	28,9	30,2	26,5	18,7	13,1	13,5	4,0	-22,5	-2,9	-2,6	2,0	-1,9
Others	10,78	13,62	21,15	20,09	23,29	27,30	33,06	37,3	26,9	22,5	24,2	26,5	28,4	28,9	2,4	-5,0	1,5	1,6	1,9	1,5
Non-energy	0,43	5,63	15,66	15,55	17,29	19,16	21,10	1,5	11,1	16,7	18,8	19,7	19,9	18,4	13,2	-0,7	1,1	1,0	1,0	1,0
Total	**28,87**	**50,57**	**93,90**	**82,92**	**87,74**	**96,29**	**114,41**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-11,7**	**0,6**	**0,9**	**1,7**	**0,6**
Coal	1,31	3,54	7,06	6,36	9,06	11,96	14,95	4,5	7,0	7,5	7,7	10,3	12,4	13,1	6,0	-10,0	3,6	2,8	2,3	2,4
Oil	14,93	28,77	40,71	35,40	31,43	29,65	34,01	51,7	56,9	43,4	42,7	35,8	30,8	29,7	3,5	-13,1	-1,2	-0,6	1,4	-0,6
Natural gas	0,14	1,11	7,48	5,99	7,25	8,91	10,94	0,5	2,2	8,0	7,2	8,3	9,2	9,6	14,8	-19,9	1,9	2,1	2,1	1,2
Electricity	3,30	7,56	22,65	20,34	24,43	29,16	35,07	11,4	15,0	24,1	24,5	27,8	30,3	30,7	6,9	-10,2	1,8	1,8	1,9	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	9,20	9,59	15,99	14,83	15,56	16,62	19,43	31,9	19,0	17,0	17,9	17,7	17,3	17,0	1,9	-7,3	0,5	0,7	1,6	0,6

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**44,18**	**95,98**	**201,79**	**198,18**	**215,51**	**236,04**	**280,44**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,4**	**-1,8**	**0,8**	**0,9**	**1,7**	**1,1**
Coal	11,05	17,77	45,22	33,68	28,17	30,80	58,98	25,0	18,5	22,4	17,0	13,1	13,0	21,0	5,0	-25,5	-1,8	0,9	6,7	0,9
Oil	10,38	10,03	0,36	0,46	0,19	0,16	0,43	23,5	10,4	0,2	0,2	0,1	0,1	0,2	-11,0	27,0	-8,6	-1,7	10,5	0,5
Natural gas	17,77	61,64	121,38	134,84	156,52	171,28	176,51	40,2	64,2	60,2	68,0	72,6	72,6	62,9	6,9	11,1	1,5	0,9	0,3	1,2
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	4,98	6,03	20,35	20,34	13,02	8,67	8,88	11,3	6,3	10,1	10,3	6,0	3,7	3,2	5,0	-0,1	-4,4	-4,0	0,2	-2,6
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	0,0	-	-	-	-	-	-
Others	0,00	0,51	14,48	8,87	17,61	25,14	35,65	0,0	0,5	7,2	4,5	8,2	10,6	12,7	-	-38,7	7,1	3,6	3,6	2,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,92**	**19,24**	**33,29**	**31,86**	**32,06**	**33,98**	**40,13**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,6**	**-4,3**	**0,1**	**0,6**	**1,7**	**0,6**
Coal	2,55	4,16	11,44	7,76	6,19	6,68	11,93	28,6	21,6	34,4	24,4	19,3	19,6	29,7	5,3	-32,1	-2,2	0,8	6,0	0,1
Oil	2,55	2,34	0,08	0,10	0,04	0,03	0,09	28,6	12,2	0,2	0,3	0,1	0,1	0,2	-11,3	27,8	-8,8	-1,6	10,3	0,5
Natural gas	3,82	12,73	21,77	24,00	25,83	27,27	28,11	42,9	66,2	65,4	75,3	80,6	80,3	70,0	6,2	10,2	0,7	0,5	0,3	0,8

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,8**	**40,0**	**43,1**	**45,6**	**49,6**	**51,2**	**50,6**								**0,5**	**5,7**	**0,8**	**0,3**	**-0,1**	**0,5**
Coal	37,3	36,7	34,0	37,3	39,1	39,7	42,5								-0,3	9,7	0,5	0,1	0,7	0,7
Oil	35,0	36,8	39,1	38,8	40,0	39,5	40,2								0,4	-0,6	0,3	-0,1	0,2	0,1
Natural gas	40,0	41,6	47,9	48,3	52,1	54,0	54,0								0,6	0,8	0,8	0,4	0,0	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,9**	**46,2**	**58,4**	**50,5**	**47,3**	**48,0**	**58,8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,7**	**-13,4**	**-0,7**	**0,2**	**2,1**	**0,0**
Coal	10,2	12,6	13,1	9,0	7,8	8,9	15,1	28,5	27,3	22,5	17,8	16,6	18,5	25,7	0,9	-31,4	-1,4	1,3	5,4	0,5
Oil	12,2	19,5	28,0	23,8	19,7	17,5	20,3	34,0	42,2	47,9	47,1	41,8	36,4	34,5	2,9	-14,9	-1,9	-1,2	1,5	-1,0
Natural gas	13,5	14,1	17,3	17,7	19,7	21,6	23,5	37,5	30,5	29,6	35,1	41,6	45,1	39,9	0,9	2,7	1,1	1,0	0,8	1,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	141,6	217,7	460,8	432,9	581,9	797,3	1.092,5	4,2	-6,0	3,0	3,2	3,2	2,8
Population (millions of people)	56,6	61,9	69,6	70,0	73,9	78,1	82,4	0,7	0,5	0,5	0,5	0,5	0,5
GDP per capita (thousands of 2015 USD/person)	2,50	3,52	6,62	6,18	7,87	10,22	13,26	3,4	-6,5	2,4	2,6	2,6	2,3
Primary energy consumption per capita (toe/person)	0,74	1,17	1,91	1,64	1,57	1,67	1,92	3,3	-14,2	-0,4	0,6	1,4	0,0
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	296	332	289	265	199	164	145	-0,1	-8,2	-2,8	-2,0	-1,2	-2,2
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	204	232	204	192	151	121	105	0,0	-6,0	-2,4	-2,2	-1,4	-2,1
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	253	212	127	117	81	60	54	-2,4	-7,9	-3,6	-3,0	-1,1	-2,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,86	0,64	0,44	0,44	0,41	0,37	0,37	-2,3	0,4	-0,8	-1,0	0,1	-0,5
Automobile ownership volume (millions of vehicles)	7,52	20,75	40,71	42,30	62,02	90,92	133,29	6,0	3,9	3,9	3,9	8,0	3,9
Automobile ownership volume per capita (vehicles per person)	0,133	0,335	0,585	0,604	0,839	1,165	1,617	5,2	3,3	3,3	3,3	6,8	3,3

Thailand LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**41,94**	**72,27**	**133,10**	**123,86**	**139,44**	**175,78**	**211,17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,1**	**-6,9**	**1,2**	**2,3**	**1,9**	**1,5**
Coal	3,82	7,67	18,50	15,09	16,96	21,60	21,71	9,1	10,6	13,9	12,2	12,2	12,3	10,3	5,6	-18,4	1,2	2,4	0,1	0,5
Oil	17,96	31,88	40,97	39,73	34,20	29,50	25,27	42,8	44,1	30,8	32,1	24,5	16,8	12,0	2,9	-3,0	-1,5	-1,5	-1,5	-1,5
Natural gas	4,99	17,36	39,59	37,81	45,39	56,32	41,25	11,9	24,0	29,7	30,5	32,6	32,0	19,5	7,4	-4,5	1,8	2,2	-3,1	0,1
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	-	-	-	-	-	-
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	1,76	3,34	45,27	0,0	0,0	0,0	0,1	1,3	1,9	21,4	-	-	31,7	6,6	29,8	-
Hydro	0,43	0,52	1,75	1,81	2,48	2,58	2,58	1,0	0,7	1,3	1,5	1,8	1,5	1,2	5,0	3,6	3,2	0,4	0,0	1,3
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	-	-	-	-	-	-
Others	14,74	14,83	32,28	29,30	38,64	62,43	75,10	35,1	20,5	24,3	23,7	27,7	35,5	35,6	2,7	-9,2	2,8	4,9	1,9	2,8
Biomass	14,69	14,59	21,60	19,43	19,53	30,64	31,27	35,0	20,2	16,2	15,7	14,0	17,4	14,8	1,3	-10,1	0,1	4,6	0,2	1,2
Solar, Wind, Ocean	0,00	0,00	0,96	1,68	5,77	10,84	13,54	0,0	0,0	0,7	1,4	4,1	6,2	6,4	-	74,8	13,1	6,5	2,3	8,9
Biofuels	0,00	0,00	2,36	2,04	3,41	4,90	6,41	0,0	0,0	1,8	1,7	2,4	2,8	3,0	-	-13,4	5,3	3,7	2,7	3,3
Electricity	0,05	0,24	7,35	6,15	9,94	16,06	23,88	0,1	0,3	5,5	5,0	7,1	9,1	11,3	18,5	-16,4	4,9	4,9	4,0	3,9

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**28,87**	**50,57**	**93,90**	**90,31**	**103,66**	**122,22**	**146,71**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-3,8**	**1,4**	**1,7**	**1,8**	**1,4**
Industry	8,65	16,72	28,73	26,99	35,04	43,74	52,70	30,0	33,1	30,6	29,9	33,8	35,8	35,9	4,2	-6,1	2,6	2,2	1,9	2,0
Transportation	9,01	14,61	28,36	26,31	25,77	29,66	39,14	31,2	28,9	30,2	29,1	24,9	24,3	26,7	4,0	-7,2	-0,2	1,4	2,8	1,0
Others	10,78	13,62	21,15	21,46	25,55	29,67	33,78	37,3	26,9	22,5	23,8	24,7	24,3	23,0	2,4	1,5	1,8	1,5	1,3	1,5
Non-energy	0,43	5,63	15,66	15,55	17,29	19,16	21,10	1,5	11,1	16,7	17,2	16,7	15,7	14,4	13,2	-0,7	1,1	1,0	1,0	1,0
Total	**28,87**	**50,57**	**93,90**	**90,31**	**103,66**	**122,22**	**146,71**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,2**	**-3,8**	**1,4**	**1,7**	**1,8**	**1,4**
Coal	1,31	3,54	7,06	6,43	9,34	12,45	15,60	4,5	7,0	7,5	7,1	9,0	10,2	10,6	6,0	-9,0	3,8	2,9	2,3	2,6
Oil	14,93	28,77	40,71	39,25	33,92	29,13	24,85	51,7	56,9	43,4	43,5	32,7	23,8	16,9	3,5	-3,6	-1,4	-1,5	-1,6	-1,6
Natural gas	0,14	1,11	7,48	6,48	8,68	11,25	13,75	0,5	2,2	8,0	7,2	8,4	9,2	9,4	14,8	-13,4	3,0	2,6	2,0	2,0
Hydrogen/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	3,30	7,56	22,65	22,21	31,80	45,33	64,33	11,4	15,0	24,1	24,6	30,7	37,1	43,8	6,9	-1,9	3,7	3,6	3,6	3,4
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	9,20	9,59	15,99	15,94	19,94	24,05	28,18	31,9	19,0	17,0	17,7	19,2	19,7	19,2	1,9	-0,3	2,3	1,9	1,6	1,8

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**44,18**	**95,98**	**201,79**	**210,14**	**287,45**	**389,65**	**544,21**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,4**	**4,1**	**3,2**	**3,1**	**3,4**	**3,3**
Coal PP	11,05	17,77	45,22	34,23	15,45	9,58	0,00	25,0	18,5	22,4	16,3	5,4	2,5	0,0	5,0	-24,3	-7,6	-4,7	-100,0	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	15,45	28,75	26,52	0,0	0,0	0,0	0,0	5,4	7,4	4,9	-	-	-	6,4	-0,8	-
Oil	10,38	10,03	0,36	1,37	0,47	0,86	1,08	23,5	10,4	0,2	0,7	0,2	0,2	0,2	-11,0	281,1	-10,2	6,4	2,3	3,6
Gas PP	17,77	61,64	121,38	131,27	90,61	53,46	0,00	40,2	64,2	60,2	62,5	31,5	13,7	0,0	6,9	8,1	-3,6	-5,1	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	90,61	160,39	144,17	0,0	0,0	0,0	0,0	31,5	41,2	26,5	-	-	-	5,9	-1,1	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,63	9,84	18,65	252,34	0,0	0,0	0,0	0,3	3,4	4,8	46,4	-	-	31,7	6,6	29,8	-
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	-	-	-	-	-	-
Solar	0,00	0,00	6,44	7,12	15,22	41,49	42,65	0,0	0,0	3,2	3,4	5,3	10,6	7,8	-	10,6	7,9	10,5	0,3	6,3
Wind	0,00	0,00	2,25	3,50	6,40	8,45	8,68	0,0	0,0	1,1	1,7	2,2	2,2	1,6	-	55,6	6,2	2,8	0,3	4,4
Hydro	4,98	6,03	20,35	21,08	28,82	30,00	30,00	11,3	6,3	10,1	10,0	10,0	7,7	5,5	5,0	3,6	3,2	0,4	0,0	1,3
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	-	-	-	-	-	-
Others	0,00	0,51	5,79	10,96	14,58	38,02	38,77	0,0	0,5	2,9	5,2	5,1	9,8	7,1	-	89,2	2,9	10,1	0,2	6,3

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,92**	**19,24**	**33,29**	**32,54**	**40,74**	**48,29**	**74,83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,6**	**-2,3**	**2,3**	**1,7**	**4,5**	**2,6**
Coal	2,55	4,16	11,44	8,66	7,63	9,15	6,11	28,6	21,6	34,4	26,6	18,7	18,9	8,2	5,3	-24,3	-1,3	1,8	-4,0	-2,0
Oil	2,55	2,34	0,08	0,30	0,10	0,19	0,23	28,6	12,2	0,2	0,9	0,3	0,4	0,3	-11,3	283,5	-10,3	6,4	2,2	3,6
Gas	3,82	12,73	21,77	23,46	31,24	35,61	23,22	42,9	66,2	65,4	72,1	76,7	73,7	31,0	6,2	7,8	2,9	1,3	-4,2	0,2
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	1,76	3,35	45,27	0,0	0,0	0,0	0,3	4,3	6,9	60,5	-	-	31,7	6,6	29,8	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,8**	**40,0**	**43,1**	**44,3**	**47,0**	**48,4**	**48,7**								**0,5**	**2,6**	**0,6**	**0,3**	**0,1**	**0,4**
Coal	37,31	36,72	34,00	33,98	34,85	36,03	37,31								-0,3	-0,1	0,3	0,3	0,3	0,3
Oil	35,00	36,82	39,08	38,83	39,21	39,18	39,58								0,4	-0,6	0,1	0,0	0,1	0,0
Gas	39,97	41,64	47,94	48,12	49,88	51,65	53,41								0,6	0,4	0,4	0,3	0,3	0,3
Hydrogen/Ammonia	-	-	-	47,99	47,95	47,94	47,94								-	-	0,0	0,0	0,0	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,9**	**46,2**	**58,4**	**53,6**	**39,2**	**28,6**	**13,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,7**	**-8,1**	**-3,1**	**-3,1**	**-7,3**	**-4,6**
Coal	10,2	12,6	13,1	9,6	5,4	4,0	1,1	28,5	27,3	22,5	18,0	13,7	14,0	7,9	0,9	-26,7	-5,7	-2,9	-12,4	-7,8
Oil	12,2	19,5	28,0	27,0	20,3	14,8	9,5	34,0	42,2	47,9	50,3	51,6	51,6	70,4	2,9	-3,5	-2,8	-3,1	-4,3	-3,4
Natural gas	13,5	14,1	17,3	17,0	13,6	9,9	2,9	37,5	30,5	29,6	31,7	34,7	34,5	21,7	0,9	-1,4	-2,2	-3,2	-11,5	-5,6

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	141,6	217,7	460,8	432,9	581,9	797,3	1.092,5	4,2	-6,0	3,0	3,2	3,2	2,8
Population (millions of people)	56,6	61,9	69,6	70,0	73,9	78,1	82,4	0,7	0,5	0,5	0,5	0,5	0,5
GDP per capita (thousands of 2015 USD/person)	2,50	3,52	6,62	6,18	7,87	10,22	13,26	3,4	-6,5	2,4	2,6	2,6	2,3
Primary energy consumption per capita (toe/person)	0,74	1,17	1,91	1,77	1,89	2,25	2,56	3,3	-7,4	0,6	1,8	1,3	0,9
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	296	332	289	286	240	220	193	-0,1	-1,0	-1,8	-0,8	-1,3	-1,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	204	232	204	209	178	153	134	0,0	2,4	-1,6	-1,5	-1,3	-1,3
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	253	212	127	124	67	36	12	-2,4	-2,2	-5,9	-6,1	-10,2	-7,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,86	0,64	0,44	0,43	0,28	0,16	0,06	-2,3	-1,3	-4,2	-5,3	-9,0	-6,0
Automobile ownership volume (millions of vehicles)	7,52	20,75	40,71	42,30	62,02	90,92	133,29	6,0	3,9	3,9	3,9	8,0	3,9
Automobile ownership volume per capita (vehicles per person)	0,133	0,335	0,585	0,604	0,839	1,165	1,617	5,2	3,3	3,3	3,3	6,8	3,3

