

Energy Outlook and Energy Saving Potential in East Asia 2020

Edited by

Shigeru Kimura
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Energy Outlook and Energy Saving Potential East Asia 2020

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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 2019–2020. Members of the Working Group, who represent the participating countries of the East Asia Summit (EAS) region, discussed and agreed to certain key assumptions and modelling approaches to enable harmonisation of the forecasting techniques. These assumptions and modelling approaches 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 ASEAN and East Asia grouping faces tremendous challenges when it comes to the future energy landscape and in trying to determine how the energy transition will embrace new architectures including sound policy and technologies to ensure energy access with affordability, energy security, and energy sustainability. The economy of the East Asia Summit (EAS) countries has been hit by the coronavirus (COVID-19) pandemic, but energy demand growth is expected to bounce back strongly as the economy recovers after 2021. Thus, all decisions and energy policy measures will need to be weighed against potentially higher energy costs, affordability, and energy security risks for the post-Covid-19 era. ERIA will release its short-term energy outlook for EAS17 taking account of the impact of the pandemic in a separate report.

ERIA continuously updated the long-term energy outlooks (up to 2050) of the EAS17 countries in 2019–2020, based on national energy data and both existing and aggressive energy policies, in other word targets of energy efficiency and conservation (EEC) and renewable energy (RE). This report, produced to reflect the updated energy outlook results, was prepared by the Working Group for Analysis of Energy Saving Potential in East Asia under the ERIA Energy Project. It covers all research activities of the Working Group from August 2019 to May 2020, including methodology, estimated impacts of current energy saving goals, and policy recommendations to the EAS/ECTF.

It is highlighted that although EAS17 countries will rely on fossil fuels until 2050, the energy mix composition will change to more renewables and clean fuels. According to the previous EAS energy outlook, coal was dominant, followed by gas in terms of power generation. But this latest outlook shows a declining trend of coal due to a rapid increase of gas and Variable Renewable Energy (VRE) following of policy changes in EAS 17 countries.

To achieve sustainable energy development in EAS17, the clean use of fossil fuel through deployment of clean technologies is indispensable for decarbonising emissions. In addition, use of renewables, increasing energy efficiency, and use of new energy technologies such as CCUS/carbon recycling and hydrogen should be accelerated along with the adoption of clean technologies in the medium to long term in the EAS17's future energy system. Investment in energy efficiency will also help to avoid the building of more power plants.

We hope this report will contribute to mitigating the problems related to energy security and climate change by increasing understanding of the potential for energy saving of a range of energy efficiency goals, action plans, and policies. Several key insights for policy development are also discussed in the report. ERIA will include commercially available energy technologies in future such as CCUS and hydrogen into the next EAS energy outlook modelling.

A handwritten signature in black ink, reading "H. Nishimura". The signature is stylized with a large, flowing initial "H" and a cursive "Nishimura".

Professor Hidetoshi Nishimura
President of ERIA

Acknowledgement

This study is a joint effort of Working Group members from the East Asia Summit countries, Economic Research Institute for ASEAN and East Asia (ERIA), and The Institute of Energy Economics, Japan (IEEJ). We would like to acknowledge the support provided by everyone involved. We especially take this opportunity to thank the members of the Working Group, ERIA's energy team; the International Affairs Division of the Agency for Natural Resources and Energy (ANRE) of the Ministry of Economy, Trade and Industry (METI) of Japan; and IEEJ's energy outlook modelling team.

Special acknowledgement also goes to Dr. Phoumin Han, Dr. Alloysius Joko Purwanto, Ms. Clara Gillispie, and Ms. Cecilya Laksmiwati Malik for their contributions in technical editing of this report.

This study could not have been realised without the invaluable support and contributions provided by many people (please see details in the 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 the report and prepare it for publication.

Shigeru Kimura

Leader of the Working Group, 2020



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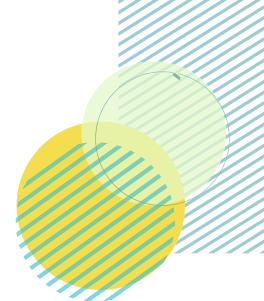


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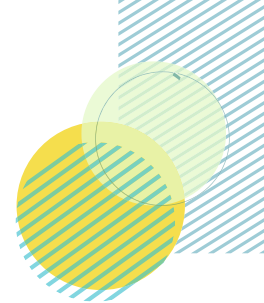
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List of Project Members



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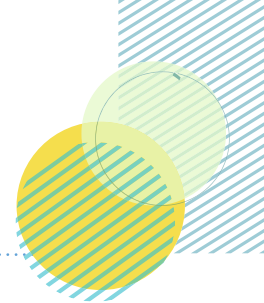
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Executive Summary



The Economic Research Institute for ASEAN and East Asia (ERIA) updated the East Asia Summit (EAS) Energy Outlook in 2019–2020 by revising the macro assumptions such as economic and population growth as well as crude oil price under the lower scenario in 2019 level. This outlook also incorporates more recent information on the EAS17 member countries' energy saving potentials and energy efficiency goals, action plans, and policies, including power development plans such as renewable electricity. However, this outlook does not reflect the impact of the coronavirus (COVID-19) pandemic.

The outlook still focuses on analysing the additional energy savings and renewable energy (RE) penetration that might be achieved by the individual countries above and beyond the Business-as-Usual (BAU) scenario projection. It continues to examine two scenarios – the BAU and the Alternative Policy Scenario (APS) – and the outlook predicts energy supply, consumption, and associated CO₂ emission from 2017 up until 2050. The APS includes not only more ambitious energy saving targets, but also rapid advances in low-carbon energy technologies and renewable energy.

Under the BAU scenario, sustained population growth and economic growth will significantly increase Total Final Energy Consumption (TFEC), by 1.4 times, from 2017 to 2050. The Primary energy supply in the EAS17 region is projected to grow at the same pace as TFEC – by 1.1% per year. EAS17 primary energy supply is projected to increase from 7,625 Mtoe in 2017 to 10,780 Mtoe in 2050. Coal will remain the largest share of primary energy supply, but its growth is expected to be slower, increasing by 0.3% per year from 2017–2050. Consequently, the share of coal in Total Primary Energy Supply (TPES) is forecast to decline from 40.2% in 2017 to 31.7% in 2050.

Fossil fuel energy consisting of coal, oil, and gas will still be dominant in 2050 and its share under the BAU will be 81.3%. If EAS17 countries remain dedicated to implementing their energy efficiency and conservation (EEC) policies and increase low-carbon energy technologies such as nuclear power generation and solar photovoltaic (PV)/wind (APS), the EAS17 region could achieve TPES savings of 17.8% and the fossil fuel share could fall to 69.7% by 2050. Consequently, CO₂ emissions would fall significantly, by about 37.9%, from BAU to APS in 2050. It is essential, therefore, that EAS17 countries implement their EEC and renewable energy policies (energy saving targets and action plans) as scheduled.

The targets and action plans that will be applied across sectors – industry, transport, residential, and commercial – should be appropriate and feasible.

Renewable energy such as hydro, geothermal, solar PV, and wind and biomass will also contribute to the expected reduction of fossil fuel consumption, which will result in a mitigation of CO₂ emissions. To increase the share of renewable energy in the primary energy mix, appropriate government policies will be crucial. Policies such as renewable energy targets, Renewable Portfolio Standards (RPS), and Feed-in-Tariff (FIT) have been implemented in some of the EAS17 member countries and have accelerated the deployment of renewable energy domestically.

Energy supply security has become a the priority energy issue for the EAS17 region. Implementing EEC measures and increasing renewable energy shares will certainly contribute to maintaining regional energy security through the reduction of fossil fuel consumption and increasing the use of domestic energy. For ASEAN, regional energy networks such as the Trans-ASEAN Gas Pipeline (TAGP) with virtual pipelines of LNG and the ASEAN Power Grid (APG), are recommended to maintain energy supply security in the region. Nuclear power generation is another option for securing the energy supply in the region.

The ERIA EAS17 Energy Outlook 2020 showed that coal power generation will remain dominant in the EAS17 region up until 2050. Increasing the use of Clean Coal Technology (CCT) and development of Carbon Capture Storage (CCS) technology will be critical for the coal power plants in this region to become carbon free. Hydrogen technology will also play a key role as an alternative to fossil fuels and can be applied across sectors such as power generation, industry, and transportation.

The Energy Outlook also includes an estimation of the investment cost required for power generation and the other energy infrastructure including the LNG receiving terminals, and oil refineries. The analysis results indicate that the EAS17 region will need around US\$3.92 trillion for the BAU case, and US\$5.93 trillion in the APS for power generation investment to meet electricity demand by 2050. The reason why investment in the APS is bigger than under BAU is an aggressive shift to variable renewable energy (VRE) such as Solar PV and wind.

The required investment cost of refinery and LNG receiving terminals in EAS17 will amount to US\$410 billion and US\$164 billion, respectively, in the BAU scenario. The investment in the APS is expected to result in a reduction of US\$77 billion for LNG receiving terminals due to the promotion of energy efficiency. However, these investment costs will be much lower than the investment cost for power generation. The share of investment cost of refineries and LNG receiving terminals in power generation facilities will be 14% under BAU and 1.2% in the APS, respectively. These results seem to indicate that petroleum demand will saturate, but that other VRE power generation will expand sharply due to an expected stable increase in electricity demand and the low-carbon policies in China and the Organisation for Economic Co-operation and Development countries in the EAS region such as Japan and the United States.

CHAPTER 1

Main Report

Phoumin Han, Shigeru Kimura, and Cecilya Laksmiwati Malik

1. Introduction

From the outset of this study, members of the working group on the Energy Outlook for ASEAN and East Asia, who are experts from the countries of the East Asia Summit (EAS)¹ plus the United States (US) (EAS17), aimed to predict the growth of medium- to long-term energy demand and supply in 2017–2050. At the time of this writing, the world economy and energy demand has been hit hard by the coronavirus disease (COVID-19) pandemic, but energy demand is expected to bounce back strongly in 2021 as the economy recovers. The Economic Research Institute for ASEAN and East Asia (ERIA) will release the short-term energy outlook in a separate report.

In the medium to long term, population and economic growth in EAS17 are the key drivers of projected increasing primary energy supply, from 7,625 million tonnes of oil equivalent (Mtoe) in 2017 to 10,780 Mtoe under the business-as-usual scenario (BAU) and to 8,860 Mtoe under the alternative policy scenario (APS) by 2050, reflecting annual growth rates of 1.1% under BAU and 0.5% under APS in 2017–2050. Under BAU, the energy intensity in final energy consumption is expected to drop by 46% from 122 tonnes of oil equivalent (toe)/million US\$ in 2017 to 64 toe/million US\$ in 2050. In primary energy consumption, the emission intensity is expected to drop from 0.70 tonnes of carbon (t-C)/toe in 2017 to 0.65 t-C/toe in 2050 under BAU.

¹ EAS is a regional forum held annually by leaders of, originally, 16 countries: 10 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic [Lao PDR], Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam); Australia; China; India; Japan; the Republic of Korea; and New Zealand. EAS membership expanded to 18 countries, including Russia and the US, at the Sixth EAS in 2011. EAS17 refers to the 10 ASEAN+7 countries: the original EAS plus the US. Since its establishment, ASEAN has led the forum. EAS meetings are held after the annual ASEAN leaders' meetings and play an important role in the regional architecture of Asia and the Pacific.

The economy will become more energy-efficient but increasing energy demand will threaten the region's energy security. Potential energy saving is, therefore, key to reducing energy demand and carbon dioxide (CO₂) emissions.

In 2007, leaders from the Association of Southeast Asian Nations (ASEAN) Member States, Australia, China, India, Japan, the Republic of Korea, and New Zealand adopted the Cebu Declaration on energy security (ASEAN Secretariat, 2007). They agreed to promote energy efficiency, new forms of renewable energy, and the clean use of coal. The leaders at the EAS Energy Minister Meeting (EMM) formed the EAS Energy Cooperation Task Force in response to the declaration, and Japan proposed to study energy saving and the potential of reducing CO₂ emissions. The topic is an area of cooperation for which ERIA officially requested support through the EAS Energy Ministers Meeting (EAS–EMM).

This study shows the energy saving potential of BAU and APS. BAU was developed for each EAS country, outlining future sector and economy-wide energy consumption, assuming no significant changes to government policies. The APS was set to examine the potential impacts if additional energy-efficiency goals, action plans, or policies being or likely to be considered were developed. The difference between BAU and APS in final and primary energy supply represents potential energy saving. The difference in the two scenarios' CO₂ emissions represents the potential to reduce them. The outlook's analysis covers EAS17. Underlying the EAS energy cooperation initiative is the Energy Research Institutes Network, of which the US is a member. Therefore, the outlook's analysis includes the US.

The study's findings shed light on the policy implications for decision-making to ensure that the region can enjoy economic growth and investment without compromising energy security and producing harmful CO₂ emissions.

1.1. East Asia Summit

The EAS17 countries are diverse, with widely varying per capita incomes, standards of living, energy resources, climate, and energy consumption per capita. Some EAS17 countries are mature economies, most are developing. Several EAS17 countries had a per capita gross domestic product (GDP) of less than US\$1,500 (in 2010 constant prices²) in 2017, whilst some mature economies had GDP per capita of more than US\$53,000.

² All US dollars in this document are in constant 2010 values unless otherwise specified.

Mature economies have higher energy consumption per capita than developing ones. A large percentage of people in developing countries still meet their energy needs mainly with traditional biomass fuels.

These differences partly explain why energy efficiency and conservation (EEC) goals, action plans, and policies are assigned different priorities across countries. Developed economies might be keen to reduce energy consumption, whilst developing countries emphasise economic growth and improving standards of living. As developing economies grow, however, their energy consumption per capita is expected to grow as well.

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

1.2. Objective and Rationale

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

The study supports the Cebu Declaration, the goals of which include the following:

- (i) Improve the efficiency and environmental performance of fossil fuel use.
- (ii) Reduce dependence on conventional fuels through intensified EEC programmes; increased share of hydropower; and expansion of renewable energy systems, biofuel production and/or utilisation, and, for interested parties, civilian nuclear power.
- (iii) Mitigate GHG emissions through effective policies and measures to help abate global climate change.

The Government of Japan asked ERIA to conduct a study on energy saving and CO₂ emission reduction potential in East Asia. Japan coordinates the energy-efficiency work stream under the Energy Cooperation Task Force. ERIA convened the working group to analyse energy saving potential. All EAS17 countries are represented in the working group.

2. Data and Methodology

2.1.Scenarios

Like the annual studies since 2007, the present study examines two scenarios: BAU, reflecting each country's current goals, action plans, and policies; and APS, including additional goals, action plans, and policies reported every year to the EAS–EMM. The latest updated policies were reported at the 13th EAS–EMM, 5 September 2019, Bangkok.

One might be tempted to call APS a 'maximum effort' but that would not be accurate. One reason is that goals, action plans, and policies for reducing energy consumption are still new in most countries. Many potential EEC policies and technological options have not been examined or incorporated in APS.

In 2014, APS assumptions were 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.

The energy models can estimate the individual impacts of the assumptions on primary energy supply and CO₂ emissions. The combination of the assumptions constitutes the APS assumptions. The main report highlights only BAU and APS. However, each country report will analyse all APS.

Detailed assumptions for each APS are as follow:

- (i) APS1 assumes the setting of reduction targets for sector final energy consumption, and the use of efficient technologies and implementation of energy-saving practices in the industry, transportation, residential and commercial, and even agriculture sectors in some countries. This scenario results in less primary energy and CO₂ emissions in proportion to reduction in final energy consumption.
 - (ii) APS2 assumes the utilisation of more efficient thermal power plant technologies, resulting in lower primary energy supply and CO₂ emissions in proportion to thermal power efficiency improvement. 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 to electricity generation and utilisation of liquid biofuels in transportation. The scenario results in lower CO₂ emissions as NRE is carbon-neutral or will not emit additional CO₂. However, the primary energy supply might not decrease because NRE, like biomass and geothermal energy, is assumed to be less efficient than fossil fuel-fired generation in converting electricity into primary energy equivalent.
- (iv) APS4 assumes the introduction of nuclear energy or a higher contribution of nuclear energy in countries already using it. The scenario produces less CO₂ emissions as nuclear energy emits minimal CO₂. However, as thermal efficiency in converting nuclear energy output into primary energy is assumed to be only 33%, the primary energy supply is not expected to be lower than under BAU.

All EAS17 countries are developing and implementing EEC goals, action plans, and policies, but progress has varied widely. Some countries are advanced in their efforts, while others are just getting started. A few countries have significant energy-saving goals, action plans, and policies built into BAU, while others have only started to quantify their goals. However, significant potential does exist in these countries at the sector and economy levels.

Every country still has a great deal to learn about what works and what does not. It is worthwhile updating this study periodically, as the quality and scope of national goals, action plans, and policies are likely to improve considerably, allowing for collaboration across countries.

2.2.Data

For consistency, the historical energy data used in this analysis come from the energy balances of EAS17 countries' energy statistics. Cambodia, Lao People's Democratic Republic (Lao PDR), and Myanmar use their national energy statistics produced with ERIA's support, and the seven other ASEAN countries use the Asia-Pacific Economic Cooperation energy database, which includes national energy data submitted by them. The seven other EAS countries use energy balance tables produced by the International Energy Agency (IEA) (IEA, 2020). The socio-economic data for all EAS17 countries were obtained from the World Bank's online World Databank – World Development Indicators and Global Development Finance.

Other data, such as those relating to transportation, buildings, and industrial production indices, were provided by the working group members from each EAS17 country where such data are available. Where official data are not available, estimates were obtained from other sources or developed by the Institute of Energy Economics, Japan (IEEJ), especially for international energy prices such as the crude oil price.

2.3. Methodology

In 2007, IEEJ's World Energy Outlook Model was used to prepare Asia/World Energy Outlook (IEEJ, 2014). Since 2008, all ASEAN Member States have used their own energy models. The seven other EAS17 countries still depend on the IEEJ model but provide their own key assumptions on population and GDP growth; electric generation fuel mixes; and EEC goals, action plans, and policies.

ASEAN countries. The energy models of ASEAN countries were developed using the Long-range Energy Alternative Planning System (LEAP) software, which is used to project energy balance tables based on final energy consumption and energy input and/or output in the transformation sector. Final energy consumption is forecast using energy demand equations by energy and sector and future macroeconomic assumptions. For this study, all ASEAN Member States used the LEAP model.

Other countries. IEEJ produced energy outlooks for other countries using its model, which has explanatory variables based on exogenously specified GDP growth rates. The IEEJ 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, energy supply and new technologies are treated exogenously. For electricity generation, the working group members specified assumptions about the future electricity generation mix in their countries by energy source. These assumptions were used to determine the future electricity generation mix.

3. Assumptions of the Study

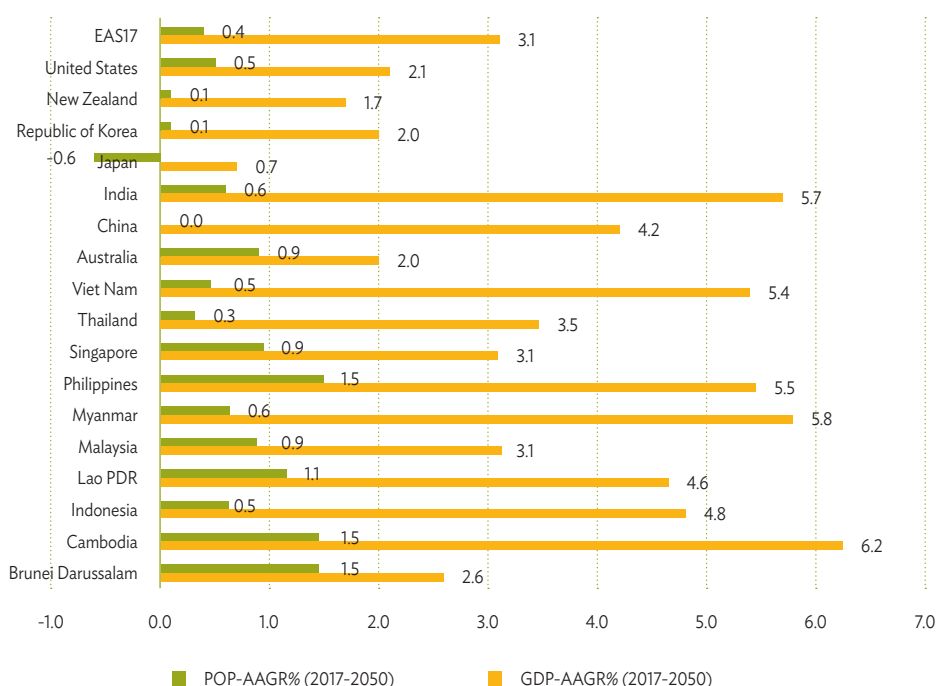
Growth in energy consumption and GHG emissions is driven by socio-economic factors. In EAS17, these factors – including growing population, sustained economic growth, increasing vehicle ownership, and greater access to electricity – will push up energy demand. Together they create a huge growth ‘headwind’ that works against efforts to limit energy consumption. Understanding the nature and size of the ‘headwind’ is critical for any analysis of energy demand. However, increased consumption of energy services is fundamental for achieving a range of socio-economic development goals.

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

3.1. Size of Population, Gross Domestic Product, and Its Growth Rate in EAS17

In the study’s models, changes in population until 2050 are set exogenously. No difference in population between BAU and APS is assumed. EAS17 countries, except China, submitted assumed changes in population based on projections from the United Nations.

Figure 1.1. Average Annual Growth Rate of Gross Domestic Product and Population in EAS17 Countries



In 2017, the total EAS17 population was about 3.89 billion. It is projected to increase at an average annual rate of about 0.4% to about 4.43 billion in 2050.

Brunei Darussalam, Cambodia, Lao PDR, and the Philippines are generally assumed to have the fastest average annual population growth rate, at 1.1%–1.5% in 2017–2050 (Figure 1-1). Indonesia, Malaysia, Singapore, Thailand, Viet Nam, Australia, India, and the US are expected to have a moderate average annual population growth rate, at 0.5%–0.9%. The Republic of Korea and New Zealand are expected to have an extremely slow average population growth rate, at just 0.1%. Japan's population is assumed to decline slowly as it continues to age, resulting in an average annual population growth rate of –0.6%.

Long-term economic growth rates are assumed to be high in developing countries, with the highest in Cambodia, India, Myanmar, the Philippines, Viet Nam, and Lao PDR (Figure 1-1). Economic growth in other developing countries is assumed to be rapid. Brunei Darussalam is expected to have a moderate average annual GDP annual growth rate of 2.6% in 2017–2050. The United States, Japan, Republic of Korea, New Zealand, and Australia are expected to have a moderate annual GDP growth rate. Rapid growth in China, India, Indonesia, and the United States is likely to be especially significant for energy demand in these large economies.

In 2017, total GDP in EAS17 was about \$42 trillion in 2010 US dollar constant prices and accounted for about 52% of global GDP. The region's GDP is assumed to grow at an average annual rate of about 3.1% in 2017–2050, implying that, by 2050, the region's total GDP will reach about US\$114.6 trillion in 2010 US dollar constant prices. China is projected to be the largest economy, with real GDP of about \$39.7 trillion in 2010 US dollar constant prices, followed by the US with about \$33.9 trillion by 2050. India and Japan are projected to be the next-largest economies, with projected GDPs of about \$16.3 trillion and \$7.7 trillion, respectively, at 2010 US dollar constant prices by 2050 (Table 1-1).

Average real GDP (2010 US dollar constant prices) per capita in EAS17 is assumed to increase from \$10,776.70 in 2017 to \$25,765.00 in 2050. However, there are, and will continue to be, significant differences in GDP per capita amongst EAS17 countries. In 2017, per capita GDP (2010 US dollar constant prices) ranged from \$1,234.60 in Cambodia to more than \$48,000.00 in Japan, the US, Singapore, and Australia. In 2050, per capita GDP is assumed to range from \$5,496.20 in Cambodia to more than \$113,000.00 in Singapore.

Table 1.1. Gross Domestic Product (in constant 2010 US dollar prices) and Population in EAS17 Countries (2017–2050)

	GDP (billion, 2010 US dollar constant prices)		Population (million)		Per Capita GDP	
	2017	2050	2017	2050	2017	2050
Brunei Darussalam	13.5	29.0	0.4	0.7	33,750.0	41,428.6
Cambodia	20.0	144.0	16.2	26.2	1,234.6	5,496.2
Indonesia	1,090.5	5,131.2	264.6	324.3	4,121.3	15,822.4
Lao PDR	12.6	80.6	7.1	11.4	1,774.6	7,070.2
Malaysia	364.6	992.5	31.1	41.4	11,723.5	23,973.4
Myanmar	79.5	510.9	53.4	65.8	1,488.8	7,764.4
Philippines	303.3	1,463.9	105.1	164.4	2,885.8	8,904.5
Singapore	318.4	871.1	5.6	7.7	56,857.1	113,129.9
Thailand	424.2	1,304.6	69.2	76.8	6,130.1	16,987.0
Viet Nam	175.3	995.7	93.7	108.9	1,870.9	9,143.3
Australia	1,432.7	2,776.2	24.6	32.8	58,239.8	84,640.2
China	10,161.1	39,687.5	1,386.4	1,403.2	7,329.1	28,283.6
India	2,650.8	16,319.9	1,339.1	1,639.8	1,979.5	9,952.4
Japan	6,157.7	7,786.5	126.8	105.2	48,562.3	74,016.2
Republic of Korea	1,345.9	2,299.9	51.5	50.1	26,134.0	45,906.2
New Zealand	181.1	314.6	4.8	6.1	37,729.2	51,573.8
United States	17,348.6	33,922.1	325.1	384.1	53,363.9	88,315.8
EAS17	42,079.8	114,630.2	3,904.7	4,448.9	10,776.7	25,766.0

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

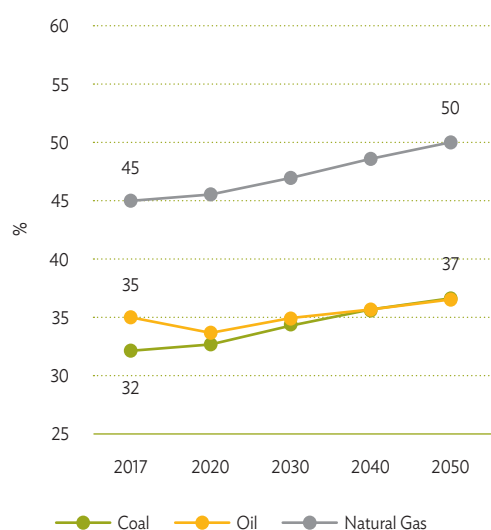
Source: Authors.

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 and was an exogenous assumption used in the study. Base year 2017 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 (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 other countries, assumptions about potential changes in thermal efficiency were based on IEEJ's Asia/World Energy Outlook 2017.

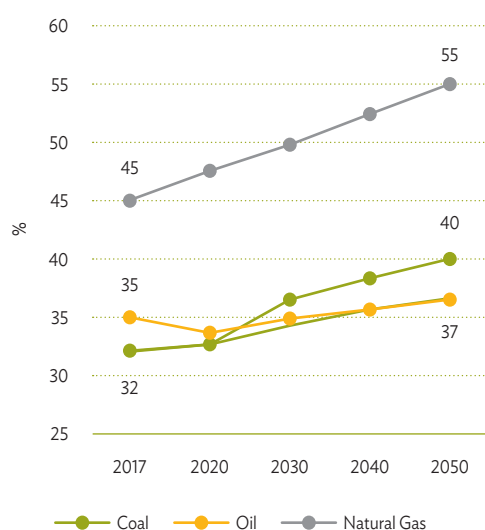
Thermal efficiencies may differ significantly amongst countries due to differences in technological availability, age of technology, cost of technology, temperatures, and cost and availability of fuel inputs. Thermal efficiency in EAS17 countries is expected to improve considerably under BAU as more advanced generation technologies, such as natural gas combined-cycle and supercritical coal-fired power plants, become available. In many countries, additional improvements are assumed under APS (Figures 1-2 and 1-3).

Figure 1.2. Average EAS17 Thermal Efficiency under Business as Usual



EAS = East Asia Summit.
Source: Authors.

Figure 1.3. Average EAS17 Thermal Efficiency under Alternative Policy Scenario



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

Table 1-2 depicts the oil price assumptions used in the modelling as adopted by IEEJ from the world energy model price data of IEA (2019). Under the reference scenario, the crude oil price was US\$71/blue barrel (bbl) in 2018. It will rise to US\$120/bbl by 2030 and to US\$236/bbl in 2050 due to combined factors such as robust demand growth in non-Organisation for Economic Co-operation and Development (OECD) countries, 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 for Real Oil, Natural Gas, and Coal
(2018 US dollar constant prices)**

Year	Crude Oil (\$/bbl)	Coal (\$/ton)	Natural Gas (\$/MBtu)		
			US	Europe	Asia
2015	52	80	3	7	10
2016	44	74	2	5	7
2017	54	99	3	6	8
2018	71	118	3	8	10
2020	80	95	3	8	9
2030	95	100	4	8	9
2040	115	104	4	8	10
2050	125	105	5	9	10

Note: 2018 US dollar constant prices are used for the energy outlook for Australia, China, India, Japan, the Republic of Korea, and New Zealand. 2018 nominal prices are used for ASEAN countries. Crude oil price assumptions start from 2018.

bbl= blue barrel, MBtu = 1,000 British thermal units, toe = ton of oil equivalent.

Source: IEEJ (2018).

**Table 1.3. Assumptions of Energy-Saving Targets under
the Alternative Policy Scenario in EAS17**

Country	Assumptions
Australia	Energy-efficiency target of 40% improvement in 2015–2030
Brunei Darussalam	Reduction of total energy consumption by 63% under BAU by 2035; 10% share of renewables in the power mix by 2035
Cambodia	Total energy saving of 27% under BAU by 2030; specific fuel efficiency target by 2050 (10% for coal, oil, gas, biomass; 20% for electricity)
China	CO ₂ emissions will peak by 2030. China aims to achieve carbon neutrality before 2060.
India	Emission intensity (CO ₂ produced for every dollar of GDP) reduced by 33%–35% by 2030 from 2005 levels. Share of non-fossil fuels increases to 40% in the power mix by 2030 from 2005 levels.
Indonesia	Committed to reduce GHG emissions by 29% unconditionally under BAU by 2030
Japan	Reduce GHG emissions by 26% from 2013 levels by 2030.
Republic of Korea	Reduce GHG emissions by 37% under BAU by 2030.
Lao People's Democratic Republic	Increase the share of small-scale renewable energy to 30% in the power mix by 2030. Biodiesel: 20% blend from 1% to 5% in 2010. Biofuels make up 10% of road transport fuels by <year>.
Malaysia	16% electricity saving by 2050 in industry, commercial, and residential sectors. 16% oil saving in final consumption by 2050. Replace 5% of diesel in road transport with biodiesel.
Myanmar	Target saving by 2050: transport and residential sectors by 20%; industry, commercial, and other sectors by 10%. Replace 8% of transport diesel with biodiesel.
New Zealand	Reduce GHG emissions by 30% from 2005 levels by 2030.
Philippines	20% saving on oil and electricity by 2050. Displace 20% of diesel and gasoline with biofuels by 2025.
Thailand	Energy-efficiency targets by 2050: transport 70%, residential 10%, commercial 40%, and industry 20% reduction in final energy demand. Biofuels to displace 12.2% of transport energy demand.
United States	Withdrew from the Paris Agreement. It is hoped that the US will re-join it. Its past commitment was to reduce GHG emissions by 26%–28% from 2005 levels by 2025.
Viet Nam	Committed to reduce GHG emissions by 8% unconditionally under BAU by 2030. Energy consumption to be reduced by 20% under BAU in all sectors by 2030.

Source: Kimura and Han (2019).

3.4. Energy Saving Goals and Other Policy Assumptions

The working group members included information on policy assumptions and targets under BAU and APS. Some EAS17 countries have clear targets for energy saving or emission reduction. Table 1-3 summarises the policy assumptions.

4. Energy Outlook for the East Asia Summit Region

4.1. Business-as-Usual Scenario

4.1.1. Final Energy Consumption

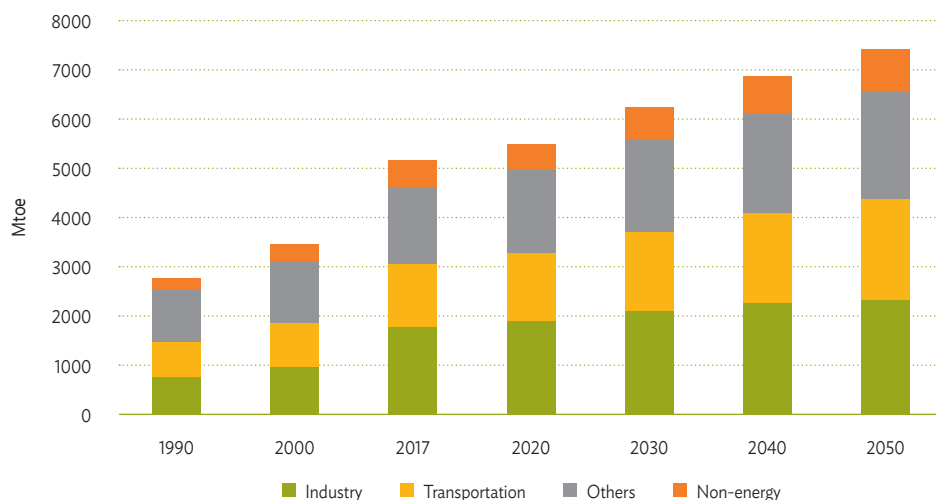
In 2017–2050, total final energy consumption³ in EAS17 is projected to grow at an average annual rate of 1.1%, reflecting the assumed 3.1% annual GDP and 0.4% population growth. Final energy consumption is projected to increase from 5,159 Mtoe in 2017 to 7,416 Mtoe in 2050. Transportation energy demand is projected to grow moderately by about 1.4% per year, and its energy consumption share is projected to be 27.7% by 2050. Industry's annual growth rate in 2017–2050 is projected at about 0.9% per year, but its energy consumption share is projected to be the largest at about 31.7% by 2050.

Commercial and residential demand will grow by 1.0% per year, higher than that of industry. However, commercial and residential energy consumption share is projected to be 29.3%, the second largest after industry. Figure 1-4 shows final energy consumption by sector under BAU in EAS17 from 1990 to 2050, and Figure 1-6 shows details of sector shares in final energy consumption.

Figures 1-6 and 1-7 show final energy consumption and shares by fuel type in EAS17 under BAU from 1990 to 2050. By energy source, electricity and natural gas demand under BAU are projected to show the fastest growth, increasing by 1.9% and 1.5% per year, respectively, from 2017 to 2050, but their shares are just 28.4% for electricity and 14.0% for natural gas. Although oil will retain the largest share at 39.9% of total final energy consumption, it is projected to grow by only 1.2% per year in 2017–2050, reaching 2,960 Mtoe in 2050. Generally, the oil share slightly increases from 38.3% in 2017 to 39.9% in 2050. Coal demand

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

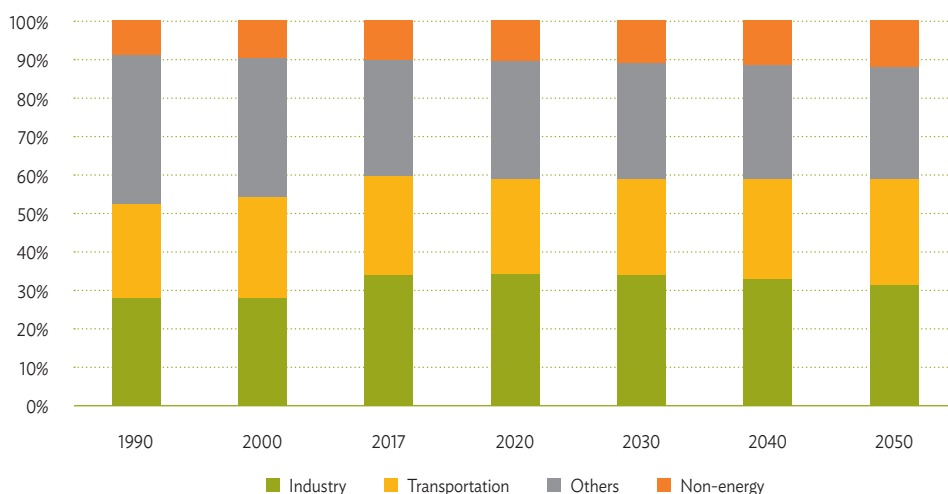
Figure 1.4. Final Energy Consumption by Sector, Business as Usual (1990–2050)



BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

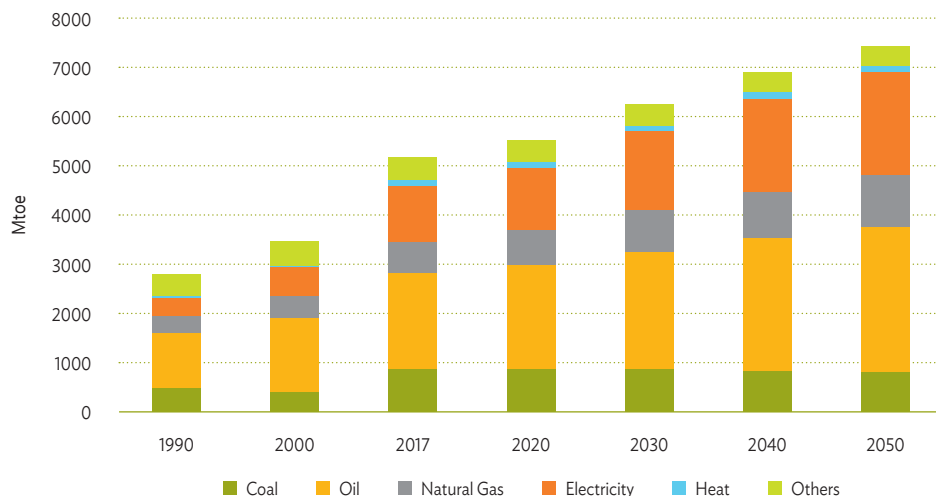
Figure 1.5. Final Energy Consumption Share by Sector (1990–2050)



Source: Authors.

will grow at -0.2% per year on average from 2017 to 2050, reaching 800.5 Mtoe in 2050. The share of other fuels such as biomass will decline from 9.2% in 2017 to 5.2% 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.

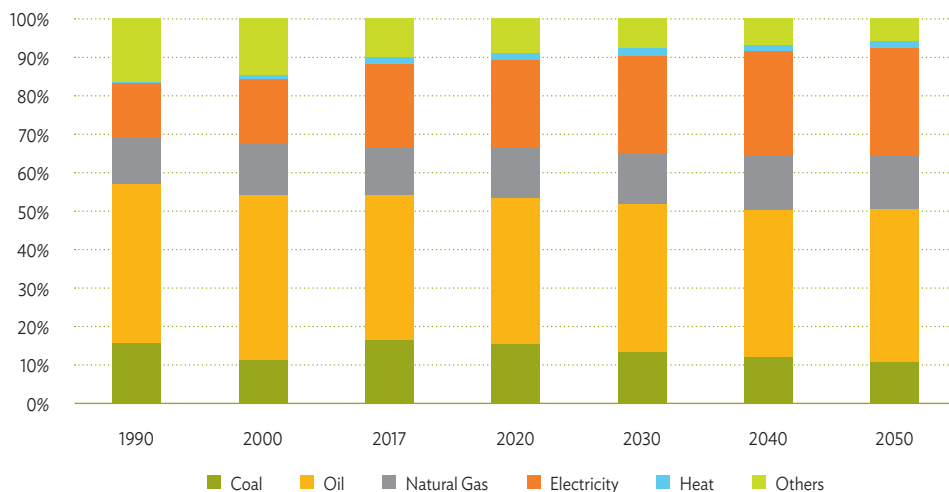
Figure 1.6. Final Energy Consumption by Fuel (1990–2050)



Mtoe = million tons of oil equivalent.

Source: Authors.

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



Source: Authors.

4.1.2. Primary Energy Supply (Business as Usual)

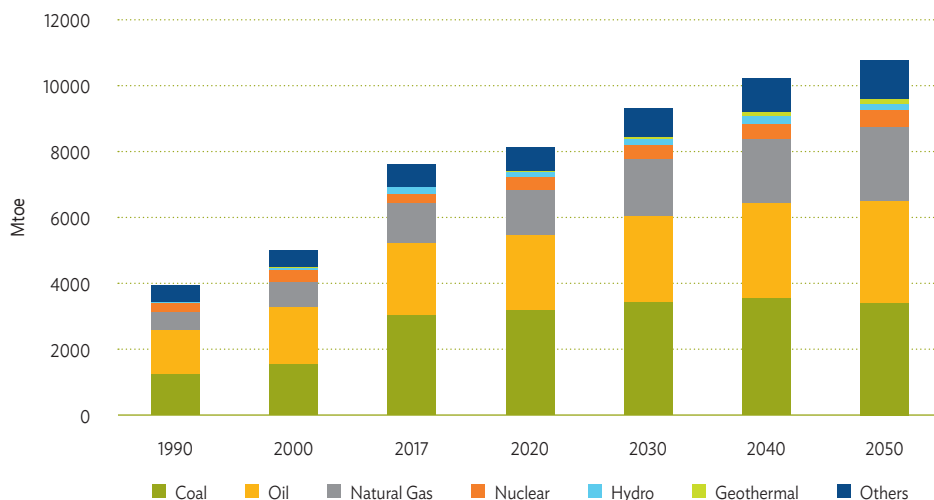
Figure 1-8 shows primary energy supply in EAS17 from 1990 to 2050.⁴ It is projected to grow slowly at 1.1% per year in 2017–2050, the same growth rate of final energy consumption.

EAS17 primary energy supply is projected to increase from 7,625 Mtoe in 2015 to 10,780

⁴ Refers to energy in its raw form, before any transformation.

Mtoe in 2050. Coal will still comprise the largest share of primary energy supply, but its growth is expected to be slower, increasing at 0.3% per year in 2017–2050.

Figure 1.8. Primary Energy Supply in EAS17 (1990–2050)



EAS = East Asia Summit, Mtoe = million tons of oil equivalent.

Source: Authors.

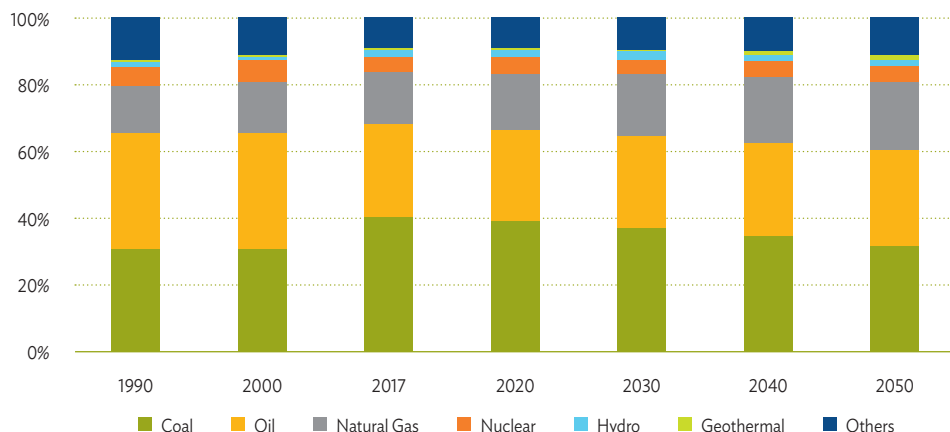
Consequently, the share of coal in total primary energy supply (TPES) is forecast to decline from 40.2% in 2017 to 31.7% in 2050.

Amongst fossil sources of energy, natural gas is projected to see moderate growth in 2017–2050, increasing at an annual average rate of 1.9%. Its share in the total will consequently increase from 15.7% (equivalent to 1,199 Mtoe) in 2017 to 20.6% (2,217 Mtoe) in 2050.

Nuclear and hydropower energy are projected to increase slowly at 1.1% per year on average in 2017–2050; the share of nuclear energy will stay at 4.5% and that of hydropower at 2.2%. It is assumed that nuclear power generation in Japan and the expansion of nuclear power generation capacity in China and India will resume. Geothermal energy is projected to grow at 3.3% per year in 2017–2050, but its share is projected to be small: about 1.3% by 2050, increasing from 0.6% in 2017.

Amongst the energy sources, 'others' – which are made up of solar, wind, and solid and liquid biofuels – will see a growth rate of 1.8% in 2017–2050, with their share increasing from 8.6% in 2017 to 10.8% in 2050. Most remarkably, wind and solar energy will see the largest average annual growth rate: 5.2% in 2017–2050, with their share in the primary energy supply increasing from 1.4% in 2017 to 5.4% in 2050. Figure 1-9 shows the share of each energy source in the total primary energy mix in 1990–2050.

Figure 1.9. Share of Primary Energy Mix by Source (1990–2050)

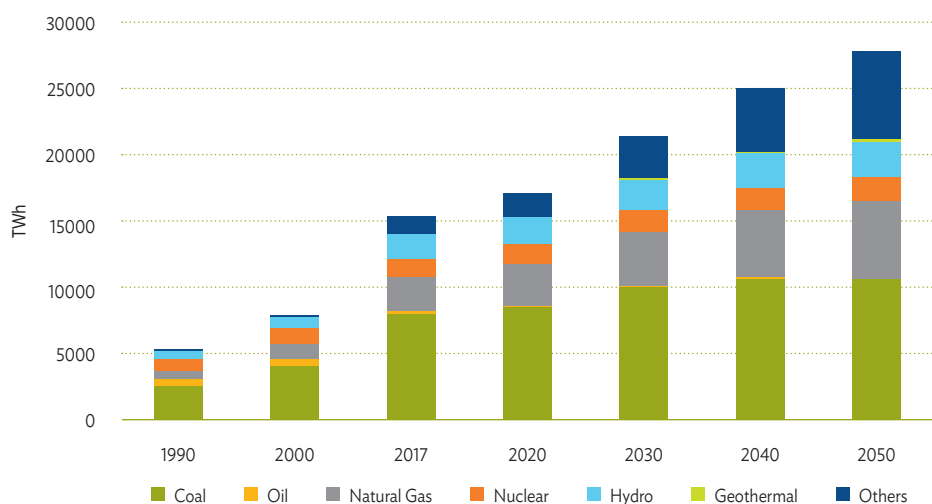


Source: Authors.

4.1.3. Power Generation in EAS17

Figure 1-10 shows power generation output in EAS17. Total power generation is projected to grow at 1.8% per year on average from 2017 (equivalent to 15,365 terawatt-hours [TWh]) to 2050 (27,812 TWh). However, the growth rate in 1990–2017 was 3.9%, more than twice that projected in 2017–2050.

Figure 1.10. Energy Mix of Power Generation in EAS17 (1990–2050)

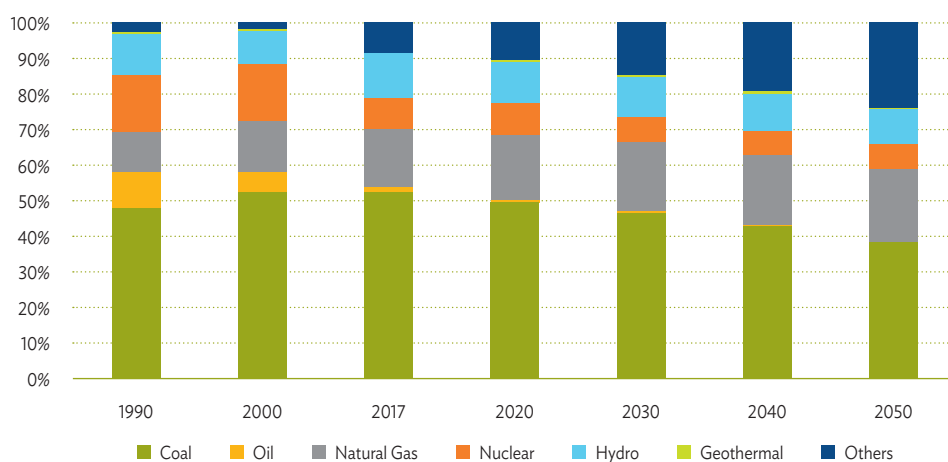


EAS = East Asia Summit, TWh = terawatt-hour.

Source: Authors.

Figure 1-11 shows the share of each energy source in electricity generation from 1990 to 2050. The share of coal-fired generation is projected to continue to be the largest at 38.4% in 2050, a large drop from 52.7% in 2017. The share of natural gas is projected to increase from 16.8% in 2017 to 20.8% in 2050. The share of nuclear power (8.5% in 2017) is forecast to decrease to 6.7% in 2050. The share of geothermal energy was 0.3% in 2017 and is projected to increase to 0.6% in 2050. Other sources (wind, solar, biomass, etc.) will record the highest average annual growth rate at 5.2% in 2017–2050. The share of combined wind, solar, and biomass energy in the power mix is expected to be 23.6% in 2050, a large increase from 8.0% in 2017. The share of oil will drop from 1.2% in 2017 to 0.1% in 2050. Oil is expected to grow at an average annual rate of –4.4% in 2017–2050 due to its higher fuel cost. The share of hydropower is projected to decrease, from 12.4% in 2017 to 9.7% in 2050. The average annual growth rate of hydropower is expected to be slow, at 1.1% in 2017–2050.

Figure 1.11. Share of Power Generation Mix in EAS17 (1990–2050)



Source: Authors.

4.1.4. Energy Indicators in EAS17 (Business as Usual and Alternative Policy Scenario)

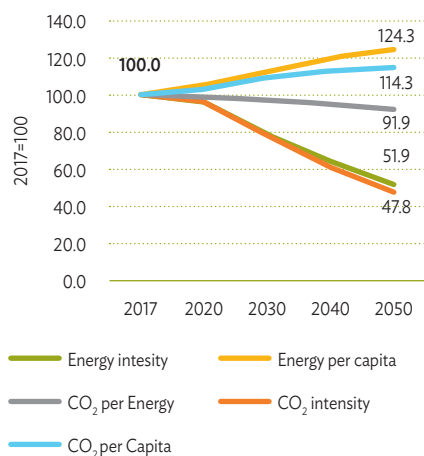
Figures 1-12 and 1-13 show the energy indicators from 2017 to 2050 for BAU and APS, respectively. The data have been normalised to 100 for the base year 2017. For BAU, primary energy intensity (toe/million US\$ in 2010 prices) in EAS17 is projected to decline by 48.1%⁵ in 2050 from 2017 levels. Under APS, energy intensity is expected to drop further by 57.3% from 2017 levels.

⁵ This can be calculated by taking the normalised number in 2050 and minus 100, which is the normalised number to 100 in base year 2017. In this case, the reduction from the base year is 51.9%–100.0%.

The improvement in primary energy intensity is reflected in improved carbon intensity (t-C/
million US\$ in 2010 prices). Under BAU, carbon intensity is expected to drop by 52.2% in 2050
from 2017 levels. Under APS, carbon intensity is expected to drop by 70.4% in 2050 from
2017 levels. The difference in BAU and APS carbon intensity in 2017–2050 is the result of the
fundamental shift from fossil fuel to renewables.

Energy demand per capita under BAU is projected to increase by 24.3% in 2050 compared
with 2017 levels. Under APS, energy demand per capita is expected to increase slightly by
2.1% in 2050 from 2017 levels. The difference between BAU and APS energy demand per
capita in 2017–2050 explains the fundamental change in terms of energy efficiency from
BAU to APS. The increase in energy per capita in 2050 compared with 2017 levels can be
attributed to projected continuing economic growth, which will bring about a more energy-
intensive lifestyle as people are able to purchase vehicles, household appliances, and other
energy-consuming devices due to increases in disposable income.

**Figure 1.12. Energy Indicators
in EAS17 (Business as Usual)**

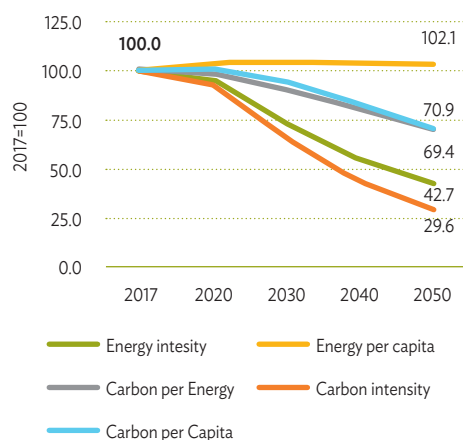


Note: Data in 2017 is normalised to 100.

CO₂ = carbon dioxide, EAS = East Asia Summit.

Source: Authors.

**Figure 1.13. Energy Indicators in
EAS17 (Alternative Policy Scenario)**



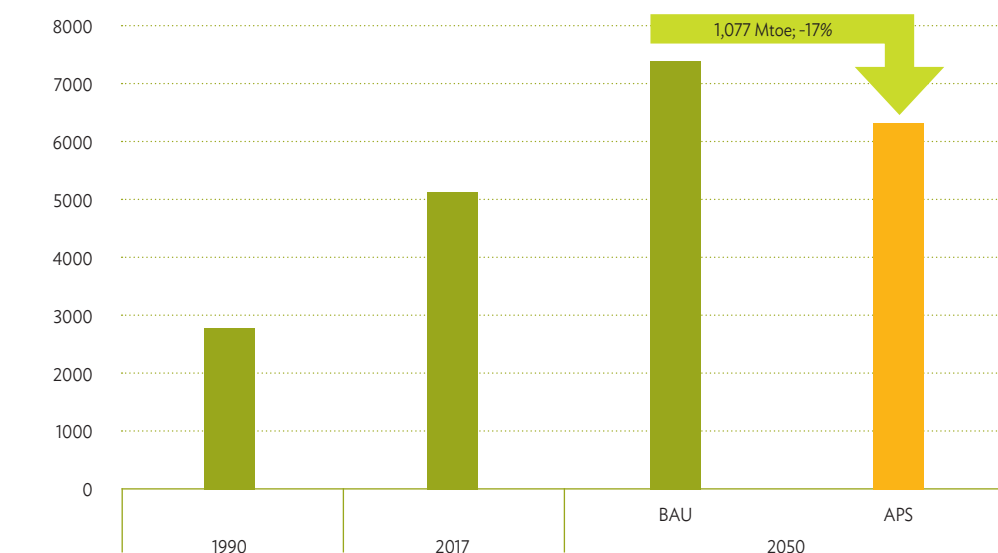
4.2.Comparison of Business as Usual and Alternative Policy Scenario

4.2.1.Total Final Energy Consumption

Under APS, final energy consumption is projected to rise from 5,160 Mtoe in 2017 to 6,338 Mtoe in 2050. In 2050, the difference between BAU and APS is 1,077 Mtoe, with APS 17% lower than BAU, because of energy-efficiency plans and programmes for supply and demand sides to be implemented by EAS17 countries. Figure 1-14 shows final energy consumption in 1990–2050 under BAU and APS.

Potential energy saving in total final energy consumption in EAS17 (1,077 Mtoe) in 2050 is more than double ASEAN's total final energy consumption in 2017 (480 Mtoe). Energy saving in EAS17 is expected largely from the transportation, industry, commercial, and residential sectors.

Figure 1.14. Total Final Energy Consumption, Business as Usual and Alternative Policy Scenario

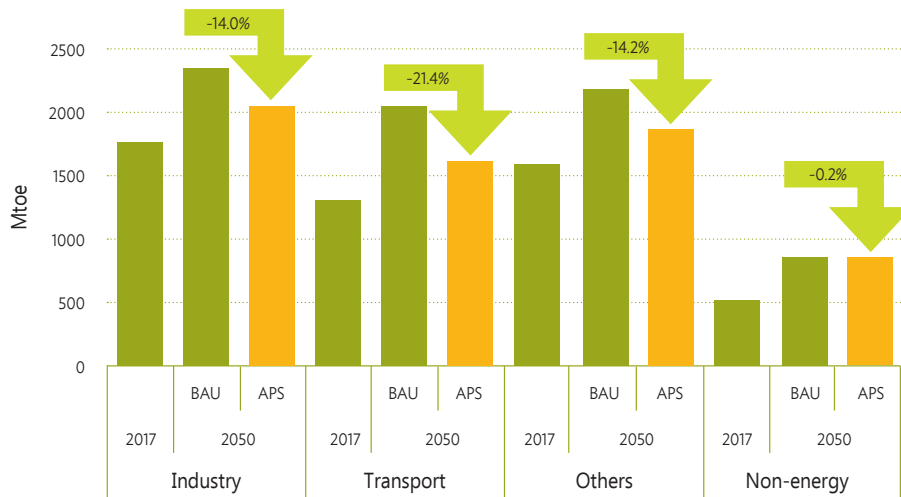


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Figure 1-15 shows the composition of final energy consumption by sector under BAU and APS. Final energy consumption in most sectors is significantly more reduced under APS than under BAU. The reduction is largest in transportation (21.4%), followed by 'others' (14.2%) and industry (14.0%). Non-energy demand will drop slightly by 0.2% from BAU.

Figure 1.15. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario



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

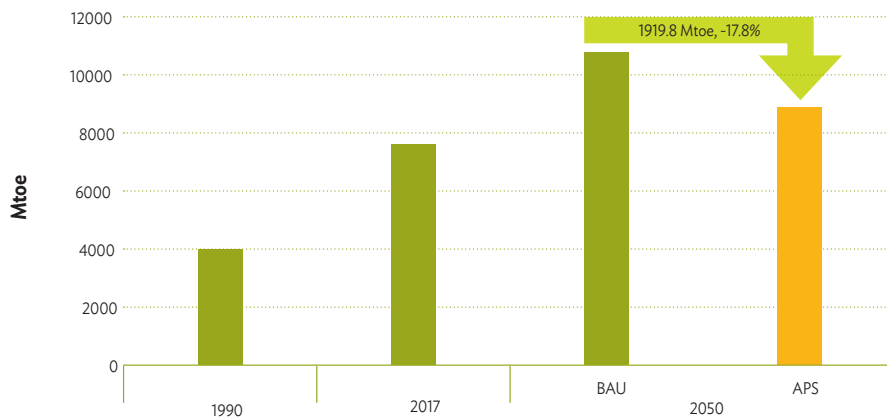
Source: Authors.

4.2.2. Primary Energy Supply

Figure 1-16 shows TPES of 10,779.6 Mtoe under BAU and 8,859.7 Mtoe under APS in 2050. Total saving potential is the difference between BAU and APS in 2050. Total saving potential in TPES is expected to be 1,919.8 Mtoe, representing a 17.8% reduction from BAU to APS.

The energy-saving potential results from improvements in the transformation sector, particularly power generation, and final energy consumption sectors such as transportation, industry, and the residential and commercial sector, where efficiencies are expected.

Figure 1.16. Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario

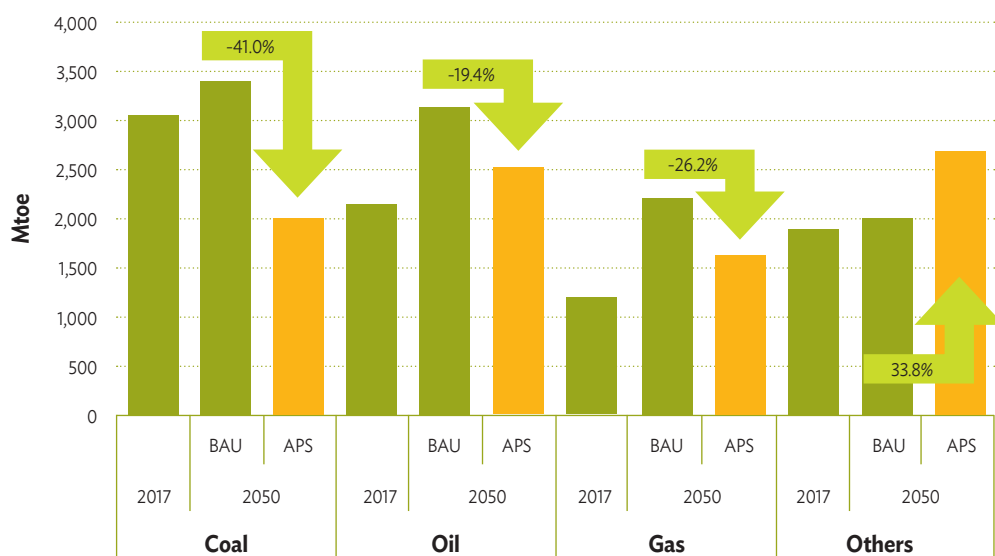


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Figure 1-17 shows primary energy supply by fuel source. Under APS, growth in primary energy supply for fossil fuels is lower than under BAU. The growth rate in primary energy supply under APS is projected at 0.5% per year on average in 2017–2050, which is lower than under BAU, projected at 1.1%. In absolute terms, the largest reduction will be in coal demand, by 1,401 Mtoe or 41% from 3,414.7 Mtoe under BAU to 2,013.7 Mtoe under APS. Potential savings for other fuels are projected at 608.9 Mtoe for oil (equivalent to a 19.4% reduction under BAU) and 580.6 Mtoe for gas (26.2% reduction under BAU). Due to increased renewable energy in the primary supply, renewable energy supply, including solar wind and biomass, is projected to increase by 33.8% from BAU to an APS of aggressively including more renewables into the supply mix.

Figure 1.17. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

4.3. Carbon Dioxide Emissions from Energy Consumption

4.3.1. Carbon Dioxide Emissions

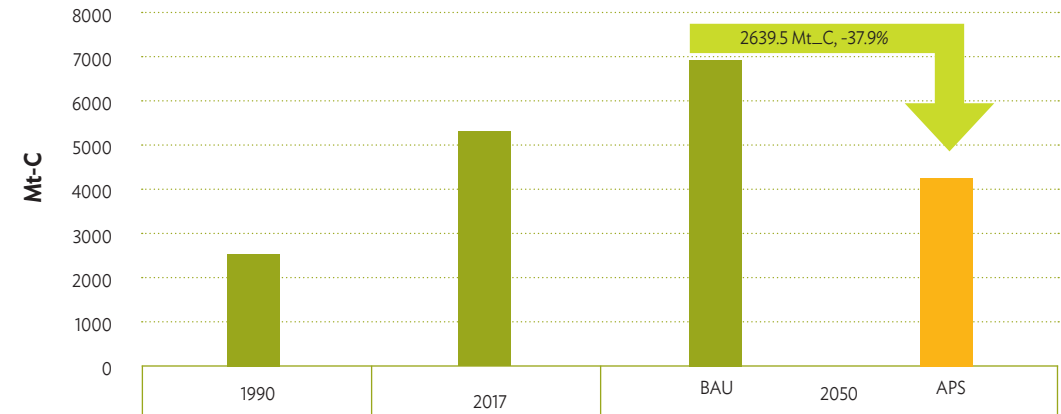
Figure 1-18 shows CO₂ emissions under BAU and APS. CO₂ emissions from energy consumption under BAU are projected to increase from 5,352.4 million tonnes of carbon (Mt-C) in 2017 to 6,957.3 Mt-C in 2050, implying an average annual growth rate of 0.8% in 2017–2050. The growth rate of emissions is lower than that of TPES of 1.1% per year. The reason is

that the share of renewables in the energy mix is increasing. Under APS, CO2 emissions are projected at 4,317.8 Mt-C in 2050, 37.9% lower than under BAU.

At the 21st Conference of the Parties (COP21) in Paris, December 2015, 195 countries adopted the first universal binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2 degrees Celsius (°C) compared with pre-industrial levels. The Paris Agreement could bridge today’s policies and climate-neutrality before the end of the century.

The CO2 emission reductions under APS in 2050 are significant but emission levels are still higher than in 2017. However, CO2 emissions due to energy demand under APS in 2050 will still be higher than 1990 levels. Scientific evidence suggests that these reductions will not be adequate to prevent severe climate change impacts. Analysis by the Intergovernmental Panel on Climate Change suggests that to keep the increase in global mean temperature to not more than 2oC compared with pre-industrial levels, global CO2 emissions would need to fall by 45% from 2010 levels by 2030. Under the Paris Agreement, the parties will ‘pursue efforts’ to limit the temperature increase to 1.5°C, which will require zero emissions in 2030–2050 (IPCCC, 2015). However, EAS, especially the ASEAN Member States, will need to balance abating climate change with energy access and affordability. Thus, the clean use of fossil fuel through innovative technologies such as clean coal technology and carbon capture utilisation and storage (CCUS) will a play central role in carbon sink around the globe.

Figure 1.18. Total Carbon Dioxide Emissions, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, CO₂ = carbon dioxide, Mt-C = million tonnes of carbon equivalent.

Source: Authors.

4.4. Necessary Energy Infrastructure Investment Cost

4.4.1. Power Generation Investment

Based on the energy outlook results, BAU, and APS, the working group estimated the necessary investment in the power sector, especially for coal, gas, nuclear, hydro, geothermal, solar photovoltaic, wind, and biomass power generation plants. The working group drew from several sources of information to obtain the current capital cost of each power plant but did not forecast capital cost due to its uncertainty. For all EAS17 countries taken together, the amount of investment to meet electricity demand would be US\$3.92 trillion under BAU and US\$5.93 trillion under APS. The investment cost considers the reduction of upfront cost of each technology due to the fast drop of unit cost of each technology, especially renewables. Figures 1-19 and 1-20 show the share of investment cost by power generation type under BAU and APS. The increment of electricity demand from 2017 to 2050 under BAU will be 12,447 TWh and under APS 9,844 TWh. The shift to a higher share of renewables in the power mix under APS will add the required 4,680 gigawatts (GW) of the incremental capacity of combined solar, wind, and biomass under APS in 2017–2050. Under BAU, the incremental capacity of combined wind, solar, and biomass energy is expected to be 2,584 GW, which is lower than under APS. Necessary investment in power generation will be higher under APS than under BAU, and the share of power generation sources will be different under BAU and APS.

Figure 1.19. Investment Share by Power Source (EAS17, Business as Usual)

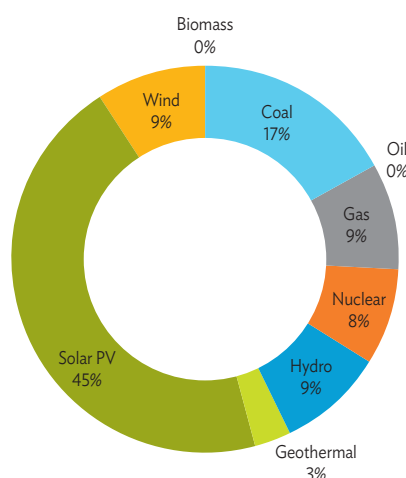
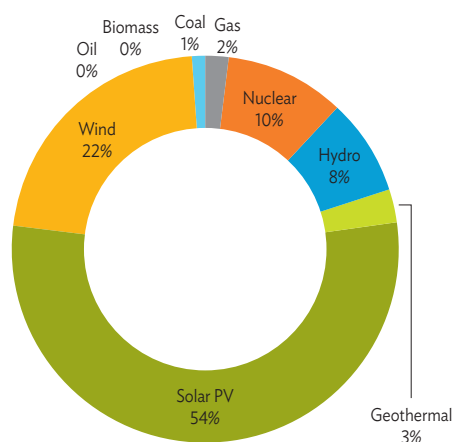


Figure 1.20. Investment Share by Power Source (EAS17, Alternative Policy Scenario)



BAU = business as usual, APS = alternative policy scenario, EAS = East Asia Summit, PV = photovoltaic.

Source: Authors.

Figures 1-21 and 1-22 show the share of investment cost of power generation in ASEAN under BAU and APS. ASEAN will require investment in power generation of about US\$540.2 billion under BAU and about US\$502.9 billion under APS in 2017–2050. The lower investment cost of power generation under APS than under BAU is due to energy efficiency and saving that reduce power demand under APS. However, the investment cost in the power mix under APS will be greater for renewables. Under BAU, investment in coal and gas power will dominate in ASEAN. However, investment under APS will be in clean energy such as hydro, geothermal, wind, solar photovoltaic, and possibly nuclear energy (Figures 1-22 and 1-23). ASEAN will seek a more balanced energy mix for power generation to increase energy security and mitigate CO₂ emissions.

Figure 1.21. Investment Share by Power Source (ASEAN, Business as Usual)

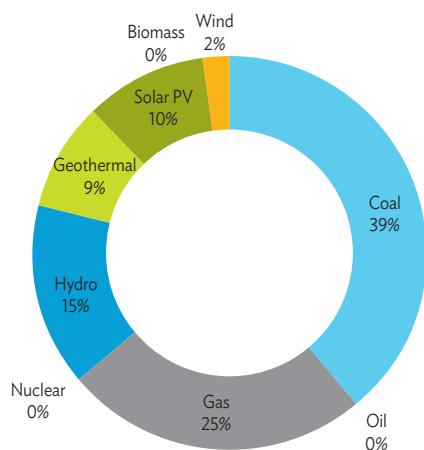
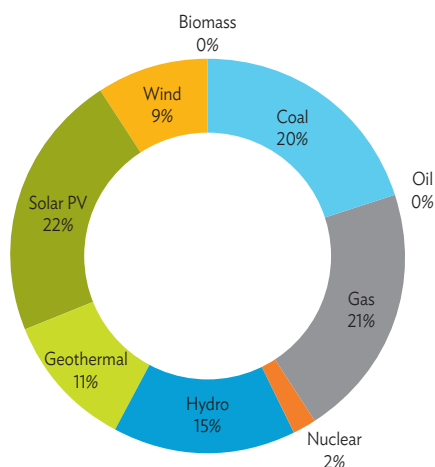


Figure 1.22. Investment Share by Power Source (ASEAN, Alternative Policy Scenario)



BAU = business as usual, APS = alternative policy scenario, EAS = East Asia Summit, PV = photovoltaic.
Source: Authors.

4.4.2 Total Energy Infrastructure Investment

Total energy infrastructure investment in 2017–2050 includes investment in power generation, refineries, and liquefied natural gas (LNG)–receiving terminals. Total energy infrastructure investment in EAS17 is estimated at US\$4.49 trillion under BAU and US\$6.01 trillion under APS in 2017–2050, in which the share of power generation will dominate (Figures 1-23 and 1-24). The investment cost of refineries in EAS17 is estimated at US\$410 billion under BAU. This study predicted that under APS, there will be no additional investment cost for refineries due to energy saving and conservation effects. The investment cost of LNG-receiving terminals in EAS17 is estimated at US\$164 billion under BAU and US\$77

billion under APS. Under APS, investment is less in refineries and LNG-receiving terminals due to the promotion of energy efficiency. However, these investment costs will be much lower than power generation costs. In EAS17, the share of combined investment cost in refineries and LNG-receiving terminals to total energy infrastructure investment will be 12.7% under BAU and 1.3% under APS. These results indicate energy transition from fossil fuel to more advanced energy technologies such as renewable energy.

Figure 1.23. Total Energy Infrastructure Investment (EAS17, Business as Usual and Alternative Policy Scenario)

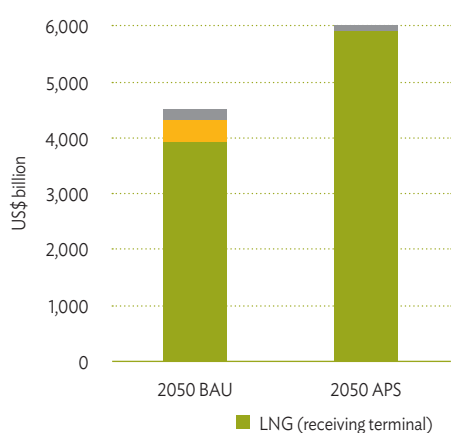
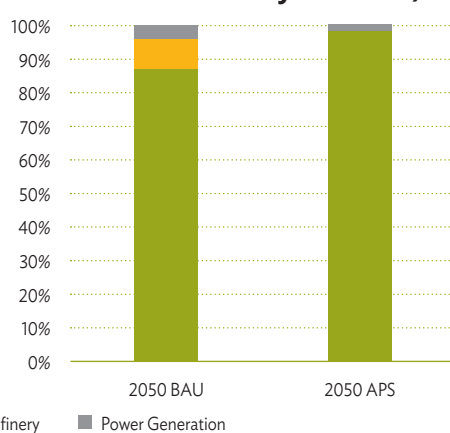


Figure 1.24. Share of Energy Infrastructure Investment (EAS17, Business as Usual and Alternative Policy Scenario)

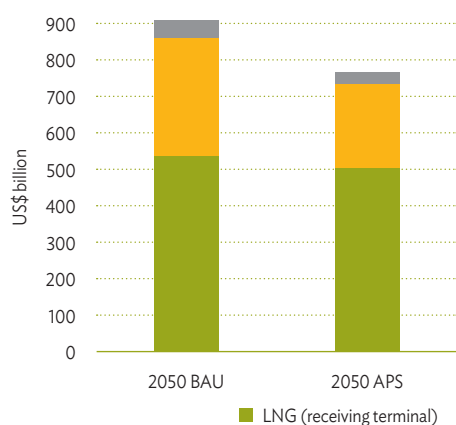


APS = alternative policy scenario, BAU = business as usual, LNG = liquefied natural gas.

Source: Authors.

In ASEAN, investments in refineries and LNG-receiving terminals are estimated at US\$322 billion and US\$52 billion, respectively, under BAU (Figure 1-25). Investments in ASEAN under APS are reduced to US\$233 billion for refineries and US\$34 billion for LNG-receiving terminals. The shares of combined investment cost of refineries and LNG-receiving terminals to total energy infrastructure investment are estimated at 40% under BAU and 35% under APS (Figure 1-26). ASEAN will still need fossil fuel. Total investment cost for power generation, refineries, and LNG-receiving terminals under APS will be lower than under BAU, which indicates that EEC in the final energy consumption sector and natural gas power plants will be crucial.

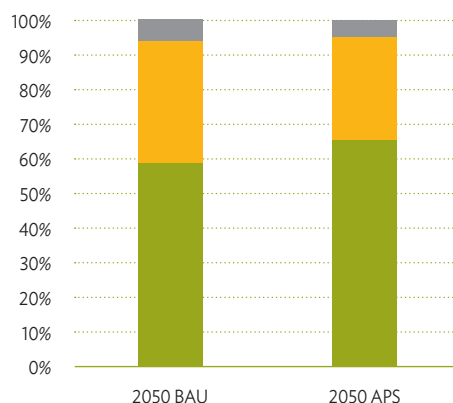
Figure 1.25. Total Energy Infrastructure Investment (ASEAN, Business as Usual and Alternative Policy Scenario)



APS = alternative policy scenario, BAU = business as usual, LNG = liquefied natural gas.

Source: Authors.

Figure 1.26. Share of Energy Infrastructure Investment (ASEAN, Business as Usual and Alternative Policy Scenario)



5. Conclusions and Recommendations

Sustained economic growth in all EAS17 countries is key to their people's well-being. Although the world economy has been impacted by the COVID-19 pandemic throughout 2020, economic growth is expected to be positive starting in 2021. The post-pandemic era will see increasing energy consumption. Decades of sustained economic growth, especially in ASEAN and India, have increased per capita incomes, significantly reducing poverty and raising living standards for hundreds of millions.

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 increasing energy demand might be associated with increasing GHG emissions and climate change challenges unless low emission technologies are used. Even if fossil fuel resources are enough, oil will likely be imported from other regions and no assurance can be given that it will be secure or affordable. EAS17 will need resilient energy infrastructure.

5.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and CO₂ emissions under BAU and APS, the working group members identified several key findings:

- (i) In 2050, fossil fuels (coal, oil, and gas) will retain the dominant share in primary energy supply, final energy consumption, and power generation mix in EAS17 under BAU (80%) and APS (70%). In final energy consumption, the share of fossil fuels will be 65% under BAU and 62% under APS. In power generation, the share of fossil fuels is projected at 60% under BAU and 35% under APS.
- (ii) Total final energy consumption in 2050 will increase by almost 44% under BAU and by 23% under APS compared with demand in 2017. The increase reflects actual average annual growth rate of 1.1% under BAU and 0.6% under APS per year in 2017–2050. Transportation energy demand is projected to grow moderately at about 1.4% per year under BAU and 0.6% under APS, and its energy consumption share is projected at 27.7% under BAU and 25.5% under APS by 2050. The annual growth rate of industry in 2017–2050 is slow at 0.9% per year under BAU and 0.4% under APS, but its energy consumption share is projected to be the largest at about 31.7% under BAU and 31.9% under APS by 2050. Commercial and residential ('others') demand will grow at 1.0% per year under BAU and 0.5% under APS, slower than transportation demand. However, commercial and residential energy consumption share is projected at 29.3% under BAU and 29.4% under APS, the second-largest share after industry.
- (iii) Total EAS17 power generation is projected to grow at an average annual rate of 1.8% under BAU and 1.5% under APS in 2017–2050, reflecting an 81% and 64% increase from 2017 under BAU and APS, respectively, by 2050. The share of coal-fired generation is projected to continue to be the largest at about 38.4% under BAU and 19.5% under APS by 2050, a large drop from 52.7% in 2015. The share of natural gas is projected to increase from 16.8% in 2015 to 20.8% under BAU and 15% under APS by 2050. The nuclear share (8.5% in 2017) is forecast to decrease to 6.7% under BAU and to increase to 9.3% under APS by 2050. Geothermal share (0.3% in 2017) will increase to 0.6% under BAU and to 1.0% under APS by 2050. The share of 'others', including wind, solar, and biomass sources, is projected to increase from 8.0% in 2017 to 23.6% under BAU and 43.2% under APS by 2050. The hydro share is projected to decrease from 12.4% in 2017 to 9.7% under BAU and 11.9% under APS by 2050. The share of oil in power generation was negligible in 2017 and will continue to be so under BAU and APS.
- (iv) Total EAS17 primary energy supply is projected to increase from 7,624 Mtoe in

2017 to 10,780 Mtoe under BAU and 8,860 Mtoe under APS by 2050. Coal will still comprise the largest share of primary energy supply but its growth is expected to be slow, at an average annual rate of 0.3% under BAU and at –1.3% under APS in 2017–2050. Consequently, the share of coal in TPES is forecast to decline from 40.2% in 2017 to 31.7% under BAU and 22.7% under APS by 2050. Amongst fossil sources of energy, natural gas is projected to see a moderate annual average growth rate of 1.9% under BAU and 0.9% under APS in 2017–2050. The share of natural gas in the total will increase from 15.7% in 2017 to 20.6% under BAU and 18.5% under APS by 2050. The share of nuclear energy was 4.5% in 2017 and is projected to remain unchanged under BAU and increase to 6.9% under APS by 2050. The reason is the assumed resumption of nuclear power generation in Japan and the expansion of nuclear power generation capacity in China and India. Geothermal energy is projected to grow fastest at 3.3% under BAU and 4.0% under APS in 2017–2050. However, its share was small at 0.6% in 2017 and is projected at 1.3% under BAU and 1.9% under APS by 2050.

- (v) The continuing reliance on fossil fuels to meet increasing energy demand will be associated with significant increases in CO₂ emissions. CO₂ emissions from energy consumption under BAU are projected to increase from 5,352 Mt-C in 2017 to 6,957 Mt-C under BAU and decrease to 4,318 Mt-C under APS by 2050, implying an average annual growth rate of 0.8% under BAU and –0.6% under APS in 2017–2050. Under APS, CO₂ emissions are projected to be 38% lower than under BAU. Since the emission reductions under APS are significant, CO₂ emissions from energy demand under APS in 2050 will still be below 2017 levels but about 1.5 times higher than in 1990. EEC and renewable energy targets in EAS17 provide great hope that energy demand and CO₂ emissions will be reduced. The results of this analysis indicate that, by 2050, the implementation of currently proposed energy-efficiency and renewable energy goals, action plans, and policies across the region could lead to the following reductions:

- (a) Large energy saving in primary energy supply is expected to be 1,920 Mtoe in 2050, representing 17.8% potential reduction from BAU to APS in 2050.
- (b) Primary energy intensity will be reduced by 48.1% under BAU and by 57.3% under APS from 2017 levels.⁶

⁶ 2017 is the base year of energy intensity and normalised to 100.

- (c) Under BAU, carbon intensity is expected to drop by 52.2% by 2050 from 2017 levels. Under APS, carbon intensity is expected to drop by 70.4% by 2050 from 2017 levels. The differences in carbon intensity between BAU and APS in 2017–2050 are the result of the shift towards more energy-efficient and renewable energy technologies and less energy-intensive economic activities in EAS17.
- (d) Energy demand per capita under BAU is projected to increase by 24.3% in 2050 compared with 2017 levels. Under APS, energy demand per capita is expected to increase slightly by 2.1% in 2050 from 2017 levels. The differences in energy demand per capita between BAU and APS in 2017–2050 are the result of the fundamental change in terms of energy efficiency from BAU to APS.
- (e) The necessary investment cost of combined power generation, refineries, and LNG-receiving terminals in EAS17 is estimated at US\$4.49 trillion under BAU and US\$6.01 trillion under APS in 2017–2050, with power generation dominating the total share of investment. For all EAS17 countries taken together, the amount of investment needed to meet electricity demand is US\$3.92 trillion under BAU and US\$5.93 trillion under APS. The investment cost of refineries in EAS17 is estimated at US\$410 billion under BAU. This study predicted that under APS, there will be no additional investment cost for refineries due to energy saving and conservation effects. The investment cost of LNG-receiving terminals in EAS17 is estimated at US\$164 billion under BAU and US\$77 billion under APS.

5.2. Policy Implications

The working group identified several policy implications, aggregated into five categories:

enhance action plans in specific sectors, prepare energy-efficiency policies, shift from fossil to non-fossil energy, rationalise energy-pricing mechanisms, and ensure that energy consumption statistics are accurate. Policies will differ between countries based on their circumstances, policy objectives, and market structures. Not all working group members agreed on all the recommendations:

- (1) Energy-efficiency action plans in final consumption sectors.** The industry, transportation, and commercial sectors will be major sources of energy saving. Several

EEC action plans will need to be introduced, implemented, and accelerated. The policies are listed by area and/or sector:

- Energy efficiency in industry will need to be applied. Energy service companies will play a crucial role in energy saving. Some ASEAN countries will need to accelerate the introduction of energy service companies, and national energy policies will need to require industries that consume large amounts of energy to have energy managers and energy auditing.
- The road transportation sector will need to consider measures to improve the fuel economy and shift to low-emission fuels such as biofuel and compressed natural gas.
- For commercial and residential energy efficiency, passive and active design policies are important. Passive design measures include setting up and enforcing building codes and rewards for green buildings, supporting energy service companies regulated by governments, and exploring and establishing a practical green building business model to fit various contexts and situations. Active design measures to improve energy efficiency include applying standard and labelling systems, using demand management systems for households and factories, developing energy managers and energy service companies, and improving thermal efficiency in power generation by constructing or replacing facilities with new and more efficient technologies.

(2) Renewable energy policies. Low-carbon fuels should be increased by enlarging the share of renewables and clean fuel such as hydrogen and nuclear energy in the energy mix. Several policies and actions need to be considered:

- Set targets and shares of renewables such as wind, solar, and biomass in the energy mix. Supportive renewable energy policies such as feed-in-tariff, renewable portfolio standard, and net metering are suggested according to the situation and the evolution of the cost perspective of these renewables and clean technologies. Supportive international financing schemes such as the Clean Development Mechanism⁷ and the Joint Credit Mechanism⁸ for renewables and energy efficiency are needed.

⁷ Allows emission-reduction projects in developing countries to earn certified emission reduction credits, each equivalent to 1 ton of CO₂.

⁸ A project-based bilateral offset crediting mechanism initiated by the Government of Japan to facilitate the diffusion of low-carbon technologies.

- The intermittent nature of renewable energy sources poses significant challenges in integrating renewable-energy generation with existing electricity grids. Thus, electricity storage technologies, combined with solar and wind power, and on-site hydrogen production for curtailed renewable electricity will be important. The combination cost is still high, however, and will need the right policy and framework to drive it down.

(3) Technology development policies. Environmental technologies will need to be considered to curb increasing CO₂ emissions:

- The development of CCUS technology will be important in controlling GHGs. Continued research and development, including the CCUS value chain, will be important to ensure the economic viability of deploying CCUS technology.
- Hydrogen could be extracted from fossil fuels, such as low-ranked coal and natural gas, through electrolysis using renewable energy. But hydrogen is still more expensive than other fuels. Hydrogen fuel development is promising and could be commercialised. Continued research and development in fuel cells and hydrogen power generation will be important for clean fuel use.
- Technological cooperation and technology diffusion, including the hydrogen value chain, will need to be accelerated in ASEAN.

(4) Energy supply security policies. Several measures are identified based on the OECD practice of increasing oil stockpiling requirements (IEA, 2020):

- Promote regional energy connectivity such as the trans-ASEAN gas pipeline using a virtual pipeline (LNG).
- Diversify sources of imports.
- Strengthen energy infrastructure, including the construction of LNG-receiving terminals and re-gasification plants.
- ASEAN might need to consider public and private strategic reserves or stockpiling requirements in the near future.

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CHAPTER 2

Australia Country Report

Shamim Ahmad and Seiya Endo



1. Introduction

Australia is the largest country in Oceania and the sixth-largest country in the world by total area. It has a land area of about 7.7 million square kilometres and is diverse in geography and climate. It has six states and two territories. Over the past 27 years, Australia's population has grown at an average annual rate of 1.4%, from 17.1 million in 1990 to 24.6 million in 2017.³¹

Australia's gross domestic product (GDP) increased at an average annual rate of 3.0%, from US\$638 billion in 1990 to US\$1.43 trillion in 2017 (constant 2010 US dollar values), i.e. an increase of per capita income from about US\$37,300 in 1990 to US\$58,200 in 2017. Economic activities are concentrated in the eastern and south-eastern seabords, where most of the population lives. In 2017, only three states – New South Wales, Victoria, and Queensland – generated 75% of Australia's GDP, whilst they represent 33%, 26%, and 20% of the national population, respectively (ABS, 2019).

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). Australia has 1.33 million tons of economically demonstrated resources of uranium, equivalent to 17,727 million tons of oil equivalent (Mtoe) or 742,179 petajoules (Geoscience Australia, 2019), more than one-third of the world's uranium resources. Australia has a major share of the world's thorium, which could be an alternative to uranium as a nuclear fuel.

³¹ All data in this chapter, unless otherwise cited, can be referenced to the 2020 energy outlook modelling results of the Institute of Energy Economics, Japan.

The country has 73,719 million tons or 10% of the world's recoverable black coal and 76,951 million tons or 24% of the world's brown coal (Geoscience Australia, 2019). The substantial conventional and unconventional gas resources of Australia account for almost 1.2% of the world's gas resources, and it has a small share (0.1%) of the world's crude oil resources (BP, 2020). The amount of recoverable resources is expected to grow with further exploration, and these resources are expected 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 due to 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 due to the dry climate and low water runoff over most of Australia. Pumped hydro for electricity storage is being considered for existing hydro 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 2017, Australia was the world's ninth-largest energy producer (405.6 Mtoe), accounting for 2.9% of global primary energy supply. The country was the world's 21st-largest energy consumer, accounting for 0.9% (127.6 Mtoe) of world primary energy supply (IEA, 2019).

Primary energy supply is largely based on fossil fuel. In 2017, coal contributed about 35% of primary energy supply; oil, 34%; and natural gas, 24%. Renewables contributed the remaining 7%, consisting of hydro (1%), solar and wind (2%), and biofuel and waste (4%) (IEA, 2019).

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 2017, Australia was the world's fourth-largest energy exporter; it exported 79% of its energy production, consisting largely of coal and liquefied natural gas. The country is the world's largest exporter of metallurgical coal, the second-largest exporter of thermal coal (IEA, 2019), and a large exporter of uranium. With limited crude oil resources, Australia is a net importer of crude oil and petroleum products; it is increasingly reliant on imported transport fuels.

Over the past 27 years, Australia's gross electricity generation has increased at an average annual rate of 1.9%, from 154 terawatt-hours (TWh) in 1990 to 258 TWh in 2017. In 2017, coal accounted for almost two-thirds (63%) of total electricity generation, followed by natural

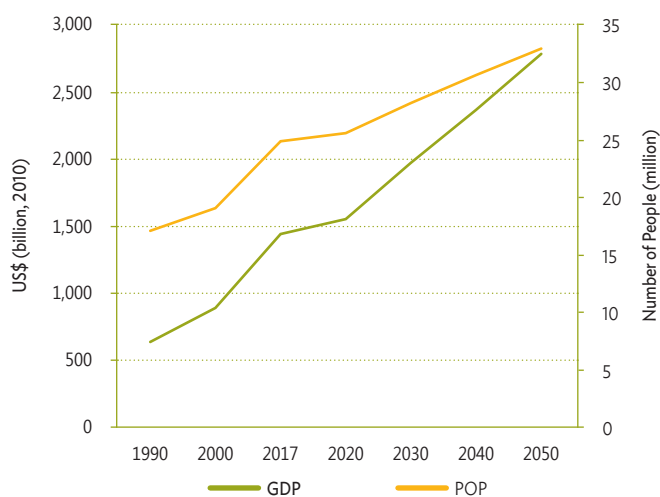
gas, 20%; hydro, 6%; oil, 2%; and others (non-hydro renewables), 9%. Coal still dominates the electricity generation mix although its share fell from 79% in 1990 to 63% in 2017. The share of natural gas and non-hydro renewables in the generation mix increased significantly over this period.

2. Modelling Assumptions

The business as usual (BAU) scenario reflects Australia's current trends of energy demand and supply and existing goals, action plans, and policy commitments. Australia's GDP is assumed to grow at an average annual rate of 2.0% from 2017 to 2050, compared with average annual growth of 3.0% from 1990 to 2017.³² The economy will gradually shift from energy-intensive industries towards less energy-intensive ones. GDP growth will gradually decrease towards the end of the projection period. The population is assumed to grow at an average annual rate of 0.9% from 2017 to 2050, which is marginally slower than the average annual growth rate of about 1.4% from 1990 to 2017 (Figure 2.1).

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

Figure 2.1. Gross National Product and Population (1990–2050)



GDP = gross domestic product, POP = population.
Source: Authors.

³² The global coronavirus disease (COVID-19) pandemic has a negative impact on GDP and energy consumption, and when the economy will return to normal is highly uncertain. The data and analysis for this report were completed before the pandemic. Its impact, therefore, has not been accounted for in modelling the two scenarios.

electricity will decrease due to 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.

The alternative policy scenario (APS) applies the same GDP and population assumptions as BAU. APS assumes improved efficiency of final energy consumption in end-use sectors. APS will see more efficient thermal power generation and higher contribution of renewable energy to total supply with no nuclear power plants. These 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 inefficient small plants. Structural changes are assumed to gradually shift the economy from energy-intensive industries. In the residential and commercial sectors, efficient end-use technologies and energy management systems are assumed to further achieve energy saving. The transportation sector 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.

By comparing APS and BAU results, this study provides a basis for determining the impacts of promoting energy efficiency and increasing the use of renewable energy on energy saving and carbon dioxide (CO₂) emission reduction in Australia.

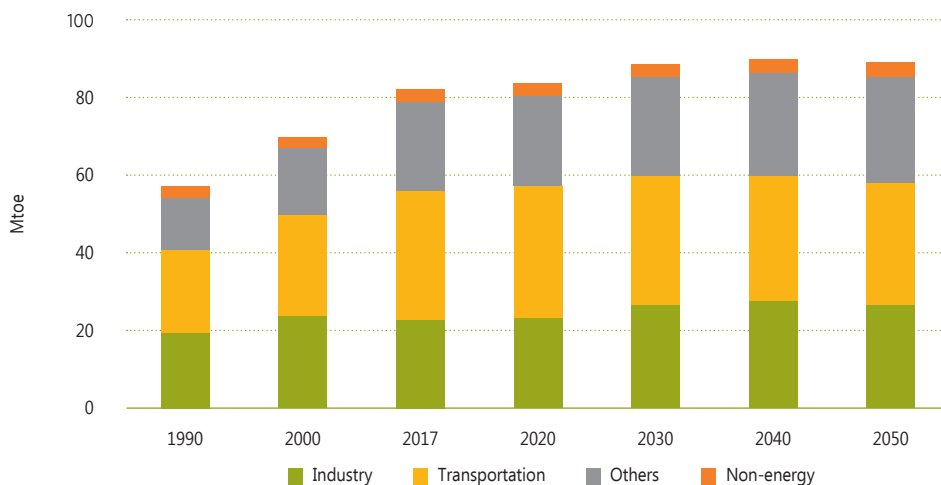
3.Outlook Results

3.1.Business as Usual

3.1.1.Final Energy Consumption

Under BAU, total final energy consumption is projected to increase by about 8.7%, from 81.8 Mtoe in 2017 to 89.0 Mtoe in 2050, or an average annual rate of 0.3% (Figure 2.2). The strongest growth is projected to occur in the 'others' sector (e.g. residential and service), increasing by 0.5% a year from 2017 to 2050. Transport energy consumption is projected to decline (0.2% a year) over the projection period, although it has seen strong growth (1.7% a year) in the past 27 years.

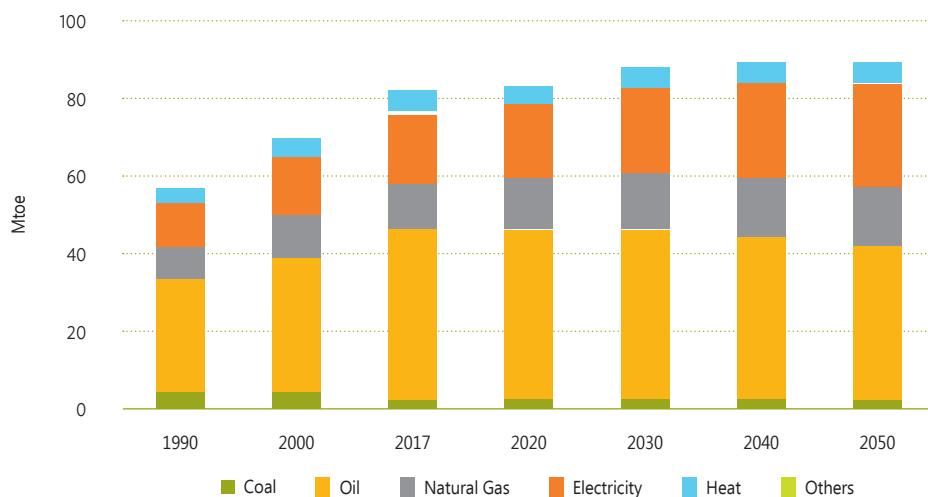
Figure 2.2. Final Energy Consumption by Sector, Business as Usual



Mtoe = million tons of oil equivalent.

Source: Authors.

Figure 2.3. Final Energy Consumption by Fuel Type, Business as Usual



Mtoe = million tons of oil equivalent.

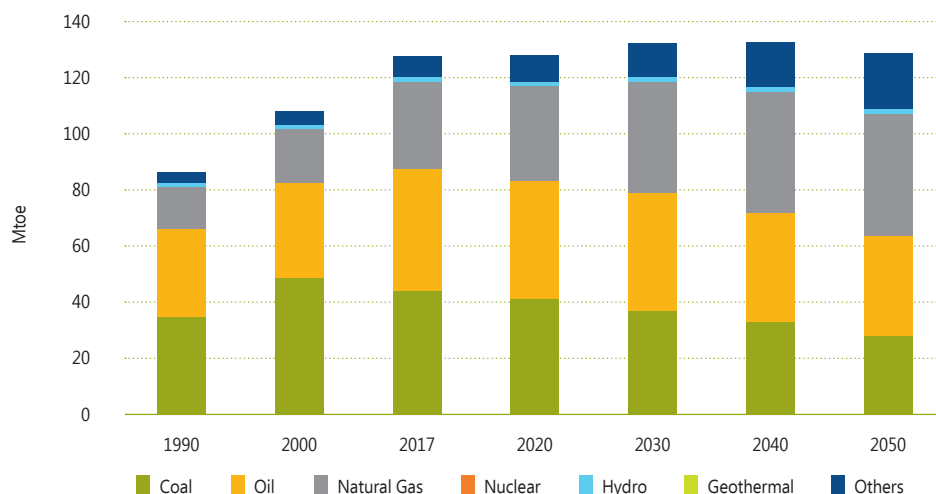
Source: Authors.

Electricity consumption is projected to have the fastest growth at an average annual rate of 1.2% per year from 2017 to 2050 (Figure 2.3). Natural gas is projected to increase at the second-highest rate of 0.5% per year. Growth in petroleum products is projected to decline by 0.3% per year. Coal consumption is expected to decline at an average rate of 0.2% per year.

3.1.2. Primary Energy Supply

Under BAU, primary energy supply is projected to remain flat, slightly increasing from 127.1 Mtoe in 2017 to 127.9 Mtoe in 2050 (Figure 2.4). Coal consumption is expected to decline at an annual average rate of 1.4% as is oil consumption (0.6% per year) from 2017 to 2050. Consumption of natural gas will increase by 1.0% per year from 2017 to 2050, with its share in the primary energy mix expected to increase from about 24.6% in 2017 to 33.9% in 2050. The overall share of fossil fuel in primary energy supply will decline from 92.9% in 2017 to 83.5% in 2050.

Figure 2.4. Primary Energy Supply by Fuel Type, Business as Usual



Mtoe = million tons of oil equivalent.

Source: Authors.

Others' (including non-hydro renewables) are projected to increase by 2.9% a year over the projection period. The share of 'others' is expected to increase from 6.0% in 2017 to about 15.3% in 2050; the increase will come mainly from solar and wind, followed by biomass. Solar, wind, biomass, and ocean energy together are expected to grow at an average annual rate of 5.5% from 2017 to 2050.

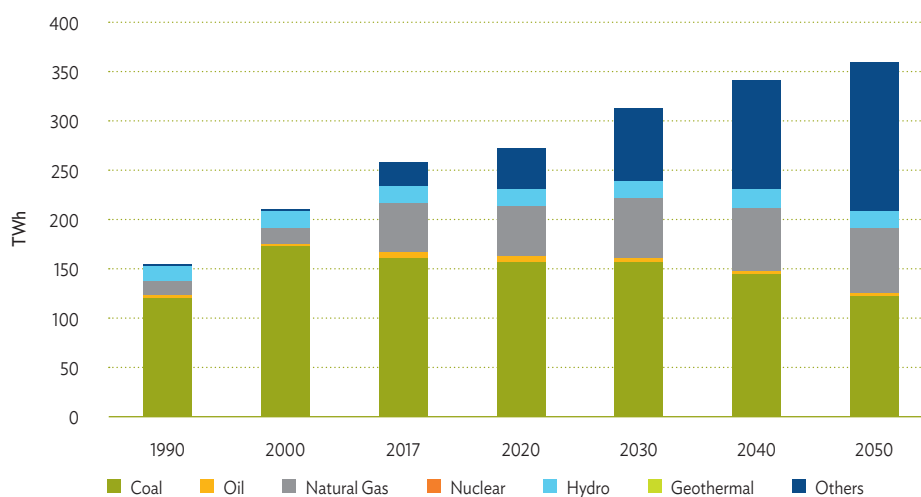
3.1.3. Power Generation

Electricity generation under BAU is projected to increase at an average rate of 1.0% per year, from 257.8 TWh in 2017 to 360.2 TWh in 2050 (Figure 2.5). The share of coal in the power

generation mix is projected to fall from 62.8% in 2017 to 34.5% in 2050, but coal will still maintain the largest share under BAU. Coal share will decline due to the scheduled closure and retirement of some old coal-fired generation plants. Generation from oil is projected to decline at an average rate of 2.8% per year, and the share of oil in the generation mix will decline from 2.0% in 2017 to 0.6% in 2050. The share of natural gas-fired generation will fall from 19.6% in 2017 to 18.3% in 2050, and natural gas use in electricity generation is projected to grow at an average rate of 0.8% per year over the period.

Hydro's share in the power generation mix is expected to decline from 6.2% in 2017 to 4.8% by 2050. The share of 'others' (non-hydro renewables), however, is expected to increase from 9.4% in 2017 to 41.8% in 2050. Electricity generation from 'others' (non-hydro renewables) is expected to grow at an average rate of 5.7% per year from 2017 to 2050. Declining costs of wind and solar technology will partly contribute to the faster growth in electricity generation from 'others' (including wind and solar).

Figure 2.5. Power Generation, Business as Usual



TWh = terawatt-hour.

Source: Authors.

3.2. Energy Saving and Carbon Dioxide Reduction Potential

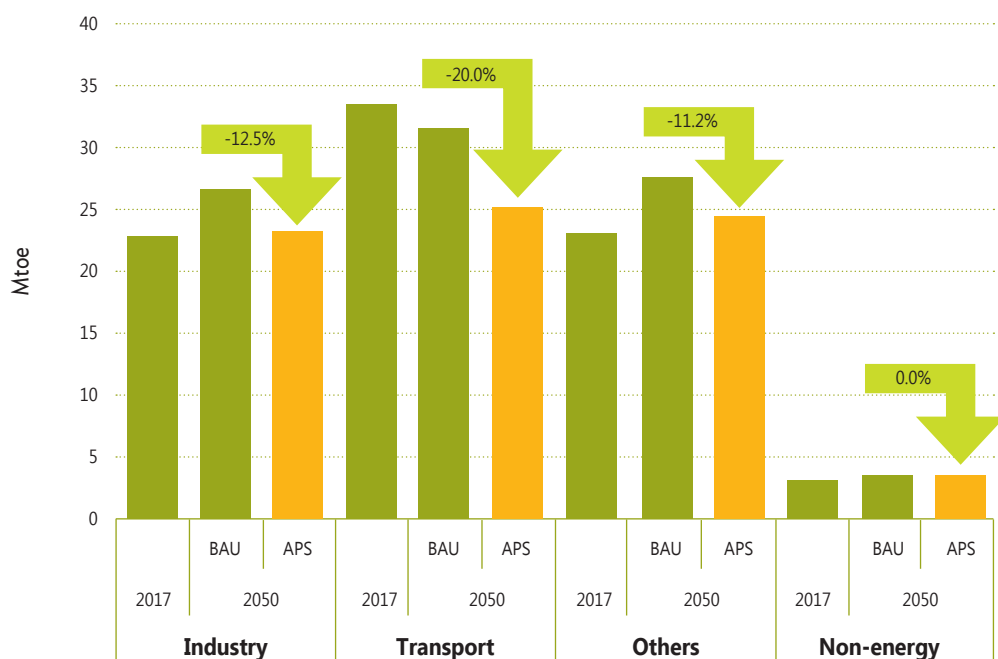
3.2.1. Final Energy Consumption

Under APS, final energy consumption is projected to decline by 0.2% per year from 81.8 Mtoe in 2017 to 76.2 Mtoe in 2050 (Figure 2.6), representing energy saving of 12.7 Mtoe or 14.3%

under APS in 2050 compared with BAU. Demand is expected to grow more slowly across all end-use sectors, excluding the non-energy sector. Transport is projected to see the highest energy saving, followed by industry and 'others' (residential and commercial sectors), reflecting improvements in vehicle fuel efficiency and end-use technologies.

In 2050, under APS, estimated savings are 3.3 Mtoe (12.5%) in industry, 6.3 Mtoe (20.0%) in transport, and 3.1 Mtoe (11.2%) in 'others' (Figure 2.6).

Figure 2.6. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario



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

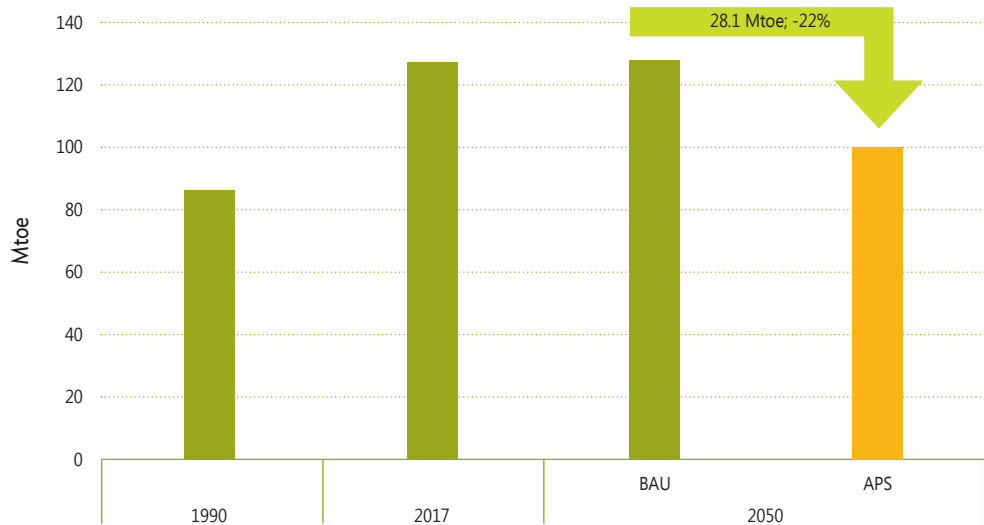
Source: Authors.

3.2.2. Primary Energy Supply

Under APS, primary energy supply is projected to decrease by 0.7% per year from 127.1 Mtoe in 2017 to 99.8 Mtoe in 2050, implying that in 2050, under APS, saving in primary energy supply will be about 28.1 Mtoe or 22.0% compared with BAU (Figure 2.7).

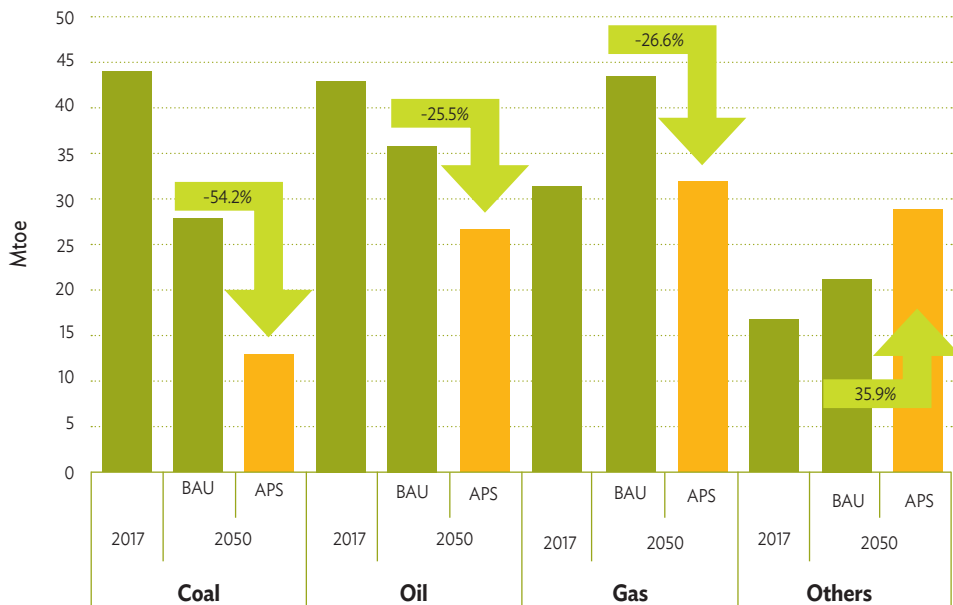
Coal is expected to decline by 3.7% per year under APS (compared with 1.4% under BAU) over the projection period, resulting in saving in coal consumption of about 15.1 Mtoe in

Figure 2.7. Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.
Source: Authors.

Figure 2.8. Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.
Source: Authors.

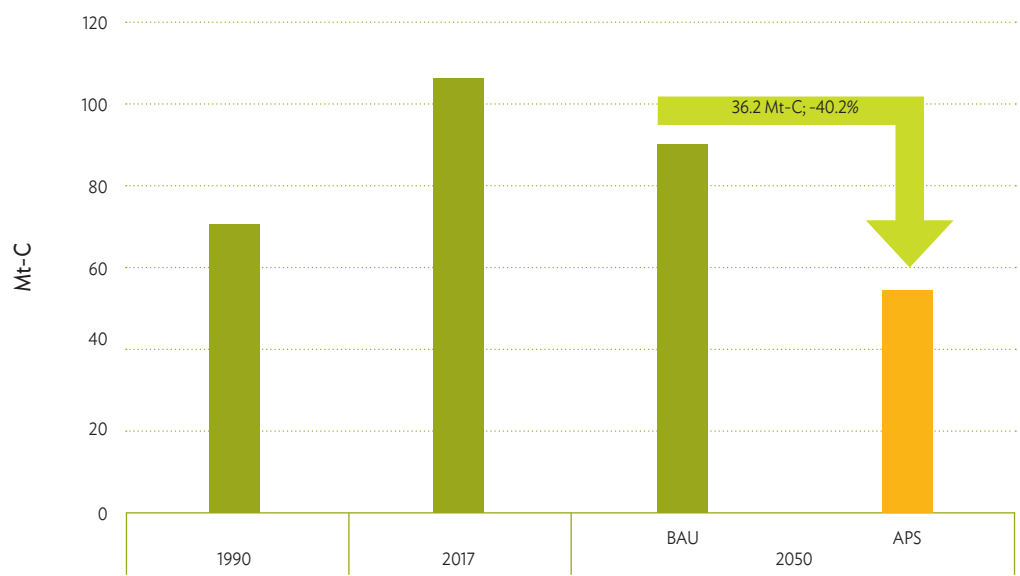
2050 compared with BAU. Similarly, negative growth in oil demand (–1.4% per year) will save oil consumption of about 9.1 Mtoe in 2050. With average annual growth of nearly 0% under APS, saving in natural gas consumption will be about 11.6 Mtoe compared with BAU. However, demand for ‘others’ (renewables) is expected to increase by about 7.6 Mtoe or 38.7% compared with BAU in 2050 (Figure 2.8).

3.3. Carbon Dioxide Emissions

CO2 emissions from energy consumption under BAU are projected to decline by 0.5% per year from 106.1 million tons of carbon (Mt-C) in 2017 to 89.9 Mt-C in 2050 (Figure 2.9). Growth in emissions appears to be less than projected growth in primary energy supply, reflecting increased use of energy sources that are less carbon-intensive.

Under APS, CO2 emissions are projected to decrease at an average annual rate of 2.0%, from 106.1 Mt-C in 2017 to 53.7 Mt-C in 2050. Emission saving under APS will be about 40.2% compared with BAU in 2050. The lower emission growth rate under APS indicates that energy-saving options are effective in reducing CO2 emissions. Reduced demand for coal in power generation and in final demand and reduced oil consumption in transport will contribute the most to expected reduction of CO2 emissions under APS.

Figure 2.9. Carbon Dioxide Emissions from Energy Combustion, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tons of carbon.
Source: Authors.

4. Implications

- (i) Energy-saving options are effective in reducing CO₂ emissions. Under APS, however, Australia will not achieve its intended nationally determined contribution target: reduce energy-related emissions of 26% to 28% below the 2005 level by 2030.
- (ii) Energy efficiency and demand-side management are important. Using improved and efficient end-use technologies will reduce final energy consumption in end-use sectors. Transport has more opportunities for energy saving. Energy saving in industry will come from improved efficiency in large energy-intensive industries.
- (iii) Fossil fuel – coal, oil, and gas – will continue to dominate the energy mix under both BAU and APS.
- (iv) Coal will continue to dominate the electricity generation mix up to 2050, but its share in the power mix is projected to decline. Advanced technologies for power generation are necessary to enhance efficiency, energy saving, and emission reduction.
- (v) Coal-fired generation is likely to remain cheaper than other energy sources. However, global attempts to curb emissions will put pressure on Australia to adopt low-emission technologies for power generation. The use of efficient and clean coal technologies is necessary. Research, development, and deployment of clean energy technologies will play a key role.
- (vi) Oil will continue to supply transport fuel needs. Improved vehicle fuel efficiency and uptake of electric vehicles will reduce oil demand in transport. Investment in new petroleum refinery plants might be necessary to reduce dependence on imported transport fuel.
- (vii) Substantial expansion of traditional hydropower is not likely due to the dry climate and low water runoff over much of Australia.
- (viii) Wind and solar technology costs will fall more quickly over the projection period. Growth in renewable energy will likely come from large-scale adoption of wind and solar energy supported by energy storage.

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CHAPTER 3

Brunei Darussalam Country Report

Ministry of Energy, Brunei Darussalam

1. Background

Brunei Darussalam is in northwest Borneo, with a coastline of 161 kilometres. It has a land area of 5,765 square kilometres and four districts: Brunei–Muara, Tutong, Belait, and Temburong. The capital city, Bandar Seri Begawan, is in Brunei–Muara. Brunei Darussalam has an equatorial climate, high rainfall, and high humidity.

Gross domestic product (GDP) in 2017 was US\$13.5 billion¹ (World Bank, 2019). The population is 429,500 and GDP per capita US\$31,400. About 55% of GDP is generated by the oil and gas sector. It dominates export value; crude oil, liquefied natural gas, and methanol account for more than 90% of total exports, primarily to Asia and the Pacific.

2. Energy Supply and Consumption in 2017

Oil and natural gas are the main sources of energy. In 2017, total primary energy supply (TPES) for both sources was 3.58 million tons of oil equivalent (Mtoe), with 2.86 Mtoe or about 80% from natural gas.

Brunei Darussalam has 890 megawatts (MW) of installed capacity in power generation of public utilities, including 1.2 MW of solar photovoltaic (PV). Electricity production from public utilities in 2017 was 3.72 terawatt-hours (TWh). Energy supply and consumption in 2017 are shown in Table 3.1

¹All US dollars in this report are in constant 2010 values unless specified

Table 3.1. Energy Supply and Consumption, 2017
(million tons of oil equivalent)

Supply and Consumption	Oil	Natural Gas	Electricity	Total
Primary energy supplies				
Indigenous production	5.96	10.32	-	16.28
Net imports and others	-5.25	-7.45	-	-12.70
Total primary energy supply	0.71	2.87	-	3.58
Final energy consumption				
Industry	0.13	-	0.01	0.14
Transport	0.52	-	-	0.52
Others	0.05	0.02	0.26	0.33
Non-energy	0.01	0.45	-	0.46
Total final energy consumption	0.71	0.47	0.27	1.45

Note: 'Others' include the residential and commercial sectors.

Source: Authors.

Total final energy consumption (TFEC) in 2017 was 1.45 Mtoe; transport had the highest energy demand, at 0.52 Mtoe or 36.3% of TFEC, followed by the non-energy sector (31.6%), 'others' (22.1%), and industry (10.0%). Oil accounted for 49.0% of final energy consumption, followed by natural gas at 32.3% and electricity 18.7%.

3. Energy Policies

3.1. Supply

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

Brunei Darussalam aims to reduce energy intensity by 45% by 2035 from the baseline year of 2005, in line with its regional commitment to the Asia-Pacific Economic Cooperation. The country targets increasing the share of renewable energy, particularly solar PV, in the power

generation mix to 100 MW by 2025. The government plans to introduce renewable energy policy and regulatory frameworks that will stimulate public and private sector investment in developing and deploying renewable energy.

3.2 Consumption

Brunei Darussalam has implemented several initiatives and activities to reduce energy intensity to 45% by 2035. Government agencies and industry collaborate on initiatives that promote energy efficiency and low-energy-intensive industry. Industry will identify and implement the latest technology to reduce energy usage, and adopt consumption behaviour, including by encouraging the embrace of energy-efficient appliances.

Efforts to achieve Energy Efficiency and Conservation (EEC) targets include power efficiency improvement, implementation of standards and labelling for electrical appliances, deployment of electric vehicles, expansion of EEC building guidelines, and use of LED lighting systems for streetlights, amongst others. The Department of Electrical Services and Berakas Power Company play major roles in improving power stations' efficiency, including by using combined-cycle turbines and co-generation power plants, whilst phasing out single-cycle power stations and carbon-intensive diesel-powered plants.

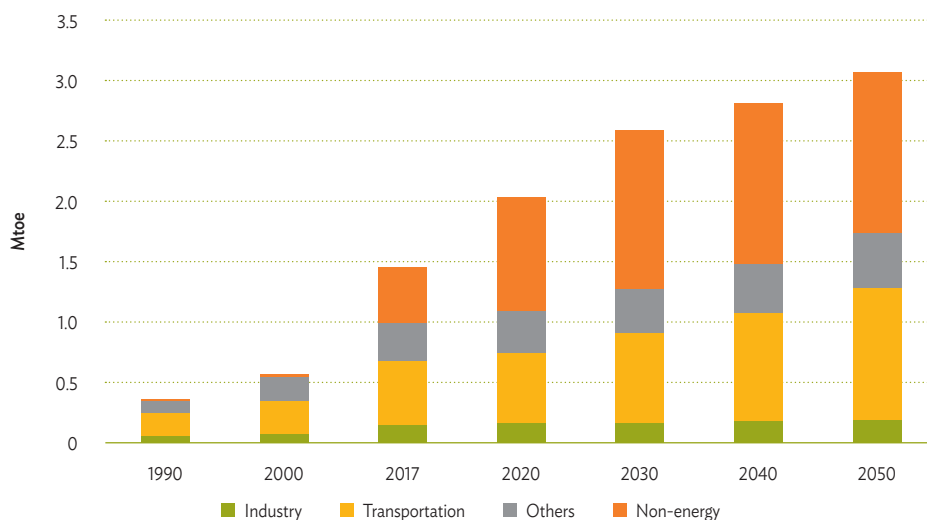
4. Outlook Result

4.1. Final Energy Consumption

4.1.1. Business as Usual

Under the business as usual (BAU) scenario, the projected TFEC in 2050 is 3.05 Mtoe (Figure 3.1). The increase in projected TFEC is linked to GDP growth rate, where the model is set at a constant rate of 2.4% per year over the projection period. In 2050, the share of oil in total demand will be 43.4%, mainly as transport fuel, whilst the share of natural gas will be 42.7%. In 2017, TFEC of oil was 0.71 Mtoe and is projected to increase to 1.32 Mtoe in 2050, whilst the TFEC of natural gas will increase from 0.47 Mtoe in 2017 to 1.30 Mtoe in 2050. The model predicts that public utilities' demand for electricity will increase at an average rate of 1.4% per year, from 0.27 Mtoe in 2017 to 0.42 Mtoe in 2050.

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



Mtoe = million tons of oil equivalent.

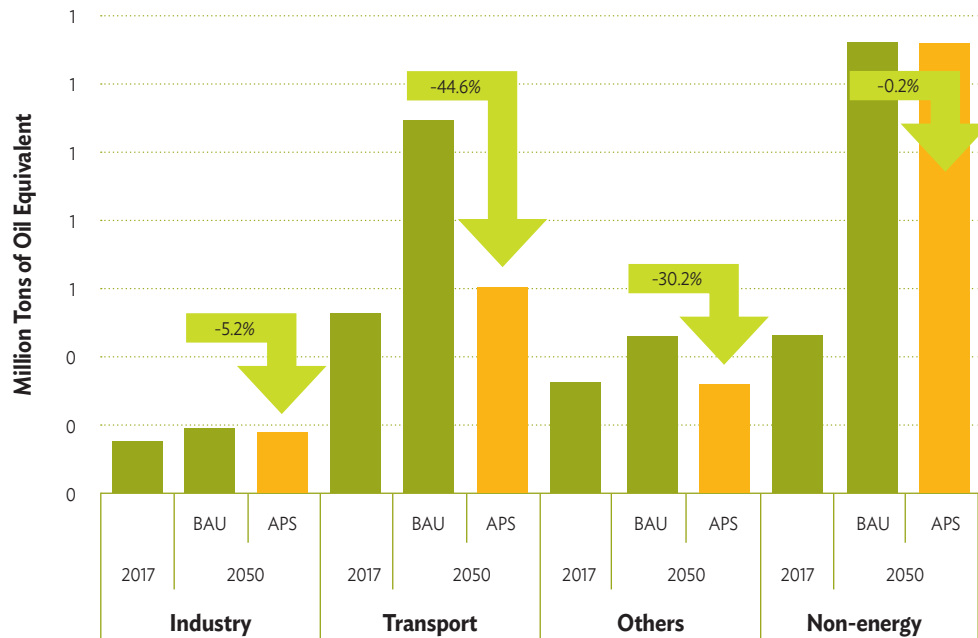
Source: Authors.

4.1.2. Alternative Policy Scenario

An alternative policy scenario (APS) was developed to estimate energy-saving potential to achieve energy intensity reduction targets by deploying advanced technologies and enforcing initiatives. Under APS, the overall TFEC in 2050 will be 2.41 Mtoe. In 2050, about 7.3% of energy demand will be from industry, 13.2% from 'others', and 24.9% from transport. Non-energy sector demand will account for 54.6%.

The introduction of electric vehicles will be a leading factor in the lower growth rate of transport fuel demand. In 2017–2050, TFEC will grow by an average of 1.6% per year. Referring to the result of Low Emission Analysis Platform (LEAP) model for energy outlook, the TFEC in 2050 under APS will be 20.8% lower than under BAU. The highest savings will be in transport at 44.6%, followed by 'others' (residential and commercial sectors) at 30.2%. Energy saving in industry will be the lowest, at 5.2%. No energy saving is assumed in the non-energy model (Figure 3.2).

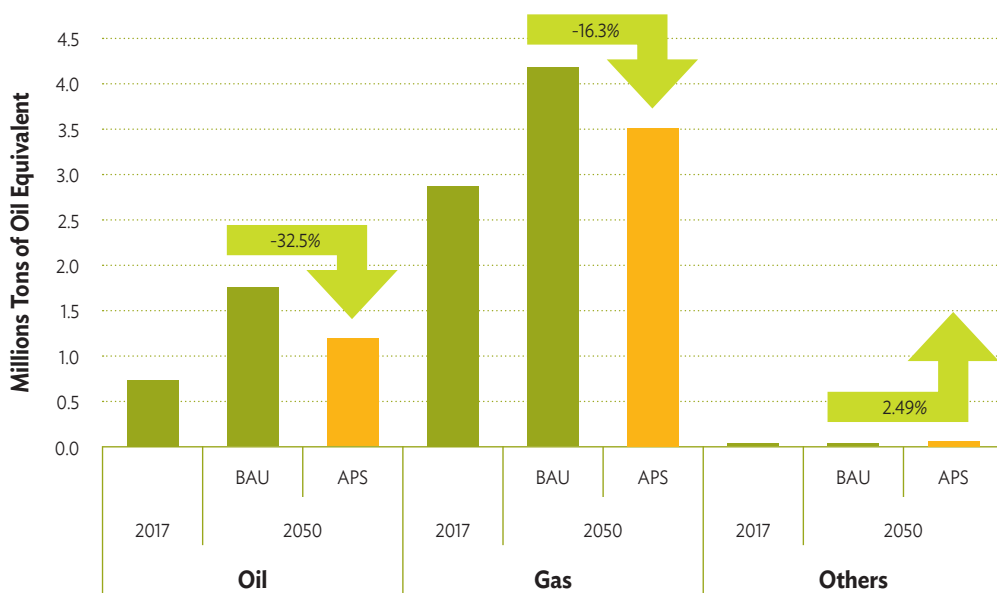
Figure 3.2. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

Figure 3.3. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual

Source: Authors.

4.2.2. Alternative Policy Scenario

A decrease in TPES for oil and natural gas is projected between BAU and APS in 2050. In 2050, oil supply under APS will be at 1.18 Mtoe against BAU at 1.74 Mtoe, or 32.5% lower. Natural gas supply under APS is predicted to be lower than under BAU by 16.3%. However, renewable energy supply, particularly from solar PV sources, will increase significantly (figure 3.3).

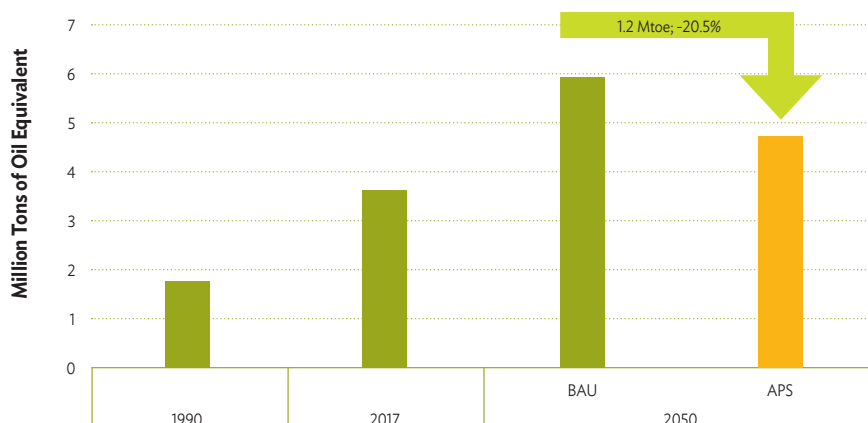
4.3. Power Generation

Power generation capacity from public utilities is dominated by natural gas. Of 890 MW of installed capacity (including 1.2 MW solar PV), diesel accounts for only 12 MW. Under BAU, about 4.9 TWh of electricity will be generated by 2050 from public utility thermal power plants, whilst only 0.002 TWh of power will be generated from renewable energy. Under APS, electricity generation from public utility thermal power plants in 2050 is projected at 4.3 TWh, a decrease of 13% from electricity generation under BAU. Solar PV is projected to produce 0.39 TWh in 2050.

4.4. Projected Energy Saving²

The energy-saving potential from implementing EEC measures and developing renewable energy is about 1.2 Mtoe of TPES or a reduction of 20.5% from BAU in 2050 (Figure 3.4).

Figure 3.4. Reduction of Primary Energy Supply, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

² The difference between primary energy supply under BAU and APS.

4.5. Carbon Dioxide Emissions

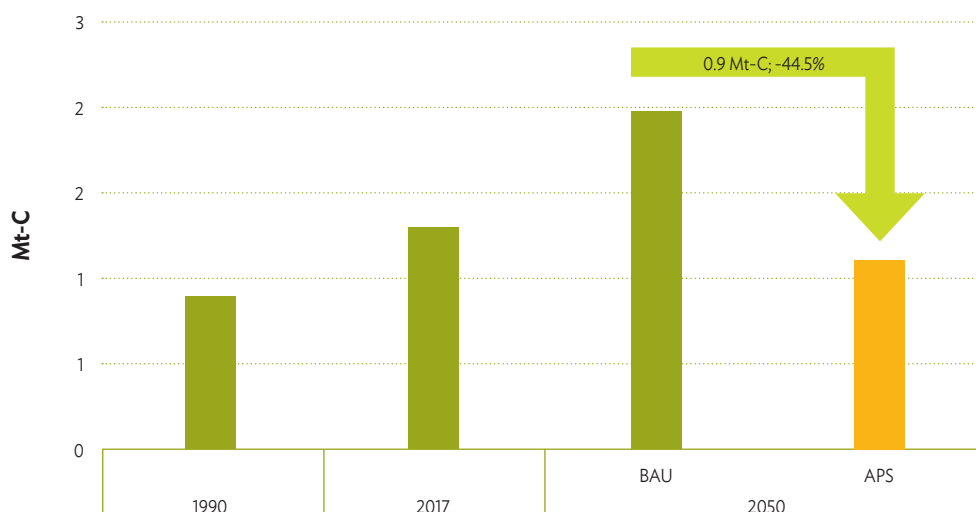
4.5.1. Business as Usual

The percentage increase in carbon dioxide (CO₂) emissions correlates to the increase in TPES, which is expected because the energy mix is 99% fossil fuel. In 2017, the LEAP model shows 1.3 million tons of carbon (Mt-C). An increase of 1.3% per year is expected under BAU, with an eventual value of 2.0 Mt-C in 2050 (Figure 3.5).

4.5.2. Alternative Policy Scenario

Under APS, CO₂ emissions could decrease by 44.5% in 2050 compared with BAU (Figure 3.5). The model shows that a total of 1.1 Mt-C will be emitted by 2050. The decrease in CO₂ is significantly attributed to the improvement in the efficiencies of power generation plants.

Figure 3.5. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

5. Policy Implications

To increase renewable energy sources and energy efficiency and conservation, Brunei Darussalam continues exploring and promoting 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 energy efficiency and conservation and by diversifying the economy to include high value-added but less energy-intensive industries.
- (b) Public and private investment in renewable energy technologies can increase the share of renewables to at least 30% of the total power generation mix by 2035.

(ii) Promoting energy efficiency and conservation

- (a) Improving supply-side efficiency. Brunei Darussalam is pursuing a strategy to improve the efficiency of existing open-cycle gas turbines whilst using more-efficient combined-cycle gas turbines to expand capacity.
- (b) Managing electricity and fuel demand. The use of fossil fuel to generate electricity and to power transport can be reduced by making energy technologies more energy-efficient and by using existing and future technologies more efficiently. The following are measures for doing so:
 - (i) Standards and labelling order. The soon-to-be implemented standards and labelling order for electrical appliances are a regulatory framework that allows only efficient technologies to be used in the residential sector and only efficient electrical appliances to be sold. This regulation will commence with air-conditioning systems then expand to cover refrigerators, lighting systems, and water heaters.
 - (ii) EEC Building Guidelines for Non-Residential Sector. The guidelines are mandatory for all government buildings. The Ministry of Energy and the Ministry

of Development are planning to extend the guidelines to the commercial sector as early as the first quarter of 2021.

- (iii) 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 system controllers (i.e. demand controllers) and building energy management systems. Buildings must have an energy manager to implement conservation measures, monitor energy consumption, assess business decisions for sustainability, and seek opportunities to increase energy efficiency. As of 2019, Brunei Darussalam had five energy managers and auditors, who had undergone the Association of Southeast Asian Nations (ASEAN) energy manager training and certification program under the ASEAN–Japan Energy Efficiency Partnership. In September 2019, 20 national energy managers ‘graduated’ from the first energy manager training workshop conducted by an ASEAN-certified energy manager and auditor. The workshop will cover commercial buildings by 2021.
- (iv) Residential tariff reforms. The progressive electricity tariff structure, introduced in 2012, encourages energy efficiency by providing a financial disincentive for high energy consumption. The new electricity tariff reform will help low-income citizens by charging them a minimum of only US\$0.01 per kilowatt-hour for basic electricity consumption, and will promote energy saving and discourage energy wastage.
- (v) Deployment of electric vehicles. The country aims to increase the share of electric vehicles to 60% of total annual sales by 2035. Achieving the target depends on the development of electric vehicle technologies and infrastructure. Government agencies, industry, and the private sector must, therefore, collaborate on promoting the use of electric vehicles. The Electric Vehicle Joint Taskforce was established in February 2020 to expedite their deployment. It is co-chaired by senior officials from the Ministry of Transport and Infocommunications and the Ministry of Energy.

The government seeks to achieve the objectives of Wawasan Brunei 2035 (Brunei Vision 2035) by encouraging a significant increase in economic activity in all sectors, including energy. Despite the increased focus on EEC, growing domestic energy demand ensures that fossil fuel will remain the primary energy source.

CHAPTER 4

Cambodia Country Report

Heang Theangseng



1. Background

Located in the lower Mekong region of Southeast Asia, Cambodia has an area of 181,035 square kilometres (km) and an 800 km border with Thailand in the west, Lao People's Democratic Republic (Lao PDR) in the north, and Viet Nam in 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 (ha) of arable land and over 0.5 million ha of pastureland.

Gross domestic product (GDP) average annual growth rate (AAGR) was 7.2% in 2010–2018. The service sector was the largest in that period and contributed the most (38%) to economy in 2018. The AAGR of services was 7.2% in 2010–2018, however, lower than that of industry (11.1%), which indicates industry's growing importance in GDP. Agriculture's share was about 34% in 2010 and decreased to 22% in 2018, with an AAGR of 1.7%. The Ministry of Economy and Finance, Cambodia predicts that GDP will stay at about 6.0% from 2023 as a result of the coronavirus disease (COVID-19) outbreak, which could cost the global economy \$77 billion–\$347 billion or 0.1%–0.4% loss of GDP.

The population increased steadily at an AAGR of 1.6% in 2010–2018. The urban population grew by 3.4% per year, faster than the rural population. The rural population, however, was still bigger than the urban population, making up 77% of the total in 2018.

Electricity generation facilities in 2018 were hydro, coal, diesel, and solar power plants, and plants using wood and other biomass. Total installed capacity of power generation grew by

Table 4.1. Power Generation Facilities by Fuel

No.	Type of Generation	Installed Capacity (megawatts)		Proportion (2018, %)
		2017	2018	
1	Hydro	979.70	1329.70	48.64
2	Diesel and heavy fuel oil	251.33	266.82	3.07
3	Renewable energy	84.27	39.27	0.82
4	Coal	538.00	551.20	31.39
5	Licensee (diesel)	13.19	0	0
6	Imported	416.50	448.50	16.09
	Total	2,282.99	2635.49	100

Source: Electricity Authority of Cambodia (2018).

13.50% during 2017–2018, whilst hydro grew by 36.00%, followed by diesel and heavy fuel oil (6.10%), coal (2.45%), and imported power (7.68%) (Table 4.1).

Final energy consumption increased steadily by 7.2% per year in 2010–2018. Electricity consumption grew the fastest, by an average of 18.3% per year, followed by oil (8.3%). Oil, however, still accounted for most of total final energy consumption, at 55.5%. Biomass increased slightly in 2010–2015 and started to decrease in 2016–2018. Although biomass consumption is declining, its share in total energy consumption remained high, at about 25.5%, in 2018.

2. Modelling Assumptions

2.1. Gross Domestic Product and Population

Based on the energy demand forecast for 2050, GDP's AAGR is assumed at 6.44% and population is at 1.5%, resulting in an AAGR of GDP per capita of 4.7% (Table 4.2).

Table 4.2. Gross Domestic Product and Population

Year	2018	2020	2030	2040	2050	AAGR (%) 2018–2050
GDP	52.97	55.99	108.09	208.11	390.64	6.44
Population	16.25	16.74	19.43	22.55	26.17	1.5

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

Source: Author.

2.2. Electricity Generation

Regarding future electricity supply, liquid natural gas (LNG) is expected to dominate the fuel mix in 2050, followed by coal. Cambodia's Power Development Master Plan 2020–2030 predicts that the country will have total additional installed electricity generation capacity of 24,384 megawatts (MW), contributed mainly by LNG (9,600 MW), hydro (5,927 MW), and coal (5,140 MW) by 2050.

**Table 4.3. Installed Capacity, Business as Usual
(megawatts)**

Technology	2020	2025	2030	2035	2040	2045	2050
HFO power plant EDC	400	400	400	400	400	400	400
Wind	0	80	180	280	380	480	580
Natural gas	0	0	3,600.00	4,800.00	6,000.00	7,200.00	9,600.00
Solar	75	525	1,725.00	1,925.00	2,125.00	2,325.00	2,525.00
Biomass	29	29	29	29	29	29	29
Hydro	2,103.00	2,103.00	4,727.00	4,727.00	5,927.00	5,927.00	5,927.00
HFO and diesel	281	183	183	183	183	183	183
Coal-fired power plant	1,000.00	3,390.00	5,140.00	5,140.00	5,140.00	5,140.00	5,140.00
Total	3,888	6,710	15,984	17,484	20,184	21,684	24,384

EDC = <>, HFO = heavy fuel oil.

Source: Author.

**Table 4.4. Installed Capacity, Alternative Policy Scenario
(megawatts)**

Technology	2020	2025	2030	2035	2040	2045	2050
Waste-to-energy power generation	0	100	450	450	650	650	1,750.00
HFO power plant EDC	400	400	400	400	400	400	400
Wind	0	80	230	330	430	830	860
Natural gas	0	0	3,000.00	4,800.00	4,800.00	4,800.00	6,800.00
Solar	75	525	1,875.00	2,075.00	2,475.00	3,475.00	4,475.00
Biomass	29	29	29	29	29	29	29
Hydro	2,103.00	2,103.00	4,727.00	4,727.00	6,127.00	6,127.00	7,127.00
HFO and diesel	281	183	183	183	183	183	183
Coal-fired power plant	1,000.00	1,640.00	1,640.00	1,640.00	1,640.00	1,640.00	1,640.00
Total	3,888	5,060	12,534	14,634	16,734	18,134	23,264

EDC = <>, HFO = heavy fuel oil.

Source: Author.

2.3. Energy Efficiency and Conservation Policies

Cambodia's energy efficiency and conservation (EE&C) programs aim to achieve integrated and sustainable improvements in major energy-consuming sectors and help prevent wasteful fuel consumption. The sectors must use energy more efficiently and have increased access to energy-efficiency project financing. The government must establish energy-efficiency regulatory frameworks. Cambodia is implementing pilot projects to achieve the following:

- (i) Improve the efficiency of the overall supply chain for home lighting in rural areas by providing decentralised energy services through a new generation of rural energy entrepreneurs.
- (ii) Help transform the market for home and office electrical appliances through bulk purchase and dissemination of high-performance lamps, showcasing of energy efficient products, support to competent organisations for testing and certification of energy-efficient products, and establishment of 'green learning rooms' in selected schools to impart life-long education on EE&C. Improve energy efficiency in buildings and public facilities.
- (iii) Improve energy efficiency, in cooperation with the United Nations Industrial Development (UNIDO) and the Ministry of Mines and Energy (MME), in rice mills, brick kilns, rubber refineries, and garment factories.

Cambodia is preparing an action plan for EE&C in cooperation with the energy efficiency design sub-working group. The MME is drafting actions plans for industry, transport, and other sectors. The action plans will result in estimated reduction of existing consumer demand by 5% by 2025 and by 20% by 2050 under the business as usual (BAU) scenario. These initial estimates were used to forecast energy demand under the alternative policy scenario (APS).

The National Energy Efficiency Policy, Strategy and Action Plan identifies five priorities:

- (i) energy efficiency in industry,
- (ii) energy efficiency of end-user products,
- (iii) energy efficiency in buildings,
- (iv) energy efficiency of rural electricity generation and distribution, and
- (v). efficient use of biomass resources for residential and industrial purposes.

The energy-efficiency assumption in the Long-range Energy Alternative Planning system (LEAP) model is based on the assessment of the energy-efficiency potential of buildings,

industry, and transport. The National Energy Efficiency Policy aims to reduce energy demand by 20% by 2050 relative to BAU.

2.4. Intended Nationally Determined Contribution

Cambodia wishes to propose a greenhouse gas (GHG) mitigation contribution for 2020–2030, conditional upon the availability of international support. In the energy sector, the aim is to reduce 3,100 gigagrams of carbon dioxide (Gg Co₂) equivalent (about 1.8 million tonnes of carbon dioxide [Mt-CO₂] equivalent) compared with baseline emissions of 11,600 Gg Co₂ equivalent by 2030.

Table 4.5. Intended Nationally Determined Contribution Targets

Sector	Priority Action	Reduction as Gg CO ₂ eq in 2030, Compared with Baseline
Energy	<ul style="list-style-type: none"> National grid-connected renewable energy generation (solar energy, hydropower, biomass, and biogas) and connection of decentralised renewable generation to the grid Off-grid electricity such as solar home systems, hydro (pico, mini, and micro) Promotion of energy efficiency by end users 	1,800 (16%)
Manufacturing	Promotion of renewable energy and adoption of energy efficiency for garment factories, rice mills, and brick kilns	727 (7%)
Transport	<ul style="list-style-type: none"> Promotion of mass public transport Improvement of operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and increased use of hybrid cars, electric vehicles, and bicycles 	390 (3%)
Other	<ul style="list-style-type: none"> Promotion of energy efficiency for buildings, more efficient cook stoves Reduction of emissions from waste through use of biodigesters and water filters Use of renewable energy for irrigation and solar lamps 	155 (1%)
Total saving		3,100 (27%)

Gg CO₂ eq = <>.

Source: MoE, 2016.

