ENERGY OUTLOOK AND **ENERGY SAVING POTENTIAL** IN **EAST ASIA** 2019

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This report was prepared by the Working Group for Analysis of Energy Saving Potential in East Asia under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. 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

Energy security and climate change are very important issues in the world. At the Second East Asia Summit (EAS) in Cebu, Philippines in January 2007, the leaders of the region declared that East Asia could mitigate problems on these two issues through strong leadership on several countermeasures. These include promoting energy conservation, and utilising biofuels, and adopting cleaner use of coal.

Two groups were designated to assist in implementing the countermeasures mentioned above: the Energy Cooperation Task Force (ECTF) and the Economic Research Institute for ASEAN and East Asia (ERIA). The ECTF is responsible for supporting the efforts of the EAS and its Energy Ministers Meeting to promote cooperation on policies to implement these countermeasures. ERIA is responsible for studying the potential impacts of the countermeasures and is focusing its energy studies in two areas: (i) promotion of energy conservation and (ii) utilisation of biofuels.

This report was prepared by the Working Group for Analysis of Energy Saving Potential in East Asia under the ERIA Energy Project. The report covers all research activities of the Working Group from August 2015 to May 2016, including methodology, estimated impacts of current energy-saving goals, and policy recommendations to the ECTF.

The structure of this report is like the earlier editions because of the application of similar methodology. However, one important accomplishment of this study is the development of energy efficiency targets for the countries that did not have targets when this project started in 2007. It could be said that those countries started adopting energy efficiency as an important energy policy as a result of this study.

This report hopefully contributes to mitigating problems related to energy security and climate change by increasing understanding of the potential for energy savings of a range of energy efficiency goals, action plans, and policies. It also discusses several key insights for policy development.

Shigeru Kimura
Leader of the Working Group
2019

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ABBREVIATIONS AND ACRONYMS

AAGR	average annual growth rate
APS	Alternative Policy Scenario
ASEAN	Association of Southeast Asian Nations
BAU	Business-As-Usual
BCA	Building and Construction Authority (Singapore)
BPS	Central Bureau of Statistics (Indonesia)
CCS	carbon capture and storage
CNG	compressed natural gas
CO2	carbon dioxide
DOE	Department of Energy (Philippines)
DSM	demand-side management
EAS	East Asia Summit
ECTF	Energy Cooperation Task Force
EEC	energy efficiency and conservation
EPU	Economic Planning Unit (Malaysia)
ERIA	Economic Research Institute for ASEAN and East Asia
FiT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
GTMP	Green Technology Master Plan (Malaysia)
GWh	gigawatt-hour
HDB	Housing and Development Board (Singapore)
IEEJ	The Institute for Energy Economics, Japan
INDC	Intended Nationally Determined Contributions
KEN	National Energy Policy (Indonesia)
ktoe	thousand tons of oil equivalent
kWh	kilowatt-hour
LEAP	Long-range Energy Alternative Planning System
LPG	liquefied petroleum gas
LSS	large-scale solar
MEF	Ministry of Economy and Finance (Cambodia)

MEGTW	Ministry of Energy, Green Technology and Water (Malaysia)
MELS	Mandatory Energy Labelling Scheme (Singapore)
MEMR	Ministry of Energy and Mineral Resources (Indonesia)
MEPS	Minimum Energy Performance Standards (Singapore)
METI	Ministry of Economy, Trade and Industry (Japan)
Mtoe	million tons of oil equivalent
Mt-C	million tons of carbon
MW	megawatts
MWh	megawatt-hour
MWp	megawatt-peak
NDC	Nationally Determined Contributions
NEB	National Energy Balance (Malaysia)
NEM	net energy metering
NRE	new and renewable energy
NREP	National Renewable Energy Program (Philippines)
OECD	Organization for Economic Cooperation and Development
PPP	purchasing power parity
PRC	People's Republic of China
RE	renewable energy
RPS	Renewable Portfolio Standards
SEDA	Sustainable Energy Development Authority (Malaysia)
TCF	trillion cubic feet
TCM	trillion cubic metres
toe	tons of oil equivalent
t-C	tons of carbon
TFEC	total final energy consumption
TPES	total primary energy supply
Tscf	trillion standard cubic feet
TWh	terawatt-hour
US$	United States dollar

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EXECUTIVE SUMMARY

The Economic Research Institute for ASEAN and East Asia–East Asia Summit (ERIA-EAS) Energy Outlook was updated in 2017–2018 through a revision of macro assumptions, such as economic and population growth as well as crude oil prices under the current lower price situation. In addition, this outlook incorporates more recent information on the EAS17 member countries' energy-saving goals and action plans, and power development plans such as renewable electricity.

The outlook still focuses on analysing the additional energy savings 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 scenario and the Alternative Policy Scenario (APS), and predicts energy supply, consumption, and CO_2 emissions from 2015 until 2040. The APS includes not only more ambitious energy-saving targets but also rapid advances in low-carbon energy technologies, especially renewable energy.

Under the BAU scenario, sustained population and economic growth will significantly increase the total final energy consumption (TFEC) by 1.6 times in 2015–2040. The total primary energy supply (TPES) in the EAS17 region is projected to grow at a slightly slower pace of 1.5% per year. It is projected to increase from 7,488 Mtoe in 2015 to 10,943 Mtoe in 2040. Coal will remain the largest share of the TPES, but its growth is expected to be slower, increasing at 1.3% per year. Consequently, the share of coal in the TPES is forecasted to decline from 41.4% in 2015 to 38.9% in 2040. Increasing the use of clean coal technology and development of carbon capture storage technology will be critical for the coal power plants in this region to mitigate CO_2 emissions and become carbon free.

Fossil fuel energy consisting of coal, oil, and gas will still be dominant in 2040 and its share under the BAU scenario will be 84.1%. 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 fossil fuel savings of 23.4% and the fossil fuel share could fall to 76.6%. CO_2 emissions would be reduced significantly about 24.2% from BAU to the APS consequently. In view of this, EAS countries need to 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. Governments of EAS17 countries are encouraged to support the activities of energy service companies as such is crucial in achieving energy efficiency and savings.

Renewable energy such as hydro, geothermal, solar PV, wind, and biomass will also contribute to the expected reduction of fossil fuel consumption, which will result in a mitigation of CO_2 emissions. To increase the share of renewable energy in the primary energy mix, appropriate government policies will be crucial. Policies such as net metering, Renewable Portfolio Standards, and feed-in tariff have been implemented in some EAS17 member countries and have accelerated the deployment of renewable energy at appropriate levels.

Energy supply security has become a top 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 imported fossil fuel consumption and increasing the use of domestic energy. In addition, regional energy networks, such as the Trans-ASEAN Gas Pipeline and the ASEAN Power Grid, and oil stockpiling are recommended to maintain energy supply security. Nuclear power generation is another option for securing the energy supply in this region.

The ERIA-EAS17 Outlook 2018 assessed the Intended Nationally Determined Contributions (INDC)/NDC reported by EAS17 countries. Some INDC/NDC might be too ambitious because CO_2 emissions targets seem to be much higher than their APS targets. Governments should review their INDC/NDC applying energy outlook models and prepare appropriate CO_2 emission targets.

This year, 2019, the Energy Outlook includes an estimation of the investment cost required for power generation and the whole energy infrastructure, including liquefied natural gas (LNG)–receiving terminals and oil refineries. The analysis results indicate that the EAS17 region will need an investment in power generation of around US$3.5 trillion for the BAU scenario and US$4 trillion for the APS to meet electricity demand by 2040. The APS will be higher than the BAU scenario because of the shift to low-carbon power sources, such as nuclear and renewable energy.

The required investment cost of refinery and LNG-receiving terminals in the EAS17 will be US$367 billion and US$132 billion, respectively, in the BAU scenario due to the increase in oil demand especially in the road transport sector and natural gas demand in the power generation sector. Investment in the APS is expected to be reduced to US$60 billion for refineries and US$75 billion for LNG-receiving terminals, respectively, due to promotion of energy efficiency. These investment costs will be much lower than power generation. Power generation and refineries and LNG-receiving terminals have different capacity factors. Usually the capacity factor of power generation is much lower (around 10%–33%) than refineries and LNG-receiving terminals.

CHAPTER 1

ENERGY OUTLOOK AND SAVING POTENTIAL IN THE EAST ASIA REGION: MAIN REPORT

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1. Introduction

Sustained population and economic growth in the East Asia Summit (EAS) region (the original EAS plus the United States of America [EAS17]) are the key drivers for the projected increasing energy demand for both primary and final energy consumption to nearly 50% from 2015 to 2040, reflecting an annual growth rate of about 1.6%. This increasing energy demand threatens the region's energy security. Hence, potential energy saving is key to reducing energy demand and carbon dioxide (CO_2) emissions.

In 2007, leaders from member countries of the Association of Southeast Asian Nations (ASEAN), as well as Australia, the People's Republic of China (henceforth, China), India, Japan, the Republic of Korea, and New Zealand (the original EAS), adopted the Cebu Declaration, which focused on energy security. The leaders agreed to promote energy efficiency, new renewable energy, and the clean use of coal. Subsequently, the EAS Energy Cooperation Task Force (ECTF) was established in response to the Cebu Declaration, and Japan proposed to undertake a study on energy savings and the potential of reducing CO_2 emissions. This is an agreed area of cooperation on which the Economic Research Institute for ASEAN and East Asia (ERIA), through the EAS Energy Ministers Meeting, officially requested to support studies.

This study shows the energy saving potential using the Business-As-Usual (BAU) scenario and Alternative Policy Scenarios (APS). The BAU scenario was developed for each EAS country, outlining future sectoral 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 the BAU scenario and the APS in both final and primary energy supply represents potential energy savings. The difference in CO_2 emissions between the two scenarios represents the potential for reducing greenhouse gas (GHG) emissions. The scope of analysis of this outlook covers the original EAS – the original EAS composed of 10 ASEAN+6 countries mentioned on page 1 – plus the United States of America (US) (EAS17). Under the EAS's initiative of energy cooperation is an energy research platform called the Energy Research Institutes Network, of which the US is a member. Therefore, the scope of this outlook extends to include the US. This publication uses the terms EAS and EAS17. The EAS refers to the 10 ASEAN+6 countries before 2012 and 10 ASEAN+8 countries after 2013. EAS17 refers to the 10 ASEAN+7 countries, meaning, the original EAS plus the US.

The findings of this study continue to shed light on the policy implications for decision-making to ensure that the region can enjoy both economic growth and investment opportunities without compromising the aversion to the threat to energy security and of environmental problems due to rising CO_2 emissions.

1.1. The East Asia Summit

The EAS17 is a collection of diverse countries, with wide variations amongst them in terms of per capita income, standards of living, energy resource endowments, climate, and energy consumption per capita. It is composed of the 10 ASEAN member countries – Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam – and seven other countries – Australia, China, India, Japan, Republic of Korea (henceforth, Korea), New Zealand, and the US.

Whereas some EAS17 countries are mature economies, the majority are developing economies. Several countries have a per capita gross domestic product (GDP) of less than US$11,000 (in 2010 prices[1]). Countries with mature economies have higher energy consumption per capita, whereas developing countries generally have lower energy consumption per capita. A large percentage of the people in developing countries still meet their energy needs using mainly traditional biomass fuels.

[1] All US$ (US dollars) in this document are stated at constant year 2010 values unless specified.

These differences partly explain why energy efficiency and conservation (EEC) goals, action plans, and policies are assigned different priorities across countries. Developed economies may be very keen in reducing energy consumption, whereas developing countries tend to emphasise economic growth and improving the standard of living. However, as the economies of these countries grow, energy consumption per capita is expected to grow as well.

Despite the differences amongst the 17 countries, the leaders agreed that the EAS could play a significant role in community building' which could be an important cornerstone in developing regional cooperation in the years to come.

Table 1.1 shows the geographic, demographic, and economic profiles of the EAS17 countries. Table 1.2 shows their economic structure and energy consumption profiles.

Table 1.1: Geographic, Demographic, and Economic Profiles, 2015

	Land Area (thousand km²)1	Population (million)	Population Density (persons/km²)	GDP (billion 2010 US$)	GDP per Capita (2010 US$/person)
Australia	7,682	23.79	3.10	1,355	56,953
Brunei Darussalam	5.3	0.42	79.03	14	33,344
Cambodia	177	15.52	87.91	16	1,025
China	9,388	1,371.22	146.06	8,910	6,498
India	2,973	1,311.05	440.96	2,288	1,745
Indonesia	1,812	258.16	142.51	988	3,828
Japan	365	126.96	348.25	5,986	47,150
Korea, Rep. of	97	51.07	523.89	1,267	24,801
Lao PDR	231	6.66	28.87	5	764
Malaysia	329	30.72	93.51	330	10,740
Myanmar	653	52.40	80.24	71	1,346
New Zealand	263	4.60	17.45	169	36,801
Philippines	298	101.72	341.14	266	2,616
Singapore	0.7	5.54	7,806.77	289	52,245
Thailand	511	65.73	128.66	394	5,989
Viet Nam	310	91.71	295.77	155	1,685
United States	9,147	321.42	35.14	16,598	51,638

GDP = gross domestic product, km^2 = square kilometre.

Source: World Bank (2018) World Databank: http://databank.worldbank.org/data/source/world-development-indicators# (accessed: 27 May 2018).

Table 1.2: Economic Structure and Energy Consumption, 2015

	GDP (Billion 2010 US$)	Share of Industry in GDP, %	Share of Services in GDP, %	Share of Agriculture in GDP, %	Primary Energy Consumption (Mtoe)	Energy Consumption per Capita (toe/person)
Australia	1,355	25.4	72.0	2.6	125	5.3
Brunei Darussalam	14	61.4	37.5	1.1	3	7.8
Cambodia	16	29.8	41.5	28.6	7	0.5
China	8,910	40.9	50.2	8.8	2,973	2.2
India	2,288	29.6	52.9	17.5	851	0.6
Indonesia	988	41.3	44.7	13.9	229	0.9
Japan	5,986	28.9	70.0	1.1	430	3.4
Korea, Rep. of	1,267	38.3	59.4	2.3	273	5.3
Lao PDR	5	31.0	49.4	19.7	9	1.4
Malaysia	330	39.1	52.4	8.5	71	2.3
Myanmar	71	34.5	38.8	26.8	20	0.4
New Zealand	169	..	..	..	21	4.5
Philippines	266	30.9	58.8	10.3	47	0.5
Singapore	289	26.1	73.8	0.0	34	6.1
Thailand	394	36.4	54.9	8.7	135	2.1
Viet Nam	155	37.0	44.2	18.9	70	0.8
United States	16,598	20.0	78.9	1.1	2,188	6.8

GDP = gross domestic product, Mtoe = million tons of oil equivalent.

Source: World Bank (2018) World Databank: http://databank.worldbank.org/data/source/world-development-indicators# (accessed 27 May 2018).

1.2. Objective and Rationale

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

The study supports the Cebu Declaration (ASEAN Secretariat, 2007), which highlighted several goals such as:

- improving the efficiency and environmental performance of fossil fuel use;
- reducing the dependence on conventional fuels through intensified EEC programmes, increased share of hydropower, expansion of renewable energy systems and biofuel production/utilisation, and, for interested parties, civilian nuclear power; and

- mitigating GHG emissions through effective policies and measures, thus contributing to global climate change abatement.

The Government of Japan asked the Economic Research Institute for ASEAN and East Asia (ERIA) to conduct a study on energy saving and CO_2 emissions reduction potential in the East Asia region. Japan is the coordinating country of the energy efficiency work stream under the ECTF. As a result, the Working Group for this study on the Analysis of Energy Savings Potential was convened. Members from all EAS17 countries are represented in the Working Group to support this study.

2. Data and Methodology

2.1. The Scenarios

The study continues to examine two scenarios, as in the studies conducted annually from 2007 to the present: a BAU scenario reflecting each country's current goals, action plans, and policies; and an APS that includes additional goals, action plans, and policies reported every year to the East Asia Energy Ministers Meeting (EAS–EMM). The latest updated policies were reported at the 11th EAS–EMM held on 28 September 2017 in Manila, Philippines.

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

In 2014, the APS assumptions were grouped into four: (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 (d) introduction or higher utilisation of nuclear energy (APS4). In addition to these four scenarios, the 2018 outlook also compares the APS to the Intended Nationally Determined Contributions (INDC) or Nationally Determined Contributions (NDC) if the countries can achieve their commitment pledged at the COP21.[2]

[2] COP stands for Conference of the Parties, referring to the countries that have signed up to the 1992 United Nations Framework Convention on Climate Change. The COP in Paris is the 21st such conference.

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

Detailed assumptions for each APS are follows:

- The assumptions in APS1 are the reduction targets in sectoral final energy consumption, assuming more efficient technologies are utilised and energy-saving practices are implemented in the industrial, transport, residential, commercial, and even the agricultural sectors for some countries. This scenario resulted in less primary energy and CO_2 emissions in proportion to the reduction in final energy consumption.
- APS2 assumes the utilisation of more efficient thermal power plant technologies in the power sector. This assumption resulted in lower primary energy supply and CO_2 emissions in proportion to the efficiency improvement in generating thermal power. The most efficient coal and natural gas combined–cycle technologies are assumed to be utilised for new power plant construction in this scenario.
- APS3 assumes higher contributions of NRE for electricity generation and utilisation of liquid biofuels in the transport sector. This results in lower CO_2 emissions as NRE is considered carbon-neutral or would not emit additional CO_2 in the atmosphere. However, primary energy supply may not decrease as NRE, like biomass and geothermal energy, is assumed to have lower efficiencies compared with fossil fuel–fired generation when electricity generated from these NRE sources is converted into their primary energy equivalent.
- APS4 assumes the introduction of nuclear energy or a higher contribution of nuclear energy in countries already using this energy source. This scenario would produce lower CO_2 emissions as nuclear energy emits minimal CO_2. However, as the assumption of thermal efficiency when converting nuclear energy output into primary energy is only 33%, primary energy supply is not expected to be lower than for the BAU scenario in this scenario.

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

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

2.2. Data

For consistency, the historical energy data used in this analysis came from the energy balances of the International Energy Agency (IEA) for Organisation for Economic Co-operation and Development (OECD) and non-OECD countries (IEA, 2017a; 2017b), except for the Lao PDR. Estimations of national energy data from the Lao PDR were made using the same methodology as that of the IEA. The socio-economic data for 17 countries were obtained from the World Bank's online World Databank – World Development Indicators and Global Development Finance; the data of Myanmar were obtained from the United Nations Statistics Division statistical databases. 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 were available. Where official data were not available, estimates were obtained from other sources or developed by the Institute of Energy Economics, Japan (IEEJ).

2.3. Methodology

In 2007, the primary model used was IEEJ's World Energy Outlook Model, which was also used in preparing the *Asia/World Energy Outlook* (IEEJ, 2014). In 2014, all 10 ASEAN member countries used their own energy models. The remaining countries provided the IEEJ their key assumptions on population and GDP growth; electric generation fuel mixes; and EEC goals, action plans, and policies. The IEEJ models were then used to develop energy projections for these countries. The next section briefly describes the energy models in this study.

ASEAN countries. The energy models of ASEAN countries were developed using the Long-range Energy Alternative Planning System (LEAP) software, an accounting system used to develop projections of energy balance tables based on final energy consumption and energy input/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 10 member countries used the LEAP model.

Other countries. Other countries used the IEEJ model, which has a macroeconomic module that calculates coefficients for various explanatory variables based on exogenously specified GDP growth rates. The macroeconomic module also 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 from the macroeconomic module. An econometric approach means that future demand and supply will be heavily influenced by historical trends. However, the supply of energy and new technologies are treated exogenously. For electricity generation, the Working Group members were asked to specify assumptions about the future electricity generation mix in their respective 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 various socio-economic factors. In the EAS17 region, these factors – including increasing population, sustained economic growth, increasing vehicle ownership, and increasing access to electricity – will tend to increase energy demand. Together they create what might be called a huge growth 'headwind' that works against efforts to limit energy consumption. Understanding the nature and size of this 'headwind' is critical for any analysis of energy demand in the region. However, an increase in consumption of energy services is fundamental for achieving a range of socio-economic development goals.

This section discusses the assumptions on key socio-economic indicators and energy policies for the EAS17 countries until 2040.

3.1. Population

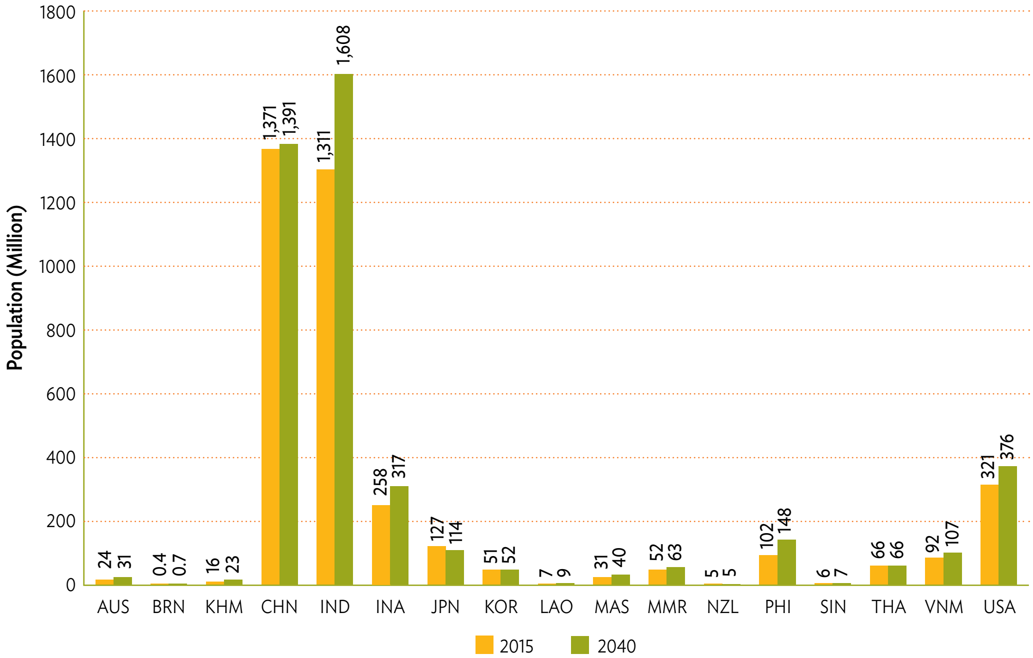
In the models used for this study, changes in population to 2040 are set exogenously. No difference in population between the BAU scenario and the APS is assumed. The EAS17 countries, except China, submitted assumed changes in population based on the population projections from the United Nations.

In 2015, the total population in the EAS17 region was about 3.84 billion. Based on the forecasts, it is projected to increase at an average annual rate of about 0.5%, reaching about 4.36 billion in 2040. Figure 1.1 shows the 2015 and projected 2040 population by country.

Brunei Darussalam is generally assumed to have the fastest population growth rate, although the country has high per capita income (Figure 1.2). Except Brunei, the fastest growth rate is assumed to be in developing countries. China and Thailand are notable and significant exceptions, as they are expected to have relatively modest population growth. Nevertheless, by 2040, India and China are assumed to account for around 70% of the total population in the EAS17 region, with populations of around 1.39 billion for China and 1.61 billion for India.

Countries with more mature economies tend to have slower population growth. New Zealand, the US, and Singapore are assumed to have low, but still significant, population growth. That of Korea is assumed to be roughly stable. Japan's population is assumed to decline slowly throughout the projection period as the population continues to age.

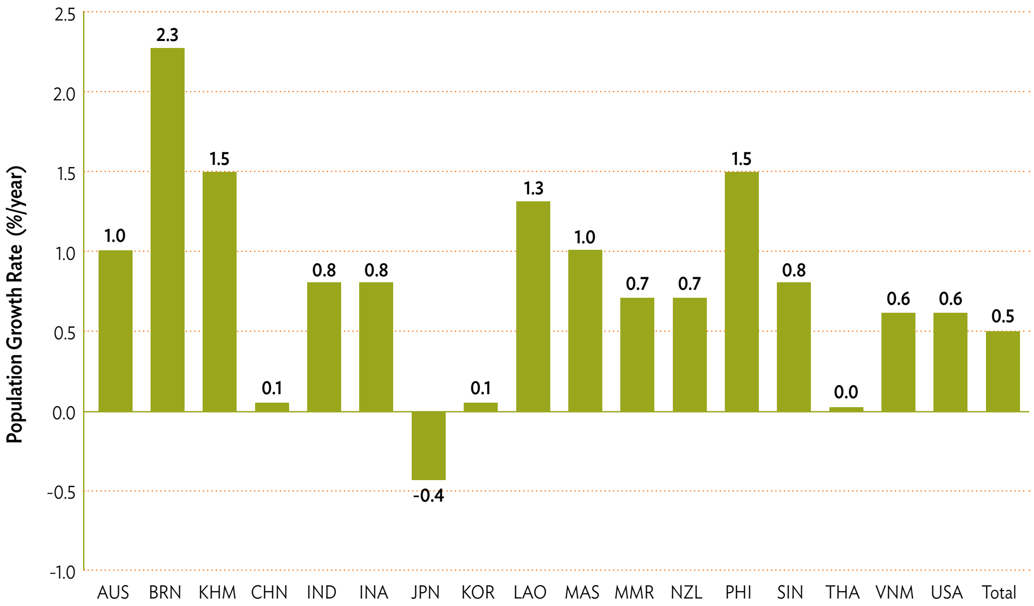
Figure 1.1: Assumed Population in the EAS17 Region, 2015 and 2040



AUS = Australia, BRN = Brunei, EAS = East Asia Summit, KHM = Cambodia, CHN = China, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America)

Source: World Bank (2018).

Figure 1.2: Assumed Average Annual Growth in Population, 2015–2040



AUS = Australia, BRN = Brunei, EAS = East Asia Summit, KHM = Cambodia, CHN = China, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America)

Source: World Bank (2018).

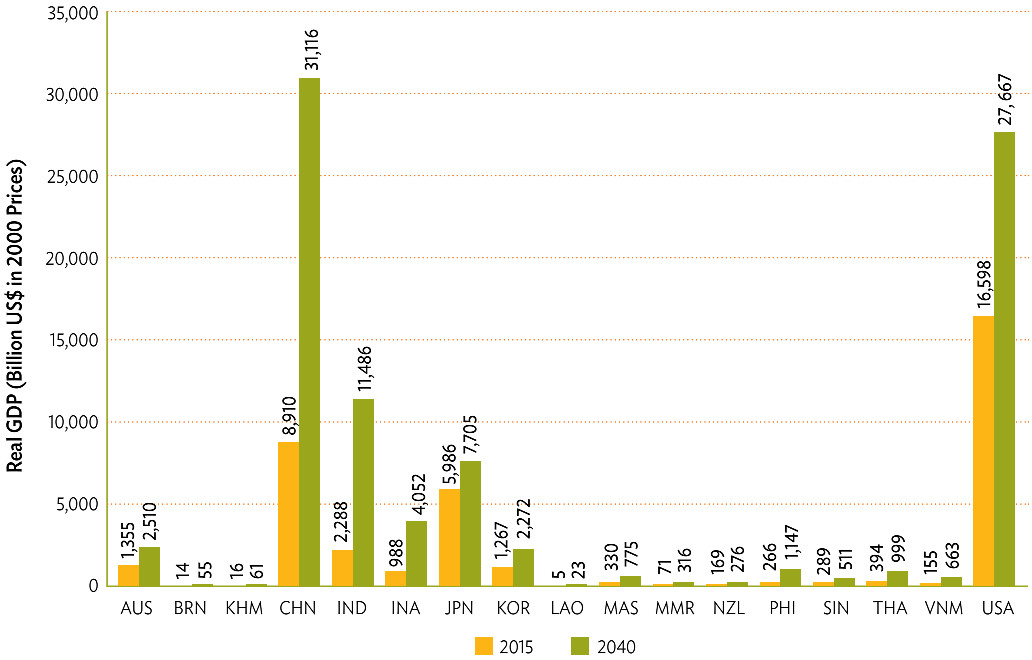
3.2. Economic Activity

In the models used for this study, assumed changes in economic output to 2040 were set exogenously. GDP data (in 2010 US$) were obtained from the World Development Indicators of the World Bank (2018). Assumed GDP growth rates to 2040 were submitted by all EAS17 countries. In general, these assumptions considered actual GDP growth rates from 2005 to 2015, which already reflect the economic recession and recovery in the US and other countries. No difference in growth rates was assumed between BAU and the APS.

In 2015, the total GDP in the EAS17 region was about US$39 trillion in 2010 US$ constant price, accounting for about 51% of global GDP. The GDP of the region is assumed to grow at an average annual rate of about 3.5% from 2015 to 2040. This implies that, by 2040, total regional GDP will reach about US$91.5 trillion in 2010 US$ constant price.

China is projected to be the largest economy in terms of real GDP (2010 US$ constant price) of about US$31.1 trillion, followed by the US of about US$27.7 trillion by 2040. India and Japan are also projected to be the next largest economies with projected GDPs of about US$11.5 trillion and $7.7 trillion, respectively, at 2010 US$ constant price by 2040 (Figure 1.3).

Figure 1.3: Assumed Economic Activity in the EAS17 Region, 2015 and 2040

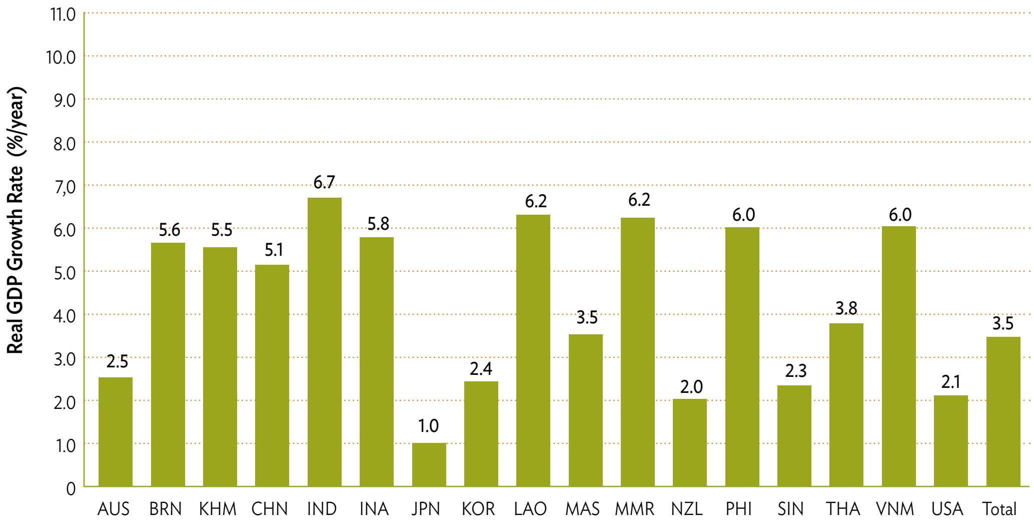


AUS = Australia, BRN = Brunei, KHM = Cambodia, CHN = China, EAS = East Asia Summit, GDP = gross domestic product, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: World Bank (2018).

Long-term economic growth rates are assumed to be quite high in the developing countries, with the highest growth rates in India, Myanmar, Lao PDR, Philippines, Viet Nam, and Cambodia (Figure 1.4). Economic growth in other developing countries is also assumed to be relatively rapid. Brunei is expected to also have high GDP annual growth rate. For developed countries in EAS17, the US, Japan, Korea, New Zealand, and Australia are expected to have moderate annual GDP growth rate. Due to their large economies, the rapid growth in China, India, and Indonesia, together with the US, are likely to be especially significant for energy demand.

Figure 1.4: Assumed Average Annual Growth in GDP, 2015–2040

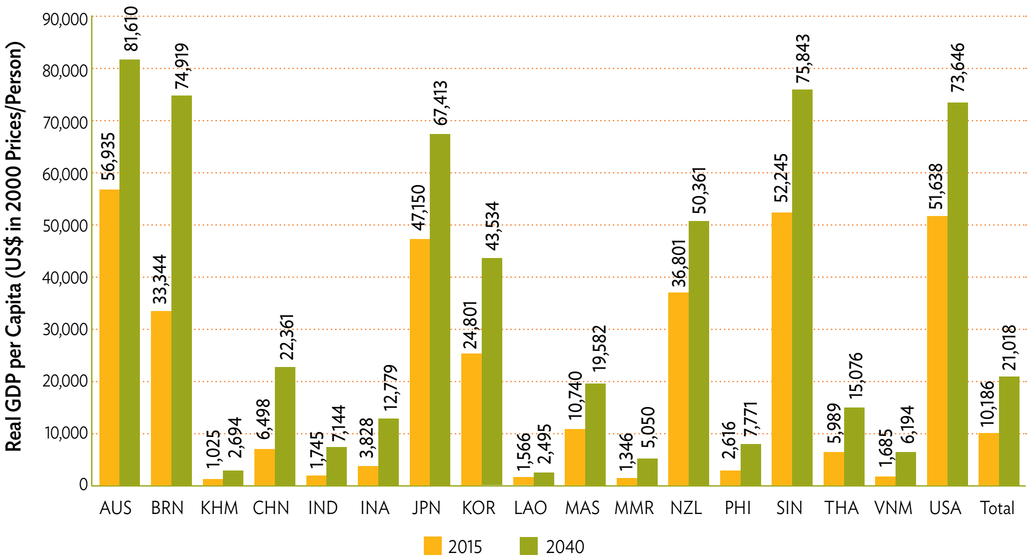


AUS = Australia, BRN = Brunei, KHM = Cambodia, CHN = China, GDP = gross domestic product, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: World Bank (2018).

The average real GDP (2010 US$ constant) per capita in the EAS17 region is assumed to increase from about US$10,186 in 2015 to about US$21,016 in 2040. However, there are, and will continue to be, significant differences in GDP per capita amongst EAS17 countries (Figure 1.5). In 2015, per capita GDP (constant price US$ 2010) ranged from about US$1,025 in Cambodia to over US$50,000 in Australia, the US, and Singapore. In 2040, per capita GDP is assumed to range from about US$2,495 in the Lao PDR to over US$80,000 in Australia.

Figure 1.5: Real GDP per Capita, 2015 and 2040



AUS = Australia, BRN = Brunei, KHM = Cambodia, CHN = China, EAS = East Asia Summit, GDP = gross domestic product, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: World Bank (2018).

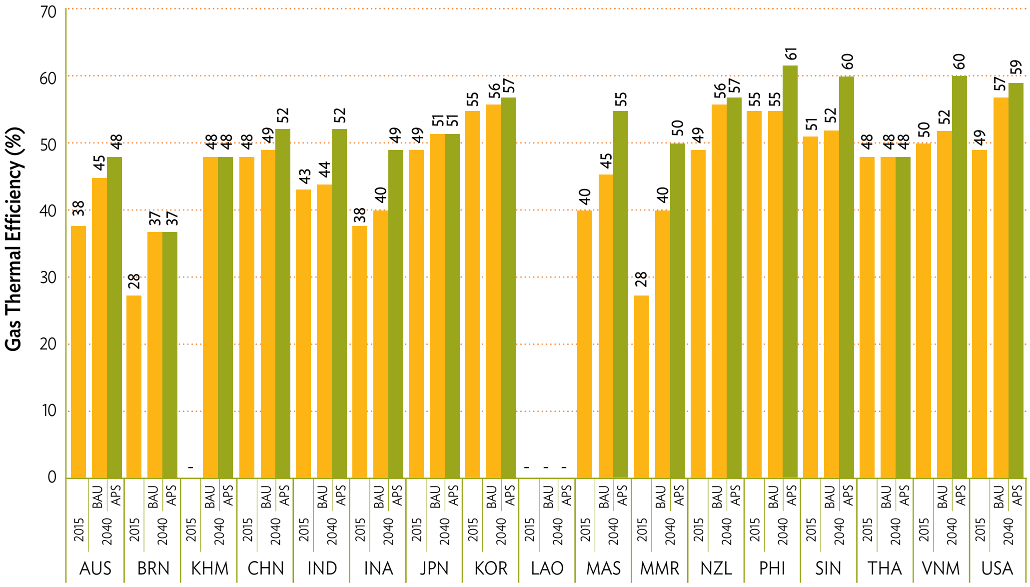
3.3. Electricity Generation

3.3.1. Electricity generation thermal efficiency

The thermal efficiency of electricity generation reflects the amount of fuel required to generate a unit of electricity. Thermal efficiency was another exogenous assumption used in this study. Base year 2015 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 the following countries: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam, and growth rates in thermal efficiency were derived from these projections. For the remaining countries, assumptions about the 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, cost of technology, temperatures, and the cost and availability of fuel inputs. Thermal efficiency in the EAS17 countries is expected to improve considerably over time in the BAU scenario as more advanced generation technologies, such as natural gas combined-cycle and supercritical coal-fired power plants, become available. In many countries, there are also assumed to be additional improvements in the APS (Figures 1.6 and 1.7).

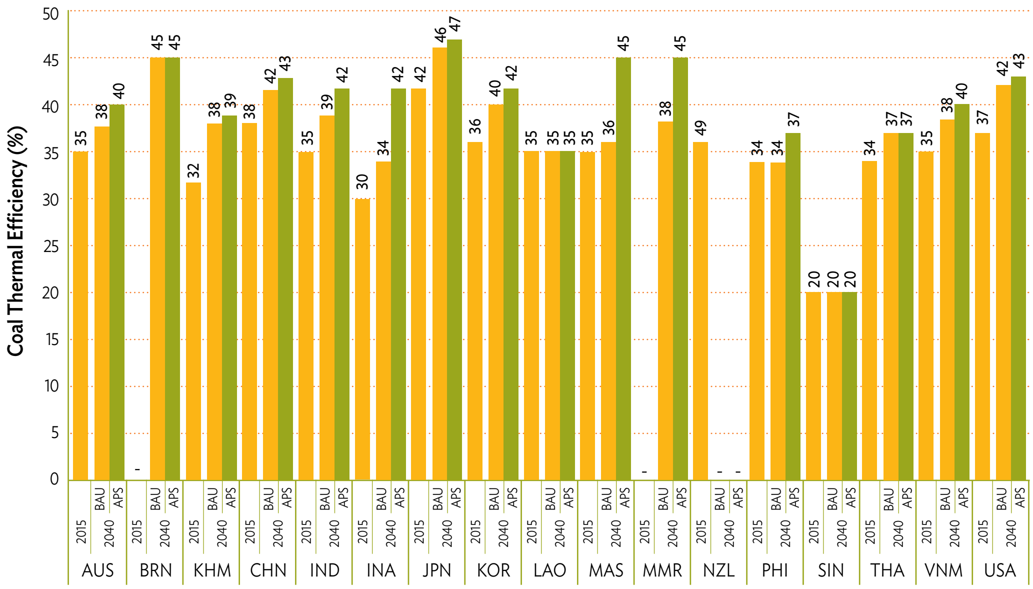
Figure 1.6: Thermal Efficiencies of Gas Electricity Generation



APS = Alternative Policy Scenario, AUS = Australia, BAU = Business-As-Usual, BRN = Brunei, KHM = Cambodia, CHN = China, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: Long-range Energy Alternatives Planning System (LEAP)'s database.

Figure 1.7: Thermal Efficiencies of Coal Electricity Generation



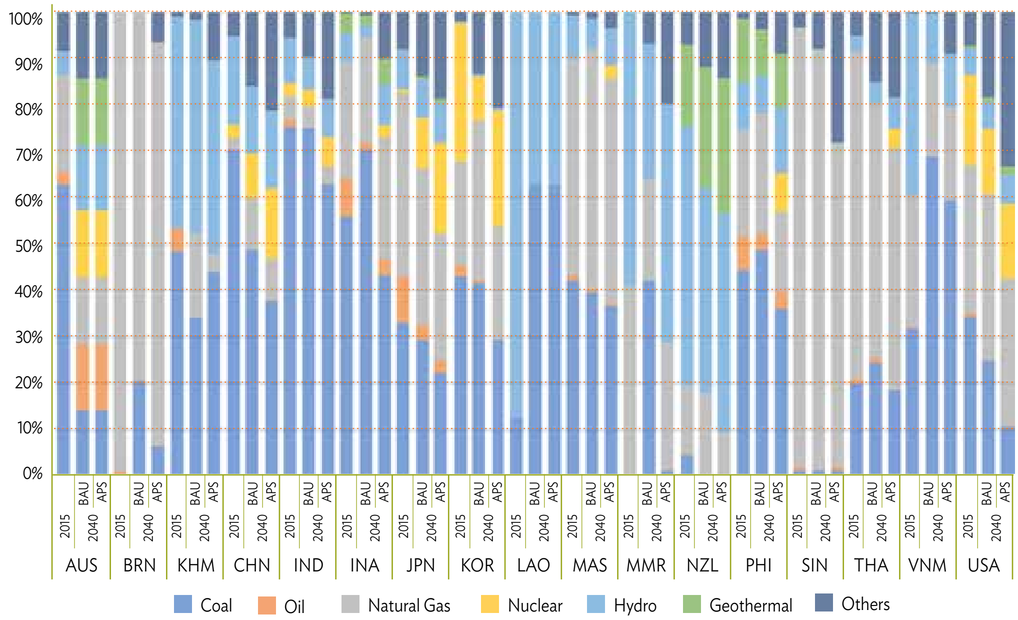
APS = Alternative Policy Scenario, AUS = Australia, BAU = Business-As-Usual scenario, BRN = Brunei, KHM = Cambodia, CHN = China, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: Long-range Energy Alternatives Planning System (LEAP)'s database.