Viet Nam BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**17,9**	**28,7**	**91,42**	**92,79**	**160,76**	**231,28**	**307,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**1,5**	**5,7**	**3,7**	**2,9**	**4,0**
Coal	2,2	4,4	49,54	52,60	87,73	129,43	174,45	12,4	15,2	54,2	56,7	54,6	56,0	56,7	11,3	6,2	5,2	4,0	3,0	4,1
Oil	2,7	7,8	21,85	21,83	38,54	59,96	85,24	15,2	27,2	23,9	23,5	24,0	25,9	27,7	7,5	-0,1	5,8	4,5	3,6	4,5
Natural gas	0,0	1,1	8,12	6,57	23,82	32,58	37,55	0,0	3,9	8,9	7,1	14,8	14,1	12,2	31,3	-19,1	13,7	3,2	1,4	5,1
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,5	1,3	5,98	5,68	7,09	7,05	8,24	2,6	4,4	6,5	6,1	4,4	3,0	2,7	9,2	-5,1	2,2	-0,1	1,6	1,0
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	12,5	14,2	5,93	6,1	3,6	2,3	1,94	69,8	49,4	6,5	6,6	2,2	1,0	0,6	-2,5	3,1	-5,2	-4,5	-1,5	-3,5
Biomass	12,5	14,2	5,32	5,1	2,6	1,3	0,89	69,8	49,4	5,8	6	1,6	0,6	0,3	-2,9	-3,6	-6,5	-6,8	-3,8	-5,6
Solar, Wind, Ocean			0,48	0,59	0,51	0,51	0,59	0,0	0,0	0,5	0,6	0,3	0,2	0,2	-	22,8	-1,4	-0,1	1,6	0,7
Biofuels			0,04	0,04	0,05	0,05	0,05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	2,9	2,5	0,5	0,3	1,1
Electricity			0,10	0,37	0,41	0,41	0,41	0,0	0,0	0,1	0,4	0,3	0,2	0,1	-	264,8	1,0	0,0	0,0	4,6

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**16,1**	**25,1**	**61,27**	**62,32**	**105,74**	**147,97**	**196,57**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,7**	**5,4**	**3,4**	**2,9**	**3,8**
Industry	4,5	7,9	33,07	35,02	57,75	73,22	90,11	28,3	31,3	54,0	56,2	54,6	49,5	45,8	7,1	5,9	5,1	2,4	2,1	3,3
Transportation	1,4	3,5	14,04	13,43	25,72	42,14	61,43	8,6	13,9	22,9	21,6	24,3	28,5	31,3	8,3	-4,3	6,7	5,1	3,8	4,9
Others	10,1	13,6	12,93	12,63	20,52	30,35	42,18	63,0	54,2	21,1	20,3	19,4	20,5	21,5	0,9	-2,4	5,0	4,0	3,3	3,9
Non-energy	0,0	0,1	1,23	1,24	1,74	2,26	2,85	0,2	0,5	2,0	2,0	1,6	1,5	1,4	13,9	1,5	3,4	2,6	2,3	2,8
Total	**16,1**	**25,1**	**61,3**	**62,3**	**105,7**	**148,0**	**196,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,7**	**5,4**	**3,4**	**2,9**	**3,8**
Coal	1,3	3,2	16,37	17,18	30,22	36,22	42,57	8,3	12,8	26,7	27,6	28,6	24,5	21,7	9,0	5,0	5,8	1,8	1,6	3,1
Oil	2,3	6,5	21,27	21,72	38,33	59,64	84,78	14,5	26,0	34,7	34,9	36,3	40,3	43,1	7,9	2,2	5,8	4,5	3,6	4,6
Natural gas	0,0	0,0	0,55	0,57	1,20	1,82	2,44	0,0	0,1	0,9	0,9	1,1	1,2	1,2	-	5,4	7,6	4,3	3,0	5,0
Electricity	0,5	1,9	17,99	17,96	33,58	49,20	66,13	3,3	7,7	29,4	28,8	31,8	33,2	33,6	12,9	-0,1	6,5	3,9	3,0	4,3
Heat	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	11,9	13,4	5,10	4,88	2,41	1,10	0,64	73,9	53,4	8,3	7,8	2,3	0,7	0,3	-2,9	-4,5	-6,8	-7,6	-5,2	-6,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,7**	**26,6**	**236,88**	**233,32**	**437,40**	**639,51**	**856,73**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,1**	**-1,5**	**6,5**	**3,9**	**3,0**	**4,2**
Coal	2,0	3,1	120,16	128,82	217,50	365,96	536,80	23,1	11,8	50,7	55,2	49,7	57,2	62,7	15,2	7,2	5,4	5,3	3,9	4,9
Oil	1,3	4,5	2,10	0,00	0,00	0,00	0,00	15,0	17,0	0,9	0,0	0,0	0,0	0,0	1,7	-100,0	-	-	-	-100,0
Natural gas	0,0	4,4	42,61	33,94	134,71	188,90	220,93	0,1	16,4	18,0	14,5	30,8	29,5	25,8	35,8	-20,3	14,8	3,4	1,6	5,5
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	5,4	14,6	57,56	52,24	69,21	68,77	80,43	61,8	54,8	24,3	22,4	15,8	10,8	9,4	8,5	-9,2	2,9	-0,1	1,6	1,1
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	14,45	18,32	15,98	15,88	18,57	0,0	0,0	6,1	7,9	3,7	2,5	2,2	-	26,8	-1,4	-0,1	1,6	0,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,3**	**3,6**	**40,9**	**41,1**	**79,7**	**123,5**	**166,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,7**	**0,6**	**6,8**	**4,5**	**3,0**	**4,6**
Coal	0,9	1,2	33,17	35,42	57,52	93,21	131,88	69,8	32,3	81,1	86,1	72,2	75,5	79,2	13,3	6,8	5,0	4,9	3,5	4,6
Oil	0,4	1,3	0,51	0,00	0,00	0,00	0,00	30,0	36,8	1,2	0,0	0,0	0,0	0,0	1,0	-100,0	-	-	-	-100,0
Natural gas	0,0	1,1	7,22	5,73	22,15	30,28	34,54	0,2	30,9	17,7	13,9	27,8	24,5	20,8	30,8	-20,6	14,5	3,2	1,3	5,2

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**22,4**	**29,0**	**34,7**	**34,0**	**38,0**	**38,6**	**39,2**								**1,5**	**-1,9**	**1,1**	**0,2**	**0,1**	**0,4**
Coal	19,4	23,5	31,2	31,3	32,5	33,8	35,0								1,7	0,4	0,4	0,4	0,4	0,4
Oil	29,4	29,7	35,6	-	-	-	-								0,7	-	-	-	-	-
Natural gas	17,2	34,1	50,8	50,9	52,3	53,7	55,0								3,8	0,4	0,3	0,3	0,2	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,7**	**12,0**	**78,5**	**81,1**	**146,1**	**216,0**	**290,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**10,2**	**3,3**	**6,1**	**4,0**	**3,0**	**4,3**
Coal	2,5	4,7	55,3	58,5	97,4	142,9	191,8	53,2	39,2	70,4	72,1	66,7	66,2	66,0	11,3	5,8	5,2	3,9	3,0	4,1
Oil	2,2	6,4	18,0	18,4	33,4	52,2	74,7	46,8	53,3	23,0	22,7	22,9	24,2	25,7	7,5	2,0	6,2	4,6	3,6	4,7
Natural gas	0,0	0,9	5,2	4,2	15,3	20,9	24,1	0,0	7,5	6,6	5,2	10,4	9,7	8,3	-	-19,1	13,7	3,2	1,4	5,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	29,5	61,1	162,19	166,90	306,02	510,45	773,93	6,1	2,9	6,2	5,2	4,2	5,2
Population (millions of people)	66,0	77,6	96,5	97,1	103,1	107,0	108,9	1,3	0,6	0,6	0,4	0,2	0,4
GDP per capita (thousands of 2015 USD/person)	0,45	0,79	1,68	1,72	3,0	4,8	7,1	4,7	2,3	5,6	4,9	4,1	4,8
Primary energy consumption per capita (toe/person)	0,27	0,37	0,95	0,96	1,56	2,16	2,82	4,4	0,9	5,0	3,3	2,7	3,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	606	470	564	556	525	453	397	-0,3	-1,4	-0,6	-1,5	-1,3	-1,1
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	545	410	378	373	346	290	254	-1,3	-1,2	-0,8	-1,7	-1,3	-1,3
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	160	196	484	486	478	423	375	3,9	0,4	-0,2	-1,2	-1,2	-0,8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,26	0,42	0,86	0,87	0,91	0,93	0,95	4,2	1,8	0,4	0,3	0,1	0,3
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

Viet Nam APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**17,9**	**28,7**	**91,4**	**92,42**	**135,70**	**168,64**	**198,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**1,1**	**3,9**	**2,2**	**1,6**	**2,5**
Coal	2,2	4,4	49,54	50,24	56,79	52,30	41,25	12,4	15,2	54,2	54,4	41,8	31,0	20,8	11,3	1,4	1,2	-0,8	-2,3	-0,6
Oil	2,7	7,8	21,85	21,68	35,47	53,49	73,18	15,2	27,2	23,9	23,5	26,1	31,7	36,9	7,5	-0,8	5,0	4,2	3,2	4,0
Natural gas	0,0	1,1	8,12	6,47	21,41	26,06	27,12	0,0	3,9	8,9	7,0	15,8	15,5	13,7	31,3	-20,3	12,7	2,0	0,4	4,0
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,5	1,3	5,98	5,87	7,74	7,01	7,58	2,6	4,4	6,5	6,4	5,7	4,2	3,8	9,2	-1,9	2,8	-1,0	0,8	0,8
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	12,5	14,2	5,93	8,15	14,29	29,78	49,30	69,8	49,4	6,5	8,8	10,5	17,7	24,8	-2,5	37,4	5,8	7,6	5,2	7,1
Biomass	12,5	14,2	5,32	6,99	9,96	14,32	19,60	69,8	49,4	5,8	7,6	7,3	8,5	9,9	-2,9	31,4	3,6	3,7	3,2	4,3
Solar, Wind, Ocean			0,48	0,76	3,87	15,00	29,24	0,0	0,0	0,5	0,8	2,9	8,9	14,7	-	58,6	17,7	14,5	6,9	14,2
Biofuels			0,04	0,04	0,05	0,05	0,05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	2,9	2,5	0,5	0,3	1,1
Electricity			0,10	0,37	0,41	0,41	0,41	0,0	0,0	0,1	0,4	0,3	0,2	0,2	-	264,8	1,0	0,0	0,0	4,6

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**16,1**	**25,1**	**61,3**	**61,9**	**95,8**	**127,6**	**160,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,0**	**4,5**	**2,9**	**2,3**	**3,2**
Industry	4,5	7,9	33,07	34,78	52,32	62,33	71,87	28,3	31,3	54,0	56,2	54,6	48,8	44,7	7,1	5,2	4,2	1,8	1,4	2,5
Transportation	1,4	3,5	14,04	13,37	24,30	38,74	54,54	8,6	13,9	22,9	21,6	25,4	30,4	33,9	8,3	-4,7	6,2	4,8	3,5	4,5
Others	10,1	13,6	12,93	12,46	17,47	24,30	31,65	63,0	54,2	21,1	20,1	18,2	19,0	19,7	0,9	-3,6	3,4	3,4	2,7	2,9
Non-energy	0,0	0,1	1,23	1,24	1,74	2,26	2,85	0,2	0,5	2,0	2,0	1,8	1,8	1,8	13,9	1,5	3,4	2,6	2,3	2,8
Total	**16,1**	**25,1**	**61,268**	**61,863**	**95,836**	**127,634**	**160,912**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,0**	**4,5**	**2,9**	**2,3**	**3,2**
Coal	1,3	3,2	16,37	17,10	28,15	32,03	35,55	8,3	12,8	26,7	27,6	29,4	25,1	22,1	9,0	4,5	5,1	1,3	1,1	2,5
Oil	2,3	6,5	21,27	21,58	35,27	53,18	72,75	14,5	26,0	34,7	34,9	36,8	41,7	45,2	7,9	1,5	5,0	4,2	3,2	4,0
Natural gas	0,0	0,0	0,55	0,57	1,02	1,46	1,83	0,0	0,1	0,9	0,9	1,1	1,1	1,1	-	4,0	6,0	3,7	2,3	4,0
Electricity	0,5	1,9	17,99	17,75	28,98	39,87	50,13	3,3	7,7	29,4	28,7	30,2	31,2	31,2	12,9	-1,3	5,0	3,2	2,3	3,4
Heat	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	11,9	13,4	5,10	4,88	2,41	1,10	0,64	73,9	53,4	8,3	7,9	2,5	0,9	0,4	-2,9	-4,5	-6,8	-7,6	-5,2	-6,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,7**	**26,6**	**236,9**	**230,49**	**376,81**	**517,36**	**648,34**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,1**	**-2,7**	**5,0**	**3,2**	**2,3**	**3,3**
Coal	2,0	3,1	120,16	121,16	115,79	90,16	31,73	23,1	11,8	50,7	52,6	30,7	17,4	4,9	15,2	0,8	-0,5	-2,5	-9,9	-4,2
Oil	1,3	4,5	2,10	0,00	0,00	0,00	0,00	15,0	17,0	0,9	0,0	0,0	0,0	0,0	1,7	-100,0	-	-	-	-100,0
Natural gas	0,0	4,4	42,61	33,53	125,60	160,60	173,57	0,1	16,4	18,0	14,5	33,3	31,0	26,8	35,8	-21,3	14,1	2,5	0,8	4,6
Nuclear	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	5,4	14,6	57,56	51,61	64,52	58,47	63,19	61,8	54,8	24,3	22,4	17,1	11,3	9,7	8,5	-10,3	2,3	-1,0	0,8	0,3
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	14,45	24,19	70,90	208,12	379,86	0,0	0,0	6,1	10,5	18,8	40,2	58,6	-	67,4	11,4	11,4	6,2	11,1

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,3**	**3,6**	**40,9**	**38,8**	**48,6**	**44,5**	**30,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,7**	**-5,1**	**2,3**	**-0,9**	**-3,7**	**-0,9**
Coal	0,9	1,2	33,2	33,1	28,6	20,3	5,7	69,8	32,3	81,1	85,5	58,9	45,6	18,6	13,3	-0,1	-1,5	-3,4	-11,9	-5,5
Oil	0,4	1,3	0,5	0,0	0,0	0,0	0,0	30,0	36,8	1,2	0,0	0,0	0,0	0,0	1,0	-100,0	-	-	-	-100,0
Natural gas	0,0	1,1	7,2	5,6	20,0	24,2	24,9	0,2	30,9	17,7	14,5	41,1	54,4	81,4	30,8	-21,8	13,5	1,9	0,3	4,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**22,4**	**29,0**	**34,7**	**34,3**	**42,7**	**48,5**	**57,8**								**1,5**	**-1,1**	**2,2**	**1,3**	**1,8**	**1,7**
Coal	19,4	23,5	31,2	31,4	34,8	38,2	47,9								1,7	0,9	1,0	1,0	2,3	1,4
Oil	29,4	29,7	35,6	-	-	-	-								0,7	-	-	-	-	-
Natural gas	17,2	34,1	50,8	51,1	54,1	57,0	60,0								3,8	0,7	0,6	0,5	0,5	0,5

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,7**	**12,0**	**78,5**	**78,3**	**108,2**	**122,3**	**128,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**10,2**	**-0,2**	**3,3**	**1,2**	**0,5**	**1,6**
Coal	2,5	4,7	55,3	55,9	63,6	58,9	46,9	53,2	39,2	70,4	71,4	58,8	48,1	36,4	11,3	1,1	1,3	-0,8	-2,2	-0,5
Oil	2,2	6,4	18,0	18,3	30,8	46,8	64,4	46,8	53,3	23,0	23,3	28,5	38,2	50,1	7,5	1,4	5,4	4,3	3,3	4,2
Natural gas	0,0	0,9	5,2	4,1	13,7	16,7	17,4	0,0	7,5	6,6	5,3	12,7	13,6	13,5	-	-20,4	12,7	2,0	0,4	4,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	29,5	61,1	162,19	166,90	306,02	510,45	773,93	6,1	2,9	6,2	5,2	4,2	5,2
Population (millions of people)	66,0	77,6	96,5	97,1	103,1	107,0	108,9	1,3	0,6	0,6	0,4	0,2	0,4
GDP per capita (thousands of 2015 USD/person)	0,45	0,79	1,68	1,72	3,0	4,8	7,1	4,7	2,3	5,6	4,9	4,1	4,8
Primary energy consumption per capita (toe/person)	0,27	0,37	0,95	0,95	1,32	1,58	1,82	4,4	0,5	3,3	1,8	1,5	2,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	606	470	564	554	443	330	256	-0,3	-1,8	-2,2	-2,9	-2,5	-2,5
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	545	410	378	371	313	250	208	-1,3	-1,9	-1,7	-2,2	-1,8	-1,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	160	196	484	469	353	240	166	3,9	-3,1	-2,8	-3,8	-3,6	-3,4
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,26	0,42	0,86	0,85	0,80	0,73	0,65	4,2	-1,3	-0,6	-0,9	-1,1	-0,9
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

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Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**17,9**	**14,5**	**91,421**	**92,415**	**135,592**	**165,327**	**194,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,8**	**1,1**	**3,9**	**2,0**	**1,6**	**2,5**
Coal	2,2	4,4	49,54	50,24	60,88	58,10	45,35	12,4	30,1	54,2	54,4	44,9	35,1	23,3	11,3	1,4	1,9	-0,5	-2,4	-0,3
Oil	2,7	7,8	21,85	21,68	33,29	35,09	15,88	15,2	53,7	23,9	23,5	24,6	21,2	8,2	7,5	-0,8	4,4	0,5	-7,6	-1,0
Natural gas	0,0	1,1	8,12	6,47	20,38	30,14	51,75	0,0	7,7	8,9	7,0	15,0	18,2	26,6	31,3	-20,3	12,2	4,0	5,6	6,2
Nuclear	0,0	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/Ammonia	0,0	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	0,5	1,3	5,98	5,87	7,34	8,04	11,31	2,6	8,6	6,5	6,4	5,4	4,9	5,8	9,2	-1,9	2,3	0,9	3,5	2,1
Geothermal	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	12,5	14,2	5,93	8,15	13,70	33,95	70,38	69,8	97,5	6,5	8,8	10,1	20,5	36,2	-2,5	37,4	5,3	9,5	7,6	8,3
Biomass	12,5		5,32	6,99	9,58	16,28	27,90	69,8	0,0	5,8	7,6	7,1	9,8	14,3	-2,9	31,4	3,2	5,5	5,5	5,5
Solar, Wind, Ocean			0,48	0,76	3,67	17,21	42,02	0,0	0,0	0,5	0,8	2,7	10,4	21,6	-	58,6	17,1	16,7	9,3	15,5
Biofuels			0,04	0,04	0,05	0,05	0,05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	2,9	2,5	0,5	0,3	1,1
Electricity			0,10	0,37	0,41	0,41	0,41	0,0	0,0	0,1	0,4	0,3	0,2	0,2	-	264,8	1,0	0,0	0,0	4,6