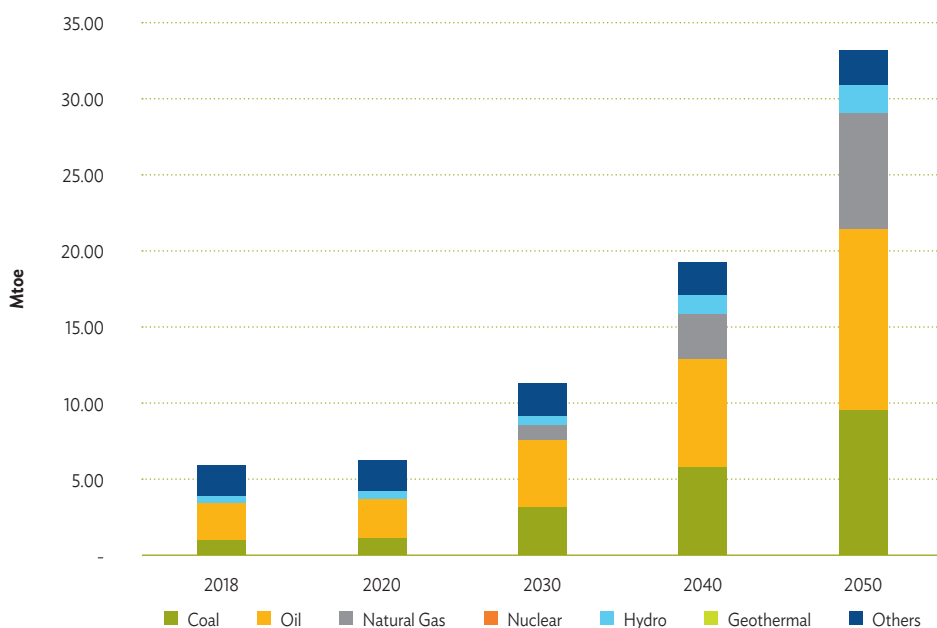
3. Outlook Results

3.1. Business as Usual

3.1.1. Primary Energy Supply

AAGR for primary energy supply will be 5.6% in 2018–2050. Primary energy supply will increase from 5.9 million tonnes of oil equivalent (Mtoe) in 2018 to 33.27 Mtoe in 2050, which is slightly faster than final energy consumption, from 4.3 Mtoe in 2018 to 22.33 Mtoe in 2050. The fastest-growing energy source is solar and wind, with AAGR of 18% in 2018–2050 (Figure 4-1).

Figure 4.1. Primary Energy Supply by Source, Business as Usual



Mtoe = million tons of oil equivalent.

Source: Authors.

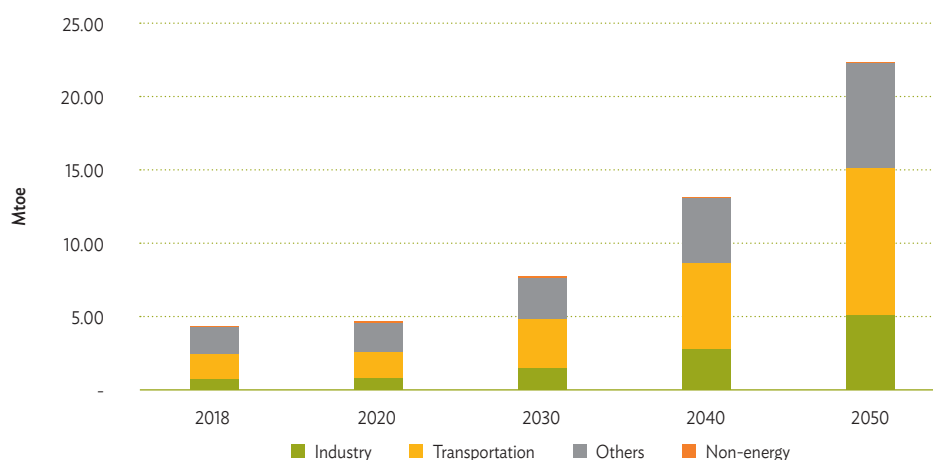
Under BAU, primary energy supply is projected to increase by 5.6% per year or 2.9 times, from 5.9 Mtoe in 2018 to 33.27 Mtoe in 2050. The fastest growth is expected in solar and wind power, increasing at an annual average rate of 18.0% in 2018–2050, followed by coal and oil at 7.4% and 5.0%, respectively. The share of solar and wind is projected to increase by 18% by 2050 to comply with the policy to promote renewable energy. The LNG share is projected to increase from 7.60% in 2030 to 21.31% in 2050 due to global limitations on using coal.

3.1.2. Final Energy Demand

3.1.2.1. By Sector

Final energy consumption will have an AAGR of 5.3% in 2018–2050. Final energy consumption by sector will increase from 4.3 Mtoe in 2018 to 22.33 Mtoe in 2050 (Figure 4-2).

Figure 4.2. Final Energy Consumption by Sector, Business as Usual



Mtoe = million tons of oil equivalent.

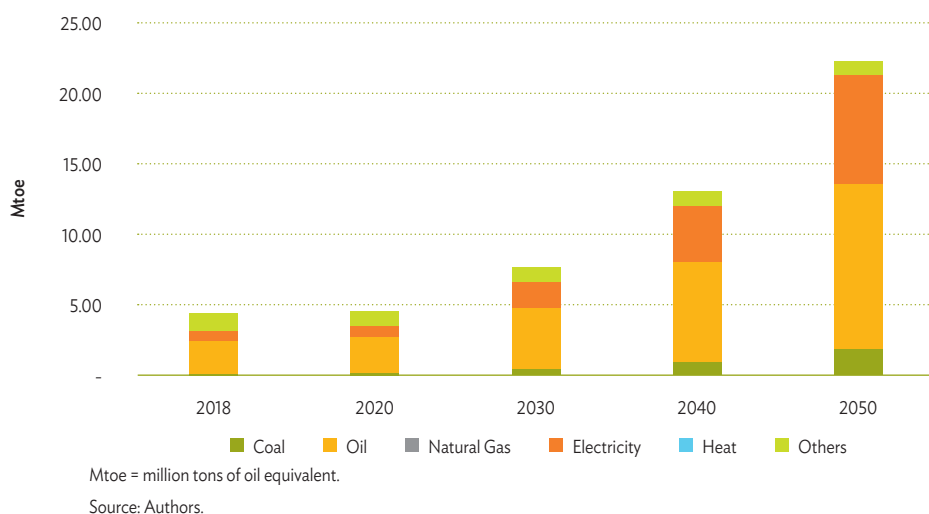
Source: Authors.

The strongest growth in demand is projected in industry, at an annual average rate of 6.2% in 2018–2050 or 5.9 times, from 0.72 Mtoe in 2018 to 5.04 Mtoe in 2050. Transport is projected to grow at an annual rate of 5.6% or 4.78 times, from 1.75 Mtoe in 2018 to 10.12 Mtoe in 2050, followed by 'others' at 4.4%, from 1.81 Mtoe in 2018 to 7.15 Mtoe in 2050.

3.1.2.2. By Fuel

Coal is projected to exhibit the fastest growth in final energy demand, at 10.3% per year or 22.06 times, from 0.08 Mtoe in 2018 to 1.74 Mtoe in 2050. Electricity is projected to have the second-highest growth rate, at 7.6% per year or 9.35 times, from 0.74 Mtoe in 2018 to 7.7 Mtoe in 2050. Oil is projected to have the third-highest growth rate, at 5.1% per year or 3.97 times, from 2.38 Mtoe in 2018 to 11.86 Mtoe in 2050 (Figure 4-3).

Figure 4.3. Final Energy Consumption by Fuel, Business as Usual

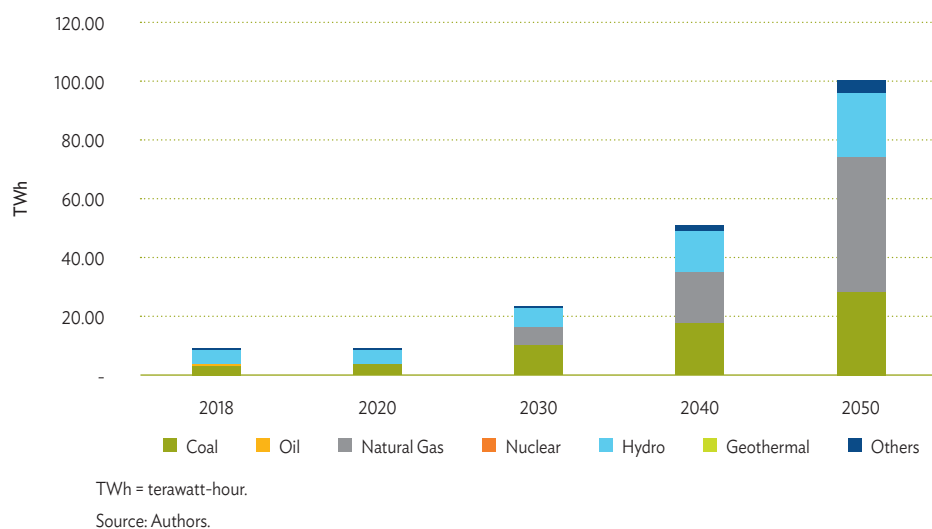


3.1.3. Electricity Generation

Electricity generation will increase by 8% per year, from 8.48 TWh in 2018 to 99.56 TWh in 2050. From 2030 to 2050, electricity generation will be provided mainly by LNG, 26.04%–46.02%; coal, 42.05%–28.16%; and hydro, 26.00%–22.00%.

Under BAU, power generation is projected to increase at an average rate of 8.0% in 2018–2050. The fastest growth will be in ‘others’ (12.3% per year) followed by coal (7.0%) and hydro (4.9%) (Figure 4-4). The share of oil-fired power plants will decrease by 0.8% due to high fuel cost (Figure 4-4).

Figure 4.4. Power Generation by Fuel, Business as Usual

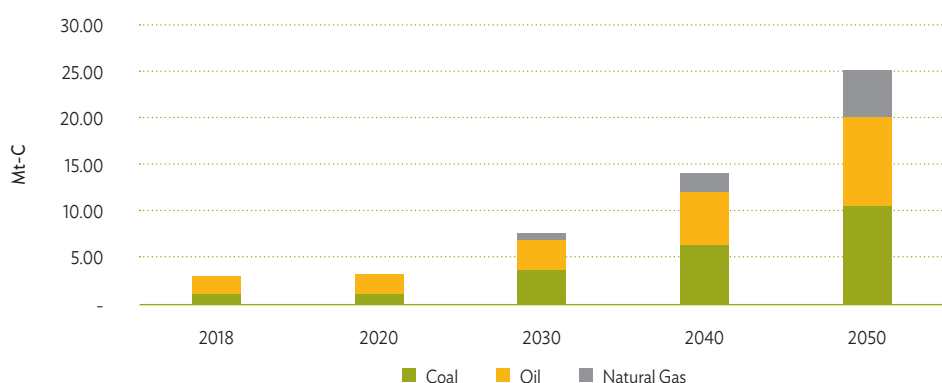


3.1.4. Carbon Dioxide Emissions

CO₂ emissions from energy consumption are projected to increase by 6.8% per year, from 3.0 Mt-C in 2018 to 25.0 Mt-C in 2050 under BAU.

Coal is the largest source of carbon emissions, which will increase the fastest, with an AAGR of 7.4%, from 1.1 Mt-C in 2018 to 10.05 Mt-C in 2050. The second-largest source of carbon emissions is oil, with an AAGR of 5.1%, from 2.0 Mt-C in 2018 to 9.7 Mt-C in 2050 (Figure 4-5).

Figure 4.5. Carbon Dioxide Emissions from Energy Consumption, Business as Usual



Mt-C = million tonnes of carbon equivalent.

Source: Authors.

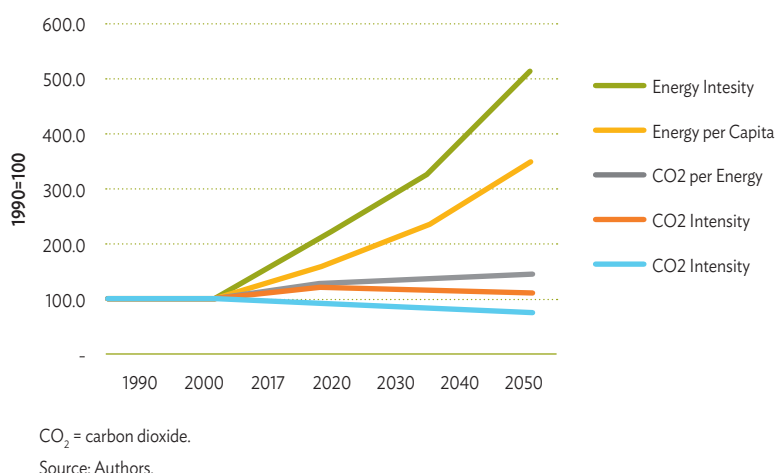
3.1.5. Energy Indicators

Primary energy intensity decreased from 775 toe/million 2010 US dollars in 1990 to 301 toe/million 2010 US dollars in 2018. Under BAU, energy intensity will further decrease to 230 toe/million 2010 US dollars in 2050 as a result of the EE&C program.

Primary energy per capita increased from 0.3 toe in 1990 to 0.4 toe in 2018. Under BAU, energy per capita will further increase to 1.3 toe in 2050 because living standards will improve, resulting in increasing energy demand per capita.

Figure 4-6 shows indicators of energy consumption.

Figure 4.6. Energy and Carbon Dioxide Indicators



CO₂ emissions per unit of primary energy consumption (ton of carbon [t-C]/toe) under BAU is projected to increase from 0.51 t-C/toe in 2018 to 0.75 t-C/toe in 2050, implying faster growth of fossil fuels in total energy consumption. However, CO₂ intensity increased from 95 t-C/million 2010 US dollars in 2000 to 155 t-C/million 2010 US dollars in 2018, and will increase to 173 t-C/million 2010 US dollars in 2050.

4. Scenario Analysis

4.1. Alternative Policy Scenario

APS consists of scenarios such as EE&C (APS1), improvement of energy efficiency in power generation (APS2), and development of renewable energy (APS3). The scenarios were individually modelled to determine their impact on reduction of energy consumption and CO₂ emissions. Below are the assumptions in each scenario:

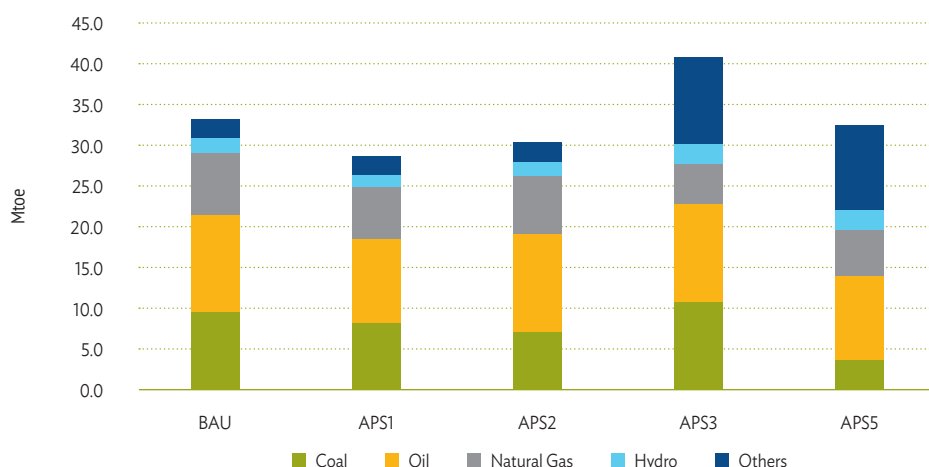
A. APS1. Focus is on EE&C on the demand side:

- (i). Energy demand in all sectors was equal in 2018 and will be reduced by 15.70% by 2050 relative to BAU.
- (ii). Efficient motorbikes and hybrid cars will be used for road transport.
- (iii). Inefficient devices will be replaced with efficient ones for commercial and residential uses, including cooking, lighting, refrigeration, air conditioning, amongst others.

- B. APS2. Thermal power plants are more energy-efficient. Energy efficiency of LNG, coal, and fuel oil thermal power plants is assumed to stay constant at 41.2% until 2050 under BAU. Under APS2, new LNG, coal, and fuel oil thermal power plants are assumed to have thermal efficiencies of 51%. APS2 is projected to improve the efficiency of thermal power generation to about 23% in 2018–2050.
- C. APS3. Under BAU, the share of renewables in the power generation mix is 37.16%, but under APS3, it is up to 55.17% by 2050. The power generation mix in 2050 will consist of hydro at 27.61%, LNG 22.08%, coal 20.49%, solar 17.34%, biomass 6.89%, and wind 3.3%.
- D. APS5 or APS. Combination of APS1 to APS3.

The APS assumptions were analysed separately to determine the individual impacts of each under APS1, APS2, APS3, and APS5. Figure 4-7 shows the changes in primary energy supply in all scenarios. APS1 and APS2 have the largest reduction in primary energy supply in 2050 due to improved energy efficiency in thermal power generation and APS1 energy-efficiency assumptions. APS1 could reduce primary energy supply under BAU by 4.64 Mtoe or 14%. Under APS2, reduction will be slower, amounting to 2.88 Mtoe or 9.5%.

Figure 4.7. Comparison of Scenarios and Total Primary Energy Supply by 2050

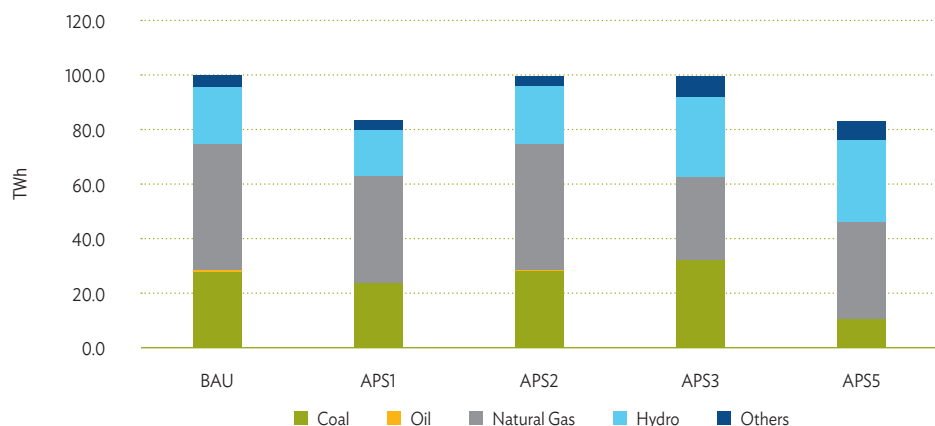


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Author.

Figure 4-8 shows total electricity generation in 2050 under all scenarios. Under APS1, due to the lower electricity demand, the share of fossil fuel electricity generation will be lower by 19.1% than under BAU. Under APS2 and APS3, the share is the same as under BAU. Under APS5, where all scenarios are combined, the reduction in the share of fossil energy-based generation will be significant, almost 19.1% lower than under BAU.

Figure 4.8. Comparison of Electricity Generation Scenarios by 2050

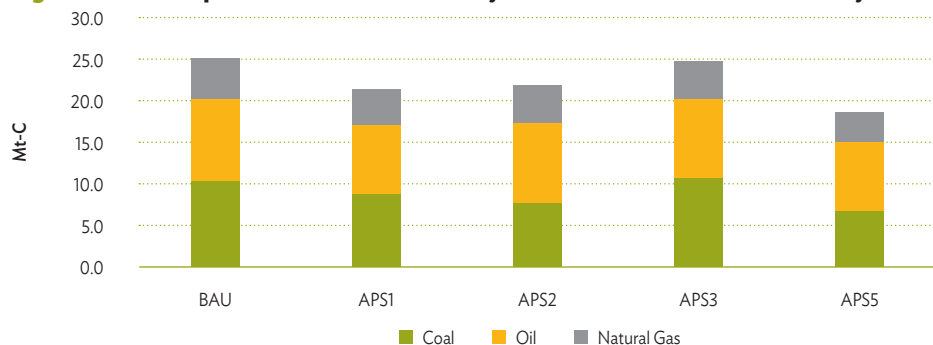


APS = alternative policy scenario, BAU = business as usual, TWh = terawatt-hour.

Source: Author.

Figure 4-9 compares all the scenarios by CO₂ emissions in 2050. The energy-efficiency assumption under APS1 could reduce emissions by 17% in 2050 compared with BAU. Under APS2, the installation of more efficient power plants is projected to reduce emissions by 13.5%. Under APS 3, as the result of small contributions from solar wind and biomass to the

Figure 4.9. Comparison of Scenarios by Carbon Dioxide Emission by 2050



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

Source: Authors.

power generation mix, emissions could be reduced slightly, by 1%. All assumptions combined (APS5) could reduce BAU CO2 emissions by 34.1% in 2050.

4.2. Energy Saving Potential and Carbon Dioxide Emission Reduction

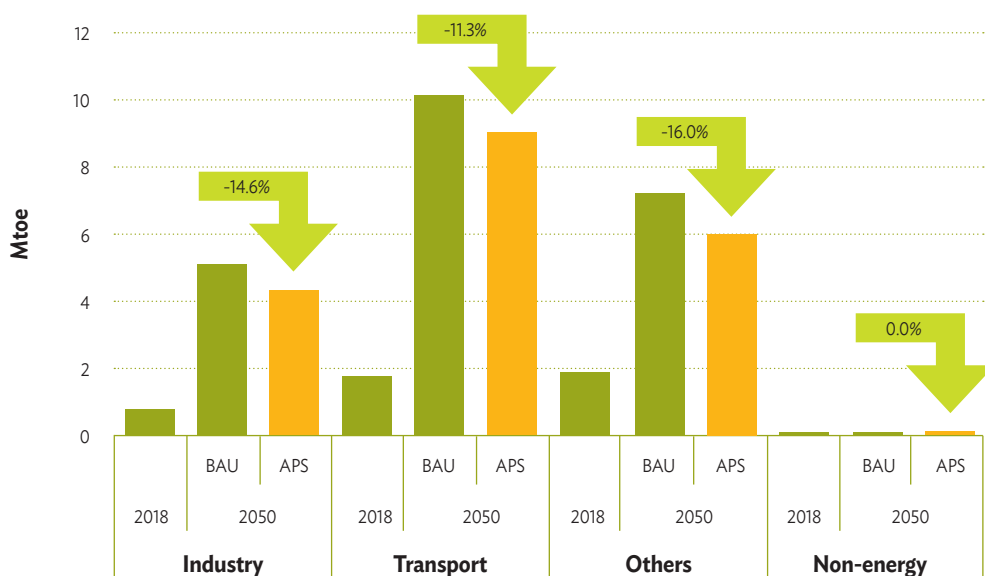
4.2.2. Final Energy Demand

Under APS5, final energy consumption is 19 Mtoe and under BAU 22 Mtoe. Final energy consumption under APS5 is projected to decrease by 13.5% compared with BAU in 2050 because of EE&C measures (APS1) in industry, transport, and residential and commercial ('others') sectors.

Final energy consumption saving between APS5 and BAU is 3 Mtoe. Saving is expected to occur in 'others' (1 Mtoe), transport (1 Mtoe), and industry (1 Mtoe).

Improvement in end-user technologies and the introduction of energy management systems are expected to help slow consumption growth, particularly in 'others', industry, and transport (Figure 4-10).

Figure 4.10. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

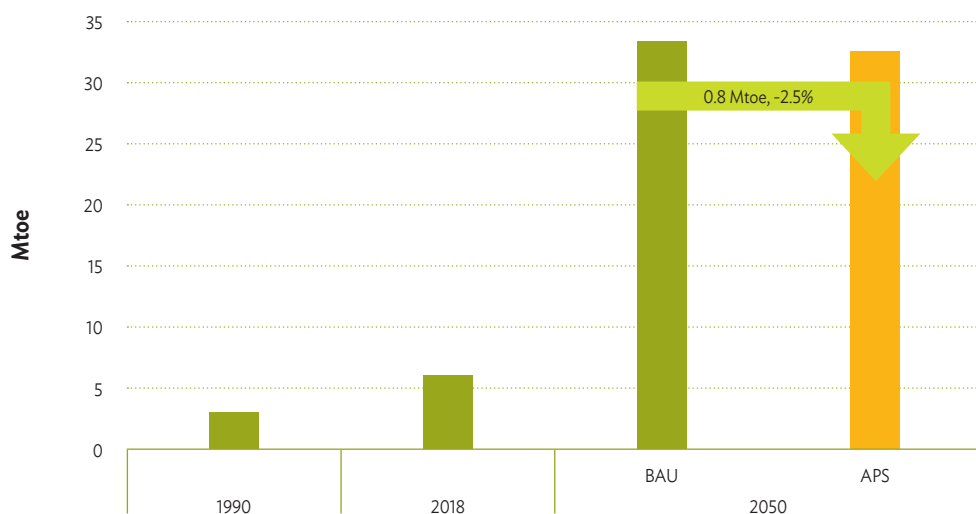
4.2.3. Primary Energy Supply

Under APS5, primary energy supply is projected to increase by 5.50% per year, from 5.90 Mtoe in 2018 to 32.43 Mtoe in 2050. Saving can be derived mostly from EE&C scenarios on the demand side and development of renewable energy technology (APS3).

Solar and wind energy are projected to grow the fastest, by 20.07% per year, compared with 18.00% under BAU, followed by hydro at 5.8% compared with 4.9% under BAU, and oil at 4.6% compared with 5.0% under BAU.

Total saving is equal to 0.8 Mtoe, which is equivalent to 2.5% of primary energy supply in 2040 (Figure 4-11).

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

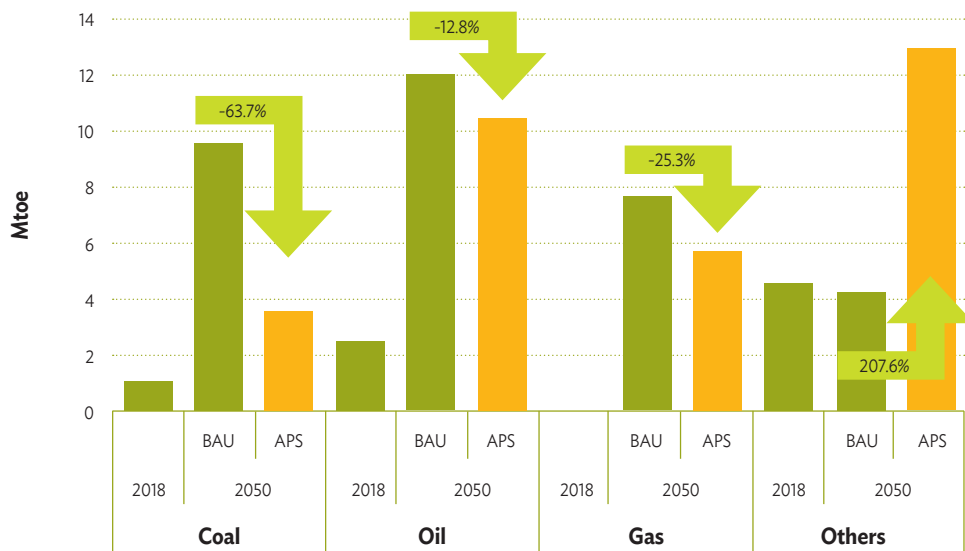


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

The reduction in consumption, relative to BAU, comes from EE&C measures on the demand side (APS1), more aggressive uptake of energy efficiency in thermal power plants (APS2), and adoption of renewable energy (APS3) on the supply side. Energy-saving potential from coal is 63.7%, followed by LNG at 25.3% and oil at 12.8% (Figure 4-12).

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



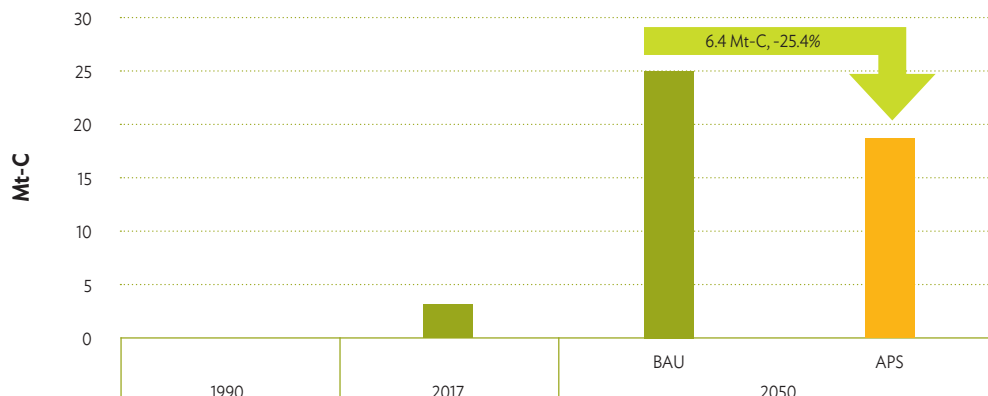
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

4.2.4. Carbon Dioxide Emissions

CO₂ emissions from energy consumption under BAU are projected to increase by 6.8% per year, from 3 Mt-C in 2018 to 25 Mt-C in 2050. Under APS5, CO₂ emissions are projected to increase by 5.8% per year in 2018–2050, representing a 34.4% reduction from BAU.

Figure 4.13. Carbon Dioxide Emission by Fuels, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

The CO₂ emission reduction will be derived mostly from EE&C measures on the demand side (APS1). Improvement of energy efficiency in thermal power plants (APS2) and development of renewable energy technologies (APS3) can contribute significantly to CO₂ reduction (Figure 4-13).

4.2.5. Intended Nationally Determined Contribution

CO₂ emissions from energy consumption under BAU are projected to increase by 6.8% per year, from 3 Mt-C in 2018 to 25 Mt-C in 2050. Under APS5, the annual increase in CO₂ emissions is projected to be 5.8% in 2018–2050.

Table 4.6. Results of Carbon Dioxide Emissions by 2050
(million tons of carbon equivalent)

	BAU	APS1	APS2	APS3	APS5
Coal	10.51	8.93	7.80	10.76	6.80
Oil	9.66	8.39	9.66	9.66	8.39
Natural gas	4.83	4.05	4.56	4.35	3.45
Total	24.99	21.37	22.02	24.77	18.64

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

Source: Author.

4.Key Findings and Policy Implications

The following are the key findings:

- (i) Energy demand is expected to continue to grow at a significant rate, driven by robust economic growth, industrialisation, urbanisation, and population growth. EE&C is the new source of energy, and measures reflected in APS are estimated to have significant potential to help meet future demand in a sustainable manner.
- (ii) Energy intensity will be further reduced due to efficient use of energy.
- (iii) The annual growth of energy demand in industry is projected to be the highest, at 6.2%, under BAU, and its share will increase from 17.0% in 2018 to 22.6% in 2050,

showing that industry has large potential for energy saving.

- (iv) Coal demand is increasing, with the highest annual growth rate of 10.3% under BAU, and is projected to be slightly lower, at 9.9%, under APS5.
- (v) LNG power plants will be the major power generation source. LNG's share in total power generation output will increase from 26.4% in 2030 to 46.02% in 2050. LNG will have the largest energy saving and GHG mitigation potential.
- (vi) Coal power plants will be the second major source of power generation. Coal's share in total of power generation output will increase from 37.86% in 2018 and drop to 28.16% in 2050 due to the huge contribution of LNG.

The following actions are recommended:

- Establish targets and a road map for EE&C. The targets should be set up for the short, medium, and long term and focused on buildings and industry. The long-term plan should be based on an assessment of energy-saving potential for all energy sectors, including residential and commercial sectors, that have large potential for energy saving up to 2050. Some activities can promote EE&C:
 - (a) support for the development of energy conservation professionals to be responsible for energy management and operation, verification and monitoring, consultancy and engineering service provision and planning, and supervision and implementation of energy conservation measures;
 - (b) support for the development of institutional capability of public and private sector agencies and organisations to be responsible for the planning, supervision, promotion, and implementation of energy conservation measures;
 - (c) support for the operation of energy service companies to alleviate technical and financial risks of entrepreneurs wishing to implement energy conservation measures; and
 - (d) sharing of knowledge about energy conservation with the public through educational institutions, and fostering of youth awareness.
-

- Require energy labelling for electrical appliances. Annual growth of residential and commercial ('others') electricity demand is projected to be higher than that of other sectors. Compulsory energy labelling for electrical appliances could be an effective management measure to generate energy saving.
- Prioritise the development of advanced hydro and coal thermal power technology. Hydro and coal thermal power plants will be the major power generators up to 2050. Advanced technologies for both resources should be prioritised for development.
- Prioritise renewable energy development. Renewable energy is important for energy independence, energy security, and GHG emission abatement. A strategy and the mechanisms to support renewable energy development must be established.

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CHAPTER 5

China Country Report

Yu Hao and Zhiqiang Gai



1. Background

1.1 Natural Conditions and History

China has a land area of 9.6 million square kilometres (km) and is situated in eastern Asia on the western shore of the Pacific Ocean, with a continental coastline of about 18,000 km. China's climate is highly diverse, ranging from an unbearable 48°C in the northwest during summer to an equally unbearable -40°C in the far north in winter.

China has more than 5,000 years of history and is one of five countries with a great ancient civilisation. The People's Republic of China was founded on 1 October 1949. China has been implementing reforms and opening its economy for 40 years and has established a socialist market economy, charting the course for socialist modernisation with Chinese characteristics.

1.2 Economy and Population

China's gross domestic product (GDP) in 2019 was about US\$14,363.58 billion, which translates into per capita GDP of about US\$10,260.0 (in 2019 US dollar terms). China is the most populous country, with about 1.4 billion people in 2019 (China National Bureau of Statistics, 2019). China has implemented a family planning policy since the 1970s, but the 'one child' policy ended in 2015 and couples who satisfy certain conditions may have two children. Urbanisation has been rapid, growing by about 1% annually since 1978, when China started reforms and opening up. By the end of 2019, about 60.6% of the population was living in urban areas.

1.3 Energy Situation.

China is endowed with coal, oil, and gas reserves and tremendous hydropower potential. China is the world's largest coal producer and has the third-largest coal reserves, with recoverable reserves of 114.5 billion tonnes. In 2019, China produced 3.85 billion tonnes of raw coal. China is still a major crude oil producer, with output of 0.191 billion tonnes in 2019 (CCTV, 2020). Driven by the rapid increase in oil demand, China became an oil importer in the 1990s. In 2019, the amount of net imported oil reached 0.51 billion tonnes, with a growth rate of 9.5% (Industry Information Network, 2019) and a dependence level of more than 72.0% (Baijiahao, 2020). China is a large producer and exporter of energy-intensive items. In 2019, it produced 1.20 billion tonnes of finished steel and 2.33 billion tonnes of cement.

China's per-capita energy reserve is considerably lower than the world average. The per-capita average of coal and hydropower resources is only about 50% of the world average, whilst the per-capita average of oil and natural gas reserves is only about 6.7% of the world average. The per-capita average of arable land is less than 30% of the world average, which hinders the development of biomass energy.

Since 1990, coal has dominated primary energy consumption, with 60.7%, whilst oil, natural gas, and hydro consumption account for 13.6%, 1.5%, and 1.2%, respectively. Biomass consumption represents 22.9%, lower than coal consumption. In 2017, coal was still a major fuel, with a share of about 63.7%. The share of other energy sources increased from 1990 levels to 18.5% for oil, 6.4% for gas, and 3.2% for hydro, but the share of biomass decreased to 3.7%. Primary energy consumption increased at an average annual rate of about 4.8% from 873.48 Million Ton Oil Equivalent (Mtoe) in 1990 to 3,066.75 Mtoe in 2017. Energy intensity (primary energy demand per unit of GDP) declined from 1,053 tonnes of oil equivalent per US\$ one million in 1990 to 302 in 2017.

Final energy consumption increased at a lower annual average rate of 4.2%, from 657.59 Mtoe in 1990 to 1,995.06 Mtoe in 2017. Coal accounted for 47.4% of final energy consumption in 1990 and 33.3% in 2017. In 1990, oil consumption accounted for 12.9% of total final energy consumption and increased rapidly by 6.9% per year from 1990 to 2017, resulting in a significant increase to 25.8%. The shares of electricity and natural gas consumption increased sharply from 5.9% and 1.3%, respectively, in 1990 to 23.9% and 6.6% in 2017. In 2017, the share of electricity consumption was almost equal to that of oil consumption.

Industry consumes the most energy, followed by the residential and commercial sectors

(‘others’). The share of industry consumption increased from 35.6% in 1990 to 49.4% in 2017. The share of ‘others’ declined from 54.1% in 1990 to 29.1% in 2017 because industry and transport grew faster.

Power generation is mainly from coal-fired plants, accounting for about 71.0% of total electricity in 1990. By 2017, this share had decreased to 67.9%. The share of hydro was 20.4% in 1990 but declined to 17.5% by 2017. Gas and oil collectively accounted for about 2.9% of total generation in 2017. The share of nuclear power increased to about 3.8% in 2017.

The government is pushing for the development of a modern energy industry. Resource conservation and environmental protection are basic policies guiding industrialisation and modernisation.

2. Modelling Assumptions

2.1 Population and Gross Domestic Product.

The model results were developed by the Institute of Energy Economics, Japan (IEEJ) based on the business as usual (BAU) scenario and the alternative policy scenario (APS).

The population increased from 1.135 billion in 1990 to 1.386 billion in 2017. Over the projection period, population growth is assumed to increase at an average rate of 0% per year from 2017 to 2050. The population will peak at 1.465 billion in about 2030 and reach 1.403 billion by 2050.

The economy grew at an average annual rate of 9.7%, from US\$830 billion in 1990 to about US\$10,161 billion in 2017 (in 2010 US dollar terms). GDP is assumed to grow more slowly, at 6.3% per year from 2017 to 2020, because of the economic ‘new normal’, 5.3% per year from 2020 to 2030, and 4.1% per year from 2030 to 2040. The average annual growth rate of GDP from 2017 to 2050 is 4.2%. GDP is calculated to reach US\$39,688 billion by 2050. GDP per capita is assumed to increase from about US\$7,330 in 2017 to US\$28,280 in 2050.

2.2. Energy and Climate Change Policies and Their Performance.

Although the country is still developing and GDP per capita was about 14.3% that of the United States in 2017 (using the nominal exchange rate), the government has set ambitious

goals for reducing energy intensity and mitigating climate change. Government data in the last 5 years show that China has significantly conserved energy and made remarkable progress in environmental protection and climate change mitigation.

The Outline of the 13th Five-Year Plan (2016–2020) for National Economic and Social Development stipulates that, by 2020, energy consumption per unit of GDP will drop by 15% from 2016. To achieve this goal, the government is implementing administrative, market-based, and legal measures to promote energy conservation. Energy intensity reduction goals are assigned to provincial governments and their progress is announced publicly every year. During the 12th Five-Year Plan (2011–2015), energy consumption grew by 3.6% per year and GDP by 7.8% per year. Energy intensity decreased by 18.2%, more than the targeted 16.0%. Energy consumption per unit of GDP in 2015 decreased by 5.6% compared with that of 2014.

The government proposes controlling total energy consumption. The Energy Development Strategic Action Plan (2014–2020) states that coal consumption (primary energy consumption) will be limited to 2,940 Mtoe in 2020 and primary energy consumption to 3,362 Mtoe. Under the 13th Five-Year Plan of Energy Development, the ratio of coal consumption to total energy consumption should be lowered by 2020 to at most 60% and natural gas consumption should account for 10%. New energy vehicles will number 2 million.

China aims to reduce carbon dioxide (CO₂) emissions per GDP (carbon intensity) by 40%–45% by 2020 and 60%–65% by 2030 from the 2005 level; CO₂ emissions will peak in 2030. China has implemented ambitious energy efficiency and fuel switching policies, including. In 2019, national emissions of sulphur dioxide, nitrogen oxides, chemical oxygen, and ammonia nitrogen decreased by 4.4%, 3.5%, 3.2%, and 3.3%, respectively. The annual target of CO₂ emissions per unit of GDP is expected to be reduced by 3.6% (Ministry of Ecology and Environment, 2020).

China has made great efforts to develop non-fossil fuel and accelerated the development of renewable energy. The People's Congress passed the Renewable Energy Development Law of China in 2005. The government announced it would target increasing the share of non-fossil energy to about 15% by 2020 (measured in coal equivalent) and 20% in 2030. Subsidy policies encourage development of wind power, solar photovoltaic, and biomass energy. In 2019, China was once again the largest investor (US\$83.4 billion) in renewable energy, but the amount was down 8% from 2018, the lowest level since 2013. Wind power investment increased by 10% to US\$55 billion but solar energy investment fell 33% to US\$25.7 billion, less than one-third of the peak in 2017 (International Energy Small Data, 2020).

In 2019, the energy sector eliminated excess capacity, shut down coal-fired power plants producing a total of 20 million kilowatts (kW), developed high-quality advanced production capacity, and promoted wind power. The first nuclear power heating project supports commercial operations, promotes ultra-low emissions and energy-saving transformation of coal power, and advances the orderly planning and construction of coal-fired power plants. Installed capacity of energy from water, wind, solar, and nuclear sources is 799 million kW.

The implementation of clean heating in winter in northern areas has been accelerated, resulting in an additional clean heating area of about 1.5 billion square metres, cumulative replacement of about 100 million tonnes of scattered coal, and a clean heating rate of 55% in northern areas and 75% in key '2+26' cities¹. The energy sector has overfulfilled its medium-term goals, produced about 200 billion kilowatt-hours of new electricity, conserved energy and reduced emissions, and reduced national energy consumption intensity by about 13.7% in the first 4 years of the 13th Five-Year Plan (Tencent News, 2020).

The 2017 analysis uses five APS scenarios: APS1 – energy efficiency and conservation (EEC) in final consumption; APS2 – EEC in thermal efficiency in coal, oil, and gas-fired power generators; APS3 – increase of hydro, geothermal, and so on; APS4 – increased use of nuclear power; APS5 – combination of APS1 to APS4. APS in this study refers to APS5 unless specified otherwise.

3. Outlook Results

3.1. Final Energy Demand

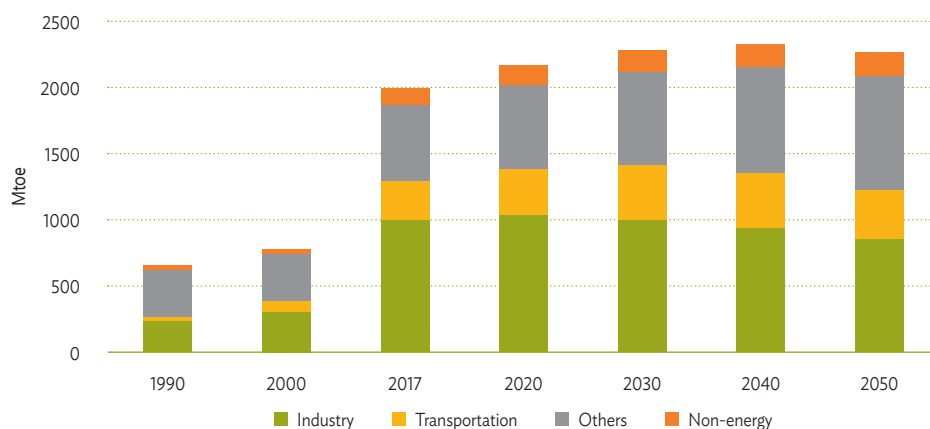
From 2017 to 2050, final energy consumption growth is projected to be slow, reflecting lower assumed economic and population growth.

Business as Usual

Final energy demand is projected to increase at an average rate of 0.4% per year from 2017 to 2050. Non-energy sector demand is projected to grow the fastest, by 1.3% a year, followed by 'others', by 1.2%. Industry energy demand is projected to grow at an average annual rate of –0.4%. Figure 5-1 shows final energy demand by sector under BAU.

¹ Including Beijing, Tianjin, Shijiazhuang, Tangshan, Langfang, Baoding, Cangzhou, Hengshui, Xingtai, Handan, Taiyuan, Yangquan, Changzhi, Jincheng, Jinan, Zibo, Jining, Dezhou, Liaocheng, Binzhou, Heze, Zhengzhou, Kaifeng, Anyang, Hebi, Xinxiang, Jiaozuo, Puyang.

Figure 5.1. Final Energy Consumption by Sector, Business as Usual

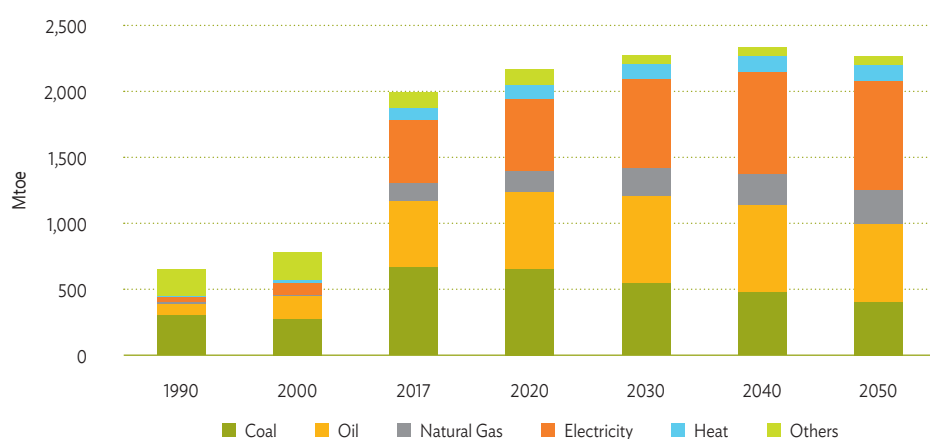


Mtoe = million tons of oil equivalent.

Source: Authors.

Natural gas is projected to grow the fastest, by 2.1% per year, from 131.58 Mtoe in 2017 to 263.94 Mtoe in 2050. Although it still accounts for a large portion of total final energy demand, coal is projected to increase by only –1.5% per year, to 402.60 Mtoe by 2050. Consumption of electricity and of heat are projected to increase at an average annual rate of 1.7% and 0.5%, respectively, over the same period, to 822.60 Mtoe and 113.19 Mtoe by 2050. Oil is projected to grow by 0.5% annually to about 597.38 Mtoe in 2050. Figure 5-2 shows final energy demand by fuel under BAU.

Figure 5.2. Final Energy Consumption by Fuel, Business as Usual



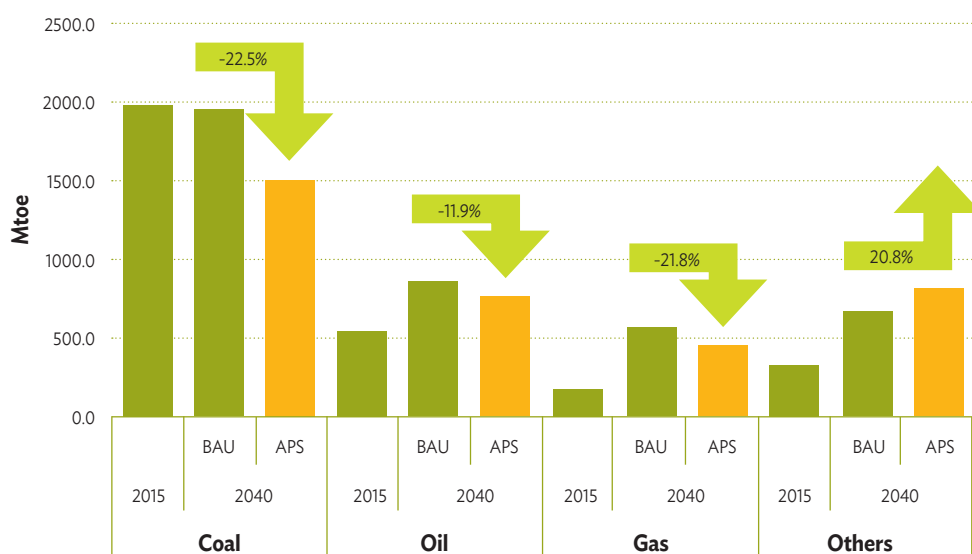
Mtoe = million tons of oil equivalent.

Source: Authors.

Alternative Policy Scenario

Final energy demand is projected to increase by 0% per year, from 1,995.06 Mtoe in 2017 to 2,011.34 Mtoe in 2050, because of EEC programmes. Improved end-use technologies and the introduction of energy management systems are expected to contribute to slower energy growth in all sectors, particularly in the commercial, residential, and transport sectors. Figure 5-3 shows final energy demand in 2017 and 2050 under BAU and APS.

Figure 5.3. Final Energy Consumption, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.
Source: Authors.

3.2 Primary Energy Consumption.

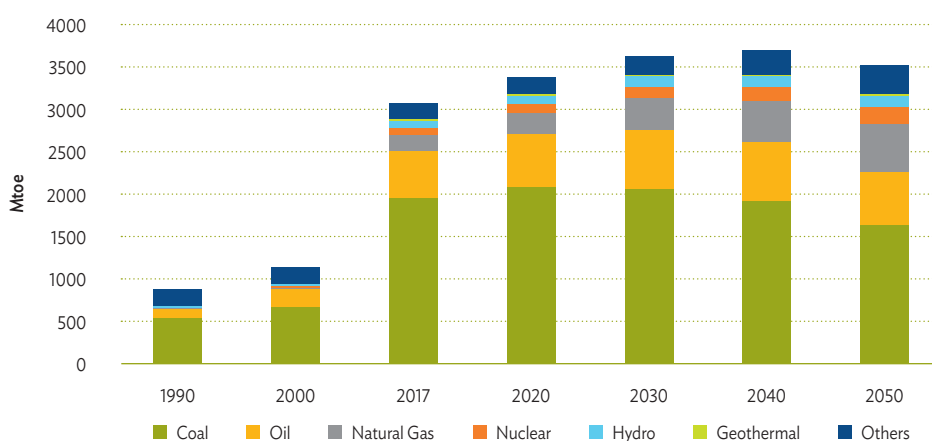
Primary energy consumption is projected to grow more slowly. Growth in primary energy demand is expected to grow slightly more slowly than final energy consumption because of improved efficiency in energy transformation.

Business as Usual

Primary energy consumption is projected to increase at an annual average rate of 0.4% per year, to 3,529.20 Mtoe in 2050. Coal will still constitute the largest share of total primary energy, but its growth is expected to be slower, increasing by -0.6% a year. Consequently, the share of coal in total primary energy is projected to decline from 63.7% in 2017 to 46.1% in 2050.

Solar, wind, and ocean energy sources are projected to grow the fastest from 2017 to 2050, increasing at an annual average rate of 4.4%. Natural gas, nuclear, and biofuel energy will increase by 3.3% per year. Oil and hydro are projected to grow by 0.4% and 0.8% per year, respectively. The share of natural gas is projected to increase from 6.4% in 2017 to 16.1% in 2050. The share of nuclear power will increase from 2.1% to 5.4%. The share of oil is projected to decrease from 18.5% in 2017 to 18.4% in 2050. The share of hydro is projected to increase from 3.2% in 2017 to 3.7% in 2050. Figure 5-4 shows primary energy consumption by energy under BAU. The share of oil is projected to decrease from 18.5% in 2017 to 18.4% in 2050. The share of hydro is projected to increase from 3.2% in 2017 to 3.7% in 2050. Figure 5-4 shows primary energy consumption by energy under BAU.

Figure 5.4. Primary Energy Supply by Fuel Type, Business as Usual



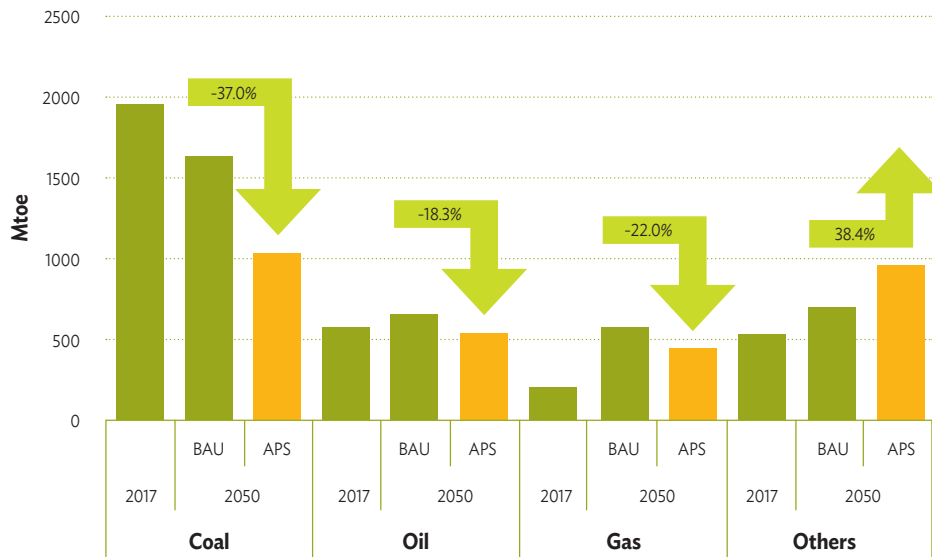
Mtoe = million tons of oil equivalent.

Source: Authors.

Alternative Policy Scenario

Under APS, primary energy consumption is projected to increase by –0.1% per year from 2017 to 2050. By 2050, primary energy consumption is projected to reach 2,948.25 Mtoe. Growth in primary energy consumption is projected to be slower under APS than under BAU (Figure 5-5). Coal is projected to grow by –1.9% a year, oil by –0.2% a year, and natural gas by 2.5% a year. The annual average growth rate of nuclear power will be higher than under BAU, increasing by 4.1% a year from 2017 to 2050. The growth rate of hydro is expected to be higher than under BAU, increasing by 1.1% per year. Consumption will be mitigated because of EEC measures on the demand side.

Figure 5.5. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario



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

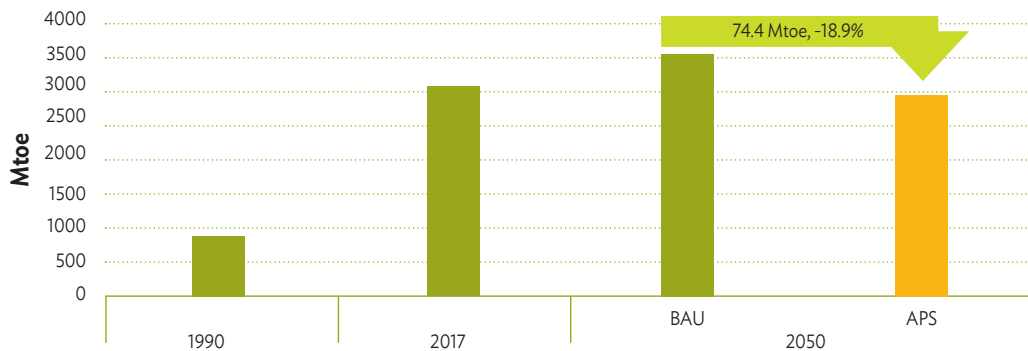
Source: Authors.

3.3. Projected Energy Savings.

Achieving the EEC goals could reduce primary energy consumption in 2050 by about 462.45 Mtoe under APS relative to BAU. Under APS, primary energy consumption is about 18.9% lower than under BAU (Figure 5-6).

Savings in final energy consumption are estimated at 210.44 Mtoe in industry and 20.16 Mtoe in transport in 2050 under APS relative to BAU.

Figure 5.6. Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario



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

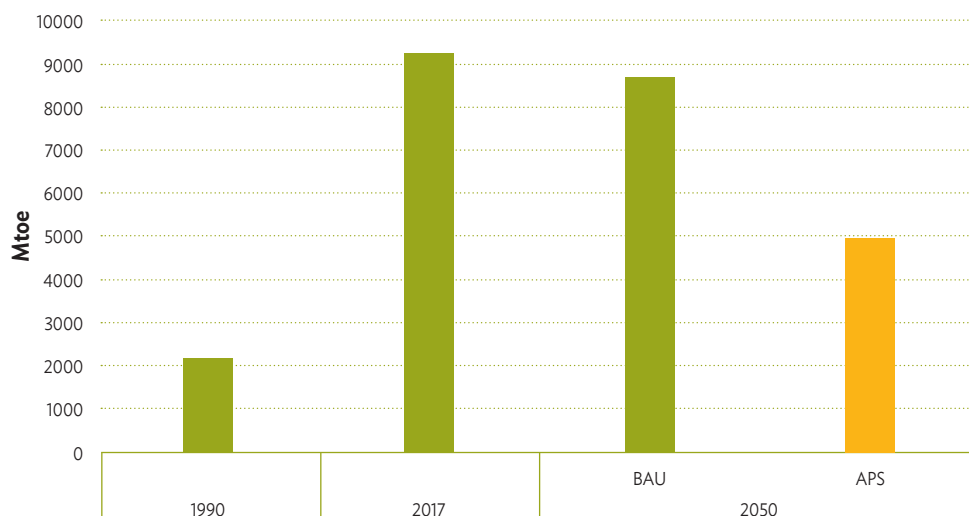
Source: Authors.

3.4. Carbon Dioxide Emissions from Energy Consumption.

CO₂ emissions from energy consumption are projected to grow by –0.2% per year, from 9,201.1 Metric Ton Carbon (Mt-C) in 2017 to 8,691.0 Mt-C in 2050 under BAU. This percentage increase is lower than for primary energy consumption (0.4%) over the same period, indicating improvement in emissions intensity.

Under APS, the annual growth in CO₂ emissions from 2017 to 2050 is projected at –1.9%, lower than the average annual growth rate of primary energy consumption over the same period. The difference between APS and BAU CO₂ emission growth rates indicates that the energy saving goals and action plans are effective (Figure 5-7).

Figure 5.7. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

3.5. Power Generation.

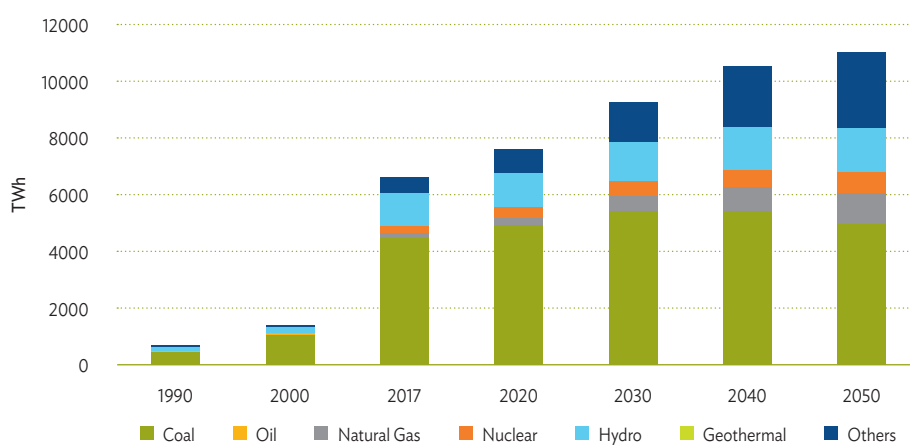
Power generation is projected to grow more slowly from 2017 to 2050 than in the last decade.

Business as Usual

Power generation is projected to grow more slowly, by 1.6% per year, from 6,602.15 Terawatt-hour (TWh) in 2017 to 11,033.80 TWh in 2050 (Figure 5-8).

The share of coal power is projected to decrease from 67.9% in 2017 to 45.1% in 2050. The shares of natural gas and nuclear are projected to grow from 2.8% and 3.8%, respectively, in 2017 to 10.0% and 6.6% in 2050. The share of oil is projected to decrease slightly. Other methods of power generation are projected to increase their share. The fast development of solar photovoltaic power generation is a typical example of adoption of clean power generation.

Figure 5.8. Power Generation, Business as Usual



TWh = terawatt-hour.

Source: Authors.

Alternative Policy Scenario

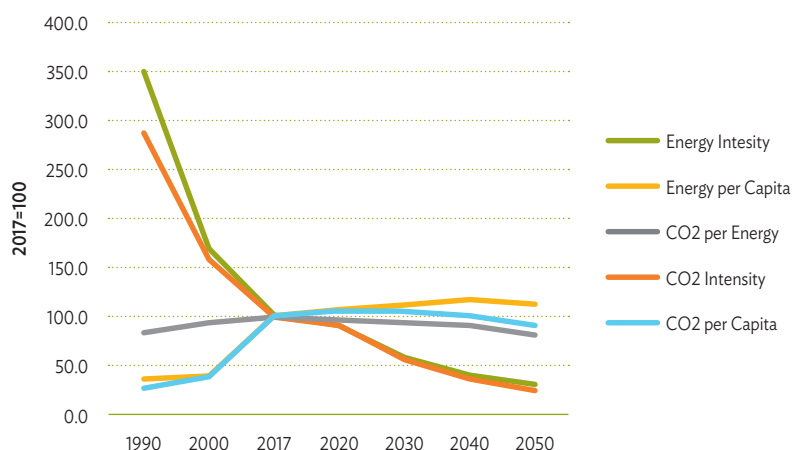
Total power generation is projected to increase by 1.4% per year from 2017 to 2050. By 2050, total power generation output is projected to reach 10,397.05 TWh. Except for coal-fired, oil, and natural gas power, energy sources are projected to grow faster than under BAU from 2017 to 2050. Nuclear, hydro, and geothermal power and 'others' are projected to increase by 4.1%, 1.1%, 5.6%, and 6.8%, respectively, from 2017 to 2050.

3.6. Energy Intensity.

Based on assumed economic and population data and projected energy information, energy intensity – defined as TPES over GDP – and energy per capita are shown in Figure 5-10, along with other vital energy indicators under BAU. From 1990 to 2017, energy intensity dropped remarkably because of energy efficiency efforts. In 2050, energy intensity is projected to drop to about 89 tonnes of oil equivalent (toe) per US\$ 1 million (in 2010 terms). With the improvement of living standards, energy per capita under BAU is projected to reach 2.52 toe

per person in 2050. Energy intensity under APS is projected to decrease faster than under BAU, by 4.6%, from 2017 to 2050.

Figure 5.9. Energy Indicators, Business as Usual



CO₂ = carbon dioxide.
Source: Authors.

4. Implications and Policy Recommendations

As the largest developing country, China has always seen eliminating poverty and improving the quality of life as its paramount tasks. China has recently witnessed fast economic growth, but the urbanisation rate is still low, at 60.6% in 2019. As the biggest energy consumer and CO₂ emitter, however, China faces great pressure to save energy and reduce CO₂ emissions. In the past 3 decades, China has set ambitious targets for energy conservation and climate change mitigation and exerted great efforts to achieve them. At the 2014 Asia-Pacific Economic Cooperation summit, China and the United States issued the Joint Announcement on Climate Change; China vowed to achieve the peak of CO₂ emissions and increase the share of non-fossil fuels in primary energy consumption to about 20% by 2030. In April 2016, China signed the Paris Agreement, which includes the above commitments and provides that China must strive to cut carbon emissions per unit of GDP by 60%–65% by 2030 from 2005 levels. The 13th Five-Year Plan (2016–2020) sets the goal of controlling total energy consumption within 41 billion tons of standard coal and reducing CO₂ emissions per unit of GDP by 18% compared with 2015.

As GDP will keep growing fast, albeit more slowly than in the last 20 years, China's energy

demand and CO2 emissions will continue to increase. To meet its targets, however, China must reduce its energy intensity (energy demand per unit of GDP) and emissions intensity (CO2 emissions per unit of GDP). The model shows that if sound EEC policies are implemented, China could reduce its total primary energy consumption by about 13.0% and CO2 emissions by about 21.6% by 2040.

Coal consumption has decreased since 2014; it decreased by 3.7% in 2015. It is projected that coal consumption can be cut by 22.5% under APS compared with BAU. To improve urban air quality, metropolises such as Beijing and Shanghai have drastically controlled the use of coal. As a result, coal consumption might grow slowly. The government encourages the development of clean and low-carbon energy, especially renewable energy and nuclear energy. To optimise the energy structure, policies such as energy and carbon taxes should be implemented to limit energy- and pollution-intensive industries. Market-based measures such as electricity market reform, energy pricing reform, and green certificate trade are needed to motivate enterprises to take action.

Energy efficiency improvement under APS has the largest potential to reduce CO2 emissions. Under APS, industry could reduce energy consumption by 10.9%. Small and inefficient power plants and coal mines and small energy-intensive plants in industries such as cement and steel must be closed; energy-intensive industries must meet stricter approval requirements. The industry structure must be changed, from heavy to light industry or industry to services. Now that the economy has entered the 'new normal' of moderately high growth and the tertiary sector accounts for half of GDP, China must increase residential, commercial, and transport energy efficiency to save energy and reduce CO2. The Belt and Road Initiative (BRI), proposed by President Xi Jinping in 2013, is a good chance to further save energy and reduce emissions. The countries along the route of the BRI contribute to 50% of global energy consumption and more than 60% of global CO2 emissions. Establishing a low-carbon BRI community is, therefore, of great significance to improve the energy structure and reduce emissions not only in China but also the world. 'Lucid waters and lush mountains are invaluable assets' is an idea that will guide energy conservation and emission reduction.

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CHAPTER 6

India Country Report ¹

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1. Country Brief

Located in South Asia, India has an area of about 3.1 million square kilometres. It is the seventh-largest country by area, the second-most populous (with over 1.35 billion people), and the biggest democracy in the world. It is bounded by the Indian Ocean in the south, the Arabian Sea in the southwest, and the Bay of Bengal in the southeast. It shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the northeast; and Bangladesh and Myanmar to the east.

The climate comprises a wide range of weather conditions across a vast and varied topography. Based on the Köppen system, India has six climatic subtypes, including 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.

The economy was nominally worth US\$2.9 trillion in 2019; it is the fifth largest by market exchange rate and the third largest by purchasing power parity (PPP), at US\$11 trillion (International Monetary Fund, 2020). With its average annual gross domestic product (GDP) growth rate of 5.8% over the past 2 decades, India is one of the fastest-growing economies. However, it ranks 139th for world nominal GDP per capita and 118th for GDP per capita at PPP. Despite economic growth in recent decades, India continues to face socio-economic challenges such as poverty and access to modern energy.

¹ Based on the Institute of Energy Economics, Japan (IEEJ) model and assumptions, with inputs from TERI School of Advanced Studies, New Delhi, India.

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2. Energy Situation

Energy systems have evolved over the last 6 decades, along with economic development, within the framework of democratic policy, a globally integrated economy, and an environmentally sensitive regime. The ever-increasing demand for energy has put tremendous pressure on limited resources and necessitated their optimum use. India has pursued a reformed development agenda since 1991. Significant effort has gone into making energy more available to support development.

Total final energy consumption (TFEC) has steadily increased across all sectors, including agriculture, industry, commercial, and residential, and is expected to continue to grow. Per-capita energy consumption, however, stands at 30% of the world's average (0.44 tonnes of oil equivalent [toe] per capita versus the global average of 1.29 toe and the International Energy Agency average of 2.9) (IEA, 2020). The rapid growth in TFEC and in power generation to supply rising electricity demand has led to the rapid increase in total primary energy supply (TPES). From 2007 to 2017, TPES increased by 55%, largely fossil fuel (IEA, 2020).

India is fuelled by primary (coal and natural gas), secondary (electricity and petroleum products), and renewable energy sources. The energy mix is dominated by coal. Coal production was 728.72 million tonnes (MT) in 2018–2019. Coal has had a compound annual growth rate (CAGR) of 3.2% since 2009–2010, when production amounted to 532.04 MT. Production of crude oil in 2018–2019 was 34.2 MT, declining by a CAGR of 4.2% from 35.7 MT in 2017–2018. The CAGRs for natural gas and electricity were –3.61% and 6.49%, respectively, from 2009–2010 to 2018–2019. Electricity had the highest CAGR amongst all commercial sources of energy during the period (National Statistical Office, 2020).

In 2018–2019, the country produced 262.36 MT of petroleum products as against 254.4 MT in 2017–2018, an increase of 3.13%. In 2018–2019, high-speed diesel oil accounted for the biggest share (42.13%), followed by motor gasoline (14.50%). Net production of natural gas for consumption increased from 31.58 billion cubic metres (BCM) in 2017–2018 to 31.96 BCM in 2018–2019, registering growth of 1.18% (National Statistical Office, 2020).

The average quality of coal is not high, necessitating the import of high-quality coal for steel plants. Imported coal increased from 73.26 MT in 2009–2010 to 235.24 MT in 2018–2019, and exported coal decreased from 2.45 MT to 1.31 MT.

India is highly dependent on imported crude oil. It increased from 159.26 MT in 2009–2010

to 220.43 MT in 2017–2018 and by 2.75% to 226.50 MT in 2018–2019. The CAGR of imported crude oil was 3.6% from 2009–2010 to 2018–2019 (National Statistical Office, 2020).

Exported petroleum products increased by a CAGR of 1.8%, from 51.15 MT in 2009–2010 to 61.10 MT in 2018–2019. Exports in 2018–2019, however, declined by 8.58% from 2017–2018. Imported petroleum products declined by 5.96% in 2018–2019 compared with 2017–2018. They increased by a CAGR of 8.6%, however, from 14.67 MT in 2009–2010 to 33.35 MT in 2018–2019. Imported natural gas increased by a CAGR of 8.3%, from 12.92 BCM in 2009–2010 to 28.69 BCM in 2018–2019.

Exported electricity increased from 105 gigawatt hours (GWh) in 2009–2010 to 8,494 GWh in 2018–2019, improving by 17.9% compared with 2017–2018. Gross imported electricity decreased by a CAGR of 1.39% from 2009–2010 (5,359 GWh) to 2018–2019 (4,657 GWh). Net imported electricity declined from 2009–2010 to 2018–2019. For 3 consecutive years, net imported electricity declined; in 2018–2019, it declined by 80.08% compared with 2017–2018 (National Statistical Office, 2020).

Total installed electricity generation capacity increased by a CAGR of 8.05%, from 190.9 GW at the end of March 2010 to 414.1 GW at the end of March 2019. Electricity generation capacity increased by 3.8% to 414.1 GW in 2018–2019 from 398.9 GW in 2017–2018. Other renewable sources registered the highest rate of annual growth in installed capacity (12.5%) from 2017–2018 to 2018–2019, followed by thermal power (1.5%). Amongst thermal sources, installed diesel capacity fell the most, by 24%. Total installed capacity of power utilities increased by a CAGR of 8.37%, from 159.398 GW at the end of March 2010 to 356.1 GW at the end of March 2019. At the end of March 2019, thermal power plants accounted for an overwhelming 68.2% of total installed capacity, with installed capacity of 282.35 GW, compared with 69.2% at the end of March 2018.

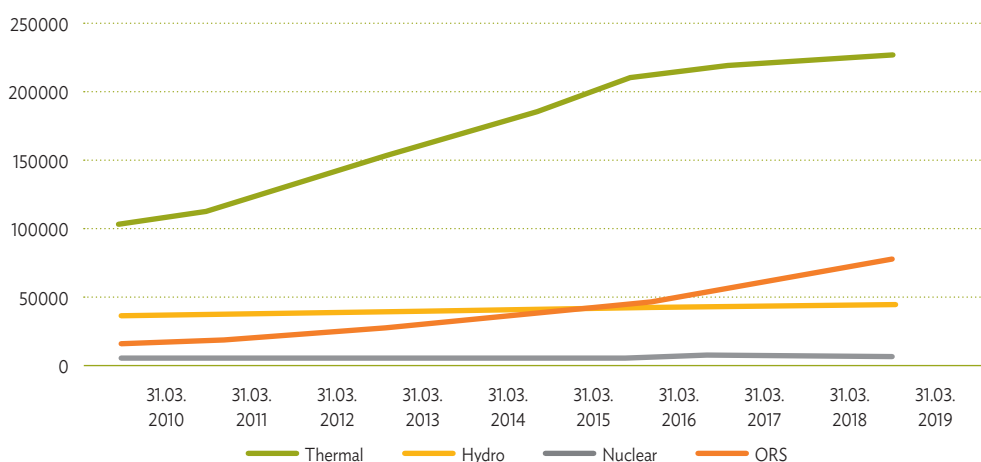
Other renewable sources (excluding hydro) had installed capacity of 79,522 GW in March 2019, accounting for 19.2% of total installed capacity, up from 17.7% as of March 2018. The shares of hydro and nuclear energy were only 10.97% and 1.64%, respectively, of total installed capacity as of March 2019. Non-utilities accounted for 14.01% (58.0 GW) of total installed electricity generation capacity (National Statistical Office, 2020).

Other renewable sources had the highest rate of annual growth in installed capacity, at 12.5%, from 2017–2018 to 2018–2019, followed by thermal power, at 1.5%. Amongst thermal

sources, installed capacity of diesel power fell by 24%. Total installed capacity of power utilities increased by a CAGR of 8.37%, from 159.4 GW as of the end of March 2010 to 356.1 GW as of the end of March 2019. Thermal power plants accounted for 282.35 GW or 68.2% of total installed capacity as of the end of March 2019, compared with 69.2% as of the end of March 2018.

Other renewable sources (excluding hydro) had installed capacity of 79.5 GW or 19.2% of total installed capacity as of March 2019, higher than the 17.7% share as of the end of March 2018. The shares of hydro and nuclear energy were only 10.97% and 1.64%, respectively, of total installed capacity as of March 2019. Non-utilities accounted for 14.01% (58.0 GW) of total installed electricity generation capacity (National Statistical Office, 2020).

Figure 6.1. Trends in Installed Electricity Generation Capacity from Utilities, 2009–2010 to 2018–2019
(megawatts)



ORS = other renewable sources.

Source: National Statistical Office (2020).

Total installed capacity of grid-interactive renewable power was 69.78 GW as of the end of March 2018 and grew by 12.23% to 78.316 GW by the end of March 2019. Of total installed generation capacity of renewable power as of the end of October 2019, wind power accounted for about 45.5%, followed by solar power, including rooftop (36.0%), and biomass power (12.5%) (National Statistical Office, 2020).

3. Modelling Assumptions

GDP is assumed to grow from US\$2.65 trillion (2010 prices) in 2017 to about US\$16.32 trillion (2010 prices) in 2050, equivalent to 5.7% average annual growth rate. The population is assumed to grow at an average annual rate of 0.6% from 1.34 billion people in 2017 to about 1.64 billion in 2050. Coal will continue to have the largest share in electricity generation. Nuclear power plants and others, especially wind and solar, are projected to increase by 2050. Shares of oil and hydro are expected to decrease.

The implementation of energy efficiency programmes in power generation and energy end-use sectors is expected to attain India's energy-saving goals. Improvements in highly energy-intensive industries and in inefficient small plants can ensure energy saving in industry. In the residential and commercial sectors, significant saving can be induced through efficient end-use technologies and energy management systems. In transport, improved vehicle fuel economy and more effective traffic management are important to increase efficiency.

4. Outlook Results

4.1. Business as Usual Scenario

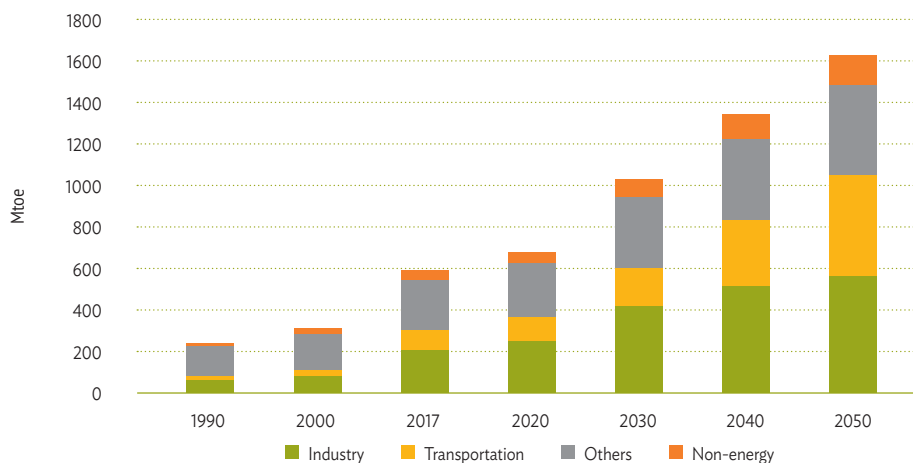
This section describes trends in energy production and utilisation, without any policy intervention, to reduce energy demand or carbon dioxide (CO₂) emissions.

4.1.1. Total Final Energy Consumption

Under the business as usual (BAU) scenario, with assumed strong economic growth and a rising population, TFEC is projected to increase at an average rate of 3.1% per year, from 591 million tons of oil equivalent (Mtoe) in 2017 to 1,631 Mtoe in 2050 (Figure 6.2). Strong growth is projected in transport and industry, at 5.0% and 3.1% per year, respectively, from 2017 to 2050. Strong growth is expected in non-energy consumption (3.6% per year). Due to the large share of non-commercial energy in final energy consumption, the growth rate of 'others', including the residential and commercial sectors, is projected to be modest, at 1.8% per year. However, residential and commercial consumption of energy, especially electricity, will increase rapidly.

The share of 'others', which was the largest, at 40.9% in 2017, will drop to 26.6% in 2050. The share of industry will remain at 34.7% in 2050, and that of transport will reach 29.8% in 2050 from 16.6% in 2017.

Figure 6.2. Final Energy Consumption by Sector, Business as Usual

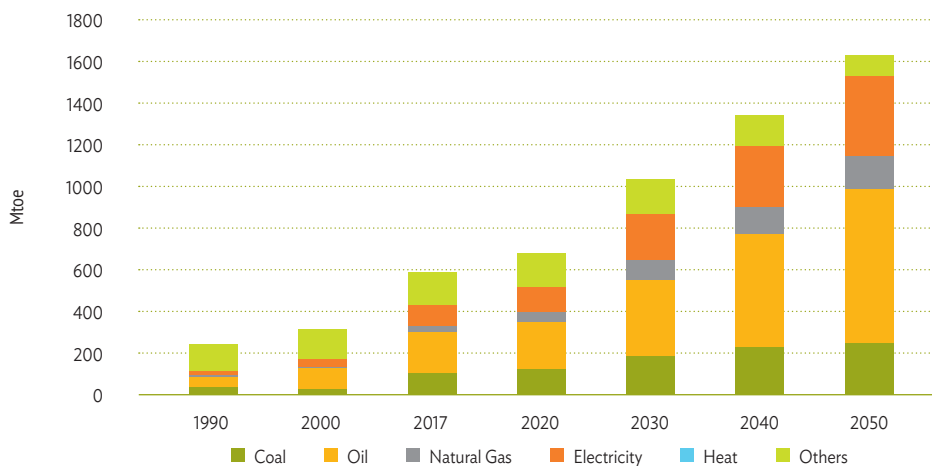


BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Natural gas will grow the fastest, increasing by 4.7% per year in 2017–2050 (Figure 6.3). Oil and electricity demand will each grow at an average of 4.1% per year, whilst coal demand will increase by 2.8% per year. 'Others' with grow by –1.4%.

Figure 6.3. Final Energy Consumption by Fuel, Business as Usual



Mtoe = million tons of oil equivalent.

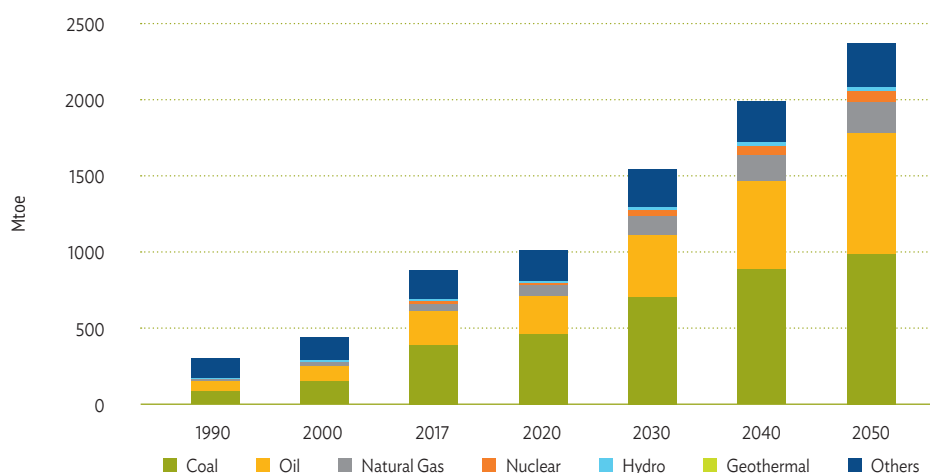
Source: Authors.

4.1.2. Primary Energy Supply

Under BAU, primary energy demand will increase by an average annual rate of 3.0%, to 2,368 Mtoe in 2050 from 882 Mtoe in 2017. Coal demand, driven by demand for power generation, will grow by 2.9% per year and reach 990 Mtoe in 2050, from 391 Mtoe in 2017, maintaining the largest share at 41.8% in 2050 (44.3% in 2017). Due to rapid motorisation, oil demand will increase to 792 Mtoe and will have the second-largest share at 33.5% in 2050. The average annual growth rate for oil demand in 2017–2050 will be 3.9%. Natural gas consumption is expected to increase by 4.4% per year in 2017–2050. Its share will be 8.9% in 2050, up from 5.8% in 2017.

Of 'others', solar and wind will increase significantly due to negative growth of non-commercial biomass, which has the largest portion, projected at –0.3% a year through to 2050. Its share will drop to 7.1% in 2050 from 21.2% in 2017. Figure 6.4 shows projected primary energy demand from 1990 to 2050 under BAU.

Figure 6.4. Primary Energy Supply by Source, Business as Usual



BAU = business as usual, Mtoe = million tons of oil equivalent.

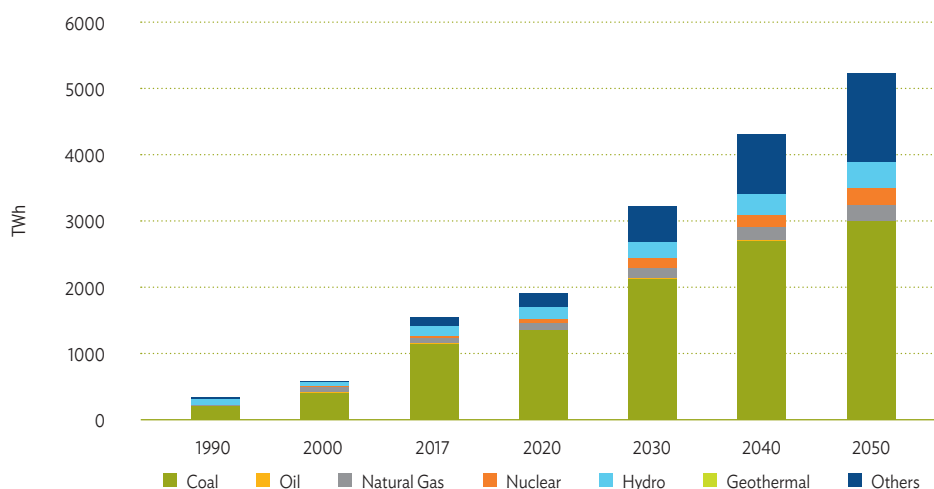
Source: Authors.

4.1.3. Power Generation

In 2017, power generation was 1,532 TWh. Under BAU, power generation will increase by an annual rate of 3.8% to 5,240 TWh in 2050. Coal will continue to dominate the power generation mix, but its share will gradually drop from 74.0% in 2017 to 57.1% in 2050. Hydro's share in the power generation mix will decline from 9.3% in 2017 to 7.3% in 2050, and oil's share will decline from 1.6% in 2017 to 0.2% in 2050. The share of nuclear power

will increase from 2.5% to 4.7%, and 'others', including wind and solar power, will increase from 8.0% to 26.0%. The share of natural gas will grow by an average of 3.9% per year in 2017–2050 to 4.7% in 2050. Figure 6.5 shows projected power generation from 1990 to 2050 under BAU.

Figure 6.5. Electricity Generation, Business as Usual



BAU = business as usual, TWh = terawatt-hour.

Source: Authors.

4.1.4. Carbon Dioxide Emissions

In 2017, CO₂ emissions from the energy sector were 589 million tons of carbon (Mt-C). Under BAU, CO₂ emissions will increase by 3.4% per year to 1,750 Mt-C in 2050. Coal is the main source of CO₂ emissions, which will rise by 2.9% per year, from 412 Mt-C in 2017 to about 1,055 Mt-C in 2050. CO₂ emissions from oil will increase by 4.1% annually, from 157 Mt-C in 2017 to 590 Mt-C in 2050, whilst emissions from natural gas will increase by 5.1% per year, from 20 Mt-C to 105 Mt-C. In 2050, coal will account for about 60.3% of total energy CO₂ emissions, followed by oil, with a share of 33.7%. The remaining 6.0% will come from natural gas.

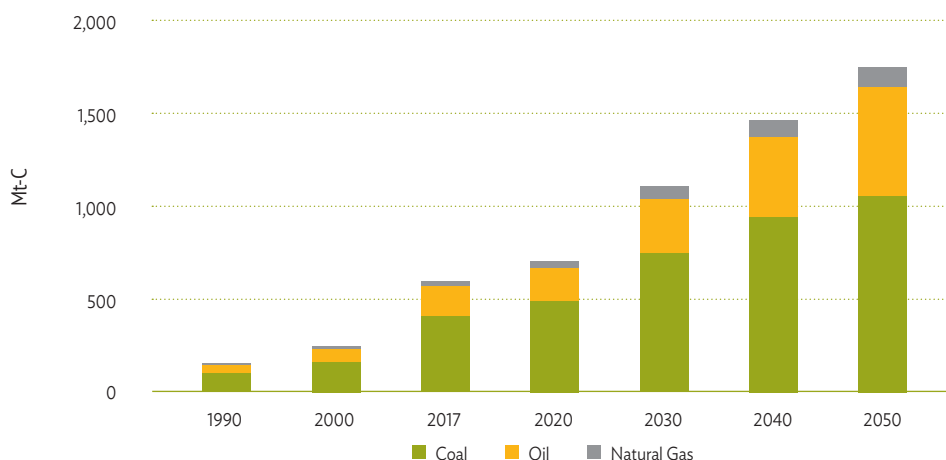
Figure 6.6 shows the projected energy-related CO₂ emissions from 1990 to 2050 under BAU.

4.2. Energy-Saving and Carbon Dioxide Reduction Potential

This section describes the energy-saving and CO₂ mitigation potential of five alternative policies: APS1 – improved efficiency in final energy demand, APS2 – more efficient thermal

power generation, APS3 – high contribution of renewable energy to total supply, APS4 – use of nuclear energy, and APS5 – a combination of APS1 to APS4.

Figure 6.6. Carbon Dioxide Emissions, Business as Usual



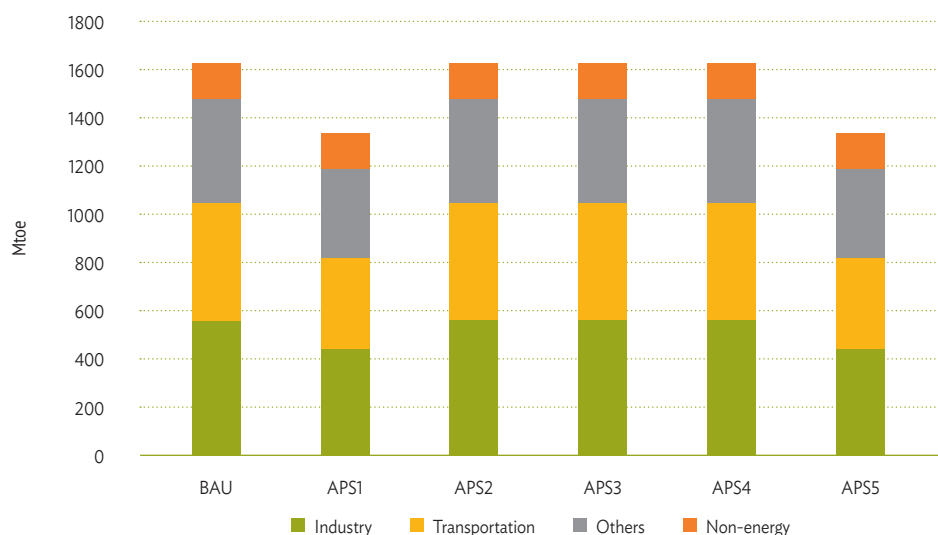
BAU = business as usual, Mt-C = million tons of carbon.

Source: Authors.

4.2.1. Final Energy Consumption

TFEC under APS2, APS3, and APS4 will be the same as under BAU (1,631 Mtoe in 2050) since they have no energy saving targets. Under APS1 and APS5, where efficiency is improved in final energy demand, TFEC will be lower, at 1,338 Mtoe in 2050 (Figure 6.7).

Figure 6.7. Final Energy Consumption, Alternative Policy Scenario

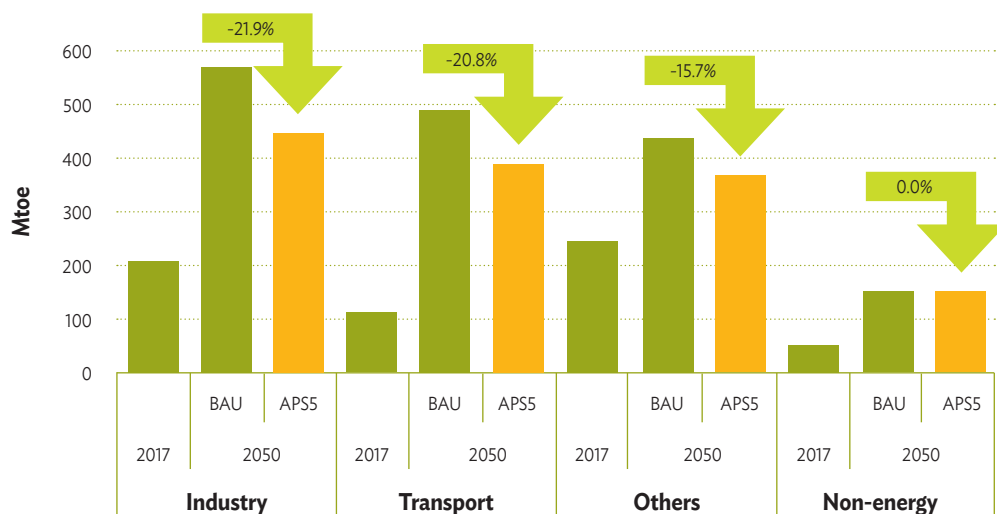


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Under APS1 and APS 5, TFEC will be 17.9% lower than under BAU in 2050. Final energy consumption is expected to decrease across all end-use sectors, reflecting improvements in end-use technologies and the introduction of energy management systems (Figure 6.8). In 2050, under APS5 relative to BAU, savings are estimated at 123 Mtoe (21.9%) in industry, 101 Mtoe (20.8%) in transport, and 68 Mtoe (15.7%) in 'others'.

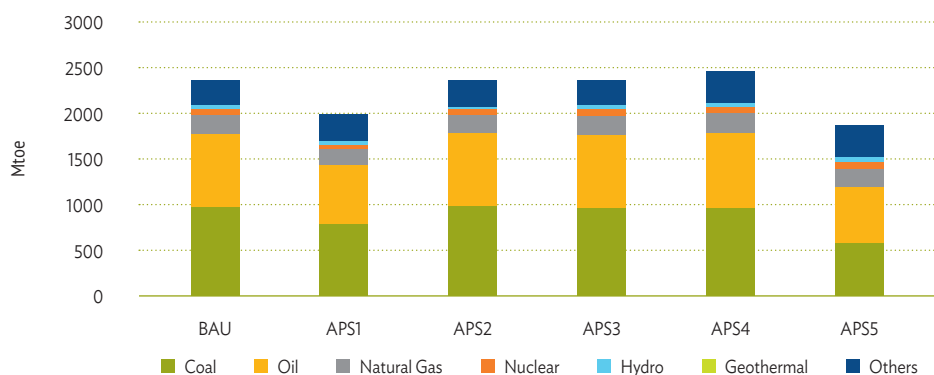
Figure 6.8. Final Energy Consumption, Business as Usual and Alternative Policy Scenario 5



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

Source: Authors.

Figure 6.9. Primary Energy Supply by Source, Alternative Policy Scenario



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

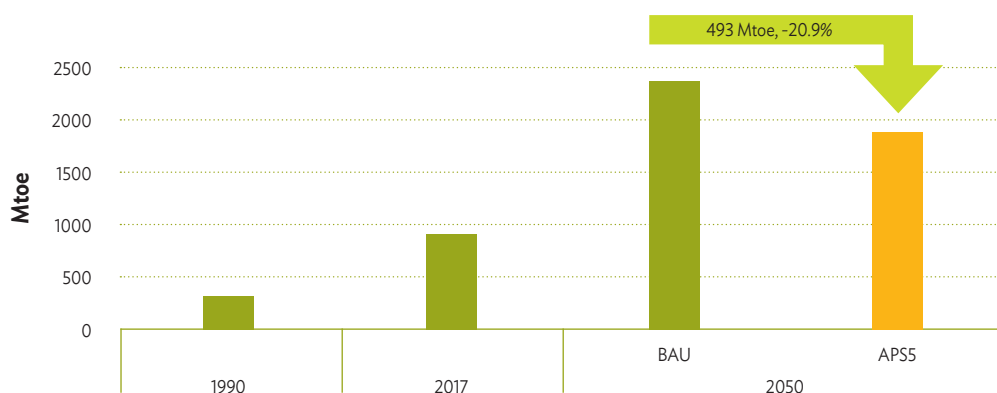
Source: Authors.

4.2.2 Primary Energy Supply

By 2050, total primary energy supply under APS1, APS2, APS3, APS4, and APS5 will be 1,984, 2,364, 2,373, 2,471, and 1,875 Mtoe, respectively (Figure 6.9). TPES under APS1 and APS5 will be lower than under BAU because of improved efficiency measures in the final sector. Under APS2, TPES will be lower than under BAU due to improved thermal efficiency of thermal power generation. TPES under APS3 and APS4 will be higher than under BAU as more renewable and nuclear energy enter the power supply mix by 2050.

Under APS5, relative to BAU, primary energy supply is projected to decrease by 493 Mtoe or 20.9% (Figure 6.10).

Figure 6.10. Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario 5

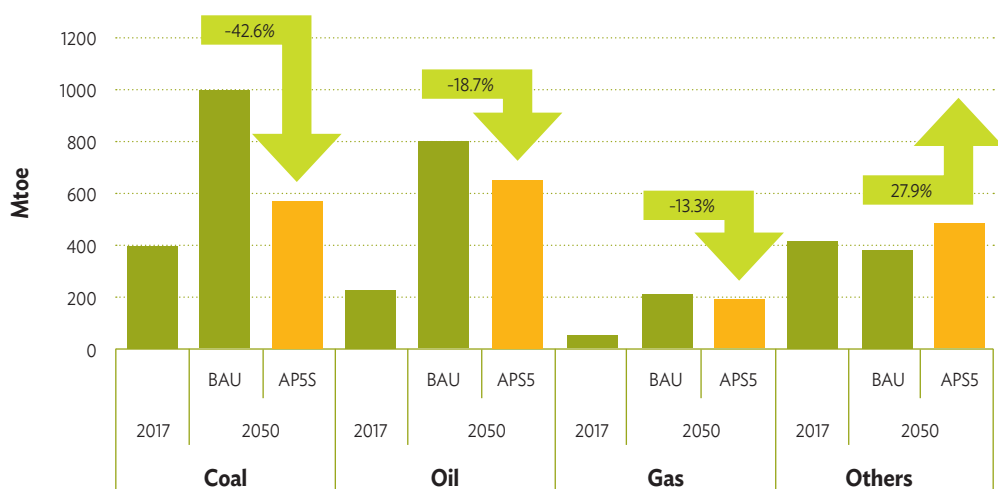


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Under APS5, compared with BAU, in 2050 (Figure 6.11), coal supply will decrease by 421.6 Mtoe or 42.6%, whilst oil supply will drop by 148.5 Mtoe or 18.7%. Natural gas supply will fall by 28.1 Mtoe or 13.38%. However, supply for 'others', driven by strong demand for renewables (wind and solar), will rise by 27.9% or 104.8 Mtoe.

Figure 6.11. Total Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario 5



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

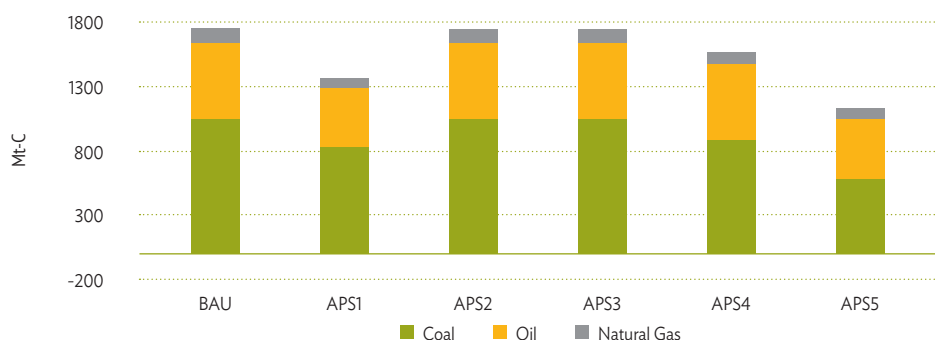
Source: Authors.

4.2.3. Carbon Dioxide Emissions from Energy Consumption

By 2050, CO₂ emissions under APS1, APS2, APS3, APS4, and APS5 will be 1,361, 1,750, 1,750, 1577 and 1,129 Mt-C, respectively, compared with 1,750 Mt-C under BAU (Figure 6.12).

Under APS5, CO₂ emissions in 2050 will be 1,129 Mt-C, 35.5% lower than under BAU. Less demand for coal in industry and power generation and for oil in transport contribute most to reduced CO₂ emissions. Figure 6.13 shows CO₂ emissions in 2050 under BAU versus APS5.

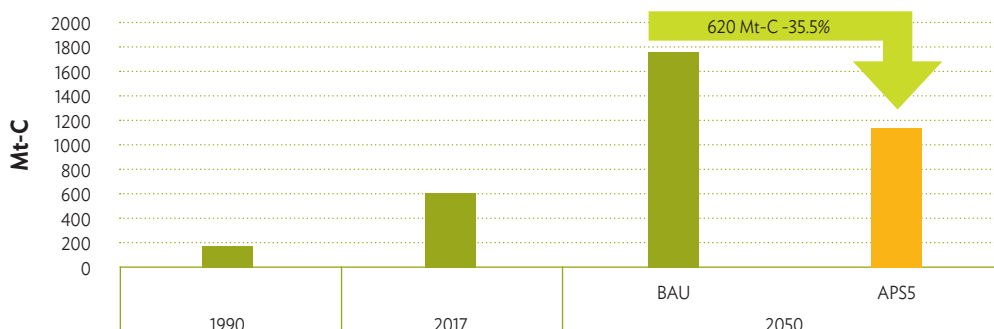
Figure 6.12. Carbon Dioxide Emissions from Energy Combustion, Business as Usual and Alternative Policy Scenario



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

Source: Authors.

Figure 6.13. Carbon Dioxide Emissions from Energy Combustion, Business as Usual and Alternative Policy Scenario 5



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

Source: Authors.

5. Implications

- (i) Energy security and access to energy are key challenges. Enhanced domestic production of energy is necessary to meet them. The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya), which aims to provide last-mile connectivity and electricity connections to all rural and urban households, must be improved and sustained. The Pradhan Mantri Ujjwala Yojana (PMUY) programme, which aims to provide free liquefied petroleum gas connections from oil marketing companies to women belonging to below-poverty-line households, must be strengthened.
- (ii) Electric mobility will be key to decarbonising transport. Concerted efforts are needed to realise the National Electric Mobility Mission Plan 2020, the Scheme for Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME India), and the EV@30 campaign.
- (iii) Hydrocarbons, particularly coal, will continue to dominate the energy mix under BAU and APS. Domestic coal for secure supply and more-efficient coal technologies such as ultra-supercritical coal power plants, amongst others, must be used. In the long and medium terms, cleaner energy research and development will play a key role.
- (iv) Natural gas will play an important role in energy supply and CO₂ mitigation. To fully utilise increasing global natural gas production, the infrastructure to import, domestically transport, and utilise natural gas must be upgraded.

- (v) The government has announced ambitious targets for renewable energy, but the cost and infrastructure will be the bottleneck. Developing domestic manufacturing capacity can play an important role in this regard.. The variability of renewable energy supply remains a key challenge, but it can be tackled by quickly realising One Sun One World One Grid (OSOWOG), which encompasses the phased development of a single, globally connected solar electricity grid to leverage solar energy's multiple benefits (low cost, zero pollution). OSOWOG's underlying logic is that a grid spread across multiple time zones can balance intermittent renewables with other renewables: the setting sun in one part of the grid is made up for by solar, wind, or hydro energy produced elsewhere. Energy cooperation with East Asian countries will play a key role in this regard.
- (vi) Energy efficiency and demand-side management are important. New power plants, new factories, new buildings, new appliances, and new cars should be more efficient. Minimum energy performance standards and mandatory energy labels should be expanded to cover more equipment.
 - a. Potential saving in the power sector is huge. Advanced technologies for power generation should be used as much as possible.
 - b. Industry has significant potential for energy saving. Energy efficiency programmes should, therefore, focus on this sector by, amongst others, broadening the scope of the perform, achieve, trade (PAT) scheme.
 - c. Growth of energy consumption in transport should be curtailed.
 - d. Losses in electricity distribution should be minimised by using better technologies.
- (vii) Energy prices across fuels and sectors must be rationalised.
- (viii) Through its nationally determined contribution (NDC), India pledges to reduce emissions intensity by 33%–35% by 2030 under APS5 from 2005 levels. India is on course to achieve its NDC and can make more climate commitments when significant progress has been made.

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CHAPTER 7

Indonesia Country Report

Cecilya Laksmiwati Malik

1. Background

Indonesia covers an area of 1,913,000 square kilometres and had a population of 264.6 million people in 2017 (World Development Indicators, 2019), up by 1.5% per year from 178.6 million in 1990.

Gross domestic product (GDP) was US\$1,090 billion (constant 2010 United States [US] dollars) in 2017, increasing by an average of 4.8% per year from 1990. The service sector is a major contributor to GDP (43.6%), followed by industry (39.4%), agriculture (13.2%), and other activities (3.8%). GDP per capita in 2017 was about US\$4,120 (constant 2010 US dollars), whilst in 1990 it was only US\$1,734 (constant 2010 US dollars).

Indonesia is richly endowed with natural resources. Its vast oil and gas reserves have 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 have not been conducive and the use of enhanced oil recovery technology to boost oil production is not yet optimal. As of January 2018, proven reserves of crude oil were 3.15 billion barrels, whilst those of natural gas were 96.1 trillion cubic feet or 2.7 trillion cubic metres (Center for Data and Information Technology-Pusdatin, 2018). Indonesia exports coal and had about 39.9 billion tons of proven coal reserves by the end of 2018.

Non-fossil energy resources include hydro, geothermal, biomass, and other renewable sources such as solar and wind. Estimated hydro potential is about 94.3 gigawatts (GW), whilst estimated geothermal potential is more than 28.0 GW (National Energy Council, 2019). In total, renewable energy potential is about 442 GW for power plants, of which only 2% or 9 GW have been utilised.

Utilisation 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 2017 and reached 5.17% in 2018. In 2019, it slowed slightly to 5.02% (Central Bank of Indonesia, 2019). Expected real GDP growth for 2020 was 5.4%, but the coronavirus disease (COVID-19) pandemic has slashed it to 2.1%. The economy is expected to bounce back to 4.3% growth in 2021.

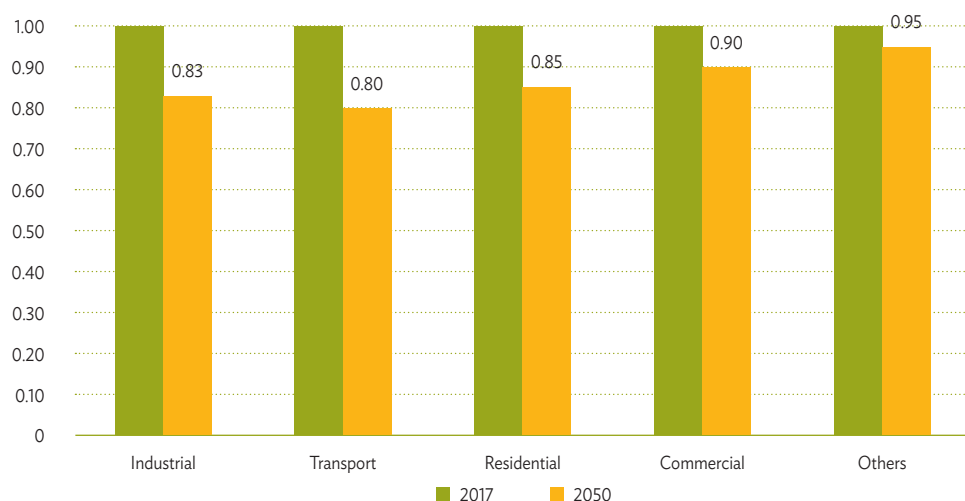
The National Energy Policy (KEN) of 2014 assumes an average annual growth rate of 8.00% from 2017 to 2025, which will slow to 7.25% in 2035 and 6.50% in 2050. Since current real GDP growth is slower than that assumed in the KEN, this study assumes that real GDP will grow by an average of 4.8% per year from 2017 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, based on the revised projection of the Central Bureau of Statistics (BPS).

The business as usual (BAU) scenario and the five alternative policy scenarios (APSs) are similar to those in the previous reports of ERIA 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. The five APSs are as follow:

- (i). APS1. More efficient final energy consumption, with energy-saving targets by sector (Figure 7-1). 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.

Figure 7.1. Energy Efficiency and Conservation Assumptions



Source: Author.

- (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 two 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.

3. Outlook Results

3.1. Business as Usual Scenario

3.1.1. Final Energy Consumption

Total final energy consumption (TFEC) increased by an average of 3.2% per year from 1990 to 2017, from 69.31 million tons of oil equivalent (Mtoe) to 163.58 Mtoe. Given the assumed

economic and population growth, TFEC will continue to grow slightly faster, by 3.5% per year, from 2017 to 2050 under BAU.

3.1.1.1. Final Energy Consumption by Sector

Growth stems from 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 6.9% per year in 1990–2017. Growth is expected to continue until 2050 under BAU but more slowly, by 5.1% per year.

Industry's final energy consumption grew more slowly than transport sector in 1990–2017 (2.8% per year) and will continue to do so in 2017–2050 (3.8%).

The final energy consumption of 'others' (mainly the residential and commercial sectors) grew by an average of 2.2% per year in 1990–2017 and is projected to slow to an average of 1.7% per year in 2017–2050.

'Others' had the highest share in TFEC in 1990–2017 because of high consumption of biomass, mainly in the residential sector. The share, however, decreased from about 55% in 1990 to about 42% in 2017. The share is expected to continue to decrease because demand from 'others' will grow more slowly than that from transport and industry. The share of 'others' in TFEC will decrease to 23.6% in 2050.

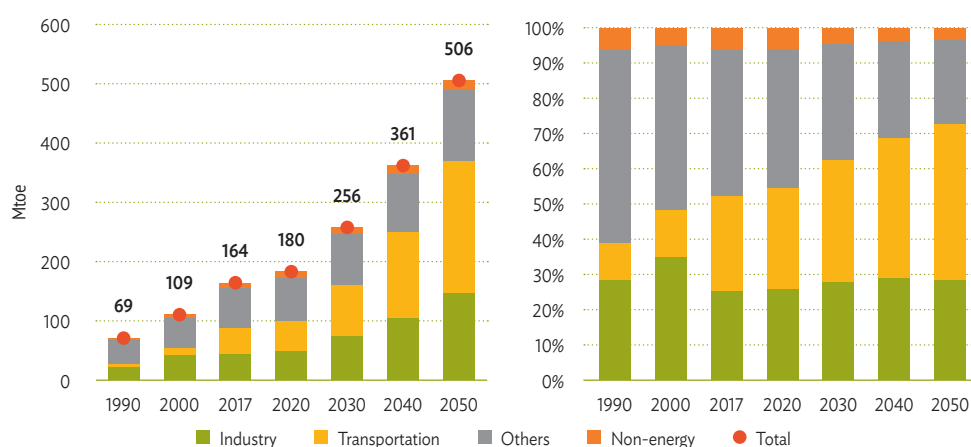
Transport's share in TFEC increased from about 10.3% in 1990 to 26.7% in 2017. The share will continue to increase to 44.7% in 2050. The combined share of oil and alternative fuels for transport will contribute to the increase of transport's share in TFEC.

Industry's share in TFEC was 28.4% in 1990 and decreased to 25.4% in 2017. This share is expected to increase to 28.4% by 2050 in line with growth in industry

3.1.1.2. Final Energy Consumption by Fuel Type

Electricity grew the fastest in 1990–2017, by an average of 8.0% per year, due to the significant increase in industry and residential consumption, from 2.4 Mtoe in 1990 to 19.2 Mtoe in 2017. Coal increased significantly over the same period as industry expanded, particularly cement. Total coal demand increased from 1.44 Mtoe in 1990 to 8.25 Mtoe in 2017, growing by an average of 6.7% per year.

Figure 7.2. Final Energy Consumption by Sector



Mtoe = million tons of oil equivalent.

Source: Author.

Natural gas and oil grew by an average of 4.4% and 4.0%, respectively, in 1990–2017. Demand for other fuels (mostly biomass for households) increased by 15.82 Mtoe over the same period, by an average of 1.3% per year.

Demand for all fuels will continue to increase. Demand for oil will increase at the fastest pace, by an average of 4.5% per year to 275 Mtoe in 2050, mainly driven by transport growth. Electricity demand is expected to grow but more slowly, by an average of 4.2% per year in 2017–2050.

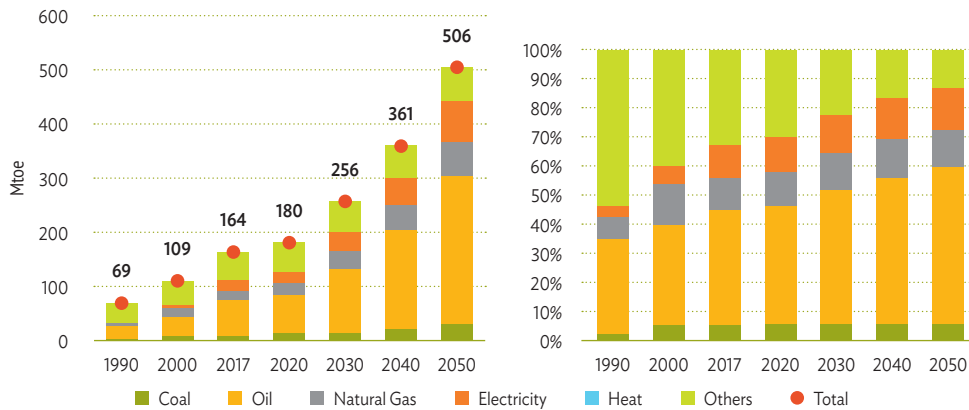
Natural gas and coal demand will grow by an average of 4.0% and 3.8% per year, respectively, in 2017–2050. Demand for other fuels will increase at the slowest pace over the same period, by an average of 0.7% per year, mainly due to declining residential consumption of biomass.

Oil will still play a major role in final energy consumption although more alternative fuels will be consumed by end-use sectors. The share of oil is expected to be about 54% in 2050, increasing from 40% in 2017. The remaining share will be composed of coal (5%), natural gas (13%), electricity (15%), and others (13%).

3.1.2. Primary Energy Supply

Total primary energy supply (TPES) grew by about 3.2% per year, from 102 Mtoe in 1990 to 236 Mtoe in 2017. The fastest-growing fuels in 1990–2017 were coal and geothermal energy. Coal supply grew by an average of 10.3% per year whilst geothermal energy grew by 9.4% per

Figure 7.3. Final Energy Consumption by Energy, Business as Usual



Mtoe = million tons of oil equivalent.

Source: Author.

year. Oil supply increased more slowly, by 2.9% per year, whilst gas had the slowest growth rate at 1.2% per year during the same period.

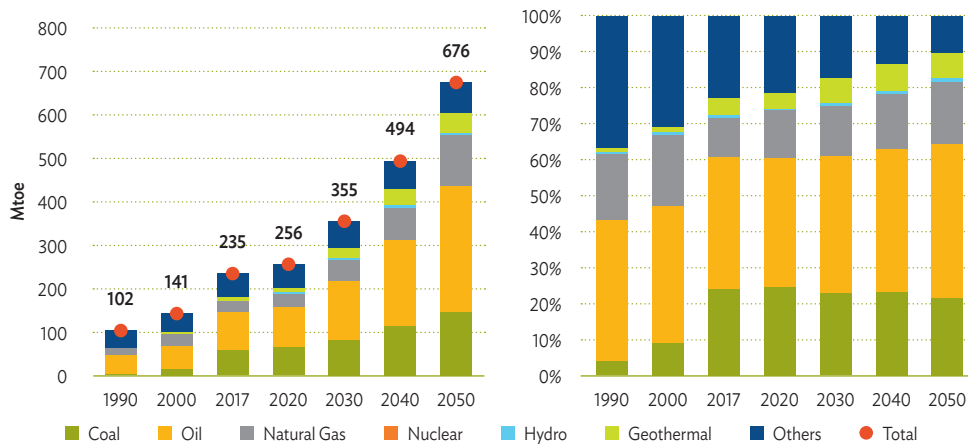
Under BAU, TPES is projected to increase by an average of 3.3% per year, reaching 676 Mtoe in 2050. Coal is projected to continue growing but more slowly, by 2.9% per year. Geothermal energy is expected to increase. The new price structure for generating electricity from renewable energy, as given in article 20 of the KEN, should stimulate the development of geothermal energy. Geothermal energy is projected to grow by 4.5% per year until 2050.

Hydro, including mini and micro hydro, will also increase over 2017–2050 but at a slower rate than geothermal, at 4.2% per year. It is assumed that more run-of-river hydropower plants will be constructed than reservoir hydropower.

Oil is projected to increase by an average of 3.8% per year in 2017–2050 and natural gas by an average of 4.7% per year.

BAU 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.

Figure 7.4. Primary Energy Supply, Business as Usual



Mtoe = million tons of oil equivalent.

Source: Author.

Oil constituted the largest share in TPES, but it declined slightly from 39.7% in 1990 to 36.6% in 2017. The share of natural gas in the total mix decreased from 18.2% in 1990 to 10.9% in 2017.

Since coal and geothermal energy grew rapidly in 1990–2017, their shares in TPES increased significantly. Coal's share in TPES increased from about 4.0% to 24.2% whilst geothermal's increased from 1.0% to 4.7%. Hydro's share increased slightly from 0.5% to 0.7% in 1990–2017. Since 'others', including biomass, solar, wind, ocean, biofuels, and electricity, grew more slowly than other fuels except natural gas, their share declined from 36.8% in 1990 to 23.1% in 2017.

Oil's share in TPES will remain dominant, from 37.0% in 2017 to 43.1% in 2050. Coal's share will decrease slightly from 24% in 2017 to 21% in 2050. The share of natural gas will increase to 17% in 2050 from 11% in 2017.

Hydro's share in TPES will increase from 0.7% in 2017 to 0.9% in 2050, whilst geothermal's will increase from 4.7% to 6.9%. The share of 'others' will reach 10.5% in 2050 from 23.0% in 2017.

3.1.3. Power Generation

Power generation output increased by an average of 7.9% per year, from about 32 TWh in 1990 to 255 TWh in 2017. In 1990, most generation output was still from oil-based plants (38%). Coal's share was below oil's at 30%. 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 58% in 2017. Coal power generation reached 148 TWh in 2017, increasing rapidly by 10.6% 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 (22% in 2017), although electricity generation from natural gas increased at the fastest pace, by 10.9% per year, reaching 56 TWh in 2017.

Under BAU, power generation is projected to reach 941 TWh by 2050, increasing by an average of 4% per year (Figure 7-5). Generation from 'others' will grow at the fastest pace, by an average of 10.6% per year. The main reason is that generation from 'others' was small tiny in 2017 but is expected to increase significantly as a result of the policy to increase the use of NREs, including solar photovoltaic (PV), wind, and biomass, amongst others. Hydro and geothermal generation are growing but slower than generation from 'others', by 4.2% and 4.5%, respectively.

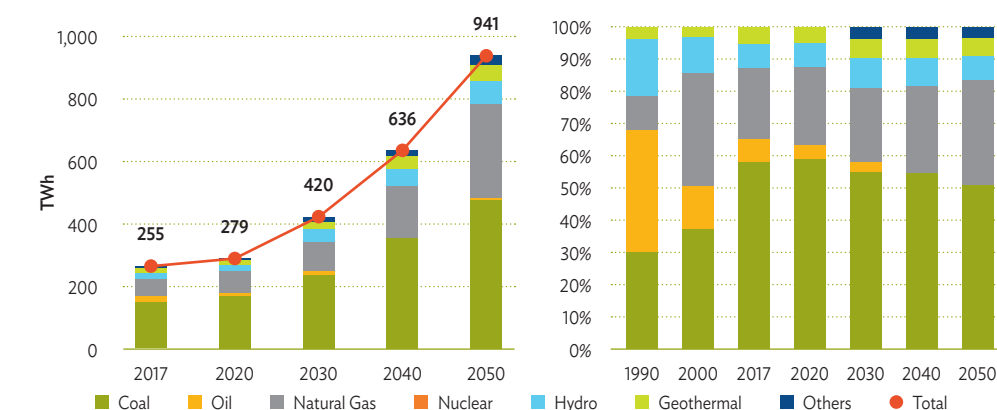
Power generation from natural gas will continue to increase at an average rate of 5.3% per year, whilst coal-based power generation will grow by an average of 3.6% per year. BAU does not include nuclear plants.

The share of coal will remain dominant in total power generation and is expected to continue to increase but eventually even out at 50.8% in 2050.

The share of natural gas will increase to 32.7% by 2050, whilst that of oil will continue to decline to 0.1% by 2050. The assumption is that oil-based plants (diesel plants) will be replaced with other fossil fuel or renewable sources except where substitution is not feasible.

The total share of renewable energy in the generation mix will reach 17.0% by 2050, with hydropower at 7.7%, geothermal at 5.7%, and other renewables at 3.0%.

Figure 7.5. Power Generation by Type of Fuel (TWh)



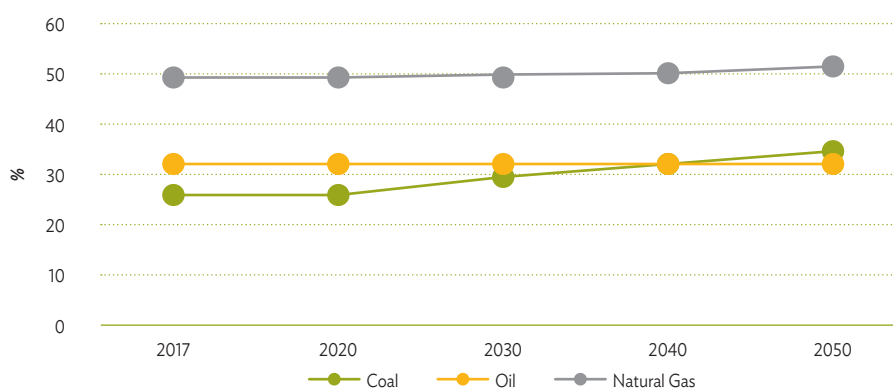
TWh = terawatt-hour.

Source: Author.

The average thermal efficiency of fossil fuel-based power plants was about 30% in 2017. Under BAU, coal and natural gas power plants are assumed to become more efficient, causing thermal efficiency of fossil fuel plants to increase to 40% by 2050.

The thermal efficiency of coal-fired power plants will increase from 26% in 2017 to 35% in 2050, whilst that of natural gas will increase from 49% to 51%. Oil will remain at 32% in 2017–2050.

Figure 7.6. Thermal Efficiency, Business as Usual



Source: Author.

3.1.4. Energy Indicators

Primary energy intensity is measured as the ratio of TPES and GDP, which is the unit consumption of primary energy per million US\$ (constant 2010 US dollar). The primary energy intensity has been declining since 1990 and reached 215 tonnes of oil equivalent

(toe)/million 2010 US\$ in 2017.. Final energy intensity (TFEC/GDP) started declining after 2000 and reached 150 toe/million 2010 US\$. 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.

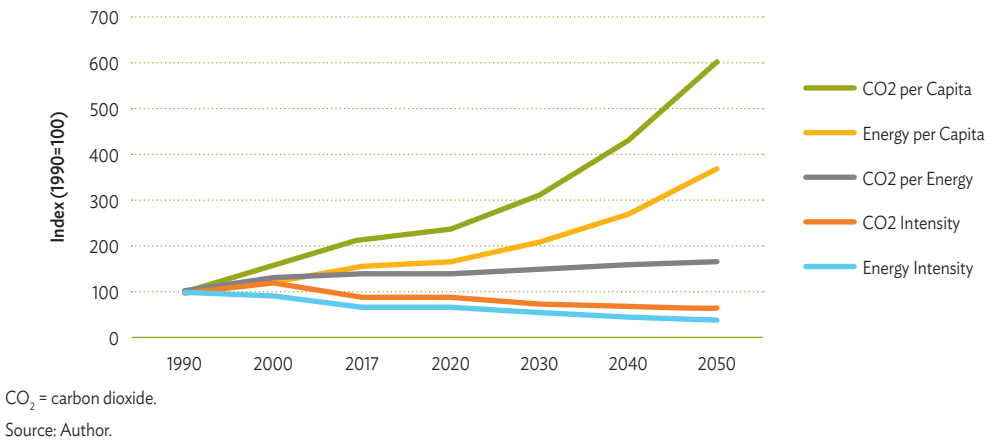
Under BAU, primary and final energy intensity are projected to decline at an average rate of 1.5% per year over 2017–2050. Primary energy intensity in 2050 will be about 132 toe/million 2010 US\$, whilst final energy intensity will be 99 toe/million 2010 US\$. The energy intensity ratio (primary and final), therefore, is expected to improve by about 40% in 2050 compared with 1990.

Per-capita energy consumption, measured as the ratio of total primary energy supply to the total population, increased from 0.6 in 1990 to 0.9 in 2017, indicating that energy access is improving. In 2017, the electrification ratio was about 95.4% and reached 98.3% by 2018 (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 will 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 2017–2050 will reach 0.72. Elasticity below 1 indicates that growth in final energy consumption will be slower than growth in GDP in 2017–2050.

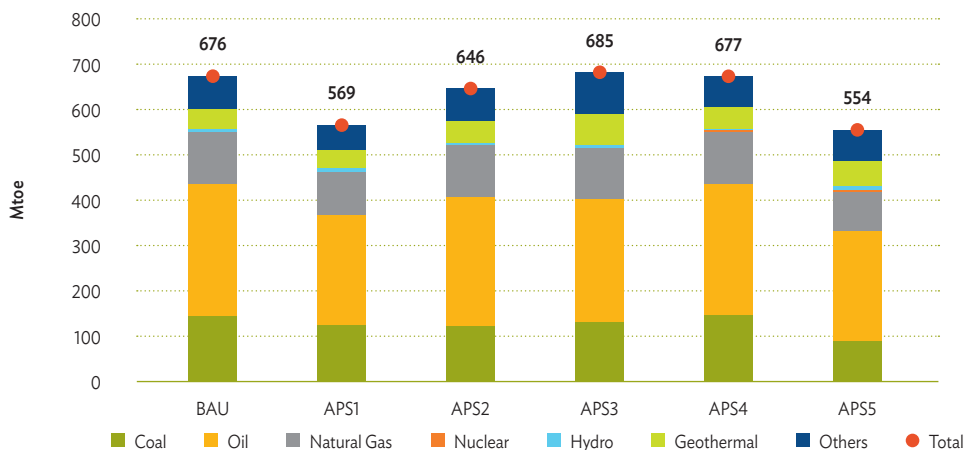
Figure 7.7. Energy Intensity and Other Energy Indicators (1990=100)



3.2. Energy Saving and Carbon Dioxide Reduction Potential

The assumptions in APS1 to APS5 were analysed separately to determine their individual impacts. Figure 7-8 shows the changes in TPES under all scenarios.

Figure 7.8. Comparison of Scenarios' Total Primary Energy Supply by 2050



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

Source: Author.

APS1 and APS5 have the largest reductions in primary energy supply in 2050 due to demand-side energy efficiency assumptions. The assumptions could reduce BAU TPES by as much as 108 Mtoe or 16.0% under APS1 and by 122 Mtoe or 18.1% under APS5.

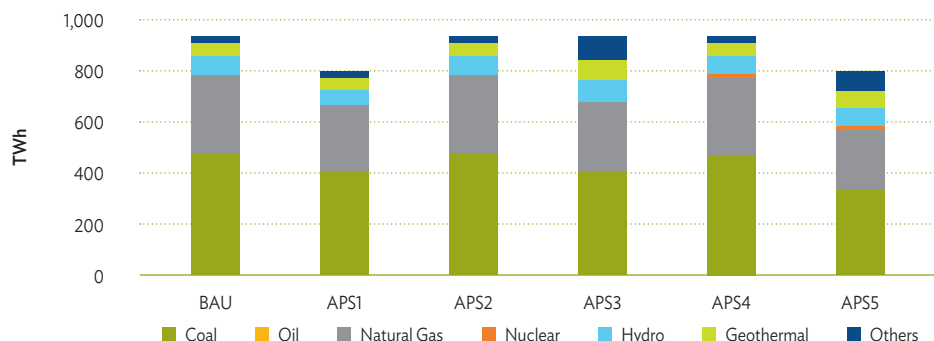
APS2, which assumes higher efficiency in thermal electricity generation, will reduce TPES in 2050 by 30 Mtoe or 4.4% compared with BAU. APS2 does not assume efficiency measures in the final sector, so it will have less impact than APS1. Therefore, the reduction is due mainly to the use of more-efficient power generation, whilst some conventional plants ceased operation after reaching the end of their technical life.

Under APS3, TPES increases slightly as more renewable energy is used to generate power and more biofuels are consumed in transport. The difference with BAU in 2050 is only about 8.8 Mtoe or 1.3%.

Nuclear power generation will be introduced only after 2045 under APS4. As a result, the increase in TPES in 2050 will not be significant, only 0.26 Mtoe or 0.04% as compared with BAU. Nuclear plants will reduce the consumption of fossil fuels (coal, oil, gas) in generating power. Considering that nuclear plants are slightly less efficient than fossil fuel plants, there might be no savings relative to BAU.

Total electricity generation in 2050 under all scenarios is shown in Figure 7.9. In APS1, lower electricity demand results in less production of electricity. Since the difference between APS1 and BAU is the amount generated, the generation mix is the same. Fossil fuel generation still dominates, at 83.6%, whilst renewable energy (hydro, geothermal, others) generation accounts for 16.4%.

Figure 7.9. Comparison of Scenarios' Electricity Generation by 2050

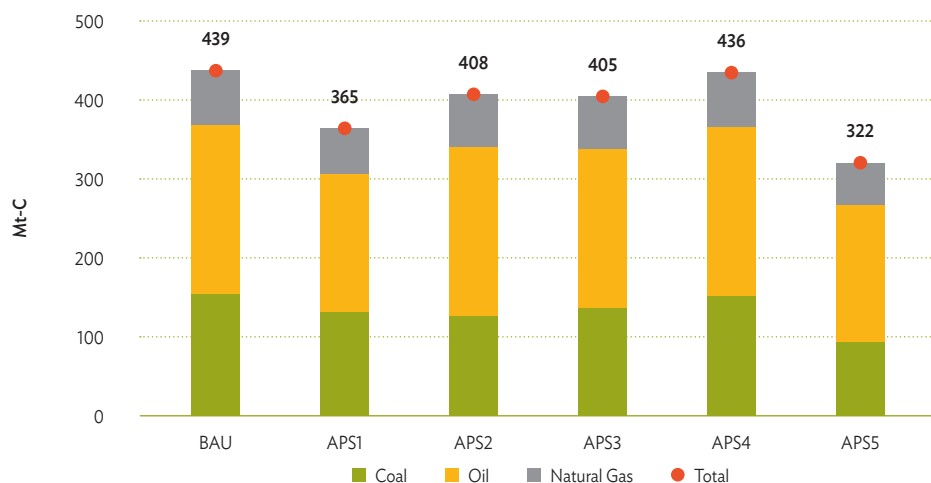


APS = alternative policy scenario, BAU = business as usual, TWh = terawatt-hour.

Source: Author.

Under APS2, the share of fossil fuel-fired generation will be the same as under BAU since the differences lie only in 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 72.7%, whilst under APS4, nuclear energy will reduce the fossil fuel share slightly to 82.3%. Under APS5, the share of fossil fuel-based generation will be significantly reduced to 12.4%.

Figure 7.10. Comparison of Scenarios' Carbon Dioxide Emissions by 2050



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

Source: Author.

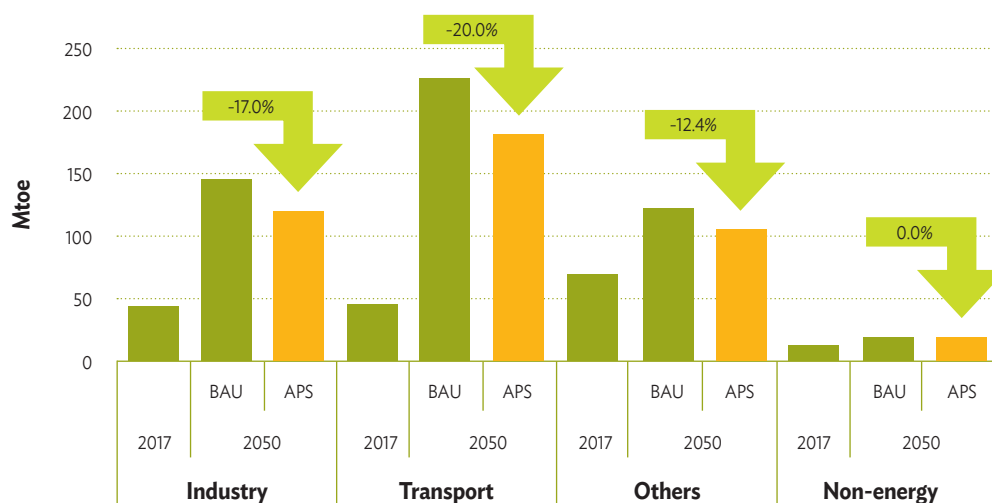
Under APS1, carbon dioxide (CO₂) emissions could be reduced by almost 11% in 2050 (Figure 7-10). Under APS2, the installation of more-efficient power plants could reduce emissions by 4.5%. More renewable energy could reduce emissions by 5%, whilst nuclear energy could reduce them by 0.4%. APS5 could reduce emissions by 17.3% in 2050.

3.2.1. Final Energy Consumption

Under APS, TFEC is projected to increase more slowly than under BAU, at an average of 2.9% per year, from 163.58 Mtoe in 2017 to 421.79 Mtoe in 2050. Slower growth under APS is projected across all sectors because of the government's EEC programme, particularly in transport. Energy demand in transport is projected to increase by 4.4% per year compared with 5.1% per year under BAU. Figure 7-11 shows TFEC by sector in 2017 and 2050 under BAU and APS.

Savings of 24.46 Mtoe in industry, 45.3 Mtoe in transport, and 14.82 Mtoe in the residential and commercial ('others') sectors are assumed by 2050 under APS.

Figure 7.11. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario



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

Source: Author.

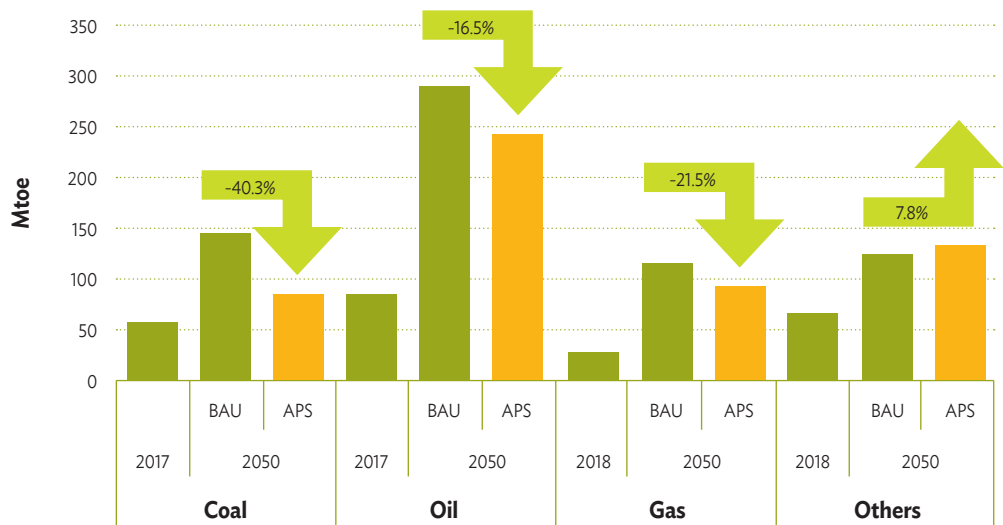
3.2.2. Primary Energy Supply

Under APS, TPES is projected to increase more slowly than under BAU, by 2.6% per year to 554.32 Mtoe in 2050. All energy sources are projected to experience positive average annual

growth rates. However, some will be slower than under BAU. A lower TPES relative to BAU reflects energy efficiency and conservation measures on the demand side. On the supply side, this will include the use of more-efficient technology to generate power.

Savings of almost 58.46 Mtoe for coal, about 48.11 Mtoe for oil, and 25.12 Mtoe for natural gas by 2050 are assumed under APS. In the case of other resources (new and renewable resources, nuclear, and ‘others’), TPES under APS in 2050 is 9.64 Mtoe higher than under BAU.

Figure 7.12. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario

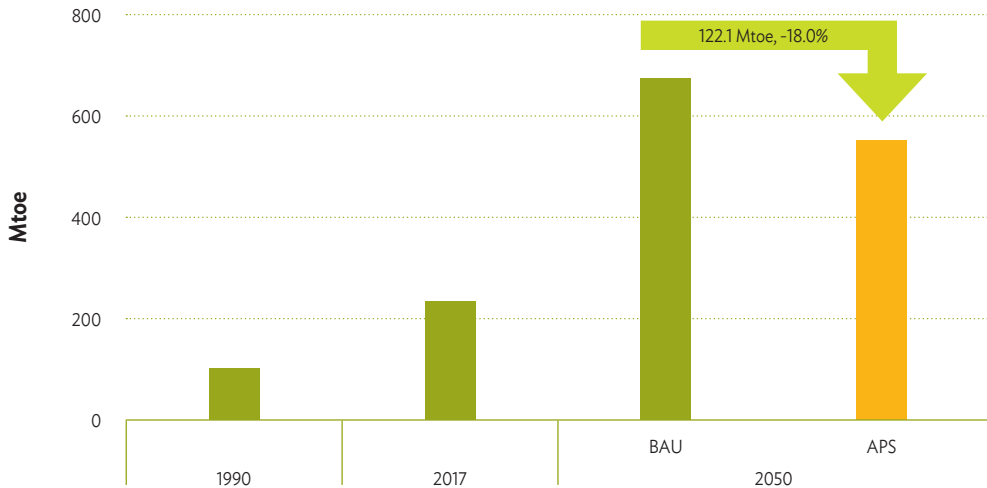


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.
Source: Author.

3.2.3. Projected Energy Savings

Total energy saving (the difference between TPES under BAU and under APS) from implementing EEC and achieving renewable energy targets, improving power plant efficiency, and introducing nuclear energy is 122.05 Mtoe in 2050, more than half of TPES in 2017, which was about 235.26 Mtoe.

Figure 7.13. Total Primary Energy Supply, BAU and APS



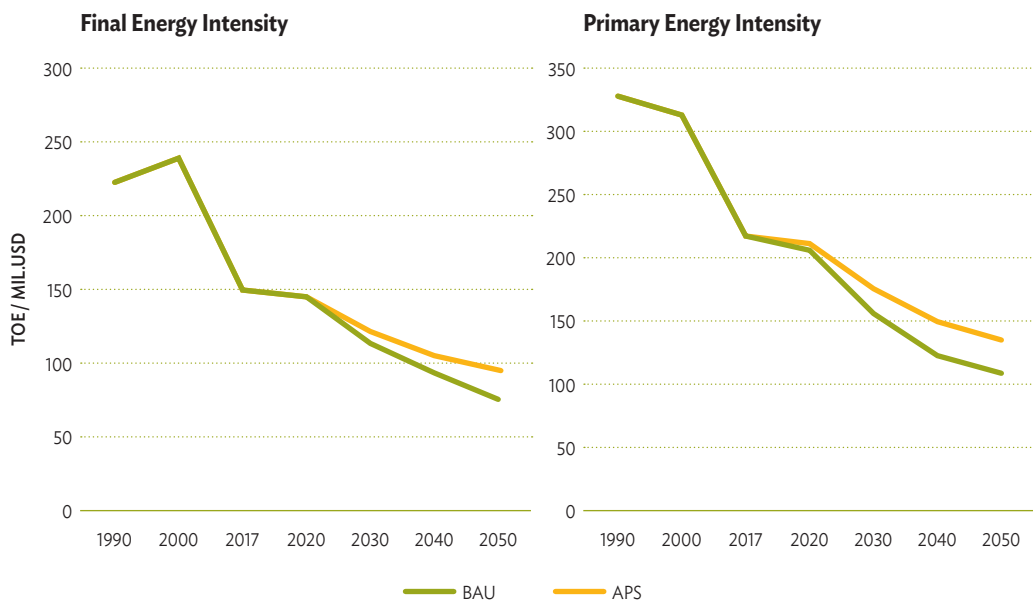
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Author.

3.2.4. Energy Intensities

The KEN targets 1% per year reduction in final energy intensity up to 2025. Under BAU, final energy intensity will decline by an average of 1.3% per year in 2017–2050. Achieving sector EEC targets under APS will hasten the decline of final energy intensity to 1.8% per year over the projection period.

Figure 7.14. Energy Intensity, BAU and APS



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

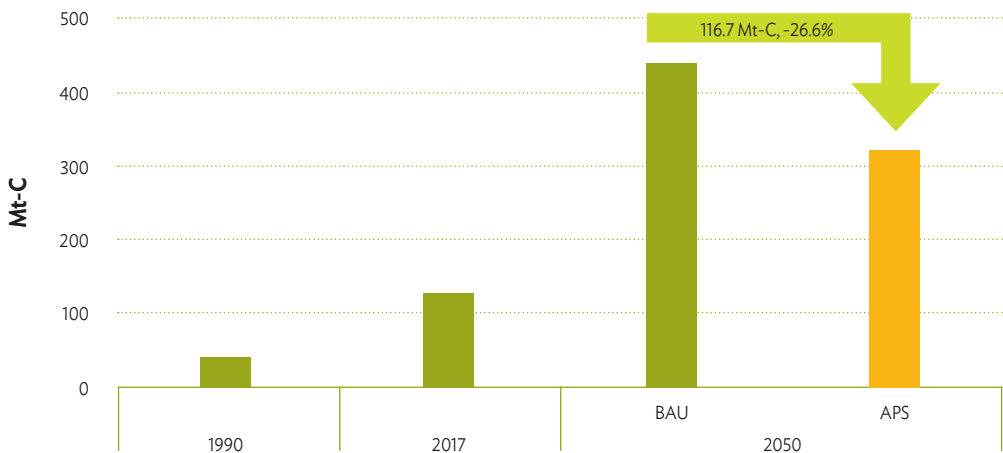
Source: Author.

Primary energy intensity will be reduced by more than 1.5% per year under BAU and by 2.1% per year under APS if the EEC sectoral targets are achieved.

3.2.5. Carbon Dioxide Emissions from Energy Consumption

CO2 emissions from energy consumption are projected to increase by an average of 3.8% per year from about 127.2 million tonnes carbon (Mt-C) in 2017 to 438.5 Mt-C in 2050 under BAU. The increase is driven by the increasing use of carbon-intensive fuels, particularly coal in power generation and industry and oil in transport.

Figure 7.15. Carbon Dioxide Emissions from Energy Consumption, BAU and APS



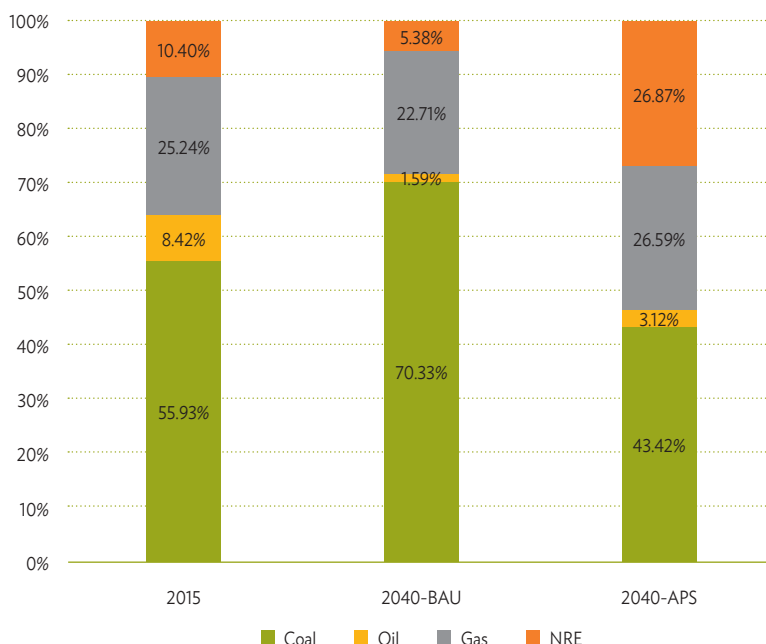
APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon equivalent.
Source: Author.