3.4.1. Electricity generation fuel mix

The combination of fuels used in electricity generation differs amongst countries, reflecting both historical and current conditions, including access to and cost of resources and technology. It was, therefore, an exogenous input to the model. It is an important input not only because it is a key driver of demand for primary fuels, but also because the fuel mix used can have important implications for GHG emissions. Figure 1.8 shows the projected electricity generation mix.

Figure 1.8: Share of Fuel Type in the Electricity Generation Mix in the EAS17 Region



APS = Alternative Policy Scenario, AUS = Australia, BAU = Business-As-Usual, BRN = Brunei, KHM = Cambodia, CHN = China, EAS = East Asia Summit, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of America.

Source: Country Energy Saving Potential Report, sub-report of this main report (2016).

Coal is projected to remain the dominant source of electricity generation in the EAS17 region in both the BAU scenario and the APS. However, the share of coal in electricity generation in the region is projected to decline from about 48% in BAU to about 35.8% in the APS by 2040, as countries are assumed to implement policies designed to reduce the emissions intensity of electricity generation. In the APS, the share of lower emission fuels such as hydro, nuclear, and non-hydro renewable energy are expected to be higher than in the BAU scenario on average. The use of oil in generating electricity is assumed to decline to almost negligible levels across the region.

3.4.2 Access to electricity

Many households in developing countries lack access to electricity, and resolving this problem is a major development goal. At the Working Group meetings, several developing countries reported on initiatives to significantly expand access to electricity in their countries by 2040. Although this increasing access to electricity is one of the drivers of increasing energy demand in the EAS17 region, it is not explicitly represented in the model used for this study. Nevertheless, the impact of increasing access to electricity on electricity demand should be largely reflected through the increased demand for electricity because of the relatively rapid GDP growth that is assumed to be experienced in these same countries.

Table 1.3 shows electricity access in EAS17. It also informs the progress of access to electricity in urban versus rural areas in 1990–2012, and a national data on energy access in 2016. Whereas tremendous progress of 100% energy access has been observed in Brunei Darussalam, Malaysia, Singapore, Thailand, Viet Nam, China, Korea, Japan, Australia, the US, and New Zealand, some Southeast Asian countries have struggled to improve energy access for their population.

Table 1.3: Access to Electricity, %

	1990			2000			2012			2016
	Rural	Urban	National	Rural	Urban	National	Rural	Urban	National	National
Cambodia	5.0	36.6	19.2	9.0	49.9	16.6	18.8	91.3	31.1	49.8
Myanmar	.	.	.	.	.	.	.	.	32*	57.0
Lao PDR	39.7	100.0	51.5	40.0	68.7	46.3	54.8	97.9	70.0	87.1
Brunei Darussalam	56.4	70.5	65.7	61.2	72.7	69.4	67.1	79.0	76.2	100.0
India	38.7	86.5	50.9	48.4	98.6	62.3	69.7	98.2	78.7	84.5
Indonesia	.	.	66.9	.	.	.	.	.	74**	97.6
Viet Nam	84.5	100.0	87.9	86.6	96.9	89.1	97.7	100.0	99.0	100.0
Philippines	46.4	85.5	65.4	51.9	92.3	71.3	81.5	93.7	87.5	91.0
Malaysia	89.2	97.3	93.2	93.0	98.5	96.4	100.0	100.0	100.0	100.0
Singapore	99.0	100.0	100.0	99.0	100.0	100.0	99.0	100.0	100.0	100.0
Thailand	82.0	75.2	80.0	87.0	72.6	82.5	99.8	100.0	100.0	100.0
Australia	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
China	92.0	100.0	94.2	95.3	100.0	98.0	100.0	100.0	100.0	100.0
Korea, Rep. of	92.0	95.0	94.2	95.3	98.7	98.0	100.0	100.0	100.0	100.0
Japan	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New Zealand	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

. = missing value.

* The number was taken from a 2014 presentation by Khin Seint Wint.

** The number was taken from ACE, 2013.

Source: World Bank (2018).

3.4. Use of Biofuels

Working Group members from each country were asked to include information on the potential use of biofuels in the BAU scenario and the APS. Some, but not all, countries in the EAS17 region plan to increase the contribution of biofuels in the transport fuel mix to enhance energy security or meet other policy objectives. For China and Japan, the assumptions on the use of biofuels were based on IEEJ's *Asia/World Energy Outlook 2017*. Table 1.4 summarises the assumptions regarding the use of biofuels.

Table 1.4: Assumptions on Biofuels – Summary by Country

Country	Period	Assumptions
Australia		No targets on biofuels
Brunei Darussalam		No targets on biofuels
Cambodia		No targets on biofuels
China	2030	BAU: 20 billion litres; APS: 60 billion litres
India	2017	20% blending of biofuels, both for biodiesel and bioethanol
Indonesia	2025	Bioethanol: 15% blend from 3% to 7% in 2010
		Biodiesel: 20% blend from 1% to 5% in 2010
Japan	2005–2030	No biofuel targets submitted
Korea, Rep. of	2012	Replace 1.4% of diesel with biodiesel
	2020	Replace 6.7% of diesel with biodiesel
	2030	Replace 11.4% of diesel with biodiesel
Lao PDR	2030	Utilise biofuels equivalent to 10% of road transport fuels
Malaysia	2030	Replace 5% of diesel in road transport with biodiesel
Myanmar	2020	Replace 8% of transport diesel with biodiesel
New Zealand	2012–2030	Mandatory biofuels sales obligation of 3.4% by 2012
Philippines	2025–2035	BAU: The Biofuels Law requires 10% bioethanol/gasoline blend and 2% biodiesel/diesel blend 2 years from enactment of the law (roughly 2009) APS: Displace 20% of diesel and gasoline with biofuels by 2025
Thailand		Biofuels to displace 12.2% of transport energy demand
United States	2011–2022	Renewable Fuels Standard – The US Environmental Protection Agency oversees the world's most ambitious programme to promote ethanol. The Renewable Fuels Standard (RFS2), created by the 2007 Energy Independence and Security Act , requires adding continually increasing volumes of renewable sources into the country's fuel supply – growing from nearly 49 billion litres (13 billion gallons) in 2011 up to 136 billion litres (36 billion gallons) by 2022.
Viet Nam	2020	10 % ethanol blend in gasoline for road transport

APS = Alternative Policy Scenario, BAU = Business-As-Usual.

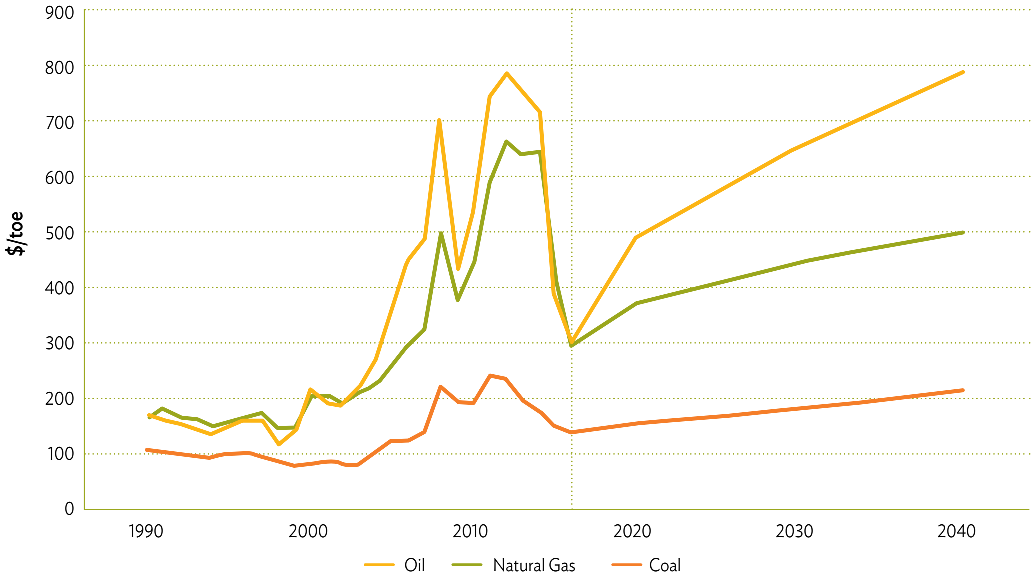
Source: Country Energy Saving Potential Report, sub-report of this main report (2018).

The largest increases in biofuel consumption in the APS are expected in the US, India, and China. In all countries, biofuels are expected to meet only a small portion of the transport fuel demand by 2040.

3.5. Crude Oil Price

Figure 1.9 depicts the oil price assumptions used in the modelling. In the Reference Scenario, the crude oil prices were US$286/tons of oil equivalent (toe) in 2016; these will rise gradually to US$653/toe by 2030 and to US$791/toe in 2040. The increase in the oil price in 2030 and 2040 are due to combined factors such as robust demand growth in non-OECD countries, new emerging geopolitical risks and financial factors, oil supply constraints reflecting rising depletion rates for oil fields, etc.

Figure 1.9: Real Oil, Natural Gas, and Coal Imported Price Assumptions (Real prices in 2016 US$)



toe = tons of oil equivalent.

Note: Crude oil price assumptions start from 2016 onwards.

Source: IEEJ's oil price assumptions (2017).

3.6. Assumptions of Fossil Fuel Production Outlook

3.6.1. Analytical method

The fossil fuel production outlook is generated through the 'expert's judgment' of the Delphi process. First, a historical data set of production volume is collected from British Petroleum and IEA statistics. The data are used to understand the transition of production volume in each country. Second, reference was made to the IEA *World Energy Outlook 2017* and the IEEJ *Asia-World Energy Outlook 2016* to understand the future direction of changes in production volume. The estimated fossil fuel outlook also utilises supplementary information such as the national plans and targets provided by each Working Group member and the country analyses issued by the Energy Information Agency (Table 1.5).

Table 1.5: Reference Materials and their Estimation

	IEA WEO 2017	IEEJ AWEO 2017
Oil	• Employ the New Policies Scenario, amongst the Current Policies Scenario, 450 Scenario, Low Oil Price Scenario. • Production increase until 2020 and decline after that time.	• Employ the Advanced Technologies Case, amongst the Reference Case, Advanced Technologies Case, Low Oil Price Case. • Production is estimated to decrease in many Asian countries.
Natural gas	• Employ the New Policies Scenario. • Production steadily increases towards 2040.	• Employ the Advanced Technologies Case. • Production is estimated to increase in line with IEA WEO 2017.
Coal	• Employ the New Policies Scenario. • Production increase in major producing countries, except China where demand for power generation and industry sectors are estimated to decrease.	• Employ the Advanced Technologies Case. • Production is estimated to decrease as demand declines.

AWEO = Asia/World Energy Outlook, IEA = International Energy Agency;
IEEJ = Institute of Energy Economics, Japan; WEO = World Energy Outlook.

Source: Working Group of the study (2016) and IEA (2017b).

3.6.2. Results of the fossil fuel production outlook

Tables 1.6 to 1.8 present the assumption of fossil fuel production outlook. The results indicated that the following:

- For crude oil, many countries will not able to maintain recent production levels except in some cases such as Australia, the Philippines, and the US where oil production amount surpasses that of 2014. In most countries, oil reserves are estimated to be depleted in the future, an estimate based on the sie of a country's oil reservoir (ERIA, 2015). Although some countries have untapped oil resources, their size seems too small to maintain current production amounts. In addition, insufficient investment in exploring new fields will hamper increasing production amounts. Furthermore, some fields may be too costly to exploit due to their geographical condition, such as deep sea and mountainous areas. However, the oil production of the US is the largest in the EAS17 region; it can provide more oil into the market and ease the tension of oil shortage if any political tension occurs in some Middle East and African countries.

- For natural gas, production is estimated to increase in almost all gas-producing countries. Overall, the region is relatively rich in natural gas resources compared to oil. Therefore, many countries are promoting the production of indigenous natural gas. Australia, China, and the US, which are richly endowed with conventional and unconventional gas resources, are expected to increase production, with Australia and the US aiming to export and China, for domestic supply. Some countries, such as Viet Nam, put natural gas at the centre of their energy mix, so they are boosting production activities.

- Coal (thermal + coking) production is estimated to decrease in China, the major coal-producing country, whereas India, the second-largest coal consumer, will increase production. Indonesia is also expected to increase production by 2040. The energy policies are different amongst China, the US, India, and Indonesia, the largest coal producers and consumers in the region. China and the US have changed their policies to pursue cleaner energy use; so they intend to curb coal consumption. Indonesia and India, however, intend to ensure energy supply at an affordable price, and thus plan to increase domestically available cheap energy sources such as coal. Australia, a major coal exporter, is estimated to decrease production as global coal demand declines due to the gradual shift to a low-carbon society. Japan and the Republic of Korea as consumers are likely to use coal for energy security although they intend to diversify the energy mix, gradually reducing coal consumption in the future.

Table 1.6: Production Outlook of Oil

	Oil Production (1,000b/d)					
	2014	2020	2025	2030	2035	2040
Australia	448	600	650	650	600	600
Brunei	138	140	130	130	120	120
China	4,341	4,300	4,250	4,200	4,100	4,000
India	895	740	680	680	700	720
Indonesia	852	830	820	800	780	770
Japan	17	15	15	15	15	15
Korea, Rep. of	20	15	15	15	15	15
Malaysia	666	650	620	600	600	600
Myanmar	20	20	20	20	20	20
Philippines	24	39	35	30	30	30
New Zealand	47	27	10	3	1	1
Thailand	453	480	470	460	450	440
United States	8,900*	10,700	11,380	11,700	11,850	11,900
Viet Nam	365	360	350	330	320	320
Total EAS	**17,186**	**18,916**	**19,445**	**19,633**	**19,601**	**19,551**

*The number is in year 2016, b/d = barrel/day.

Source: IEA (2017b).

Table 1.7: Production Outlook of Gas

	Gas Production (bcm)					
	2014	2020	2025	2030	2035	2040
Australia	58.8	133.0	144.5	165.5	175.5	174.0
Brunei	11.9	12.5	12.5	12.5	12.5	12.5
China	134.5	172.0	212.0	255.0	299.0	342.0
India	31.7	38.0	45.0	55.0	69.0	89.0
Indonesia	73.4	80.0	82.0	83.0	84.0	85.0
Japan	3.9	3.5	3.0	3.0	3.0	2.5
Korea, Rep. of	0.5	0.5	0.5	0.5	0.5	0.5
Malaysia	66.4	68.0	70.0	67.0	65.0	65.0
Myanmar	16.8	17.5	18.5	18.5	18.5	18.5
Philippines	3.4	3.0	4.0	7.0	7.0	8.0
New Zealand	5.4	4.0	3.0	2.0	1.0	1.0
Thailand	42.1	42.0	41.0	40.0	40.0	40.0
United States	27,000*	32,700	35,800	37,900	38,800	40,200
Viet Nam	11.1	11.0	15.0	18.0	22.0	25.0
Total EAS	**27,460**	**33,285**	**36,451**	**38,627**	**39,597**	**41,063**

*The number is in year 2016, bcm = billion cubic metre.

Source: IEA (2017b).

Table 1.8: Production Outlook of Coal

	Coal Production (Mton)					
	2014	2020	2025	2030	2035	2040
Australia	431	437	421	412	411	405
China	3,532	3,548	3,383	3,286	3,132	2,944
India	604	627	650	624	652	683
Indonesia	444	471	476	478	478	480
Korea, Rep. of	2.09	1.76	1.20	0.63	0.07	0
Lao PDR	0.5	0.7	0.7	0.7	0.7	0.7
Malaysia	3.0	3.2	3.6	4.0	4.0	4.0
Myanmar	0.8	0.6	0.8	0.9	1.0	1.0
Philippines	7.3	7.1	7.9	9	9	9
New Zealand	4.9	4.1	4.0	3.9	3.8	3.7
Thailand	18	19	18	14	10	7
Viet Nam	42	42	41	42	49	53
United States	741*	731	738	750	736	746
Total EAS	**5,831**	**5,892**	**5,745**	**5,625**	**5,488**	**5,337**

*The number is in year 2016, Mton = million tons.

Source: IEA (2017b).

3.7. Energy-Saving Goals

Collected from each Working Group member from the EAS17 countries was information about the potential energy savings achievable under specific policy initiatives to increase energy efficiency and reduce energy consumption. Each member specified which policies exist and should be applied to the BAU scenario, and which are proposed and should be applied only to the APS. Quantitative energy savings were estimated based on the countries' own assumptions and modelling results. Table 1.9 summarises energy-saving goals, action plans, and policies collected from each EAS Working Group member in 2017.

Table 1.9: Summary of Energy Saving Goals, Action Plans, and Policies Collected from Each EAS17 Working Group Member

	Indicator	Goals
Australia	Carbon pollution	Australia's emissions reduction target of 26%–28% below 2005 level by 2030
Brunei Darussalam	Energy intensity	45% improvement by 2035 from 2005 level
Cambodia	Carbon pollution	Reduce 3,100 Gg CO2 equivalent (approximately 1.8 Mt CO2e.) compared to baseline emission 11,600 Gg Co2e by 2030
China	Energy intensity	By 2020, energy consumption per unit of GDP will drop by 15% from 2016
India	Not submitted	
Indonesia	Energy intensity	Reduce by 1% per year until 2025
Japan	Energy intensity	30% improvement in energy intensity in 2030 from 2003 level
Korea, Rep. of	Energy intensity	46.7% reduction by 2030 from 2006 level
Lao PDR	Final energy consumption	• 10% reduction from BAU by 2030 • 5% energy intensity reduction by 2030, from 2015.
Malaysia	Final energy consumption	8.6% reduction from BAU by 2020
Myanmar	TPES	• 5% reduction from BAU by 2020 • 10% reduction from BAU by 2030 (Final energy consumption: 5% by 2020 and 8% by 2030).
New Zealand	Energy intensity	1.3% per year improvement from 2011 to 2016
Philippines	Final energy consumption	10% savings from BAU by 2030
Singapore	Energy intensity	• 20% reduction by 2020 from 2005 level • 35% reduction by 2030 from 2005 level
Thailand	Energy intensity	• 15% reduction by 2020 from 2005 level • 25% reduction by 2030 from 2005 level
Viet Nam	Final energy consumption	• 3%–5% savings from BAU until 2015 • 5%–8% savings from BAU after 2015
United States	This Vision for the National Action Plan for Energy Efficiency targets achieving all cost-effective energy efficiency by 2025	• The action plan presents 10 implementation goals for states, utilities, and other stakeholders to consider achieving this goal; describes what 2025 might look like if the goal is achieved; and provides a means for measuring progress. It is a framework for implementing the five policy recommendations of the Action Plan, announced in July 2006, which can be modified and improved over time.

BAU = Business-As-Usual, EAS = East Asia Summit, Gg CO_2 = greenhouse gas emissions, TPES = total primary energy supply.

Source: EAS Energy Outlook and Saving Potential Working Group Members (2017).

3.8. Economic Growth and Climate Change Mitigation

Economic growth in the EAS countries is needed to provide for the region's growing population and improving living standards. Economic growth is assumed to exceed population growth in 2015–2040. This relatively strong economic growth and rising per capita incomes in the EAS countries could mean significant reductions in poverty and significant increases in living standards for hundreds of millions of people.

With economic growth will come increasing access to, and demand for, electricity and rising levels of vehicle ownership. The continued reliance on fossil fuels to meet the increases in energy demand may be associated with increased GHG emissions and climate change challenges unless low-emission technologies are used. Even if fossil fuel resources are enough, most of the fuel will likely be imported from other regions, and no assurance can be given that they will be secure or affordable.

Fossil fuel consumption using today's technologies will lead to considerable increases in greenhouse gas emissions, potentially creating new longer-term threats to the region's living standards and economic vitality. Growing adverse health impacts throughout the region are also likely because of particulate emissions.

Given this, considerable improvements in energy efficiency and greater uptake of cleaner energy technologies and renewable energy are required to address a range of energy, environmental, and economic challenges. Yet, efforts to limit energy consumption and GHGs will be very challenging given such strong growth. However, as will be discussed in Section 4.3, sharp reductions in GHGs are being called for by scientists. This huge 'headwind' working against EEC and emission reductions poses a challenge to the EAS region that needs to be addressed.

4. Energy Outlook for the EAS Region

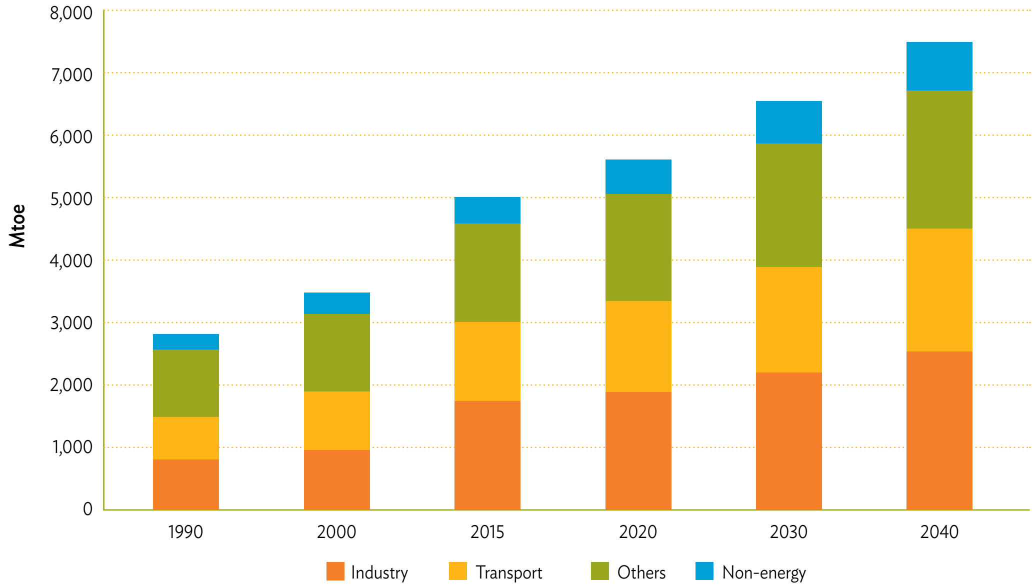
4.1. Business-As-Usual Scenario

4.1.1. Final energy consumption

Between 2015 and 2040, total final energy consumption[3] in the EAS17 countries is projected to grow at an average annual rate of 1.6%, reflecting the assumed 3.5% annual GDP growth and 0.5% population growth. Final energy consumption is projected to increase from 5,020 Mtoe in 2015 to 7,410 Mtoe in 2040. By sector, transport energy demand is projected to grow moderately about 1.7% per year, and its energy consumption share is projected to be 26.1% by 2040. For the industry sector, its annual growth rate in 2015–2040 is just about 1.6% per year, but its energy consumption share is projected to be the largest at about 34.1% by 2040. The demand of the commercial and residential ('others') sector will grow at a lower rate of 1.3% per year, slower than that of the industry sector. However, its energy consumption share is projected to be 29.4%, the second-largest share after the industry sector. Figure 1.10 shows final energy consumption by sector under the BAU scenario in EAS17 from 1990 to 2040. Figure 1.11 shows details of sectoral shares in final energy consumption.

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.

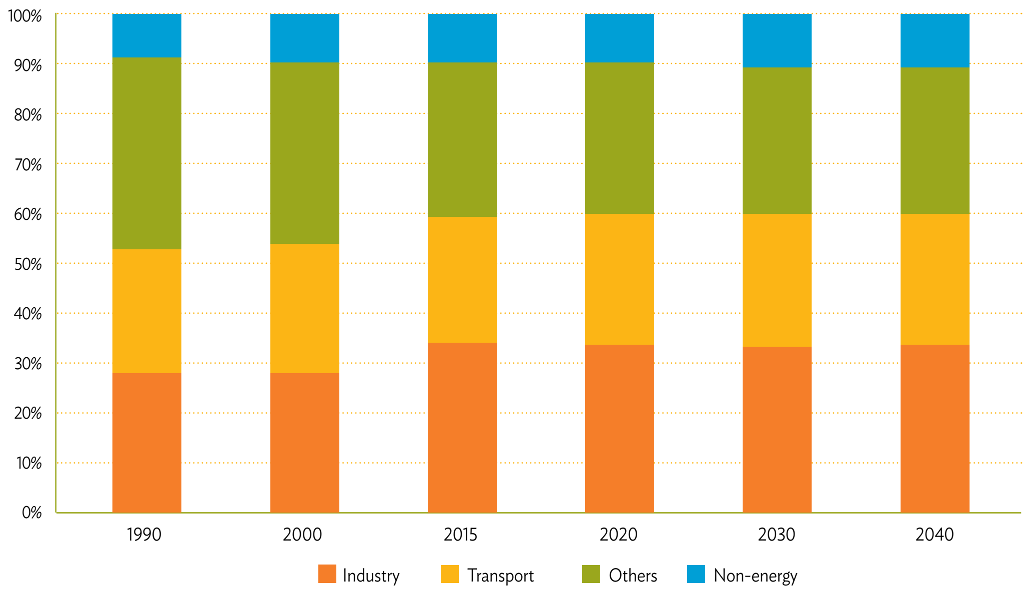
Figure 1.10: Final Energy Consumption by Sector, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

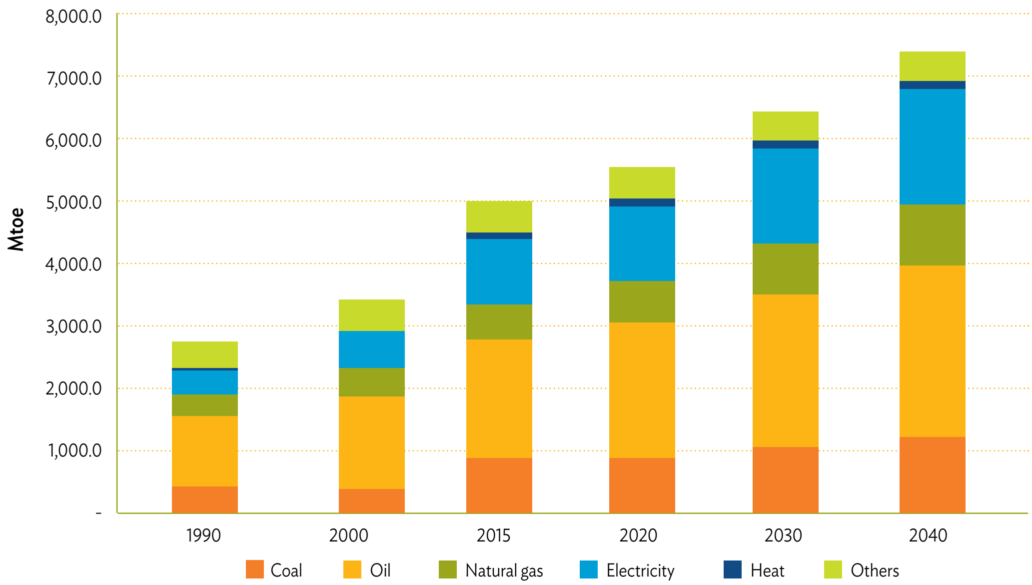
Figure 1.11: Final Energy Consumption Share by Sector (1990–2040)



Source: Authors' calculation.

Figures 1.12 and 1.13 show final energy consumption and shares by fuel type in the EAS17 under the BAU scenario from 1990 to 2040. By energy source, electricity and natural gas demand in the BAU scenario are projected to show the fastest growth, increasing by 2.3% and 2.1% per year, respectively, but their share will just be 25.1% for electricity and 13.2% for natural gas. Although oil will retain the largest share at 37.5% of total final energy consumption, it is projected to grow at a lower rate of 1.5% per year in 2015–2040, reaching 2,779 Mtoe in 2040. Generally, oil share slightly dropped from 37.7% in 2015 to 37.5% in 2040. Coal demand will grow at a slower rate of 1.2% per year on average from 2015 to 2040, reaching 1,218 Mtoe in 2040. The share of other fuels such as biomass will decline from 9.9% in 2015 to 6.2% in 2040. This slow growth is due to the gradual shift from non-commercial biomass to conventional fuels like liquefied petroleum gas (LPG) and electricity in the residential sector.

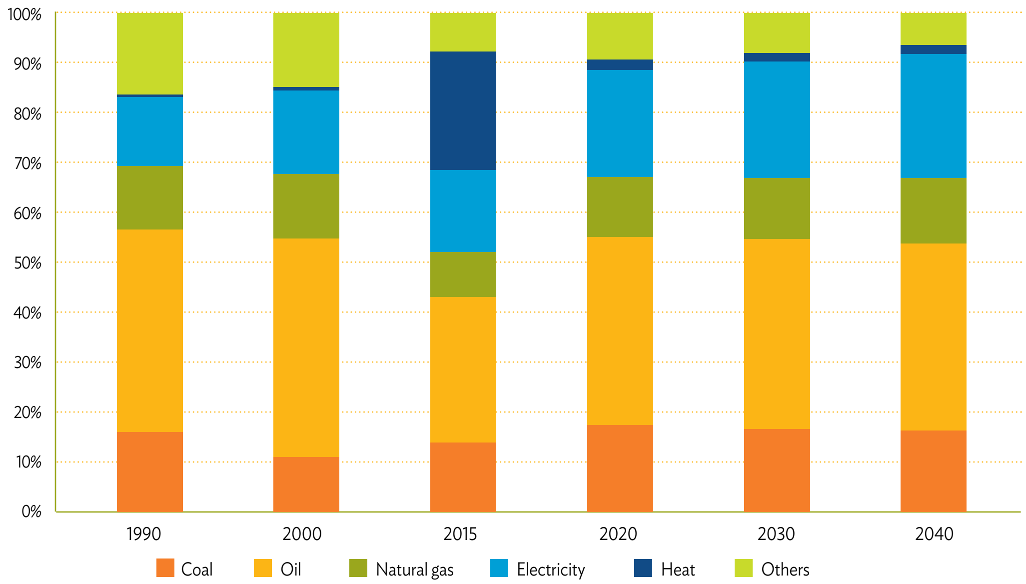
Figure 1.12: Final Energy Consumption by Fuel Type (1990–2040)



Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Figure 1.13: Final Energy Consumption Share by Fuel Type (1990–2040)



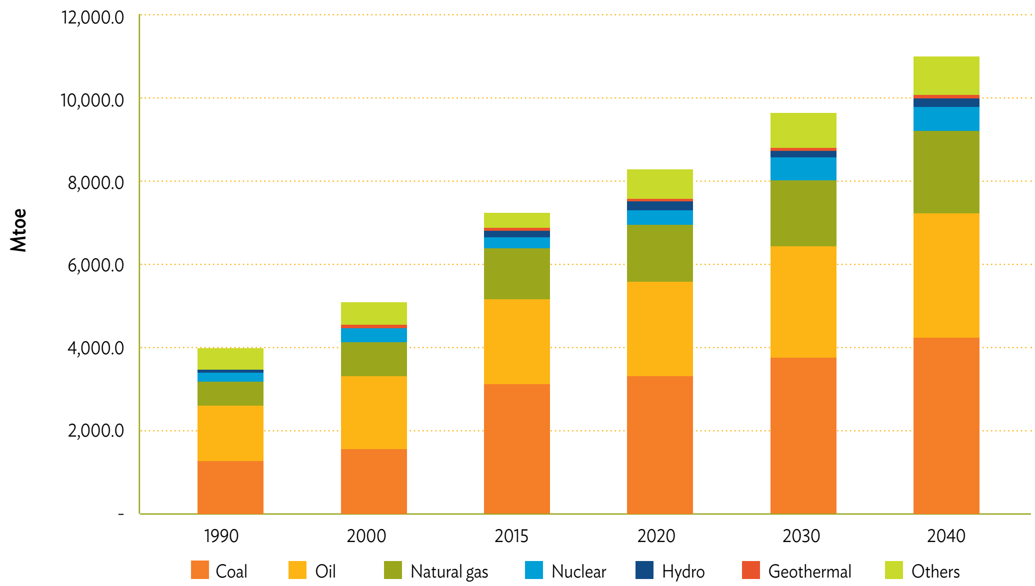
Source: Authors' calculation.

4.1.2. Primary energy supply

Figure 1.14 shows primary energy supply in EAS17 from 1990 to 2040. Primary energy supply[4] in the region is projected to grow at a slightly slower pace, of 1.5% per year, as final energy consumption grows at 1.6% per year. EAS17 primary energy supply is projected to increase from 7,488 Mtoe in 2015 to 10,943 Mtoe in 2040. Coal will still comprise the largest share of primary energy supply, but its growth is expected to be slower, increasing at 1.3% per year. Consequently, the share of coal in total primary energy supply (TPES) is forecast to decline from 41.4% in 2015 to 38.9% in 2040.

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

Figure 1.14: Primary Energy Supply in EAS17 (1990–2040)



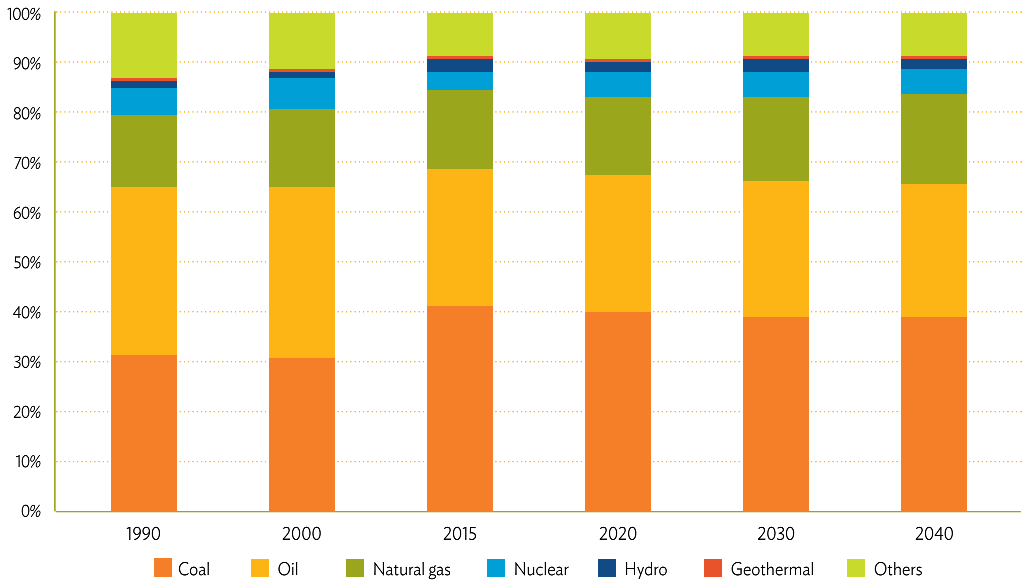
EAS = East Asia Summit , Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Amongst fossil sources of energy, natural gas is projected to see moderate growth in 2015–2040, increasing at an annual average rate of 2.2% Its share in the total will consequently increase from 15.4% (equivalent to 1,155 Mtoe) in 2015 to 18% (equivalent to 1,972 Mtoe) in 2040. Nuclear energy is projected to increase at a similar rate of natural gas rate of 2.2% per year on average. Its share will grow from 4.2% in 2015 to 5% in 2040. This is due to the assumed resumption of nuclear power generation in Japan and the expansion of nuclear power generation capacity in China and India. Geothermal is projected to grow the fastest at 3.1% per year during 2015–2040. However, its share is projected to be relatively small, about 0.9% by 2040, increasing from 0.6% in 2015.

Amongst the energy sources, others – which is made up of solar, wind, and solid and liquid biofuels – will see the slowest growth rate of 1.3% Consequently, the share of these other sources of energy will decrease from 8.4% in 2015 to 8.1% in 2040. The growth of hydro will also be low at 1.3% per year and its share will remain low, at around 1.9% by 2040. Figure 1.15 shows the shares of each energy source in the total primary energy mix in 1990–2040.

Figure 1.15: Share of Primary Energy Mix by Source (1990–2040)

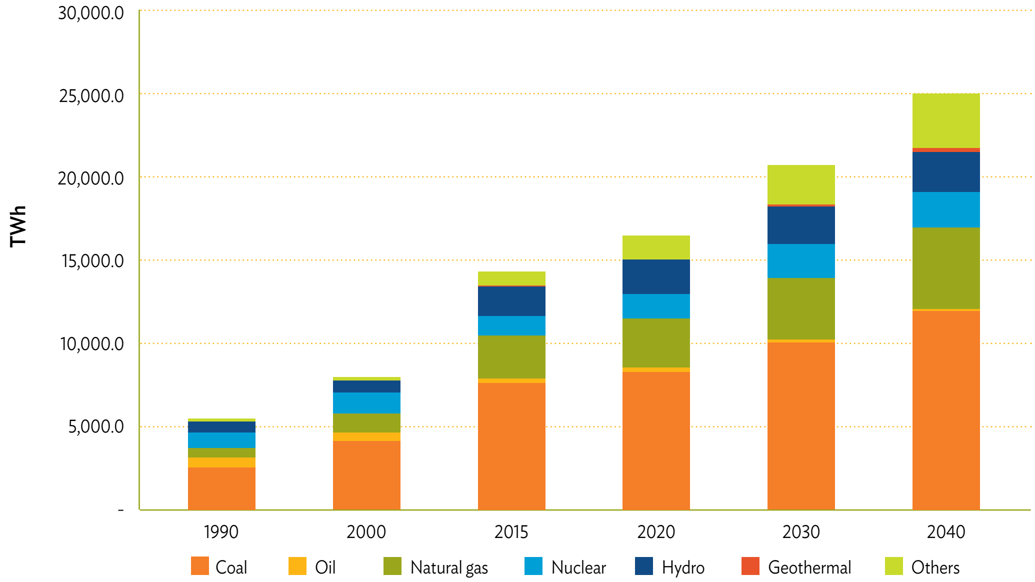


Source: Authors' calculation.

4.1.3. Power generation in EAS17

Figure 1.16 shows the power generation output in the EAS region. Total power generation is projected to grow at 2.3% per year on average, from 2015 (equivalent to 14,290 terawatt-hours [TWh]) to 2040 (equivalent to 25,030 TWh). However, the growth rate in 1990–2015 was 3.9%, nearly twice as high as the projected growth rate in 2015–2040.

Figure 1.16: Power Generation in EAS17 (1990–2040)

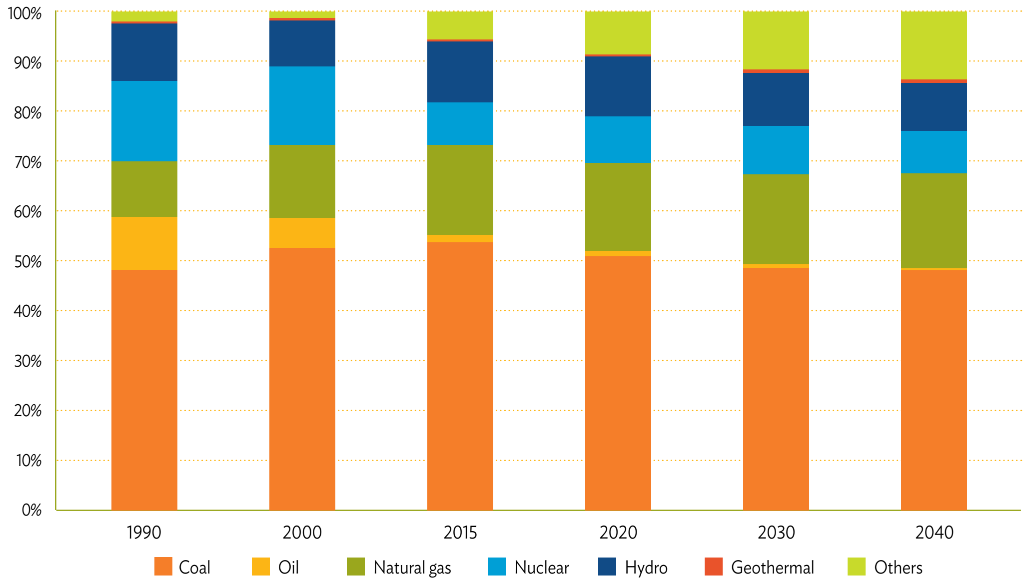


EAS = East Asia Summit, TWh = terawatt-hour.