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**16,1**	**25,1**	**61,3**	**61,863**	**94,051**	**114,001**	**121,9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,0**	**4,3**	**1,9**	**0,7**	**2,2**
Industry	4,5	7,9	33,07	34,78	52,32	60,63	66,55	28,3	31,3	54,0	56,2	55,6	53,2	54,6	7,1	5,2	4,2	1,5	0,9	2,3
Transportation	1,4	3,5	14,04	13,37	22,52	26,81	20,86	8,6	13,9	22,9	21,6	23,9	23,5	17,1	8,3	-4,7	5,3	1,8	-2,5	1,3
Others	10,1	13,6	12,93	12,46	17,47	24,30	31,65	63,0	54,2	21,1	20,1	18,6	21,3	26,0	0,9	-3,6	3,4	3,4	2,7	2,9
Non-energy	0,0	0,1	1,23	1,24	1,74	2,26	2,85	0,2	0,5	2,0	2,0	1,9	2,0	2,3	13,9	1,5	3,4	2,6	2,3	2,8
Total	**16,1**	**25,1**	**61,3**	**61,863**	**94,051**	**114,001**	**121,913**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,7**	**1,0**	**4,3**	**1,9**	**0,7**	**2,2**
Coal	1,3	3,2	16,37	17,10	28,15	29,25	26,29	8,3	12,8	26,7	27,6	29,9	25,7	21,6	9,0	4,5	5,1	0,4	-1,1	1,5
Oil	2,3	6,5	21,27	21,58	33,13	34,91	15,80	14,5	26,0	34,7	34,9	35,2	30,6	13,0	7,9	1,5	4,4	0,5	-7,6	-1,0
Natural gas	0,0	0,0	0,55	0,57	1,02	1,46	1,83	0,0	0,1	0,9	0,9	1,1	1,3	1,5	-	4,0	6,0	3,7	2,3	4,0
Hydrogen/Ammonia	0,0	0,0	0,00	0,00	0,00	5,54	22,93	0,0	7,7	0,0	0,0	0,0	4,9	18,8		-	-	-	15,3	-
Electricity	0,5	1,9	17,99	17,75	29,34	41,74	54,42	3,3	0,0	29,4	28,7	31,2	36,6	44,6	12,9	-1,3	5,2	3,6	2,7	3,6
Heat	0,0	0,0	0,00	0,00	0,00	0,00	0,00	0,0	53,4	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	11,9	13,4	5,10	4,88	2,41	1,10	0,64	73,9	0,0	8,3	7,9	2,6	1,0	0,5	-2,9	-4,5	-6,8	-7,6	-5,2	-6,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**8,7**	**26,6**	**236,88**	**230,49**	**381,58**	**620,67**	**1.017,92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,1**	**-2,7**	**5,2**	**5,0**	**5,1**	**4,8**
Coal PP	2,0	3,1	120,16	110,01	79,39	70,05	0,37	23,1	0,0	50,7	47,7	20,8	11,3	0,0	15,2	-8,4	-3,2	-1,2	-40,8	-17,0
Coal PP with CCS			0,00	11,15	54,46	59,94	84,78	0,0	0,0	0,0	4,8	14,3	9,7	8,3	-	-	17,2	1,0	3,5	-
Oil	1,3	4,5	2,10	0,00	0,00	0,00	0,04	15,0	0,0	0,9	0,0	0,0	0,0	0,0	1,7	-100,0	-	-	-	-12,1
Gas PP	0,0	4,4	0,11	0,00	0,00	0,00	0,05	0,1	0,0	0,0	0,0	0,0	0,0	0,0	10,4	-100,0	-	-	-	-2,3
Gas PP PP with CCS			42,51	33,53	119,20	184,79	292,13	0,0	0,0	17,9	14,5	31,2	29,8	28,7	-	-21,1	13,5	4,5	4,7	6,4
Hydrogen/Ammonia PP	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	-	-	-	-	-	-
Solar	0,0	0,0	4,82	7,73	13,96	60,57	161,14	0,0	0,0	2,0	3,4	3,7	9,8	15,8	-	60,3	6,1	15,8	10,3	12,0
Wind	0,0	0,0	0,72	1,06	28,74	139,62	327,52	0,0	0,0	0,3	0,5	7,5	22,5	32,2	-	47,2	39,1	17,1	8,9	21,8
Hydro	5,4	14,6	66,12	64,85	81,12	88,87	124,25	61,8	0,0	27,9	28,1	21,3	14,3	12,2	9,0	-1,9	2,3	0,9	3,4	2,1
Geothermal	0,0	0,0						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,0	0,0	0,35	2,16	4,71	16,84	27,65	0,0	0,0	0,1	0,9	1,2	2,7	2,7	-	515,8	8,1	13,6	5,1	15,1

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1,3**	**3,6**	**40,9**	**38,8**	**51,7**	**57,1**	**68,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12,7**	**-5,1**	**2,9**	**1,0**	**1,8**	**1,7**
Coal	0,9	1,2	33,17	33,15	32,73	28,85	19,065	69,8	32,3	81,1	85,5	63,3	50,5	27,9	13,3	-0,1	-0,1	-1,3	-4,1	-1,8
Oil	0,4	1,3	0,51	0,00	0,00	0,00	0,01	30,0	36,8	1,2	0,0	0,0	0,0	0,0	1,0	-100,0	-	-	-	-12,0
Gas	0,0	1,1	7,22	5,64	18,96	28,24	49,264	0,2	30,9	17,7	14,5	36,7	49,5	72,1	30,8	-21,8	12,9	4,1	5,7	6,4
Hydrogen/Ammonia	0,0	0,0	0,00					0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**22,4**	**29,0**	**34,7**	**34,3**	**42,1**	**47,4**	**47,5**								**1,5**	**-1,1**	**2,1**	**1,2**	**0,0**	**1,0**
Coal	19,38	23,48	31,16	31,44	35,17	38,75	38,41								1,7	0,9	1,1	1,0	-0,1	0,7
Oil	29,38	29,67	35,65	-	-	-	35,01								0,7	-	-	-	-	-0,1
Gas	17,20	34,09	50,76	51,11	54,07	56,26	51,01								3,8	0,7	0,6	0,4	-1,0	0,0
Hydrogen/Ammonia	-	-	-	-	-	-	-								-	-	-	-	-	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**4,7**	**12,0**	**78,53**	**78,3**	**109,6**	**104,8**	**20,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**10,2**	**-0,2**	**3,4**	**-0,5**	**-15,0**	**-4,2**
Coal	2,5	4,7	55,28	55,90	68,00	57,49	5,44	53,2	39,2	70,4	71,4	62,0	54,9	26,5	11,3	1,1	2,0	-1,7	-21,0	-7,2
Oil	2,2	6,4	18,04	18,29	28,58	29,79	11,40	46,8	53,3	23,0	23,3	26,1	28,4	55,5	7,5	1,4	4,6	0,4	-9,2	-1,5
Natural gas	0,0	0,9	5,21	4,15	13,06	17,52	3,71	0,0	7,5	6,6	5,3	11,9	16,7	18,0	-	-20,4	12,2	3,0	-14,4	-1,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	29,5	61,1	162,19	166,90	306,02	510,45	773,93	6,1	2,9	6,2	5,2	4,2	5,2
Population (millions of people)	66,0	77,6	96,5	97,1	103,1	107,0	108,9	1,3	0,6	0,6	0,4	0,2	0,4
GDP per capita (thousands of 2015 USD/person)	0,45	0,79	1,68	1,72	3,0	4,8	7,1	4,7	2,3	5,6	4,9	4,1	4,8
Primary energy consumption per capita (toe/person)	0,27	0,19	0,95	0,95	1,31	1,55	1,79	4,4	0,5	3,3	1,6	1,5	2,1
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	606	238	564	554	443	324	252	-0,3	-1,8	-2,2	-3,1	-2,5	-2,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	545	410	378	371	307	223	158	-1,3	-1,9	-1,9	-3,1	-3,4	-2,8
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	160	196	484	469	358	205	27	3,9	-3,1	-2,7	-5,4	-18,5	-8,9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,26	0,82	0,86	0,85	0,81	0,63	0,11	4,2	-1,3	-0,5	-2,4	-16,4	-6,5
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

United States BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.914,47**	**2.272,86**	**2.212,75**	**2.077,50**	**2.168,26**	**2.129,65**	**2.082,97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-6,1**	**0,4**	**-0,2**	**-0,2**	**-0,2**
Coal	459,57	533,02	274,92	249,16	224,35	198,58	165,16	24,0	23,5	12,4	12,0	10,3	9,3	7,9	-1,8	-9,4	-1,0	-1,2	-1,8	-1,6
Oil	756,84	871,15	792,88	702,70	745,50	685,37	631,39	39,5	38,3	35,8	33,8	34,4	32,2	30,3	0,2	-11,4	0,6	-0,8	-0,8	-0,7
Natural gas	438,36	547,74	742,30	715,81	788,38	790,27	766,51	22,9	24,1	33,5	34,5	36,4	37,1	36,8	1,8	-3,6	1,0	0,0	-0,3	0,1
Nuclear	159,36	207,85	219,74	214,49	166,88	157,69	156,96	8,3	9,1	9,9	10,3	7,7	7,4	7,5	1,1	-2,4	-2,5	-0,6	0,0	-1,1
Hydro	23,49	21,77	24,92	25,16	26,15	26,77	27,13	1,2	1,0	1,1	1,2	1,2	1,3	1,3	0,2	1,0	0,4	0,2	0,1	0,3
Geothermal	14,10	13,09	9,11	9,31	17,60	30,69	37,06	0,7	0,6	0,4	0,4	0,8	1,4	1,8	-1,5	2,2	6,6	5,7	1,9	4,6
Others	62,76	78,24	148,89	160,87	199,40	240,27	298,78	3,3	3,4	6,7	7,7	9,2	11,3	14,3	3,0	8,0	2,2	1,9	2,2	2,3
Biomass	62,27	73,25	108,43	115,22	127,99	131,94	135,89	3,3	3,2	4,9	5,5	5,9	6,2	6,5	1,9	6,3	1,1	0,3	0,3	0,7
Solar, Wind, Ocean	0,32	2,07	37,10	42,29	68,05	104,97	159,53	0,0	0,1	1,7	2,0	3,1	4,9	7,7	17,8	14,0	4,9	4,4	4,3	4,8
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	0,17	2,92	3,36	3,36	3,36	3,36	3,36	0,0	0,1	0,2	0,2	0,2	0,2	0,2	10,8	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.492,54**	**1.584,58**	**1.545,94**	**1.509,04**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-6,0**	**0,6**	**-0,2**	**-0,2**	**-0,2**
Industry	283,74	332,27	268,01	252,66	271,67	272,17	270,52	21,9	21,5	16,9	16,9	17,1	17,6	17,9	-0,2	-5,7	0,7	0,0	-0,1	0,0
Transportation	487,57	588,24	637,29	570,23	612,54	569,25	537,31	37,7	38,0	40,1	38,2	38,7	36,8	35,6	0,9	-10,5	0,7	-0,7	-0,6	-0,5
Others	403,18	472,73	525,20	518,12	534,74	529,26	518,84	31,2	30,6	33,1	34,7	33,7	34,2	34,4	0,9	-1,3	0,3	-0,1	-0,2	0,0
Non-energy	119,05	153,03	157,98	151,54	165,62	175,27	182,37	9,2	9,9	9,9	10,2	10,5	11,3	12,1	1,0	-4,1	0,9	0,6	0,4	0,5
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.492,54**	**1.584,58**	**1.545,94**	**1.509,04**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-6,0**	**0,6**	**-0,2**	**-0,2**	**-0,2**
Coal	55,64	32,56	15,40	14,01	11,80	10,05	8,37	4,3	2,1	1,0	0,9	0,7	0,7	0,6	-4,3	-9,0	-1,7	-1,6	-1,8	-1,9
Oil	683,29	793,42	763,80	682,98	724,32	667,58	616,91	52,8	51,3	48,1	45,8	45,7	43,2	40,9	0,4	-10,6	0,6	-0,8	-0,8	-0,7
Natural gas	303,08	359,99	382,60	374,82	386,43	365,50	341,77	23,4	23,3	24,1	25,1	24,4	23,6	22,6	0,8	-2,0	0,3	-0,6	-0,7	-0,4
Electricity	226,45	300,90	329,32	323,72	363,17	407,09	448,68	17,5	19,5	20,7	21,7	22,9	26,3	29,7	1,3	-1,7	1,2	1,1	1,0	1,0
Heat	2,15	5,28	6,03	5,68	5,62	5,27	4,80	0,2	0,3	0,4	0,4	0,4	0,3	0,3	3,6	-5,8	-0,1	-0,6	-0,9	-0,7
Others	22,93	54,12	91,32	91,32	93,24	90,45	88,51	1,8	3,5	5,7	6,1	5,9	5,9	5,9	4,9	0,0	0,2	-0,3	-0,2	-0,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.202,81**	**4.025,89**	**4.370,99**	**4.295,78**	**4.821,86**	**5.151,41**	**5.634,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,7**	**1,2**	**0,7**	**0,9**	**0,8**
Coal	1.699,65	2.129,50	1.069,53	1.002,67	1.032,95	875,96	717,62	53,1	52,9	24,5	23,3	21,4	17,0	12,7	-1,6	-6,3	0,3	-1,6	-2,0	-1,3
Oil	130,65	118,48	35,79	33,12	29,03	20,75	10,44	4,1	2,9	0,8	0,8	0,6	0,4	0,2	-4,4	-7,5	-1,3	-3,3	-6,6	-3,9
Natural gas	381,67	634,29	1.639,83	1.567,74	1.973,94	2.181,08	2.313,11	11,9	15,8	37,5	36,5	40,9	42,3	41,1	5,2	-4,4	2,3	1,0	0,6	1,1
Nuclear	611,59	797,72	843,33	823,19	641,60	607,71	603,93	19,1	19,8	19,3	19,2	13,3	11,8	10,7	1,1	-2,4	-2,5	-0,5	-0,1	-1,1
Hydro	273,15	253,20	289,80	292,58	304,62	312,61	316,30	8,5	6,3	6,6	6,8	6,3	6,1	5,6	0,2	1,0	0,4	0,3	0,1	0,3
Geothermal	16,01	14,62	18,36	18,80	36,32	64,01	77,35	0,5	0,4	0,4	0,4	0,8	1,2	1,4	0,5	2,4	6,8	5,8	1,9	4,7
Others	90,094	78,07	474,35	557,68	803,39	1.089,30	1.595,64	2,8	1,9	10,9	13,0	16,7	21,1	28,3	5,9	17,6	3,7	3,1	3,9	4,0

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**513,01**	**696,21**	**537,08**	**494,80**	**517,54**	**512,88**	**480,36**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,2**	**-7,9**	**0,5**	**-0,1**	**-0,7**	**-0,4**
Coal	396,00	501,59	247,21	224,62	201,61	178,14	147,20	77,2	72,0	46,0	45,4	39,0	34,7	30,6	-1,6	-9,1	-1,1	-1,2	-1,9	-1,7
Oil	27,25	57,71	7,73	7,70	6,50	4,52	2,20	5,3	8,3	1,4	1,6	1,3	0,9	0,5	-4,2	-0,4	-1,7	-3,6	-6,9	-4,0
Natural gas	89,76	136,92	282,14	262,47	309,44	330,21	330,96	17,5	19,7	52,5	53,0	59,8	64,4	68,9	4,0	-7,0	1,7	0,7	0,0	0,5

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,1**	**35,6**	**44,0**	**45,3**	**50,4**	**51,6**	**54,4**								**0,6**	**2,9**	**1,1**	**0,2**	**0,5**	**0,7**
Coal	36,9	36,5	37,2	38,4	44,1	42,3	41,9								0,0	3,2	1,4	-0,4	-0,1	0,4
Oil	41,2	17,7	39,8	37,0	38,4	39,4	40,7								-0,1	-7,1	0,4	0,3	0,3	0,1
Natural gas	36,6	39,8	50,0	51,4	54,9	56,8	60,1								1,1	2,8	0,7	0,3	0,6	0,6