Under APS, CO2 emissions in 2050 are expected to be 26.6% lower than under BAU because of greater energy conservation, higher efficiency, elevated renewable targets, and the inclusion of nuclear energy after 2020. The government has committed to reduce CO2 emissions in 2030 by 29% without international assistance and by 41% with international assistance. This study’s CO2 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.

CO2 emission reduction is highest in case of coal replacement, as compared with oil and gas. Most oil is consumed by transport. Although alternatives to oil have been introduced in transport, oil will still be dominant. Coal is mainly used in the power sector. Increasing the share of NRE as outlined in the KEN will significantly reduce the coal share. Figure 7-16 shows the share of the different sources of energy in total generation of electricity in 2050. Growth of electricity production by coal-based power plants is slower than that by NRE- and

gas-based power plants in BAU and APS. Solar- and biomass-based power generation grows at the fastest pace.

Figure 7.16. Power Generation Mix, BAU and APS



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

Source: Author.

4. Implications and Policy Recommendations

Primary energy intensity (TPES/GDP) and final energy intensity (TFEC/GDP) are declining because producers and consumers are using efficient energy technologies. Under BAU, primary energy intensity declined by 1.5% per year over the projection period. Further adaptation of the sectoral target combined with the renewable portfolio, efficient power plant technology, and introduction of nuclear energy, will reduce energy intensity even more, by 2.1% per year. Elasticity of primary energy supply is projected to decrease to below 1.0 under BAU (0.7) and further to 0.5 under APS2, APS3, and APS4 if they are implemented fully.

Primary energy supply per capita is 1.7–2.1 toe/person under all scenarios by 2050, which is less than that of Thailand and Malaysia. Developing energy infrastructure, particularly in remote areas and small islands, will improve the electrification ratio, i.e. accessibility to energy.

Oil will still have the largest share in the total primary energy mix. The KEN sets targets of less than 25% in 2025 and less than 20% in 2050. This analysis, which includes electric vehicle (EV) and biofuel targets for transport and efficient boilers for industry, concludes that saving in oil consumption between BAU and APS could be as high as 23% in 2050.

Considering that transport is the major consumer of oil, programmes to reduce oil use will be important. These include improving public transport, increasing the use of alternative fuels such as biofuels and natural gas, and encouraging the production of more-efficient vehicles. In 2019, the President issued a decree on accelerating the battery-powered EV programme. Derivative regulations on the operational aspects of the programme are being deliberated by ministries and state agencies. Some issues still being discussed include the electricity tariff for charging stations.

EVs will reduce oil consumption but require more electricity generation. If more coal is used to generate electricity for EVs, they will have a negative impact on the environment. The EV promotion policy should, therefore, require building NRE-based power plants.

The KEN targeted NRE shares of 23% and 31% of TPES for 2025 and 2050, respectively. APS results show that the NRE share will be about 24% of TPES by 2050.

Solar energy can help Indonesia attain 100% green electricity by 2050. Decreasing costs of setting up solar PV farms and the availability of large areas to install them encourage the promotion of solar energy, which contributed only 1.7% to total electricity production in 2019. The renewable energy regulation (to be issued soon) will improve the investment climate in the renewable energy sector by revising the formula for the feed-in tariff in the bidding process.

The government is revising Government Regulation No. 70/2009 on Energy Conservation. An important change is mandatory energy management for industries consuming more than 4,000 toe, down from more than 6,000 toe.

Some technologies being considered to enhance energy efficiency in industry include high-efficiency boilers, efficient electric motors, cogeneration, and waste heat recovery for power generation (WHRPG). Two cement factories are applying WHRPG, in Padang in West Sumatra and Gresik in East Java.

Pursuing energy efficiency and conservation programmes and accelerating renewable energy

development will further reduce CO₂ emissions. Under APS, CO₂ emissions will be about 27% less than under BAU by 2050.

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CHAPTER 8

Japan Country Report

Seiya Endo

1. Background

Japan is a small island nation in East Asia consisting of several thousand islands and spanning a land area of approximately 377,960 square kilometres, most of which is mountainous and thickly forested. Japan's gross domestic product (GDP) in 2017 was \$6,158 billion (constant 2010 prices), and the population was about 127 million. In 2017, Japan was the third largest economy in the world.

1.1 Energy Situation

As of 2017, Japan's primary energy supply was 432.0 million tonnes of oil equivalent (Mtoe). Oil accounts for 40.7% of the energy mix, followed by coal at 27.0%, with demand for coking coal driven by steel production and demand for steam coal driven by power generation, pulp and paper, and cement production. Natural gas comes third at 23.4%, and is mainly used for electricity generation, reticulated city gas, and industrial fuels. Of the remaining 9.0%, nuclear energy accounts for 2.0%, while renewable energy (such as hydropower, geothermal, wind, and solar) represents 7.0%. In 2017, net imports of energy accounted for about 93% of the net primary energy supply. With scarce indigenous fossil fuel sources, Japan imported almost 100% of its oil and coal supply, and 97% of its natural gas.

Japan's final energy consumption increased slightly from 287.3 Mtoe in 1990 to 292.8 Mtoe in 2017 (roughly 0.1% per year). During this period the residential and commercial sector ('others') saw the highest growth at 1.0% per year, while the transport sector saw growth of only 0.1% per year. Industry consumption decreased at a rate of 0.8% per year on average from 1990 to 2017. Oil was the dominant fuel, accounting for 61.5% of final energy consumption in 1990; this

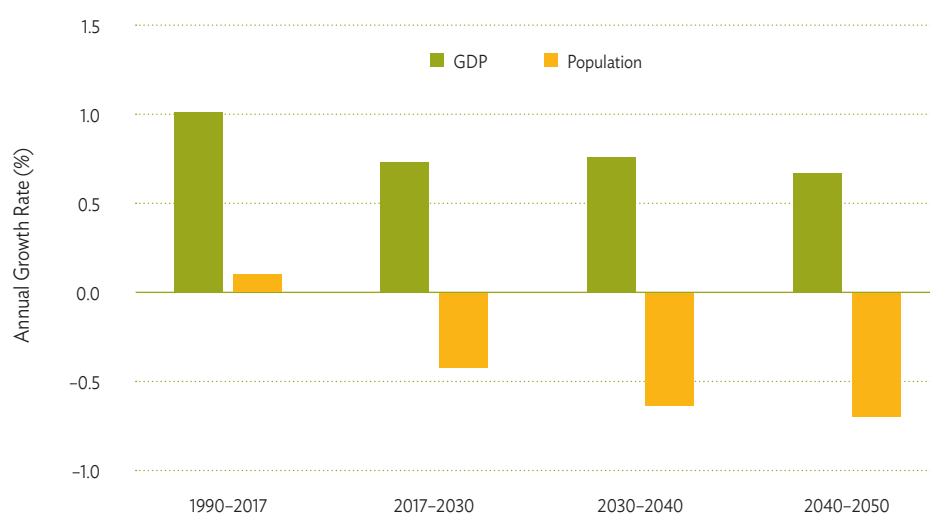
decreased to 51.6% in 2017. Electricity came second, accounting for 28.3% of final energy consumption in 2017.

In the same year, 292 gigawatts of power generation capacity was installed in Japan generating 1,061 terawatt-hours of electricity. Thermal power (coal, natural gas, and oil) accounted for 77.3%; nuclear, 3.1%; hydropower, 7.8%; and geothermal, solar, and wind the remaining 11.8%. Before the Great East Japan earthquake and severe Fukushima Daiichi nuclear power plant accident in 2011, nuclear accounted for about 30% of power generation in Japan. Nuclear reactors in Japan were stopped from operating after the accident, but some have restarted with government approval.

2. Modelling Assumptions

During this report's outlook period (2017–2050), Japan's slow and steady economic growth is expected to continue in the long run. GDP is expected to grow at an average annual rate of 0.7%, with the service industry as a key driver of overall new growth. On the other hand, population growth is expected to decline by about 0.6% per year from 2017 to 2050 as a result of the country's decreasing birth rate, and Japan's population is projected to decrease from 127 million in 2017 to 105 million by 2050. Figure 8.1 shows the assumptions for GDP and population growth used in this study. GDP per capita is projected to reach \$74 by 2050, 1.5 times the figure in 2017.

Figure 8.1. Annual Growth Rate of Gross Domestic Product and Population



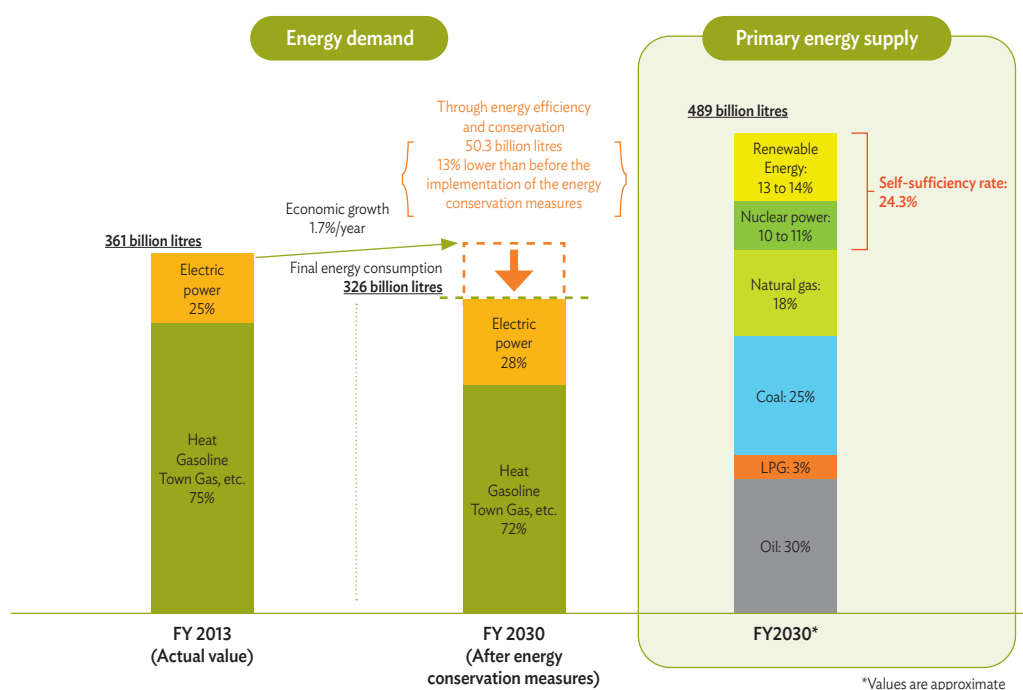
GDP = gross domestic product.

Source: Author's analysis based on United Nations and International Monetary Fund projections.

Japan's infrastructure and manufacturing facilities have already matured to some extent; and production of crude steel, cement, and ethylene will gradually decline over the outlook period. The number of automobiles will also decline as the population shrinks.

According to the Long-Term Energy Supply and Demand Outlook approved by the Ministry of Economy, Trade and Industry in July 2015, final energy consumption in 2030 will decrease to 326 billion litres of oil equivalent (a 9.7% decrease from 2013), while economic growth is expected to continue at a rate of 1.7% per year. The government aims to conserve 50.3 billion litres of oil equivalent from the baseline (Figure 8.2).

Figure 8.2. Energy Balance Target in 2030

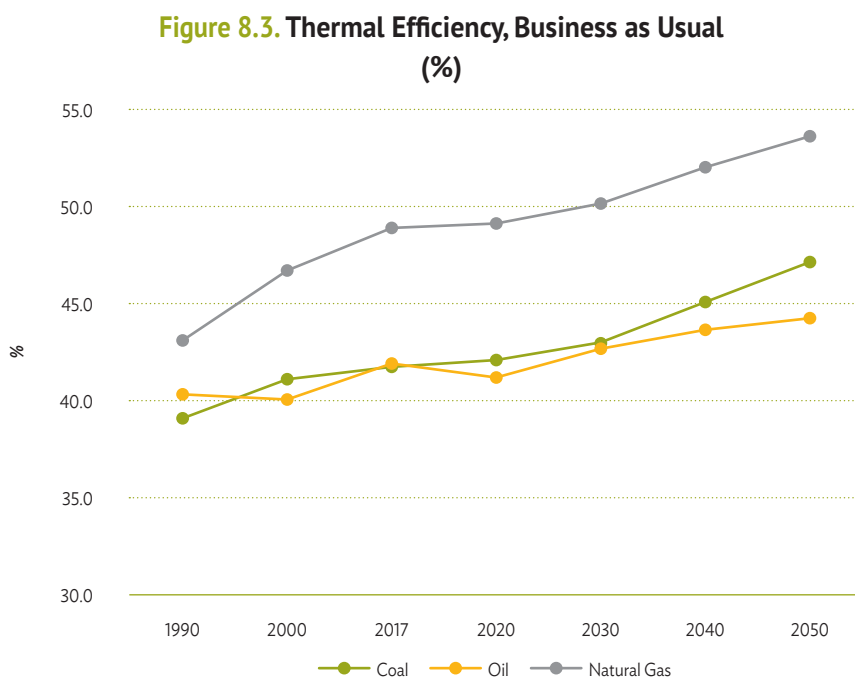


Note: The fiscal year (FY) of the Government of Japan ends on 31 March. 'FY' before a calendar year denotes the year in which the fiscal year ends, e.g., FY2020 ends on 31 March 2020.

Source: Ministry of Economy, Trade and Industry, Japan (2015), Long-Term Energy Supply and Demand Outlook. Tokyo.

The outlook also forecasts the power generation mix in 2030, projecting that the share of nuclear power will decrease from about 30% in 2010 (before the Great East Japan Earthquake) to 20%–22% by 2030; renewable energy will increase from 11% before the earthquake to 22%–24% by 2030; and baseload power from non-variable sources (e.g. hydropower, coal-fired thermal power, and nuclear power) will be 56%.

Japan's energy savings goal will be attained through the implementation of national energy efficiency programmes in all demand sectors. For the industry sector, energy savings are expected from improvements in manufacturing technologies. In the residential and commercial sectors, the Top Runner Programme¹ is projected to induce huge savings, in addition to programmes involving energy management systems and improvements in adiabatic efficiency, lighting systems, and heat pump systems. In the transport sector, vehicle fuel efficiency will be improved, including increases in the stock of hybrid vehicles and structural changes in vehicles. In the power generation sector, related laws set efficiency targets for thermal power plants. According to this benchmark target, the efficiency of new capacity should match the highest efficiency levels of current plants. Thermal plants will continue to improve their efficiency, and coal and natural gas in particular are expected to achieve significant progress because of advances in technology and regulatory frameworks. Figure 8.3 shows the assumed thermal efficiencies of thermal power plants under business as usual (BAU).



Source: Author's analysis.

¹ This is Japan's energy efficiency programme, which aims to improve the energy efficiency of household and office appliances as well as vehicles. It sets the end-use energy performance of the best technology available in the market as the standard for each product category.

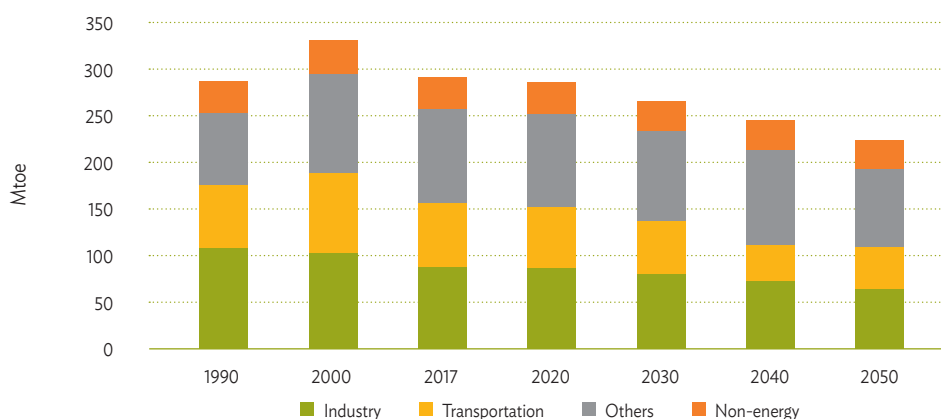
3. Simulation Results

3.1 Business as Usual Scenario

3.1.1 Final Energy Consumption

Figure 8.4 shows the projected final energy consumption by sector from 1990 to 2050 under BAU. Between 2017 and 2050, Japan's final energy consumption is projected to decrease by 0.8% per year, on average. Expectations of steady economic growth and population decline are both key contributing factors to this general trajectory. However, improved energy efficiency in the transport sector is also an important factor. During the outlook period, transport sector demand is expected to decrease by 1.4% per year because of fuel economy improvements for conventional internal combustion engine vehicles, and greater penetration of hybrid vehicles.

Figure 8.4. Final Energy Consumption by Sector, Business as Usual

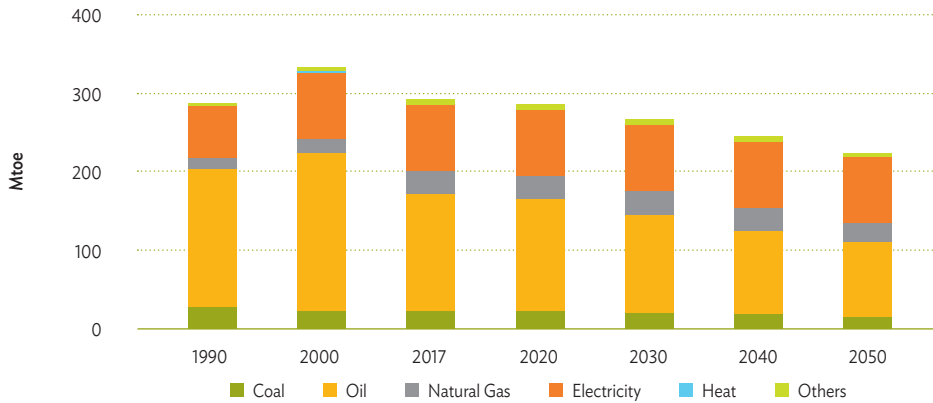


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Energy conservation and electrification will be promoted in the outlook period. By fuel type, fossil fuel consumption is projected to decrease at an average annual rate of 1.4% for coal, 1.4% for oil, and 0.4% for natural gas from 2017 to 2050. On the other hand, the share of oil is expected to reach 42.5% by 2050, making this the largest source of final energy consumption. Power demand is projected to remain steady over this period, while its share will increase from 28.3% in 2017 to 37.4% in 2050. Figure 8.5 shows the projected final energy consumption by source from 1990 to 2050 under BAU.

Figure 8.5. Final Energy Consumption by Source, Business as Usual



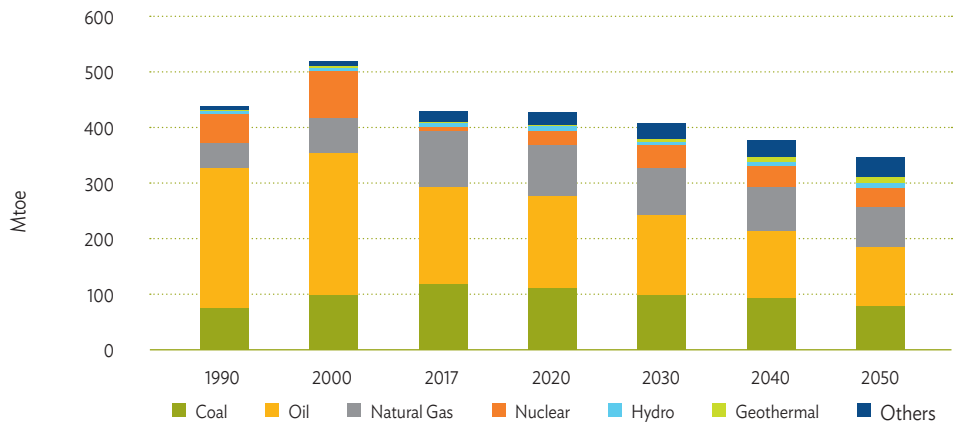
Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.1.2. Primary Energy Supply

From 2017 to 2050 Japan's primary energy demand is projected to decrease by 0.7% per year, on average, under BAU. Oil, the largest primary energy source in 2017, is expected to remain dominant in 2050. However, its share will shrink from 40.7% in 2017 to 30.2% in 2050 because of substitution with other fossil fuels and forms of renewable energy.

Figure 8.6. Primary Energy Supply, Business as Usual



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

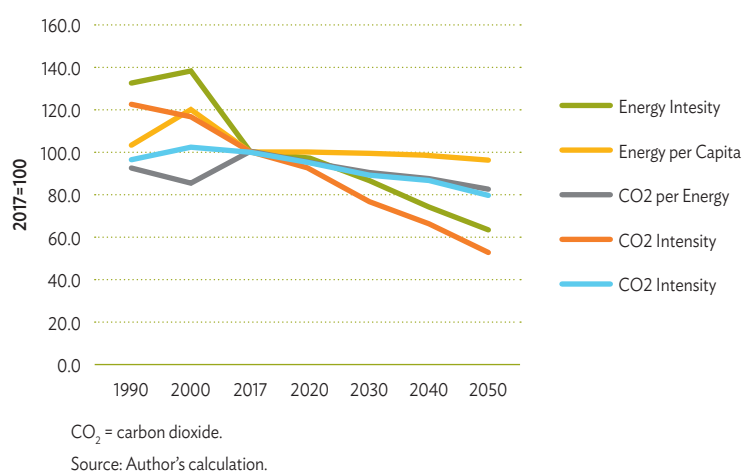
Under BAU, Japan's net primary energy supply is projected to decrease at an average annual rate of 0.7% from 432.0 Mtoe in 2017 to 346.6 Mtoe in 2050 (Figure 8.6). Oil will decrease at a rate of 1.6% per year, driven by energy conservation and fuel substitution in each sector.

On the other hand, nuclear energy will grow at an average annual rate of 4.5% and renewable energy by 1.7%. This energy transformation will contribute significantly to energy security in Japan. The self-sufficiency rate of primary energy will increase from 7.2% in 2017 to 20.8% in 2050.

3.1.3 Energy Indicators

Energy consumption per capita will diminish towards 2050, and energy intensity will drop by 36%. ‘Decoupling’ energy consumption and GDP will be achieved through energy conservation along with modest GDP growth. All energy indicators will decrease from 2017 to 2050, and carbon dioxide (CO₂) intensity (CO₂ emissions per unit of energy consumption) will almost halve. Figure 8.7 shows the evolution of indicators of energy consumption in Japan from 1990 to 2050 under BAU.

Figure 8.7. Indices of Energy and Carbon Dioxide Intensities, Energy per Capita, and Carbonisation Rate, Business as Usual (1990–2050)



3.2. Energy Saving and Carbon Dioxide Reduction Potential

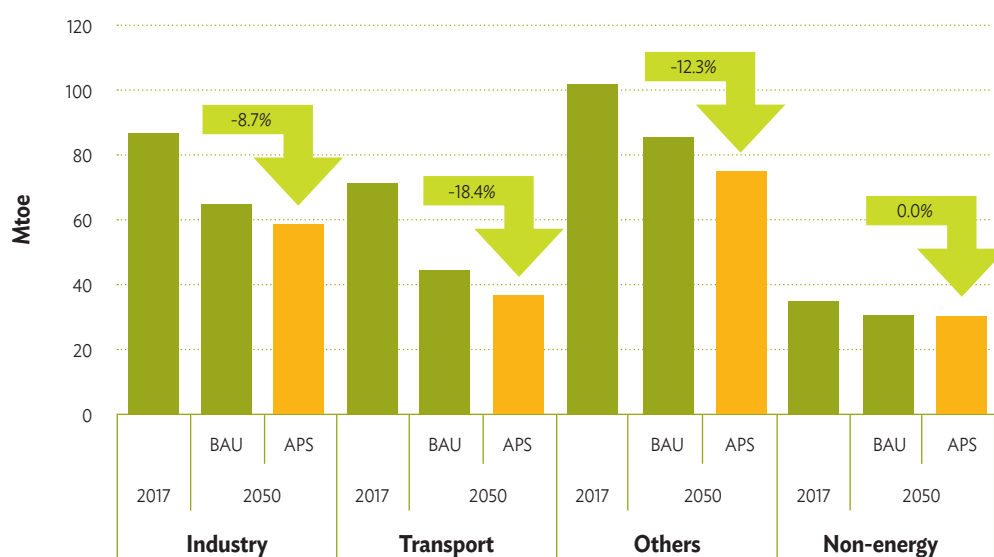
3.2.1. Final Energy Consumption

In the alternative policy scenario (APS), final energy consumption is projected to drop more quickly at 1.1% per year, from 292.8 Mtoe in 2017 to 200.0 Mtoe in 2050. In the APS, total energy consumption in 2050 is 11% less than under BAU. In all demand sectors (i.e. industry, transport, and ‘others’), energy consumption will continue to decrease because of improved energy efficiency. The transport sector in particular will achieve remarkable savings of

2.0% per year due to the Top Runner Programme, greater penetration of electric and hybrid electric vehicles, and more advanced energy management systems. This scenario assumes that Japan will make continuous efforts to improve energy efficiency, especially regarding the penetration of energy-efficient passenger cars.

The industry and services sectors will also make efforts to improve their energy efficiency, although it will be difficult for these sectors to do so drastically because energy efficiency and conservation in those sectors has already been carried out. Figure 8.8 shows the final energy consumption by sector under BAU and in the APS.

Figure 8.8. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario (2017 and 2050)



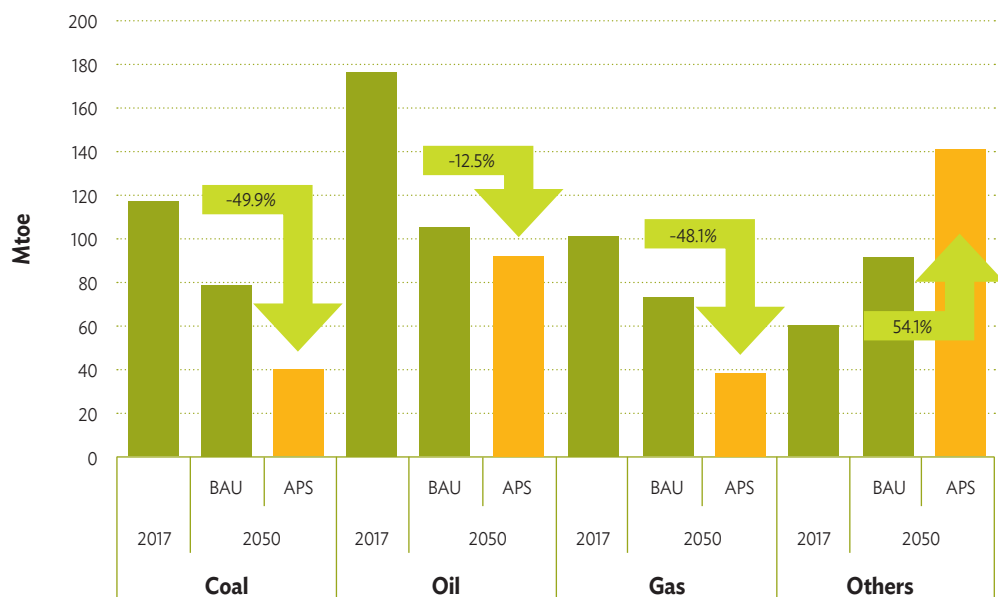
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of energy equivalent.

Source: Author's calculation.

3.2.2. Primary Energy Supply

In the APS, Japan's projected primary energy supply will decline at a rate of 1% per year to 308.7 Mtoe in 2050, 11% less than BAU. Coal and natural gas demands will drop by about half respectively from BAU, because of a substantial transition of power generation towards nuclear and renewable energy. Figure 8.8 shows the primary energy supply by source under BAU and the APS.

Figure 8.9. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario (2017–2050)



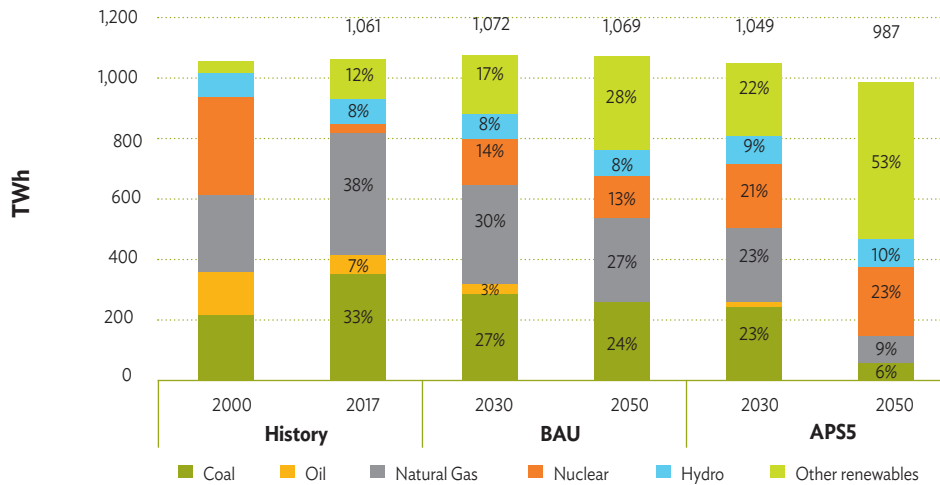
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.3. Power Generation

Under BAU, total power generation in 2050 will roughly equal that in 2017, since the effects of energy conservation and electrification will balance each other. The share of renewables and nuclear power will steadily expand, and zero-emission power will account for 50% of total power generation (Figure 8.10). In the APS, the share of zero-emission power generation will grow to 52% of the energy mix in 2030 and 85% in 2050. This power transition will significantly contribute to CO₂ reduction and energy independence in Japan. On the other hand, many dispatchable power plants will be replaced with non-dispatchable plants, including photovoltaics and wind whose output fluctuates according to weather conditions. This requires greater effort to keep the power demand and supply in balance by using batteries, employing demand responses, and reinforcing the power grid.

Figure 8.10. Power Generation Mix, Business as Usual and the Alternative Policy Scenario (2017–2050)



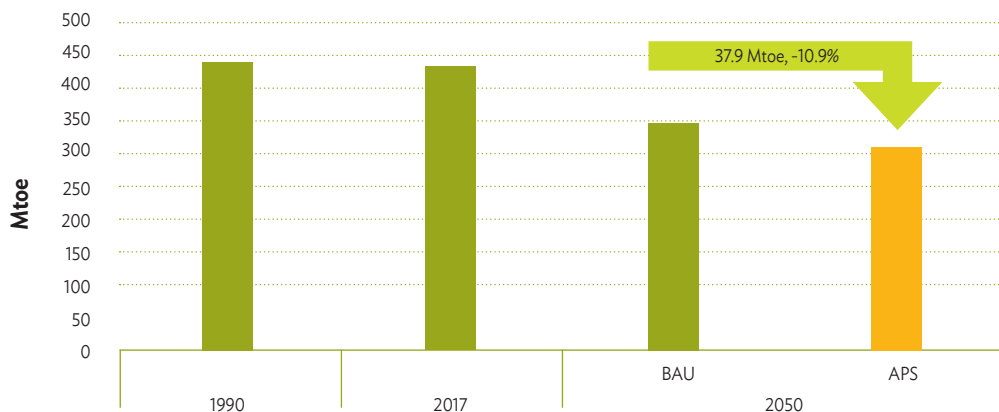
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation.

3.2.4. Projected Energy Savings

Potential energy savings from efforts exerted in each demand sector in Japan amount to 37.94 Mtoe, the difference between the primary energy demand under BAU and that in the APS (Figure 8.11). This is equivalent to a 10.9% decrease in consumption under BAU by 2050. In the APS, estimated savings in final energy consumption will amount to 10.5 Mtoe in the residential and commercial sectors and 8.2 Mtoe in the transport sector by 2050. These sectors will drive energy conservation in the future.

Figure 8.11. Total Energy Consumption, Business as Usual and the Alternative Policy Scenario (1990, 2017, and 2050)



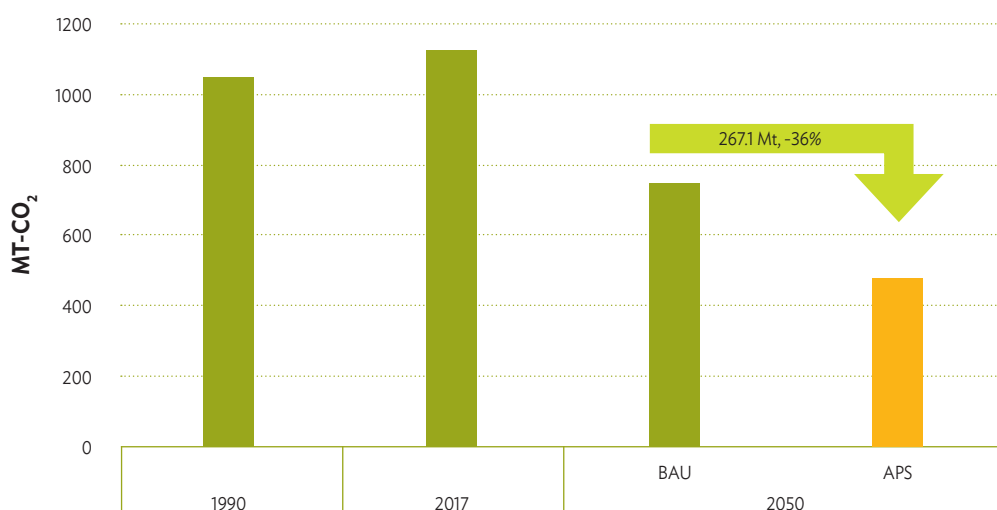
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.5. Carbon Dioxide Emissions from Energy Consumption

Under BAU, CO₂ emissions from energy consumption are projected to decrease by 66% from 1,122.5 million metric tonnes (Mt) of CO₂ in 2017 to 475.1 Mt-CO₂ in 2050. In the APS, a 36% CO₂ reduction from BAU will be achieved and total emissions will decrease to 267.1 Mt-CO₂ by 2050 (Figure 8.12).

Figure 8.12. Carbon Dioxide Emissions from Fossil Fuel Combustion, Business as Usual and the Alternative Policy Scenario



Source: Author's calculation.

4. Japan's Intended Nationally Determined Contributions

Japan's intended nationally determined contribution is to reduce greenhouse gas emissions by 26% from fiscal year 2013 to fiscal year 2030 (1,042 Mt-CO₂ equivalent in 2030). The country's energy-related CO₂ emissions target for 2030 is 927 Mt-CO₂. That target is consistent with the Ministry of Economy, Trade and Industry's Long-Term Energy Supply and Demand Outlook with respect to Japan's quantitative policy target for energy mix by 2030. Under BAU, CO₂ emissions will reach 952 Mt-CO₂ by 2030, surpassing the emissions target by 2.8%. In the APS, emissions will decrease to 851 Mt-CO₂ by 2030, well below the target.

5. Implications and Policy Recommendations

Japan's CO₂ emissions are projected to be much lower by 2030 than in 1990, both under BAU and in the APS. However, to achieve and exceed the 26% reduction target for 2030, Japan could benefit from additional efforts with respect to both energy efficiency and zero-emission energy. To this end, energy efficiency can play a key role in reducing Japan's CO₂ emissions. Japan's primary energy intensity has been declining since 1980, and the country's overall efficiency level is one of the highest in the world. This could be due to enormous improvements in energy efficiencies in both supply- and demand-side technologies developed and implemented in the country. Nonetheless, the APS highlights several ways in which the country might be able to achieve a 1.1% improvement per year for energy consumers in Japan. The transportation sector especially has significant potential for energy conservation through the improvement of internal combustion engines and greater penetration of electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles. The Government of Japan is targeting a 30–40% share in sales for hybrid vehicles and a 20%–30% share for electric vehicles and plug-in hybrid electric vehicles. In 2017, hybrid cars accounted for 31.2% of all cars, while electric vehicles and plug-in hybrid electric vehicles accounted for just 1.5%. This transformation of vehicle types is in progress but is only half completed. Fuel transformation from gasoline to electricity is the next challenge for the transportation sector.

Additionally, renewable and nuclear energy can both play a key role in decarbonising power generation and enhancing energy security, as suggested by findings in the APS. To achieve intensive renewable energy penetration like in the APS, it is necessary to reduce capital costs significantly, invest in grids to cope with fluctuating power from photovoltaics and wind, and implement effective grid rules. As for nuclear energy, advanced safety measures and sufficient communication with local communities concerning the possibility of restarting the plants are required.

Even in the APS, fossil fuels will play a key role in Japan's energy supply for the next 30 years; however, demand will gradually diminish to less than half the 2017 level. Japan is now a major importer of fossil fuel, and energy security is a key factor in its energy policy. Over the next 3 decades, the importance of energy security will not diminish and stabilisation of the fuel supply will be necessary.



CHAPTER 9

Republic of Korea

Country Report

Kyung-Jin Boo

1. Background

The Republic of Korea (henceforth Korea) is located on the southern half of the Korean Peninsula and shares a 238-kilometre (km) border with the Democratic People's Republic of Korea. It covers 100,188 square kilometres (km²) of land and includes about 3,000 islands (mostly small and uninhabited). Korea is a mountainous country in which lowlands account for only 30% of the total land area. The climate is temperate, with heavy rainfall from June to July. As of 2017, Korea had a population of 51.466 million, of whom more than 80% live in urban areas. Beginning in the 1950s, Korea recorded tremendous economic growth, and it was able to overcome both the 1998 Asian financial crisis and 2007–2008 global economic crisis, after which its growth slowed. Korea's economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals.

As Korea has no domestic oil resources and produces only a small amount of anthracite coal and negligible amount of natural gas, it imports most of its coal (which is bituminous coal) and natural gas, as well as all of its oil. Consequently, as of 2017 Korea was the fifth largest oil importer and fourth largest coal importer. It is also the third largest importer of liquefied natural gas in the world.

In 2017, Korea's total primary energy supply was 282.3 million tonnes of oil equivalent (Mtoe), representing a 4.2% annual increase, on average, since 1990. Although oil and coal dominate the primary energy supply, nuclear power and liquefied natural gas also supply a significant share of

the country's primary energy. Between 1990 and 2017, the strongest annual growth occurred in natural gas (10.8%), followed by renewable energy (9.3%), coal (4.5%), nuclear (3.9%), and oil (3.0%).

Total final energy consumption in 2017 was 183.2 Mtoe, increasing at an average annual growth rate (AAGR) of 3.9% from 1990. Industry accounted for 26.4% of final energy consumption in 2017, followed by non-energy (28.7%) and transportation (19.5%). While coal consumption has gradually decreased, final consumption of natural gas grew rapidly at an AAGR of 13.8% between 1990 and 2017.

In 2017, Korea generated 562.7 terawatt-hours of electric power, with coal and nuclear combined providing nearly three-fourths of the country's electricity, followed by natural gas, at 22.4%. Total electricity consumption grew at an AAGR of 6.4% between 1990 and 2017. When broken down by fuel type, coal grew by an AAGR of 10.4%, natural gas by 10.0%, and nuclear by 3.9% between 1990 and 2017. However, over the same period, oil recorded an AAGR of -1.7% and hydropower an AAGR of -3.0%, while other energy sources such as new and renewable energy (NRE) grew rapidly at an AAGR of 43.8%.

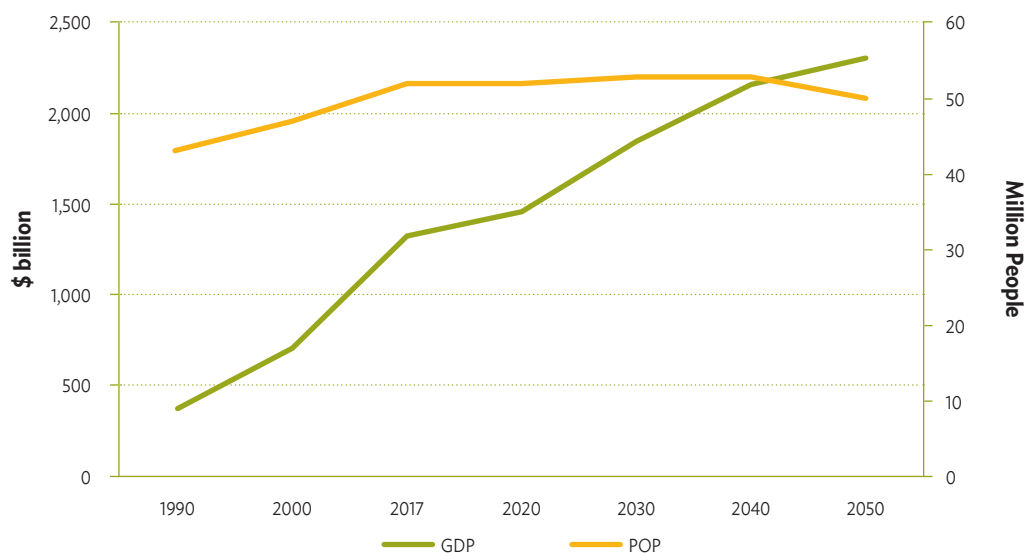
Since the 1990s, the Government of the Republic of Korea has established six basic plans for the rationalisation of energy use; these plans, which are revised every 5 years, contain various policy tools and programmes developed and implemented under the auspices of the Ministry of Trade, Industry and Energy. Several energy saving measures were announced to encourage the general public to conserve energy voluntarily, and voluntary energy conservation campaigns were launched to reduce heating and fuel consumption. The government has also urged energy-intensive industries to enhance the energy efficiency of their products. In addition, the Ministry of Trade, Industry and Energy and the Board of Audit and Inspection of Korea formed a task force to examine 660 public and private organisations to measure their progress in implementing voluntary energy saving plans.

The Fifth Basic Plan for the Rationalization of Energy Use (2013–2017) encompasses various key policy tools and programmes to reach the country's energy savings targets, including voluntary agreements, energy audits, energy service companies, appliance labelling and standards, fuel economies, and public transit and mode shifting. These policy tools have played and 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 2017. This report assumes that Korea's GDP will grow at an AAGR of 1.6% from 2017 to 2050. Although the recent global economic slowdown has somewhat shaken Korea's economy, the economy is still in good shape and its growth is expected to recover to 2.4% per year from 2017 to 2030, before slowing to 1.1% per year from 2030 to 2050.

Figure 9.1. Growth Assumptions for Gross Domestic Product and Population (1990–2050)



GDP = gross domestic product, POP = population.

Source: Author.

Korea is expected to continue to rely heavily on coal and nuclear energy to meet its baseload power generation needs, although overall reliance on nuclear is anticipated to decline steadily by the end of the reference period. Gas-fired power generation is projected to increase from 2017 to 2050, while oil-fired generation is projected to decline. Generation from hydropower sources is projected to remain relatively stable after 2020. Moreover, strong growth is expected in electricity generated from wind power and solar photovoltaics driven by the renewable portfolio standards launched in January 2012. A larger uptake of renewable energy is expected thanks to the recently announced Renewable Energy 3020 Plan and the Energy Transition Policy.

Korea can attain its energy saving goals by implementing energy efficiency improvement programmes in all energy sectors. In the industry sector, the expansion of voluntary

agreements, the highly efficient equipment programme, and the development of alternative energy and improvements in efficient technologies are expected to contribute to energy savings. 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 2010¹.

3. Outlook Results

3.1. Final Energy Consumption

Between 1990 and 2017, Korea's final energy consumption grew at an AAGR of 3.9% per year, from 64.9 Mtoe to 183.2 Mtoe.² The non-energy sector had the highest growth rate during this period at 7.9% per year, followed by the industry sector with 3.5%. Energy consumption in the residential and commercial and public ('others') sector grew at a relatively slow pace of 2.4% per year. Oil was the most consumed fuel, accounting for 67.3% of the energy mix in 1990; this declined to 53.1% in 2017. The share of coal in the final energy consumption declined by 13.4 percentage points between 1990 and 2017, whereas the share of electricity almost doubled, making it the second-largest consumed fuel.

Business as Usual Scenario

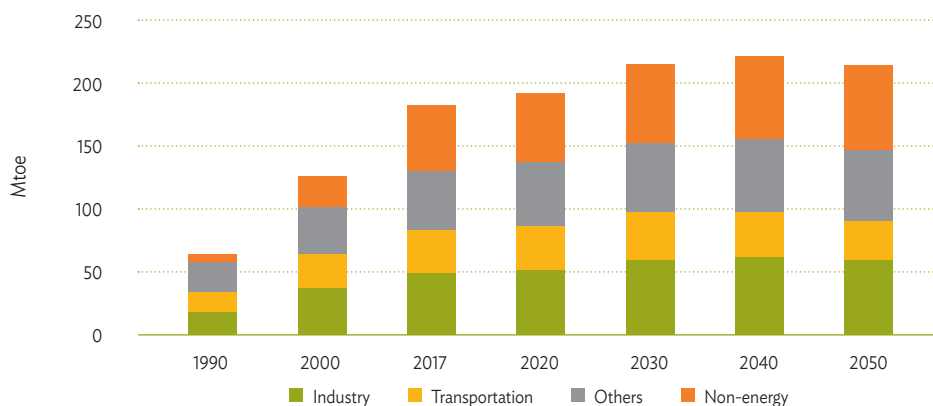
Assuming low economic and population growth, final energy consumption in Korea is projected to reach 215.8 Mtoe by 2050, increasing at a low average rate of 0.5% a year from 2017 to 2050 under business as usual (BAU). This is largely due to the negative growth in energy consumption in the transport sector, which is projected to decrease at an AAGR of -0.4% between 2017 and 2050. Annual growth in final energy consumption up to 2030 is expected to be led by the industry sector (at 1.5%) and non-energy sector (1.3%).

The non-energy sector will then take the lead at an AAGR of 0.5% up to 2050. Nevertheless, all sectors are expected to slow or show a negative AAGR.

¹ In 2010, the Korea Energy Agency introduced the e-Standby Korea programme, a voluntary agreement urging manufacturers to minimise standby power and select sleep mode during standby.

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

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

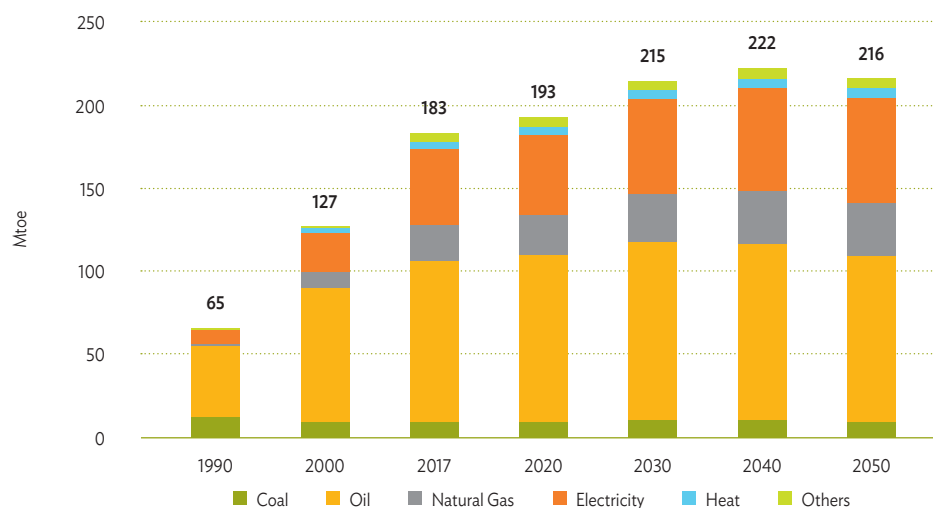


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is expected to follow energy consumption by sector. The AAGR is expected to be 0.3% for coal, 0.1% for oil, 1.1% for natural gas, 1.0% for electricity, and 0.4% for heat from 2017 to 2050. Coal consumption is expected to peak around 2040 and oil around 2030, before gradually decreasing, to show negative growth. Heat energy consumption is anticipated to follow the same pattern as oil because of the expected decrease in population as well as changing lifestyles, leading to a tendency to use more electricity for heating. The decrease in oil consumption is more likely due to slowing energy consumption in the transport sector caused by the increased deployment of electric vehicles. Other energy types, including NRE and natural gas, will increase, and clean and green energy will help reduce CO₂ emissions considerably.

Figure 9.3. Final Energy Consumption by Energy, Business as Usual (1990–2050)



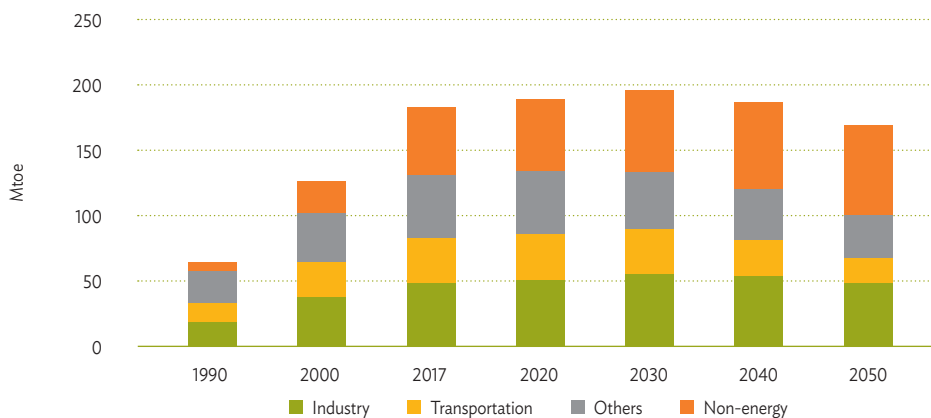
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Alternative Policy Scenario

This section discusses the alternative policy scenario (APS) based on a combination of policy options: (i) improved efficiency of final energy consumption, (ii) more efficient thermal power generation, (iii) a higher contribution of renewable energy to the total supply, and (iv) the contribution of nuclear energy to the total supply. Total final energy consumption in the APS is expected to decrease by 7.5% from 183.2 Mtoe in 2017 to 169.4 Mtoe in 2050, yielding an AAGR of -0.2% . Figure 9.4 shows final energy consumption by sector in the APS. The transport sector shows the fastest decrease at -1.7% per year, followed by 'others' at -1.1% per year. The share of final energy consumption by sector shows a structural change from 2017. The shares of the transport and 'others' sectors are forecasted to decrease, while that of the non-energy sector will increase more quickly, reaching 40.5% in 2050.

Figure 9.4. Final Energy Consumption by Sector, Alternative Policy Scenario (1990–2050)

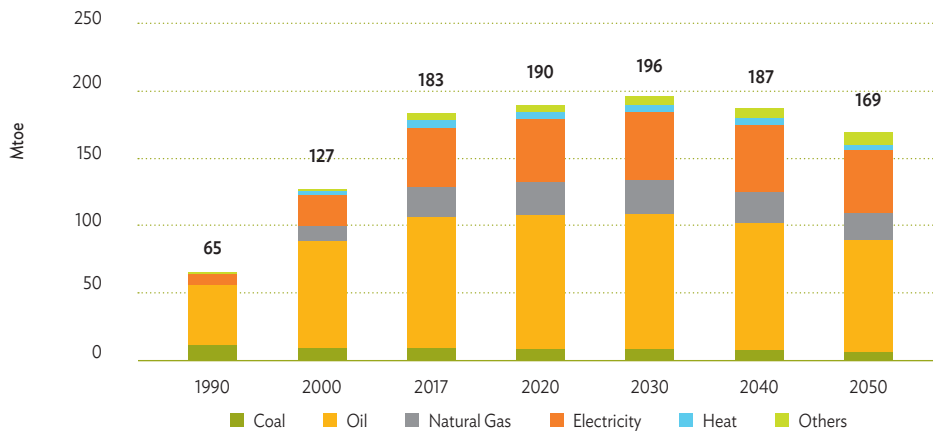


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is shown in Figure 9.5. Oil is expected to dominate the energy mix, accounting for 46.4% of its share, followed by electricity at 27.6% and natural gas at 11.8%. Coal will be marginalised as a minor energy source for industrial as well as residential and commercial use.

Figure 9.5. Final Energy Consumption by Energy, Alternative Policy Scenario (1990–2050)

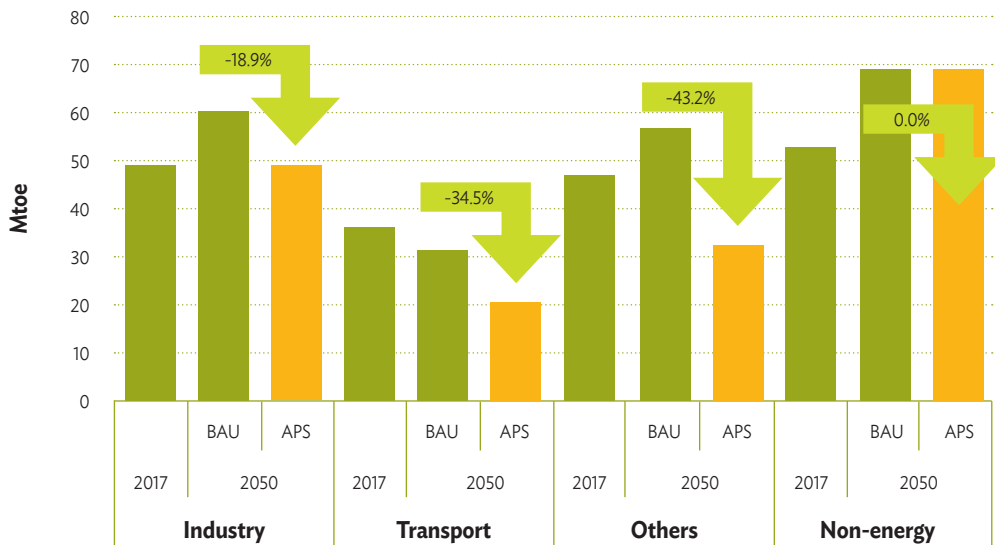


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 9.6 shows the final energy consumption by sector under BAU versus the APS in 2050. Under BAU, energy demand is projected to increase by 18% from 2017 to 2050, with the industry and 'others' (residential and commercial) sectors driving this growth. In the APS, 46.4 Mtoe (21.5%) will be saved compared to BAU by 2050; most of these savings will come from the 'others' and transport sectors. Rates of reduction will be –43.2% in the 'others' sector, –34.5% in the transport sector, and –18.9% in the industry sector, whereas almost no change will take place in the non-energy sector.

Figure 9.6. Final Energy Consumption by Sector, Business as Usual versus the Alternative Policy Scenario (2017 and 2050)

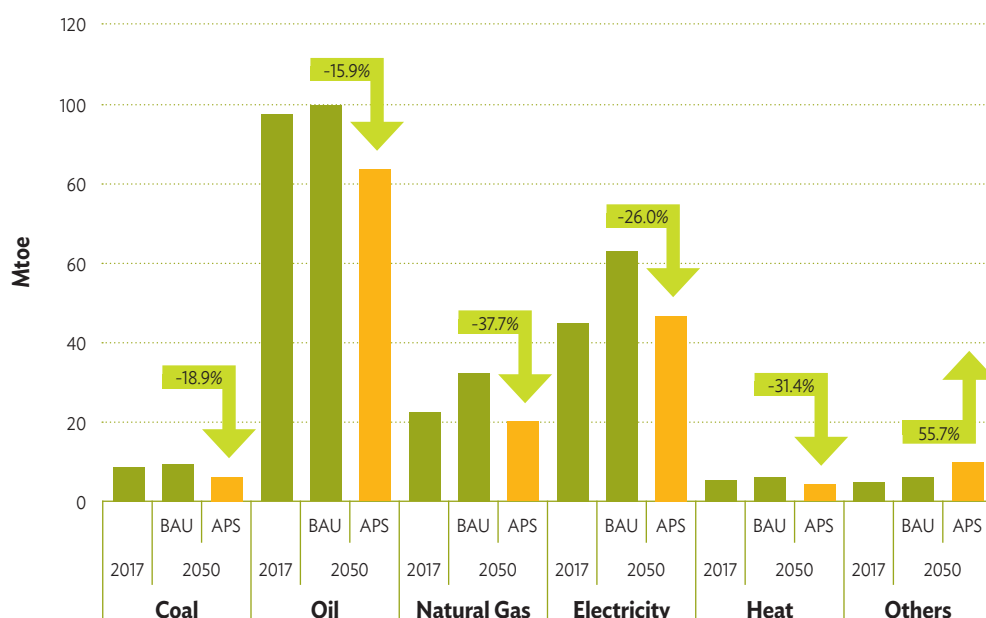


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy is shown in Figure 9.5. Under BAU, the oil share is projected to stay around 50%, remaining dominant in final energy consumption. In the APS, oil accounts for 15.9 Mtoe of energy savings, the largest share, followed by electricity (16.4 Mtoe) and natural gas (12.1 Mtoe). Most energy savings will come from these three major energy types, which will account for 95.7% of total energy saved. In the APS, improved energy efficiency in the ‘other’ sectors (residential, commercial, and public) is responsible for a considerable share of the savings in natural gas and electricity.

Figure 9.7. Final Energy Consumption by Energy, Business as Usual versus the Alternative Policy Scenario (2017 and 2050)



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

Source: Author's calculation.

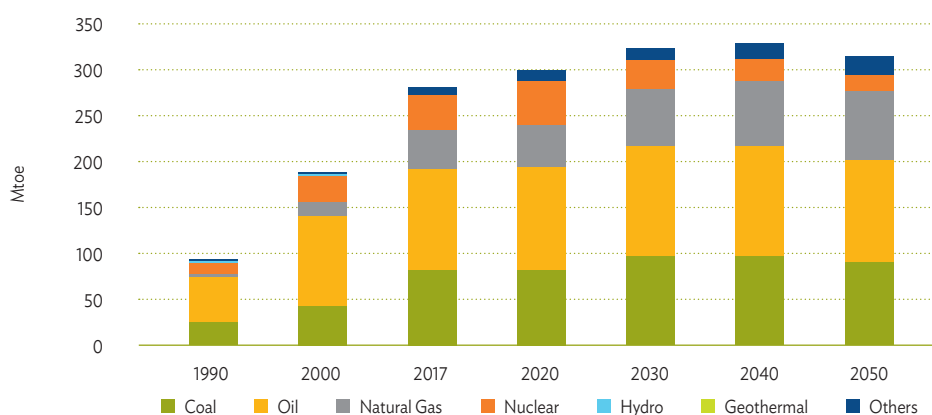
3.2. Primary Energy Demand

Primary energy demand in Korea increased at an AAGR of 4.2%, from 92.9 Mtoe in 1990 to 282.3 Mtoe in 2017. Among the major energy sources, natural gas grew the fastest at an average annual rate of 10.8%, followed by coal at 4.5%, oil at 3.0%, and nuclear at 3.9% over the same period. Although starting from a notably lower base, other energy sources—mainly renewable energy such as solar, wind, biomass, and ocean energy—grew rapidly at a rate of 9.6% over the same period. This indicates that the government has been successfully implementing the Low Carbon, Green Growth and Energy New Industry policies initiated by previous administrations.

Business as Usual Scenario

Under BAU, the primary energy demand in Korea is projected to increase at an AAGR of 0.3%, from 282.3 Mtoe in 2017 to 315.7 Mtoe in 2050. The relative pace of new growth in all energy sources is projected to slow, compared with 1990–2017. Consumption of natural gas grew the fastest at a rate of 1.7% per year, while coal (0.3%) and oil (0.0%) grew much more slowly from 2017 to 2050. The growth in natural gas will largely be at the expense of nuclear, which is projected to decline from 13.7% in 2017 to 5.5% in 2050.

Figure 9.8. Primary Energy Supply by Energy, Business as Usual (1990–2050)



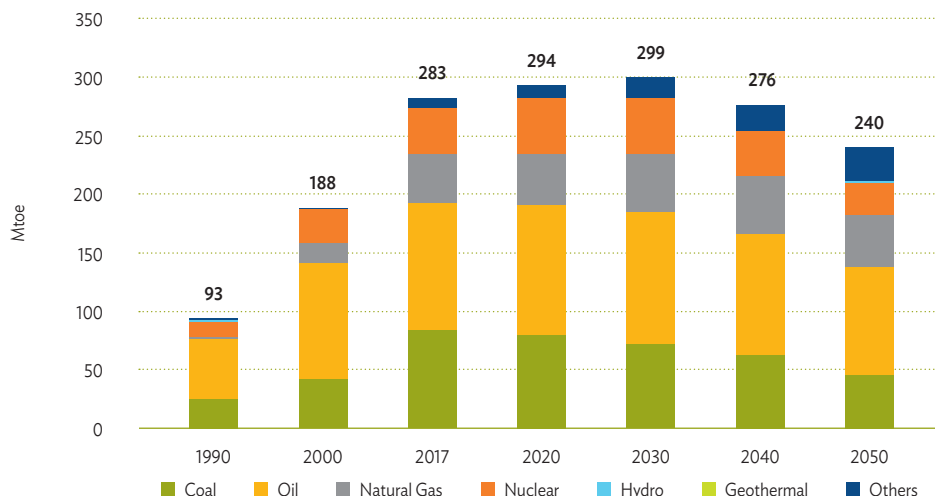
Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Alternative Policy Scenario

In the APS, the primary energy supply is projected to decrease at an AAGR of -0.4% , from 282.3 Mtoe in 2017 to 239.0 Mtoe in 2050. Consumption of coal, oil, and nuclear will gradually decrease from 2017 to 2050, whereas that of hydropower will increase by 0.6% and 'others' (NRE) by 3.7% per year (Figure 9.9). The 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 main contributors to the reduced consumption of fossil fuels and nuclear energy.

Figure 9.9. Total Primary Energy Supply: Alternative Policy Scenario (2017–2050)



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Projected Energy Savings

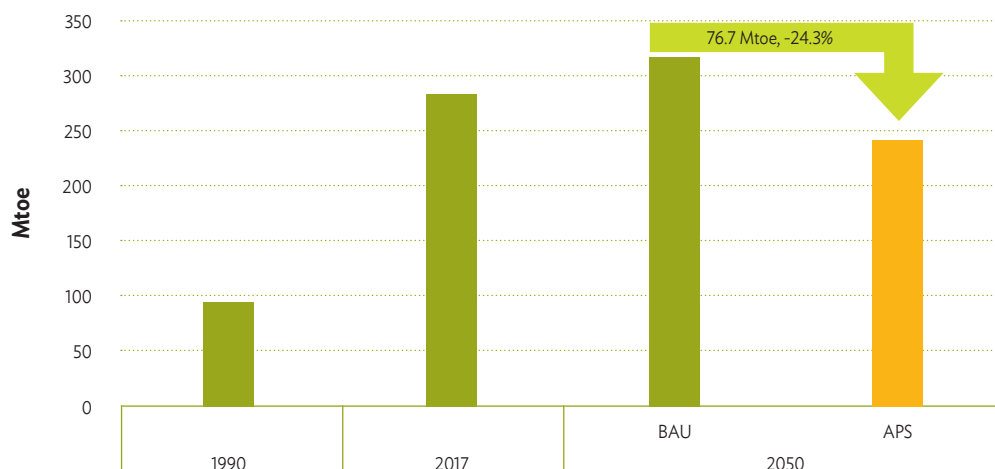
Major energy policy approaches to reduce the energy demand in Korea are as follows:

- (i) Energy policy should be shifted from a supply-oriented approach to a demand-oriented one. The most pressing issue is reform in energy pricing and energy taxation. In this context, market mechanisms should be introduced in energy pricing to induce rational energy use by sharing information on the full cost of energy production and consumption.
- (ii) The transformation of the industrial structure to be less energy-intensive, currently underway, should be accelerated towards knowledge-based, service, and green industries that consume less and clean energy.
- (iii) Energy efficiency standards and codes should be applied in the product design and production process, as well as in designing and constructing systems such as factories, buildings, and plants. Under these policy directions, the government should develop and implement an action plan containing milestones and strategies with specific and cost-effective policy tools.

The energy saving targets, action plans, and policy tools mentioned in the previous paragraph could yield energy savings of 76.7 Mtoe by 2050, the difference between the primary energy supply under BAU and in the APS (Figure 9.10). This is equivalent to a –24.3% reduction from 2017. Figure 9.11 shows the energy saving potential by energy source. Of all the energy sources, coal has the largest potential reduction in energy demand (–50.0%), followed by

natural gas (–42.6%) and oil (–16.9%). In contrast, other energy sources, primarily renewable energy, will increase by 55.9% over BAU.

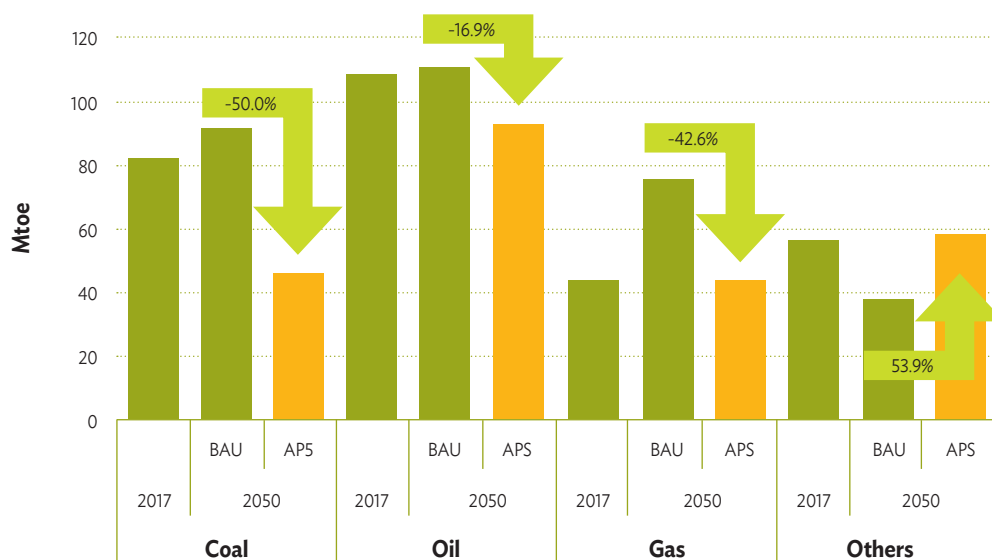
Figure 9.10. Total Primary Energy Supply, Business as Usual and the Alternative Policy Scenario (2017 and 2050)



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

Source: Author's calculation.

Figure 9.11. Primary Energy Supply by Source, Business as Usual versus the Alternative Policy Scenario

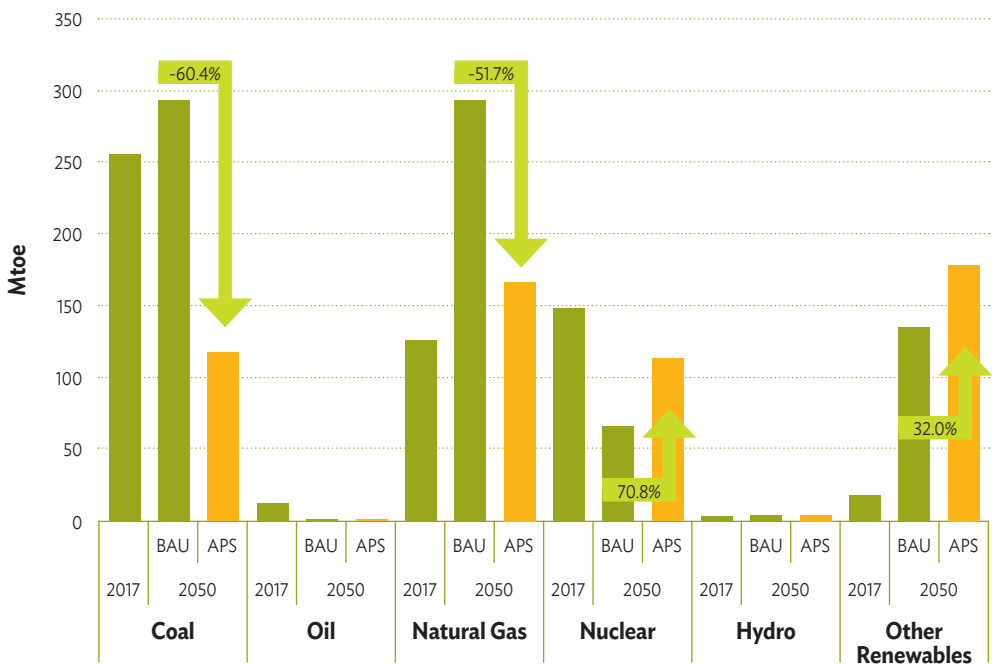


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 9.12 shows power generation under BAU and in the APS. Under BAU, gas-fired power generation will more than double from 2017 to 2050, only slightly behind coal-fired power as the largest source of generated power. In the APS, zero-emission power sources such as nuclear, hydropower, and other renewables will account for half of power generation, while input from fossil fuels in power generation will also decline to less than half that under BAU, contributing to a comparative reduction in CO2 emissions.

Figure 9.12. Power Generation by Source, Business as Usual versus the Alternative Policy Scenario

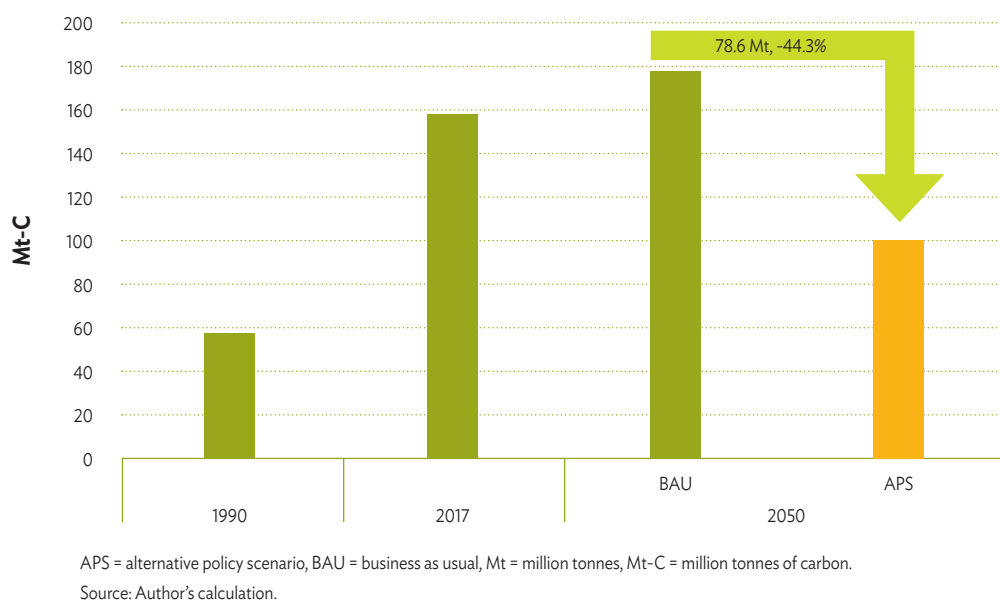


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
Source: Author’s calculation.

3.3. Carbon Dioxide Emissions from Energy Consumption

CO2 emissions from energy consumption are projected to increase at an AAGR of 0.4%, from 158.0 million tonnes of carbon (Mt-C) in 2017 to 177.6 Mt-C in 2050 based on BAU. This growth rate is roughly on par with that of the primary energy supply. In the APS, CO2 emissions are projected to decline at an AAGR of –1.4% between 2017 and 2050. The difference in CO2 emissions between BAU and the APS is 78.6 Mt-C or –44.3% (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 CO2 emissions.

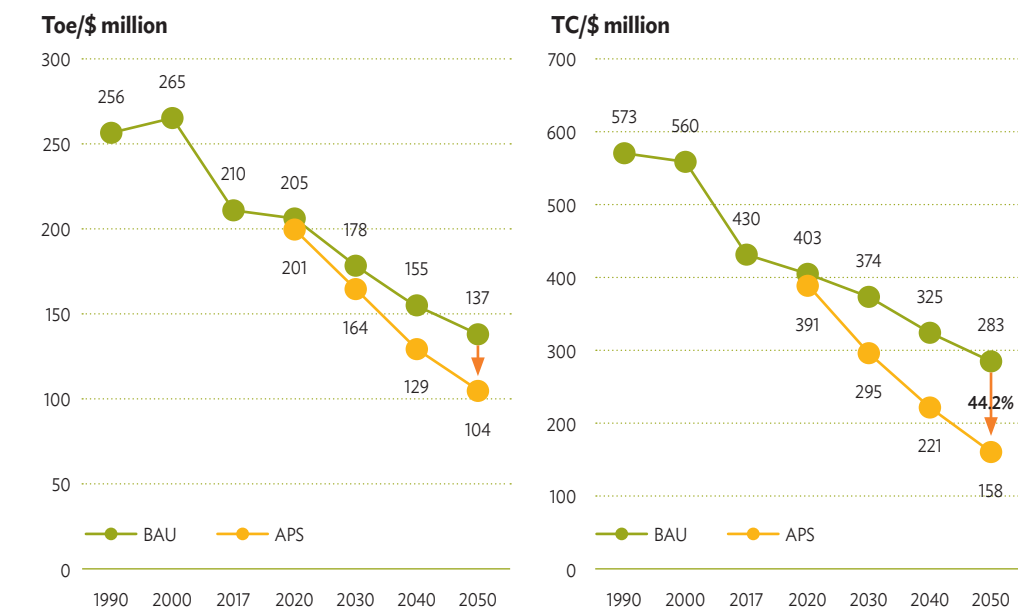
Figure 9.13. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenario (2015 and 2040)



3.4. Energy and Carbon Intensity

As a result of energy savings, the country's energy intensity of GDP is projected to improve (Figure 9.14). Under BAU, energy consumption per unit of GDP (tonnes of oil equivalent per million dollars [toe/\$ million]) is projected to decline from 210 toe/\$ million in 2017 to 137 toe/\$ million in 2050, a 3.2% improvement. In the APS, this accelerated to 63.3%. Energy intensity in the APS is 24.1% below BAU. Carbon intensity is also projected to improve both under BAU and in the APS, mainly because of the reduction in the primary energy supply in terms of energy intensity, which will be accelerated by the aggressive introduction of low-carbon energy sources and technologies along with energy efficiency technologies. Improvement in carbon intensity, that is, CO₂ emissions per unit of GDP (tonnes of carbon per million dollars [t-C/\$ million]), is more salient than improvement in energy intensity. It is projected to decline from 117 t-C/\$ million to 77 t-C/\$ million under BAU (a 34.2% decrease) and 43 t-C/\$ million in the APS (a 63.2% decrease). Carbon intensity in the APS is 42.9% less than under BAU.

Figure 9.14. Energy and Carbon Intensities (1990–2040)



APS = alternative policy scenario, BAU = business as usual, TC = tonnes of carbon, Toe = tonnes of oil equivalent.

Source: Author's calculation.

4. Implications and Policy Recommendations

Given its limited economically viable domestic fossil fuel resources, Korea has been importing 98% of its required fossil fuel supplies. Thus, Korea's top energy policy agenda is the maintenance of a stable energy supply to sustain its economy. However, at the beginning of the 21st century, the government shifted its energy policy to a sustainable, efficient, and energy-saving approach, which has been fully outlined in the First (2009), Second (2014), and most recently, Third (2019) Energy Basic Plan.

In the 1990s, Korea's total primary and final energy consumption increased faster than GDP, the growth of which was driven by energy-intensive industries such as the petrochemical, steel, and cement industries. Since 1997, the contribution of these industries to Korea's GDP has gradually declined, resulting in reduced energy intensity. However, as it will take time to shift to a less energy-intensive industrial structure, energy-intensive industries will prevail in the short to medium term. However, Korea will and must transform its industrial structure into a less energy-intensive one in the longer term.

The Second National Energy Basic Plan released in 2014 was the first full-scale energy basic plan with a feasible target and action plan, and set the policy approach of completely shifting

the industrial structure from a supply orientation to a demand orientation. Its basic policy direction consists of six major agendas prioritising demand-oriented energy policy. Five other key agendas include building a distributed generation system, harmonising the environment and safety, strengthening energy security and stabilising the energy supply, and implementing energy policy with public support.

Another policy agenda uses an environmental approach, namely, setting a target for reduced greenhouse gas emissions in response to global climate change. The government announced an ambitious, aggressive target to reduce its greenhouse gas emissions by 37% from BAU (850.6 million tonnes of CO₂) by 2030 across all economic sectors. Domestic activities will meet 25.7% of this target, and the emissions trade in the international market will account for the remaining 11.3%. This is a proactive response to and fulfilment of its international responsibility for the new climate regime established as a follow-up action to the Paris Agreement in December 2015.

Since the 1990s, the government has mostly been concerned with energy security, energy efficiency, and environmental preservation. It had addressed energy security by promoting the import of foreign resources and renewable energy development. It has improved energy efficiency through programmes supported by a series of 5-year basic plans for the rationalisation of energy use. Relevant offices in the Ministry of Environment have tackled the environmental issues caused by the consumption of fossil fuels and nuclear energy. Now is the time for Korea to synergise the efforts exerted so far by selecting and concentrating policy tools and programmes through coordination among relevant ministries, as clearly specified in the Second National Energy Basic Plan.

In 2017, the new government led by President Moon Jae-In proposed reforms to the current energy policy, and announced a new energy policy direction, 'energy transition', which has completely reframed the existing national energy policy. Energy transition rests on two major energy policy agendas: (i) the step-wise reduction of nuclear power plants and coal-fired plants ('de-nuclearisation' and 'de-coalisation' policies), and (ii) the expansion of renewable energy to 20% of the energy mix by 2030 (Renewable Energy 3020 Plan). These policy agendas will be reflected in the Eighth Electricity Demand and Supply Basic Plan and the Third National Energy Basic Plan.

The basic spirit of the energy transition policy direction was fully reflected in the Third Energy Basic Plan, which establishes a national energy blueprint up to the year 2040. This plan builds on the idea of a sustainable energy system stipulated in the First and Second

Energy Basic Plans, while also focusing on the innovative transition of the overall energy system from the supply side to the demand side. In this context, the Third Energy Basic Plan sets the goal of achieving sustainable growth and enhancing quality of life through energy transition.

The Third Energy Basic Plan proposes two strategic goals: (i) transition of the energy supply, consumption, and industry; and (ii) a foundation for energy transition. Under these goals, five basic policy directions are suggested: (i) innovation in the energy consumption structure, (ii) a transition towards a safe and green energy mix, (iii) the expansion of a distributed and participatory energy system, (iv) strengthened global competitiveness of the energy industry, and (v) better infrastructure and market systems for energy transition.

Meanwhile, the government recently announced the Green New Deal, an upgraded version of the previous Low-Carbon, Green Growth plan. Under this new plan, government has pledged to reach zero emissions by 2050 and to pass legislation to support this goal, which will facilitate the country's transition from a high-carbon economy to a low-carbon one. Along with this new initiative, the Third Energy Basic Plan, Renewable Energy 3020, and the Hydrogen Economy Roadmap (2019) have been established to ensure the successful implementation of energy transition.

If successfully implemented, energy transition through the Third Energy Basic Plan and Green New Deal initiatives will result in a complete turnaround from the traditional energy system based on coal and nuclear power to a sustainable energy system based on renewable energy and gas-fired power generation. However, this change in the energy mix does not necessarily 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. 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.

The impacts and implications of this energy mix reform remain to be seen. Such reform calls for a vast amount of investment in rebuilding infrastructure, hardware, and software, along with a complete institutional rearrangement. It also entails a change not only in the energy sector per se but also in the cultural, political, and social domains. Having successfully effected two energy transitions in the past, the Korean government is highly confident in going ahead with its current policy goals of transitioning to a less energy-intensive, greener economic structure; and implementing major policy agendas and their corresponding policy tools and programmes. Such nationwide efforts and campaigns would eventually make the

Korean economy less energy-intensive and greener in terms of energy savings and reduced CO₂ emissions. Moreover, such an achievement will position Korea as a leading nation globally in terms of low-carbon green growth and energy transition.

CHAPTER 10

The Lao People's Democratic Republic Country Report

Phaysone Phouthonesy

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. The Lao PDR has a total area of 236,800 square kilometres, about 70% of which is covered by mountains; and a population of 7,013,000 as of 2018. The average population density is 27 persons per square kilometre. The Lao PDR comprises 18 provinces, and Vientiane is the capital.

Since 1986 when the Lao PDR changed its economic policy to an open-door policy, the economy has been progressing and expanding rapidly. The gross domestic product (GDP) in 2018 increased 6.29% from the previous year, to KN7,274 billion in 2012 constant prices (equivalent to \$14,713 million), bringing per capita income to \$2,098¹. The economy has been changing gradually from agriculture-oriented activities to a wider range of activities, such as services and industry. For example, in 2018, the service sector accounted for 41.61% of GDP, while agriculture only accounted for 15.71%. Industry accounted for 31.53%, and its share is expected to expand in the coming years due to large investments in the mineral and hydropower sectors.

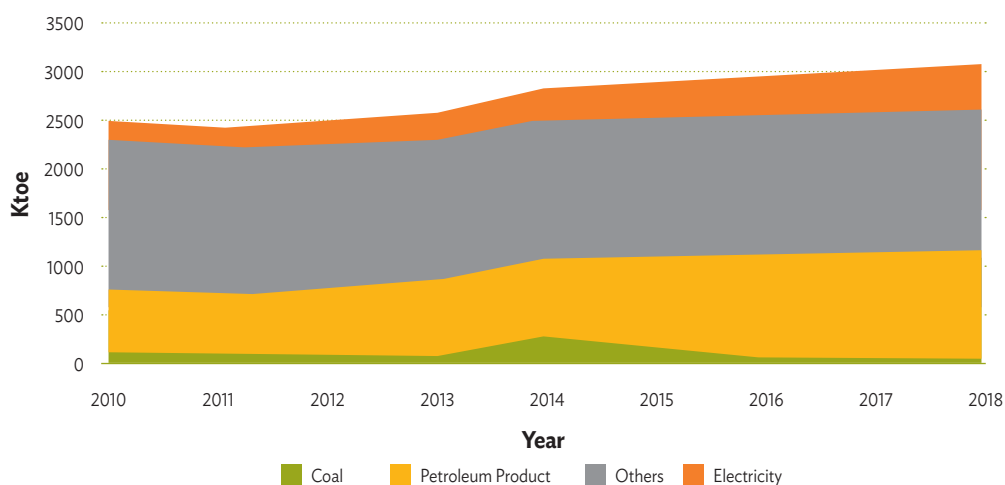
¹ Lao Statistics Bureau. www.lsb.gov.la

1.2 Energy Supply–Demand Situation

The 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 the Lao PDR receives a significant amount of hard currencies from those power exports. This is widely considered to be one of the driving forces to boost socioeconomic development and energy security in the country.

The Lao PDR's total final energy consumption (TFEC) grew by 2.7% from 2010 to 2018 (Figure 10.1). Electricity grew the fastest at 10.5% per year, followed by petroleum products at 7.3%. Biomass consumption, which has the highest share in the TFEC, decreased at an average rate of 0.76% per year. A small amount of coal consumption was noted in the industry sector.

Figure 10.1. Total Final Energy Consumption by Sector



Ktoe = kilotonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table (EBT) Collection... Historical. 24 July.

Source: Author's calculation.

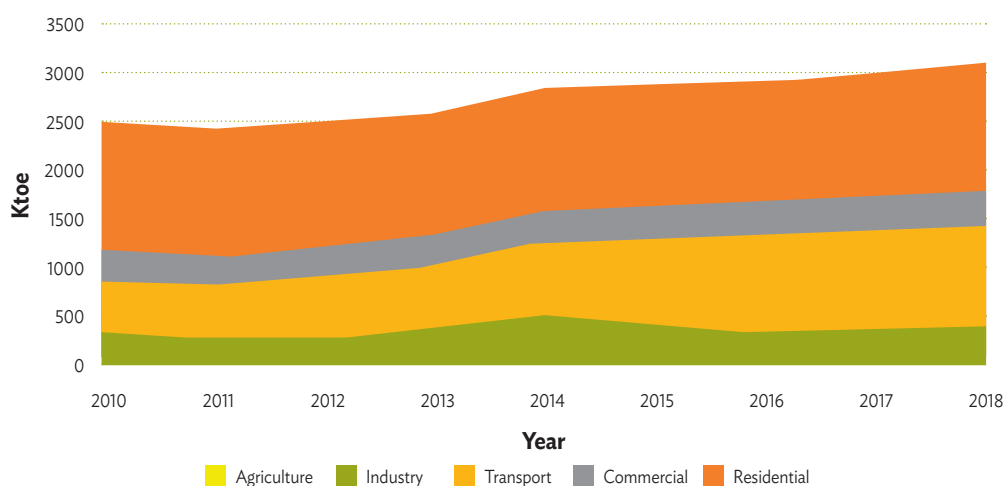
The residential sector is a major consumer of biomass. The industry and commercial sectors consume biomass but at a lower rate than the residential sector, which dominates the country's consumption. However, its share declined from 60.8% in 2010 to 46.1% in 2018, indicating the replacement of household biomass consumption with that of liquefied petroleum gas (LPG) and greater use of efficient biomass stoves in rural areas.

In 2018, the transport sector had the second largest share (33%) in the TFEC, but its consumption increased the fastest from 2010 to 2018, at an average rate of 9.9% per year.

This increase was mainly driven by the road transport sector given the rapid growth in the number of motor vehicles. Based on licensed vehicle statistics, the total number of vehicles increased by an average of 10% per year from 2010 to 2016.

Industry accounted for around 14% of the TFEC, while the commercial sector accounted for around 12%. The industrial sector's consumption grew at an average annual rate of 2.0%, while that of the commercial sector grew at a rate of 1.8% (Figure 10.2).

Figure 10.2. Total Final Energy Consumption by Sector



Ktoe = kilotonnes of oil equivalent.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table (EBT) Collection_Historical. 24 July.

Source: Author's calculation

In 2018, the Lao PDR's total primary energy supply (TPES) was 6.38 million tonnes of oil equivalent (Mtoe), and the energy mix consisted of hydropower, oil, coal, and biomass. As there were many power plants in the Lao PDR generating electricity for export in 2018, the export figure reached 26,708 gigawatt-hours (GWh), the equivalent of 2.65 Mtoe. This amounted to more than half of all electricity consumed in the country and 77% of total hydropower generation. Biomass remained an important energy and was the most consumed energy type in the country. 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 can be obtained everywhere free of charge. In 2018, 1.4 Mtoe of biomass was used, representing 22.7% of the TPES. Consumption of oil products was the second highest after biomass. As the Lao PDR has not yet finished constructing its oil refinery, all oil product demand in the country is met by imports from Thailand and Viet Nam. In 2018, the Lao PDR imported 1.13 Mtoe of oil products to supply the demand from the transport sector and others. In the same year, the 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, the Lao PDR is rich in hydropower resources. According to the Mekong River Commission Study in 1995, the 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 has been realised. In 2020 the 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.² Power exports are projected to increase sharply because the Government of the Lao PDR has agreed to export 7,000 MW to Thailand and 5,000 MW to Viet Nam from 2020 to 2030. Exported power is mainly generated from hydropower; however, the Hongsa plant has 1,878 MW of installed capacity to generate electricity for export, and exported 95% of its generated electricity in 2018.

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, in the long term it will increase because the government plans to assume ownership of private power plants. The electrification rate in the Lao PDR was 93.79% in 2018,³ and the government is striving to raise this to 98.00% by 2025. This plan is part of the government's strategy to eradicate poverty in the country. Considering the increasing demand for electricity in the 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 in particular has been gaining 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 among ASEAN members can be credited for this improvement.

Although the Lao PDR is landlocked, it is located in the middle of the Mekong subregion and

² Department of Energy Policy and Planning (2020), Summary of Power Generation Project of Lao PDR. Vientiane.

³ Department of Energy Policy and Planning (2018), Electricity Statistics Yearbook.

is surrounded by three large economies—China, Thailand, and Viet Nam—and two medium economies—Myanmar and Cambodia. As a result, the Lao PDR can promote 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 high energy demand in these countries can support the energy trade and power integration in the region to boost energy security and sustainable development in the region. The Lao PDR has been trading electricity with Thailand for many decades and has now expanded this policy to other neighbouring countries to support regional energy cooperation. Specifically, the Lao PDR will increase power exports to 15,000 MW by 2030, including 10,000 MW to Thailand and 5,000 MW to Viet Nam, Cambodia, and Myanmar.

According to the Ninth Five-Year Energy and Mines Development Plan 5 (2021–2025), the Ministry of Energy and Mines has set the following six goals for the power sector:

- (i) increase power supply efficiency by 65% for hydropower, 30% for thermal power plants, and 5% 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; and
- (vi) promote energy savings and conservation by reducing energy consumption by 10% by 2030.

2. Modelling Assumption

This study aims to forecast energy supply and demand in the Lao PDR from 2018 to 2050, and to determine the country's potential for energy savings and carbon dioxide (CO₂) emission reduction, improved energy efficiency, and feasible renewable development if the Lao PDR uses or implements certain alternative policy scenarios (APSs). Therefore, this study considers five scenarios: business as usual (BAU), APS 1, APS 2, APS 3, and APS 5, described below.⁴

- (i) BAU is calculated based on the assumed growth of GDP, population, and oil prices.
- (ii) In APS 1, the Lao PDR will implement energy saving and conservation programmes, reducing energy consumption by 10% during the study period (2018–2030) and 10% from 2030 to 2050.
- (iii) In APS 2, the Lao PDR will make thermal power generation more efficient, increasing

⁴ The APS 4, which promotes nuclear power generation, is omitted because there is no nuclear power plan.

thermal efficiency by 30% by 2030 and 32% by 2050.

(iv) APS 3 involves a higher contribution of renewable energy to the total supply.

(v) APS 5 combines APS 1, APS 2, and APS 3 into a single scenario.

Table 10.1. Assumption of Annual Average Growth of Gross Domestic Product and Population

Projection period	GDP growth	Population growth
2018–2020	7.1%	1.5%
2020–2030	6.4%	
2030–2050	5.7%	

Source: World Bank, World Development Indicators

3. Outlook Results

3.1 Business as Usual Scenario

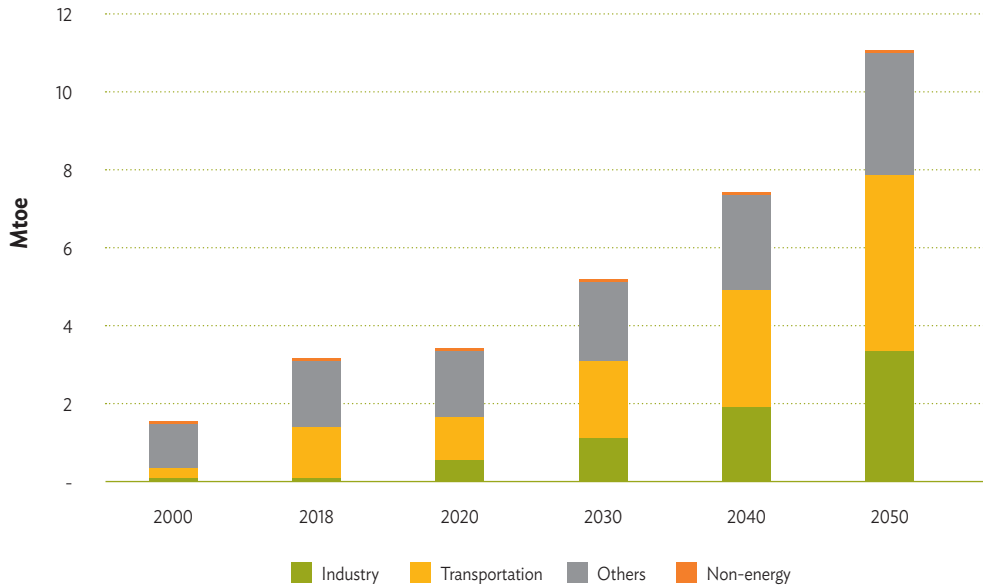
3.1.1 Final Energy Consumption

In the Lao PDR, the final energy mix comprises coal, oil, electricity, and ‘others’. The country’s TFEC increased from 1.51 Mtoe in 2000 to 3.09 Mtoe in 2018, an AAGR of 4.1%. This growth will continue at a rate of 4.9% in 2018–2020, 4.1% in 2020–2030, 3.8% in 2030–2040, and 4.1% in 2040–2050. From 2018 to 2050, this growth will increase at a constant rate of 4.0% per year.

With respect to final energy consumption by sector, like other Southeast Asian countries, the four main energy-using sectors in the Lao PDR are industry, transport, others, and non-energy. ‘Others’ covers subsectors such as residential, agriculture, services, and commerce. During 2000–2018, the industry sector grew the fastest, at a rate of 9.5% per year, followed by the transport sector at 8.0% per year, and the ‘others’ sector at 1.9% per year. Industry’s high growth rate is expected to continue from 2018 to 2050, that of the transport sector at 4.8%, and that of ‘others’ at 2.0%.

In terms of energy types, ‘others’ (biomass, consisting of wood and charcoal) was the most frequently used in 2018, reaching 1.42 Mtoe, 46.1% of the TFEC. This is expected to decrease to 15.6% by 2050. Oil will become dominant in 2030–2050 and electricity will come second during 2040–2050. From 2000 to 2018, ‘others’ (including biomass) is expected to remain dominant from 2018 to 2050 in the Lao PDR because the majority of Lao people still live in

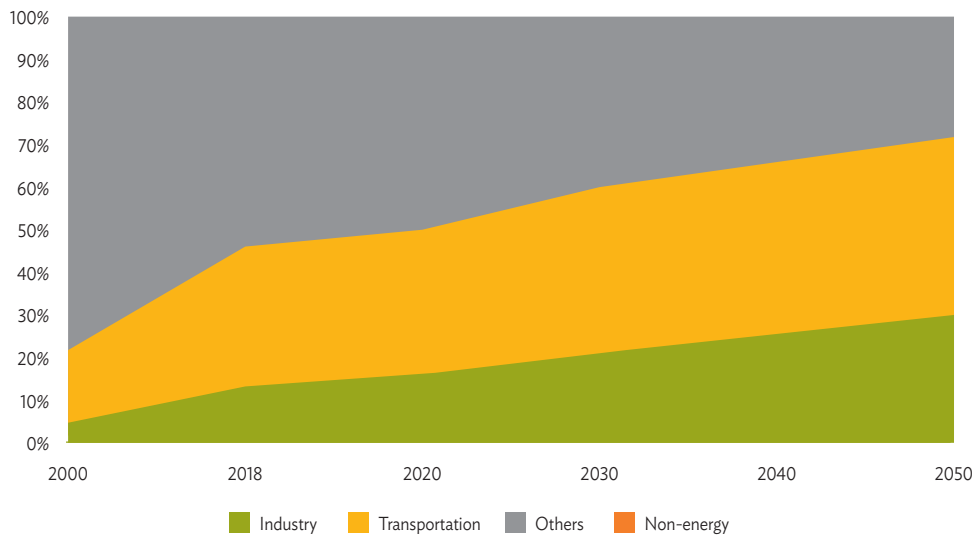
Figure 10.3. Final Energy Consumption by Sector



Mtoe = million tonnes of oil equivalent.

Source: Author's calculation

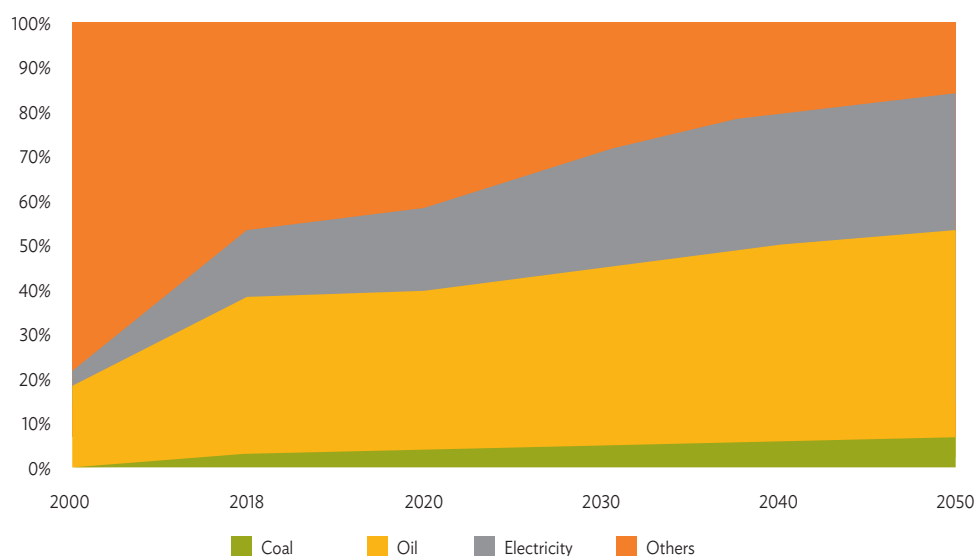
Figure 10.4. Sectors' Share in Final Energy Consumption



Source: Author's calculation

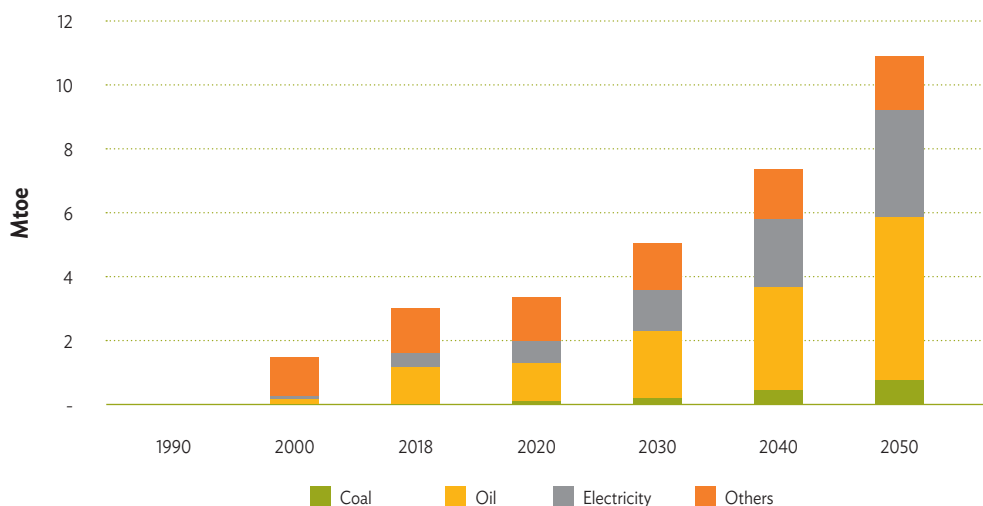
rural areas and rely on wood as the main fuel for cooking. Biomass consumption will decrease slightly because LPG and electric equipment will replace biomass. Although wood is more inconvenient than other energy types like electricity and LPG, which are mostly used for cooking in urban areas, it costs less.

Figure 10.5. Fuels' Share in Final Energy Consumption



Source: Author's calculation

Figure 10.6. Final Energy Consumption by Fuel Type



Mtoe = million tonnes of oil equivalent.

Source: Author's calculation

Oil is an important energy source for the 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 the 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. In 2018, 1.09 Mtoe of oil was consumed, and demand is projected to increase from 1.09 Mtoe in 2018 to 5.06 Mtoe in 2050 (an AAGR of 4.9%), the third highest relative to coal, electricity, and biomass during this period.

3.1.2 Primary Energy Supply

The Lao PDR's energy primarily comes from coal, oil, hydropower, and 'others' (including biomass, biofuels, and electricity for export). The Lao PDR's TPES increased from 1.62 Mtoe in 2000 to 6.38 Mtoe in 2018, an AAGR of 7.7%. This growth is expected to decrease steadily at a rate of 0.4% per year from 2018–2020, because the Hongsa plant consumes coal lignite. The TPES growth rate is projected to decrease steadily at a slower rate of 3.1% per year from 2018–2050.

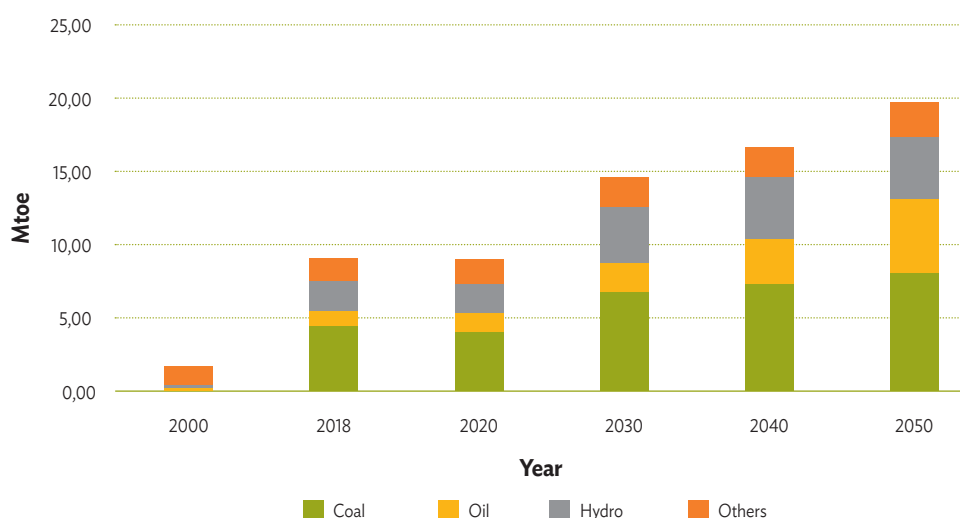
In 2018, coal was the most frequently used energy at 4.46 Mtoe, followed by hydropower at 1.98 Mtoe and biomass at 1.44 Mtoe. The Hongsa plant is driving the high rate of coal consumption, which is expected to increase by 1.9% from 2018 to 2050. Although coal's share of the TPES is projected to decrease from 69.98% in 2018 to 47.8% in 2050, coal is expected to remain dominant in 2050.

Hydropower generated 1.98 Mtoe (31% of the TFES) in 2018, and is expected to generate 4.25 Mtoe (25.1% of the TFES) in 2050. It is forecasted to grow at an AAGR of 2.4% from 2018 to 2050 because the Lao PDR has been developing hydropower projects intensively to meet increasing domestic demand and export more to its neighbours. Specifically, the Lao PDR has agreed to export 7,000 MW to Thailand by 2025 and 5,000 MW to Viet Nam by 2030.

Biomass is frequently used in the 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 1.44 Mtoe in 2018, and is projected to increase to 1.98 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 1% during 2018–2050.

Oil is also experiencing high growth in the Lao PDR because many people can now afford to buy private cars, significantly raising the number of vehicles. As of 2018, the Lao PDR did not produce crude oil, and all oil products are imported. There are 11 oil import and export companies and 12 oil distribution companies authorised within the Lao PDR. In 2000, 0.27 Mtoe of oil was used, accounting for 16.8% of the TPES; this increased to 1.09 Mtoe (17.1% of the TPES) in 2018, an AAGR of 8.0% during 2000–2018. From 2018 to 2050, oil consumption is projected to grow at an AAGR of 4.9%, and oil will account for 29.9% of the TPES in 2050.

Figure 10.7. Primary Energy Supply



Hydro = hydropower, TWh = terawatt-hour.

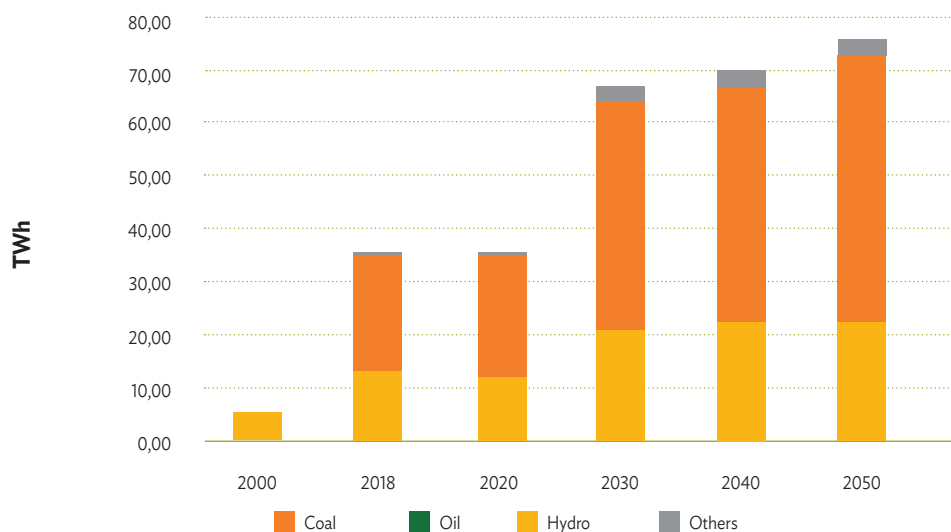
Source: Author's calculation

3.1.3 Power Generation

The history of power generation in the Lao PDR can be divided into two periods: 1970–2015, when all power was generated from hydropower sources; and after 2015, when the Hongsa plant began operating. In 1990, the Lao PDR only produced 0.82 terawatt-hours (TWh) of electricity; this increased to 3.51 TWh in 2000 and 36.76 TWh in 2018, and is forecasted to increase to 76.94 TWh by 2050. Power generation outputs are also estimated to rise dramatically from 2018 to 2050, at an AAGR of 2.3%. The inauguration of the first thermal power plant in 2015 changed the power generation mix in the Lao PDR (see Figure 10.8 for data from 2018). In 2018, hydropower accounted for 62.6% of total generation and the Hongsa plant accounted for 37.1%, with the remaining 0.3% coming from solar and biomass. Hydropower is forecasted to continue to dominate the Lao PDR's power sector. For example, it is projected that by 2050 hydropower will account for 65.1% of total generation, and the Hongsa plant 29.9%. According to the country's power mix policy, hydropower should

account for 65% and thermal power 30%, with the remaining 5% coming from other sources. Therefore, it appears that the power generation mix under BAU will comply with this policy by 2050.

Figure 10.8. Electricity Generation 2050



Mtoe = million tonnes of oil equivalent.

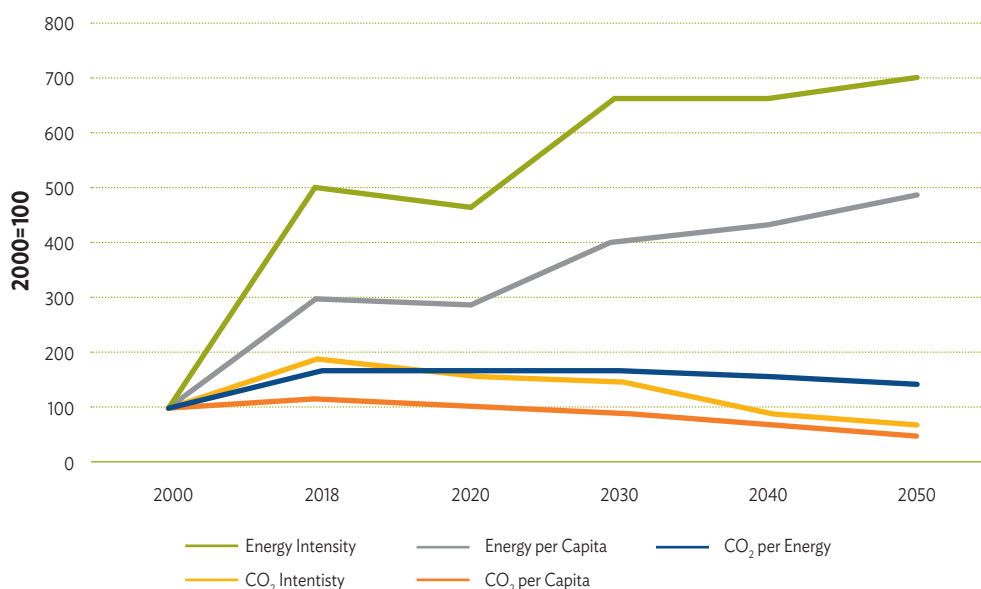
Source: Author's calculation

3.1.4 Energy Indicators

The Lao PDR's primary energy intensity (TPES/GDP) increased from 452 tonnes of oil equivalent per million dollars (toe/\$ million) to 505 toe/\$ million in 2018 because of steadily increasing coal consumption by the thermal power plant; this is expected to decline to 210 toe/\$ million by 2050.⁵ The final energy intensity is projected to decline even lower to 137 toe/\$ million by 2050. This indicates that energy consumers are implementing energy efficiency and conservation programmes.

⁵ 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)



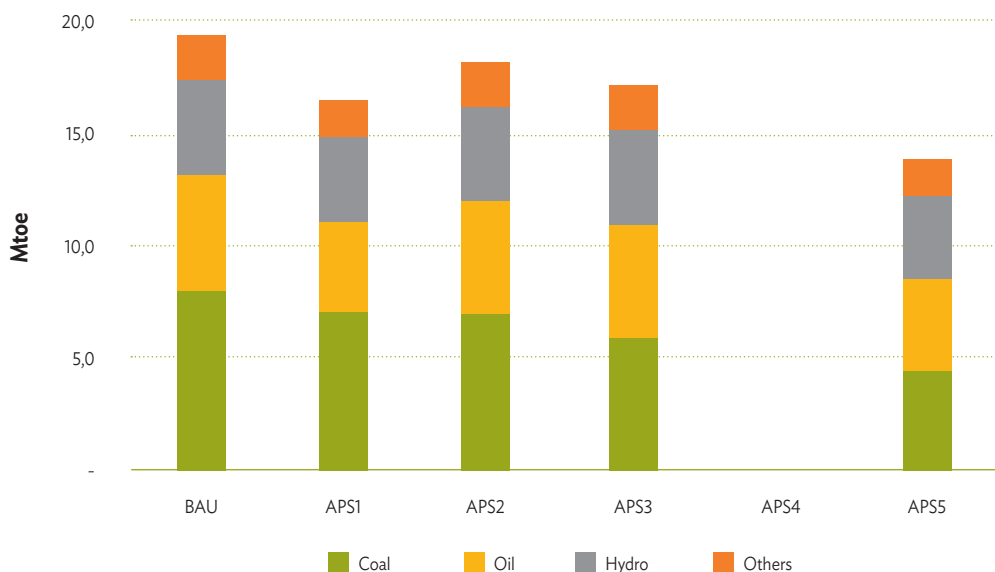
CO₂ = carbon dioxide.

Source: Author's calculation

3.2 Energy Saving and Carbon Dioxide Reduction Potential (Alternative Policy Scenario)

As outlined above, this study considers four APSs with respect to the Lao PDR's energy saving and CO₂ 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. Under APS 1 the TPES decreases by 2.89 Mtoe (from 19.4 Mtoe to 16.5 Mtoe) compared with BAU. Under APS 2, more efficient thermal power generation reduces the TPES to 1.13 Mtoe. Under APS 3, replacing coal power generation with wind and solar will decrease the TPES from 19.4 Mtoe under BAU to 17.2 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.

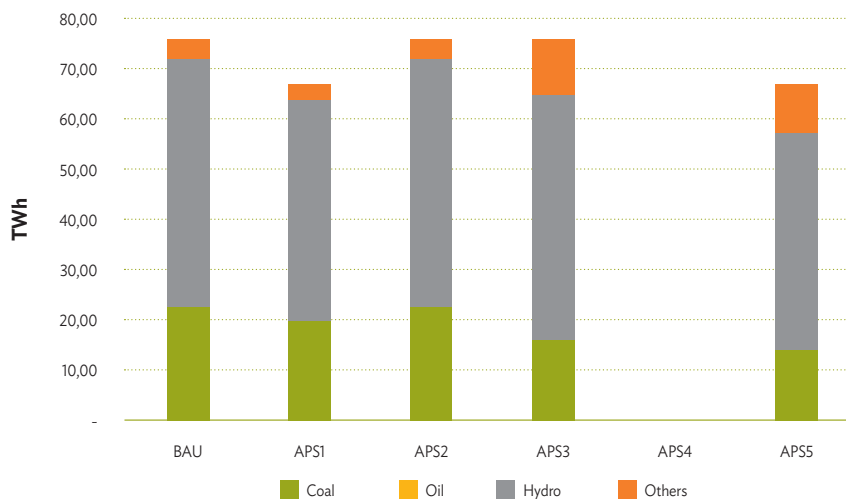
Figure 10.10. Comparison of Scenarios for Total Primary Energy Supply (2050)



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

Source: Author's calculation

Figure 10.11. Comparison of Scenarios for Electricity Generation (2050)

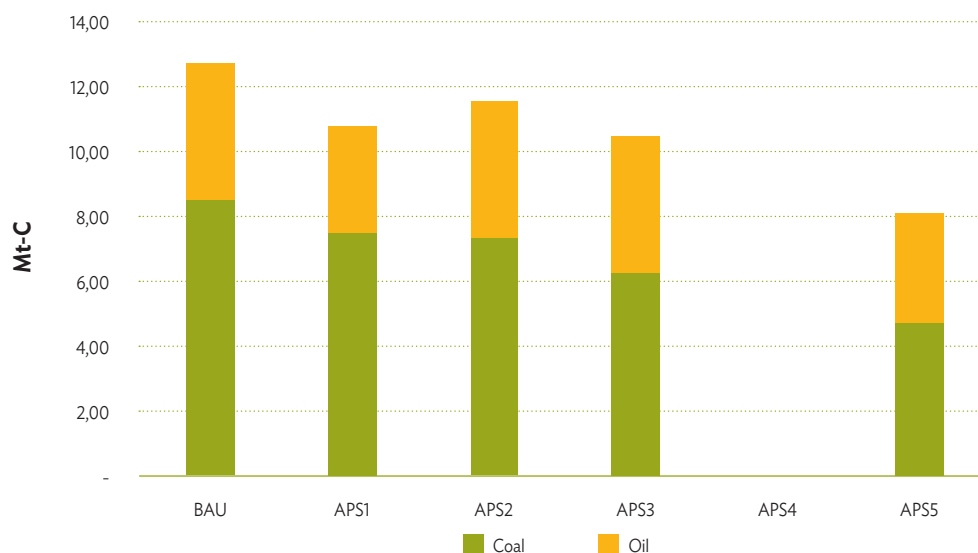


APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation

Comparing projected levels of CO₂ emissions across these five scenarios reveals that APS 5 will eliminate 2.26 million tonnes of carbon (Mt-C), followed by APS 1 at 1.9 Mt-C, and APS 2 at 1.2 Mt-C. In total, this study projects that APS 5 will reduce total CO₂ by 4.65 Mt-C, from 12.7 Mt-C of BAU to 8.09 Mt-C by 2050 (Figure 10.12).

Figure 10.12. Comparison of Scenarios (2050)



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

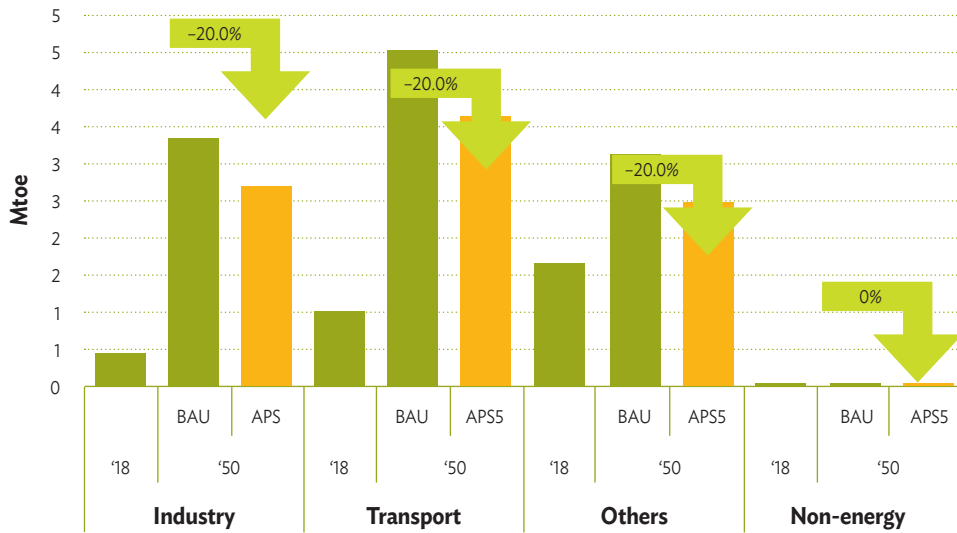
Source: Author's calculation

With respect to trends of final energy consumption under BAU and in the APSs in each sector, the model yields the following results: in APS 1, final energy consumption is expected to increase from 3.09 Mtoe in 2018 to 8.80 Mtoe in 2050. Under BAU, the largest consumer is the 'others' sector, which consumes 1.65 Mtoe, or 53.5% of the TFEC in 2018; this will increase to 3.12 Mtoe (28.3%) by 2050. The transport sector, the second largest consumer, consumes 1.01 Mtoe or 32.8% of the TFEC, this is projected to increase to 4.54 Mtoe by 2050, making this sector the largest consumer of energy. The industry sector's consumption is also expected to increase at a rate of 6.7% from 2018 to 2050, making it the second largest consumer by 2050.

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%.

Figure 10.13. Final Energy Demand by Sector – Business as Usual, and Alternative Policy Scenario 5



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

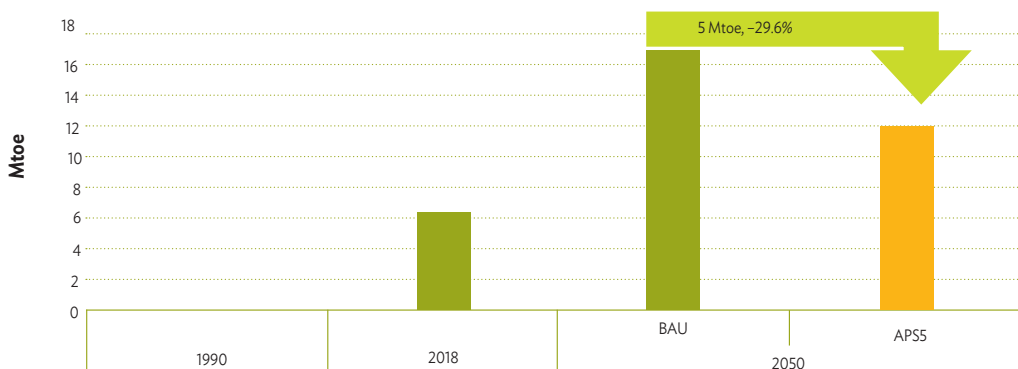
Source: Author's calculation

3.2.1 Primary Energy Supply

3.2.2 Projected Energy Savings

By 2050, primary energy is expected to decrease by 5 Mtoe or 29.6% from BAU to the APS 5 level (Figure 10.14). 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.

Figure 10.14. Total Primary Energy Demand – Business as Usual, and Alternative Policy Scenario 5



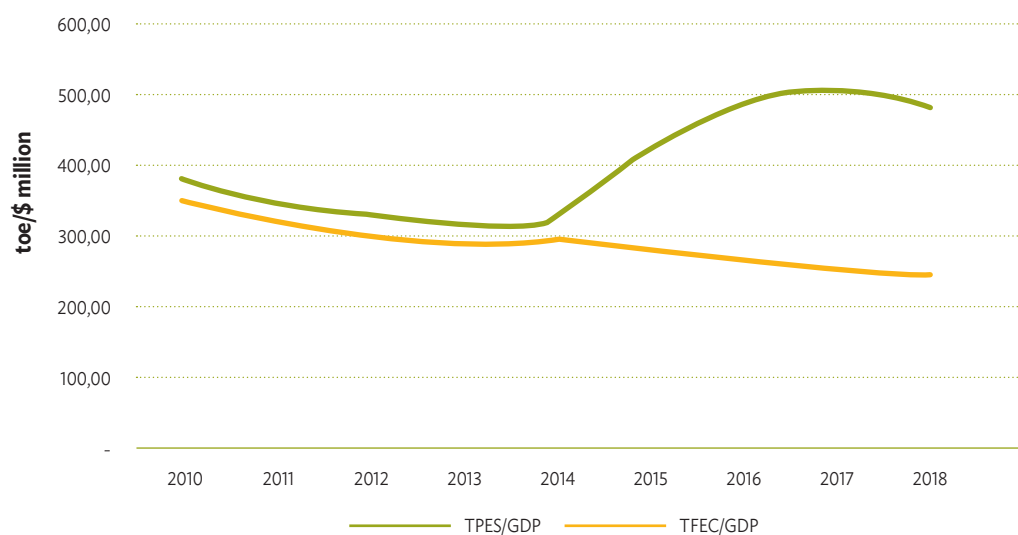
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation

3.2.3 Energy Intensities

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 4.2% through 2017, and decreased again to 4.5% from 2017 to 2018. This indicates that energy intensity increased from 380 toe/\$ million in 2010 to 484.33 toe/\$ million in 2018 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 decreasing use of biomass consumption from 349.59 toe/\$ million to 244.76 toe/\$ million during the same period.

Figure 10.15. Energy Intensity (2010–2018)



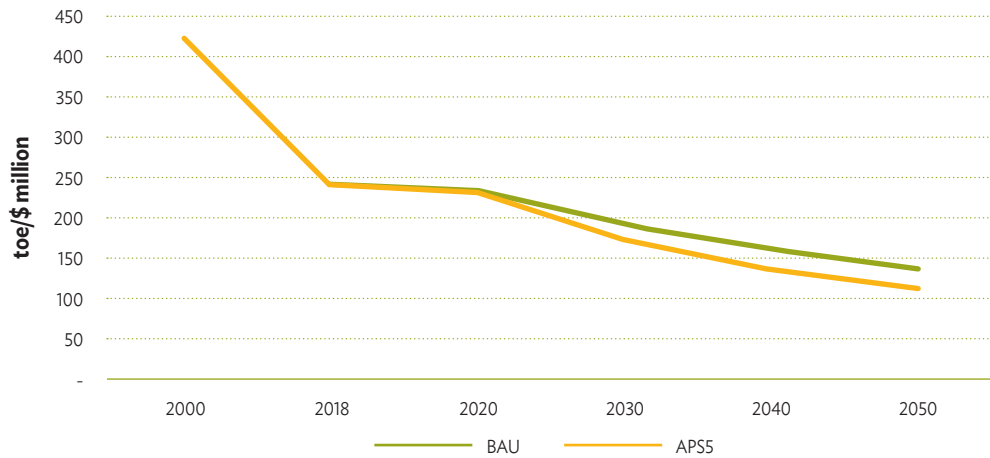
GDP = gross domestic product, toe = tonnes of oil equivalent, TPES = total primary energy supply.

Source: The Lao People's Democratic Republic, Department of Energy Policy and Planning (2019), Lao Energy Balance Table (EBT) Collection... Historical. 24 July.

Source: Author's calculation.

As the Lao PDR endeavours to make its economy more efficient and competitive and promote sustainable development, energy intensity, both final and primary, has been significantly reduced. The final energy intensity is projected to decrease from 245 toe/\$ million in 2018 to 137 toe/\$ million 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 10% energy savings in APS 1.

**Figure 10.16. Final Energy Intensity—
Business as Usual and Alternative Policy Scenario 5**

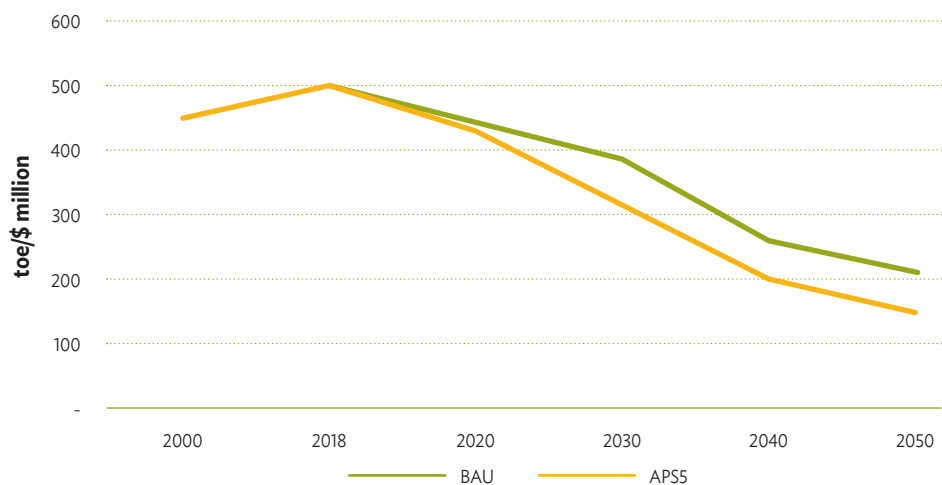


APS = alternative policy scenario, BAU = business as usual, toe = tonnes of oil equivalent.

Source: Author's calculation.

The primary energy intensity is also expected to decline from 505 toe/\$ million in 2018 to 210 toe/\$ million by 2050. As shown in Figure 10.17, in APS 5 the primary energy intensity is expected to decline more than 30% from BAU, from 210 toe/\$ million to 148 toe/\$ million 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**



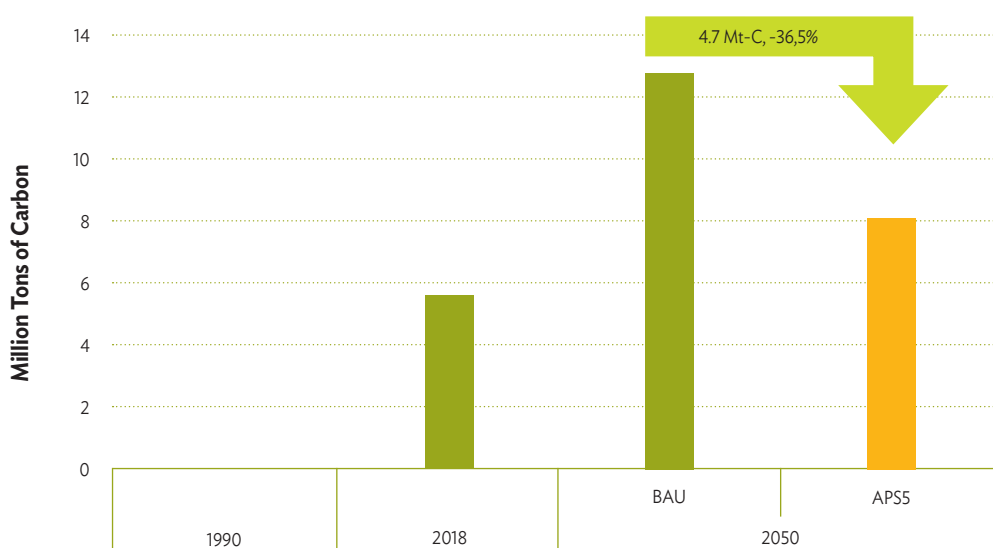
APS = alternative policy scenario, BAU = business as usual, toe = tonnes of oil equivalent.

Source: Author's calculation.

3.2.4 Carbon Dioxide Emissions from Energy Consumption

CO₂ emissions from energy consumption are projected to decrease by 36.5% from 12.7 Mt-C under BAU to 8.1 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 CO₂ emissions by around 1.9 Mt-C or 15% from BAU, APS 2 by 1.2 Mt-C or 9%, and APS 3 by 2.2 Mt-C or 18%.

**Figure 10.18. Carbon Dioxide Emissions from Energy Combustion—
Business as Usual versus Alternative Policy Scenario 5**



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

Source: Author's calculation.

4. Implications and Policy Recommendations

This study suggests that the Lao PDR has more options with respect to its future energy outlook, including energy efficiency and conservation, reducing the TFEC by 10%, improving the efficiency of thermal power generation, promoting renewable energy, and reducing the use of fossil fuels in the primary energy supply.

To reduce both the TPES and TFEC, as well as CO₂ emissions, the Lao PDR should extend its renewable energy and energy efficiency and conservation programmes until 2050. As these programmes are of primary importance in reducing energy consumption, they should be proposed as a Lao PDR energy policy. At the same time, sound projects and programmes should be implemented. The industry sector should install an energy management system, develop and implement its own energy saving or reduction plans, cooperate with the

government on energy security, and conduct regular seminars on energy saving measures. The transport sector should increase public transport in large cities and conduct campaigns to promote the use of that transport. Other sectors should raise public awareness of energy conservation and implement energy management in the building sector. In addition, a study of the correlation between GDP and 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 CO₂ emissions.
- (iv) Include the findings of this study in the Lao PDR's energy policy and plan.
- (v) Promote electric vehicles, which can reduce oil imports as well as CO₂ 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 64% hydropower, 21% thermal power, and 15% other sources (such as solar, wind, and biomass) from 2030 to 2050.
- (ix) Promote power interconnection and power trade through system-to-system transmission within ASEAN.



CHAPTER 11

Malaysia Country Report

Zaharin Zulkifli

1. Introduction

Malaysia is a federal constitutional monarchy in Southeast Asia consisting of 13 states and three federal territories, separated by the South China Sea into two regions: Peninsular Malaysia and Borneo's East Malaysia. Peninsular Malaysia shares a land and maritime border with Thailand and maritime borders with Singapore, Viet Nam, and Indonesia. East Malaysia shares land and maritime borders with Brunei Darussalam and Indonesia, and a maritime border with the Philippines and Viet Nam. Malaysia's territory covers 330,621 square kilometres (km²), including Peninsular Malaysia, Sabah, and Sarawak.

Malaysia is a relatively open, state-oriented, and newly industrialised market economy. The state plays a significant but declining role in guiding economic activity through macroeconomic plans. Malaysia has had one of the best economic records in Asia, with gross domestic product (GDP) growing 6.5% annually, on average, from 1957 to 2005. Malaysia's economy in 2014–2015 was one of the most competitive in Asia, ranking sixth in Asia and 20th in the world, above countries like Australia, France, and the Republic of Korea. In 2014, Malaysia's economy grew by 6%, the second highest growth in the Association of Southeast Asian Nations behind the Philippines' growth of 6.1%. In April 2019, Malaysia's economy in terms of GDP at purchasing power parity was estimated at \$999.397 billion, the third largest in the Association of Southeast Asian Nations and the 25th largest in the world.¹

Malaysia is rich in conventional energy resources such as oil, gas, and coal, as well as renewable energy such as hydropower, biomass, and solar. As of January 2018, its conventional energy reserves included 4.553 billion barrels of crude oil, 79.531 trillion cubic feet of natural gas, and

¹ All United States dollars in this report are in constant 2010 values unless specified.

1,938.37 million tonnes of coal. Malaysia's gas reserves are four times the size of its crude oil reserves in terms of energy equivalency. Natural gas reserves off the east coast of Peninsular Malaysia are earmarked for domestic consumption, while those in Sarawak are allocated as revenue earners in the form of liquefied natural gas exports. Malaysia is a net energy exporter. Crude oil, liquefied natural gas, and petroleum products contributed RM156,665 million, 15.6% of the economy's export earnings in 2018.

Energy plays a pivotal role in achieving Malaysia's sustainable growth and development goals. The sustainability of energy resources has been strategically planned over the years and energy policies developed after careful evaluation of the current and future energy needs and supply of energy. Historically, Malaysia's energy policies have focused on increasing the accessibility and affordability of energy as well as energy security. Malaysia's National Energy Policy (1979) set out to ensure the more cost-effective use of resources and more efficient use of energy. The Four Fuel Diversification Policy (1981) aimed to reduce overdependence on oil by introducing more coal and gas as energy sources. The Five Fuel Diversification Policy, which came into effect in 2001, added renewable energy to the mix.

Malaysia is focussing intently on the sustainable use of energy and the prudent and efficient management of resources under the 11th Malaysia Plan (2016–2020) through the introduction of the National Energy Efficiency Action Plan (NEEAP) (2016–2025). The NEEAP provides instruments for the successful implementation of energy efficiency strategies in the country through the well-coordinated and cost-effective implementation of energy efficiency measures in the industrial, commercial, and residential sectors. Recognising the need to improve on its energy efficiency and conservation initiatives, Malaysia is developing a comprehensive new Energy Efficiency and Conservation Act (EECA) in pursuit of its national aspirations, as well as the effective utilisation of energy across key sectors. The EECA will outline comprehensive measures necessary to promote the efficient utilisation of energy, including target setting, communication, and education. It will also initiate steps to reduce greenhouse gas emissions as a regulatory approach.

Renewable energy largely comes from hydropower plants in Peninsular Malaysia, Sabah, and Sarawak. In 2018, hydropower made up 93% of the renewable energy generation mix. The potential of geothermal, wind, and ocean energy as additional renewable energy sources is also being explored. Solar photovoltaics has been mooted as a long-term renewable energy source in Malaysia, and it contributed less than 1% of total power generation in 2018. Several schemes have been introduced to drive the growth of solar in Malaysia, such as the Feed-in-Tariff (FiT) programme and the Net Energy Metering (NEM) scheme. Both were introduced

to incentivise consumers to install solar photovoltaics in buildings or in homes, but resulted in low uptake rates. Lack of funding and low return on investment for consumers are two reasons cited for this. To expedite the use of solar in the country, Malaysia introduced its Large Scale Solar (LSS) programme. In March 2016, the Energy Commission of Malaysia announced the first round of bidding to build LSS photovoltaic plants, with the aim of achieving a total capacity of 250 alternating-current megawatts in Peninsular Malaysia and 50 alternating-current megawatts in Sabah.

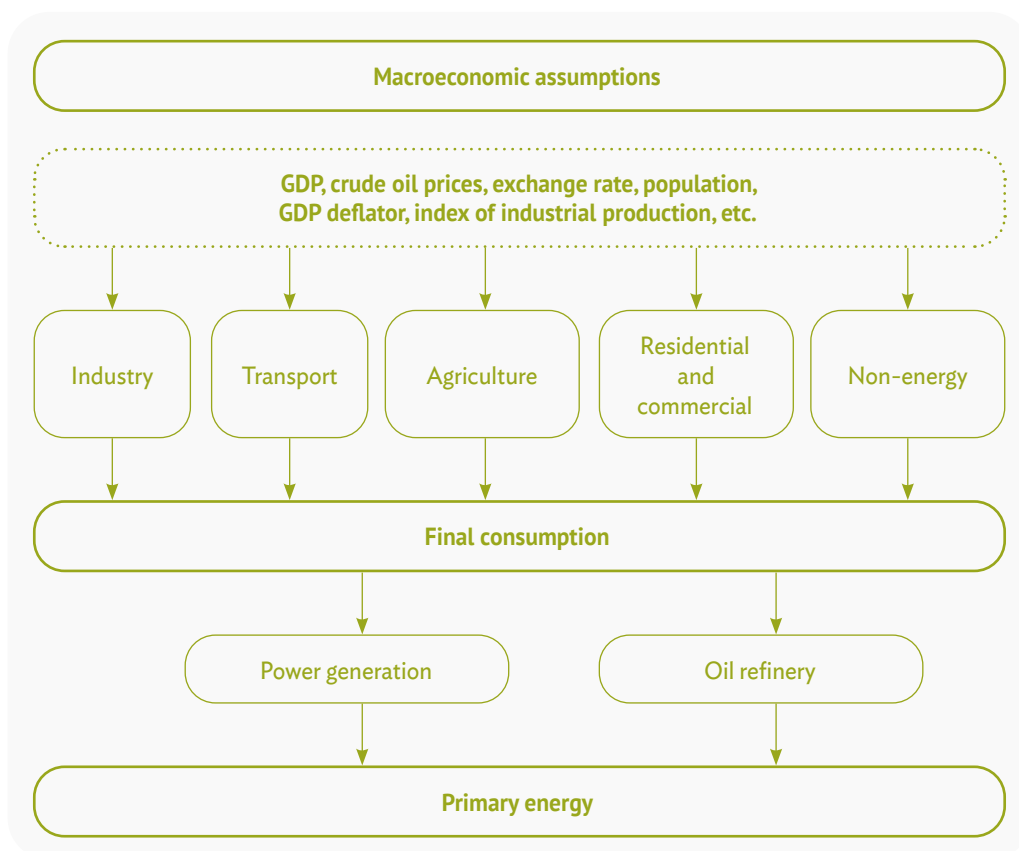
2. Modelling Assumptions

Energy demand projections up to 2050 were estimated using the econometric approach. Historical energy demand data were taken from the National Energy Balance published by the Energy Commission of Malaysia. Economic indicators used in energy modelling such as GDP were taken from the World Bank's World Development Indicators. Energy modelling involved estimating final energy consumption and the corresponding primary energy supply. Figure 11.1 shows the model structure for projecting final energy consumption and estimating transformation inputs to arrive at the primary energy supply.

The econometric approach was applied to forecast final energy consumption. The historical correlation between energy demand and macroeconomic and activity indicators were derived by regression analysis using Microfit, an interactive software package written for microcomputers and designed especially for the econometric modelling of time series data. It has powerful features for data processing, file management, graphic display, estimation, hypothesis testing, and forecasting under various univariate and multivariate model specifications.

The future energy demand for various energy sources was estimated using assumed values of the macroeconomic and activity indicators. Future values of these indicators were also derived using historical data depending on the sufficiency of such analysis. In the model structure, energy demand is modelled as a function of activity such as income, industrial production, number of vehicles, number of households, number of appliances, and floor area of buildings. In the residential sector, for example, the demand for electricity could be a function of the number of households, disposable income, and penetration rate of electrical appliances. In the commercial sector, energy consumption could be driven by building floor area, private consumption, and other factors that encourage commercial activities. However, because of a lack of information on the activity indicators, macroeconomic data

Figure 11.1. Modelling Structure



GDP = gross domestic product.

Source: Author.

(GDP) was the best variable to use to search for the relationship with the energy demand trend. GDP information was broken down into industry GDP, services GDP, agriculture GDP, and manufacturing GDP. These macroeconomic indicators were mainly used to generate the model equations. In some cases, where regression analysis is not applicable because of insufficient data or failure to derive a statistically sound equation, other methods such as share of%age approach or growth rates are used.

GDP growth rates are a main driver of the modelling assumption. The GDP growth rates assumption forecast was based on IHS² data from a study conducted by the Economic Planning Unit of Malaysia (IHS Energy Insight, 2016). Most energy demand equations for Malaysia use GDP as the key factor in determining future projections, because of the high correlation between energy demand and GDP. Table 11.1 shows assumptions of GDP growth

² IHS Markit Ltd is a London-based global information provider formed in 2016 by the merger of IHS Inc. and Markit Ltd.

rates by sector.

Annual average population growth was also a key driver of future energy growth. Malaysia's population is projected to increase from 31.1 million in 2017 to 41.4 million by 2050, a 32.9%

Table 11.1. Gross Domestic Product Growth Assumptions by Sector to 2050
(% per year)

GDP growth rate (%)	2021–2025	2026–2030	2031–2035	2036–2050
Agriculture	2.26	2.09	1.91	1.74
Mining and quarrying	1.01	3.03	3.74	5.17
Manufacturing	3.16	2.77	2.47	2.30
Construction	3.01	2.54	2.26	2.09
Services	4.42	3.67	3.07	2.67
Total GDP	3.77	3.19	2.74	2.43

GDP = gross domestic product.

Source: IHS data from the Economic Planning Unit (2016).

increase. However, the annual population growth rate is projected to decrease from 1.02% in 2021–2026 to 0.87% in 2026–2030, 0.74% in 2031–2035, and 0.63% in 2036–2040. This situation is in tandem with the targeted decline in fertility rates and international migration. This assumption of future population growth rates was obtained from the Department of Statistics Malaysia (Table 11.2).

Under the energy efficiency and conservation scenario, potential savings of 8% from business as usual (BAU) are projected (Table 11.3), based on the NEEAP findings. As NEEAP only

Table 11.2. Population Growth Assumption to 2050

	2021–2025	2026–2030	2031–2035	2036–2050
Population (million)	36.0	38.1	39.9	41.5
Population growth (%)	1.02	0.87	0.74	0.63

Source: Department of Statistics (2016) from 2021 to 2050.

focusses on the electricity sector, this 8% savings is applied to all fuel types for this project. The NEEAP's time horizon is through 2025; however, for this project the projection period will extend until 2050. The 8% savings target will start from 2017 and will increase to 16% by 2050. These assumptions were made to reflect the effectiveness of the NEEAP activities and programmes until 2050. Furthermore, the newly proposed EECA will increase the potential savings from energy efficiency in the energy efficiency and conservation scenario.

As Malaysia aims to increase renewable energy's share in the capacity mix to 20% by 2025, the government has implemented several renewable energy-related programmes, including FiT, NEM, LSS, and Self Consumption for Solar Installations. Renewable energy started in Malaysia with small renewable energy programmes and FiT projects, mainly in oil palm estates. Now, the country has progressed to LSS, and is moving increasingly toward solar energy as the preferred renewable energy source. Solar appears to be the most promising renewable energy source because it is most easily implemented, compared to biogas, biomass, and others. For biomass, the challenge is having several biomass plants sourcing feedstock from the same area; after a few years, these plants are unable to operate because of a feedstock shortage. Biogas is limited to palm oil millers and its energy generating capacity is very low. Furthermore, biogas plants are usually in remote locations, where sparse populations lead to a low uptake rate. Although there is huge potential for mini-hydropower to be developed in Malaysia, this resource is located mostly in rural areas, and connection to the main grid is very costly. As indicated in Table 11.3, the renewable energy scenario combines all potential renewable energy capacity from existing and future power generation programmes in the country. Although Malaysia's Power Development Plan only extends to 2035, for this project the targeted number will be extended to 2050.