Source: Authors' calculation.

Figure 1.17 shows the share of each energy source in electricity generation from 1990 to 2040. The share of coal-fired generation is projected to continue to be the largest and will be about 48% in 2040, a drop from the 53.8% share in 2015. The share of natural gas is projected to increase from 17.8% in 2015 to 19.4% in 2040. Nuclear share (8.5% in 2015) is forecast to decrease to 8.3% in 2040. The share of geothermal (0.4% in 2015) and other (wind, solar, biomass, etc.) sources at 5.7% will also increase to 0.5% and 13.7% in 2040, respectively. The share of oil and hydro are projected to decrease, from 1.6% to 0.4% and from 12.3% to 9.7% respectively, over the same period.

Figure 1.17: Share of Power Generation Mix in EAS17 (1990–2040)

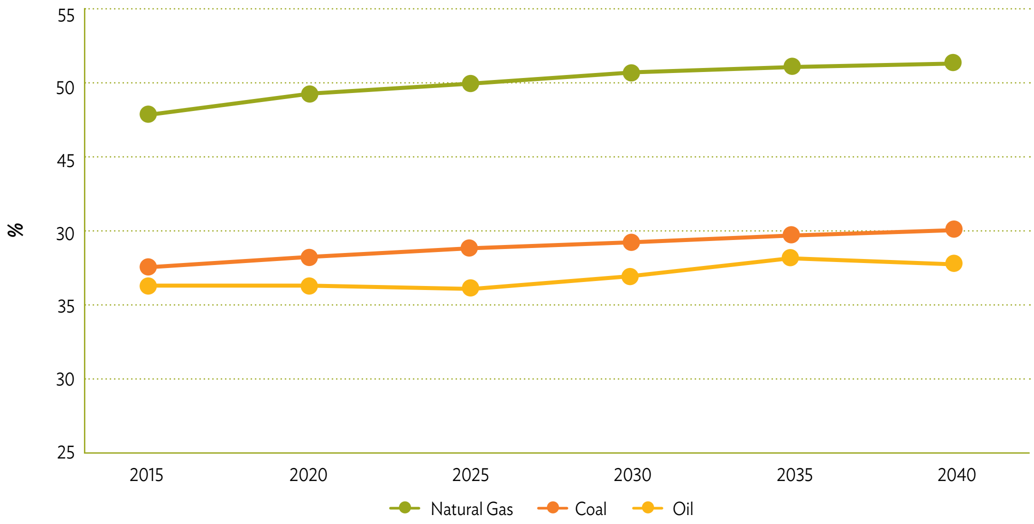


EAS = East Asia Summit.

Source: Authors' calculation.

Figure 1.18 shows the thermal efficiency of coal-, oil-, and natural gas–fired power plants from 1990 to 2040. Thermal efficiency is projected to grow in EAS17 from 2015 to 2040 due to improvement in electricity generation technologies like combined-cycle gas turbines and advanced coal power plant technologies. The efficiency of coal thermal power plants, which is a mix of old and new power plants, will increase slightly, from 37.5% in 2015 to 40.1% in 2040. The efficiency of natural gas power plants will also increase, from 47.9% in 2015 to 51.3% in 2040. Oil power plants, which will not be used very much in the future, will deteriorate in efficiency, slightly increasing from 36.3% in 2015 to 37.7% in 2040.

Figure 1.18: Thermal Efficiency by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual.

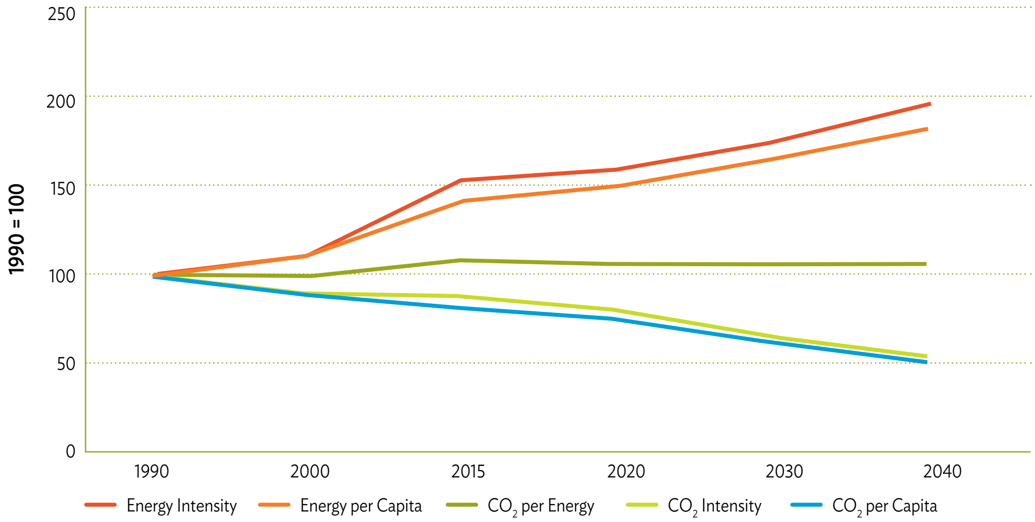
Source: Authors' calculation.

4.1.4. Primary energy intensity and per capita energy demand

Figure 1.19 shows the energy intensity and energy per capita from 1990 to 2040. For the BAU scenario, energy intensity in the EAS is projected to decline by 38%, from 192 toe/million US$ (constant 2010) in 2015 to 120 toe/million US$ in 2040. The improvement in energy intensity is also reflected in the improvement in CO_2 intensity at a similar pace.

In contrast to energy intensity, energy demand per capita is projected to increase by 28.7%, from 1.95 toe per person in 2015 to 2.51 toe per person in 2040. This could be attributed to the projected continuing economic growth in the region, 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. As energy demand per capita increases, CO_2 per capita is projected to increase at a similar rate.

Figure 1.19: Energy Indicators in EAS17



EAS = East Asia Summit, CO_2 = carbon dioxide.

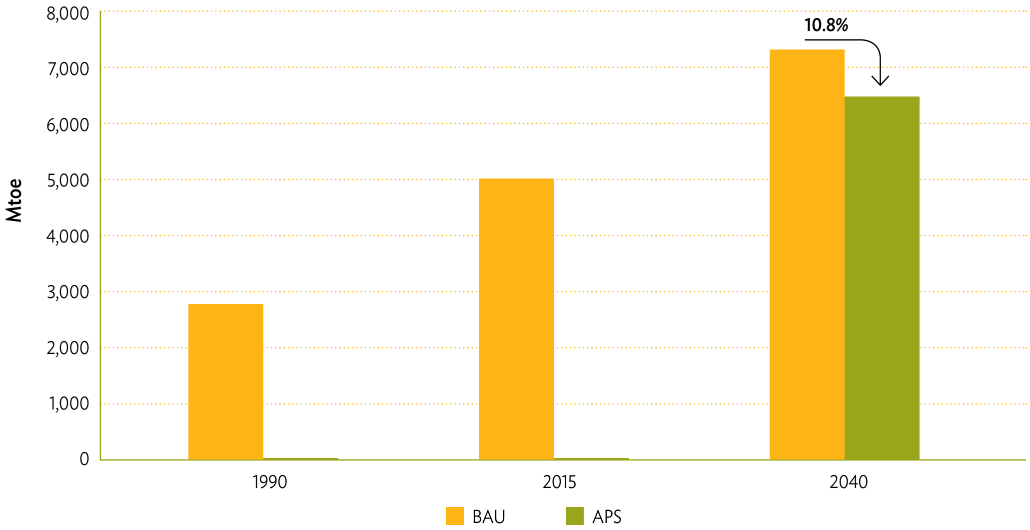
Source: Authors' calculation.

4.2. Comparison of BAU and APS

4.2.1. Total final energy consumption, BAU vs APS

In the APS, final energy consumption is projected to rise from 5,020 Mtoe in 2015 to 6,615 Mtoe. Comparing the BAU scenario and the APS, final energy consumption is projected to be 795 Mtoe or 10.8% lower than in the BAU scenario in 2040. This is due to the various energy efficiency plans and programmes, presented in Section 3, on both the supply and demand sides that are to be implemented by EAS17 countries. Figure 1.20 shows the evolution of final energy consumption in 1990–2040 in both the BAU scenario and APS.

Figure 1.20: Total Final Energy Consumption, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil eqivalent.

Source: Authors' calculation.

4.2.2. Final energy consumption by sector – BAU vs APS

Figure 1.21 shows the composition of final energy consumption by sector in both the BAU scenario and the APS. Final energy consumption in most sectors is significantly reduced in the APS compared with the BAU scenario. In percentage terms, the reduction is largest in the transportation sector (14.6%), followed by the industry sector (11.4%), the 'others' sector (10.2%); non-energy demand will be the same as the BAU scenario.

Figure 1.21: Final Energy Consumption by Sector, BAU vs APS

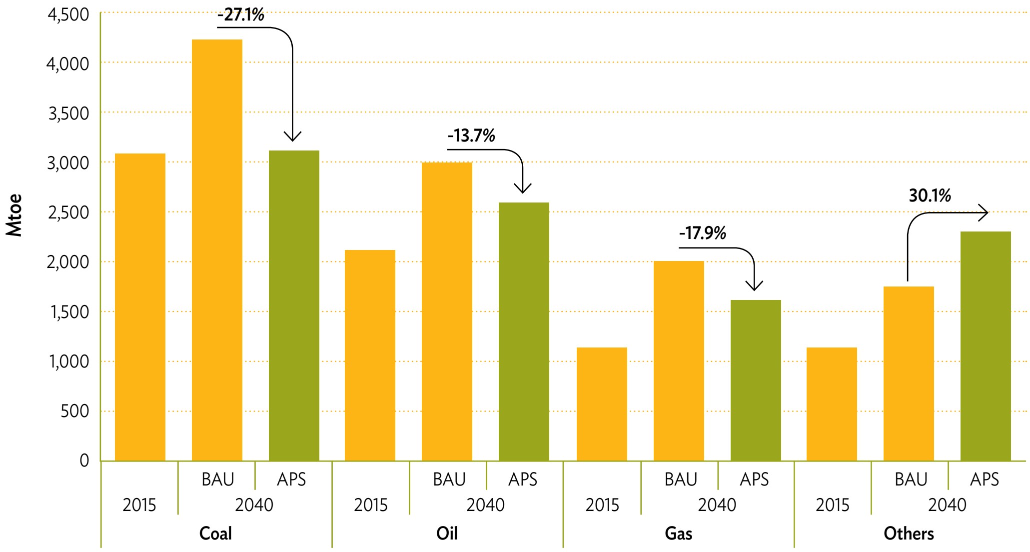
APS = Alternative Policy Scenario , BAU = Business-As-Usual .

Source: Authors' calculation.

4.2.3. Primary energy supply by sources – BAU vs APS

Figure 1.22 shows primary energy supply by fuel source. In the APS, growth in primary energy supply for fossil fuels is lower compared with the BAU scenario. The growth rate in primary energy supply of the APS is projected to be 1% per year on average from 2015 to 2040. This rate is lower than the BAU scenario in which the growth rate is projected to be 1.5%. In absolute terms, the largest reduction will be in coal demand, by 1,154 Mtoe or 27.1% from the BAU scenario's 4,254 Mtoe to 3,100 Mtoe in the APS. The savings potential for other fuels are projected to be 408 Mtoe for oil (equivalent to a 13.7% reduction from the BAU scenario), and 355 Mtoe for gas (equivalent to a 17.9% reduction from the BAU scenario). Due to increased renewable energy in the primary supply, renewable energy supply including biomass is projected to increase by 30.1% from the BAU scenario to the APS for the aggressive policy scenario of including more renewables into the supply mix.

Figure 1.22: Primary Energy Supply by Source, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent..

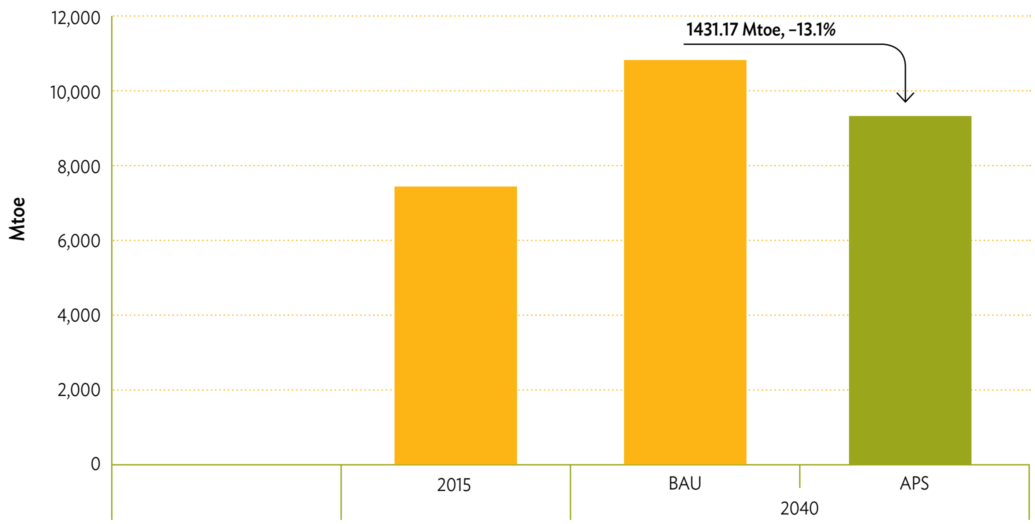
Source: Authors' calculation.

4.2.4. Total primary energy supply – BAU vs APS

Figure 1.23 shows the TPES in both the BAU scenario and the APS. The total savings potential in the TPES is expected to be 1,431 Mtoe, a consumption reduction from 10,943 Mtoe in the BAU scenario to 9,512 Mtoe in the APS. This savings potential represents a 13.1% reduction from the BAU scenario to the APS.

The energy savings potential is brought about by improvements both in the transformation sector, particularly power generation, and the final energy consumption sector where efficiencies of household appliances and more efficient building designs are expected. The 'others' sector has an expected increase of renewable energy in the energy supply, which is projected to be a 31.1% increase from the BAU scenario to the APS.

Figure 1.23: Total Primary Energy Supply – BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

4.3. CO_2 Emissions from Energy Consumption

4.3.1. CO_2 emissions

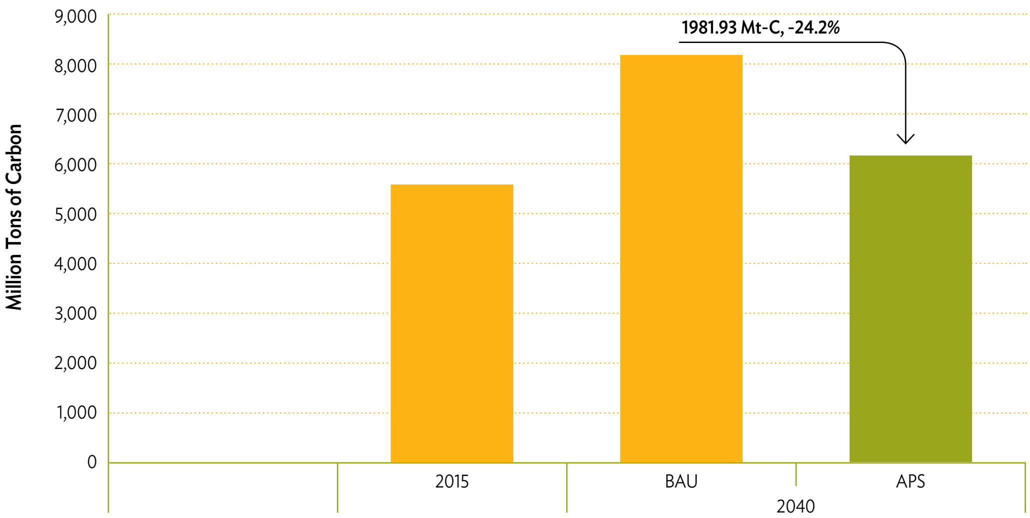
CO_2 emissions from energy consumption in the BAU scenario are projected to increase from 5,660 million tons of carbon (Mt-C) in 2015 to 8,189 Mt-C in 2040, implying an average annual growth rate of 1.5% (Figure 1.24). This is the same growth rate of TPES of 1.5% per year. In the APS, CO_2 emissions are projected to be 6,207 Mt-C in 2040, 24.2% lower than the BAU scenario.

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally 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°C. The Paris Agreement could be a bridge between today's policies and climate-neutrality before the end of the century.

Although the emission reductions under the APS are significant, CO_2 emissions from energy demand in the APS in 2040 will still be above 2015 levels and more than two times 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 2°C compared with pre-industrial levels, global CO_2 emissions need to peak between 2000 and 2015.

In the adopted version of the Paris Agreement, the parties will also 'pursue efforts' to limit the temperature increase to 1.5°C, which will require zero emissions between 2030 and 2050, according to scientists. However, this study shows that even in the APS, the emissions will be about 6,207 Mt-C. It is supposed to be at zero emissions for the efforts to limit the temperature increase to 1.5°C to be successful.

Figure 1.24 Total CO_2 Emissions – BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, CO_2 = carbon dioxide, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

4.4. NDC/INDC Scenario

This working group also assessed reducing the effect of CO_2 emissions brought by NDC/INDC targets that countries submit to the United Nations Framework Convention on Climate Change following the Paris Agreement (Table 1.10). The results clearly show that INDC/NDC targets of the following ASEAN countries and Australia are more ambitious than the EAS targets.

Table 1.10: Comparison of CO_2 Emissions amongst the Scenarios in 2040, Mt-C

Country	BAU	APS	INDC/NDC
Malaysia	116	90	78
Philippines	271	191	87
Thailand	410	252	220
Australia	100	80	50

APS = Alternative Policy Scenario, BAU = Business-As-Usual, INDC = Intended Nationally Determined Contributions, NDC = Nationally Determined Contributions.

Source: Authors.

Cambodia, the Lao PDR, Myanmar, Singapore, and Viet Nam were not assessed due to their technical problems. Other countries such as Brunei Darussalam, Indonesia, and China could already achieve their INDC/NDC targets with their APS targets.

To achieve the INDC/NDC targets, additional efforts need to be made to reduce emissions in the APS to reach INDC/NDC in some countries. For example, CO_2 emissions reduction target rate from APS to INDC/NDC are 13% for Malaysia, 54% for the Philippines, 13% for Thailand, and 38% for Australia. The INDC/NDC targets of the Philippines and Australia seem to be too ambitious; these countries should review their INDC/NDC targets from the scientific viewpoint.

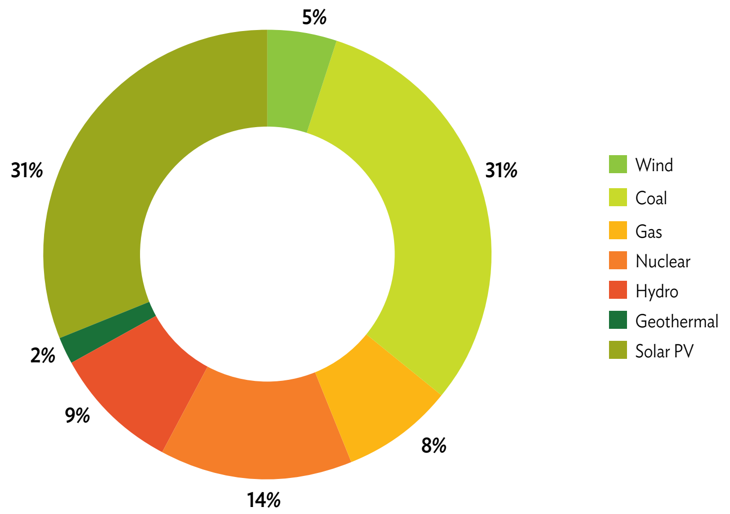
4.5. Necessary Investment Cost

4.5.1 Power infrastructure

Based on the energy outlook results for the BAU scenario and the APS, the Working Group estimated the necessary investment in the power sector, especially for power generation facilities, comprising coal, gas, nuclear, hydro, geothermal, solar PV, 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 it did not forecast future capital cost due to its uncertainty. For all EAS17 countries taken together, the amount of investment needs to meet electricity demand would be US$3.5 trillion for the BAU scenario and US$4 trillion for the APS. This investment cost considers the reduction of upfront cost of each technology due to a fast drop of unit cost of each technology, especially renewables. Figures 1.25 and 1.26 show the investment shares by power generation type for the BAU scenario and the APS in the region. The Increment of electricity demand from 2015 to 2040 of the BAU scenario will be 13,361 TWh. On the other hand, its APS will be

12,641 TWh. But the APS will shift to renewables and nuclear energy. In the case of the high share of renewables in the power generation mix, the total expected power capacity will be 3,119 GW in the APS, which is 2,875 GW higher than the BAU scenario due to the lower operation (or lower efficiency) rate of renewable energy. Consequently, the APS will be higher than the BAU scenario in terms of necessary investment for power generation, and the share of power generation sources will be different between the BAU scenario and the APS.

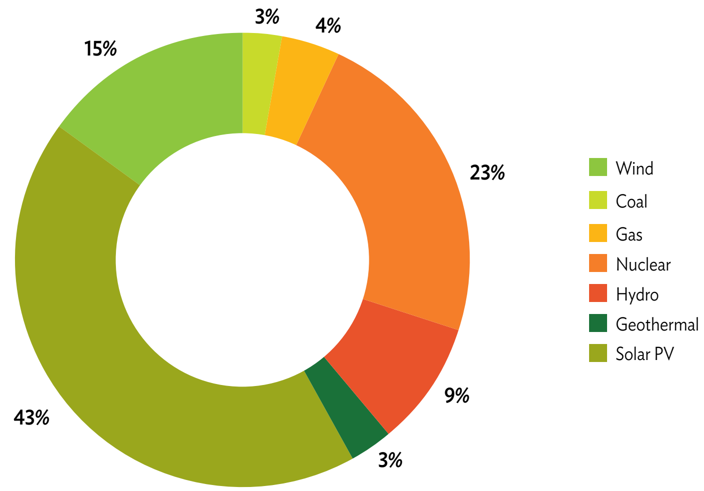
Figure 1.25: Investment Share by Power Source (EAS17-BAU)



BAU = Business-As-Usual, EAS = East Asia Summit, PV = photovoltaic.

Source: Authors' calculation.

Figure 1.26: Investment Share by Power Sources (EAS17-APS)

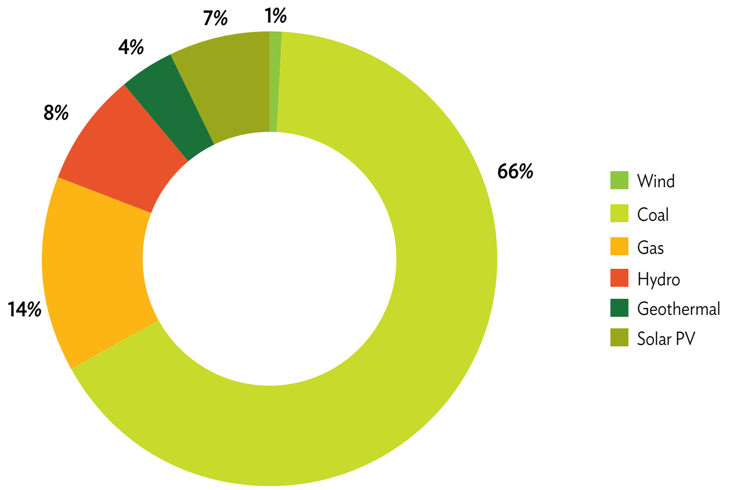


APS = Alternative Policy Scenario, EAS = East Asia Summit, PV = photovoltaic.

Source: Authors' calculation.

Figure 1.27 shows the investment needs of the 10 ASEAN Member States. ASEAN would account for about US$432 billion for the BAU scenario, and about US$440 billion in the APS. The investment shares by power generation source are different between the BAU scenario and the APS. Investment in coal and gas power are the dominant shares in the ASEAN–BAU case, while investment in the APS is more towards clean energy such as hydro, geothermal, wind, solar PV, and possibly nuclear as well (Figure 1.28). In other words, ASEAN will seek for a more balanced energy mix for power generation to increase energy security and mitigate CO_2 emissions.

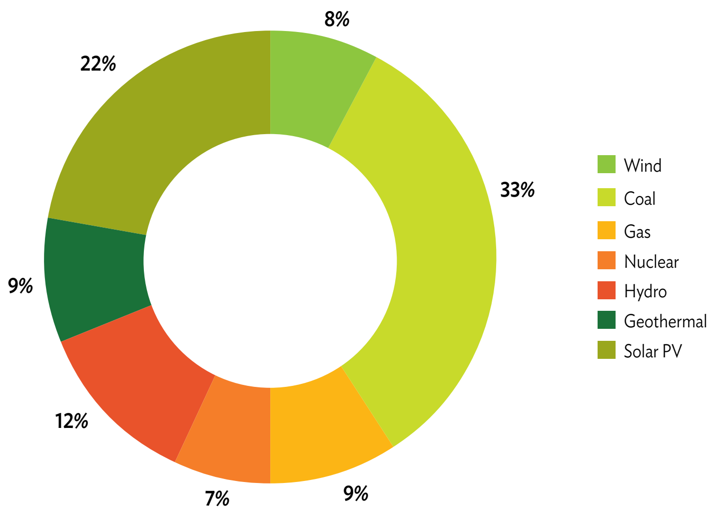
Figure 1.27: Investment Share by Power Source (ASEAN–BAU)



ASEAN = Association of Southeast Asian Nations, BAU = Business-As-Usual, PV = photovoltaic.

Source: Authors' calculation.

Figure 1.28: Investment Share by Power Source (ASEAN–APS)



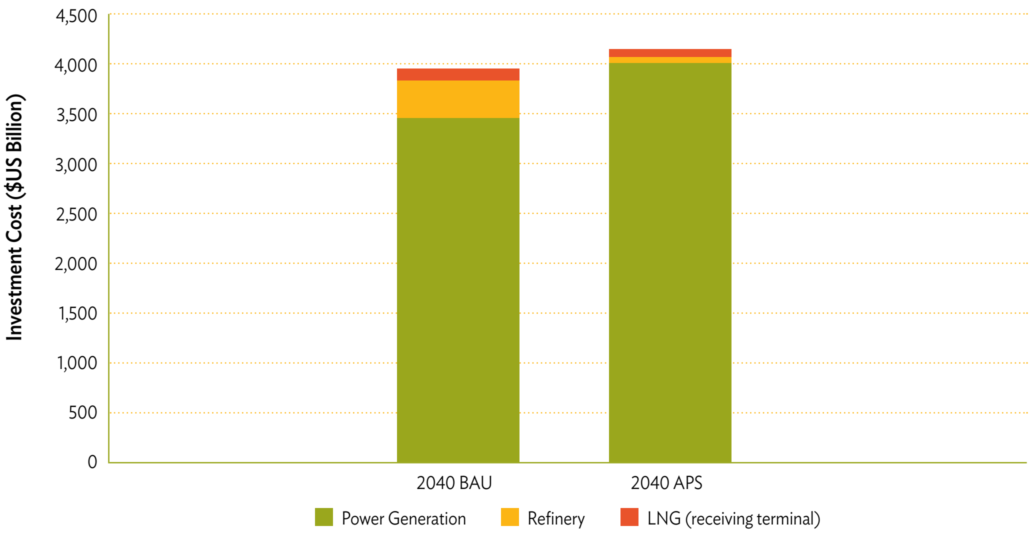
APS = Alternative Policy Scenario, ASEAN = Association of Southeast Asian Nations, PV = photovoltaic.

Source: Authors' calculation.

4.5.2 Other energy infrastructure

There are many necessary investments in energy infrastructure in the future, but here we focus on necessary investment cost for refineries and liquefied natural gas (LNG)–receiving terminals. Natural gas will have a higher growth rate until 2040 but its supply to EAS17 will shift from domestic production to countries outside EAS17. In this regard, LNG-receiving terminals will also be essential. The investment for refineries and LNG-receiving terminals in EAS17 will be estimated at US$367 billion and US$132 billion, respectively, in the BAU scenario. The investments in the APS are reduced to US$60 billion for refineries, and US$75 billion for LNG-receiving terminals due to promotion of energy efficiency. However, these investment costs will be much lower than power generation. The share of investment cost of refineries and LNG-receiving terminals to power generation facilities will be 13% of the BAU scenario and 3% of the APS, respectively. These results seem to indicate energy transition from fossil fuel to more advanced energy technologies such as renewable energy (Figure 1.29).

Figure 1.29: Energy Infrastructure Investment (EAS17, BAU–APS)

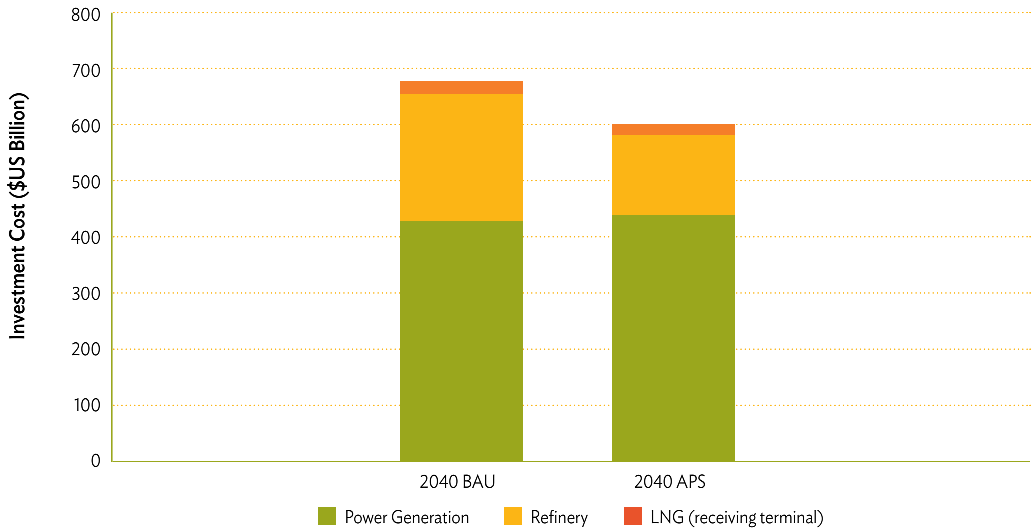


APS = Alternative Policy Scenario, BAU = Business-As-Usual, EAS = East Asia Summit, LNG = liquefied natural gas.

Source: Authors' calculation.

The investments for refineries and LNG-receiving terminals in ASEAN are estimated at US$226 billion and US$28 billion, respectively, in the BAU scenario. The investments in ASEAN in the APS are reduced to US$149 billion for refineries and US$16 billion for LNG-receiving terminals. The share of investment cost of refineries and LNG-receiving terminals to power generation facilities will be 59% of the BAU scenario and 17% of the APS. ASEAN will still need fossil fuel for its economic and social activities. The total investment cost for power generation, refineries, and LNG-receiving terminals of the APS will be lower than the BAU scenario. This indicates that the EEC in the final energy consumption sector and natural gas power plants will be crucial (Figure 1.30).

Figure 1.30: Energy Infrastructure Investment (ASEAN, BAU-APS)



APS = Alternative Policy Scenario, ASEAN = Association of Southeast Asian Nations, BAU = Business-As-Usual, LNG = liquefied natural gas.

Source: Authors' calculation.

5. Conclusions and Recommendations

At the third Working Group meeting, the members discussed the key findings and implications of the analysis based on the two energy outlook scenarios – the BAU scenario and the APS.

5.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and CO_2 emissions in the BAU scenario and the APS, the Working Group members identified several key findings:

1) Sustained population and economic growth in the EAS region will lead to significant increases in energy demand. Total final energy consumption in 2040 will increase by almost 50%, reflecting actual annual growth rate of 1.6% per year between 2015 and 2040. By sector, transport energy demand is projected to grow moderately at about 1.7% per year, and its energy consumption share is projected to be 26.1% by 2040. The annual growth rate of the industry sector in 2015–2040 is just about 1.6% per year, but its energy consumption share is projected to be the largest, about 34.1% by 2040. Demand of the commercial and residential ('others') sectors will grow at a lower rate of 1.3% per year, slower than that of the industry and the transport sectors. However, its energy consumption share is projected to be 29.4%, the second-largest share after the industry sector.

2) The total EAS17 power generation is projected to grow at 2.3% per year on average, from 2015 (equivalent to 14,290 TWh) to 2040 (equivalent to 25,030 TWh), reflecting an increase of 1.8 times during the period. The share of coal-fired generation is projected to continue to be the largest and will be about 48% in 2040, a drop from the 53.8% share in 2015. The share of natural gas is projected to increase from 17.8% in 2015 to 19.4% in 2040. The nuclear share (8.5% in 2015) is forecast to decrease to 8.3% in 2040. Geothermal (0.4% in 2015) and other (wind, solar, biomass, etc.) sources at 5.7% share will also increase to 0.5% and 13.7% in 2040, respectively. The shares of oil and hydro are projected to decrease, from 1.6% to 0.4%, and from 12.3% to 9.7%, respectively, over the same period.

3) The total EAS17 primary energy supply is projected to increase from 7,488 Mtoe in 2015 to 10,943 Mtoe in 2040. Coal will still comprise the largest share of primary energy supply, but its growth is expected to be slower, increasing at 1.3% per year. Consequently, the share of coal in the TPES is forecast to decline from 41.4% in 2015 to 38.9% in 2040. Amongst fossil sources of energy, natural gas is projected to see a moderate annual average growth rate of 2.2%. Its share in the total will consequently increase from 15.4% (equivalent to 1,155 Mtoe) in 2015 to 18% (equivalent to 1,972 Mtoe) in 2040. Nuclear energy is projected to increase at a similar rate as natural gas at 2.2% per year on average; its share will grow from 4.2% in 2015 to 5% in 2040. This is due to the assumed resumption of nuclear power generation in Japan, and the expansion of nuclear power generation capacity in China and India. Geothermal is projected to grow fastest at 3.1% per year in 2015–2040. However, its share is projected to be relatively small, about 0.9% by 2040, increasing from 0.6% in 2015.

4) The continuing reliance on fossil fuels to meet increasing energy demand will also be associated with significant increases in CO_2 emissions. The CO_2 emissions from energy consumption in the BAU scenario are projected to increase from 5,660 Mt-C in 2015 to 8,189 Mt-C in 2040, implying an average annual growth rate of 1.5%. In the APS, CO_2 emissions are projected to be 6,207 Mt-C in 2040, 24.2% lower than in the BAU scenario. Although the emissions reductions under the APS are significant, CO_2 emissions from energy demand in the APS in 2040 will still be above 2015 levels and more than two times higher than 1990 levels.

5) However, the EEC in EAS17 provides strong hope for the region to reduce energy demand and CO_2 emissions. The results of this analysis indicate that, by 2040, the implementation of currently proposed energy efficiency goals, action plans, and policies across the region could lead to the following reductions:
   - o 13.1% in primary energy supply,
   - o 38% in energy intensity, and
   - o 24.2% in energy-derived CO_2 emissions.

6) According to assessment results of INDC/NDC targets based on comparison of CO_2 emissions in the BAU scenario, APS, and INDC/NDC scenarios, the APS of many EAS17 countries clearly shows lower CO_2 emissions than their INDC/NDC targets. But several countries show much lower CO_2 emissions compared to the APS. It is suggested that those countries review them from a scientific viewpoint.

7) Based on the key findings, the necessary investment cost of combined power generation, refineries, and LNG-receiving terminals in EAS17 is estimated to be US$4.0 trillion in the BAU scenario by 2040, and US$4.2 trillion in the APS. Investments in refineries and LNG-receiving terminals in EAS17 are estimated to cost US$67 billion and US$131 billion, respectively, in the BAU scenario. Investments in the APS are reduced to US$60 billion for refineries and US$75 billion for LNG-receiving terminals. In the APS, although electricity demand is lower due to the implementation of efficiency measures, the estimated investment cost of power generation will be larger (US$4.0 trillion in the APS from US$3.5 trillion in the BAU scenario) mainly because of the increased share of renewables imposed under the APS in addition to the EEC measures. The largest share of total investment will be for additional capacity of NRE plants, such as hydro, geothermal, solar PV, wind, and biomass.

5.2. Policy Implications

Based on the above key findings, the Working Group members identified several policy implications, aggregated into five major categories. The identified policy implications are based on a shared desire to enhance action plans in specific sectors, prepare appropriate energy efficiency policies, shift from fossil energy to non-fossil energy, rationalise energy pricing mechanisms, and a need for accurate energy consumption statistics. The implications identified by the Working Group are listed below. It should be noted that appropriate policies will differ between countries based on differences in country circumstances, policy objectives, and market structures, and that not all members necessarily agreed to all recommendations.

1) ***Energy efficiency action plans in final consumption sectors.*** The industry sector will be a major source of energy savings because it will still be the largest energy-consuming sector by 2040, followed by transport especially road and residential/commercial sectors. Several EEC action plans will be implemented, which include building design and replacement of existing facilities and equipment with more efficient ones. Those policies are listed by area/sector:
   - The building sector would need both passive and active design policies such as
     - setting up and enforcing building codes and rewards for green building,
     - supporting energy service companies regulated by governments, and
     - exploring and establishing a good and practical green building business model to meet the context and situation.

- The road transport sector will need to consider measures to reduce energy consumption per unit of transport activities such as
  - o improving fuel economy of internal combustion engine and hybrid vehicles;
  - o shifting from personal to mass transportation mode;
  - o shifting to more low-emission fuels, such as biofuels and compressed natural gas vehicles;
  - o shifting to next-generation vehicle technologies, such as electric vehicles, plug-in hybrid vehicles, and fuel cell vehicles;
- Other sectors will need to consider measures to improve energy efficiency such as
  - o applying standards and labelling systems;
  - o using demand management systems such as household energy management systems and factory energy management systems;
  - o growing energy managers and energy service companies;
  - o improving thermal efficiency in the power generation sector by constructing or replacing existing facilities with new and more efficient generation technologies.

2) ***Renewable energy policies.*** Low-carbon fuels need to be increased. This could be attained by increasing the share of NRE and nuclear energy in the energy mix of each country. Several policies and actions should be considered:
   - Renewable technologies are not as competitive as thermal power generation technologies using fossil fuel in terms of their costs. Supportive renewable energy policies such as feed-in tariffs (FiT), renewable portfolio standards, and net metering are suggested. In addition, international financing schemes, which include clean development mechanisms and joint credit mechanisms, are also penetrating renewable energy. The key to incentivise private investment in renewable energy is to lower the risks related to renewable energy projects and improve profitability prospects.
   - 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, will be very important, but the combination cost is still high.

3) ***Technology development policies.*** Environmental technologies will need to be considered to curb the increasing CO_2 emissions:
   - The development of carbon capture and storage (CCS) technology will be very important in controlling the release of GHGs into the atmosphere. Continued research and development will be important to ensure the future economic viability of deploying CCS technology.

- Hydrogen could be extracted from fossil fuels, such as oil and natural gas, and through electrolysis using renewable energy. But its cost is still higher than existing fuels. Hydrogen fuel development is very promising and could be commercialised in the future. Continued research and development in fuel cells and hydrogen power generation will be important for future clean fuel use.
- Technological cooperation and technology diffusion need to be accelerated in the ASEAN region.

4) ***Energy supply security policies.*** The region will largely depend on imported oil and gas. Thus, measures to secure the supply of energy will be very important for the region. Several measures are identified:
   - Promote regional energy connectivity such as the trans-ASEAN gas pipeline and the ASEAN Power Grid.
   - Diversify sources of import.
   - Strengthen energy infrastructure, including the construction of LNG-receiving terminals and re-gasification plants.
   - Increase domestic energy such as renewable energy share.
   - ASEAN may need to look into the strategic reserve or stockpiling requirement on both public and private bases in the near future.