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,6**	**1.536,3**	**1.293,7**	**1.178,0**	**1.222,0**	**1.141,7**	**1.043,6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-8,9**	**0,4**	**-0,7**	**-0,9**	**-0,7**
Coal	501,3	592,0	301,2	272,2	245,0	217,0	180,7	38,7	38,5	23,3	23,1	20,0	19,0	17,3	-1,7	-9,6	-1,0	-1,2	-1,8	-1,6
Oil	517,9	595,2	525,8	457,8	486,6	435,3	390,7	40,0	38,7	40,6	38,9	39,8	38,1	37,4	0,1	-12,9	0,6	-1,1	-1,1	-1,0
Natural gas	274,5	349,2	466,7	448,1	490,4	489,4	472,2	21,2	22,7	36,1	38,0	40,1	42,9	45,3	1,8	-4,0	0,9	0,0	-0,4	0,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9.825	13.775	19.975	19.275	25.907	31.794	38.670	2,5	-3,5	3,0	2,1	2,0	2,2
Population (millions of people)	249,6	282,2	328,2	330,2	348,8	365,7	378,5	0,9	0,6	0,5	0,5	0,3	0,5
GDP per capita (thousands of 2015 USD/person)	39,36	48,82	60,85	58,38	74,28	86,95	102,18	1,5	-4,1	2,4	1,6	1,6	1,7
Primary energy consumption per capita (toe/person)	7,67	8,06	6,74	6,29	6,22	5,82	5,50	-0,4	-6,7	-0,1	-0,7	-0,6	-0,7
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	195	165	111	108	84	67	54	-1,9	-2,7	-2,5	-2,2	-2,2	-2,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	132	112	80	77	61	49	39	-1,7	-2,6	-2,3	-2,3	-2,2	-2,3
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	132	112	65	61	47	36	27	-2,4	-5,6	-2,6	-2,7	-2,8	-2,8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,68	0,58	0,57	0,56	0,54	0,50	-0,5	-3,0	-0,1	-0,5	-0,7	-0,5
Automobile ownership volume (millions of vehicles)	188,8	221,5	286,9	285,6	327,6	362,5	399,5	1,5	-0,5	1,4		2,0	1,1
Automobile ownership volume per capita (vehicles per person)	0,756	0,785	0,874	0,865	0,939	0,991	1,055	0,5	-1,0	0,8		1,2	0,6

United States APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.914,47**	**2.272,86**	**2.212,75**	**2.088,70**	**2.087,25**	**1.917,07**	**1.767,98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-5,6**	**0,0**	**-0,8**	**-0,8**	**-0,7**
Coal	459,57	533,02	274,92	252,65	160,19	88,97	32,80	24,0	23,5	12,4	12,1	7,7	4,6	1,9	-1,8	-8,1	-4,5	-5,7	-9,5	-6,6
Oil	756,84	871,15	792,88	703,05	675,61	525,96	424,74	39,5	38,3	35,8	33,7	32,4	27,4	24,0	0,2	-11,3	-0,4	-2,5	-2,1	-2,0
Natural gas	438,36	547,74	742,30	723,40	747,97	661,22	503,55	22,9	24,1	33,5	34,6	35,8	34,5	28,5	1,8	-2,5	0,3	-1,2	-2,7	-1,2
Nuclear	159,36	207,85	219,74	214,49	194,15	202,89	217,61	8,3	9,1	9,9	10,3	9,3	10,6	12,3	1,1	-2,4	-1,0	0,4	0,7	0,0
Hydro	23,49	21,77	24,92	25,16	28,03	30,76	33,48	1,2	1,0	1,1	1,2	1,3	1,6	1,9	0,2	1,0	1,1	0,9	0,9	1,0
Geothermal	14,10	13,09	9,11	9,31	24,91	41,14	56,78	0,7	0,6	0,4	0,4	1,2	2,1	3,2	-1,5	2,2	10,3	5,1	3,3	6,1
Others	62,76	78,24	148,89	160,63	256,37	366,14	499,02	3,3	3,4	6,7	7,7	12,3	19,1	28,2	3,0	7,9	4,8	3,6	3,1	4,0
Biomass	62,27	73,25	108,43	114,99	145,75	159,06	173,75	3,3	3,2	4,9	5,5	7,0	8,3	9,8	1,9	6,0	2,4	0,9	0,9	1,5
Solar, Wind, Ocean	0,32	2,07	37,10	42,28	107,27	203,73	321,89	0,0	0,1	1,7	2,0	5,1	10,6	18,2	17,8	14,0	9,8	6,6	4,7	7,2
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	0,17	2,92	3,36	3,36	3,36	3,36	3,36	0,0	0,1	0,2	0,2	0,2	0,2	0,2	10,8	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.491,85**	**1.510,26**	**1.363,91**	**1.251,43**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-6,1**	**0,1**	**-1,0**	**-0,9**	**-0,8**
Industry	283,74	332,27	268,01	252,66	266,70	251,01	229,28	21,9	21,5	16,9	16,9	17,7	18,4	18,3	-0,2	-5,7	0,5	-0,6	-0,9	-0,5
Transportation	487,57	588,24	637,29	569,99	565,00	467,36	416,87	37,7	38,0	40,1	38,2	37,4	34,3	33,3	0,9	-10,6	-0,1	-1,9	-1,1	-1,4
Others	403,18	472,73	525,20	517,66	512,94	470,27	422,90	31,2	30,6	33,1	34,7	34,0	34,5	33,8	0,9	-1,4	-0,1	-0,9	-1,1	-0,7
Non-energy	119,05	153,03	157,98	151,54	165,62	175,27	182,37	9,2	9,9	9,9	10,2	11,0	12,9	14,6	1,0	-4,1	0,9	0,6	0,4	0,5
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.491,85**	**1.510,26**	**1.363,91**	**1.251,43**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-6,1**	**0,1**	**-1,0**	**-0,9**	**-0,8**
Coal	55,64	32,56	15,40	13,73	7,88	5,89	4,28	4,3	2,1	1,0	0,9	0,5	0,4	0,3	-4,3	-10,9	-5,4	-2,9	-3,1	-4,0
Oil	683,29	793,42	763,80	683,01	660,39	521,67	428,59	52,8	51,3	48,1	45,8	43,7	38,2	34,2	0,4	-10,6	-0,3	-2,3	-1,9	-1,8
Natural gas	303,08	359,99	382,60	374,56	361,31	299,08	236,15	23,4	23,3	24,1	25,1	23,9	21,9	18,9	0,8	-2,1	-0,4	-1,9	-2,3	-1,5
Electricity	226,45	300,90	329,32	323,52	367,38	418,85	456,12	17,5	19,5	20,7	21,7	24,3	30,7	36,4	1,3	-1,8	1,3	1,3	0,9	1,1
Heat	2,15	5,28	6,03	5,69	5,43	4,58	3,60	0,2	0,3	0,4	0,4	0,4	0,3	0,3	3,6	-5,7	-0,5	-1,7	-2,4	-1,7
Others	22,93	54,12	91,32	91,35	107,87	113,85	122,69	1,8	3,5	5,7	6,1	7,1	8,3	9,8	4,9	0,0	1,7	0,5	0,8	1,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.202,81**	**4.025,89**	**4.370,99**	**4.292,89**	**4.877,59**	**5.549,35**	**5.997,37**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,8**	**1,3**	**1,3**	**0,8**	**1,0**
Coal	1.699,65	2.129,50	1.069,53	992,48	692,11	375,77	105,96	53,1	52,9	24,5	23,1	14,2	6,8	1,8	-1,6	-7,2	-3,5	-5,9	-11,9	-7,2
Oil	130,65	118,48	35,79	33,08	24,17	13,80	4,53	4,1	2,9	0,8	0,8	0,5	0,2	0,1	-4,4	-7,6	-3,1	-5,5	-10,5	-6,5
Natural gas	381,67	634,29	1.639,83	1.575,08	1.829,79	1.819,22	1.352,37	11,9	15,8	37,5	36,7	37,5	32,8	22,5	5,2	-3,9	1,5	-0,1	-2,9	-0,6
Nuclear	611,59	797,72	843,33	823,19	745,14	778,65	835,16	19,1	19,8	19,3	19,2	15,3	14,0	13,9	1,1	-2,4	-1,0	0,4	0,7	0,0
Hydro	273,15	253,20	289,80	292,58	326,00	357,70	389,39	8,5	6,3	6,6	6,8	6,7	6,4	6,5	0,2	1,0	1,1	0,9	0,9	1,0
Geothermal	16,01	14,62	18,36	18,80	51,61	85,75	118,64	0,5	0,4	0,4	0,4	1,1	1,5	2,0	0,5	2,4	10,6	5,2	3,3	6,2
Others	90,094	78,07	474,35	557,68	1.208,76	2.118,46	3.191,33	2,8	1,9	10,9	13,0	24,8	38,2	53,2	5,9	17,6	8,0	5,8	4,2	6,3

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**513,01**	**696,21**	**537,08**	**507,02**	**444,12**	**351,14**	**212,23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,2**	**-5,6**	**-1,3**	**-2,3**	**-4,9**	**-3,0**
Coal	396,00	501,59	247,21	228,44	141,63	73,10	19,38	77,2	72,0	46,0	45,1	31,9	20,8	9,1	-1,6	-7,6	-4,7	-6,4	-12,4	-7,9
Oil	27,25	57,71	7,73	8,01	5,67	3,15	0,97	5,3	8,3	1,4	1,6	1,3	0,9	0,5	-4,2	3,5	-3,4	-5,7	-11,1	-6,5
Natural gas	89,76	136,92	282,14	270,57	296,82	274,88	191,88	17,5	19,7	52,5	53,4	66,8	78,3	90,4	4,0	-4,1	0,9	-0,8	-3,5	-1,2

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,1**	**35,6**	**44,0**	**44,1**	**49,3**	**54,1**	**59,3**	**0,6**	**0,4**	**1,1**	**0,9**	**0,9**	**1,0**
Coal	36,9	36,5	37,2	37,4	42,0	44,2	47,0	0,0	0,4	1,2	0,5	0,6	0,8
Oil	41,2	17,7	39,8	35,5	36,6	37,6	40,2	-0,1	-10,7	0,3	0,3	0,7	0,0
Natural gas	36,6	39,8	50,0	50,1	53,0	56,9	60,6	1,1	0,2	0,6	0,7	0,6	0,6

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,6**	**1.536,3**	**1.293,7**	**1.186,9**	**1.043,2**	**751,6**	**501,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-8,3**	**-1,3**	**-3,2**	**-4,0**	**-3,0**
Coal	501,3	592,0	301,2	276,0	162,0	85,2	23,1	38,7	38,5	23,3	23,3	15,5	11,3	4,6	-1,7	-8,4	-5,2	-6,2	-12,2	-8,0
Oil	517,9	595,2	525,8	458,0	430,9	311,2	234,3	40,0	38,7	40,6	38,6	41,3	41,4	46,7	0,1	-12,9	-0,6	-3,2	-2,8	-2,6
Natural gas	274,5	349,2	466,7	453,0	450,3	355,2	244,0	21,2	22,7	36,1	38,2	43,2	47,3	48,7	1,8	-2,9	-0,1	-2,3	-3,7	-2,1

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9.825	13.775	19.975	19.275	25.907	31.794	38.670	2,5	-3,5	3,0	2,1	2,0	2,2
Population (millions of people)	250	282	328	330	349	366	379	0,9	0,6	0,5	0,5	0,3	0,5
GDP per capita (thousands of 2015 USD/person)	39,36	48,81	60,86	58,37	74,27	86,94	102,17	1,5	-4,1	2,4	1,6	1,6	1,7
Primary energy consumption per capita (toe/person)	7,67	8,05	6,74	6,33	5,98	5,24	4,67	-0,4	-6,2	-0,6	-1,3	-1,1	-1,2
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	195	165	111	108	81	60	46	-1,9	-2,2	-2,9	-2,9	-2,7	-2,8
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	132	112	80	77	58	43	32	-1,7	-2,7	-2,8	-3,0	-2,8	-2,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	132	112	65	62	40	24	13	-2,4	-4,9	-4,2	-5,2	-5,8	-5,1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,68	0,58	0,57	0,50	0,39	0,28	-0,5	-2,8	-1,3	-2,4	-3,2	-2,3
Automobile ownership volume (millions of vehicles)	188,8	221,5	286,9	285,6	327,6	362,5	399,5	1,5	-0,5	1,4	2,4	2,0	1,1
Automobile ownership volume per capita (vehicles per person)	0,756	0,785	0,874	0,865	0,939	0,991	1,055	0,5	-1,1	0,8	1,4	1,2	0,6

United States LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.914,47**	**2.272,86**	**2.212,75**	**2.072,19**	**1.893,14**	**1.681,66**	**1.499,98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,5**	**-6,4**	**-0,9**	**-1,2**	**-1,1**	**-1,2**
Coal	459,57	533,02	274,92	252,65	78,00	57,58	18,96	24,0	23,5	12,4	12,2	4,1	3,4	1,3	-1,8	-8,1	-11,1	-3,0	-10,5	-8,3
Oil	756,84	871,15	792,88	703,05	611,96	342,12	143,28	39,5	38,3	35,8	33,9	32,3	20,3	9,6	0,2	-11,3	-1,4	-5,6	-8,3	-5,4
Natural gas	438,36	547,74	742,30	723,40	646,71	505,89	344,76	22,9	24,1	33,5	34,9	34,2	30,1	23,0	1,8	-2,5	-1,1	-2,4	-3,8	-2,4
Nuclear	159,36	207,85	219,74	214,49	215,27	267,59	309,56	8,3	9,1	9,9	10,4	11,4	15,9	20,6	1,1	-2,4	0,0	2,2	1,5	1,1
Hydrogen/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	-	-	-	-	-	-
Hydro	23,49	21,77	24,92	25,16	30,07	35,97	40,05	1,2	1,0	1,1	1,2	1,6	2,1	2,7	0,2	1,0	1,8	1,8	1,1	1,5
Geothermal	14,10	13,09	9,11	8,98	26,65	46,11	67,78	0,7	0,6	0,4	0,4	1,4	2,7	4,5	-1,5	-1,4	11,5	5,6	3,9	6,7
Others	62,76	78,24	148,89	144,46	284,47	426,40	575,59	3,3	3,4	6,7	7,0	15,0	25,4	38,4	3,0	-3,0	7,0	4,1	3,0	4,5
Biomass	62,27	73,25	108,43	98,82	89,22	118,56	146,88	3,3	3,2	4,9	4,8	4,7	7,1	9,8	1,9	-8,9	-1,0	2,9	2,2	1,0
Solar, Wind, Ocean	0,32	2,07	37,10	42,28	191,89	304,48	425,35	0,0	0,1	1,7	2,0	10,1	18,1	28,4	17,8	14,0	16,3	4,7	3,4	8,2
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	0,17	2,92	3,36	3,36	3,36	3,36	3,36	0,0	0,1	0,2	0,2	0,2	0,2	0,2	10,8	0,0	0,0	0,0	0,0	0,0

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.475,34**	**1.361,76**	**1.090,34**	**901,24**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-7,1**	**-0,8**	**-2,2**	**-1,9**	**-1,8**
Industry	283,74	332,27	268,01	252,66	246,95	222,13	194,31	21,9	21,5	16,9	17,1	18,1	20,4	21,6	-0,2	-5,7	-0,2	-1,1	-1,3	-1,0
Transportation	487,57	588,24	637,29	569,99	495,29	352,72	264,63	37,7	38,0	40,1	38,6	36,4	32,3	29,4	0,9	-10,6	-1,4	-3,3	-2,8	-2,8
Others	403,18	472,73	525,20	501,16	453,90	340,22	259,93	31,2	30,6	33,1	34,0	33,3	31,2	28,8	0,9	-4,6	-1,0	-2,8	-2,7	-2,2
Non-energy	119,05	153,03	157,98	151,54	165,62	175,27	182,37	9,2	9,9	9,9	10,3	12,2	16,1	20,2	1,0	-4,1	0,9	0,6	0,4	0,5
Total	**1.293,54**	**1.546,28**	**1.588,48**	**1.475,34**	**1.361,76**	**1.090,34**	**901,24**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,7**	**-7,1**	**-0,8**	**-2,2**	**-1,9**	**-1,8**
Coal	55,64	32,56	15,40	13,73	6,78	4,11	1,77	4,3	2,1	1,0	0,9	0,5	0,4	0,2	-4,3	-10,9	-6,8	-4,9	-8,1	-6,7
Oil	683,29	793,42	763,80	683,01	597,74	336,80	143,48	52,8	51,3	48,1	46,3	43,9	30,9	15,9	0,4	-10,6	-1,3	-5,6	-8,2	-5,3
Natural gas	303,08	359,99	382,60	374,56	298,93	156,92	61,67	23,4	23,3	24,1	25,4	22,0	14,4	6,8	0,8	-2,1	-2,2	-6,2	-8,9	-5,7
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	11,02	60,25	102,57	0,0	0,0	0,0	0,0	0,8	5,5	11,4	-	-	-	18,5	5,5	-
Electricity	226,45	300,90	329,32	323,52	394,25	463,26	505,13	17,5	19,5	20,7	21,9	29,0	42,5	56,0	1,3	-1,8	2,0	1,6	0,9	1,4
Heat	2,15	5,28	6,03	5,69	4,87	3,55	2,47	0,2	0,3	0,4	0,4	0,4	0,3	0,3	3,6	-5,7	-1,6	-3,1	-3,6	-2,8
Others	22,93	54,12	91,32	74,84	48,17	65,44	84,15	1,8	3,5	5,7	5,1	3,5	6,0	9,3	4,9	-18,0	-4,3	3,1	2,5	-0,3