Palm biodiesel, which is produced from palm oil through a chemical process, is an environmentally friendly biofuel used as a substitute for petroleum diesel. Biodiesel is a renewable resource while petroleum diesel is a limited resource. Types of diesel sold at pump stations are Euro 2M (black nozzle) and Euro 5 (blue nozzle), which are mixed with palm biodiesel at 10% (B10) for Euro 2M and 7% (B7) for Euro 5. Argentina, Brazil, Colombia, the European Union, Indonesia, and the United States have been using B10 and B20 biodiesel blends since the early 2000s. Malaysia implemented a B5 programme in June 2011 and a B7 programme in December 2014 in the transport sector. The B10 programme was implemented in the transport sector by phases starting on 1 December 2018, and mandatory implementation nationwide was introduced in February 2019. Recently, the B20 programme was launched in January 2020, and this will be extended nationwide by stages until the middle of 2021. By 2030, the government would like to increase the share of blended biodiesel by 30%.

Malaysia's Third National Communication and Second Biennial Update Report to the United Nations Framework Convention on Climate Change (UNFCCC), set a mitigation action target for advanced technologies in coal and natural gas power plants. The target for highly efficient technologies for new power plants was set at 46% for coal and 60% for natural gas. This assumption was made as old and inefficient power plants will be retired and replaced by

high-efficiency plants, thus lowering fuel consumption and directly reducing carbon dioxide (CO₂) emissions.

Plans for Malaysia to have its own nuclear power plant to cope with the country's high energy consumption were recently nullified when the government decided not to pursue nuclear energy in Malaysia. The government set up the Malaysia Nuclear Power Corporation in 2011 to research nuclear energy usage for the country, and the corporation originally planned to build two nuclear power plants by 2030. However, after several months of planning, the decision to stop its development was announced, and the government clarified that Malaysia will not use nuclear energy due to concerns about radioactive waste. Cancelling the construction of the nuclear power plants also resulted in the closure of the Malaysia Nuclear Power Corporation. As a replacement for nuclear energy, the government has suggested that Malaysia should opt for renewable energy such as biomass, biogas, and solar energy. As a result, this project does not include a nuclear scenario.

The details of the scenarios considered by this project as well as several assumptions or scenarios are outlined in Table 11.3.

Table 11.3. Potential Mitigation Scenarios

Scenario	Mitigation Actions
Energy Efficiency and Conservation (EEC)	Improve final energy consumption of all energy types by 8% in 2017 and by 16% in 2050.
Renewable Energy (RE)	(i) Achieve the following targets for use of renewable energy in the power sector by 2035:
	(a) Hydropower: 8,573 megawatts (MW)
	(b) Solar: 6,279 MW
	(c) Biomass: 947 MW
	(d) Biogas: 525 MW
	(e) MSW: 212 MW
	Total: 16,536 MW
	(ii) Increase the share of biodiesel in the energy mix to 10% by 2019, 20% by 2020, and 30% by 2030.
Energy Efficiency in the Power Sector (EEP)	Improve the efficiency of power plants as follows:
	(i) Natural gas by 60% by 2050
	(ii) Coal by 46% by 2050
Alternative Policy Scenario (APS)	Combination of all scenarios:
	APS = EEC + RE + EEP

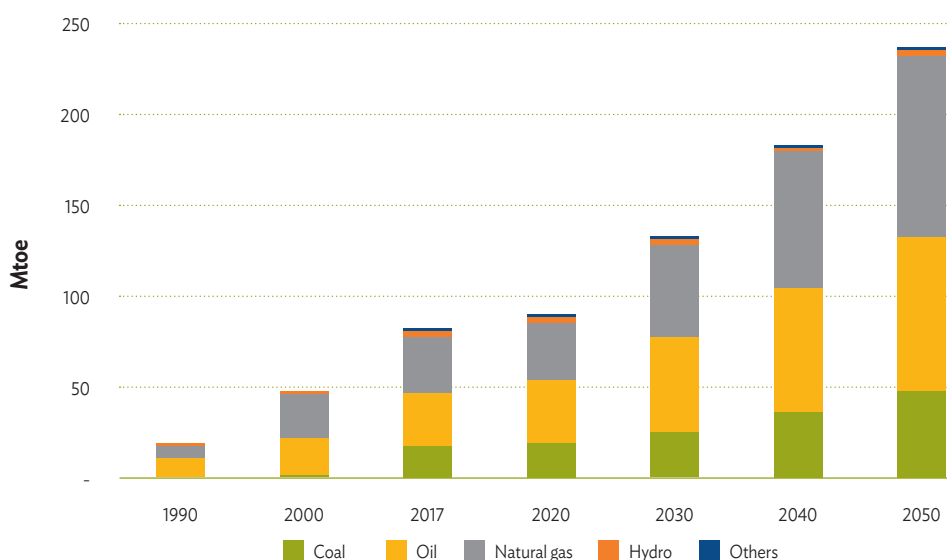
Source: Author's assumptions.

3. Outlook Results

3.1. Business as Usual Scenario

Under BAU, the total primary energy supply (TPES) registered an average annual growth rate (AAGR) of 5.6% from 1990 to 2017. The outlook results showed that the TPES is projected to increase by 3.3% per year from 2017 to 2050 (Figure 11.2). Other sources (biomass, solar, and biofuel) will increase from 0.15 million tonnes of oil equivalent (Mtoe) in 2017 to 1.79 Mtoe in 2050, an AAGR of 7.7%. The supply of natural gas will increase at 3.7% per year from 2017 to 2050, and oil will increase from 29.23 Mtoe in 2017 to 84.18 Mtoe in 2050, an AAGR of 3.3%. Coal (consumed mainly by the power sector) is expected to increase by 2.8% per year in 2017–2050.

Figure 11.2. Primary Energy Supply by Fuel Type, Business as Usual (1990–2050)



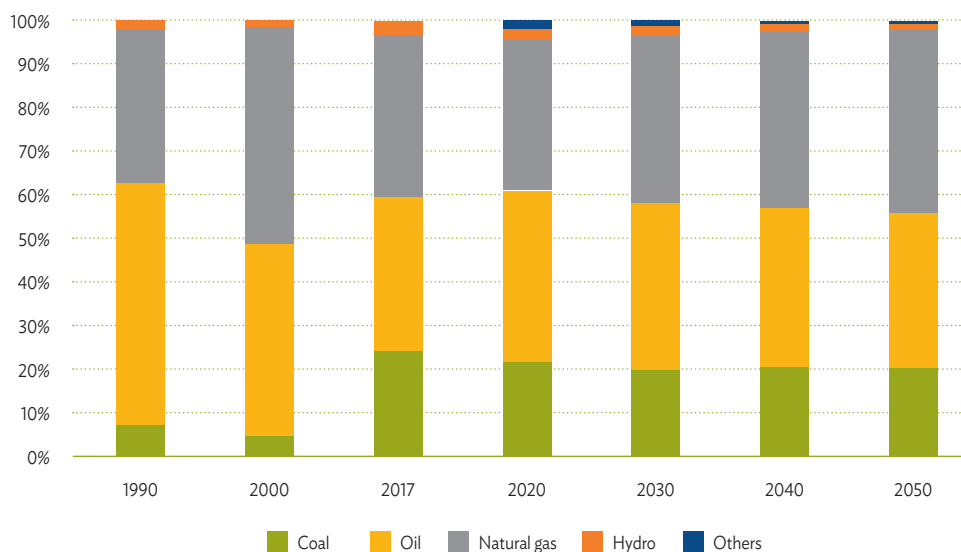
BAU = business as usual, Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

In terms of share by fuel type, from 2017 to 2050 oil will decrease from 35.8% to 35.5%, natural gas will increase from 37.3% to 42.1%, and coal will decrease from 23.9% to 20.5%. Finally, hydropower will decrease from 2.8% in 2015 to 1.2% in 2050 (Figure 11.3).

Under BAU, total final energy consumption will increase from 59.88 Mtoe in 2017 to 177.18 Mtoe in 2050, an AAGR of 3.3%. Final consumption of natural gas will see the highest AAGR at 3.7% from 2015 to 2050. From 2017 to 2050, oil demand will grow from 28.27 Mtoe to

Figure 11.3. Share of Primary Energy Supply by Fuel Type, Business as Usual (1990–2050)

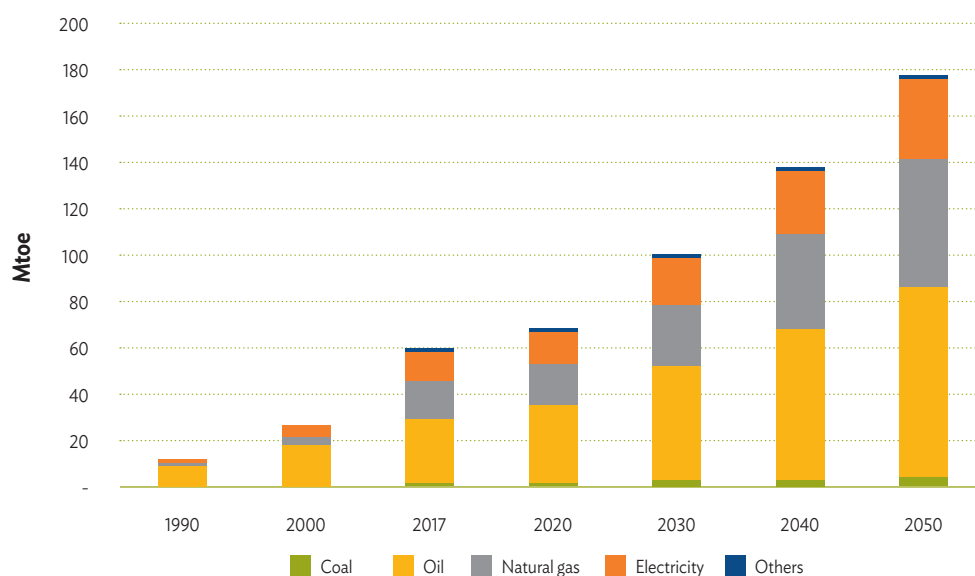


BAU = business as usual, Hydro = hydropower.

Source: Author's calculation.

82.17 Mtoe (an AAGR of 3.3%), coal demand will increase 3.2% per year, and electricity will grow from 12.60 Mtoe to 34.23 Mtoe (an AAGR of 3.1%). Demand for other sources such as biodiesel is expected to increase from 0.38 Mtoe to 0.53 Mtoe, an AAGR of 1.0% (Figure 11.4).

Figure 11.4. Final Energy Consumption by Fuel Type, Business as Usual (1990–2050)

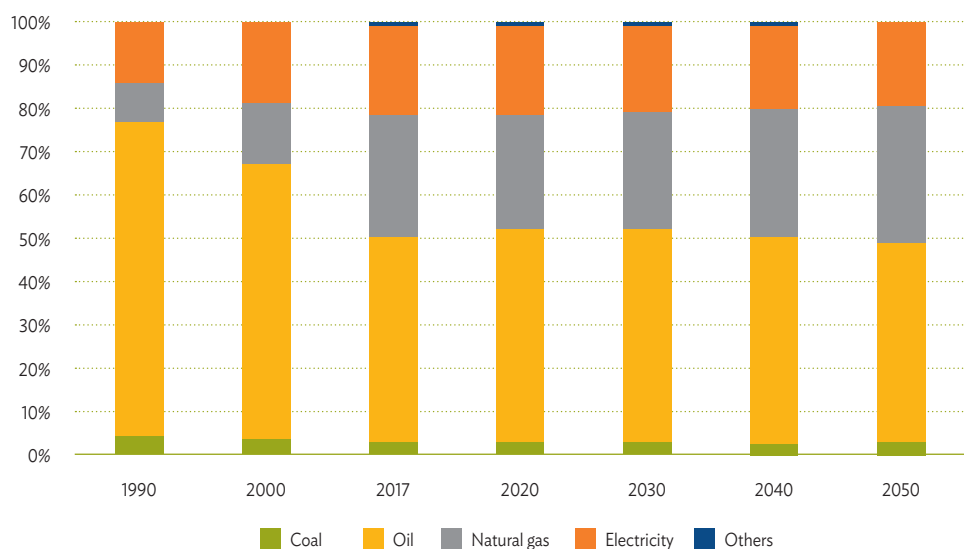


Mtoe = million tonnes of oil equivalent

Source: Author's calculation.

Analysis by share shows that oil will still dominate in 2050 with 46.4%, a slight decrease from 47.2% in 2017. It will be followed by natural gas (31.2%) and electricity (19.3%) in 2050. The share of coal will decrease from 3.0% in 2017 to 2.8% in 2050 (Figure 11.5).

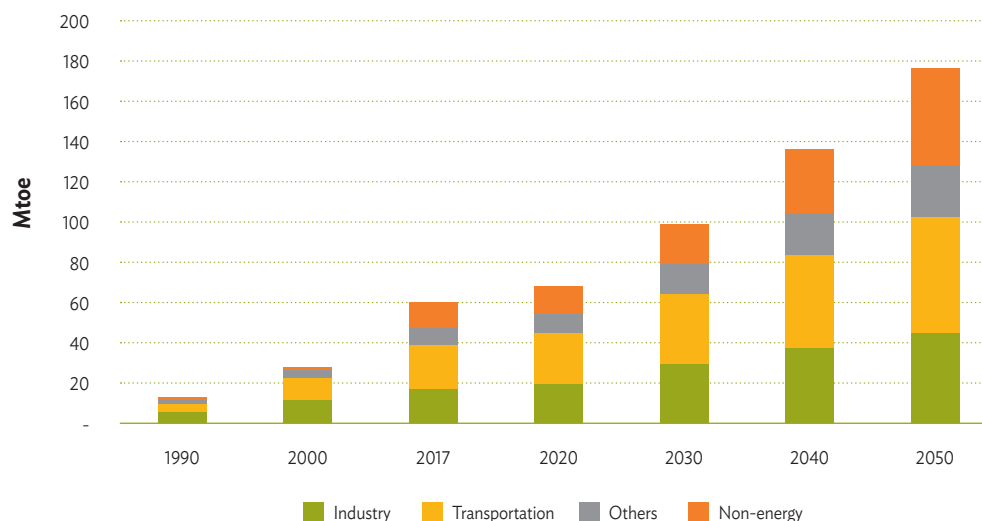
Figure 11.5. Share of Final Energy Consumption by Fuel Type, Business as Usual (1990–2050)



Source: Author's calculation.

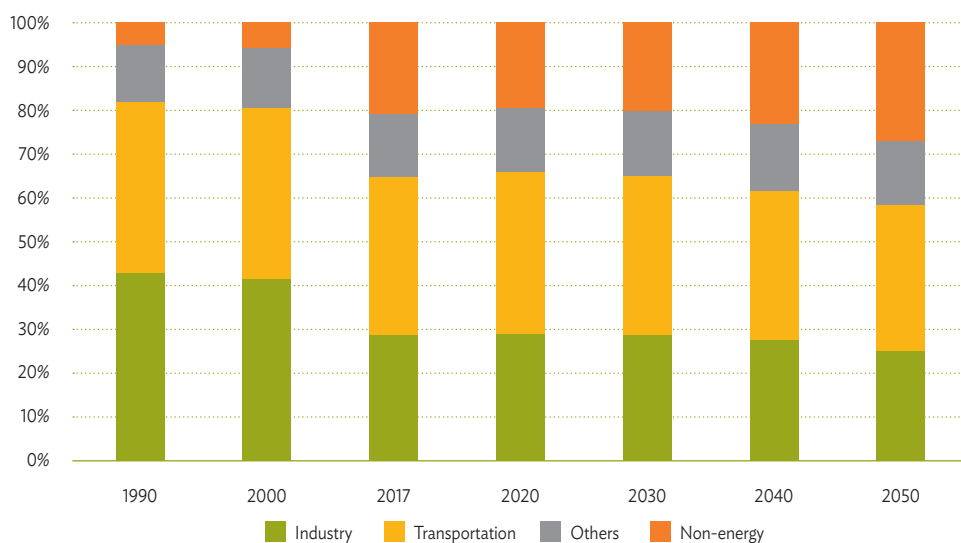
In terms of final energy consumption by sector, from 2017 to 2050, the non-energy use sector will lead the growth with 4.2% per year, followed by the 'others' sector, which will grow from 8.46 Mtoe to 25.78 Mtoe, an AAGR of 3.4%. Over the same period the transport sector is expected to increase from 21.45 Mtoe to 58.45 Mtoe (an AAGR of 3.1%), and the industry sector will see an AAGR of 2.9% (Figure 11.6).

Figure 11.6. Final Energy Consumption by Sector, Business as Usual (1990–2050)



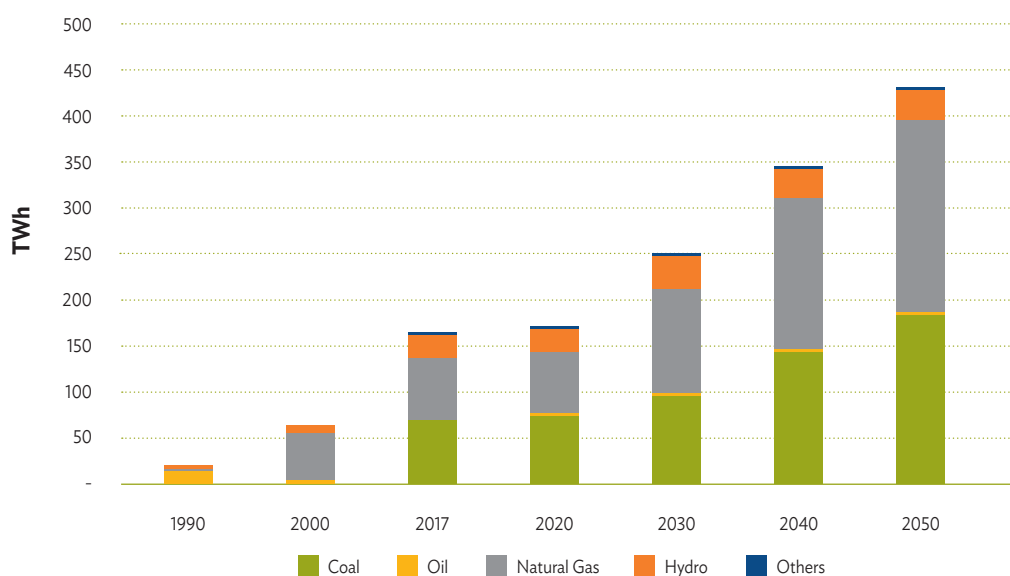
Analysis by share shows that the transport sector will still dominate energy use in 2050, with 33.0% compared to 35.8% in 2017. This will be followed by the industry sector with a 25.4% share in 2050 compared to 29.1% in 2017. Non-energy use is projected to account for 27.1% of TFE in 2050, compared to 20.9% in 2017, while the 'others' sector is expected to account for 14.6% in 2050 (Figure 11.7).

Figure 11.7. Share of Final Energy Consumption by Sector, Business as Usual (1990–2050)



Under BAU, total power generation is expected to grow by around 3.0% per year from 2017 until 2050, reaching 431.91 terawatt-hours (TWh). Power generation from other types of fuel (biomass, biogas, solar, and municipal solid waste) will see the fastest growth at 4.4% per year during this period. From 2017 to 2050, power generation from natural gas is projected to increase from 63.27 TWh to 207.45 TWh, power generation from coal will grow 2.9% per year from 71.96 TWh to 184.64 TWh, power generation from oil is expected to increase by 1.6% per year from 1.53 TWh to 2.59 TWh, and electricity generated from hydropower is expected to increase by 0.6% per year (Figure 11.8).

Figure 11.8. Power Generation by Fuel Type, Business as Usual (1990–2050)

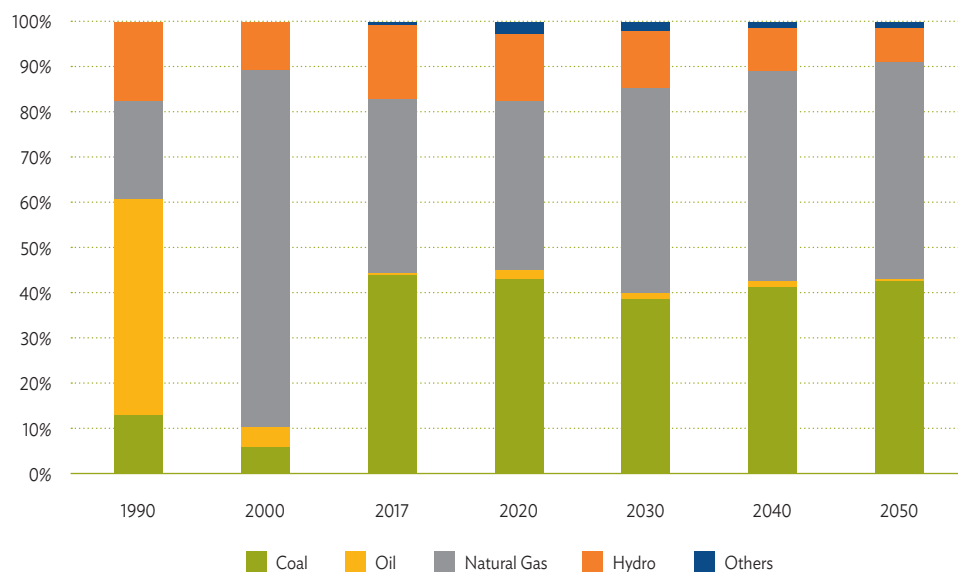


Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation.

In 2050, the power generation mix will be dominated by natural gas, with a 48.0% share; and coal, with a 42.7% share. These will be followed by hydropower with a 7.5% share in 2050 compared to 16.2% in 2017. Other sources will account for 1.1% of the total power generation in 2050, and oil will account for 0.6%, compared to 0.9% in 2017 (Figure 11.9).

Figure 11.9. Share of Power Generation by Fuel Type, Business as Usual (1990–2050)

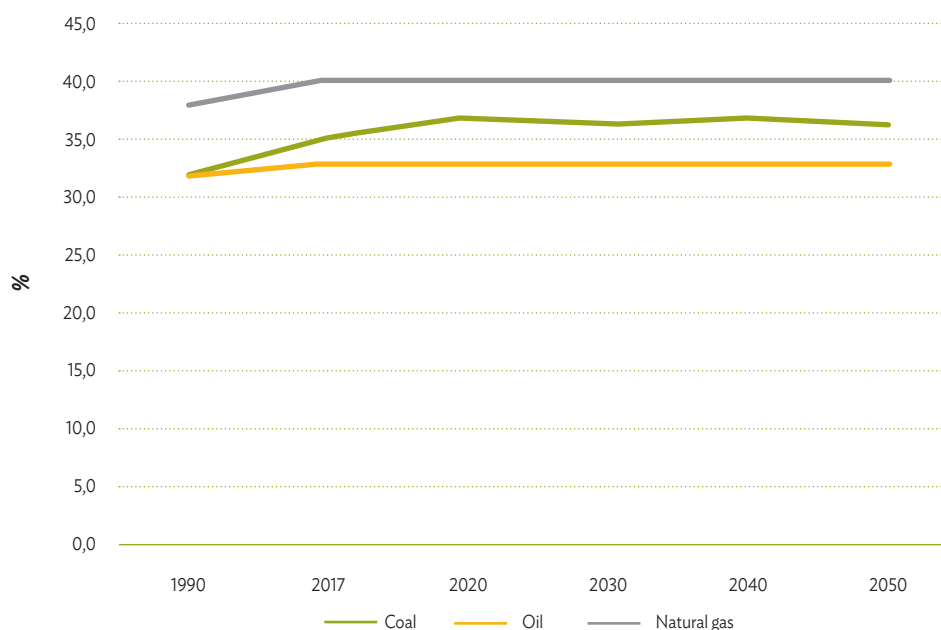


Hydro = hydropower.

Source: Author's calculation.

Under BAU, the thermal efficiency of coal power plants is expected to improve from 35.0% in 2017 to 36.4% in 2050. Over the same period, the thermal efficiency of oil power plants is projected to remain at 33.0%, and that of natural gas power plants will also remain at 40.0% (Figure 11.10).

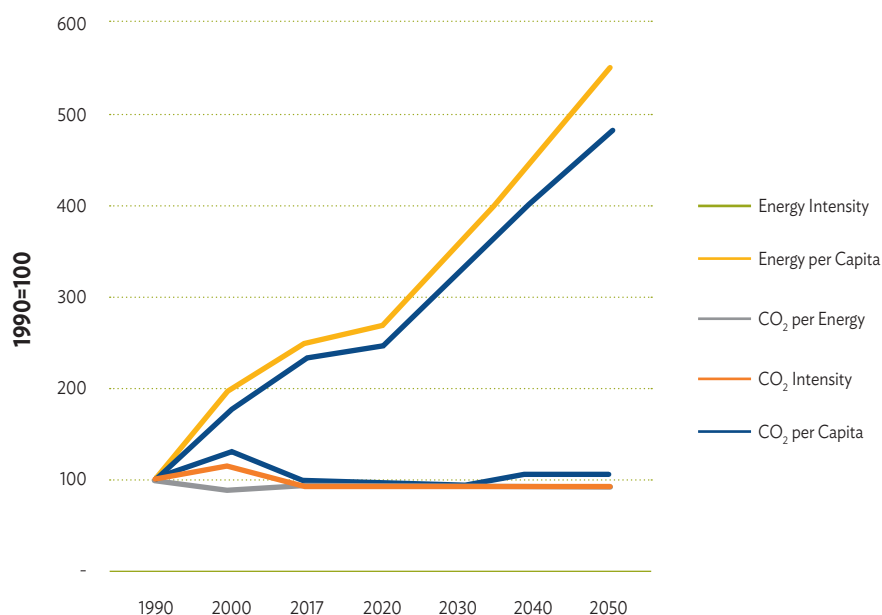
Figure 11.10. Thermal Efficiency by Fuel Type, Business as Usual (1990–2050)



Source: Author's calculation.

From 2017 to 2050, Malaysia's primary energy intensity is expected to increase from 224 tonnes of oil equivalent per million dollars (toe/\$ million) to 236 toe/\$ million, final energy intensity is expected to increase from 164 toe/\$ million to 177 toe/\$ million, and primary energy supply per capita is projected to increase from 2.62 toe/person to 5.73 toe/person (Figure 11.11).

Figure 11.11. Energy Indicators, Business as Usual (1990–2050)



CO₂ = carbon dioxide.

Source: Author's calculation.

From 2017 to 2050, it is expected that CO₂ intensity will decrease from 151 tonnes of carbon per million dollars (t-C/\$ million) to 150 t-C/\$ million, and CO₂ per primary energy will decrease slightly from 0.67 t-C/toe to 0.64 t-C/toe.

3.2 Alternative Policy Scenario

In the alternative policy scenario (APS), growth in final energy consumption will be at 3.1% per year from 2017 to 2050, slightly lower than BAU at 3.3% per year. The slower projected rate of increase in the APS would result from improvements in manufacturing technologies, as well as efforts to improve energy efficiency, particularly in the industry and 'others' sectors. Thus, savings of 16% in the industry sector could be expected in 2050. In the 'others' sector, the annual growth rate of energy consumption is projected to be 2.9%, slower than BAU at 3.4% in BAU. Potential savings of 16% in 2050 can be achieved through the implementation of energy efficiency measures (Figure 11.12).

Figure 11.12. Final Energy Consumption by Sector, Business as Usual and the Alternative Policy Scenario (2017 and 2050)

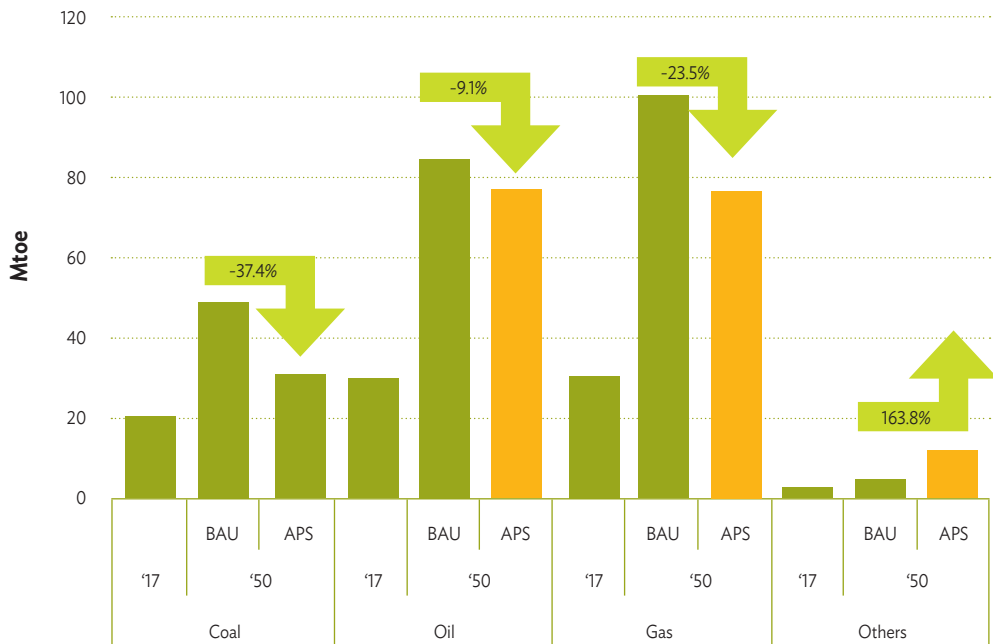


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

The TPES is projected to increase at a slower rate in the APS than in BAU, from 81.57 Mtoe in 2017 to 195.49 Mtoe in 2050, a 2.7% AAGR (Figure 11.13). Other sources (biomass, solar, and biofuels) will grow the fastest at an average rate of 11.2% per year. This is because the implementation of FiT, NEM, and LSS in power generation will significantly impact the primary energy supply by 2050, as more renewable energy for power generation is expected to be commissioned. Higher biodiesel blending rates will also contribute to this growth. Consequently, the renewable energy supply ('others') in the APS will be 163.8% higher than BAU by 2050. On the other hand, by 2050 coal in the APS will be 37.4% lower than under BAU due to the implementation of higher efficiency coal power plants. Coal is expected to increase at a rate of 1.4% per year in the APS, compared to 2.8% per year under BAU. Natural gas will grow at 2.8% per year in the APS, compared to 3.7% under BAU. As a result, by 2050, the primary natural gas supply will be 23.5% lower in the APS compared with BAU. Oil in the APS is expected to increase at 3.0% per year, compared to 3.3% per year under BAU. In 2050, the primary oil supply will decrease by 9.1% in the APS compared to BAU.

Figure 11.13. Primary Energy Supply by Fuel Type, Business as Usual and the Alternative Policy Scenario (2017 and 2050)



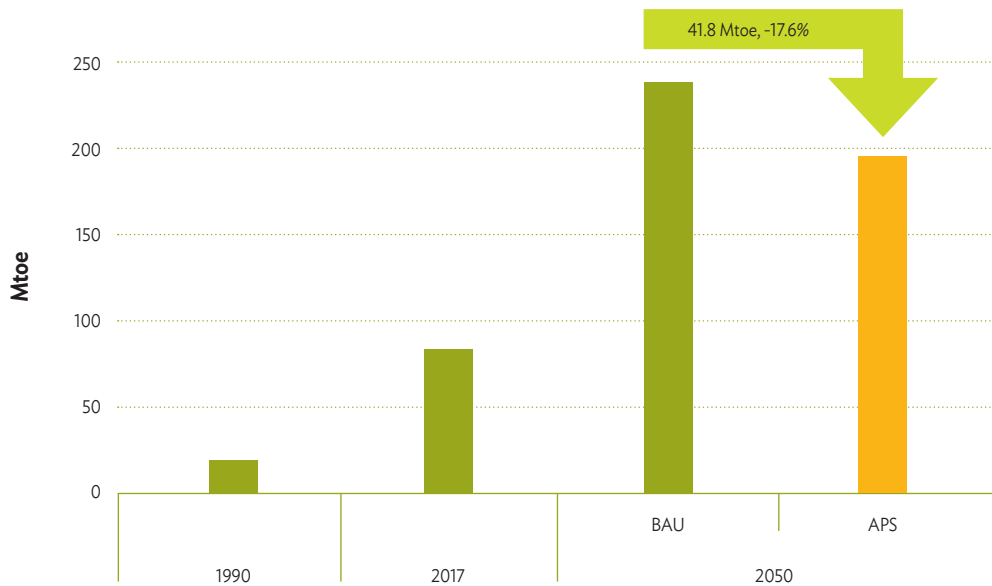
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.3 Projected Energy Savings

The potential energy savings can be obtained from the difference in total primary energy supply between BAU and the APS. These energy savings can be achieved by energy efficiency efforts in the industry and 'others' sectors, as well as through a more efficient thermal power supply. Potential energy savings of 41.8 Mtoe (17.6%) in 2050 can be achieved as indicated from the difference in TPES between BAU and the APS in 2050 (Figure 11.14).

Figure 11.14. Total Primary Energy Supply, Business as Usual and the Alternative Policy Scenario (2017 and 2050)



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

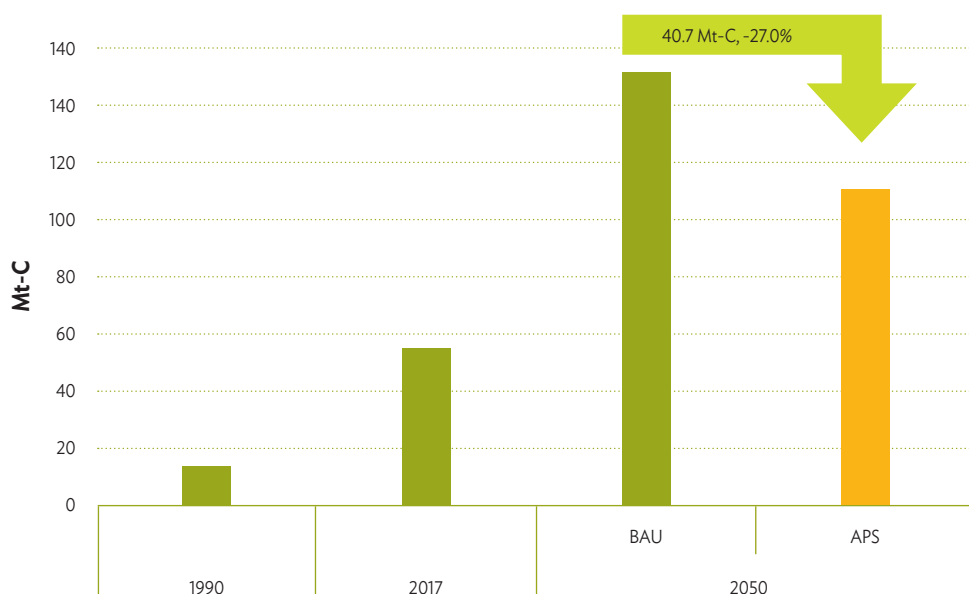
Source: Author's calculation.

Major savings can be achieved by switching from coal or natural gas to renewable energy such as biomass or solar, and total savings of 11.32 Mtoe in final energy consumption – comprising savings of 7.19 Mtoe in the industry sector and 4.12 Mtoe in the 'others' sector – can potentially be achieved in 2050.

3.4 Carbon Dioxide Emissions from Energy Consumption

Under BAU, total CO₂ emissions from energy consumption are projected to increase by 3.1% per year from 2017 to 2050. In 2017, the CO₂ level was at 55.0 million tonnes of carbon (Mt-C) and was expected to increase to 150.9 Mt-C by 2050 under BAU. In the APS, the annual increase in CO₂ emissions from 2017 to 2050 will be lower than BAU at 2.1% per year, consistent with the growth in the primary energy supply. This reduction of CO₂ emissions in the APS of 40.7 Mt-C (27.0%) relative to BAU is also due to a significant decrease in coal consumption for power generation in the APS, given the improved efficiency of the power plants. Further, coal consumption is being replaced by natural gas and renewable energy such as biomass, biogas, solar, and municipal solid waste. Lower energy usage in the industry and 'others' sectors has also contributed to this reduction. This indicates that Malaysia's energy-saving efforts and renewable energy action plan will be effective in reducing CO₂ emissions. Use of biodiesel in the transport sector will also help slow the growth of total CO₂ emissions (Figure 11.15).

Figure 11.15. Carbon Dioxide Emissions from Energy Combustion, Business as Usual and the Alternative Policy Scenario (2017 and 2050)



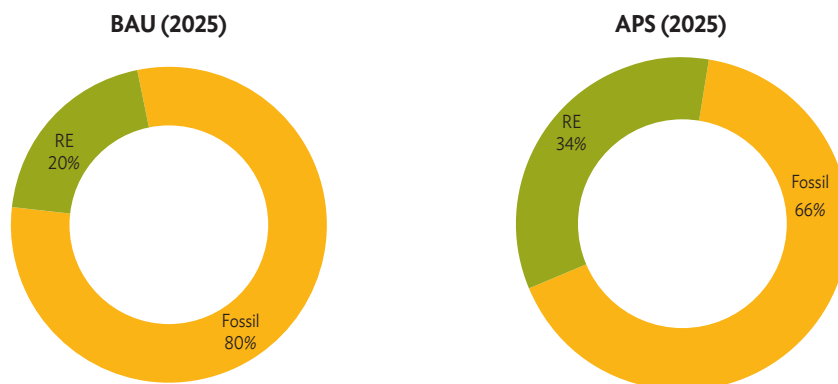
APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Author's calculation.

3.5 Policy Implications

The government target for renewable energy capacity (20% of total capacity) can be achieved under BAU. Based on the current development of renewable energy, this target will be met in 2025. However, the renewable energy capacity mix will be much higher under the APS at 34%

Figure 11.16. Generation Capacity Mix of Fossil Fuels versus Renewable Energy for Business as Usual and the Alternative Policy Scenario in 2025



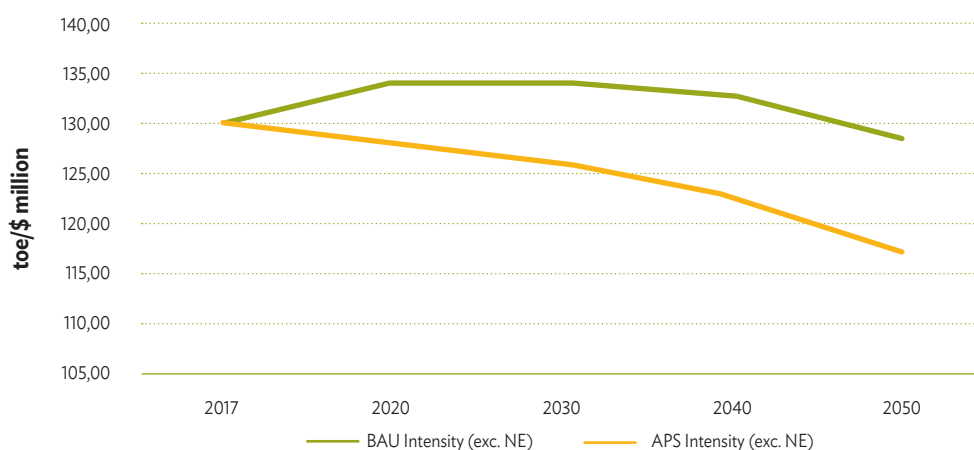
APS = alternative policy scenario, BAU = business as usual, RE = renewable energy.

Source: Author's calculation.

(Figure 11.16). This finding shows that Malaysia can achieve higher targets with respect to renewable energy capacity in long-term projections.

Malaysia has great energy saving potential under its energy efficiency measures. Based on the outlook results, under BAU, final energy intensity (excluding non-energy) will decrease by 0.94% from 2017 to 2050. Efforts such as the implementation of the newly proposed EECA can further reduce the final energy intensity. Under the APS, the final energy intensity (excluding non-energy) is projected to decrease by 9.6% from 2017 to 2050 (Figure 11.17).

Figure 11.17. Final Energy Intensity (Excluding Non-Energy) for Business as Usual and the Alternative Policy Scenario

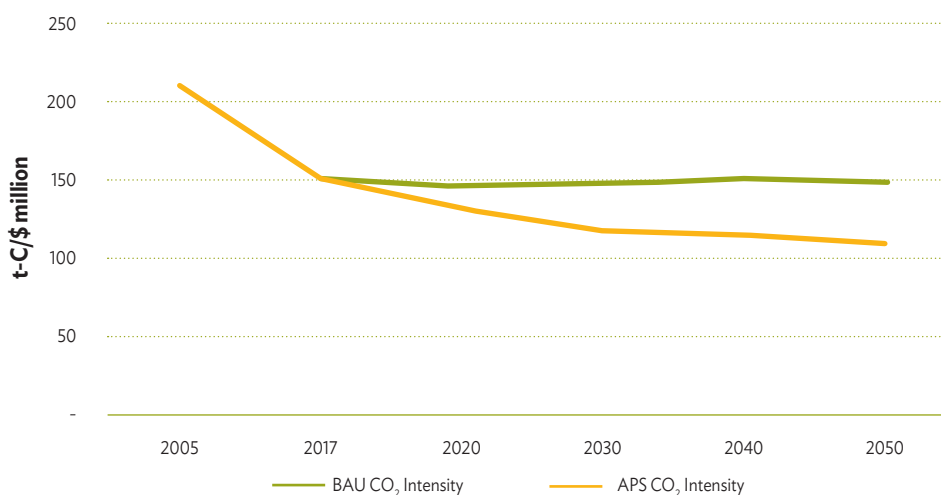


APS = alternative policy scenario, BAU = business as usual, toe = tonnes of oil equivalent, NE = non-energy.

Source: Author's calculation.

As pledged in its nationally determined contribution, Malaysia intends to reduce the greenhouse gas emissions intensity of GDP by 45% from 2005 to 2030. Of this 45%, 35% is unconditional, and the remaining 10% is conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries. At the 21st Conference of Parties to the UNFCCC, Malaysia reiterated its commitment to maintain at least 50% of the country under forest cover. Based on the outlook results, under BAU, Malaysia's CO₂ intensity will decline by 28.4% from 2005 to 2030. However, in the APS CO₂ intensity is expected to decline by 43.0% from 2005 to 2030 (Figure 11.18). This indicates that Malaysia will easily achieve its nationally determined contribution unconditional target under the APS.

**Figure 11.18. Carbon Dioxide Intensity
for Business as Usual and the Alternative Policy Scenario**



APS = alternative policy scenario, BAU = business as usual, CO₂ = carbon dioxide, t-c = tonnes of carbon.

Source: Author's calculation.

4. Conclusions

Under BAU, Malaysia's final energy intensity will continue to rise. Greater efforts to ensure energy efficiency are needed. If the current trend continues, Malaysia will spend more than necessary just to sustain the economy. Bold actions need to be taken to tackle issues of energy efficiency without sacrificing public welfare. Promising action plans and effective regulation can be good tools to address this issue.

This study sees no potential savings in the transport sector due to unclear targets for potential savings. The electric vehicles target is still very low and will not directly impact overall energy consumption in the transport sector. Moreover, the incremental consumption of electricity will increase electricity generation, with the supply possibly coming from coal. This will drive up CO₂ emissions. At present, old and inefficient vehicles can still use Malaysia's roads without restriction, and Malaysia continues to allow used internal combustion engine vehicles from abroad to enter its market.

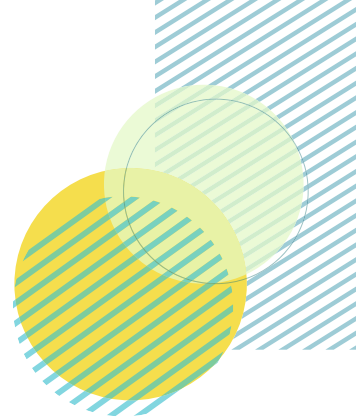
A clear and effective roadmap as well as energy action plans must be developed to reduce energy and carbon intensity. A successful energy action plan will require complete and detailed information, as well as smart strategies to enable all parties to contribute.

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CHAPTER 12

Myanmar Country Report



Tin Zaw Myint

1. Background

1.1 Country Profile

Myanmar is the largest country in mainland Southeast Asia, with a land area of 676,577 square kilometres (km) and a border 5,858 km long, which it shares 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 is utilised for agriculture. Myanmar had a population of 56 million in 2019 with an average annual population growth rate of 1.0% from 1990 to 2015.

Myanmar is located in the western part of the Indochina Peninsula and has three distinct seasons. It enjoys 3–4 months of heavy monsoon and abundant sunshine year-round, making it ideal for accumulating water resources 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 country's two major river systems enter the Bay of Bengal as well the 2,832 km coastal strip in the south are good areas for the development of marine ecosystems and an abundant source of marine products and chemicals.

Myanmar is endowed with rich natural resources for producing commercial energy. Currently, the available energy sources in Myanmar are crude oil, natural gas, hydropower, biomass, and coal. Wind energy, solar, geothermal, bioethanol, biodiesel, and biogas are other potential energy sources. In 2017, Myanmar's proven energy reserves comprised 105 million barrels of oil, 5.56 trillion cubic feet of gas, and 542.56 million metric tonnes 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 Socioeconomic Status

Myanmar's population grew at 1.0% per year from 41.3 million in 1990 to 52.4 million in 2015. Myanmar's gross domestic product (GDP) was \$70.5 billion in 2015, and its GDP per capita grew from around \$200 in 1990 to \$1,300 in 2015.¹ To enhance economic development in Myanmar, four short-term 5-year plans were formulated and implemented during 1992–2013. Under the first plan (1992–1995), GDP saw an average annual growth rate (AAGR) of 7.5%, followed by 8.5% under the second plan (1996–2000), 12.8% under the third plan (2001–2005), and 12.0% under the fourth plan (2006–2010). The most recent Myanmar Sustainable Development Plan (2018–2030) has been formulated to achieve an AAGR of 7.0% in GDP.

1.3 Energy Consumption in the Base Year

In 2017, Myanmar's total primary energy supply (TPES) was 20.12 million tonnes of oil equivalent (Mtoe). Natural gas is mainly used for electricity generation and in industry. In the power sector, Myanmar has 5,848 megawatts (MW) of installed generation capacity, and produced almost 22 terawatt-hours (TWh) of electricity in 2018. In the same year, thermal power (coal, natural gas, and oil) accounted for 44% of total electricity generation and hydropower accounted for 56%.

Table 12.1. Installed Capacity and Power Generation by Fuel Type, 2018–2019

	Type of Fuel		
		Installed (MW)	Generation (GWh)
1	Hydropower	3,259	12,395
2	Gas and steam	2,352	9,294
3	Coal	120	
4	Diesel	117	562
Total		5,848	22,298

GWh = gigawatt-hour, MW = megawatt.

Source: Myanmar Ministry of Electricity and Energy.

¹ All United States dollars in this report are in constant 2010 values unless specified.

2. Modelling Assumptions

2.1. Gross Domestic Product and Population Growth

Based on data from the Ministry of Labour, Immigration and Population, this report assumes that Myanmar's GDP will grow at an average annual rate of around 5.8% from 2017 to 2050, slowing from 9.1% during 1990–2015. The population is assumed to increase by about 0.71% per year from 2017 to 2050.

2.2. Energy Consumption and Electricity Generation

Hydropower and natural gas dominate the electricity generation mix in Myanmar; other fuels such as oil and coal contributed less than 13% in 1990. The government plans to increase the share of natural gas, coal, hydropower, and other renewables further and decrease that of oil. Myanmar also plans to export electricity from its hydropower plants to neighbouring countries such as Thailand and China.

Myanmar's yearly plan for the construction of power plants from 2018 to 2022 (Table 12.2) mostly covers gas-based power plants (including liquefied natural gas), along with some hydropower and solar power plants. The yearly plan excludes coal-based power plants, of which the country currently has 120 MW of installed capacity.

Based on the Energy Masterplan of Myanmar, three scenarios are considered (Table 12.3).

In this masterplan, the shares differ between scenarios. The lowest are seen in the power resource balance scenario (Scenario 3), under which total installed capacity will reach 23,594 MW by 2030, with hydropower accounting for 38%, coal 33%, and gas 20% of the total, with the remaining 8% provided by renewables (such as solar and wind).

Table 12.2. Yearly Plan for the Construction of Power Plant Projects
(MW)

No.	Project Name	2018	2019	2020	2021	2022	Total
1	Thahtone CCGT (World Bank)	118					
2	MyinGyan CCGT (Sembcorp)	225					
3	Minbu Solar (Green Earth)		40	40	40	50	
4	Baelin Gas Engine (Rental)		135				
5	Myingyan Gas Engine		90				
6	Myanaung Gas Engine (Japan Grant)			20			
7	Pahtoelon CCGT (JICA)			12			
8	Ahlon LNG to Power (Toyo Thai)			356			
9	Kyaukphyu CCGT (Sinohydro)			135			
10	Melaunggyaing LNG to Power (Zhefu)				1,390		
11	Kanbauk LNG to Power (Total and Siemens)				820	410	
12	Ywama (W.B.) (gas)				150	75	
13	Upper Kyaingtaung (hydropower)				51		
14	Upper Yeywa (hydropower)				280		
15	Middle Paunglaung (Energize)					152	
16	Dee Dote (Andritz)					60	
Total		343	265	563	2,731	747	4649

CCGT = combined cycle power plant, JICA = Japan International Cooperation Agency, LNG = liquefied natural gas.

Source: Department of Electric Power Planning, Myanmar Ministry of Electricity and Energy.

Table 12.3. Installed Capacity and Power Supply in Three Scenarios for 2030

	Scenario 1 (Domestic energy consumption)			Scenario 2 (Least cost)		Scenario 3 (Power resource balance)	
	Energy resources	Installed capacity		Installed capacity		Installed capacity	
		(MW)	%	(MW)	%	(MW)	%
1	Hydropower (large)	12,147	42	12,147	43	1,412	6
2	Hydropower (small and medium)	6,891	24	6,891	24	7,484	32
3	Gas	4,986	17	2,484	9	4,758	20
4	Coal	2,760	10	5,030	18	7,940	34
5	Renewable	2,000	7	2,000	7	2,000	8
Total		28,784		28,552		23,594	

MW = megawatt.

Source: Myanmar Energy Master Plan.

2.3. Energy and Climate Change and Environmental Policies

Myanmar's energy policy generally strives to maintain energy independence by increasing indigenous production of available primary energy resources through intensive exploration and development activities. It 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. It also advocates the utilisation of water resources, a renewable resource for generating electricity, to save non-renewable sources of energy such as fossil fuels for alternative and future use. Energy efficiency and conservation is emphasised to save energy through effective energy management and reduce energy consumption so as to minimise harmful environmental impacts. Use of new and renewable energy sources is encouraged, especially solar and wind, which are abundant in Myanmar. The policy also accepts that people will still need to use traditional energy sources such as wood and charcoal. Regulations and anticipatory actions are necessary to sustain the harvesting of these primary energy sources.

Myanmar can save energy by implementing energy efficiency programmes in all energy-consuming sectors. In the industry sector, improved manufacturing technologies are expected to generate energy savings of at least 14% from BAU by 2020. In the residential and commercial ('others') sector, efficient end-use technologies and energy management systems are also projected to yield significant savings. In the transport sector, improved vehicle fuel economy and more effective traffic management will improve efficiency.

Although Myanmar still lacks a national strategy and action plan for mitigating and adapting to climate change, several ministries have been implementing sector-specific initiatives relevant to climate change. The government is already encouraging the use of biofuel in the transport and agriculture sectors to reduce oil dependency and curb carbon dioxide (CO₂) emissions, although the amount of biofuel used in the country remains low. The Ministry of Electricity and Energy (MOEE) has initiated a Clean Fuel Program to reduce CO₂ emissions by increasing the use of natural gas in the industrial sector and for power generation; this includes converting gasoline, diesel, and liquefied petroleum gas (LPG) vehicles to compressed natural gas vehicles.

The Ministry of Natural Resources and Environmental Conservation, formerly the Ministry of Forestry, and the designated national clean development mechanism authority, has submitted one hydropower project to the United Nations Framework Convention on Climate Change for consideration. The National Environmental Conservation Committee was formed in 2004 and

re-formed in April 2011, replacing the National Commission for Environmental Affairs, and now serves as the focal organisation for environmental matters. It is chaired by the Ministry of Natural Resources and Environmental Conservation, and its membership includes 19 ministries.

The Environmental Conservation Law enacted in March 2012 provides a legal basis for implementing a range of enhanced environmental management measures. In addition, a draft Environmental Conservation Rule, containing regulations and technical guidelines and creating enabling conditions for their effective implementation, is being drawn up and will be submitted to the authorised body.

2.4 National Efficiency Policies

According to the 2015 Asian Development Bank report 'National Energy Efficiency and Conservation Policy, Strategy and Roadmap of Myanmar', electricity consumption in all sectors and achievable energy saving potential should reach 12% by 2020, 16% by 2025, and 20% by 2030. In the industry sector, the energy savings are expected to reach 5.34% in 2020, 5.31% in 2025, and 6.63% in 2030. In the commercial sector, savings are expected to reach 1.99% in 2020, 2.98% in 2025, and 3.98% in 2030. In the residential sector, savings are expected to reach 0.68% in 2020, 1.02% in 2025, and 1.36% in 2030; and in the 'others' sector, savings are expected to reach 0.68% in 2020, 1.02% in 2025, and 1.36% in 2030. Relative to 2012, biomass savings should reach 2.3% in 2020, 5.0% in 2015, and 7.0% in 2030.

These goals can be achieved through the following strategies. For the residential sector, (i) introduce energy efficiency performance standards and labelling for appliances, testing and certification facilities for appliances; (ii) introduce incentives for energy efficiency equipment; (iii) phase out inefficient appliances from the market; (iv) promote efficient biomass cooking stoves; (v) increase consumer awareness of the benefits of using LPG for cooking; (vi) introduce an energy efficiency labelling scheme for LPG cooking stoves; and (vii) conduct regular energy efficiency awareness campaigns in the national media. For the commercial sector, the activities include (i) energy audits, (ii) energy performance standards for appliances, (iii) the incorporation of energy efficiency in the design of new buildings, (iv) the implementation of an energy efficiency building code and refurbishment guidelines, and (v) energy efficiency guidelines for commercial buildings.

Under Action Plan 2018–2021, harmonised energy efficiency performance standards for air conditioning units and lighting will be implemented and implementation activities conducted

step by step. The following measures are also considered important to achieve these goals:

- (i) high-efficiency lighting and refrigeration, and cooking with LPG in the residential sector;
- (ii) cogeneration; energy-efficient boilers, kilns, and motors; and waste heat recovery in the industrial sector; and
- (iii) high-efficiency lighting and air conditioning units, cooking with LPG, solar water heating, standard labelling equipment of appliances, and light-emitting diode lights in the commercial sector.

2.5 Internationally and Nationally Determined Contributions

Mitigation actions and policies in the energy sector include the following:

- (i) Renewable energy—including mini-hydropower; biomass; and solar, wind, and solar minigrid technologies—should account for 30% of electricity in rural areas.
- (ii) Approximately 260,000 energy-efficient cooking stoves should be distributed to encourage clean cooking and heating during 2016–2031.
- (iii) Hydropower should generate 9.4 gigawatt-hours of electricity by 2030.
- (iv) Energy efficiency should contribute to electricity savings of 20% of the total forecast electricity consumption by 2030.
- (v) Renewable energy—including small and mini-hydropower, biomass (rice husk and municipal solid waste), wind, and solar—should account for 12% of the national energy mix (>2000 MW) by 2030.

2.6 Alternative Policy Scenarios

Previous studies have formulated two scenarios to analyse the impact of policy interventions on the energy sector: BAU, which serves as the reference case to project energy demand and CO₂ emissions; and the alternative policy scenario (APS), which makes it possible to evaluate the impacts of policy interventions on the development and utilisation of energy resources in the country. The APS includes policies to increase energy efficiency and conservation targets, expedite the penetration of new and renewable energy, and introduce cleaner technology, including an option for nuclear power plants. To understand the impact of individual policy interventions further, this year's study formulated the following five APSs:

- (i) APS 1: greater energy efficiency of final energy consumption;
- (ii) APS 2: more efficient thermal electricity generation;
- (iii) APS 3: higher contribution of new and renewable energy (electricity generation and biofuels in the transport sector are assumed);

- (iv) APS 4: the introduction or higher contribution of nuclear energy; and
- (v) APS 5: the combined impact of APSs 1, 2, and 3.

As Myanmar has no plan to introduce nuclear energy for power generation, this analysis does not consider APS 4; thus, APS 5 only includes APSs 1, 2, and 3. In APS 3, which includes more renewable energy in Myanmar's power generation mix by 2030, the additional installed capacity of coal- and gas-based power plants is replaced by renewable energy capacity, including that of hydropower plants. Beside the APSs, this study also considers the emission plans and targets of East Asia Summit member countries under the internationally and nationally determined contributions for the energy sector.

3. Outlook Results

3.1. Business as Usual Scenario

3.1.1 Final Energy Consumption

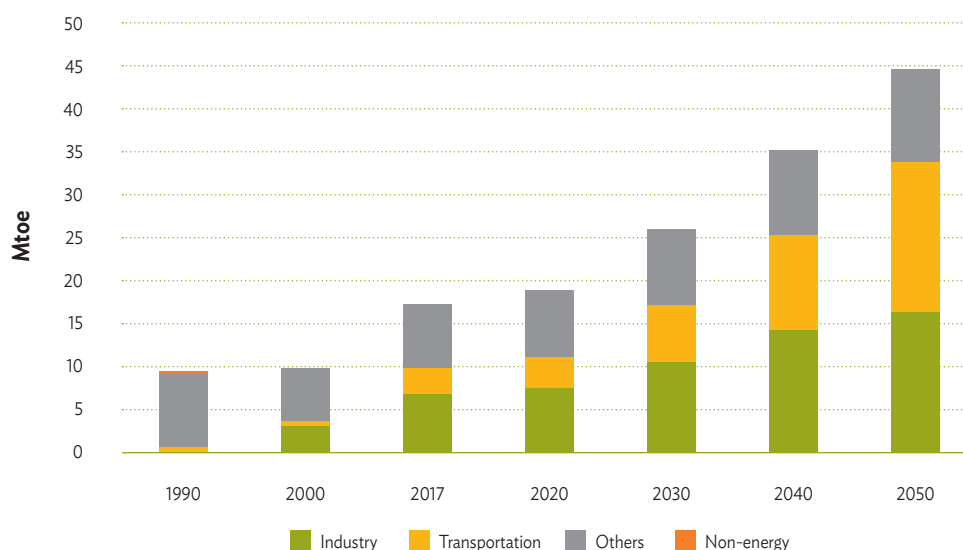
Myanmar's total final energy consumption (TFEC) increased by about 2.3% per year from 9.4 Mtoe in 1990 to 17.46 Mtoe in 2017. The transport sector grew the fastest with an AAGR of 7.5% between 1990 and 2017. Consequently, this sector's share of the TFEC increased from around 4.7% in 1990 to almost 17.8% in 2017. Industry was the second fastest growing sector, with an AAGR of 11.2% over the same period, from 4.2% in 1990 to 39.5% in 2017.

The 'others' sector, which comprises the commercial, residential, and agricultural sectors, was the largest contributor to the TFEC. However, this sector's share declined from 90.1% in 1990 to 42.8% in 2017, indicating that annual demand growth in this sector was slower than in industry and transport. The AAGR of the demand in this sector decreased by 0.5% between 1990 and 2017.

Based on these socioeconomic assumptions, final energy consumption in Myanmar is projected to grow at an annual rate of 2.9% under BAU to 44.70 Mtoe in 2050. The transport sector is still projected to experience the fastest growth in final energy consumption during 2017–2050, but this growth rate is lower than in 1990–2015. The final energy consumption of the transport sector will increase at an average rate of 5.4% per year, while demand in the industry sector will grow at a rate of 2.7% per year. In the 'others' sector (mainly the residential and commercial sectors), final energy demand is projected to grow at an annual

average rate of 1.1%, slower than in the past. This is mainly because of reduced demand for biomass, which represents the majority of the fuel consumed by this sector. Figure 12.1 shows the final energy consumption by sector to 2050 under BAU.

Figure 12.1. Final Energy Consumption by Sector, Business as Usual



Mtoe = million tonnes of oil equivalent.

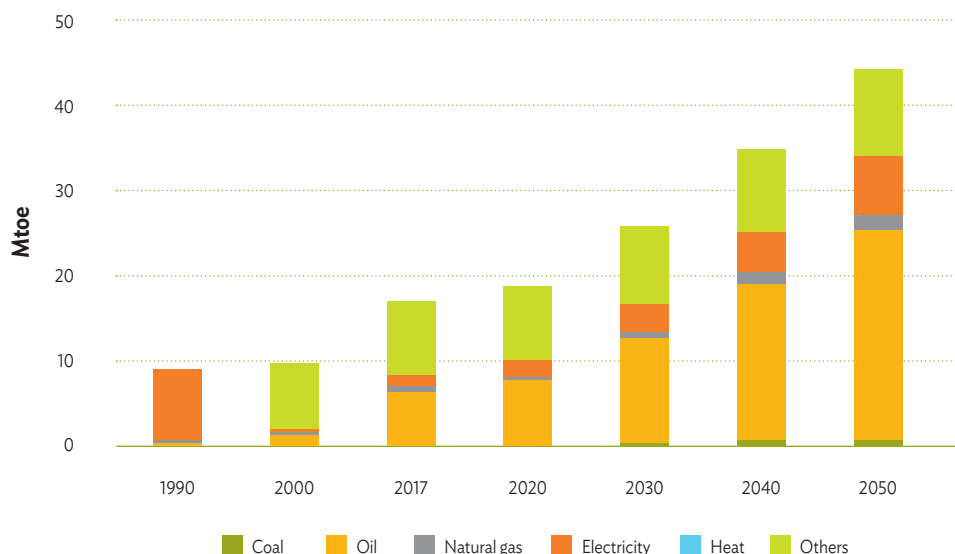
Source: Author's calculation.

Sector growth under BAU will result in the continuous increase of the transport, industrial, and non-energy sector shares in the TFEC, and a decline in that of the 'others' sector. The share of the transport sector is projected to increase to 39.1%, and that of the industrial sector to 36.6% in 2050. Meanwhile, the 'others' sector share will decline from 42.8% in 2017 to around 24.4% in 2050.

By fuel type, 'others' (mostly biomass) was the most consumed fuel in 1990, accounting for 89.2% of the TFEC of the country. Its share decreased to 50.3% in 2017 due to the increased growth of other fuels. From 1990 to 2017, natural gas demand increased from 0.23 Mtoe to 0.43 Mtoe, while oil demand increased from 0.59 Mtoe to 6.50 Mtoe over the same period, an AAGR of 9.3% (the fastest of all the fuel types).

Under BAU, the share of 'other' fuels will decline to 22.5% by 2050, indicating that its future use will grow more slowly than that of other fuels. In contrast, the share of oil will continue to increase, from 37.2% in 2017 to 55.7% in 2050, an AAGR of 4.2%. This is because of the rapid increase in transport sector activities from 2017 to 2050. Figure 12.2 shows final energy consumption by fuel type to 2050 under BAU.

Figure 12.2. Final Energy Consumption by Fuel, Business as Usual



Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

From 2017 to 2050, coal is projected to see an AAGR of 4.0%, slower than that of natural gas at 3.8%; while electricity demand will grow the fastest at an AAGR of 4.9%, from 8.4% to 16.1%.

3.1.2 Primary Energy Supply

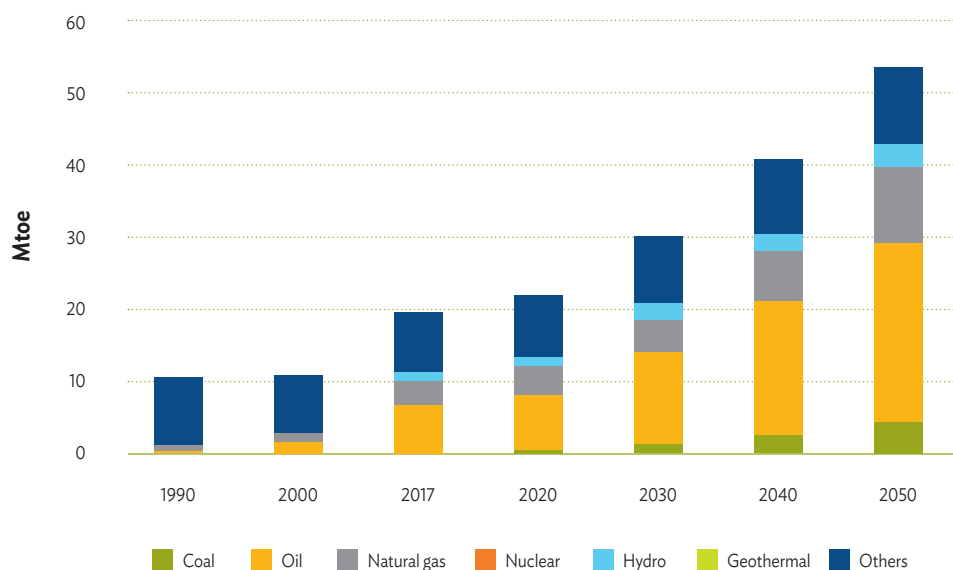
Primary energy supply in Myanmar grew at an average annual rate of 2.4% from 10.68 Mtoe in 1990 to 20.12 Mtoe in 2017. Among the major energy sources, the fastest growing were hydropower and oil, with AAGRs of 9.1% (hydropower) and 8.4% (oil). Over the same period, natural gas consumption grew at an average annual rate of 5.6%, and coal consumption increased by 8.0% per year, on average. 'Other' fuels, such as biomass, dominated the primary energy supply mix in 2017, with a 43.0% share, followed by oil with 32.4%, and natural gas with 16.5%.

Under BAU, Myanmar's primary energy supply is projected to increase at an annual average rate of 3.0% per year to 53.95 Mtoe in 2050. From 2017 to 2050, it is expected that hydropower will grow at an average annual rate of 3.4%, natural gas at 3.5%, coal at 6.9% (the fastest), and oil at 4.1%.

From 2017 to 2050, the share of oil in Myanmar's total primary energy mix will increase from 32.4% to 46.2%, and that of hydropower from 5.4% to 6.0%. The share of coal will also

increase from 2.7% to 9.0%, and that of natural gas from 16.5% to 19.1%. Notably, the share of biomass will decrease from 43.6% to 19.6% due to its slow growth, which is driven by the growth of the rural population.

Figure 12.3. Primary Energy Supply by Source, Business as Usual



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

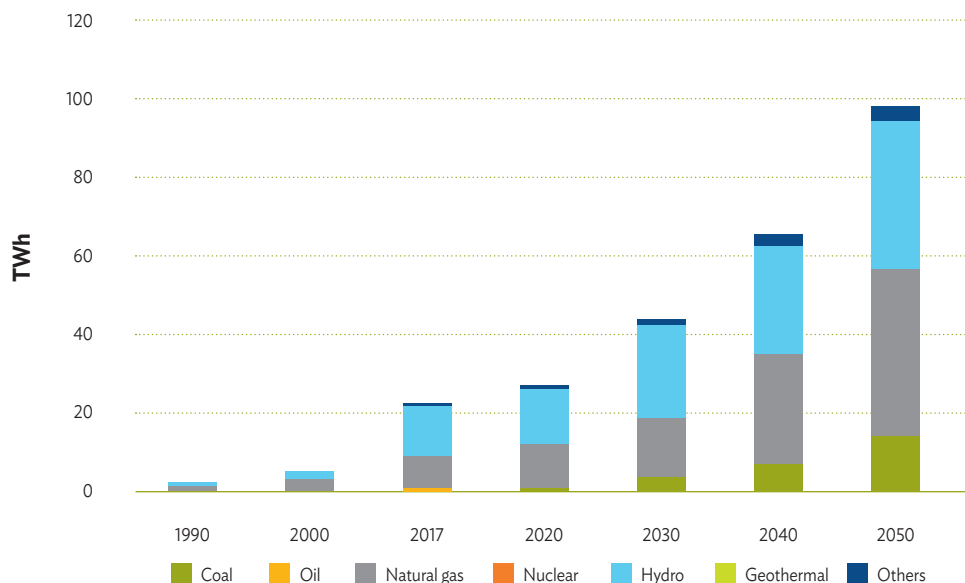
Source: Author's calculation.

Power Generation

Hydropower and natural gas dominate Myanmar's power sector fuel mix. In 2017, the share of hydropower in the power generation mix reached 59.0%, while that of natural gas was 39.0%. The remaining 2.0% was accounted for by coal and oil.

Under BAU, oil-based power plants will cease operating by 2030 while both hydropower and natural gas will continue to contribute to the power sector mix. However, their shares will change: hydropower-based power plants will have a 38.0% share while that of natural gas will be 43.0%. The other fuel types will increasingly play a role in the future. The share of coal-based power generation will increase to 15% of the total fuel mix by 2050, becoming the dominant power generation sector, while other renewables (solar, wind, and biomass) will reach 4%. Total electricity generation will grow at an average annual rate of 4.7% over 2017–2050, with natural gas-based power plants growing at an average annual rate of 5.1%.

Figure 12.4. Power Generation Mix, Business as Usual



Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation.

Hydropower generation will increase but at a slower average annual rate of 3.4% over the same period.

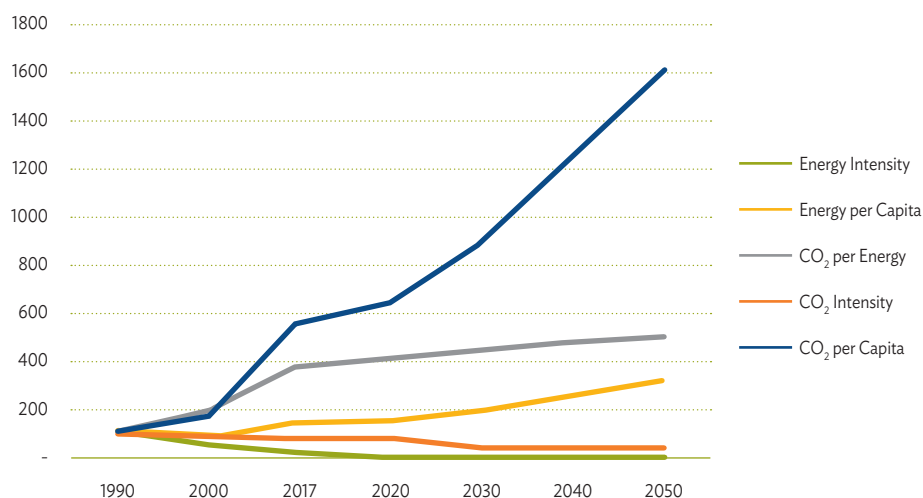
3.1.3 Energy Intensity, Energy per Capita, and Energy Elasticity

Myanmar's primary energy intensity (TPES/GDP) has been declining since 1990. In 2017, the primary energy intensity was 253.1 tonnes of oil equivalent per million dollars (toe/\$ million), lower than 1990 when it was 1,333 toe/\$ million. It is projected that the intensity will continue to decrease to 105.6 toe/\$ million by 2050 at an average rate of 3.0% per year. Energy consumption per capita grew from 0.3 toe in 1990 to 0.4 toe in 2017, and will increase to 0.8 by 2050, an AAGR of 2.3%. CO₂ intensity decreased from 140 tonnes of carbon per million dollars (t-C/\$ million) in 1990 to 100.3 t-C/\$ million in 2017, and is projected to decrease to 55.6 t-C/\$ million by 2050, at an AAGR of -1.7%. Figure 12.5 shows the evolution of these energy indicators from 1990 to 2050.

3.2 Energy Saving Potential (Alternative Policy Scenario)

The APSs were analysed separately to determine the individual impacts of the policy interventions assumed in APSs 1, 2, and 3. The combination of all these policy interventions was further analysed in APS 5. Figure 12.6 shows the changes in TPES in all of the scenarios.

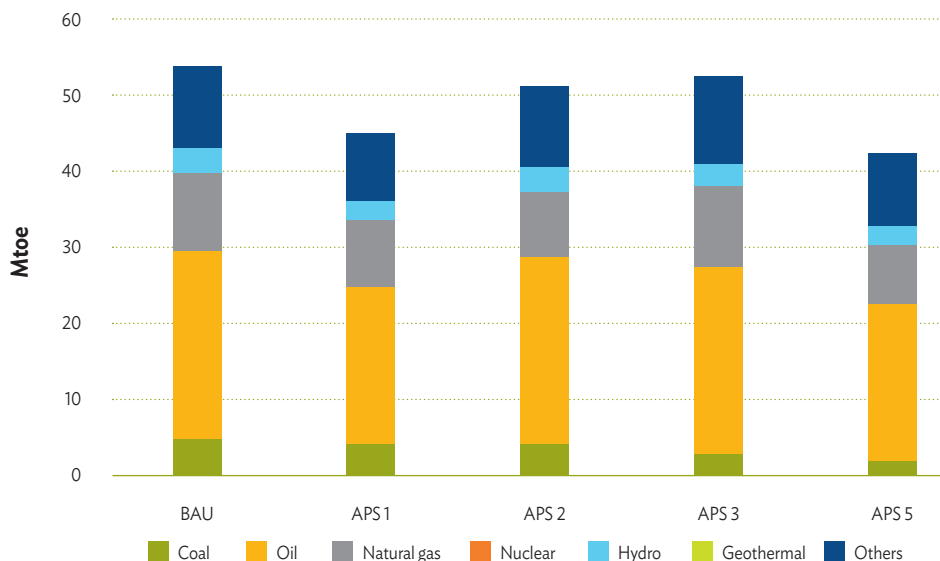
Figure 12.5. Energy Intensity, Carbon Dioxide Intensity, and Energy per Capita



CO₂ = carbon dioxide.

Source: Author's calculation.

Figure 12.6. Comparison of Scenarios to Total Primary Energy Supply by 2050



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

Source: Author's calculation.

In Figure 12.6 above, APS 5 sees the largest reduction in TPES due to the implementation of energy efficiency and conservation action plans, improved thermal efficiency of fossil-fueled power plants, and higher penetration of new and renewable energy in the country's supply mix. The AAGR of the TPES under APS 5 will be around 1.8% over the projection period. In 2050, the primary energy supply in APS 5 will be reduced by 11.24 Mtoe (20.8%) from BAU.

Individually, the implementation of energy efficiency targets and a masterplan as defined in APS 1 will reduce Myanmar's TPES by 7.69 Mtoe or 14.2% in 2050 compared to BAU. The AAGR of the primary energy supply in APS 1 will be 2.5%, higher than in APS 5. APS 2, which assumes greater efficiency in thermal electricity generation, will reduce the TPES by 2.51 Mtoe, or 4.6% compared to BAU. The country's TPES under APS 2 will grow at an annual average rate of 2.9%, slightly slower than under BAU. Since no final energy consumption efficiency measures were assumed for APS 2, the impact on the primary energy supply will be lower than in APS 1 or APS 5. Of all the fossil fuels considered, the implementation of greater efficiency in thermal power generation will reduce the use of coal and natural gas for power generation. For coal use in the power sector, thermal efficiency could reduce coal consumption by almost 15% from BAU to the APS.

Implementation of a policy to encourage higher penetration of new and renewable energy will also reduce the TPES compared to BAU by 1.03 Mtoe or 2%. By fuel type, coal consumption will decline while use of renewable energy will increase by 7.69 Mtoe or 65%. Implementing policy interventions will also impact the country's power generation capacity. Figure 12.7 shows the total electricity generation in 2050 in all scenarios. In APSs 1 and 5, lower electricity demand will reduce power generation by 14.55 Mtoe or 15% compared to BAU. This reduction will come from natural gas, coal, and hydropower plants, with the highest reduction from coalpower plants (12.54 Mtoe in APS 1 and 4.79 Mtoe in APS 5).

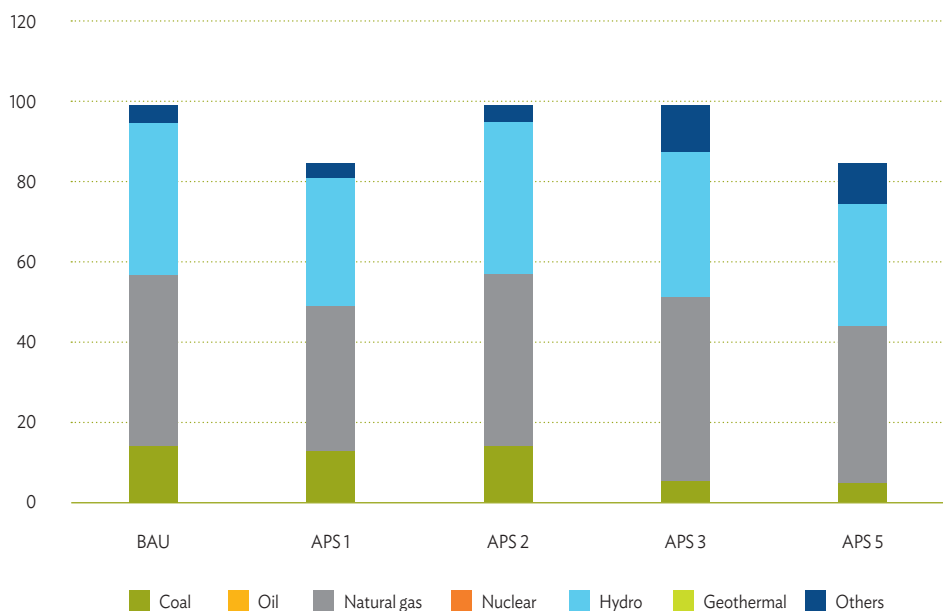
Under APSs 2 and 3, the total amount of electricity generated will be similar to BAU because no efficiency measures were imposed on the final energy consumption sector. However, the differences lie in the power generation fuel mix under APS 3. More renewable power plants using 'other' sources such as solar, wind, and biomass will be in operation over the planning period.

In terms of CO₂ emission reduction, energy efficiency in APS 5 is expected to reduce emissions by around 22.8 million tonnes of carbon (Mt-C), a decrease of 20% from BAU. This indicates that the energy saving goals, action plans, and policies, including switching to less carbon-intensive technologies such as renewable sources in the supply mix, will be effective in reducing CO₂ emissions. Figure 12.8 shows the projected CO₂ emissions in 2040 in all scenarios.

In APS 1, the TFEC will be lower, reducing CO₂ emissions from energy consumption to 23.8 Mt-C, a reduction of around 15 Mt-C, and an around 38% decrease compared to BAU. In APS 3, higher contributions from renewable energy could reduce emissions by 27% compared

to BAU. Total CO₂ emissions under APS 3 will be around 28.6 Mt-C. This decrease in CO₂ indicates that increasing renewable energy shares in the total supply will reduce CO₂ emissions further.

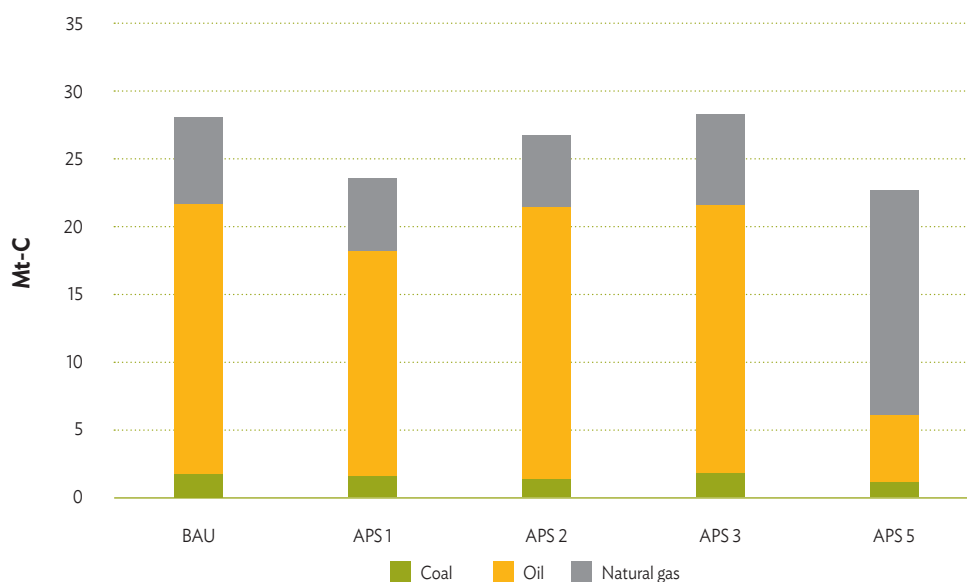
Figure 12.7. Comparison of Scenarios of Electricity Generation by 2050



APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation.

Figure 12.8. Comparison of Scenarios of Carbon Dioxide Emissions by 2050



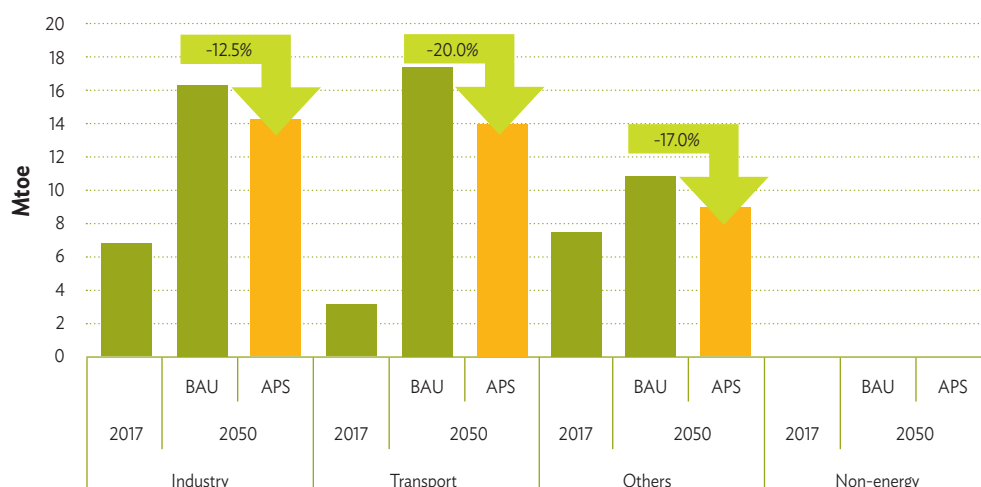
APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Author's calculation.

3.2.1 Final Energy Consumption

In APS 5, final energy consumption is projected to grow at a lower average annual rate of 2.3%, compared to the 2.9% annual growth under BAU. This is the result of technological improvement in manufacturing processes and a reduction in final energy consumption of electricity and oil in the residential and commercial ('other') sector. Figure 12.9 shows the differences in final energy consumption in 2050 by sector under BAU and in the APS.

Figure 12.9. Final Energy Consumption 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's calculation.

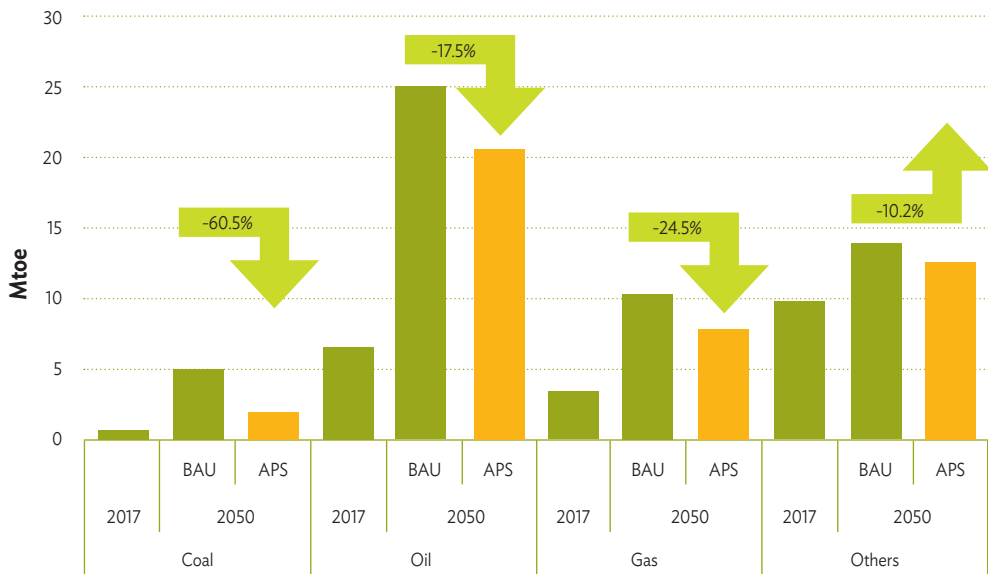
Primary Energy Supply

In the APS, Myanmar's primary energy supply is projected to increase at a slightly lower rate compared to BAU from 20.12 Mtoe in 2017 to 42.71 Mtoe in 2050, an AAGR of 1.8%. From 2017 to 2050, it is expected that coal will grow the fastest at 3.9% per year, followed by oil at 3.5%, hydropower at 2.7%, and natural gas at 2.6%. Figure 12.10 shows the primary energy supply by source in 2050 under BAU and in the APS.

Projected Energy Savings

In Myanmar, commercial energy consumption is projected on the basis of the energy requirements of major sectors (industry, transport, and agriculture)). Choice of fuel type is determined by available supply, since energy demand must be met mainly by domestic

Figure 12.10. Primary Energy Supply by Source, Business as Usual and the Alternative Policy Scenario



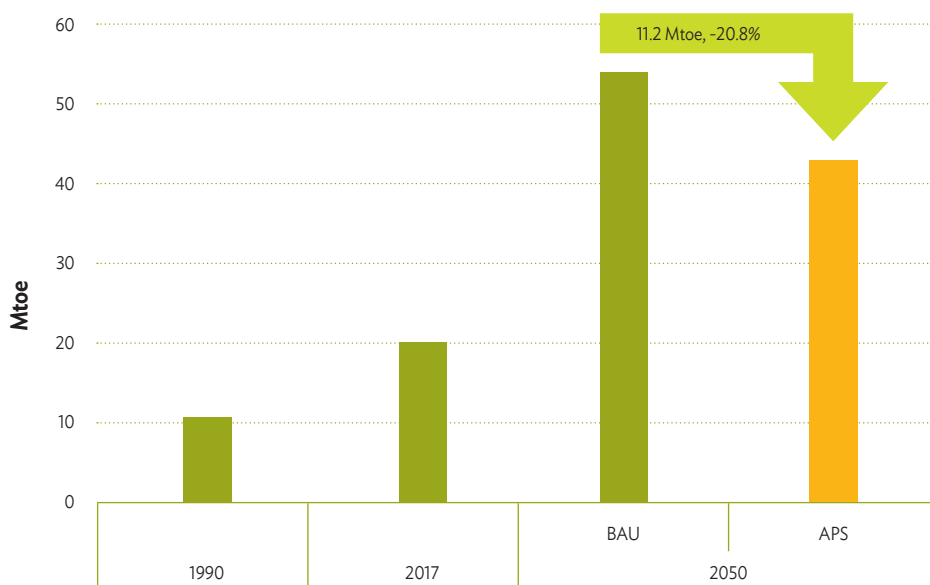
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

sources. Although there is a gap between demand and supply, demand is much higher than the actual requirement. Due to these constraints, coefficients derived from time series regression are applied to allocate energy. These allocations are made in accordance with the priorities of state organisations and enterprises. For the private sector, allocations are made in accordance with the registered licensed capacity of the firm.

Future energy savings can be achieved through savings in the primary energy supply in the residential, commercial, transport, and industrial sectors. To this end, Myanmar has implemented a range of energy efficiency and conservation goals and action plans targeting energy savings in all sectors of the economy and in cooperation with both the private and public sectors. These will yield estimated savings of 11.2 Mtoe by 2050 in the APS, relative to BAU, equivalent to 20.8% savings in the primary energy supply by 2050 under BAU (Figure 12.11). Myanmar also plans to limit the growth of the primary energy supply by implementing a range of energy efficiency and conservation measures on the demand side.

Figure 12.11. Evolution of Primary Energy Supply, Business as Usual and the Alternative Policy Scenario



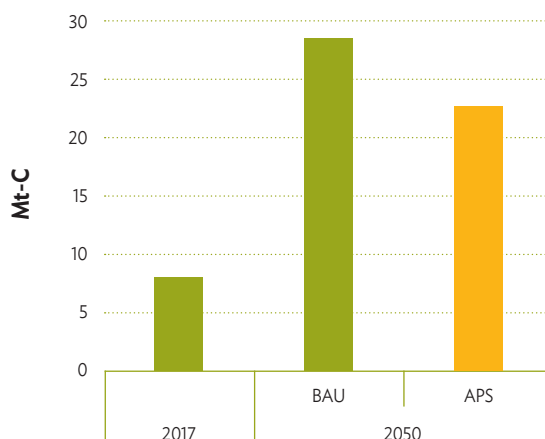
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Study outcome.

3.2.2 Carbon Dioxide Reduction Potential

In the APS, Myanmar's energy efficiency policy is projected to reduce the growth in CO₂ emissions from energy consumption. By 2050, in the APS, CO₂ emissions from energy consumption are projected to reach about 5.6 Mt-C, about 19.8% less than BAU (Figure 12.12).

Figure 12.12. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and the Alternative Policy Scenario



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

Source: Study outcome.

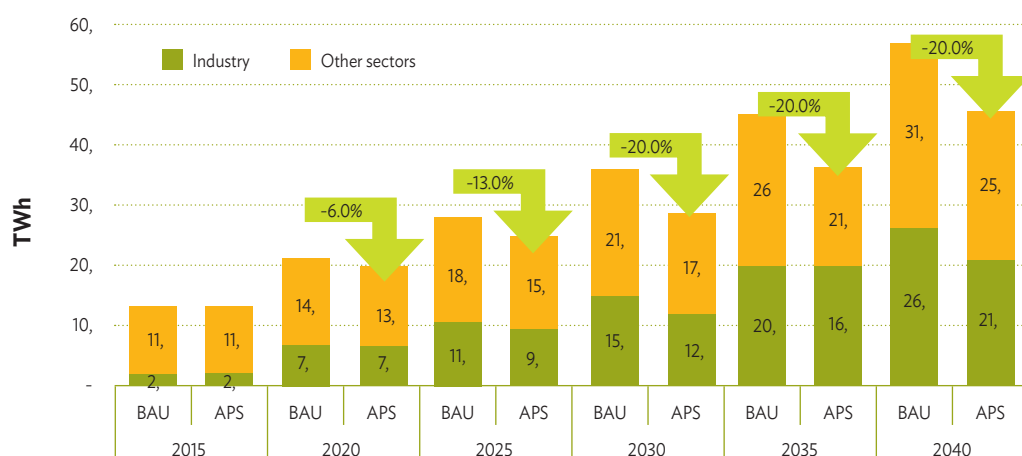
3.3 Internationally and Nationally Determined Contributions

The current energy outlook model considers the mitigation actions and policies of Myanmar in the energy sector, as specified above. These include potential savings of 12% with respect to electricity and 20% in the transport sector by 2050. The following energy sector mitigation actions and policies are represented in the APS:

- (i) Energy savings in various final sectors (industry, transport, residential, commercial, and others) as a result of the introduction of more efficient technologies (APS 1). These savings were projected as follows:
 - (a) a 12% reduction in electricity demand compared to BAU,
 - (b) 20% savings in the oil sector compared to BAU, and
 - (c) a 7% reduction in biofuel demand compared to BAU.
- (ii) The introduction of high-efficiency technologies for fossil fuel use in the power sector (APS 2).
- (iii) An increased share of renewable energy in the power generation mix (APS 3), with solar, wind, and biomass (excluding hydropower) at 12.0%.

By 2050, the electricity demand was expected to reach 98.79 TWh under BAU, compared to only 84.24 TWh in the APS, a difference of 15 percentage points. This electricity saving is assumed to continue to 2050 as no additional target is available after 2050. Figure 12.13 shows the electricity demand of the final sectors from 2015 to 2040. Other sectors include residential, commercial, agriculture, and construction. The current outlook excludes electricity demand in the transport sector.

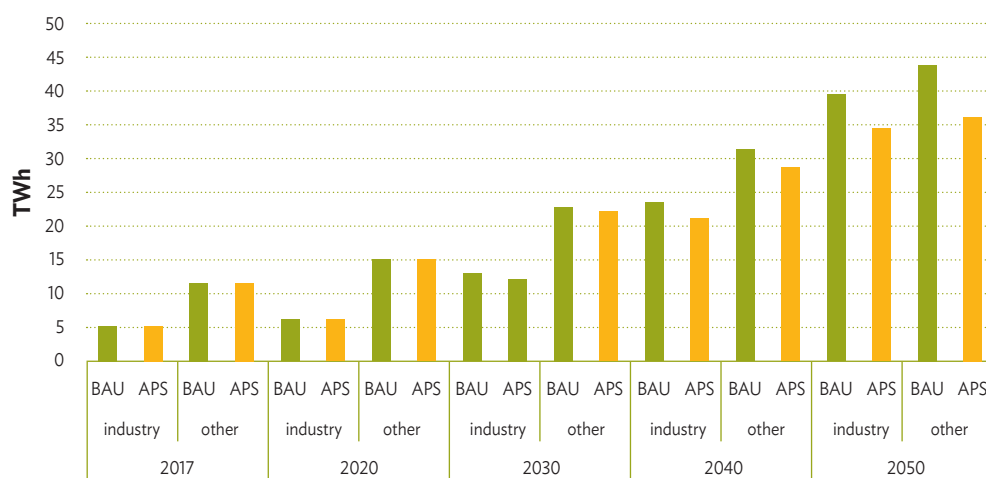
Figure 12.13. Electricity Demand, Business as Usual and the Alternative Policy Scenario



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

Source: Author's calculation.

Figure 12.14. Electricity Demand by Sectors, Business as Usual and the Alternative Policy Scenario

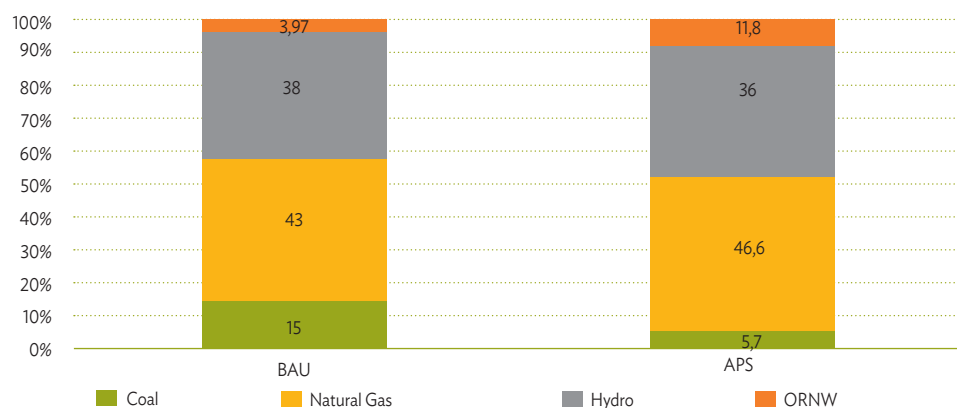


APS = alternative policy scenario, BAU = business as usual, TWh = terawatt-hour.

Source: Author's calculation.

In the APS, generation capacity will lean more towards renewable energy, compared to BAU (Figure 12.14). As explained above, the APS excludes some of the additional capacity from coal and natural gas after 2025, while more will be made available from renewable energy sources. Hydropower resources will reach a capacity of 9.4 gigawatts by 2030 as stipulated in the mitigation actions and policies for Myanmar's energy sector. These include not only large but also mini- and micro-hydropower plants. The hydropower share reached 36.0% under the APS, compared to 38.0% under BAU, while that of other renewable sources such as solar, wind, and biomass will also increase compared to BAU (4.0% compared to 11.8%).

Figure 12.15. Share of Power Generation Capacity in 2050, Business as Usual and the Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, ORNW = other renewable sources.

Source: Study outcome.

Considering the lower final energy consumption and greater share of renewables in the APS, the impact of the APS on the environment would be lower CO₂ emissions. Total CO₂ emissions under BAU will be 28.43 Mt-C by 2050. In the APS, CO₂ emissions will be around 22.80 Mt-C in 2050, a reduction of 5.63 Mt-C compared to BAU, or approximately 20%. As previously shown, in the APS, CO₂ emissions will decrease by 38% by 2040, a reduction of around 32.8 million tonnes of carbon equivalent (or 8.9 Mt-C).

4. Conclusions and Policy Implications

Although energy intensity will decline, energy consumption is still increasing because of economic, population, and vehicle population growth. Myanmar should increasingly adopt energy-efficient technologies to mitigate growth in energy consumption and should also diversify energy availability. The energy saving programme will target the residential, commercial, transport, and industry sectors. The current energy supply has been kept below its potential because of the scarcity of the technical and financial resources needed to reverse the decline and subsequently accelerate the development and production of natural gas and oil.

The country has been experiencing serious energy shortages, which will become more acute in the absence of further energy sector investment. First, there should be more aggressive exploration of the upstream energy sector, as well as more financial and technical assistance in each energy subsector to secure the national energy supply, increase electricity production, rehabilitate existing electricity transmission and distribution, expand rural electrification, build coal- or gas-fired power plants, and promote renewable energy in Myanmar's fuel mix as secure energy sources. The framework would list all potential renewable energy projects in the country, outlining priorities and sequencing, along with funding requirements based on completed studies.

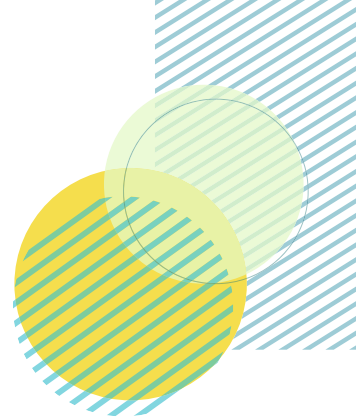
In this regard, the following points are proposed for consideration:

- (i) In promoting coal-fired power generation, the MOEE should be mindful of the need to apply clean coal technologies.
- (ii) The continuous use of biomass will fully depend on the MOEE's support, which should provide efficient biomass cooking stoves to households (especially in rural areas) at reasonable prices.

- (iii) There is a need for a detailed policy mechanism for the renewable energy sector to implement potential programmes and projects. This mechanism should be developed and planned in conjunction with external stakeholders who can offer experience, advanced technologies, new markets, and investment.
- (iv) The MOEE should seek international cooperation with entities such as the Asian Development Bank and the International Renewable Energy Agency to support the increase in variable renewable energy in Myanmar.
- (v) There is a need to improve energy management practices in the industrial and commercial sectors.
- (vi) A dedicated energy efficiency body should be established to oversee Myanmar's energy efficiency programme.
- (vii) The current energy efficiency target should be refined to include all sectors' numerical targets and detailed action plans.
- (viii) Myanmar needs to establish a comprehensive integrated energy plan to guide the development of the energy sector, including an energy efficiency labelling programme for energy service companies and appliances.
- (ix) The government needs to formulate schemes to enhance private participation, including by foreign companies, to accelerate power sector development, including transmission and distribution systems to ensure the reliable supply of electricity to consumers.
- (x) The Ministry of Planning, Finance and Industry should set specific targets for each sector on energy efficiency, and the government should implement the committed energy policy to achieve these targets.
- (xi) Importing liquefied natural gas in the form of floating terminals should be considered in the short term to meet the projected rapid growth of electricity demand while new domestic natural gas resources are being explored.

CHAPTER 13

New Zealand Country Report



Hien Dang and Seiya Endo

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. Its land area is approximately 269,000 square kilometres (km²), smaller than Japan or Italy, but larger than the United Kingdom. Most of New Zealand is hilly or mountainous and has a mild temperate climate. The population was about 5.0 million as of 31 March 2020. Although it has some light and heavy industry, foreign trade is heavily dependent on agriculture, tourism, forestry, and fishing. In 2017, New Zealand had a nominal gross domestic product (GDP) of about \$181.1 billion in United States dollars, or about \$37,800 per capita¹. Although close to the per capita average for Organisation for Economic Co-operation and Development countries, New Zealand tends to rank high in international quality-of-life surveys.

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 generally exported because of its high quality and, therefore, high value on the international market. To meet its oil demand, in 2018 about 76% of all of New Zealand's imported oil was sourced from the Middle East. Remaining energy reserves as of 1 January 2019 included 70.5 million barrels of oil (2P ²) and 52.5 billion cubic metres of natural gas (2P1),

¹ All United States dollars in this report are in constant 2010 values unless specified.

² 2P values may be totalled safely using arithmetic summation since they are the mid-point of the probability distribution.

Source: Ministry of Business, Innovation and Employment (2019), New Zealand Energy in New Zealand 2019 Report.

as well as in-ground resources of over 15 billion tonnes of coal, 80% of which is lignite in the South Island.

In 2017, New Zealand's total primary energy supply (TPES) was around 20.7 million tonnes of oil equivalent (Mtoe). By share, oil represented the largest source at about 33%, followed by natural gas at 20% and geothermal energy at 24%. The remainder of the primary energy supply came from hydropower (10%), coal (6%), biomass (6%), and a smaller percentage of other renewables such as wind, solar photovoltaics, and biofuels.

Final energy consumption was about 14.6 Mtoe in 2017. By share, the transport sector was the largest at around 36% because New Zealand depends heavily on private road vehicles, road freight, and air transport. The industrial sector was the second largest with about 30%, followed by the agricultural, residential, and commercial sectors with 26% altogether. The non-energy sector consumed the remaining 8%.

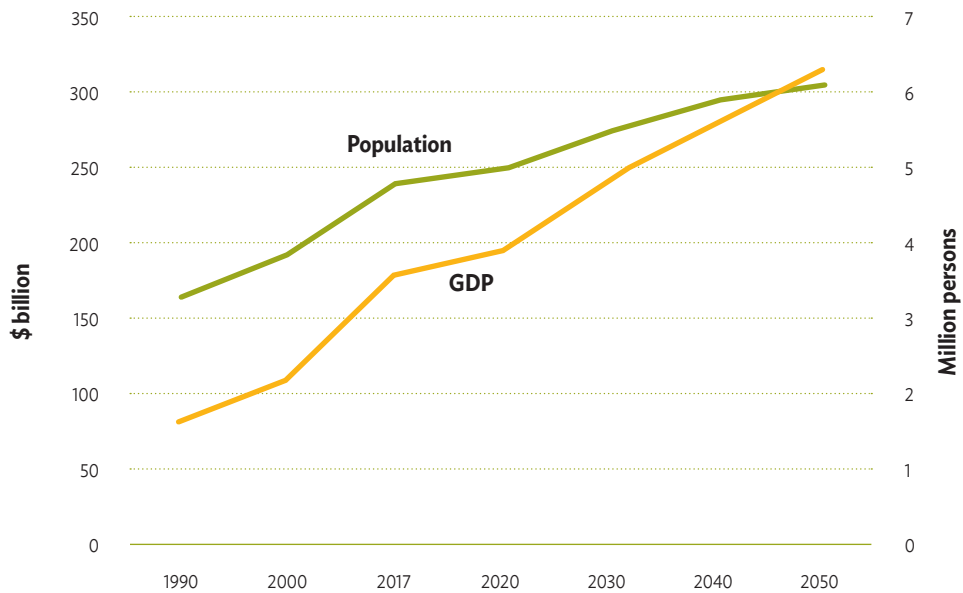
In 2017, the total gross power generation output was about 44.2 terawatt-hours, of which hydropower accounted for about 57% (the most utilised source), followed by geothermal with about 18%, natural gas with about 16%, coal with 3%, and other renewables with 6%. Oil, a minor source in electricity generation, is only used for peaking and emergency supply.

2. Modelling Assumptions

This outlook assumes that New Zealand's GDP will grow at an average annual rate of 1.7% between 2017 and 2050, and its population will increase by about 28% from 4.8 million in 2017 to 6.1 million by 2050 (Figure 13.1).

Under business as usual (BAU), generation from renewable sources is projected to increase as new capacities for geothermal and wind will increase in the future. Hydropower is projected to decrease slightly at an annual average rate of 0.6% from 2017 to 2050. Generation from natural gas-based plants is projected to increase slightly, at an annual average rate of 0.4%. Geothermal power generation will increase at an annual average rate of 1.7% and wind generation will continue to grow, but will still only account for a small share of New Zealand's electricity by 2050. In contrast, coal power generation will decrease at an annual average rate of 0.3% (Figure 13.2). Thermal efficiency of gas- and oil-fired power plants may not increase so much in the future, because no new large fossil fuel-based plants are planned. Moreover,

Figure 13.1. Gross Domestic Product and Population



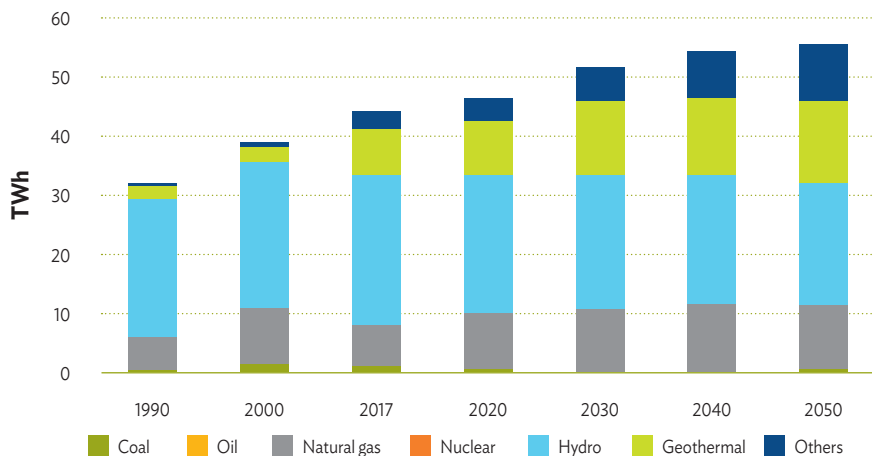
GDP = gross domestic product.

Source: Author's calculations.

Genesis Energy (New Zealand's largest energy company) has decided to decommission its coal-fired power plants by 2023.

In terms of primary energy supply, the overall energy intensity of the economy improved in real terms at an annual average rate of 1.1% from 1990 to 2017.

Figure 13.2. Power Generation by Fuel, Business as Usual



GDP = gross domestic product.

Source: Author's calculations.

The Government of New Zealand implemented an emissions trading scheme in 2010 and is currently undertaking a review of that scheme to determine how it can best support New Zealand in both meeting its climate change targets and transitioning to a low-emissions economy. New Zealand has also, through its Energy and Energy Efficiency and Conservation Strategies, set a target for 90% of electricity to be generated from renewable sources by 2025. 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. Outlook Results

3.1. Final Energy Consumption

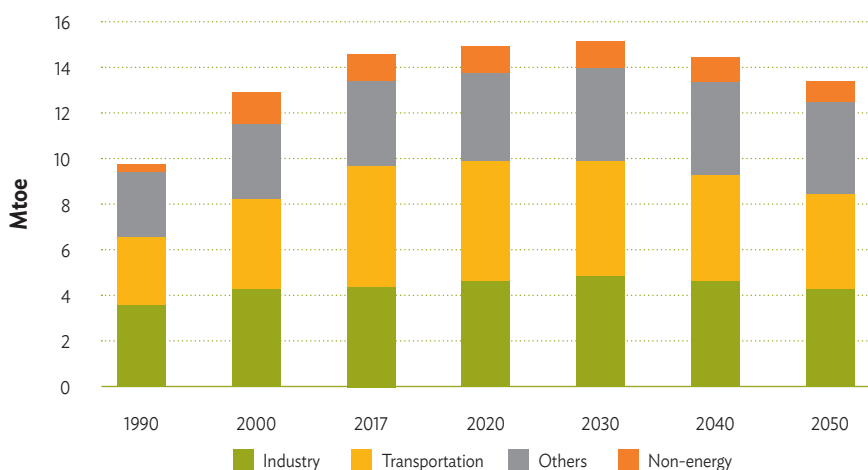
New Zealand's final energy consumption grew by 1.5% per year from 9.7 Mtoe in 1990 to 14.6 Mtoe in 2017. Oil increased from 4.0 Mtoe to 6.6 Mtoe, electricity rose from 2.4 Mtoe to 3.4 Mtoe, and natural gas rose from 1.8 Mtoe to 2.8 Mtoe for the same period. 'Other' energy sources, which include biomass, solar, wind, liquid biofuels, and biogas, also increased from 0.8 Mtoe to 1.3 Mtoe. On the other hand, coal was in decline, falling from 0.7 Mtoe to 0.6 Mtoe.

3.1.1. Business as Usual Scenario

Under BAU, final energy consumption from 2017 to 2050 is projected to decrease by 1.2 Mtoe at an average rate of 0.3% per year. The 'others' sector (agricultural, residential, and commercial) will see a smaller rise of 0.2 Mtoe between 2017 and 2050, an average annual growth rate of 0.1%. Transport sector consumption is projected to decrease by 1.0 Mtoe at an annual rate of 0.7% and the industry sector is also projected to decrease by 0.2 Mtoe in 2050. Non-energy sector consumption is projected to fall by 0.1 Mtoe from 2017 to 2050 (Figure 13.3).

By source, final electricity demand will steadily increase by 0.9 Mtoe between 2017 and 2050 at an average rate of 0.7% per year. Final demand of other renewable energy, including geothermal, solar, biogas, and woody biomass used for direct-use heat applications, will decrease slightly from 2017 to 2050 at an average rate of 0.2% per year. By 2050 final oil demand will decrease by 1.6 Mtoe at an average rate of 0.8% per year, coal demand will decrease by 0.1 Mtoe at an average rate of 0.6% per year, and natural gas will decrease slightly by 0.3 Mtoe at an average rate of 0.3% per year (Figure 13.4).

Figure 13.3. Final Energy Consumption by Sector, Business as Usual

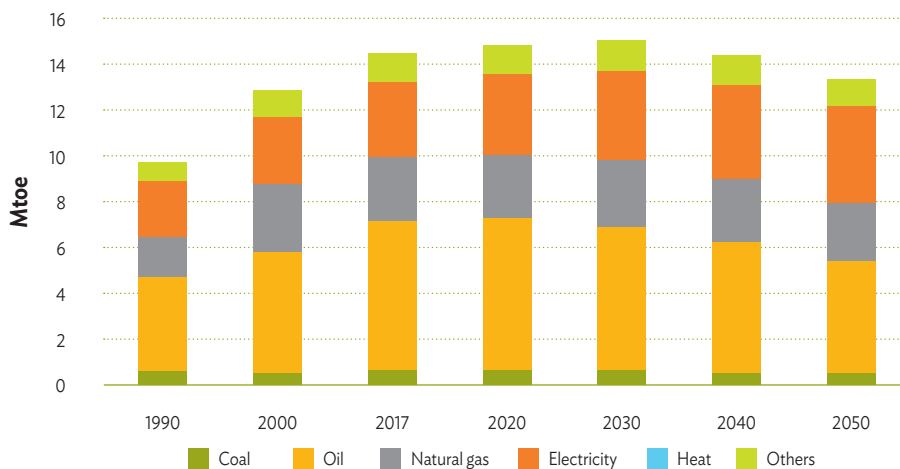


BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Note: 'Others' includes the agricultural, residential, and commercial sectors.

Source: Author's calculations.

Figure 13.4. Final Energy Consumption by Fuel, Business as Usual



BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Note: The 'Others' sector includes geothermal, solar, biogas, and woody biomass.

Source: Author's calculations.

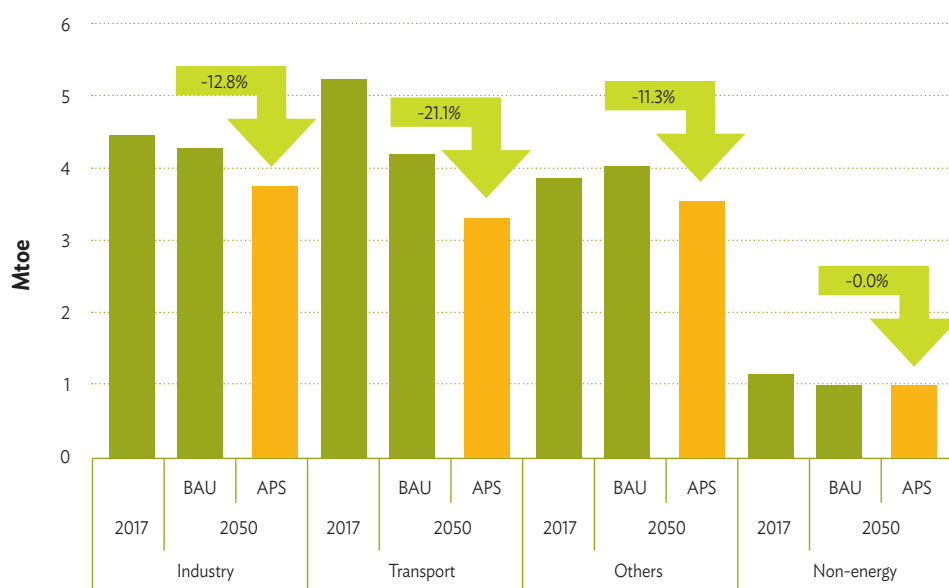
3.1.2. Alternative Policy Scenario

In the alternative policy scenario (APS), final energy consumption will be slightly lower in 2050. Final energy consumption will decrease by 3.1 Mtoe between 2017 and 2050. Energy use in the 'others' sector (agricultural, residential, and commercial) will decrease at an average

rate of 0.2% per year, reflecting the use of efficient appliances and highly energy-efficient heat pumps, and the replacement of incandescent bulbs with compact fluorescent lamp and light-emitting diode light bulbs in the residential and commercial sectors.² Energy use in the industrial sector is projected to decrease at an annual average rate of 0.5%. Energy use in the transport sector will decrease at an average rate of 1.4% per year, reflecting a shift to more energy-efficient vehicles, particularly electric vehicles. Energy use in the non-energy sector is projected to decrease at an annual average rate of 0.4%.

Final energy consumption by in 2017 and 2050 under BAU and in the APS is shown in Figure 13.5.

Figure 13.5. Final Energy Consumption by Sector, Business as Usual and the Alternative Policy Scenario



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

Source: Author's calculations.

3.2. Primary Energy Supply

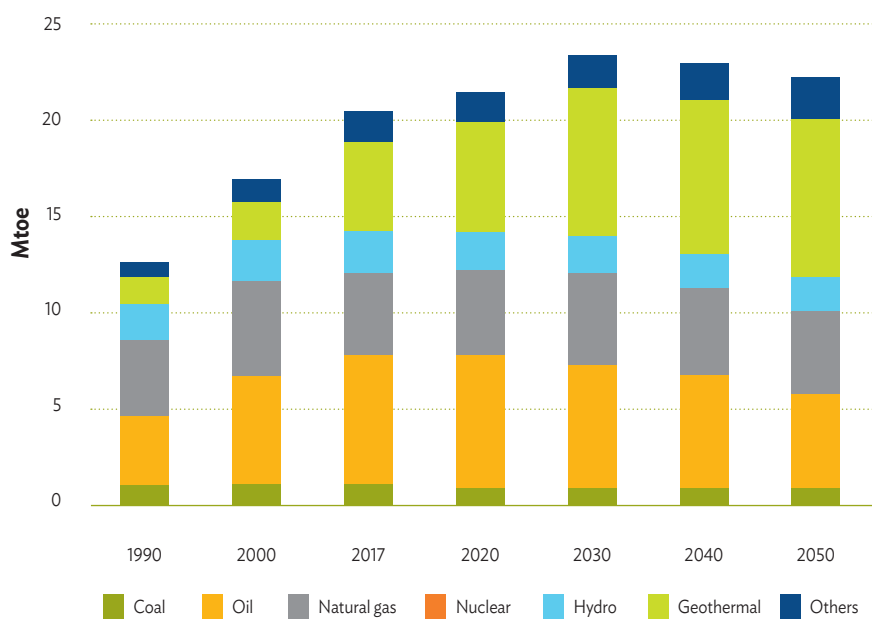
Primary energy supply in New Zealand grew at an average annual rate of 1.8% per year from 12.8 Mtoe in 1990 to 20.7 Mtoe in 2017. The fastest growing primary fuel in absolute terms was oil, rising from 3.5 Mtoe in 1990 to 6.8 Mtoe in 2017. The increase in oil is due to the rapid growth in transport energy demand.

Natural gas consumption increased at an average annual rate of 0.3% and oil consumption increased at an annual average rate of 2.5%. Geothermal energy use for electricity generation grew from 1.5 Mtoe in 1990 to 4.9 Mtoe in 2017, an annual rate of 4.5%; while hydropower demand for electricity production increased slightly from 2.0 Mtoe in 1990 to 2.2 Mtoe in 2017. 'Other' energy sources, which include biomass, solar, wind, liquid biofuels, and biogas, increased at an annual average rate of 2.2% per year.

3.2.1. Business as Usual Scenario

Under BAU, New Zealand's primary energy supply will grow at an average annual rate of 0.3% to 22.5 Mtoe in 2050 from 20.7 Mtoe in 2017. Geothermal energy is projected to contribute the most to the incremental growth of the primary energy supply between 2017 and 2050, and will account for 37.1% of the TPES in 2050. 'Other' primary energy will grow at an annual average rate of 1.2% per year, mainly reflecting the expected growth in wind power; and 'others' will account for 9.6% of the TPES in 2050. In contrast, primary fossil fuel will decrease slightly at an average rate of 0.5%, and will account for 45.4% of the total in 2050, down from 58.8% in 2017. Hydropower for electricity generation will account for the remaining 7.9% of the total by 2050, decreasing at an annual average rate of 0.6% (Figure 13.6).

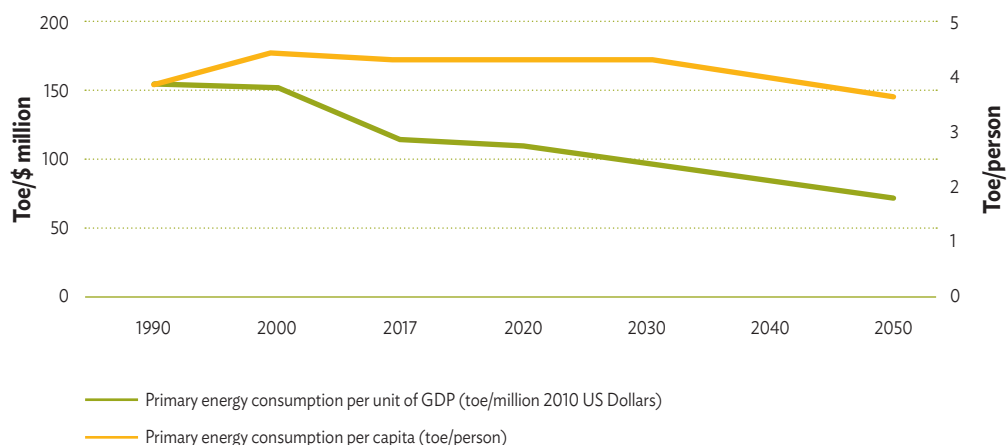
Figure 13.6. Primary Energy Supply by Fuel, Business as Usual



BAU = business as usual, Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

Figure 13.7. Primary Energy Intensity and Energy per Capita Indicator, Business as Usual



BAU = business as usual, GDP = gross domestic product, toe = tonnes of oil equivalent.

Source: Author's calculations.

The lower growth of the primary energy supply relative to GDP growth will result in lower energy intensity in the future. From 114 tonnes of oil equivalent per million dollars (toe/\$ million) in 2017, energy intensity will improve to 72 toe/\$ million in 2050. Primary energy supply per capita will decrease from 4.3 toe per person in 2017 to 3.7 toe per person in 2050. Figure 13.7 shows the primary energy intensity and energy per capita as indicators.

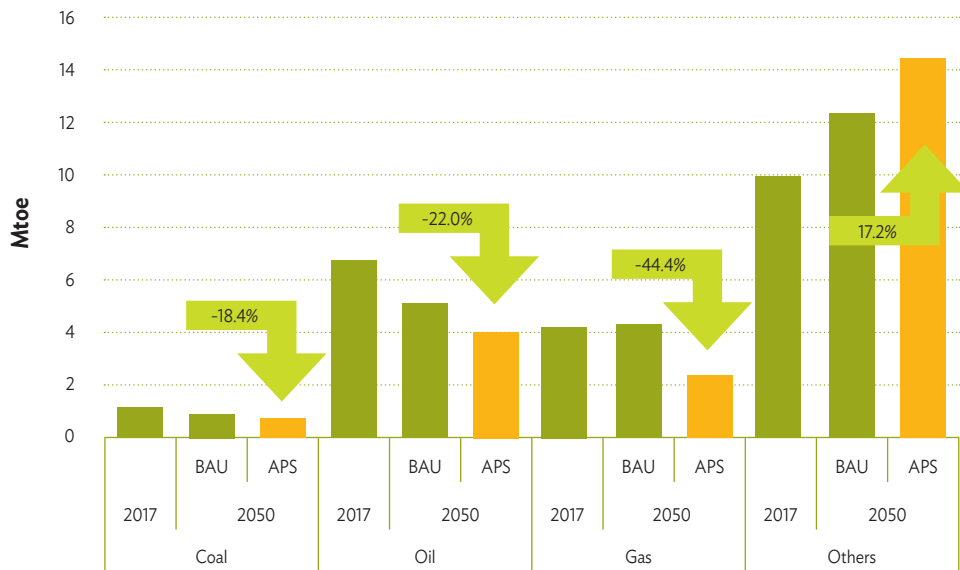
3.2.2. Alternative Policy Scenario

In the APS, the energy supply is projected to grow at a lower rate of 0.1% per year to 21.5 Mtoe in 2050. Significant declines are expected in gas (1.7%), oil (1.6%), and coal (1.5%). Geothermal primary energy is expected to grow by 2.3% per year. 'Other' primary energy, which includes biomass, solar, wind, liquid biofuels, and biogas, is expected to grow by 1.6% per year (Figure 13.8).

3.3. Projected Energy Savings

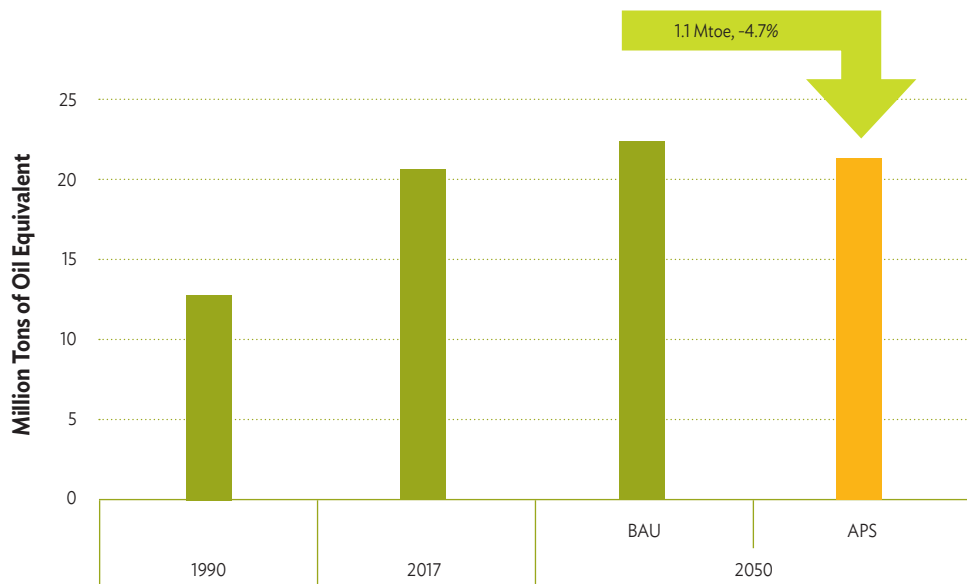
In the APS, the primary energy supply is projected to save about 1.1 Mtoe or 4.7% less than BAU in 2050 (Figure 13.9).

Figure 13.8. Primary Energy Supply by Fuel, Business as Usual and the Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Note: The 'others' sector includes biomass, solar, wind, liquid biofuels, biogas, hydropower, and geothermal.
 Source: Author's calculations.

Figure 13.9. Total Primary Energy Supply, Business as Usual and the Alternative Policy Scenario



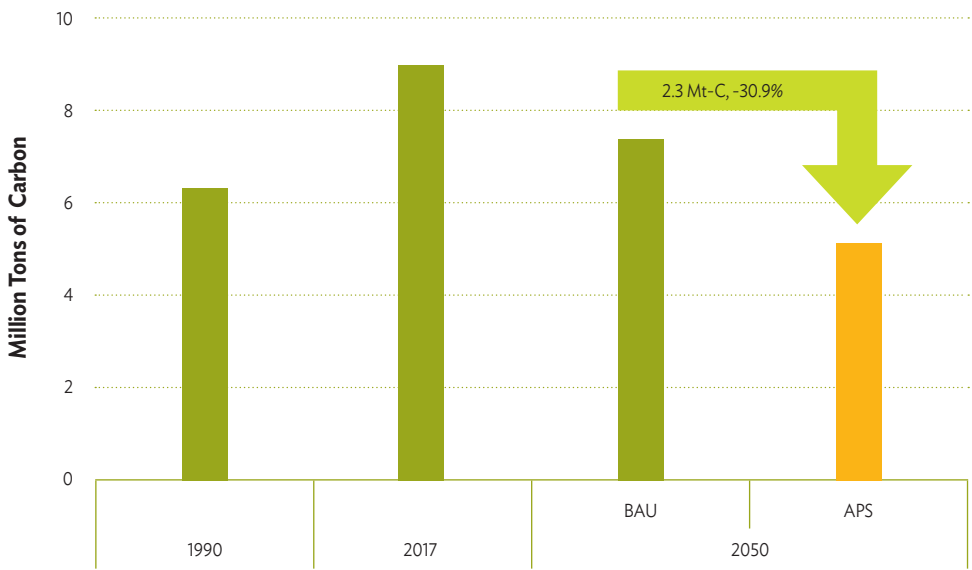
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.
 Source: Author's calculations.

The above savings in primary energy are mainly due to the switch to more efficient vehicles, particularly electric vehicles, in the transport sector, along with improved insulation, use of more efficient appliances, and replacement of incandescent bulbs with compact fluorescent lamp and light-emitting diode light bulbs in the residential and commercial sectors.

3.4. Carbon Dioxide Emissions

Under BAU, carbon dioxide (CO2) emissions will decrease slightly, from 8.9 million tonnes of carbon (Mt-C) in 2017 to 7.4 Mt-C in 2050. In the APS, CO2 emissions will decrease by 1.7% per year from 2017 to 2050, reflecting the switch to renewable energy in electricity generation, and the switch to electric vehicles in the transport sector. Figure 13.10 shows the difference in CO2 emissions from energy consumption between BAU and the APS in 2050 compared with 1990 and 2017 in New Zealand.

Figure 13.10. Carbon Dioxide Emissions from Energy Consumption, Business as Usual and Alternative Policy Scenario



APS = alternative policy scenario, BAU = business as usual, CO2 = carbon dioxide, Mt-C = million tonnes of carbon.
Source: Author's calculations.

4. Implications and Policy Recommendations ³

Although New Zealand's primary energy intensity (energy per dollar of GDP) has been declining since 1990, energy use has continued to grow steadily, reflecting economic growth, population growth, and increasing numbers of private road vehicles. New Zealand generates over 80% of its electricity from renewable sources. In the first quarter of 2020, increases in hydropower generation (up 2.1%), wind (up 8.2%), and geothermal (up 3.8%) helped lift renewable sources' share of electricity generation. Meanwhile, generation from non-renewable sources declined: generation from gas fell 1.6%, and generation from coal fell 22.6%, despite historically high coal consumption during this quarter.

In 2011, New Zealand set an ambitious goal to generate 90% of its electricity from renewable sources by 2025; and to reduce greenhouse gas emissions by 30% from 2005 to 2030, and by 50% from 1990 to 2050. However, New Zealand's large base of renewable generation limits the opportunity to reduce CO₂ emissions in the electricity generation sector. The goal of the New Zealand Energy Efficiency and Conservation Strategy (2017–2022), titled *Unlocking Our Energy Productivity and Renewable Potential*, is for New Zealand to become an energy-productive and low-emissions economy. It encourages businesses, individuals, and public sector agencies to take actions to help unlock renewable energy, energy efficiency, and productivity potential. The strategy's three priority areas are (i) the renewable and efficient use of process heat, (ii) efficient and low-emission transport, and (iii) the innovative and efficient use of electricity. It also contains targets for renewable energy and greenhouse gas emissions reduction.

Other opportunities for New Zealand to boost energy efficiency include improving vehicle efficiency, building insulation, and the efficiency of heat production in industry, as well as switching to lower-carbon fuels. The largest potential energy and carbon savings are in the transport and process heat sectors. Growth in energy consumption in the transport sector has been slowing in recent years, mainly because of high fuel prices and a shift to smaller vehicles.

In late 2019 the government announced a \$200 million fund aimed at reducing the state sector's carbon footprint. The first projects announced in a 'clean-powered public service' are the replacement of coal-fired boilers in schools and hospitals. Switching to electric vehicles and increasing the use of biofuels can further reduce emissions from the transport

³ Ministry of Business, Innovation and Employment and the Energy Efficiency and Conservation Authority (2017), *New Zealand Energy Efficiency and Conservation Strategy (2017–2022), Unlocking Our Energy Productivity and Renewable Potential*. Auckland.

sector. Electric vehicles are a good match for New Zealand given the high proportion of electricity generated from renewables, the relatively short distance of average trips, and the fact that charging infrastructure already exists in most residential dwellings. Aiming to reach 64,000 electric vehicles by the end of 2021, the government has introduced several measures to encourage their use by removing barriers preventing households and businesses from choosing electric cars; these include a limited selection of available models and lack of widespread public charging infrastructure. Government funding for electric vehicles is available under the Low Emission Vehicles Contestable Fund, the purpose of which is to encourage innovation and investment and accelerate the uptake of electric and other low-emission vehicles in New Zealand, which might not otherwise happen.

In early 2019 the government announced a raft of changes to the Building Act 2004, signalling that this would result in significant reform of the sector's main legislation. New Zealand should consider a package of measures (including regulatory instruments) to improve the energy efficiency of industrial heat plants.

The government strategy includes a target for each priority area. Achieving these targets will require the government to work with businesses and individuals to develop the right mix of policies and programmes. The strategy builds on achievements to date and does not include a full list of government energy efficiency and renewable initiatives. This approach will ensure that the document stays relevant throughout its 5-year life, allowing initiatives to end and new programmes to begin. Public sector agencies list the full range of initiatives in their public accountability documents and websites. Investment in quality energy end-use data and analysis will support the government's approach. Good data is critical for reviewing existing programmes and informing new policy design. The Ministry of Business, Innovation and Employment; Statistics New Zealand; the Electricity Authority; the Gas Industry Company; the Ministry of Transport; and the Energy Efficiency and Conservation Authority will continue to publish such data.

CHAPTER 14

Philippines Country Report



S. Magnolia, B. Olvido, and Lilibeth T. Morales

1. Background

1.1 Socio-economic

The Philippines, officially known as the Republic of the Philippines, consists of more than 7,000 islands in three main geographical archipelagoes or divisions such as Luzon, Visayas, and Mindanao. The country's capital, officially known as the National Capital Region (NCR) or commonly known as Metro Manila or Manila, is located in Luzon.

In 2017, the country's population was roughly 105.2 million.¹ Gross domestic product (GDP) per capita was recorded at US\$2,884.40, with the NCR accounting for the largest share of the economy (36.4%)².

In total, the Philippines' economy grew 6.7% over the preceding year, slightly below the 6.9% GDP growth recorded in 2016. While GDP dipped a few notches, the Philippines was still considered one of the fastest-growing economies in Asia during the period. Manufacturing, trade, and real estate, renting and business activities were the main drivers of overall growth³. Government spending also grew by 14.3% in the last quarter of the year, a significant increase compared to the same period in 2016. However, the greatest growth rates during this period were in the industrial and services sectors, which posted annual growth rates of 7.2% and 6.8%,

¹ <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=PH> (accessed 1 August 2020).

² Gross Domestic Product of the Philippines (2018) Highlights for 2017. Manila: Philippine Statistics Authority (PSA). <https://psa.gov.ph/grdp/highlights-id/131382> (accessed 1 August 2020)

³ Gross Domestic Product of the Philippines (2018) Highlights for 2017. Manila: Philippine Statistics Authority (PSA). <https://psa.gov.ph/grdp/highlights-id/131382> (accessed 1 August 2020).

respectively. The growth of the industrial sector can be attributed to the manufacturing sub-sector, which grew by 8.4%. The services sector accounted for about 57.5% of the GDP, which can be attributed to the robust domestic trade and a boom in real estate. Meanwhile, agriculture, hunting, forestry and fishing registered 4% growth over the preceeding year, as the growth in the agriculture and forestry sector rebounded and registered a growth rate of 4%.

1.2 Policy

The Philippine Department of Energy (DOE) has set forth strategic directions and an energy agenda to assist the current administration in attaining its development goals as envisioned in the AmBisyon Natin 2040—the blue-print of a long-term, collective vision and aspiration of Filipinos, and supported by national economic strategies that will provide opportunities for inclusive growth. Within AmBisyon Natin 2040, the Philippine energy sector plays a vital role as an indispensable factor for economic growth. The DOE is primarily focused on consumer-first policies, reliability of energy supplies and affordability of tariffs.

The Philippine DOE has set eight “Energy Sector Strategic Directions” as follows: 1) ensure energy security; 2) expand energy access; 3) promote a low-carbon future; 4) strengthen the collaboration between the private sector and government agencies on energy-related issues; 5) implement, monitor and integrate sectoral and technological 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.

The following are the policies that are aligned with the strategic directions:

- In 2016, the DOE issued Department Order No. DO2016-01-0013 entitled “Creating the Nuclear Energy Program Implementing Organization (NEPIO) in the Department of Energy” to ensure continuous and adequate supply of energy via a firm national policy on nuclear energy. On 24 July 2020, President Rodrigo R. Duterte issued Executive Order 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.

- Promoted and adopted in 2017, Executive Order (EO) No. 30, which President Rodrigo R. Duterte signed to create an Energy Investment Coordinating Council, is tasked with developing a simplified permitting and approval process to achieve a timely and expeditious implementation of energy projects tagged with “National Significance” by harmonising the regulations of all government agencies involved in obtaining permits and approvals.
- In 2017, the DOE issued Department Circular No. DC2017-11-0012, known as the Philippine Downstream Natural Gas Regulation, to establish the rules and regulations governing the downstream natural gas industry and the continued operations of gas-fired power plants upon depletion of natural gas supply from Malampaya, the country’s indigenous natural gas resource. This is in line with the aspiration of transforming the country into a regional LNG trading trans-shipment hub.
- In 2018, the DOE pushed for the mainstreaming of Resiliency Planning and Program through the issuance of Department Circular No. DC2018-01-0001 entitled the “Adoption of Energy Resiliency in the Planning and Programming of the Energy Sector to Mitigate Potential Impacts of Disasters”. This policy paves the way for the inclusion of disaster risk and reduction programs into the energy project planning and investments and adoption of both engineering and non-engineering mechanisms on existing energy infrastructure to ensure continuous delivery of energy services to consumers.
- After 3 decades, the Republic Act No. 11285 (The Energy Efficiency and Conservation Act) was finally passed into law and institutionalised in 2019, which aims to enhance efficient use of energy in the country through the development of policy mechanisms and standards in the different sectors.
- Pertinent policies were adopted and integrated into the power sector such as Department Circular No. DC2017-12-0015 (Promulgating the Rule and Guidelines Governing the Establishment of the Renewable Portfolio Standard for On-Grid Areas), which aims to produce a specified portion of the electricity requirements from eligible renewables resources in order to develop indigenous and environment-friendly energy sources to attain the aspirational target of 35% in the generation mix expressed in MWh by 2030.

The DOE is adopting a technology-neutral policy in coming up with an optimal energy mix, especially for the power sector. The power sector implements a 25% reserve requirement to be able to meet the peak requirement of the Luzon, Visayas and Mindanao grid. In addition, efforts to develop and promote indigenous energy such as renewables and hydrocarbon fuels (oil, gas, and coal) and to tap clean and smart technologies include the following priority infrastructure projects:

- Completing transmission projects, such as the Visayas-Mindanao Interconnection Project, by December 2020 will facilitate greater energy access through a 100% national and regional electrification;
- The Small-Island Interconnection will connect isolated island provinces in the main grid. One of the flagship programs is the Semirara-Mindoro-Panay Interconnection in support of a One-Grid Philippines goal.
- The country's Liquefied Natural Gas (LNG) capacities and capabilities will be harnessed through the PHP100 billion Batangas Integrated LNG by 2020 with an initial 5 million tonnes per annum throughput and initial reserve capacity of 200 MW.
- A Pro-Consumer Distribution Framework for energy affordability, choice and transparency through the “E-Power Mo” campaign, which was launched in 2018, will empower consumers.

Below are some of the highlights of the Philippine energy sector's plans and programmes:

Increase Renewable Energy Installed Capacity to at least 20,000 MW

The passage of Republic Act No. 9513, or the Renewable Energy Act of 2008, supported the policy and programme framework for renewables. On 14 June 2011, the government unveiled the National Renewable Energy Program (NREP) or the “Green Energy Roadmap”, anchored on the DOE's Energy Reform Agenda, which aims to ensure greater energy supply security for the country. Under the updated roadmap, which guides efforts in realising the market penetration targets of each renewable energy resource in the country, the target of 15,304 megawatt (MW) installed renewables capacity by 2030 is envisioned to be increased to at least 20,000 MW by 2040. To achieve this, the NREP also provides for policy mechanisms to support the

Renewable Energy Act. These policy mechanisms include: Renewable Portfolio Standards (RPS), Feed-in Tariff (FIT), Green Energy Option Program and Net-Metering for Renewable Energy.

The RPS sets the minimum percentage of generation from eligible renewables resources, provided by the generators, distribution utilities and electric suppliers. In 2017, the on-grid target RPS was set to 35% in MWh by 2030 to 2040. At the end of 2017, renewables resources reached a total of 7,080 MW installed capacity, or about 31% of the total.

On the other hand, the FIT provides guaranteed payments on a fixed rate per kWh for renewables generation, excluding for own use. The Energy Regulatory Commission (ERC) has approved FIT rates that will apply to renewables resources, particularly run-of-river hydro, biomass, wind, and solar. Effective October 2015, the approved FIT rates for biomass, hydropower, solar and wind are PhP⁴ 6.63, PhP5.90, PhP8.69, PhP7.40 per kWh, respectively. Currently, there is no FIT rate for ocean energy since the technology is still in the research and development stage. In 2019, the ERC approved a lower FIT-All rate of PhP0.0495 per kWh charged to all on-grid consumers supplied with electricity⁵.

Biofuel Blending as Mandated by the “Biofuels Act of 2006”

The DOE is aggressively implementing Republic Act No. 9367 or the Biofuels Act of 2006. The law intends to tap the country’s indigenous agricultural resources as potential feedstock for biofuel to contribute to energy security, as well as to augment farmers’ incomes, generate rural employment, and reduce greenhouse gas (GHG) emissions.

The mandatory 1% biodiesel blend in all diesel fuel sold in the country since May 2007 was increased to 2% in February 2009 on a voluntary basis. On the other hand, the country now enjoys an accelerated use of E10 (10%) bioethanol blend, as supplied by most of the gasoline retailers. The DOE, together with the National Biofuels Board, is revisiting/re-evaluating the blending requirement, with due consideration on the availability feedstock and to facilitate the scheduled blending of biofuels in compliance with the Biofuels Law.

⁴ Philippine peso

⁵ ERC Approves a Lower Feed-in Tariff Allowance, Energy Regulatory Commission (<https://www.erc.gov.ph/ContentPage/61912>) (accessed 1 August 2020).

Intensification of Electricity Access through Household Electrification

The provision of electricity is now focused on households throughout the country. Household electrification levels reached 88.3% in 2017. There were about 20.9 million electrified households out of the 23.7 million total in 2017 based on the Distribution Development Plan 2018-2027 by the Distribution Utilities. On a grid level, in 2017, Luzon has the highest electrification at 94.8%, with Visayas at 88.2% and Mindanao at 70.8%. Aside from these, there are also various grid and off-grid programs that also aim to contribute to 100% electrification of all targeted and identified households accessible to the grid by 2022. These are embodied in the Household Electrification Development Plan.