5.3. Recommendations

Based on this study, energy consumption in the EAS region will increase remarkably due to stable economic and population growth. It will continue to depend largely on fossil fuel energy, such as coal, oil, and gas, until 2040 (the BAU scenario) even though a higher crude oil assumption (about US$120 per barrel in 2040 at 2016 constant price) reflects the current market situation. But if EAS17 countries dedicate themselves to implementing their EEC policies and increase low-carbon energy technologies, such as nuclear power generation and solar PV/wind (APS), the region could achieve remarkable energy savings in the APS, especially through fossil fuel savings, and significantly reduce CO_2 emissions. The APS of many EAS17 countries is appropriate because their expected CO_2 emissions reduction is the same or larger than the countries' INDC/NDC targets. Therefore, EAS17 countries need to apply the plan-do-check-act cycle approach in promoting their EEC and renewable energy policies (energy-saving targets and action plans) according to their respective timetables.

Natural gas will grow the highest up to 2040 amongst fossil fuels and will be an important fuel as transition to a new energy system in the future occurs because of lower price than crude oil, various import sources, and lower carbon emissions compared to oil and coal. To realise this increase, the establishment of a transparent LNG market in Asia, the removal of destination clause, and consumers' participation in LNG development, and others are recommended.

This energy outlook study also shows that a lot of energy savings, especially on oil and electricity consumption by final users, will come from energy efficiency activities. So, the following EEC policies (specified by energy-saving targets and action plans) of EAS17 countries are recommended: (i) standards and labelling systems for appliances and energy facilities such as boilers and compressors; (ii) energy service companies; (iii) increase of next-generation vehicles including hybrid vehicles, electric vehicles, plug-in hybrid vehicles, and fuel cell vehicles; (iv) green building index; (v) and advanced energy management system.

Increasing the share of renewable energy – such as hydro, geothermal, solar PV, wind, and biomass – will contribute to reduced fossil fuel consumption and mitigate CO_2 emissions, and thus contribute to INDC/NDC and SDGs. It will require appropriate government policies such as renewable targets, legal approaches such as FiT/Renewable Portfolio Standards (RPS), and revised FiT to include bidding and tendering processes.

Energy supply security in the EAS17 region is a top priority energy issue. EEC and renewable energy contribute to maintaining regional energy security by reducing fossil fuel consumption and increasing the use of domestic energy. Moreover, energy supply sources can be diversified through regional energy networks such as the Trans-ASEAN Gas Pipeline, including LNG transportation as virtual pipeline, and the ASEAN Power Grid (APG) with region-wide electricity trade market. The Lao PDR, Thailand, and Myanmar are a starting point of the APG. Oil stockpiling and nuclear power generation are other options to secure energy supply in the region.

According to the energy outlook's results, as coal power generation will still be dominant in the EAS region in 2040, the greater use of clean coal technology and development of CCS technology are critical because they will make coal-fired power plants in the region carbon free. Hydrogen technology also has a key role as an alternative to fossil fuels, as it can be applied across sectors, such as the power generation, industry, and road transport sectors.

This energy outlook also estimates the necessary investment cost for combined energy infrastructure such as power generation, LNG-receiving terminals, and refineries. The EAS17 region will need around US$4 trillion for the construction of power plants, refineries, and LNG-receiving terminals in the BAU scenario, but power generation plants will be the largest share estimated at US$3.5 trillion. ASEAN needs about US$686 billion in the BAU scenario for the total energy infrastructure of combined power generation, refineries, and LNG-receiving terminals, and US$605 billion in the APS. The difference comes from refineries and LNG-receiving terminals due to savings in oil and gas consumption. In the BAU scenario, a lot of money will be allocated to coal-fired power plants (clean coal technology), whereas under the APS, more money will be allocated to low-carbon energy electricity, such as nuclear, geothermal hydropower, solar PV/wind, and biomass. Consequently, financing schemes to develop energy infrastructure such as public–private partnership, public financing of international/regional banks, clean development mechanism, and/or joint credit mechanism, etc. will be essential.

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CHAPTER 2

AUSTRALIA COUNTRY REPORT

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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 around 7.7 million square kilometres, and is diverse in geography and climate. It has six states and two territories. Over the past 25 years, Australia's population grew at an average annual rate of 1.3%, from 17.1 million in 1990 to 23.8 million in 2015.

Australia's gross domestic product (GDP) increased at an average annual rate of 3.1%, from US$636 billion in 1990 to US$1.36 trillion in 2015 (constant 2010 US$ values), which translates the increase of Australia's per capita income from around US$37,300 in 1990 to US$56,950 in 2015. Economic activities are focused on the eastern and southeastern seaboard, where most of the population lives. For example, in 2016, only three states – New South Wales, Victoria, and Queensland – generated 73% of Australia's GDP, while these states represent 32%, 25%, and 20% of the national population, respectively (Carr et al., 2017).

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 1.27 million tons of economic demonstrated resources of uranium, which is equivalent to 16,984 million tons of oil equivalent (Mtoe) or 711,076 petajoules (Geoscience Australia, 2018). This amount is more than one-third of the world's uranium resources. Australia also has a major share of the world's thorium resources, and thorium could be an alternative to uranium as a nuclear fuel in the future.

The country has 70,927 million tons of recoverable black coal resources, which is 10% of the world's black coal resources. It has a further 76,508 million tons of brown coal resources, about 24% of the world's brown coal reserves (Geoscience Australia, 2017). Australia's substantial conventional and unconventional gas resources account for almost 2% of the world's gas resources, and it has a relatively small share (0.2%) of crude oil resources (BP, 2017). 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 also has large, widely distributed wind, solar, geothermal, hydroelectricity, ocean energy, and bioenergy resources. Wind energy technology is relatively mature, and its uptake is growing faster in the country. Generation capacity of solar electricity is also increasing rapidly due to the rapid reductions of 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 examined at existing hydro installations and new sites.

Australia's 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 2015, Australia was the world's eighth-largest energy producer (381.3 Mtoe), accounting for 2.8% of global primary energy supply. It was the world's 21st-largest energy consumer, accounting for 0.9% (125.3 Mtoe) of world primary energy supply (IEA, 2017).

Primary energy supply is largely based on fossil fuels. In 2015, coal contributed about 34% of primary energy supply; oil, 33%; and natural gas, 26%. Renewables contributed the remaining 7%, consisting of hydro (1%), solar and wind (2%), and biofuel and waste (4%) (IEA, 2017).

Australia plays a prominent role in meeting the increasing energy demand of the Asia-Pacific region and the world. In 2015, Australia was the world's fourth-largest energy exporter; it exported 78% of its energy production, consisting largely of coal and liquefied natural gas. It is the world's largest exporter of metallurgical coal and the second-largest exporter of thermal coal (IEA, 2017). It is also 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 imports for its transport fuels.

Over the past 25 years, Australia's gross electricity generation has increased at an average annual rate of 2% from 154 terawatt-hours (TWh) in 1990 to 252 TWh in 2015. In 2015, coal accounted for almost two-thirds (63%) of total electricity generation; followed by natural gas, 21%; hydro, 5%; oil, 3%; and others (non-hydro renewables), 8%. Coal still dominates Australia's electricity generation mix, though its share has fallen from 79% in 1990 to 63% in 2015. The share of natural gas and non-hydro renewables in the generation mix has increased significantly over this period.

2. Modelling Assumptions

Australia's GDP is assumed to grow at an average annual rate of 2.5% between 2015 to 2040, compared with the average annual growth rate of 3.1% between 1990 and 2015. The Australian economy will gradually shift from energy-intensive industries towards less energy-intensive ones. Its GDP growth will gradually decrease towards the end of the projection period. Australia's population is assumed to grow at an average annual rate of 1% between 2015 to 2040, which is marginally slower than the average annual growth rate of about 1.3% from 1990 to 2015.

Fossil fuels will remain the dominant energy source in Australia's primary energy mix due to their relative abundance and costs. In electricity generation, no new coal plants will be installed, and the share of coal-fired electricity generation will decrease due to the scheduled closure and/or retirement of a few coal-fired electricity plants. Gas-fired electricity and non-hydro renewable electricity generation is assumed to rise to meet the increasing demand over the projection period.

The Alternative Policy Scenario (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 a higher contribution of renewable energy to the total supply. Combined effects of these measures are assumed to provide maximum energy savings over the projection period. Energy savings in the industry sector are 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 away from energy-intensive industries. In the residential and commercial sectors, efficient end-use technologies and energy management systems are assumed to further achieve energy savings. The transport sector is assumed to be more energy efficient through 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.

This study further attempts to develop a Nationally Determined Contributions (NDC) scenario to analyse Australia's emissions reduction target for 2030. This scenario in this study is designed to meet Australia's emissions reduction target of 26%–28% below the 2005 level by 2030.

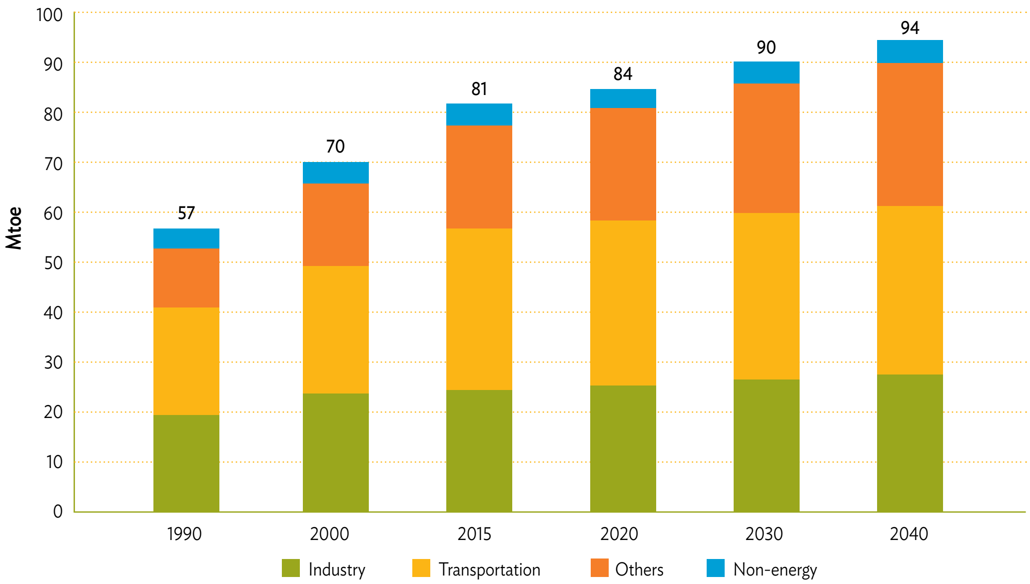
3. Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final energy consumption

Under the BAU scenario, total final energy consumption in Australia is projected to increase from 81.3 Mtoe in 2015 to 94.1 Mtoe in 2040, a rise of about 15.7% over the projection period and an average annual rate of increase at 0.6% (Figure 2.1). The strongest growth is projected to occur in the 'others' sector (e.g. residential and services sectors), increasing at 1.3% per year between 2015 and 2040. The growth of energy consumption in the transport sector is projected to remain slow (0.1% per year) over the projection period, though it saw relatively strong growth (1.7% per year) in the past 25 years.

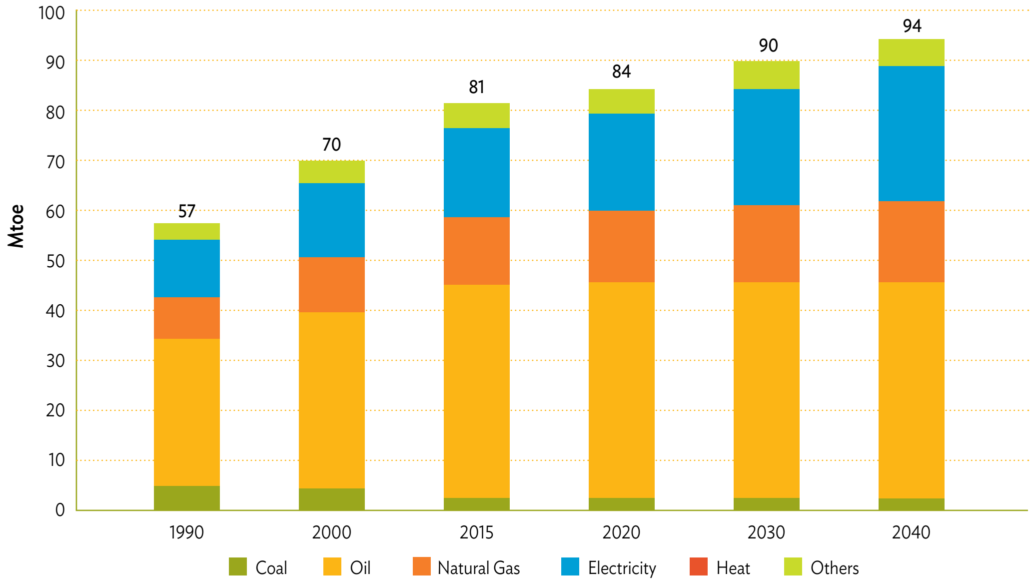
Figure 2.1: Final Energy Consumption by Sector, BAU Scenario



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Figure 2.2: Final Energy Consumption by Fuel Type, BAU



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

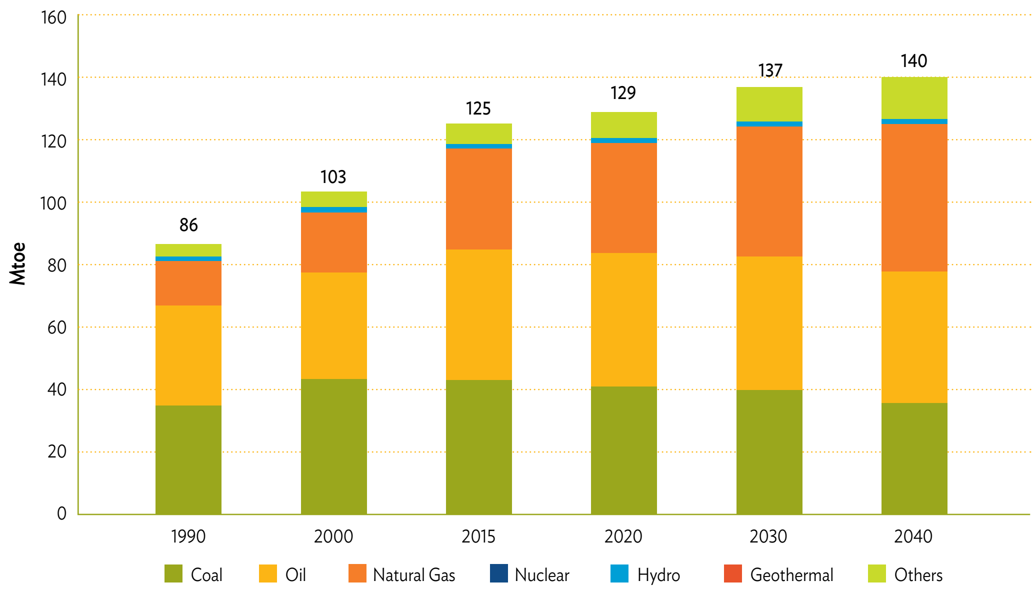
Source: Authors' calculation.

Electricity consumption is projected to have the fastest growth at an average annual rate of 1.7% per year between 2015 and 2040 (Figure 2.2). Natural gas is projected to increase at the second highest rate of 0.7% per year. Petroleum products are projected to see a slower growth rate, with an average rate of 0.1% per year. Coal consumption is expected to decline at an average rate of 0.9% per year.

3.1.2. Primary energy supply

Under the BAU scenario, Australia's primary energy supply is projected to increase from 125.3 Mtoe in 2015 to 140.1 Mtoe in 2040 at an average annual rate of 0.4% (Figure 2.3). Coal consumption is expected to decline at an annual average rate of 0.8% during this period, and growth in oil consumption is projected to remain flat. Natural gas will increase at 1.5% per year between 2015 and 2040, where its share in the primary energy mix is expected to increase from about 26% in 2015 to 34% in 2040. The overall share of fossil fuel in Australia's primary energy supply will decline from 94% in 2015 to 89% in 2040.

Figure 2.3: Primary Energy Supply by Fuel Type



Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

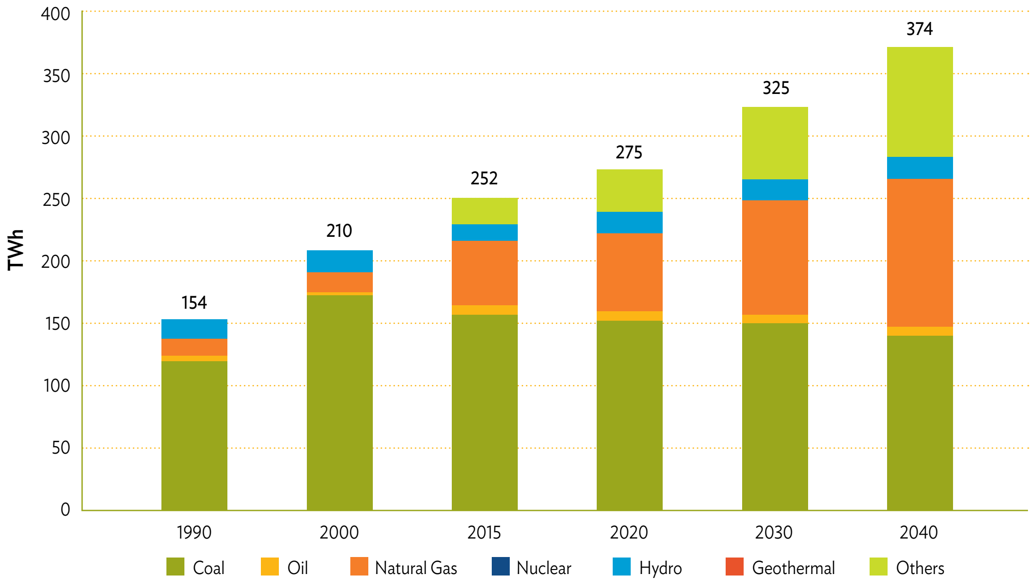
'Others' (including non-hydro renewables) is projected to increase by 2.7% a year over the projection period. The share of 'others' is expected to increase from 5.7% in 2015 to about 10% in 2040, where the major contribution to this increase would come from solar and wind followed by biofuels and biomass. Solar, wind, and ocean energy together are expected to grow at an average annual rate of 5.9% between 2015 and 2040.

3.1.3. Power generation

Electricity generation in Australia, under the BAU scenario, is projected to increase from 252.3 TWh in 2015 to 373.7 TWh in 2040 at an average rate of 1.6% per year (Figure 2-4). The share of coal in Australia's power generation mix is projected to fall from 63% in 2015 to 38% in 2040, which will still maintain its largest share in the generation mix under the BAU scenario. Coal share will decline due to the scheduled closure and retirement of some old coal-fired generation plants. Generation from oil is also projected to decline at an average rate of 0.1% per year, and the share of oil in the generation mix will decline from 2.7% in 2015 to 1.8% in 2040. In contrast, the share of natural gas–fired generation will increase from 21% in 2015 to 32% in 2040, and natural gas use in electricity generation is projected to grow at an average rate of 3.3% per year over the period.

Hydro's share in Australia's power generation mix is expected to decline slightly from 5.3% in 2015 to 4.7% by 2040. Electricity generation from 'others' (non-hydro renewables) is expected to grow faster at an average rate of 6% per year between 2015 and 2040. Declining costs of wind and solar technology would partly contribute to the faster growth of electricity generation from 'others' (including wind and solar) in Australia.

Figure 2.4: Power Generation under BAU



BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Authors' calculation.

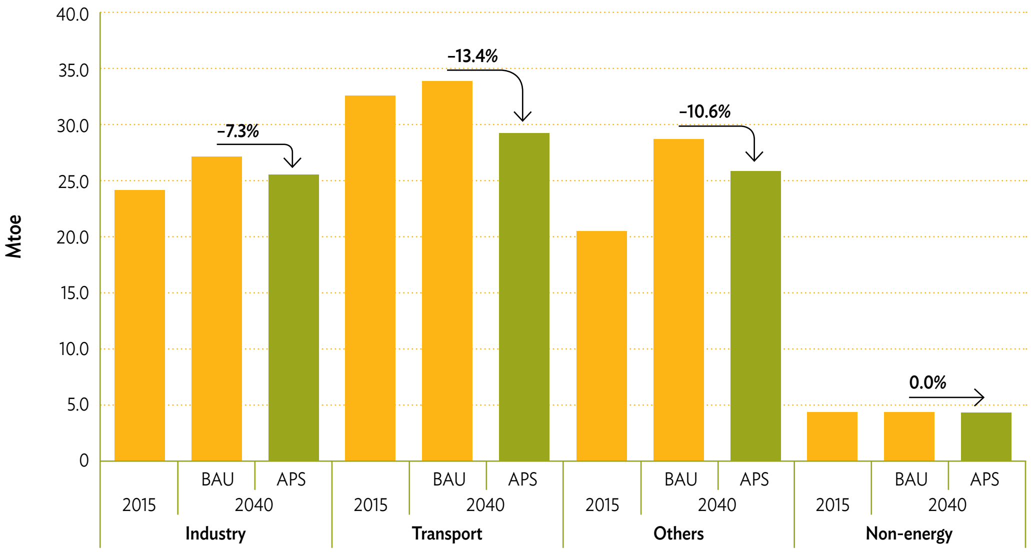
3.2. Energy Saving and CO_2 Reduction Potential

3.2.1. Final energy consumption

Under the APS, final energy consumption is projected to increase at a slower rate of 0.2% per year from 81.3 Mtoe in 2015 to 84.5 Mtoe in 2040 (Figure 2.5). This shows energy savings of 9.6 Mtoe, or 10.2%, under the APS in 2040, compared to that of the BAU scenario in 2040. The slower growth in demand is expected to occur across all end-use sectors, excluding the non-energy sector. The transport sector is projected to see the highest energy savings followed by the 'others' (residential and commercial) sector. These reflect the improvements in vehicle fuel efficiency and end-use technologies.

In 2040, under the APS, estimated savings are 2.0 Mtoe (7.3%) in the industry sector, 4.5 Mtoe (13.4%) in the transport sector, and 3.0 Mtoe (10.6%) in the 'others' sector (Figure 2.5).

Figure 2.5: Final Energy Consumption by Sector, BAU and APS



BAU = Business-As-Usual, APS = Alternative Policy Scenario, Mtoe = million tons of oil equivalent.

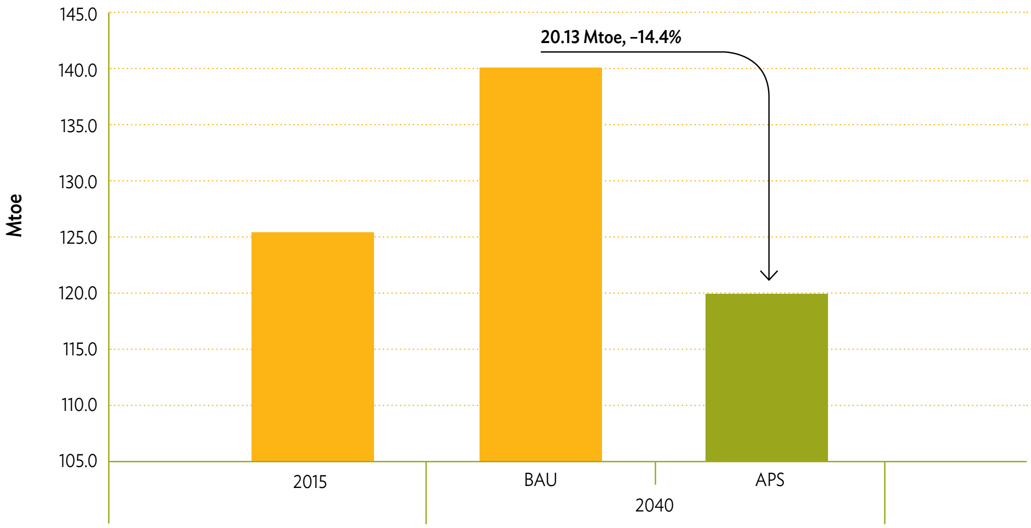
Source: Authors' calculation.

Under the NDC scenario, final energy consumption is forecast to decrease at a rate of 0.6% per year from 81.3 Mtoe in 2015 to 70.5 Mtoe in 2040. Therefore, the NDC scenario shows further savings of 14 Mtoe final energy compared to the savings under the APS. The highest contribution to final energy savings would come from the transport sector, followed by 'others' (i.e. residential and services) in this scenario.

3.2.2. Primary energy supply

Under the APS, Australia's primary energy supply is projected to decrease at a rate of 0.2% per year from 125.3 Mtoe in 2015 to 119.9 Mtoe in 2040. This implies that in 2040, under the APS, savings of primary energy supply will be around 20.1 Mtoe or 14.4% compared to BAU (Figure 2.6).

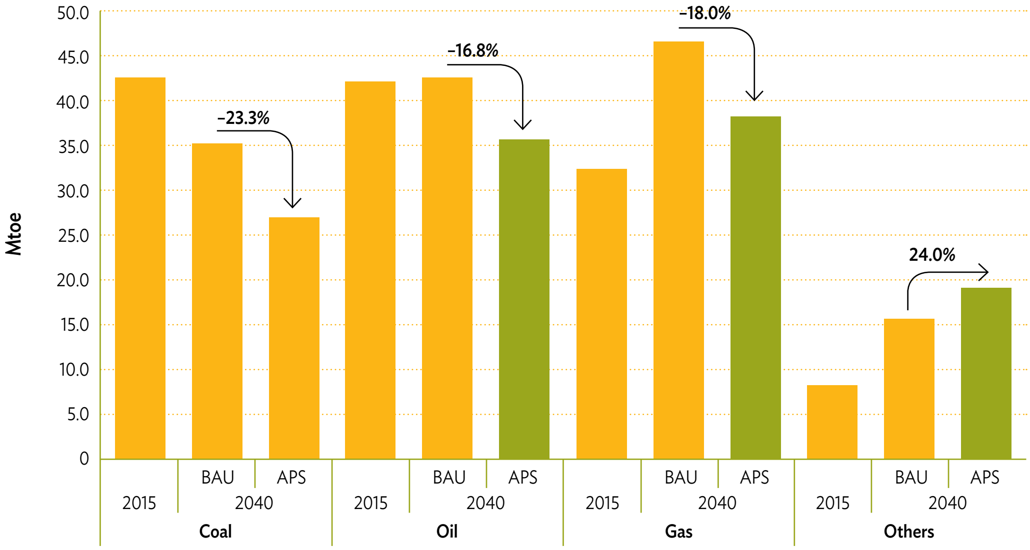
Figure 2.6: Total Primary Energy Supply, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Figure 2.7: Primary Energy Supply by Fuel Type, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Primary energy supply in the APS is expected to decline for coal at 1.8% per year (compared to a decline of 0.8% per year in the BAU scenario) over the projection period. This will result in a saving of coal consumption by about 8.3 Mtoe in 2040 compared to the BAU scenario. Similarly, the negative growth of oil demand (0.7% per year) will save oil consumption of about 7.1 Mtoe in 2040. With an average annual growth of 0.7%, savings on natural gas consumption will be about 8.4 Mtoe compared to the BAU scenario. However, the demand for 'others' (renewables) is expected to increase by about 3.7 Mtoe, or 24%, compared to the BAU scenario in 2040 (Figure 2.7).

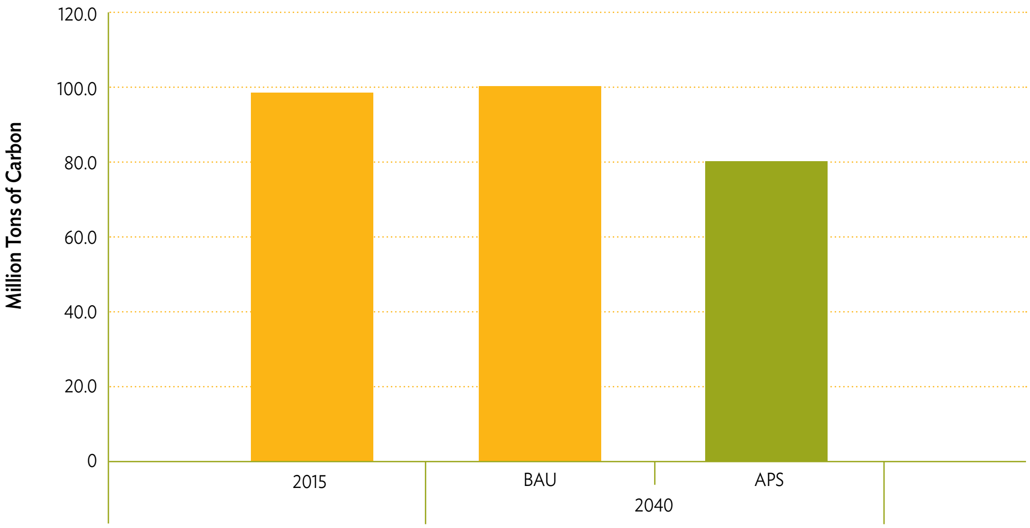
Primary energy supply under the NDC scenario is projected to decline at a rate of 1.3% per year, from 125.3 Mtoe in 2015 to 89.3 Mtoe in 2040. Therefore, this scenario provides additional savings of 31 Mtoe of primary energy compared to the APS in 2040. The share of renewables in the primary energy mix needs to increase from 11% in 2015 to about 27% in 2040 under the NDC scenario.

3.3. CO_2 Emissions

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 0.1% per year from 98.8 million tons of carbon (Mt-C) in 2015 to 100.3 Mt-C in 2040 (Figure 2.8). The growth in emissions appears to be less than the projected growth in primary energy supply, reflecting increased use of fewer carbon-intensive energy sources over the period.

In the APS, CO_2 emissions are projected to decrease at an average annual rate of 0.8% from 98.8 Mt-C in 2015 to 80.0 Mt-C in 2040. Emissions savings in the APS will be about 20% compared to the BAU scenario in 2040. The lower growth rate for the APS indicates that the energy-saving options are effective in reducing CO_2 emissions in Australia. Reduced demand for coal in power generation and in final demand, including reduced oil consumption in the transport sector, will contribute the most to the expected reduction of CO_2 emissions in the APS.

Figure 2.8: CO_2 Emissions from Energy Combustion, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Authors' calculation.

CO_2 emissions under the NDC scenario will decline at an average annual rate of 2.6% from 100.3 Mt-C to 50.5 Mt-C in 2040. This is about 50% reduction of CO_2 emissions compared to the BAU scenario in 2040.

In 2005, energy-related CO_2 emissions in Australia were 94.1 Mt-C. In 2030, such emissions are projected to be 101.9 Mt-C in the BAU scenario, 88.8 Mt-C in the APS, and 69.5 Mt-C in the NDC scenario. It appears that the energy-related emissions reduction target of 26%–28% below the 2005 level by 2030 will not be achieved under the APS. The NDC scenario in this study is designed to meet Australia's emissions reduction target of 26% below the 2005 level by 2030, by further enhancing the assumptions of energy efficiency and renewable energy.

4. Implications

- Fossil fuels – namely, coal, oil, and gas – will continue to dominate the energy mix in both the BAU scenario and the APS.
- Coal will continue to dominate Australia's electricity generation mix over the period up to 2040; however, the share of coal in the power mix is projected to decline. Advance technologies for power generation would be necessary to enhance efficiency, energy savings, and emissions reduction.
- Australia has substantial reserves and a secure supply of coal. Coal prices are expected to remain much lower over the long term. Coal-fired generation is likely to remain cheaper than other energy sources. However, global attempts to curb emissions would put pressure on Australia to adopt low-emission technologies for power generation. The use of efficient and clean coal technologies will be necessary. Research, development, and deployment of clean energy technologies will play a key role.
- Substantial expansion of traditional hydropower will likely not occur due to the dry climate and low water runoff in much of Australia. While wind and solar technology costs are going to fall more quickly over the next 25 years, the growth of renewable energy will likely come from large-scale adoption of wind and solar energy supported by energy storage. Better integration of variable renewable energy sources into Australia's energy systems will be necessary.
- Energy efficiency and demand-side management are important. The implementation of improved and efficient end-use technologies will reduce final energy consumption in the end-use sectors. Energy savings in the industry sector will come from the improved efficiency of large energy-intensive industries.
- Oil will continue to supply Australia's transport fuel needs. Improved vehicle fuel efficiency and uptake of electric vehicles would reduce oil demand in the transport sector. Investment in new petroleum refinery plants may be necessary to reduce import dependence of transport fuel.

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CHAPTER 3

BRUNEI DARUSSALAM COUNTRY REPORT

Ministry of Energy and Industry, Brunei Darussalam

1. Background

Brunei Darussalam (Brunei) is a small nation on the northwest coast of the island of Borneo. It is located in Southeast Asia and has a coastline of 161 kilometres along the South China Sea in the north. The East Malaysian state of Sarawak completely surrounds Brunei on all other sides. The country has a total land area of only 5,765 square kilometres and comprises four main districts: Belait, Tutong, Temburong, and Brunei-Muara. Its capital city is Bandar Seri Begawan located in the Brunei-Muara district. Because of its proximity to the equator, the country experiences a hot and wet climate throughout the year.

Brunei Darussalam is an economy with great economic potential. Its gross domestic product (GDP) in 2015 was US$13.9 billion at constant year 2010. With a population of 416,500, Brunei's GDP per capita was US$33,340 at constant year 2010. About 60% of Brunei's GDP is generated by the energy sector. This reflects the significant contribution of this sector to the country's economy. The energy sector also dominates Brunei's export value as crude oil, natural gas (in the form of liquefied natural gas), and methanol exports account for more than 90% of its total exports, which are primarily destined to Japan, the Republic of Korea, India, China, and (ASEAN) countries.

To drive the economy into a sustainable future, the country supports the implementation of three strategic goals set out in the Brunei Darussalam's Energy White Paper launched in March 2014. The White Paper sets out strategic goal 2, which is specifically for energy supply and demand, i.e. to ensure a safe, secure, reliable, and efficient supply of energy in Brunei Darussalam. Strategic goal 1 focuses on strengthening oil and gas upstream and downstream activities while goal 3 focuses on maximising economic spin-off from the energy sector.

2. Energy Supply and Consumption in 2015

Oil and natural gas remain the main sources of energy for Brunei Darussalam. In 2015, the total primary energy supply (TPES) of the country for both energy sources was 3.26 million tons of oil equivalent (Mtoe) in total, with 3.07 Mtoe or 94.3% from natural gas (Table 3.1).

Brunei Darussalam has 922 MW of installed capacity in power generation of public utilities, including a solar photovoltaic (PV) at 1.2 MW. Electricity production from the public utilities in 2015 was 3.78 terawatt-hours (TWh). In the same year, the installed capacity of auto producers was 116.99 MW, which produced 0.39 TWh of electricity.

Table 3.1: Energy Supply and Consumption 2015 (Mtoe)

Supply and Consumption	Oil	Natural Gas	Electricity	Total
Primary energy supply				
Indigenous production	8.88	11.19	-	20.07
Net import and others	-8.69	-8.12	-	-16.81
Total primary energy supply	**0.19**	**3.07**	**-**	**3.26**
Final energy consumption				
Industry sector	0.18	-	0.02	0.20
Transport sector	0.31	-	-	0.31
Others sector[a]	0.02	0.02	0.24	0.28
Non-energy	0.02	-	-	0.02
Total final energy consumption	**0.53**	**0.02**	**0.26**	**0.81**

Mtoe = million tons of oil equivalent.

[a]The 'others' sector includes the residential and commercial sectors.

Source: Author's calculation.

The total final energy consumption (TFEC) of Brunei Darussalam in 2015 was 0.81 Mtoe, with the transport sector having the highest energy demand at 0.31 Mtoe or 38.27% of the TFEC. This is followed by the 'others' sector (34.57%), industry sector (24.69%), and non-energy use (2.47%). In terms of energy source, oil accounted for 65.43% of final energy consumption, followed by electricity at 32.10% and gas at 2.47%.

3. Energy Policies

3.1. Supply

Brunei seeks to expand exploration areas to increase reserves and ensure long-term sustainability and conservation of oil and gas reserves. A core focus as well is to rejuvenate the current producing assets to enhance recovery from the field and maximise production, which are aligned with the national vision, *Wawasan Brunei 2035*. The country is also maximising its potential for economic spin-off from upstream production and assets. In this regard, Brunei Darussalam has set strategies to strengthen and grow the upstream and downstream activities of oil and gas, with the targets set as follows:

1) To sustain a reserve replacement ratio of greater than 1 also means ensuring that Brunei continues to benefit from production in the energy sector in the long term;
2) To increase production of oil and gas to 650,000 barrels of oil equivalent per day by 2035;
3) To grow revenue from domestic downstream industries and reach at least B$5 billion by 2035 through the development of infrastructure and facilities, including chemical and petrochemical plants and a refinery.

Despite its aspiration to increase oil and gas production to 650 kboe per day by 2035, the country acknowledges the importance of reducing energy intensity by 45% by 2035 in line with its commitment to the Asia-Pacific Economic Cooperation. Brunei has also targeted to increase the share of its power generation mix from renewable energy to at least 10% by 2035. It has considered and started to develop renewable energy, particularly solar PV and waste-to-energy, which are deemed feasible at this stage. To support the development of renewable energy sources, the government plans to introduce renewable energy policies and regulatory frameworks that will stimulate investment from both the public and the private sectors in developing and deploying renewable energy.

3.2. Consumption

Brunei has been actively improving energy efficiency and conservation (EEC) to reduce energy intensity by 2035. In achieving the energy intensity target, relevant government agencies and industries have been collaborating to set up legislation and to introduce financial and fiscal policy measures that promote energy efficiency and low energy-intensive industries. Industries' roles include identification of technical levers that may assist the reduction of energy use over time while individuals shift consumption behaviour towards energy efficiency that include making choices on highly energy-efficient appliances.

Efforts towards achieving EEC targets were through power generation efficiency, standard and labelling, fuel economy regulation, EEC building guidelines, street lighting alternate switching off, and LED-fitting lighting for street lights.

The Department of Electrical Services and Berakas power management company play major roles in setting out plans to increase power generation efficiency. The plan will emphasise the implementation of combined-cycle turbine and cogeneration power plants, reduction of partial load operation, and improvement of transmission and distribution losses.

4. Outlook Result

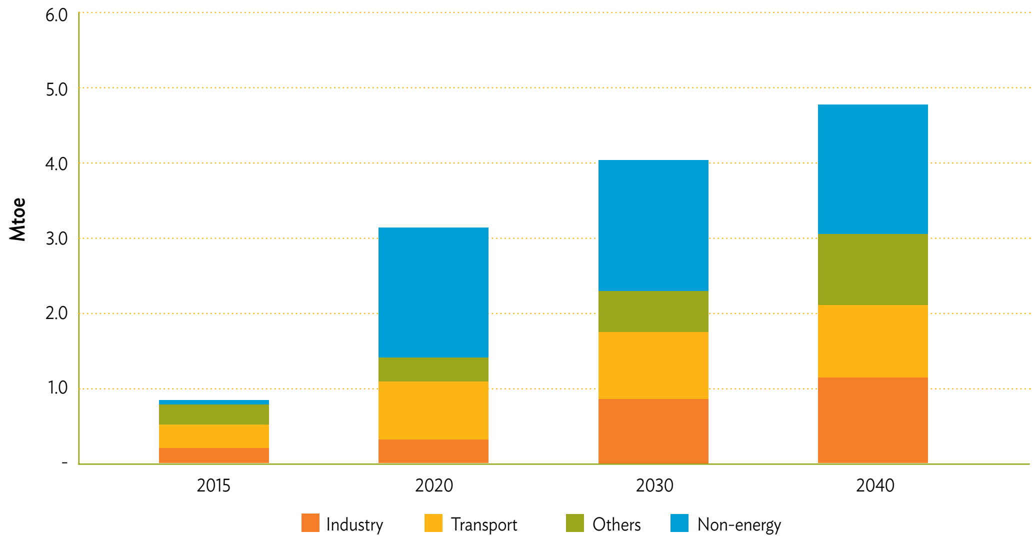
4.1. Final Energy Consumption

Business-As-Usual Scenario

Under the Business-As-Usual (BAU) scenario, the projected TFEC in the year 2040 is 4.78 Mtoe. The increase of projected TFEC is linked to the GDP growth rate which, in the model, is set at a constant rate of 5.6% per year over the projection period. The high GDP growth rate is supported by the country's aspiration to strengthen its economic structure to develop the commercial, services, and industry sectors. For instance, as per projection from the BAU scenario, industry TFEC in 2040 is expected to grow to 1.13 Mtoe, compared with 0.20 Mtoe in 2015.