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.202,81**	**4.025,89**	**4.370,99**	**4.292,89**	**5.232,59**	**6.349,30**	**7.173,99**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1,1**	**-1,8**	**2,0**	**2,0**	**1,2**	**1,6**
Coal PP	1.699,65	2.129,50	1.069,53	992,48	298,26	74,30	0,00	53,1	52,9	24,5	23,1	5,7	1,2	0,0	-1,6	-7,2	-11,3	-13,0	-100,0	-100,0
Coal PP with CCS	0,00	0,00	0,00	0,00	15,70	144,23	63,37	0,0	0,0	0,0	0,0	0,3	2,3	0,9	-	-	-	24,8	-7,9	-
Oil	130,65	118,48	35,79	33,08	25,93	18,13	5,42	4,1	2,9	0,8	0,8	0,5	0,3	0,1	-4,4	-7,6	-2,4	-3,5	-11,4	-5,9
Gas PP	381,67	634,29	1.639,83	1.575,08	1.508,52	473,06	0,00	11,9	15,8	37,5	36,7	28,8	7,5	0,0	5,2	-3,9	-0,4	-10,9	-100,0	-100,0
Gas PP PP with CCS	0,00	0,00	0,00	0,00	79,40	918,30	967,10	0,0	0,0	0,0	0,0	1,5	14,5	13,5	-	-	-	27,7	0,5	-
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,00	0,00	63,49	143,48	0,0	0,0	0,0	0,0	0,0	1,0	2,0	-	-	-	-	8,5	-
Nuclear	611,59	797,72	843,33	823,19	826,20	1.027,00	1.188,05	19,1	19,8	19,3	19,2	15,8	16,2	16,6	1,1	-2,4	0,0	2,2	1,5	1,1
Solar	0,00	0,18	93,94	104,44	637,35	1.152,06	1.808,63	0,0	0,0	2,1	2,4	12,2	18,1	25,2	42,9	11,2	19,8	6,1	4,6	10,0
Wind	3,07	5,65	298,20	345,78	1.104,78	1.421,66	1.617,36	0,1	0,1	6,8	8,1	21,1	22,4	22,5	17,1	16,0	12,3	2,6	1,3	5,6
Hydro	273,15	253,20	289,80	292,58	349,73	418,30	465,78	8,5	6,3	6,6	6,8	6,7	6,6	6,5	0,2	1,0	1,8	1,8	1,1	1,5
Geothermal	16,01	14,62	18,36	18,80	55,37	96,39	141,91	0,5	0,4	0,4	0,4	1,1	1,5	2,0	0,5	2,4	11,4	5,7	3,9	6,8
Others	87,03	72,24	82,21	107,46	331,37	542,38	772,88	2,7	1,8	1,9	2,5	6,3	8,5	10,8	-0,2	30,7	11,9	5,1	3,6	7,5

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**513,01**	**696,21**	**537,08**	**507,02**	**322,70**	**286,01**	**187,31**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,2**	**-5,6**	**-4,4**	**-1,2**	**-4,1**	**-3,3**
Coal	396,00	501,59	247,21	228,44	62,03	46,48	13,39	77,2	72,0	46,0	45,1	19,2	16,3	7,1	-1,6	-7,6	-12,2	-2,8	-11,7	-9,0
Oil	27,25	57,71	7,73	8,01	6,00	4,66	1,38	5,3	8,3	1,4	1,6	1,9	1,6	0,7	-4,2	3,5	-2,9	-2,5	-11,5	-5,4
Gas	89,76	136,92	282,14	270,57	254,68	225,44	152,51	17,5	19,7	52,5	53,4	78,9	78,8	81,4	4,0	-4,1	-0,6	-1,2	-3,8	-2,0
Hydrogen/Ammonia	0,00	0,00	0,00	0,00	0,00	9,43	20,03	0,0	0,0	0,0	0,0	0,0	3,3	10,7	-	-	-	-	7,8	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**37,1**	**35,6**	**44,0**	**44,1**	**51,4**	**50,9**	**54,1**								**0,6**	**0,4**	**1,5**	**-0,1**	**0,6**	**0,7**
Coal	36,9	36,5	37,2	37,4	43,5	40,4	40,7								0,0	0,4	1,5	-0,7	0,1	0,3
Oil	41,2	17,7	39,8	35,5	37,2	33,5	33,8								-0,1	-10,7	0,5	-1,0	0,1	-0,5
Gas	36,6	39,8	50,0	50,1	53,6	53,1	54,5								1,1	0,2	0,7	-0,1	0,3	0,3
Hydrogen/Ammonia	-	-	-	-	-	57,9	61,6								-	-	-	-	0,6	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**1.293,6**	**1.536,3**	**1.293,7**	**1.186,9**	**844,7**	**322,0**	**7,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0,0**	**-8,3**	**-3,3**	**-9,2**	**-31,7**	**-15,4**
Coal	501,3	592,0	301,2	276,0	82,0	27,0	1,6	38,7	38,5	23,3	23,3	9,7	8,4	22,6	-1,7	-8,4	-11,4	-10,5	-24,6	-15,5
Oil	517,9	595,2	525,8	458,0	379,8	154,3	0,0	40,0	38,7	40,6	38,6	45,0	47,9	0,0	0,1	-12,9	-1,9	-8,6	-100,0	-100,0
Natural gas	274,5	349,2	466,7	453,0	382,8	140,7	5,5	21,2	22,7	36,1	38,2	45,3	43,7	77,4	1,8	-2,9	-1,7	-9,5	-27,6	-13,3

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	9.825	13.775	19.975	19.275	25.907	31.794	38.670	2,5	-3,5	3,0	2,1	2,0	2,2
Population (millions of people)	249,6	282,2	328,2	330,2	348,8	365,7	378,5	0,9	0,6	0,5	0,5	0,3	0,5
GDP per capita (thousands of 2015 USD/person)	39,36	48,82	60,85	58,38	74,28	86,95	102,18	1,5	-4,1	2,4	1,6	1,6	1,7
Primary energy consumption per capita (toe/person)	7,67	8,06	6,74	6,28	5,43	4,60	3,96	-0,4	-6,9	-1,4	-1,6	-1,5	-1,7
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	195	165	111	108	73	53	39	-1,9	-3,0	-3,8	-3,2	-3,1	-3,3
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	132	112	80	77	53	34	23	-1,7	-3,8	-3,7	-4,2	-3,8	-3,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	132	112	65	62	33	10	0	-2,4	-4,9	-6,2	-11,0	-33,0	-17,2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,68	0,68	0,58	0,57	0,45	0,19	0,00	-0,5	-2,0	-2,5	-8,1	-30,9	-14,4
Automobile ownership volume (millions of vehicles)	188,8	221,5	286,9	285,6	327,6	362,5	399,5	1,5	-0,5	1,4	1,0	2,0	1,1
Automobile ownership volume per capita (vehicles per person)	0,756	0,785	0,874	0,865	0,939	0,991	1,055	0,5	-1,0	0,8	0,5	1,2	0,6

ASEAN BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**210,65**	**342,86**	**661,31**	**647,78**	**925,77**	**1.275,82**	**1.717,18**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**-2,0**	**3,6**	**3,3**	**3,0**	**3,1**
Coal	12,39	32,89	192,23	191,76	268,58	374,71	505,12	5,9	9,6	29,1	29,6	29,0	29,4	29,4	9,9	-0,2	3,4	3,4	3,0	3,2
Oil	79,59	139,93	218,49	208,82	294,74	407,64	553,95	37,8	40,8	33,0	32,2	31,8	32,0	32,3	3,5	-4,4	3,5	3,3	3,1	3,0
Natural gas	39,85	81,60	134,83	135,59	200,50	283,52	387,22	18,9	23,8	20,4	20,9	21,7	22,2	22,5	4,3	0,6	4,0	3,5	3,2	3,5
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	2,41	4,36	15,32	15,56	23,04	27,23	33,31	1,1	1,3	2,3	2,4	2,5	2,1	1,9	6,6	1,6	4,0	1,7	2,0	2,5
Geothermal	5,67	12,27	21,32	21,90	49,84	64,71	83,91	2,7	3,6	3,2	3,4	5,4	5,1	4,9	4,7	2,7	8,6	2,6	2,6	4,5
Others	70,74	71,81	79,13	74,14	89,07	118,00	153,69	33,6	20,9	12,0	11,4	9,6	9,2	8,9	0,4	-6,3	1,9	2,9	2,7	2,2
Biomass	70,69	71,79	62,13	59,93	62,25	71,49	85,09	33,6	20,9	9,4	9,3	6,7	5,6	5,0	-0,4	-3,5	0,4	1,4	1,8	1,0
Solar, Wind, Ocean	0,00	0,00	2,47	3,02	8,78	13,79	15,66	0,0	0,0	0,4	0,5	0,9	1,1	0,9	-	22,3	11,3	4,6	1,3	6,1
Biofuels	0,00	0,00	9,66	8,51	15,83	28,08	47,54	0,0	0,0	1,5	1,3	1,7	2,2	2,8	-	-11,9	6,4	5,9	5,4	5,3
Electricity	0,05	0,01	4,87	2,68	2,22	4,65	5,40	0,0	0,0	0,7	0,4	0,2	0,4	0,3	16,9	-44,9	-1,9	7,7	1,5	0,3

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**130,34**	**219,98**	**447,72**	**437,28**	**623,83**	**861,99**	**1.166,91**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-2,3**	**3,6**	**3,3**	**3,1**	**3,1**
Industry	36,50	70,62	150,16	147,67	211,59	286,62	378,30	28,0	32,1	33,5	33,8	33,9	33,3	32,4	5,0	-1,7	3,7	3,1	2,8	3,0
Transportation	30,56	57,15	141,52	130,94	204,64	309,44	451,55	23,4	26,0	31,6	29,9	32,8	35,9	38,7	5,4	-7,5	4,6	4,2	3,9	3,8
Others	52,94	70,41	107,72	109,93	150,58	200,74	262,91	40,6	32,0	24,1	25,1	24,1	23,3	22,5	2,5	2,1	3,2	2,9	2,7	2,9
Non-energy	10,33	21,80	48,32	48,75	57,01	65,20	74,16	7,9	9,9	10,8	11,1	9,1	7,6	6,4	5,5	0,9	1,6	1,4	1,3	1,4
Total	**130,36**	**219,99**	**447,73**	**437,28**	**623,83**	**861,99**	**1.166,91**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-2,3**	**3,6**	**3,3**	**3,1**	**3,1**
Coal	4,73	13,71	52,04	50,91	76,82	101,51	130,88	3,6	6,2	11,6	11,6	12,3	11,8	11,2	8,6	-2,2	4,2	2,8	2,6	3,0
Oil	63,37	118,73	209,46	203,10	287,55	400,57	546,77	48,6	54,0	46,8	46,4	46,1	46,5	46,9	4,2	-3,0	3,5	3,4	3,2	3,1
Natural gas	11,15	19,37	45,55	42,99	55,24	74,68	98,40	8,6	8,8	10,2	9,8	8,9	8,7	8,4	5,0	-5,6	2,5	3,1	2,8	2,5
Electricity	11,13	27,63	92,24	93,37	151,99	221,58	308,85	8,5	12,6	20,6	21,4	24,4	25,7	26,5	7,6	1,2	5,0	3,8	3,4	4,0
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	39,97	40,54	48,43	46,90	52,23	63,66	82,00	30,7	18,4	10,8	10,7	8,4	7,4	7,0	0,7	-3,2	1,1	2,0	2,6	1,7

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**154,99**	**367,70**	**1.142,83**	**1.166,05**	**1.910,43**	**2.753,30**	**3.831,78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,1**	**2,0**	**5,1**	**3,7**	**3,4**	**4,0**
Coal	27,80	76,19	493,07	493,48	705,28	1.045,29	1.517,87	17,9	20,7	43,1	42,3	36,9	38,0	39,6	10,4	0,1	3,6	4,0	3,8	3,7
Oil	63,46	65,00	18,88	13,55	16,44	15,62	15,77	40,9	17,7	1,7	1,2	0,9	0,6	0,4	-4,1	-28,2	2,0	-0,5	0,1	-0,6
Natural gas	28,46	160,45	389,81	403,89	737,09	1.096,81	1.564,53	18,4	43,6	34,1	34,6	38,6	39,8	40,8	9,4	3,6	6,2	4,1	3,6	4,6
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	28,08	50,78	165,93	167,23	254,66	303,50	371,92	18,1	13,8	14,5	14,3	13,3	11,0	9,7	6,3	0,8	4,3	1,8	2,1	2,6
Geothermal	6,59	14,27	24,95	25,87	65,84	87,44	111,07	4,3	3,9	2,2	2,2	3,4	3,2	2,9	4,7	3,7	9,8	2,9	2,4	4,9
Others	0,60	1,00	50,19	62,02	131,12	204,64	250,61	0,4	0,3	4,4	5,3	6,9	7,4	6,5	16,5	23,6	7,8	4,6	2,0	5,3

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,11**	**71,81**	**220,74**	**222,61**	**331,33**	**474,00**	**652,78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,0**	**0,8**	**4,1**	**3,6**	**3,3**	**3,6**
Coal	7,37	19,00	140,18	140,86	191,75	273,20	374,24	23,7	26,5	63,5	63,3	57,9	57,6	57,3	10,7	0,5	3,1	3,6	3,2	3,2
Oil	16,68	18,57	5,21	3,75	4,32	4,01	3,85	53,6	25,9	2,4	1,7	1,3	0,8	0,6	-3,9	-28,1	1,4	-0,8	-0,4	-1,0
Natural gas	7,07	34,24	75,35	78,01	135,26	196,79	274,70	22,7	47,7	34,1	35,0	40,8	41,5	42,1	8,5	3,5	5,7	3,8	3,4	4,3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,1**	**36,1**	**35,1**	**35,2**	**37,9**	**39,1**	**40,8**								**0,2**	**0,2**	**0,7**	**0,3**	**0,4**	**0,5**
Coal	32,4	34,5	30,2	30,1	31,6	32,9	34,9								-0,2	-0,4	0,5	0,4	0,6	0,5
Oil	32,7	30,1	31,1	31,1	32,7	33,5	35,2								-0,2	-0,1	0,5	0,2	0,5	0,4
Natural gas	34,6	40,3	44,5	44,5	46,9	47,9	49,0								0,9	0,1	0,5	0,2	0,2	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**103,9**	**161,5**	**425,2**	**419,1**	**609,7**	**860,5**	**1.177,4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**-1,4**	**3,8**	**3,5**	**3,2**	**3,3**
Coal	19,37	39,60	199,88	199,86	280,49	391,69	528,84	18,6	24,5	47,0	47,7	46,0	45,5	44,9	8,4	0,0	3,4	3,4	3,0	3,2
Oil	51,16	71,02	158,71	152,73	220,19	309,82	426,72	49,2	44,0	37,3	36,4	36,1	36,0	36,2	4,0	-3,8	3,7	3,5	3,3	3,2
Natural gas	33,35	50,92	66,64	66,49	109,05	158,99	221,84	32,1	31,5	15,7	15,9	17,9	18,5	18,8	2,4	-0,2	5,1	3,8	3,4	4,0

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	742	1.185	3.046	2.912	4.591	7.022	10.494	5,0	-4,4	4,7	4,3	4,1	4,07
Population (millions of people)	435	518	661	667	729	787	841	1,5	0,9	0,9	0,8	0,7	0,78
GDP per capita (thousands of 2015 USD/person)	1,71	2,29	4,61	4,4	6,3	8,9	12,5	3,5	-5,3	3,7	3,6	3,4	3,3
Primary energy consumption per capita (toe/person)	0,48	0,66	1,00	0,97	1,27	1,62	2,04	2,5	-2,9	2,7	2,5	2,3	2,3
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	284	289	217	222	202	182	164	-0,9	2,4	-1,0	-1,0	-1,0	-0,9
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	176	186	147	150	136	123	111	-0,6	2,1	-1,0	-1,0	-1,0	-0,9
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	140	136	140	144	133	123	112	0,0	3,1	-0,8	-0,8	-0,9	-0,7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,47	0,64	0,65	0,66	0,67	0,69	0,9	0,6	0,2	0,2	0,2	0,2
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

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Primary energy consumption

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**210,65**	**342,86**	**661,31**	**634,04**	**841,60**	**1.117,81**	**1.454,53**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**-4,1**	**2,9**	**2,9**	**2,7**	**2,6**
Coal	12,39	32,89	192,23	185,54	220,16	233,90	251,06	5,9	9,6	29,1	29,3	26,2	20,9	17,3	9,9	-3,5	1,7	0,6	0,7	0,9
Oil	79,59	139,93	218,49	201,94	265,96	353,13	458,81	37,8	40,8	33,0	31,8	31,6	31,6	31,5	3,5	-7,6	2,8	2,9	2,7	2,4
Natural gas	39,85	81,60	134,83	128,87	165,77	221,33	280,82	18,9	23,8	20,4	20,3	19,7	19,8	19,3	4,3	-4,4	2,6	2,9	2,4	2,4
Nuclear	0,00	0,00	0,00	0,00	0,00	0,00	4,02	0,0	0,0	0,0	0,0	0,0	0,0	0,3	-	-	-	-	-	-
Hydro	2,41	4,36	15,32	15,94	22,77	26,08	33,96	1,1	1,3	2,3	2,5	2,7	2,3	2,3	6,6	4,1	3,6	1,4	2,7	2,6
Geothermal	5,67	12,27	21,32	23,09	55,24	91,06	138,80	2,7	3,6	3,2	3,6	6,6	8,1	9,5	4,7	8,3	9,1	5,1	4,3	6,2
Others	70,74	71,81	79,13	78,67	111,69	192,31	287,06	33,6	20,9	12,0	12,4	13,3	17,2	19,7	0,4	-0,6	3,6	5,6	4,1	4,2
Biomass	70,69	71,79	62,13	63,52	77,43	125,66	178,80	33,6	20,9	9,4	10,0	9,2	11,2	12,3	-0,4	2,2	2,0	5,0	3,6	3,5
Solar, Wind, Ocean	0,00	0,00	2,47	3,33	15,40	33,90	58,46	0,0	0,0	0,4	0,5	1,8	3,0	4,0	-	35,0	16,5	8,2	5,6	10,7
Biofuels	0,00	0,00	9,66	9,58	18,06	30,79	46,34	0,0	0,0	1,5	1,5	2,1	2,8	3,2	-	-0,8	6,5	5,5	4,2	5,2
Electricity	0,05	0,01	4,87	2,24	0,80	1,96	3,47	0,0	0,0	0,7	0,4	0,1	0,2	0,2	16,9	-54,0	-9,7	9,3	5,9	-1,1