1.3 Energy Supply-Demand Situation

In terms of demand, the country's total final energy consumption in 2017 was recorded at 36.7 million tonnes of oil equivalent (Mtoe). Amongst the fuels, oil constituted the largest share at 48.5% (17.8 Mtoe), which can be attributed to transport sector fuel demand. Others (primarily biomass, which is largely consumed in residential use), and electricity closely followed with shares of 24.5% (9.0 Mtoe) and 18.2% (6.7 Mtoe), respectively.

On a per sector basis, transport has been the largest single-sector user of energy, accounting for 32.3% of the total demand, while industry is at 21.6%. Others collectively (most prominently residential, as well as commercial, and agriculture, forestry and fishery(AFF) make up 41.7%).

The country's total primary energy supply⁶ in 2017 reached 55.9 Mtoe. Oil continued to be the major source of supply which accounted for 33.5% in the total energy supply, followed by coal and geothermal, with 26.2% and 15.8%, respectively. Total indigenous energy production reached 29.5 Mtoe, bringing energy self-sufficiency to 50.9% during the period (Figure 14-2).

Meanwhile, the country's total electricity generation in 2017 reached 94.4 TWh. Coal-fired power plants remained as the major source for power generation, with total installed capacity of 8,049 MW during the period. Coal contributed 49.6%, or 46.8 TWh, to the total power generation mix of the country. Meanwhile, natural gas-fired power plants accounted for 21.8%, or 20.5 TWh in the power mix. The country has five existing natural gas power plants, with a combined installed capacity of 2,862 MW. On the other hand, the combined share of renewables in the total power generation mix was registered at 24.6% during the period.

⁶ Based on the 2017 Philippine Energy Balance Table

2. Modelling Assumptions

Five scenarios were developed to assess the energy savings potential of the country aside from the Business-as-Usual (BAU) scenario. The BAU scenario serves as the reference case in the projection of the energy demand and carbon dioxide (CO₂) emissions of the energy sector. The BAU incorporates the energy sector's existing policies, plans and programmes, which are being implemented and pursued within the forecast period.

The Alternative Policy Scenario (APS) 1 assessed possible policy interventions in terms of efficient and environment-friendly technologies for future energy use, together with corresponding CO₂ emissions reductions. The scenario assumed that a 20% energy savings will be achieved in 2050 through a range of measures, including intensified energy utilisation management programs in the commercial and industrial sectors, power plants and distribution utilities, as well as the continuous use of alternative fuels and technologies. The Information and Education Campaign (IEC) Program of the DOE will also contribute to the energy saving goals of the country. In the residential and commercial sectors, energy labelling and ratings on major electrical appliances will help consumers to choose more efficient electrical products.

The APS2 assessed the effect of a more efficient thermal power generation, particularly for future coal and natural gas power plant technologies.

The APS3 measured the result of the combined contribution of renewables and alternative fuels to the total energy supply. As part of the government's initiatives to ensure security of energy supply and, at the same time, to protect the environment and promote green technology, the targets set under the NREP were incorporated in the model to test its impact in the total primary energy supply. The NREP lays down the foundation for developing the country's RE resources, stimulating investments, developing technologies and providing the impetus for national and local renewable utilisation. It sets out indicative interim targets for the delivery of renewables within the timeframe. In this scenario, the aggregated 20 gigawatt (GW) renewables capacity is assumed in 2050.

Under APS4, or the Nuclear Scenario, a 1,200 MW capacity was considered to determine the impact of possible long-term nuclear option in the country. The scenario is considered as a diversification measure that will aid energy security. Although the country has no firm policy direction on nuclear energy, the President of the Philippines has issued Executive Order (EO) No. 116, which directs the conduct of study for the adoption of national position on Nuclear

Energy Program in the Philippines. Lastly, the APS5 will focus on the combined effects of APS1, APS2, APS3 and APS4.

In the model, the gross domestic product (GDP) is projected to grow at an annual rate of around 4.9% for the period 2017 to 2050. The population of the country is expected to grow at the rate of 1.4% yearly for the same period. Population growth is based on the adjusted 2000 Census-based medium population projections using the results of the 2010 census of population.

3. Outlook Results

3.1. Business as Usual Scenario

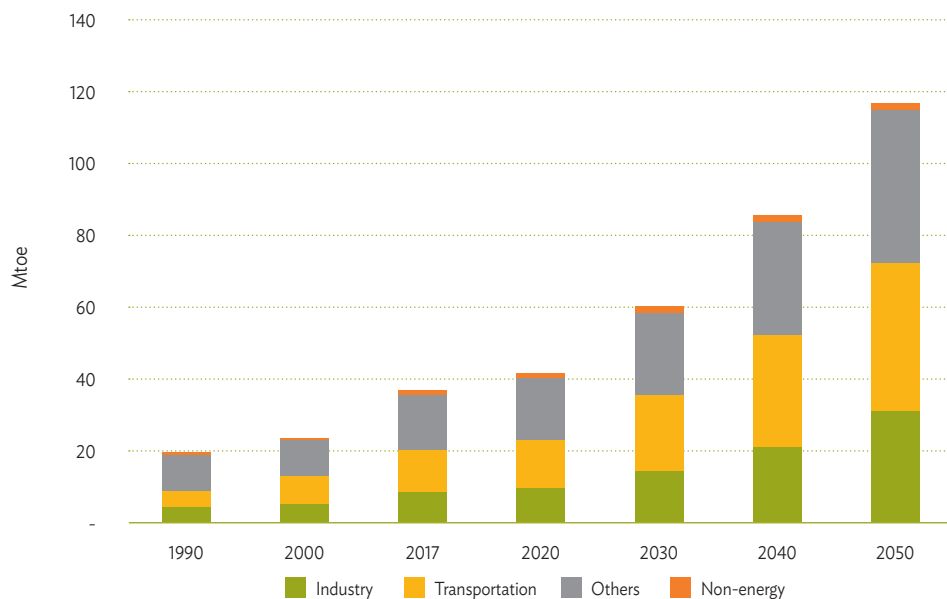
3.1.1 Total final energy consumption

3.1.1.1 Total final energy consumption by sector

The Philippines' final energy consumption grew from 19.0 Mtoe in 1990 to 36.7 Mtoe in 2017 at an average annual growth rate of about 2.5%. During this period, energy demand in the transport sector grew at an average annual rate of 3.5%, while the industry sector grew at 2.4%. Residential, commercial and AFF (others) initially had the biggest share at 51.6% in 1990 and declined to 41.7% share in the total final energy consumption mix due to its sluggish growth of 1.7% average per year from 1990-2017.

Meanwhile, final energy consumption is expected to grow at an annual average rate of 3.6% in the BAU scenario over the planning period 2017 to 2050. By the end of 2050, the combined demand of the other sectors will contribute a substantial share of 36.6% in the total final energy consumption, albeit with a slightly slower growth rate of 3.1% average per year. This can be attributed to the continuous expansion of the commercial sector as services and the business environment improves, and to the government's modernisation programs in the agriculture sector. However, as a single sector, transport will remain the most energy-intensive, taking up a 32.3% share in 2017 and growing at an average rate of 3.9% per year. Industry will grow vigorously at an average annual growth rate of 4.1% as the country's economy boosts government programs in the manufacturing sector. (Figures 14-1 and 14-2).

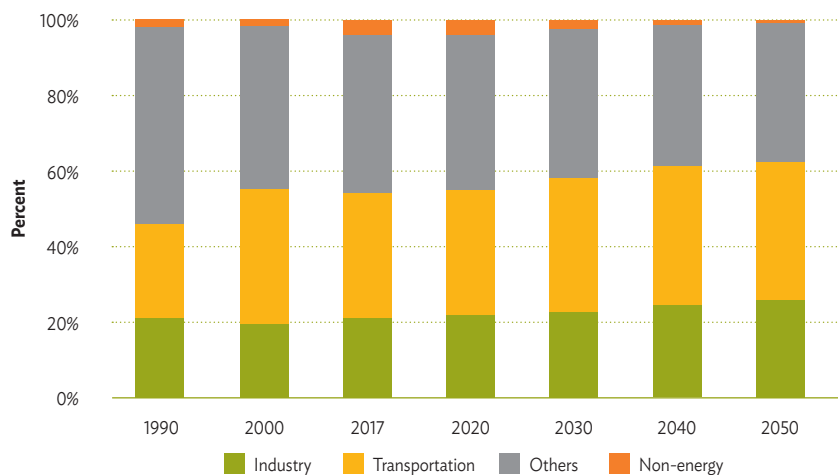
Figure 14.1. Total Final Energy Consumption by Sector, BAU



BAU = business as usual.

Source: Author's calculation.

Figure 14.2. Share of Total Final Energy Consumption, BAU



BAU = business as usual.

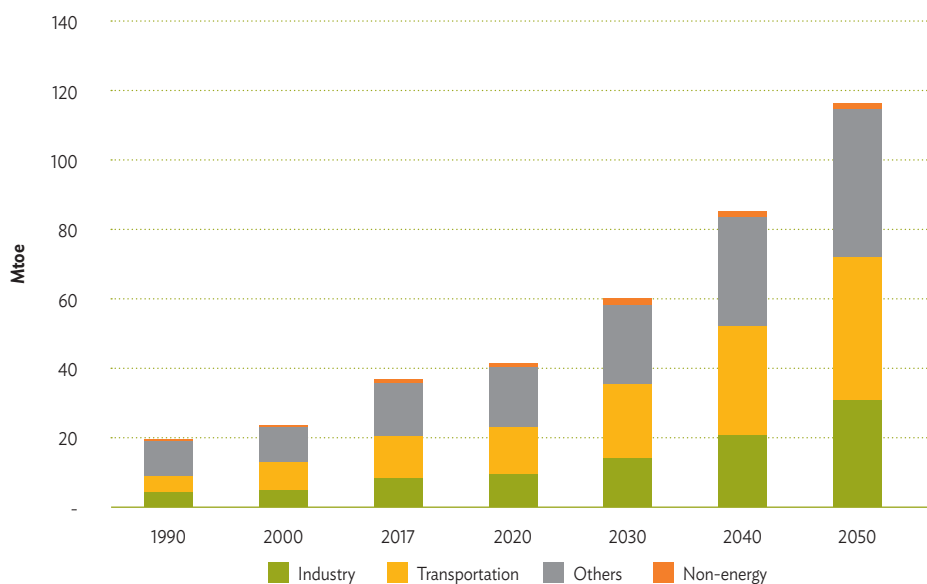
Source: Author's calculation.

3.1.1.2 Total final energy consumption by fuel

Petroleum products remain the most consumed fuel throughout the planning period due to the demand in the transport sector. Oil demand share of total final energy consumption takes about 48.5% in 2017, though it slightly decreases to a 45.1% share in 2050. Electricity is the second-most consumed energy source after oil and initially started with a share of 18.2% in 2017 in the demand mix and will grow to 33.2% in 2050. Electricity demand will quintuple from 6.7 Mtoe in 2017 to 38.6 Mtoe in 2050 due to the increased demand from all sectors, including: 1) expansion of the mass and light railway systems in the transport sector; 2) increase in household consumption due to fuel switching between electricity and LPG for cooking; 3) upsurge of the processes in the industry sector due to the resurgence of the manufacturing sub-sector; and 4) boost in activity in the modernisation of the agricultural sector.

Coal, which is largely used in the industry sector, is seen as having an upward trend, with demand quadrupling from 3.2 Mtoe in 2017 to 14.5 Mtoe in 2050 as industry requirements in cement and other energy-intensive manufacturing subsectors increase. On the other hand, the demand for other fuels such as biomass and other renewables is projected to have a minimal growth of 0.5% per year (Figures 14-3 and 4-4).

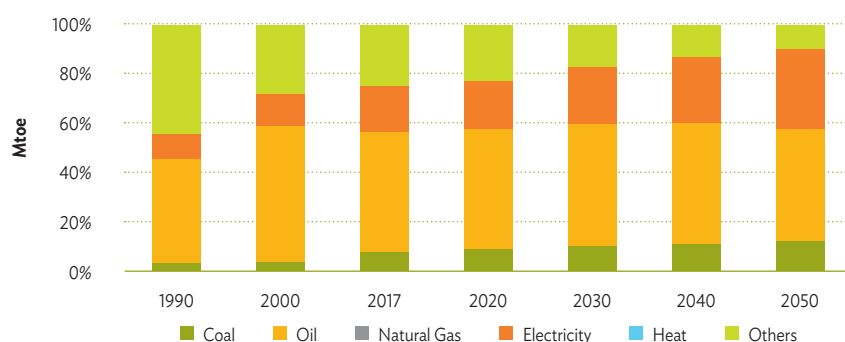
Figure 14.3. Total Final Energy Consumption by Fuel, BAU



BAU = business as usual.

Source: Author's calculation.

Figure 14.4. Share of Total Final Energy Consumption, BAU



BAU = business as usual.

Source: Author's calculation.

3.1.2 Total primary energy supply by fuel

Primary energy supply in the Philippines grew from 28.7 Mtoe in 1990 to 55.9 Mtoe in 2017 at an annual average rate of 2.5%. Amongst the major energy sources, coal grew the fastest, at 8.7% 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 increments of 2.4%, 2% and 1.7%, respectively. On the other hand, primary energy supply of other fuels went down by 0.5% per year.

For the planning period 2017 to 2050, the country's primary energy supply is expected to expand three folds from its 2017 level of 55.9 Mtoe to 176.6 Mtoe in 2050 at an average growth rate of 3.5% per year. Consumption for all major energy sources are projected to rise with coal growing at 4.7% per year. Coal will account for the largest share in the total energy supply of the country from 26.2% in 2017 to 38.4% in 2050. This is to provide for the growing demand of the economic sectors particularly in the industry sub-sectors.

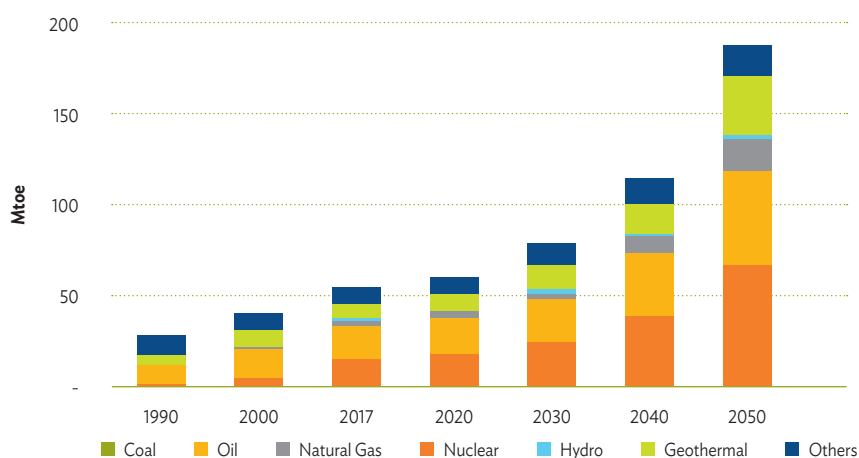
Oil will remain as one of the country's major energy requirements. However, it will display a downward trend in its overall average annual growth rate during the planning period, averaging only 3.3% growth for the period in review. The share of oil in the energy supply will decrease from 33.5% in 2017 to 30.6% in 2050 due to the penetration of alternative fuels such as biofuels and electricity and improvement in efficiencies and mileage in the transport sector.

Natural gas will expand at an annual average growth rate of 5.7% and consumption will reach 20.5 Mtoe, which will be mainly used for power generation. This is in line with the

ambitious government programme being pushed for the development of an LNG hub in the country to secure future supplies of natural gas.

On the other hand, major renewables supplies from geothermal and hydro will grow at a slower pace at an average rate of 1.9% and 2.5%, respectively, for the planning period. Other fuels' (such as biomass, solar, wind and ocean technologies) aggregated consumption will be at 9% of total consumption in 2050 and its average annual growth rate proceeds at a snail's pace of 1.5% across the planning period (Figures 14-5 and 14-6).

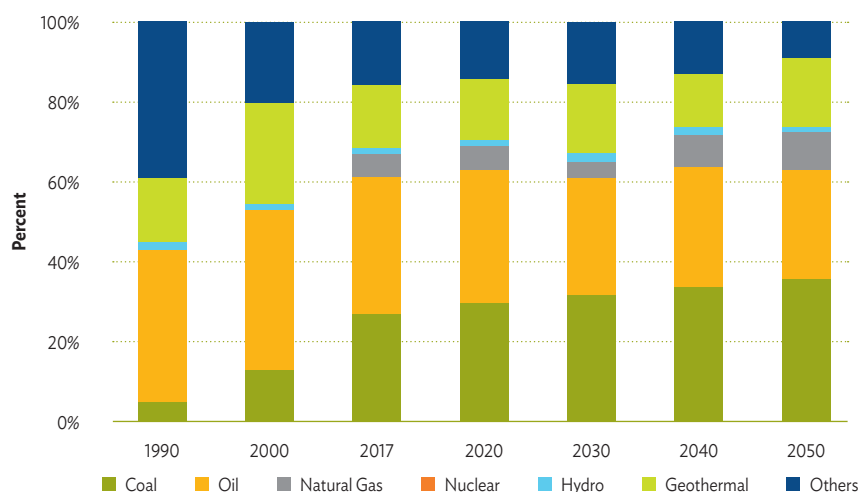
Figure 14.5. Total Primary Energy Supply by Energy, BAU



BAU = business as usual.

Source: Author's calculation.

Figure 14.6. Share of Total Primary Energy Supply by Energy, BAU



BAU = business as usual.

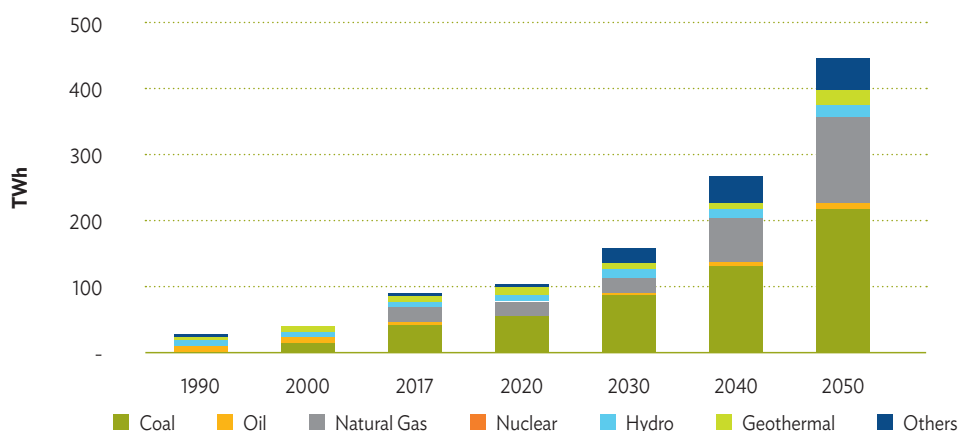
Source: Author's calculation.

3.1.3 Power generation

Total power generation in 2017 reached 94.4 TWh, more than 3.5 times the country's level of 26.3 TWh in 1990. With the committed and indicative capacities based on the Power Development Plan, the total power generation output is projected to rise by 4.8% yearly and reach 448.9 TWh by 2050. Coal will be country's major source of power, accounting for about 49.6% in 2017, peaking at 55.6% share in 2030, and declining to 49.2% in 2050. Power generation from coal will grow 4.7 times its 2017 level of 46.8 TWh and reach 221 TWh at the end of the planning period. Natural gas-fired power plants are also expected to follow an upward trend like coal, but will grow faster at 5.8% average per year, with generation levels rising more than six times its 2017 level of 20.5 TWh to 130.6 TWh in 2050.

Major renewables sources, such as hydro and geothermal, are expected to contribute an aggregate share of 9.1% (4.3% share for geothermal and 4.8% share for hydro) to the country's generation mix in 2050, as output will grow at an average annual rate of 1.9 and 2.5%, respectively. Generation from other fuels (solar, wind and biomass) is expected to increase at an average annual rate of 8.5%. Meanwhile, oil has an average annual growth of 1.9% during the planning period and by 2050 is anticipated to only account for 1.6% of total power generation. (Figures 14-7 and 14-8).

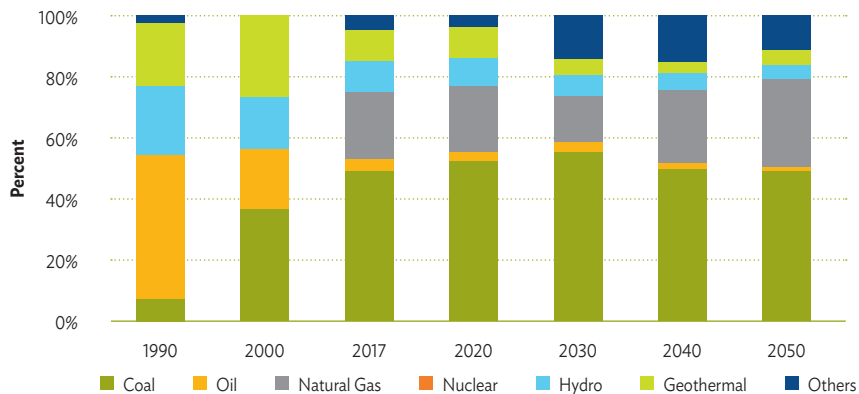
Figure 14.7. Power Generation by Fuels, BAU



BAU = business as usual.

Source: Author's calculation.

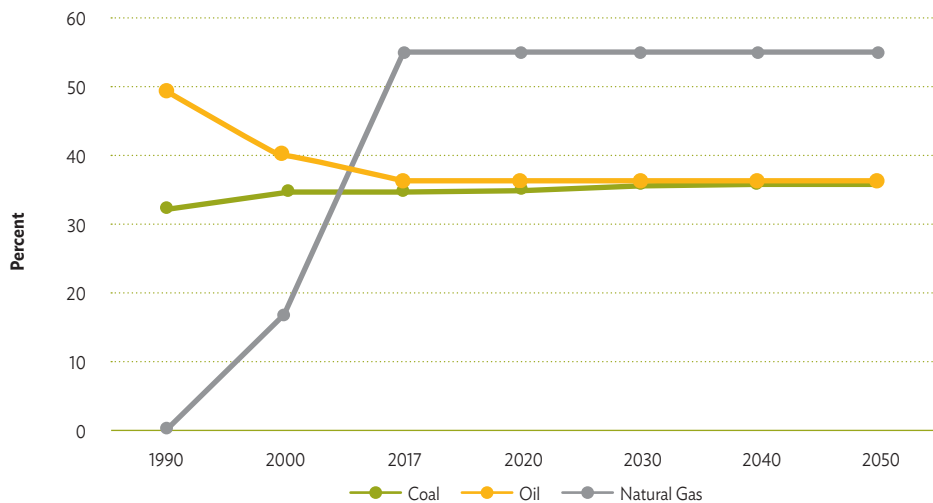
Figure 14.8. Share of Power Generation by Fuels, BAU



BAU = business as usual.

Source: Author's calculation.

Figure 14.9. Thermal Efficiency, BAU



Source: Author's calculation.

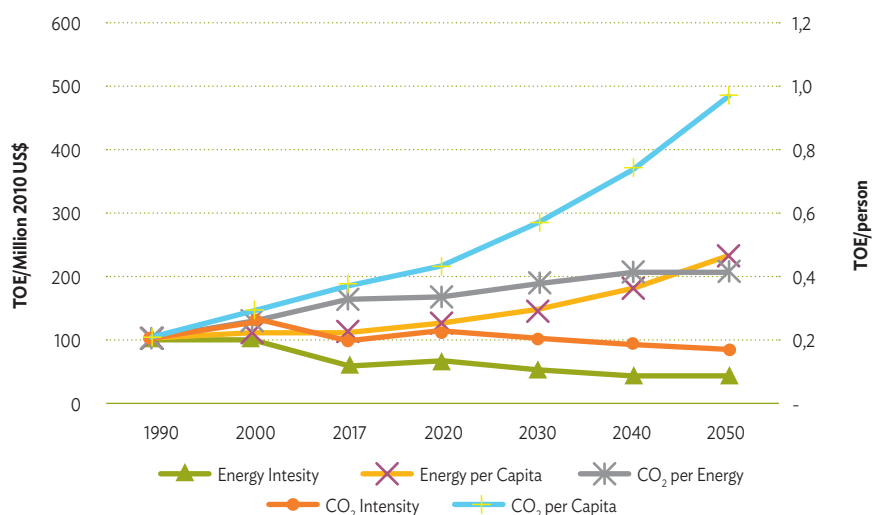
The thermal efficiencies of coal, oil, and natural gas under the BAU are projected to be fairly constant for the whole planning period. Coal thermal efficiency fluctuates between 35% and 35.9%, while oil and natural gas efficiencies are set at around 36% and 55%, respectively, for the entire planning period (Figure 14-9).

3.1.4 Energy indicators

Under the BAU, the country's average annual energy intensity decreases at 1.3% for the period 2017 to 2050. Energy intensity is the ratio of total primary energy over GDP. The significant

reduction of energy intensity is attributable to the government's efforts in promoting energy conservation and efficiency in the different sectors of the economy. Meanwhile, energy per capita has an increasing trend from 0.5 tonnes of oil equivalent (toe)/person in 2017 to 1.1 toe/person in 2050. The increasing trend is due to the improvement on the standard of living and income of the people (Figure 14-10).

Figure 14.10. Energy Intensity, Energy Per Capita and Energy Elasticity



Source: Author's calculation.

3.2. Alternative Policy Scenarios

As mentioned above, the assumptions in the APSs were analysed separately to determine the individual impacts of each assumption in APS1 (energy efficiency), APS2 (thermal efficiency), APS3 (higher renewables), APS4 (contribution of nuclear energy) and APS5 (the combination of all these assumptions).

3.2.1 Total primary energy supply by fuel

Figure 14-11 shows the changes in total primary energy supply in all the scenarios. APS1, which assumes improved efficiency of final energy consumption, is projected to increase at a rate of 3.3% per year as levels reach 163.7 Mtoe by 2050. Compared to the BAU scenario, APS1 has the second-largest energy saving potential next to APS5, compared to other scenarios registering a 7.3% reduction, or 12.9 Mtoe lower. This is attributable to the projected savings from the range of measures that will be implemented in the energy sector, such as intensified energy utilisation management programs in the commercial and industrial

sectors, power plants and distribution utilities, the continuous use of alternative fuels and technologies and other measures that will be developed with the implementation of RA No. 11285, or the Energy Efficiency and Conservation Act.

APS2's total primary energy supply will be lower by 5.1% or 9 Mtoe as compared to the BAU scenario and will reach 167.6 Mtoe in 2050, indicating that improving thermal efficiency alone in fossil fuel-based power plants can lead to notable energy savings.

Under APS3, the total primary energy supply will be at 182.3 Mtoe, which is higher by 5.7 Mtoe as compared to BAU. This is mainly due to the ramp up in utilisation of geothermal, hydropower and other renewables in power generation. Efficiencies of renewables are lower as compared to fossil fuels, resulting to higher fuel input, thus increasing total primary energy supply. During the planning period, geothermal energy will grow at an average rate of 4% per year and will grow from 8.8 Mtoe in 2017 to 31.8 Mtoe in 2050. The aggregate generation output from solar, wind and ocean is expected to increase at an average rate of 10% per year.

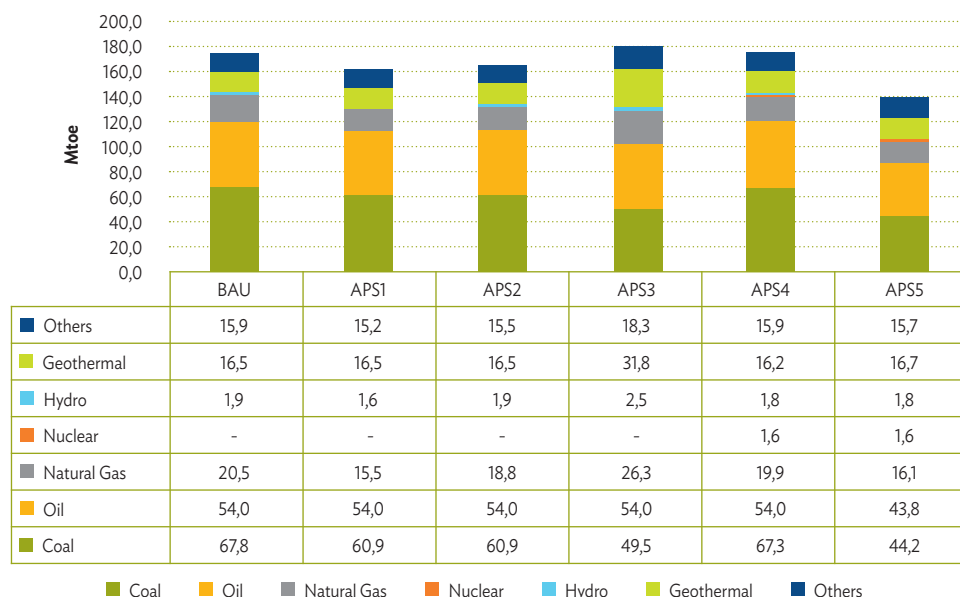
Under APS4, where nuclear energy is assumed to be part of the energy mix, total primary energy supply is expected to be higher by 0.2 Mtoe compared to BAU. This is due to the assumption that nuclear power plants' thermal efficiency is at 33%, lower than the efficiencies of the natural gas and coal power plants at 35%–35.9% and 55%, respectively.

Combining all scenarios, the country's total primary energy supply under the APS5 will grow at an annual average rate of 2.8% and reach 139.8 Mtoe in 2050. The combined effect of APS1 and APS4 is expected to yield the largest reduction at 36.7 Mtoe, which is 20.8% lower than the supply level under the BAU. This indicates the effectiveness of combining various energy assumptions (improved efficiency in the energy demand and thermal power generation, higher contribution of renewables and entry of nuclear in the supply mix) to achieve the feasible level of total primary energy supply by 2050 (Figure 14-11).

3.2.2 Total electricity generation

Figure 14-12 shows the total electricity generation in 2050 in all scenarios. Due to the efficiency measures resulting to lower electricity demand, APS1's total generation output is projected at 359.3 TWh. All fuels registered reduced generation output vis-à-vis the BAU scenario (save for nuclear, which is set at zero in both scenarios). APS1's annual average growth rate will increase by 4.1%. Natural gas is seen to grow the fastest at an average of

Figure 14.11. Total Primary Energy Supply by Energy, BAU and APS, by 2050



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

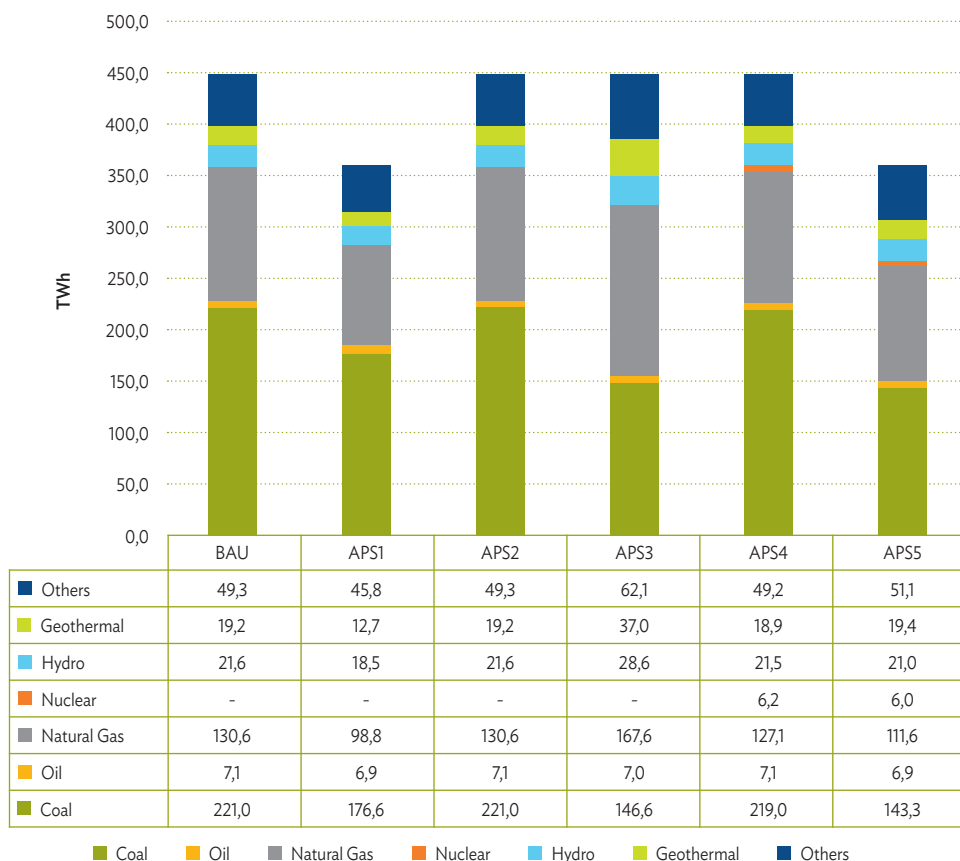
4.9% per year and output reduction at 24.3% as compared to BAU. Due to reduced consumption of electricity, the total fuel input reduced significantly by 21.1% from the BAU level of 75.4 Mtoe.

APS2, APS3 and APS4 yield the same total generation output of 448.9 Mtoe. Under APS2, there is no difference in terms of power generation output as compared with BAU. However, the effect of higher thermal efficiencies of the fossil fuel plants reduced the fuel input by 11.4%. It will only require 46.4 Mtoe of input for coal power generation in APS2, as compared to 53.3 Mtoe in BAU, to produce the same power generation output of 221 TWh as coal capacities process efficiency increases from 35% to 41%.

APS3, on the other hand, will have higher generation share from natural gas and renewables technologies. Amongst the renewables technologies, geothermal will significantly increase by 92%, as compared to BAU, and will have an annual average growth rate of 4% as the government continues to harness the geothermal potential in the country.

While APS5's total generation output is equal to that of APS1 for 2050 at 359.3 TWh, the aggregate level of power output from coal and oil from APS1 to APS5 will decline by 18%, or from 183.5 TWh to 150.1 TWh.

Figure 14.12. Total Primary Energy Supply by Energy, BAU and APS, by 2050



APS = Alternative Policy Scenario, BAU = business as usual.

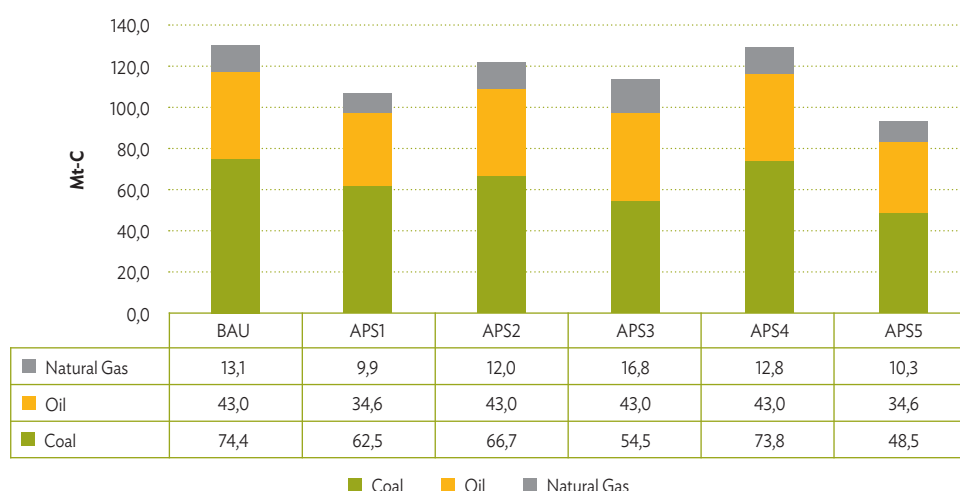
Source: Author's calculation.

3.2.3 Total CO₂ emissions

APS1 (or the energy efficiency scenario) has the second-largest reduction of 23.4 million metric tonnes of carbon (Mt-C), or 17.9% lower than the BAU level of 130.5 Mt-C for 2050 and will generate 107.1 Mt-C in total. The decrease in CO₂ indicates that the energy savings goals, action plans and policies in the promotion of energy efficiency and conservation programme will have a substantial impact in reducing emissions (Figure 14-13).

The improvement of thermal efficiency under APS2 will reduce the total CO₂ emissions by 8.7 Mt-C or 6.7% relative to BAU. On the other hand, a boost in the share of renewables technology under APS3 will lead to a reduction of 16.2 Mt-C or 12.4%. Additional capacity of 1,200 MW from nuclear by 2035 in APS4 will slightly shed off 0.9 Mt-C or 0.7% relative to BAU. Combining all the assumptions in APS1, APS2, APS3 and APS4 will give an aggregate reduction of CO₂ emissions from the BAU at 37 Mt-C or 28.4%.

Figure 14.13. CO₂ Emissions by Fuels in 2050, BAU and APS



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

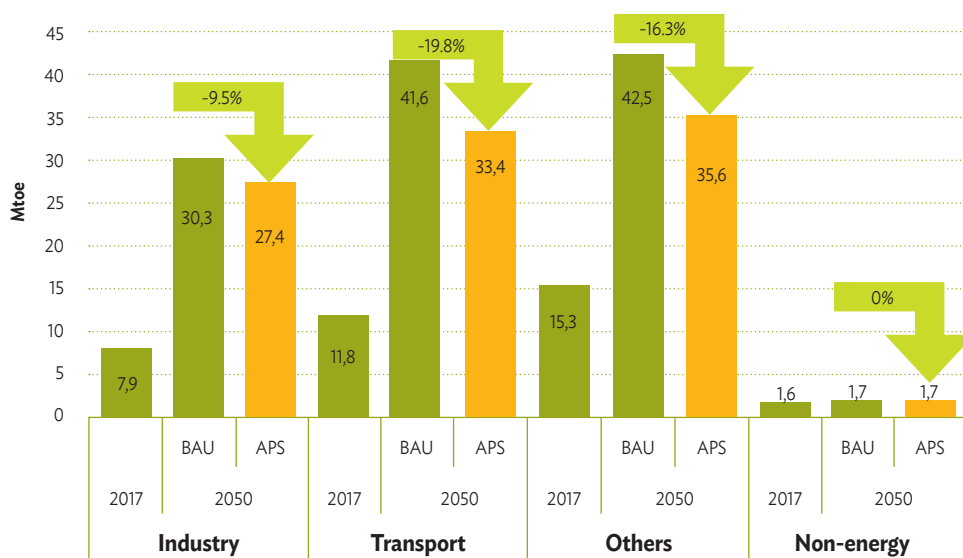
3.2.4 Energy savings potential

Figure 14-10 shows the level of total final energy consumption by sector between BAU and APS5 in 2050. Due to the improved economy-wide energy efficiency under APS5, the total final energy consumption will reduce by 15.5% or from 116.1 Mtoe in BAU to 98.1 Mtoe in APS5. A reduction of 19.8% can be observed from the transport sector, the highest reduction amongst the sectors, due to set higher efficiency standards for vehicles mandated through the passage of the 2019 Energy Efficiency and Conservation Law. It can also be attributed to use of mass transport, as well as improved networks and highways. Energy demand from residential, commercial and AFF (others) at 35.6 Mtoe in APS1 is 16.3% lower than its BAU level of 42.5 Mtoe. This can be attributed to an aggressive energy labelling programme, energy efficiency solutions for commercial purposes and infrastructures and technology improvement. Lastly, the industry sector will contribute 9.5% reduction in its utilisation from 30.3 Mtoe in BAU down to 27.4 Mtoe in APS5 due to advancement in technologies and efficient industry systems and practices.

Figure 14-15 illustrates the comparison between the BAU and APS5 total primary energy supply by fuel in 2050. The impact of improved efficiency is evident in all the fossil fuel-based sources. Coal shows a significant decline in consumption from 67.8 Mtoe in BAU to 44.2 Mtoe in APS5, the largest absolute and relative reduction of (34.8%) of any single source. This is followed by natural gas and oil, which declined substantially at 21.6% and

18.9%, respectively. This is mainly due to improved thermal efficiencies of the fossil fuel-based power plants. On the other hand, consumption of non-fossil sources increases by 4.3% compared to BAU.

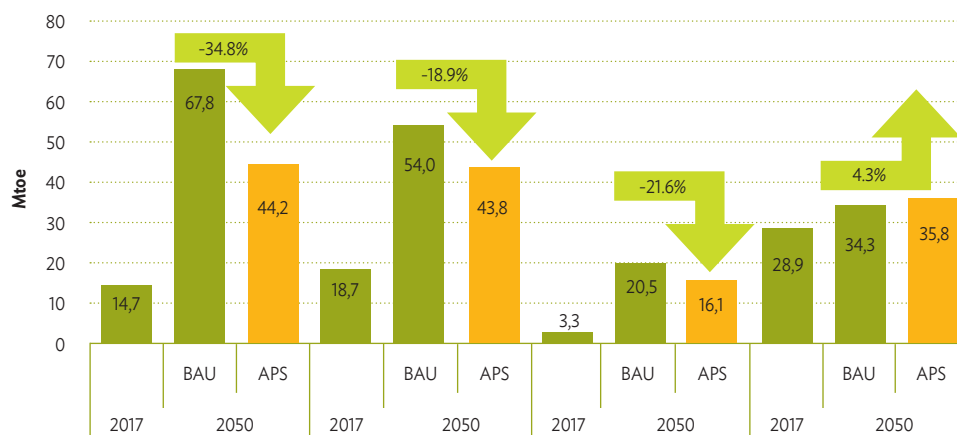
Figure 14.14. Final Energy Consumption by Sector in 2050, BAU vs APS



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

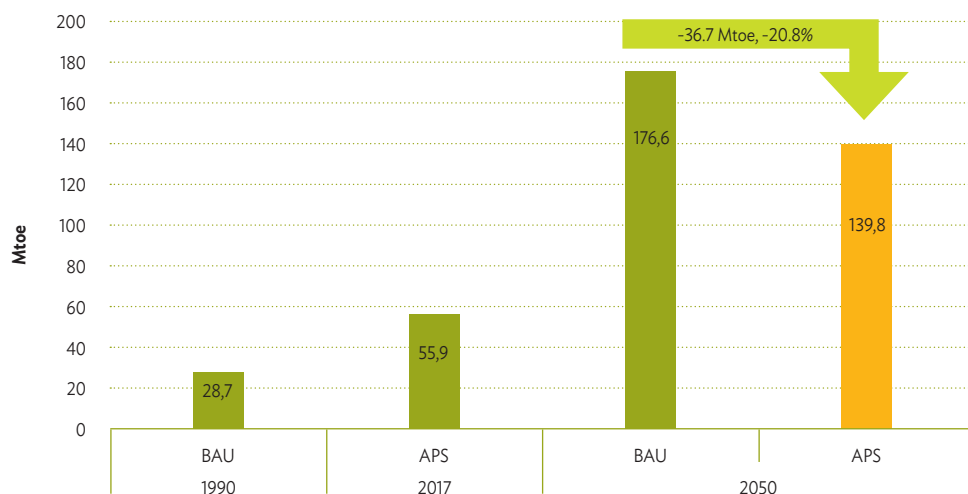
Figure 14.15. Total Primary Energy Supply by Fuel in 2050, BAU vs APS



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

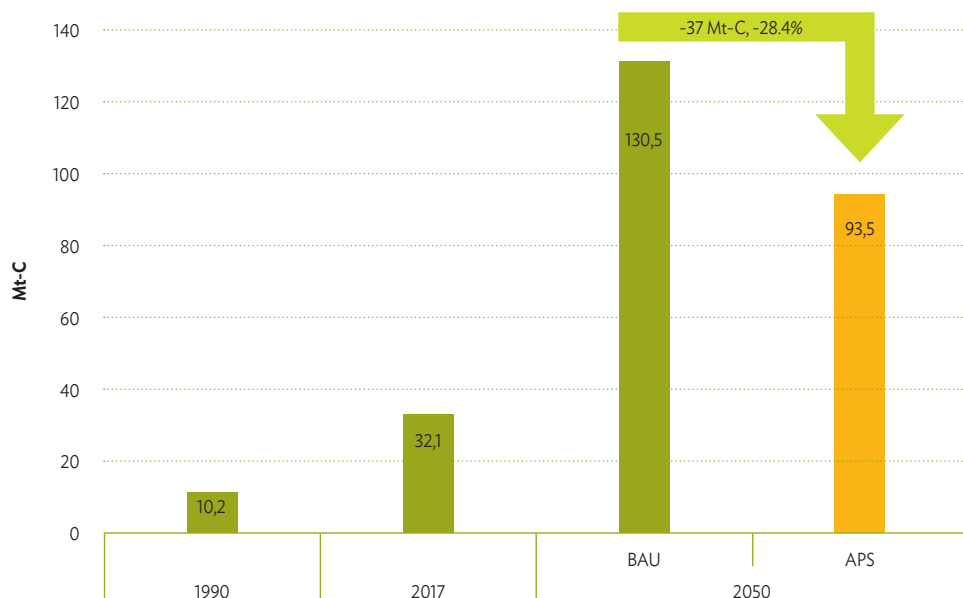
Figure 14.16. Total Primary Energy Supply in 2050, BAU vs APS



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

Figure 14.17. CO₂ Emissions in 2050, BAU vs APS



APS = Alternative Policy Scenario, BAU = business as usual.

Source: Author's calculation.

Figure 14-16 shows the comparison between the total primary energy supply between BAU and APS5 in 2050. With the combination of energy efficiency measures, the primary energy supply in total will have a reduction of about 36.7 Mtoe or 20.8% from the BAU level of 176.6 Mtoe.

Figure 14-17 shows the comparison of CO₂ emissions between BAU and APS5 in 2050. The implication of energy savings in the total primary energy supply resulted to 37 Mt-C or 28.4% reduction in the CO₂ emissions in APS5 compared to BAU level. This will help the country reduce its CO₂ emissions in general and achieve its Nationally Determined Contribution target.

4. Implications and Policy Recommendations

Overall, the result of this study implies the significant energy savings potential that the Philippines will achieve based on the given assumptions. Notable in the results is the energy savings potential through the implementation of energy efficiency and conservation standards and measures. Fortunately, the Philippine energy sector has realised the importance of having a policy that would drive the economic sectors toward a more prudent utilisation of energy resources and higher energy efficiency without sacrificing the economic needs reflected through the energy demand in the future. Based on the projections in BAU, the final energy consumption is expected to triple from the 2017 level of 36.7 Mtoe to 116.1 Mtoe by 2050. This shows the large energy requirement of a developing country such as the Philippines, for which the current administration has set an aspirational goal for the Philippine economy as outlined in the *AmBisyon Natin 2040*. On the demand side, oil will remain as the biggest share in the final energy consumption, or almost half of the demand mix at the end of the planning period. Nonetheless, demand for oil will yield higher energy potential savings with the implementation of the energy efficiency and conservation programme and alternative fuel and technology development. The results of the model indicate that the share of oil in the total demand is at a range between 43% to 45.1% across different scenarios.

One policy recommendation is for the government to focus on the promotion of alternative fuels in the transport sector to substitute partly and directly for the use of oil in the sector, with the extended implementation of alternative fuels in the transport programme. However, the challenges in promoting alternative fuels must be addressed accordingly for a successful penetration in the market. While the government has passed a law on energy efficiency and conservation, the target for electric vehicle penetration should be decided and supporting policies for charging stations must be decided as well. Energy demand is also affected by consumer behaviour. **The government should intensify its promotion of energy efficiency and conservation measures with specific targets and strategy.**

With an expected growth in the energy requirement, the energy sector should lay its

energy supply plan to meet the growing energy needs of the country. The study shows the optimal energy mix that can be adopted given the different APS scenarios. For the case of the Philippines, coal will remain as a major power source due to its availability and more economical cost of production compared to other technologies. In fact, more than 70% of the committed capacities in the short term to medium term will come from coal power projects.

With this, **a recommendation is to improve the thermal efficiencies of fossil fuel-based plants, specifically for coal power plants.** The results of APS2 show that improvement of thermal efficiency of coal power plants will already give an energy savings potential of about 11.4% reduction in terms of fuel input compared to the BAU scenario. Further reduction can also be met in the improvement of thermal efficiencies of natural gas and oil power plants. Moreover, this may have substantial effect in the CO₂ emissions reduction. APS2 shows a reduction of 8.7 Mt-C, or about 6.7%, just by improving the thermal efficiency of power plants. On the other hand, investments and upfront costs may be high in acquiring power plants with high thermal efficiency. However, the long-term effect on the cost of power due to lower production requirements is something to be further investigated to consider adopting such a policy. Nonetheless, the foreseeable impact can be seen in terms of energy security in general, as this will at least reduce importation requirements for coal. However, a policy challenge is that the power sector is a deregulated industry and driven by private sector investments. The government may need to think of a policy solution to drive investments in highly efficient technologies in the future.

The Philippines government has been dedicated to the implementation of the Renewable Energy Act of 2008 to further increase and enhance the utilisation of indigenous, clean and efficient alternative fuels through the development of indigenous energy such as geothermal, hydro, solar, wind, biomass, and other emerging renewables technology as a strategy for energy security through higher dependence on indigenous resources. The renewables policy mechanisms such as FIT, RPS for on-grid and off-grid, the renewables market, the Green Energy Option Program, as well as other future policy mechanisms, will ensure the share of renewables in the power generation mix.

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CHAPTER 15

Singapore Country Report



Zhong Sheng

1. Background

Singapore is a small island-state in Southeast Asia, located along the Straits of Malacca between Malaysia and Indonesia. It is the most urbanised and industrialised country in the Association of Southeast Asian Nations (ASEAN), with a per capita gross domestic product (GDP) of US\$58,829.60 (in constant 2010 US dollars) in 2019. Under the Copenhagen Accord, Singapore also has a voluntary target of reducing CO₂ emissions by 7% to 11% below business-as-usual (BAU) levels in 2020 (NCCS, 2012), which will be increased to 16% if there is a global agreement on climate change. Singapore has signed off on the Paris Agreement as of 22 April 2016 (Ministry of Foreign Affairs, Singapore, 2016) and submitted its Enhanced Nationally Determined Contribution (NDC) and Long-Term Low-Emissions Development Strategy to the United Nations Framework Convention on Climate Change Secretariat on the 31 March 2020 (NCCS, 2020c). Singapore's Enhanced NDC now states an absolute emissions target of 65 million tonnes of carbon dioxide equivalent (MtCO₂e) around 2030. In addition, the Enhanced NDC will expand the scope of the country's pledge to include a seventh greenhouse gas, nitrogen trifluoride, within this peak emissions ceiling. The Long-Term Low-Emissions Development Strategy will reduce Singapore's emissions from its peak to 33 MtCO₂e by 2050, with a view to achieving net zero emissions as soon as viable in the second half of the century.

2. Singapore's Policy Initiatives

The Inter-Ministerial Committee on Climate Change was created in 2007 to facilitate a Whole-of-Government approach to addressing climate change-related issues. Chaired by Mr. Teo Chee Hean, Senior Minister and Co-ordinating Minister for National Security, the Committee is

attended by the Ministers for the Environment and Water Resources, Finance, Foreign Affairs, National Development, Trade and Industry, as well as Transport, to provide overarching strategic planning for Singapore's mitigation efforts.

Switching to cleaner fuels, energy efficiency improvements and the promotion of alternative sources of energy were highlighted as the main tenets of Singapore's mitigation policies. These policies were developed as part of the country's national policy framework to support its multi-pronged objectives of achieving economic competitiveness, energy security and environmental sustainability all at the same time (Ministry of Trade and Industry of Singapore, 2007).

Fuel Switch

Singapore started switching from oil to natural gas as a source for power generation since the early 2000s. Today, natural gas remains a key component of Singapore's power generation mix. Imports into Singapore increased by 0.9% in 2018, and in 2019, natural gas represented 95.3% of the fuel mix for electricity generation in Singapore. Petroleum products, coal and others accounted for the remaining 0.7%, 1.2% and 2.9%, respectively (EMA, 2020c). According to the Third Biennial Update Report published by the National Climate Change Secretariat in 2018 (NCCS, 2018), there are limits to how much more emissions can be reduced by switching fuels, as natural gas already constitutes more than 95% of Singapore's fuel mix for electricity generation.

To expand the country's import capability and sourcing options for liquefied natural gas (LNG), the Singapore LNG terminal began operations in May 2013, with two storage tanks and an initial throughput capacity of 3.5 million tonnes per annum (Mtpa). A third tank and additional regasification facilities were completed in January 2014, increasing the throughput capacity of the terminal to 6 Mtpa, and a secondary jetty was added to the operations in March 2014. Subsequently, in 2018, a fourth LNG storage tank and additional regasification facilities were completed. This further increased the terminal's send-out capacity to around 11 Mtpa (EMA, 2020b).

Promoting Solar Energy

Singapore has been very active in promoting solar energy as the only renewable source of energy to meet its needs. Although there are no subsidies for solar technology, there is policy support for removal of non-market barriers, as well as for facilitating system integration

of the intermittency of solar energy without compromising grid stability and for research, development and demonstration efforts aimed at cost reduction and efficiency improvement of solar modules.

As part of the policy objective of accelerating the scale of solar deployment in Singapore, the Housing and Development Board (HDB), together with the Economic Development Board launched the SolarNova programme in 2014, which is a Whole-Of-Government effort promoting solar deployment through aggregating demand across the public sector. This programme is estimated to generate about 420 GWh of solar energy annually, which is approximately 5% of Singapore's total energy consumption, or equivalent to powering 88,000 four-room flats. According to the HDB, SolarNova Phase 1 and Phase 2 tenders have been successfully launched in 2015 and 2016, respectively, which have added another 94 MWp of solar panels to be installed across an estimated 1,500 HDB blocks (HDB, 2020). New SolarNova tenders will be launched until 2020, which is estimated to reach an overall solar target of 350 MWp.

Other approaches to further promote the deployment of solar include floating panels. The Public Utilities Board (PUB), Singapore's National Water Agency launched a floating solar testbed at Tengeh Reservoir in Singapore in October 2016. Further, PUB has plans that implement more floating solar projects in reservoirs in Singapore, such as Bedok, Lower Seletar, Tengeh and Upper Peirce. In particular, the current floating solar project in Tengeh Reservoir offers a large scale solar of 50 MWp. The total amount of energy generated from the four reservoirs can potentially power 15,000 four-room HDB homes (NCCS, 2018).

Energy Efficiency Improvements

Energy efficiency is another integral part of Singapore's mitigation efforts. The Energy Efficiency Programme Office (E2PO), led by the National Environment Agency and the Energy Market Authority, was established in May 2007. The E2PO is a multi-agency committee that jointly promotes and facilitates energy efficiency in Singapore (Energy Efficiency Programme Office, 2020a). Across the nation, energy efficiency improvements are promoted through a plethora of standards and regulations, public awareness and messaging, as well as the adoption of more efficient appliance stock.

Households

The household sector accounts for about 16% of the total electricity consumption in Singapore and thus is a key sector for energy efficiency policies. The Mandatory Energy Labelling Scheme (MELS) and Minimum Energy Performance Standards (MEPS) are two pillars of residential energy efficiency policies. The MELS, introduced in 2008, imposes compulsory display of energy labels on relevant household appliances. This requirement is imposed on all registrable air conditioners and refrigerators, as well as smaller appliances such as television sets, clothes dryers and lighting more recently. The MELS informs consumers and helps them identify, and thereby purchase, more energy-efficient appliances. In September 2014, the tick ratings on energy labels were improved to help consumers better differentiate the energy efficiency of various models.

The MEPS is a supply-side policy that complements the MELS by prohibiting sale of appliance models that do not meet the minimum specified energy efficiency levels. MEPS for air conditioners and refrigerators were raised in 2016 and 2017, respectively. MEPS were also extended to clothes dryers on 1 April 2014 and lamps on 1 July 2015 (NCCS, 2018). They help consumers avoid being locked into using inefficient appliances with high operating costs and encourage suppliers to import more energy-efficient appliances as innovation progresses over time. Both the MELS and MEPS are constantly evaluated and revised to ensure policy efficacy and efficiency.

In addition to the MELS and MEPS, various public messaging campaigns targeting behavioural change in households were also introduced. These initiatives target both the initial purchasing decision, as well as behaviour at the consumption stage. For example, the Life Cycle Calculator and the Saving Energy at Home initiatives, which improves consumer awareness and provides information related to energy efficiency at home. In 2017, the Singapore Government organised “The Energy-Saving Challenge” to encourage households to be more energy efficient and practise energy-saving habits. The Challenge received close to 7,000 entries and participants saved a total of 330,000 kWh.

Transport

According to the E2PO, energy efficiency in the transport sector is governed by three complementary policy objectives: (1) reducing private transport (2) promoting public

transport ridership and (3) promoting non-motorised transport. The mitigation measures in the transport sector are projected to achieve 1.64–1.68 MtCO₂e abatement by 2020, with an estimated 0.9 MtCO₂e abatement in 2016.

The Vehicle Quota System (VQS) regulates the growth of the vehicle population in Singapore. Under the VQS, anyone who wishes to register or buy a new vehicle in Singapore must first obtain a Certificate of Entitlement, which represents a right to vehicle ownership for 10 years. In view of the land constraints on road expansion, the annual vehicle population growth rate has been reduced to 0% effectively from February 2018 onward. The Fuel Economy Labelling Scheme and the Carbon Emissions-based Vehicle Scheme were introduced in 2013 (NCCS, 2018). The Fuel Economy Labelling Scheme provides information on the fuel economy for more informed decisions on high-emissions cars. The Carbon Emissions-based Vehicle Scheme was replaced by the Vehicular Emissions Scheme with a new label in January 2018.

Public transport is the most energy-efficient mode of travel. Under the Land Transport Masterplan, Singapore targets a 70% public transport modal share during peak hours by 2020, and 75% by 2030, up from 59% in 2008 and 67% in 2017. In a nutshell, the promotion of public transport ridership is achieved by ensuring the efficiency and reliability of public transport services. In particular, 1,000 new buses and 80 new bus services were added to the bus network between 2012 and 2017.

In addition to constantly upgrading and expanding the current fleet of public transport vehicles, actions were also taken to expand the existing metro lines and outreach. The length of the rail networks will increase from 230 km to about 360 km by 2030. This will enable eight in 10 households to be within a 10-minute walk of a train station, and 85% of public transport journeys of less than 20 km to be completed within 60 minutes.

To improve the overall experience of commuters, especially in the first and last mile of their journeys, the Government will also be building more than 200 km of sheltered walkways island-wide. The aim is to provide a cycling path network in every public housing town, and an island-wide off-road cycling path network of more than 750 km by 2025, rising from 440 km today (LTA, 2020). More integrated transport hubs will also be built to enable commuters to switch between different types of transport easily, with convenient access to retail, dining and other lifestyle services. Cycling and walking are also encouraged through public messaging campaigns. In addition, various trials are underway to promote the use of the electric vehicles in Singapore. In December 2017, Singapore rolled out an electric car-sharing programme, which aimed to introduce 1,000 shared electric cars and 2,000 charging

kiosks island-wide by 2020. In the first quarter of 2019 and mid-2020, 50 hybrid buses and 60 electric buses are planned to be in use, respectively (NCCS, 2018).

Buildings

At the design stage, energy efficiency in building is governed by the Building and Construction Authority of Singapore's Green Mark Scheme. Launched in January 2005, the Green Mark Scheme targets environment-friendly design in buildings, with a focus on energy efficiency, water efficiency, environmental protection, indoor environmental quality and other green features allowing landlords to 'go green' (Energy Efficiency Programme Office, 2020b). As of 2008, all new buildings are required by law, under the Building Control (Environmental Sustainability) Regulations, to meet standards that are equivalent to the Green Mark Certified rating. The Green Mark Scheme promotes green building technologies and reduces the use of electricity in the commercial sector via efficiency improvements and conservation. There are also incentives and financing schemes, such as the SGD50 million Green Mark Incentive Scheme for Existing Buildings and Premises and Building Retrofit Energy Efficiency Financing scheme, for developers to achieve higher-tier Green Mark ratings. The aim is to achieve Green Buildings standards for at least 80% of the total gross floor area in Singapore by 2030, compared to more than 34% as of 1 January 2018.

Since 2006, the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) initiative have placed the public sector at the front of building energy efficiency. Under the PSTLES, public sector agencies have been encouraged to put in place environmental sustainability measures that encompass energy efficiency, water efficiency and recycling. In 2014, the PSTLES initiative was enhanced by, for example, requiring each Ministry to appoint a Sustainability Manager, set sustainability targets for FY2020 and develop a resource management plan. Moreover, the Guaranteed Energy Savings Performance (GESP) Contracts initiative was introduced to ensure reaping the expected energy savings. Under the GESP Contract structure, a public sector agency is expected to engage an accredited Energy Services Company to carry out an energy audit, implement the relevant energy efficiency measures and guarantee annual energy savings over the contract term (typically 5 years) (Energy Efficiency Programme Office, 2020c). As of March 2017, 28 large building owners have called GESP contracts for their building retrofit works, which, on average, help building owners save 16% of their total electricity use, enabling the public sector to save a total of SGD8.5 million annually.

Industry

According to Singapore's third biennial update report, industry consumes the most energy in Singapore; thus, improving industrial energy efficiency is key to reducing emissions. The Singapore Government has implemented various grants, private sector financing schemes and tax incentives to encourage energy-efficient technologies. Mandatory energy management requirements for energy-intensive companies in the industry sector were later introduced in April 2013 under the Energy Conservation Act (ECA). The ECA has been further enhanced. For example, since 2018, companies under the ECA are required to adopt specified methodologies for greenhouse gas measurement and reporting. From 2021, companies under the ECA will be required to put in place a structured energy management and assessment system at existing industrial facilities. In particular, minimum energy performance standards were introduced in late 2018 to phase out the least-efficient industrial electrical motors.

The financing schemes include the Grant for Energy Efficiency Technologies, which is designed to offset part of the initial capital investments in energy-efficient technologies. Similarly, the Energy Efficiency Improvement Assistance Scheme provides co-funding for companies to conduct energy assessments. In 2017, the Energy Efficiency Improvement Assistance Scheme and other existing incentive schemes were consolidated to form the New Energy Efficiency Fund. In addition, Singapore has plans for national schemes for building energy efficiency capabilities within the workforce. Overall, these mitigation measures are estimated to achieve 1.43 MtCO₂e abatement by 2020, with an estimated 1.27 MtCO₂e abatement in 2016.

3. Modelling Assumptions

The model is calculated under the Business as Usual (BAU) scenario and several Alternative Policy Scenarios (APS). APS1 – 3 allow for larger changes in power generation or sectoral electricity demand, as compared to the BAU scenario. APS5 is the scenario combining changes applied in all other APS scenarios.

3.1 Power Generation Sector

For a BAU scenario, the generation efficiency of combined-cycle gas turbine plants are assumed to improve from 56.48% in 2017 to 58% in 2050. Single-cycle thermal plants are expected to improve marginally as well, from 24.3% in 2017 to 45% in 2050. With respect to

the use of solar generation capacity, it is assumed to grow from 0.32% in 2017 to around 6% of total electricity generated in 2050, as part of public efforts towards promoting renewable energies. In addition, the share of municipal solid waste is assumed to increase from 1.16% in 2017 to 1.32% in 2050.

With respect to APS2, which takes into account greater potential for efficiency in the power generation sector, combined-cycle gas turbine plants will reach 65% efficiency by 2050, while single-cycle thermal plants could reach an efficiency of 48% by 2050. APS3 allows for the share of solar to reach 25% of Singapore total electricity needs in 2050.

3.2 Transport Sector

Demand for petrol, natural gas and diesel for Singapore's road vehicles is assumed to be dependent primarily on vehicle growth. Consistent with quota targets set by the Land Transport Authority, vehicle growth will stay at 0% from 2017 to 2050 for the BAU scenario. Electricity demand for the Mass Rapid Transit system is mainly driven by the expected expansion of railway length, which will increase from 203 km in 2017 to 380 km by 2050, an annual average growth rate of 1.91% per year. All APS remain similar to BAU here, as no further vehicle growth reductions or railway efficiency improvements have been assumed.

3.3 Residential Sector

In the BAU scenario, residential electricity demand is assumed to be reduced by 2.5% by 2020 due to the MEPS as compared to the projected values. From 2021 to 2050, the demand is the same with the projected values. The projected residential electricity demand until 2050 is assumed to be affected by GDP per capita and previous year's demand. The projections were conducted by the ordinary least squares estimator with robust standard errors. Electricity demand can be further reduced by 10% by 2030 due to the MEPS as compared to the projected values in the APS1 and APS5 scenarios. Demand for natural gas and oil products increase at the same rate with the growth of population in all scenarios.

3.4 Commercial Sector

In the BAU scenario, the electricity demand is assumed to decrease by 5% by 2020 due to the BCA Green Mark Scheme as compared to the projected values. From 2021 to 2050, the electricity demand changes at the projection rates. The ordinary least squares estimator with standard errors is applied to the projections, which are associated with the commercial

sector's GDP and the previous year's demand. The APS1 and APS5 scenarios will lead to a further reduction of 10% by 2030 as compared to the projected values. No reduction is expected in natural gas and oil consumption.

3.5 Industry Sector

For industry, The BAU scenario assumes that industrial electricity demand is reduced by 5% by 2020 due to the ECA as compared to the econometric projected values. From 2021 to 2050, the demand is the same with the projected values. The electricity demand is assumed to be associated with the GDP and previous year's value. In the APS1 scenario, the demand is further reduced by 10% by 2030 as compared to the projections. The industrial natural gas is assumed to grow at the annual rate of 0.024, whereas residual fuel oil is assumed to grow at the same rate with the industrial GDP. Other fuels, such as gasworks gas, diesel, kerosene, petroleum coke, refinery gas, LPG and coal, are assumed to be unchanged over years.

4. Outlook Results

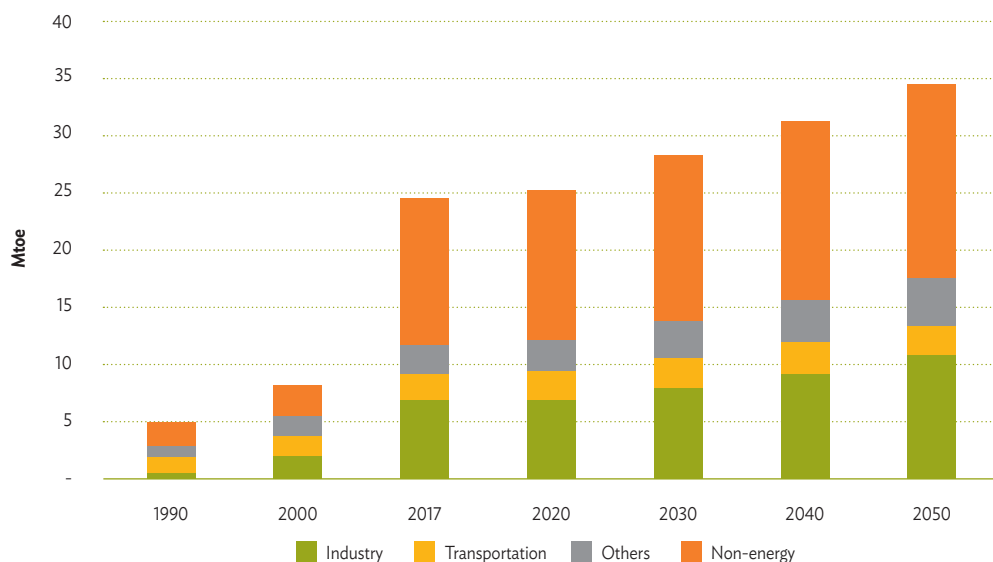
4.1. Final energy consumption

Singapore's final energy consumption grew at an annual rate of 6.1% from 5.01 million tonnes of oil equivalent (Mtoe) in 1990 to 24.56 Mtoe in 2017. During the same period, oil was the dominant energy source, with 3.81 Mtoe and 18.83 Mtoe consumed in 1990 and 2017, respectively. Approximately 51.8% of the country's final energy is consumed for non-energy uses in 2017, particularly as feedstock for petrochemical production. In 1990, 27.1% of the final energy consumption was used in the transport sector, although its share in the total final energy consumption declined to around 9.98% only in 2017.

Under the BAU, final energy consumption is projected to grow by 1% annually between 2017 and 2050. Non-energy sector demand is projected to grow by 0.9%, while industry demand will increase by 1.4% per year. The transport sector is projected to grow by 0.2% per year. The "others" (i.e., residential and commercial) sector is projected to grow by 1.6% per year.

Under the BAU, industry consumption will become the highest share in the total final energy consumption, followed by the non-energy sector. By end of 2050, non-energy use will decline

Figure 15.1. Final Energy Consumption by Sector, BAU



BAU = business as usual.

Source: Author's calculation.

from 51.8% in 2017 to 48.8% of the total energy mix. The industrial sector's share will increase from 27.8% in 2017 to around 31.2% in 2050.

The transport sector's share in the final energy consumption for the period 2017 to 2050 is expected to decrease to 7.7% from its 27.1% height in 1990. This decrease stems from the national policies advocating for more efficient automobile technology and the promotion of public transport. In addition, the Certificate of Entitlement quotas are also expected to remain effective in curbing vehicle growth.

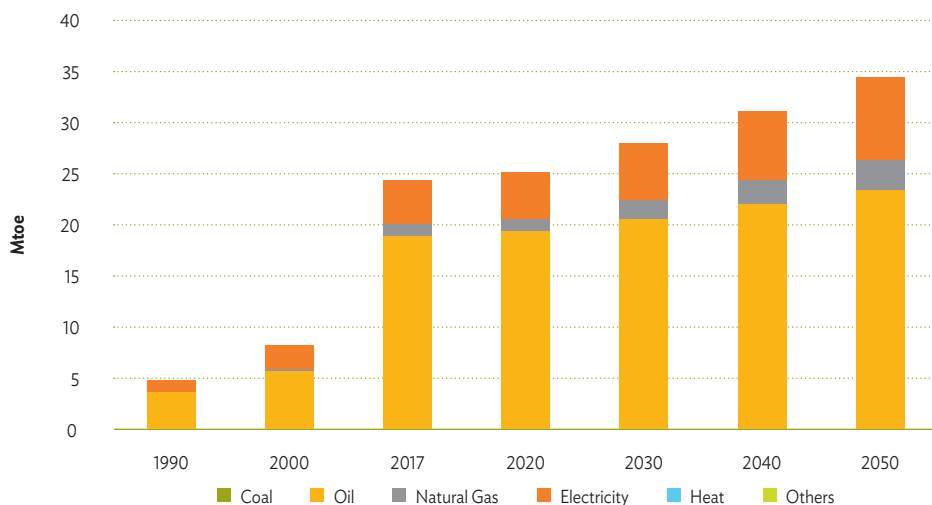
By fuel type, natural gas experienced the fastest growth from 1990 to 2017, at an average rate of 12% per year. The growth of natural gas was due to increasing demand mainly in the rapidly expanding industry sector. Also from 1990 to 2017, demand for electricity grew at an average annual growth of 5.1%.

Under the BAU, the demand for natural gas is expected to continue expanding but at a slower average growth of 2.4% per year till 2050. Meanwhile, electricity demand will only be growing at an average of about 2% per year.

Oil is still expected to play a major role in the country's final energy consumption. For the past 2 decades, that is, from 1990 to 2017, the share of oil increased from 76% to around 76.6%. Under the BAU, oil's share to the final energy consumption will fall to 76% in 2020

before falling further to 67.9% in 2050. This decline is mainly due to high growth in natural gas usage, which will increase from its share of 5.3% in 2017 to 8.3% in 2050. Meanwhile, the share of electricity in the final energy consumption will increase to around 17.7% starting 2020 and before rising further to 23.3% until 2050. Figure 15-2 shows the final energy consumption by fuel.

Figure 15.2. Final Energy Consumption by Fuel, BAU



BAU = business as usual.

Source: Author's calculation.

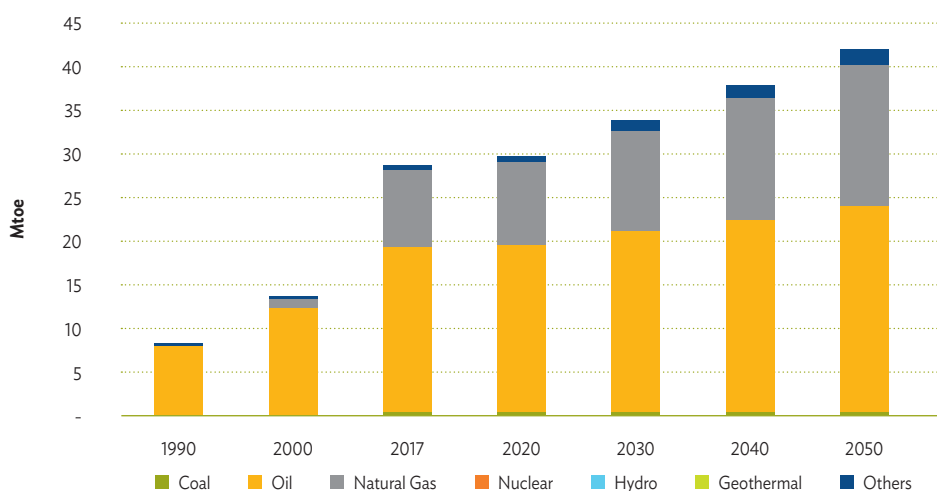
4.1.2 Primary energy supply

Primary energy supply grew by 4.7% per year, from 8.38 Mtoe in 1990 to 29.06 Mtoe in 2017. Singapore's dominant source of energy in 1990 was oil (98.2%), consumption of which increased by 3.1% yearly from 8.23 Mtoe in 1990 to 18.96 Mtoe in 2017. Following the construction of pipelines for gas-fired power plants, the first of which sourced gas from Malaysia in 1991, and two more recent pipelines from Indonesia, the share of natural gas consequently increased. Natural gas consumption increased rapidly from 0.06 Mtoe in 1990 to 8.9 Mtoe in 2017.

Primary energy supply in the BAU is projected to grow by 1.2% per year between 2017 and 2050 (Figure 15-3). Amongst the energy sources, solar energy is expected to grow the fastest at 3.3% a year, followed by biomass and natural gas at 2% and 1.8% per year, respectively. Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

Oil is expected to remain the primary energy source, accounting for 55.5% of primary energy

Figure 15.3. Primary Energy Supply, BAU



BAU = business as usual.

Source: Author's calculation.

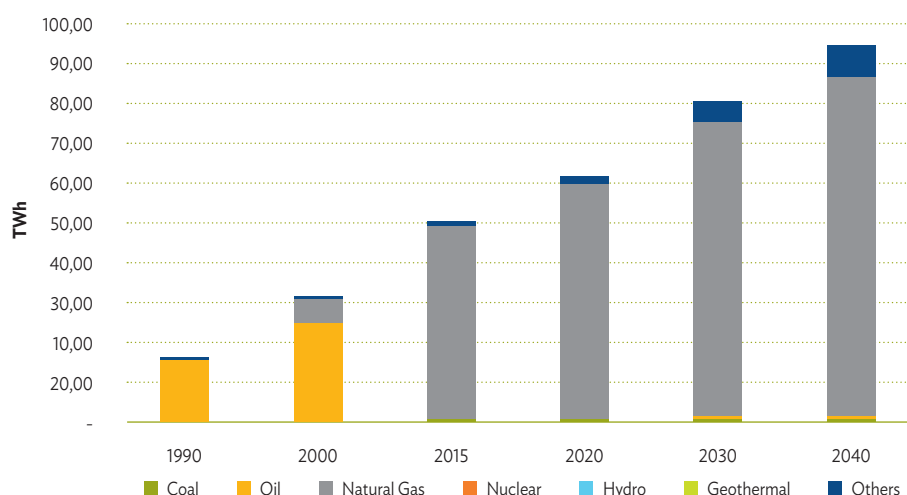
demand in 2050 followed by natural gas at 38%. Between 1990 and 2017, the annual growth of coal consumption was about 12.4%. From 2017 to 2050, the annual growth of coal consumption is projected to be about 1.4%, with its share in total primary energy supply rising from 1.6% in 2017 to about 1.7% in 2050.

4.1.3 Power generation

Electricity generation grew by 4.6% per year from 15.71 TWh to 52.66 TWh over the period 1990 to 2017. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 18.5% of electricity generation in Singapore in 2000, grew rapidly to supply 94.9% of Singapore's electricity in 2017. Fuel oil use for thermal power generation is around 0.37 TWh in 2017. In the same period, biomass and solar takes up a small proportion of the mix, totaling around 3.1%. Coal started to be used in 2013 as a substitute for supply of hydrogen and carbon monoxide as feedstock for the energy and petrochemical sector. It is projected to grow only marginally at 2% per annum.

In the BAU scenario, power generation is projected to increase at 2% per year from 2017 to 2050, reaching 99.64 TWh in 2050. By type of fuel, generation from "Others", which comprises biomass and solar power, will have the fastest growth at an average rate of almost 5.3% per year. "Others" power generation is expected to increase its share from a minimal share of 3.1% in 2017 to 9.1% in 2050.

Figure 15.4. Electricity Generation, BAU



BAU = business as usual.

Source: Author's calculation.

Starting in 2017 and extending into the future, at least 89.5% of the country's power generation mix will come from natural gas under the BAU. Its share of generation mix gradually declines over time from 94.9% in 2017 to 89.5% in 2050 as more solar power is used. On the other hand, the share of oil will decline from 0.7% in 2017 to 0.1% over the same period.

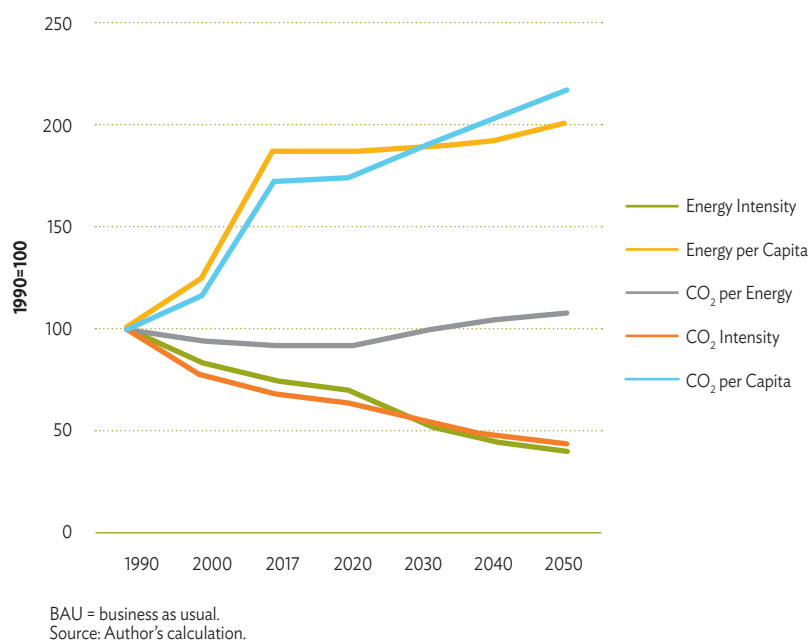
The average thermal efficiency of Singapore's fossil-fueled power plants was around 30.2% in 1990 and improved to 54.6% in 2017 as more natural gas-fired power plants were in operation. In the BAU scenario, thermal efficiency of fossil plants is expected to improve further to around 56.4% in 2050.

By fuel, natural gas plants' thermal efficiency will be 58% in 2050, while oil will be at 45%.

4.1.4. Energy indicators

Primary energy intensity, which is computed as the ratio of primary energy supply over GDP, is expected to decrease. Energy intensity continues to decrease as total primary energy supply will grow at a slower rate compared to population growth. CO₂ intensity, defined as emissions per unit of GDP, is projected to have similar declining trends compared to energy intensity. Energy and CO₂ per capita increases as population growth is expected to remain lower than fossil fuel demand growth.

Figure 15.5. Energy Indicators, BAU

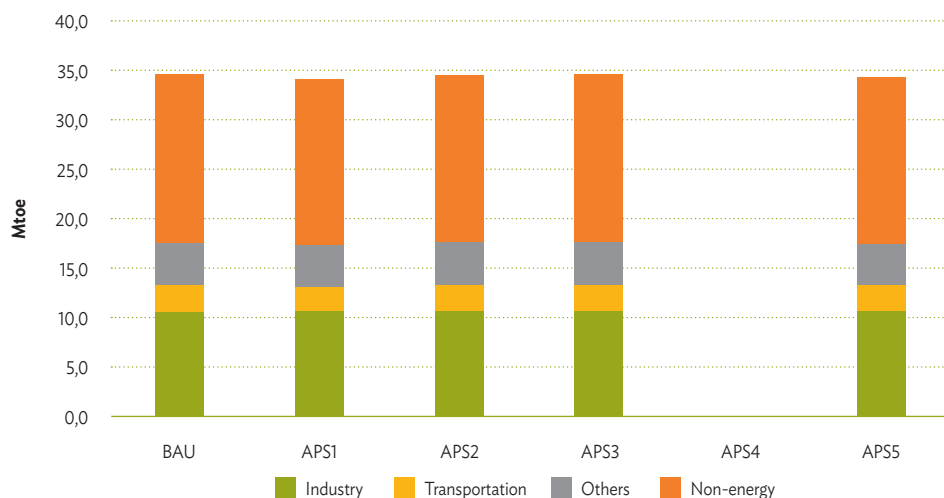


4.2. Energy Savings and CO₂ Reduction Potential

4.2.1. Final energy consumption

Final energy consumption under APS1 is projected to increase by 1% annually from 2017 to 2050. Similar to the BAU case, the non-energy sector grows at 0.9% per year. The other (residential and commercial) sector grows at 1.4%, which is followed by the industry sector at 1.3% and transportation at 0.2%. APS2 and APS3 include the same reduction targets due to energy conservation policies for end demand with the BAU scenario, but have different power generation efficiency or renewable energy shares. APS5 has the highest reduction targets, renewable targets and renewable share. In particular, under BAU, the total final energy consumption in 2050 is projected to be 34.65 Mtoe, which is also the projected value for APS2 and APS3. Amongst all APS scenarios, APS1 has the lowest final energy consumption of 34.23 Mtoe, followed by APS5 with 34.43 Mtoe.

Figure 15.6. Final Energy Consumption by Sector in 2050, BAU and APS1-5



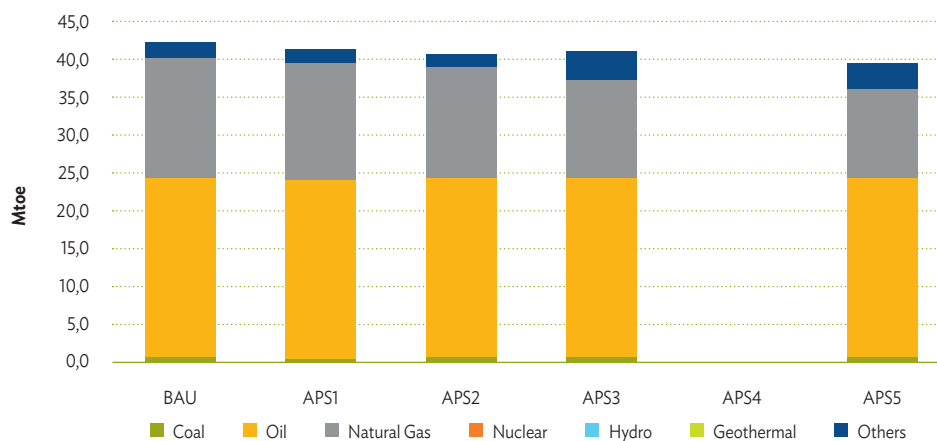
APS = alternative policy scenario, BAU = business as usual.

Source: Author's calculation.

4.2.2. Primary energy supply

Results from APS2 show that primary energy supply for 2017–2050 will increase at an average annual rate of 1%, a 1.4 Mtoe decrease from BAU (Figure 15-7) in 2050. This translates to a percentage reduction of 3.3% from BAU in 2050. APS1 and APS3 will help to lower primary energy supply by 0.8 Mtoe and 1.2 Mtoe respectively in 2050. This illustrates that policies targeting end-user energy efficiency policies and renewables currently still play only a secondary role to power generation efficiency policies in reducing primary energy demand.

Figure 15.7. Total Primary Energy Supply by Fuel in 2050, BAU and APS1-5



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

Source: Author's calculation.

Most of the reduction in primary energy supply will come from natural gas at 4.2 Mtoe, which is a drop of 26.4% from BAU (Figure 15-8). Oil only slightly increases by 0.4% as it is limited by the already declining BAU consumption for power generation, as well as the large consumption in the petrochemical non-energy use. Biomass' consumption will remain relatively constant, while solar power progresses significantly, but is still small in magnitude. Hence, this leads to an increase in consumption of "others" by 75.5%.

Figure 15.8. Primary Energy Supply by Fuel, BAU and APS5



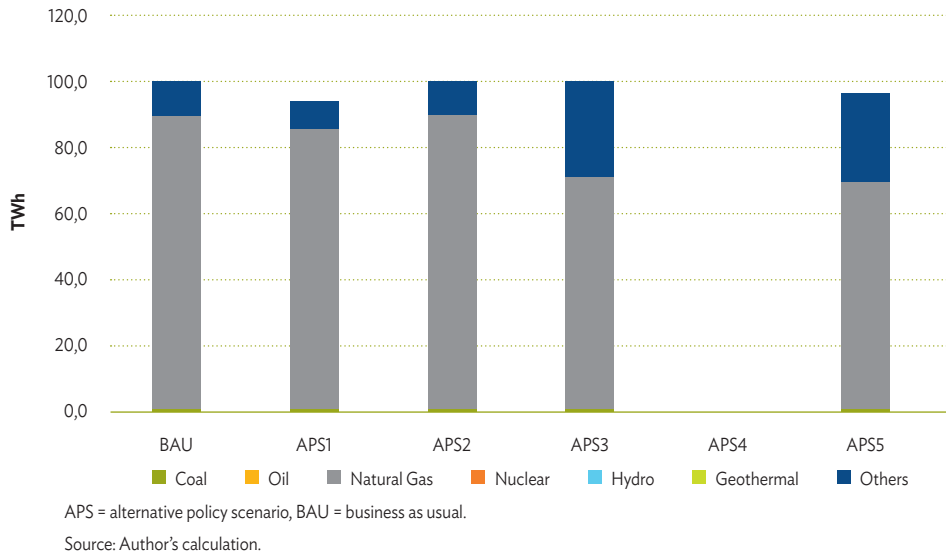
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

4.2.3. Power generation

Result from APS1 and APS5 shows a decrease in electricity generation, registering a drop of 5.17 TWh and 2.71 TWh from BAU, respectively. APS2 and APS3 assume the same generation as BAU since final energy consumption does not fall for these two scenarios (i.e., 99.64 TWh).

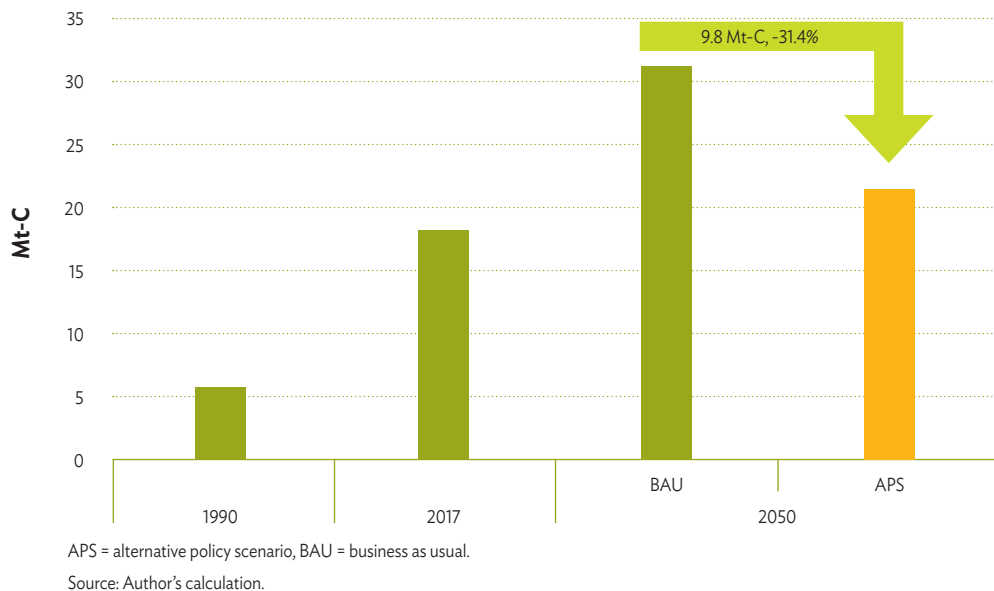
Figure 15.9. Electricity Generation in 2050, TWh



4.2.4. CO₂ reduction potential

Under BAU, CO₂ emissions from energy demand are projected to increase at an average annual rate of 1.6%, from 18.2 million tonnes of carbon (Mt-C) in 2017 to around 31.1 Mt-C in 2050 (Figure 15-10).

Figure 15.10. CO₂ Emissions from Energy Consumption, BAU and APS



CO2 emissions reduction potential comes mainly from improvements in thermal efficiency for power generation (APS2), with savings of 3.35 Mt-C in 2050, equivalent to a 10.8% decrease from BAU. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with APS1 registering emissions reduction of 1.62 Mt-C in the same time period (5.21% reduction from BAU). Increased utilisation of solar power (APS3) offers large emissions reduction of 6.53 Mt-C (20.1% reduction from BAU). Overall, APS5 will contribute to emissions reduction of 9.8 Mt-C, which is a 31.4% reduction from the BAU scenario. Under this scenario, carbon emissions will increase at an annual average growth rate of 0.5% from 2017 to 2050, compared to 1.6% under BAU.

5. Implications and Policy Recommendations

The Singapore government has been progressively implementing diversified sectoral measures to help incentivise the adoption of clean energy technologies and emissions reduction (NCCS, 2020a). These include, in the power sector, switching fuel mix and encouraging solar test-bedding and research, sludge incineration in waste water management, MEPS in the residential sector, the Green Mark system in buildings, promoting public transport and the Vehicular Emissions Scheme in the transport sector, and the Grant for Energy Efficient Technologies and the Energy Efficiency Fund in the industry sector.

In particular, ongoing innovation has focused on electric vehicles, including electric taxis (starting in February 2017), electric buses (starting in 2018) and an electric car-sharing programme (a 10-year programme, starting on 30 June 2017) (LTA, 2020b). The fleet of electric taxis is expected to be increased to 800 by July 2022. The electric car-sharing programme will deploy 1,000 electric vehicles and build a total of 2,000 charging points by 2020. These programmes will further explore mitigation potentials from the transport sector.

Singapore has also taken measures to ensure that its energy needs are diversified across more countries for energy imports rather than depending on gas pipeline flows from Malaysia and Indonesia as it shifts toward using more natural gas to power its electricity needs. Currently, Singapore has plans to increase LNG import storage facilities, and regulates each stage of gas value chains via a gas license system (e.g., transport, shipping, retail, import of gas, operation of the LNG terminal and onshore receiving facilities for piped natural gas) (EMA, 2020c).

As shown in the forecast results for BAU with 2017 as the base year, Singapore's CO2

emissions will grow to 31.1 MtCO₂e in 2050, with an average annual growth rate of 1.6%, where estimations show the potential to go as low as 21.08 MtCO₂e, if much greater efforts are taken to reduce emissions.

While Singapore is actively supporting research on clean energy innovation and transition, there is limited access to alternative or renewable energy. Singapore has committed to maintain a balance between development and protecting the environment (NCCS, 2020b). In addition to climate/energy policies, public awareness and behaviour change will be essential.

Remarks

All results in this document are for academic research purposes. The views and conclusions contained in this document are those of the author and should not be interpreted as representing the official opinions, either expressed or implied, of National University of Singapore, the Singapore Government or any other governmental organisations.

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CHAPTER 16

Thailand Country Report

Supit Kamalad

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 km, with great plains at the centre, mountainous areas up north, and highlands in the northeast. Its gross domestic product (GDP) in 2017 was around US\$424.2 billion (in constant 2010 US dollar terms). In 2017, the population was 69.2 million and income per capita was around US\$6,130.

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 2017, proven reserves were 0.16 billion barrels (25.4 million cubic metres) of oil and 6.4 trillion cubic feet (0.18 trillion cubic metres) of natural gas.

Thailand's total primary energy supply (TPES) reached 122.5 Mtoe in 2017. Oil accounted for the largest share at around 36.1%, followed by natural gas (31.2%), and coal (12.2%). 'Others' accounted for the remaining 20.2%. In 2017, net imports of energy accounted for 58% of TPES. Due to very limited indigenous oil and coal resources, Thailand imported around 85% of its oil and most of its bituminous coal. Although Thailand produces large quantities of natural gas, about 28% was imported from Myanmar and other countries. In Thailand, natural gas is used as a major energy source for power generation. In 2017, primary natural gas supply registered at 38.2 Mtoe, around 72% of which was sourced from domestic supplies and the rest imported

from neighboring countries. Coal was mainly used for power generation, but it was also heavily used in industrial cement and paper production.

Thailand has 38.6 GW of installed electricity generation capacity and power generation was about 167.5 TWh in 2017. The majority of Thailand's power came from thermal generation (coal, natural gas, and oil), accounting for 93.8% of generation, followed by hydro at 2.8%, together with geothermal, solar, small hydro, and biomass making up the remainder.

2. Modelling Assumptions

GDP growth from 1990 to 2017 was a moderate 4.1% per year. Thailand's GDP is assumed to grow at an average rate of 3.5% per year between 2017 and 2050. Population growth is also projected to be quite slow at around 0.3% per year between 2017 and 2050, compared with average growth of about 0.7% per year between 1990 and 2017.

Natural gas and coal are projected to be the largest energy sources for power generation. Conversely, the shares of fuel oil and diesel power plants are projected to remain at the lowest share. Renewable energy is projected to increase its shares in the power generation mix under the Alternative Policy Scenario (APS).

Thailand's energy-saving goals are expected to be achieved through efficiency programmes in all sectors. In the industrial sector, improvements in manufacturing processes should help improve energy efficiency. In the residential and commercial ('other') sector, large energy savings are projected, driven by programmes to promote public awareness of energy efficiency and energy efficiency labelling. In the transportation sector, further development in the Bangkok metro area railway network will contribute to energy savings. Significant improvements in energy efficiency in passenger vehicles are also expected to be achieved in line with new developments in car technologies and the introduction of the next phase of the Eco car programme II.

Government policies will continue to encourage the increased use of alternative fuels, especially biofuels. Reductions in CO₂ 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 CO₂ emissions from electricity generation. Gasohol and biodiesel as oil alternatives are also expected to help curb CO₂ emissions from transportation.

3. Outlook Results

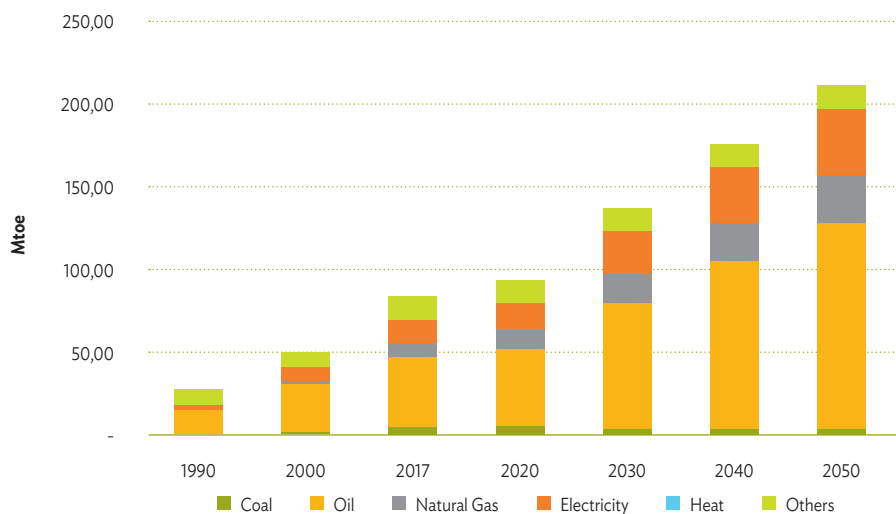
3.1. Business-as-Usual Scenario

Between 1990 and 2017, Thailand's final energy consumption grew at an average rate of 4.1% per year from 28.9 Mtoe in 1990 to 85.3 Mtoe in 2017 (see 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 2.8% per year between 2017 and 2050.

Oil has been the dominant fuel in Thailand's final energy consumption, accounting for 42.1 Mtoe or a 49.4% share in 2017. Electricity was the second-largest energy fuel, accounting for 15.0 Mtoe, or a 17.6% share in 2017.

Oil is expected to remain the largest final energy source throughout the projection period. Its share is projected to rise continuously from the 2017 level to 58.0% in 2050. In 2050, the shares of electricity and natural gas in final energy consumption are projected to increase to 18.9% and 13.8%, respectively, while the share of coal is projected to decline to 2.4%.

Figure 16.1. Final Energy Consumption by Fuel, BAU
(in Mtoe)



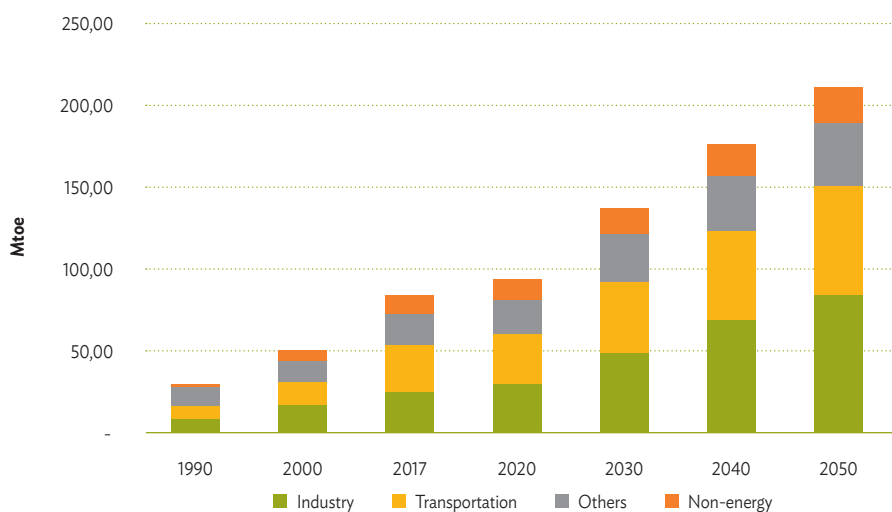
BAU = Business-as-Usual scenario; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

The industry sector had a 30% share in the total final energy consumption of Thailand in 1990 at a level of 8.7 Mtoe (see Figure 16-2). The demand of the sector grew at an average rate of 4.0% a year between 1990 and 2017, and its share slightly went down to 29.4% (equivalent to 25.1 Mtoe) in 2017, which made it the second-largest consuming sector. However, industry is projected to be the largest consumer, accounting for 40.4% (equivalent to 85.6 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 18.4%, while previously it was 37.3% in 1990.

Primary energy supply grew at an average annual rate of 4.0% from 42.6 Mtoe in 1990 to 122.5 Mtoe in 2017, 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 2017, the major sources of primary energy were oil, natural gas, and coal with shares of 36.1% (44.3 Mtoe), 31.2% (38.2 Mtoe), and 12.2% (14.9 Mtoe), respectively.

Figure 16.2. Final Energy Consumption by Sector, BAU
(in Mtoe)



BAU = Business-as-Usual scenario; Mtoe = million tonnes of oil equivalent.

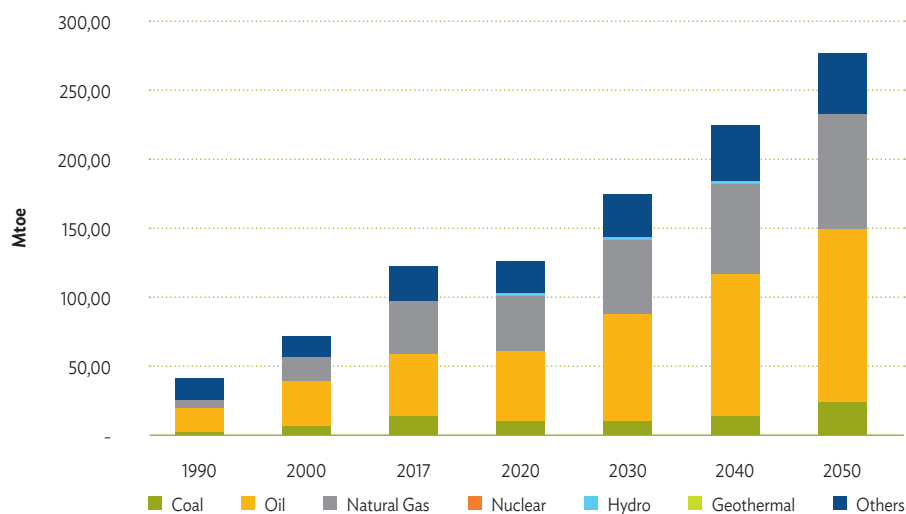
Source: Author's calculation.

Although oil remained the largest source between 1990 and 2017, its share in primary energy supply decreased slightly from 42.1% in 1990 to 36.1% in 2017. 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 11.7% in 1990 to 31.2% in 2017. The share of hydropower declined from 1.0% in 1990 to only 0.3% in 2017.

In the Business-as-Usual scenario (BAU), primary energy supply is projected to grow on average by 2.5% per year from 2017 to 2050, reaching 277.6 Mtoe in 2050 (see Figure 16-3). The highest average annual growth rate is expected in oil (3.2%), with consumption projected to reach 125.1 Mtoe in 2050. Natural gas will follow at an annual average growth rate of 2.3%, reaching 81.9 Mtoe in 2050. Coal growth in the same period will be slower than from 1990 to 2017; it is projected to increase at an average rate of 1.6% per year. The share of oil will increase again to 45.0% in 2050 while the shares of coal and natural gas will be around 9.2% and 29.5%, respectively. Biomass is expected to grow at an average rate of 0.9% per year between 2017 and 2050.

This rate is slower than the annual average growth rate of total primary energy supply (2.5%), and as a result the share of biomass in the total primary energy mix will decline from 16.8% in 2017 to 9.9% in 2050.

Figure 16.3. Primary Energy Supply by Fuel, BAU
(in Mtoe)



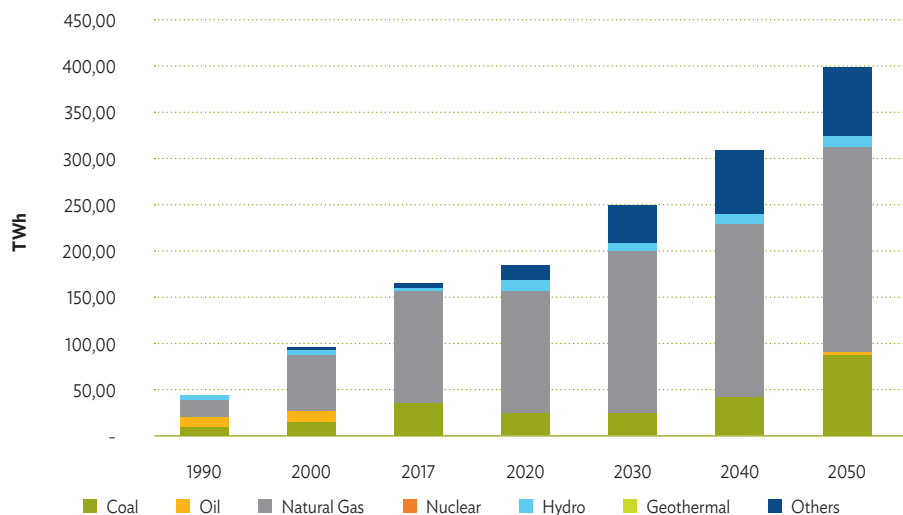
BAU = Business-as-Usual scenario; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

In 1990, the total power generation was 44.2 TWh and it reached 167.5 TWh in 2017, with an average growth rate of 5.1% 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 7.4% per year from 17.8 TWh (40.2% share) in 1990 to 121.0 TWh (72.3% share) in 2017. Coal had the second largest share at 25.0% in 1990, but it fell to 21.3% in 2017. Oil was the least-used fuel in power generation, with only 0.3 TWh in 2017.

In the BAU scenario, power generation is expected to grow at around 2.7% per year from 2017 to 2050 and will reach 401.7 TWh in 2050. In 2050, natural gas will remain the dominant fuel used in power generation with the highest share of 56.0% or 224.9 TWh. Coal will still be the second largest source of power generation with a 22.2% share or a level of 89.3 TWh expected in 2050. Power generation from hydro will increase by 2.6% per year from 4.7 TWh in 2017 to 11.2 TWh in 2050.

Figure 16.4. Power Generation by Fuel, BAU
(in TWh)



BAU = Business-as-Usual scenario; TWh = terawatt-hour.

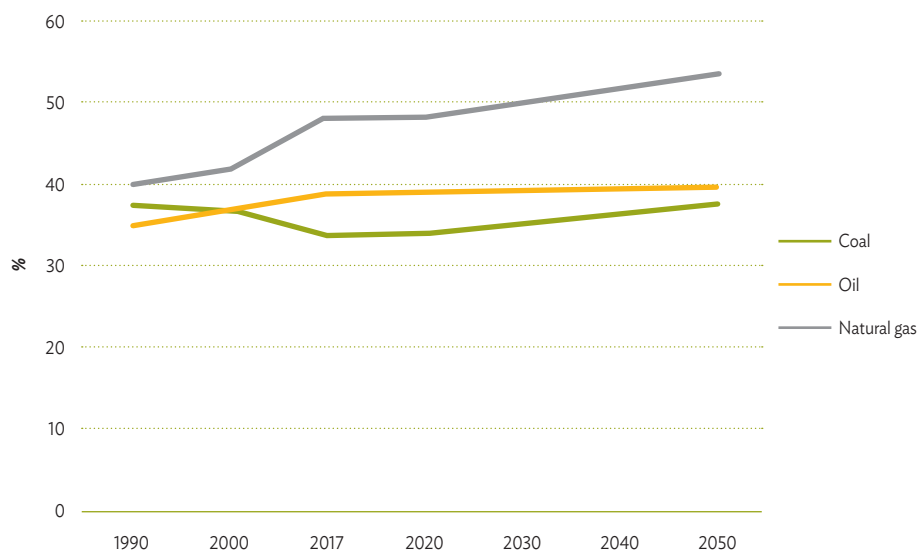
Source: Author's calculation.

Natural gas has the highest thermal efficiency improvement. A 40% efficiency of natural gas in 1990 improved to almost 48% in 2017 and is expected to increase to 53.4% in 2050. Coal thermal efficiency declined by almost 3.4% from 1990 to 2017, and is expected to improve to 37.3% over the study period (Figure 16-5).

Figure 16-6 shows the energy indicators. Energy intensity reached 289 toe/million in 2017, calculated in 2010 US dollars. In the BAU, energy intensity is projected to decline by 0.9% per year to reach 213 toe/million in 2050, calculated in 2010 US dollars. Energy per capita will increase from almost 1.8 toe per person in 2017 to 3.6 toe per person in 2050.

Energy elasticity between 1990 and 2017 was 0.98, which indicates that energy demand rose at almost the same rate as economic output. In the BAU, energy elasticity is projected at 0.71 between 2017 and 2050, which indicates that energy demand will grow at a slower rate than economic output.

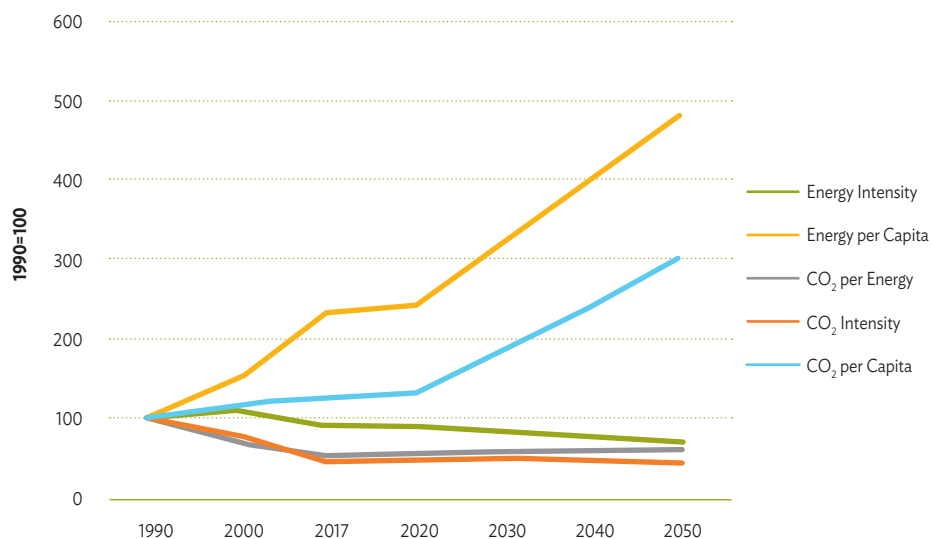
Figure 16.5. Thermal Efficiency by Fuel, BAU
(%)



BAU = Business-as-Usual scenario.

Source: Author's calculation.

Figure 16.6. Energy Indicators



CO₂ = carbon dioxide.

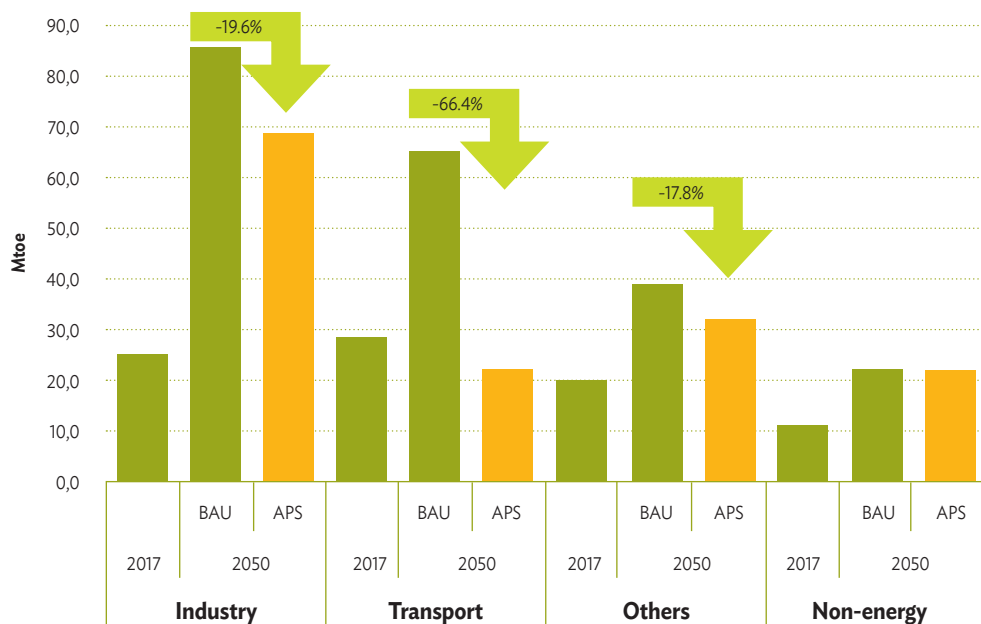
Source: Author's calculation.

3.2. Energy Savings and CO2 Reduction Potential

3.2.1. Final energy consumption

In the APS, final energy consumption is projected to grow by 1.6% per year, from 85.3 Mtoe in 2017 to 145.0 Mtoe in 2050. This is 31.6% lower than in the BAU. The majority of energy savings will be achieved through energy efficiency improvement programmes implemented in the industry (19.6%) and transportation (66.4%) sectors. Improvements will also be achieved in 'other' sectors (17.8%), as shown in Figure 16-7.

Figure 16.7. Final Energy Consumption by Sector, BAU and APS
(in Mtoe)



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

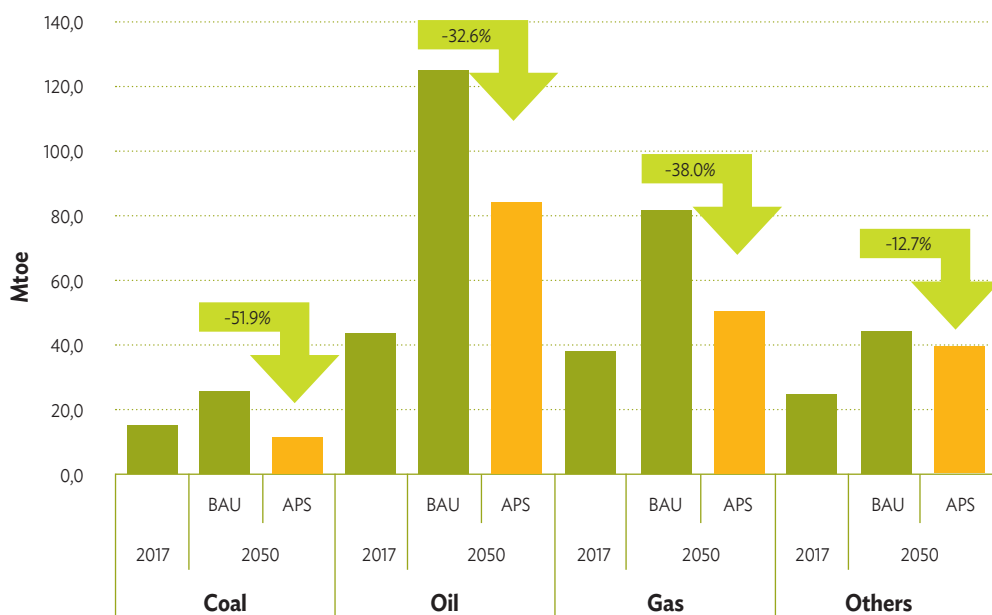
3.2.2. Primary energy supply

In the APS, growth in primary energy supply is projected to be much slower than in the BAU, increasing at 1.3% per year (compared with 2.5% in the BAU) to reach 186.6 Mtoe in 2050. Primary APS energy supply is expected to be about 32.8% lower the BAU in 2050—an energy savings of about 91.0 Mtoe.

Coal and oil are projected to increase at slower annual average rates of -0.6% and 2.0%, respectively (1.6% and 3.2% in the BAU). Natural gas use is projected to increase at an annual

average rate of 0.9% (2.3% in the BAU) from 38.2 Mtoe in 2017 to 50.8 Mtoe in 2050. The lower growth rates compared with 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, BAU and APS
(in Mtoe)



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tonnes of oil equivalent.

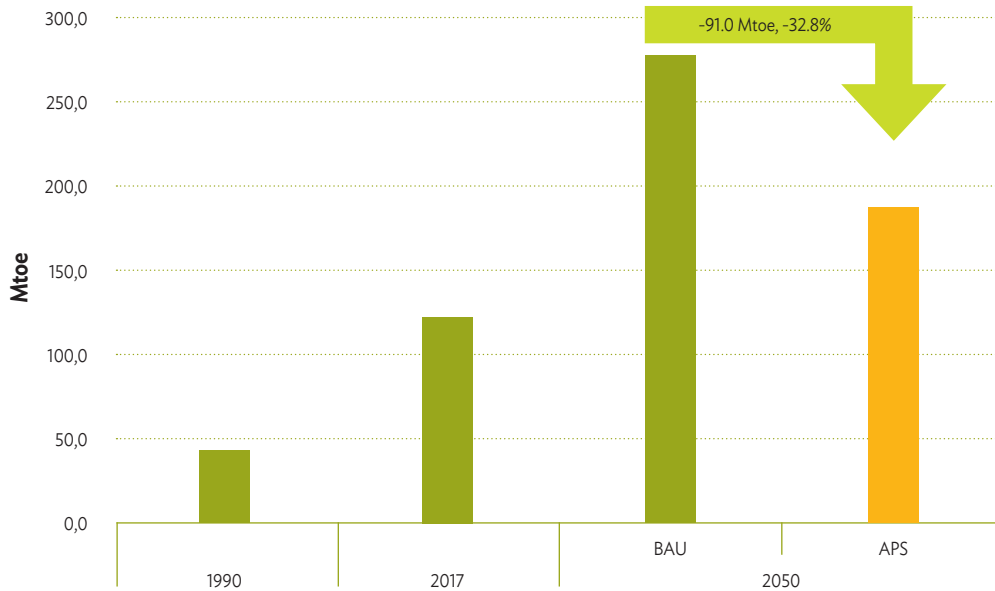
Source: Author's calculation.

3.2.3. Projected energy savings

The difference between primary energy supply in the BAU and the APS in 2050 is 91.0 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 40.8 Mtoe, followed by coal at 13.3 Mtoe. Energy savings from natural gas will reach 31.1 Mtoe in 2050, but the contribution of non-fossil energy sources will also be 5.6 Mtoe lower than in the BAU.

In final energy consumption, the savings in the APS compared with the BAU in 2050 will reach 66.9 Mtoe. The largest savings are expected to be achieved in the transport sector, at 43.2 Mtoe. The industry and 'other' sectors are expected to achieve energy savings of 16.7 Mtoe and 6.9 Mtoe, respectively.

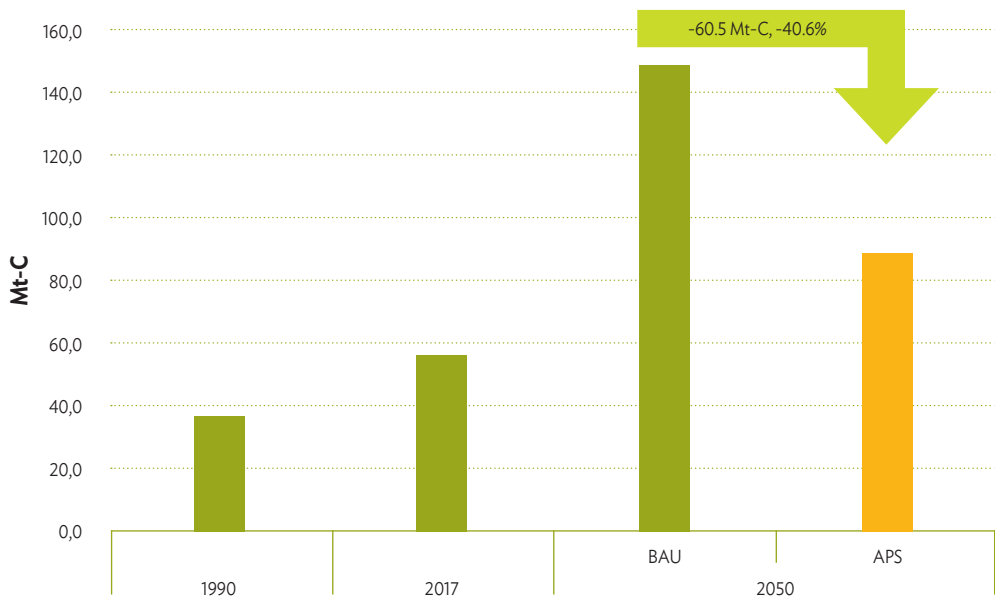
Figure 16.9. Total Primary Energy Supply, BAU and APS
(in Mtoe)



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Figure 16.10. CO₂ Emissions from Energy Consumption, BAU and APS



CO₂ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tonnes of carbon.

Source: Author's calculation.

3.3. CO2 Emissions

CO2 emissions from energy consumption are projected to increase by 3.0% per year on average from 55.8 Mt-C in 2017 to 148.9 Mt-C in 2050 under the BAU. Under the APS, the average annual growth in CO2 emissions from 2017 to 2050 is projected to be 1.4%, with an emissions level of 88.4 Mt-C in 2050. The difference in CO2 emissions between the BAU and the APS is 60.5 Mt-C, or 40.6%. This reduction in CO2 emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans (Figure 16-10).

4. Implications and Policy Recommendations

Strong economic growth prior to the Asian Financial Crisis in 1997 contributed to relatively high energy intensity in Thailand between 1990 and 2011. However, the energy intensity of the economy has declined since it recovered from the crisis. Furthermore, with Thailand's energy efficiency programmes in a wide range of areas (including industry, transportation, and residential sectors), and high oil prices in the world market, a further decline in the energy intensity of the Thai economy is to be expected.

Improving energy efficiency will also help Thailand (which is an oil importer) to address the challenges posed by high world oil prices (especially during the period 2011–15). Thailand is committed to reducing the intensity of energy consumption, particularly oil consumption, and to looking for more sustainable energy sources and environment-friendly fuels. It was recognised that the more energy Thailand saves, the less it would be affected by fluctuations of world energy prices and supply. Furthermore, Thailand has realised that energy saving is important and that it should put greater efforts into it.

Although Thailand has an alternatives policy for the next 20 years, oil will remain a major energy source for its economy. Oil is one of the most sensitive energies in terms of price and security. Thailand should focus more on oil savings in order to become less dependent on this fuel. Furthermore, Thailand intends to reduce transport consumption in the future, in particular through the use of electric and fuel-cell electric vehicles. The greater the energy savings that can be achieved in the transport sector, the greater the benefits for the economy as a whole.

CHAPTER 17

Viet Nam Country Report



Nguyen Minh Bao

1. Background

Viet Nam is a developing country in Southeast Asia. The total land area is 331,100 km², 50% of which is in productive use.

In 2017, Viet Nam's population was 93.7 million, which represents an average annual increase of 1.3% (27.7 million) from its 1990 level of 66.0 million.

Viet Nam's gross domestic product (GDP) increased at an average annual rate of 6.8%, from US\$29.5 billion in 1990 to US\$175.3 billion in 2017 (constant 2010 US dollar value). The commercial sector contributes the most to Viet Nam's GDP (38.8%), followed by the industry sector (35.0%), agriculture (14.8%), and other activities (11.4%). GDP per capita was US\$1,871 in 2017.

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 m³ of crude oil reserves, and 610 billion m³ of gas reserves.

In 2017, 38.4 million tonnes of coal, 9.87 billion m³ of natural gas and 15.52 million tonnes of crude oil were produced. Because of limited capacity at the Dung Quat oil refinery (6.5 million tonnes a year), over 40% of produced crude oil 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.

Viet Nam had around 42.4 GW of installed generating capacity and produced 193.0 TWh of electricity in 2017. The main share of electricity generation comes from thermal sources (coal, natural gas, and oil), accounting for 54.3% of total generation; the remaining is hydro (45.5%) and others (around 0.2%).

The rural electrification programme has been implemented over the past few years. According to reports by Viet Nam Electricity (EVN), by the end of 2017, 99.98% of communes and 98.83% of households have 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 in general and the need for electricity in remote areas in particular.

1.2. Targets on Greenhouse Gas Emissions Reduction and Energy Development

Viet Nam's fast-paced economic development and GDP growth have resulted in a high energy demand, especially for electricity, in manufacturing industries and amongst residential consumers, as well as natural gas and coal for power generation. This trend is expected to continue in the future. Thus, power generation will be the main source of GHG emissions in the decades to come.

1.2.1. Targets on Greenhouse Gas Emissions Reduction

To meet this growing energy demand, Viet Nam's government recently promulgated a series of programmes and new policies that aim to increase the share of renewables in power generation and promote energy efficiency to minimise the gap between demand and supply and reduce GHG emissions. The table below summarises the targets on reduction of GHG emissions, energy savings and renewables development in the related legal documents:

1.2.2. Energy development

A reliable power supply is an important requirement for an emerging economy in Viet Nam. By the end of 2018, the total installed capacity of the power generation system of Viet Nam was around 48.6 GW, an increase of 14.6% over 2017.¹ Coal takes the largest share of 38.1% in total installed capacity, followed by hydropower with 35.1% and natural gas with

¹ EVN-Annual Report, 2018

Table 17.1. Targets on Reduction of GHG Emissions, Energy Saving and Renewables Development

Item	Targets	Legal documents
GHG emissions	<ul style="list-style-type: none"> • GHG reduction target of 8% from Business-As-Usual (BAU) by 2030 with domestic resources. • GHG reduction target of 25% from BAU by 2030 with international support. 	Viet Nam's NDC (2015)
Renewable energy	<ul style="list-style-type: none"> - Biomass power: to reach 3%, 6.3% and 8.1% of total electricity output by 2020, 2030 and 2050, respectively. - Wind power: to reach 1.0%, 2.7% and 5.0% of total electricity output by 2020, 2030 and 2050, respectively. - Solar power: to reach to 0.5%, 6.0% and 20.0% of total electricity output by 2020, 2030 and 2050, respectively. - Increase the share of renewables in power generation to 9.9% in 2020, 12.5% in 2025, and 21% in 2030 in terms of installed capacity. - Increase the share of electricity generated from renewable resources to 6.5% in 2020, 6.9% in 2025, and 10.7% in 2030. 	<p>The Viet Nam Renewable Energy Development Strategy to 2030, outlook up to 2050 (2015)</p> <p>Revised National Power Development Plan VII (Revised PDP VII) 2011–2020, with outlook to 2030 (2016)</p>
Energy savings	<ul style="list-style-type: none"> • 5%–7% saving from BAU in the period of 2019–25 • 8%–10% saving from BAU in the period of 2019–30. 	National Energy Efficiency Program for the period 2019–2030 (2019)

GHG = greenhouse gas.

Source: Authors, compiled from various sources.

18.5%. According to the Revised Power Development Plan VII, coal power plants will mainly contribute to the essential capacity expansion, accounting for 42.6% by 2030, followed by renewables with 21.0%, hydro with 16.9%, natural gas 14.7% and others with 4.8%. Because of the high increase of fossil-based power plants, the fossil resource demand will exceed the domestic supply and Viet Nam's fuel import dependency will increase.

In order to diversify import fuel sources, beside coal, liquefied natural gas (LNG) is considered as a major import fuel in coming years. According to the Viet Nam Gas Industry Development Master Plan up to 2035, import of LNG will be started by 2021 and demand will be increased to around 5 million tonnes by 2025, 10 million tonnes by 2030 and 15 million tonnes by 2035. To achieve this, Viet Nam will develop three or four LNG import terminal systems with a the estimated capacity of each depot 1–3 million tonnes per year in the period of 2021–25 and further five or six LNG import terminals with the estimated capacity of each terminal around 3 million tonnes per year in the period of 2026–35. Almost all LNG terminal systems will be located in the Southern Viet Nam to supply gas to domestic power plants and industrial buyers.

Besides the Dung Quat refinery, the second oil refinery of Nghi Son was put in operation in 2019, with capacity 10 million tonnes a year, thus meeting around 80% of total current petroleum demand in Viet Nam. Moreover, some other oil refinery projects are being prepared

for investment in the period 2025–30 to achieve the total capacity of around 30 million tonnes a year in 2030.

2. Modelling Assumptions

In this outlook, Viet Nam's GDP is assumed to grow at an average annual rate of 5.4% from 2017 to 2050. Growth is projected to be faster in the first outlook period, increasing at 7% per year between 2017 and 2020. For the remaining periods of 2020–30, 2030–40 and 2040–50, the country's economic growth will be slightly moderate at an annual rate of 6.2%, 5.2% and 4.2%, respectively. Population growth is projected to increase at a much slower rate, increasing by 0.5% per year between 2017 and 2050.

Future changes in crude oil prices remain highly uncertain. In this study, the crude oil price, as referred to Japan's average import price (nominal dollars per barrel), is assumed to increase from US\$54 a barrel in 2017 to US\$77 a barrel in 2020, US\$110 a barrel in 2030, US\$150 a barrel in 2040 and US\$185 a barrel in 2050.

In power generation, thermal efficiencies per fuel (coal, gas and oil) in Viet Nam were projected based on the forecasts for future power plant technologies estimated by the International Energy Agency (IEA). 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 hydropower plants, coal and natural gas power plants. The share of electricity generated from natural gas and coal-fired power plants is projected to increase considerably in the period of 2017–2030, while the share of electricity generated from hydropower plants will decline due to the limited development of the hydropower sources because its potential is almost fully exploited. However, the share of coal-fired power plants is intended to be reduced after 2030, with natural gas (or imported LNG) being an alternative source (to reduce dependency on imported coal). Viet Nam is expected to increase its imports of electricity, particularly from the Lao People's Democratic Republic and China.

Viet Nam's energy-saving goals are assumed to be 5%–7% of total energy consumption between 2019 and 2025, and 8%–10% of total energy consumption between 2019 and 2030,

in line with the targets on National Energy Efficiency Program. The energy savings goals are expected to be attained through energy efficiency programmes in industry, transport, residential and commercial sectors on the demand side.

On the supply side, energy efficiency improvements in power generation and development of renewables technologies, particularly small hydro, solar, wind and biomass are expected to come on line intensively from 2018, in line with the master plan on renewables development.

From above analysis, the APSs proposed are as follows: Implementation of the energy efficiency and conservation (EEC) measures on the demand side (APS1); improvement of energy efficiencies in power generation (APS2); and development of renewables sources (APS3).

APS1: Promote EEC activities in all sectors.

This is assumed that the promotion of EEC activities will achieve the level of energy reduction from BAU with 7% in 2025, 10% in 2030 and 12% in 2050.

APS2: Improve energy efficiency in thermal power plants.

The efficiencies of coal and residue fuel oil thermal power plants are assumed to increase to 42% and 37% by 2050 compared with 37% and 35% in BAU, respectively, while natural gas with combined cycle gas turbines technology's efficiency will increase to 58% by 2050 compared with 53% in BAU.

APS3: Development of renewables technologies.

Installed electricity-generating capacity from renewables is assumed to reach 60,500 MW in 2050 with solar contributing 35,000 MW; wind, 15,000 MW; small hydro, 6,200 MW; biomass, 4,000 MW; and biogas, 300 MW.

APS5: Combining APS1 to APS3.

3. Outlook Results

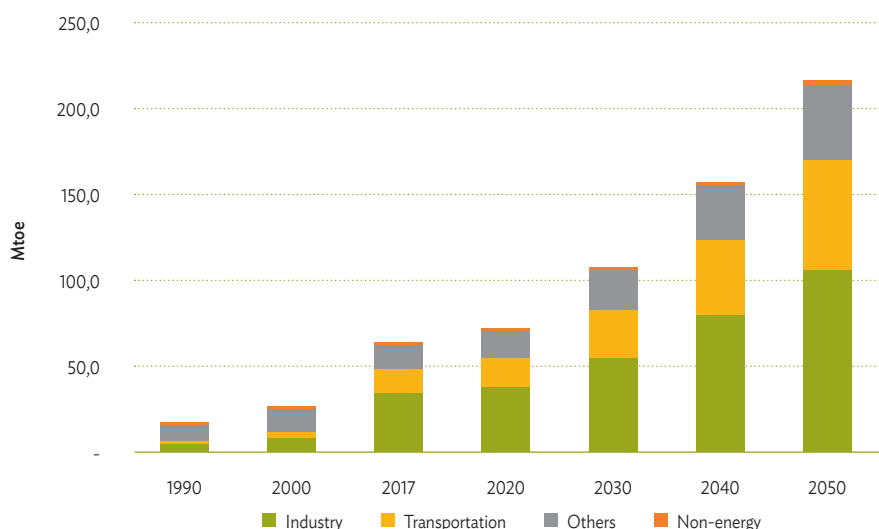
3.1. Business-As-Usual Scenario

3.1.1. Total final energy consumption

Viet Nam's total final energy consumption (TFEC) in 2017 was 63.8 million tonnes of oil equivalent (Mtoe), which has increased at 5.2% per year, 4.0 times more than its 1990 level of 16.1 Mtoe. On a per sector basis, the fastest growth occurred in the transport sector (8.8% per year), followed by the industry sector (7.8%) and the residential/commercial ('others') sector (1.4% per year). Non-energy use is expected to grow at 12.2% per year.

For 2017–50, the TFEC is projected to increase at an average rate of 3.8% per year under the BAU scenario. The growth is driven by strong economic growth, which is assumed to be at an average annual growth of 5.4%, and the rising population at an average annual growth of 0.5%. On a per sector basis, the strongest growth in consumption is projected to occur in transport, increasing by 4.7% per year. This is followed by the industry sector (3.4% per year) and the residential/commercial ('others') sector (3.4% per year). Non-energy use is expected to grow at 4.2% per year. Figure 17-1 shows the final energy consumption by sectors from 1990 to 2050.

Figure 17.1. Final Energy Consumption by Sector, BAU (1990–2050)



BAU = Business-As-Usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculations.

The bulk of the country's energy consumption (around 63% in 1990) comes from the residential/commercial ('others') sector, where biomass fuel used for residential cooking takes the dominant share. This share decreases to 23.2% by 2017 and to 20.6% by 2050 due to the substitution of biomass fuels by commercial fuels with higher efficiency under the effects of growing economy. Economic growth will improve the standard of living, thus increasing the transition from biomass to modern fuels such as LPG.

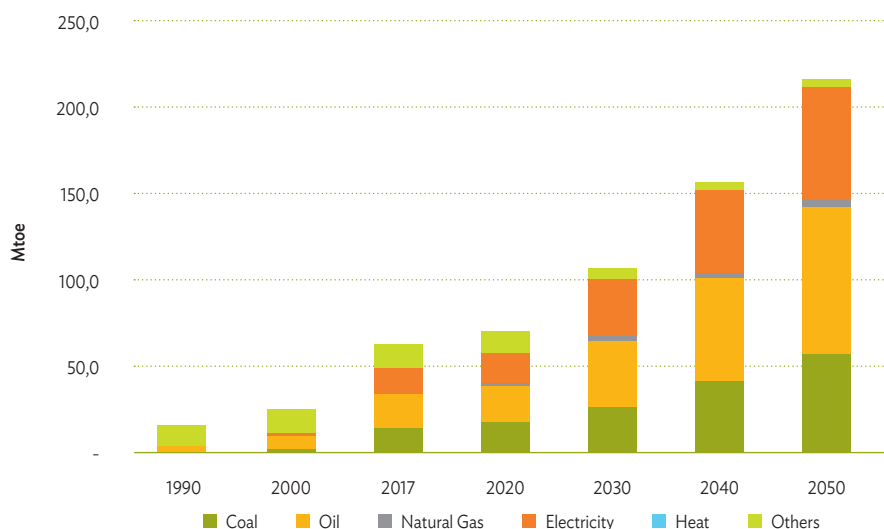
In 2017–50, the industry sector will keep the largest consuming sector in Viet Nam but its share of energy consumption in the industry sector will slightly decrease from 54.5% in 2017 to 49.3% in 2050. The second-largest consumer will be the transport sector and its share will increase slowly from 21.3% in 2017 to 29.0% in 2050.

Meanwhile, other fuels (mostly biomass) were the most-consumed product, accounting for 73.9% of the TFEC in 1990; however, it declined to 21.7% in 2017. Oil was the second-most-consumed product, accounting for 14.5% of the TFEC in 1990 and increasing to 29.6% in 2017. The share of coal consumption increased from 8.3% in 1990 to 23.8% in 2017. Electricity took a small share of 3.3% in 1990, but increased significantly to 23.3% in 2017.

On a per fuel basis under BAU, natural gas is projected to exhibit the fastest growth in final energy consumption, increasing at 5.4% per year between 2017 and 2050. Oil is projected to have the second-highest growth rate of 4.7% per year, followed by electricity and coal with 4.6% and 4.1%, respectively. Other fuels (mostly biomass) are projected to decrease at an annual rate of 3.9% due to the transition from biomass to modern fuels.

Oil products took the largest share of 29.6% in 2017; this share is projected to increase to 39.4% in 2050. The second-largest share of demand is coal, which is projected to increase from 23.8% in 2017 to 26.3% in 2050. This is followed by electricity, other fuels (dominated by biomass) and natural gas with their shares of 23.3%, 21.7% and 1.6% in 2017, respectively. However, the shares of electricity and natural gas will increase up to 29.9% and 2.7%, respectively, while other fuels will reduce rapidly to 1.7% in 2050 (Figure 17-2).

Figure 17.2. Final Energy Consumption by Fuel, BAU (1990–2050)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

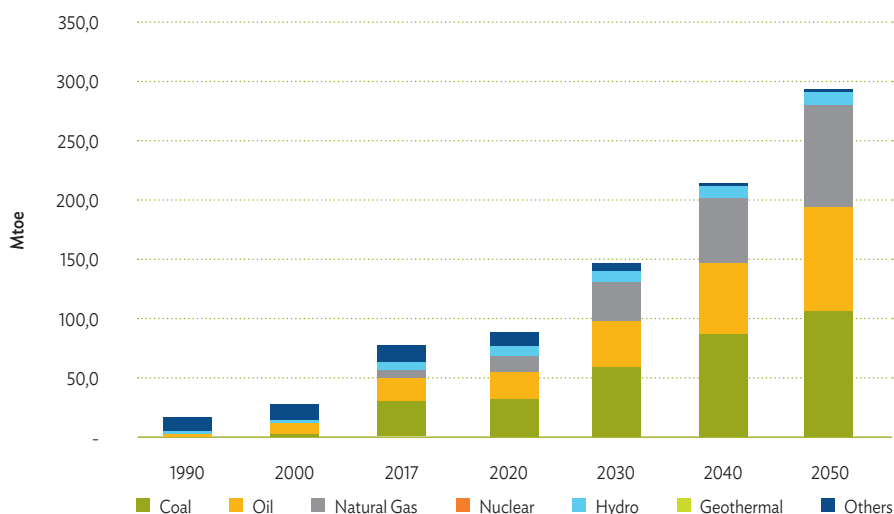
Source: Author's calculations.

3.1.2. Total Primary Energy Supply

Viet Nam's total primary energy supply (TPES) grew at a higher rate than TFEC; it increased at 5.7% per year, or 4.4 times, from 17.9 Mtoe in 1990 to 78.9 Mtoe in 2017. Among the major energy sources, the fastest-growing were natural gas, hydro, coal, and oil. Natural gas consumption grew at an average annual rate of 33.8% between 1990 and 2017, while hydro, coal and oil grew at 10.9%, 10.2% and 7.6% per year, respectively.

In the BAU scenario, Viet Nam's TPES is projected to increase at an annual rate of 4.1%, or 3.7 times, from 78.9 Mtoe in 2017 to 293.1 Mtoe in 2050. The fastest growth is expected in natural gas, increasing at an annual average rate of 7.5% between 2017 and 2050, followed by oil (4.6%), coal (3.9%) and hydro (1.2%), while other fuels (mostly biomass) will decrease strongly at 6.1% per year. Figure 17-3 shows the primary energy supply by source in the period 1990–2050.

Figure 17.3. Primary Energy Supply, BAU (1990–2050)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

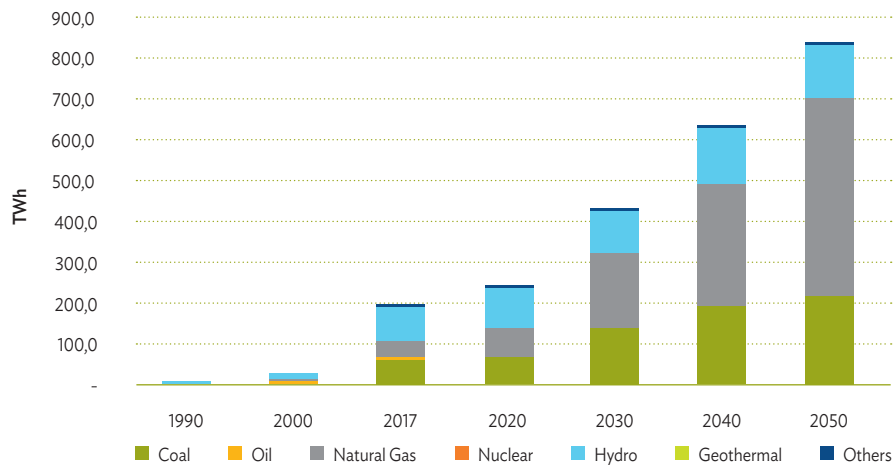
Coal accounted for the largest share of 38.9% of the TPES in 2017 and will slightly decrease to 36.7% in 2050. The shares of oil and natural gas are projected to increase from 25.0% and 9.9% in 2017 to 30.0% and 28.9% in 2050, respectively. This growth is due to the projected decline of hydro and others from 9.6% and 16.7% in 2017 to 3.9% and 0.6% in 2050, respectively.

3.1.3. Power generation

Power generation output increased at 12.2% per year, or 22.2 times, from 8.7 TWh in 1990 to 193.0 TWh in 2017. The fastest growth occurred in the natural gas power generation (38.7% per year), followed by coal (13.6%) and hydro power (10.9%). These fast growths are due to the high increase in electricity demand, as well as the decrease of oil power generation (2.2%).