In 2040, the share of oil in the country's total demand will be 65%, mainly to be consumed as transportation fuel. In 2015, the TFEC of oil was 0.52 Mtoe and is projected to increase to 1.75 Mtoe in 2040. The model also predicts that the demand for electricity will increase at an average of 6.6% per year, from 0.26 Mtoe in 2015 to 1.26 Mtoe in 2040 (Figure 3.1).

Figure 3.1: Final Energy Consumption by Sector, BAU



BAU = Business-As-Usual.

Source: Authors' calculation.

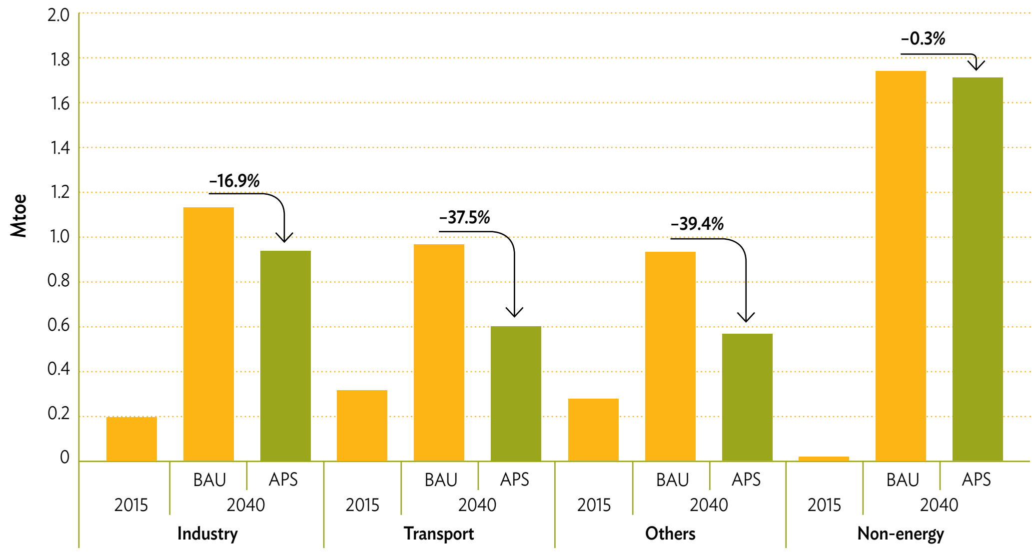
Alternative Policy Scenario

An Alternative Policy Scenario (APS) was developed as a basis to estimate the energy saving potential for Brunei Darussalam to achieve the energy intensity reduction targets through the deployment of advanced technologies for energy saving and enforcement of relevant initiatives. Under the APS, the overall TFEC in 2040 will be 3.86 Mtoe. In 2040, the 'others' sector will require about 14.8% of energy demand, followed by the transport sector at 15.5% and the industry sector at 24.4%. Demand of the non-energy sector will be at 45.1%.

The improvement in vehicle fuel efficiency in the future due to proposed fuel economy regulations would be the main factor for the declining growth rate of demand in the transport sector. For the period 2015–2040, the TFEC will grow at 2.7% per year on average. Referring to the results of the LEAP[1] model for energy outlook, the TFEC under the APS will be reduced by 19.2% compared to the BAU scenario. The 'others' sector (residential and commercial sectors) will decrease by 39.4%; transport, by 37.5%; and industry, by 16.9% from the BAU scenario. Meanwhile, non-energy use will also decline by 0.3% (Figure 3.2).

[1] LEAP stands for Long-range Energy Alternative Planning System.

Figure 3.2: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

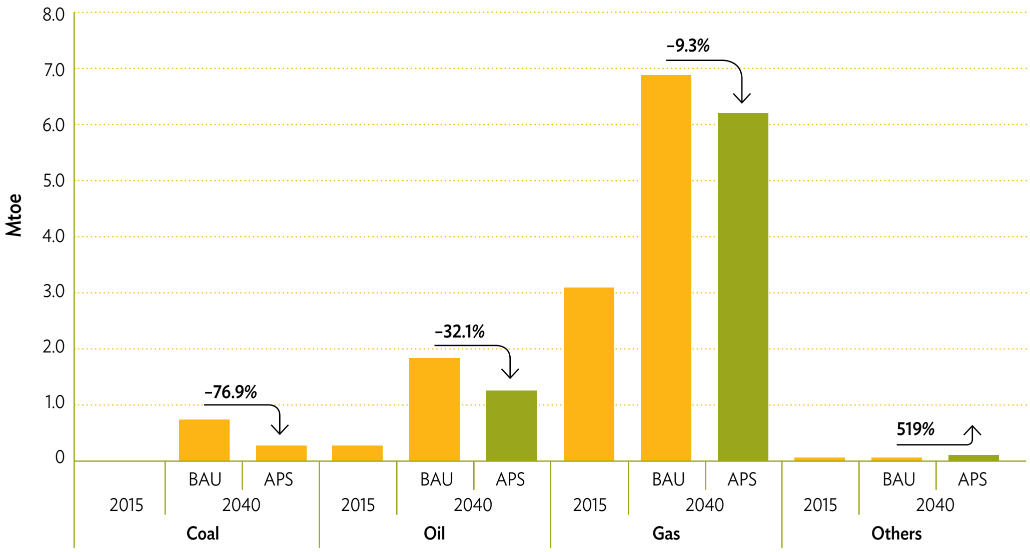
4.2 Primary Energy Supply

Business-As-Usual Scenario

Under the BAU scenario, the TPES of Brunei is projected to reach 9.39 Mtoe in 2040, increasing at 4.3% per year from 3.26 Mtoe in 2015. Its TPES was dominated by natural gas at 94.2% in 2015, while oil share was about 5.8%.

The TPES for natural gas is expected to increase at 3.3% per year from 3.07 Mtoe in 2015 to 6.86 Mtoe in 2040. The country will continue to be a net exporter of energy in the future.

Figure 3.3: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Alternative Policy Scenario

A significant decrease in the TPES for oil and natural gas is projected between the BAU scenario and the APS in 2040. In 2040, oil supply under the APS will be 1.25 Mtoe against the BAU scenario at 1.84 Mtoe, or 32.1% lower. Natural gas supply under the APS is also predicted to be lower by 9.3% compared to the BAU scenario. However, supply from renewable energy, particularly from solar and waste-to-energy sources, will significantly increase (Figure 3.3).

4.3 Power Generation

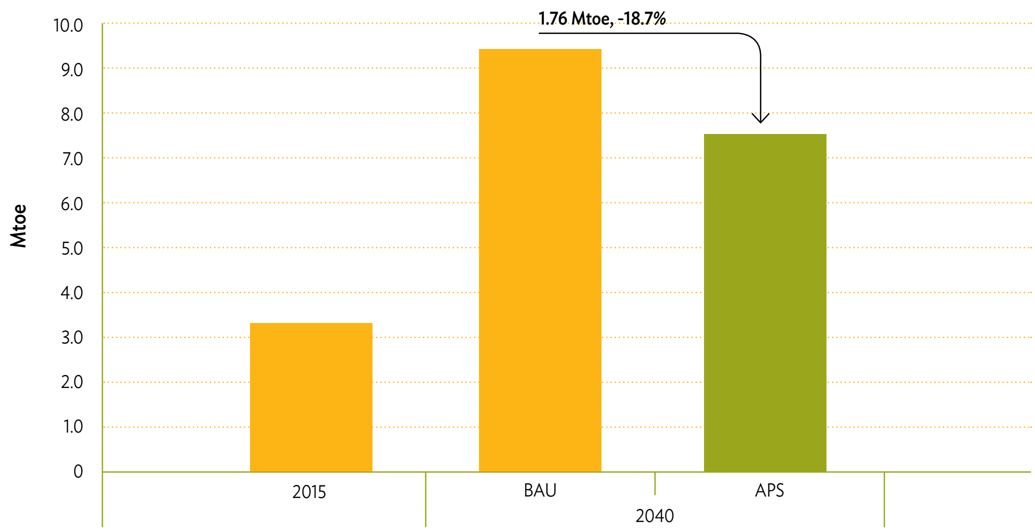
In Brunei Darussalam, power generation capacity from public utilities is dominated by natural gas. From 806.2 MW of installed capacity (including 1.2 MW solar PV), diesel contributes only 12 MW. In addition to the public utilities capacity, autoproducers' capacity in 2015 was 116.9 MW. Based on the model projection under BAU, about 17.74 TWh of electricity will be generated in 2040 from both public utilities and autoproducers, including from renewable energy of 0.05 TWh. Under the APS, electricity generation in 2040 is projected at about 13.08 TWh, a decrease of 26.3% in electricity generation from the BAU scenario, which includes renewable energy at 0.9 TWh. The decrease is due to the decommissioning of the diesel power plants in Temburong in 2021. As planned in the

APS, all thermal power plants in Brunei Darussalam will be combined-cycle gas turbines (with improved efficiency of 45%) and cogeneration power plants.

4.4 Projected Energy Savings[2]

The energy saving potential that could be achieved through the implementation of legislative measures on EEC, as well as the development of renewable energy in Brunei Darussalam, is about 1.76 Mtoe of the TPES, or equivalent to a reduction of 18.7% from the BAU scenario in 2040.

Figure 3.4: Reduction of Primary Energy Supply, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

4.5 Carbon Dioxide Emissions

Business-As-Usual Scenario

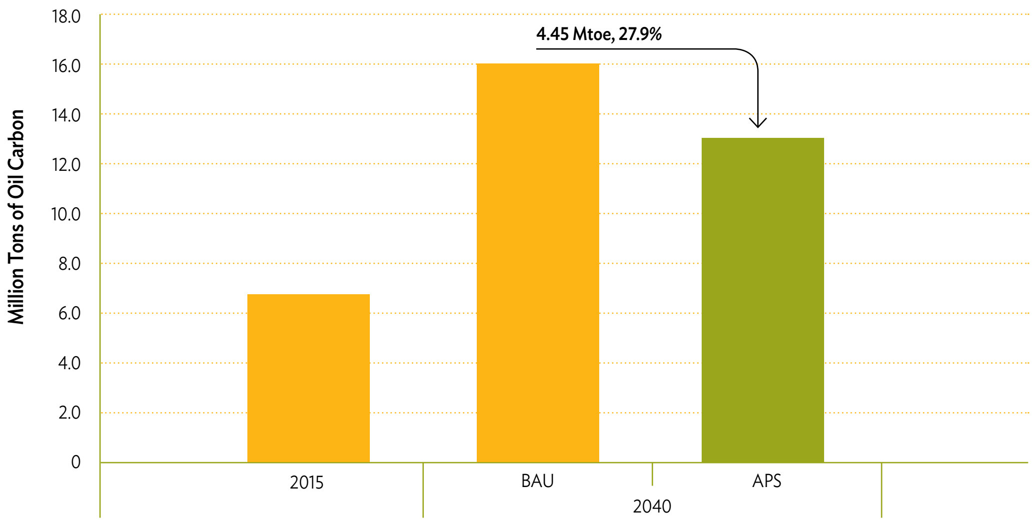
The percentage increase in carbon dioxide (CO_2) emissions correlates to the increase in the TPES. This is expected because the energy mix for Brunei Darussalam is 99% dependent on fossil fuels. In 2015, the LEAP model shows 6.7 million tons of carbon (Mt-C). An increase of 3.6% per year is expected with an eventual value of 16.0 Mt-C in 2040 (Figure 3.5).

2 The difference between primary energy consumption in BAU and the APS.

Alternative Policy Scenario

As of this writing, Brunei Darussalam is still finalising the Nationally Determined Contributions (NDC) target, which will be reported before 2020. Therefore, the current APS is equal to the target of the NDC. In the APS, CO_2 emissions could decrease by 27.9% in 2040 compared to the BAU scenario. The results of the model show that a total of 10.6 Mt-C will be emitted by 2040. The decrease in CO_2 is significantly attributed to improved efficiencies of power generation plants (Figure 3.5).

Figure 3.5: CO_2 Emissions from Energy Consumption, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

5. Policy Implications

Based on Brunei's second national communication submitted to the United Nations Framework Convention on Climate Change in November 2017, major mitigation efforts of the energy sector mainly focused on the following:

a) Setting Sustainable Development Targets for the Energy Sector
   i) The energy sector aims to reduce energy intensity by 45% in 2035 from the baseline year of 2005. Energy intensity can be reduced through energy efficiency improvements and energy conservation as well as by diversifying the economy to high value-added but less energy-intensive industries.

ii) Deployment of renewable energy technologies is targeted to increase by 10% by 2035. This could be achieved by both public and private sector investments on these technologies. At present, policy frameworks that incentivise private sector investments are being prepared.

b) Promoting EEC
   i) Improving supply-side efficiency. The government is pursuing a strategy to improve efficiency of existing open-cycle gas turbines through the installation of heat recovery steam generators while more efficient combined-cycle gas turbines are being used for new capacity expansion.
   ii) Managing electricity demand. Demand management is one strategy to reduce the use of fossil fuels in electricity generation. This could be achieved by improving energy efficiency of the stock of energy technologies and increasing the efficiency of the use of existing technologies.
      - EEC building guidelines and standards and labelling scheme. The Building Guidelines and the soon-to-be implemented standards and labelling order for electrical appliances are regulatory frameworks that allow only efficient technologies to be used in new buildings, and only efficient electrical appliances to be sold in the market.
      - Energy management. The planned energy management scheme will ensure that existing equipment and technologies are operating at efficiency levels consistent with industry's best practices.
      - Tariff reforms. The progressive electricity tariff structure, which was introduced in 2012, is an economic tool to manage efficient use of energy by providing a financial disincentive to higher energy consumption.
   iii) Managing transport energy demand. Among the end-use sectors, the contribution of the transport sector in the overall emissions is significant. Road transport energy demand management is key to reducing fossil fuel consumption of the sector. The strategies outlined in the Land Transport Master Plan could be categorised as follows:
      - Efficient transport technologies. Promoting the deployment of efficient and less-polluting vehicles and fuel technologies is outlined in the 4th strategy of the Land Transport Master Plan. The implementation of measures under this strategy will improve the overall efficiency of the road transport fleet.
      - Improving fuel economy through traffic flow improvement. Vehicles often reach their optimal fuel economy at specific speeds. Vehicles have lower fuel economy at slower speeds. Managing traffic volume and reducing road congestion would improve fuel economy of the vehicle fleet.

- Managing private transport demand. The strategy to reduce car dependency through the development of public transport systems would eventually reduce individual transport demand and consequently reduce fuel consumption. In addition, strengthening the management of the transport infrastructure and services would further encourage a shift from individual travel towards a mass transport system.

Along with economic development to achieve the objectives of Wawasan Brunei 2035, a significant increase in the activity level of all economic sectors, including the energy sector, is expected. Despite the increased focus on EEC, energy demand of Brunei Darussalam is projected to increase steadily. In meeting the growing domestic energy demand, fossil fuels will remain as the primary source of supply for the country.

The results of the model used by this study show the improvement in energy efficiency, when coupled with the implementation of appropriate legislative measures and development of renewable energy, contributing to the reduction in the TPES and the TFEC at 18.7% and 19.2%, respectively. The model also shows that improvement in energy efficiency will help reduce CO_2 emissions by 27.9%.

CHAPTER 4

CAMBODIA COUNTRY REPORT

Chiphong Sarasy, *Ministry of Mines and Energy, Cambodia*

1. Background

The Kingdom of Cambodia is located in the lower Mekong region of Southeast Asia. The country has an area of 181,035 square kilometres; with an 800 kilometre border with Thailand in the west, Lao People's Democratic Republic in the north, and Viet Nam in the east. The physical landscape is dominated by lowland plains around the Mekong River and Tonle Sap Lake. About 2.5 million hectares are arable land and over 0.5 million hectares are pastureland.

The real gross domestic product (GDP) in 2015 was almost US$[1] 15.9 billion (World Bank, 2017), comprising agriculture (29%), industry (26.18%), and services (39.43%). Cambodia's economy maintained high economic growth exceeding 7% since 2011. The Ministry of Economy and Finance predicted that the GDP growth rate will be maintained at the 7% range.

The population census of Cambodia 2008 revealed 13,388,910 people, 56% of whom were under 24 years old (NIS, 2009). Cambodia's population in 2015 was 15.5 million. As migration into urban areas has been continuous, the urban population can be more than 15% of the national population. The population density is about 75 people per square kilometres. About 85%–90% reside in rural areas. Phnom Penh, the capital city, has about 2 million people, and Siem Reap Province has about 100,000.

Cambodia's power generation facility by fuel type is shown in Table 4.1. The installed capacity of hydropower occupied around 55% of the total. The generated energy by hydropower in 2016 was around 1.2 times as much as in 2015. Cambodia's hydropower energy potential was estimated with the theoretical potential of about 10,000 megawatts (MW), of which 50% is in the Mekong mainstream, 40% in its tributaries, and the remaining 10% is in the southwestern coastal area outside the Mekong River Basin. Hydropower capacity will be developed up to 4,000 MW by 2030. Coal-fired power generation will have a capacity of 403 MW by 2015.

[1] All US$ in this report are in constant 2010 values unless specified.

Table 4.1: Power Generation Facility by Fuel Type

No	Type of Generation	Installed Capacity (MW)		Proportion in % for 2016
		2015	2016	
1	Hydro	929.7	930.0	55.3
2	Diesel/heavy fuel oil	304.6	304.2	18.1
3	Biomass	19.9	17.6	1.1
4	Coal	403.0	429.2	25.5
5	Solar	0.0	0.0	0.00
	Total	**1,657.2**	**1,689.0**	**100.00**

MW = megawatt.

Source: EAC (2017).

Cambodia's total primary energy supply in 2015 stood at 7 million tons of oil equivalent (Mtoe). Renewable energy (mostly biomass) represented the first-largest share of the total primary energy supply at 62.4% while oil was the second-largest share at 27.4%, followed by coal at 8.3%. The remaining share is the electricity import (1.9%).

Total final energy consumption was about 6 million tons of oil equivalent (Mtoe) in 2015. It is dependent on imports of petroleum products, having no crude oil production or oil refining facilities. Its electricity supply is dominated by hydro at 45.5% with oil, coal, biomass, and imports accounting for the rest.

2. Modelling Assumptions

2.1. GDP and Population

Forecasting energy demand to 2040 assumes that the GDP of Cambodia will grow at an annual rate of 5.5%. Its population, on the other hand, is projected to grow at 1.5% per year resulting in a growth rate of GDP per capita of 3.9% per year up to 2040 (Table 4.2).

Table 4.2: Updated Cambodia Energy Information

Year	2015	2020	2030	2040	AAGR (%) 2015–2040
GDP	15.9	20.8	35.5	60.6	5.5
Population	15.5	16.7	19.4	22.5	1.5

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

Source: Author's assumptions based on various consultations.

2.2. Electricity Generation

On future electricity supply, hydro is expected to dominate Cambodia's fuel mix in 2040, followed by coal. This is a big change from the current oil-dominated electricity generation. According to the Electricity Supply Development Master Plan for 2010–2020, Cambodia will have a total additional installed electricity generation capacity of 3,536 MW, of which 1,050 MW will come from coal-fired power plants to be installed from 2010 to 2018. Hydro will make up 2,606 MW of the total. From 2020 to 2040, hydro will meet the additional electricity generation capacity requirements (Tables 4.3 and 4.4).

Table 4.3: BAU Installed Capacity

Technology	Installed Capacity (MW)					
	2017	2020	2025	2030	2035	2040
Coal	535	785	1,385	1,985	2,185	2,485
Oil	264	0	0	0	0	0
Natural gas	0	0	0	900	900	1500
Hydro	979	1,379	2,523	3,819	4,019	4,619
Other						
Biomass	74	74	74	74	74	74
Solar, wind	10	10	10	10	300	300
Biofuel	0	0	0	0	0	0
Electricity	416	416	416	416	416	416
Total	**2,278**	**2,664**	**4,408**	**7,204**	**7,894**	**9,394**

BAU = Business-As-Usual.

Source: Author's assumptions based on administrative data of various agencies.

Table 4.4: APS Installed Capacity

Technology	Installed Capacity (MW)					
	2017	2020	2025	2030	2035	2040
Coal	535	535	535	535	535	535
Oil	264	0	0	0	0	0
Natural gas	0	300	300	300	300	300
Hydro	979	2,000	2,800	3,600	4,800	5,600
Other						
Biomass	74	150	200	300	400	500
Solar, wind	10	100	400	600	800	1,000
Biofuel	0	0	0	0	0	0
Electricity	416	650	900	1,200	1,500	1,800
Total	**2,278**	**3,735**	**5,135**	**6,535**	**8,335**	**9,735**

APS = Alternative Policy Scenario, MW = megawatt.

Source: Author's assumptions based on administrative data of various agencies.

2.3. Energy Efficiency and Conservation Policies

Cambodia's energy efficiency and conservation (EEC) policies aim to achieve an integrated and sustainable programme that will facilitate improvements in energy efficiency in the major energy-consuming sectors and help prevent wasteful fuel consumption. To achieve these aims, the country realises the need to transform the market towards more efficient energy use, increased access to energy efficiency project financing, and the establishment of energy efficiency regulatory frameworks. As a start, Cambodia is implementing the following pilot projects:

- Improving the efficiency of the overall supply chain for home lighting in rural areas by providing decentralised rural energy services through a new generation of rural energy entrepreneurs.
- Assisting in market transformation for home and office electrical appliances through bulk purchases 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 the relevance of EEC.
- Improving energy efficiency in buildings and public facilities.
- Improving energy efficiency in industries in cooperation with the United Nations Industrial Development Organization and the Ministry of Industry, Mines and Energy (now changed to Ministry of Mines and Energy) to be implemented in the following sectors: rice mill, brick kiln, rubber refinery, and garment.

Cambodia has also started preparing an action plan for EEC in cooperation with the Energy Efficiency Design sub-working group. Specific actions plans are being drafted for the industry, transport, and 'others' sectors. The initial estimates of sector demand reduction of existing consumers from these actions plans are 10% by 2015 and 15% by 2035 relative to the BAU scenario. These initial estimates were used in forecasting the energy demand in the Alternative Policy Scenario (APS).

The previous Ministry of Industry, Mines and Energy, in close consultation with the European Union Energy Initiative Partnership Dialogue Facility , agreed to launch a project to support the Royal Government of Cambodia in the elaboration of the National Energy Efficiency Policy, Strategy and Action Plan (MIME, 2013). The inception phase of the project began in August 2012; the project was concluded in April 2013 through a final workshop, which elaborated the recommendations and conclusion in the plan.

The National Energy Efficiency Policy, Strategy and Action Plan targets energy efficiency in the following priority areas: industry, end-user products, buildings, rural electricity generation and distribution, and use of biomass resources for residential and industrial purposes.

The energy efficiency assumptions in the Long-range Energy Alternatives Planning System, or LEAP model, are based on the assessment of the energy efficiency potential for buildings, industry, and transport. The overarching target of the National Energy Efficiency Policy is to reduce energy demand by 20% in 2035 relative to the BAU scenario.

2.4. Cambodia's Intended Nationally Determined Contributions (INDC)

Cambodia's intended greenhouse gas (GHG) mitigation contribution for the non-LULUCF[2] sectors, conditional upon the availability of support from the international community, will be a reduction of 3,100 total greenhouse gas emissions (Gg CO_2e) compared to the baseline emissions of 11,600 Gg CO_2e by 2030. This amounts to 27% reduction of GHG emissions by 2030 (Table 4.5).

Table 4.5: Cambodia's INDC Targets

Sector	Priority Action	Reduction as Gg CO_2eq and % in 2030 Compared to the Baseline
Energy industry	• National grid connected renewable energy generation (solar energy, hydropower, biomass, and biogas) and connecting decentralised renewable generation to the grid • Off-grid electricity such as solar home systems, hydro (pico, mini, and micro) • Promoting energy efficiency by end users	1,800 (16%)
Manufacturing industries	Promoting use of renewable energy and adopting energy efficiency for garment factories, rice mills, and brick kilns.	727 (7%)
Transport	• Promoting mass public transport • Improving operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and the increased use of hybrid cars, electric vehicles, and bicycles	390 (3%)
Other	• Promoting energy efficiency for buildings and more efficient cook stoves • Reducing emissions from waste through use of biodigesters and water filters • Using of renewable energy for irrigation and solar lamps	155 (1%)
Total Savings		**3,100 (27%)**

Gg CO_2e - total greenhouse gas emissions, INDC = Intended Nationally Determined Contributions.
Source: Kingdom of Cambodia (2015).

2 Land use, land-use change, and forestry.

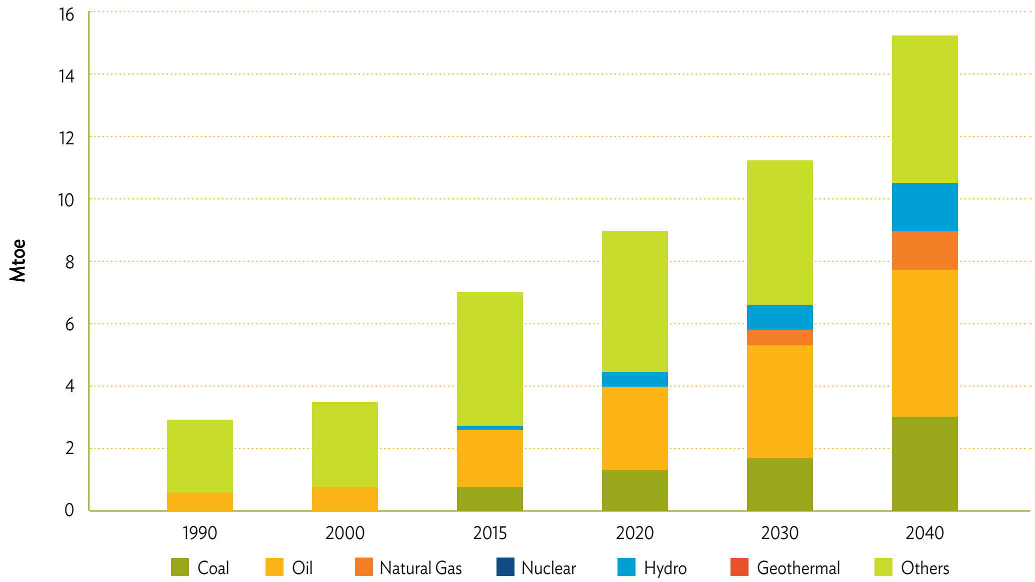
3. Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final energy consumption

Primary energy consumption in Cambodia grew at 4.6% per year, which is a slightly faster rate than final energy demand from 2.84 Mtoe in 1995 to 7.04 Mtoe in 2015. Amongst the major energy sources, oil grew the fastest. Oil consumption grew at an average annual rate of 6.9% between 1995 and 2015 (Figure 4.1).

Figure 4.1: Primary Energy Supply by Source, BAU



BAU = Business-As-Usual, Mtoe = miilion tons of oil equivalent.

Source: Author's calculation.

In the BAU scenario, Cambodia's primary energy consumption is projected to increase at an annual rate of 3.1% per year or 2.2 times, from 7.04 Mtoe in 2015 to 15.24 Mtoe in 2040. The fastest growth is expected in hydro, increasing at an annual average rate of 9.1% between 2015 and 2040, followed by coal (6.7%) and oil (3.7%). The share of hydro is projected to increase from 2.4% in 2015 to 9.9% in 2040. This growth in the share is due to the huge potential of water reserves available in Cambodia. The share of oil is projected to increase from 27.4% in 2015 to 31.2% in 2040 due to the growth of the number of cars and motorbikes.

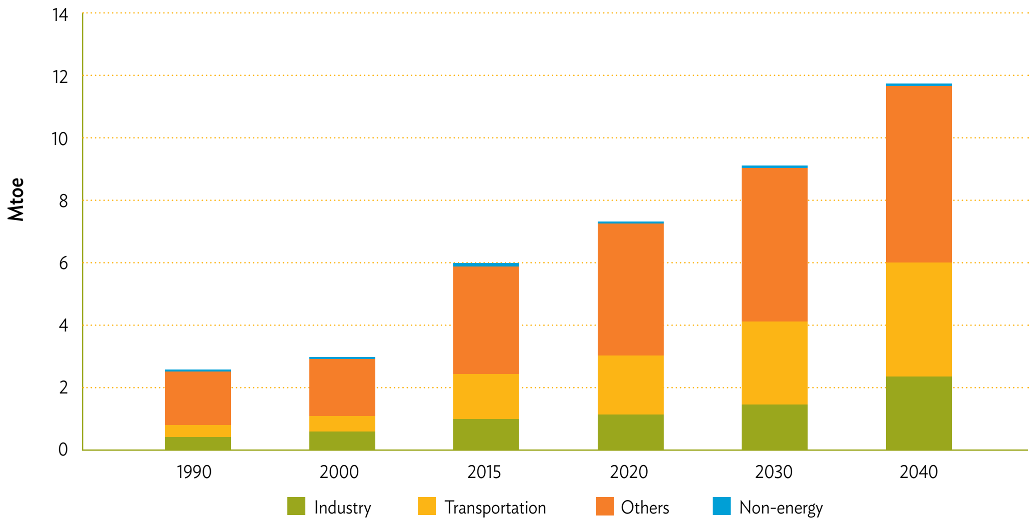
3.1.2. Final energy demand

3.1.2.1. By sector

Cambodia's final energy demand grew at an average annual rate of 4.3% per year, from 2.54 Mtoe in 1995 to 5.93 Mtoe in 2015.

In the BAU scenario, driven by assumed strong economic growth and an increasing population, final energy demand is projected to increase at an average annual rate of 2.8% or around 2 times, from 5.93 Mtoe in 2015 to 11.77 Mtoe in 2040 (Figure 4.2).

Figure 4.2: Final Energy Consumption by Sector, BAU



BAU = Business-As-Usual, Mtoe = miilion tons of oil equivalent.

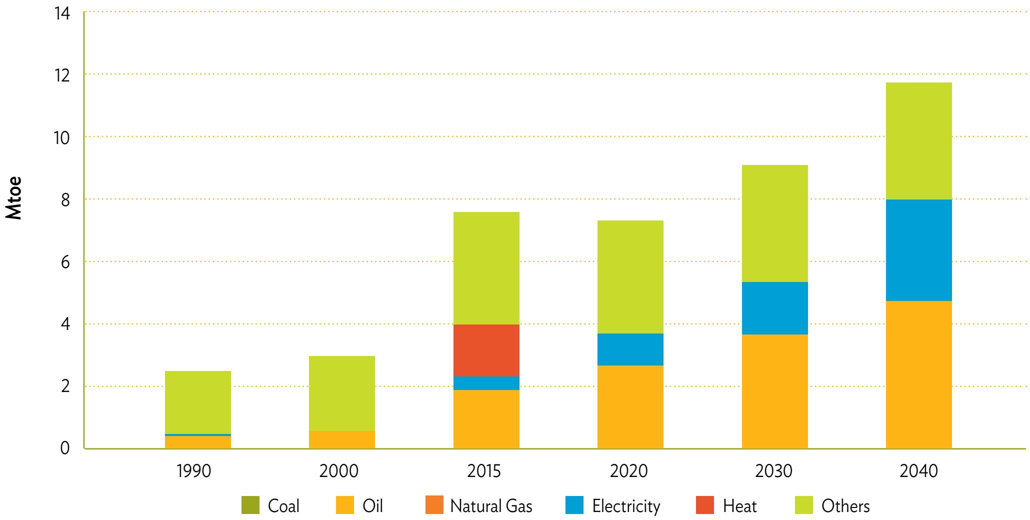
Source: Author's calculation.

The strongest growth in demand is projected to occur in the transport sector at an average annual rate of 3.9% per year or 2.6 times, from 1.39 Mtoe in 2015 to 3.59 Mtoe in 2040. In addition, the industry sector is projected to grow at an annual rate of 3.5% or 2.3 times, from 1.03 Mtoe in 2015 to 2.41 Mtoe in 2040, followed by the non-energy sector at 3.2% (from 0.05 Mtoe in 2015 to 0.10 Mtoe in 2040) and the 'others' sector at 2% (from 3.45 Mtoe in 2015 to 5.67 Mtoe in 2040).

3.1.2.2. By fuel type

Electricity is projected to exhibit the fastest growth in final energy demand at 8.4% per year, or 7.6 times, from 0.43 Mtoe in 2015 to 3.24 Mtoe in 2040. Oil is projected to have the second-highest growth rate of 3.8% per year or 2.5 times, from 1.87 Mtoe in 2015 to 4.75 Mtoe in 2040. 'Others', which mainly include solid and liquid biofuels, will increase at 0.2% per year from 3.62 Mtoe in 2015 to 3.76 Mtoe in 2040 (Figure 4.3).

Figure 4.3: Final Energy Consumption by Fuel Type, BAU



BAU = Business-As-Usual, Mtoe = miilion tons of oil equivalent.

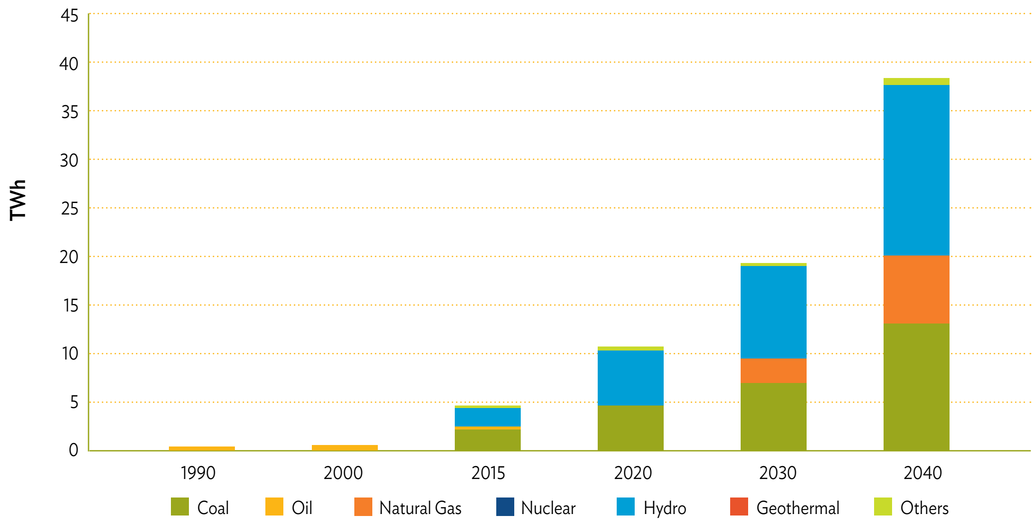
Source: Authors' calculation.

3.1.3. Electricity generation

Electricity generation in Cambodia increased at 16.8% per year from 0.20 TWh in 1995 to 4.40 TWh in 2015. From 1995 to 2000, electricity was 100% generated by oil-powered power plants. By 2015, three other types of power plants had contributed in electricity generation in Cambodia. Coal-fired power plants have a share of 48.4%, hydro with a 45.5% share, and 'others' with a 0.9% share.

In the BAU scenario, to meet the demand for electricity, power generation is projected to increase at an average rate of 9% per year between 2015 and 2040. The fastest growth in electricity generation will be in 'others' (11.7% per year), followed by hydro (9.1% per year) and coal (7.5% per year) (Figure 4.4). Generation from oil-fired power plants will decrease considerably due to high fuel costs.

Figure 4.4: Power Generation by Fuel Type, BAU



BAU = Business-As-Usual, TWh = terawatt-hour.

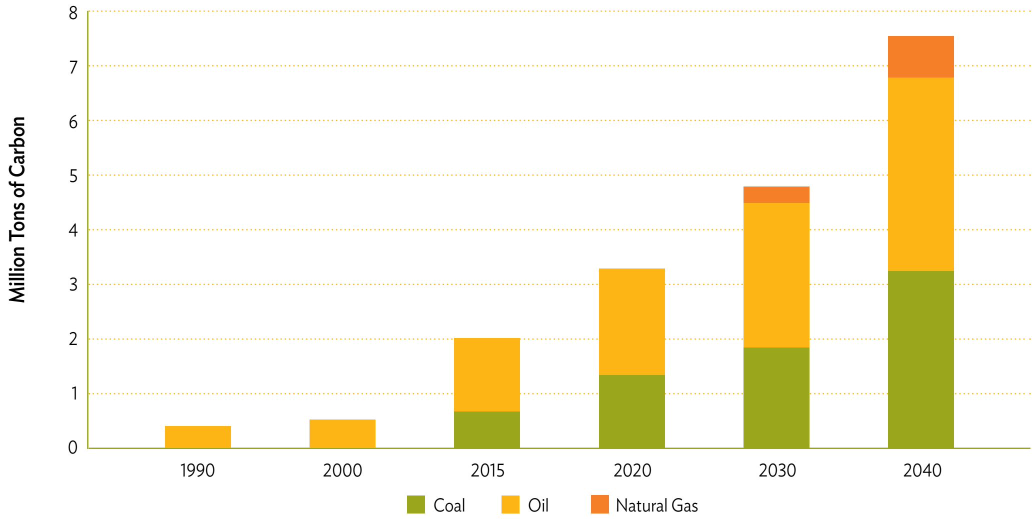
Source: Author's calculation.

3.1.4. CO_2 emissions

CO_2 emissions from energy consumption are projected to increase by 5.4% per year from 2.02 million tons of carbon (Mt-C) in 2015 to 7.60 Mt-C in 2040 under the BAU scenario.

Oil is the largest source of carbon emissions; it will increase from 1.39 Mt-C in 2015 to 3.55 Mt-C in 2040. Emissions from coal would grow the fastest at 6.8% per year, from 0.63 Mt-C in 2015 to 3.24 Mt-C in 2040 (Figure 4.5).

Figure 4.5: CO_2 Emissions from Energy Consumption, BAU



BAU = Business-As-Usual.

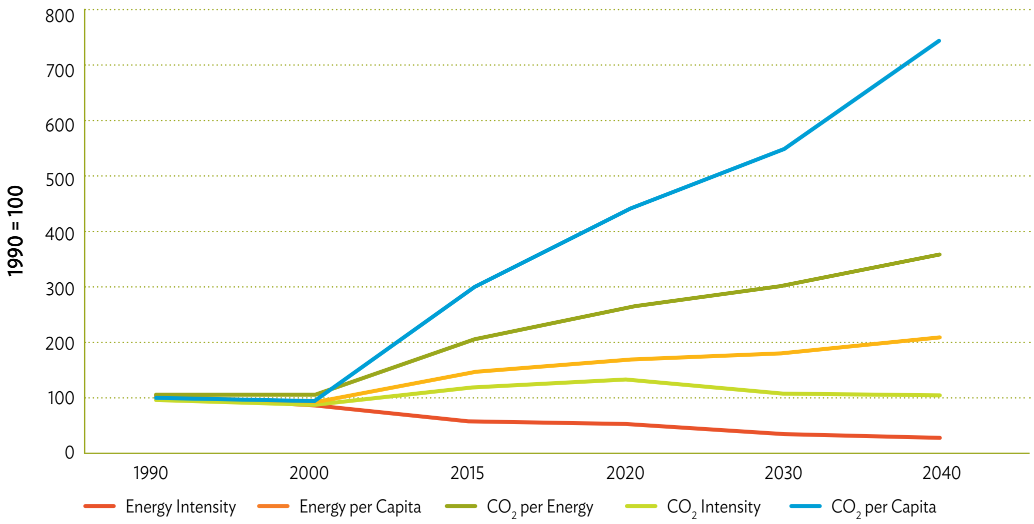
Source: Author's calculation.

3.1.5. Energy indicators

Primary energy intensity had a decreasing trend from US$775 toe/million in 1995 to US$ 442 toe/million in 2015. In the BAU scenario, energy intensity will further decrease to US$ 251 toe/million in 2040. This indicates that energy will be used more efficiently in economic development. Such is mainly due to the dominance of conventional biomass use in the rural areas of the country, and its future growth will be slower than GDP growth.

Primary energy per capita had been increasing from 0.3 toe per person in 1995 to 0.5 toe per person in 2015. In the BAU scenario, energy per capita will further increase to 0.68 toe per person in 2040. This indicates that living standards of people are improving, resulting in increasing energy demand per capita. Figure 4.6 shows various indicators for energy consumption.

Figure 4.6: Energy and CO_2 Indicators



Source: Author's calculation.