Final energy demand

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**130,34**	**219,98**	**447,72**	**426,67**	**575,87**	**767,18**	**995,55**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-4,7**	**3,0**	**2,9**	**2,6**	**2,6**
Industry	36,50	70,62	150,16	143,93	195,10	254,45	320,57	28,0	32,1	33,5	33,7	33,9	33,2	32,2	5,0	-4,2	3,1	2,7	2,3	2,5
Transportation	30,56	57,15	141,52	126,05	183,27	266,31	369,35	23,4	26,0	31,6	29,5	31,8	34,7	37,1	5,4	-10,9	3,8	3,8	3,3	3,1
Others	52,94	70,41	107,72	107,94	140,49	181,23	231,47	40,6	32,0	24,1	25,3	24,4	23,6	23,3	2,5	0,2	2,7	2,6	2,5	2,5
Non-energy	10,33	21,80	48,32	48,75	57,01	65,19	74,15	7,9	9,9	10,8	11,4	9,9	8,5	7,4	5,5	0,9	1,6	1,3	1,3	1,4
Total	**130,36**	**219,99**	**447,73**	**426,67**	**575,87**	**767,17**	**995,55**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**-4,7**	**3,0**	**2,9**	**2,6**	**2,6**
Coal	4,73	13,71	52,04	50,43	72,33	91,61	111,26	3,6	6,2	11,6	11,8	12,6	11,9	11,2	8,6	-3,1	3,7	2,4	2,0	2,5
Oil	63,37	118,73	209,46	196,20	259,27	346,37	452,05	48,6	54,0	46,8	46,0	45,0	45,1	45,4	4,2	-6,3	2,8	2,9	2,7	2,5
Natural gas	11,15	19,37	45,55	41,89	52,04	68,32	86,95	8,6	8,8	10,2	9,8	9,0	8,9	8,7	5,0	-8,0	2,2	2,8	2,4	2,1
Electricity	11,13	27,63	92,24	90,69	138,20	194,17	262,53	8,5	12,6	20,6	21,3	24,0	25,3	26,4	7,6	-1,7	4,3	3,5	3,1	3,4
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	39,97	40,54	48,43	47,46	54,04	66,69	82,77	30,7	18,4	10,8	11,1	9,4	8,7	8,3	0,7	-2,0	1,3	2,1	2,2	1,7

Power generation Output

	TWh							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**154,99**	**367,70**	**1.142,83**	**1.127,55**	**1.734,24**	**2.410,88**	**3.226,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,1**	**-1,3**	**4,4**	**3,3**	**3,0**	**3,4**
Coal	27,80	76,19	493,07	474,69	574,52	647,43	688,77	17,9	20,7	43,1	42,1	33,1	26,9	21,3	10,4	-3,7	1,9	1,2	0,6	1,1
Oil	63,46	65,00	18,88	13,46	14,83	14,65	14,81	40,9	17,7	1,7	1,2	0,9	0,6	0,5	-4,1	-28,7	1,0	-0,1	0,1	-0,8
Natural gas	28,46	160,45	389,81	383,76	629,03	903,02	1.210,88	18,4	43,6	34,1	34,0	36,3	37,5	37,5	9,4	-1,6	5,1	3,7	3,0	3,7
Nuclear	0,00	0,00	0,00	0,00	0,00	0,00	15,42	0,0	0,0	0,0	0,0	0,0	0,0	0,5	-	-	-	-	-	-
Hydro	28,08	50,78	165,93	168,75	237,63	278,69	369,11	18,1	13,8	14,5	15,0	13,7	11,6	11,4	6,3	1,7	3,5	1,6	2,8	2,6
Geothermal	6,59	14,27	24,95	27,16	79,77	130,95	193,73	4,3	3,9	2,2	2,4	4,6	5,4	6,0	4,7	8,9	11,4	5,1	4,0	6,8
Others	0,60	1,00	50,19	59,72	198,45	436,15	734,17	0,4	0,3	4,4	5,3	11,4	18,1	22,8	16,5	19,0	12,8	8,2	5,3	9,0

Power generation Input

	Mtoe							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,11**	**71,81**	**220,74**	**212,16**	**257,86**	**289,78**	**327,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,0**	**-3,9**	**2,0**	**1,2**	**1,2**	**1,3**
Coal	7,37	19,00	140,18	135,11	147,83	142,29	140,29	23,7	26,5	63,5	63,7	57,3	49,1	42,8	10,7	-3,6	0,9	-0,4	-0,1	0,0
Oil	16,68	18,57	5,21	3,76	3,83	3,70	3,45	53,6	25,9	2,4	1,8	1,5	1,3	1,1	-3,9	-27,9	0,2	-0,3	-0,7	-1,3
Natural gas	7,07	34,24	75,35	73,29	106,20	143,79	183,67	22,7	47,7	34,1	34,5	41,2	49,6	56,1	8,5	-2,7	3,8	3,1	2,5	2,9

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,1**	**36,1**	**35,1**	**35,3**	**40,6**	**46,4**	**50,3**	**0,2**	**0,6**	**1,4**	**1,3**	**0,8**	**1,2**
Coal	32,4	34,5	30,2	30,2	33,4	39,1	42,2	-0,2	-0,1	1,0	1,6	0,8	1,1
Oil	32,7	30,1	31,1	30,8	33,3	34,0	36,9	-0,2	-1,1	0,8	0,2	0,8	0,5
Natural gas	34,6	40,3	44,5	45,0	50,9	54,0	56,7	0,9	1,2	1,2	0,6	0,5	0,8

CO_2 emissions

	Mt-C							%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**103,9**	**161,5**	**425,2**	**403,0**	**512,9**	**626,2**	**761,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**-5,2**	**2,4**	**2,0**	**2,0**	**1,9**
Coal	19,37	39,60	199,88	193,14	227,95	240,12	256,23	18,6	24,5	47,0	47,9	44,4	38,3	33,7	8,4	-3,4	1,7	0,5	0,7	0,8
Oil	51,16	71,02	158,71	147,07	196,52	265,07	348,81	49,2	44,0	37,3	36,5	38,3	42,3	45,8	4,0	-7,3	2,9	3,0	2,8	2,6
Natural gas	33,35	50,92	66,64	62,78	88,43	121,02	156,31	32,1	31,5	15,7	15,6	17,2	19,3	20,5	2,4	-5,8	3,5	3,2	2,6	2,8

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	742	1.185	3.046	2.912	4.591	7.022	10.494	5,0	-4,4	4,7	4,3	4,1	4,07
Population (millions of people)	435	518	661	667	729	787	841	1,5	0,9	0,9	0,8	0,7	0,78
GDP per capita (thousands of 2015 USD/person)	1,71	2,29	4,61	4,4	6,3	8,9	12,5	3,5	-5,3	3,7	3,6	3,4	3,3
Primary energy consumption per capita (toe/person)	0,48	0,66	1,00	0,95	1,15	1,42	1,73	2,5	-5,0	2,0	2,1	2,0	1,8
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	284	289	217	218	183	159	139	-0,9	0,3	-1,7	-1,4	-1,4	-1,4
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	176	186	147	147	125	109	95	-0,6	-0,3	-1,5	-1,4	-1,4	-1,4
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	140	136	140	138	112	89	73	0,0	-0,9	-2,1	-2,2	-2,0	-2,1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,47	0,64	0,64	0,61	0,56	0,52	0,9	-1,2	-0,4	-0,8	-0,7	-0,7
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

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Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**210,6**	**342,9**	**661,3**	**653,4**	**852,9**	**1.081,9**	**1.361,5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,0**	**-1,2**	**2,7**	**2,4**	**2,3**	**2,4**
Coal	12,39	32,89	192,23	183,54	185,97	194,05	184,85	5,9	9,6	29,1	28,1	21,8	17,9	13,6	9,9	-4,5	0,1	0,4	-0,5	-0,1
Oil	79,59	139,93	218,45	214,67	263,50	276,76	262,12	37,8	40,8	33,0	32,9	30,9	25,6	19,3	3,5	-1,7	2,1	0,5	-0,5	0,6
Natural gas	39,85	81,60	134,90	130,14	167,03	229,49	269,40	18,9	23,8	20,4	19,9	19,6	21,2	19,8	4,3	-3,5	2,5	3,2	1,6	2,3
Nuclear	0,00	0,00	0,00	0,00	0,00	4,93	9,04	0,0	0,0	0,0	0,0	0,0	0,5	0,7	-	-	-	-	6,3	-
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	1,76	41,47	128,78	0,0	0,0	0,0	0,0	0,2	3,8	9,5	-	-	31,7	37,2	12,0	-
Hydro	2,41	4,36	15,32	16,08	25,41	38,54	66,44	1,1	1,3	2,3	2,5	3,0	3,6	4,9	6,6	5,0	4,7	4,3	5,6	4,8
Geothermal	5,67	12,27	21,32	23,73	75,04	78,92	120,29	2,7	3,6	3,2	3,6	8,8	7,3	8,8	4,7	11,3	12,2	0,5	4,3	5,7
Others	70,74	71,81	79,13	85,15	134,18	217,68	320,61	33,6	20,9	12,0	13,0	15,7	20,1	23,5	0,4	7,6	4,7	5,0	3,9	4,6
Biomass	70,69	57,61	62,13	64,88	87,18	124,67	160,71	33,6	16,8	9,4	9,9	10,2	11,5	11,8	-0,4	4,4	3,0	3,6	2,6	3,1
Solar, Wind, Ocean	0,00	0,00	2,47	3,66	17,92	42,59	79,36	0,0	0,0	0,4	0,6	2,1	3,9	5,8	-	48,3	17,2	9,0	6,4	11,8
Biofuels	0,00	0,00	9,66	12,54	25,02	41,69	60,33	0,0	0,0	1,5	1,9	2,9	3,9	4,4	-	29,8	7,2	5,2	3,8	6,1
Electricity	0,05	0,01	4,87	4,07	4,06	8,73	20,21	0,0	0,0	0,7	0,6	0,5	0,8	1,5	16,9	-16,3	0,0	8,0	8,8	4,7

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**130,34**	**219,98**	**447,72**	**448,22**	**589,77**	**748,54**	**914,51**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**0,1**	**2,8**	**2,4**	**2,0**	**2,3**
Industry	36,50	70,62	150,16	148,76	208,57	263,52	301,20	28,0	32,1	33,5	33,2	35,4	35,2	32,9	5,0	-0,9	3,4	2,4	1,3	2,3
Transportation	30,56	57,15	141,52	140,29	184,65	245,54	325,76	23,4	26,0	31,6	31,3	31,3	32,8	35,6	5,4	-0,9	2,8	2,9	2,9	2,7
Others	52,94	70,41	107,72	110,10	138,30	172,39	210,47	40,6	32,0	24,1	24,6	23,5	23,0	23,0	2,5	2,2	2,3	2,2	2,0	2,2
Non-energy	10,33	21,80	48,32	49,07	58,25	67,08	77,08	7,9	9,9	10,8	10,9	9,9	9,0	8,4	5,5	1,5	1,7	1,4	1,4	1,5
Total	**130,4**	**220,0**	**447,7**	**448,2**	**589,8**	**747,9**	**912,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4,3**	**0,1**	**2,8**	**2,4**	**2,0**	**2,3**
Coal	4,73	13,71	52,04	53,19	78,72	84,05	79,57	3,6	6,2	11,6	11,9	13,3	11,2	8,7	8,6	2,2	4,0	0,7	-0,5	1,4
Oil	63,37	118,73	209,46	208,71	254,76	269,91	256,31	48,6	54,0	46,8	46,6	43,2	36,1	28,1	4,2	-0,4	2,0	0,6	-0,5	0,7
Natural gas	11,15	19,37	45,55	44,09	59,15	67,86	74,11	8,6	8,8	10,2	9,8	10,0	9,1	8,1	5,0	-3,2	3,0	1,4	0,9	1,6
Hydrogen/Ammonia	0,00	0,06	0,00	0,00	0,00	44,46	109,83	0,0	12,6	0,0	0,0	0,0	5,9	12,0		-	-	-	9,5	-
Electricity	11,13	27,63	92,24	91,06	134,07	200,93	292,52	8,5	0,0	20,6	20,3	22,7	26,9	32,1	7,6	-1,3	3,9	4,1	3,8	3,8
Heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	18,4	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	39,97	40,54	48,43	51,18	63,06	80,74	99,93	30,7	0,0	10,8	11,4	10,7	10,8	11,0	0,7	5,7	2,1	2,5	2,2	2,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**155,2**	**365,1**	**1.142,4**	**1.120,3**	**1.652,5**	**2.541,0**	**3.848,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,1**	**-1,9**	**4,0**	**4,4**	**4,2**	**4,0**
Coal PP	27,99	77,05	493,07	444,96	348,45	247,82	157,51	18,0	0,0	43,2	39,7	21,1	9,8	4,1	10,4	-9,8	-2,4	-3,4	-4,4	-3,6
Coal PP with CCS	0,00	0,00	0,00	11,15	69,91	249,50	346,33	0,0	0,0	0,0	1,0	4,2	9,8	9,0	-	-	20,1	13,6	3,3	-
Oil	63,46	65,00	18,90	14,64	24,44	16,89	13,71	40,9	0,0	1,7	1,3	1,5	0,7	0,4	-4,1	-22,5	5,3	-3,6	-2,1	-1,0
Gas PP	28,46	160,44	347,30	344,20	349,66	219,78	131,47	18,3	0,0	30,4	30,7	21,2	8,6	3,4	9,0	-0,9	0,2	-4,5	-5,0	-3,1
Gas PP PP with CCS	0,00	0,02	42,51	33,53	209,81	660,80	984,94	0,0	0,0	3,7	3,0	12,7	26,0	25,6	-	-21,1	20,1	12,2	4,1	10,7
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,63	9,84	18,65	252,34	0,0	0,0	0,0	0,1	0,6	0,7	6,6	-	-	31,7	6,6	29,8	-
Nuclear	0,00	0,00	0,00	0,00	0,00	18,92	34,69	0,0	0,0	0,0	0,0	0,0	0,7	0,9	-	-	-	-	6,3	-
Solar	0,17	0,00	14,66	20,47	119,12	238,18	407,43	0,1	0,0	1,3	1,8	7,2	9,4	10,6	16,6	39,6	19,3	7,2	5,5	11,3
Wind	0,00	0,00	4,50	6,23	59,63	202,06	431,26	0,0	0,0	0,4	0,6	3,6	8,0	11,2	-	38,4	25,3	13,0	7,9	15,9
Hydro	28,08	47,28	174,63	183,63	291,24	412,83	703,58	18,1	0,0	15,3	16,4	17,6	16,2	18,3	6,5	5,2	4,7	3,6	5,5	4,6
Geothermal	6,59	14,27	24,79	27,60	87,26	91,78	139,88	4,2	3,9	2,2	2,5	5,3	3,6	3,6	4,7	11,3	12,2	0,5	4,3	5,7
Others	0,43	1,00	22,01	33,29	83,10	163,75	245,08	0,3	0,3	1,9	3,0	5,0	6,4	6,4	14,5	51,3	9,6	7,0	4,1	8,1

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**31,1**	**71,8**	**220,7**	**206,8**	**212,1**	**264,2**	**339,3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7,0**	**-6,3**	**0,3**	**2,2**	**2,5**	**1,4**
Coal	7,37	19,00	140,18	130,35	107,25	110,01	105,28	23,7	26,5	63,5	63,0	50,6	41,6	31,0	10,7	-7,0	-1,9	0,3	-0,4	-0,9
Oil	16,68	18,57	5,22	4,07	6,26	4,24	3,31	53,6	25,9	2,4	2,0	3,0	1,6	1,0	-3,9	-22,1	4,4	-3,8	-2,4	-1,5
Gas	7,07	34,24	75,35	72,29	96,78	146,60	185,47	22,7	47,7	34,1	35,0	45,6	55,5	54,7	8,5	-4,1	3,0	4,2	2,4	2,9
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	1,76	3,35	45,27	0,0	0,0	0,0	0,1	0,8	1,3	13,3	-	-	31,7	6,6	29,8	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**33,1**	**36,2**	**35,1**	**35,3**	**41,0**	**46,0**	**47,8**								**0,2**	**0,5**	**1,5**	**1,1**	**0,4**	**1,0**
Coal	32,67	34,88	30,25	30,09	33,55	38,88	41,16								-0,3	-0,5	1,1	1,5	0,6	1,0
Oil	32,72	30,10	31,15	30,98	33,60	34,23	35,56								-0,2	-0,6	0,8	0,2	0,4	0,4
Gas	34,65	40,31	44,49	44,94	49,71	51,66	51,77								0,9	1,0	1,0	0,4	0,0	0,5
Hydrogen/Ammonia	-	-	-	47,99	47,95	47,94	47,94								-	-	0,0	0,0	0,0	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**103,9**	**161,5**	**423,7**	**408,4**	**453,4**	**439,0**	**301,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5,0**	**-3,6**	**1,0**	**-0,3**	**-3,7**	**-1,1**
Coal	19,40	40,16	201,42	191,74	189,87	168,00	85,70	18,7	24,9	47,5	46,9	41,9	38,3	28,5	8,4	-4,8	-0,1	-1,2	-6,5	-2,7
Oil	51,82	72,00	156,46	154,54	189,62	193,17	170,56	49,9	44,6	36,9	37,8	41,8	44,0	56,6	3,9	-1,2	2,1	0,2	-1,2	0,3
Natural gas	32,66	49,38	65,79	62,13	73,89	77,86	44,94	31,4	30,6	15,5	15,2	16,3	17,7	14,9	2,4	-5,6	1,7	0,5	-5,3	-1,2

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	742	1.185	3.046	2.912	4.591	7.022	10.494	5,0	-4,4	4,7	4,3	4,1	4,1
Population (millions of people)	435	518	661	667	729	787	841	1,5	0,9	0,9	0,8	0,7	0,8
GDP per capita (thousands of 2015 USD/person)	1,71	2,29	4,61	4,37	6,3	8,9	12,5	3,5	-5,3	3,7	3,6	3,4	3,3
Primary energy consumption per capita (toe/person)	0,48	0,66	1,00	0,98	1,17	1,37	1,62	2,5	-2,1	1,8	1,6	1,6	1,6
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	284	289	217	224	186	154	130	-0,9	3,3	-1,9	-1,9	-1,7	-1,6
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	176	186	147	154	128	107	87	-0,6	4,7	-1,8	-1,8	-2,0	-1,7
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	140	136	139	140	99	63	29	0,0	0,8	-3,4	-4,5	-7,5	-5,0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,49	0,47	0,64	0,63	0,53	0,41	0,22	0,9	-2,4	-1,6	-2,7	-5,9	-3,4
Automobile ownership volume (millions of vehicles)								-	-	-		-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-		-	-