Power generation is projected to increase at an average rate of 4.5% per year, or 4.3 times between 2017 and 2050, to meet electricity demand under the BAU scenario. The fastest growth will be in natural gas power generation (7.8% per year), followed by coal (3.8%) and other (1.6%). These fast growths are due to the low growth of hydro (1.2% per year) and the decrease of oil (3.1%). 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, BAU (1990–2050)



BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculations.

By the end of 2017, the majority of the country's power came from hydropower, which comprised about 45.5% of the total power generation mix. The share of coal power generation was around 32.7%, while the rest were from natural gas (21.2%), oil (0.4%) and other power generation (around 0.2%).

In BAU, natural gas will be the major fuel for power generation in 2030–50, with its share increasing from the second-largest share of 29.5% in 2020 to the largest shares of 42.9% in 2030, 48.3% in 2040 and 58.0% in 2050. On the other hand, the share of coal and hydro in the total power generation will decline from 32.1% and 24.8% in 2030 to 26.2% and 15.7% in 2050, respectively.

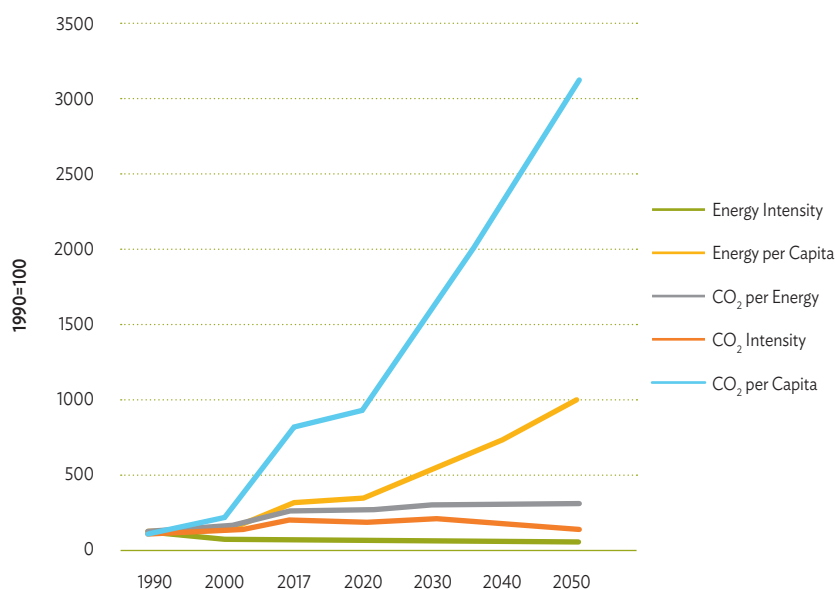
3.1.4. Energy indicators

From 1990 to 2017, Viet Nam's energy intensity showed a decreasing trend. Both primary and final energy intensities of the country decreased from 606 toe/million and 545 toe/million 2010 US\$ in 1990 to 450 toe/million and 364 toe/million 2010 US\$ in 2017, respectively. This was due to the complementary relation between modern energy and biomass. The stable economic growth will increase modern energy such as oil and electricity significantly; on the other hand biomass will be phased out because of its inconvenience. The final energy intensity under the BAU is estimated to continue the decreasing trend from 364 toe/million 2010 US\$ in 2017 to 217 toe/million 2010 US\$ by 2050. This decreasing trend indicates that energy will be used efficiently for economic development.

Meanwhile, primary energy per capita increased from 0.27 toe/person in 1990 to 0.84 toe/person in 2017; it will continue to increase to 2.69 toe/person in 2050. This indicates that, in the future, people's income increase will push up living standards and industrial structure change (shift from primary industry to secondary and service industries), resulting in rising the primary energy supply per capita.

Regarding GHG emissions, CO₂ intensity and CO₂ per energy increased from 160 t-C/million 2010 US\$ and 0.26 t-C/toe in 1990 to 311 t-C/million 2010 US\$ and 0.69 t-C/toe in 2017, respectively. In the BAU scenario, CO₂ intensity will slightly decline to 243 t-C/million 2010 US\$ in 2050, while CO₂ per energy will slightly increase at around 0.83 t-C/toe in 2050. Moreover, CO₂ per capita will also significantly increase due to energy demand rising faster than population growth (Figure 17-5)

Figure 17.5. Energy Indicators (1990–2050)



Source: Author's calculations.

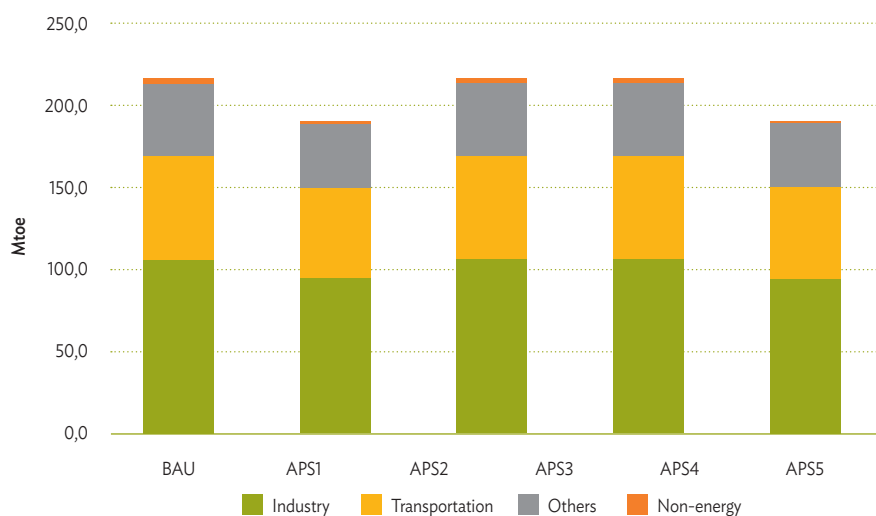
3.2. Energy Savings and CO₂ Reduction Potential

3.2.1. Total Final Energy Consumption

In the Alternative Policy Scenarios (APSs), the TFE_{EC} is projected to increase at a slower rate of 3.4% per year (compared with 3.8% in BAU), from 63.8 Mtoe in 2017 to 190.7 Mtoe in 2050 because of EEC measures (APS1) in the industry, transport, and 'others' (residential and commercial) sectors. APS2 and APS3 do not include EEC measures on demand-side, therefore,

are like the BAU scenario. APS5 combines all APSs; hence, it will be similar to APS1. The TFEC by sector in the BAU scenario and APSs are presented in Figure 17-6 below.

Figure 17.6. Total Final Energy Consumption by Sector in BAU and APSs

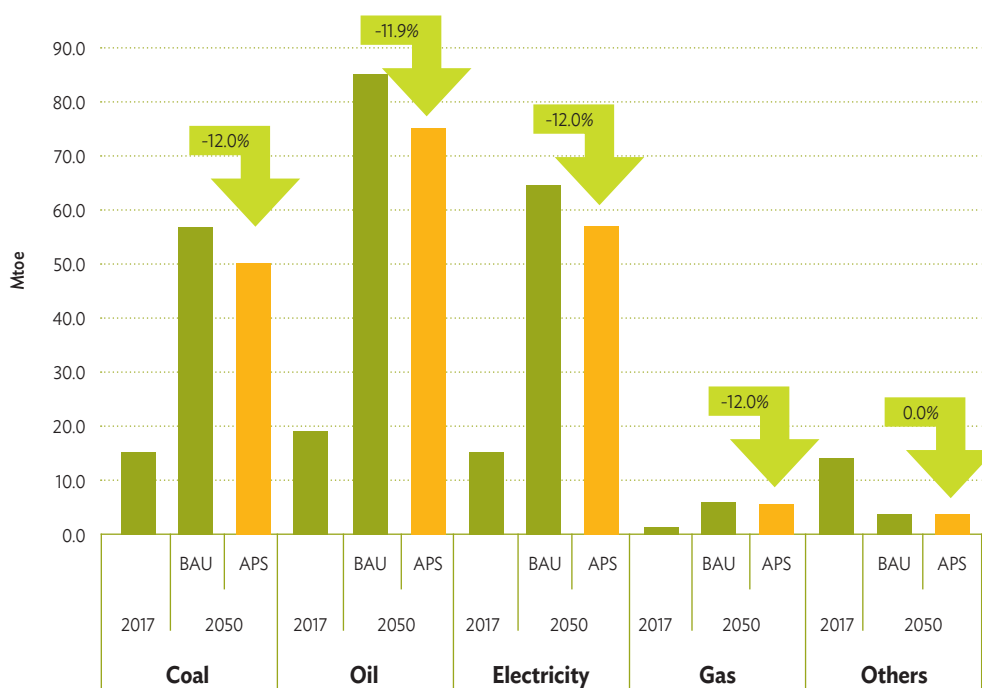


APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

On a per fuel basis under APS5, natural gas is projected to grow at the highest average annual rate of 5.0%, compared with 5.4% in the BAU scenario. This is followed by oil with 4.3%, electricity with 4.1%, coal with 3.7% and others with -3.9%, compared with 4.7%, 4.6%, 4.1% and -3.9% in BAU, respectively, over the same period. However, energy savings potential comes mainly from oil products due to energy efficiency in the transport sector, with savings of 10.1 Mtoe in 2050, equivalent to a 11.9% decrease from the BAU scenario. This is followed by electricity, coal and natural gas with savings of 7.7 Mtoe, 6.8 Mtoe and 0.7 Mtoe, respectively, and all of these are equivalent to a 12.0% decrease from the BAU scenario in 2050. 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, BAU and APS5 (2017 and 2050)



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

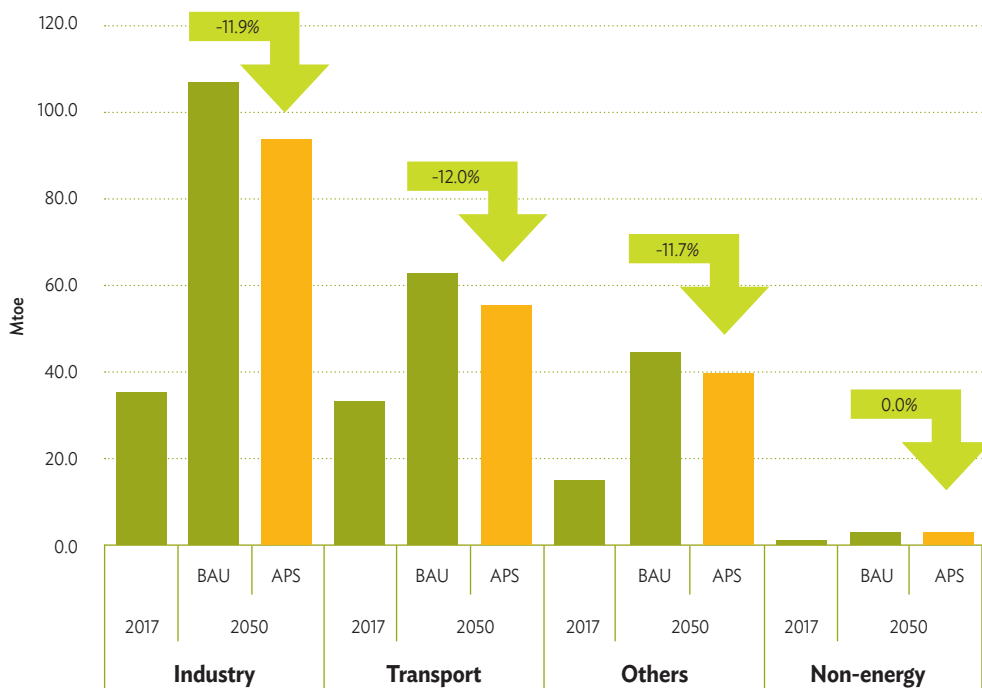
The bulk of the demand-side savings are expected to occur in the industry sector with 12.7 Mtoe (equivalent to 11.9% reduction), followed by the transport sector with 7.5 Mtoe (equivalent to 12.0% reduction), and the 'others' sector with 5.2 Mtoe (equivalent to 11.7% reduction).

An improvement in end-use technologies and the introduction of EEC measures are expected to contribute to the slower rate of consumption growth, particularly in the industry, transport, and 'others' (residential and commercial) sectors (Figure 17-8).

3.2.2. Total primary energy supply

In APS5, the TPES is projected to increase at a slower rate of 3.5% per year, from 78.9 Mtoe in 2017 to 243.8 Mtoe in 2050. Natural gas is projected to grow at the highest average annual rate of 6.8% compared with 7.5% in the BAU scenario. This is followed by oil (4.2%) and coal (2.4%), compared with 4.6% and 3.9% in BAU, respectively, over the same period.

Figure 17.8. Final Energy Consumption by Sector, BAU and APS5 (2017 and 2050)

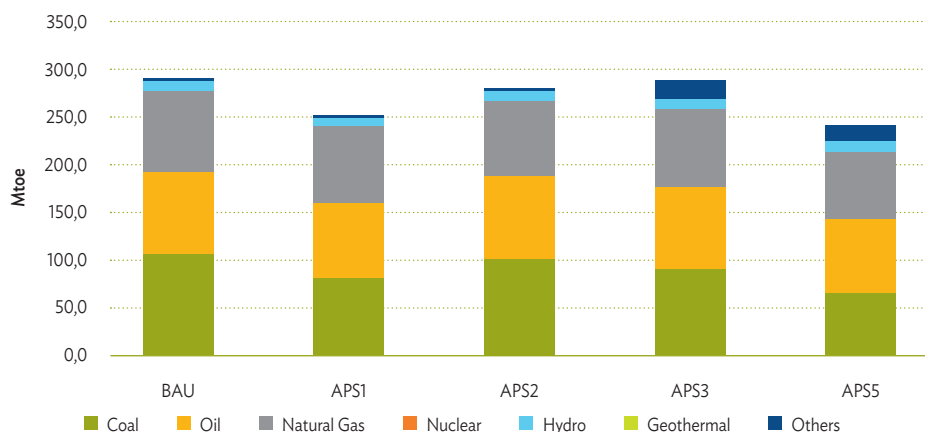


APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

The slower growth in consumption, compared to BAU, stems from EEC measures on the demand side (APS1), and the more aggressive uptake of energy efficiency in thermal power plants (APS2) and renewables (APS3) on the supply side. The TPES by fuel in the BAU scenario and APSs are presented in Figure 17-9 below.

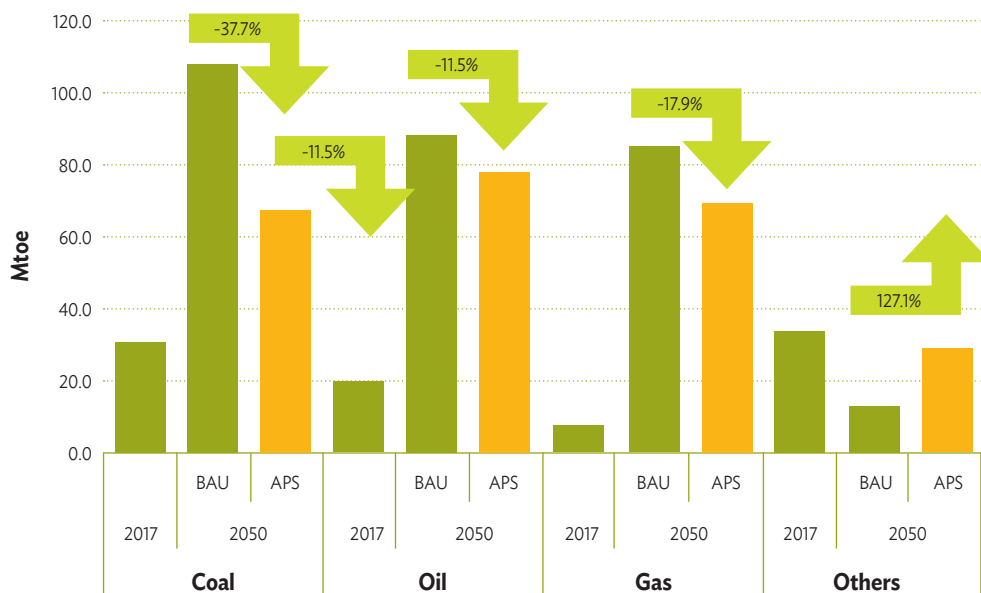
Figure 17.9. Total Primary Energy Supply by Fuel in BAU and APSs



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

Figure 17.10. Primary Energy Saving Potential by Fuel, BAU and APS5 (2017 and 2050)



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

On the energy savings aspect, coal has the highest energy savings potential with 37.7%, followed by natural gas (17.9%) and oil (11.5%). The primary energy savings potential by fuel in the BAU scenario and APSs are presented in Figure 17-10 below.

The difference between TPES in the APS5 and the BAU scenario is total energy savings, amounting to 49.3 Mtoe equivalent to 16.8% of Viet Nam's TPES in 2050 (Figure 17.11). This energy savings could be achieved from demand-side EEC efforts, further improvement of thermal power plant efficiency and higher contribution of renewables resources.

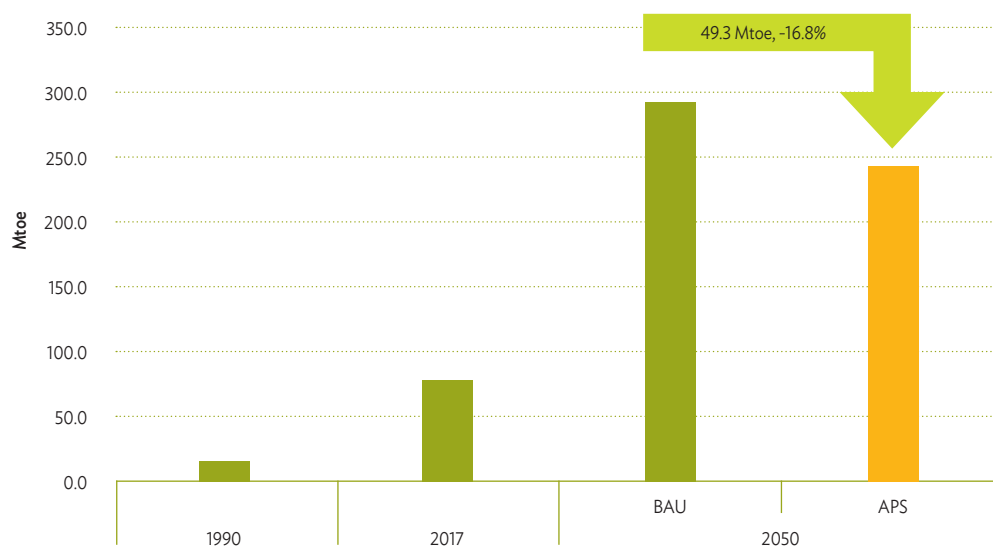
3.2.3. CO2 reduction potential

CO2 emissions from energy consumption under the BAU scenario are projected to increase by 4.6% per year from 54.5 million metric tonnes of carbon (Mt-C) in 2017 to 242.4 Mt-C in 2050. Meanwhile, under APSs, the annual increase in CO2 emissions between 2017 and 2050 is projected to be 3.7% yearly, which is 0.9% points lower than BAU.

Reduced CO2 emissions are mostly derived from EEC measures on the demand side (APS1). Moreover, improvement of energy efficiency in thermal power plants (APS2) and development

of renewables technologies (APS3) also contributed significantly to CO₂ reduction (Figure 17-12).

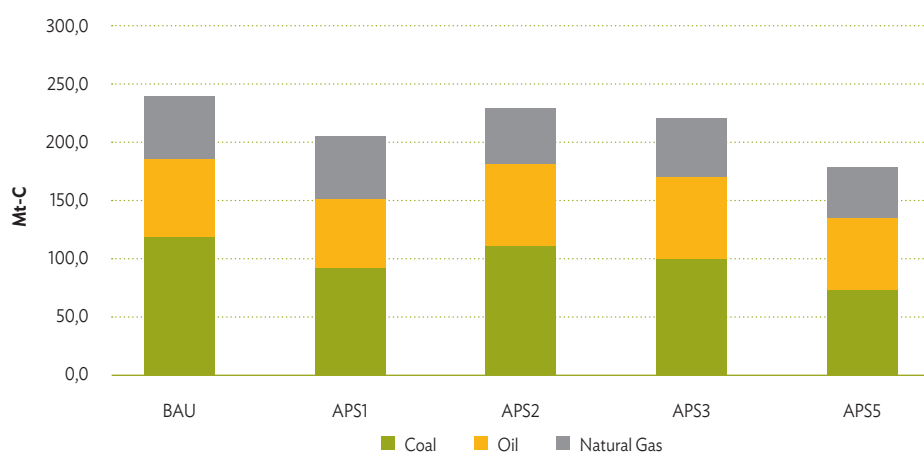
Figure 17.11. Evolution of Primary Energy Supply, BAU and APS5 (1990, 2017, and 2050)



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

Figure 17.12. CO₂ Emissions by Fuel, BAU and APSs

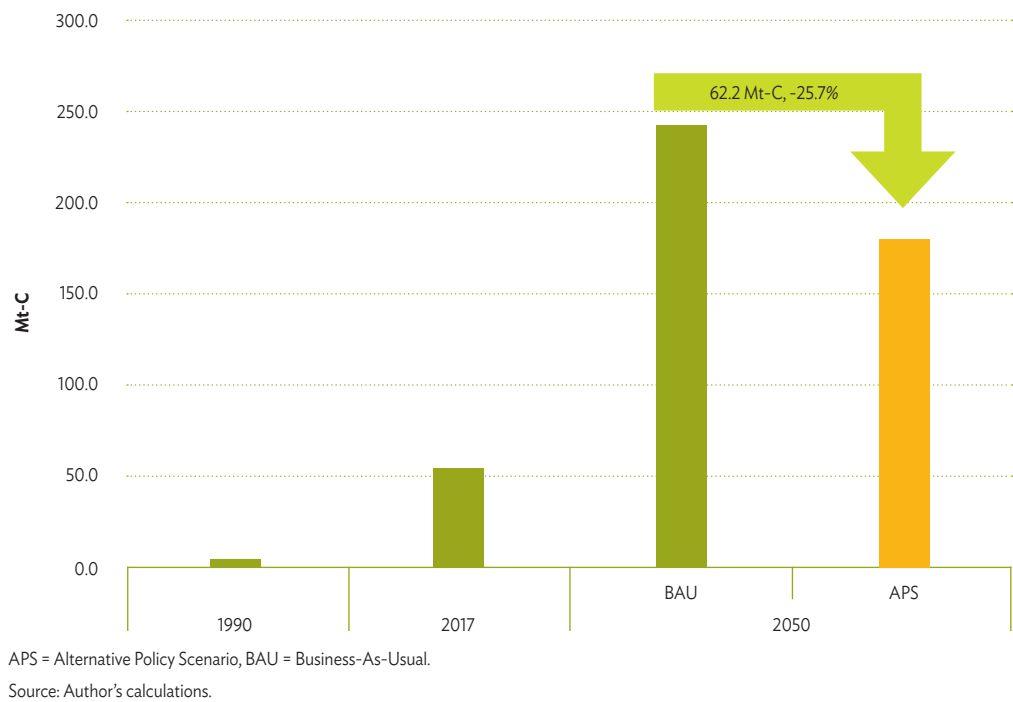


APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculations.

Improvement in CO2 emissions under the APSs will be lower than BAU by 62.2 Mt-C, equal to 25.7% reduction in 2050. This indicates that the energy savings goals and action plans of Viet Nam are very effective in reducing CO2 emissions (see Figure 17-13).

Figure 17.13. Evolution of CO₂ Emissions, BAU and APS5 (1990, 2017, and 2050)



4. Implications and Policy Recommendations

Energy demand in Viet Nam is expected to continue to grow significantly, driven by robust economic growth, industrialisation, urbanisation, and population growth. Promoting EEC is essential for Viet Nam in order to reduce energy consumption, especially fossil fuel consumption. The Government of Viet Nam should support implementable EEC action plans through setting up appropriate policies such as mandatory basis and incentive basics.

Coal thermal power plants are one of the major power sources to meet the growing electricity demand in Viet Nam. Because of the limitation of domestic coal sources, Viet Nam will shift to natural gas from coal for power generation and will import natural gas or LNG. Transparent markets in Asia will surely contribute to increasing Viet Nam's LNG supply security.

The demand for petroleum products in Viet Nam will be increasing in the coming years. Viet Nam is a net exporter of crude oil but is an importer of petroleum products for domestic

demand because of limited capacity at the Dung Quat oil refinery (6.5 million tonnes a year) that theoretically could meet around over 30% of domestic consumption. Viet Nam will expand its refinery capacity, but it will still have to import petroleum products until 2040. Petroleum products are mainly used for road transport, making shifting to efficient vehicles an important policy in Viet Nam.

Biomass will phase out of the energy market in Viet Nam due to shifts to more convenient fuels such as LPG. However, biomass still is a major fuel until 2030, especially for household cooking in rural areas. Therefore, the application of high-efficiency biomass cooking stoves will be an option for Viet Nam in order to reduce fossil fuel consumption.

The development of renewables technologies to replace fossil fuels for power generation is an important factor for energy independence, energy security, and GHG abatement. Therefore, it is necessary to support renewables development.

In order to assess the effects of energy-efficient technologies, it is suggested that Viet Nam shift from a macro approach to a bottom-up approach of energy outlook modelling.

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CHAPTER 18

United States Country Report¹

Clara Gillispie and Seiya Endo

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 US population has grown by about 2.3 million people per year, reaching approximately 330 million in 2020 (US Census Bureau, 2020a). Currently, more than 80% of the total US population lives in urban areas (US Census Bureau, 2010).

The US is the world's largest (or second-largest depending on metric) economy, with a gross domestic product (GDP) of US\$21.34 trillion and per capita income of US\$65,880 as of year-end 2019 (World Bank, 2020f). By sector of origin, 77.4% of US GDP can be linked to services, while 18.2% is linked to industry including construction (World Bank, 2020d). Agriculture, forestry and fishing collectively make up just 0.9% (World Bank, 2020a). More broadly, international trade also plays a crucial role in the overall strength and health of the US economy. As one measure of this, studies have suggested that, in numerous areas of the country, more than one-quarter of state-level GDP can be attributed to international trade, including in Washington, Michigan, Louisiana, Texas and New Jersey (Perry, 2018).

1.1. Energy Situation

The US is the world's second-largest consumer of energy and second-largest emitter of CO₂, though by per capita measures it ranks first in both categories. In 1990, US final energy consumption was 1,293.56 million tonnes of oil equivalent (Mtoe). Over the following decade, consumption increased (reaching 1,546.29 Mtoe by 2000), and then experienced a modest

¹ Unless otherwise cited, all data in this report can be attributed to Institute of Energy Economics Japan's economic modelling results for the US, which are included in full as an appendix to this publication.

overall decline from 2000 to 2017 so that consumption was 1,520.46 Mtoe as of the end of 2017. Alongside these trends, US CO₂ emissions rose sharply in the 1990s and then declined through the period ending in 2017, so that emissions were 4,760.8 million tonnes of carbon (Mt-C) in 2017 (slightly lower than levels in 1990).

During this period, coal consumption also declined sharply from 55.66 Mtoe to 17.01 Mtoe, but growth in consumption of natural gas and renewables more than offset this decline.

A key contributor to this was major shifts in the US domestic energy supply outlook.

While the US has long had abundant, diverse resource potential—including substantial natural endowments in fossil fuels such as coal, shale oil, and natural gas; geothermal and hydroelectric potential; and good conditions for wind and solar energy—up until recently, significant portions of this potential were not considered technically or economically viable. However, breakthroughs in technology, declining production costs, and favourable environments for development and investment have contributed to growing accessible domestic resource potential. Between 2008 and 2013, the incremental increase alone of US daily oil production was equivalent to the total daily oil production of Iraq in 2010. Natural gas production also increased 12-fold during a similar period, resulting in the US become a top producer of natural gas (Richardson-Barlow et al., 2014). Meanwhile, between 2008 and 2014, US solar installations grew 35-fold (US Department of Energy, 2014).

Such developments have had a dramatic impact on US energy outlooks. Increased US oil and natural gas production has contributed to reducing or backing out import requirements from Canada and other country sources. Combined with other market and policy factors, these developments have also accelerated the transformation of the US power generation mix.

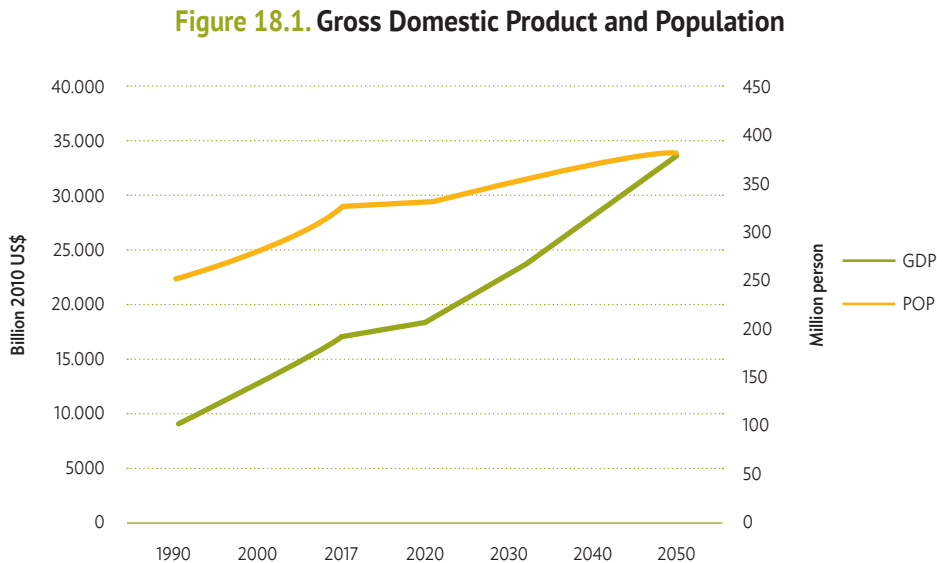
In 2014, for the first time ever, natural gas surpassed coal as the largest share of US power generation. Meanwhile, wind and solar experienced the largest rates of increase of any fuel source during the 1990–2017 period, and the Energy Information Association (EIA) notes that generation costs for these renewables are continuing to decline (US Energy Information Administration, 2020a). In some parts of the US, including Texas and Iowa, wind energy is now considered cost-competitive with traditional fuel sources, which, going forward, may further incentivise consumption (Gillispie, Johnson, and Schwartz, 2017).

As a result of these transformations, the EIA now projects that the US will become a net energy exporter in 2020. The country is also anticipated to play an increasingly important role as a key exporter to the Asia and the Pacific region. To date, US liquefied natural gas exports have been delivered to several major economies in Asia, including Japan, Taiwan, India, South Korea and China (US Energy Information Administration, 2020c). The US is also an

important global exporter of coal, with India, Japan and South Korea representing three of the top five recipients of US steam coal exports in 2020 (US Energy Information Administration, 2020b). Going forward, while each of these fuel sources has the potential to contribute to regional energy security outlooks, several considerations, such as the overall competitiveness of US supplies, social license considerations and potential infrastructure bottlenecks, may limit overall US exports.

2. Modelling Assumptions

Over this study’s outlook period of 2017–50, both overall 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 17.1). While US birth rates are projected to remain below replacement levels during the outlook window, the population continues to grow overall due to sustained immigration and improvements in 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 1.0% of the 1990–2017 period.



GDP = gross domestic product, POP = population.
Source: Authors.

Between 1990 and 2017, the US GDP grew at an average annual rate of 2.4%. Despite significant disruption in this overarching trend during the 2007–08 global economic crisis, US economic outlooks had generally recovered and stabilised by 2019. As of this report going to press, the Covid-19 pandemic has injected significant uncertainty into near-term economic

outlooks globally; the effects in the US have been particularly acute. Still, this model projects that GDP growth rates will restabilise over the outlook period at an annual average growth rate of 2.1% per year. This estimate aligns with expectations of continued efficiency and productivity gains coupled with modest yet sustained population growth. It also assumes continued US leadership on innovation in emerging fields alongside global market recovery.

Under the Business-as-Usual (BAU) scenario, oil is anticipated to retain its dominance through the outlook period, reflecting that, by sector, transportation is also anticipated to remain the single largest driver of total final energy consumption. In terms of electricity generation, while coal and nuclear energy remain critical components of the overall US mix, between 2017–50, both are anticipated to decline in terms of their overall share. This is primarily due to unfavourable economics and domestic policy and social license factors when compared with the outlooks for non-hydro renewables and natural gas. Coal in particular is expected to undergo a dramatic decline, given projected retirements of older, inefficient coal-fired plants during the outlook period. Meanwhile, investments in cleaner consumption technologies are anticipated to boost the overall efficiency of generation. However, uncertainties about the pace and scale of retirement of existing nuclear power plants weigh on the overall trajectory of US CO₂ emissions.

The Alternative Policy Scenarios (APSs) assume progress toward the full implementation and realisation of a range of established efforts to strengthen a country's energy savings potential. For the US, these include efforts to strengthen efficiency of final energy consumption; improve efficient thermal power generation; sustain a robust role for nuclear energy as a source of baseload power generation; and realise a higher contribution from renewable energy in total supply. Calculations are modelled based on a review and assessment of current laws and policies in place at the national and state level. This study then reviews the results of the APSs to determine their cumulative impact in reducing CO₂ emissions and encouraging energy savings beyond BAU.

3. Outlook Results

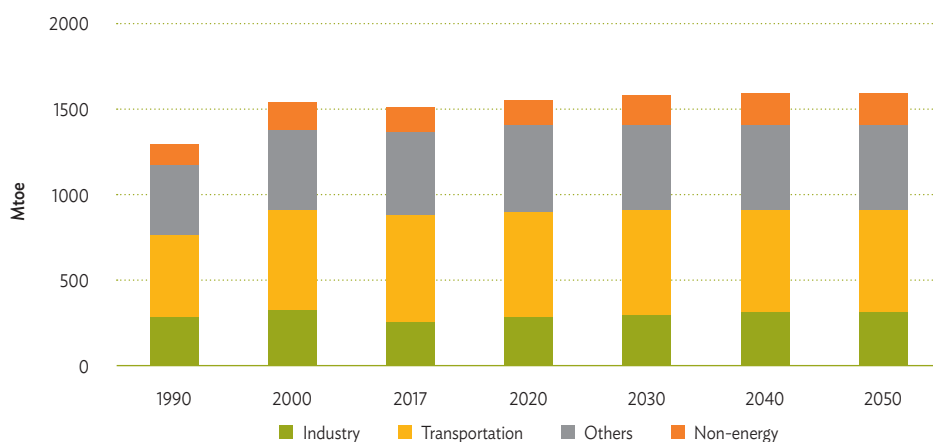
3.1. Business-as-Usual Scenario

3.1.1. Final energy consumption

Under BAU, total final energy consumption is anticipated to rise slightly between 2017

and 2050, at an average annual growth rate of 0.2% (Figure 18.2). The largest growth is experienced in industry, though non-energy sector consumption is not far behind, and also grows at the fastest rate. Meanwhile, the transportation sector is the only sector where consumption is anticipated to decline—albeit by only 0.1%—as efficiency improvements and other structural changes within the sector offset prospects of potential growth from a rise in vehicle ownership and utilisation.

Figure 18.2. Final Energy Consumption by Sector, BAU



BAU = Business as usual.

Source: Authors.

During this same period, electricity consumption is anticipated to grow from 321.42 Mtoe to 445.99 Mtoe. Non-hydropower renewables, primarily wind, solar and geothermal, experience the most dramatic growth during this period. Natural gas consumption grows overall, but shows signs of a potential peak near the end of the outlook period. Coal consumption declines throughout the entire 2017–50 period, although at a much slower pace than the previous 25 years and with most of this decline occurring in the 2020s. Oil consumption also declines, given expectations for continued efficiency gains, as well as switching in the transportation sector to natural gas, biofuels and other sources, as well as increased deployment of electric vehicles. By 2050, oil consumption is anticipated to fall to 686.10 Mtoe (roughly on par with levels in 1990).

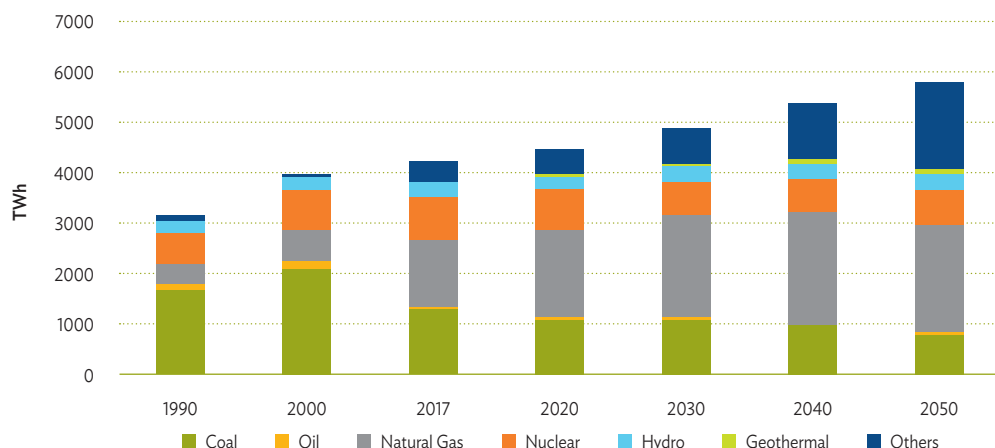
3.1.2 Primary Energy Supply

Under BAU, total primary energy supply is anticipated to rise from 2,155.23 Mtoe in 2017 to 2,254.78 Mtoe in 2050, with an average annual rate of increase of 0.1%. Coal consumption is anticipated to decline at a rate of 1.7% during this period, while nuclear declines by 0.6%. In

contrast, non-hydropower renewables experience the largest growth in consumption at 5.2%, followed by geothermal at 4.3%.

3.1.3 Power generation

Figure 18.3. Power Generation, BAU



BAU = Business as usual.

Source: Authors.

Electricity generation in the US, under BAU, is projected to increase over the outlook period, though at a slower pace than the previous 25 years. Generation output increases from 4,263.68 to 5,822.49 between 2017 and 2050, for an average annual growth rate of 0.9%.

After surpassing coal as the largest share of the US power generation mix in 2014, natural gas retains its number one rank through 2050, representing 37.6% of the overall mix. The largest average annual growth rates are seen in non-hydro renewables, most prominently solar and wind, as well as, potentially, geothermal. When combined with shares for nuclear and hydro, these growth rates suggest that, by 2050, close to 50% of US power generation output may come from zero-carbon sources. Improved economics alongside other considerations could also contribute to incentivising higher levels of consumption of wind and solar, though, as aptly noted by the EIA, many existing tax credits begin to expire in the early 2020s, potentially raising questions for the road ahead.

Retirements of older, inefficient coal-fired plants, as well as ongoing technological improvements promoting more efficient consumption, are assumed to play important roles in shaping this outlook, alongside broader market and policy forces that may incentivise switching. Coal is now expected to decline sharply at 1.5% a year, and in 2050 it is anticipated to account for only 13.9% of all US power generation (down from 31.0% in 2017). However,

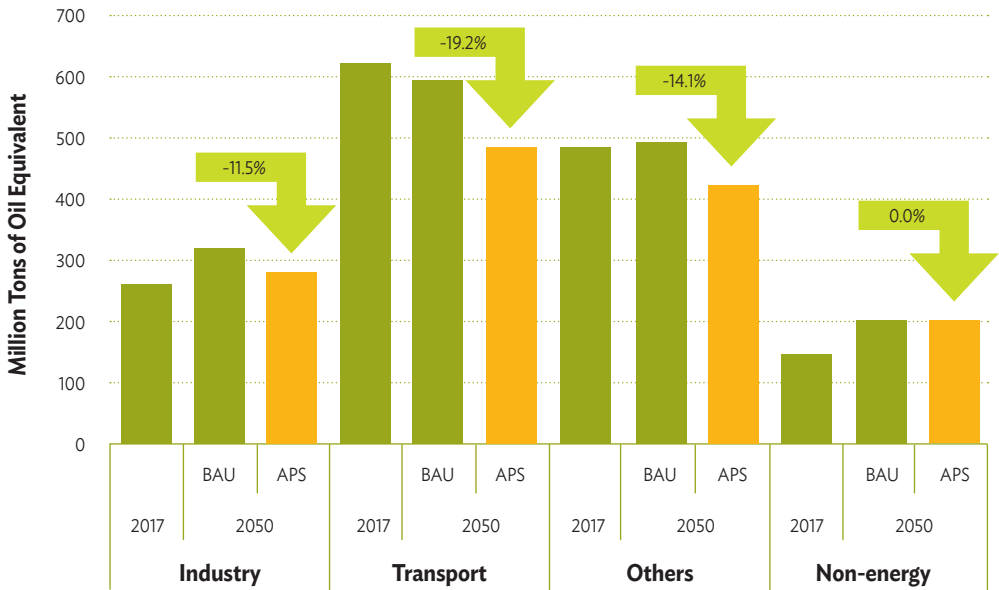
uncertainties in investments and progress toward strengthening existing, aging grid infrastructure may challenge efforts to bring new generation on line in ways that promote energy savings and CO2 reductions.

3.2. Energy Saving and CO2 Reduction Potential

3.2.1. Final energy consumption

This study projects that, rather than continuing to grow, total final energy consumption in the US begins to decline under APS. To that end, under APS, consumption declines from 1,520.46 Mtoe to 1,392.08 Mtoe during 2017–50. When compared with BAU, this shows an energy savings of 221.36 Mtoe, or 13.72% during the period. Transportation realises a saving of 114.78 Mtoe (19.2%), industry saves 36.78 Mtoe (11.53%), and residential and commercial (others) saves 69.8 Mtoe (14.1%). Meanwhile, in contrast to expectations under BAU, both transportation and residential and commercial now realise some level of declining overall consumption.

Figure 18.4. Final Energy Consumption by Sector in BAU vs. APS

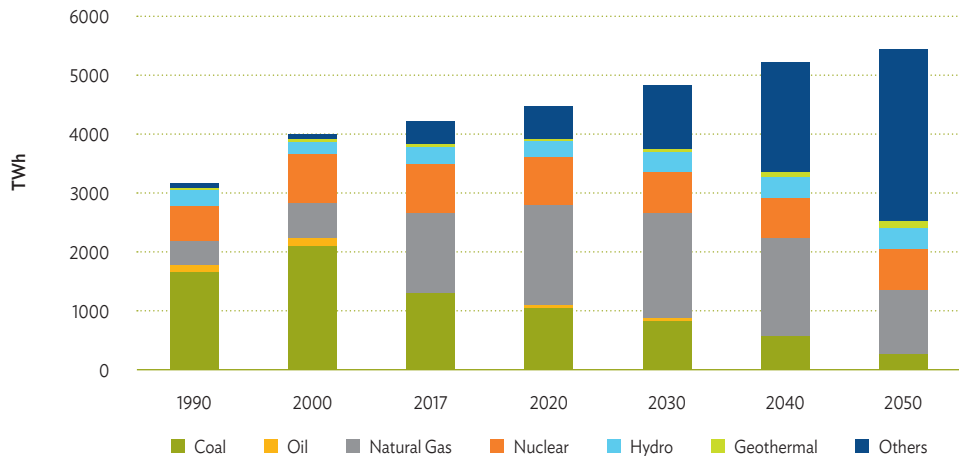


APS = alternative policy scenario, BAU = Business as usual.
 Source: Authors.

Under APS, electricity consumption is still anticipated to grow, although at a modestly slower rate than in BAU. Much more dramatic, however, is the overall transformation of the US power generation mix. In line with increasingly favourable economics and this scenario’s assumptions around additional technological improvements (including in storage

technologies), non-hydro renewables overtake natural gas as the largest share of the US power generation mix. By 2050, roughly 75% of US power generation output comes from zero-carbon sources; natural gas makes up 20% while coal is responsible for less than 5% (see Figure 18.5).

Figure 18.5. Electricity Generation under APS

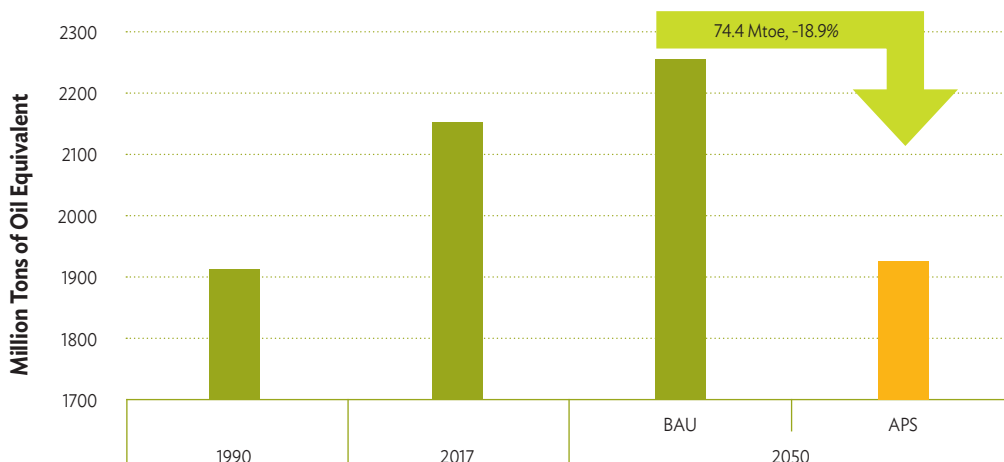


EAS = East Asia Summit, Mtoe = million tons of oil equivalent.

Source: Authors.

3.2.2. Primary energy supply

Figure 18.6. Total Primary Energy Supply in BAU vs. APS



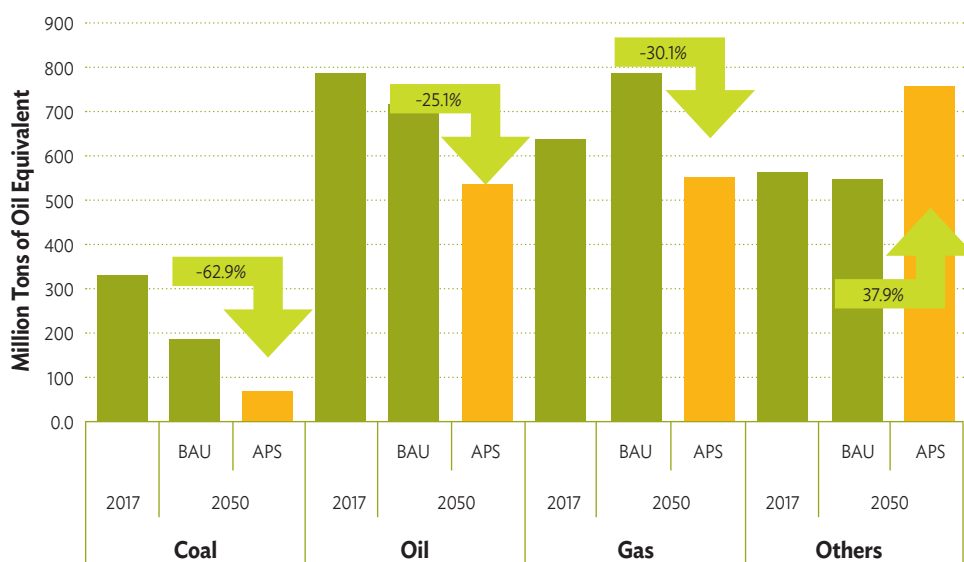
APS = alternative policy scenario, BAU = Business as usual.

Source: Authors.

Under the APS, the US primary energy supply is anticipated to decrease from 2,155.23 in 2017 to 1,924.39 in 2050. This implies that, in 2050, under APS, savings of primary energy supplies will be around 330.39 Mtoe, or 14.65% lower compared with BAU (Figure 18.6).

Primary energy demand in the APS is expected to decline for coal to 70.36 Mtoe. This represents a total energy savings of 119.33 Mtoe in 2050 compared with BAU. Oil consumption is also anticipated to decline compared to BAU, with a potential saving of 180.91 Mtoe (or 25.09%) by 2050, while natural gas is also anticipated to see an even more pronounced level of decline (30.11%). In contrast, the combined demand for all others is anticipated to increase about 208.82 Mtoe (37.92%) compared to BAU in 2050.

Figure 18.7. Total Primary Energy Supply by Fuel in BAU vs. APS



APS = alternative policy scenario, BAU = Business as usual.

Source: Authors.

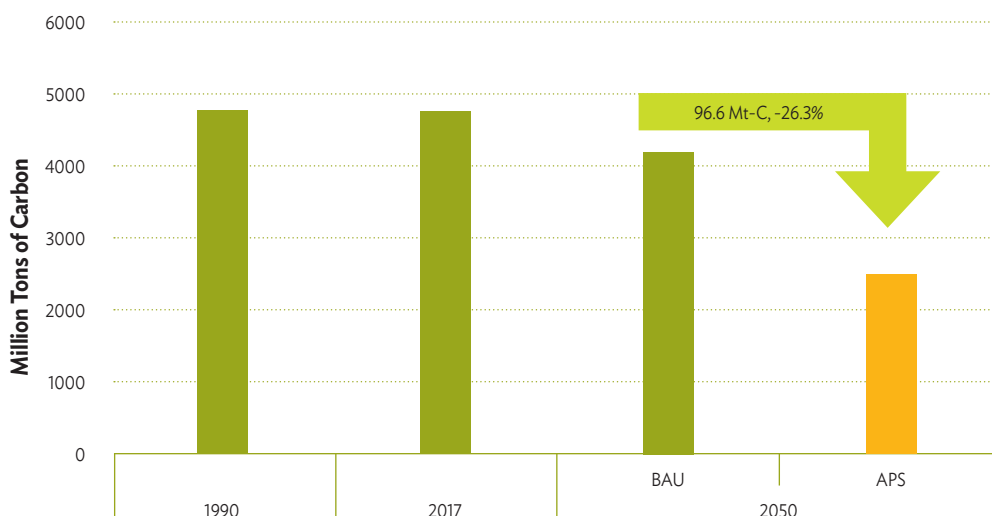
3.3. CO2 Emissions

CO2 emissions from energy consumption, under the BAU, are anticipated to decline modestly from 4,760.8 Mt-C in 2017 to 4,191.7 Mt-C in 2050. This is equivalent to an annual average rate of decrease of 0.4%. Key drivers of this shift include that, while energy consumption overall continues to grow in the BAU scenario, continued switching in the US electricity mix—particularly decreases in coal consumption and increased consumption of non-fossil sources—contributes to modest improvements in the country's overall emission profile, as does a decrease in oil consumption.

In the APS, CO₂ emissions are projected to decrease at an average annual rate of 2% from 4,760.8 Mt-C in 2017 to 2,485.1 Mt-C in 2050. Emissions savings in the APS are thus 40.71% compared to the BAU in 2050. The most dramatic shifts between BAU and APS link to absolute reductions in emissions from natural gas (681 Mt-C) and oil (517.6 Mt-C), though coal undergoes the most substantial relative reduction, down 66.51%.

In its official Intended Nationally Determined Contribution submission, the US pledged to reduce CO₂ emissions by 26%–28% from 2005 levels by 2025. Although the current US administration has announced that it intends to formally withdraw from the Paris Climate Accord in November 2020, thus abandoning its current Intended Nationally Determined Contribution pledge, this study suggests that the US has already made substantial progress toward this goal. However, even under APS more robust action may be necessary to fully achieve this target by 2025.

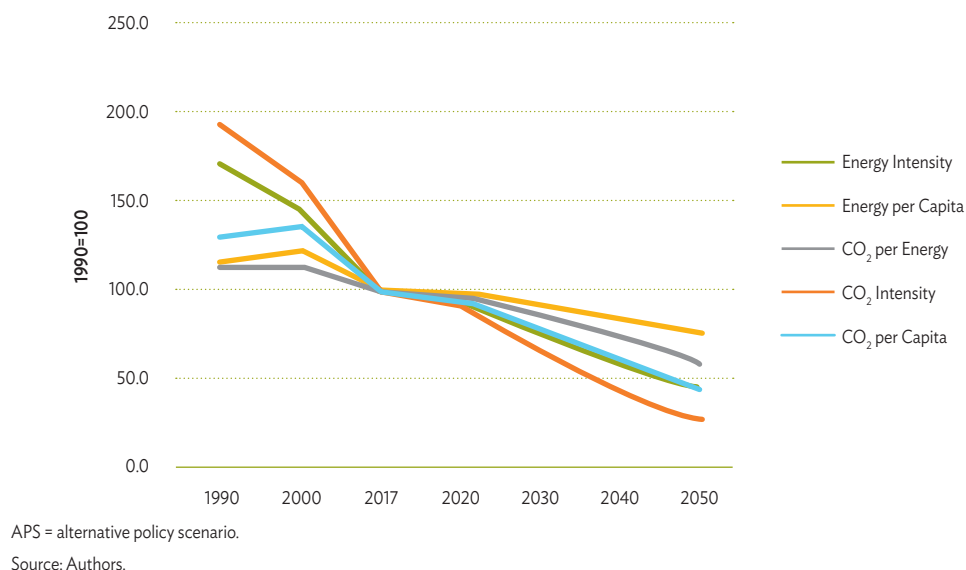
Figure 18.8. CO₂ Emission Trends in BAU vs. APS



APS = alternative policy scenario, BAU = Business as usual.

Source: Authors.

Figure 18.9. Energy Indicators under APS



4. Implications

- Oil and natural gas will continue to dominate the US energy mix in both BAU and APS. However, demand for coal will continue to steadily decline in both scenarios, with an even more dramatic reduction projected under APS.
- 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. Moreover, under APS, zero-carbon sources overtake natural gas as the greatest share of the US electricity generation mix. However, as aptly noted by the EIA, substantial uncertainties lie ahead, including determining the implications and desirable responses to expiring tax credits and fiscal incentives for renewable energy in the 2020s. Greater attention to addressing aging infrastructure as well as new breakthroughs in storage technologies are also critical to maintaining the overall pace and trajectory of additional gains.
- Continued efforts to strengthen the transportation sector are envisioning as a critical opportunity for energy saving under both BAU and APS. In addition to accelerated deployment of electric vehicles, greater attention to fuel efficiency and technologies for overall cleaner consumption will be critical given expectations of a continued

prominent role for oil.

- US energy exports to Asia could contribute immensely to strengthening regional energy security outlooks. However, factors such as overall competitiveness, social license considerations on both sides of the Pacific, and the need to overcome infrastructure bottlenecks may limit overall US export growth potential.

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Annex 1

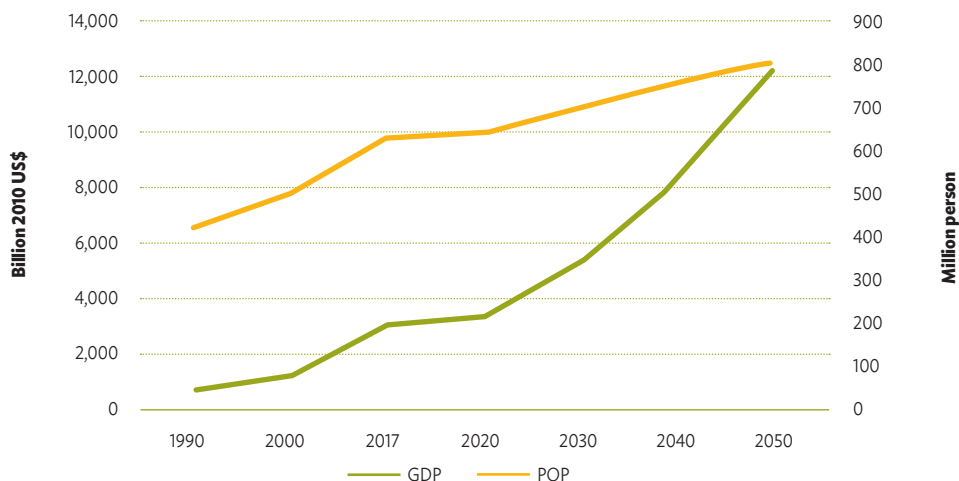
Energy Outlook Results of Total ASEAN

Alloysius Joko Purwanto

1. Background

According to the World Bank World Development Indicators (WDI) databank¹, the 10 (ten) Member States of the Association of South East Asian Nations (ASEAN) reached a total Gross Domestic Products (GDP) of around US\$² 3.1 trillion by 2017. According to the ASEAN Secretariat (2019)³, by 2018, ASEAN as a region is fifth largest economy in the world, only behind the United States (US\$20.5 trillion), China (US\$13.4 trillion), Japan (US\$5.0 trillion), and Germany (US\$4.0 trillion).

Figure A1-1. Gross Domestic Product (GDP) and Population of ASEAN



¹Available at <https://databank.worldbank.org/source/world-development-indicators> as accessed 5 November 2020
Constant 2010 US\$ is used in this report

³ The ASEAN Secretariat (2019), ASEAN Key Figures 2019, Jakarta, ASEAN Secretariat, October, available in https://www.aseanstats.org/wp-content/uploads/2019/11/ASEAN_Key_Figures_2019.pdf as accessed 23 October 2020

The total 10 ASEAN Member States' GDP would rise from around US\$ 3.1 trillion in 2017 to around 12250 billion US\$ in 2050, i.e. an average yearly growth of around 4.3%. At the same time, the total ASEAN population would increase from around 636 million of inhabitants in 2017 to around 810 million of inhabitants in 2050, i.e. an average growth rate of 0.7% per year. The GDP per capita would increase then from around US\$ 4875 in 2017 to US\$ 15150 in 2050.

ASEAN Member States are taking individual actions to address climate change issues as stated in their Intended Nationally Determined Contributions (INDCs) as shown in the Table A1-1. Individual measures range from energy efficiency improvements to increase in renewable energy use in energy intensive consuming sectors, for instance household, transport, industry, buildings, etc., which are explained in detail in country chapters of this report.

Table A1-1 ASEAN Member States Individual Intended Nationally Determined Contributions (INDCs)

Table A1-1. ASEAN Member States Individual Intended Nationally Determined Contributions (INDCs)

Country	Reduction Target
Brunei Darussalam	Brunei Darussalam has a commitment to reduce 63% of its total energy consumption by 2035
Cambodia	Cambodia has a commitment to reduce 27% of its greenhouse gas emissions conditionally, taken from aggregate reductions from energy, transport, manufacturing and others and additional contribution from the LULUCF sector
Indonesia	Indonesia has a commitment to unconditionally reduce 26% of its greenhouse gas emissions by 2020 and 29% by 2030 compared to its Business-as-Usual (BAU) scenario. Reduction target would be increased to 41% by 2030 if support is provided from international cooperation.
Lao PDR	Lao PDR has set policies and measures to reduce greenhouse gas emissions in multiple sectors, to be implemented by 2030.
Malaysia	Malaysia intends to reduce its greenhouse gas emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005. This reduction consists of 35% on an unconditional basis and a further 10% upon receipt of climate finance, technology transfer and capacity building from developed countries
Myanmar	Myanmar has set policies and measures to reduce greenhouse gas emissions in multiple sectors, to be implemented by 2030
Philippines	Philippines has a commitment to reduce 70 % of its greenhouse gas emissions by 2030 relative to its BAU Scenario. The mitigation contribution is conditioned on the extent of financial resources, including technology development and transfer, financial resources, and capacity building
Singapore	Compared to the 2005 base year, Singapore intends to reduce its emissions intensity by 36% by 2030, and stabilize its emissions with the aim of peaking around 2030
Thailand	Thailand has a commitment to reduce its greenhouse gas emissions by 20 % from the BAU level by 2030. The target could increase up to 25 percent, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity building support through a balanced and ambitious global agreement under the (UNFCCC).
Viet Nam	Viet Nam intends to reduce its greenhouse gas emissions by 8% unconditionally by 2030. The target could be increased to 25% if international support is received through bilateral and multilateral cooperation, as well as through the implementation of new mechanisms under the Global Climate Agreement, in which emission intensity per unit of GDP will be reduced by 30% compared to 2010 levels.

Source: Summarized of ASEAN Member States information in the INDC Portal available at <https://www4.unfccc.int/sites/submissions/INDC/Submission%20Pages/submissions.aspx> as accessed on 29 October 2020

Collective actions are also taken at ASEAN level which are represented by the Joint Declarations on Climate Change which have been issued since 2007. In their most recent Joint Declaration on Climate Change, signed in Kuala Lumpur, 21 November 2015⁴, ASEAN Leaders called upon Member States to work effectively and in good faith for an agreed outcome with legal force under the Convention and submit Intended Nationally Determined Contributions (INDCs) in advance of the 21st UNFCCC Conference of Parties (COP-21) in Paris in December 2015.

ASEAN Plan of Action for Energy Cooperation (APAEC) as the regional blueprint for the energy sector in the framework of the ASEAN Economic Community (AEC) implementation might be the most important measure taken at the ASEAN level that concerns energy infrastructures development. With its seven program areas, APAEC is the blueprint of the energy cooperation in the region that plays a vital role in setting a sustainable future of ASEAN energy landscape.

In this chapter we present the energy outlook of the aggregation of 10 ASEAN Member States results. We provide first the outlook results of the business-as-usual (BAU) scenario and then the outlook results of the alternative scenario (APS5 or simply APS) scenario. In the country chapters, alternative scenarios (APS) have been developed based on the energy efficiency and renewable energy penetration targets in each country which are set without any direct relationship with the country's INDC as described in the Table A1-1.

In each scenario we show the development of the final energy demand, primary energy consumption, power generation sector, and several energy indicators that synthesize the region's performance on the improvements of energy efficiency and reduction of energy intensity and CO₂ emissions.

2. Outlook Results

2.1. Business-as-Usual Scenario

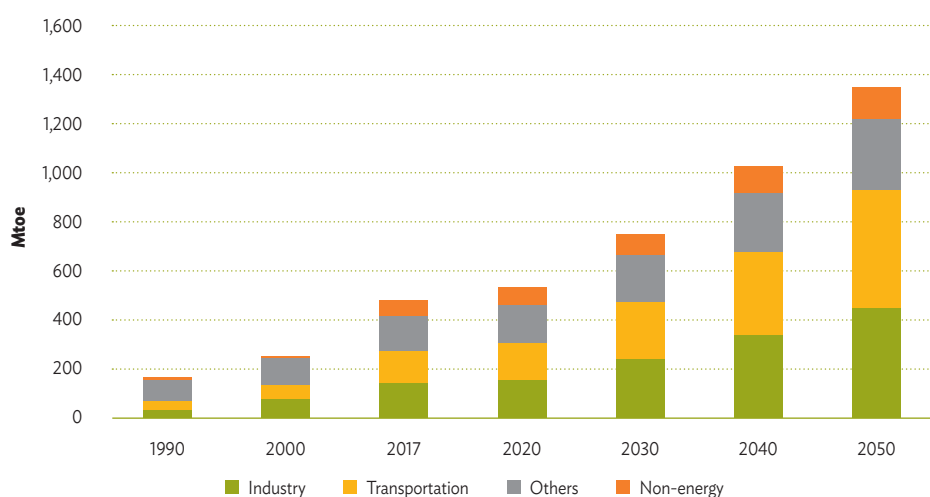
2.1.1. Final Energy Demand

ASEAN's final energy demand grew at an annual rate of 4.0% from 165 Mtoe in 1990 to 480 Mtoe in 2017. During the same period, the "Others" sector, i.e. residential and commercial,

⁴ ASEAN Joint Statement on Climate Change to the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) (Adopted). Available at <http://environment.asean.org/wp-content/uploads/2018/11/ASEAN-Joint-Statement-on-Climate-Change-Adopted-2015.pdf> as accessed 29 October 2020.

was the dominant energy use share, with 81 Mtoe and 141 Mtoe consumed in 1990 and 2017, respectively, i.e. an annual growth at 2.1%. With an annual growth of around 5.5%, transport sector was the second fast growing sector in that period followed by industry sector with 4.6% yearly growth rate. In 2017, with around 148 Mtoe, industry sector has the lion share of the energy consumption (31%), followed closely by the “Others” sectors (141 Mtoe or 29% share) and then transport sector (129 Mtoe or 27% share). Approximately only around 7% of the region’s final energy is consumed for non-energy uses in 2017, particularly as feedstock for petrochemical production.

Figure A1-2. Final Energy Demand by Sector, BAU



Source: Author's compilation

Under the BAU scenario, final energy demand is projected to grow by 3.2% a year between 2017 and 2050. The fastest average annual grow can be expected to happen in the transport sector (4.1%), followed by the industry sector (3.4%). The “others” and Non-energy sectors demand are projected to grow yearly by 2.2% each. The slow growth in the “others” sector is caused by the shift from traditional biomass use especially in residential to other commercial and more efficient energy sources such as oil and electricity.

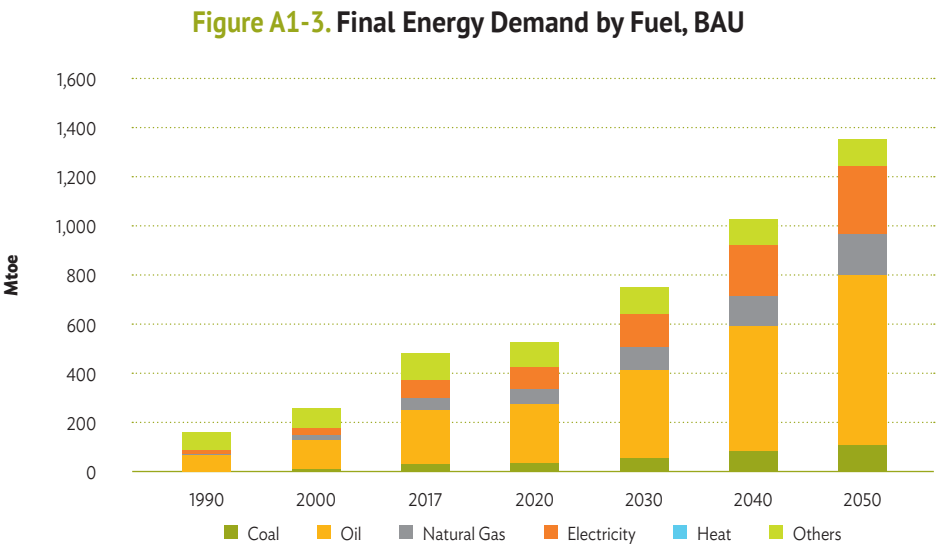
Under the BAU, transport sector consumption will become the highest share in the total final energy demand in ASEAN followed by the industry sector and then the “Others” sector. By 2050, transport sector energy use share would reach around 36% whilst those of industry and the “Others” sectors would reach 33% and 22% consecutively.

By fuel type, natural gas experienced the fastest growth over the 1990 to 2017 period, at an average rate of 7.3% per year mainly caused by the rapidly expanding industry sector. Coal and electricity demand grew annually at similar rate of 7.2% during the period 1990 to 2017. Demand for oil grew at an average annual growth of 4.6% percent while the “Others” sources, mostly consisted of traditional biomass, grew annually at 1.1%.

In term of fuel share, it is interesting to observe that the “Others” with 75 Mtoe and 45% of share, was the dominant fuel in 1990. This share dropped sharply to 21% (101 Mtoe) in 2017. In 2017, with 45%, oil had the lion share of fuel use followed by electricity (16%), natural gas (10%) and coal (7%).

Under the BAU, the demand for natural gas and electricity is expected to continue expanding but at a slower average growth of around 3.9 and 3.8 % annually until 2050. Meanwhile, coal and oil demand will only be growing at an average of of about 3.6% and 3.6% per year, respectively. Demand for the “Others” fuel, mostly composed by the use of traditional biomass would decrease by around 0.1% per year.

With a share of around 51% in 2050, oil is still expected to play a major role in the ASEAN’s final energy demand. For the past two decades, that is, periods 1990 to 2017, the share of oil increased from 40% to around 45%. Under the BAU, oil’s share to the final energy demand will increase slightly to 46% in 2020 then further to 51% in 2050. Meanwhile, the share of electricity in the final energy demand will increase to around 17% starting 2020 and before rising further to 21% until 2050. Figure 3 shows the final energy demand by fuel.



Source: Author’s compilation

2.1.2 Primary Energy Consumption

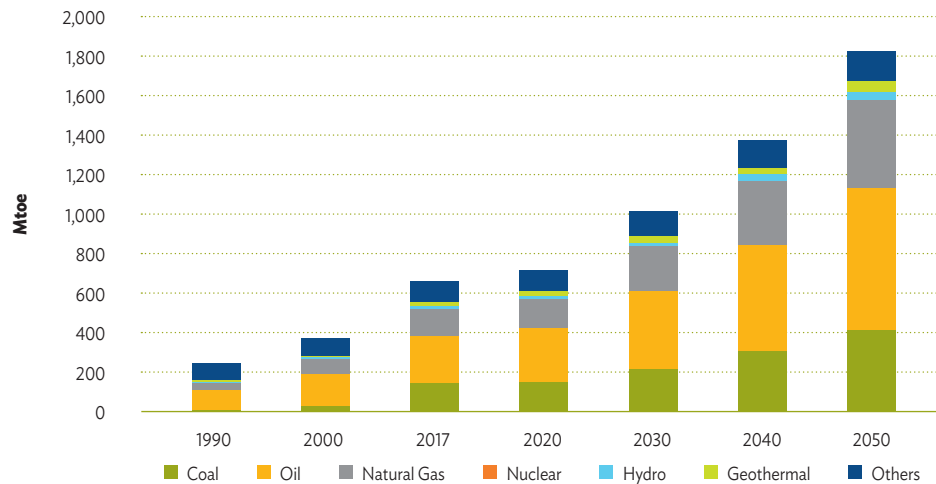
Primary energy consumption grew by 3.9 % per year, from 238 Mtoe in 1990 to 662 Mtoe in 2017. ASEAN region's dominant source of energy in 1990 was oil which made 42 % of the total primary energy consumption share, of which consumption increased yearly by 3.4 % from 99 Mtoe in 1990 to 244 Mtoe in 2017. The second dominant source of commercial energy was natural gas. In 1990 natural gas made 14% share of the total primary energy consumption in the region and in 2017 this share reached 20%, i.e. a yearly increase of 5.2% from 33 Mtoe in 1990 to 129 Mtoe in 2017. Nevertheless, with an annual growth rate of 9.3%, coal is the fastest growing energy source who increased from 13 Mtoe to 143 Mtoe between 1990 and 2017. During the same period, hydro and geothermal increased with annual growth rates of 7.3% and 4.7% respectively. "Others" sources of energy, consisted mainly by traditional biomass in made 36% of the total final energy consumption in 1990 which is the second biggest after oil. However, in 2017 its share was only 17% as its consumption increased only by around 1% per year from 85 Mtoe to 110 Mtoe between 1990 and 2017.

As shown in the Figure 4, Primary energy consumption in the BAU is projected to grow by 3.1% per year between 2017 and 2050. Among the energy sources, natural gas is expected to grow the fastest at 3.9 % a year, followed by coal and oil, at 3.2% and 3.3% per year, respectively. Geothermal and hydro are expected to increase at consecutively 3.6% and 2.0% per year. By 2050, with around 40% of the total primary energy consumption share, oil would remain as the dominant energy sources followed by natural gas (25%) and coal (22%) whilst, hydro and geothermal shares would remain limited at 2% and 3% respectively. The share of the "others" sources of energy in 2050 would be 8% as it is expected to grow by only 0.9% during the period of 2017 – 2050.

2.1.3 Power Generation

Electricity generation grew by 7.9% per year from 170 TWh to 1040 TWh over the period 1990 to 2017. The power generation mix has changed significantly over the past decade which marked principally by the shift from oil to natural gas, coal, and hydro. Natural gas and coal, which each accounted for respectively 17% (around 28 TWh) of electricity generation in ASEAN in 1990, grew rapidly to supply respectively 40% (415 TWh) and 37% (380 TWh) of the region's electricity in 2017. Hydro share grew from 16% (27 Mtoe) in 1990 to 18% (183 TWh) in 2017 whilst fuel oil share for thermal power generation drop from 46% (80 TWh) in 1990 to merely around 3% (25 TWh) in 2017. In the same period, "Others" sources of energy that

Figure A1-4. Primary Energy Consumption, BAU

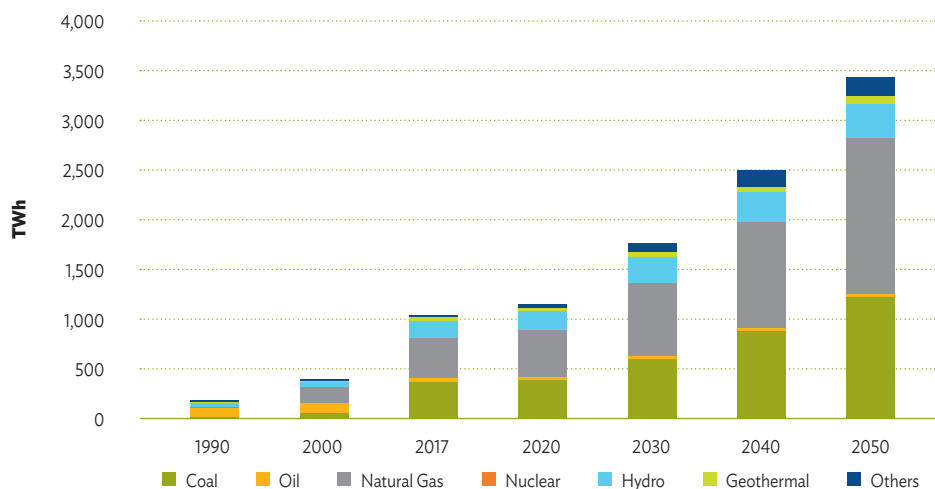


Source: Author's compilation

includes biomass and solar, took up only a small proportion of the mix, nearly zero in 1990 to totaling to around 1% in 2017.

In the BAU scenario, power generation is projected to increase at 3.7% per year over the period 2017 – 2050, reaching 3440 TWh in 2050. Natural gas is expected to take the lion share of the power generation mix, i.e. 46% of the total energy output in power generation in 2050, followed by coal (36%) and hydro (10%). Generation from “Others”, which comprises of biomass and solar power, will have the fastest growth at an average rate of almost 8% per year. “Others” power generation is expected to increase its share from a minimal share of 1% (14 TWh) in 2017 to 5 % (184 TWh) in 2050.

Figure A1-5. Electricity Generation, BAU



Source: Author's compilation

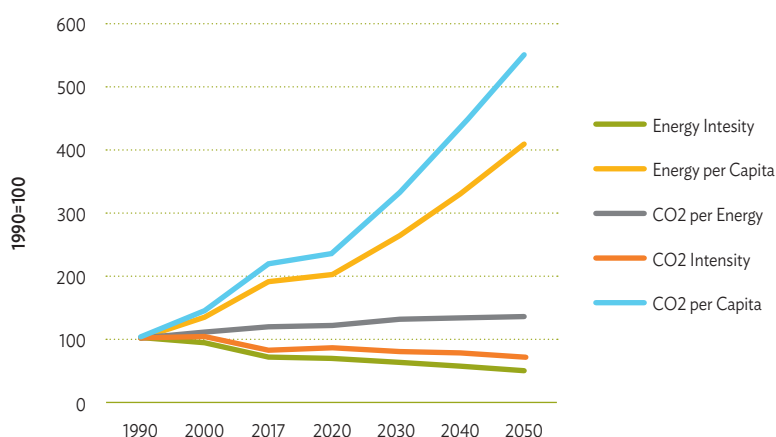
The average thermal efficiency of the whole ASEAN's fossil-fueled power plants was around 33% in 1990 and improved to 37% in 2017 as more natural gas fired power plants (especially CCGT) were in operation. In the BAU scenario, thermal efficiency of fossil plants is expected to improve further to around 43% in 2050.

By fuel, natural gas plants thermal efficiency will be 51% in 2050 while oil and gas will be at 35% and 36% respectively.

2.1.4 Energy Indicators

As shown in the Figure 6, primary energy intensity, which is computed as the ratio of primary energy consumption over GDP, is expected to decrease. Energy intensity continues to decrease as TPES will grow at a slower rate compared to economic growth. CO2 intensity, defined as CO2 emissions per unit of GDP, is projected to have similar declining trends compared to energy intensity. Energy and CO2 per capita increases due to several factors, i.e. rapid industrialization, life style change toward more energy intensive way of live and slower population growth than fossil fuel demand growth.

Figure A1-6. Energy Indicators, BAU



Source: Author's compilation

2.2 Energy Saving and CO2 Reduction Potential in the Alternative Policy Scenario (APS)

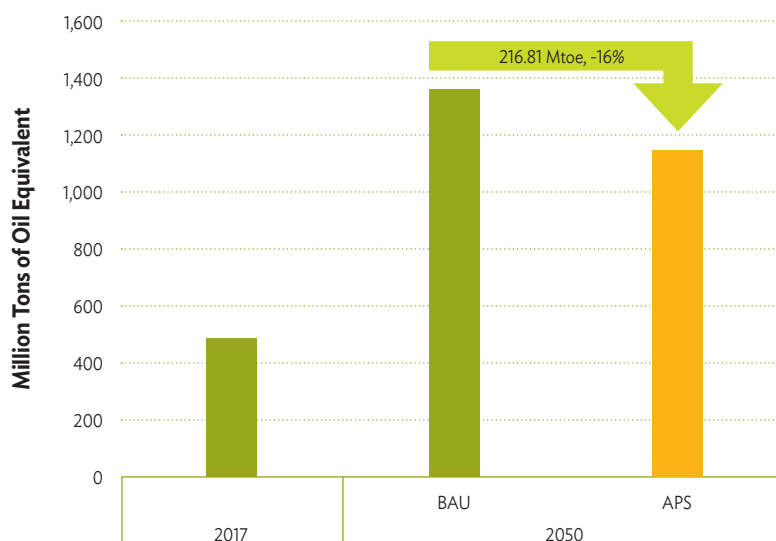
The Alternative Policy Scenario (APS) applies same GDP and population assumptions as assumed for the BAU scenario. The APS assumes the implementation of improved efficiency of final energy consumption in the end-use sectors. The APS will see more efficient thermal power generation, and higher contribution of renewable energy to the total supply with no nuclear power plants.

By comparing the APS results with the BAU scenario results, this section provides a basis for determining the impacts of promoting energy efficiency and increased use of renewable energy on energy saving and CO2 emissions reductions in ASEAN.

2.2.1 Final Energy Demand

Final energy demand under the APS is projected to increase by 2.7% annually from 2017 to 2050 which is slower than BAU's yearly growth rate, i.e. 3.2%. As shown in the Figure 7, by 2050, the total final energy demand of APS should reach around 1140 Mtoe which is 16% less than that of BAU scenario. Between 2017 and 2050, transportation sector grows annually at 3.3%, followed by the industry sector at 2.9% and the other (residential and commercial) sector at 1.8 %. Similar to the BAU case, the non-energy sector grows at 2.2 % per year.

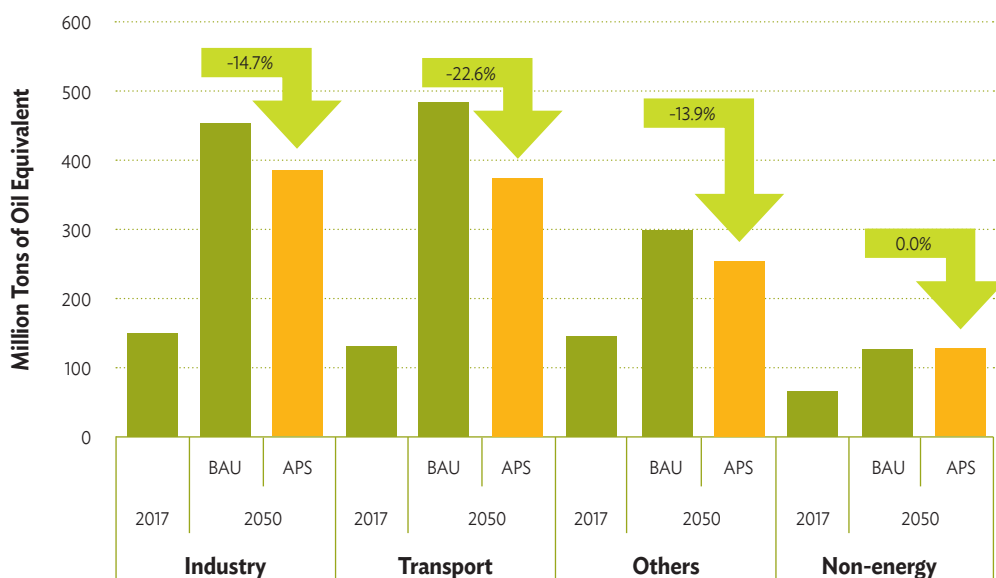
Figure A1-7. Total Final Energy Demand in 2050, BAU and APS



Source: Author's compilation

Transportation sector can be expected to be the sector that shall experience the most reduction of energy use in the APS. Figure 8 shows that in 2050 transport energy consumption would decrease by more than 22% in the APS compared to BAU scenario. By 2050, energy consumption the industry sector of APS should be 14.7% lower than BAU whilst consumption of the “others” sectors of the APS would be nearly 14% lower than of BAU.

Figure A1-8. Total Final Energy Demand by Sector in 2050, BAU and APS



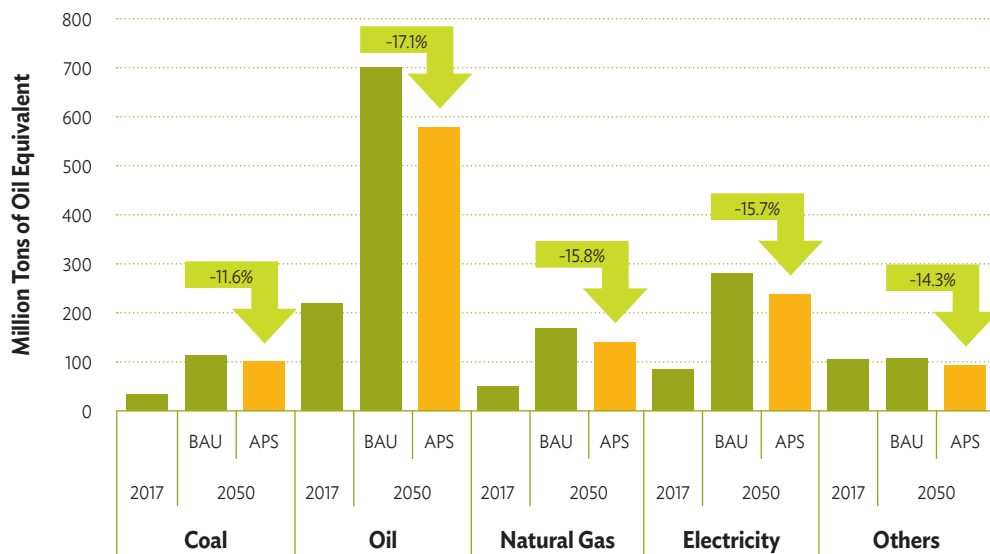
Source: Author's compilation

As given in the Figure 9, from the fuel type point of view, in 2050 in comparison to BAU, APS is expected to reduce oil consumption by more than 17% and natural gas and electricity consumption by around 15.7% each. Coal demand in APS would be 11.6% lower than in BAU whilst the “others” types of fuel consumption would be 14.3% lower.

2.2.2 Primary Energy Consumption

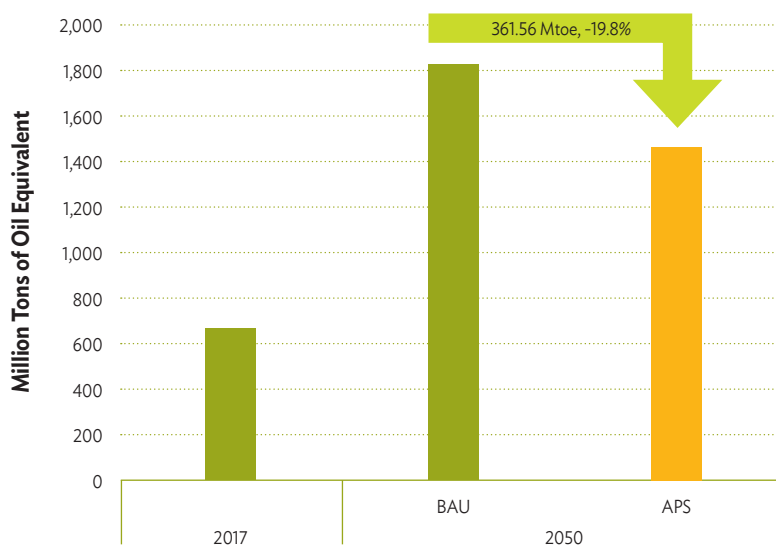
In 2050, with regards to BAU scenario, measures in APS would decrease the total primary energy consumption by around 360 Mtoe or nearly 20% (Figure 10). Most of the reduction in primary energy consumption will come from coal at 159 Mtoe, which is a drop of around 39% from BAU (Figure 12). Natural gas and oil consumption would decrease by 24% and 16.5% consecutively. In APS scenario, nuclear power plants would penetrate whilst geothermal power generation as well as solar, wind, ocean and biofuel would increase stronger than in BAU. Biomass' consumption will remain relatively constant. Altogether this should lead to an increase in consumption of “others” by 10%.

Figure A1-9. Total Final Energy Demand by Fuel in 2050, BAU and APS



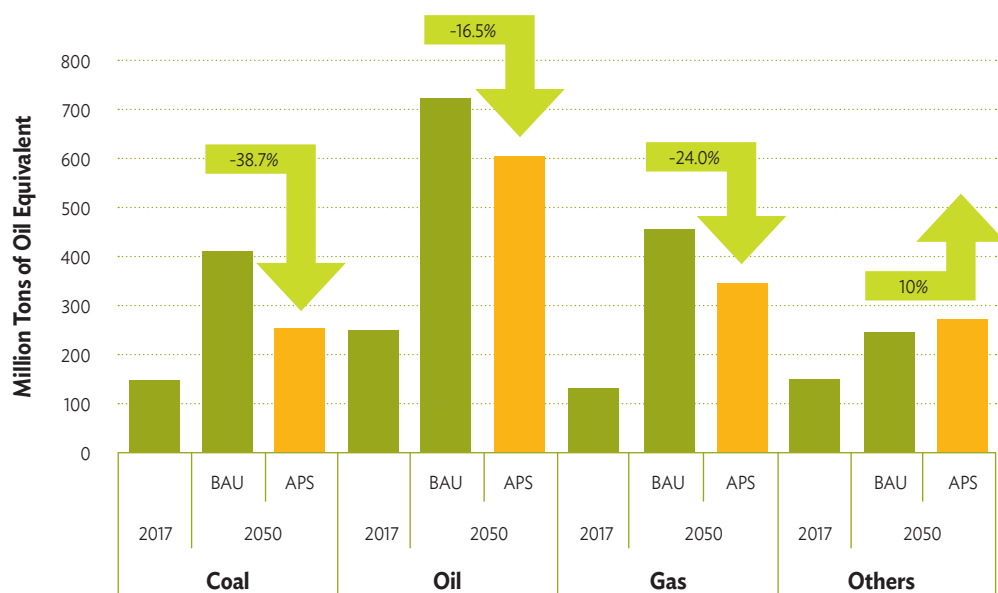
Source: Author's compilation

Figure A1-10. Total Primary Energy Consumption in 2050, BAU and APS



Source: Author's compilation

Figure A1-11. Total Primary Energy Consumption by Fuel in 2050, BAU and APS

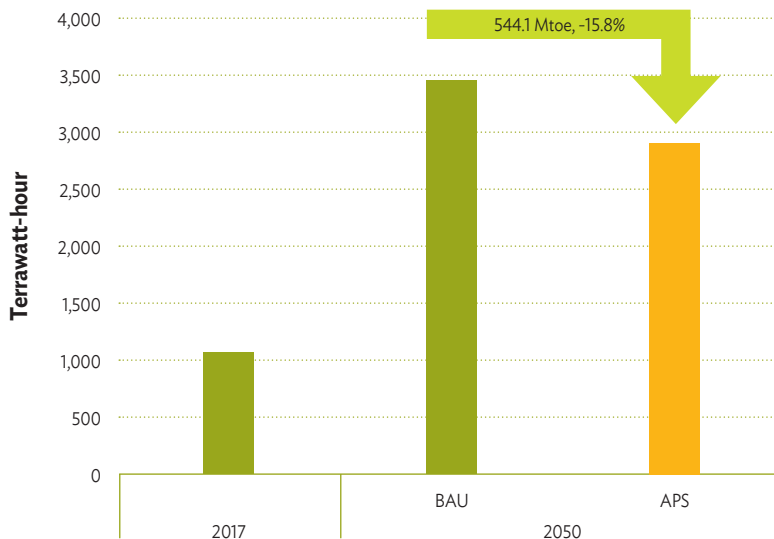


Source: Author's compilation

2.2.3 Power Generation

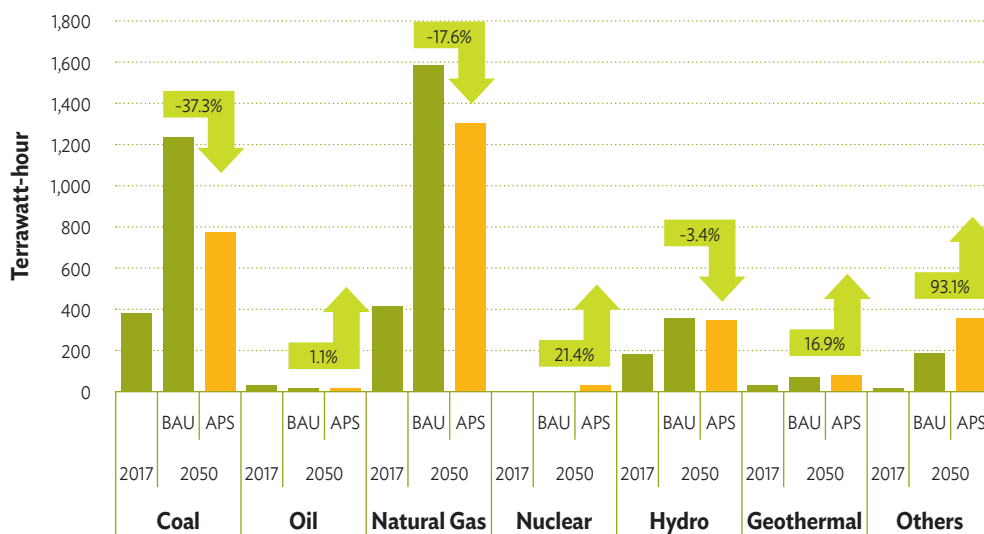
APS shows a decrease in electricity generation, registering a drop of around 544 TWh or nearly 16% from BAU (Figure 12). In 2050, with regards to BAU scenario, policy measures in APS should reduce the coal-fired electricity production by more than 37% and the gas-fired electricity production by 17.6%. The use of “others” energy sources, mainly from solar, to generate electricity would almost double in APS (356 TWh) with regards to BAU scenario (185 TWh). In 2050, electricity generated in geothermal plants would increase by nearly 17% from BAU to APS. In APS nuclear plants can be expected to generate up to 21 TWh in 2050 while in BAU no nuclear based power generation will occur.

Figure A1-12. Electricity Generation in 2050
(TWh)



Source: Author's compilation

Figure A1-13. Electricity Generation in 2050 by sources
(TWh)

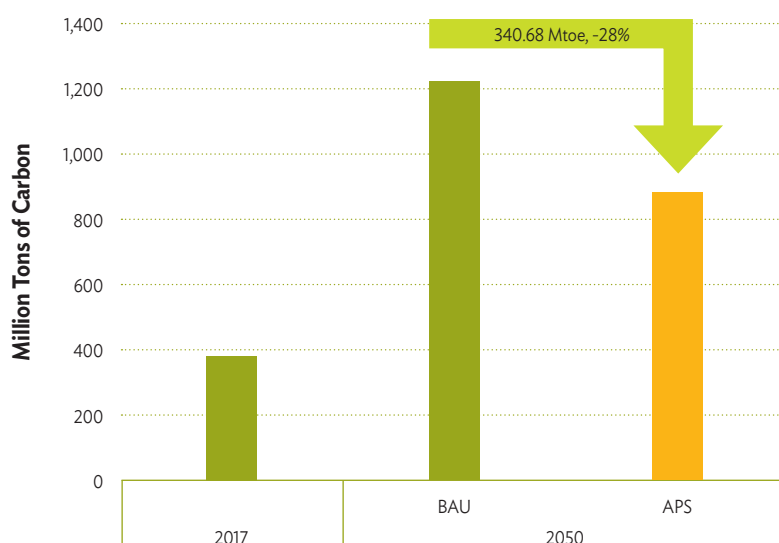


Source: Author's compilation

2.2.4. CO2 Reduction Potential

Under BAU, carbon dioxide (CO₂) emissions from energy demand are projected to increase at an average annual rate of 3.6%, from 376 Mt-C in 2017 to around 1217 Mt-C in 2050 (Figure 14). During the same period, in APS, emission would grow yearly by an annual growth rate of 2.6% to reach 876 Mt-C only in 2050. Therefore, CO₂ emissions reduction potential in APS would save around 341 Mt-C in 2050, equivalent to around 28% decrease from BAU.

Figure A1-14. CO₂ Emissions from Energy Consumption, BAU and APS



Source: Author's compilation

3. Implications and Policy Recommendations

At least four main conclusions can be derived based on the outlook results:

First, energy consumption in ASEAN will continuously increase due to stable economic growth up to 2050.

Second, Individual Member States' governments have been implementing diversified sectoral measures to promote and advocate the adoption of clean energy technologies and sources,

and emissions reduction. If by implementing those measures ASEAN Member States could accomplish their energy efficiency and renewable energy penetration targets during next 3 decades, then ASEAN as a region would reduce energy consumption significantly as well as CO₂ emissions.

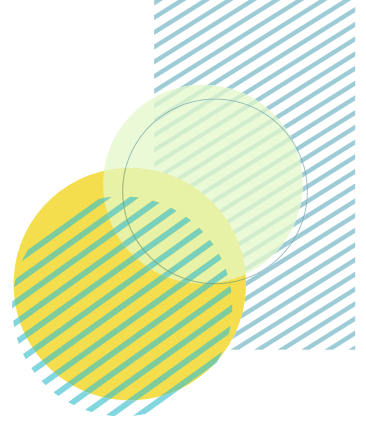
Three, at the regional level, ASEAN has also put forward several initiatives and programs mainly through the ASEAN Plan of Action for Energy Cooperation (APAEC) as the regional blueprint. ASEAN should implement APAEC by increasing regional collaboration as well as international cooperation regarding energy efficiency and renewable energy.

Fourth, energy efficiency promotion measures in transport fuel and electric generation will be essential. For RE, affordable and stable use of RE will be also crucial. For RE promotion, parallel use of natural gas will be a key but pay attention to use of affordable natural gas. LNG hub in Asia is an option to secure stable and affordable natural gas supply to ASEAN.

ASEAN as the current fifth largest economy in the world also plays an important role in the world in term of energy consumption and greenhouse gas emissions. Continuous monitoring and observation of the energy saving and emission reduction situation at ASEAN level including regular updating of the regional energy outlook as in this chapter is therefore among the most essential activities needed to prepare a suitable energy policy making at ASEAN level.

Several further in-depth studies need to perform to answer the following two important research questions: what are the effects of ASEAN energy initiatives and programs to the individual Member States' energy outlook? How can individual Member States' energy measures be synchronized at regional level to increase their effectiveness at country level as well as at ASEAN level?

Elements of answers to those questions would serve as on the basis for developing ASEAN energy strategy in energy saving and emission reduction potential in the future.



Annex 2

Result Summary Tables

AUS (BAU)

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	86,14	108,11	127,03	127,18	131,95	131,99	127,74	100	100	100	100	100	100	100	1,4	0,0	0,4	0,0	-0,3	0,0	
Coal	34,89	48,15	43,91	40,93	36,80	32,49	27,78	40,5	44,5	34,6	32,2	27,9	24,6	21,7	0,9	-2,3	-1,1	-1,2	-1,6	-1,4	
Oil	31,20	34,15	42,90	42,74	41,95	39,17	35,66	36,2	31,6	33,8	33,6	31,8	29,7	27,9	1,2	-0,1	-0,2	-0,7	-0,9	-0,6	
Natural gas	14,79	19,27	31,31	33,10	39,40	43,00	43,38	17,2	17,8	24,7	26,0	29,9	32,6	34,0	2,8	1,9	1,8	0,9	0,1	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	1,38	1,45	1,46	1,47	1,48	1,4	1,3	1,1	1,1	1,1	1,1	1,2	0,5	1,6	0,1	0,1	0,1	0,2	
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	-	93,0	22,3	5,2	2,4	15,4	
Others	4,04	5,13	7,63	9,12	12,47	15,99	19,55	4,7	4,7	6,0	7,2	9,4	12,1	15,3	2,4	6,1	3,2	2,5	2,0	2,9	
Biomass	3,96	5,04	5,38	5,39	5,97	6,45	6,77	4,6	4,7	4,2	4,2	4,5	4,9	5,3	1,1	0,1	1,0	0,8	0,5	0,7	
Solar, Wind, Ocean	0,08	0,09	2,15	3,56	6,34	9,38	12,62	0,1	0,1	1,7	2,8	4,8	7,1	9,9	12,9	18,3	5,9	4,0	3,0	5,5	
Biofuels	0,00	0,00	0,10	0,16	0,16	0,16	0,16	0,0	0,0	0,1	0,1	0,1	0,1	0,1	-	17,5	0,0	0,0	0,0	1,5	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	56,66	69,58	81,84	83,25	88,14	89,58	88,96	100	100	100	100	100	100	100	1,4	0,6	0,6	0,2	-0,1	0,3	
Industry	19,32	23,79	22,48	23,42	26,39	27,12	26,53	34,1	34,2	27,5	28,1	29,9	30,3	29,8	0,6	1,4	1,2	0,3	-0,2	0,5	
Transportation	21,11	25,66	33,35	33,23	33,13	32,41	31,51	37,3	36,9	40,8	39,9	37,6	36,2	35,4	1,7	-0,1	0,0	-0,2	-0,3	-0,2	
Others	12,27	15,71	21,18	21,70	23,49	24,82	25,68	21,7	22,6	25,9	26,1	26,6	27,7	28,9	2,0	0,8	0,8	0,6	0,3	0,6	
Non-energy	3,95	4,43	4,83	4,91	5,13	5,23	5,24	7,0	6,4	5,9	5,9	5,8	5,8	5,9	0,7	0,5	0,5	0,2	0,0	0,2	
Total	56,66	69,58	81,84	83,25	88,14	89,58	88,96	100	100	100	100	100	100	100	1,4	0,6	0,6	0,2	-0,1	0,3	
Coal	4,56	4,20	2,52	2,57	2,64	2,55	2,38	8,0	6,0	3,1	3,1	3,0	2,9	2,7	-2,2	0,6	0,3	-0,3	-0,7	-0,2	
Oil	29,00	34,72	43,66	43,49	43,25	41,62	39,43	51,2	49,9	53,3	52,2	49,1	46,5	44,3	1,5	-0,1	-0,1	-0,4	-0,5	-0,3	
Natural gas	8,66	11,39	12,94	13,25	14,68	15,29	15,27	15,3	16,4	15,8	15,9	16,7	17,1	17,2	1,5	0,8	1,0	0,4	0,0	0,5	
Electricity	11,11	14,85	18,12	19,17	22,32	24,71	26,50	19,6	21,3	22,1	23,0	25,3	27,6	29,8	1,8	1,9	1,5	1,0	0,7	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	3,32	4,42	4,61	4,78	5,24	5,41	5,37	5,9	6,4	5,6	5,7	5,9	6,0	6,0	1,2	1,2	0,9	0,2	-0,1	0,5	

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	154,29	209,86	257,77	272,51	314,12	342,10	360,16	100	100	100	100	100	100	100	1,9	1,9	1,4	0,9	0,5	1,0
Coal	121,48	174,25	161,83	157,50	157,29	144,57	124,36	78,7	83,0	62,8	57,8	50,1	42,3	34,5	1,1	-0,9	0,0	-0,8	-1,5	-0,8
Oil	3,55	1,78	5,27	4,93	4,21	3,15	2,04	2,3	0,9	2,0	1,8	1,3	0,9	0,6	1,5	-2,2	-1,6	-2,8	-4,3	-2,8
Natural gas	14,36	16,25	50,46	51,86	61,45	66,13	65,94	9,3	7,7	19,6	19,0	19,6	19,3	18,3	4,8	0,9	1,7	0,7	0,0	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	14,15	16,36	16,04	16,84	16,96	17,08	17,20	9,2	7,8	6,2	6,2	5,4	5,0	4,8	0,5	1,6	0,1	0,1	0,1	0,2
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	-	93,0	22,3	5,2	2,4	15,4
Others	0,75	1,23	24,17	41,37	74,19	111,13	150,57	0,5	0,6	9,4	15,2	23,6	32,5	41,8	13,7	19,6	6,0	4,1	3,1	5,7

Power generation Input

Power generation input	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	33.34	45.77	52.41	49.56	46.08	41.39	35.34	100	100	100	100	100	100	100	1.7	-1.8	-0.7	-1.1	-1.6	-1.2		
Coal	28.92	41.19	39.19	36.09	31.83	27.62	23.15	86.8	90.0	74.8	72.8	69.1	66.7	65.5	1.1	-2.7	-1.2	-1.4	-1.7	-1.6		
Oil	0.95	0.53	1.22	1.16	1.01	0.75	0.47	2.8	1.1	2.3	2.3	2.2	1.8	1.3	0.9	-1.4	-1.4	-2.9	-4.6	-2.9		
Natural gas	3.47	4.06	12.01	12.31	13.24	13.02	11.71	10.4	8.9	22.9	24.8	28.7	31.5	33.2	4.7	0.8	0.7	-0.2	-1.1	-0.1		

Thermal Efficiency

Thermal Efficiency	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	36,0	36,1	35,7	37,2	41,6	44,4	46,8								0,0	1,4	1,1	0,7	0,5	0,8
Coal	36,1	36,4	35,5	37,5	42,5	45,0	46,2								-0,1	1,9	1,2	0,6	0,3	0,8
Oil	32,3	29,2	37,3	36,4	35,9	36,2	37,5								0,5	-0,8	-0,1	0,1	0,4	0,0
Natural gas	35,6	34,4	36,1	36,2	39,9	43,7	48,4								0,1	0,1	1,0	0,9	1,0	0,9

CO₂ emissions

	CO ₂ emissions																			
	Mt-C								AAGR (%)											
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	70.2	90.8	106.1	103.8	102.5	97.7	89.9	100	100	100	100	100	100	100	1.5	-0.7	-0.1	-0.5	-0.8	-0.5
Coal	38.7	51.9	48.2	44.9	40.4	35.6	30.4	55.2	57.1	45.4	43.3	39.4	36.4	33.8	0.8	-2.3	-1.1	-1.2	-1.6	-1.4
Oil	22.5	27.0	37.8	37.7	37.0	34.7	31.9	32.1	29.7	35.6	36.3	36.1	35.5	35.5	1.9	-0.1	-0.2	-0.6	-0.8	-0.5
Natural gas	8.9	12.0	20.1	21.2	25.2	27.4	27.6	12.7	13.2	19.0	20.5	24.5	28.0	30.7	3.1	1.8	1.7	0.9	0.1	1.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	638	884	1.433	1.545	1.956	2.365	2.776	3,0	2,5	2,4	1,9	1,6	2,0
Population (millions of people)	17,1	19,2	24,6	25,5	28,2	30,6	32,8	1,4	1,2	1,0	0,8	0,7	0,9
GDP per capita (thousands of 2010 USD/person)	37,38	46,15	58,23	60,54	69,35	77,29	84,55	1,7	1,3	1,4	1,1	0,9	1,1
Primary energy consumption per capita (toe/person)	5,05	5,64	5,16	4,98	4,68	4,31	3,89	0,1	-1,2	-0,6	-0,8	-1,0	-0,9
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	135	122	89	82	67	56	46	-1,5	-2,4	-2,0	-1,9	-1,9	-2,0
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	89	79	57	54	45	38	32	-1,6	-1,9	-1,8	-1,7	-1,7	-1,7
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	110	103	74	67	52	41	32	-1,5	-3,2	-2,5	-2,3	-2,4	-2,5
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,81	0,84	0,84	0,82	0,78	0,74	0,70	0,1	-0,8	-0,5	-0,5	-0,5	-0,5
Automobile ownership volume (millions of vehicles)	9,78	12,29	18,31	19,10	21,79	24,25	26,57	2,4	1,4	1,3	1,1	0,9	1,1
Automobile ownership volume per capita (vehicles per person)	0,573	0,642	0,744	0,749	0,773	0,793	0,809	1,0	0,2	0,3	0,3	0,2	0,3

AUS (APS)

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	86,14	108,11	127,03	125,86	123,78	113,39	99,12	100	100	100	100	100	100	100	1,4	-0,3	-0,2	-0,9	-1,3	-0,7		
Coal	34,89	48,15	43,91	39,91	31,16	22,33	12,72	40,5	44,5	34,6	31,7	25,2	19,7	12,8	0,9	-3,1	-2,4	-3,3	-5,5	-3,7		
Oil	31,20	34,15	42,90	42,35	38,75	32,65	26,55	36,2	31,6	33,8	33,7	31,3	28,8	26,8	1,2	-0,4	-0,9	-1,7	-2,0	-1,4		
Natural gas	14,79	19,27	31,31	32,57	37,53	36,71	31,82	17,2	17,8	24,7	25,9	30,3	32,4	32,1	2,8	1,3	1,4	-0,2	-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	1,38	1,45	1,46	1,47	1,48	1,4	1,3	1,1	1,2	1,2	1,3	1,5	0,5	1,6	0,1	0,1	0,1	0,2		
Geothermal	0,00	0,00	0,00	0,01	0,03	0,05	0,06	0,0	0,0	0,0	0,0	0,0	0,0	0,1	-	144,5	17,3	4,5	1,8	16,0		
Others	4,04	5,13	7,63	9,80	15,25	20,69	27,12	4,7	4,7	6,0	7,8	12,3	18,2	27,4	2,4	8,7	4,5	3,1	2,7	3,9		
Biomass	3,96	5,04	5,38	5,57	6,49	7,10	7,43	4,6	4,7	4,2	4,4	5,2	6,3	7,5	1,1	1,1	1,5	0,9	0,5	1,0		
Solar, Wind, Ocean	0,08	0,09	2,15	4,01	8,37	13,08	19,06	0,1	0,1	1,7	3,2	6,8	11,5	19,2	12,9	23,0	7,6	4,6	3,8	6,8		
Biofuels	0,00	0,00	0,10	0,22	0,39	0,50	0,63	0,0	0,0	0,1	0,2	0,3	0,4	0,6	-	31,0	5,6	2,7	2,3	5,8		
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	56,66	69,58	81,84	82,90	84,28	80,95	76,25	100	100	100	100	100	100	100	1,4	0,4	0,2	-0,4	-0,6	-0,2		
Industry	19,32	23,79	22,48	23,39	25,75	25,19	23,22	34,1	34,2	27,5	28,2	30,5	31,1	30,4	0,6	1,3	1,0	-0,2	-0,8	0,1		
Transportation	21,11	25,66	33,35	32,99	30,81	27,70	25,20	37,3	36,9	40,8	39,8	36,6	34,2	33,0	1,7	-0,4	-0,7	-1,1	-0,9	-0,8		
Others	12,27	15,71	21,18	21,62	22,59	22,83	22,59	21,7	22,6	25,9	26,1	26,8	28,2	29,6	2,0	0,7	0,4	0,1	-0,1	0,2		
Non-energy	3,95	4,43	4,83	4,91	5,13	5,23	5,24	7,0	6,4	5,9	5,9	6,1	6,5	6,9	0,7	0,5	0,5	0,2	0,0	0,2		
Total	56,66	69,58	81,84	82,90	84,28	80,95	76,25	100	100	100	100	100	100	100	1,4	0,4	0,2	-0,4	-0,6	-0,2		
Coal	4,56	4,20	2,52	2,49	2,19	1,91	1,63	8,0	6,0	3,1	3,0	2,6	2,4	2,1	-2,2	-0,5	-1,2	-1,4	-1,6	-1,3		
Oil	29,00	34,72	43,66	43,19	40,62	36,15	31,68	51,2	49,9	53,3	52,1	48,2	44,7	41,5	1,5	-0,4	-0,6	-1,2	-1,3	-1,0		
Natural gas	8,66	11,39	12,94	13,25	14,29	13,97	13,10	15,3	16,4	15,8	16,0	17,0	17,3	17,2	1,5	0,8	0,8	-0,2	-0,6	0,0		
Electricity	11,11	14,85	18,12	19,13	21,79	23,44	24,44	19,6	21,3	22,1	23,1	25,8	29,0	32,1	1,8	1,8	1,3	0,7	0,4	0,9		
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	3,33	4,42	4,61	4,84	5,39	5,48	5,40	5,9	6,4	5,6	5,8	6,4	6,8	7,1	1,2	1,6	1,1	0,2	-0,1	0,5		

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	154,29	209,86	257,77	271,51	307,87	325,83	331,20	100	100	100	100	100	100	100	1,9	1,7	1,3	0,6	0,2	0,8		
Coal	121,48	174,25	161,83	152,59	129,65	93,30	47,67	78,7	83,0	62,8	56,2	42,1	28,6	14,4	1,1	-1,9	-1,6	-3,2	-6,5	-3,6		
Oil	3,55	1,78	5,27	4,77	3,52	2,11	0,82	2,3	0,9	2,0	1,8	1,1	0,6	0,2	1,5	-3,3	-3,0	-5,0	-9,0	-5,5		
Natural gas	14,36	16,25	50,46	50,24	57,92	55,66	36,02	9,3	7,7	19,6	18,5	18,8	17,1	10,9	4,8	-0,1	1,4	-0,4	-4,3	-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	14,15	16,36	16,04	16,84	16,96	17,08	17,20	9,2	7,8	6,2	6,2	5,5	5,2	5,2	0,5	1,6	0,1	0,1	0,1	0,2		
Geothermal	0,00	0,00	0,00	0,01	0,04	0,06	0,07	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	144,5	17,3	4,5	1,8	16,0		
Others	0,75	1,23	24,17	47,06	99,78	157,62	229,41	0,5	0,6	9,4	17,3	32,4	48,4	69,3	13,7	24,9	7,8	4,7	3,8	7,1		

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	33,34	45,77	52,41	48,22	40,03	29,85	15,92	100	100	100	100	100	100	100	1,7	-2,7	-1,8	-2,9	-6,1	-3,5
Coal	28,92	41,19	39,19	35,17	26,73	18,26	9,05	86,8	90,0	74,8	72,9	66,8	61,2	56,9	1,1	-3,5	-2,7	-3,7	-6,8	-4,3
Oil	0,95	0,53	1,22	1,13	0,85	0,51	0,19	2,8	1,1	2,3	2,3	2,1	1,7	1,2	0,9	-2,5	-2,8	-5,0	-9,3	-5,5
Natural gas	3,47	4,06	12,01	11,93	12,45	11,08	6,68	10,4	8,9	22,9	24,7	31,1	37,1	41,9	4,7	-0,2	0,4	-1,2	-4,9	-1,8

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	36,0	36,1	35,7	37,0	41,1	43,5	45,6								0,0	1,2	1,0	0,6	0,5	0,7
Coal	36,1	36,4	35,5	37,5	42,5	45,0	46,2								-0,1	1,9	1,2	0,6	0,3	0,8
Oil	32,3	29,2	37,3	36,4	35,7	35,9	37,2								0,5	-0,8	-0,2	0,1	0,4	0,0
Natural gas	35,6	34,4	36,1	36,2	40,0	43,2	46,4								0,1	0,1	1,0	0,8	0,7	0,8

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	70,2	90,8	106,1	102,0	89,3	71,9	53,7	100	100	100	100	100	100	100	1,5	-1,3	-1,3	-2,1	-2,9	-2,0		
Coal	38,7	51,9	48,2	43,8	31,7	20,8	10,5	55,2	57,1	45,4	42,9	35,4	28,9	19,5	0,8	-3,1	-3,2	-4,1	-6,6	-4,5		
Oil	22,5	27,0	37,8	37,4	34,4	29,4	24,5	32,1	29,7	35,6	36,6	38,5	40,9	45,6	1,9	-0,4	-0,8	-1,6	-1,8	-1,3		
Natural gas	8,9	12,0	20,1	20,9	23,3	21,7	18,7	12,7	13,2	19,0	20,5	26,1	30,2	34,8	3,1	1,3	1,1	-0,7	-1,5	-0,2		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	638	884	1.433	1.545	1.956	2.365	2.776	3,0	2,5	2,4	1,9	1,6	2,0
Population (millions of people)	17,1	19,2	24,6	25,5	28,2	30,6	32,8	1,4	1,2	1,0	0,8	0,7	0,88
GDP per capita (thousands of 2010 USD/person)	37,38	46,15	58,23	60,54	69,35	77,29	84,55	1,7	1,3	1,4	1,1	0,9	1,1
Primary energy consumption per capita (toe/person)	5,05	5,64	5,16	4,93	4,39	3,71	3,02	0,1	-1,5	-1,2	-1,7	-2,0	-1,6
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	135	122	89	81	63	48	36	-1,5	-2,8	-2,5	-2,7	-2,9	-2,7
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	89	79	57	54	43	34	27	-1,6	-2,1	-2,2	-2,3	-2,2	-2,2
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	110	103	74	66	46	30	19	-1,5	-3,7	-3,6	-4,0	-4,4	-4,0
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,81	0,84	0,84	0,81	0,72	0,63	0,54	0,1	-1,0	-1,2	-1,3	-1,6	-1,3
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

BRUNEI (BAU)

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	1,72	2,39	3,58	4,57	5,32	5,60	5,92	100	100	100	100	100	100	100	2,7	8,4	1,5	0,5	0,6	1,5	
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Oil	0,05	0,54	0,71	1,21	1,36	1,53	1,74	2,7	22,4	20,0	26,5	25,5	27,4	29,5	10,6	19,1	1,2	1,2	1,3	2,7	
Natural gas	1,68	1,85	2,86	3,36	3,96	4,07	4,17	97,3	77,6	80,0	73,5	74,5	72,6	70,5	2,0	5,4	1,7	0,3	0,3	1,1	
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	-	-	-	-	-	-	
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	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	0,0	0,0	0,0	0,0	0,0	
Biomass	0,00	0,00	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, Wind, Ocean	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	0,0	0,0	0,0	0,0	0,0	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	0.35	0.57	1.45	2.03	2.58	2.79	3.05	100	100	100	100	100	100	100	5.4	11.9	2.4	0.8	0.9	2.3	
Industry	0.06	0.07	0.14	0.15	0.17	0.18	0.19	17.4	12.4	10.0	7.5	6.4	6.3	6.1	3.3	1.8	0.8	0.6	0.6	0.8	
Transportation	0.19	0.26	0.52	0.59	0.73	0.89	1.09	53.6	46.7	36.3	28.9	28.4	32.0	35.7	3.9	3.8	2.2	2.0	2.0	2.2	
Others	0.09	0.21	0.32	0.34	0.37	0.41	0.46	24.2	37.0	22.1	16.8	14.2	14.6	15.0	5.0	2.0	0.7	1.1	1.1	1.1	
Non-energy	0.02	0.02	0.46	0.95	1.31	1.32	1.32	4.8	3.9	31.6	46.8	51.0	47.1	43.3	13.0	27.5	3.3	0.0	0.0	3.3	
Total	0.35	0.57	1.45	2.03	2.58	2.79	3.05	100	100	100	100	100	100	100	5.4	11.9	2.4	0.8	0.9	2.3	
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	
Oil	0.26	0.36	0.71	0.78	0.94	1.11	1.32	74.1	63.2	49.0	38.3	36.4	39.9	43.4	3.8	3.1	1.9	1.7	1.7	1.9	
Natural gas	0.00	0.00	0.47	0.95	1.30	1.30	1.30	0.0	0.0	32.3	47.1	50.5	46.6	42.7	-	26.8	3.1	0.0	0.0	3.1	
Electricity	0.09	0.21	0.27	0.30	0.34	0.38	0.42	24.7	36.8	18.7	14.6	13.1	13.6	13.9	4.3	3.1	1.3	1.1	1.1	1.4	
Heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-	-	-	-	
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-	-	-	-	

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,17	2,54	3,72	3,81	4,49	4,69	4,90	100	100	100	100	100	100	100	4,4	0,7	1,7	0,4	0,4	0,8		
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Oil	0,01	0,02	0,05	0,04	0,00	0,00	0,00	0,9	0,9	1,2	1,1	0,0	0,0	0,0	5,4	-2,6	-100,0	-	-	-100,0		
Natural gas	1,16	2,52	3,68	3,76	4,48	4,69	4,90	99,1	99,1	98,7	98,9	100,0	100,0	100,0	4,4	0,8	1,8	0,4	0,4	0,9		
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	0,00	0,00	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	0,00	0,00	0,00	0,00	0,00	0,0015	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	0,0	0,0	0,0	0,0	0,0		

Power generation Input

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	0,46	0,86	1,10	1,12	1,32	1,38	1,44	100	100	100	100	100	100	100	3,3	0,7	1,7	0,4	0,4	0,8		
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Oil	0,00	0,01	0,01	0,01	0,00	0,00	0,00	0,6	0,6	1,2	1,1	0,0	0,0	0,0	5,6	-2,6	-100,0	-	-	-100,0		
Natural gas	0,46	0,86	1,08	1,11	1,32	1,38	1,44	99,4	99,4	98,8	98,9	100,0	100,0	100,0	3,2	0,8	1,8	0,4	0,4	0,9		

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	21,8	25,3	29,2	29,2	29,2	29,2	29,2								1,1	0,0	0,0	0,0	0,0	0,0
Coal	-	-	-	-	-	-	-								-	-	-	-	-	-
Oil	31,5	39,6	30,2	30,2	-	-	-								-0,2	0,0	-	-	-	-
Natural gas	21,8	25,3	29,2	29,2	29,2	29,2	29,2								1,1	0,0	0,0	0,0	0,0	0,0

CO₂ emissions

2	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	0,9	1,0	1,3	1,4	1,6	1,8	2,0	100	100	100	100	100	100	100	1,4	1,7	1,7	1,1	1,1	1,3		
Coal	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	-	-	-	-	-	-		
Oil	0,2	0,3	0,6	0,6	0,8	0,9	1,1	22,4	30,2	45,3	47,0	47,2	50,3	53,5	4,1	2,9	1,7	1,7	1,7	1,8		
Natural gas	0,7	0,7	0,7	0,7	0,8	0,9	0,9	77,6	69,8	54,7	53,0	52,8	49,7	46,5	0,1	0,7	1,6	0,4	0,4	0,8		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	6,9	8,6	13,5	15,3	19,2	23,6	29,0	2,5	4,3	2,3	2,1	2,1	2,4
Population (millions of people)	0,3	0,3	0,4	0,4	0,5	0,6	0,7	1,9	1,4	1,4	1,4	1,4	1,4
GDP per capita (thousands of 2010 USD/person)	26,83	25,93	31,75	34,59	37,67	40,35	43,23	0,6	2,9	0,9	0,7	0,7	0,9
Primary energy consumption per capita (toe/person)	6,71	7,19	8,43	10,32	10,46	9,58	8,81	0,9	7,0	0,1	-0,9	-0,8	0,1
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	250	277	266	298	278	237	204	0,2	3,9	-0,7	-1,6	-1,5	-0,8
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	51	66	107	132	134	118	105	2,8	7,3	0,2	-1,3	-1,2	-0,1
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	128	161	95	88	83	75	68	-1,1	-2,5	-0,6	-1,0	-1,0	-1,0
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,51	0,58	0,36	0,30	0,30	0,32	0,33	-1,3	-6,2	0,1	0,5	0,6	-0,2
Automobile ownership volume (millions of vehicles)			0,24	0,25	0,28	0,33	0,38	-	1,4	1,4		2,8	1,4
Automobile ownership volume per capita (vehicles per person)	-	-	0,559	0,559	0,559	0,559	0,559	-	0,0	0,0		0,0	0,0

Brunei [APS5]

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,72	2,39	3,58	4,08	4,47	4,52	4,70	100	100	100	100	100	100	100	2,7	4,4	0,9	0,1	0,4	0,8		
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Oil	0,05	0,54	0,71	1,17	1,12	1,10	1,18	2,7	22,4	20,0	28,8	25,0	24,4	25,0	10,6	17,9	-0,5	-0,1	0,6	1,5		
Natural gas	1,68	1,85	2,86	2,90	3,33	3,39	3,49	97,3	77,6	80,0	71,2	74,5	74,9	74,3	2,0	0,4	1,4	0,2	0,3	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	0,00	0,00	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	0,00	0,00	0,00	0,02	0,03	0,03	0,0	0,0	0,0	0,0	0,5	0,7	0,7	-	53,1	46,8	4,1	0,0	18,2		
Biomass	0,00	0,00	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, Wind, Ocean	0,00	0,00	0,00	0,00	0,02	0,03	0,03	0,0	0,0	0,0	0,0	0,5	0,7	0,7	-	53,1	46,8	4,1	0,0	18,2		
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	0,35	0,57	1,45	1,98	2,30	2,31	2,41	100	100	100	100	100	100	100	5,4	11,0	1,5	0,1	0,4	1,6		
Industry	0,06	0,07	0,14	0,15	0,16	0,17	0,18	17,4	12,4	10,0	7,7	7,0	7,3	7,3	3,3	1,6	0,6	0,4	0,5	0,6		
Transportation	0,19	0,26	0,52	0,55	0,53	0,53	0,60	53,6	46,7	36,3	27,9	23,0	23,1	24,9	3,9	1,7	-0,4	0,1	1,2	0,4		
Others	0,09	0,21	0,32	0,32	0,30	0,30	0,32	24,2	37,0	22,1	16,4	12,9	12,8	13,2	5,0	0,6	-0,9	0,0	0,7	0,0		
Non-energy	0,02	0,02	0,46	0,95	1,31	1,32	1,32	4,8	3,9	31,6	48,0	57,1	56,9	54,6	13,0	27,5	3,3	0,0	0,0	3,3		
Total	0,35	0,57	1,45	1,98	2,30	2,31	2,41	100	100	100	100	100	100	100	5,4	11,0	1,5	0,1	0,4	1,6		
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Oil	0,26	0,36	0,71	0,74	0,70	0,68	0,76	74,6	63,2	49,0	37,5	30,2	29,6	31,3	3,8	1,6	-0,6	-0,2	1,0	0,2		
Natural gas	0,00	0,00	0,47	0,95	1,30	1,30	1,30	0,0	0,0	32,3	48,3	56,5	56,2	53,8	-	26,8	3,1	0,0	0,0	3,1		
Electricity	0,09	0,21	0,27	0,28	0,30	0,33	0,36	24,9	36,8	18,7	14,2	13,2	14,2	14,8	4,3	1,3	0,8	0,8	0,8	0,9		
Heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,6	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-		

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,17	2,54	3,72	3,70	4,12	4,30	4,65	100	100	100	100	100	100	100	4,4	-0,2	1,1	0,4	0,8	0,7		
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Oil	0,01	0,02	0,05	0,04	0,00	0,00	0,00	0,9	0,9	1,2	1,1	0,0	0,0	0,0	5,4	-3,5	-100,0	-	-	-100,0		
Natural gas	1,16	2,52	3,68	3,65	3,86	3,92	4,26	99,1	99,1	98,7	98,7	93,7	91,0	91,7	4,4	-0,2	0,6	0,1	0,9	0,5		
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	0,00	0,00	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	0,00	0,00	0,01	0,26	0,39	0,39	0,0	0,0	0,0	0,1	6,3	9,0	8,3	-	53,1	46,8	4,1	0,0	18,2		

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	0,46	0,86	1,10	0,67	0,69	0,70	0,76	100	100	100	100	100	100	100	3,3	-15,3	0,4	0,1	0,9	-1,1
Coal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Oil	0,00	0,01	0,01	0,01	0,00	0,00	0,00	0,6	0,6	1,2	1,7	0,0	0,0	0,0	5,6	-3,5	-100,0	-	-	-100,0
Natural gas	0,46	0,86	1,08	0,65	0,69	0,70	0,76	99,4	99,4	98,8	98,3	100,0	100,0	100,0	3,2	-15,5	0,6	0,1	0,9	-1,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	21,8	25,3	29,2	47,7	48,0	48,0	48,0								1,1	17,7	0,1	0,0	0,0	1,5
Coal	-	-	-	-	-	-	-								-	-	-	-	-	-
Oil	31,5	39,6	30,2	30,2	-	-	-								-0,2	0,0	-	-	-	-
Natural gas	21,8	25,3	29,2	48,0	48,0	48,0	48,0								1,1	18,0	0,0	0,0	0,0	1,5

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	0,9	1,0	1,3	1,0	1,0	1,0	1,1	100	100	100	100	100	100	100	1,4	-7,0	-0,3	0,0	0,9	-0,5		
Coal	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	-	-	-	-	-	-		
Oil	0,2	0,3	0,6	0,6	0,6	0,6	0,6	22,4	30,2	45,3	58,7	56,0	55,3	55,6	4,1	1,4	-0,8	-0,2	1,0	0,1		
Natural gas	0,7	0,7	0,7	0,4	0,4	0,4	0,5	77,6	69,8	54,7	41,3	44,0	44,7	44,4	0,1	-15,3	0,3	0,1	0,9	-1,1		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	6,9	8,6	13,5	15,3	19,2	23,6	29,0	2,5	4,3	2,3	2,1	2,1	2,4
Population (millions of people)	0,3	0,3	0,4	0,4	0,5	0,6	0,7	1,9	1,4	1,4	1,4	1,4	1,4
GDP per capita (thousands of 2010 USD/person)	26,8	25,9	31,75	34,59	37,67	40,35	43,23	0,6	2,9	0,9	0,7	0,7	0,9
Primary energy consumption per capita (toe/person)	6,7	7,2	8,50	9,21	8,79	7,74	7,00	0,9	2,7	-0,5	-1,3	-1,0	-0,6
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	250	277	268	266	233	192	162	0,3	-0,2	-1,3	-1,9	-1,7	-1,5
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	51	66	107	129	120	98	83	2,8	6,4	-0,7	-2,0	-1,6	-0,8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	128	120	95	68	52	42	38	-1,1	-10,8	-2,5	-2,1	-1,1	-2,8
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,5	0,4	0,36	0,25	0,22	0,22	0,23	-1,3	-10,9	-1,2	-0,1	0,5	-1,3
Automobile ownership volume (millions of vehicles)	-	-	0,24	0,25	0,28	0,33	0,38	-	1,4	1,4	-	2,8	1,4
Automobile ownership volume per capita (vehicles per person)	-	-	0,559	0,559	0,559	0,559	0,559	-	0,0	0,0	0,0	0,0	0,0

Cambodia [BAU]

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050	
Total	2,84	3,42	5,9	6,2	11,2	19,2	33,27	100	100	100	100	100	100	100	2,7	2,7	6,1	5,5	5,6	5,6	
Coal	0,00	0,00	0,97	1,05	3,14	5,69	9,57	0,0	0,0	16,5	16,9	28,0	29,6	28,8	-	4,2	11,5	6,1	5,3	7,4	
Oil	0,51	0,70	2,47	2,66	4,42	7,26	11,93	18,0	20,5	41,8	42,7	39,3	37,7	35,9	5,8	3,8	5,2	5,1	5,1	5,0	
Natural gas					1,02	2,93	7,58	0,0	0,0	0,0	0,0	9,0	15,2	22,8	-	-	-	11,2	10,0	-	
Nuclear								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Hydro	0,00	0,00	0,42	0,43	0,54	1,18	1,91	0,0	0,0	7,1	6,9	4,8	6,2	5,7	-	0,9	2,5	8,1	4,9	4,9	
Geothermal								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Others	2,33	2,72	2,04	2,08	2,12	2,17	2,28	82,0	79,5	34,6	33,5	18,9	11,3	6,9	-0,5	1,0	0,2	0,2	0,5	0,3	
Biomass	2,33	2,72	1,94	1,94	1,92	1,90	1,88	82,0	79,5	32,9	31,2	17,1	9,9	5,6	-0,6	0,1	-0,1	-0,1	-0,1	-0,1	
Solar, Wind, Ocean	0,00	0,00	0,00	0,01	0,07	0,14	0,27	0,0	0,0	0,0	0,1	0,6	0,7	0,8	-	93,0	29,3	7,9	6,7	18,0	
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Electricity	0,00	0,00	0,10	0,13	0,13	0,13	0,13	0,0	0,0	1,7	2,2	1,2	0,7	0,4	-	14,6	0,0	0,0	0,0	0,9	

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	2,54	2,95	4,30	4,55	7,67	13,06	22,33	100	100	100	100	100	100	100	1,9	2,9	5,4	5,5	5,5	5,3
Industry	0,44	0,61	0,72	0,77	1,41	2,69	5,04	17,2	20,7	16,9	16,9	18,4	20,6	22,6	1,8	2,9	6,3	6,7	6,5	6,2
Transportation	0,38	0,43	1,75	1,90	3,48	5,96	10,12	15,0	14,6	40,7	41,8	45,3	45,7	45,3	5,6	4,2	6,2	5,5	5,4	5,6
Others	1,72	1,90	1,81	1,87	2,78	4,40	7,15	67,5	64,4	42,2	41,1	36,2	33,7	32,0	0,2	1,5	4,0	4,7	5,0	4,4
Non-energy	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,3	0,3	0,3	0,2	0,1	0,1	0,1	1,7	0,0	0,0	0,0	0,0	0,0
Total	2,54	2,95	4,30	4,55	7,67	13,06	22,33	100	100	100	100	100	100	100	1,9	2,9	5,4	5,5	5,5	5,3
Coal	0,00	0,00	0,08	0,10	0,35	0,84	1,74	0,0	0,0	1,8	2,1	4,5	6,4	7,8	-	12,3	13,7	9,3	7,6	10,3
Oil	0,44	0,54	2,38	2,56	4,35	7,20	11,86	17,3	18,1	55,5	56,2	56,7	55,1	53,1	6,2	3,6	5,5	5,2	5,1	5,1
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity	0,01	0,03	0,74	0,80	1,91	3,99	7,70	0,4	1,0	17,3	17,7	24,9	30,5	34,5	16,2	4,0	9,1	7,6	6,8	7,6
Heat								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	2,09	2,39	1,09	1,09	1,06	1,04	1,02	82,2	80,8	25,5	24,0	13,9	8,0	4,6	-2,3	-0,2	-0,2	-0,2	-0,2	-0,2

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050		
Total	0,20	0,45	8,48	8,90	23,58	50,84	99,56	100	100	100	100	100	100	100	14,4	2,5	10,2	8,0	7,0	8,0		
Coal			3,21	3,44	10,02	17,37	28,03	0,0	0,0	37,9	38,6	42,5	34,2	28,2	-	3,5	11,3	5,7	4,9	7,0		
Oil	0,20	0,45	0,31	0,37	0,24	0,24	0,24	100,0	100,0	3,6	4,1	1,0	0,5	0,2	1,6	9,5	-4,2	0,0	0,0	-0,8		
Natural gas					6,14	17,74	45,81	0,0	0,0	0,0	0,0	26,0	34,9	46,0	-	-	-	11,2	10,0	-		
Nuclear								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Hydro	0,00	0,00	4,88	4,97	6,34	13,77	22,22	0,0	0,0	57,6	55,8	26,9	27,1	22,3	-	0,9	2,5	8,1	4,9	4,9		
Geothermal								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	0,00	0,00	0,08	0,12	0,84	1,73	3,25	0,0	0,0	0,9	1,4	3,6	3,4	3,3	-	24,7	21,1	7,4	6,5	12,3		

Power generation Input

Power generation input	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050		
Total	0,10	0,09	0,98	1,06	3,88	7,85	15,47	100	100	100	100	100	100	100	8,5	4,0	13,8	7,3	7,0	9,0		
Coal			0,90	0,96	2,80	4,85	7,83	0	0	91	90	72	62	51	-	3,5	11,3	5,7	4,9	7,0		
Oil	0,10	0,09	0,09	0,10	0,07	0,07	0,07	100	100	9	10	2	1	0	-0,5	9,5	-4,2	0,0	0,0	-0,8		
Natural gas	-	-	0,00	0,00	1,02	2,93	7,58	0	0	0	0	26	37	49	-	-	-	11,2	10,0	-		

Thermal Efficiency

Thermal Efficiency	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	17,2	43,0	30,8	30,8	36,4	38,7	41,2								2,1	0,0	1,7	0,6	0,6	0,9
Coal	-	-	31	31	31	31	31								-	0,0	0,0	0,0	0,0	0,0
Oil	17,2	43,0	31	31	31	31	31								2,1	0,0	0,0	0,0	0,0	0,0
Natural gas	-	-	-	-	52	52	52								-	-	-	0,0	0,0	-

CO₂ emissions

CO ₂ emissions	Mt-C																AAGR (%)									
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050						
Total	0,0	0,5	3,0	3,3	7,6	13,9	25,0	-	100	100	100	100	100	100	-	3,9	8,8	6,2	6,0	6,8						
Coal	0,00	0,00	1,1	1,2	3,5	6,2	10,5	0,0	0,0	35,1	35,4	45,3	44,8	42,0	-	4,2	11,5	6,1	5,3	7,4						
Oil	0,00	0,50	2,0	2,1	3,5	5,8	9,7	0,0	100,0	64,9	64,6	46,2	41,8	38,6	-	3,7	5,2	5,2	5,2	5,1						
Natural gas	0,00	0,00	0,0	0,0	0,6	1,9	4,8	0,0	0,0	0,0	0,0	8,5	13,4	19,3	-	-	-	11,2	10,0	-						

Energy and economic indicators

								AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
GDP (billions of 2010 US dollars)	3,66	5,24	20	21	40	77	144	6,2	2,8	6,8	6,8	6,5	6,4
Population (millions of people)	8,97	12,16	16	17	19	23	26	2,1	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2010 USD/person)	0,4	0,4	1,2	1,2	2,1	3,4	5,5	3,9	1,3	5,2	5,2	4,9	4,9
Primary energy consumption per capita (toe/person)	0,3	0,3	0,4	0,4	0,6	0,9	1,3	0,5	1,2	4,5	4,0	4,1	4,0
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	775	653	301	301	281	250	230	-3,3	-0,1	-0,7	-1,2	-0,8	-0,8
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	695	563	219	220	192	170	155	-4,0	0,0	-1,3	-1,2	-0,9	-1,1
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	-	95	155	158	191	181	173	-	1,1	1,9	-0,5	-0,5	0,3
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	-	0,15	0,51	0,53	0,68	0,72	0,75	-	1,2	2,6	0,7	0,4	1,2
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	873.64	1,129.87	3,063.43	3,372.68	3,632.41	3,706.27	3,521.60	100	100	100	100	100	100	100	4.8	3.3	0.7	0.2	-0.5	0.4	
Coal	530.52	664.72	1,953.30	2,080.20	2,058.30	1,914.19	1,627.27	60.7	58.8	63.8	61.7	56.7	51.6	46.2	4.9	2.1	-0.1	-0.7	-1.6	-0.6	
Oil	118.79	220.81	568.08	631.17	704.23	708.41	647.40	13.6	19.5	18.5	18.7	19.4	19.1	18.4	6.0	3.6	1.1	0.1	-0.9	0.4	
Natural gas	12.80	20.76	195.19	258.43	389.25	497.19	566.67	1.5	1.8	6.4	7.7	10.7	13.4	16.1	10.6	9.8	4.2	2.5	1.3	3.3	
Nuclear	0.00	4.36	64.64	98.55	128.52	159.20	189.01	0.0	0.4	2.1	2.9	3.5	4.3	5.4	-	15.1	2.7	2.2	1.7	3.3	
Hydro	10.90	19.12	99.49	103.80	119.52	127.87	131.37	1.2	1.7	3.2	3.1	3.3	3.5	3.7	8.5	1.4	1.4	0.7	0.3	0.8	
Geothermal	0.00	1.66	10.37	11.50	13.28	14.82	15.99	0.0	0.1	0.3	0.3	0.4	0.4	0.5	-	3.5	1.5	1.1	0.8	1.3	
Others	200.64	198.44	174.55	193.80	224.89	290.73	350.36	23.0	17.6	5.7	5.7	6.2	7.8	9.9	-0.5	3.5	1.5	2.6	1.9	2.1	
Biomass	200.45	198.17	113.84	107.48	79.18	83.80	94.58	22.9	17.5	3.7	3.2	2.2	2.3	2.7	-2.1	-1.9	-3.0	0.6	1.2	-0.6	
Solar, Wind, Ocean	0.03	0.99	59.64	82.68	141.24	201.92	250.41	0.0	0.1	1.9	2.5	3.9	5.4	7.1	32.0	11.5	5.5	3.6	2.2	4.4	
Biofuels	0.00	0.00	2.19	4.76	5.59	6.13	6.49	0.0	0.0	0.1	0.1	0.2	0.2	0.2	-	29.5	1.6	0.9	0.6	3.3	
Electricity	0.16	-0.72	-1.12	-1.12	-1.12	-1.12	-1.12	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-207.5	0.0	0.0	0.0	0.0	0.0	

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	657.59	781.19	1,995.06	2,163.06	2,286.15	2,338.13	2,273.42	100	100	100	100	100	100	100	4.2	2.7	0.6	0.2	-0.3	0.4
Industry	233.85	302.21	985.92	1,035.88	987.10	934.14	855.21	35.6	38.7	49.4	47.9	43.2	40.0	37.6	5.5	1.7	-0.5	-0.5	-0.9	-0.4
Transportation	30.20	83.64	310.27	352.44	420.19	427.16	379.32	4.6	10.7	15.6	16.3	18.4	18.3	16.7	9.0	4.3	1.8	0.2	-1.2	0.6
Others	350.68	338.37	536.74	586.61	652.85	725.00	777.64	53.3	43.3	26.9	27.1	28.6	31.0	34.2	1.6	3.0	1.1	1.1	0.7	1.1
Non-energy	42.86	56.96	162.13	188.14	226.00	251.83	261.25	6.5	7.3	8.1	8.7	9.9	10.8	11.5	5.1	5.1	1.9	1.1	0.4	1.5
Total	657.59	781.19	1,995.06	2,163.06	2,286.15	2,338.13	2,273.42	100	100	100	100	100	100	100	4.2	2.7	0.6	0.2	-0.3	0.4
Coal	311.40	274.47	663.45	662.93	559.56	483.29	402.60	47.4	35.1	33.3	30.6	24.5	20.7	17.7	2.8	0.0	-1.7	-1.5	-1.8	-1.5
Oil	84.60	180.37	514.29	574.39	647.76	652.23	597.38	12.9	23.1	25.8	26.6	28.3	27.9	26.3	6.9	3.8	1.2	0.1	-0.9	0.5
Natural gas	8.87	13.38	131.58	169.15	218.91	246.63	263.94	1.3	1.6	6.6	7.8	9.6	10.5	11.6	10.5	8.7	2.6	1.2	0.7	2.1
Electricity	39.03	89.13	476.11	547.17	676.97	774.99	822.60	5.9	11.4	23.9	25.3	29.6	33.1	36.2	9.7	4.7	2.2	1.4	0.6	1.7
Heat	13.21	25.50	95.73	104.48	109.41	113.79	113.19	2.0	3.3	4.8	4.8	4.8	4.9	5.0	7.6	3.0	0.5	0.4	-0.1	0.5
Others	200.48	199.35	113.89	104.94	73.54	67.20	73.71	30.5	25.5	5.7	4.9	3.2	2.9	3.2	-2.1	-2.7	-3.5	-0.9	0.9	-1.3

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	621.27	1,355.74	6,602.15	7,577.38	9,305.58	10,530.56	11,033.80	100	100	100	100	100	100	100	9.1	4.7	2.1	1.2	0.5	1.6		
Coal	441.34	1,060.37	4,485.36	4,933.05	5,405.55	5,409.77	4,975.40	71.0	78.2	67.9	65.1	58.1	51.4	45.1	9.0	3.2	0.9	0.0	-0.8	0.3		
Oil	50.37	47.27	9.87	10.38	9.54	7.52	4.87	8.1	3.5	0.1	0.1	0.1	0.1	0.0	-5.9	1.7	-0.8	-2.3	-4.3	-2.1		
Natural gas	2.77	5.77	183.10	271.30	568.34	866.87	1,099.95	0.4	0.4	2.8	3.6	6.1	8.2	10.0	16.8	14.0	7.7	4.3	2.4	5.6		
Nuclear	0.00	16.74	248.07	378.22	493.25	610.99	725.38	0.0	1.2	3.8	5.0	5.3	5.8	6.6	-	15.1	2.7	2.2	1.7	3.3		
Hydro	126.72	222.41	1,157.09	1,207.18	1,390.00	1,487.18	1,527.87	20.4	16.4	17.5	15.9	14.9	14.1	13.8	8.5	1.4	1.4	0.7	0.3	0.8		
Geothermal	0.06	0.11	0.13	0.17	0.33	0.45	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	10.4	7.0	3.1	1.3	4.3		
Others	0.01	3.07	518.54	777.09	1,438.56	2,147.79	2,699.83	0.0	0.2	7.9	10.3	15.5	20.4	24.5	49.0	14.4	6.4	4.1	2.3	5.1		