CO_2 per primary energy in the BAU scenario is projected to increase from 0.3 metric tons of carbon per toe (t-C/toe) in 2015 to 0.50 t-C/toe in 2040, implying faster growth of fossil fuels in total energy consumption. However, CO_2 intensity had been increasing from 108 t-C/million US$ in 1995 to 127 t-C/million US$ in 2015. It will drop to 125 t-C/million US$ in 2040.

4. Scenario Analysis

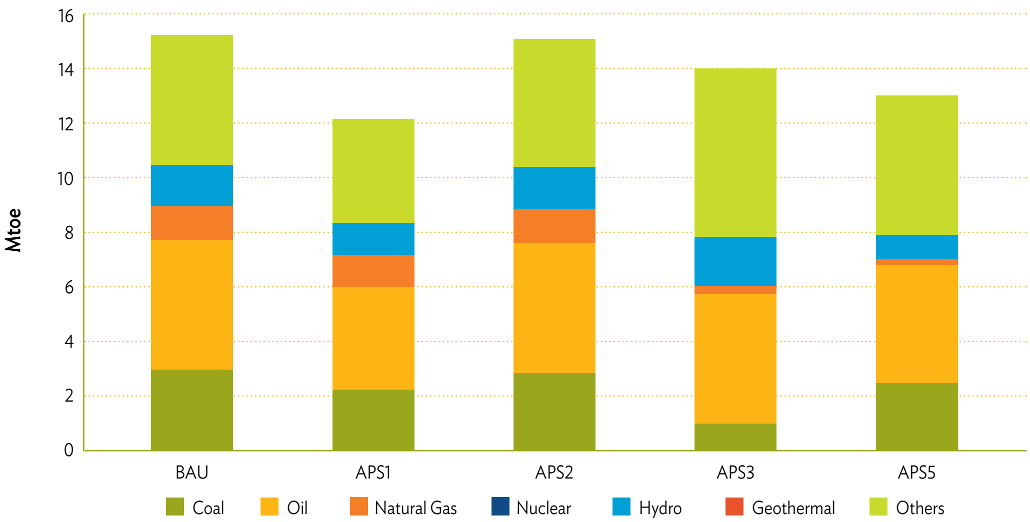
4.1. Alternative Policy Scenario

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

- APS1: focus on EEC on the demand side, such as
  - energy demand in all sectors to be equal in numbers in 2015 and reduced by 20% by the year 2040 relative to the BAU scenario
  - using efficient motorbikes and hybrid car in road transport
  - replacing inefficient devices with efficient ones in the commercial and residential sectors, such as in cooking, lighting, refrigeration, air conditioning.
- APS2: improvement of energy efficiency in thermal power plants. Energy efficiency of coal and fuel oil thermal power plants is assumed to stay constant at 32% until 2040 in the BAU scenario. In the APS, new coal fired power plants are assumed to have thermal efficiencies of 39%.
- APS3: Maximum capacity of 5,000 MW for hydro power plants by 2040 is assumed in this scenario.
- APS5 or APS: combination of APS1 to APS3.

The assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, and APS5. Figure 4.7 shows the changes in primary energy supply in all scenarios. APS1 and APS5 have the largest reduction in primary energy supply in 2040 due to the energy efficiency assumptions on the demand side. Energy efficiency assumptions in APS1 could reduce primary energy supply in the BAU scenario by as much as 12.2 Mtoe or 20%. For APS5, the reduction will be slower, amounting to 13 Mtoe or 14.4%.

Figure 4.7: Comparison of Scenarios to Total Primary Energy Supply by 2040

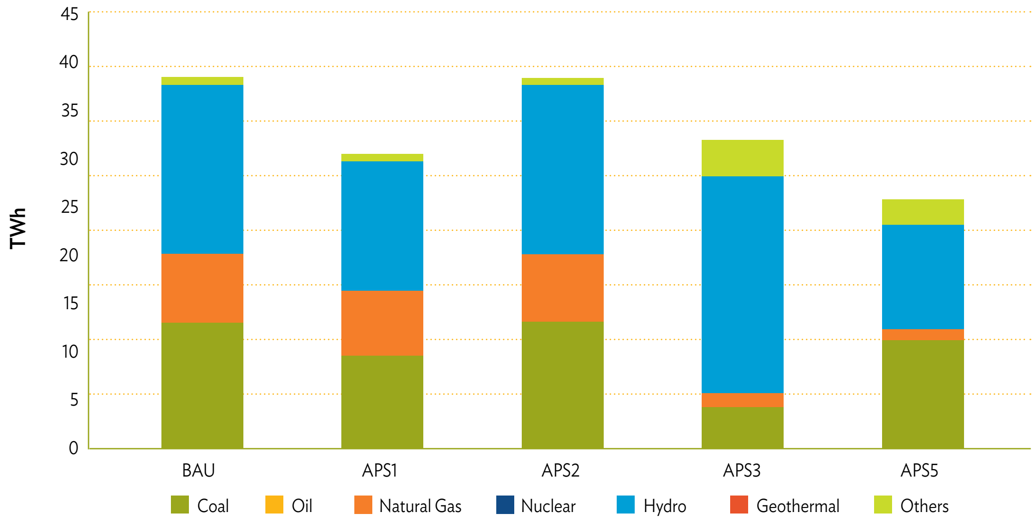


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = millions of oil equivalent.

Source: Author's calculation.

Figure 4.8 shows the total electricity generation in 2040 in all scenarios. In APS1, due to the lower electricity demand, the fossil fuel–fired electricity generation will be lower than 19% compared to the BAU scenario. In APS2, the share is the same as that of the BAU scenario. In APS3, due to the assumption of more renewable energy, the fossil fuel–fired generation will only be 14%. In APS5, where all scenarios are combined, the reduction in the share of fossil energy–based generation will be significant at almost 32.6% lower than the BAU scenario.

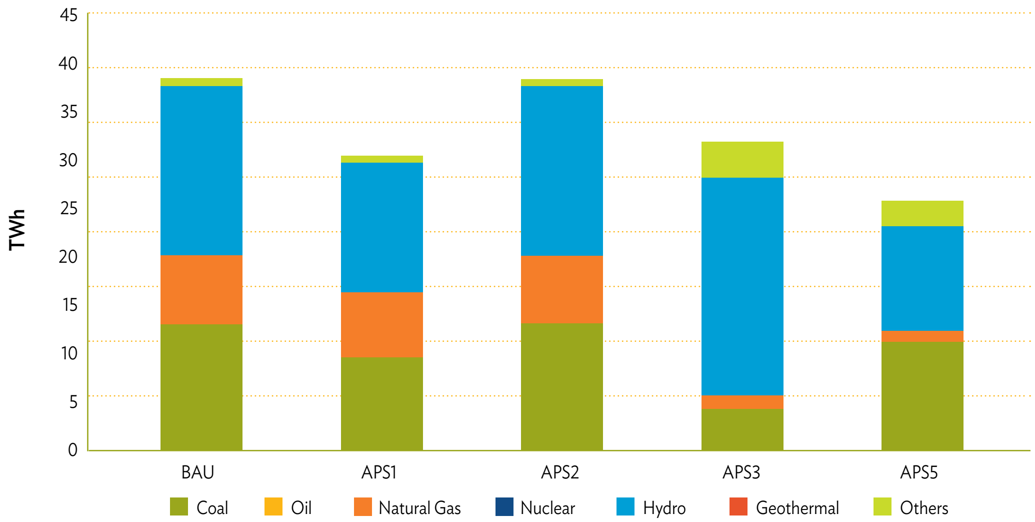
Figure 4.8: Comparison of Scenarios of Electricity Generation by 2040



Source: Author's calculation.

Figure 4.9 compares scenarios of CO_2 emissions in 2040. In terms of CO_2 emission reduction, the energy efficiency assumption in APS1 could reduce emissions by 21.2% in 2040 compared with the BAU scenario. In APS2, the installation of more efficient new power plants is projected to reduce emissions by 16.8%. Higher contributions from renewable energy could reduce emissions by 36.9%. All these assumptions combined (APS5) could reduce the BAU scenario CO_2 emissions by 34.5% in 2040.

Figure 4.9: Comparison of Scenarios to CO_2 Emissions, 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

4.2. Energy Saving Potential and CO_2 Emissions Reduction

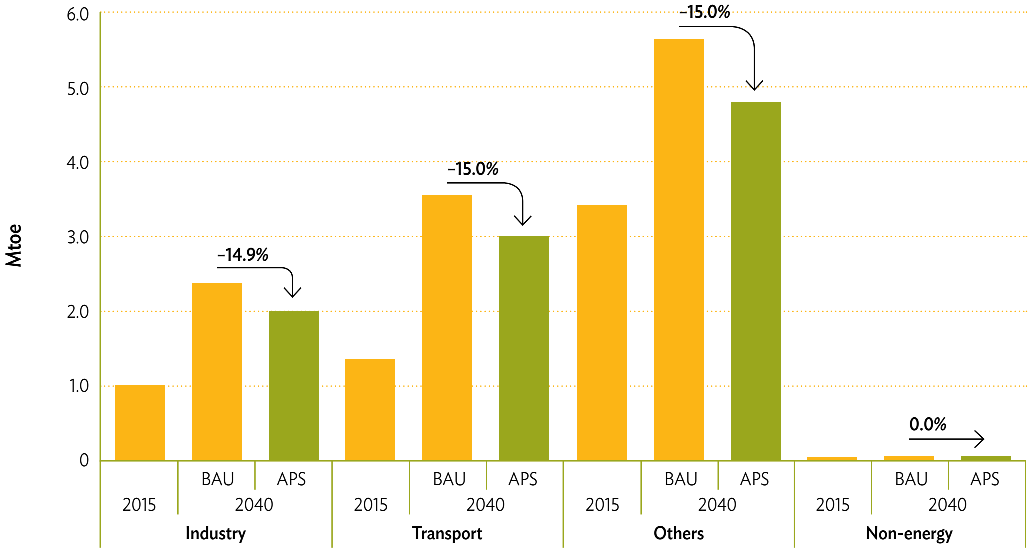
4.2.2. Final energy demand

In the APS, final energy demand is projected to increase at a slower rate of 2.8% (compared with 2.8% in the BAU scenario), from 5.93 Mtoe in 2015 to 10.02 Mtoe in 2040 because of EEC measures assumed in APS1 in the industry, transport, and 'others' (residential and commercial) sectors.

The APS final energy demand is 1.8 Mtoe lower than the BAU scenario, indicating that the APS includes savings up to 1.8 Mtoe. The bulk of the savings are expected to occur in the 'others' sector (0.9 Mtoe), followed by the transport sector (0.5 Mtoe), and the industry sector (0.4 Mtoe).

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

Figure 4.10: Final Energy Consumption by Sector, BAU vs APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = millions of oil equivalent.

Source: Author's calculation.

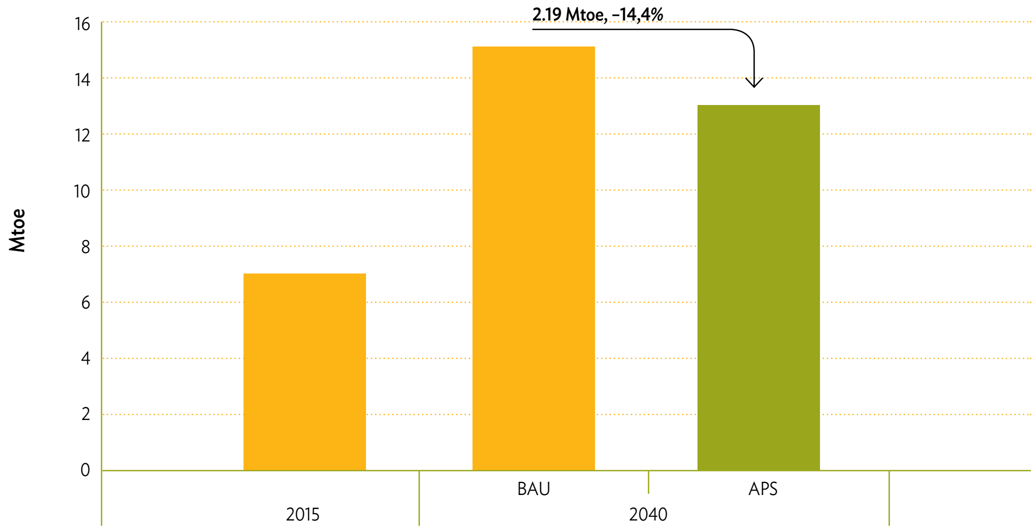
4.2.3. Primary energy consumption

In the APS, primary energy consumption is projected to have a slower increase rate of 2.5% per year, from 7.04 Mtoe in 2015 to 13.04 Mtoe in 2040. The savings could mostly be derived from the EEC scenarios on the demand side and development of renewable energy technology (APS3).

In the APS, hydro is projected to grow at an average annual rate of 7.0% compared with the 9.1% annual growth in the BAU scenario, followed by coal with a 5.9% annual growth rate compared with 6.7% in the BAU scenario, and oil with 3.3% compared with 3.7% in the BAU scenario over the same period.

The total savings amount to 2.2 Mtoe, which is equivalent to 21.5% of Cambodia's primary energy consumption in 2040 (Figure 4.11).

Figure 4.11: Primary Energy Supply by Fuel, BAU and APS

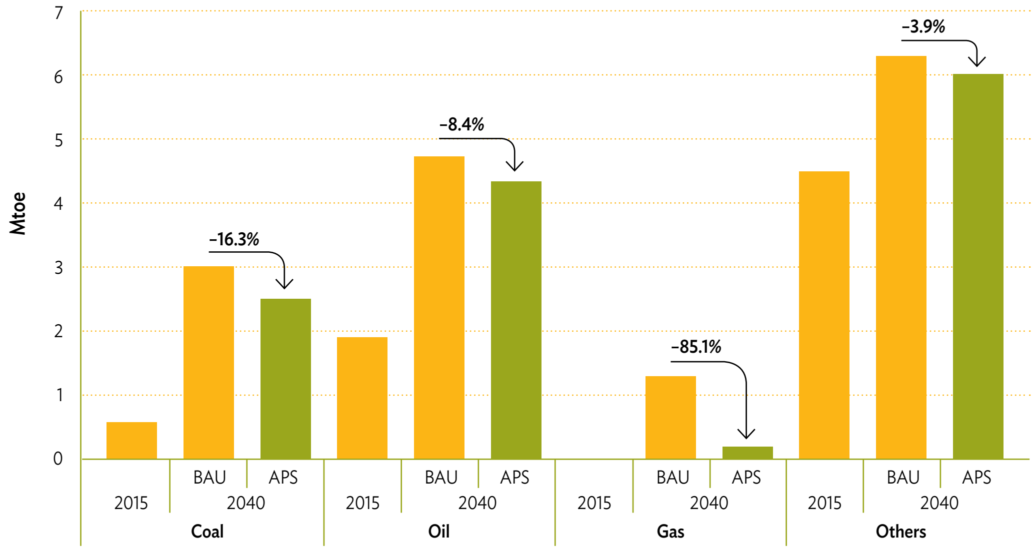


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe - million tons of oil equivalent.

Source: Authors' calculation.

The reduction in consumption, relative to the BAU scenario, comes from EEC 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. Accordingly, the energy saving potential from gas energy sources would be 85.1%, followed by coal at 16.3%, oil at 8.4%, and 'others' at 3.9% (Figure 4.12).

Figure 4.12: Total Primary Energy Saving Potential by Fuel Type, BAU vs APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

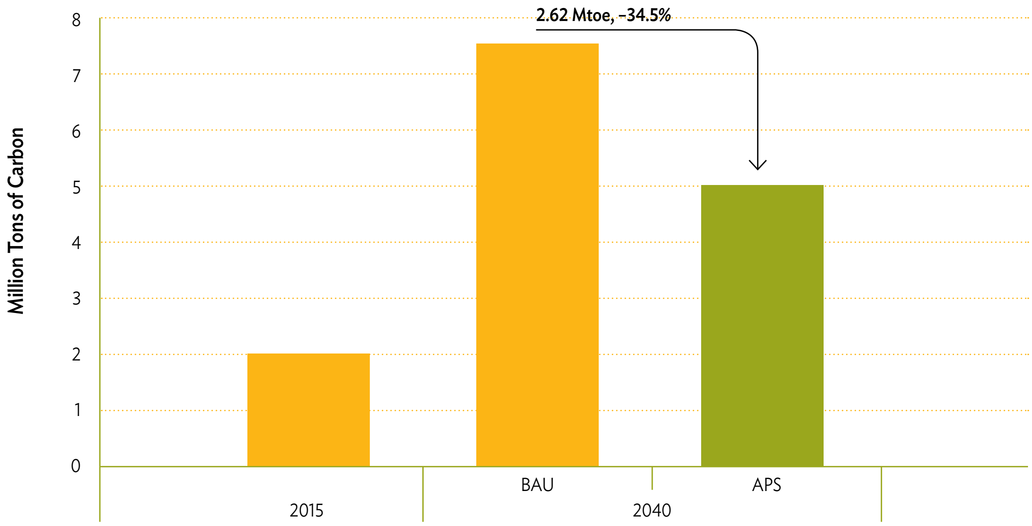
Source: Author's calculation.

4.2.4. CO_2 emissions

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 5.4% per year from 2.02 (Mt-C) in 2015 to 7.60 Mt-C in 2040. Under the APS, the annual increase in CO_2 emissions is projected to be 3.7% per year between 2015 and 2040, which represents a 34.5% reduction from the BAU scenario.

The CO_2 emissions reduction would be mostly derived from EEC measures on the demand side (APS1). Improvement of energy efficiency in thermal power plants (APS2) and development of renewable energy technologies (APS3) can also contribute significantly to CO_2 reduction (Figure 4.13).

Figure 4.13: CO_2 Emissions by Fuel Type, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = millions of oil equivalent.

Source: Authors' calculation.

4.2.5. Intended Nationally Determined Contributions/Nationally Determined Contributions

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 5.4% per year from 7.41 Mt-CO_2e in 2015 to 27.8 Mt-CO_2e in 2040. Under the APS, the annual increase in CO_2 emissions is projected to be 3.7% per year between 2015 and 2040. The APS emission in 2030 will be 3.9 Mt-CO_2e lower than BAU, which is in line with Cambodia's INDC.

Table 4.6: Results of CO_2 Emissions by Scenario (Million Tons CO_2)

Scenarios	2015	2020	2025	2030	2035	2040	AAGR (%) 2015-40
Reference (BAU)	7.41	12.00	14.27	17.51	21.56	27.83	54357.3%
Energy Efficiency (APS1)	7.41	11.35	14.48	14.92	15.63	21.93	4.4%
Efficient Supply (APS2)	7.41	12.00	13.49	16.21	19.84	23.15	4.7%
Renewable Energy (APS3)	7.41	10.57	11.61	12.94	14.79	17.57	3.5%
APS (Combined APS)	7.41	10.80	13.15	13.63	14.29	18.22	3.7%

AAGR = average annual growth rate, Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculation.

5. Key Findings and Policy Implications

The above analysis on energy saving potential yields the following key findings:

- Energy demand in Cambodia is expected to continue to grow significantly, driven by robust economic growth, industrialisation, urbanisation, and population growth. EEC is the 'new source' of energy, and measures reflected in the APS are estimated to have significant potential to help meet future demand in a sustainable manner.
- Cambodia's energy intensity will be further reduced due to efficient use of energy.
- The annual growth of energy demand in the transport sector is projected to be the highest at 3.9% in the BAU scenario and its share will increase continuously from 23.5% in 2015 to 30.5% in 2040. This shows that the transport sector has a large energy saving potential.
- Electricity demand is increasing at the highest annual growth rate of 8.4% in the BAU scenario and is projected to be a slightly lower at 7.7% in the APS.
- Hydropower plants will be the major power generation source in Cambodia. Their share in the total power generation output is increasing slightly from 5.5% in 2015, leading up to 45.8% in 2040.
- Coal thermal plants will be the second major source of power generation in Cambodia. Its share in the total power generation output would decrease continuously from 48.4% in 2015 to 34.1% in 2040.

From the findings above and to be able to implement EEC activities in Cambodia effectively, the following actions are recommended:

- *Promotion of the establishment of targets and road map for EEC implementation*. The targets for EEC in Cambodia should be set up for the short, medium, and long term and focused on the building and industry sectors. The long-term plan should be set up based on an assessment of energy saving potential for all energy sectors, including the residential and commercial sectors, which have a large potential on energy saving until 2040. Moreover, some activities can promote EEC in Cambodia. Examples are (i) support for the development of professionals in the energy conservation field to be responsible persons for energy management and operation, verification and monitoring, consultancy, and engineering services provision and the planning, supervision, and promotion of the implementation of energy conservation measures; (ii) support for the development of institutional capability of agencies/organisations in the public and private sectors responsible for the planning, supervision, and promotion of the implementation of energy conservation measures; (iii) support for the operation of energy-saving companies to alleviate technical and financial risks of entrepreneurs wishing to implement energy conservation measures; (iv) public relations and provision of knowledge on energy conservation to the general public via the teaching/learning process in educational institutions, fostering youth awareness.
- *Compulsory energy labelling for electrical appliances*. The annual growth of electricity demand in the residential and commercial sectors is projected to be substantial compared to the other sectors. Compulsory energy labelling for electrical appliances could be an effective management measure to generate energy savings.
- *Priority for the development of advanced hydro and coal thermal power technology*. Hydro and coal thermal power plants will be the major power generation in Cambodia up to 2040. Therefore, advanced technologies for both types of resources should be prioritised for development from the project design stage.
- *Priority for renewable energy development*. Renewable energy is an important resource for energy independence, energy security, and GHG emissions abatement. It is necessary to build up the strategy and mechanisms to support renewable energy development.

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CHAPTER 5

CHINA COUNTRY REPORT

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1. Background

1.1 Natural Conditions and History

China (officially known as the People's Republic of China, the PRC) has a land area of 9.6 million square kilometres (km2) and is situated in eastern Asia on the western shores of the Pacific Ocean. China's continental coastline extends for about 18,000 kilometres, and its vast sea surface is studded with more than 5,000 islands. Due to its size, China's climate is 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. The PRC was founded on 1 October 1949. China has been implementing reforms and opening up its economy for 40 years and has established a socialist market economy, thereby charting the course for socialist modernisation with Chinese characteristics.

1.2 Economy and Population

China's gross domestic product (GDP) in 2017 was around US$12,225 trillion, which translates into a per capita GDP of around US$8,848.0 (in 2017 US$ terms). China is currently the world's most populous country, with about 1.39 billion people in 2017 (National Bureau of Statistics, 2017). To mitigate population growth, China has implemented a family planning policy since the 1970s. However, in 2015, the 'one child' policy ended, and couples that satisfy the conditions can have two children. China has been experiencing fast urbanisation at the annual growth rate of about 1% since 1978 when China's reform and opening up started. At the end of 2017, around 58.5% of the population lived in urban areas.

1.3 Energy Situation

In terms of energy resources, 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 tons. In 2015, the country produced 3.75 billion tons of raw coal. China is still a major crude oil producer, with output of 214.6 million tons of crude oil in 2015. However, driven by very fast increases in oil demand, China became an oil importer in the 1990s. In 2014, the amount of net imported oil reached 328 million tons with a growth rate of 6.4% and a dependence level of more than 60%. China is also a large producer and exporter of energy-intensive items. In 2015, it produced 2.36 billion tons of cement and 1.12 billion tons of finished steel, of which 112 million tons were exported (National Bureau of Statistics and China Energy Statistics Yearbook).

China's per capita energy reserves are considerably lower than those of the world average. The per capita average of both coal and hydropower resources is only about 50% of the world average, while the per capita average of both oil and natural gas reserves is only about one-fifteenth 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, at 60.6%, while oil, natural gas, and hydro consumption accounted for 13.6%, 1.5%, and 1.3%, respectively. However, biomass consumption represented 23%, which is only lower than that of coal consumption. In 2015, coal was still a major fuel, with a higher share of about 66.7%. The share of other energy sources increased from 1990 levels to 18.0% for oil, 5.3% for gas, and 3.2% for hydro, but the share of biomass decreased to 3.5%. Primary energy consumption in China increased at an average annual rate of around 5% from 870.7 million tons of oil equivalent (Mtoe) in 1990 to 2,973.3 Mtoe in 2015. Energy intensity (primary energy demand per unit of GDP) declined from 1,050 tons of oil equivalent per million US$ in 1990 to 344 tons of oil equivalent per million US$ in 2015.

Final energy consumption in China increased at a lower average annual rate of 4.4%, from 664.2 Mtoe in 1990 to 1,905.7 Mtoe in 2015. Coal accounted for 47.9% of final energy consumption in 1990 and 36.8% in 2015. In 1990, oil consumption accounted for 12.7% of total final energy consumption and had increased rapidly at 7.4% per year between 1990 and 2015, significantly increasing its share to 25.2% in 2015. Both electricity and natural gas consumption grew sharply at 16.0% and 5.5% per year, respectively, between 1990 and 2015. It makes the shares of electricity and natural gas consumption increase from 5.9% and 1.3% in 1990 to 21.9% and 5.5% in 2015. In 2015, the share of electricity consumption had almost reached the same as that of oil consumption.

Industry is the major energy-consuming sector in China, followed by the residential and commercial ('others') sectors. The share of industry consumption increased from 36.7% in 1990 to 50.7% in 2015. Conversely, the share of energy consumption in the 'others' sector declined from 51.8% in 1990 to 25.4% in 2015 because of relatively faster growth in the industry and transport sectors.

Power in China is mainly generated from coal-fired power plants, whose electricity generation accounted for around 71% of the total amount in 1990. By 2015, this share increased to 78.2%. The share of hydro was 20.4% in 1990 but declined to 16.4% in 2015. Gas and oil, collectively, accounted for about 2.7% of total generation in 2015. The share of nuclear power increased to about 2.9% in 2015.

The Chinese government is pushing for the development of a modern energy industry. Resource conservation and environmental protection are two basic state policies, giving prominence to building a resource-conserving and environment-friendly society in the course of its industrialisation and modernisation.

2. Modelling Assumptions

2.1. Population and Gross Domestic Product

The model results for China have been developed by the Institute of Energy Economics, Japan and were taken from modelling of the Business-As-Usual (BAU) scenario and the Alternative Policy Scenarios (APS).

China's population increased from 1.135 billion in 1990 to 1.375 billion in 2015. It is assumed to increase at an average rate of 0.2% per year in 2015–2040, the projection period. The population will peak at 1.450 billion around 2030 and reach 1.428 billion by 2040.

China's economy grew at an average annual rate of 10.2% from US$530.6 billion in 1990 to about US$4.913 trillion in 2013 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.5% per year from 2015 to 2020 because of the 'new normal' state of China's economy, 5.3% per year in 2020–2030, and 4.2% per year in 2030–2040. The average annual growth rate of GDP in 2015–2040 is 5.1%. It is calculated to reach US$31.116 trillion by 2040. Given GDP and population assumptions, GDP per capita in China is assumed to increase from around US$6,500 per capita in 2015 to US$22,400 per capita in 2040.

2.2. Energy and Climate Change Policies and their Performance

Although China is still a developing country and its GDP per capita is around one-seventh that of the United States (according to nominal exchange rate) in 2015, the government has set ambitious goals of reducing energy intensity and addressing climate change issues. According to the data from relevant official departments, in the last 5 years, China has achieved significant energy conservation and remarkable progress in environmental protection and climate change mitigation.

China's Outline of the 13th Five-Year Plan (2016–2020) for the 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 has already implemented administrative, market-based, and legal measures to promote energy conservation. Energy intensity reduction goals are assigned to provincial governments and progress is announced publicly every year. During the 12th Five-Year Plan (2011–2015), energy consumption grew at the rate of 3.6% and GDP increased at the rate of 7.8%. Accordingly, energy intensity decreased by 18.2%, successfully achieving the target of 16%. Energy consumption per unit of GDP in 2015 decreased by 5.6% compared with that of 2014.

In addition to energy intensity targets, controlling the total amount of energy consumption is proposed. According to the Energy Development Strategic Action Plan (2014–2020), China's coal consumption (primary energy consumption) would be controlled at 2,940 Mtoe in 2020 and primary energy consumption would be controlled at 3,362 Mtoe in 2020. According to the 13th Five-Year Plan of Energy Development, by 2020, the ratio of coal consumption to total energy consumption should be lowered to at most 60%, and natural gas consumption should account for 10% of the total amount. In addition, the amount of new energy vehicles will reach 2 million.

China announced its goal of reducing CO_2 emissions per GDP (carbon intensity) by 40%–45% by 2020 and 60%–65% by 2030 from the 2005 level. Apart from the carbon intensity target, China also declared that the CO_2 emissions will reach their peak at around 2030. To meet the target, China has implemented ambitious energy efficiency and fuel-switching policies. For instance, the government proclaimed its goal of cultivating 40 million hectares of forested land to mitigate greenhouse gas emissions. In 2014, China's CO_2 emissions per unit of GDP dropped by 9.1% compared to the level of 2013.

China also exerted great effort to develop non-fossil fuels and accelerate the development of renewable energy. The National People's Congress passed the Renewable Energy Development Law of China in 2005 to support renewable energy development in the country. The government also announced the target of increasing the share of non-fossil energy to about 15% by 2020 (measured in coal-equivalent) and about 20% in 2030. Subsidisation policies have also been developed to encourage the development of wind power, solar photovoltaic (PV), and biomass. In 2015, China invested US$102.9 billion on renewable energy, accounting for 36% of the total amount in the world. By the end of 2015, power generation capacity had reached 1,508 gigawatts (GW). Within this, the capacity of hydropower, which ranked first globally, reached 319 GW, increasing at a growth rate of 4.9%; the capacity of nuclear power plants was 26.08 GW; on-grid wind power capacity, which was the largest in the world, amounted to 129.34 GW, increasing 33.5% year on year; on-grid solar power reached 43.18 GW, growing 73.7% from a year earlier. The installed electricity capacity of non-fossil fuel such as hydro, nuclear, wind, and solar energy – in 2015 took up 34.3% of the whole, 1.5% higher than that of 2014. The electricity generated from non-fossil fuels accounted for 25.1% of the total on-grid electricity in 2015. China's current installed capacity, under-construction capacity, and generation of hydropower, the accumulative installed capacity of PV solar power, and the capacity of under-construction nuclear power all rank first in the world, which have positively contributed to addressing the problem of global climate change.

After the evaluation in 2015, China phased out the backward production capacity in the following industries: small thermal power units (4.23 GW), cement (50 million tons), and steel (30 million tons). To consume the surplus production capacity, from 2016 no new coal mine projects will be approved for 3 years, and steel production capacity will decrease by between 100 million and 150 million tons over 5 years.

The 2015 scenario analyses set five APSs: APS1 – energy efficiency and conservation (EEC) in the final consumption sectors; APS2 – EEC in thermal efficiency in coal, oil- and gas-fired power generation; APS3 – increase of hydro, geothermal, and new and renewable energy; APS4 – increase in nuclear energy; APS5 – implement APS1 to APS4. If not specifically declared, all results shown in this chapter under the APS refer to APS5.

3. Outlook Results

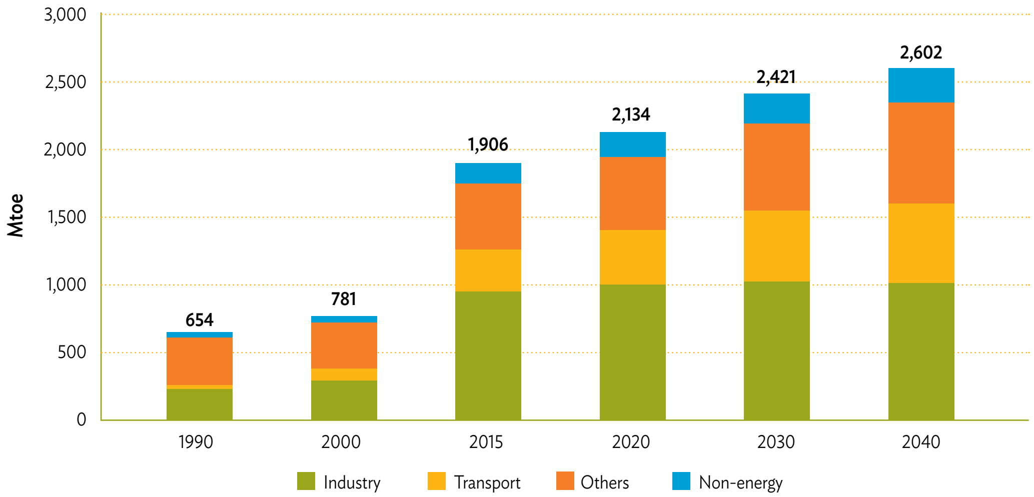
3.1. Total Final Energy Consumption

Between 2015 and 2040, China's final energy consumption is projected to grow slowly, reflecting lower assumed economic and population growth.

Business-As-Usual Scenario

Final energy consumption is projected to increase at an average rate of 1.3% per year between 2015 and 2040. Transport sector consumption is projected to grow the fastest, increasing by 2.7% a year, followed by the non-energy sector of 1.9%. Energy consumption in the industry sector is projected to grow at an average annual rate of 0.2%. Figure 5.1 shows China's final energy consumption by sector under the BAU scenario.

Figure 5.1: Final Energy Consumption by Sector, BAU

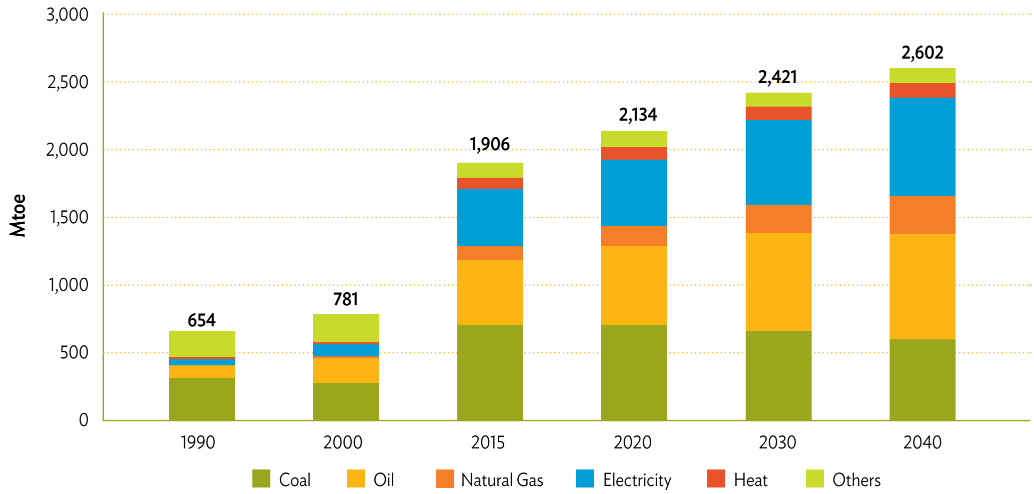


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Amongst energy sources, natural gas consumption in the BAU scenario, which is projected to exhibit the fastest growth, will increase by 5.2% per year, from 158.5 Mtoe in 2015 to 556.5 Mtoe in 2040. Though coal is still a large portion in the whole final energy consumption, it is projected to increase at such a lower growth rate, -0.1% per year, achieving 1938.6 Mtoe in 2040, compared with -0.7% per year over the last 2 decades. Consumption of electricity and heat is projected to increase at an average annual rate of 2.3% and 0.8%, respectively, over the same period, achieving 737.6 Mtoe and 110.0 Mtoe in 2040. Oil is projected to grow by 1.9% annually to around 853.4 Mtoe in 2040. Figure 5.2 shows China's final energy consumption by fuel type under the BAU scenario.

Figure 5.2: Final Energy Consumption by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Alternative Policy Scenario

In the APS, final energy consumption is projected to increase by 0.6% per year, from 2,973.3 Mtoe in 2015 to 3,494.9 Mtoe in 2040, as a result of EEC programmes. An improvement in 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 the final energy consumption in China in 2015 and 2040 in both the BAU scenario and the APS.

Figure 5.3: Final Energy Consumption, BAU and APS (2015 and 2040)

APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.2. Primary Energy Supply

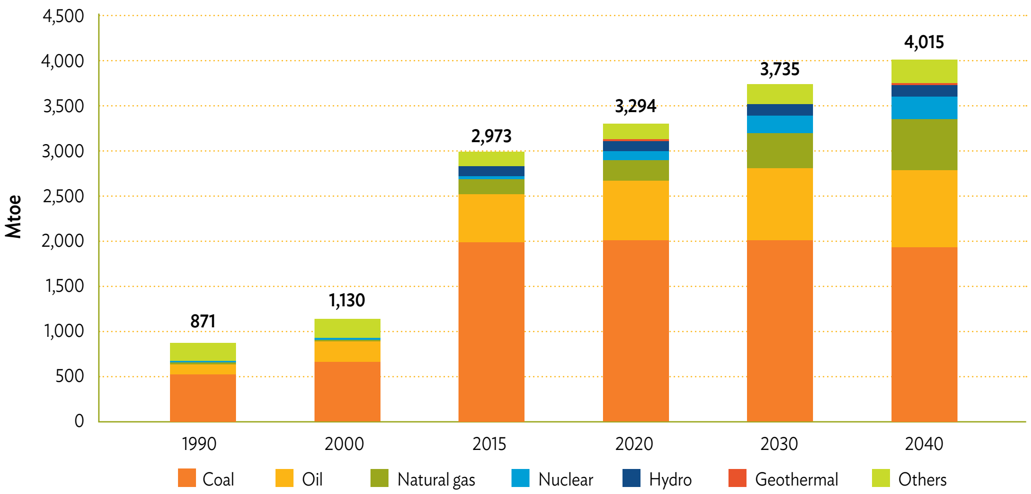
Primary energy supply in China is projected to grow at a slower pace than in the past years. Growth in primary energy supply is also expected to be slightly slower than final energy consumption because of improved efficiency in the energy transformation sector.

Business-As-Usual Scenario

In the BAU scenario, China's primary energy supply is projected to increase at an average annual rate of 1.2% per year to 4,014.9 Mtoe in 2040. Coal will still constitute the largest share in total primary energy, but its growth is expected to be slower and decreasing by -0.1% a year on average. Consequently, the share of coal in total primary energy is projected to decline from 66.7% in 2015 to 48.3% in 2040.

Nuclear energy is projected to exhibit the fastest growth between 2015 and 2040, increasing at an annual average rate of 7.2%, followed by natural gas at 5.2%. Oil and hydro are projected to grow at lower rates of 1.9% and 1.1% per year, respectively. The share of natural gas is projected to increase from 5.3% in 2015 to 13.9% in 2040, whereas the share of nuclear will increase from 1.5% to 6.3%. The share of oil is projected to increase from 18% in 2015 to 21.3% in 2040, and hydro is projected to decrease from 3.2% in 2015 to 3.1% in 2040. Figure 5.4 shows China's primary energy supply by energy type under the BAU scenario.

Figure 5.4: Primary Energy Supply by Energy Type, BAU (1990–2040)



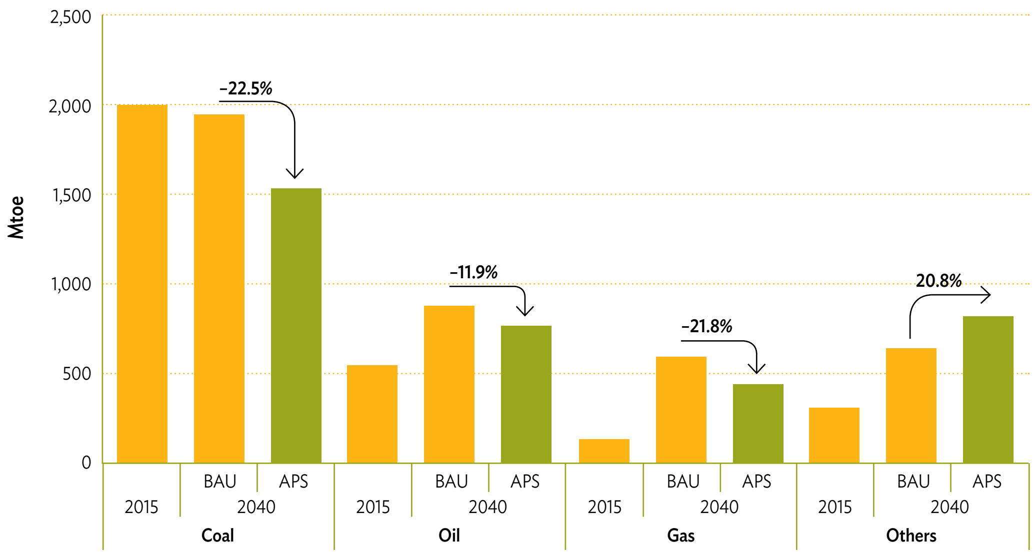
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

Alternative Policy Scenario

In the APS, primary energy consumption is projected to increase by 0.6% per year between 2015 and 2040, reaching 3,494.9 Mtoe by 2040. The growth in primary energy supply is projected to be slower under the APS than the BAU scenario (Figure 5.5). Coal is projected to decrease by -1.1% a year, oil by 1.4% a year, and natural gas by 4.1% a year. For nuclear, the average annual growth rate will be higher than the BAU scenario, increasing by 8.7% a year between 2015 and 2040. The growth rate of hydro in the APS is expected to be higher than that of the BAU scenario, increasing by 1.3% per year. The consumption mitigated in the APS is achieved through EEC measures on the demand side.