EAS 17 Countries BAU

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.908,21**	**4.993,00**	**8.046,02**	**7.744,09**	**9.004,48**	**9.754,97**	**10.467,49**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,5**	**-3,8**	**1,5**	**0,8**	**0,7**	**0,9**
Coal	1.233,77	1.565,04	3.195,14	3.066,14	3.348,18	3.411,98	3.400,66	31,6	31,3	39,7	39,6	37,2	35,0	32,5	3,3	-4,0	0,9	0,2	0,0	0,2
Oil	1.349,55	1.735,87	2.208,63	2.028,88	2.420,33	2.650,52	2.915,38	34,5	34,8	27,4	26,2	26,9	27,2	27,9	1,7	-8,1	1,8	0,9	1,0	0,9
Natural gas	567,09	780,14	1.360,03	1.338,67	1.646,36	1.859,44	2.046,93	14,5	15,6	16,9	17,3	18,3	19,1	19,6	3,1	-1,6	2,1	1,2	1,0	1,3
Nuclear	227,44	328,92	377,25	372,97	412,42	440,55	483,91	5,8	6,6	4,7	4,8	4,6	4,5	4,6	1,8	-1,1	1,0	0,7	0,9	0,8
Hydro	54,27	62,74	170,26	175,10	204,32	226,25	244,24	1,4	1,3	2,2	2,2	2,3	2,3	2,3	4,1	-2,8	1,8	1,0	0,8	1,1
Geothermal	22,84	32,08	56,61	59,30	101,81	134,50	163,45	0,6	0,6	0,7	0,8	1,1	1,4	1,6	3,2	4,8	5,6	2,8	2,0	3,5
Others	453,26	488,22	673,26	707,87	871,06	1.031,74	1.212,93	11,6	9,8	8,4	9,1	9,7	10,6	11,6	1,4	5,1	2,1	1,7	1,6	1,9
Biomass	451,04	481,61	516,69	532,09	577,20	591,36	604,38	11,5	9,6	6,4	6,9	6,4	6,1	5,8	0,5	3,0	0,8	0,2	0,2	0,5
Solar, Wind, Ocean	1,72	4,28	140,39	162,94	274,16	405,99	553,95	0,0	0,1	1,7	2,1	3,0	4,2	5,3	16,4	16,1	5,3	4,0	3,2	4,5
Biofuels	0,00	0,00	9,66	8,51	15,83	28,08	47,54	0,0	0,0	0,1	0,1	0,2	0,3	0,5	-	-11,9	6,4	5,9	5,4	5,3
Electricity	0,19	2,32	6,82	4,28	3,81	6,24	7,00	0,0	0,0	0,1	0,1	0,0	0,1	0,1	13,1	-37,2	-1,1	5,0	1,2	0,1

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.719,19**	**3.383,20**	**5.317,50**	**5.135,40**	**5.928,42**	**6.424,64**	**6.965,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-3,4**	**1,4**	**0,8**	**0,8**	**0,9**
Industry	763,21	959,11	1.840,42	1.798,75	1.996,83	2.055,96	2.102,97	28,1	28,3	34,6	35,0	33,7	32,0	30,2	3,1	-2,3	1,1	0,3	0,2	0,4
Transportation	679,63	905,93	1.352,63	1.214,36	1.522,77	1.739,12	2.040,07	25,0	26,8	25,4	23,6	25,7	27,1	29,3	2,4	-10,2	2,3	1,3	1,6	1,3
Others	1.046,11	1.192,00	1.596,00	1.604,58	1.802,69	1.951,82	2.088,51	38,5	35,2	30,0	31,2	30,4	30,4	30,0	1,5	0,5	1,2	0,8	0,7	0,9
Non-energy	230,23	326,16	528,45	517,71	606,13	677,74	734,22	8,5	9,6	9,9	10,1	10,2	10,5	10,5	2,9	-2,0	1,6	1,1	0,8	1,1
Total	**2.719,21**	**3.383,21**	**5.317,51**	**5.135,40**	**5.928,42**	**6.424,64**	**6.965,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-3,4**	**1,4**	**0,8**	**0,8**	**0,9**
Coal	454,05	388,55	780,88	761,53	718,32	676,51	653,45	16,7	11,5	14,7	14,8	12,1	10,5	9,4	1,9	-2,5	-0,6	-0,6	-0,3	-0,6
Oil	1.139,07	1.512,47	2.014,83	1.862,40	2.227,03	2.449,61	2.706,01	41,9	44,7	37,9	36,3	37,6	38,1	38,8	2,0	-7,6	1,8	1,0	1,0	1,0
Natural gas	353,92	450,09	707,53	700,57	802,49	840,01	868,24	13,0	13,3	13,3	13,6	13,5	13,1	12,5	2,4	-1,0	1,4	0,5	0,3	0,7
Electricity	382,26	573,32	1.241,78	1.237,35	1.592,06	1.896,59	2.200,18	14,1	16,9	23,4	24,1	26,9	29,5	31,6	4,1	-0,4	2,6	1,8	1,5	1,9
Heat	15,57	34,62	123,40	126,53	132,50	128,84	121,53	0,6	1,0	2,3	2,5	2,2	2,0	1,7	7,4	2,5	0,5	-0,3	-0,6	0,0
Others	374,35	424,16	449,09	447,03	456,03	433,09	416,36	13,8	12,5	8,4	8,7	7,7	6,7	6,0	0,6	-0,5	0,2	-0,5	-0,4	-0,2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5.422,00**	**7.903,07**	**16.533,51**	**16.474,36**	**21.263,43**	**24.873,22**	**28.514,50**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-0,4**	**2,6**	**1,6**	**1,4**	**1,8**
Coal	2.622,45	4.167,97	8.350,81	8.134,13	9.905,27	10.665,69	11.268,13	48,4	52,7	50,5	49,4	46,6	42,9	39,5	4,1	-2,6	2,0	0,7	0,6	1,0
Oil	528,96	425,58	121,55	108,66	87,92	56,78	33,46	9,8	5,4	0,7	0,7	0,4	0,2	0,1	-4,9	-10,6	-2,1	-4,3	-5,2	-4,1
Natural gas	620,23	1.166,31	2.897,57	2.831,81	3.972,36	4.957,40	5.932,17	11,4	14,8	17,5	17,2	18,7	19,9	20,8	5,5	-2,3	3,4	2,2	1,8	2,3
Nuclear	872,89	1.262,37	1.447,85	1.431,40	1.583,97	1.693,28	1.858,76	16,1	16,0	8,8	8,7	7,4	6,8	6,5	1,8	-1,1	1,0	0,7	0,9	0,8
Hydro	631,20	729,71	2.024,23	1.966,33	2.363,45	2.619,32	2.825,89	11,6	9,2	12,2	11,9	11,1	10,5	9,9	4,1	-2,9	1,9	1,0	0,8	1,1
Geothermal	26,53	35,27	54,31	57,52	121,32	175,11	215,62	0,5	0,4	0,3	0,3	0,6	0,7	0,8	2,5	5,9	7,7	3,7	2,1	4,5
Others	119,74	115,84	1.637,19	1.944,51	3.229,15	4.705,63	6.380,47	2,2	1,5	9,9	11,8	15,2	18,9	22,4	9,4	18,8	5,2	3,8	3,1	4,5

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**906,29**	**1.397,74**	**2.605,20**	**2.521,82**	**3.024,65**	**3.285,30**	**3.434,89**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**-3,2**	**1,8**	**0,8**	**0,4**	**0,9**
Coal	645,58	1.023,32	2.054,90	1.994,13	2.321,09	2.437,25	2.452,81	71,2	73,2	78,9	79,1	76,7	74,2	71,4	4,1	-3,0	1,5	0,5	0,1	0,6
Oil	119,50	133,45	31,02	25,99	21,15	13,18	7,70	13,2	9,5	1,2	1,0	0,7	0,4	0,2	-4,5	-16,2	-2,0	-4,6	-5,2	-4,4
Natural gas	141,21	240,96	519,28	501,70	682,42	834,88	974,38	15,6	17,2	19,9	19,9	22,6	25,4	28,4	4,6	-3,4	3,1	2,0	1,6	2,1

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,8**	**35,4**	**37,5**	**37,8**	**39,7**	**41,0**	**43,1**	**0,2**	**0,6**	**0,5**	**0,3**	**0,5**	**0,5**
Coal	34,9	35,0	34,9	35,1	36,7	37,6	39,5	0,0	0,4	0,5	0,3	0,5	0,4
Oil	38,1	27,4	33,7	36,0	35,8	37,1	37,4	-0,4	6,7	-0,1	0,4	0,1	0,3
Natural gas	37,8	41,6	48,0	48,5	50,1	51,1	52,4	0,8	1,2	0,3	0,2	0,3	0,3

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.556,5**	**3.331,4**	**5.605,8**	**5.340,5**	**6.089,3**	**6.425,7**	**6.708,7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,7**	**-4,7**	**1,3**	**0,5**	**0,4**	**0,6**
Coal	1.280,83	1.701,54	3.347,57	3.237,51	3.534,58	3.598,21	3.584,53	50,1	51,1	59,7	60,6	58,0	56,0	53,4	3,4	-3,3	0,9	0,2	0,0	0,2
Oil	918,29	1.143,32	1.440,39	1.296,42	1.564,72	1.716,73	1.909,91	35,9	34,3	25,7	24,3	25,7	26,7	28,5	1,6	-10,0	1,9	0,9	1,1	0,9
Natural gas	357,42	486,52	817,89	806,60	989,98	1.110,72	1.214,22	14,0	14,6	14,6	15,1	16,3	17,3	18,1	2,9	-1,4	2,1	1,2	0,9	1,3

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	16.605	24.208	47.844	46.818	69.793	96.961	129.204	3,7	-2,1	4,1	3,3	2,9	3,26
Population (millions of people)	2.880	3.316	3.961	3.988	4.178	4.315	4.371	1,1	0,7	0,5	0,3	0,1	0,32
GDP per capita (thousands of 2015 USD/person)	5,77	7,30	12,08	11,74	16,71	22,47	29,56	2,6	-2,8	3,6	3,0	2,8	2,93
Primary energy consumption per capita (toe/person)	1,36	1,51	2,03	1,94	2,16	2,26	2,39	1,4	-4,4	1,1	0,5	0,6	0,53
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	235	206	168	165	129	101	81	-1,2	-1,6	-2,5	-2,5	-2,1	-2,33
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	164	140	111	110	85	66	54	-1,3	-1,3	-2,5	-2,5	-2,0	-2,31
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	154	138	117	114	87	66	52	-0,9	-2,6	-2,6	-2,7	-2,4	-2,59
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,67	0,70	0,69	0,68	0,66	0,64	0,2	-1,0	-0,2	-0,3	-0,3	-0,27
Automobile ownership volume (millions of vehicles)	271	346	714	728	961	1.307	1.834	3,4	2,1	2,8	3,1	3,4	3,09
Automobile ownership volume per capita (vehicles per person)	0,094	0,104	0,180	0,183	0,230	0,303	0,419	2,3	1,4	2,3	2,8	3,3	2,76

EAS 17 Countries APS

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.908,21**	**4.993,00**	**8.046,02**	**7.740,74**	**8.554,54**	**8.596,60**	**8.558,09**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,5**	**-3,8**	**1,0**	**0,0**	**0,0**	**0,2**
Coal	1.233,77	1.565,04	3.195,14	3.060,84	2.846,58	2.311,92	1.765,00	31,6	31,3	39,7	39,5	33,3	26,9	20,6	3,3	-4,2	-0,7	-2,1	-2,7	-1,9
Oil	1.349,55	1.735,87	2.208,63	2.022,54	2.254,63	2.201,68	2.143,68	34,5	34,8	27,4	26,1	26,4	25,6	25,0	1,7	-8,4	1,1	-0,2	-0,3	-0,1
Natural gas	567,09	780,14	1.360,03	1.340,51	1.546,72	1.609,76	1.511,69	14,5	15,6	16,9	17,3	18,1	18,7	17,7	3,1	-1,4	1,4	0,4	-0,6	0,3
Nuclear	227,44	328,92	377,25	372,97	513,18	616,39	730,17	5,8	6,6	4,7	4,8	6,0	7,2	8,5	1,8	-1,1	3,2	1,8	1,7	2,2
Hydro	54,27	62,74	175,10	170,64	211,18	237,44	261,70	1,4	1,3	2,2	2,2	2,5	2,8	3,1	4,1	-2,5	2,2	1,2	1,0	1,3
Geothermal	22,84	32,08	56,61	60,50	115,94	172,03	238,58	0,6	0,6	0,7	0,8	1,4	2,0	2,8	3,2	6,9	6,7	4,0	3,3	4,7
Others	453,26	488,22	673,26	712,74	1.066,30	1.447,37	1.907,26	11,6	9,8	8,4	9,2	12,5	16,8	22,3	1,4	5,9	4,1	3,1	2,8	3,4
Biomass	451,04	481,61	516,69	536,00	623,23	677,63	760,87	11,5	9,6	6,4	6,9	7,3	7,9	8,9	0,5	3,7	1,5	0,8	1,2	1,3
Solar, Wind, Ocean	1,72	4,28	140,39	163,27	422,56	735,33	1.094,86	0,0	0,1	1,7	2,1	4,9	8,6	12,8	16,4	16,3	10,0	5,7	4,1	6,9
Biofuels	0,00	0,00	9,66	9,58	18,06	30,79	46,34	0,0	0,0	0,1	0,1	0,2	0,4	0,5	-	-0,8	6,5	5,5	4,2	5,2
Electricity	0,19	2,21	6,82	4,19	2,75	3,91	5,41	0,0	0,0	0,1	0,1	0,0	0,0	0,1	13,1	-38,6	-4,1	3,6	3,3	-0,7

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.719,19**	**3.383,20**	**5.317,50**	**5.123,51**	**5.670,76**	**5.723,78**	**5.773,79**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-3,6**	**1,0**	**0,1**	**0,1**	**0,3**
Industry	763,21	959,11	1.840,42	1.795,01	1.942,74	1.859,68	1.726,37	28,1	28,3	34,6	35,0	34,3	32,5	29,9	3,1	-2,5	0,8	-0,4	-0,7	-0,2
Transportation	679,63	905,93	1.352,63	1.209,17	1.401,40	1.435,84	1.550,10	25,0	26,8	25,4	23,6	24,7	25,1	26,8	2,4	-10,6	1,5	0,2	0,8	0,4
Others	1.046,11	1.192,00	1.596,00	1.601,61	1.721,27	1.751,90	1.764,68	38,5	35,2	30,0	31,3	30,4	30,6	30,6	1,5	0,4	0,7	0,2	0,1	0,3
Non-energy	230,23	326,16	528,45	517,71	605,35	676,36	732,64	8,5	9,6	9,9	10,1	10,7	11,8	12,7	2,9	-2,0	1,6	1,1	0,8	1,1
Total	**2.719,21**	**3.383,21**	**5.317,51**	**5.135,40**	**5.928,42**	**6.424,64**	**6.965,76**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-3,4**	**1,4**	**0,8**	**0,8**	**0,9**
Coal	454,05	388,55	780,88	759,96	666,71	572,84	499,50	16,7	11,5	14,7	14,8	11,2	8,9	7,2	1,9	-2,7	-1,3	-1,5	-1,4	-1,4
Oil	1.139,07	1.512,47	2.014,83	1.855,71	2.077,45	2.041,02	2.002,71	41,9	44,7	37,9	36,1	35,0	31,8	28,8	2,0	-7,9	1,1	-0,2	-0,2	0,0
Natural gas	353,92	450,09	707,53	699,37	762,43	712,49	644,06	13,0	13,3	13,3	13,6	12,9	11,1	9,2	2,4	-1,2	0,9	-0,7	-1,0	-0,3
Electricity	382,26	573,32	1.241,78	1.234,25	1.582,05	1.861,98	2.119,52	14,1	16,9	23,4	24,0	26,7	29,0	30,4	4,1	-0,6	2,5	1,6	1,3	1,7
Heat	15,57	34,62	123,40	126,58	128,63	113,49	93,38	0,6	1,0	2,3	2,5	2,2	1,8	1,3	7,4	2,6	0,2	-1,2	-1,9	-0,9
Others	374,35	424,16	449,09	447,64	453,50	421,96	414,62	13,8	12,5	8,4	8,7	7,6	6,6	6,0	0,6	-0,3	0,1	-0,7	-0,2	-0,3

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5.422,00**	**7.903,07**	**16.533,51**	**16.433,05**	**21.120,42**	**24.550,00**	**27.531,73**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-0,6**	**2,5**	**1,5**	**1,2**	**1,7**
Coal	2.622,45	4.167,97	8.350,81	8.103,61	7.874,20	6.262,98	4.469,22	48,4	52,7	50,5	49,3	37,3	25,5	16,2	4,1	-3,0	-0,3	-2,3	-3,3	-2,0
Oil	528,96	425,58	121,55	108,53	68,19	41,89	22,99	9,8	5,4	0,7	0,7	0,3	0,2	0,1	-4,9	-10,7	-4,5	-4,8	-5,8	-5,2
Natural gas	620,23	1.166,31	2.897,57	2.820,64	3.639,41	4.348,27	4.328,46	11,4	14,8	17,5	17,2	17,2	17,7	15,7	5,5	-2,7	2,6	1,8	0,0	1,3
Nuclear	872,89	1.262,37	1.447,85	1.431,40	1.969,55	2.365,66	2.802,31	16,1	16,0	8,8	8,7	9,3	9,6	10,2	1,8	-1,1	3,2	1,8	1,7	2,2
Hydro	631,20	729,71	2.024,23	1.967,85	2.428,82	2.736,80	3.017,68	11,6	9,2	12,2	12,0	11,5	11,1	11,0	4,1	-2,8	2,1	1,2	1,0	1,3
Geothermal	26,53	35,27	54,31	58,81	154,14	246,41	348,54	0,5	0,4	0,3	0,4	0,7	1,0	1,3	2,5	8,3	10,1	4,8	3,5	6,2
Others	119,74	115,84	1.637,19	1.942,21	4.986,11	8.547,99	12.542,53	2,2	1,5	9,9	11,8	23,6	34,8	45,6	9,4	18,6	9,9	5,5	3,9	6,8