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	144.73	297.16	1,114.08	1,238.89	1,395.12	1,410.13	1,266.32	100	100	100	100	100	100	100	7.9	3.6	1.2	0.1	-1.1	0.4
Coal	131.74	284.28	1,072.56	1,176.34	1,267.67	1,224.90	1,044.04	91.0	95.7	96.3	95.0	90.9	86.9	82.4	8.1	3.1	0.8	-0.3	-1.6	-0.1
Oil	12.37	11.61	2.42	2.55	2.30	1.75	1.11	8.5	3.9	0.2	0.2	0.2	0.1	0.1	-5.9	1.7	-1.0	-2.7	-4.5	-2.3
Natural gas	0.61	1.27	39.10	60.00	125.15	183.47	221.17	0.4	0.4	3.5	4.8	9.0	13.0	17.5	16.7	15.3	7.6	3.9	1.9	5.4

Thermal Efficiency

	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	29.4	32.2	36.1	36.2	36.9	38.3	41.3							
Coal	28.8	32.1	36.0	36.1	36.7	38.0	41.0	0.8	0.1	0.2	0.4	0.7	0.4	
Oil	35.0	35.0	35.0	35.0	35.7	37.0	37.8	0.0	0.0	0.2	0.4	0.2	0.2	
Natural gas	39.0	39.0	40.3	38.9	39.1	40.6	42.8	0.1	-1.2	0.0	0.4	0.5	0.2	

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	585.3	856.5	2,509.4	2,711.3	2,790.7	2,687.3	2,370.3	100	100	100	100	100	100	100	5.5	2.6	0.3	-0.4	-1.2	-0.2		
Coal	505.3	704.0	2,023.1	2,147.2	2,103.3	1,943.2	1,635.4	86.3	82.2	80.6	79.2	75.4	72.3	69.0	5.3	2.0	-0.2	-0.8	-1.7	-0.6		
Oil	74.5	142.5	366.0	405.3	448.1	437.9	385.4	12.7	16.6	14.6	14.9	16.1	16.3	16.3	6.1	3.5	1.0	-0.2	-1.3	0.2		
Natural gas	5.5	10.0	120.2	158.8	239.4	306.1	349.5	0.9	1.2	4.8	5.9	8.6	11.4	14.7	12.1	9.7	4.2	2.5	1.3	3.3		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	830	2,237	10,161	12,209	20,439	30,536	39,688	9.7	6.3	5.3	4.1	2.7	4.2
Population (millions of people)	1,135	1,263	1,386	1,440	1,465	1,450	1,403	0.7	1.3	0.2	-0.1	-0.3	0.0
GDP per capita (thousands of 2010 USD/person)	0.73	1.77	7.33	8.48	13.95	21.06	28.28	8.9	5.0	5.1	4.2	3.0	4.2
Primary energy consumption per capita (toe/person)	0.77	0.89	2.21	2.34	2.48	2.56	2.51	4.0	2.0	0.6	0.3	-0.2	0.4
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.053	505	301	276	178	121	89	-4.5	-2.9	-4.3	-3.7	-3.1	-3.6
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	793	349	196	177	112	77	57	-5.0	-3.4	-4.5	-3.7	-2.9	-3.7
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	706	383	247	222	137	88	60	-3.8	-3.5	-4.7	-4.3	-3.8	-4.2
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.67	0.76	0.82	0.80	0.77	0.73	0.67	0.7	-0.6	-0.5	-0.6	-0.7	-0.6
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	873.64	1,129.87	3,063.43	3,338.39	3,381.31	3,237.46	2,931.31	100	100	100	100	100	100	100	4.8	2.9	0.1	-0.4	-1.0	-0.1	
Coal	530.52	664.72	1,953.30	2,042.34	1,783.15	1,427.12	1,025.98	60.7	58.8	63.8	61.2	52.7	44.1	35.0	4.9	1.5	-1.3	-2.2	-3.2	-1.9	
Oil	118.79	220.81	568.08	628.35	664.75	615.72	528.79	13.6	19.5	18.5	18.8	19.7	19.0	18.0	6.0	3.4	0.6	-0.8	-1.5	-0.2	
Natural gas	12.80	20.76	195.19	254.63	349.09	422.21	441.83	1.5	1.8	6.4	7.6	10.3	13.0	15.1	10.6	9.3	3.2	1.9	0.5	2.5	
Nuclear	0.00	4.36	64.64	98.55	146.93	196.12	244.24	0.0	0.4	2.1	3.0	4.3	6.1	8.3	-	15.1	4.1	2.9	2.2	4.1	
Hydro	10.90	19.12	99.49	106.26	127.79	139.23	144.02	1.2	1.7	3.2	3.2	3.8	4.3	4.9	8.5	2.2	1.9	0.9	0.3	1.1	
Geothermal	0.00	1.66	10.37	11.48	12.92	13.90	14.52	0.0	0.1	0.3	0.3	0.4	0.4	0.5	-	3.4	1.2	0.7	0.4	1.0	
Others	200.64	198.44	174.55	201.58	305.66	438.90	547.74	23.0	17.6	5.7	6.0	9.0	13.6	18.7	-0.5	4.9	4.3	3.7	2.2	3.5	
Biomass	200.45	198.17	113.84	110.30	94.39	110.82	131.52	22.9	17.5	3.7	3.3	2.8	3.4	4.5	-2.1	-1.0	-1.5	1.6	1.7	0.4	
Solar, Wind, Ocean	0.03	0.99	59.64	87.60	203.41	313.53	401.71	0.0	0.1	1.9	2.6	6.0	9.7	13.7	32.0	13.7	8.8	4.4	2.5	6.0	
Biofuels	0.00	0.00	2.19	4.80	8.98	15.68	15.63	0.0	0.0	0.1	0.1	0.3	0.5	0.5	-	29.9	6.5	5.7	0.0	6.1	
Electricity	0.16	-0.72	-1.12	-1.12	-1.12	-1.12	-1.12	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-207.5	0.0	0.0	0.0	0.0	0.0	

Final energy demand

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	657.59	781.19	1,995.06	2,155.40	2,204.98	2,153.48	2,013.34	100	100	100	100	100	100	100	4.2	2.6	0.2	-0.2	-0.7	0.0	
Industry	233.85	302.21	985.92	1,034.78	971.05	886.57	775.48	35.6	38.7	49.4	48.0	44.0	41.2	38.6	5.5	1.6	-0.6	-0.9	-1.3	-0.7	
Transportation	30.20	83.64	310.27	348.98	383.18	351.18	290.11	4.6	10.7	15.6	16.2	17.4	16.3	14.4	9.0	4.0	0.9	-0.9	-1.9	-0.2	
Others	350.68	338.37	536.74	583.65	625.56	665.23	685.89	53.3	43.3	26.9	27.1	28.4	30.9	34.1	1.6	2.8	0.7	0.6	0.3	0.7	
Non-energy	42.86	56.96	162.13	187.09	225.19	250.51	259.86	6.5	7.3	8.1	8.7	10.2	11.6	12.9	5.1	5.1	1.8	1.1	0.4	1.4	
Total	657.59	781.19	1,995.06	2,155.40	2,204.98	2,153.48	2,013.34	100	100	100	100	100	100	100	4.2	2.6	0.2	-0.2	-0.7	0.0	
Coal	311.40	274.47	663.45	659.36	535.81	438.83	344.87	47.4	35.1	33.3	30.6	24.3	20.4	17.1	2.8	-0.2	-2.1	-2.0	-2.4	-2.0	
Oil	84.60	180.37	514.29	571.93	612.49	569.06	491.30	12.9	23.1	25.8	26.5	27.8	26.4	24.4	6.9	3.6	0.7	-0.7	-1.5	-0.1	
Natural gas	8.87	12.38	131.58	169.09	207.18	217.36	220.62	1.3	1.6	6.6	7.8	9.4	10.1	11.0	10.5	8.7	2.1	0.5	0.1	1.6	
Electricity	39.03	89.13	476.11	546.10	665.56	742.74	763.87	5.9	11.4	23.9	25.3	30.2	34.5	38.0	9.7	4.7	2.0	1.1	0.3	1.4	
Heat	13.21	25.50	95.73	104.26	106.43	105.92	100.44	2.0	3.3	4.8	4.8	4.8	4.9	5.0	7.6	2.9	0.2	0.0	-0.5	0.1	
Others	200.48	199.35	113.89	104.66	77.51	79.56	90.24	30.5	25.5	5.7	4.9	3.5	3.7	4.5	-2.1	-2.8	-3.0	0.3	1.3	-0.7	

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	621.27	1,355.74	6,602.15	7,556.44	9,104.74	10,055.12	10,397.05	100	100	100	100	100	100	100	9.1	4.6	1.9	1.0	0.3	1.4
Coal	441.34	1,060.37	4,485.36	4,822.30	4,371.68	3,462.97	2,452.11	71.0	78.2	67.9	63.8	48.0	34.4	23.6	9.0	2.4	-1.0	-2.3	-3.4	-1.8
Oil	50.37	47.27	9.87	10.15	7.70	4.88	2.32	8.1	3.5	0.1	0.1	0.1	0.0	0.0	-5.9	0.9	-2.7	-4.5	-7.2	-4.3
Natural gas	2.77	5.77	183.10	265.21	475.61	721.92	815.36	0.4	0.4	2.8	3.5	5.2	7.2	7.8	16.8	13.1	6.0	4.3	1.2	4.6
Nuclear	0.00	16.74	248.07	378.22	563.91	752.69	937.36	0.0	1.2	3.8	5.0	6.2	7.5	9.0	-	15.1	4.1	2.9	2.2	4.1
Hydro	126.72	222.41	1,157.09	1,235.76	1,486.15	1,619.24	1,674.96	20.4	16.4	17.5	16.4	16.3	16.1	16.1	8.5	2.2	1.9	0.9	0.3	1.1
Geothermal	0.06	0.11	0.13	0.19	0.43	0.59	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	14.9	8.6	3.1	2.5	5.6
Others	0.01	3.07	518.54	844.62	2,199.25	3,492.83	4,514.17	0.0	0.2	7.9	11.2	24.2	34.7	43.4	49.0	17.7	10.0	4.7	2.6	6.8

Power generation Input

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	144.73	297.16	1,114.08	1,203.67	1,129.18	946.97	680.89	100	100	100	100	100	100	100	7.9	2.6	-0.6	-1.7	-3.2	-1.5	
Coal	131.74	284.28	1,072.56	1,144.52	1,028.94	803.60	526.88	91.0	95.7	96.3	95.1	91.1	84.9	77.4	8.1	2.2	-1.1	-2.4	-4.1	-2.1	
Oil	12.37	11.61	2.42	2.49	1.88	1.16	0.54	8.5	3.9	0.2	0.2	0.2	0.1	0.1	-5.9	0.9	-2.8	-4.7	-7.3	-4.4	
Natural gas	0.61	1.27	39.10	56.66	98.36	142.21	153.47	0.4	0.4	3.5	4.7	8.7	15.0	22.5	16.7	13.2	5.7	3.8	0.8	4.2	

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	29.4	32.2	36.1	36.4	37.0	38.0	41.3								0.8	0.3	0.2	0.3	0.8	0.4
Coal	28.8	32.1	36.0	36.2	36.5	37.1	40.0								0.8	0.3	0.1	0.1	0.8	0.3
Oil	35.0	35.0	35.0	35.0	35.3	36.1	36.7								0.0	0.0	0.1	0.2	0.2	0.1
Natural gas	39.0	39.0	40.3	40.3	41.6	43.7	45.7								0.1	0.0	0.3	0.5	0.5	0.4

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	585.3	856.5	2,509.4	2,666.7	2,435.6	2,001.5	1,347.4	100	100	100	100	100	100	100	5.5	2.0	-0.9	-1.9	-3.9	-1.9
Coal	505.3	704.0	2,023.1	2,107.3	1,813.3	1,416.7	840.5	86.3	82.2	80.6	79.0	74.4	70.8	62.4	5.3	1.4	-1.5	-2.4	-5.1	-2.6
Oil	74.5	142.5	366.0	402.9	416.0	364.2	293.7	12.7	16.6	14.6	15.1	17.1	18.2	21.8	6.1	3.3	0.3	-1.3	-2.1	-0.7
Natural gas	5.5	10.0	120.2	156.4	206.3	220.6	213.2	0.9	1.2	4.8	5.9	8.5	11.0	15.8	12.1	9.2	2.8	0.7	-0.3	1.8

Energy and economic indicators

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IND [BAU]

Primary energy consumption

	MTOE															AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	305.74	440.93	881.94	1,018.20	1,553.90	1,993.26	2,367.97	100	100	100	100	100	100	100	4.0	4.9	4.3	2.5	1.7	3.0	
Coal	92.70	145.92	390.94	459.49	706.11	885.99	989.71	30.3	33.1	44.3	45.1	45.4	44.4	41.8	5.5	5.5	4.4	2.3	1.1	2.9	
Oil	61.10	111.99	223.32	254.52	407.59	586.04	792.40	20.0	25.4	25.3	25.0	26.2	29.4	33.5	4.9	4.5	4.8	3.7	3.1	3.9	
Natural gas	10.57	23.07	51.02	67.95	127.87	175.29	210.25	3.5	5.2	5.8	6.7	8.2	8.8	8.9	6.0	10.0	6.5	3.2	1.8	4.4	
Nuclear	1.60	4.40	9.99	15.38	37.79	50.57	64.31	0.5	1.0	1.1	1.5	2.4	2.5	2.7	7.0	15.5	9.4	3.0	2.4	5.8	
Hydro	6.16	6.40	12.19	15.15	21.01	26.88	32.74	2.0	1.5	1.4	1.5	1.4	1.3	1.4	2.6	7.5	3.3	2.5	2.0	3.0	
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	133.61	149.14	194.48	205.70	253.51	268.50	278.57	43.7	33.8	22.1	20.2	16.3	13.5	11.8	1.4	1.9	2.1	0.6	0.4	1.1	
Biomass	133.48	148.85	187.14	191.34	211.75	197.09	168.31	43.7	33.8	21.2	18.8	13.6	9.9	7.1	1.3	0.7	1.0	-0.7	-1.6	-0.3	
Solar, Wind, Ocean	0.01	0.18	7.48	14.51	41.90	71.54	110.40	0.0	0.0	0.8	1.4	2.7	3.6	4.7	27.6	24.7	11.2	5.5	4.4	8.5	
Biofuels	0.00	0.07	0.40	0.73	1.06	1.52	1.92	0.0	0.0	0.0	0.1	0.1	0.1	0.1	-	22.2	3.8	3.7	2.3	4.9	
Electricity	0.12	0.11	-0.14	-0.14	-0.14	-0.14	-0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-200.5	0.0	0.0	0.0	0.0	0.0	

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	242.88	314.09	591.23	680.46	1,035.45	1,343.42	1,630.80	100	100	100	100	100	100	100	3.3	4.8	4.3	2.6	2.0	3.1
Industry	66.75	83.41	205.01	252.00	415.81	518.60	565.13	27.5	26.6	34.7	37.0	40.2	38.6	34.7	4.2	7.1	5.1	2.2	0.9	3.1
Transportation	20.75	31.92	98.22	113.48	192.25	316.82	485.57	8.5	10.2	16.6	16.7	18.6	23.6	29.8	5.9	4.9	5.4	5.1	4.4	5.0
Others	142.10	171.96	242.06	261.22	341.28	391.50	433.61	58.5	54.7	40.9	38.4	33.0	29.1	26.6	2.0	2.6	2.7	1.4	1.0	1.8
Non-energy	13.28	26.80	45.94	53.77	86.12	116.49	146.49	5.5	8.5	7.8	7.9	8.3	8.7	9.0	4.7	5.4	4.8	3.1	2.3	3.6
Total	242.88	314.09	591.23	680.46	1,035.45	1,343.42	1,630.80	100	100	100	100	100	100	100	3.3	4.8	4.3	2.6	2.0	3.1
Coal	38.24	33.15	101.15	120.71	183.84	225.41	247.82	15.7	10.6	17.1	17.7	17.8	16.8	15.2	3.7	6.1	4.3	2.1	1.0	2.8
Oil	50.17	94.47	195.52	227.43	372.05	542.92	741.86	20.7	30.1	33.1	33.4	35.9	40.4	45.5	5.2	5.2	5.0	3.9	3.2	4.1
Natural gas	5.64	9.67	36.10	47.70	97.11	135.18	163.09	2.3	3.1	6.1	7.0	9.4	10.1	10.0	7.1	9.7	7.4	3.4	1.9	4.7
Electricity	18.49	32.35	100.09	124.34	216.53	300.73	379.32	7.6	10.3	16.9	18.3	20.9	22.4	23.3	6.5	7.5	5.7	3.3	2.3	4.1
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	130.35	144.46	158.38	160.28	165.92	139.17	98.71	53.7	46.0	26.8	23.6	16.0	10.4	6.1	0.7	0.4	0.3	-1.7	-3.4	-1.4

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	292.73	569.69	1,532.23	1,897.27	3,223.19	4,313.05	5,240.28	100	100	100	100	100	100	100	6.3	7.4	5.4	3.0	2.0	3.8		
Coal	191.63	390.23	1,133.63	1,337.72	2,115.77	2,683.68	2,990.96	0.0	68.5	74.0	70.5	65.6	62.2	57.1	6.8	5.7	4.7	2.4	1.1	3.0		
Oil	13.31	29.16	25.04	18.90	23.12	20.16	11.56	4.5	5.1	1.6	1.0	0.7	0.5	0.2	2.4	-8.9	2.0	-1.4	-5.4	-2.3		
Natural gas	9.96	55.96	70.89	97.58	152.51	204.08	248.20	3.4	9.8	4.6	5.1	4.7	4.7	4.7	7.5	11.2	4.6	3.0	2.0	3.9		
Nuclear	6.14	16.90	38.35	59.03	145.04	194.09	246.81	2.1	3.0	2.5	3.1	4.5	4.5	4.7	7.0	15.5	9.4	3.0	2.4	5.8		
Hydro	71.66	74.46	141.80	176.24	244.40	312.56	380.72	24.5	13.1	9.3	9.3	7.6	7.2	7.3	2.6	7.5	3.3	2.5	2.0	3.0		
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	0.03	2.96	122.53	207.80	542.34	898.48	1,362.02	0.0	0.5	8.0	11.0	16.8	20.8	26.0	35.7	19.3	10.1	5.2	4.2	7.6		

Power generation Input

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	56.84	121.39	284.31	331.86	507.35	626.51	675.85	100	100	100	100	100	100	100	6.1	5.3	4.3	2.1	0.8	2.7		
Coal	48.37	103.17	261.76	306.31	469.78	580.97	626.15	85.1	85.0	92.1	92.3	92.6	92.7	92.6	6.5	5.4	4.4	2.1	0.8	2.7		
Oil	5.01	8.96	8.31	6.13	7.16	6.04	3.43	8.8	7.4	2.9	1.8	1.4	1.0	0.5	1.9	-9.6	1.6	-1.7	-5.5	-2.6		
Natural gas	3.46	9.26	14.24	19.42	30.40	39.50	46.27	6.1	7.6	5.0	5.9	6.0	6.3	6.8	5.4	10.9	4.6	2.7	1.6	3.6		

Thermal Efficiency

	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	32.5	33.7	37.2	37.7	39.1	40.3	42.0							
Coal	34.1	32.5	37.2	37.6	38.7	39.7	41.1	0.5	0.4	0.4	0.3	0.4	0.4	
Oil	22.8	28.0	25.9	26.5	27.8	28.7	29.0	0.3	0.3	0.3	0.3	0.3	0.3	
Natural gas	24.7	52.0	42.8	43.2	44.6	45.9	47.7	0.5	0.8	0.5	0.3	0.1	0.3	
								2.1	0.3	0.3	0.3	0.4	0.3	

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	144.2	241.4	589.4	694.3	1,105.2	1,460.6	1,749.9	100	100	100	100	100	100	100	5.4	5.6	4.8	2.8	1.8	3.4		
Coal	98.9	154.8	412.2	485.8	750.4	943.4	1,054.7	68.6	64.1	69.9	70.0	67.9	64.6	60.3	5.4	5.6	4.4	2.3	1.1	2.9		
Oil	41.8	76.8	157.0	180.1	294.8	430.7	590.1	29.0	31.8	26.6	25.9	26.7	29.5	33.7	5.0	4.7	5.1	3.9	3.2	4.1		
Natural gas	3.6	9.9	20.2	28.5	60.1	86.5	105.1	2.5	4.1	3.4	4.1	5.4	5.9	6.0	6.6	12.1	7.8	3.7	2.0	5.1		

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	506	870	2.651	3.272	6.273	10.518	16.320	6,3	7,3	6,7	5,3	4,5	5,7	
Population (millions of people)	870	1.053	1.339	1.381	1.504	1.593	1.640	1,6	1,0	0,9	0,6	0,3	0,6	
GDP per capita (thousands of 2010 USD/person)	0,58	0,83	1,98	2,37	4,17	6,60	9,95	4,6	6,2	5,8	4,7	4,2	5,0	
Primary energy consumption per capita (toe/person)	0,35	0,42	0,66	0,74	1,03	1,25	1,44	2,4	3,8	3,4	1,9	1,4	2,4	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	605	507	333	311	248	190	145	-2,2	-2,2	-2,3	-2,6	-2,6	-2,5	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	480	361	223	208	165	128	100	-2,8	-2,3	-2,3	-2,5	-2,4	-2,4	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	285	277	222	212	176	139	107	-0,9	-1,5	-1,8	-2,4	-2,6	-2,2	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,47	0,55	0,67	0,68	0,71	0,73	0,74	1,3	0,7	0,4	0,3	0,1	0,3	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

IND [APS]

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	305,74	440,93	881,94	1,006,40	1,425,98	1,681,69	1,874,69	100	100	100	100	100	100	100	4,0	4,5	3,5	1,7	1,1	2,3		
Coal	92,70	145,92	390,94	446,03	569,00	577,95	568,13	30,3	33,1	44,3	44,3	39,9	34,4	30,3	5,5	4,5	2,5	0,2	-0,2	1,1		
Oil	61,10	111,99	223,32	253,25	390,85	523,96	643,95	20,0	25,4	25,3	25,2	27,4	31,2	34,3	4,9	4,3	4,4	3,0	2,1	3,3		
Natural gas	10,57	23,07	51,02	66,92	130,27	167,24	182,19	3,5	5,2	5,8	6,6	9,1	9,9	9,7	6,0	9,5	6,9	2,5	0,9	3,9		
Nuclear	1,60	4,40	9,99	15,55	45,00	77,11	91,21	0,5	1,0	1,1	1,5	3,2	4,6	4,9	7,0	15,9	11,2	5,5	1,7	6,9		
Hydro	6,16	6,40	12,19	15,75	23,69	31,79	40,05	2,0	1,5	1,4	1,6	1,7	1,9	2,1	2,6	8,9	4,2	3,0	2,3	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	133,61	149,14	194,48	208,90	267,17	303,66	349,16	43,7	33,8	22,1	20,8	18,7	18,1	18,6	1,4	2,4	2,5	1,3	1,4	1,8		
Biomass	133,48	148,85	187,14	191,88	203,18	185,93	172,51	43,7	33,8	21,2	19,1	14,2	11,1	9,2	1,3	0,8	0,6	-0,9	-0,7	-0,2		
Solar, Wind, Ocean	0,01	0,18	7,48	17,16	64,12	117,86	176,79	0,0	0,0	0,8	1,7	4,5	7,0	9,4	27,6	31,9	14,1	6,3	4,1	10,1		
Biofuels	0,00	0,07	0,40	0,83	1,67	3,63	8,27	0,0	0,0	0,0	0,1	0,1	0,2	0,4	-	27,7	7,2	8,0	8,6	9,6		
Electricity	0,12	0,11	-0,14	-0,14	-0,14	-0,14	-0,14	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-200,5	0,0	0,0	0,0	0,0	0,0		

Final energy demand

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	242,88	314,09	591,23	674,27	971,50	1,179,09	1,338,29	100	100	100	100	100	100	100	3,3	4,5	3,7	2,0	1,3	2,5		
Industry	66,75	83,41	205,01	251,25	394,32	447,81	441,51	27,5	26,6	34,7	37,3	40,6	38,0	33,0	4,2	7,0	4,6	1,3	-0,1	2,4		
Transportation	20,75	31,92	98,22	112,51	179,27	272,52	384,76	8,5	10,2	16,6	16,7	18,5	23,1	28,7	5,9	4,6	4,8	4,3	3,5	4,2		
Others	142,10	171,96	242,06	256,74	311,79	342,27	365,54	58,5	54,7	40,9	38,1	32,1	29,0	27,3	2,0	2,0	2,0	0,9	0,7	1,3		
Non-energy	13,28	26,80	45,94	53,77	86,12	116,49	146,49	5,5	8,5	7,8	8,0	8,9	9,9	10,9	4,7	5,4	4,8	3,1	2,3	3,6		
Total	242,88	314,09	591,23	674,27	971,50	1,179,09	1,338,29	100	100	100	100	100	100	100	3,3	4,5	3,7	2,0	1,3	2,5		
Coal	38,24	33,15	101,15	119,81	172,99	196,50	199,87	15,7	10,6	17,1	17,8	17,8	16,7	14,9	3,7	5,8	3,7	1,3	0,2	2,1		
Oil	50,17	94,47	195,52	226,48	375,97	486,75	602,70	20,7	30,1	33,1	33,6	36,8	41,3	45,0	5,2	5,0	4,7	3,1	2,2	3,5		
Natural gas	5,64	9,67	36,10	47,62	92,01	117,38	129,39	2,3	3,1	6,1	7,1	9,5	10,9	9,7	7,1	9,7	6,8	2,5	1,0	3,9		
Electricity	18,49	32,35	100,09	123,65	206,71	272,85	336,11	7,6	10,3	16,9	18,3	21,3	23,1	25,1	6,5	7,3	5,3	2,8	2,1	3,7		
Heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	130,35	144,46	158,38	156,70	141,82	105,61	70,22	53,7	46,0	26,8	23,2	14,6	9,0	5,2	0,7	-0,4	-1,0	-2,9	-4,0	-2,4		

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	292,73	569,69	1,532,23	1,881,15	3,017,22	3,772,40	4,483,75	100	100	100	100	100	100	100	6,3	7,1	4,8	2,3	1,7	3,3
Coal	191,63	390,23	1,133,63	1,280,42	1,529,52	1,362,67	1,201,84	0,0	68,5	74,0	68,1	50,7	36,1	26,8	6,8	4,1	1,8	-1,1	-1,2	0,2
Oil	13,31	29,16	25,04	18,09	16,98	10,27	4,38	4,5	5,1	1,6	1,0	0,6	0,3	0,1	2,4	-10,3	-0,6	-4,9	-8,2	-5,1
Natural gas	9,96	55,96	70,89	93,40	196,38	265,03	288,80	3,4	9,8	4,6	5,0	6,5	7,0	6,4	7,5	9,6	7,7	3,0	0,9	4,3
Nuclear	6,14	16,90	38,35	59,69	172,72	295,93	350,05	2,1	3,0	2,5	3,2	5,7	7,8	7,8	7,0	15,9	11,2	5,5	1,7	6,9
Hydro	71,66	74,46	141,80	183,14	275,48	369,68	465,75	24,5	13,1	9,3	9,7	9,1	9,8	10,4	2,6	8,9	4,2	3,0	2,3	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	0,03	2,96	122,53	246,41	826,14	1,468,83	2,172,93	0,0	0,5	8,0	13,1	27,4	38,9	48,5	35,7	26,2	12,9	5,9	4,0	9,1

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	56,84	121,39	284,31	318,31	381,46	345,86	303,22	100	100	100	100	100	100	100	6,1	3,8	1,8	-1,0	-1,3	0,2
Coal	48,37	103,17	261,76	293,96	339,21	294,65	251,30	85,1	85,0	92,1	92,3	88,9	85,2	82,9	6,5	3,9	1,4	-1,4	-1,6	-0,1
Oil	5,01	8,96	8,31	5,87	5,26	3,07	1,30	8,8	7,4	2,9	1,8	1,4	0,9	0,4	1,9	-10,9	-1,1	-5,2	-8,3	-5,5
Natural gas	3,46	9,26	14,24	18,49	36,99	48,14	50,62	6,1	7,6	5,0	5,8	9,7	13,9	16,7	5,4	9,1	7,2	2,7	0,5	3,9

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050							1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	32.5	33.7	37.2	37.6	38.7	39.5	41.2							0.5	0.4	0.3	0.2	0.4	0.3	
Coal	34.1	32.5	37.2	37.6	38.8	39.8	41.1							0.3	0.3	0.3	0.3	0.3	0.3	
Oil	22.8	28.0	25.9	26.6	27.8	28.7	29.1							0.5	0.8	0.5	0.3	0.1	0.3	
Natural gas	24.7	52.0	42.8	43.5	45.7	47.3	49.1							2.1	0.5	0.5	0.4	0.4	0.4	

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	144.2	241.4	589.4	678.1	935.1	1,058.5	1,129.2	100	100	100	100	100	100	100	5.4	4.8	3.3	1.2	0.6	2.0
Coal	98.9	154.8	412.2	471.3	595.9	605.5	585.6	68.6	64.1	69.9	69.5	63.7	57.2	51.9	5.4	4.6	2.4	0.2	-0.3	1.1
Oil	41.8	76.8	157.0	179.0	280.5	378.3	466.1	29.0	31.8	26.6	26.4	30.0	35.7	41.3	5.0	4.5	4.6	3.0	2.1	3.4
Natural gas	3.6	9.9	20.2	27.8	58.7	74.7	77.5	2.5	4.1	3.4	4.1	6.3	7.1	6.9	6.6	11.2	7.8	2.4	0.4	4.2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	506	870	2.651	3.272	6.273	10.518	16.320	6,3	7,3	6,7	5,3	4,5	5,7
Population (millions of people)	870	1.053	1.339	1.381	1.504	1.593	1.640	1,6	1,0	0,9	0,6	0,3	0,6
GDP per capita (thousands of 2010 USD/person)	0,58	0,83	1,98	2,37	4,17	6,60	9,95	4,6	6,2	5,8	4,7	4,2	5,0
Primary energy consumption per capita (toe/person)	0,35	0,42	0,66	0,73	0,95	1,06	1,14	2,4	3,4	2,7	1,1	0,8	1,7
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	605	507	333	308	227	160	115	-2,2	-2,6	-3,0	-3,5	-3,3	-3,2
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	480	361	223	206	155	112	82	-2,8	-2,6	-2,8	-3,2	-3,1	-3,0
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	285	277	222	207	149	101	69	-0,9	-2,3	-3,2	-3,9	-3,7	-3,5
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,47	0,55	0,67	0,67	0,66	0,63	0,60	1,3	0,3	-0,3	-0,4	-0,4	-0,3
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Indonesia [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	101.63	141.20	234.96	255.77	355.33	493.71	676.37	100	100	100	100	100	100	100	3.2	2.9	3.3	3.3	3.2	3.3
Coal	4.04	13.14	57.05	63.32	80.67	114.03	144.93	4.0	9.3	24.3	24.8	22.7	23.1	21.4	10.3	3.5	2.5	3.5	2.4	2.9
Oil	40.32	53.70	86.24	91.68	135.68	197.82	291.01	39.7	38.0	36.7	35.8	38.2	40.1	43.0	2.9	2.1	4.0	3.8	3.9	3.8
Natural gas	18.47	27.95	25.61	33.38	50.69	76.57	117.01	18.2	19.8	10.9	13.0	14.3	15.5	17.3	1.2	9.2	4.3	4.2	4.3	4.7
Nuclear	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Hydro	0.49	0.86	1.60	1.73	3.31	4.67	6.20	0.5	0.6	0.7	0.7	0.9	0.9	0.9	4.5	2.7	6.7	3.5	2.9	4.2
Geothermal	0.97	2.28	10.98	11.08	24.41	35.24	46.52	1.0	1.6	4.7	4.3	6.9	7.1	6.9	9.4	0.3	8.2	3.7	2.8	4.5
Others	37.35	43.29	53.48	54.58	60.57	65.38	70.70	36.8	30.7	22.8	21.3	17.0	13.2	10.5	1.3	0.7	1.0	0.8	0.8	0.8
Biomass	37.35	43.29	49.60	49.60	51.18	49.52	45.65	36.8	30.7	21.1	19.4	14.4	10.0	6.7	1.1	0.0	0.3	-0.3	-0.8	-0.3
Solar, Wind, Ocean	-	-	0.01	0.00	0.48	0.77	1.03	0.0	0.0	0.0	0.0	0.1	0.2	0.2	-	-39.8	75.6	4.8	3.0	15.9
Biofuels	-	-	3.77	4.92	8.91	15.09	24.02	0.0	0.0	1.6	1.9	2.5	3.1	3.6	-	9.3	6.1	5.4	4.8	5.8
Electricity	-	-	0.10	0.06	0.00	0.00	0.00	0.0	0.0	0.04	0.02	0.0	0.0	0.0	-	-16.1	-100.0	-	-	-100.0

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	69.31	108.65	163.58	180.22	256.14	360.82	506.36	100	100	100	100	100	100	100	3.2	3.3	3.6	3.5	3.4	3.5
Industry	19.69	38.30	41.60	46.16	72.11	103.57	143.86	28.4	35.3	25.4	25.6	28.2	28.7	28.4	2.8	3.5	4.6	3.7	3.3	3.8
Transportation	7.14	14.10	43.72	51.66	88.75	145.35	226.48	10.3	13.0	26.7	28.7	34.6	40.3	44.7	6.9	5.7	5.6	5.1	4.5	5.1
Others	38.23	50.69	68.08	72.07	83.85	98.57	119.56	55.2	46.7	41.6	40.0	32.7	27.3	23.6	2.2	1.9	1.5	1.6	1.9	1.7
Non-energy	4.26	5.56	10.17	10.33	11.44	13.34	16.46	6.1	5.1	6.2	5.7	4.5	3.7	3.3	3.3	0.5	1.0	1.5	2.1	1.5
Total	69.31	108.65	163.58	180.22	256.14	360.82	506.36	100	100	100	100	100	100	100	3.2	3.3	3.6	3.5	3.4	3.5
Coal	1.44	5.07	8.25	9.43	14.26	20.38	27.52	2.1	4.7	5.0	5.2	5.6	5.6	5.4	6.7	4.6	4.2	3.6	3.0	3.7
Oil	22.54	37.60	65.08	74.28	117.41	181.70	274.78	32.5	34.6	39.8	41.2	45.8	50.4	54.3	4.0	4.5	4.7	4.5	4.2	4.5
Natural gas	5.60	15.82	17.89	20.52	33.62	47.82	65.50	8.1	14.6	10.9	11.4	13.1	13.3	12.9	4.4	4.7	5.1	3.6	3.2	4.0
Electricity	2.38	6.87	19.19	21.92	33.59	50.89	75.24	3.4	6.3	11.7	12.2	13.1	14.1	14.9	8.0	4.5	4.4	4.2	4.0	4.2
Heat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Others	37.35	43.29	53.17	54.06	57.26	60.04	63.32	53.9	39.8	32.5	30.0	22.4	16.6	12.5	1.3	0.6	0.6	0.5	0.5	0.5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	32.29	90.98	254.69	279.44	419.98	636.27	940.77	100	100	100	100	100	100	100	7.9	3.1	4.2	4.2	4.0	4.0
Coal	9.77	34.00	147.96	165.61	231.64	348.45	477.82	30	37	58	59	55	55	51	10.6	3.8	3.4	4.2	3.2	3.6
Oil	12.32	12.41	18.99	11.07	12.32	2.32	0.75	38	14	7	4	3	0	0	1.6	-16.5	1.1	-15.4	-10.7	-9.3
Natural gas	3.40	31.91	55.79	68.56	96.93	169.58	307.73	11	35	22	25	23	27	33	10.9	7.1	3.5	5.8	6.1	5.3
Nuclear	-	-	-	-	-	-	-	0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	5.67	10.02	18.63	20.15	38.44	54.36	72.12	18	11	7	7	9	9	8	4.5	2.7	6.7	3.5	2.9	4.2
Geothermal	1.13	2.65	12.76	12.89	28.39	40.98	54.09	3	3	5	5	7	6	6	9.4	0.3	8.2	3.7	2.8	4.5
Others	0.00	0.00	0.55	1.16	12.25	20.58	28.25	0	0	0	0	3	3	3	-	28.1	26.5	5.3	3.2	12.7

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	7.31	18.01	63.61	68.77	86.32	123.02	169.12	100	100	100	100	100	100	100	8.3	2.6	2.3	3.6	3.2	3.0
Coal	2.60	8.07	48.80	53.88	66.40	93.65	117.41	35.6	44.8	76.7	78.4	76.9	76.1	69.4	11.5	3.4	2.1	3.5	2.3	2.7
Oil	3.96	4.37	5.10	2.97	3.31	0.62	0.20	54.2	24.3	8.0	4.3	3.8	0.5	0.1	0.9	-16.5	1.1	-15.4	-10.7	-9.3
Natural gas	0.75	5.58	9.70	11.91	16.60	28.75	51.51	10.3	31.0	15.3	17.3	19.2	23.4	30.5	9.9	7.1	3.4	5.6	6.0	5.2

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	30.0	37.4	30.1	30.7	34.0	36.4	40.0								0.0	0.6	1.0	0.7	1.0	0.9
Coal	32.3	36.3	26	26	30	32	35								-0.8	0.5	1.3	0.6	0.9	0.9
Oil	26.8	24.4	32	32	32	32	32								0.7	0.0	0.0	0.0	0.0	0.0
Natural gas	39.0	49.2	49	50	50	51	51								0.9	0.0	0.1	0.1	0.1	0.1

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	40.2	70.6	127.2	142.5	206.6	307.2	438.5	100	100	100	100	100	100	100	4.4	3.9	3.8	4.0	3.6	3.8
Coal	4.43	14.41	60.4	67.0	85.4	120.7	153.4	11.0	20.4	47.5	47.0	41.3	39.3	35.0	10.2	3.5	2.5	3.5	2.4	2.9
Oil	23.92	38.30	51.3	56.9	91.7	141.1	215.7	59.5	54.2	40.3	39.9	44.4	45.9	49.2	2.9	3.5	4.9	4.4	4.3	4.5
Natural gas	11.83	17.90	15.6	18.6	29.5	45.4	69.4	29.4	25.4	12.2	13.1	14.3	14.8	15.8	1.0	6.2	4.7	4.4	4.3	4.6

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	309.8	453.4	1,090	1,220	2,038	3,304	5,131	4.8	3.8	5.3	4.9	4.5	4.8	
Population (millions of people)	178.6	208.9	264.6	272.1	294.1	311.6	324.3	1.5	0.9	0.8	0.6	0.4	0.6	
GDP per capita (thousands of 2010 USD/person)	1.7	2.2	4.1	4.5	6.9	10.6	15.8	3.3	2.8	4.5	4.3	4.1	4.2	
Primary energy consumption per capita (toe/person)	0.6	0.7	0.9	0.9	1.2	1.6	2.1	1.7	1.9	2.5	2.7	2.8	2.6	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	328	311	215	210	174	149	132	-1.5	-0.9	-1.8	-1.5	-1.2	-1.5	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	224	240	150	148	126	109	99	-1.5	-0.5	-1.6	-1.4	-1.0	-1.3	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	130	156	117	117	101	93	85	-0.4	0.1	-1.4	-0.9	-0.8	-0.9	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.40	0.50	0.54	0.56	0.58	0.62	0.65	1.2	1.0	0.4	0.7	0.4	0.5	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

Indonesia [APS5]

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	101,63	141,20	234,96	252,71	330,79	426,77	554,32	100	100	100	100	100	100	100	3,2	2,5	2,7	2,6	2,6	2,6		
Coal	4,04	13,14	57,05	61,51	67,98	78,25	86,47	4,0	9,3	24,3	24,3	20,6	18,3	15,6	10,3	2,5	1,0	1,4	1,0	1,3		
Oil	40,32	53,70	86,24	91,63	129,47	181,15	242,89	39,7	38,0	36,7	36,3	39,1	42,4	43,8	2,9	2,0	3,5	3,4	3,0	3,2		
Natural gas	18,47	27,95	25,61	32,71	47,77	68,49	91,89	18,2	19,8	10,9	12,9	14,4	16,0	16,6	1,2	8,5	3,9	3,7	3,0	3,9		
Nuclear	-	-	-	-	-	-	4,02	0,0	0,0	0,0	0,0	0,0	0,0	0,7	-	-	-	-	-	-		
Hydro	0,49	0,86	1,60	1,70	3,51	4,99	6,33	0,5	0,6	0,7	0,7	1,1	1,2	1,1	4,5	2,0	7,5	3,6	2,4	4,3		
Geothermal	0,97	2,28	10,98	10,91	22,89	31,19	56,99	1,0	1,6	4,7	4,3	6,9	7,3	10,3	9,4	-0,2	7,7	3,1	6,2	5,1		
Others	37,35	43,29	53,48	54,25	59,17	62,69	65,73	36,8	30,7	22,8	21,5	17,9	14,7	11,9	1,3	0,5	0,9	0,6	0,5	0,6		
Biomass	37,35	43,29	49,60	49,31	49,55	46,92	43,05	36,8	30,7	21,1	19,5	15,0	11,0	7,8	1,1	-0,2	0,0	-0,5	-0,9	-0,4		
Solar, Wind, Ocean	-	-	0,01	0,00	1,22	2,18	3,46	0,0	0,0	0,0	0,0	0,4	0,5	0,6	-	-36,9	90,0	6,0	4,7	20,2		
Biofuels	-	-	3,77	4,88	8,40	13,59	19,21	0,0	0,0	1,6	1,9	2,5	3,2	3,5	-	9,0	5,6	4,9	3,5	5,1		
Electricity	-	-	0,10	0,06	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-161,0	-100,0	-	-	-100,0		

Final energy demand

Final energy demand	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	69.31	108.65	163.58	178.95	243.05	327.00	421.79	100	100	100	100	100	100	100	3.2	3.0	3.1	3.0	2.6	2.9		
Industry	19.69	38.30	41.60	45.79	68.00	93.21	119.40	28.4	35.3	25.4	25.6	28.0	28.5	28.3	2.8	3.3	4.0	3.2	2.5	3.2		
Transportation	7.14	14.10	43.72	51.25	83.69	130.82	181.18	10.3	13.0	26.7	28.6	34.4	40.0	43.0	6.9	5.4	5.0	4.6	3.3	4.4		
Others	38.23	50.69	68.08	71.58	79.93	89.64	104.74	55.2	46.7	41.6	40.0	32.9	27.4	24.8	2.2	1.7	1.1	1.2	1.6	1.3		
Non-energy	4.26	5.56	10.17	10.33	11.44	13.34	16.46	6.1	5.1	6.2	5.8	4.7	4.1	3.9	3.3	0.5	1.0	1.5	2.1	1.5		
Total	69.31	108.65	163.58	178.95	243.05	327.00	421.79	100	100	100	100	100	100	100	3.2	3.0	3.1	3.0	2.6	2.9		
Coal	1.44	5.07	8.25	9.36	13.45	18.34	22.84	2.1	4.7	5.0	5.2	5.5	5.6	5.4	6.7	4.3	3.7	3.2	2.2	3.1		
Oil	22.54	37.60	65.08	73.78	111.53	165.12	226.70	32.5	34.6	39.8	41.2	45.9	50.5	53.7	4.0	4.3	4.2	4.0	3.2	3.9		
Natural gas	5.60	15.82	17.89	20.38	31.93	43.58	55.82	8.1	14.6	10.9	11.4	13.1	13.3	13.2	4.4	4.5	4.6	3.2	2.5	3.5		
Electricity	2.38	6.87	19.19	21.77	31.85	45.93	63.86	3.4	6.3	11.7	12.2	13.1	14.0	15.1	8.0	4.3	3.9	3.7	3.4	3.7		
Heat	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-		
Others	37.35	43.29	53.17	53.67	54.29	54.04	52.57	53.9	39.8	32.5	30.0	22.3	16.5	12.5	1.3	0.3	0.1	0.0	-0.3	0.0		

Power generation Output

Power generation Output	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	32.29	90.98	254.69	277.41	398.26	574.24	798.46	100	100	100	100	100	100	100	7.9	2.9	3.7	3.7	3.4	3.5
Coal	9.77	34.00	147.96	164.28	197.87	273.22	337.22	30.2	37.4	58.1	59.2	49.7	47.6	42.2	10.6	3.5	1.9	3.3	2.1	2.5
Oil	12.32	12.41	18.99	12.75	11.09	2.01	0.61	38.2	13.6	7.5	4.6	2.8	0.4	0.1	1.6	-12.4	-1.4	-15.7	-11.2	-9.9
Natural gas	3.40	31.91	55.79	66.57	93.46	155.55	230.70	10.5	35.1	21.9	24.0	23.5	27.1	28.9	10.9	6.1	3.5	5.2	4.0	4.4
Nuclear	-	-	-	-	-	-	15.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	-	-	-	-	-
Hydro	5.67	10.02	18.63	19.79	40.82	58.03	73.63	17.6	11.0	7.3	7.1	10.2	10.1	9.2	4.5	2.0	7.5	3.6	2.4	4.3
Geothermal	1.13	2.65	12.76	12.69	26.62	36.27	66.27	3.5	2.9	5.0	4.6	6.7	6.3	8.3	9.4	-0.2	7.7	3.1	6.2	5.1
Others	0.00	0.00	0.55	1.34	28.39	49.16	74.61	0.0	0.0	0.2	0.5	7.1	8.6	9.3	-	34.3	35.7	5.6	4.3	16.0

Power generation Input

Power generation input	MTOE																AAGR (%)				
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	7.31	18.01	63.61	66.95	72.87	85.36	99.86	100	100	100	100	100	100	100	8.3	1.7	0.9	1.6	1.6	1.4	
Coal	2.60	8.07	48.80	52.15	54.53	59.90	63.62	35.6	44.8	76.7	77.9	74.8	70.2	63.7	11.5	2.2	0.4	0.9	0.6	0.8	
Oil	3.96	4.37	5.10	3.43	2.98	0.54	0.16	54.2	24.3	8.0	5.1	4.1	0.6	0.2	0.9	-12.4	-1.4	-15.7	-11.2	-9.9	
Natural gas	0.75	5.58	9.70	11.38	15.36	24.92	36.07	10.3	31.0	15.3	17.0	21.1	29.2	36.1	9.9	5.5	3.0	5.0	3.8	4.1	

Thermal Efficiency

	%																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	30	37	30	31	36	43	49								0.0	1.3	1.3	2.0	1.2	1.5		
Coal	32	36	26	27	31	39	46								-0.8	1.3	1.4	2.3	1.5	1.7		
Oil	27	24	32	32	32	32	32								0.7	0.0	0.0	0.0	0.0	0.0		
Natural gas	39	49	49	50	52	54	55								0.9	0.6	0.4	0.3	0.2	0.3		

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	40.2	70.6	127.2	140.1	186.3	250.7	321.8	100	100	100	100	100	100	100	4.4	3.3	2.9	3.0	2.5	2.9
Coal	4.43	14.41	60.37	65.1	71.9	82.8	91.5	11.0	20.4	47.5	46.4	38.6	33.0	28.4	10.2	2.5	1.0	1.4	1.0	1.3
Oil	23.92	38.30	51.27	56.9	86.7	127.6	176.9	59.5	54.2	40.3	40.6	46.5	50.9	55.0	2.9	3.5	4.3	3.9	3.3	3.8
Natural gas	11.83	17.90	15.56	18.2	27.7	40.2	53.4	29.4	25.4	12.2	13.0	14.9	16.1	16.6	1.0	5.4	4.3	3.8	2.9	3.8

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	310	453	1,090	1,220	2,038	3,304	5,131	4.8	3.8	5.3	4.9	4.5	4.8	
Population (millions of people)	179	209	265	272	294	312	324	1.5	0.9	0.8	0.6	0.4	0.6	
GDP per capita (thousands of 2010 USD/person)	1.7	2.2	4.1	4.5	6.9	10.6	15.8	3.3	2.8	4.5	4.3	4.1	4.2	
Primary energy consumption per capita (toe/person)	0.6	0.7	0.9	0.9	1.1	1.4	1.7	1.7	1.5	1.9	2.0	2.2	2.0	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	328	311	215	207	162	129	108	-1.5	-1.3	-2.4	-2.3	-1.8	-2.1	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	224	240	150	147	119	99	82	-1.5	-0.7	-2.1	-1.8	-1.8	-1.8	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	130	156	117	115	91	76	63	-0.4	-0.5	-2.3	-1.8	-1.9	-1.9	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.40	0.50	0.54	0.55	0.56	0.59	0.58	1.2	0.8	0.2	0.4	-0.1	0.2	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

JPN [BAU]

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	438,66	518,17	432,03	428,51	408,32	378,39	346,63	100	100	100	100	100	100	100	-0,1	-0,3	-0,5	-0,8	-0,9	-0,7	
Coal	76,70	97,01	116,48	108,97	98,76	91,10	78,59	17,5	18,7	27,0	25,4	24,2	24,1	22,7	1,6	-2,2	-1,0	-0,8	-1,5	-1,2	
Oil	250,26	255,02	175,99	166,43	142,28	121,76	104,64	57,1	49,2	40,7	38,8	34,8	32,2	30,2	-1,3	-1,8	-1,6	-1,5	-1,5	-1,6	
Natural gas	44,12	65,63	100,90	94,93	87,76	82,08	72,48	10,1	12,7	23,4	22,2	21,5	21,7	20,9	3,1	-2,0	-0,8	-0,7	-1,2	-1,0	
Nuclear	52,70	83,91	8,58	24,62	39,63	36,76	36,66	12,0	16,2	2,0	5,7	9,7	9,7	10,6	-6,5	42,1	4,9	-0,7	0,0	4,5	
Hydro	7,56	7,23	7,12	6,99	7,28	7,41	7,44	1,7	1,4	1,6	1,6	1,8	2,0	2,1	-0,2	-0,6	0,4	0,2	0,0	0,1	
Geothermal	1,58	3,10	2,24	2,89	5,27	8,41	10,85	0,4	0,6	0,5	0,7	1,3	2,2	3,1	1,3	8,8	6,2	4,8	2,6	4,9	
Others	5,74	6,27	20,73	23,69	27,33	30,88	35,98	1,3	1,2	4,8	5,5	6,7	8,2	10,4	4,9	4,5	1,4	1,2	1,5	1,7	
Biomass	4,57	5,43	15,21	17,12	18,57	19,48	19,79	1,0	1,0	3,5	4,0	4,5	5,1	5,7	4,6	4,0	0,8	0,5	0,2	0,8	
Solar, Wind, Ocean	1,17	0,85	5,52	6,56	8,75	11,40	16,19	0,3	0,2	1,3	1,5	2,1	3,0	4,7	5,9	5,9	2,9	2,7	3,6	3,3	
Biofuels	0,00	0,00	0,42	0,44	0,44	0,44	0,44	0,0	0,0	0,1	0,1	0,1	0,1	0,1	-	1,3	0,0	0,0	0,0	0,1	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	287,34	332,41	292,80	286,17	266,06	244,63	224,22	100	100	100	100	100	100	100	0,1	-0,8	-0,7	-0,8	-0,9	-0,8
Industry	108,30	103,68	86,38	85,14	79,63	72,66	64,51	37,7	31,2	29,5	29,8	29,9	29,7	28,8	-0,8	-0,5	-0,7	-0,9	-1,2	-0,9
Transportation	68,37	85,66	70,75	67,52	58,31	50,51	44,42	23,8	25,8	24,2	23,6	21,9	20,6	19,8	0,1	-1,5	-1,5	-1,4	-1,3	-1,4
Others	77,71	107,24	101,05	99,62	95,33	89,75	84,76	27,0	32,3	34,5	34,8	35,8	36,7	37,8	1,0	-0,5	-0,4	-0,6	-0,6	-0,5
Non-energy	32,96	35,82	34,62	33,89	32,79	31,71	30,52	11,5	10,8	11,8	11,8	12,3	13,0	13,6	0,2	-0,7	-0,3	-0,3	-0,4	-0,4
Total	287,34	332,41	292,80	286,17	266,06	244,63	224,22	100	100	100	100	100	100	100	0,1	-0,8	-0,7	-0,8	-0,9	-0,8
Coal	27,26	21,02	21,75	21,22	18,79	16,29	13,51	9,5	6,3	7,4	7,4	7,1	6,7	6,0	-0,8	-0,8	-1,2	-1,4	-1,9	-1,4
Oil	176,57	201,54	151,07	144,01	125,46	108,88	95,25	61,5	60,6	51,6	50,3	47,2	44,5	42,5	-0,6	-1,6	-1,4	-1,4	-1,3	-1,4
Natural gas	13,64	21,35	29,99	30,68	31,16	28,90	25,99	4,7	6,4	10,2	10,7	11,7	11,8	11,6	3,0	0,8	0,2	-0,7	-1,1	-0,4
Electricity	65,76	83,64	82,88	83,07	83,88	84,40	83,92	22,9	25,2	28,3	29,0	31,5	34,5	37,4	0,9	0,1	0,1	0,1	-0,1	0,0
Heat	0,20	0,54	0,54	0,51	0,44	0,38	0,31	0,1	0,2	0,2	0,2	0,2	0,2	0,1	3,7	-1,6	-1,4	-1,6	-1,9	-1,6
Others	3,90	4,33	6,58	6,68	6,32	5,78	5,24	1,4	1,3	2,2	2,3	2,4	2,4	2,3	2,0	0,5	-0,5	-0,9	-1,0	-0,7

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	861,54	1,055,05	1,061,02	1,063,22	1,072,36	1,077,04	1,068,73	100	100	100	100	100	100	100	0,8	0,1	0,1	0,0	-0,1	0,0
Coal	122,69	222,61	351,83	320,24	289,59	283,79	256,46	14,2	21,1	33,2	30,1	27,0	26,3	24,0	4,0	-3,1	-1,0	-0,2	-1,0	-1,0
Oil	250,18	134,28	69,93	57,56	34,39	17,36	1,74	29,0	12,7	6,6	5,4	3,2	1,6	0,2	-4,6	-6,3	-5,0	-6,6	-20,6	-10,6
Natural gas	168,45	258,32	398,14	361,79	325,40	317,27	285,33	19,6	24,5	37,5	34,0	30,3	29,5	26,7	3,2	-3,1	-1,1	-0,3	-1,1	-1,0
Nuclear	202,27	322,05	32,91	94,51	152,10	141,09	140,70	23,5	30,5	3,1	8,9	14,2	13,1	13,2	-6,5	42,1	4,9	-0,7	0,0	4,5
Hydro	87,90	84,05	82,85	81,29	84,65	86,14	86,51	10,2	8,0	7,8	7,6	7,9	8,0	8,1	-0,2	-0,6	0,4	0,2	0,0	0,1
Geothermal	1,74	3,35	2,46	3,22	6,01	9,69	12,54	0,2	0,3	0,2	0,3	0,6	0,9	1,2	1,3	9,4	6,4	4,9	2,6	5,1
Others	28,31	30,39	122,89	144,63	180,22	221,69	285,45	3,3	2,9	11,6	13,6	16,8	20,6	26,7	5,6	5,6	2,2	2,1	2,6	2,6

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	113,90	122,98	156,84	140,85	120,75	110,03	92,93	100	100	100	100	100	100	100	1,2	-3,5	-1,5	-0,9	-1,7	-1,6
Coal	27,03	46,66	72,41	65,39	58,02	54,18	46,81	23,7	37,9	46,2	46,4	48,1	49,2	50,4	3,7	-3,3	-1,2	-0,7	-1,5	-1,3
Oil	53,31	28,76	14,36	12,03	6,92	3,42	0,34	46,8	23,4	9,2	8,5	5,7	3,1	0,4	-4,7	-5,7	-5,4	-6,8	-20,7	-10,7
Natural gas	33,56	47,57	70,07	63,42	55,81	52,42	45,78	29,5	38,7	44,7	45,0	46,2	47,6	49,3	2,8	-3,3	-1,3	-0,6	-1,3	-1,3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	40,9	43,0	45,0	45,2	46,2	48,3	50,3								0,4	0,1	0,2	0,4	0,4	0,3
Coal	39,0	41,0	41,8	42,1	42,9	45,0	47,1								0,3	0,3	0,2	0,5	0,5	0,4
Oil	40,4	40,2	41,9	41,1	42,7	43,6	44,3								0,1	-0,6	0,4	0,2	0,1	0,2
Natural gas	43,2	46,7	48,9	49,1	50,1	52,0	53,6								0,5	0,1	0,2	0,4	0,3	0,3

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	285,3	312,1	306,1	288,8	259,9	234,8	202,4	100	100	100	100	100	100	100	0,3	-1,9	-1,0	-1,0	-1,5	-1,2
Coal	83,0	95,4	121,0	113,1	102,4	94,4	81,4	29,1	30,5	39,5	39,2	39,4	40,2	40,2	1,4	-2,2	-1,0	-0,8	-1,5	-1,2
Oil	17,7	17,1	11,0	10,5	7,6	7,0	5,7	6,2	5,1	3,6	3,6	3,3	3,0	2,8	-1,5	-2,2	-2,0	-2,0	-2,1	-2,0
Natural gas	30,4	44,4	64,9	61,1	56,4	52,8	46,6	10,7	14,2	21,2	21,1	21,7	22,5	23,0	2,8	-2,0	-0,8	-0,7	-1,2	-1,0

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	4.704	5.349	6.158	6.296	6.762	7.291	7.787	1,0	0,7	0,7	0,8	0,7	0,7	
Population (millions of people)	123,5	126,8	126,8	125,8	120,1	112,7	105,2	0,1	-0,3	-0,5	-0,6	-0,7	-0,6	
GDP per capita (thousands of 2010 USD/person)	38,07	42,17	48,57	50,07	56,32	64,69	74,01	0,9	1,0	1,2	1,4	1,4	1,3	
Primary energy consumption per capita (toe/person)	3,55	4,09	3,41	3,41	3,40	3,36	3,29	-0,2	0,0	0,0	-0,1	-0,2	-0,1	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	93	97	70	68	60	52	45	-1,0	-1,0	-1,2	-1,5	-1,5	-1,4	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	61	62	48	45	39	34	29	-0,9	-1,5	-1,4	-1,6	-1,5	-1,5	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	61	58	50	46	38	32	26	-0,7	-2,6	-1,8	-1,8	-2,1	-1,9	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,65	0,60	0,71	0,67	0,64	0,62	0,58	0,3	-1,7	-0,6	-0,3	-0,6	-0,6	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

JPN [APS]

Primary energy consumption

	MTOE																AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050			
Total	438,66	518,17	432,03	427,81	398,26	354,73	308,69	100	100	100	100	100	100	100	-0,1	-0,3	-0,7	-1,2	-1,4	-1,0			
Coal	76,70	97,01	116,48	107,81	87,97	65,64	39,36	17,5	18,7	27,0	25,2	22,1	18,5	12,7	1,6	-2,5	-2,0	-2,9	-5,0	-3,2			
Oil	250,26	255,02	175,99	164,81	133,71	109,81	91,54	57,1	49,2	40,7	38,5	33,6	31,0	29,7	-1,3	-2,2	-2,1	-1,9	-1,8	-2,0			
Natural gas	44,12	65,63	100,90	92,01	72,91	58,88	37,65	10,1	12,7	23,4	21,5	18,3	16,6	12,2	3,1	-3,0	-2,3	-2,1	-4,4	-2,9			
Nuclear	52,70	83,91	8,58	28,14	56,42	58,61	58,45	12,0	16,2	2,0	6,6	14,2	16,5	18,9	-6,5	48,6	7,2	0,4	0,0	6,0			
Hydro	7,56	7,23	7,12	7,14	7,77	8,04	8,11	1,7	1,4	1,6	1,7	2,0	2,3	2,6	-0,2	0,1	0,8	0,4	0,1	0,4			
Geothermal	1,58	3,10	2,24	3,59	6,51	10,86	15,66	0,4	0,6	0,5	0,8	1,6	3,1	5,1	1,3	17,0	6,1	5,2	3,7	6,1			
Others	5,74	6,27	20,73	24,29	32,97	42,89	57,92	1,3	1,2	4,8	5,7	8,3	12,1	18,8	4,9	5,4	3,1	2,7	3,0	3,2			
Biomass	4,57	5,43	15,21	17,13	21,34	23,70	25,26	1,0	1,0	3,5	4,0	5,4	6,7	8,2	4,6	4,0	2,2	1,1	0,6	1,5			
Solar, Wind, Ocean	1,17	0,85	5,52	7,16	11,63	19,19	32,66	0,3	0,2	1,3	1,7	2,9	5,4	10,6	5,9	9,0	5,0	5,1	5,5	5,5			
Biofuels	0,00	0,00	0,42	0,44	0,44	0,44	0,44	0,0	0,0	0,1	0,1	0,1	0,1	0,1	-	1,3	0,0	0,0	0,0	0,1			
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	287,34	332,41	292,80	285,13	255,88	225,99	199,99	100	100	100	100	100	100	100	0,1	-0,9	-1,1	-1,2	-1,2	-1,1		
Industry	108,30	103,68	86,38	85,04	78,30	69,08	58,91	37,7	31,2	29,5	29,8	30,6	30,6	29,5	-0,8	-0,5	-0,8	-1,2	-1,6	-1,2		
Transportation	68,37	85,66	70,75	66,91	53,22	42,79	36,27	23,8	25,8	24,2	23,5	20,8	18,9	18,1	0,1	-1,8	-2,3	-2,2	-1,6	-2,0		
Others	77,71	107,24	101,05	99,29	91,58	82,41	74,30	27,0	32,3	34,5	34,8	35,8	36,5	37,1	1,0	-0,6	-0,8	-1,0	-1,0	-0,9		
Non-energy	32,96	35,82	34,62	33,89	32,79	31,71	30,52	11,5	10,8	11,8	11,9	12,8	14,0	15,3	0,2	-0,7	-0,3	-0,3	-0,4	-0,4		
Total	287,34	332,41	292,80	285,13	255,88	225,99	199,99	100	100	100	100	100	100	100	0,1	-0,9	-1,1	-1,2	-1,2	-1,1		
Coal	27,26	21,02	21,75	20,98	17,41	14,13	10,97	9,5	6,3	7,4	7,4	6,8	6,3	5,5	-0,8	-1,2	-1,8	-2,1	-2,5	-2,1		
Oil	176,57	201,54	151,07	143,45	119,86	99,02	82,82	61,5	60,6	51,6	50,3	46,8	43,8	41,4	-0,6	-1,7	-1,8	-1,9	-1,8	-1,8		
Natural gas	13,64	21,35	29,99	30,67	30,05	26,42	22,60	4,7	6,4	10,2	10,8	11,7	11,7	11,3	3,0	0,7	-0,2	-1,3	-1,5	-0,9		
Electricity	65,76	83,64	82,88	82,89	82,06	80,44	77,49	22,9	25,2	28,3	29,1	32,1	35,6	38,7	0,9	0,0	-0,1	-0,2	-0,4	-0,2		
Heat	0,20	0,54	0,54	0,51	0,43	0,36	0,28	0,1	0,2	0,2	0,2	0,2	0,2	0,1	3,7	-1,5	-1,6	-1,9	-2,3	-1,9		
Others	3,90	4,33	6,58	6,63	6,07	5,62	5,84	1,4	1,3	2,2	2,3	2,4	2,5	2,9	2,0	0,3	-0,9	-0,8	0,4	-0,4		

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	861,54	1,055,05	1,061,02	1,060,93	1,048,83	1,026,16	986,96	100	100	100	100	100	100	100	0,8	0,0	-0,1	-0,2	-0,4	-0,2
Coal	122,69	222,61	351,83	316,29	243,37	162,56	60,30	14,2	21,1	33,2	29,8	23,2	15,8	6,1	4,0	-3,5	-2,6	-4,0	-9,4	-5,2
Oil	250,18	134,28	69,93	52,71	20,38	8,36	0,48	29,0	12,7	6,6	5,0	1,9	0,8	0,0	-4,6	-9,0	-9,1	-8,5	-24,8	-14,0
Natural gas	168,45	258,32	398,14	344,98	242,58	191,22	89,28	19,6	24,5	37,5	32,5	23,1	18,6	9,0	3,2	-4,7	-3,5	-2,4	-7,3	-4,4
Nuclear	202,27	322,05	32,91	108,01	216,54	224,93	224,32	23,5	30,5	3,1	10,2	20,6	21,9	22,7	-6,5	48,6	7,2	0,4	0,0	6,0
Hydro	87,90	84,05	82,85	83,07	90,33	93,55	94,35	10,2	8,0	7,8	7,8	8,6	9,1	9,6	-0,2	0,1	0,8	0,4	0,1	0,4
Geothermal	1,74	3,35	2,46	4,04	7,46	12,54	18,14	0,2	0,3	0,2	0,4	0,7	1,2	1,8	1,3	18,0	6,3	5,3	3,8	6,2
Others	28,31	30,39	122,89	151,84	228,17	333,00	500,09	3,3	2,9	11,6	14,3	21,8	32,5	50,7	5,6	7,3	4,2	3,9	4,2	4,3

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	113,90	122,98	156,84	136,16	95,41	65,13	25,64	100	100	100	100	100	100	100	1,2	-4,6	-3,5	-3,7	-8,9	-5,3
Coal	27,03	46,66	72,41	64,62	49,23	31,86	11,33	23,7	37,9	46,2	47,5	51,6	48,9	44,2	3,7	-3,7	-2,7	-4,3	-9,8	-5,5
Oil	53,31	28,76	14,36	11,02	4,16	1,66	0,09	46,8	23,4	9,2	8,1	4,4	2,5	0,4	-4,7	-8,4	-9,3	-8,8	-25,0	-14,2
Natural gas	33,56	47,57	70,07	60,52	42,02	31,61	14,22	29,5	38,7	44,7	44,4	44,0	48,5	55,4	2,8	-4,8	-3,6	-2,8	-7,7	-4,7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	40,9	43,0	45,0	45,1	45,6	47,8	50,3								0,4	0,1	0,1	0,5	0,5	0,3
Coal	39,0	41,0	41,8	42,1	42,9	45,0	47,1								0,3	0,3	0,2	0,5	0,5	0,4
Oil	40,4	40,2	41,9	41,1	42,1	43,4	44,3								0,1	-0,6	0,2	0,3	0,2	0,2
Natural gas	43,2	46,7	48,9	49,0	49,6	52,0	54,0								0,5	0,1	0,1	0,5	0,4	0,3

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	285,3	312,1	306,1	284,4	232,1	183,9	129,6	100	100	100	100	100	100	100	0,3	-2,4	-2,0	-2,3	-3,4	-2,6		
Coal	83,0	95,4	121,0	111,9	91,4	68,1	40,7	29,1	30,5	39,5	39,4	39,4	37,0	31,4	1,4	-2,6	-2,0	-2,9	-5,0	-3,2		
Oil	171,7	172,1	113,0	104,3	79,4	60,8	47,4	60,2	55,1	36,9	36,7	34,2	33,0	36,6	-1,5	-2,6	-2,7	-2,6	-2,5	-2,6		
Natural gas	30,4	44,4	64,9	59,2	47,0	38,0	24,4	10,7	14,2	21,2	20,8	20,2	20,6	18,8	2,8	-3,0	-2,3	-2,1	-4,3	-2,9		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	4.704	5.349	6.158	6.296	6.762	7.291	7.787	1,0	0,7	0,7	0,8	0,7	0,71
Population (millions of people)	123,5	126,8	126,8	125,8	120,1	112,7	105,2	0,1	-0,3	-0,5	-0,6	-0,7	-0,56
GDP per capita (thousands of 2010 USD/person)	38,07	42,17	48,57	50,07	56,32	64,69	74,01	0,9	1,0	1,2	1,4	1,4	1,3
Primary energy consumption per capita (toe/person)	3,55	4,09	3,41	3,40	3,32	3,15	2,93	-0,2	-0,1	-0,3	-0,5	-0,7	-0,5
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	93	97	70	68	59	49	40	-1,0	-1,1	-1,4	-1,9	-2,0	-1,7
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	61	62	48	45	38	31	26	-0,9	-1,6	-1,8	-2,0	-1,9	-1,8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	61	58	50	45	34	25	17	-0,7	-3,1	-2,7	-3,0	-4,1	-3,3
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,65	0,60	0,71	0,66	0,58	0,52	0,42	0,3	-2,1	-1,3	-1,2	-2,1	-1,6
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

KOR [BAU]

Primary energy consumption

	MTOE															AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040	
Total	92.91	188.16	282.25	298.41	325.34	330.52	315.72	100	100	100	100	100	100	100	4.2	1.9	0.9	0.2	-0.5	0.3	0.7	
Coal	25.38	41.95	82.60	82.44	97.05	98.38	91.71	27.3	22.3	29.3	27.6	29.8	29.8	29.0	4.5	-0.1	1.6	0.1	-0.7	0.3	0.8	
Oil	49.73	99.04	109.10	112.12	120.09	118.60	110.63	53.5	52.6	38.7	37.6	36.9	35.9	35.0	3.0	0.9	0.7	-0.1	-0.7	0.0	0.4	
Natural gas	2.73	17.01	43.21	46.43	62.60	71.62	75.66	2.9	9.0	15.3	15.6	19.2	21.7	24.0	10.8	2.4	3.0	1.4	0.6	1.7	2.2	
Nuclear	13.78	28.39	38.67	47.33	31.69	24.55	17.28	14.8	15.1	13.7	15.9	9.7	7.4	5.5	3.9	7.0	-3.9	-2.5	-3.4	-2.4	-2.0	
Hydro	0.55	0.34	0.24	0.30	0.30	0.30	0.30	0.6	0.2	0.1	0.1	0.1	0.1	0.1	-3.0	7.4	0.0	0.0	0.0	0.6	0.9	
Geothermal	0.00	0.00	0.18	0.20	0.23	0.23	0.23	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	3.4	1.1	0.2	-0.3	0.6	1.0	
Others	0.74	1.42	8.19	9.54	13.32	16.77	19.85	0.8	0.8	2.9	3.2	4.1	5.1	6.3	9.3	5.2	3.4	2.3	1.7	2.7	3.2	
Biomass	0.73	1.38	7.19	8.13	9.40	9.81	9.55	0.8	0.7	2.5	2.7	2.9	3.0	3.0	8.8	4.2	1.5	0.4	-0.3	0.9	1.4	
Solar, Wind, Ocean	0.01	0.04	1.00	1.42	3.92	6.96	10.30	0.0	0.0	0.4	0.5	1.2	2.1	3.3	18.6	12.2	10.7	5.9	4.0	7.3	8.8	
Biofuels	0.00	0.00	0.53	0.50	0.50	0.50	0.50	0.0	0.0	0.2	0.2	0.2	0.1	0.2	-	-2.1	0.0	0.0	0.0	-0.2	-0.3	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	64.91	127.11	183.15	192.85	215.17	222.04	215.83	100	100	100	100	100	100	100	3.9	1.7	1.1	0.3	-0.3	0.5	0.8
Industry	19.26	38.47	48.39	50.90	58.96	61.93	59.91	29.7	30.3	26.4	26.4	27.4	27.9	27.8	3.5	1.7	1.5	0.5	-0.3	0.6	1.1
Transportation	14.57	26.27	35.62	36.69	39.07	36.51	30.95	22.5	20.7	19.5	19.0	18.2	16.4	14.3	3.4	1.0	0.6	-0.7	-1.6	-0.4	0.1
Others	24.35	37.34	46.63	50.07	54.98	56.88	56.41	37.5	29.4	25.5	26.0	25.6	25.6	26.1	2.4	2.4	0.9	0.3	-0.1	0.6	0.9
Non-energy	6.73	25.03	52.51	55.20	62.16	66.72	68.57	10.4	19.7	28.7	28.6	28.9	30.1	31.8	7.9	1.7	1.2	0.7	0.3	0.8	1.0
Total	64.91	127.11	183.15	192.85	215.17	222.04	215.83	100	100	100	100	100	100	100	3.9	1.7	1.1	0.3	-0.3	0.5	0.8
Coal	11.72	9.07	8.60	8.88	9.65	9.85	9.38	18.1	7.1	4.7	4.6	4.5	4.4	4.3	-1.1	1.1	0.8	0.2	-0.5	0.3	0.6
Oil	43.66	79.88	97.34	100.56	107.38	106.20	99.46	67.3	62.8	53.1	52.1	49.9	47.8	46.1	3.0	1.1	0.7	-0.1	-0.7	0.1	0.4
Natural gas	0.67	10.93	22.17	24.35	29.68	31.96	32.18	1.0	8.6	12.1	12.6	13.8	14.4	14.9	13.8	3.2	2.0	0.7	0.1	1.1	1.6
Electricity	8.12	22.62	44.99	48.28	56.69	61.95	63.06	12.5	17.8	24.6	25.0	26.3	27.9	29.2	6.5	2.4	1.6	0.9	0.2	1.0	1.4
Heat	0.00	3.29	5.08	5.28	5.73	5.90	5.80	0.0	2.6	2.8	2.7	2.7	2.7	2.7	-	1.3	0.8	0.3	-0.2	0.4	0.6
Others	0.74	1.32	4.97	5.51	6.03	6.19	5.95	1.1	1.0	2.7	2.9	2.8	2.8	2.8	7.3	3.5	0.9	0.3	-0.4	0.5	1.0

Power generation Output

	TWh																AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040		
Total	105.37	288.53	562.69	604.98	712.87	779.19	791.58	100	100	100	100	100	100	100	6.4	2.4	1.7	0.9	0.2	1.0	1.4		
Coal	17.66	111.40	255.51	250.63	312.84	319.87	293.80	16.8	38.6	45.4	41.4	43.9	41.1	37.1	10.4	-0.6	2.2	0.2	-0.8	0.4	1.0		
Oil	18.86	34.58	11.80	10.75	9.66	5.41	0.12	17.9	12.0	2.1	1.8	1.4	0.7	0.0	-1.7	-3.0	-1.1	-5.6	-31.7	-13.0	-3.3		
Natural gas	9.60	29.46	125.95	132.52	206.79	260.66	292.78	9.1	10.2	22.4	21.9	29.0	33.5	37.0	10.0	1.7	4.5	2.3	1.2	2.6	3.2		
Nuclear	52.89	108.96	148.43	181.64	121.61	94.23	66.33	50.2	37.8	26.4	30.0	17.1	12.1	8.4	3.9	7.0	-3.9	-2.5	-3.4	-2.4	-2.0		
Hydro	6.36	4.01	2.82	3.49	3.49	3.49	3.49	6.0	1.4	0.5	0.6	0.5	0.4	0.4	-3.0	7.4	0.0	0.0	0.0	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	18.20	25.89	58.48	95.52	135.06	0.0	0.0	3.2	4.3	8.2	12.3	17.1	43.8	12.5	8.5	5.0	3.5	6.3	7.5		

Power generation Input

	MTOE																AAGR (%)							
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040			
Total	12.52	40.44	83.87	83.08	103.66	107.05	100.94	100	100	100	100	100	100	100	7.3	-0.3	2.2	0.3	-0.6	0.6	1.1			
Coal	5.98	27.06	59.56	58.18	68.01	65.63	56.98	47.7	66.9	71.0	70.0	65.6	61.3	56.5	8.9	-0.8	1.6	-0.4	-1.4	-0.1	0.4			
Oil	4.51	7.63	2.95	2.49	2.28	1.31	0.03	36.0	18.9	3.5	3.0	2.2	1.2	0.0	-1.6	-5.6	-0.8	-5.4	-31.6	-13.0	-3.5			
Natural gas	2.04	5.76	21.36	22.42	33.36	40.11	43.93	16.3	14.2	25.5	27.0	32.2	37.5	43.5	9.1	1.6	4.1	1.9	0.9	2.2	2.8			

Thermal Efficiency

	%														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	31.7	37.3	40.3	40.8	43.9	47.1	50.0								0.9	0.4	0.7	0.7	0.6	0.7	0.7
Coal	25.4	35.4	36.9	37.0	39.6	41.9	44.3								1.4	0.1	0.7	0.6	0.6	0.6	0.6
Oil	35.9	39.0	34.4	37.2	36.4	35.6	35.1								-0.2	2.7	-0.2	-0.2	-0.1	0.1	0.2
Natural gas	40.5	44.0	50.7	50.9	53.3	55.9	57.3								0.8	0.1	0.5	0.5	0.3	0.4	0.4

CO₂ emissions

	Mt-C														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	56.7	108.5	158.0	160.3	186.4	189.1	177.6	100	100	100	100	100	100	100	3.9	0.5	1.5	0.1	-0.6	0.4	0.8
Coal	23.6	45.3	84.6	84.4	99.3	100.5	93.7	41.6	41.8	53.5	52.6	53.2	53.2	52.7	4.8	-0.1	1.6	0.1	-0.7	0.3	0.8
Oil	31.4	52.2	45.4	45.9	46.8	42.4	35.2	55.3	48.2	28.7	28.6	25.1	22.4	19.8	1.4	0.3	0.2	-1.0	-1.8	-0.8	-0.3
Natural gas	1.7	10.9	28.0	30.1	40.4	46.2	48.8	3.1	10.1	17.7	18.7	21.7	24.4	27.5	10.8	2.4	3.0	1.3	0.5	1.7	2.2

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
GDP (billions of 2010 US dollars)	363	710	1.346	1.457	1.830	2.135	2.300	5,0	2,7	2,3	1,6	0,7	1,6	2,0
Population (millions of people)	42,9	47,0	51,5	51,9	52,7	52,8	50,1	0,7	0,3	0,2	0,0	-0,5	-0,1	0,1
GDP per capita (thousands of 2010 USD/person)	8,46	15,10	26,15	28,09	34,70	40,45	45,92	4,3	2,4	2,1	1,5	1,3	1,7	1,9
Primary energy consumption per capita (toe/person)	2,17	4,00	5,48	5,75	6,17	6,26	6,30	3,5	1,6	0,7	0,1	0,1	0,4	0,6
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	256	265	210	205	178	155	137	-0,7	-0,8	-1,4	-1,4	-1,2	-1,3	-1,3
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	179	179	136	132	118	104	94	-1,0	-0,9	-1,2	-1,2	-1,0	-1,1	-1,2
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	156	153	117	110	102	89	77	-1,1	-2,2	-0,8	-1,4	-1,4	-1,3	-1,2
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,61	0,58	0,56	0,54	0,57	0,57	0,56	-0,3	-1,4	0,6	0,0	-0,2	0,0	0,1
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	92.91	188.16	282.25	293.10	298.44	274.84	239.04	100	100	100	100	100	100	100	4.2	1.3	0.2	-0.8	-1.4	-0.5	-0.1
Coal	25.38	41.95	82.60	79.52	72.21	61.97	45.85	27.3	22.3	29.3	27.1	24.2	22.5	19.2	4.5	-1.3	-1.0	-1.5	-3.0	-1.8	-1.2
Oil	49.73	99.04	109.10	111.06	112.17	104.39	91.96	53.5	52.6	38.7	37.9	37.6	38.0	38.5	3.0	0.6	0.1	-0.7	-1.3	-0.5	-0.2
Natural gas	2.73	17.01	43.21	44.73	49.95	50.34	43.40	2.9	9.0	15.3	15.3	16.7	18.3	18.2	10.8	1.2	1.1	0.1	-1.5	0.0	0.7
Nuclear	13.78	28.39	38.67	47.33	48.46	36.83	29.53	14.8	15.1	13.7	16.1	16.2	13.4	12.4	3.9	7.0	0.2	-2.7	-2.2	-0.8	-0.2
Hydro	0.55	0.34	0.24	0.30	0.30	0.30	0.30	0.6	0.2	0.1	0.1	0.1	0.1	0.1	-3.0	7.4	0.0	0.0	0.0	0.6	0.9
Geothermal	0.00	0.00	0.18	0.20	0.19	0.17	0.15	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	2.3	-0.1	-1.1	-1.7	-0.7	-0.2
Others	0.74	1.42	8.72	10.47	16.03	21.72	28.75	0.8	0.8	3.1	3.6	5.4	7.9	12.0	9.6	6.3	4.4	3.1	2.8	3.7	4.0
Biomass	0.73	1.38	7.19	8.29	10.41	12.00	14.39	0.8	0.7	2.5	2.5	2.8	3.5	4.4	6.0	8.8	4.9	2.3	1.4	1.8	2.1
Solar, Wind, Ocean	0.01	0.04	1.00	1.62	4.69	8.78	13.42	0.0	0.0	0.4	0.6	1.6	3.2	5.6	18.6	17.3	11.2	6.5	4.3	8.2	9.9
Biofuels	0.00	0.00	0.53	0.56	0.94	0.94	0.94	0.0	0.0	0.2	0.2	0.3	0.3	0.4	-	2.1	5.3	0.0	0.0	1.8	2.5
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	64.91	127.11	183.15	189.83	196.12	187.14	169.43	100	100	100	100	100	100	100	3.9	1.2	0.3	-0.5	-1.0	-0.2	0.1
Industry	19.26	38.47	48.30	50.56	55.50	54.30	48.58	29.7	30.3	26.4	26.6	28.3	29.0	28.7	3.5	1.5	0.9	-0.2	-1.1	0.0	0.5
Transportation	14.57	26.27	35.62	36.20	34.43	27.67	20.27	22.5	20.7	19.5	19.1	17.6	14.8	12.0	3.4	0.5	-0.5	-2.2	-3.1	-1.7	-1.1
Others	24.35	37.34	46.63	47.86	44.03	38.45	32.01	37.5	29.4	25.5	25.2	22.5	20.5	18.9	2.4	0.9	-0.8	-1.3	-1.8	-1.1	-0.8
Non-energy	6.73	25.03	52.51	55.20	62.16	66.72	68.57	10.4	19.7	28.7	29.1	31.7	35.7	40.5	7.9	1.7	1.2	0.7	0.3	0.8	1.0
Total	64.91	127.11	183.15	189.83	196.12	187.14	169.43	100	100	100	100	100	100	100	3.9	1.2	0.3	-0.5	-1.0	-0.2	0.1
Coal	11.72	9.07	8.60	8.60	7.85	6.96	5.81	18.1	7.1	4.7	4.5	4.0	3.7	3.4	-1.1	0.0	-0.9	-1.2	-1.8	-1.2	-0.9
Oil	43.66	79.88	97.34	99.72	101.08	94.33	83.63	67.3	62.8	53.1	52.5	51.5	50.4	49.4	3.0	0.8	0.1	-0.7	-1.2	-0.5	-0.1
Natural gas	0.67	10.93	22.17	23.55	24.84	23.08	20.07	1.0	8.6	12.1	12.4	12.7	12.3	11.8	13.8	2.0	0.5	-0.7	-1.4	-0.3	0.2
Electricity	8.12	22.62	44.99	47.29	50.95	50.85	46.68	12.5	17.8	24.6	24.9	26.0	27.2	27.6	6.5	1.7	0.7	0.0	-0.9	0.1	0.5
Heat	0.00	3.29	5.08	5.14	4.99	4.56	3.98	0.0	2.6	2.8	2.7	2.5	2.4	2.3	-	0.4	-0.3	-0.9	-1.4	-0.7	-0.5
Others	0.74	1.32	4.97	5.52	6.42	7.36	9.26	1.1	1.0	2.7	2.9	3.3	3.9	5.5	7.3	3.6	1.5	1.4	2.3	1.9	1.7

Power generation Output

	TWh														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	105.37	288.53	562.69	592.09	637.66	634.10	578.62	100	100	100	100	100	100	100	6.4	1.7	0.7	-0.1	-0.9	0.1	0.5
Coal	17.66	111.40	255.51	240.56	212.45	179.04	116.47	16.8	38.6	45.4	40.6	33.3	28.2	20.1	10.4	-2.0	-1.2	-1.7	-4.2	-2.4	-1.5
Oil	18.86	34.58	11.80	10.32	6.91	3.40	0.06	17.9	12.0	2.1	1.7	1.1	0.5	0.0	-1.7	-4.4	-3.9	-6.8	-33.5	-14.9	-5.3
Natural gas	9.60	29.46	125.95	127.25	159.30	186.02	167.01	9.1	10.2	22.4	21.5	25.0	29.3	28.9	10.0	0.3	2.3	1.6	-1.1	0.9	1.7
Nuclear	52.89	108.96	148.43	181.64	185.98	141.35	113.32	50.2	37.8	26.4	30.7	29.2	22.3	19.6	3.9	7.0	0.2	-2.7	-2.2	-0.8	-0.2
Hydro	6.36	4.01	2.82	3.49	3.49	3.49	3.49	6.0	1.4	0.5	0.6	0.5	0.6	0.6	-3.0	7.4	0.0	0.0	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	18.20	28.84	69.52	120.80	178.26	0.0	0.0	3.2	4.9	10.9	19.1	30.8	43.8	16.6	9.2	5.7	4.0	7.2	8.6

Power generation Input

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	12.52	40.44	83.87	79.74	75.00	66.23	46.69	100	100	100	100	100	100	100	7.3	-1.7	-0.6	-1.2	-3.4	-1.8	-1.0
Coal	5.98	27.06	59.56	55.84	47.81	37.70	22.89	47.7	66.9	71.0	70.0	63.7	56.9	49.0	8.9	-2.1	-1.5	-2.3	-4.9	-2.9	-2.0
Oil	4.51	7.63	2.95	2.39	1.63	0.82	0.01	36.0	18.9	3.5	3.0	2.2	1.2	0.0	-1.6	-6.8	-3.8	-6.6	-33.4	-14.9	-5.4
Natural gas	2.04	5.76	21.36	21.52	25.56	27.71	23.79	16.3	14.2	25.5	27.0	34.1	41.8	51.0	9.1	0.3	1.7	0.8	-1.5	0.3	1.1

Thermal Efficiency

	%														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	31.7	37.3	49.3	40.8	43.4	47.8	52.2								0.9	0.4	0.6	1.0	0.9	0.8	0.7
Coal	25.4	35.4	36.9	25.4	35.4	36.9	37.1								1.4	-11.6	3.4	0.4	0.0	0.0	0.0
Oil	35.9	39.0	34.4	37.2	36.6	35.7	35.1								-0.2	2.7	-0.2	-0.2	-0.2	0.1	0.2
Natural gas	40.5	44.0	50.7	50.9	53.6	57.7	60.4								0.8	0.1	0.5	0.7	0.4	0.5	0.6

CO₂ emissions

	Mt-C														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
Total	56.7	108.5	158.0	155.5	147.3	128.8	99.0	100	100	100	100	100	100	100	3.9	-0.5	-0.5	-1.3	-2.6	-1.4	-0.9
Coal	23.6	45.3	84.6	81.4	74.0	63.6	47.1	41.6	41.8	53.5	52.4	50.3	49.4	47.6	4.8	-1.3	-0.9	-1.5	-3.0	-1.8	-1.2
Oil	31.4	52.2	45.4	45.1	40.9	32.6	23.8	55.3	48.2	28.7	29.0	27.8	25.3	24.1	1.4	-0.3	-1.0	-2.2	-3.1	-1.9	-1.4
Natural gas	1.7	10.9	28.0	29.0	32.3	32.6	28.1	3.1	10.1	17.7	18.6	21.9	25.3	28.4	10.8	1.1	1.1	0.1	-1.5	0.0	0.7

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	2017-2040
GDP (billions of 2010 US dollars)	363	710	1,346	1,457	1,830	2,135	2,300	5,0	2,7	2,3	1,6	0,7	1,6	2,0
Population (millions of people)	42,9	47,0	51,5	51,9	52,7	52,8	50,1	0,7	0,3	0,2	0,0	-0,5	-0,08	0,1
GDP per capita (thousands of 2010 USD/person)	8,46	15,10	26,15	28,09	34,70	40,45	45,92	4,3	2,4	2,1	1,5	1,3	1,7	1,9
Primary energy consumption per capita (toe/person)	2,17	4,00	5,48	5,65	5,66	5,21	4,77	3,5	1,0	0,0	-0,8	-0,9	-0,4	-0,2
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	256	265	210	201	163	129	104	-0,7	-1,4	-2,1	-2,3	-2,1	-2,1	-2,1
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	179	179	136	130	107	88	74	-1,0	-1,4	-1,9	-2,0	-1,7	-1,8	-1,9
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	156	153	117	107	80	60	43	-1,1	-3,1	-2,8	-2,8	-3,3	-3,0	-2,9
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,61	0,58	0,56	0,53	0,49	0,47	0,41	-0,3	-1,8	-0,7	-0,5	-1,2	-0,9	-0,8
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

LAO PDR [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	1,62	6,38	6,43	10,28	12,16	16,91	-	100	100	100	100	100	100	-	0,4	4,8	1,7	3,4	3,1
Coal		0,01	4,46	4,10	6,81	6,37	8,09	0,0	0,6	69,9	63,8	66,2	52,4	47,8	-	-4,1	5,2	-0,7	2,4	1,9
Oil		0,27	1,09	1,22	2,06	3,23	5,06	0,0	16,8	17,1	19,0	20,1	26,6	29,9	-	6,0	5,4	4,6	4,6	4,9
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	1,98	2,15	3,80	3,45	4,25	0,0	18,7	31,0	33,5	37,0	28,3	25,1	-	4,3	5,9	-1,0	2,1	2,4
Geothermal		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,00	1,04	-1,15	-1,05	-2,39	-0,89	-0,48	0,0	64,0	-18,0	-16,3	-23,3	-7,3	-2,8	-	-4,4	8,6	-9,4	-6,0	-2,7
Biomass		1,26	1,44	1,43	1,69	1,79	1,98	0,0	77,9	22,6	22,3	16,5	14,7	11,7	-	-0,3	1,7	0,5	1,1	1,0
Solar, Wind, Ocean			0,01	0,03	0,25	0,22	0,27	0,0	0,0	0,1	0,5	2,4	1,8	1,6	-	137,7	23,8	-1,0	2,1	13,2
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		-0,22	-2,60	-2,51	-4,33	-2,90	-2,73	0,0	-13,9	-40,70	-39,10	-42,1	-23,8	-16,2	-	-1,6	5,6	-3,9	-0,6	0,4

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	1,51	3,09	3,40	5,11	7,39	11,00	-	100	100	100	100	100	100	-	4,9	4,1	3,8	4,1	4,0
Industry		0,08	0,42	0,57	1,15	1,95	3,35	0,0	5,4	13,7	16,7	22,5	26,4	30,4	-	15,8	7,3	5,4	5,5	6,7
Transportation		0,25	1,01	1,14	1,94	2,97	4,54	0,0	16,8	32,8	33,5	37,9	40,2	41,2	-	6,0	5,4	4,4	4,3	4,8
Others		1,17	1,65	1,70	2,02	2,47	3,12	0,0	77,7	53,5	49,8	39,6	33,4	28,3	-	1,3	1,8	2,0	2,4	2,0
Non-energy	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	0,0	0,0	0,0	0,0	0,0
Total	0,00	1,51	3,09	3,40	5,11	7,39	11,00	-	100	100	100	100	100	100	-	4,9	4,1	3,8	4,1	4,0
Coal		0,01	0,11	0,13	0,26	0,47	0,85	0,0	0,6	3,6	3,8	5,0	6,4	7,7	-	7,2	7,2	6,2	6,0	6,5
Oil		0,27	1,09	1,22	2,06	3,23	5,06	0,0	17,9	35,2	35,9	40,4	43,7	46,0	-	6,0	5,4	4,6	4,6	4,9
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		0,06	0,47	0,65	1,33	2,12	3,38	0,0	3,6	15,1	19,1	26,0	28,6	30,7	-	17,9	7,4	4,7	4,8	6,4
Heat		0,00						-	-	-	-	-	-	-	-	-	-	-	-	-
Others		1,17	1,42	1,40	1,46	1,57	1,72	0,0	77,8	46,1	41,2	28,5	21,3	15,6	-	-0,7	0,4	0,8	0,9	0,6

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	3,51	36,76	37,92	68,21	61,67	75,94	-	100	100	100	100	100	100	-	1,6	6,0	-1,0	2,1	2,3
Coal			13,66	12,47	20,57	18,52	22,73	0	0	37	33	30	30	30	-	-4,4	5,1	-1,0	2,1	1,6
Oil								0	0	0	0	0	0	0	-	-	-	-	-	-
Natural gas								0	0	0	0	0	0	0	-	-	-	-	-	-
Nuclear								0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro		3,51	23,00	25,04	44,24	40,07	49,41	0	100	63	66	65	65	65	-	4,3	5,9	-1,0	2,1	2,4
Geothermal		0,00						0	0	0	0	0	0	0	-	-	-	-	-	-
Others		0,00	0,11	0,41	3,40	3,08	3,80	0	0	0	1	5	5	5	-	96,0	23,5	-1,0	2,1	11,8

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	0,00	4,35	3,97	6,55	5,90	7,24	-	-	100	100	100	100	100	-	-4,4	5,1	-1,0	2,1	1,6
Coal			4,35	3,97	6,55	5,90	7,24	0,0	0,0	100,0	100,0	100,0	100,0	100,0	-	-4,4	5,1	-1,0	2,1	1,6
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

Thermal Efficiency	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050							1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050	
Total	-	-	27,0	27,0	27,0	27,0	27,0							-	0,0	0,0	0,0	0,0	0,0	
Coal	-	-	27	27	27	27	27							-	0,0	0,0	0,0	0,0	0,0	
Oil	-	-	-	-	-	-	-							-	-	-	-	-	-	
Natural gas	-	-	-	-	-	-	-							-	-	-	-	-	-	

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,0	0,9	5,6	5,4	8,9	9,4	12,7	-	100	100	100	100	100	100	-	-2,4	5,2	0,6	3,1	2,6
Coal		0,04	4,7	4,3	7,2	6,7	8,6	0,0	4,3	84,0	81,1	80,9	71,6	67,2	-	-4,1	5,2	-0,7	2,4	1,9
Oil		0,81	0,9	1,0	1,7	2,7	4,2	0,0	95,7	16,0	18,9	19,1	28,4	32,8	-	5,9	5,4	4,6	4,6	4,9
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-					

Energy and economic indicators

								AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
GDP (billions of 2010 US dollars)		3,6	13	14	27	46	81	-	6,7	6,3	5,7	5,7	6,0
Population (millions of people)		5,3	7,1	7,3	8,4	9,8	11,4	-	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2010 USD/person)	-	0,7	1,8	2,0	3,2	4,7	7,1	-	5,2	4,8	4,1	4,1	4,4
Primary energy consumption per capita (toe/person)	-	0,3	0,9	0,9	1,2	1,2	1,5	-	-1,1	3,3	0,2	1,8	1,6
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	-	452	505	446	387	263	210	-	-6,0	-1,4	-3,8	-2,2	-2,7
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	-	421	245	236	192	160	137	-	-1,7	-2,1	-1,8	-1,6	-1,8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	-	238	445	372	335	203	158	-	-8,6	-1,0	-4,9	-2,5	-3,2
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	-	0,53	0,88	0,83	0,87	0,77	0,75	-	-2,8	0,4	-1,1	-0,3	-0,5
Automobile ownership volume (millions of vehicles)								-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

LAO PDR [APS5]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	1,62	6,38	6,18	8,30	9,32	11,90	-	100	100	100	100	100	100	-	-1,6	3,0	1,2	2,5	2,0
Coal		0,01	4,46	3,84	4,98	4,15	4,48	0,0	0,6	69,9	62,2	60,0	44,6	37,6	-	-7,2	2,6	-1,8	0,8	0,0
Oil		0,27	1,09	1,20	1,86	2,75	4,05	0,0	16,8	17,1	19,4	22,4	29,5	34,0	-	5,1	4,4	4,0	3,9	4,2
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	1,98	2,19	3,89	3,26	3,71	0,0	18,7	31,0	35,4	46,9	35,0	31,2	-	5,2	5,9	-1,8	1,3	2,0
Geothermal		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	0,00	1,04	-1,15	-1,05	-2,44	-0,84	-0,33	0,0	64,0	-18,0	-17,0	-29,3	-9,1	-2,8	-	-4,3	8,8	-10,1	-8,9	-3,8
Biomass		1,26	1,44	1,41	1,55	1,54	1,61	0,0	77,9	22,6	22,8	18,7	16,5	13,5	-	-1,1	0,9	-0,1	0,4	0,3
Solar, Wind, Ocean			0,01	0,05	0,35	0,52	0,80	0,0	0,0	0,1	0,8	4,2	5,5	6,7	-	213,6	21,1	4,1	4,4	17,1
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		-0,22	-2,60	-2,51	-4,33	-2,90	-2,73	0,0	-13,9	-40,7	-40,6	-52,2	-31,1	-23,0	-	-1,6	5,6	-3,9	-0,6	0,2

Final energy demand

Final energy demand	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	1,51	3,09	3,35	4,60	6,28	8,80	-	100	100	100	100	100	100	-	4,0	3,2	3,2	3,4	3,3
Industry		0,08	0,42	0,56	1,03	1,66	2,68	0,0	5,4	13,7	16,7	22,5	26,4	30,4	-	14,9	6,4	4,8	4,9	5,9
Transportation		0,25	1,01	1,12	1,74	2,53	3,63	0,0	16,8	32,8	33,5	37,9	40,2	41,2	-	5,1	4,5	3,8	3,7	4,1
Others		1,17	1,65	1,67	1,82	2,10	2,49	0,0	77,7	53,5	49,8	39,6	33,4	28,3	-	0,4	0,9	1,4	1,7	1,3
Non-energy		0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	0,0	0,0	0,0	0,0	0,0
Total	0,00	1,51	3,09	3,35	4,60	6,28	8,80	-	100	100	100	100	100	100	-	4,0	3,2	3,2	3,4	3,3
Coal		0,01	0,11	0,13	0,23	0,40	0,68	0,0	0,6	3,6	3,8	5,0	6,4	7,7	-	6,3	6,2	5,6	5,4	5,8
Oil		0,27	1,09	1,20	1,86	2,75	4,05	0,0	17,9	35,2	35,9	40,4	43,7	46,0	-	5,1	4,4	4,0	3,9	4,2
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Electricity		0,06	0,47	0,64	1,20	1,80	2,70	0,0	3,6	15,1	19,1	26,0	28,6	30,7	-	16,9	6,5	4,2	4,2	5,6
Heat		0,00						0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others		1,17	1,42	1,38	1,31	1,34	1,38	0,0	77,8	46,1	41,2	28,5	21,3	15,6	-	-1,6	-0,5	0,2	0,3	-0,1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	3,51	36,76	37,78	66,43	57,47	67,11	-	100	100	100	100	100	100	-	1,4	5,8	-1,4	1,6	1,9
Coal			13,66	11,67	16,57	13,08	14,15	0,0	0,0	37,1	30,9	25,0	22,8	21,1	-	-7,5	3,6	-2,3	0,8	0,1
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	23,00	25,44	45,28	37,92	43,16	0,0	100,0	62,6	67,3	68,2	66,0	64,3	-	5,2	5,9	-1,8	1,3	2,0
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	-	-	-	-	-	-
Others		0,00	0,11	0,66	4,58	6,47	9,80	0,0	0,0	0,3	1,8	6,9	11,3	14,6	-	149,0	21,3	3,5	4,2	15,2

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	0,00	0,00	4,35	3,72	4,75	3,75	3,80	-	-	100	100	100	100	100	-	-7,5	2,5	-2,3	0,1	-0,4
Coal			4,35	3,72	4,75	3,75	3,80	0,0	0,0	100,0	100,0	100,0	100,0	100,0	-	-7,5	2,5	-2,3	0,1	-0,4
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

Thermal Efficiency	%							AAGR (%)							AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
Total	-	-	27	27	30	30	32	-	-	-	-	-	-	-	-	0,0	1,1	0,0	0,6	0,5
Coal	-	-	27	27	30	30	32	-	-	-	-	-	-	-	-	0,0	1,1	0,0	0,6	0,5
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natural gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050		
Total	0,0	0,9	5,6	5,1	6,8	6,7	8,1	-	100	100	100	100	100	100	-	-5,1	3,0	-0,2	2,0	1,1		
Coal		0,04	4,7	4,1	5,3	4,4	4,7	0,0	4,3	84,0	80,4	77,4	65,9	58,6	-	-7,2	2,6	-1,8	0,8	0,0		
Oil		0,81	0,9	1,0	1,5	2,3	3,3	0,0	95,7	16,0	19,6	22,6	34,1	41,4	-	5,0	4,4	4,0	3,9	4,2		
Natural gas								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		

Energy and economic indicators

								AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2018	2018-2020	2020-2030	2030-2040	2040-2050	2018-2050
GDP (billions of 2010 US dollars)		4	13	14	27	46	81	-	6,7	6,3	5,7	5,7	6,0
Population (millions of people)		5	7	7	8	10	11	-	1,5	1,5	1,5	1,5	1,5
GDP per capita (thousands of 2010 USD/person)	-	0,7	1,8	2,0	3,2	4,7	7,1	-	5,2	4,8	4,1	4,1	4,4
Primary energy consumption per capita (toe/person)	-	0,3	0,9	0,8	1,0	1,0	1,0	-	-3,0	1,5	-0,3	1,0	0,5
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	-	452	505	429	312	201	148	-	-7,8	-3,1	-4,3	-3,0	-3,8
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	-	421	245	233	173	136	109	-	-2,5	-2,9	-2,4	-2,2	-2,5
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	-	238	445	352	256	144	100	-	-11,1	-3,1	-5,6	-3,5	-4,5
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	-	0,53	0,88	0,82	0,82	0,72	0,68	-	-3,6	0,0	-1,4	-0,5	-0,8
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Malaysia [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	18,84	47,89	81,57	90,95	133,47	184,59	237,25	100	100	100	100	100	100	100	5,6	3,7	3,9	3,3	2,5	3,3
Coal	1,36	2,31	19,48	19,87	26,40	37,88	48,70	7,2	4,8	23,9	21,8	19,8	20,5	20,5	10,4	0,7	2,9	3,7	2,5	2,8
Oil	10,43	21,09	29,23	35,22	51,54	67,39	84,18	55,4	44,0	35,8	38,7	38,6	36,5	35,5	3,9	6,4	3,9	2,7	2,2	3,3
Natural gas	6,71	23,89	30,43	31,77	51,05	74,80	99,80	35,6	49,9	37,3	34,9	38,2	40,5	42,1	5,8	1,4	4,9	3,9	2,9	3,7
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	-	-	-	-	-	-
Hydro	0,34	0,60	2,29	2,25	2,78	2,78	2,78	1,8	1,3	2,8	2,5	2,1	1,5	1,2	7,3	-0,5	2,1	0,0	0,0	0,6
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	0,00	0,15	1,84	1,69	1,74	1,79	0,0	0,0	0,2	2,0	1,3	0,9	0,8	-	129,4	-0,8	0,3	0,3	7,7
Biomass	0,00	0,00	0,23	1,17	1,17	1,17	1,17	0,0	0,0	0,3	1,3	0,9	0,6	0,5	-	71,3	0,0	0,0	0,0	5,0
Solar, Wind, Ocean	0,00	0,00	0,03	0,06	0,06	0,06	0,06	0,0	0,0	0,0	0,1	0,0	0,0	0,0	-	24,7	0,0	0,0	0,0	2,0
Biofuels	0,00	0,00	0,38	0,39	0,43	0,48	0,53	0,0	0,0	0,5	0,4	0,3	0,3	0,2	-	1,0	1,0	1,0	1,0	1,0
Electricity	0,00	0,00	-0,49	0,23	0,04	0,04	0,04	0,0	0,0	-0,6	0,2	0,0	0,0	0,0	-	-177,4	-16,3	0,0	0,0	-192,6

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	12,41	27,79	59,88	68,22	99,66	137,26	177,18	100	100	100	100	100	100	100	6,0	4,4	3,9	3,3	2,6	3,3
Industry	5,30	11,51	17,45	19,68	28,95	38,03	44,96	42,7	41,4	29,1	28,9	29,0	27,7	25,4	4,5	4,1	3,9	2,8	1,7	2,9
Transportation	4,88	10,80	21,45	25,17	35,68	46,63	58,45	39,4	38,9	35,8	36,9	35,8	34,0	33,0	5,6	5,5	5,6	2,7	2,3	3,1
Others	1,62	3,97	8,46	10,24	15,12	20,28	25,78	13,1	14,3	14,1	15,0	15,2	14,8	14,6	6,3	6,6	4,0	3,0	2,4	3,4
Non-energy	0,61	1,50	12,51	13,13	19,91	32,33	47,98	4,9	5,4	20,9	19,2	20,0	23,6	27,1	11,9	1,6	4,3	5,0	4,0	4,2
Total	12,41	27,79	59,88	68,22	99,66	137,27	177,18	100	100	100	100	100	100	100	6,0	4,4	3,9	3,3	2,6	3,3
Coal	0,51	0,99	1,80	2,23	3,12	4,02	5,04	4,1	3,6	3,0	3,3	3,1	2,9	2,8	4,8	7,3	3,4	2,6	2,3	3,2
Oil	9,09	17,70	28,27	33,69	49,52	65,38	82,17	73,3	63,7	47,2	49,4	49,7	47,6	46,4	4,3	6,0	3,9	2,8	2,3	3,3
Natural gas	1,09	3,83	16,83	17,91	26,57	39,86	55,21	8,8	13,8	28,1	26,3	26,7	29,0	31,2	10,7	2,1	4,0	4,1	3,3	3,7
Electricity	1,72	5,26	12,60	14,01	20,01	27,52	34,23	13,8	18,9	21,0	20,5	20,1	20,0	19,3	7,7	3,6	3,6	3,2	2,2	3,1
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	0,38	0,39	0,43	0,48	0,53	0,0	0,0	0,6	0,6	0,4	0,3	0,3	-	1,0	1,0	1,0	1,0	1,0

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	23,01	64,28	164,51	174,01	252,12	347,02	431,91	100	100	100	100	100	100	100	7,6	1,9	3,8	3,2	2,2	3,0
Coal	3,00	4,04	71,96	75,39	98,36	144,70	184,64	13,0	6,3	43,7	43,3	39,0	41,7	42,7	12,5	1,6	2,7	3,9	2,5	2,9
Oil	11,00	2,94	1,53	3,07	2,66	2,58	2,59	47,8	4,6	0,9	1,8	1,1	0,7	0,6	-7,1	26,2	-1,4	-0,3	0,0	1,6
Natural gas	5,02	50,31	63,27	64,46	113,87	162,52	207,45	21,8	78,3	38,5	37,0	45,2	46,8	48,0	9,8	0,6	5,9	3,6	2,5	3,7
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	-	-	-	-	-	-
Hydro	3,99	6,99	26,58	26,22	32,36	32,35	32,36	17,3	10,9	16,2	15,1	12,8	9,3	7,5	7,3	-0,5	2,1	0,0	0,0	0,6
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	0,00	1,17	4,87	4,87	4,87	4,87	0,0	0,0	0,7	2,8	1,9	1,4	1,1	-	60,9	0,0	0,0	0,0	4,4

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4,94	14,31	31,68	32,30	48,45	69,47	88,93	100	100	100	100	100	100	100	7,1	0,6	4,1	3,7	2,5	3,2
Coal	0,81	1,50	17,68	17,64	23,28	33,86	43,66	16,4	10,4	55,8	54,6	48,0	48,7	49,1	12,1	-0,1	2,8	3,8	2,6	2,8
Oil	2,99	0,78	0,40	0,80	0,69	0,67	0,68	60,5	5,5	1,3	2,5	1,4	1,0	0,8	-7,2	26,2	-1,4	-0,3	0,0	1,6
Natural gas	1,14	12,04	13,60	13,86	24,48	34,94	44,59	23,1	84,1	42,9	42,9	50,5	50,3	50,1	9,6	0,6	5,9	3,6	2,5	3,7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	33,1	34,4	37,1	38,1	38,1	38,4	38,2								0,4	0,8	0,0	0,1	0,0	0,1
Coal	31,7	33,2	35,0	36,8	36,3	36,8	36,4								0,4	1,6	-0,1	0,1	-0,1	0,1
Oil	31,6	32,2	33,0	33,0	33,0	33,0	33,0								0,2	0,0	0,0	0,0	0,0	0,0
Natural gas	37,9	36,0	40,0	40,0	40,0	40,0	40,0								0,2	0,0	0,0	0,0	0,0	0,0

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	13,6	30,7	55,0	60,5	88,0	120,1	150,9	100	100	100	100	100	100	100	5,3	3,3	3,8	3,2	2,3	3,1
Coal	1,4	2,6	20,7	21,1	28,1	40,3	51,8	10,3	8,5	37,7	34,9	31,9	33,6	34,3	10,5	0,7	2,9	3,7	2,5	2,8
Oil	10,3	15,7	21,1	25,8	37,5	49,2	61,6	75,7	51,1	38,4	42,6	42,6	41,0	40,8	2,7	6,9	3,8	2,8	2,3	3,3
Natural gas	1,9	12,4	13,2	13,6	22,4	30,5	37,5	14,0	40,4	23,9	22,5	25,5	25,4	24,8	7,4	1,2	5,1	3,1	2,1	3,2

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	82	163	365	402	547	737	993	5,7	3,3	3,1	3,0	3,0	3,1	
Population (millions of people)	18	23	31	32	36	39	41	2,0	1,4	1,1	0,8	0,6	0,9	
GDP per capita (thousands of 2010 USD/person)	4,54	7,01	11,72	12,40	15,21	18,94	23,95	3,6	1,9	2,1	2,2	2,4	2,2	
Primary energy consumption per capita (toe/person)	1,04	2,07	2,62	2,81	3,71	4,74	5,73	3,5	2,3	2,8	2,5	1,9	2,4	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	230	295	224	226	244	250	239	-0,1	0,4	0,8	0,3	-0,5	0,2	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	152	171	164	170	182	186	179	0,3	1,1	0,7	0,2	-0,4	0,3	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	166	189	151	151	161	163	152	-0,4	0,0	0,7	0,1	-0,7	0,0	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,72	0,64	0,67	0,67	0,66	0,65	0,64	-0,3	-0,4	-0,1	-0,1	-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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	18,84	47,89	81,57	85,23	119,47	159,29	198,65	100	100	100	100	100	100	100	5,6	1,5	3,4	2,9	2,2	2,7		
Coal	1,36	2,31	19,48	17,06	20,13	26,56	32,64	7,2	4,8	23,9	20,0	16,8	16,7	16,4	10,4	-4,3	1,7	2,8	2,1	1,6		
Oil	10,43	21,09	29,23	34,06	49,66	64,58	80,25	55,4	44,0	35,8	40,0	41,6	40,5	40,4	3,9	5,2	3,8	2,7	2,2	3,1		
Natural gas	6,71	23,89	30,43	28,82	43,54	61,71	79,08	35,6	49,9	37,3	33,8	36,4	38,7	39,8	5,8	-1,8	4,2	3,5	2,5	2,9		
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	0,34	0,60	2,29	2,30	2,90	2,91	2,91	1,8	1,3	2,8	2,7	2,4	1,8	1,5	7,3	0,2	2,3	0,1	0,0	0,7		
Geothermal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	0,00	0,00	0,15	2,99	3,25	3,54	3,78	0,0	0,0	0,2	3,5	2,7	2,2	1,9	-	169,5	0,9	0,8	0,7	10,2		
Biomass	0,00	0,00	0,23	1,60	1,63	1,68	1,68	0,0	0,0	0,3	1,9	1,4	1,1	0,8	-	90,2	0,2	0,3	0,0	6,2		
Solar, Wind, Ocean	0,00	0,00	0,03	0,20	0,40	0,40	0,40	0,0	0,0	0,0	0,2	0,3	0,3	0,2	-	92,7	6,9	0,2	0,0	8,4		
Biofuels	0,00	0,00	0,38	0,96	1,19	1,41	1,66	0,0	0,0	0,5	1,1	1,0	0,9	0,8	-	36,2	2,2	1,7	1,6	4,6		
Electricity	0,00	0,00	-0,49	0,23	0,04	0,04	0,04	0,0	0,0	-0,6	0,3	0,0	0,0	0,0	-	-177,4	-16,3	0,0	0,0	-192,6		

Final energy demand

	MTOE															AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	12,41	27,79	59,88	65,68	94,80	129,39	165,86	100	100	100	100	100	100	100	6,0	3,1	3,7	3,2	2,5	3,1	
Industry	5,30	11,51	17,45	18,01	25,76	32,89	37,77	42,7	41,4	29,1	27,4	27,2	25,4	22,8	4,5	1,1	3,6	2,5	1,4	2,4	
Transportation	4,88	10,80	21,45	25,17	35,68	46,63	58,45	39,4	38,9	35,8	38,3	37,6	36,0	35,2	5,6	5,5	3,6	2,7	2,3	3,1	
Others	1,62	3,97	8,46	9,37	13,45	17,54	21,66	13,1	14,3	14,1	14,3	14,2	13,6	13,1	6,3	3,4	3,7	2,7	2,1	2,9	
Non-energy	0,61	1,50	12,51	13,13	19,91	32,33	47,98	4,9	5,4	20,9	20,0	21,0	25,0	28,9	11,9	1,6	4,3	5,0	4,0	4,2	
Total	12,41	27,79	59,88	65,68	94,81	129,40	165,86	100	100	100	100	100	100	100	6,0	3,1	3,7	3,2	2,5	3,1	
Coal	0,51	0,99	1,80	2,04	2,78	3,48	4,23	4,1	3,6	3,0	3,1	2,9	2,7	2,6	4,8	4,2	3,1	2,3	2,0	2,6	
Oil	9,09	17,70	28,27	32,58	47,61	62,55	78,23	73,3	63,7	47,2	49,6	50,2	48,3	47,2	4,3	4,8	3,9	2,8	2,3	3,1	
Natural gas	1,09	3,83	16,83	17,28	25,42	38,14	52,97	8,8	13,8	28,1	26,3	26,8	29,5	31,9	10,7	0,9	3,9	4,1	3,3	3,5	
Electricity	1,72	5,26	12,60	12,82	17,82	23,82	28,78	13,8	18,9	21,0	19,5	18,8	18,4	17,4	7,7	0,6	3,3	2,9	1,9	2,5	
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	0,38	0,96	1,19	1,41	1,66	0,0	0,0	0,6	1,5	1,3	1,1	1,0	-	36,2	2,2	1,7	1,6	4,6	

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	23,01	64,28	164,51	159,01	224,40	300,25	362,95	100	100	100	100	100	100	100	7,6	-1,1	3,5	3,0	1,9	2,4		
Coal	3,00	4,04	71,96	65,74	80,72	114,64	148,71	13,0	6,3	43,7	41,3	36,0	38,2	41,0	12,5	-3,0	2,1	3,6	2,6	2,2		
Oil	11,00	2,94	1,53	2,87	2,76	2,69	2,66	47,8	4,6	0,9	1,8	1,2	0,9	0,7	-7,1	23,4	-0,4	-0,2	-0,1	1,7		
Natural gas	5,02	50,31	63,27	55,52	95,77	138,34	167,02	21,8	78,3	38,5	34,9	43,1	46,1	46,0	9,8	-4,3	5,7	3,6	1,9	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	3,99	6,99	26,58	26,76	33,67	33,84	33,84	17,3	10,9	16,2	16,8	15,0	11,3	9,3	7,3	0,2	2,3	0,1	0,0	0,7		
Geothermal	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	0,00	0,00	1,17	8,12	10,48	10,73	10,73	0,0	0,0	0,7	5,1	4,7	3,6	3,0	-	90,8	2,6	0,2	0,0	6,9		

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4.94	14.31	31.68	27.31	36.19	47.36	55.21	100	100	100	100	100	100	100	7.1	-4.8	2.9	2.7	1.5	1.7
Coal	0.81	1.50	17.68	15.02	17.35	23.08	28.41	16.4	10.4	55.8	55.0	47.9	48.7	51.5	12.1	-5.3	1.5	2.9	2.1	1.4
Oil	2.99	0.78	0.40	0.75	0.72	0.70	0.69	60.5	5.5	1.3	2.7	2.0	1.5	1.3	-7.2	23.4	-0.4	-0.2	-0.1	1.7
Natural gas	1.14	12.04	13.60	11.54	18.13	23.58	26.11	23.1	84.1	42.9	42.3	50.1	49.8	47.3	9.6	-5.3	4.6	2.7	1.0	2.0

Thermal Efficiency

	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	33,1	34,4	37,1	39,1	42,8	46,4	49,6							
Coal	31,7	23,2	35,0	37,6	40,0	42,7	45,0							
Oil	31,6	32,2	33,0	33,0	33,0	33,0	33,0							
Natural gas	37,9	36,0	40,0	41,4	45,9	50,5	55,0							

CO₂ emissions

2	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	13,6	30,7	55,0	54,7	75,0	97,3	117,3	100	100	100	100	100	100	100	5,3	-0,2	3,2	2,6	1,9	2,3		
Coal	1,4	2,6	20,7	18,1	21,4	28,2	34,7	10,3	8,5	37,7	33,2	28,5	29,0	29,6	10,5	-4,3	1,7	2,8	2,1	1,6		
Oil	10,3	15,7	21,1	24,8	36,0	46,9	58,3	75,7	51,1	38,4	45,3	47,9	48,2	49,7	2,7	5,5	3,8	2,7	2,2	3,1		
Natural gas	1,9	12,4	13,2	11,8	17,6	22,2	24,3	14,0	40,4	23,9	21,5	23,5	22,8	20,7	7,4	-3,7	4,1	2,3	0,9	1,9		

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	82	163	365	402	547	737	993	5,7	3,3	3,1	3,0	3,0	3,1	
Population (millions of people)	18	23	31	32	36	39	41	2,0	1,4	1,1	0,8	0,6	0,9	
GDP per capita (thousands of 2010 USD/person)	4,54	7,01	11,72	12,40	15,21	18,94	23,95	3,6	1,9	2,1	2,2	2,4	2,2	
Primary energy consumption per capita (toe/person)	1,04	2,07	2,62	2,63	3,32	4,09	4,79	3,5	0,1	2,4	2,1	1,6	1,8	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	230	295	224	212	218	216	200	-0,1	-1,8	0,3	-0,1	-0,8	-0,3	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	152	171	164	163	173	176	167	0,3	-0,2	0,6	0,1	-0,5	0,1	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	166	189	151	136	137	132	118	-0,4	-3,4	0,1	-0,4	-1,1	-0,7	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,72	0,64	0,67	0,64	0,63	0,61	0,59	-0,3	-1,6	-0,2	-0,3	-0,3	-0,4	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	10,68	11,10	20,12	22,52	30,51	41,27	53,95	100	100	100	100	100	100	100	2,4	3,8	3,1	3,1	2,7	3,0		
Coal	0,07	0,06	0,54	0,87	1,75	2,80	4,85	0,6	0,5	2,7	3,9	5,7	6,8	9,0	8,0	17,4	7,2	4,8	5,7	6,9		
Oil	0,73	1,79	6,52	7,67	12,52	18,74	24,92	6,8	16,2	32,4	34,0	41,0	45,4	46,2	8,4	5,5	5,0	4,1	2,9	4,1		
Natural gas	0,76	1,35	3,32	3,91	4,73	7,04	10,29	7,1	12,2	16,5	17,4	15,5	17,1	19,1	5,6	5,6	1,9	4,1	3,9	3,5		
Nuclear								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Hydro	0,10	0,16	1,08	1,28	2,03	2,40	3,24	1,0	1,5	5,4	5,7	6,7	5,8	6,0	9,1	5,7	4,7	1,7	3,0	3,4		
Geothermal								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	9,02	7,73	8,66	8,79	9,48	10,28	10,65	84,5	69,7	43,0	39,0	31,1	24,9	19,7	-0,2	0,5	0,8	0,8	0,4	0,6		
Biomass	9,02	7,73	8,78	8,91	9,52	10,28	10,58	84,5	69,7	43,6	39,6	31,2	24,9	19,6	-0,1	0,5	0,7	0,8	0,3	0,6		
Solar, Wind, Ocean	-	-	0,00	0,01	0,08	0,13	0,19	0,0	0,0	0,0	0,0	0,3	0,3	0,3	-	84,4	31,4	4,8	4,2	17,9		
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Electricity	-	-	-0,12	-0,12	-0,12	-0,12	-0,12	0,0	0,0	-0,59	-0,53	-0,4	-0,3	-0,2	-	0,1	0,0	0,0	0,0	0,0		

Final energy demand

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	9,400	9,93	17,46	19,25	26,28	35,19	44,70	100	100	100	100	100	100	100	2,3	3,3	3,2	3,0	2,4	2,9		
Industry	0,39	3,25	6,89	7,63	10,73	14,34	16,34	4,2	32,7	39,4	39,6	40,9	40,7	36,6	11,2	3,5	3,5	2,9	1,3	2,7		
Transportation	0,44	0,93	3,10	3,77	6,74	11,06	17,47	4,7	9,4	17,8	19,6	25,7	31,4	39,1	7,5	6,7	6,0	5,1	4,7	5,4		
Others	8,47	5,75	7,47	7,85	8,80	9,79	10,89	90,1	57,9	42,8	40,8	33,5	27,8	24,4	-0,5	1,7	1,1	1,1	1,1	1,1		
Non-energy	0,09	0,00	0,00	0,00	0,00	0,00	0,00	1,0	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-		
Total	9,400	9,93	17,46	19,25	26,28	35,19	44,70	100	100	100	100	100	100	100	2,3	3,3	3,2	3,0	2,4	2,9		
Coal	0,05	0,06	0,29	0,34	0,54	0,77	1,07	0,5	0,6	1,7	1,8	2,0	2,2	2,4	6,7	5,2	4,7	3,8	3,3	4,0		
Oil	0,59	1,60	6,50	7,66	12,52	18,74	24,91	6,2	16,1	37,2	39,8	47,6	53,2	55,7	9,3	5,6	5,0	4,1	2,9	4,2		
Natural gas	0,23	0,40	0,43	0,49	0,76	1,15	1,50	2,4	4,0	2,5	2,6	2,9	3,3	3,4	2,4	4,5	4,5	4,2	2,7	3,8		
Electricity	0,15	0,28	1,47	1,85	3,12	4,75	7,18	1,6	2,8	8,4	9,6	11,9	13,5	16,1	8,8	8,0	5,4	4,3	4,2	4,9		
Heat								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-		
Others	8,39	7,59	8,78	8,91	9,34	9,78	10,04	89,2	76,5	50,3	46,3	35,5	27,8	22,5	0,2	0,5	0,5	0,5	0,3	0,4		

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	2,48	5,12	21,46	26,64	43,82	65,88	98,79	100	100	100	100	100	100	100	8,3	7,5	5,1	4,2	4,1	4,7
Coal	0,04	0,00	0,45	0,97	3,80	7,20	14,56	2	0	2	4	9	11	15	9,4	28,9	14,7	6,6	7,3	11,1
Oil	0,27	0,04	0,07	0,00	0,00	0,00	0,00	11	1	0	0	0	0	0	-4,9	-100,0	-	-	-	-100,0
Natural gas	0,97	3,19	8,34	10,74	14,91	27,65	42,55	39	62	39	40	34	42	43	8,3	8,8	3,3	6,4	4,4	5,1
Nuclear								0	0	0	0	0	0	0	-	-	-	-	-	-
Hydro	1,19	1,89	12,58	14,87	23,61	27,94	37,72	48	37	59	56	54	42	38	9,1	5,7	4,7	1,7	3,0	3,4
Geothermal								0	0	0	0	0	0	0	-	-	-	-	-	-
Others	-	0,00	0,01	0,06	1,50	3,08	3,97	0	0	0	0	3	5	4	-	84,4	38,1	7,4	2,5	20,1

Power generation Input

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	0,51	0,82	3,16	3,95	5,18	7,91	12,57	100	100	100	100	100	100	100	7,9	7,8	2,7	4,3	4,7	4,3		
Coal	0,01	0,00	0,25	0,54	1,21	2,02	3,78	2,4	0,0	7,9	13,5	23,4	25,6	30,1	11,9	28,9	8,5	5,3	6,5	8,6		
Oil	0,06	0,01	0,02	0,00	0,00	0,00	0,00	12,5	1,4	0,6	0,0	0,0	0,0	0,0	-4,5	-100,0	-	-	-	-100,0		
Natural gas	0,43	0,81	2,89	3,42	3,97	5,89	8,79	85,1	98,6	91,5	86,5	76,6	74,4	69,9	7,3	5,8	1,5	4,0	4,1	3,4		

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	21,7	33,9	24,1	25,5	31,1	37,9	39,1								0,4	1,8	2,0	2,0	0,3	1,5
Coal	28,7	-	16	16	27	31	33								-2,2	0,0	5,7	1,3	0,8	2,3
Oil	36,4	27,7	32	-	-	-	-								-0,5	-	-	-	-	-
Natural gas	19,3	34,0	25	27	32	40	42								0,9	2,8	1,8	2,3	0,3	1,6

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,1	2,2	8,0	9,6	14,3	21,1	28,4	100	100	100	100	100	100	100	7,5	6,5	4,0	4,0	3,0	3,9		
Coal	0,1	0,07	0,6	0,9	1,1	1,4	1,7	8,9	3,0	7,2	9,6	7,9	6,6	6,0	6,7	17,4	2,1	2,0	2,1	3,4		
Oil	0,6	1,29	5,3	6,2	10,2	15,2	20,2	50,0	58,1	66,3	64,5	71,1	72,2	71,0	8,7	5,6	5,1	4,1	2,8	4,1		
Natural gas	0,5	0,86	2,1	2,5	3,0	4,5	6,6	41,1	38,9	26,6	25,9	21,0	21,3	23,1	5,8	5,6	1,9	4,1	3,9	3,5		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	8,0	16,0	79	97	185	314	511	8,9	7,0	6,6	5,4	5,0	5,80
Population (millions of people)	41,3	46,7	53,4	55,0	59,4	62,7	65,8	1,0	1,0	0,8	0,5	0,5	0,6
GDP per capita (thousands of 2010 USD/person)	0,2	0,3	1,5	1,8	3,1	5,0	7,8	7,8	5,9	5,8	4,9	4,5	5,1
Primary energy consumption per capita (toe/person)	0,3	0,2	0,4	0,4	0,5	0,7	0,8	1,4	2,8	2,3	2,5	2,2	2,4
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.333	694	253	231	165	132	106	-6,0	-3,0	-3,3	-2,3	-2,2	-2,6
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.173	621	220	198	142	112	87	-6,0	-3,5	-3,2	-2,4	-2,5	-2,8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	140	139	100	99	78	67	56	-1,2	-0,4	-2,4	-1,4	-1,9	-1,8
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,10	0,20	0,40	0,43	0,47	0,51	0,53	5,0	2,6	0,9	0,9	0,3	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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050				
Total	10,68	11,10	20,12	22,32	27,63	35,37	42,71	100	100	100	100	100	100	100	2.4	3.5	2.2	2.5	1.9	2.3				
Coal	0,07	0,06	0,54	0,80	0,83	1,14	1,92	0,6	0,5	2,7	3,6	3,0	3,2	4,5	8,0	14,0	0,3	3,2	5,3	3,9				
Oil	0,73	1,79	6,52	7,67	11,58	16,35	20,55	6,8	16,2	32,4	34,3	41,9	46,2	48,1	8,4	5,5	4,2	3,5	2,3	3,5				
Natural gas	0,76	1,35	3,32	3,73	3,88	6,24	7,76	7,1	12,2	16,5	16,7	14,0	17,6	18,2	5,6	4,0	0,4	4,9	2,2	2,6				
Nuclear								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-				
Hydro	0,10	0,16	1,08	1,28	2,11	2,03	2,60	1,0	1,5	5,4	5,7	7,7	5,7	6,1	9,1	5,7	5,2	-0,4	2,5	2,7				
Geothermal	-	0,00	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	9,02	7,73	8,66	8,84	9,22	9,60	9,87	84,5	69,7	43,0	39,6	33,4	27,2	23,1	-0,2	0,7	0,4	0,4	0,3	0,4				
Biomass	9,02	7,73	8,78	8,91	9,10	9,46	9,39	84,5	69,7	43,6	39,9	32,9	26,7	22,0	-0,1	0,5	0,2	0,4	-0,1	0,2				
Solar, Wind, Ocean	-	-	0,00	0,05	0,24	0,27	0,60	0,0	0,0	0,0	0,2	0,9	0,8	1,4	-	289,2	17,6	0,9	8,3	22,1				
Biofuels								0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-				
Electricity	-	-	-0,12	-0,12	-0,12	-0,12	-0,12	0,0	0,0	-0,6	-0,5	-0,4	-0,3	-0,3	-	0,1	0,0	0,0	0,0	0,0				

Final energy demand

Final energy demand	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	9.40	9.93	17.46	19.25	24.69	31.21	37.31	100	100	100	100	100	100	100	2.3	3.3	2.5	2.4	1.8	2.3		
Industry	0.39	3.25	6.89	7.63	10.20	12.90	14.30	4.2	32.7	39.4	39.6	41.3	41.3	38.3	11.2	3.5	2.9	2.4	1.0	2.2		
Transportation	0.44	0.93	3.10	3.77	6.07	9.40	13.98	4.7	9.4	17.8	19.6	24.6	30.1	37.5	7.5	6.7	4.9	4.5	4.0	4.7		
Others	8.47	5.75	7.47	7.85	8.42	8.90	9.04	90.1	57.9	42.8	40.8	34.1	28.5	24.2	-0.5	1.7	0.7	0.6	0.2	0.6		
Non-energy	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-	-	-	-		
Total	9.40	9.93	17.46	19.25	24.69	31.21	37.31	100	100	100	100	100	100	100	2.3	3.3	2.5	2.4	1.8	2.3		
Coal	0.05	0.06	0.29	0.34	0.51	0.70	0.94	0.5	0.6	1.7	1.8	2.1	2.2	2.5	6.7	5.2	4.2	3.2	3.0	3.6		
Oil	0.59	1.60	6.50	7.66	11.58	16.34	20.55	6.2	16.1	37.2	39.8	46.9	52.4	55.1	9.3	5.6	4.2	3.5	2.3	3.6		
Natural gas	0.23	0.40	0.43	0.49	0.71	1.01	1.25	2.4	4.0	2.5	2.6	2.9	3.2	3.3	2.4	4.5	3.7	3.6	2.1	3.3		
Electricity	0.15	0.28	1.47	1.85	2.98	4.30	6.10	1.6	2.8	8.4	9.6	12.1	13.8	16.4	8.8	8.0	4.9	3.7	3.6	4.4		
Heat								0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-		
Others	8.39	7.59	8.78	8.91	8.92	8.86	8.48	89.2	76.5	50.2	46.2	36.1	28.4	22.7	0.2	0.5	0.0	-0.1	-0.4	-0.1		

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	2.48	5.12	21.46	26.64	41.93	59.77	84.24	100	100	100	100	100	100	100	8.3	7.5	4.6	3.6	3.5	4.2		
Coal	0.04	0.00	0.45	0.97	0.97	1.90	4.79	1.6	0.0	2.1	3.6	2.3	3.2	5.7	9.4	28.9	0.0	7.0	9.7	7.4		
Oil	0.27	0.04	0.07	0.00	0.00	0.00	0.00	10.9	0.7	0.3	0.0	0.0	0.0	0.0	-4.9	-100.0	-	-	-	-100.0		
Natural gas	0.97	3.19	8.34	10.24	12.94	29.17	39.23	39.3	62.3	38.9	38.4	30.9	48.8	46.6	8.3	7.1	2.4	8.5	3.0	4.8		
Nuclear								0.0	0.0	0.0	0.0	0.0	0.0	0.0								
Hydro	1.19	1.89	12.58	14.87	24.60	23.65	30.29	48.1	37.0	58.6	55.8	58.7	39.6	36.0	9.1	5.7	5.2	-0.4	2.5	2.7		
Geothermal								0.0	0.0	0.0	0.0	0.0	0.0	0.0								
Others	-	0.00	0.01	0.56	3.43	5.06	9.92	0.0	0.0	0.0	2.1	8.2	8.5	11.8	-	289.2	19.9	4.0	7.0	23.5		

Power generation Input

Power generation input	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	0.51	0.82	3.16	3.70	3.49	5.67	7.49	100	100	100	100	100	100	100	7.0	5.5	-0.6	5.0	2.8	2.7
Coal	0.01	0.00	0.25	0.46	0.32	0.44	0.98	2.4	0.0	7.9	12.5	9.2	7.8	13.1	11.9	22.8	-3.6	3.3	8.3	4.2
Oil	0.06	0.01	0.02	0.00	0.00	0.00	0.00	12.5	1.4	0.6	0.0	0.0	0.0	0.0	-4.5	-100.0	-	-	-	-100.0
Natural gas	0.43	0.81	2.89	3.24	3.17	5.23	6.51	85.1	98.6	91.5	87.5	90.8	92.2	86.9	7.3	3.9	-0.2	5.1	2.2	2.5

Thermal Efficiency

Thermal Efficiency	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	22	34	24	26	34	47	51								0.4	2.5	2.8	3.2	0.7	2.3
Coal	29	-	16	18	26	37	42								-2.2	4.9	3.8	3.5	1.3	3.1
Oil	36	28	32	-	-	-	-								-0.5	-	-	-	-	-
Natural gas	19	34	25	27	35	48	52								0.9	3.0	2.6	3.2	0.8	2.3

CO₂ emissions

	CO ₂ emissions																			
	Mt-C								AAGR (%)											
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1.1	2.2	8.0	9.4	12.8	18.3	22.8	100	100	100	100	100	100	100	7.5	5.8	3.1	3.6	2.2	3.2
Coal	0.10	0.07	0.57	0.8	0.9	1.0	1.2	8.9	3.0	7.2	9.0	6.9	5.5	5.3	6.7	14.0	0.3	1.3	1.9	2.3
Oil	0.56	1.29	5.28	2.4	2.5	4.0	4.9	50.0	58.1	66.3	25.2	19.4	21.8	21.7	8.7	-23.3	0.4	4.9	2.2	-0.2
Natural gas	0.46	0.86	2.12	6.2	9.4	13.3	16.7	41.1	38.9	26.6	65.8	73.8	72.8	73.0	5.8	43.2	4.2	3.5	2.2	6.4

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	8.01	15.98	79.50	97.39	184.51	313.68	510.96	8.9	7.0	6.6	5.4	5.0	5.8	
Population (millions of people)	41.34	46.72	53.38	55.00	59.40	62.68	65.76	1.0	1.0	0.8	0.5	0.5	0.6	
GDP per capita (thousands of 2010 USD/person)	0.2	0.3	1.5	1.8	3.1	5.0	7.8	7.8	5.9	5.8	4.9	4.5	5.1	
Primary energy consumption per capita (toe/person)	0.3	0.2	0.4	0.4	0.5	0.6	0.6	1.4	2.5	1.4	2.0	1.4	1.7	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.333	694	253	229	150	113	84	-6.0	-3.3	-4.2	-2.8	-2.9	-3.3	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.173	621	220	198	134	99	73	-6.0	-3.5	-3.8	-2.9	-3.0	-3.3	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	140	139	100	97	69	58	45	-1.2	-1.1	-3.3	-1.7	-2.6	-2.4	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.10	0.20	0.40	0.42	0.46	0.52	0.53	5.0	2.2	0.9	1.1	0.3	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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	12.87	17.14	20.70	21.79	23.75	23.38	22.55	100	100	100	100	100	100	100	1.8	1.7	0.9	-0.2	-0.4	0.3
Coal	1.18	1.11	1.16	0.99	0.96	0.93	0.88	9.2	6.5	5.6	4.6	4.0	4.0	3.9	-0.1	-5.1	-0.3	-0.3	-0.5	-0.9
Oil	3.51	5.71	6.77	6.84	6.60	5.89	5.07	27.3	33.3	32.7	31.4	27.8	25.2	22.5	2.5	0.3	-0.4	-1.1	-1.5	-0.9
Natural gas	3.87	5.06	4.25	4.63	4.71	4.58	4.28	30.1	29.5	20.5	21.3	19.8	19.6	19.0	0.3	2.9	0.2	-0.3	-0.7	0.0
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Hydro	1.99	2.10	2.17	2.01	1.93	1.85	1.77	15.5	12.3	10.5	9.2	8.1	7.9	7.9	0.3	-2.5	-0.4	-0.4	-0.4	-0.6
Geothermal	1.49	1.96	4.88	5.71	7.65	8.03	8.37	11.6	11.4	23.6	26.2	32.2	34.4	37.1	4.5	5.4	3.0	0.5	0.4	1.7
Others	0.81	1.20	1.48	1.61	1.91	2.09	2.17	6.3	7.0	7.2	7.4	8.0	8.9	9.6	2.2	2.8	1.7	0.9	0.4	1.2
Biomass	0.78	1.16	1.26	1.36	1.49	1.50	1.46	6.1	6.8	6.1	6.2	6.3	6.4	6.5	1.8	2.6	0.9	0.1	-0.3	0.4
Solar, Wind, Ocean	0.03	0.04	0.22	0.25	0.41	0.59	0.71	0.3	0.3	1.1	1.2	1.7	2.5	3.2	7.4	4.2	5.0	3.6	2.0	3.6
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	-	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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	9.76	12.95	14.65	14.99	15.22	14.51	13.45	100	100	100	100	100	100	100	1.5	0.8	0.2	-0.5	-0.8	-0.3
Industry	3.62	4.24	4.45	4.61	4.82	4.64	4.29	37.1	32.7	30.4	30.8	31.6	32.0	31.9	0.8	1.2	0.4	-0.4	-0.8	-0.1
Transportation	2.96	4.06	5.23	5.27	5.11	4.67	4.18	30.3	31.4	35.7	35.2	33.5	32.2	31.1	2.1	0.3	-0.3	-0.9	-1.1	-0.7
Others	2.57	3.00	3.49	3.61	3.83	3.81	3.68	26.3	23.2	23.8	24.1	25.1	26.2	27.4	1.1	1.2	0.6	-0.1	-0.3	0.2
Non-energy	0.62	1.64	1.48	1.49	1.47	1.40	1.30	6.3	12.7	10.1	9.9	9.7	9.6	9.6	3.3	0.3	-0.1	-0.5	-0.7	-0.4
Total	9.76	12.95	14.65	14.99	15.22	14.51	13.45	100	100	100	100	100	100	100	1.5	0.8	0.2	-0.5	-0.8	-0.3
Coal	0.67	0.52	0.57	0.58	0.57	0.52	0.47	6.9	4.0	3.9	3.9	3.7	3.6	3.5	-0.6	0.6	-0.2	-0.8	-1.1	-0.6
Oil	4.03	5.31	6.64	6.70	6.46	5.79	5.01	41.2	41.0	45.3	44.7	42.4	39.9	37.3	1.9	0.3	-0.4	-1.1	-1.4	-0.8
Natural gas	1.80	3.01	2.80	2.85	2.88	2.73	2.51	18.4	23.3	19.1	19.0	18.9	18.8	18.7	1.7	0.6	0.1	-0.5	-0.8	-0.3
Electricity	2.46	2.94	3.35	3.51	3.92	4.15	4.26	25.2	22.7	22.8	23.4	25.8	28.6	31.7	1.2	1.6	1.1	0.6	0.3	0.7
Heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Others	0.81	1.18	1.29	1.35	1.39	1.31	1.19	8.3	9.1	8.8	9.0	9.1	9.1	8.9	1.8	1.4	0.3	-0.6	-0.9	-0.2

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	32.26	39.25	44.21	46.41	51.68	54.53	55.88	100	100	100	100	100	100	100	1.2	1.6	1.1	0.5	0.2	0.7
Coal	0.66	1.55	1.21	0.57	0.43	0.44	0.45	2.1	3.9	2.7	1.2	0.8	0.8	0.8	2.3	-22.3	-2.8	0.3	0.1	-3.0
Oil	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.9	7.1	0.3	0.8	0.0	1.0
Natural gas	5.71	9.57	7.05	9.58	10.48	11.30	11.30	17.7	24.4	16.0	20.6	20.3	20.7	20.2	0.8	10.7	0.9	0.8	0.0	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	23.18	24.43	25.18	23.36	22.44	21.53	20.61	71.9	62.3	57.0	50.3	43.4	39.5	36.9	0.3	-2.5	-0.4	-0.4	-0.4	-0.6
Geothermal	2.13	2.92	7.91	9.31	12.58	13.26	13.87	6.6	7.4	17.9	20.1	24.3	24.3	24.8	5.0	5.6	3.1	0.5	0.5	1.7
Others	0.57	0.78	2.85	3.59	5.74	7.99	9.65	1.8	2.0	6.4	7.7	11.1	14.7	17.3	6.2	7.9	4.8	3.4	1.9	3.8