Figure 5.5: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

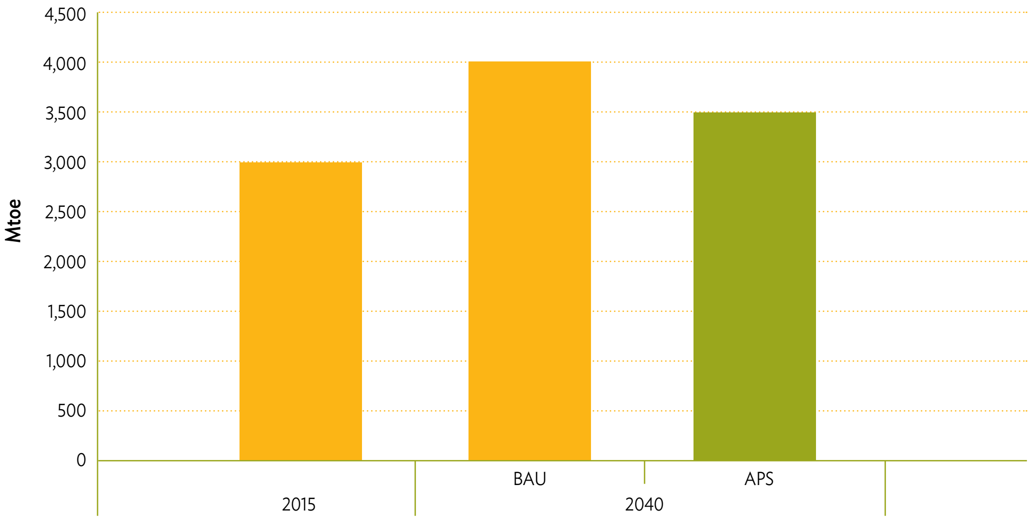
Source: Authors' calculation.

3.3. Projected Energy Savings

The implementation of EEC goals and action plans in China could reduce primary energy supply in 2040 by about 267.3 Mtoe under the APS relative to the BAU scenario. In the APS, China's primary energy demand is around 10.3% lower than the BAU scenario (Figure 5.6).

In terms of final energy consumption, there are estimated savings of 110.6 Mtoe in the industry sector, 71.5 Mtoe in the transport sector, and 85 Mtoe in the 'others' sector in 2040 under the APS.

Figure 5.6: Total Primary Energy Supply, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

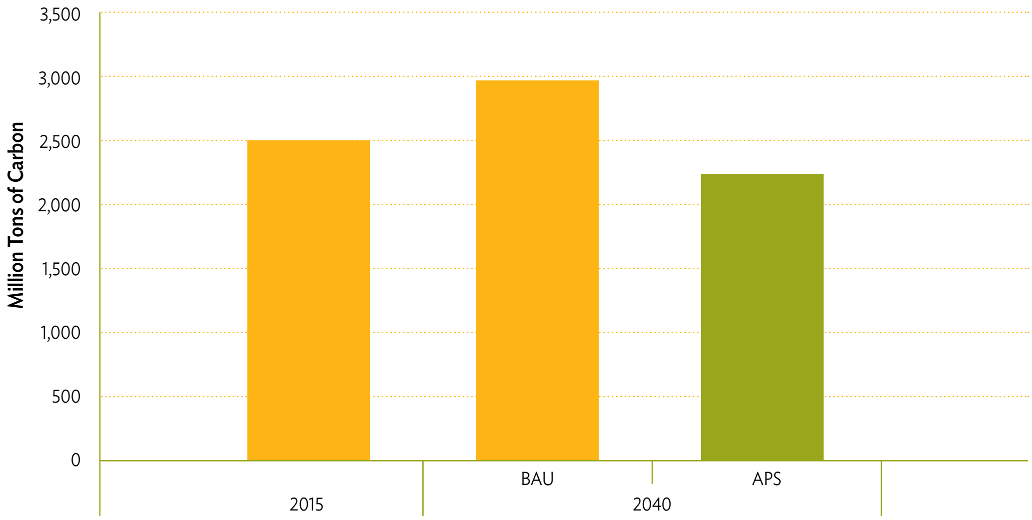
Source: Authors' calculation.

3.4. CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 0.6% per year, from 2,545.4 million tons of carbon (Mt-C) in 2015 to 2930.9 Mt-C in 2040, under the BAU scenario. This percentage increase is lower than that in primary energy supply (1.3%) over the same period, indicating improved emissions intensity in China's economy.

In the APS, the annual increase in CO_2 emissions between 2015 and 2040 is projected to be -0.4%. This rate is also lower than the average annual growth rate in primary energy supply over the same period. The difference between the APS and the BAU scenario CO_2 emissions growth rates indicates that the energy-saving goals and action plans of China are effective in reducing CO_2 emissions (Figure 5.7).

Figure 5.7: CO_2 Emissions from Energy Consumption, BAU and APS (2015 and 2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.5. Power Generation

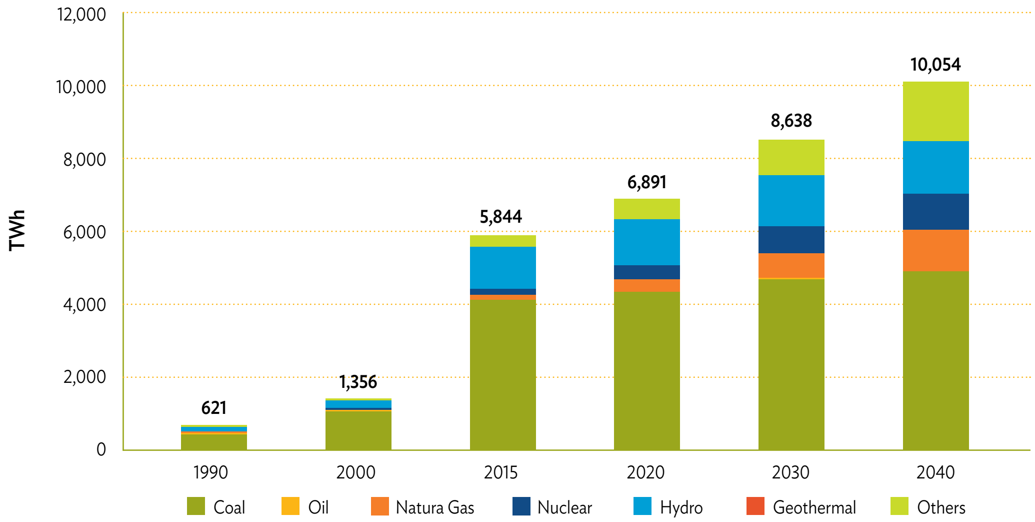
Power generation in China is projected to grow more slowly between 2015 and 2040 than in the last decade.

Business-As-Usual Scenario

In the BAU scenario, power generation in China is projected to grow at a slower pace, by 2.5% per year from 5,844.2 terawatt-hour (TWh) in 2015 to 10,054.5 TWh in 2040 (Figure 5.8).

The share of coal power under the BAU scenario is projected to experience a decreasing trend from 70.3% in 2015 to 48.6% in 2040. Conversely, the share of natural gas and nuclear are both projected to grow because of cleanness, from 2.5% and 2.9% in 2015 to 11.3% and 9.6% in 2040, respectively. The share of oil is projected to decrease slightly. In addition, other methods of power generation are projected to be increasing. The fast development of PV power generation in China is a typical example reflecting the country's clean power generation tendency. China's thermal efficiency by fuel under the BAU scenario is projected to increase between 2015 and 2040 (Figure 5.9).

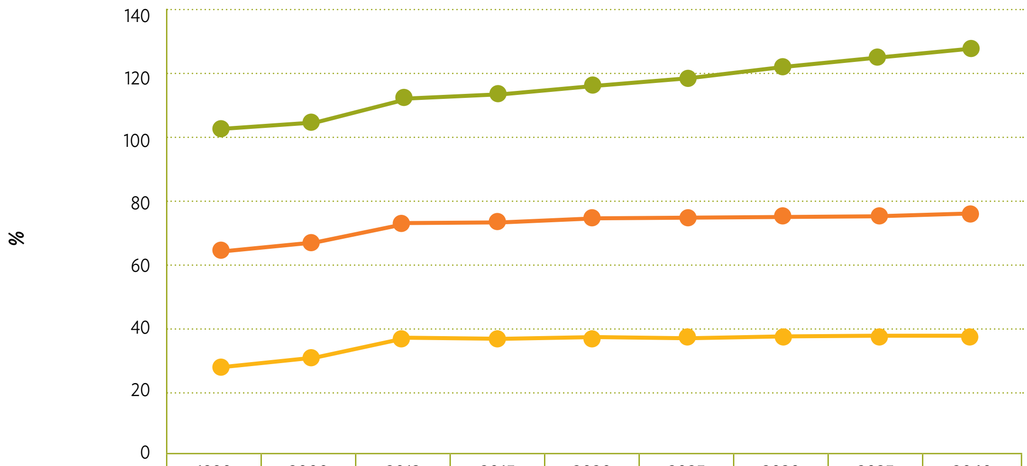
Figure 5.8: Power Generation, BAU (1990–2040)



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

Source: Authors' calculation.

Figure 5.9: Thermal Efficiency by Fuel, BAU



%	1990	2000	2013	2015	2020	2025	2030	2035	2040
Natural Gas	38.9	38.9	38.9	39.8	42.2	44.5	46.8	49.1	51.4
Oil	35.0	35.0	35.0	35.6	36.0	36.3	36.7	37.0	37.4
Coal	28.8	32.0	38.0	38.1	38.2	38.4	38.6	38.8	38.9

BAU = Business-As-Usual.

Source: Authors' calculation.

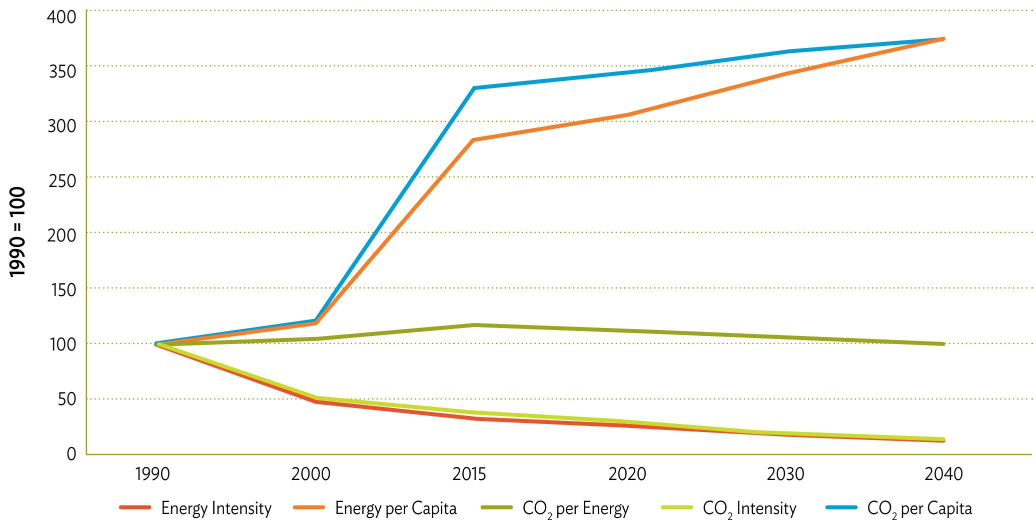
Alternative Policy Scenario

In the APS, total power generation will increase by 2.2% per year between 2015 and 2040. By 2040, total power generation output is projected to reach 10,054.5 TWh. Except for coal-fired power, oil power, and natural gas power, the annual growth rate per year between 2015 and 2040 of all other fuels under the APS is projected to grow faster than in the BAU scenario. In 2040, nuclear power, hydro power, geothermal power, and 'others' are projected to increase under the APS by 7.2%, 1.1%, 5.1%, 7.0% in 2015–2040, respectively.

3.6. Energy Intensity

According to the assumed economic and population data, along with the projected energy information of China, energy intensity defined as total primary energy supply/GDP (TPES/GDP) and energy per capita are accounted and illustrated in Figure 5.10, along with other vital energy indicators under the BAU scenario. From 1990 to 2015, China's energy intensity experienced a remarkable drop through efforts on energy efficiency. In 2040, it is projected to drop to about 257 toe per million (in 2005 US$ terms). With improved living standards in China, energy per capita under the BAU scenario is projected to reach 3.18 toe per person in 2040. Compared with the energy intensity in the BAU scenario, that in the APS is projected to show a faster decreasing rate of 3.6% from 2015 to 2040.

Figure 5.10: Energy Indicators, BAU (1990–2040)



BAU = Business-As-Usual.

Source: Authors' calculation.

4. Implications and Policy Recommendations

For China, which is the world's largest developing country, eliminating poverty and improving the quality of life have always been paramount tasks. In recent years, China has witnessed fast growth in its economy, but the urbanisation rate is still low, with 58.5% in 2017.

On the other hand, being the world's biggest energy consumer and CO_2 emitter, China also faces great pressure to save energy and reduce CO_2. Since the1990s, China has made great efforts and set ambitious targets on energy conservation and climate change mitigation. During the 2014 Asia-Pacific Economic Cooperation summits, China and the United States issued a joint announcement on climate change, in which China vowed to decrease CO_2 emissions from its peak and increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030. In April 2016, China signed the Paris Agreement, which includes the above commitments in addition to the provision that China cut its carbon emissions per unit of GDP by 60%–65% by 2030 from the 2005 levels. In the 13th Five-Year Plan (2016–2020), China plans to control the total energy consumption within 41 billion tons of standard coal and decrease its CO_2 emissions per unit of GDP by 18% compared with 2015 levels.

As China's GDP keeps growing, albeit at a slower pace compared with that of the last 20 years, its energy demand and CO_2 emissions will increase in the foreseeable future accordingly. However, energy intensity (energy demand per unit of GDP) and emissions intensity (CO_2 emissions per unit of GDP) are required to decrease considering China's targets. According to the model results, if sound energy efficiency and conservation policies could be implemented, China could reduce its total primary energy consumption by around 13.0% and CO_2 emissions by about 21.6% by 2040.

Coal consumption has decreased since 2014; it decreased by 3.7% in 2015. It is projected to be cut by 22.5% in the APS compared with the BAU scenario. To improve urban air quality, Chinese metropolises, such as Beijing and Shanghai, have shown great ambitions in controlling the use of coal, so the relatively low growth rate of coal consumption may persist in the following years. Therefore, clean and low-carbon energies are encouraged to develop, especially renewable and nuclear energy in the power generation sector. To optimise the energy structure, policies such as on energy and carbon taxes should be carried out, to limit the energy- and pollution-intensive industries. On the other hand, more market-based measures, for instance, electricity market reform, energy pricing reform, and green certificate trade, are needed to make energy more market-oriented and to motivate more enterprises to act.

The energy efficiency improvement in APS5 has the largest potential to reduce CO_2 emissions. Based on our calculation of 2015 scenario, within the APS5, the industry sector can potentially reduce energy consumption by 10.9% based on the APS5 results. Measures such as the closure of small and inefficient power plants, coal mines, and small energy-intensive plants in industries like cement and steel, and stricter approval requirements for energy-intensive industries are necessarily implemented. Moreover, the change in industrial structure (heavy to light industries or industry to services) is also needed. Furthermore, since China has entered the 'new normal' state of economy, in which economic growth rate would be moderately high, and the GDP of the tertiary sector has accounted for half of the total amount, in the long run, it is more important to enhance energy efficiency in the residential, commercial, and transport sectors for energy saving and CO_2 reduction. Moreover, the Belt and Road Initiative (BRI) proposed by President Xi in 2013 is also a good chance to further save energy and reduce emissions. The countries along the route of BRI contribute to 50% of global energy consumption and more than 60% of global carbon emissions. Thus, establishing a BRI low-carbon community is greatly significant to the improvement of energy structure and emissions reduction in both China and the world.

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CHAPTER 6

INDIA COUNTRY REPORT[a,b]

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1. Country Brief

India, also called the Republic of India, is a country in South Asia and occupies an area of around 3.1 million square kilometres. It is the seventh-largest country by area, the second-most populous country (with over 1.2 billion people), and the most populous 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.

Its climate comprises a wide range of weather conditions across a vast geographic scale and varied topography, making generalisations difficult. Based on the Köppen system, India hosts six major climatic subtypes, ranging from 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.

According to the International Monetary Fund (IMF, 2018), India's economy in 2017 was nominally worth US$2.611 trillion. It is the sixth-largest economy by market exchange rate, and the third-largest by purchasing power parity (PPP) at US$9.459 trillion. With its average annual gross domestic product (GDP) growth rate of 5.8% over the past 2 decades and reaching 6.1% in 2011–2012, India is one of the world's fastest-growing economies. However, the country ranks 140th in the world in nominal GDP per capita and 129th in GDP per capita at PPP. Despite economic growth during recent decades, India continues to face socio-economic challenges, such as poverty and modern energy access.

[a] Based on model run and broad assumptions by The Institute of Energy Economics, Japan, with inputs provided by TERI School of Advanced Studies.

[b] Unless otherwise specified, the information in figures come from the results of the model run.

2. Energy Situation

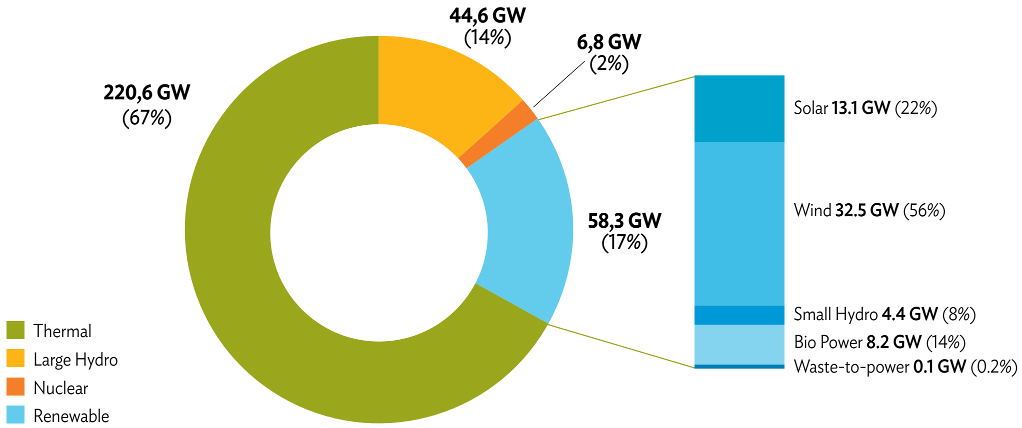
Energy systems in India have evolved over the last 6 decades along with the country's economic development, supporting the aspiration of 1.2 billion people within the framework of democratic polity, a globally integrated economy, and an environmentally sensitive regime. The ever-increasing demand of energy has posed tremendous pressure on its limited resources and has necessitated optimum use of its resources. India has pursued a reformed development agenda since 1991. Significant effort has gone into improving energy availability to support the country's development initiatives.

India is fuelled by primary (coal and lignite, natural gas), secondary (electricity and petroleum products), and renewable energy sources. India's energy mix is dominated by coal. Coal forms the largest source of primary energy in India, accounting for around 50% of the total primary energy supply (GoI, 2017). Coal production has witnessed an upward trend. It was about 430.83 million tons (MTs) in 2006–2007, and increased to 639.23 MTs in 2015–2016 with a compound annual growth rate (CAGR) of 4.02%. Production of crude petroleum increased from 33.99 MTs in 2006–2007 to 36.95 MTs in 2015–2016, a CAGR of about 0.84%.

Crude oil imports increased by 10 MT, although the value of imports fell for the second year in a row. The total share of imported crude oil in India's total supply was 84.3% in 2015/16. India's refining capacity increased to 230 MT per annum (MMTPA) owing to the commissioning of the Paradip refinery in Odisha, with a capacity of 15 MMTPA. The production of natural gas declined for the fifth year in a row to 32.2 billion cubic metres in 2015/16. Imports of liquefied natural gas grew to 19.95 MT in 2015/16. Import dependency of natural gas stands at 46%.

As of 31 January 2017, the total installed capacity of the power sector in India was 330 gigwatts (GW), with thermal power having the largest share of 67% in total installed capacity (Figure 6.1).

Figure 6.1: Grid Power Sources (GW) and their Percentage Shares up to June 2017



GW = gigawatt.

Sources: CEA (2017a), MNRE (2017).

The all-India gross electricity generation from utilities, excluding that from captive generating plants, was 670,654 gigawatt-hours (GWh) in 2006–2007. It rose to 1,116,850 GWh in 2014–2015 (CSO, 2017). During 2015–2016, the production of electricity from utilities has further increased to 1,167,584 GWh, registering an annual growth rate of about 4.54%. Total electricity generation in the country from utilities and non-utilities in 2015–2016 was 1,335,956 GWh. Out of the total electricity generated through utilities, 943,013 GWh was generated from thermal, 121,377 GWh was from hydro, and 37,414 GWh was generated from nuclear sources. Total output from non-utilities was 168,372 GWh.

As of June 2017, the cumulative installed capacity from renewable sources was 58.3 GW in India, which was 17% of the total installed capacity of 330 GW. Currently, India ranks sixth worldwide in renewable energy capacity (REN21, 2017). The current installed nuclear power capacity of the country is 5,780 MW, and it is expected to increase to 10,080 MW by 2019. India is ranked 12th in terms of power generation from nuclear sources as per data published in May 2015 by the Power Reactor Information System of the International Atomic Energy Agency (IAEA). India has signed nuclear agreements with the United States (US), France, Russia, Namibia, Mongolia, Republic of Korea, Argentine Republic, United Kingdom, Republic of Kazakhstan, Canada, Sri Lanka, and Australia (PIB, 2015). India's installed capacity of hydro was 44,189.43 MW as of 31 January 2017 (CEA, 2017b). Of the all-India target of 10,897 MW under the Twelfth Five-Year Plan, 3,311.02 MW of hydro capacity has been achieved (as of August 2015).

India's final energy consumption has increased more than seven times since 1980, with the industry sector consuming the largest amount of energy. In 2015–2016, the industry sector accounted for about 52% of final energy consumption. This is followed by the transport sector (24%), and then the residential and commercial sectors (17%). The agriculture sector accounts for the least share of final commercial energy demand during the same period.

3. Modelling Assumptions

India's GDP is assumed to grow from US$ 2.29 trillion of 2010 in 2015 to around US$ 11.49 trillion of 2010 in 2040, equivalent to 6.5% and 6.7% average annual growth rates in 2015 and 2040, respectively. The population is assumed to grow at an average annual rate of 0.9% from 1.31 billion persons in 2015 to around 1.61 billion persons in 2040.
Regarding future electricity supply, coal share in electricity generation will continue to be the largest. Meanwhile, nuclear power plants and others, especially wind and solar, are projected to increase to 2040. On the other hand, the shares of oil and hydro are expected to decrease.

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

4. Outlook Results

4.1. Business-As-Usual (BAU) Scenario

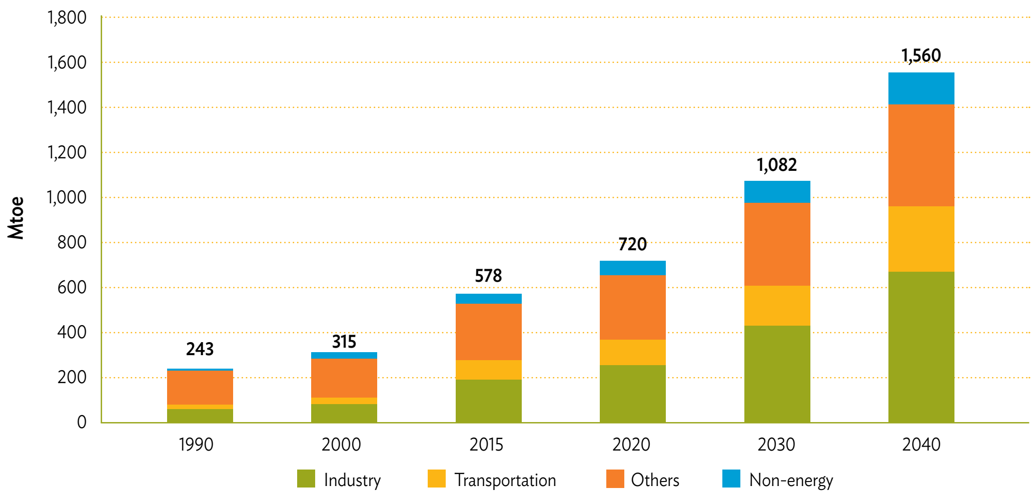
This section describes the current trend of energy production and utilisation in the country, without any policy intervention, aimed at reducing energy demand or CO_2 emissions.

4.1.1. Total final energy consumption

Under the BAU scenario, with assumed strong economic growth and a rising population, India's final energy demand is projected to increase at an average rate of 4.1% per year, from 578 million tons of oil equivalent (Mtoe) in 2015 to 1,560 Mtoe in 2040 (Figure 6.2). The strong growth is projected to occur in the transport and the industry sectors, increasing at 5.1% a year between 2015 and 2040. Strong growth is also expected in non-energy consumption (4.8% a year). Due to the large share of non-commercial energy in the final energy consumption, the growth rate of the 'others' sector that includes residential and commercial sectors is projected to be modest at 2.3% per year. However, in the residential and commercial sectors, the consumption of commercial energy, especially electricity, will increase rapidly.

The share of 'others' which is the largest at 43% in 2015, will drop to 28.3% in 2040. Meanwhile, the share of industry will increase to 43.1% in 2040 from 33.7% in 2015, and that of transport will reach 19% in 2040, from 14.9% in 2015.

Figure 6.2: Final Energy Consumption by Sector, BAU (1990–2040)

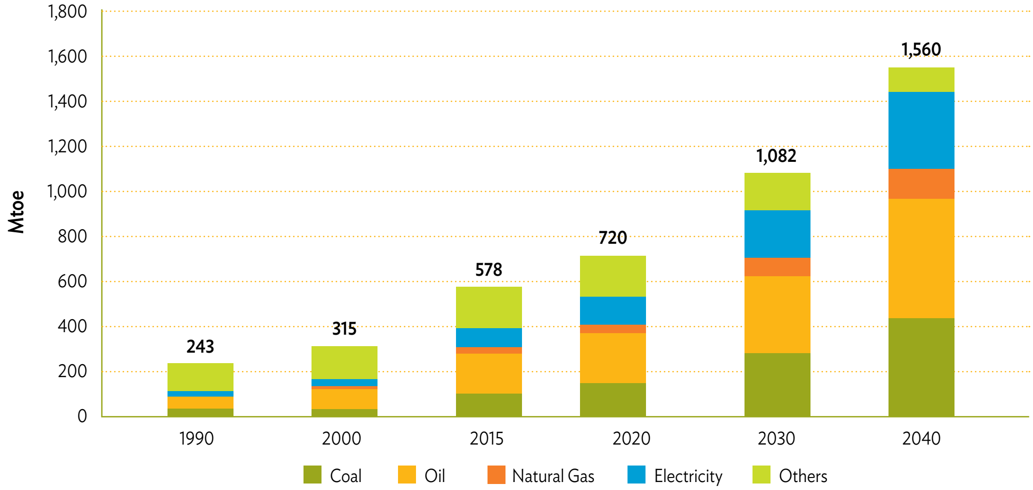


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

In the final energy consumption by source, natural gas will have the fastest growth, increasing by 6.1% per year over the period 2015–2040 (Figure 6.3). Coal demand will have the second highest increase of 5.8% a year, followed by electricity (5.4% per year) and then oil (4.7% per year).

Figure 6.3: Final Energy Consumption by Fuel Type (1990–2040)



Mtoe = million tons of oil equivalent.

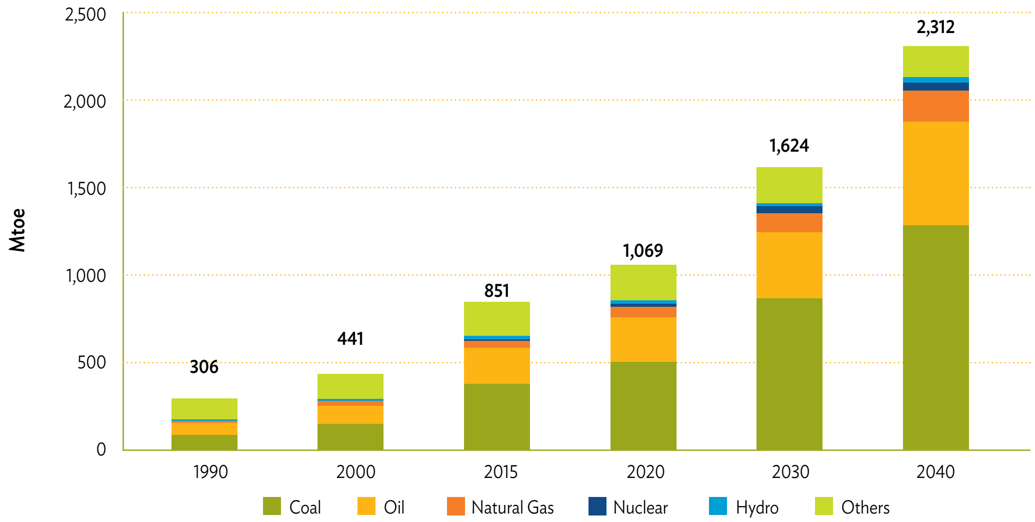
Source: Model results.

4.1.2. Primary energy supply

Under the BAU scenario, India's primary energy supply will increase at an average annual rate of 4.1% to 2,312 Mtoe in 2040 from 851 Mtoe in 2015. Coal demand, driven by the demand of power generation, will grow at 5% per year and reach 1,290 Mtoe in 2040, from 379 Mtoe in 2015, maintaining the largest share at 56% in 2040 (45% in 2015). Due to rapid motorisation, oil will increase to 592 Mtoe and will have the second-largest share at 26% in 2040. The average annual growth rate for oil demand in 2015–2040 would be 4.3%. Natural gas consumption is expected to increase by 5.8% per year between 2015 and 2040. Its share will be 7.6% in 2040, 2.5 percentage points up from 5.1% in 2015. Figure 6.4 shows the projected primary energy supply in India from 1990 to 2040 under the BAU scenario.

Within 'others', solar and wind will increase significantly. However, due to the negative growth of non-commercial biomass, which has the largest portion, 'others' is projected to decrease by 0.5% a year through to 2040. Its share will drop to 7.7% from 23.4% in 2015.

Figure 6.4: Primary Energy Supply by Source, BAU (1990–2040)



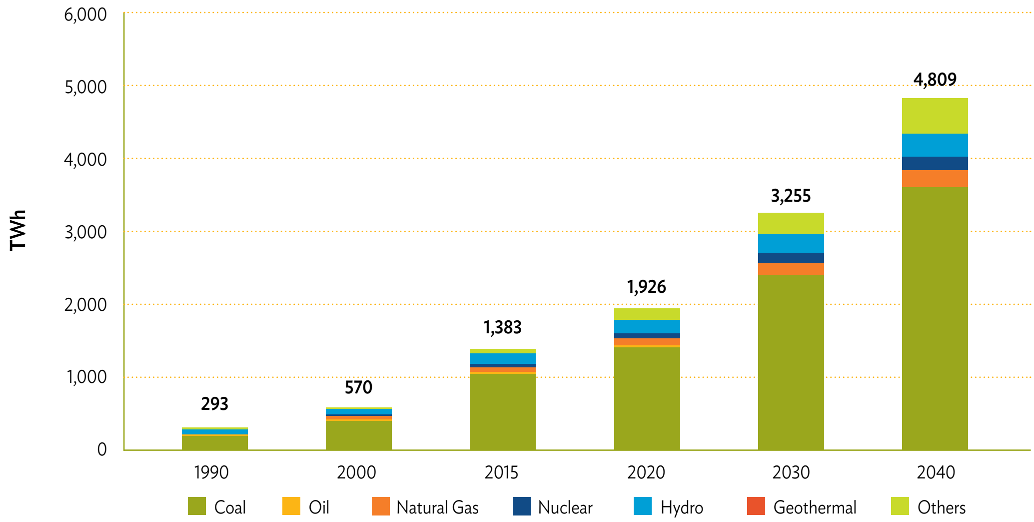
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.1.3. Power generation

In 2015, power generation in India was 1,383 terawatt-hours (TWh). Under the BAU scenario, it will be increasing at the rate of 5.1% per year to 4,809 TWh in 2040. Coal will continue to dominate India's power generation mix; however, the share will slightly drop from 75.3% in 2015 to 74.8% in 2040. Hydro's share in India's power generation mix will decline from 10% in 2015 to 6.7% in 2040, and oil's share will decline from 1.7% in 2015 to 0% in 2040. In contrast, the share of nuclear power will increase from 2.7% to 3.9%, and 'others', including wind and solar power, will increase from 5.4% to 9.8%. The share of natural gas will be 4.7% in 2040, and the average growth rate during 2015–2040 will be 5% per year. Figure 6.5 shows the projected power generation in India from 1990 to 2040 under the BAU scenario.

Figure 6.5: Electricity Generation, BAU (1990–2040)



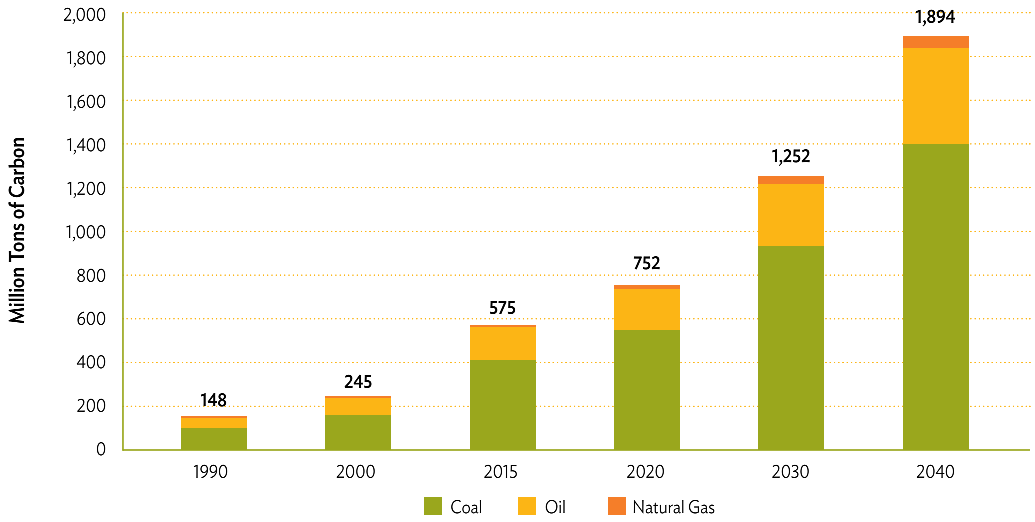
BAU = Business-As-Usual, TWH = terawatt-hour.

Source: Model results.

4.1.4. CO_2 emissions

In 2015, CO_2 emissions from India's energy sector were 575 million tons of carbon (Mt-C). Under the BAU scenario, CO_2 emissions will be increasing at an annual rate of 4.9% to 1,894 Mt-C in 2040. Coal is the main source of CO_2 emissions in India. CO_2 emissions from coal will rise at an annual rate of 5% from 409 Mt-C in 2015 to about 1,393 Mt-C in 2040. CO_2 emissions from oil will increase by 4.4% annually, from 151 Mt-C in 2015 to 441 Mt-C in 2040, while emissions from natural gas will increase at a rate of 5.6% from 15 Mt-C to 59 Mt-C during the same period. In 2040, coal will account for around 73.5% of total energy CO_2 emissions, followed by oil with a share of 23.3%; the remaining 3.2% comes from natural gas. Figure 6.6 shows the projected energy-related CO_2 emissions in India from 1990 to 2040 under the BAU scenario.

Figure 6.6: CO_2 Emissions under BAU (1990–2040)



BAU = Business-As-Usual.

Source: Model results.

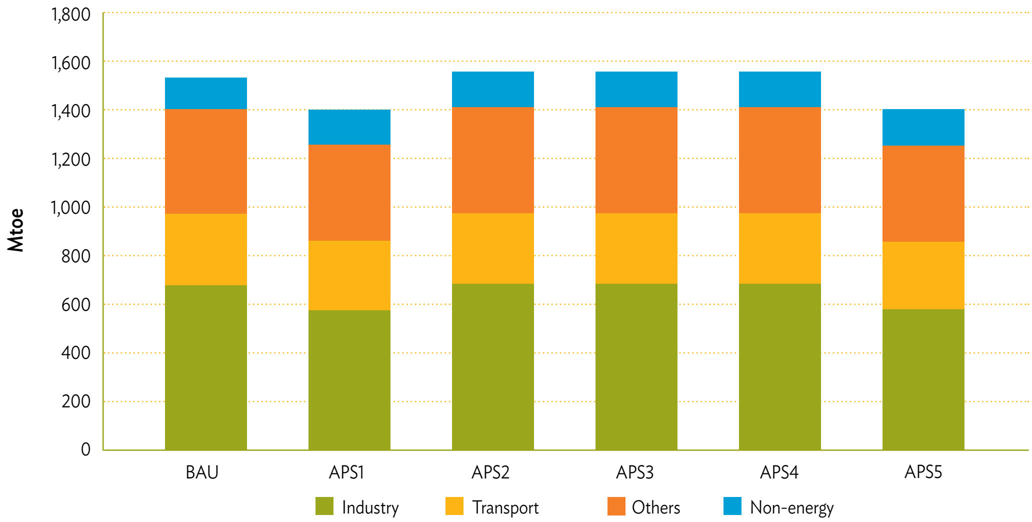
4.2. Energy Saving and CO_2 Reduction Potential

This section describes the energy saving and CO_2 mitigation potential of different energy policies. Five alternative policy scenarios (APS) are considered and have been tagged as APS1, APS2, APS3, APS4, and APS5. APS1 is a scenario of improved efficiency in final energy demand. APS2 deals with more efficient thermal power generation. APS3 assumes a high contribution of renewable energy to total supply. APS4 involves the use of nuclear energy in the total supply, and APS5 is a combined effect of APS1, APS2, APS3, and APS4.

4.2.1 Final energy demand

Total final energy consumption by 2040 in APS1, APS2, APS3, APS4, and APS5 will be 1400, 1560, 1560, 3121, and 1400 Mtoe, respectively. This implies that only APS1 and APS5 can potentially reduce energy demand. (Figure 6.7). It may be observed that the final energy demand of APS2 and APS3 are the same with the BAU scenario.