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**906,29**	**1.397,74**	**2.605,20**	**2.523,51**	**2.525,57**	**2.187,91**	**1.702,03**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**-3,1**	**0,0**	**-1,4**	**-2,5**	**-1,4**
Coal	645,58	1.023,32	2.054,90	1.991,48	1.882,60	1.462,72	1.002,67	71,2	73,2	78,9	78,9	74,5	66,9	58,9	4,1	-3,1	-0,6	-2,5	-3,7	-2,3
Oil	119,50	133,45	31,02	26,32	17,08	9,93	5,26	13,2	9,5	1,2	1,0	0,7	0,5	0,3	-4,5	-15,2	-4,2	-5,3	-6,2	-5,6
Natural gas	141,21	240,96	519,28	505,72	625,89	715,26	694,10	15,6	17,2	19,9	20,0	24,8	32,7	40,8	4,6	-2,6	2,2	1,3	-0,3	0,9

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,8**	**35,4**	**37,5**	**37,6**	**39,4**	**41,9**	**44,6**								**0,2**	**0,2**	**0,5**	**0,6**	**0,6**	**0,6**
Coal	34,9	35,0	34,9	35,0	36,0	36,8	38,3								0,0	0,1	0,3	0,2	0,4	0,3
Oil	38,1	27,4	33,7	35,5	34,3	36,3	37,6								-0,4	5,3	-0,3	0,6	0,3	0,4
Natural gas	37,8	41,6	48,0	48,0	50,0	52,3	53,6								0,8	0,0	0,4	0,4	0,3	0,4

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.556,5**	**3.331,4**	**5.605,8**	**5.331,4**	**5.307,2**	**4.607,1**	**3.760,2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,7**	**-4,9**	**0,0**	**-1,4**	**-2,0**	**-1,3**
Coal	1.280,83	1.701,54	3.347,57	3.231,93	2.975,64	2.397,69	1.716,63	50,1	51,1	59,7	60,6	56,1	52,0	45,7	3,4	-3,5	-0,8	-2,1	-3,3	-2,1
Oil	918,29	1.143,32	1.440,39	1.291,04	1.431,10	1.364,91	1.311,44	35,9	34,3	25,7	24,2	27,0	29,6	34,9	1,6	-10,4	1,0	-0,5	-0,4	-0,3
Natural gas	357,42	486,52	817,89	808,41	900,45	844,46	732,10	14,0	14,6	14,6	15,2	17,0	18,3	19,5	2,9	-1,2	1,1	-0,6	-1,4	-0,4

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	16.605	24.208	47.844	46.818	69.793	96.961	129.204	3,7	-2,1	4,1	3,3	2,9	3,26
Population (millions of people)	2.880	3.316	3.961	3.988	4.178	4.315	4.371	1,1	0,7	0,5	0,3	0,1	0,32
GDP per capita (thousands of 2015 USD/person)	5,77	7,30	12,08	11,74	16,71	22,47	29,56	2,6	-2,8	3,6	3,0	2,8	2,93
Primary energy consumption per capita (toe/person)	1,36	1,51	2,03	1,94	2,05	1,99	1,96	1,4	-4,4	0,5	-0,3	-0,2	-0,12
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	235	206	168	165	123	89	66	-1,2	-1,7	-2,9	-3,2	-2,9	-2,96
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	164	140	111	109	81	59	45	-1,3	-1,5	-2,9	-3,1	-2,7	-2,90
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	154	138	117	114	76	48	29	-0,9	-2,8	-4,0	-4,6	-4,8	-4,39
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,67	0,70	0,69	0,62	0,54	0,44	0,2	-1,1	-1,0	-1,5	-2,0	-1,48
Automobile ownership volume (millions of vehicles)	271	346	714	728	961	1.307	1.834	3,4	2,1	2,8	3,1	3,4	3,09
Automobile ownership volume per capita (vehicles per person)	0,094	0,104	0,180	0,183	0,230	0,303	0,419	2,3	1,4	2,3	2,8	3,3	2,76

EAS 17 Countries LCET

Primary energy consumption

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**3.908,21**	**4.990,90**	**8.046,04**	**7.534,38**	**7.982,93**	**7.786,18**	**7.347,36**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,5**	**-6,4**	**0,6**	**-0,2**	**-0,6**	**-0,3**
Coal	1.233,77	1.565,04	3.195,14	3.058,84	2.434,86	1.952,32	1.036,57	31,6	31,4	39,7	40,6	30,5	25,1	14,1	3,3	-4,3	-2,3	-2,2	-6,1	-3,6
Oil	1.349,55	1.735,87	2.208,58	2.035,28	2.138,04	1.624,86	1.166,85	34,5	34,8	27,4	27,0	26,8	20,9	15,9	1,7	-7,8	0,5	-2,7	-3,3	-2,0
Natural gas	567,09	780,14	1.360,10	1.341,79	1.360,99	1.285,35	1.118,24	14,5	15,6	16,9	17,8	17,0	16,5	15,2	3,1	-1,3	0,1	-0,6	-1,4	-0,6
Nuclear	227,44	328,92	377,25	372,97	530,89	763,90	1.026,99	5,8	6,6	4,7	5,0	6,7	9,8	14,0	1,8	-1,1	3,6	3,7	3,0	3,3
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	6,58	80,03	180,32	0,0	0,0	0,0	0,0	0,1	1,0	2,5	-	-	50,3	28,4	8,5	-
Hydro	54,27	62,74	175,10	170,78	216,57	270,17	325,18	1,4	1,3	2,2	2,3	2,7	3,5	4,4	4,1	-2,5	2,4	2,2	1,9	2,0
Geothermal	22,84	32,08	56,61	41,34	146,44	163,82	222,68	0,6	0,6	0,7	0,5	1,8	2,1	3,0	3,2	-27,0	13,5	1,1	3,1	4,5
Others	453,26	486,12	673,26	513,27	1.148,55	1.645,72	2.270,53	11,6	9,7	8,4	6,8	14,4	21,1	30,9	1,4	-23,8	8,4	3,7	3,3	4,0
Biomass	451,04	465,33	516,69	331,41	544,21	608,27	716,24	11,5	9,3	6,4	4,4	6,8	7,8	9,7	0,5	-35,9	5,1	1,1	1,6	1,1
Solar, Wind, Ocean	1,72	4,28	140,39	163,59	573,61	985,38	1.472,09	0,0	0,1	1,7	2,2	7,2	12,7	20,0	16,4	16,5	13,4	5,6	4,1	7,9
Biofuels	0,00	0,00	9,66	12,54	25,02	41,69	60,33	0,0	0,0	0,1	0,2	0,3	0,5	0,8	-	29,8	7,2	5,2	3,8	6,1
Electricity	0,19	2,21	6,82	6,02	6,01	10,68	22,15	0,0	0,0	0,1	0,1	0,1	0,1	0,3	13,1	-11,7	0,0	5,9	7,6	3,9

Final energy demand

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.719,19**	**3.381,10**	**5.317,50**	**4.919,30**	**5.356,19**	**4.954,99**	**4.644,64**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-7,5**	**0,9**	**-0,8**	**-0,6**	**-0,4**
Industry	763,21	959,11	1.840,42	1.799,85	1.861,96	1.713,47	1.515,93	28,1	28,4	34,6	36,6	34,8	34,6	32,6	3,1	-2,2	0,3	-0,8	-1,2	-0,6
Transportation	679,63	905,93	1.352,63	1.223,41	1.325,70	1.137,44	1.092,60	25,0	26,8	25,4	24,9	24,8	23,0	23,5	2,4	-9,6	0,8	-1,5	-0,4	-0,7
Others	1.046,11	1.189,90	1.596,00	1.378,01	1.561,94	1.425,83	1.300,55	38,5	35,2	30,0	28,0	29,2	28,8	28,0	1,5	-13,7	1,3	-0,9	-0,9	-0,7
Non-energy	230,23	326,16	528,45	518,03	606,59	678,25	735,57	8,5	9,6	9,9	10,5	11,3	13,7	15,8	2,9	-2,0	1,6	1,1	0,8	1,1
Total	**2.719,21**	**3.381,16**	**5.317,51**	**4.919,30**	**5.356,17**	**4.954,40**	**4.642,40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,3**	**-7,5**	**0,9**	**-0,8**	**-0,6**	**-0,4**
Coal	454,05	388,55	780,88	762,73	599,09	444,52	307,94	16,7	11,5	14,7	15,5	11,2	9,0	6,6	1,9	-2,3	-2,4	-2,9	-3,6	-3,0
Oil	1.139,07	1.512,47	2.014,83	1.868,22	1.979,08	1.497,54	1.070,77	41,9	44,7	37,9	38,0	36,9	30,2	23,1	2,0	-7,3	0,6	-2,7	-3,3	-2,0
Natural gas	353,92	450,09	707,53	701,57	645,14	447,42	299,02	13,0	13,3	13,3	14,3	12,0	9,0	6,4	2,4	-0,8	-0,8	-3,6	-3,9	-2,7
Hydrogen/Ammonia	0,00	0,06	0,00	0,00	15,27	175,58	339,13	0,0	0,0	0,0	0,0	0,3	3,5	7,3	-	-	158,0	27,7	6,8	-
Electricity	382,26	573,32	1.241,78	1.234,62	1.619,90	1.953,36	2.199,25	14,1	17,0	23,4	25,1	30,2	39,4	47,4	4,1	-0,6	2,8	1,9	1,2	1,9
Heat	15,57	34,62	123,40	126,58	118,60	80,88	45,89	0,6	1,0	2,3	2,6	2,2	1,6	1,0	7,4	2,6	-0,6	-3,8	-5,5	-3,1
Others	374,35	422,06	449,09	225,59	379,10	355,11	380,39	13,8	12,5	8,4	4,6	7,1	7,2	8,2	0,6	-49,8	5,3	-0,7	0,7	-0,5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**5.422,20**	**7.900,43**	**16.533,04**	**16.425,83**	**21.624,23**	**27.097,71**	**32.119,78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,9**	**-0,6**	**2,8**	**2,3**	**1,7**	**2,2**
Coal PP	2.622,65	4.168,83	8.350,81	8.073,88	6.606,81	3.532,37	1.000,22	48,4	52,8	50,5	49,2	30,6	13,0	3,1	4,1	-3,3	-2,0	-6,1	-11,9	-6,6
Coal PP with CCS	0,00	0,00	0,00	11,15	245,65	1.683,54	1.152,09	0,0	0,0	0,0	0,1	1,1	6,2	3,6	-	-	36,2	21,2	-3,7	-
Oil	528,96	425,58	121,57	109,71	80,26	50,54	21,87	9,8	5,4	0,7	0,7	0,4	0,2	0,1	-4,9	-9,8	-3,1	-4,5	-8,0	-5,4
Gas PP	620,23	1.166,31	2.855,06	2.781,08	2.878,72	1.466,42	484,85	11,4	14,8	17,3	16,9	13,3	5,4	1,5	5,4	-2,6	0,3	-6,5	-10,5	-5,6
Gas PP PP with CCS	0,00	0,02	42,51	33,53	345,59	2.070,42	2.896,81	0,0	0,0	0,3	0,2	1,6	7,6	9,0	-	-21,1	26,3	19,6	3,4	14,6
Hydrogen/Ammonia PP	0,00	0,00	0,00	0,63	26,58	543,95	1.538,53	0,0	0,0	0,0	0,0	0,1	2,0	4,8	-	-	45,5	35,2	11,0	-
Nuclear	872,89	1.262,37	1.447,85	1.431,40	2.037,52	2.931,76	3.941,48	16,1	16,0	8,8	8,7	9,4	10,8	12,3	1,8	-1,1	3,6	3,7	3,0	3,3
Solar	0,24	0,56	480,09	567,12	2.246,57	4.210,38	6.751,86	0,0	0,0	2,9	3,5	10,4	15,5	21,0	29,9	18,1	14,8	6,5	4,8	8,9
Wind	3,10	8,18	809,00	972,33	3.565,21	5.861,55	8.298,01	0,1	0,1	4,9	5,9	16,5	21,6	25,8	21,2	20,2	13,9	5,1	3,5	7,8
Hydro	631,20	726,21	2.032,93	1.982,73	2.514,44	3.106,65	3.712,75	11,6	9,2	12,3	12,1	11,6	11,5	11,6	4,1	-2,5	2,4	2,1	1,8	2,0
Geothermal	26,53	35,27	54,15	59,25	178,93	222,27	318,47	0,5	0,4	0,3	0,4	0,8	0,8	1,0	2,5	9,4	11,7	2,2	3,7	5,9
Others	116,40	107,09	339,08	403,03	897,95	1.417,87	2.002,83	2,1	1,4	2,1	2,5	4,2	5,2	6,2	3,8	18,9	8,3	4,7	3,5	5,9

Power generation Input

	Mtoe														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**906,29**	**1.397,74**	**2.605,20**	**2.518,16**	**2.157,23**	**1.976,26**	**1.379,95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3,7**	**-3,3**	**-1,5**	**-0,9**	**-3,5**	**-2,0**
Coal	645,58	1.023,32	2.054,90	1.986,71	1.575,46	1.248,51	505,95	71,2	73,2	78,9	78,9	73,0	63,2	36,7	4,1	-3,3	-2,3	-2,3	-8,6	-4,4
Oil	119,50	133,45	31,03	26,62	19,95	12,72	5,46	13,2	9,5	1,2	1,1	0,9	0,6	0,4	-4,5	-14,2	-2,8	-4,4	-8,1	-5,5
Gas	141,21	240,96	519,28	504,71	557,40	620,51	603,48	15,6	17,2	19,9	20,0	25,8	31,4	43,7	4,6	-2,8	1,0	1,1	-0,3	0,5
Hydrogen/Ammonia	0,00	0,00	0,00	0,11	4,43	94,52	265,06	0,0	0,0	0,0	0,0	0,2	4,8	19,2	-	-	44,4	35,8	10,9	-

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050								1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**35,8**	**35,4**	**37,5**	**37,6**	**40,6**	**40,7**	**44,2**								**0,2**	**0,2**	**0,8**	**0,0**	**0,8**	**0,5**
Coal	34,94	35,03	34,95	35,00	37,41	35,93	36,58								0,0	0,1	0,7	-0,4	0,2	0,1
Oil	38,07	27,43	33,69	35,44	34,60	34,17	34,44								-0,4	5,2	-0,2	-0,1	0,1	0,1
Gas	37,77	41,63	47,99	47,96	49,75	49,02	48,19								0,8	-0,1	0,4	-0,1	-0,2	0,0
Hydrogen/Ammonia	-	-	-	47,99	51,62	49,49	49,92								-	-	0,7	-0,4	0,1	-

CO_2 emissions

	Mt-C														AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
Total	**2.556,5**	**3.331,4**	**5.604,3**	**5.336,8**	**4.508,8**	**2.671,5**	**1.026,0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2,7**	**-4,8**	**-1,7**	**-5,1**	**-9,1**	**-5,3**
Coal	1.280,86	1.702,11	3.349,11	3.230,53	2.441,16	1.412,16	463,86	50,1	51,1	59,8	60,5	54,1	52,9	45,2	3,4	-3,5	-2,8	-5,3	-10,5	-6,2
Oil	918,95	1.144,30	1.438,14	1.298,51	1.302,92	829,44	421,24	35,9	34,3	25,7	24,3	28,9	31,0	41,1	1,6	-9,7	0,0	-4,4	-6,6	-3,9
Natural gas	356,73	484,98	817,04	807,77	764,75	429,92	140,89	14,0	14,6	14,6	15,1	17,0	16,1	13,7	2,9	-1,1	-0,5	-5,6	-10,6	-5,5

Energy and economic indicators

								AAGR (%)					
	1990	2000	2019	2020	2030	2040	2050	1990-2019	2019-2020	2020-2030	2030-2040	2040-2050	2019-2050
GDP (billions of 2015 US dollars)	16.605	24.208	47.844	46.818	69.793	96.961	129.204	3,7	-2,1	4,1	3,3	2,9	3,26
Population (millions of people)	2.880	3.316	3.961	3.988	4.178	4.315	4.371	1,1	0,7	0,5	0,3	0,1	0,32
GDP per capita (thousands of 2015 USD/person)	5,77	7,30	12,08	11,74	16,71	22,47	29,56	2,6	-2,8	3,6	3,0	2,8	2,93
Primary energy consumption per capita (toe/person)	1,36	1,50	2,03	1,89	1,91	1,80	1,68	1,4	-7,0	0,1	-0,6	-0,7	-0,61
Primary energy consumption per unit of GDP (toe/million 2015 US Dollars)	235	206	168	161	114	80	57	-1,2	-4,3	-3,4	-3,5	-3,4	-3,44
Final energy consumption per unit of GDP (toe/million 2015 US Dollars)	164	140	111	105	77	51	36	-1,3	-5,5	-3,1	-4,0	-3,5	-3,58
CO_2 emissions per unit of GDP (t-C/million 2015 US Dollars)	154	138	117	114	65	28	8	-0,9	-2,7	-5,5	-8,2	-11,7	-8,32
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0,65	0,67	0,70	0,71	0,56	0,34	0,14	0,2	1,7	-2,2	-4,9	-8,6	-5,05
Automobile ownership volume (millions of vehicles)	271	346	714	728	961	1.307	1.834	3,4	2,1	2,8	3,1	3,4	3,09
Automobile ownership volume per capita (vehicles per person)	0,094	0,104	0,180	0,183	0,230	0,303	0,419	2,3	1,4	2,3	2,8	3,3	2,76