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1.41	2.28	1.60	1.77	1.80	1.82	1.74	100	100	100	100	100	100	100	0.5	3.5	0.2	0.1	-0.5	0.3
Coal	0.17	0.38	0.31	0.15	0.11	0.11	0.11	11.9	16.7	19.5	8.2	6.1	6.2	6.6	2.3	-22.4	-2.8	0.3	0.1	-3.0
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	0.1	0.1	-7.1	31.6	-2.2	0.1	-0.6	1.7
Natural gas	1.24	1.90	1.28	1.62	1.69	1.71	1.62	87.7	83.3	80.4	91.7	93.8	93.7	93.3	0.1	8.1	0.4	0.1	-0.5	0.7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	38.8	41.9	44.5	49.3	52.1	55.4	58.1								0.5	3.4	0.6	0.6	0.5	0.8
Coal	34.0	34.8	33.4	33.5	33.5	33.5	33.5								-0.1	0.1	0.0	0.0	0.0	0.0
Oil	13.8	-	60.3	32.5	42.0	44.7	47.4								5.6	-18.6	2.6	0.6	0.6	-0.7
Natural gas	39.6	43.4	47.2	59.7	53.3	56.9	59.8								0.7	2.4	0.5	0.7	0.5	0.7

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	6.3	7.9	8.9	9.0	8.9	8.2	7.4	100	100	100	100	100	100	100	1.3	0.4	-0.2	-0.8	-1.1	-0.6
Coal	1.3	1.2	1.4	1.2	1.1	1.1	1.0	20.6	15.4	15.1	12.8	12.6	13.1	13.9	0.1	-5.1	-0.3	-0.3	-0.5	-0.9
Oil	3.2	4.3	5.6	5.6	5.4	4.8	4.2	50.8	54.4	62.1	61.9	60.8	58.8	56.8	2.1	0.3	-0.4	-1.1	-1.4	-0.8
Natural gas	1.8	2.4	2.0	2.3	2.4	2.3	2.2	28.5	30.2	22.8	25.3	26.6	28.1	29.4	0.5	3.9	0.3	-0.2	-0.6	0.2

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	83	112	181	197	243	281	315	2,9	2,8	2,1	1,5	1,1	1,7	
Population (millions of people)	3	4	5	5	5	6	6	1,4	1,5	0,9	0,6	0,5	0,7	
GDP per capita (thousands of 2010 USD/person)	24,83	28,97	37,78	39,23	44,31	48,04	51,36	1,6	1,3	1,2	0,8	0,7	0,9	
Primary energy consumption per capita (toe/person)	3,86	4,44	4,32	4,34	4,33	4,00	3,68	0,4	0,2	0,0	-0,8	-0,8	-0,5	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	156	153	114	111	98	83	72	-1,1	-1,1	-1,2	-1,6	-1,5	-1,4	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	118	116	81	76	63	52	43	-1,4	-2,0	-1,9	-1,9	-1,9	-1,9	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	76	71	49	46	37	29	23	-1,6	-2,4	-2,3	-2,2	-2,2	-2,2	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,49	0,46	0,43	0,42	0,37	0,35	0,33	-0,5	-1,3	-1,0	-0,6	-0,7	-0,8	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	12,87	17,14	20,70	22,07	23,79	23,98	21,49	100	100	100	100	100	100	100	1,8	2,2	0,8	-0,3	-0,7	0,1		
Coal	1,18	1,11	1,16	0,95	0,87	0,79	0,71	9,2	6,5	5,6	4,3	3,6	3,4	3,3	-0,1	-6,4	-0,9	-0,9	-1,0	-1,5		
Oil	3,51	5,71	6,77	6,80	6,22	5,05	3,96	27,3	33,3	32,7	30,8	26,2	22,0	18,4	2,5	0,1	-0,9	-2,1	-2,4	-1,6		
Natural gas	3,87	5,06	4,25	4,40	3,87	3,20	2,38	30,1	29,5	20,5	19,9	16,3	13,9	11,1	0,3	1,2	-1,3	-1,9	-2,9	-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	-	-	-	-	-	-		
Hydro	1,99	2,10	2,17	2,01	1,93	1,85	1,77	15,5	12,3	10,5	9,1	8,1	8,1	8,2	0,3	-2,5	-0,4	-0,4	-0,4	-0,6		
Geothermal	1,49	1,96	4,88	6,23	8,83	9,80	10,17	11,6	11,4	23,6	28,2	37,1	42,6	47,3	4,5	8,5	3,6	1,0	0,4	2,3		
Others	0,81	1,20	1,48	1,68	2,06	2,29	2,49	6,3	7,0	7,2	7,6	8,7	10,0	11,6	2,2	4,1	2,1	1,1	0,9	1,6		
Biomass	0,78	1,16	1,26	1,37	1,53	1,55	1,55	6,1	6,8	6,1	6,2	6,4	6,8	7,2	1,8	3,0	1,1	0,2	0,0	0,6		
Solar, Wind, Ocean	0,03	0,04	0,22	0,30	0,52	0,73	0,93	0,3	0,3	1,1	1,3	2,2	3,2	4,4	7,4	9,8	5,9	3,3	2,6	4,4		
Biofuels	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,0	0,0	0,0	0,0	0,0	0,1	0,1	-	19,8	7,1	1,8	0,0	4,4		
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	9,76	12,95	14,65	14,93	14,61	13,16	11,57	100	100	100	100	100	100	100	1,5	0,6	-0,2	-1,0	-1,3	-0,7		
Industry	3,62	4,24	4,45	4,60	4,70	4,30	3,74	37,1	32,7	30,4	30,8	32,2	32,7	32,3	0,8	1,2	0,2	-0,9	-1,4	-0,5		
Transportation	2,96	4,06	5,23	5,24	4,76	3,95	3,30	30,3	31,4	35,7	35,1	32,5	30,0	28,5	2,1	0,0	-1,0	-1,8	-1,8	-1,4		
Others	2,57	3,00	3,49	3,60	3,68	3,51	3,23	26,3	23,2	23,8	24,1	25,2	26,7	28,0	1,1	1,0	0,2	-0,5	-0,8	-0,2		
Non-energy	0,62	1,64	1,48	1,49	1,47	1,40	1,30	6,3	12,7	10,1	10,0	10,1	10,6	11,2	3,3	0,3	-0,1	-0,5	-0,7	-0,4		
Total	9,76	12,95	14,65	14,93	14,61	13,16	11,57	100	100	100	100	100	100	100	1,5	0,6	-0,2	-1,0	-1,3	-0,7		
Coal	0,67	0,52	0,57	0,56	0,49	0,42	0,35	6,9	4,0	3,9	3,8	3,4	3,2	3,0	-0,6	-0,3	-1,3	-1,7	-1,9	-1,5		
Oil	4,03	5,31	6,64	6,66	6,12	5,02	4,01	41,2	41,0	45,3	44,6	41,9	38,2	34,6	1,9	0,1	-0,8	-2,0	-2,2	-1,5		
Natural gas	1,80	3,01	2,80	2,85	2,79	2,52	2,19	18,4	23,3	19,1	19,1	19,1	19,1	18,9	1,7	0,5	-0,2	-1,0	-1,4	-0,7		
Electricity	2,46	2,94	3,35	3,50	3,82	3,92	3,90	25,2	22,7	22,8	23,5	26,1	29,8	33,7	1,2	1,6	0,9	0,3	-0,1	0,5		
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	1,18	1,29	1,35	1,39	1,27	1,13	8,3	9,1	8,8	9,1	9,5	9,7	9,7	1,8	1,5	0,3	-0,8	-1,2	-0,4		

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	32,26	39,25	44,21	46,27	50,26	51,45	51,02	100	100	100	100	100	100	100	1,2	1,5	0,8	0,2	-0,1	0,4		
Coal	0,66	1,55	1,21	0,48	0,42	0,42	0,42	2,1	3,9	2,7	1,0	0,8	0,8	0,8	2,3	-26,5	-1,3	0,0	-0,1	-3,2		
Oil	0,01	0,00	0,01	0,01	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-1,9	1,3	-4,2	-5,1	-20,8	-9,4		
Natural gas	5,71	9,57	7,05	8,10	5,61	3,32	0,33	17,7	24,4	16,0	17,5	11,2	6,5	0,6	0,8	4,7	-3,6	-5,1	-20,7	-8,9		
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	23,18	24,43	25,18	23,36	22,44	21,53	20,61	71,9	62,3	57,0	50,5	44,7	41,8	40,4	0,3	-2,5	-0,4	-0,4	-0,4	-0,6		
Geothermal	2,13	2,92	7,91	10,19	14,59	16,26	16,94	6,6	7,4	17,9	22,0	29,0	31,6	33,2	5,0	8,8	3,7	1,1	0,4	2,3		
Others	0,57	0,78	2,85	4,13	7,19	9,92	12,73	1,8	2,0	6,4	8,9	14,3	19,3	24,9	6,2	13,1	5,7	3,3	2,5	4,6		

Power generation Input

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,41	2,28	1,60	1,52	1,05	0,64	0,15	100	100	100	100	100	100	100	0,5	-1,6	-3,7	-4,8	-13,3	-6,8		
Coal	0,17	0,38	0,31	0,12	0,11	0,11	0,10	11,9	16,7	19,5	8,1	10,1	16,5	67,7	2,3	-26,6	-1,6	0,0	-0,1	-3,3		
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	-7,1	24,5	-6,6	-5,7	-21,2	-8,7		
Natural gas	1,24	1,90	1,28	1,40	0,94	0,54	0,05	87,7	83,3	80,4	91,8	89,8	83,4	32,2	0,1	2,9	-3,9	-5,5	-21,1	-9,4		

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	38,8	41,9	44,5	48,5	49,7	50,2	41,4								0,5	2,9	0,2	0,1	-1,9	-0,2
Coal	34,0	34,8	33,4	33,5	34,4	34,4	34,4								-0,1	0,1	0,3	0,0	0,0	0,1
Oil	13,8	-	60,3	32,5	42,0	44,7	47,4								5,6	-18,7	2,6	0,6	0,6	-0,7
Natural gas	39,6	43,4	47,2	49,8	51,4	53,3	56,1								0,7	1,8	0,3	0,4	0,5	0,5

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	6,3	7,9	8,9	8,8	7,9	6,5	5,1	100	100	100	100	100	100	100	1,3	-0,4	-1,1	-1,9	-2,4	-1,7
Coal	1,3	1,2	1,4	1,1	1,0	0,9	0,8	20,6	15,4	15,1	12,6	12,8	14,2	16,4	0,1	-6,3	-0,9	-0,9	-1,0	-1,4
Oil	3,2	4,3	5,6	5,6	5,1	4,2	3,3	50,8	54,4	62,1	63,1	64,2	63,7	64,2	2,1	0,1	-0,9	-2,0	-2,3	-1,6
Natural gas	1,8	2,4	2,0	2,1	1,8	1,4	1,0	28,5	30,2	22,8	24,3	23,0	22,1	19,4	0,5	1,7	-1,6	-2,3	-3,7	-2,2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	83	112	181	197	243	281	315	2,9	2,8	2,1	1,5	1,1	1,7
Population (millions of people)	3	4	5	5	5	6	6	1,4	1,5	0,9	0,6	0,5	0,75
GDP per capita (thousands of 2010 USD/person)	24,83	28,97	37,78	39,23	44,31	48,04	51,36	1,6	1,3	1,2	0,8	0,7	0,9
Primary energy consumption per capita (toe/person)	3,86	4,44	4,32	4,40	4,33	3,93	3,51	0,4	0,6	-0,1	-1,0	-1,1	-0,6
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	156	153	114	112	98	82	68	-1,1	-0,6	-1,4	-1,8	-1,8	-1,5
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	118	116	81	76	60	47	37	-1,4	-2,1	-2,3	-2,5	-2,4	-2,4
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	76	71	49	45	33	23	16	-1,6	-3,2	-3,1	-3,3	-3,5	-3,3
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,49	0,46	0,43	0,40	0,33	0,28	0,24	-0,5	-2,5	-1,8	-1,6	-1,8	-1,8
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Philippines [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	28.71	39.99	55.95	62.25	83.57	118.16	176.59	100	100	100	100	100	100	100	2.5	3.6	3.0	3.5	4.1	3.5
Coal	1.53	5.16	14.67	17.63	28.12	42.32	67.78	5.3	12.9	26.2	28.3	33.6	35.8	38.4	8.7	6.3	4.8	4.2	4.8	4.7
Oil	10.84	16.05	18.73	21.07	30.63	42.11	54.04	37.8	40.1	33.5	33.8	36.7	35.6	30.6	2.0	4.0	3.8	3.2	2.5	3.3
Natural gas	0.00	0.01	3.26	3.61	3.80	10.25	20.48	0.0	0.0	5.8	5.8	4.5	8.7	11.6	-	3.4	0.5	10.4	7.2	5.7
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	-	-	-	-	-	-
Hydro	0.52	0.67	0.83	0.83	0.94	1.31	1.86	1.8	1.7	1.5	1.3	1.1	1.1	1.1	1.7	0.2	1.2	3.4	3.5	2.5
Geothermal	5	10	8.83	9.16	7.33	7.04	16.55	16.4	25.0	15.8	14.7	8.8	6.0	9.4	2.4	1.2	-2.2	-0.4	8.9	1.9
Others	11.12	8.10	9.63	9.95	12.75	15.12	15.88	38.7	20.3	17.2	16.0	15.3	12.8	9.0	-0.5	1.1	2.5	1.7	0.5	1.5
Biomass	11.12	8.10	8.89	9.15	10.28	10.82	10.79	38.7	20.3	15.9	14.7	12.3	9.2	6.1	-0.8	1.0	1.2	0.5	0.0	0.6
Solar, Wind, Ocean	0.00	0.00	0.20	0.22	1.70	3.34	3.93	0.0	0.0	0.4	0.3	2.0	2.8	2.2	-	3.0	23.0	7.0	1.6	9.5
Biofuels	0.00	0.00	0.54	0.59	0.76	0.96	1.16	0.0	0.0	1.0	0.9	0.9	0.8	0.7	-	3.0	2.6	2.3	1.9	2.4
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	19.02	23.20	36.70	41.54	59.76	85.02	116.13	100	100	100	100	100	100	100	2.5	4.2	3.7	3.6	3.2	3.6
Industry	4.13	4.53	7.94	9.10	13.78	20.69	30.32	21.7	19.5	21.6	21.9	23.1	24.3	26.1	2.4	4.7	4.2	4.1	3.9	4.1
Transportation	4.69	8.30	11.84	13.84	21.21	31.15	41.65	24.6	35.8	32.3	33.3	35.5	36.6	35.9	3.5	5.3	4.4	3.9	2.9	3.9
Others	9.82	9.96	15.31	16.01	23.09	31.49	42.47	51.6	42.9	41.7	40.7	38.6	37.0	36.6	1.7	3.4	3.2	3.1	3.0	3.1
Non-energy	0.39	0.40	1.61	1.69	1.69	1.69	1.69	2.0	1.7	4.4	4.1	2.8	2.0	1.5	5.4	1.6	0.0	0.0	0.0	0.1
Total	19.02	23.20	36.70	41.54	59.76	85.02	116.13	100	100	100	100	100	100	100	2.5	4.2	3.7	3.6	3.2	3.6
Coal	0.70	0.84	3.16	3.83	6.42	10.05	14.50	3.7	3.6	8.6	9.2	10.7	11.8	12.5	5.8	6.6	5.3	4.6	3.7	4.7
Oil	8.08	12.83	17.80	20.33	29.24	40.62	52.32	42.5	55.3	48.5	48.9	48.9	47.8	45.1	3.0	4.5	3.7	3.3	2.6	3.3
Natural gas	0.00	0.00	0.05	0.05	0.06	0.06	0.07	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	0.8	0.8	0.8	0.8	0.8
Electricity	1.82	3.14	6.69	8.00	13.77	23.25	38.60	9.6	13.6	18.2	19.3	23.0	27.3	33.2	4.9	6.1	5.6	5.4	5.2	5.5
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	9.00	9.33	10.28	11.04	10.64	44.3	27.5	24.5	22.5	17.2	13.0	9.2	0.2	1.2	1.0	0.7	-0.4	0.5

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	26.33	45.29	94.37	105.84	160.11	270.39	448.91	100	100	100	100	100	100	100	4.8	3.9	4.2	5.4	5.2	4.8
Coal	1.93	16.66	46.85	56.16	89.06	134.71	221.03	7.3	36.8	49.6	53.1	55.6	49.8	49.2	12.5	6.2	4.7	4.2	5.1	4.8
Oil	12.43	9.19	3.77	2.99	5.72	6.17	7.09	47.2	20.3	4.0	2.8	3.6	2.3	1.6	-4.3	-7.5	6.7	0.8	1.4	1.9
Natural gas	0.00	0.02	20.55	22.75	23.95	65.17	130.59	0.0	0.0	21.8	21.5	15.0	24.1	29.1	-	3.5	0.5	10.5	7.2	5.8
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	6.06	7.80	9.61	9.66	10.90	15.25	21.61	23.0	17.2	10.2	9.1	6.8	5.6	4.8	1.7	0.2	1.2	3.4	3.5	2.5
Geothermal	5	12	10.20	10.66	8.53	8.19	19.25	20.8	25.7	10.9	10.1	5.3	3.0	4.3	2.4	1.2	-2.2	-0.4	8.9	1.9
Others	0	0.00	3.32	3.64	21.96	40.91	49.33	1.6	0.0	3.5	3.4	13.7	15.1	11.0	7.9	3.0	19.7	6.4	1.9	8.5

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	2.69	6.09	15.63	18.07	26.81	43.94	75.39	100	100	100	100	100	100	100	6.7	5.0	4.0	5.1	5.5	4.9
Coal	0.51	4.11	11.51	13.80	21.70	32.28	53.28	18.9	67.5	73.7	76.4	80.9	73.5	70.7	12.3	6.2	4.6	4.0	5.1	4.8
Oil	2.18	1.97	0.91	0.71	1.37	1.47	1.69	81.1	32.4	5.8	3.9	5.1	3.4	2.2	-3.2	-7.6	6.7	0.8	1.4	1.9
Natural gas	0.00	0.01	3.21	3.56	3.74	10.19	20.42	0.0	0.1	20.6	19.7	14.0	23.2	27.1	-	3.5	0.5	10.5	7.2	5.8

Thermal Efficiency

	%							AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	45.9	36.5	39.2	39.0	38.1	40.3	40.9	-0.6	-0.2	-0.2	0.6	0.1	0.1
Coal	33	35	35	35	35	36	36	0.2	0.0	0.1	0.2	-0.1	0.1
Oil	49	40	36	36	36	36	36	-1.2	0.2	0.0	0.0	0.0	0.0
Natural gas	-	16	55	55	55	55	55	-	0.0	0.0	0.0	0.0	0.0

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	10.2	18.3	32.1	37.4	56.9	86.4	130.5	100	100	100	100	100	100	100	4.3	5.2	4.3	4.3	4.2	4.3
Coal	1.4	5.2	15.8	19.0	30.6	46.5	74.4	13.4	28.7	49.3	50.8	53.7	53.8	57.0	9.5	6.3	4.9	4.3	4.8	4.8
Oil	8.8	13.1	14.2	16.1	23.9	33.3	43.0	86.6	71.3	44.2	43.0	42.0	38.6	32.9	1.8	4.2	4.1	3.4	2.6	3.4
Natural gas	0.0	0.0	2.1	2.3	2.4	6.6	13.1	0.0	0.0	6.5	6.2	4.3	7.6	10.1	-	3.4	0.5	10.4	7.2	5.7

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	95	125	303	303	522	882	1,464	4.4	0.0	5.6	5.4	5.2	4.9	
Population (millions of people)	62	78	105	105	122	142	164	2.0	0.0	1.5	1.5	1.5	1.4	
GDP per capita (thousands of 2010 USD/person)	1.5	1.6	2.9	2.9	4.3	6.2	8.9	2.4	0.0	4.0	3.8	3.6	3.5	
Primary energy consumption per capita (toe/person)	0.5	0.5	0.5	0.6	0.7	0.8	1.1	0.5	3.6	1.5	2.0	2.6	2.2	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	304	319	184	205	160	134	121	-1.8	3.6	-2.5	-1.8	-1.0	-1.3	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	201	185	121	137	114	96	79	-1.9	4.2	-1.8	-1.7	-1.9	-1.3	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	108	146	106	123	109	98	89	-0.1	5.2	-1.2	-1.1	-0.9	-0.5	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.35	0.46	0.57	0.60	0.68	0.73	0.74	1.8	1.5	1.3	0.7	0.1	0.8	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

Philippines [APS5]

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	28.71	39.99	55.95	60.12	77.93	101.70	139.84	100	100	100	100	100	100	100	2.5	2.4	2.6	2.7	3.2	2.8		
Coal	1.53	5.16	14.67	15.90	21.75	31.24	44.18	5.3	12.9	26.2	26.5	27.9	30.7	31.6	8.7	2.7	3.2	3.7	3.5	3.4		
Oil	10.84	16.05	18.73	21.07	29.15	36.77	43.82	37.8	40.1	33.5	35.0	37.4	36.2	31.3	2.0	4.0	3.3	2.3	1.8	2.6		
Natural gas	0.00	0.01	3.26	3.31	4.13	8.54	16.06	0.0	0.0	5.8	5.5	5.3	8.4	11.5	-	0.5	2.2	7.5	6.5	4.9		
Nuclear	0.00	0.00	0.00	0.00	0.00	1.15	1.55	0.0	0.0	0.0	0.0	0.0	1.1	1.1	-	-	15.8	108.1	3.0	-		
Hydro	0.52	0.67	0.83	0.83	0.99	1.19	1.81	1.8	1.7	1.5	1.4	1.3	1.2	1.3	1.7	0.2	1.8	1.8	4.3	2.4		
Geothermal	4.70	10.00	8.83	9.16	9.11	7.86	16.71	16.4	25.0	15.8	15.2	11.7	7.7	12.0	2.4	1.2	-0.1	-1.5	7.8	2.0		
Others	11.12	8.10	9.63	9.84	12.80	14.94	15.70	38.7	20.3	17.2	16.4	16.4	14.7	11.2	-0.5	0.7	2.7	1.6	0.5	1.5		
Biomass	11.12	8.10	8.89	9.04	10.22	10.69	10.70	38.7	20.3	15.9	15.0	13.1	10.5	7.7	-0.8	0.5	1.2	0.4	0.0	0.6		
Solar, Wind, Ocean	0.00	0.00	0.20	0.22	1.84	3.37	3.99	0.0	0.0	0.4	0.4	2.4	3.3	2.9	-	3.0	23.9	6.2	1.7	9.5		
Biofuels	0.00	0.00	0.54	0.59	0.74	0.88	1.01	0.0	0.0	1.0	1.0	0.9	0.9	0.7	-	3.0	2.3	1.8	1.4	1.9		
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	19.02	23.20	36.70	41.55	57.67	76.83	98.11	100	100	100	100	100	100	100	2.5	4.2	3.3	2.9	2.5	3.0		
Industry	4.13	4.53	7.94	9.10	13.47	19.48	27.45	21.7	19.5	21.6	21.9	23.4	25.4	28.0	2.4	4.7	4.0	3.8	3.5	3.8		
Transportation	4.69	8.30	11.84	13.84	20.16	27.15	33.41	24.6	35.8	32.3	33.3	35.0	35.3	34.1	3.5	5.3	3.8	3.0	2.1	3.2		
Others	9.82	9.96	15.31	16.91	22.35	28.51	35.56	51.6	42.9	41.7	40.7	38.8	37.1	36.2	1.7	3.4	2.8	2.5	2.2	2.6		
Non-energy	0.39	0.40	1.61	1.69	1.69	1.69	1.69	2.0	1.7	4.4	4.1	2.9	2.2	1.7	5.4	1.6	0.0	0.0	0.0	0.1		
Total	19.02	23.20	36.70	41.55	57.67	76.83	98.11	100	100	100	100	100	100	100	2.5	4.2	3.3	2.9	2.5	3.0		
Coal	0.70	0.84	3.16	3.83	6.42	10.05	14.50	3.7	3.6	8.6	9.2	11.1	13.1	14.8	5.8	6.6	5.3	4.6	3.7	4.7		
Oil	8.08	12.83	17.80	20.33	27.85	35.53	42.15	42.5	55.3	48.5	48.9	48.3	46.2	43.0	3.0	4.5	3.2	2.5	1.7	2.6		
Natural gas	0.00	0.00	0.05	0.05	0.06	0.06	0.07	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	0.8	0.8	0.8	0.8	0.8		
Electricity	1.82	3.14	6.69	8.00	13.08	20.23	30.89	9.6	13.6	18.2	19.3	22.7	26.3	31.5	4.9	6.1	5.0	4.5	4.3	4.7		
Heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-		
Others	8.42	6.39	9.00	9.33	10.26	10.96	10.49	44.3	27.5	24.5	22.5	17.8	14.3	10.7	0.2	1.2	0.9	0.7	-0.4	0.5		

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	26.33	45.29	94.37	105.84	152.12	235.29	359.25	100	100	100	100	100	100	100	4.8	3.9	3.7	4.5	4.3	4.1
Coal	1.93	16.66	46.85	56.16	72.16	102.16	143.27	7.3	36.8	49.6	53.1	47.4	43.4	39.9	12.5	6.2	2.5	3.5	3.4	3.4
Oil	12.43	9.19	3.77	2.99	5.34	5.11	6.87	47.2	20.3	4.0	2.8	3.5	2.2	1.9	-4.3	-7.5	6.0	-0.4	3.0	1.8
Natural gas	0.00	0.02	20.55	22.75	28.39	59.14	111.61	0.0	0.0	21.8	21.5	18.7	25.1	31.1	-	3.5	2.2	7.6	6.6	5.3
Nuclear			0.00	0.00	0.00	4.43	5.95	0.0	0.0	0.0	0.0	0.0	1.9	1.7	-	-	-	-	3.0	-
Hydro	6.06	7.80	9.61	9.66	11.53	13.80	21.02	23.0	17.2	10.2	9.1	7.6	5.9	5.9	1.7	0.2	1.8	1.8	4.3	2.4
Geothermal	5.47	11.63	10.27	10.66	10.60	9.15	19.44	20.8	25.7	10.9	10.1	7.0	3.9	5.4	2.4	1.2	-0.1	-1.5	7.8	2.0
Others	0.43	0.00	3.32	3.64	24.10	41.51	51.09	1.6	0.0	3.5	3.4	15.8	17.6	14.2	7.9	3.0	20.8	5.6	2.1	8.6

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	2.69	6.09	15.63	16.05	20.67	30.90	47.32	100	100	100	100	100	100	100	6.7	0.9	2.6	4.1	4.4	3.4
Coal	0.51	4.11	11.51	12.07	15.33	21.20	29.68	18.9	67.5	73.7	75.2	74.1	68.6	62.7	12.3	1.6	2.4	3.3	3.4	2.9
Oil	2.18	1.97	0.91	0.71	1.28	1.22	1.64	81.1	32.4	5.8	4.4	6.2	4.0	3.5	-3.2	-7.6	6.0	-0.4	3.0	1.8
Natural gas	0.00	0.01	3.21	3.26	4.07	8.48	15.99	0.0	0.1	20.6	20.3	19.7	27.4	33.8	-	0.5	2.2	7.6	6.6	5.0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	46	37	39	44	44	46	48								-0,6	3,9	0,0	0,5	0,3	0,6
Coal	33	35	35	40	40	41	42								0,2	4,6	0,1	0,2	0,0	0,5
Oil	49	40	36	36	36	36	36								-1,2	0,2	0,0	0,0	0,0	0,0
Natural gas	-	16	55	60	60	60	60								-	2,9	0,0	0,0	0,0	0,3

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	10.2	18.3	32.1	35.3	48.9	68.6	93.5	100	100	100	100	100	100	100	4.3	3.2	3.3	3.4	3.1	3.3
Coal	1.36	5.25	15.8	17.1	23.6	34.2	48.5	13.4	28.7	49.3	48.5	48.2	49.9	51.9	9.5	2.7	3.3	3.8	3.5	3.5
Oil	8.80	13.05	14.2	16.1	22.7	28.9	34.6	86.6	71.3	44.2	45.5	46.4	42.1	37.1	1.8	4.2	3.5	2.5	1.8	2.7
Natural gas	0.00	0.01	2.1	2.1	2.6	5.5	10.3	0.0	0.0	6.5	6.0	5.4	8.0	11.0	-	0.5	2.2	7.5	6.5	4.9

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	95	125	303	303	522	882	1,464	4,4	0,0	5,6	5,4	5,2	4,9
Population (millions of people)	62	78	105	105	122	142	164	2,0	0,0	1,5	1,5	1,5	1,4
GDP per capita (thousands of 2010 USD/person)	1,5	1,6	2,9	2,9	4,3	6,2	8,9	2,4	0,0	4,0	3,8	3,6	3,5
Primary energy consumption per capita (toe/person)	0,5	0,5	0,5	0,6	0,6	0,7	0,9	0,5	2,4	1,1	1,2	1,7	1,4
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	304	319	184	198	149	115	96	-1,8	2,4	-2,8	-2,5	-1,9	-2,0
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	201	185	121	137	110	87	67	-1,9	4,2	-2,1	-2,3	-2,6	-1,8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	108	146	106	116	94	78	64	-0,1	3,2	-2,1	-1,8	-2,0	-1,5
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,35	0,46	0,57	0,59	0,63	0,67	0,67	1,8	0,8	0,7	0,7	-0,1	0,5
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Singapore [BAU]

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	8,38	13,89	29,06	29,99	34,00	38,14	42,41	100	100	100	100	100	100	100	4,7	1,1	1,3	1,2	1,1	1,2	
Coal	0,02	0,00	0,47	0,49	0,57	0,65	0,74	0,2	0,0	1,6	1,6	1,7	1,7	1,7	12,4	1,1	1,6	1,4	1,2	1,4	
Oil	8,23	12,46	18,96	19,36	20,74	22,13	23,55	98,2	89,7	65,2	64,6	61,0	58,0	55,5	3,1	0,7	0,7	0,7	0,6	0,7	
Natural gas	0,06	1,23	8,90	9,35	11,55	13,80	16,10	0,7	8,9	30,6	31,2	34,0	36,2	38,0	20,3	1,6	2,1	1,8	1,5	1,8	
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	0,00	0,00	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	0,72	0,79	1,14	1,55	2,02	0,8	1,4	2,5	2,7	3,4	4,1	4,8	9,0	3,2	3,7	3,1	2,7	3,2	
Biomass	0,07	0,20	0,07	0,07	0,09	0,11	0,13	0,8	1,4	0,2	0,2	0,3	0,3	0,3	-0,1	1,7	2,3	1,9	1,6	2,0	
Solar, Wind, Ocean	0,00	0,00	0,66	0,72	1,05	1,44	1,89	0,0	0,0	2,3	2,4	3,1	3,8	4,5	-	3,3	3,8	3,2	2,8	3,3	
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	5,01	8,31	24,56	25,31	28,28	31,39	34,65	100	100	100	100	100	100	100	6,1	1,0	1,1	1,0	1,0	1,0
Industry	0,61	2,18	6,84	7,02	8,08	9,35	10,80	12,2	26,2	27,8	27,7	28,6	29,8	31,2	9,4	0,9	1,4	1,5	1,5	1,4
Transportation	1,36	1,75	2,45	2,50	2,63	2,65	2,66	27,1	21,1	10,0	9,9	9,3	8,4	7,7	2,2	0,6	0,5	0,0	0,0	0,2
Others	1,13	1,65	2,54	2,69	3,19	3,76	4,29	22,6	19,9	10,4	10,6	11,3	12,0	12,4	3,1	1,8	1,7	1,7	1,3	1,6
Non-energy	1,91	2,72	12,73	13,11	14,37	15,64	16,90	38,1	32,8	51,8	51,8	50,8	49,8	48,8	7,3	1,0	0,9	0,8	0,8	0,9
Total	5,01	8,31	24,56	25,31	28,28	31,39	34,65	100	100	100	100	100	100	100	6,1	1,0	1,1	1,0	1,0	1,0
Coal	0,02	0,00	0,17	0,17	0,17	0,17	0,17	0,4	0,0	0,7	0,7	0,6	0,6	0,5	8,3	0,0	0,0	0,0	0,0	0,0
Oil	3,81	5,86	18,83	19,25	20,65	22,08	23,53	76,0	70,5	76,6	76,0	73,0	70,3	67,9	6,1	0,7	0,7	0,7	0,6	0,7
Natural gas	0,06	0,11	1,29	1,40	1,80	2,28	2,88	1,2	1,3	5,3	5,5	6,4	7,3	8,3	12,0	2,6	2,5	2,4	2,3	2,4
Electricity	1,12	2,35	4,27	4,49	5,66	6,86	8,08	22,4	28,2	17,4	17,7	20,0	21,8	23,3	5,1	1,7	2,3	1,9	1,6	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	0,00	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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	15,71	31,67	52,66	55,41	69,80	84,60	99,64	100	100	100	100	100	100	100	4,6	1,7	2,3	1,9	1,6	2,0
Coal	0,00	0,00	0,68	0,72	0,90	1,10	1,29	0,0	0,0	1,3	1,3	1,3	1,3	1,3	-	1,7	2,3	1,9	1,6	2,0
Oil	15,54	25,32	0,37	0,36	0,32	0,24	0,11	98,9	79,9	0,7	0,6	0,5	0,3	0,1	-12,9	-1,1	-0,9	-2,9	-7,7	-3,6
Natural gas	0,00	5,86	49,98	52,32	64,76	77,11	89,18	0,0	18,5	94,9	94,4	92,8	91,1	89,5	-	1,5	2,2	1,8	1,5	1,8
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	0,00	0,00	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	1,63	2,02	3,81	6,16	9,06	1,1	1,5	3,1	3,6	5,5	7,3	9,1	8,7	7,4	6,6	4,9	3,9	5,3

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4,42	7,72	8,04	8,38	10,24	12,06	13,81	100	100	100	100	100	100	100	2,2	1,4	2,0	1,6	1,4	1,7
Coal	0,00	0,00	0,30	0,32	0,40	0,48	0,57	0,0	0,0	3,7	3,8	3,9	4,0	4,1	-	1,7	2,3	1,9	1,6	2,0
Oil	4,42	6,60	0,13	0,12	0,09	0,05	0,02	100,0	85,5	1,6	1,4	0,8	0,4	0,2	-12,2	-3,5	-3,0	-4,5	-9,1	-5,4
Natural gas	0,00	1,12	7,61	7,95	9,76	11,52	13,22	0,0	14,5	94,7	94,8	95,3	95,6	95,7	-	1,5	2,1	1,7	1,4	1,7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	30,2	34,7	54,6	54,8	55,4	56,0	56,4								2,2	0,1	0,1	0,1	0,1	0,1
Coal	-	-	19,6	19,6	19,6	19,6	19,6								-	0,0	0,0	0,0	0,0	0,0
Oil	30,2	33,0	24,3	26,2	32,5	38,7	45,0								-0,8	2,5	2,2	1,8	1,5	1,9
Natural gas	-	45,0	56,5	56,6	57,1	57,5	58,0								-	0,1	0,1	0,1	0,1	0,1

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	5,7	8,9	18,2	19,0	23,1	27,2	31,1	100	100	100	100	100	100	100	4,4	1,4	2,0	1,6	1,4	1,6
Coal	0,1	0,0	0,0	0,0	0,0	0,0	0,0	1,8	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-
Oil	5,6	8,0	0,3	0,3	0,2	0,1	0,1	98,2	89,9	1,8	1,6	0,9	0,5	0,2	-10,0	-3,5	-3,0	-4,5	-9,1	-5,4
Natural gas	0,0	0,9	17,9	18,7	22,9	27,1	31,1	0,0	10,1	98,2	98,4	99,1	99,5	99,8	-	1,5	2,1	1,7	1,4	1,7

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	68,8	136,3	318,4	355,8	508,6	683,0	871,1	5,8	3,8	3,6	3,0	2,5	3,1
Population (millions of people)	3,0	4,0	5,6	5,8	6,5	7,2	7,7	2,3	1,1	1,2	0,9	0,7	0,9
GDP per capita (thousands of 2010 USD/person)	22,57	33,85	56,74	61,35	77,82	95,46	113,68	3,5	2,6	2,4	2,1	1,8	2,1
Primary energy consumption per capita (toe/person)	2,75	3,45	5,18	5,17	5,20	5,33	5,53	2,4	0,0	0,1	0,2	0,4	0,2
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	122	102	91	84	67	56	49	-1,1	-2,6	-2,3	-1,8	-1,4	-1,9
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	73	61	77	71	56	46	40	0,2	-2,7	-2,4	-1,9	-1,4	-2,0
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	83	65	57	53	45	40	36	-1,4	-2,3	-1,6	-1,3	-1,1	-1,4
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,68	0,64	0,63	0,63	0,68	0,71	0,73	-0,3	0,3	0,7	0,5	0,3	0,5
Automobile ownership volume (millions of vehicles)			0,82	0,82	0,82	0,82	0,82	-	0,0	0,0	0,0	0,0	0,0
Automobile ownership volume per capita (vehicles per person)	-	-	0,146	0,141	0,125	0,115	0,107	-	-1,1	-1,2	-1,6	-1,6	-0,9

Singapore [APS]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	8,38	13,89	29,06	29,84	32,98	36,36	39,76	100	100	100	100	100	100	100	4,7	0,9	1,0	1,0	0,9	1,0
Coal	0,02	0,00	0,47	0,49	0,56	0,64	0,72	0,2	0,0	1,6	1,6	1,7	1,8	1,8	12,4	1,0	1,4	1,4	1,2	1,3
Oil	8,23	12,46	18,96	19,32	20,73	22,17	23,63	98,2	89,7	65,2	64,7	62,9	61,0	59,4	3,1	0,6	0,7	0,7	0,6	0,7
Natural gas	0,06	1,23	8,90	9,08	10,08	11,06	11,85	0,7	8,9	30,6	30,4	30,6	30,4	29,8	20,3	0,6	1,1	0,9	0,7	0,9
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	0,00	0,00	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	0,72	0,96	1,61	2,48	3,55	0,8	1,4	2,5	3,2	4,9	6,8	8,9	9,0	9,8	5,3	4,4	3,6	4,9
Biomass	0,07	0,20	0,07	0,07	0,09	0,11	0,13	0,8	1,4	0,2	0,2	0,3	0,3	0,3	-0,1	1,6	2,1	2,0	1,7	1,9
Solar, Wind, Ocean	0,00	0,00	0,66	0,89	1,52	2,38	3,43	0,0	0,0	2,3	3,0	4,6	6,5	8,6	-	10,5	5,6	4,5	3,7	5,1
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050										
Total	5,01	8,31	24,56	25,29	28,11	31,20	34,43	100	100	100	100	100	100	100	6,1	1,0	1,1	1,0	1,0	1,0										
Industry	0,61	2,18	6,84	7,02	8,08	9,35	10,80	12,2	26,2	27,8	27,8	28,8	30,0	31,4	9,4	0,9	1,4	1,5	1,5	1,4										
Transportation	1,36	1,75	2,45	2,50	2,63	2,65	2,66	27,1	21,1	10,0	9,9	9,4	8,5	7,7	2,2	0,6	0,5	0,0	0,0	0,2										
Others	1,13	1,65	2,54	2,67	3,02	3,56	4,07	22,6	19,9	10,4	10,5	10,8	11,4	11,8	3,1	1,6	1,3	1,7	1,3	1,4										
Non-energy	1,91	2,72	12,73	13,11	14,37	15,64	16,90	38,1	32,8	51,8	51,8	51,1	50,1	49,1	7,3	1,0	0,9	0,8	0,8	0,9										
Total	5,01	8,31	24,56	25,29	28,11	31,20	34,43	100	100	100	100	100	100	100	6,1	1,0	1,1	1,0	1,0	1,0										
Coal	0,02	0,00	0,17	0,17	0,17	0,17	0,17	0,4	0,0	0,7	0,7	0,6	0,6	0,5	8,3	0,0	0,0	0,0	0,0	0,0										
Oil	3,81	5,86	18,83	19,25	20,65	22,08	23,53	76,0	70,5	76,6	76,1	73,5	70,8	68,3	6,1	0,7	0,7	0,7	0,6	0,7										
Natural gas	0,06	0,11	1,29	1,40	1,80	2,28	2,88	1,2	1,3	5,3	5,5	6,4	7,3	8,4	12,0	2,6	2,5	2,4	2,3	2,4										
Electricity	1,12	2,35	4,27	4,47	5,49	6,66	7,86	22,4	28,2	17,4	17,7	19,5	21,4	22,8	5,1	1,6	2,1	2,0	1,7	1,9										
Heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-										
Others	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-										

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	15,71	31,67	52,66	55,17	67,76	82,21	96,93	100	100	100	100	100	100	100	4,6	1,6	2,1	2,0	1,7	1,9		
Coal	0,00	0,00	0,68	0,72	0,88	1,07	1,26	0,0	0,0	1,3	1,3	1,3	1,3	1,3	-	1,6	2,1	2,0	1,7	1,9		
Oil	15,54	25,32	0,37	0,22	0,32	0,44	0,59	98,9	79,9	0,7	0,4	0,5	0,5	0,6	-12,9	-15,8	3,8	3,4	2,9	1,4		
Natural gas	0,00	5,86	49,98	51,11	57,66	63,76	67,85	0,0	18,5	94,9	92,6	85,1	77,5	70,0	-	0,7	1,2	1,0	0,6	0,9		
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	0,00	0,00	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	1,63	3,12	8,90	16,95	27,23	1,1	1,5	3,1	5,7	13,1	20,6	28,1	8,7	24,2	11,0	6,7	4,9	8,9		

Power generation Input

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	4,42	7,72	8,04	8,06	8,75	9,34	9,63	100	100	100	100	100	100	100	2,2	0,1	0,8	0,7	0,3	0,5		
Coal	0,00	0,00	0,30	0,31	0,39	0,47	0,55	0,0	0,0	3,7	3,9	4,4	5,0	5,7	-	1,6	2,1	2,0	1,7	1,9		
Oil	4,42	6,60	0,13	0,07	0,08	0,09	0,11	100,0	85,5	1,6	0,9	0,9	1,0	1,1	-12,2	-18,1	1,3	1,4	1,3	-0,6		
Natural gas	0,00	1,12	7,61	7,68	8,29	8,78	8,98	0,0	14,5	94,7	95,2	94,7	94,0	93,2	-	0,3	0,8	0,6	0,2	0,5		

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	30,2	34,7	54,6	55,5	57,8	60,1	62,2								2,2	0,6	0,4	0,4	0,4	0,4
Coal	-	-	19,6	19,6	19,6	19,6	19,6								-	0,0	0,0	0,0	0,0	0,0
Oil	30,2	33,0	24,3	26,5	33,7	40,8	48,0								-0,8	2,9	2,4	1,9	1,6	2,1
Natural gas	-	45,0	56,5	57,3	59,8	62,4	65,0								-	0,5	0,4	0,4	0,4	0,4

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	5,7	8,9	18,2	18,2	19,7	20,9	21,3	100	100	100	100	100	100	100	4,4	0	0,8	0,6	0,2	0,5		
Coal	0,1	0,0	0,0	0,0	0,0	0,0	0,0	1,8	0,0	0,0	0,0	0,0	0,0	0,0	-100,0	-	-	-	-	-		
Oil	5,6	8,0	0,3	0,2	0,2	0,2	0,3	98,2	89,9	1,8	1,0	1,0	1,1	1,3	-10,0	-18,1	1,3	1,4	1,3	-0,6		
Natural gas	0,0	0,9	17,9	18,0	19,5	20,6	21,1	0,0	10,1	98,2	99,0	99,0	98,9	98,7	-	0,3	0,8	0,6	0,2	0,5		

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	69	136	318	356	509	683	871	5,8	3,8	3,6	3,0	2,5	3,10
Population (millions of people)	3	4	6	6	7	7	8	2,3	1,1	1,2	0,9	0,7	0,95
GDP per capita (thousands of 2010 USD/person)	22,6	33,9	56,7	61,4	77,8	95,5	113,7	3,5	2,6	2,4	2,1	1,8	2,1
Primary energy consumption per capita (toe/person)	2,75	3,45	5,18	5,15	5,05	5,08	5,19	2,4	-0,2	-0,2	0,1	0,2	0,0
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	122	102	91	84	65	53	46	-1,1	-2,8	-2,5	-2,0	-1,5	-2,1
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	73	61	77	71	55	46	40	0,2	-2,7	-2,5	-1,9	-1,4	-2,0
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	83	65	57	51	39	31	25	-1,4	-3,6	-2,8	-2,3	-2,2	-2,5
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,68	0,64	0,63	0,61	0,60	0,57	0,54	-0,3	-0,9	-0,2	-0,4	-0,7	-0,5
Automobile ownership volume (millions of vehicles)			0,82	0,82	0,82	0,82	0,82	-	0,0	0,0	0,0	0,0	0,0
Automobile ownership volume per capita (vehicles per person)	-	-	0,146	0,141	0,125	0,115	0,107	-	-1,1	-1,2	-1,6	-1,6	-0,9

Thailand [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	41.94	72.27	122.45	127.76	175.24	225.07	277.63	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.0	1.4	3.2	2.5	2.1	2.5
Coal	3.82	7.67	14.91	11.65	11.24	15.36	25.57	9.1	10.6	12.2	9.1	6.4	6.8	9.2	5.2	-7.9	-0.4	3.2	5.2	1.6
Oil	17.96	31.88	44.25	49.59	77.01	101.96	125.07	42.8	44.1	36.1	38.8	43.9	45.3	45.0	3.4	3.9	4.5	2.8	2.1	3.2
Natural gas	4.99	17.36	38.17	41.45	54.14	65.71	81.85	11.9	24.0	31.2	32.4	30.9	29.2	29.5	7.8	2.8	2.7	2.0	2.2	2.3
Nuclear								-	-	-	-	-	-	-	-	-	-	-	-	-
Hydro	0.43	0.52	0.41	0.92	0.93	0.93	0.96	1.0	0.7	0.3	0.7	0.5	0.4	0.3	-0.2	31.4	0.1	0.1	0.3	2.6
Geothermal								-	-	-	-	-	-	-	-	-	-	-	-	-
Others	14.74	14.83	24.71	24.14	31.92	41.10	44.18	35.1	20.5	20.2	18.9	18.2	18.3	15.9	1.9	-0.8	2.8	2.6	0.7	1.8
Biomass	14.69	14.59	20.60	18.42	20.74	24.53	27.41	35.0	20.2	16.8	14.4	11.8	10.9	9.9	1.3	-3.7	1.2	1.7	1.1	0.9
Solar, Wind, Ocean			0.04	1.16	2.71	4.74	4.65	-	-	0.0	0.9	1.5	2.1	1.7	-	206.9	8.9	5.7	-0.2	15.5
Biofuels			1.93	1.93	2.23	2.50	2.77	-	-	1.6	1.5	1.3	1.1	1.0	-	0.1	1.4	1.2	1.0	1.1
Electricity	0.05	0.24	2.15	2.62	6.24	9.34	9.35	0.1	0.3	1.8	2.1	3.6	4.1	3.4	14.7	6.9	9.0	4.1	0.0	4.6

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	28.87	50.57	85.28	94.65	137.16	176.31	211.90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.1	3.5	3.8	2.5	1.9	2.8
Industry	8.65	16.72	25.10	30.03	50.11	68.62	85.56	30.0	33.1	29.4	31.7	36.5	38.9	40.4	4.0	6.2	5.3	3.2	2.2	3.8
Transportation	9.01	14.61	28.68	30.31	42.96	54.59	65.11	31.2	28.9	33.6	32.0	31.3	31.0	30.7	4.4	1.9	3.5	2.4	1.8	2.5
Others	10.78	13.62	20.16	21.83	28.05	33.77	38.97	37.3	26.9	23.6	23.1	20.4	19.2	18.4	2.3	2.7	2.5	1.9	1.4	2.0
Non-energy	0.43	5.63	11.34	12.48	16.05	19.33	22.25	1.5	11.1	13.3	13.2	11.7	11.0	10.5	12.9	3.2	2.5	1.9	1.4	2.1
Total	28.87	50.57	85.28	94.65	137.16	176.31	211.90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.1	3.5	3.8	2.5	1.9	2.8
Coal	1.31	3.54	5.47	5.43	5.29	5.15	4.99	4.5	7.0	6.4	5.7	3.9	2.9	2.4	5.4	-0.3	-0.3	-0.3	-0.3	-0.3
Oil	14.93	28.77	42.09	47.21	74.58	99.82	122.84	51.7	56.9	49.4	49.9	54.4	56.6	58.0	3.9	4.7	3.0	2.1	3.3	3.3
Natural gas	0.14	1.11	8.51	10.80	17.55	23.76	29.28	0.5	2.2	10.0	11.4	12.8	13.5	13.8	16.5	8.2	5.0	3.1	2.1	3.8
Electricity	3.30	7.56	14.99	17.03	25.34	33.01	40.04	11.4	15.0	17.6	18.0	18.5	18.7	18.9	5.8	4.3	4.1	2.7	1.9	3.0
Heat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Others	9.20	9.59	14.22	14.19	14.39	14.57	14.74	31.9	19.0	16.7	15.0	10.5	8.3	7.0	1.6	-0.1	0.1	0.1	0.1	0.1

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	44.18	95.98	167.47	186.26	249.70	311.12	401.68	100.0	100.0	100.0	100.0	100.0	100.0	100.0	5.1	3.6	3.0	2.2	2.6	2.7
Coal	11.05	17.77	35.73	24.72	24.23	42.86	89.27	25.0	18.5	21.3	13.3	9.7	13.8	22.2	4.4	-16	-0.2	5.9	7.6	2.8
Oil	10.38	10.03	0.33	1.37	1.63	0.42	0.89	23.5	10.4	0.2	0.7	0.7	0.1	0.2	-12.0	60.7	1.7	-12.6	7.7	3.1
Natural gas	17.77	61.64	121.04	132.02	174.73	187.44	224.85	40.2	64.2	72.3	70.9	70.0	60.2	56.0	7.4	2.9	2.8	0.7	1.8	1.9
Nuclear			0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydro	4.98	6.03	4.72	10.70	10.79	10.87	11.16	11.3	6.3	2.8	5.7	4.3	3.5	2.8	-0.2	31.4	0.1	0.1	0.3	2.6
Geothermal								-	-	-	-	-	-	-	-	-	-	-	-	-
Others		0.51	5.65	17.45	38.33	69.53	75.52	-	0.5	3.4	9.4	15.3	22.3	18.8	-	45.7	8.2	6.1	0.8	8.2

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	8.92	19.24	30.86	29.97	36.31	41.45	56.98	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.7	-1.0	1.9	1.3	3.2	1.9
Coal	2.55	4.16	9.07	6.23	5.95	10.21	20.58	28.6	21.6	29.4	20.8	16.4	24.6	36.1	4.8	-11.8	-0.5	5.5	7.3	2.5
Oil	2.55	2.34	0.07	0.30	0.36	0.09	0.19	28.6	12.2	0.2	1.0	1.0	0.2	0.3	-12.3	60.6	1.7	-12.6	7.7	3.0
Natural gas	3.82	12.73	21.71	23.44	30.00	31.15	36.20	42.9	66.2	70.4	78.2	82.6	75.1	63.5	6.6	2.6	2.5	0.4	1.5	1.6

Thermal Efficiency

	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	37.8	40.0	43.8	45.4	47.5	47.9	47.5							
Coal	37	37	34	34	35	36	37	-0.4	0.3	0.3	0.3	0.3	0.3	
Oil	35	37	39	39	39	39	40	0.4	0.1	0.1	0.1	0.1	0.1	
Natural gas	40	42	48	48	50	52	53	0.7	0.3	0.3	0.3	0.3	0.3	

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	35.9	46.2	55.8	58.9	87.0	114.3	148.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.7	1.8	4.0	2.8	2.7	3.0
Coal	10.2	12.6	10.6	7.6	7.3	11.9	22.9	28.5	27.3	18.9	12.8	8.4	10.4	15.4	0.1	-10.5	-0.3	4.9	6.8	2.4
Oil	12.2	19.5	28.5	32.1	52.5	71.1	88.4	34.0	42.2	50.9	54.5	60.4	62.2	59.4	3.2	4.1	5.0	3.1	2.2	3.5
Natural gas	13.5	14.1	16.8	19.2	27.1	31.3	37.6	37.5	30.5	30.1	32.6	31.2	27.4	25.2	0.8	4.6	3.5	1.4	1.8	2.5

Energy and economic indicators

	AAGR(%)						
	1990	2000	2017	2020	2030	2040	2050
GDP (billions of 2010 US dollars)	141.6	217.7	424.2	464.8	675.0	952.1	1,304.6
Population (millions of people)	56.6	61.9	69.2	69.9	72.1	74.4	76.8
GDP per capita (thousands of 2010 USD/person)	2.50	3.52	6.13	6.7	9.4	12.8	17.0
Primary energy consumption per capita (toe/person)	0.74	1.17	1.77	1.83	2.43	3.02	3.61
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	296	332	289	275	260	236	213
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	204	232	201	204	203	185	162
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	253	212	132	127	129	120	114
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.86	0.64	0.46	0.46	0.50	0.51	0.54
Automobile ownership volume (millions of vehicles)	7.52	20.75	38.31	41.98	59.18	85.93	124.78
Automobile ownership volume per capita (vehicles per person)	0.133	0.335	0.554	0.601	0.821	1.155	1.625

Primary energy consumption / Final energy demand								Elasticity				
PEC / FEC (%)								AAGR(%)				
1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
1.4526	1.4290	1.4358	1.3497	1.2776	1.2766	1.3102	0.9870	1.1406	0.9945	0.7264	0.5800	0.8074

Thailand [APS5]

Primary energy consumption

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	41.94	72.27	122.45	114.61	133.68	153.94	186.63	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.0	-2.2	1.6	1.4	1.9	1.3		
Coal	3.82	7.67	14.91	10.28	9.33	9.62	12.30	9.1	10.6	12.2	9.0	7.0	6.2	6.6	5.2	-11.7	-1.0	0.3	2.5	-0.6		
Oil	17.95	31.88	44.25	44.52	57.64	67.96	84.24	42.8	44.1	36.1	38.8	43.1	44.1	45.1	3.4	0.2	2.6	1.7	2.2	2.0		
Natural gas	4.99	17.36	38.17	35.73	38.16	42.02	50.76	11.9	24.0	31.2	31.2	28.5	27.3	27.2	7.8	-2.2	0.7	1.0	1.9	0.9		
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-		
Hydro	0.43	0.52	0.41	1.19	0.91	0.75	0.76	1.0	0.7	0.3	1.0	0.7	0.5	0.4	-0.2	43.1	-2.6	-2.0	0.2	1.9		
Geothermal	0.00	0.00						-	-	-	-	-	-	-	-	-	-	-	-	-		
Others	14.74	14.83	24.71	22.90	27.64	33.60	38.57	35.1	20.5	20.2	20.0	20.7	21.8	20.7	1.9	-2.5	1.9	2.0	1.4	1.4		
Biomass	14.69	14.59	20.60	17.86	20.66	23.69	25.96	35.0	20.2	16.8	15.6	15.5	15.4	13.9	1.3	-4.6	1.5	1.4	0.9	0.7		
Solar, Wind, Ocean	0.00	0.00	0.04	0.88	1.68	2.52	3.23	-	-	0.0	0.8	1.3	1.6	1.7	-	179.7	6.7	4.1	2.5	14.2		
Biofuels	0.00	0.00	1.93	1.59	1.14	0.76	0.84	-	-	1.6	1.4	0.9	0.5	0.5	-	-6.1	-3.3	-4.0	1.0	-2.5		
Electricity	0.05	0.24	2.15	2.56	4.15	6.63	8.55	0.1	0.3	1.8	2.2	3.1	4.3	4.6	14.7	6.1	4.9	4.8	2.6	4.3		

Final energy demand

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	28.87	50.57	85.28	86.34	105.66	120.83	145.02	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.1	0.4	2.0	1.4	1.8	1.6		
Industry	8.65	16.72	25.10	27.91	42.45	55.42	68.83	30.0	33.1	29.4	32.3	40.2	45.9	47.5	4.0	3.6	4.3	2.7	2.2	3.1		
Transportation	9.01	14.61	28.68	25.14	22.84	18.26	21.88	31.2	28.9	33.6	29.1	21.6	15.1	15.1	4.4	-4.3	-1.0	-2.2	1.8	-0.8		
Others	10.78	13.62	20.16	20.81	24.31	27.82	32.05	37.3	26.9	23.6	24.1	23.0	23.0	22.1	2.3	1.1	1.6	1.4	1.4	1.4		
Non-energy	0.43	5.63	11.34	12.48	16.05	19.33	22.25	1.5	11.1	13.3	14.5	15.2	16.0	15.3	12.9	3.2	2.5	1.9	1.4	2.1		
Total	28.87	50.57	85.28	86.34	105.66	120.83	145.02	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.1	0.4	2.0	1.4	1.8	1.6		
Coal	1.31	3.54	5.47	5.34	5.06	4.85	4.73	4.5	7.0	6.4	6.2	4.8	4.0	3.3	5.4	-0.8	-0.5	-0.4	-0.3	-0.4		
Oil	14.93	28.77	42.09	42.16	55.27	65.85	82.13	51.7	56.9	49.4	48.8	52.3	54.5	56.6	3.9	0.1	2.7	1.8	2.2	2.0		
Natural gas	0.14	1.11	8.51	9.86	12.63	13.59	16.24	0.5	2.2	10.0	11.4	12.0	11.2	11.2	16.5	5.0	2.5	0.7	1.8	2.0		
Electricity	3.30	7.56	14.99	15.68	20.56	25.14	30.53	11.4	15.0	17.6	18.2	19.5	20.8	21.0	5.8	1.5	2.7	2.0	2.0	2.2		
Heat	0.00	0.00						-	-	-	-	-	-	-	-	-	-	-	-	-		
Others	9.20	9.59	14.22	13.30	12.13	11.39	11.39	31.9	19.0	16.7	15.4	11.5	9.4	7.9	1.6	-2.2	-0.9	-0.6	0.0	-0.7		

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	44.18	95.98	167.47	169.49	212.17	240.91	288.19	100.0	100.0	100.0	100.0	100.0	100.0	100.0	5.1	0.4	2.3	1.3	1.8	1.7
Coal	11.05	17.77	35.73	21.98	20.61	23.18	37.91	25.0	18.5	21.3	13.0	9.7	9.6	13.2	4.4	-15.0	-0.6	1.2	5.0	0.2
Oil	10.38	10.03	0.33	1.22	1.38	0.27	0.37	23.5	10.4	0.2	0.7	0.7	0.1	0.1	-12.0	54.5	1.3	-15.2	3.4	0.4
Natural gas	17.77	61.64	121.04	117.36	148.60	161.74	181.03	40.2	64.2	72.3	69.2	70.0	67.1	62.8	7.4	-1.0	2.4	0.9	1.1	1.2
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydro	4.98	6.03	4.72	13.83	10.58	8.67	8.83	11.3	6.3	2.8	8.2	5.0	3.6	3.1	-0.2	43.1	-2.6	-2.0	0.2	1.9
Geothermal	0.00	0.00						-	-	-	-	-	-	-	-	-	-	-	-	-
Others	0.00	0.51	5.65	15.10	31.00	47.05	60.05	-	0.5	3.4	8.9	14.6	19.5	20.8	-	38.8	7.5	4.3	2.5	7.4

Power generation Input

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	8.92	19.24	30.86	25.82	29.00	30.58	36.47	100.0	100.0	100.0	100.0	100.0	100.0	100.0	4.7	-5.8	1.2	0.5	1.8	0.5	
Coal	2.55	4.16	9.07	4.93	4.27	4.77	7.57	28.6	21.6	29.4	19.1	14.7	15.6	20.7	4.8	-18.4	-1.4	1.1	4.7	-0.5	
Oil	2.55	2.34	0.07	0.27	0.30	0.06	0.08	28.6	12.2	0.2	1.0	1.0	0.2	0.2	-12.3	54.2	1.1	-15.2	3.4	0.3	
Natural gas	3.82	12.73	21.71	20.62	24.42	25.75	28.83	42.9	66.2	70.4	79.9	84.2	84.2	79.0	6.6	-1.7	1.7	0.5	1.1	0.9	

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050							1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	37.8	40.0	43.8	46.8	50.6	52.1	51.7							0.5	2.3	0.8	0.3	-0.1	0.5	
Coal	37.3	36.7	33.9	38.3	41.5	41.8	43.1							-0.4	4.2	0.8	0.1	0.3	0.7	
Oil	35.0	36.8	38.8	39.0	39.7	40.0	40.0							0.4	0.2	0.2	0.1	0.0	0.1	
Natural gas	40.0	41.6	47.9	49.0	52.3	54.0	54.0							0.7	0.7	0.7	0.3	0.0	0.4	

CO₂ emissions

	Mt-C								AAGR (%)											
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	35.9	46.2	55.8	50.9	62.4	70.5	88.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.7	-3.0	2.1	1.2	2.3	1.4
Coal	10.2	12.6	10.6	6.1	5.3	5.8	8.8	28.5	27.3	18.9	12.0	8.5	8.2	10.0	0.1	-16.7	-1.4	0.9	4.3	-0.5
Oil	12.2	19.5	28.5	28.0	36.7	43.3	55.0	34.0	42.2	50.9	54.9	58.7	61.4	62.2	3.2	-0.6	2.8	1.7	2.4	2.0
Natural gas	13.5	14.1	16.8	16.8	20.5	21.4	24.5	37.5	30.5	30.1	33.1	32.8	30.3	27.8	0.8	0.0	2.0	0.4	1.4	1.2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	141.6	217.7	424.2	464.8	675.0	952.1	1,304.6	4.1	3.1	3.8	3.5	3.2	3.5
Population (millions of people)	56.6	61.9	69.2	69.9	72.1	74.4	76.8	0.7	0.32	0.32	0.32	0.32	0.32
GDP per capita (thousands of 2010 USD/person)	2.50	3.52	6.13	6.7	9.4	12.8	17.0	3.4	2.8	3.5	3.2	2.9	3.1
Primary energy consumption per capita (toe/person)	0.74	1.17	1.77	1.64	1.85	2.07	2.43	3.3	-2.5	1.2	1.1	1.6	1.0
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	296	332	289	247	198	162	143	-0.1	-5.1	-2.2	-2.0	-1.2	-2.1
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	204	232	201	186	157	127	111	-0.1	-2.6	-1.7	-2.1	-1.3	-1.8
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	253	212	132	110	93	74	68	-2.4	-6.0	-1.7	-2.2	-0.9	-2.0
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.86	0.64	0.46	0.44	0.47	0.46	0.47	-2.3	-0.9	0.5	-0.2	0.3	0.1
Automobile ownership volume (millions of vehicles)	7.52	20.75	38.31	41.98	59.18	85.93	124.78	6.2	3.1	3.5	3.8	3.8	3.6
Automobile ownership volume per capita (vehicles per person)	0.133	0.335	0.554	0.601	0.821	1.155	1.625	5.4	2.8	3.2	3.5	3.5	3.3

Viet Nam [BAU]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	17,86	28,74	78,91	89,16	147,26	215,93	293,13	100	100	100	100	100	100	100	5,7	4,2	5,1	3,9	3,1	4,1
Coal	2,21	4,37	30,69	34,10	60,81	86,97	107,69	12,4	15,2	38,9	38,2	41,3	40,3	36,7	10,2	3,6	6,0	3,6	2,2	3,9
Oil	2,71	7,81	19,72	22,84	38,80	60,76	87,83	15,2	27,2	25,0	25,6	26,3	28,1	30,0	7,6	5,0	5,4	4,6	3,8	4,6
Natural gas	0,00	1,12	7,81	12,81	33,09	53,94	84,63	0,0	3,9	9,9	14,4	22,5	25,0	28,9	33,8	17,9	10,0	5,0	4,6	7,5
Nuclear	0,00	0,00	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	0,46	1,25	7,55	8,41	9,15	11,58	11,33	2,6	4,4	9,6	9,4	6,2	5,4	3,9	10,9	3,6	0,9	2,4	-0,2	1,2
Geothermal	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	12,47	14,19	13,14	11,01	5,42	2,67	1,66	69,8	49,4	16,7	12,3	3,7	1,2	0,6	0,2	-5,7	-6,8	-6,8	-4,7	-6,1
Biomass	12,47	14,19	13,24	10,55	5,29	2,54	1,52	69,8	49,4	16,8	11,8	3,6	1,2	0,5	0,2	-7,3	-6,7	-7,1	-5,0	-6,3
Solar, Wind, Ocean	-	-	0,03	0,02	0,02	0,02	0,02	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-4,2	0,1	-0,1	-0,2	-0,4
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	-	-	-0,13	0,44	0,11	0,11	0,11	0,0	0,0	-0,2	0,5	0,1	0,1	0,0	-	-249,2	-13,0	0,0	0,0	-199,4

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	16,06	25,09	63,79	70,53	107,13	157,78	216,02	100	100	100	100	100	100	100	5,2	3,4	4,3	3,9	3,2	3,8
Industry	4,54	7,86	34,79	38,09	55,21	80,24	106,48	28,3	31,3	54,5	54,0	51,5	50,9	49,3	7,8	3,1	3,8	3,8	2,9	3,4
Transportation	1,38	3,50	13,59	16,05	27,98	43,44	62,63	8,6	13,9	21,3	22,8	26,1	27,5	29,0	8,8	5,7	5,7	4,5	3,7	4,7
Others	10,11	13,60	14,79	15,67	22,78	32,38	44,48	63,0	54,2	23,2	22,2	21,3	20,5	20,6	14	1,9	3,8	3,6	3,2	3,4
Non-energy	0,03	0,13	0,63	0,73	1,15	1,72	2,42	0,2	0,5	1,0	1,0	1,1	1,1	1,1	12,2	4,9	4,7	4,1	3,5	4,2
Total	16,06	25,09	63,79	70,53	107,13	157,78	216,02	100	100	100	100	100	100	100	5,2	3,4	4,3	3,9	3,2	3,8
Coal	1,33	3,22	15,19	18,22	27,64	42,05	56,78	8,3	12,8	23,8	25,8	25,8	26,7	26,3	9,4	6,2	4,3	4,3	3,0	4,1
Oil	2,33	6,51	18,86	21,46	37,26	58,70	85,07	14,5	26,0	29,6	30,4	34,8	37,2	39,4	8,1	4,4	5,7	4,7	3,8	4,7
Natural gas	0,00	0,02	1,04	1,38	2,87	4,37	5,86	0,0	0,1	1,6	2,0	2,7	2,8	2,7	-	9,8	7,6	4,3	3,0	5,4
Electricity	0,53	1,93	14,86	18,36	33,10	48,56	64,53	3,3	7,7	23,3	26,0	30,9	30,8	29,9	13,1	7,3	6,1	3,9	2,9	4,6
Heat	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	11,87	13,41	13,84	11,10	6,26	4,09	3,78	73,9	53,4	21,7	15,7	5,8	2,6	1,7	0,6	-7,1	-5,6	-4,2	-0,8	-3,9

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	8,68	26,57	193,04	234,85	430,03	629,80	837,32	100	100	100	100	100	100	100	12,2	6,8	6,2	3,9	2,9	4,5
Coal	2,00	3,14	63,07	64,96	138,06	190,13	219,06	23,1	11,8	32,7	27,7	32,1	30,2	26,2	13,6	1,0	7,8	3,3	1,4	3,8
Oil	1,31	4,52	0,73	2,06	0,47	0,26	0,26	15,0	17,0	0,4	0,9	0,1	0,0	0,0	-2,2	41,7	-13,7	-5,7	-0,2	-3,1
Natural gas	0,01	4,36	41,02	69,39	184,36	304,01	485,53	0,1	16,4	21,2	29,5	42,9	48,3	58,0	38,7	19,1	10,3	5,1	4,8	7,8
Nuclear	0,00	0,00	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	5,37	14,55	87,82	97,75	106,43	134,70	131,79	61,8	54,8	45,5	41,6	24,8	21,4	15,7	10,9	3,6	0,9	2,4	-0,2	1,2
Geothermal	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	-	-	0,40	0,69	0,70	0,69	0,68	0,0	0,0	0,2	0,3	0,2	0,1	0,1	-	20,1	0,1	-0,1	-0,2	1,6

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,27	3,56	22,44	27,81	63,50	94,55	129,74	100	100	100	100	100	100	100	11,2	7,4	8,6	4,1	3,2	5,5
Coal	0,89	1,15	15,49	15,88	33,17	44,92	50,91	69,8	32,3	69,0	57,1	52,2	47,5	39,2	11,2	0,8	7,6	3,1	1,3	3,7
Oil	0,38	1,31	0,18	0,50	0,11	0,06	0,06	30,0	36,8	0,8	1,8	0,2	0,1	0,0	-2,8	41,4	-13,9	-6,0	-0,2	-3,3
Natural gas	0,00	1,10	6,77	11,43	30,22	49,57	78,77	0,2	30,9	30,2	41,1	47,6	52,4	60,7	33,1	19,1	10,2	5,1	4,7	7,7

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	22,4	29,0	40,2	42,2	43,7	45,0	46,7								2,2	1,6	0,4	0,3	0,4	0,5
Coal	19,4	23,5	35,0	35,2	35,8	36,4	37,0								2,2	0,2	0,2	0,2	0,2	0,2
Oil	29,4	29,7	35,0	35,2	36,1	37,0	37,0								0,7	0,2	0,2	0,2	0,0	0,2
Natural gas	17,2	34,1	52,1	52,2	52,5	52,7	53,0								4,2	0,1	0,1	0,1	0,1	0,1

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4,7	12,0	54,6	64,0	118,7	178,4	242,5	100	100	100	100	100	100	100	9,5	5,4	6,4	4,2	3,1	4,6
Coal	2,5	4,7	34,1	37,9	67,1	96,0	119,0	53,2	39,2	62,5	59,2	56,6	53,8	49,1	10,2	3,6	5,9	3,6	2,2	3,9
Oil	2,2	6,4	15,5	17,9	30,3	47,8	69,2	46,8	53,3	28,3	27,9	25,6	26,8	28,6	7,5	4,9	5,4	4,6	3,8	4,6
Natural gas	0,0	0,9	5,0	8,2	21,2	34,6	54,2	0,0	7,5	9,2	12,8	17,9	19,4	22,4	-	17,9	10,0	5,0	4,6	7,5

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	17.8	36.8	175.3	214.7	393.7	656.7	995.7	8.9	7.0	6.2	5.2	4.2	5.4	
Population (millions of people)	66.0	77.6	93.7	96.6	103.1	107.0	108.9	1.3	1.0	0.7	0.4	0.2	0.5	
GDP per capita (thousands of 2010 USD/person)	0.27	0.47	1.87	2.22	3.82	6.14	9.14	7.4	5.9	5.6	4.9	4.1	4.9	
Primary energy consumption per capita (toe/person)	0.27	0.37	0.84	0.92	1.43	2.02	2.69	4.3	3.1	4.5	3.5	2.9	3.6	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	1.006	780	450	415	374	329	294	-2.9	-2.7	-1.0	-1.3	-1.1	-1.3	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	905	681	364	328	272	240	217	-3.3	-3.4	-1.9	-1.2	-1.0	-1.6	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	265	326	311	298	301	272	244	0.6	-1.5	0.1	-1.0	-1.1	-0.7	
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0.26	0.42	0.69	0.72	0.81	0.83	0.83	3.6	1.2	1.2	0.2	0.0	0.5	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

Viet Nam [APS5]

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	17,86	28,74	78,91	85,09	125,12	181,64	242,73	100	100	100	100	100	100	100	5,7	2,5	3,9	3,8	2,9	3,5	
Coal	2,21	4,37	30,69	28,94	38,22	54,48	67,14	12,4	15,2	38,9	34,0	30,5	30,0	27,7	10,2	-1,9	2,8	3,6	2,1	2,4	
Oil	2,71	7,81	19,72	22,15	35,10	54,40	77,72	15,2	27,2	25,0	26,0	28,1	29,9	32,0	7,6	4,0	4,7	4,5	3,6	4,2	
Natural gas	0,00	1,12	7,81	12,74	29,35	46,21	69,47	0,0	3,9	9,9	15,0	23,5	25,4	28,6	33,8	17,7	8,7	4,6	4,2	6,8	
Nuclear	0,00	0,00	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Hydro	0,46	1,25	7,55	8,66	9,43	11,79	11,47	2,6	4,4	9,6	10,2	7,5	6,5	4,7	10,9	4,7	0,9	2,3	-0,3	1,3	
Geothermal	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-	
Others	12,47	14,19	13,14	12,60	13,02	14,77	16,93	69,8	49,4	16,7	14,8	10,4	8,1	7,0	0,2	-1,4	0,3	1,3	1,4	0,8	
Biomass	12,47	14,19	13,24	11,49	9,51	10,19	11,12	69,8	49,4	16,8	13,5	7,6	5,6	4,6	0,2	-4,6	-1,9	0,7	0,9	-0,5	
Solar, Wind, Ocean	-	-	0,03	0,87	3,40	4,48	5,70	0,0	0,0	0,0	1,0	2,7	2,5	2,3	-	215,8	14,5	2,8	2,5	17,5	
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	-	-	-0,13	0,23	0,11	0,11	0,11	0,0	0,0	-0,2	0,3	0,1	0,1	0,0	-	-220,3	-7,2	0,0	0,0	-199,4	

Final energy demand

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	16.06	25.09	63.79	68.99	97.13	140.97	190.65	100	100	100	100	100	100	100	5.2	2.6	3.5	3.8	3.1	3.4	
Industry	4.54	7.86	34.79	37.28	50.04	71.58	93.81	28.3	31.3	54.5	54.0	51.5	50.8	49.2	7.8	2.3	3.0	3.6	2.7	3.1	
Transportation	1.38	3.50	13.59	15.63	25.20	38.67	55.13	8.6	13.9	21.3	22.7	25.9	27.4	28.9	8.8	4.8	4.9	4.4	3.6	4.3	
Others	10.11	13.60	14.79	15.36	20.74	29.00	39.30	63.0	54.2	23.2	22.3	21.4	20.6	20.6	1.4	1.3	3.0	3.4	3.1	3.0	
Non-energy	0.03	0.13	0.63	0.73	1.15	1.72	2.42	0.2	0.5	1.0	1.1	1.2	1.2	1.3	12.2	4.9	4.7	4.1	3.5	4.2	
Total	16.06	25.09	63.79	68.99	97.13	140.97	190.65	100	100	100	100	100	100	100	5.2	2.6	3.5	3.8	3.1	3.4	
Coal	1.33	3.22	15.19	17.74	24.88	37.43	49.97	8.3	12.8	23.8	25.7	25.6	26.6	26.2	9.4	5.3	3.4	4.2	2.9	3.7	
Oil	2.33	6.51	18.86	20.92	33.62	52.34	74.96	14.5	26.0	29.6	30.3	34.6	37.1	39.3	8.1	3.5	4.9	4.5	3.7	4.3	
Natural gas	0.00	0.02	1.04	1.35	2.58	3.89	5.16	0.0	0.1	1.6	2.0	2.7	2.8	2.7	-	8.9	6.7	4.2	2.9	5.0	
Electricity	0.53	1.93	14.86	17.88	29.79	43.22	56.79	3.3	7.7	23.3	25.9	30.7	30.7	29.8	13.1	6.4	5.2	3.8	2.8	4.1	
Heat	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	
Others	11.87	13.41	13.84	11.10	6.26	4.09	3.78	73.9	53.4	21.7	16.1	6.4	2.9	2.0	0.6	-7.1	-5.6	-4.2	-0.8	-3.9	

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	8,68	26,57	193,04	230,98	386,90	560,38	736,69	100	100	100	100	100	100	100	12,2	6,2	5,3	3,8	2,8	4,1
Coal	2,00	3,14	63,07	46,41	58,58	79,07	83,87	23,1	11,8	32,7	20,1	15,1	14,1	11,4	13,6	-9,7	2,4	3,0	0,6	0,9
Oil	1,31	4,52	0,73	1,48	0,24	0,24	0,23	15,0	17,0	0,4	0,6	0,1	0,0	0,0	-2,2	26,9	-16,7	-0,1	-0,3	-3,4
Natural gas	0,01	4,36	41,02	69,76	169,48	276,70	433,82	0,1	16,4	21,2	30,2	43,8	49,4	58,9	38,7	19,4	9,3	5,0	4,6	7,4
Nuclear	0,00	0,00	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Hydro	5,37	14,55	87,82	100,72	109,69	137,08	133,42	61,8	54,8	45,5	43,6	28,4	24,5	18,1	10,9	4,7	0,9	2,3	-0,3	1,3
Geothermal	-	-	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-	-	-	-
Others	-	-	0,40	12,61	48,91	67,29	85,36	0,0	0,0	0,2	5,5	12,6	12,0	11,6	-	216,1	14,5	3,2	2,4	17,7

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,27	3,56	22,44	22,95	40,17	59,43	81,54	100	100	100	100	100	100	100	11,2	0,8	5,8	4,0	3,2	4,0
Coal	0,89	1,15	15,49	11,20	13,34	17,05	17,17	69,8	32,3	69,0	48,8	33,2	28,7	21,1	11,2	-10,3	1,8	2,5	0,1	0,3
Oil	0,38	1,31	0,18	0,36	0,06	0,05	0,05	30,0	36,8	0,8	1,6	0,1	0,1	0,1	-2,8	26,4	-17,0	-0,1	-0,3	-3,6
Natural gas	0,00	1,10	6,77	11,39	26,77	42,32	64,31	0,2	30,9	30,2	49,6	66,6	71,2	78,9	33,1	19,0	8,9	4,7	4,3	7,1

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	22,4	29,0	40,2	44,1	48,9	51,5	54,6								2,2	3,2	1,0	0,5	0,6	0,9
Coal	19,4	23,5	35,0	35,6	37,8	39,9	42,0								2,2	0,6	0,6	0,5	0,5	0,6
Oil	29,4	29,7	35,0	35,4	37,0	37,0	37,0								0,7	0,4	0,4	0,0	0,0	0,2
Natural gas	17,2	34,1	52,1	52,7	54,4	56,2	58,0								4,2	0,3	0,3	0,3	0,3	0,3

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4,7	12,0	54,6	57,7	88,6	132,8	180,3	100	100	100	100	100	100	100	9,5	1,9	4,4	4,1	3,1	3,7
Coal	2,5	4,7	34,1	32,2	42,5	60,6	74,8	53,2	39,2	62,5	55,9	47,9	45,6	41,5	10,2	-1,8	2,8	3,6	2,1	2,4
Oil	2,2	6,4	15,5	17,3	27,3	42,6	61,0	46,8	53,3	28,3	30,0	30,9	32,1	33,8	7,5	3,8	4,7	4,5	3,7	4,2
Natural gas	0,0	0,9	5,0	8,2	18,8	29,6	44,5	0,0	7,5	9,2	14,2	21,2	22,3	24,7	-	17,7	8,7	4,6	4,2	6,8

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	17,8	36,8	175,3	214,7	393,7	656,7	995,7	8,9	7,0	6,2	5,2	4,2	5,40
Population (millions of people)	66,0	77,6	93,7	96,6	103,1	107,0	108,9	1,3	1,0	0,7	0,4	0,2	0,46
GDP per capita (thousands of 2010 USD/person)	0,27	0,47	1,87	2,2	3,8	6,1	9,1	7,4	5,9	5,6	4,9	4,1	4,9
Primary energy consumption per capita (toe/person)	0,22	0,37	0,84	0,88	1,21	1,70	2,23	4,3	1,5	3,3	3,4	2,8	3,0
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	1,006	780	450	396	318	277	244	-2,9	-4,2	-2,2	-1,4	-1,3	-1,8
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	905	681	364	321	247	215	191	-3,3	-4,1	-2,6	-1,4	-1,1	-1,9
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	265	326	311	269	225	202	181	0,6	-4,8	-1,8	-1,1	-1,1	-1,6
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,26	0,42	0,69	0,68	0,71	0,73	0,74	3,6	-0,6	0,4	0,3	0,2	0,2
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

USA[BAU]

Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	1,915,02	2,273,78	2,155,23	2,194,55	2,242,61	2,265,79	2,254,78	100	100	100	100	100	100	100	0,4	0,6	0,2	0,1	0,0	0,1	
Coal	460,12	533,94	330,75	271,44	253,68	228,62	189,69	24,0	23,5	15,3	12,4	11,3	10,1	8,4	-1,2	-6,4	-0,7	-1,0	-1,8	-1,7	
Oil	756,84	871,15	790,28	801,69	773,18	745,61	720,89	39,5	38,3	36,7	36,5	34,5	32,9	32,0	0,2	0,5	-0,4	-0,4	-0,3	-0,3	
Natural gas	438,36	547,74	643,93	725,01	804,43	819,11	793,61	22,9	24,1	29,9	33,0	35,9	36,2	35,2	1,4	4,0	1,0	0,2	-0,3	0,6	
Nuclear	159,36	207,85	218,57	208,31	176,43	176,26	178,59	8,3	9,1	10,1	9,5	7,9	7,8	7,9	1,2	-1,6	-1,6	0,0	0,1	-0,6	
Hydro	23,49	21,77	26,00	24,88	25,98	26,65	27,03	1,2	1,0	1,2	1,1	1,2	1,2	1,2	0,4	-1,4	0,4	0,3	0,1	0,1	
Geothermal	14,10	13,09	9,21	9,24	17,54	30,65	37,03	0,7	0,6	0,4	0,4	0,8	1,4	1,6	-1,6	0,1	6,6	5,7	1,9	4,3	
Others	62,76	78,24	136,49	153,96	191,37	238,89	307,93	3,3	3,4	6,3	7,0	8,5	10,5	13,7	2,9	4,1	2,2	2,2	2,6	2,5	
Biomass	62,27	73,25	101,16	106,85	123,14	130,95	139,00	3,3	3,2	4,7	4,9	5,5	5,8	6,2	1,8	1,8	1,4	0,6	0,6	1,0	
Solar, Wind, Ocean	0,32	2,07	30,49	42,27	63,38	103,09	164,08	0,0	0,1	1,4	1,9	2,8	4,5	7,3	18,4	11,5	4,1	5,0	4,8	5,2	
Biofuels	0,00	3,19	37,44	36,75	40,79	42,40	44,38	0,0	0,1	1,7	1,7	1,8	1,9	2,0	-	-0,6	1,0	0,4	0,5	0,5	
Electricity	0,17	2,92	4,84	4,84	4,84	4,84	4,84	0,0	0,1	0,2	0,2	0,2	0,2	0,2	13,2	0,0	0,0	0,0	0,0	0,0	

Final energy demand

	MTOE																AAGR (%)				
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	1,293,56	1,546,29	1,520,46	1,569,65	1,597,01	1,610,70	1,613,44	100	100	100	100	100	100	100	0,6	1,1	0,2	0,1	0,0	0,2	
Industry	283,76	332,29	261,43	277,32	294,99	308,97	318,95	21,9	21,5	17,2	17,7	18,5	19,2	19,8	-0,3	2,0	0,6	0,5	0,3	0,6	
Transportation	487,57	588,24	626,38	627,56	615,09	603,85	597,86	37,7	38,0	41,1	40,0	38,5	37,5	37,1	0,9	0,1	-0,2	-0,2	-0,1	-0,1	
Others	403,18	472,73	488,33	504,40	508,44	506,65	494,88	31,2	30,6	32,1	32,1	31,8	31,5	30,7	0,7	1,1	0,1	0,0	-0,2	0,0	
Non-energy	119,05	153,03	145,33	160,36	178,48	191,22	201,74	9,2	9,9	9,6	10,2	11,2	11,9	12,5	0,7	3,3	1,1	0,7	0,5	1,0	
Total	1,293,56	1,546,29	1,520,46	1,569,65	1,597,01	1,610,70	1,613,44	100	100	100	100	100	100	100	0,6	1,1	0,2	0,1	0,0	0,2	
Coal	55,66	32,58	17,01	17,65	15,62	14,28	13,26	4,3	2,1	1,1	1,1	1,0	0,9	0,8	-4,3	1,2	-1,2	-0,9	-0,7	-0,8	
Oil	683,29	793,42	747,62	757,62	734,18	708,76	686,10	52,8	51,3	49,2	48,3	46,0	44,0	42,5	0,3	0,4	-0,3	-0,4	-0,3	-0,3	
Natural gas	303,08	359,99	346,31	364,62	377,16	376,90	369,33	23,4	23,3	22,8	23,2	23,6	23,4	22,9	0,5	1,7	0,3	0,0	-0,2	0,2	
Electricity	226,45	300,90	321,42	341,20	374,30	413,56	445,99	17,5	19,5	21,1	21,7	23,4	25,7	27,6	1,3	2,0	0,9	1,0	0,8	1,0	
Heat	2,15	5,28	5,86	6,07	5,68	5,36	4,94	0,2	0,3	0,4	0,4	0,4	0,3	0,3	3,8	1,2	-0,7	-0,6	-0,8	-0,5	
Others	22,93	54,12	82,23	82,48	90,07	91,84	93,82	1,8	3,5	5,4	5,3	5,6	5,7	5,8	4,8	0,1	0,9	0,2	0,2	0,4	

Power generation Output

	TWh																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	3,202,81	4,025,89	4,263,68	4,527,24	4,950,30	5,437,54	5,822,49	100	100	100	100	100	100	100	1,1	2,0	0,9	0,9	0,7	0,9		
Coal	1,699,65	2,129,50	1,321,42	1,119,40	1,109,99	1,001,81	811,18	53,1	52,9	31,0	24,7	22,4	18,4	13,9	-0,9	-5,4	-0,1	-1,0	-2,1	-1,5		
Oil	130,65	118,48	32,41	32,25	26,77	18,25	8,58	4,1	2,9	0,8	0,7	0,5	0,3	0,1	-5,0	-0,2	-1,8	-3,8	-7,3	-3,9		
Natural gas	381,67	634,29	1,337,70	1,725,74	2,042,17	2,218,79	2,190,76	11,9	15,8	31,4	38,1	41,3	40,8	37,6	4,8	8,9	1,7	0,8	-0,1	1,5		
Nuclear	611,59	797,72	838,86	799,47	677,11	676,48	685,40	19,1	19,8	19,7	17,7	13,7	12,4	11,8	1,2	-1,6	-1,6	0,0	0,1	-0,6		
Hydro	273,15	253,20	302,36	289,40	302,10	309,99	314,40	8,5	6,3	7,1	6,4	6,1	5,7	5,4	0,4	-1,4	0,4	0,3	0,1	0,1		
Geothermal	16,01	14,62	18,73	18,80	36,25	63,75	77,15	0,5	0,4	0,4	0,4	0,7	1,2	1,3	0,6	0,1	6,8	5,8	1,9	4,4		
Others	90,09	78,07	412,19	542,19	755,89	1,148,47	1,735,02	2,8	1,9	9,7	12,0	15,3	21,1	29,8	5,8	9,6	3,4	4,3	4,2	4,5		

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	513,01	696,21	547,02	543,86	564,66	548,64	487,30	100	100	100	100	100	100	100	0,2	-0,2	0,4	-0,3	-1,2	-0,3
Coal	396,00	501,59	308,48	248,39	232,05	206,99	167,39	77,2	72,0	56,4	45,7	41,1	37,7	34,3	-0,9	-7,0	-0,7	-1,1	-2,1	-1,8
Oil	27,25	57,71	7,01	7,75	6,37	4,27	1,95	5,3	8,3	1,3	1,4	1,1	0,8	0,4	-4,9	3,4	-2,0	-3,9	-7,6	-3,8
Natural gas	89,76	136,92	231,53	287,72	326,25	337,39	317,97	17,5	19,7	42,3	52,9	57,8	61,5	65,3	3,6	7,5	1,3	0,3	-0,6	1,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050							1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	37,1	35,6	42,3	45,5	48,4	50,8	53,1							0,5	2,4	0,6	0,5	0,5	0,7	
Coal	36,9	36,5	36,8	38,8	41,1	41,6	41,7							0,0	1,7	0,6	0,1	0,0	0,4	
Oil	41,2	17,7	39,7	35,8	36,2	36,7	37,9							-0,1	-3,5	0,1	0,2	0,3	-0,1	
Natural gas	36,6	39,8	49,7	51,6	53,8	56,6	59,3							1,1	1,3	0,4	0,5	0,5	0,5	

CO₂ emissions

	Mt-C																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	1,299,1	1,532,9	1,298,4	1,284,2	1,278,3	1,229,2	1,143,2	100	100	100	100	100	100	100	0,0	-0,4	0,0	-0,4	-0,7	-0,4		
Coal	503,7	592,9	361,2	296,9	277,7	250,5	208,3	38,8	38,7	27,8	23,1	21,7	20,4	18,2	-1,2	-6,3	-0,7	-1,0	-1,8	-1,7		
Oil	524,0	603,4	545,4	547,0	520,5	494,1	470,7	40,3	39,4	42,0	42,6	40,7	40,2	41,2	0,1	0,1	-0,5	-0,5	-0,5	-0,4		
Natural gas	271,3	336,6	391,8	440,2	480,1	484,6	464,2	20,9	22,0	30,2	34,3	37,6	39,4	40,6	1,4	4,0	0,9	0,1	-0,4	0,5		

Energy and economic indicators

									AAGR(%)					
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
GDP (billions of 2010 US dollars)	9.064	12.713	17.349	18.602	22.684	28.174	33.922	2,4	2,4	2,0	2,2	1,9	2,1	
Population (millions of people)	249,6	282,2	325,1	331,5	351,5	369,9	384,1	1,0	0,6	0,6	0,5	0,4	0,5	
GDP per capita (thousands of 2010 USD/person)	36,31	45,06	53,36	56,12	64,53	76,17	88,31	1,4	1,7	1,4	1,7	1,5	1,5	
Primary energy consumption per capita (toe/person)	7,67	8,06	6,63	6,62	6,38	6,13	5,87	-0,5	0,0	-0,4	-0,4	-0,4	-0,4	
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	211	179	124	118	99	80	66	-1,9	-1,7	-1,8	-2,0	-1,9	-1,9	
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	143	122	88	84	70	57	48	-1,8	-1,3	-1,8	-2,1	-1,8	-1,8	
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	525	442	274	253	207	160	124	-2,4	-2,7	-2,0	-2,5	-2,5	-2,4	
CO ₂ emissions per unit of primary energy consumption (t-C/Toe)	2,49	2,47	2,21	2,15	2,09	1,99	1,86	-0,4	-1,0	-0,3	-0,5	-0,7	-0,5	
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-	

USA[APS5]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,915.02	2,273.78	2,155.23	2,177.55	2,125.39	2,035.26	1,924.39	100	100	100	100	100	100	100	0.4	0.3	-0.2	-0.4	-0.6	-0.3
Coal	460.12	533.94	330.75	265.80	199.60	135.53	70.36	24.0	23.5	15.3	12.2	9.4	6.7	3.7	-1.2	-7.0	-2.8	-3.8	-6.3	-4.6
Oil	756.84	871.15	790.28	793.05	711.80	619.24	539.98	39.5	38.3	36.7	36.4	33.5	30.4	28.1	0.2	0.1	-1.1	-1.4	-1.4	-1.1
Natural gas	438.36	547.74	643.93	714.01	735.54	679.20	554.65	22.9	24.1	29.9	32.8	34.6	33.4	28.8	1.4	3.5	0.3	-0.8	-2.0	-0.5
Nuclear	159.36	207.85	218.57	208.31	180.96	182.11	184.42	8.3	9.1	10.1	9.6	8.5	8.9	9.6	1.2	-1.6	-1.4	0.1	0.1	-0.5
Hydro	23.49	21.77	26.00	25.22	27.78	30.33	32.88	1.2	1.0	1.2	1.2	1.3	1.5	1.7	0.4	-1.0	1.0	0.9	0.8	0.7
Geothermal	14.10	13.09	9.21	9.24	24.86	41.13	56.81	0.7	0.6	0.4	0.4	1.2	2.0	3.0	-1.6	0.1	10.4	5.2	3.3	5.7
Others	62.76	78.24	136.49	161.91	244.85	347.71	485.29	3.3	3.4	6.3	7.4	11.5	17.1	25.2	2.9	5.9	4.2	3.6	3.4	3.9
Biomass	62.27	73.25	101.16	113.37	143.30	161.22	181.57	3.3	3.2	4.7	5.2	6.7	7.9	9.4	1.8	3.9	2.4	1.2	1.2	1.8
Solar, Wind, Ocean	0.32	2.07	30.49	43.70	96.70	181.61	298.75	0.0	0.1	1.4	2.0	4.5	8.9	15.5	18.4	12.8	8.3	6.5	5.1	7.2
Biofuels	0.00	3.19	37.44	41.07	55.04	64.44	73.83	0.0	0.1	1.7	1.9	2.6	3.2	3.8	-	3.1	3.0	1.6	1.4	2.1
Electricity	0.17	2.92	4.84	4.84	4.84	4.84	4.84	0.0	0.1	0.2	0.2	0.2	0.2	0.3	13.2	0.0	0.0	0.0	0.0	0.0

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,293.56	1,546.29	1,520.46	1,562.08	1,526.23	1,457.67	1,392.08	100	100	100	100	100	100	100	0.6	0.9	-0.2	-0.5	-0.5	-0.3
Industry	283.76	332.29	261.43	276.94	288.70	288.69	282.17	21.9	21.5	17.2	17.7	18.9	19.8	20.3	-0.3	1.9	0.4	0.0	-0.2	0.2
Transportation	487.57	588.24	625.38	622.79	571.52	516.73	483.08	37.7	38.0	41.1	39.9	37.4	35.4	34.7	0.9	-0.1	-0.9	-1.0	-0.7	-0.8
Others	403.18	472.73	488.33	501.99	487.52	461.03	425.08	31.2	30.6	32.1	32.1	31.9	31.6	30.5	0.7	0.9	-0.3	-0.6	-0.8	-0.4
Non-energy	119.05	153.03	145.33	160.36	178.48	191.22	201.74	9.2	9.9	9.6	10.3	11.7	13.1	14.5	0.7	3.3	1.1	0.7	0.5	1.0
Total	1,293.56	1,546.29	1,520.46	1,562.08	1,526.23	1,457.67	1,392.08	100	100	100	100	100	100	100	0.6	0.9	-0.2	-0.5	-0.5	-0.3
Coal	55.66	32.58	17.01	16.74	12.46	10.45	8.70	4.3	2.1	1.1	1.1	0.8	0.7	0.6	-4.3	-0.5	-2.9	-1.7	-1.8	-2.0
Oil	683.29	793.42	747.62	749.77	678.57	593.88	521.59	52.8	51.3	49.2	48.0	44.5	40.7	37.5	0.3	0.1	-1.0	-1.3	-1.3	-1.1
Natural gas	302.08	359.99	346.31	362.51	356.76	333.86	308.64	23.4	23.3	22.8	23.2	23.4	22.9	22.2	0.5	1.5	-0.2	-0.7	-0.8	-0.3
Electricity	226.45	300.90	321.42	340.05	366.99	397.83	418.35	17.5	19.5	21.1	21.8	24.0	27.3	30.1	1.3	1.9	0.8	0.8	0.5	0.8
Heat	2.15	5.28	5.86	6.07	5.52	4.94	4.32	0.2	0.3	0.4	0.4	0.4	0.3	0.3	3.8	1.2	-0.9	-1.1	-1.3	-0.9
Others	22.93	54.12	82.23	86.95	105.93	116.70	130.48	1.8	3.5	5.4	5.6	6.9	8.0	9.4	4.8	1.9	2.0	1.0	1.1	1.4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	3,202.81	4,025.89	4,263.68	4,510.01	4,866.38	5,262.12	5,484.89	100	100	100	100	100	100	100	1.1	1.9	0.8	0.8	0.4	0.8
Coal	1,699.65	2,129.50	1,321.42	1,073.60	862.08	577.15	266.63	53.1	52.9	31.0	23.8	17.7	11.0	4.9	-0.9	-6.7	-2.2	-3.9	-7.4	-4.7
Oil	130.65	118.48	32.41	31.74	22.51	12.34	3.65	4.1	2.9	0.8	0.7	0.5	0.2	0.1	-5.0	-0.7	-3.4	-5.8	-11.5	-6.4
Natural gas	381.67	634.29	1,337.70	1,727.12	1,819.71	1,673.39	1,089.12	11.9	15.8	31.4	38.3	37.4	31.8	19.9	4.8	8.9	0.5	-0.8	-4.2	-0.6
Nuclear	611.59	797.72	838.86	799.47	694.52	698.92	707.78	19.1	19.8	19.7	17.7	14.3	13.3	12.9	1.2	-1.6	-1.4	0.1	0.1	-0.5
Hydro	273.15	253.20	302.36	293.31	323.02	352.73	382.44	8.5	6.3	7.1	6.5	6.6	6.7	7.0	0.4	-1.0	1.0	0.9	0.8	0.7
Geothermal	16.01	14.62	18.73	18.80	51.61	85.75	118.64	0.5	0.4	0.4	0.4	1.1	1.6	2.2	0.6	0.1	10.6	5.2	3.3	5.8
Others	90.09	78.07	412.19	565.96	1,092.93	1,861.84	2,916.64	2.8	1.9	9.7	12.5	22.5	35.4	53.2	5.8	11.1	6.8	5.5	4.6	6.1

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	513.01	696.21	547.02	531.45	469.91	368.75	207.02	100	100	100	100	100	100	100	0.2	-1.0	-1.2	-2.4	-5.6	-2.9
Coal	396.00	501.59	308.48	243.74	181.46	118.37	53.70	77.2	72.0	56.4	45.9	38.6	32.1	25.9	-0.9	-7.6	-2.9	-4.2	-7.6	-5.2
Oil	27.25	57.71	7.01	7.64	5.42	2.92	0.83	5.3	8.3	1.3	1.4	1.2	0.8	0.4	-4.9	2.9	-3.4	-6.0	-11.8	-6.3
Natural gas	89.76	136.92	231.53	280.06	283.02	247.45	152.49	17.5	19.7	42.3	52.7	60.2	67.1	73.7	3.6	6.5	0.1	-1.3	-4.7	-1.3

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	37.1	35.6	42.3	45.8	49.5	52.8	56.5								0.5	2.7	0.8	0.6	0.7	0.9
Coal	36.9	36.5	36.8	37.9	40.9	41.9	42.7								0.0	0.9	0.8	0.3	0.2	0.4
Oil	41.2	17.7	39.7	35.7	35.7	36.3	37.8								-0.1	-3.5	0.0	0.2	0.4	-0.2
Natural gas	36.6	39.8	49.7	53.0	55.3	58.2	61.4								1.1	2.2	0.4	0.5	0.5	0.6

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,299.1	1,532.9	1,298.4	1,264.1	1,107.4	898.1	677.8	100	100	100	100	100	100	100	0.0	-0.9	-1.3	-2.1	-2.8	-2.0
Coal	503.7	592.9	361.2	290.8	211.5	141.8	69.8	38.8	38.7	27.8	23.0	19.1	15.8	10.3	-1.2	-7.0	-3.1	-3.9	-6.8	-4.9
Oil	524.0	603.4	545.4	539.9	470.5	392.7	329.5	40.3	39.4	42.0	42.7	42.5	43.7	48.6	0.1	-0.3	-1.4	-1.8	-1.7	-1.5
Natural gas	271.3	336.6	391.8	433.4	425.4	363.7	278.5	20.9	22.0	30.2	34.3	38.4	40.5	41.1	1.4	3.4	-0.2	-1.6	-2.6	-1.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	9.064	12.713	17.349	18.602	22.684	28.174	33.922	2,4	2,4	2,0	2,2	1,9	2,05
Population (millions of people)	249,6	282,2	325,1	331,5	351,5	369,9	384,1	1,0	0,6	0,6	0,5	0,4	0,51
GDP per capita (thousands of 2010 USD/person)	36,31	45,06	53,36	56,12	64,53	76,17	88,31	1,4	1,7	1,4	1,7	1,5	1,5
Primary energy consumption per capita (toe/person)	7,67	8,06	6,63	6,57	6,05	5,50	5,01	-0,5	-0,3	-0,8	-0,9	-0,9	-0,8
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	211	179	124	117	94	72	57	-1,9	-2,0	-2,2	-2,6	-2,4	-2,3
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	143	122	88	84	67	52	41	-1,8	-1,4	-2,2	-2,6	-2,3	-2,3
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	525	442	274	249	179	117	73	-2,4	-3,2	-3,3	-4,2	-4,6	-3,9
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	2,49	2,47	2,21	2,13	1,91	1,62	1,29	-0,4	-1,2	-1,1	-1,6	-2,2	-1,6
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

ASEAN [BAU]

Primary energy consumption

	Primary energy consumption																					
	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	238,14	372,96	662,04	719,39	1,008,98	1,372,77	1,822,57	100	100	100	100	100	100	100	3,9	2,8	3,4	3,1	2,9	3,1		
Coal	13,06	32,72	142,75	152,52	216,94	307,04	409,08	5,5	8,8	21,6	21,2	21,5	22,4	22,4	9,3	2,2	3,6	3,5	2,9	3,2		
Oil	99,50	158,03	244,41	269,22	391,08	537,82	720,93	41,8	42,4	36,9	37,4	38,8	39,2	39,6	3,4	3,3	3,8	3,2	3,0	3,3		
Natural gas	32,73	75,99	129,27	148,98	224,56	319,98	450,43	13,7	20,4	19,5	20,7	22,3	23,3	24,7	5,2	4,8	4,2	3,6	3,5	3,9		
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	2,35	4,37	15,73	17,58	22,94	27,13	30,63	1,0	1,2	2,4	2,4	2,3	2,0	1,7	7,3	3,8	2,7	1,7	1,2	2,0		
Geothermal	5,67	12,27	19,81	20,25	31,75	42,28	63,07	2,4	3,3	3,0	2,8	3,1	3,1	3,5	4,7	0,7	4,6	2,9	4,1	3,6		
Others	84,84	89,58	110,07	110,85	121,72	138,51	148,43	35,6	24,0	16,6	15,4	12,1	10,1	8,1	1,0	0,2	0,9	1,3	0,7	0,9		
Biomass	84,78	89,56	102,93	99,37	100,06	100,86	99,37	35,6	24,0	15,5	13,8	9,9	7,3	5,5	0,7	-1,2	0,1	0,1	-0,1	-0,1		
Solar, Wind, Ocean	0,00	0,00	1,62	2,94	7,40	12,15	13,94	0,0	0,0	0,2	0,4	0,7	0,9	0,8	-	21,9	9,7	5,1	1,4	6,7		
Biofuels	0,00	0,00	6,61	7,83	12,33	19,03	28,48	0,0	0,0	1,0	1,1	1,2	1,4	1,6	-	5,8	4,6	4,4	4,1	4,5		
Electricity	0,05	0,01	-1,09	0,71	1,93	6,47	6,65	0,0	0,0	-0,2	0,1	0,2	0,5	0,4	-211,8	-187,0	10,5	12,8	0,3	-205,6		

Final energy demand

	MTOE																AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	165.44	263.90	480.36	530.48	750.37	1,025.34	1,355.63	100	100	100	100	100	100	100	4.0	3.4	3.5	3.2	2.8	3.2		
Industry	43.99	86.67	148.01	165.45	248.36	346.30	452.67	26.6	32.8	30.8	31.2	33.1	33.8	33.4	4.6	3.8	4.1	3.4	2.7	3.4		
Transportation	30.45	56.27	128.83	147.53	231.25	341.37	482.72	18.4	21.3	26.8	27.8	30.8	33.3	35.6	5.5	4.6	4.6	4.0	3.5	4.1		
Others	81.37	102.26	141.33	151.98	190.45	236.67	294.30	49.2	38.8	29.4	28.6	25.4	23.1	21.7	2.1	2.4	2.3	2.2	2.2	2.2		
Non-energy	9.64	18.70	62.18	65.52	80.30	101.00	125.94	5.8	7.1	12.9	12.4	10.7	9.9	9.3	7.1	1.8	2.1	2.3	2.2	2.2		
Total	165.44	263.90	480.36	530.47	750.36	1,025.35	1,355.63	100	100	100	100	100	100	100	4.0	3.4	3.5	3.2	2.8	3.2		
Coal	5.38	13.73	34.63	39.95	57.87	83.24	111.08	3.3	5.2	7.2	7.5	7.7	8.1	8.2	7.1	4.9	3.8	3.7	2.9	3.6		
Oil	65.44	117.36	218.05	245.12	364.83	513.46	695.52	39.6	44.5	45.4	46.2	48.6	50.1	51.3	4.6	4.0	4.1	3.5	3.1	3.6		
Natural gas	7.17	21.40	47.81	54.91	86.33	122.89	164.48	4.3	8.1	10.0	10.4	11.5	12.0	12.1	7.3	4.7	4.6	3.6	3.0	3.8		
Electricity	12.23	30.00	79.07	91.10	141.92	204.19	279.78	7.4	11.4	16.5	17.2	18.9	19.9	20.6	7.2	4.8	4.5	3.7	3.2	3.9		
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	-100.0	-	-	-	-	-		
Others	75.23	81.44	100.80	99.39	99.42	101.57	104.77	45.5	30.9	21.0	18.7	13.2	9.9	7.7	1.1	-0.5	0.0	0.2	0.3	0.1		

Power generation Output

Power generation Output	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	169.56	397.61	1,041.34	1,159.60	1,768.05	2,496.04	3,439.49	100	100	100	100	100	100	100	7.0	3.7	4.3	3.5	3.3	3.7
Coal	27.80	75.62	381.05	401.71	607.53	888.75	1,231.70	16.4	19.0	36.6	34.6	34.4	35.6	35.8	10.2	1.8	4.2	3.9	3.3	3.6
Oil	78.80	89.78	26.19	21.31	23.45	12.25	11.80	46.5	22.6	2.5	1.8	1.3	0.5	0.3	-4.0	-6.7	1.0	-6.3	-0.4	-2.4
Natural gas	28.33	165.67	413.65	476.32	742.76	1,075.27	1,581.96	16.7	41.7	39.7	41.1	42.0	43.1	46.0	10.4	4.8	4.5	3.8	3.9	4.1
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	-	-	-	-	-	-
Hydro	27.26	50.78	182.94	204.40	266.77	315.53	356.16	16.1	12.8	17.6	17.6	15.1	12.6	10.4	7.3	3.8	2.7	1.7	1.2	2.0
Geothermal	6.59	14.27	23.03	23.55	36.92	49.17	73.34	3.9	3.6	2.2	2.0	2.1	2.0	2.1	4.7	0.7	4.6	2.9	4.1	3.6
Others	0.77	1.49	14.47	32.32	90.64	155.06	184.53	0.5	0.4	1.4	2.8	5.1	6.2	5.4	11.5	30.7	10.9	5.5	1.8	8.0

Power generation Input

Power generation input	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	34,95	78,34	188,89	202,71	294,91	411,74	569,02	100	100	100	100	100	100	100	6,4	2,4	3,8	3,4	3,3	3,4
Coal	7,37	18,99	107,76	112,56	159,07	223,80	297,99	21,1	24,2	57,0	55,5	53,9	54,4	52,4	10,4	1,5	3,5	3,5	2,9	3,1
Oil	20,97	23,99	6,95	5,54	6,01	3,03	2,87	60,0	30,6	3,7	2,7	2,0	0,7	0,5	-4,0	-7,3	0,8	-6,6	-0,6	-2,6
Natural gas	6,61	35,36	74,19	84,61	129,84	184,91	268,17	18,9	45,1	39,3	41,7	44,0	44,9	47,1	9,4	4,5	4,4	3,6	3,8	4,0

Thermal Efficiency

Thermal Efficiency	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	33,2	36,3	37,4	38,2	40,1	41,3	42,7		0,4	0,7	0,5	0,3	0,3	0,4
Coal	32,4	34,3	30,4	30,7	32,8	34,2	35,5		-0,2	0,3	0,7	0,4	0,4	0,5
Oil	32,3	32,2	32,4	33,1	33,5	34,7	35,4		0,0	0,7	0,1	0,4	0,2	0,3
Natural gas	36,9	40,3	48,0	48,4	49,2	50,0	50,7		1,0	0,3	0,2	0,2	0,1	0,2

CO₂ emissions

	Mt-C								AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050
Total	117,9	199,7	375,9	417,6	628,3	893,0	1,216,6	100	100	100	100	100	100	4,4
Coal	20,2	39,6	146,9	157,8	226,8	323,5	431,7	17,1	19,9	39,1	37,8	36,1	36,2	35,5
Oil	69,4	111,4	137,9	157,2	249,1	361,6	503,5	58,8	55,8	36,7	37,6	39,6	40,5	41,4
Natural gas	28,3	48,7	91,2	102,6	152,4	207,9	281,4	24,0	24,4	24,3	24,6	24,3	23,3	23,1

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	798	1 297	3 100	3 443	5 424	8 281	12 251	5,2	3,6	4,6	4,3	4,0	4,25
Population (millions of people)	429	510	636	650	709	761	809	1,5	0,8	0,9	0,7	0,6	0,73
GDP per capita (thousands of 2010 USD/person)	1,86	2,54	4,88	5,3	7,7	10,9	15,1	3,6	2,8	3,8	3,6	3,4	3,5
Primary energy consumption per capita (toe/person)	0,56	0,73	1,04	1,11	1,42	1,80	2,25	2,4	2,0	2,6	2,4	2,2	2,4
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	298	288	214	209	186	166	149	-1,2	-0,7	-1,2	-1,1	-1,1	-1,1
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	207	204	155	154	138	124	111	-1,1	-0,2	-1,1	-1,1	-1,1	-1,0
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	148	154	121	121	116	108	99	-0,7	0,0	-0,5	-0,7	-0,8	-0,6
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,50	0,54	0,57	0,58	0,62	0,65	0,67	0,5	0,7	0,7	0,4	0,3	0,5
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

ASEAN [APS]

Primary energy consumption

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	238,14	372,96	662,04	690,01	893,35	1,145,27	1,461,01	100	100	100	100	100	100	100	3,9	1,4	2,6	2,5	2,5	2,4
Coal	13,06	32,72	142,75	139,31	164,33	206,72	250,57	5,5	8,8	21,6	20,2	18,4	18,0	17,2	9,3	-0,8	1,7	2,3	1,9	1,7
Oil	99,50	158,03	244,41	262,10	357,03	469,40	601,96	41,8	42,4	36,9	38,0	40,0	41,0	41,2	3,4	2,4	3,1	2,8	2,5	2,8
Natural gas	32,73	75,99	129,27	138,11	190,33	258,73	342,22	13,7	20,4	19,5	20,0	21,3	22,6	23,4	5,2	2,2	3,3	3,1	2,8	3,0
Nuclear	0,00	0,00	0,00	0,00	0,00	1,15	5,57	0,0	0,0	0,0	0,0	0,0	0,1	0,4	-	-	15,8	108,1	17,0	-
Hydro	2,35	4,37	15,73	18,15	23,75	26,91	29,59	1,0	1,2	2,4	2,6	2,7	2,3	2,0	7,3	4,9	2,7	1,3	1,0	1,9
Geothermal	6	12	20	20,07	32,00	39,05	73,70	2,4	3,3	3,0	2,9	3,6	3,4	5,0	4,7	0,4	4,8	2,0	6,6	4,1
Others	84,84	89,58	110,07	112,27	125,91	143,30	157,39	35,6	24,0	16,6	16,3	14,1	12,5	10,8	1,0	0,7	1,2	1,3	0,9	1,1
Biomass	84,78	89,56	102,93	99,76	102,40	104,38	103,76	35,6	24,0	15,5	14,5	11,5	9,1	7,1	0,7	-1,0	0,3	0,2	-0,1	0,0
Solar, Wind, Ocean	0,00	0,00	1,62	4,04	12,19	18,53	25,07	0,0	0,0	0,2	0,6	1,4	1,6	1,7	-	35,7	11,7	4,3	3,1	8,7
Biofuels	0,00	0,00	6,61	8,02	11,47	16,64	22,73	0,0	0,0	1,0	1,2	1,3	1,5	1,6	-	6,6	3,6	3,8	3,2	3,8
Electricity	0,05	0,01	-1,09	0,45	-0,15	3,76	5,84	0,0	0,0	-0,2	0,1	0,0	0,3	0,4	-211,8	-174,3	-	-	4,5	-205,2

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	165,44	263,92	480,36	516,67	686,12	897,22	1,138,82	100	100	100	100	100	100	100	4,0	2,5	2,9	2,7	2,4	2,7
Industry	43,99	86,67	148,01	160,47	227,28	306,02	386,02	26,6	32,8	30,8	31,1	33,1	34,1	33,9	4,6	2,7	3,5	3,0	2,3	2,9
Transportation	30,45	56,27	128,83	141,47	201,18	279,27	373,58	18,4	21,3	26,8	27,4	29,3	31,1	32,8	5,5	3,2	3,6	3,3	3,0	3,3
Others	81,37	102,26	141,33	149,21	177,37	210,93	253,29	49,2	38,8	29,4	28,9	25,9	23,5	22,2	2,1	1,8	1,7	1,7	1,8	1,8
Non-energy	9,64	18,70	62,18	65,52	80,30	101,00	125,94	5,8	7,1	12,9	12,7	11,7	11,3	11,1	7,1	1,8	2,1	2,3	2,2	2,2
Total	165,44	263,92	480,36	516,67	686,12	897,22	1,138,82	100	100	100	100	100	100	100	4,0	2,5	2,9	2,7	2,4	2,7
Coal	5,38	13,73	34,63	39,12	53,66	75,59	98,22	3,3	5,2	7,2	7,6	7,8	8,4	8,6	7,1	4,2	3,2	3,5	2,7	3,2
Oil	65,44	117,36	218,05	237,87	331,31	445,31	576,57	39,6	44,5	45,4	46,0	48,3	49,6	50,6	4,6	2,9	3,4	3,0	2,6	3,0
Natural gas	7,17	21,40	47,81	53,17	78,23	106,13	138,55	4,3	8,1	10,0	10,3	11,4	11,8	12,2	7,3	3,6	3,9	3,1	2,7	3,3
Electricity	12,23	30,00	79,07	87,86	128,57	178,10	235,72	7,4	11,4	16,5	17,0	18,7	19,8	20,7	7,2	3,6	3,9	3,3	2,8	3,4
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	-	-	-	-	-	-
Others	75,23	81,44	100,80	98,65	94,36	92,10	89,75	45,5	30,9	21,0	19,1	13,8	10,3	7,9	1,1	-0,7	-0,4	-0,2	-0,3	-0,4

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	169,56	397,61	1,041,34	1,121,18	1,621,84	2,197,04	2,895,40	100	100	100	100	100	100	100	7,0	2,5	3,8	3,1	2,8	3,1
Coal	27,80	75,62	381,05	368,63	449,24	609,39	772,44	16,4	19,0	36,6	32,9	27,7	27,7	26,7	10,2	-1,1	2,0	3,1	2,4	2,2
Oil	78,80	89,78	26,19	21,78	21,44	11,21	11,93	46,5	22,6	2,5	1,9	1,3	0,5	0,4	-4,0	-6,0	-0,2	-6,3	0,6	-2,4
Natural gas	28,33	165,67	413,65	448,08	668,83	952,07	1,303,37	16,7	41,7	39,7	40,0	41,2	43,3	45,0	10,4	2,7	4,1	3,6	3,2	3,5
Nuclear	0,00	0,00	0,00	0,00	0,00	4,43	21,37	0,0	0,0	0,0	0,0	0,0	0,2	0,7	-	-	-	-	17,0	-
Hydro	27,26	50,78	182,94	211,07	275,17	312,99	344,18	16,1	12,8	17,6	18,8	17,0	14,2	11,9	7,3	4,9	2,7	1,3	1,0	1,9
Geothermal	6,59	14,27	23,03	23,34	37,22	45,41	85,70	3,9	3,6	2,2	2,1	2,3	2,1	3,0	4,7	0,4	4,8	2,0	6,6	4,1
Others	0,77	1,49	14,47	48,28	168,94	261,55	356,41	0,5	0,4	1,4	4,3	10,4	11,9	12,3	11,5	49,4	13,3	4,5	3,1	10,2

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	34,95	78,34	188,89	183,29	225,34	282,43	351,73	100	100	100	100	100	100	100	6,4	-1,0	2,1	2,3	2,2	1,9
Coal	7,37	18,99	107,76	100,18	110,66	131,13	152,34	21,1	24,2	57,0	54,7	49,1	46,4	43,3	10,4	-2,4	1,0	1,7	1,5	1,1
Oil	20,97	23,99	6,95	5,67	5,49	2,76	2,84	60,0	30,6	3,7	3,1	2,4	1,0	0,8	-4,0	-6,6	-0,3	-6,6	0,3	-2,7
Natural gas	6,61	35,36	74,19	77,44	109,19	148,54	196,55	18,9	45,1	39,3	42,3	48,5	52,6	55,9	9,4	1,4	3,5	3,1	2,8	3,0

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	33,2	36,3	37,4	39,3	43,5	47,9	51,0								0,4	1,7	1,0	1,0	0,6	0,9
Coal	32,4	34,3	30,4	31,6	34,9	40,0	43,6								-0,2	1,3	1,0	1,4	0,9	1,1
Oil	32,3	32,2	32,4	33,0	33,6	34,9	36,1								0,0	0,6	0,2	0,4	0,3	0,3
Natural gas	36,9	40,3	48,0	49,8	52,7	55,1	57,0								1,0	1,2	0,6	0,5	0,3	0,5

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	117,9	199,7	375,9	390,7	521,2	687,6	876,0	100	100	100	100	100	100	100	4,4	1,3	2,9	2,8	2,5	2,6
Coal	20,2	39,6	146,9	143,6	170,8	217,1	264,3	17,1	19,9	39,1	36,8	32,8	31,6	30,2	7,6	-0,7	1,8	2,4	2,0	1,8
Oil	69,4	111,4	137,9	147,3	214,3	296,6	395,3	58,8	55,8	36,7	37,7	41,1	43,1	45,1	2,6	2,2	3,8	3,3	2,9	3,2
Natural gas	28,3	48,7	91,2	99,8	136,0	173,9	216,4	24,0	24,4	24,3	25,5	26,1	25,3	24,7	4,4	3,1	3,1	2,5	2,2	2,7

Energy and economic indicators

															AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050

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Primary energy consumption

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	6,238.3	8,176.5	13,709.8	14,756.3	16,834.8	18,365.6	19,521.0	100	100	100	100	100	100	100	3.0	2.5	1.3	0.9	0.6	0.1	
Coal	2,022.0	2,629.8	5,936.8	6,206.5	6,397.4	6,234.8	5,778.7	32.4	32.2	43.3	42.1	38.0	33.9	29.6	4.1	1.5	0.3	-0.3	-0.8	-0.1	
Oil	2,069.1	2,775.2	3,742.8	3,989.3	4,648.8	5,231.7	5,822.4	33.2	33.9	27.3	27.0	27.6	28.5	29.8	2.2	2.1	1.5	1.2	1.1	1.3	
Natural gas	714.2	1,074.8	1,865.7	2,143.4	2,779.6	3,311.1	3,734.0	11.4	13.1	13.6	14.5	16.5	18.0	19.1	3.6	4.7	2.6	1.8	1.2	2.1	
Nuclear	295.5	450.0	462.3	583.8	710.9	817.2	914.8	4.7	5.5	3.4	4.0	4.2	4.4	4.7	1.7	8.1	2.0	1.4	1.1	2.1	
Hydro	87.3	108.1	319.2	341.6	411.3	459.0	493.2	1.4	1.3	2.3	2.3	2.4	2.5	2.5	4.9	2.3	1.9	1.1	0.7	1.3	
Geothermal	37.2	63.3	104.0	111.6	168.0	220.6	312.9	0.6	0.8	0.8	0.8	1.0	1.2	1.6	3.9	2.4	4.2	2.8	3.6	3.4	
Others	1,013.0	1,075.2	1,284.0	1,390.5	1,734.8	2,114.6	2,488.9	16.2	13.2	9.4	9.4	10.3	11.5	12.7	0.9	2.7	2.2	2.0	1.6	2.0	
Biomass	1,009.1	1,067.0	1,073.7	1,074.5	1,093.0	1,099.8	1,105.9	16.2	13.0	7.8	7.3	6.5	6.0	5.7	0.2	0.0	0.2	0.1	0.1	0.1	
Solar, Wind, Ocean	3.0	6.5	186.1	277.4	583.3	917.4	1,257.8	0.0	0.1	1.4	1.9	3.5	5.0	6.4	16.5	14.2	7.7	4.6	3.2	6.0	
Biofuels	0.0	3.3	64.6	73.9	97.1	127.1	159.5	0.0	0.0	0.5	0.5	0.6	0.7	0.8	-		3.8	2.7	2.3	2.8	
Electricity	0.9	1.7	-0.7	4.5	6.3	19.3	21.7	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-199.3	-283.1	2.5	11.8	1.2	-210.8	

Final energy demand

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	4,423.2	5,601.9	9,238.5	9,929.0	11,376.0	12,613.0	13,689.6	100	100	100	100	100	100	100	2.8	2.4	1.4	1.0	0.8	1.2
Industry	1,317.6	1,700.8	3,398.5	3,657.8	4,107.9	4,400.3	4,525.1	29.8	30.4	36.8	36.8	36.1	34.9	33.1	3.6	2.5	1.2	0.7	0.3	0.9
Transportation	892.9	1,268.8	2,117.4	2,274.3	2,714.0	3,165.9	3,686.5	20.2	22.6	22.9	22.9	23.9	25.1	26.9	3.2	2.4	1.8	1.6	1.5	1.7
Others	1,867.8	2,127.3	2,813.2	2,991.5	3,336.9	3,638.4	3,906.9	42.2	38.0	30.5	30.1	29.3	28.8	28.5	1.5	2.1	1.1	0.9	0.7	1.0
Non-energy	345.0	505.1	909.4	1,005.4	1,217.2	1,408.4	1,571.1	7.8	9.0	9.8	10.1	10.7	11.2	11.5	3.7	3.4	1.9	1.5	1.1	1.7
Total	4,423.2	5,602.0	9,238.5	9,929.0	11,376.0	12,613.1	13,689.6	100	100	100	100	100	100	100	2.8	2.4	1.4	1.0	0.8	1.2
Coal	859.5	758.6	1,716.8	1,765.2	1,697.1	1,654.3	1,576.3	19.4	13.5	18.6	17.8	14.9	13.1	11.5	2.6	0.9	-0.4	-0.3	-0.5	-0.3
Oil	1,648.9	2,327.4	3,385.9	3,640.4	4,302.9	4,898.6	5,503.4	37.3	41.5	36.6	36.7	37.8	38.8	40.2	2.7	2.4	1.7	1.3	1.2	1.5
Natural gas	403.0	561.4	958.3	1,099.8	1,390.0	1,585.7	1,742.0	9.1	10.0	10.4	11.1	12.2	12.6	12.7	3.3	4.7	2.4	1.3	0.9	1.8
Electricity	550.8	877.3	2,002.6	2,252.0	2,870.4	3,419.2	3,871.7	12.5	15.7	21.7	22.7	25.2	27.1	28.3	4.9	4.0	2.5	1.8	1.3	2.0
Heat	29.0	63.9	208.6	226.3	233.1	236.3	228.9	0.7	1.1	2.3	2.3	2.0	1.9	1.7	7.6	2.8	0.3	0.1	-0.3	0.3
Others	932.0	1,013.3	966.3	945.3	882.4	819.1	767.3	21.1	18.1	10.5	9.5	7.8	6.5	5.6	0.1	-0.7	-0.7	-0.7	-0.7	-0.7

Power generation Output

	TWh														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	7,815.4	12,192.5	27,419.5	30,744.9	38,861.9	45,516.5	50,962.5	100	100	100	100	100	100	100	4.8	3.9	2.4	1.6	1.1	1.9
Coal	3,574.0	6,277.1	15,248.3	16,109.2	17,555.4	17,513.8	16,602.7	45.7	51.5	55.6	52.4	45.2	38.5	32.6	5.5	1.8	0.9	0.0	-0.5	0.3
Oil	1,008.9	832.2	354.7	295.4	231.4	136.4	72.4	12.9	6.8	1.3	1.0	0.6	0.3	0.1	-3.8	-5.9	-2.4	-5.1	-6.1	-4.7
Natural gas	888.4	1,870.2	4,149.9	4,836.9	6,549.5	8,365.1	9,983.3	11.4	15.3	15.1	15.7	16.9	18.4	19.6	5.9	5.2	3.1	2.5	1.8	2.7
Nuclear	1,134.2	1,727.0	1,774.4	2,240.4	2,728.3	3,136.2	3,511.1	14.5	14.2	6.5	7.3	7.0	6.9	6.9	1.7	8.1	2.0	1.4	1.1	2.1
Hydro	1,014.9	1,257.0	3,712.5	3,973.2	4,783.5	5,337.8	5,735.7	13.0	10.3	13.5	12.9	12.3	11.7	11.3	4.3	2.9	1.9	1.1	0.7	1.3
Geothermal	43.6	70.2	108.8	116.4	188.8	260.4	372.4	0.6	0.6	0.4	0.4	0.5	0.6	0.7	3.4	2.5	5.0	3.3	3.6	3.8
Others	151.4	158.6	2,070.9	3,173.5	6,825.0	10,766.8	14,684.9	1.9	1.3	7.6	10.3	17.6	23.7	28.8	10.2	15.3	8.0	4.7	3.2	6.1

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,334.72	2,176.02	4,485.79	4,751.88	5,263.64	5,396.86	5,222.40	100	100	100	100	100	100	100	4.6	1.9	1.0	0.3	-0.3	-0.5
Coal	902.52	1,564.02	3,644.54	3,811.65	4,051.14	3,930.51	3,543.13	67.6	71.9	81.2	80.2	77.0	72.8	67.8	5.3	1.5	0.6	-0.3	-1.0	0.1
Oil	233.84	231.63	86.28	71.77	57.30	33.57	18.06	17.5	10.6	1.9	1.5	1.1	0.6	0.3	-3.6	-6.0	-2.2	-5.2	-6.0	-4.6
Natural gas	198.36	380.37	754.98	868.46	1,155.19	1,432.77	1,661.21	14.9	17.5	16.8	18.3	21.9	26.5	31.8	5.1	4.8	2.9	2.2	1.5	2.4

Thermal Efficiency

	%							AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	35.3	35.5	37.9	38.4	39.8	41.5	43.9							
Coal	34.1	34.5	36.0	36.3	37.3	38.3	40.3							
Oil	37.1	30.9	35.4	35.4	34.7	34.9	34.5							
Natural gas	38.5	42.3	47.3	47.9	48.8	50.2	51.7							

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	3,937.6	5,349.7	9,752.0	10,342.4	11,328.1	11,808.3	11,805.1	100	100	100	100	100	100	100	3.4	2.0	0.9	0.4	0.0	0.6
Coal	2,065.9	2,816.7	6,184.8	6,451.8	6,611.9	6,418.6	5,775.1	52.5	52.7	63.4	62.4	58.4	54.4	48.9	4.1	1.4	-0.2	-0.3	-1.1	-0.2
Oil	1,411.1	1,872.4	2,411.9	2,566.9	3,014.5	3,415.3	3,853.5	35.8	35.0	24.7	24.8	26.6	28.9	32.6	2.0	2.1	1.6	1.3	1.2	1.4
Natural gas	460.3	660.0	1,140.8	1,305.9	1,673.0	1,940.4	2,142.2	11.7	12.3	11.7	12.6	14.8	16.4	18.1	3.4	4.6	2.5	1.5	1.0	1.9

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	25.573	36.665	69.911	78.214	113.024	158.057	207.590	3,8	3,8	3,8	3,4	2,8	3,4
Population (millions of people)	5.932	6.854	8.121	8.362	8.855	9.174	9.323	1,2	1,0	0,6	0,4	0,2	0,4
GDP per capita (thousands of 2010 USD/person)	4.31	5.35	8,61	9.35	12,76	17,23	22,27	2,6	2,8	3,2	3,0	2,6	2,9
Primary energy consumption per capita (toe/person)	1.05	1.19	1,69	1.76	1,90	2,00	2,09	1,8	1,5	0,7	0,5	0,5	0,7
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	244	223	196	189	149	116	94	-0,8	-1,3	-2,3	-2,5	-2,1	-2,2
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	173	153	132	127	101	80	66	-1,0	-1,3	-2,3	-2,3	-1,9	-2,1
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	154	146	139	132	100	75	57	-0,4	-1,8	-2,7	-2,9	-2,7	-2,7
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,63	0,65	0,71	0,70	0,67	0,64	0,60	0,4	-0,5	-0,4	-0,5	-0,6	-0,5
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	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050		
Total	8,067.2	10,342.1	15,738.0	16,777.3	18,712.6	20,041.3	20,956.1	100	100	100	100	100	100	100	2.5	2.2	1.1	0.7	0.4	0.9		
Coal	2,447.2	3,115.6	6,223.6	6,418.2	6,507.6	6,237.5	5,662.8	30.3	30.1	39.5	38.3	34.8	31.1	27.0	3.5	1.0	0.1	-0.4	-1.0	-0.3		
Oil	2,794.7	3,612.2	4,490.2	4,732.5	5,284.6	5,743.4	6,207.8	34.6	34.9	28.5	28.2	28.2	28.7	29.6	1.8	1.8	1.1	0.8	0.8	1.0		
Natural gas	1,137.8	1,603.3	2,478.3	2,813.4	3,441.6	3,886.0	4,137.0	14.1	15.5	15.7	16.8	18.4	19.4	19.7	2.9	4.3	2.0	1.2	0.6	1.6		
Nuclear	454.9	657.8	680.9	792.1	891.8	1,000.4	1,104.8	5.6	6.4	4.3	4.7	4.8	5.0	5.3	1.5	5.2	1.2	1.2	1.0	1.5		
Hydro	109.5	128.4	343.8	366.0	438.4	487.6	523.6	1.4	1.2	2.2	2.2	2.3	2.4	2.5	4.3	2.1	1.8	1.1	0.7	1.3		
Geothermal	51.3	76.4	113.2	120.7	193.1	258.5	380.3	0.6	0.7	0.7	0.7	1.0	1.3	1.8	3.0	2.2	4.8	3.0	3.9	3.7		
Others	1,071.7	1,148.3	1,412.9	1,544.7	1,971.3	2,451.1	2,963.6	13.3	11.1	9.0	9.2	10.5	12.2	14.1	1.0	3.0	2.5	2.2	1.9	2.3		
Biomass	1,067.4	1,135.2	1,169.5	1,182.8	1,232.7	1,258.1	1,285.1	13.2	11.0	7.4	7.1	6.6	6.3	6.1	0.3	0.4	0.4	0.2	0.2	0.3		
Solar, Wind, Ocean	3.2	8.4	214.4	318.7	678.4	1,096.0	1,555.0	0.0	0.1	1.4	1.9	3.6	5.5	7.4	16.8	14.1	7.8	4.9	3.6	6.2		
Biofuels	0.0	6.5	101.9	115.0	151.1	188.9	227.4	0.0	0.1	0.6	0.7	0.8	0.9	1.1	-	4.1	2.8	2.3	1.9	2.5		
Electricity	1.1	4.7	4.1	9.0	9.1	21.4	25.8	0.0	0.0	0.0	0.1	0.0	0.1	0.1	5.2	30.0	0.0	9.0	1.9	5.7		

Final energy demand

	MTOE														AAGR (%)						
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	5,660.1	7,078.7	10,677.1	11,394.0	12,749.8	13,853.0	14,775.9	100	100	100	100	100	100	100	2.4	2.2	1.1	0.8	0.6	1.0	
Industry	1,582.0	2,009.3	3,637.4	3,906.3	4,349.1	4,621.6	4,714.0	28.0	28.4	34.1	34.1	34.1	34.1	31.9	3.1	2.4	1.1	0.6	0.2	0.8	
Transportation	1,359.3	1,831.4	2,709.4	2,857.8	3,222.3	3,588.1	4,029.0	24.0	25.9	25.4	25.1	25.3	25.9	27.3	2.6	1.8	1.2	1.1	1.2	1.2	
Others	2,258.7	2,584.3	3,280.3	3,469.0	3,787.8	4,048.9	4,265.3	39.9	36.5	30.7	30.4	29.7	29.2	28.9	1.4	1.9	0.9	0.7	0.5	0.8	
Non-energy	460.1	653.7	1,049.9	1,160.8	1,390.5	1,594.4	1,767.6	8.1	9.2	9.8	10.2	10.9	11.5	12.0	3.1	3.4	1.8	1.4	1.0	1.6	
Total	5,660.1	7,078.7	10,677.1	11,394.0	12,749.8	13,853.0	14,775.9	100	100	100	100	100	100	100	2.4	2.2	1.1	0.8	0.6	1.0	
Coal	910.6	787.0	1,731.3	1,778.6	1,702.8	1,654.5	1,569.7	16.1	11.1	16.2	15.6	13.4	11.9	10.6	2.4	0.9	-0.4	-0.3	-0.5	-0.3	
Oil	2,303.2	3,086.1	4,089.8	4,339.4	4,904.7	5,382.7	5,866.6	40.7	43.6	38.3	38.1	38.5	38.9	39.7	2.1	2.0	1.2	0.9	0.9	1.1	
Natural gas	697.4	910.0	1,291.7	1,447.3	1,724.0	1,887.5	2,009.5	12.3	12.9	12.1	12.7	13.5	13.6	13.6	2.3	3.9	1.8	0.9	0.6	1.3	
Electricity	766.2	1,163.4	2,305.9	2,569.6	3,201.7	3,766.2	4,219.5	13.5	16.4	21.6	22.6	25.1	27.2	28.6	4.2	3.7	2.2	1.6	1.1	1.8	
Heat	31.1	69.2	214.4	232.3	238.6	241.2	233.3	0.6	1.0	2.0	2.0	1.9	1.7	1.6	7.4	2.7	0.3	0.1	-0.3	0.3	
Others	951.6	1,063.0	1,043.9	1,026.8	978.0	920.9	877.4	16.8	15.0	9.8	9.0	7.7	6.6	5.9	0.3	-0.6	-0.5	-0.6	-0.5	-0.5	

Power generation Output

	TWh															AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050	
Total	10,863.9	16,008.5	31,425.4	34,944.0	43,268.0	50,137.5	55,543.1	100	100	100	100	100	100	100	4.0	3.6	2.2	1.5	1.0	1.7	
Coal	5,152.1	8,232.4	16,407.9	16,992.2	18,101.9	17,667.0	16,285.7	47.4	51.4	52.2	48.6	41.8	35.2	29.3	4.4	1.2	0.6	-0.2	-0.8	0.0	
Oil	1,136.0	948.9	381.8	322.7	247.7	144.5	74.1	10.5	5.9	1.2	0.9	0.6	0.3	0.1	-4.0	-5.5	-2.6	-5.2	-6.5	-4.8	
Natural gas	1,255.7	2,488.3	5,437.1	6,483.9	8,233.9	9,849.2	10,727.9	11.6	15.5	17.3	18.6	19.0	19.6	19.3	5.6	6.0	2.4	1.8	0.9	2.1	
Nuclear	1,745.8	2,524.7	2,613.2	3,039.9	3,422.8	3,839.5	4,240.2	16.1	15.8	8.3	8.7	7.9	7.7	7.6	1.5	5.2	1.2	1.2	1.0	1.5	
Hydro	1,273.9	1,493.9	3,998.8	4,256.3	5,099.0	5,670.9	6,089.0	11.7	9.3	12.7	12.2	11.8	11.3	11.0	4.3	2.1	1.8	1.1	0.7	1.5	
Geothermal	59.7	84.8	127.5	134.9	240.7	342.3	503.3	0.5	0.5	0.4	0.6	0.7	0.9	2.9	1.9	6.0	3.6	3.9	4.2	4.2	
Others	240.8	235.5	2,458.9	3,714.0	7,922.1	12,624.0	17,622.8	2.2	1.5	7.8	10.6	18.3	25.2	31.7	9.0	14.7	7.9	4.8	3.4	6.1	

Power generation Input

	MTOE														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	1,814.39	2,826.46	4,980.41	5,214.35	5,617.90	5,594.91	5,176.79	100	100	100	100	100	100	100	3.8	1.5	0.7	0.0	-0.8	0.1
Coal	1,269.60	2,024.42	3,913.83	4,006.92	4,152.37	3,928.60	3,428.03	70.0	71.6	78.6	76.8	73.9	70.2	66.2	4.3	0.8	0.4	-0.6	-1.4	-0.4
Oil	260.14	288.82	92.08	78.38	61.19	35.48	18.40	14.3	10.2	1.8	1.5	1.1	0.6	0.4	-3.8	-5.2	-2.4	-5.3	-6.4	-4.8
Natural gas	284.65	513.23	974.50	1,129.05	1,404.33	1,630.84	1,730.36	15.7	18.2	19.6	21.7	25.0	29.1	33.4	4.7	5.0	2.2	1.5	0.6	1.8

Thermal Efficiency

	%														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050								1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	35.8	35.5	38.4	39.3	40.7	42.5	45.0								0.3	0.8	0.4	0.4	0.6	0.5
Coal	34.9	35.0	36.1	36.5	37.5	38.7	40.9								0.1	0.4	0.3	0.3	0.6	0.4
Oil	37.6	28.3	35.7	35.4	34.8	35.0	34.6								-0.2	-0.2	-0.2	0.1	-0.1	-0.1
Natural gas	37.9	41.7	48.0	49.4	50.4	51.9	53.3								0.9	1.0	0.2	0.3	0.3	0.3

CO₂ emissions

	Mt-C														AAGR (%)					
	1990	2000	2017	2020	2030	2040	2050	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
Total	5,166.5	6,791.8	10,944.3	11,475.8	12,225.9	12,403.3	12,052.2	100	100	100	100	100	100	100	2.8	1.6	0.6	0.1	-0.3	0.3
Coal	2,520.9	3,357.8	6,497.8	6,683.4	6,727.0	6,418.3	5,647.0	49.0	49.4	59.4	58.2	55.0	51.7	46.9	3.6	0.9	0.1	-0.5	-1.3	-0.4
Oil	1,912.6	2,448.8	2,919.5	3,059.3	3,413.2	3,708.0	4,043.0	37.0	36.1	26.7	26.7	27.9	29.9	33.5	1.6	1.6	1.1	0.8	0.9	1.0
Natural gas	722.7	984.6	1,512.5	1,715.3	2,056.9	2,242.7	2,328.0	14.0	14.5	13.8	14.9	16.8	18.1	19.3	2.8	4.3	1.8	0.9	0.4	1.3

Energy and economic indicators

									AAGR(%)				
	1990	2000	2017	2020	2030	2040	2050	1990-2017	2017-2020	2020-2030	2030-2040	2040-2050	2017-2050
GDP (billions of 2010 US dollars)	33.999	48.494	85.826	95.271	133.753	183.866	238.736	3,5	3,5	3,5	3,2	2,6	3,1
Population (millions of people)	6.165	7.117	8.421	8.668	9.179	9.513	9.674	1,2	1,0	0,6	0,4	0,2	0,4
GDP per capita (thousands of 2010 USD/person)	5,52	6,81	10,19	10,99	14,57	19,33	24,68	2,3	2,5	2,9	2,9	2,5	2,7
Primary energy consumption per capita (toe/person)	1,31	1,45	1,87	1,94	2,04	2,11	2,17	1,3	1,2	0,9	0,3	0,3	0,4
Primary energy consumption per unit of GDP (toe/million 2010 US Dollars)	237	213	183	176	140	109	88	-0,9	-1,3	-2,3	-2,5	-2,1	-2,2
Final energy consumption per unit of GDP (toe/million 2010 US Dollars)	166	146	124	120	95	75	62	-1,1	-1,3	-2,2	-2,3	-1,9	-2,1
CO ₂ emissions per unit of GDP (t-C/million 2010 US Dollars)	152	140	128	120	91	67	50	-0,6	-1,9	-2,7	-3,0	-2,9	-2,8
CO ₂ emissions per unit of primary energy consumption (t-C/toe)	0,64	0,66	0,70	0,68	0,65	0,62	0,58	0,3	-0,5	-0,5	-0,5	-0,7	-0,6
Automobile ownership volume (millions of vehicles)	-	-	-	-	-	-	-	-	-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-