Figure 6.7: Final Energy Consumption under APSs



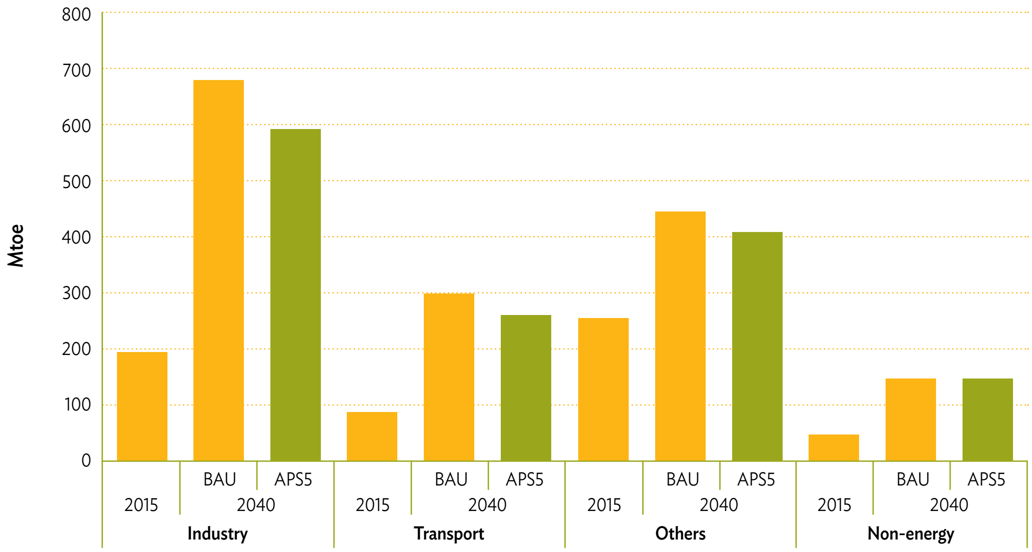
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

Under APS5, final energy demand is projected to decrease by 10.3% in 2040 compared to the BAU scenario. The reduction in energy demand is expected to occur across all end-use sectors, reflecting improvements in end-use technologies and the introduction of energy management systems (Figure 6.8).

In 2040, under APS5 relative to the BAU scenario, are estimated savings of 82 Mtoe (12.2%) in the industry sector, 40 Mtoe (13.4%) in the transport sector, and 38 Mtoe (8.5%) in the 'others' sector.

Figure 6.8: Final Energy Consumption, BAU vs APS5 (2015 and 2040)



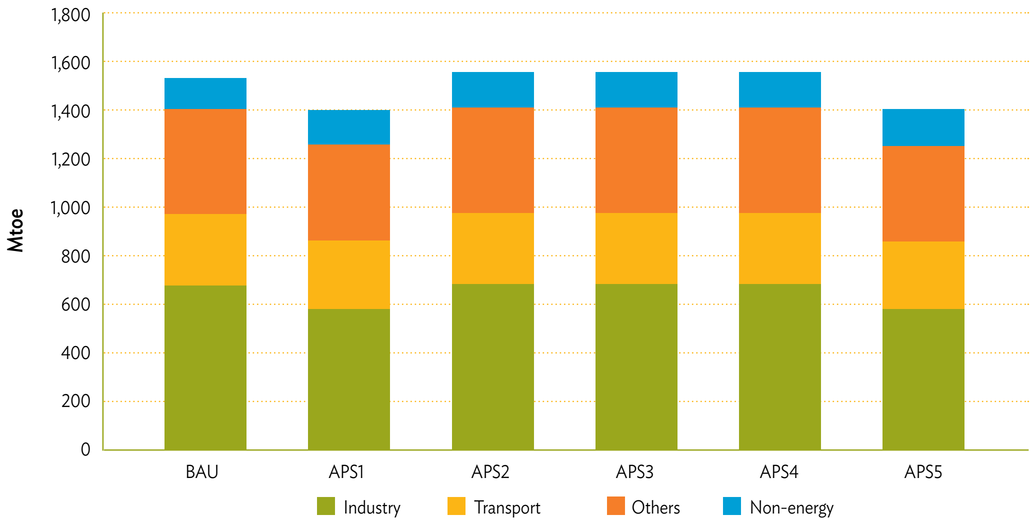
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.2.2 Primary energy demand

By 2040, primary energy demand in APS1, APS2, APS3, APS4, and APS5 will be 2057, 2245, 2276, 2115, and 1973 Mtoe, respectively (Figure 6.9). The results indicate that primary energy supply in 2040 will reduce in APS1, APS2, APS3, and APS5 compared to the BAU scenario. Analysis shows that primary energy demand in APS4 will be higher than the BAU scenario.

Figure 6.9: Primary Energy Supply by Sectors, BAU vs APS5

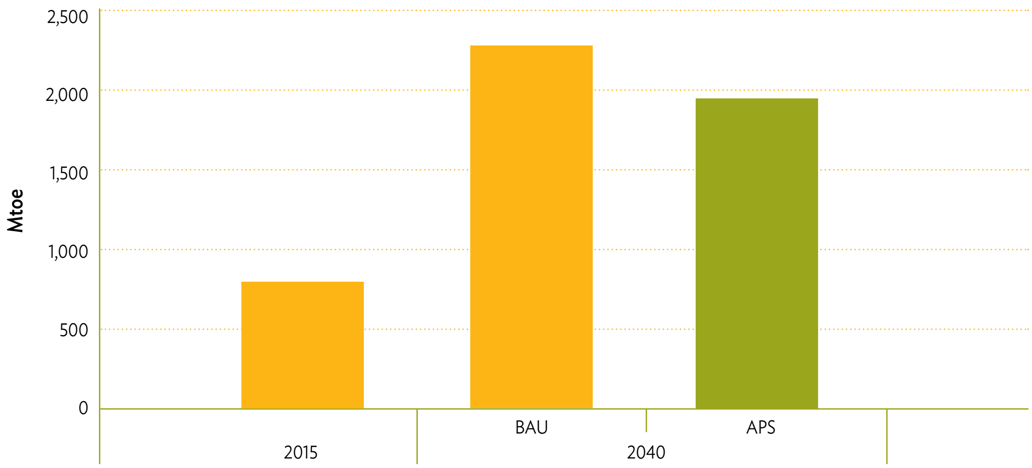


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

Under APS5 relative to the BAU scenario, India's primary energy demand is projected to decrease by 339 Mtoe or 14.7% (Figure 6.10).

Figure 6.10: Total Primary Energy Supply, BAU vs APS5 (2015 and 2040)

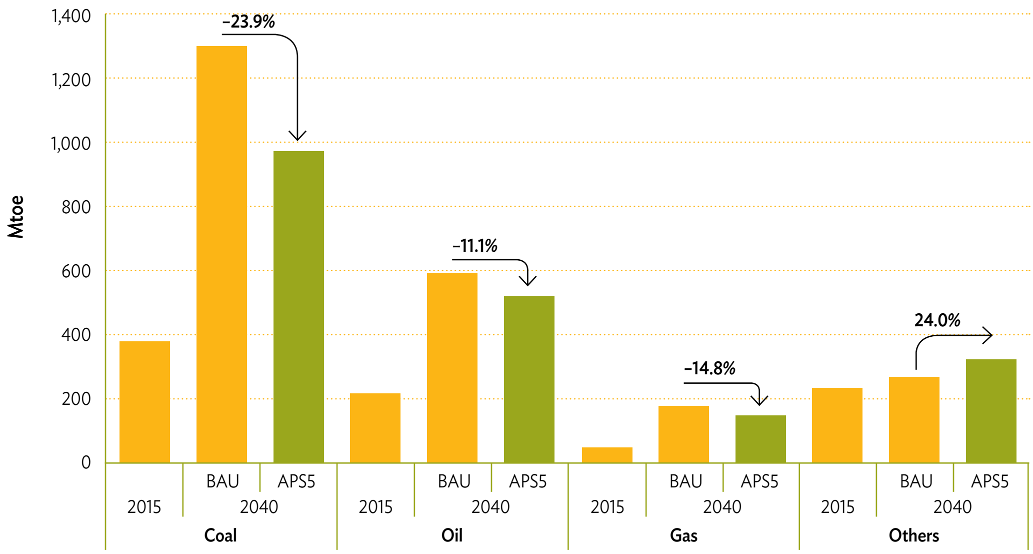


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

In APS5 in 2040 (Figure 6.11), coal consumption will decrease by 308 Mtoe or 23.9% while oil demand will drop by 66 Mtoe or 11.1%. The demand for natural gas is seen to fall by 26 Mtoe (14.8%). However, the demand for 'others', driven by strong demand for renewables (wind and solar), is observed to rise by 59.4% or 61 Mtoe.

Figure 6.11: Total Primary Energy Supply by Fuel Type, BAU vs APS5 (2015 and 2040)



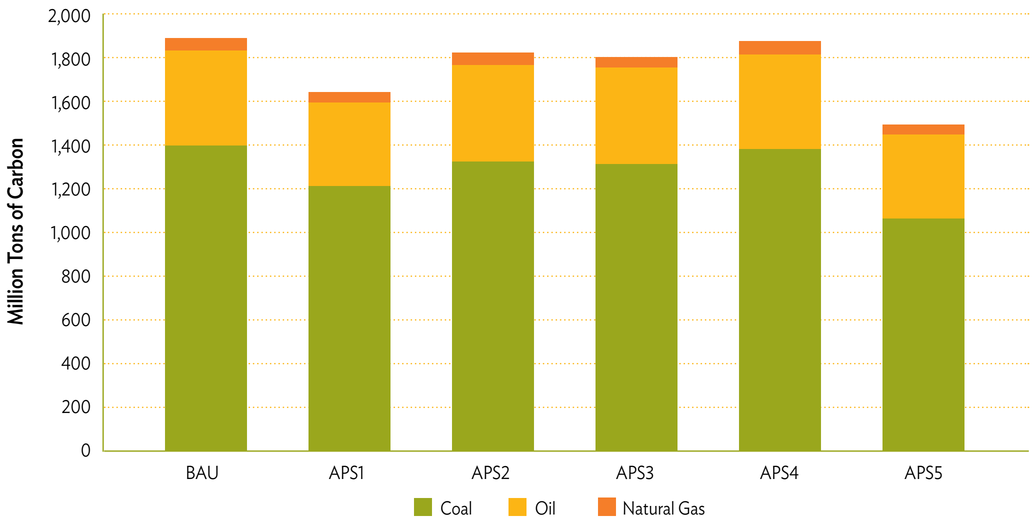
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.2.3. CO_2 emissions from energy consumption

By 2040, CO_2 emissions in APS1, APS2, APS3, APS4, and APS5 will be 1646, 1824, 1807, 1874, and 1489 Mt-C, respectively, compared to 1,984 Mt-C in the BAU scenario. The results indicate that CO2 emissions in 2040 will decrease by 405 Mt-C in APS5 compared to the BAU scenario (Figure 6.12).

Figure 6.12: CO_2 Emissions from Energy Combustion, BAU vs APSs

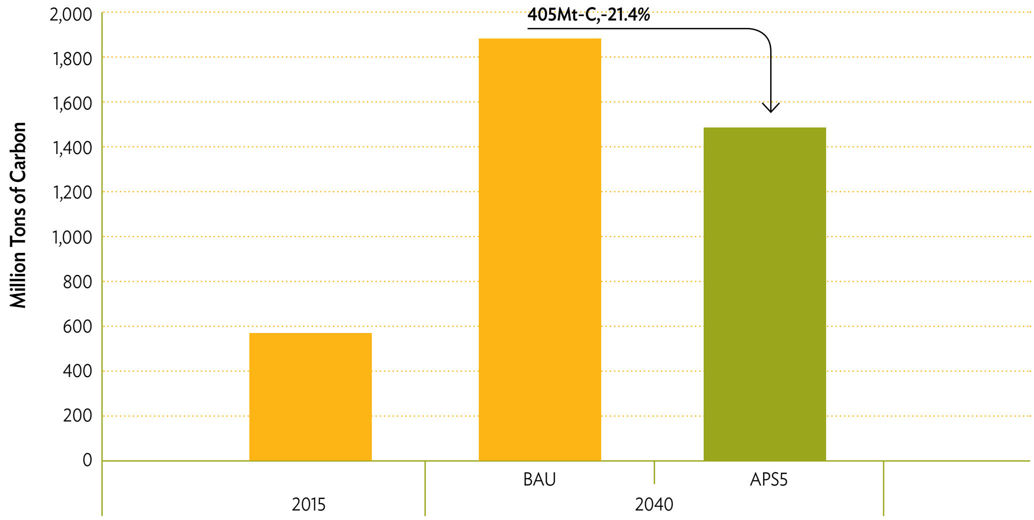


APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Model results.

In APS5, CO_2 emissions in 2040 will be 1,489 Mt-C, 21% lower than in the BAU scenario. Less demand of coal in final demand and in power generation and of oil in the transport sector will contribute most to reduced CO_2 emissions. Emissions from coal, oil, and natural gas in 2040 will decrease by 333 (24% reduction), 55.3 (13% reduction), and 16.7 (28% reduction) Mt-C compared to the BAU scenario. Figure 6.13 shows CO_2 emissions in 2040 under the BAU scenario versus APS5 in this energy outlook.

Figure 6.13: CO_2 Emissions from Energy Combustion, BAU and APS5 (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Model results.

4.2.4. Implications

- Energy security and access to energy are key challenges to India. Enhanced domestic production of energy is necessary to address these challenges.
- Hydrocarbons, particularly coal and oil, will continue to dominate the energy mix in both the BAU scenario and the APS. Use of domestic coal to secure supply as well as more efficient coal technologies such as ultra-supercritical, etc. would be necessary. In the long and medium terms, research and development on cleaner energy development will play a key role.
- Natural gas can play an important role in energy supply and environment issues. To fully utilise the increasing global natural gas production, the infrastructure for importation, domestic transportation, and utilisation needs to be enhanced.
- The Government of India announced ambitious targets for renewable energy, but the cost and infrastructure will be the bottlenecks. Developing domestic manufacturing capacity can play an important role.

- Energy efficiency and demand-side management are important. New power plants, new factories, new buildings, new appliances, and new cars should be more efficient. The Minimum Energy Performance Standard and mandatory energy labels should be expanded to more equipment.
  - The power sector has huge potential savings. Advance technologies for power generation should be used as much as possible.
  - Industry will account for 43% of the incremental energy use to 2040; energy efficiency programmes should be focused on this sector. Broadening the scope of the Perform, Achieve, Trade scheme will be an important way to achieve this.
  - Growth of energy consumption in the transport sector should be curtailed.
  - Losses in electricity distribution should be minimised by using better technologies.
- Rationalising energy prices across fuels and sectors is necessary.
- In its Nationally Determined Contributions (NDC), India pledged to reduce the emissions intensity of its GDP by 33% to 35% by 2030 from the 2005 level. This can be achieved between APS2 to APS5. This implies that India is on course to achieve its NDC and make more climate commitments in the future when significant progress has been made towards achieving the NDC.

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CHAPTER 7

INDONESIA COUNTRY REPORT

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1. Background

Indonesia is the largest archipelagic state in Southeast Asia comprising 17,504 islands scattered over both sides of the equator. The five largest islands are Java, Sumatra, Kalimantan (the Indonesian part of Borneo), New Guinea (shared with Papua New Guinea), and Sulawesi. The country shares land borders with Papua New Guinea, Timor-Leste, and Malaysia. Other neighbouring countries include Singapore, the Philippines, Australia, and the Indian territories of Andaman and Nicobar Islands.

Indonesia covers an area of 1.913 million square kilometres and is the world's 16th largest country in terms of land area. The 2010 population census showed that Indonesia's population reached 238 million people with an average population density of 124 people per square kilometre. It increased to 258 million people in 2015 and, by the end of 2016, reached 261 million people (World Bank, 2017).

Indonesia's gross domestic product (GDP) was US$988 billion (constant 2010 US$) in 2015, increasing at an average rate of 4.9% from 2014. This growth rate was the lowest experienced by the country since 2010. In 2016, real GDP increased slightly faster at 5.02%, reaching US$1,038 billion (constant 2010 US$). From 1990, GDP grew at an average rate of 4.7% per year to 2015. GDP per capita in 2015 was almost US$4,000 (constant 2010 US$) while it was only US$1,700 in 1990 (constant 2010 US$).

Indonesia is richly endowed with natural resources. The country's vast oil and gas reserves have made Indonesia a significant player in the international oil and gas industry. As of January 2017, its crude oil proven reserves were 3.17 billion barrels while natural gas proven reserves were 100.4 trillion cubic feet (TCF) or 2.8 trillion cubic metres (TCM) (Ministry of Energy and Mineral Resources, 2017). Indonesia is also a coal exporter with proven coal reserves of around 29.9 billion tons. In addition to fossil energy resources, Indonesia's non-fossil energy resources include hydro, geothermal, biomass, and other renewables such as solar and wind. For hydro, the estimated potential is around 75 gigawatts (GW) while the estimated geothermal potential is more than 28 GW. In total, renewable energy potential in Indonesia is around 441.7 GW. Out of this, only 2%, or around 9 GW, has been utilised.

2. Modelling Assumptions

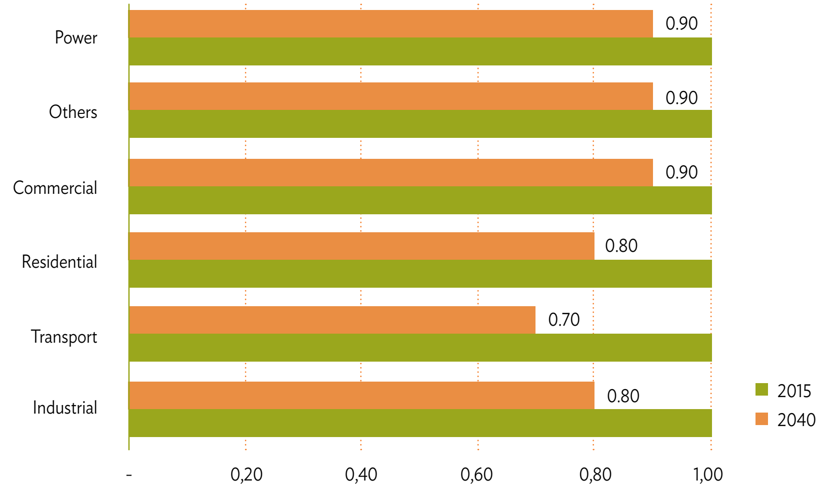
Indonesia's real GDP growth was 5.03% in 2016 and 5.07% in 2017 (Indrawati, 2018). The expected real GDP growth for 2018 is 5.4%. For 2019, the proposed state budget (APBN) 2019 targeted the real GDP growth in the range of 5.4%–5.8%. The National Energy Policy (KEN) of 2014 assumed an average annual growth rate (AAGR) of 8% from 2015 to 2025 and will slow down to 7.25% in 2035 and 6.5% in 2050.

Since the current real GDP growth is slower than that assumed in KEN, this study assumes that real GDP would grow at an AAGR of 5.8% in 2015–2040. This was based on the economic projections of the International Monetary Fund and the World Bank. For population, the growth assumption will be 0.8% per year over 2015–2040 period, based on the revised population projection of the Central Bureau of Statistics (2013).

The scenarios are like the previous EOSP reports (since 2013); i.e. Business-As-Usual (BAU) scenario and the five Alternative Policy Scenarios (APSs). These APSs reflected the additional policy interventions likely to be implemented. These are 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, etc. For Indonesia, the five APSs considered are as follows:

1) More efficient final energy consumption (APS1), with specific energy saving targets by sector (Figure 7.1). In addition, Article 9 of the 2014 KEN states that energy elasticity will be less than 1 by 2025 and that final energy intensity will also be decreasing at 1% per year. These goals and targets were also the energy saving targets for this year's study.

Figure 7.1: Energy Efficiency and Conservation Assumptions



Source: Author's assumptions.

2) More efficient thermal power generation (APS2), where higher improvement of existing coal-fired power plants and the introduction of cleaner coal technologies, were considered in the analysis. Also considered for this scenario are most efficient natural gas combined–cycle technologies.
3) Higher contribution of new and renewable energy (NRE) and biofuels (APS3) – In this case, higher penetration of NRE for electricity generation and utilisation of liquid biofuels in the transport sector is assumed compared to the BAU scenario.
4) Introduction or higher utilisation of nuclear energy (APS4), an assumption that it will be in operation after 2020. This is in line with the current plan where two units will be constructed after 2020, each with a capacity of 1,000 megawatts (MW).
5) The combination of APS1 to APS4 constitutes the assumptions of the APS (APS5).

3. Outlook Results

3.1. Business-As Usual (BAU) Scenario

3.1.1. Final energy consumption

Indonesia's total final energy consumption (TFEC) increased at an average annual rate of 2.9% between 1990 and 2015, increasing from 80 million tons of oil equivalent (Mtoe) to 163 Mtoe. Given the assumed economic and population growth, the growth in the TFEC will continue but at a faster rate of 4.4% per year in 2015–2040 in the BAU scenario (Figure 7.2).

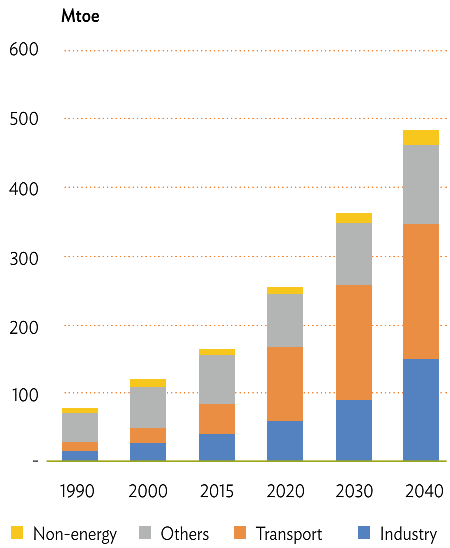
This growth stems from the rapid increase of the energy consumed in the transport and industry sectors. The transport sector is still heavily dependent on oil. In the past, the final energy consumption of the transport sector grew at an average rate of 5.8% per year over 1990–2015. This growth is expected to continue up to 2040 for the BAU scenario at a faster rate of 6.1% per year.

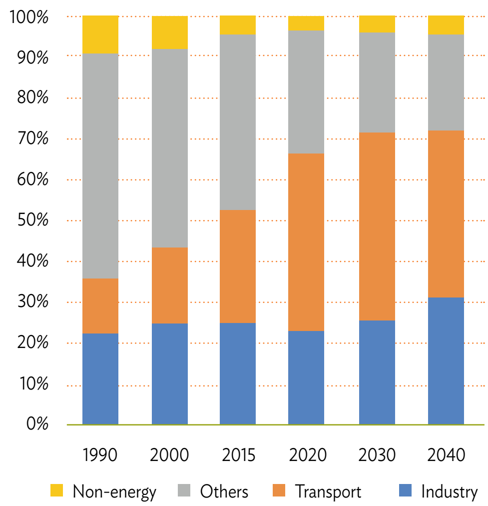
Final energy consumption in the industry sector grew at a slower rate than the transport sector in 1990–2015 (3.4% per year). It will still grow slower than the transport sector for the period 2015–2040 at an average rate of 5.3% per year.

Final energy consumption of the ‘others’ sector (mainly consisting of residential and commercial) grew at an average rate of 1.9% per year in 1990–2015. The final energy consumption of this sector is projected to experience a similar growth rate for the period 2015–2040.

The ‘others’ sector had the highest share in the TFEC in 1990–2015 because of the high consumption of biomass mainly in the residential sector. The share, however, decreased from around 55% in 1990 to 43% in 2015. This is mainly due to the rapid increase of the fuel consumption of the transport sector. The share will continue to decline in the future as household appliances become more efficient and households use more alternatives, such as natural gas and liquefied petroleum gas or LPG. The sector’s share in the TFEC will decrease to 23% in 2040.

Figure 7.2: Final Energy Consumption by Sector (1990–2040)





Mtoe = million tons of oil equivalent.

Source: Author’s calculations.

The share of the transport sector in the TFEC had increased from around 13% in 1990 to 27% in 2015. This share will continue to increase, reaching 41% in 2040. The combined share of oil and alternative fuels for transport will contribute more to the increase of the transport's share in the TFEC.

The industry sector's share in the TFEC was 23% in 1990–2015. This share is expected to increase to 32% by 2040 in line with the growth in industrial activities.

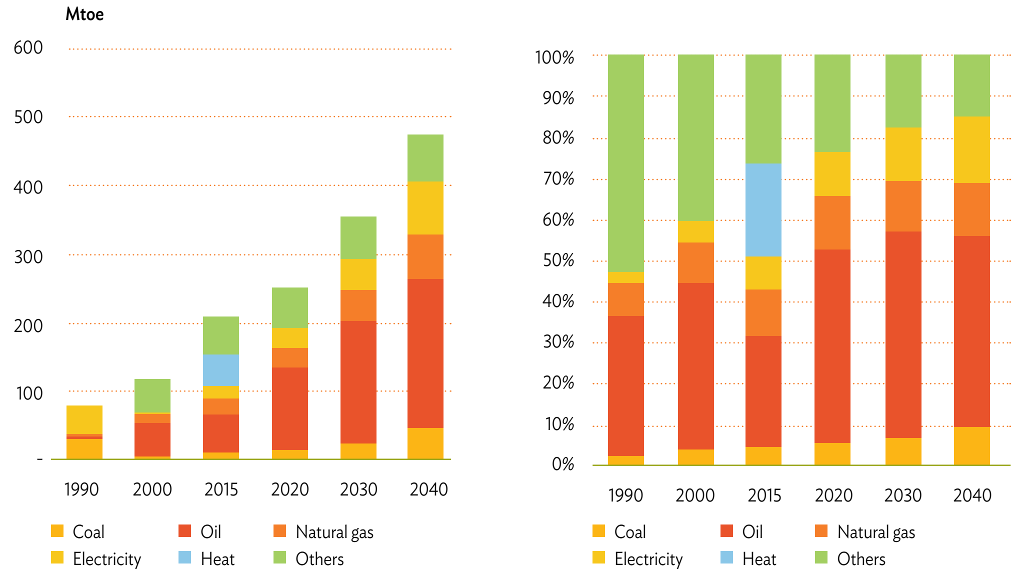
By fuel type, electricity experienced the fastest growth in 1990–2015, at an average rate of 8.1% per year. This rapid growth of electricity demand was due to the significant increase in the consumption of the industry and residential sectors, from 2.4 Mtoe in 1990 to 17.2 Mtoe in 2015. Coal is also increasing significantly over the same period as industry expands, particularly the cement industries. Total coal demand increased from 2 Mtoe in 1990 to almost 10 Mtoe in 2015, growing at an average rate of 6.2% per year.

As for natural gas and oil, the average annual growth of these fuels in 1990–2015 was 5.7% and 2.9%, respectively. Demand for other fuels (mostly biomass for households) increased by 13.5 Mtoe, at an average rate of 1.1% per year.

In the future, the demand for all fuels will continue to increase. For coal, demand will increase the fastest at an average rate of 6.4% per year to 45.6 Mtoe in 2040. Electricity is also expected to grow but at a slower rate than in the past. The AAGR for electricity demand would be 6.2% per year over the 2015–2040 period.

Natural gas and oil demand will grow at an average rate of 4.0% per year and 5.6% per year, respectively, between 2015 and 2040. Demand for other fuels will increase the slowest over the same period, at an average growth rate of 0.9% per year. This is mainly due to the decrease in the growth rate of biomass consumption of the residential sector.

Figure 7.3: Final Energy Consumption by Energy Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

Oil will still play a major role in the country's final energy consumption although more alternative fuels will be consumed by the end-use sectors. The share of oil is expected to be around 46% in 2040, increasing from 34.5% in 2015. The remaining share will be that of coal (9.6%), natural gas (13.5%), electricity (16.3%), and others (14.6%).

3.1.2. Primary Energy Supply

Total primary energy supply (TPES) in Indonesia grew faster than the final energy consumption at about 3.4% per year, from 98.6 Mtoe in 1990 to 229.5 Mtoe in 2015. Amongst the major energy sources, the fastest-growing fuels 1990–2015 were coal and geothermal energy. Coal supply grew at an average annual rate of 10.8% while geothermal energy grew at 9.2% a year. Gas supply increased at a slower rate of 3.8% per year while oil grew slightly slower at 2.9% per year.

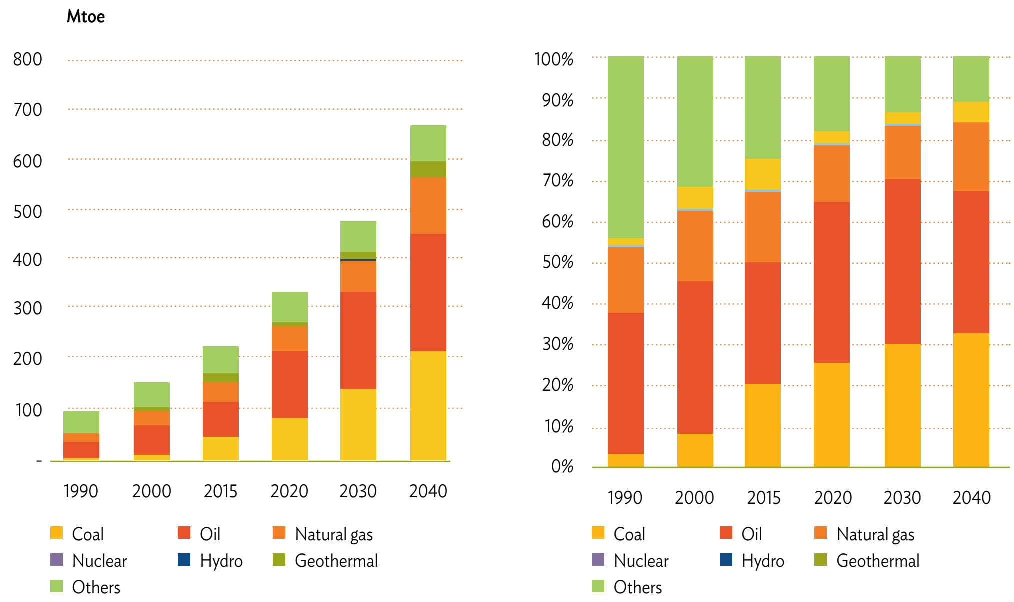
In the BAU scenario, Indonesia's TPES is projected to increase at an average annual rate of 4.4%, reaching 671.4 Mtoe in 2040. Coal is projected to continue growing but at a slower rate of 6.4% per year. Geothermal energy is also expected to increase over the same period. The new price structure for generating electricity from renewable energy will stimulate the development of geothermal energy, amongst others. The projected growth rate of geothermal energy until 2040 is 2.6% per year.

Hydro, including mini and small hydro, will also increase at the same rate of geothermal in 2015–2040. Consideration is being given to building more run-of-river-type hydro rather than reservoir type.

Oil is projected to increase at an average annual rate of 5.1% in 2015–2040. At the same time, natural gas supply will also increase but slower than oil at an average rate of 4.2% per year.

No uptake of nuclear energy is assumed in the BAU scenario. Thus, renewable energy will have a significant role in the future primary energy supply mix as the uptake of cleaner alternatives to oil increases. Other renewable energy resources include solar, wind, biofuels, and biomass.

Figure 7.4: Primary Energy Supply, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

Oil constituted the largest fossil fuel share in the TPES, but the share had declined slightly from 33.8% in 1990 to 29.5% in 2015. The share of natural gas in the total mix slightly increased from 16% in 1990 to 17.5% in 2015.

Since both coal and geothermal rapidly grew in 1990–2015, the shares of these energy sources in the TPES have increased significantly. Coal share in the TPES increased from around 4% to 20% while geothermal share increased from 2% to 7.5%. Hydro's share remains the same at 0.5% over the same period. Since others, which include biomass, solar, wind, ocean, biofuels, and electricity, grew slower than the other fuels, its share declined from 44.1% in 1990 to 24.7% in 2015.

In the BAU scenario, oil's share will still be dominant throughout the 2015–2040 period, and its share in the TPES will reach 35% in 2040. Natural gas share will decrease slightly to 16.6% by the end of 2040, while coal share will increase to 32.5%.

Since the supply of hydro, geothermal, and 'others' is growing slower than fossil fuel sources, the shares will be declining over 2015–2040. Hydro's share in the TPES will decrease to 0.3% by 2040 and geothermal share, to 4.9%. The share of 'others' will reach 10.8% in 2040, from 24.7% in 2015

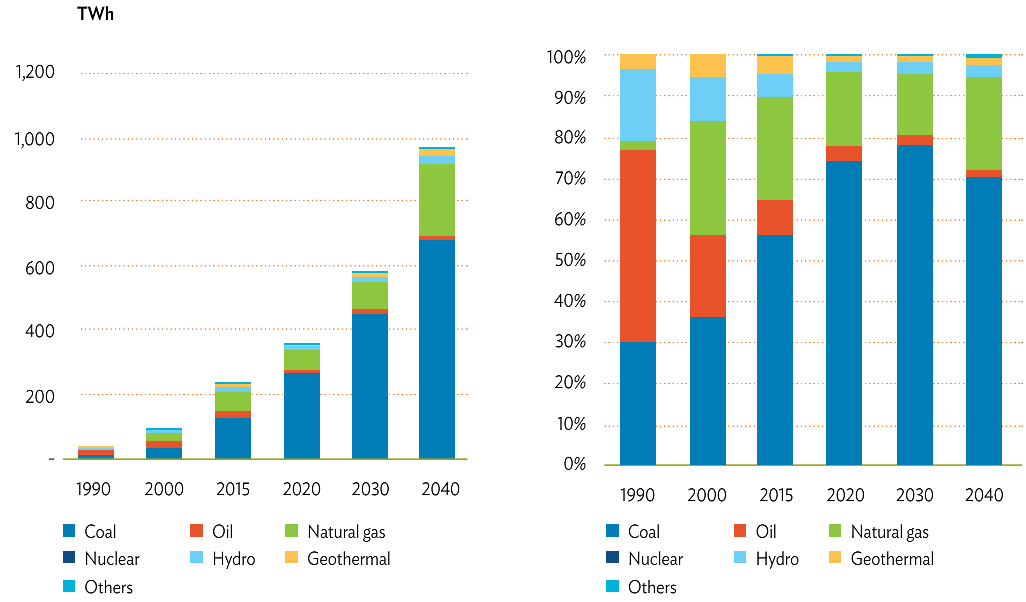
3.1.3. Power generation

Power generation output increased at an average rate of 8.2% per year over the past 2 decades, from around 33 TWh in 1990 to 233 TWh in 2015. The fastest growth occurred in the production of electricity from natural gas plants at 19.2% per year. This is due to the increase in gas turbine and combined cycle capacities as natural gas became increasingly available.

In the BAU scenario, to meet electricity demand, power generation is projected to increase at a slower rate of 5.9% per year reaching almost 969 TWh in 2040. By type of fuel, generation from 'others' will grow the fastest at an average rate of 10.9% per year. The main reason for this very rapid growth is that generation from these other sources was very small in 2015 but is expected to increase significantly as a result of the government's policy of increasing the use of NRE sources, including solar PV, wind, biomass, etc., classified as 'others'.

Generation from geothermal and hydro is also growing, but much slower than 'others', both at 2.6%.

Figure 7.5: Power Generation by Fuel Type (TWh) (1990–2040)



TWh = terawatt-hour.

Source: Author's calculations.

Power generation from natural gas will continue to increase but at a much slower rate of 5.4% per year while coal-based power generation will be growing at an average annual rate of 6.8%. No nuclear plant is considered under the BAU scenario.

The share of coal will remain dominant in the total power generation of the country. Its share in total power generation was lower than oil in 1990 (30%). The share increased over time as more coal-fired power plants were constructed. In 2015, the share increased to almost 56%, higher than that of oil. This share is expected to continue to increase in the future, reaching around 70% in 2040.

Oil had the largest share in power generation in 1990 (47%). By 2015, the share of oil declined to around 8.4% as production from coal and natural gas plants increased rapidly. Natural gas share in 2015 reached 25.2% and declined to 22.7% by 2040 under the BAU scenario.

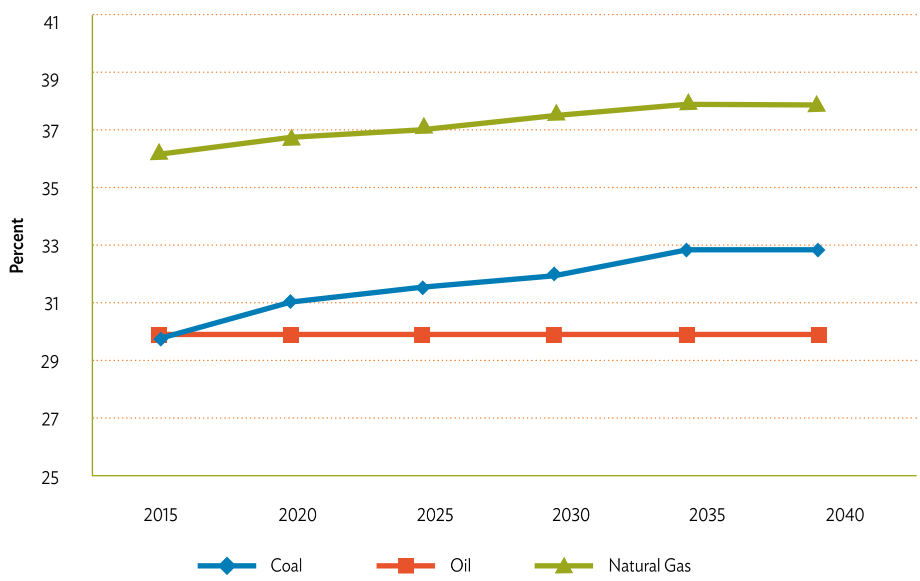
Hydro's share in the total electricity production of the country was 17.5% in 1990. The share declined to 5.9% in 2015. Under the BAU scenario, hydro's share is expected to continue to decline and reach 2.7% in 2040.

The share of geothermal and other renewables constituted about 4.5% of the power generation in 2015. The share of these renewables declined to 2.7% by 2040 under the BAU scenario.

The average thermal efficiency of fossil fuel–based power plants was around 32% in 2015. the BAU scenario assumes a slight improvement in the efficiency of coal and natural gas power plants causing the thermal efficiency of fossil fuel plants to increase to almost 35% in 2040.

By fuel, the thermal efficiency of coal-fired power plants will increase from 30% in 2015 to 34% in 2040 while natural gas is assumed to increase from 38% to 40%. Oil will remain less than 31% over the 2015–2040 period (Figure 7.6).

Figure 7.6: Thermal Efficiency, BAU (2015–2040)



Source: Author's assumptions.

3.1.4. Energy indicators

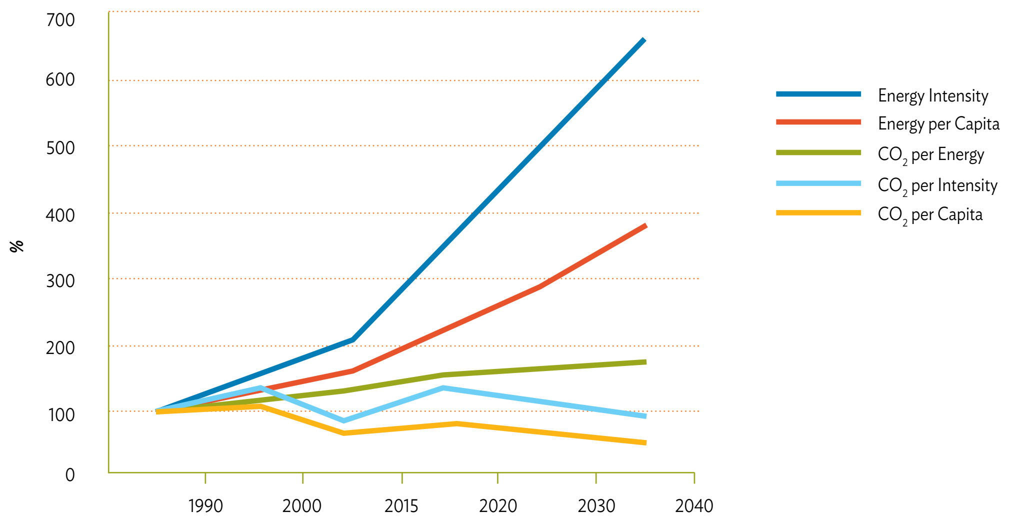
Indonesia's primary energy intensity (TPES/GDP) had been increasing until 2000. Since then, the intensity declined and reached a level of 232 toe/million 2010 US$ in 2015. The final energy intensity had been declining and reached a level of 165 toe/million 2010 US$ in 2015. These indicate that energy producers and consumers have started to effectively use energy by implementing energy conservation measures and greater utilisation of energy-efficient technologies.

In the BAU scenario, primary and final energy intensity is projected to decline at an average annual rate of 1.3% in 2015–2040. Primary energy intensity in 2040 will be around 166 toe/million 2010 US$ while final energy intensity will be 118 toe/million 2010 US$.

Thus, the energy intensity ratio (primary and final) is expected to improve by almost 29% in 2040 compared to 2015.

Per capita energy consumption, measured as the ratio of TPES to the total population, had been increasing since 1990, from 0.5 to 0.9 in 2015. This level of energy consumption per capita indicates improving energy access of society, which can be reflected by the electrification ratio. In 2015, the electrification ratio was around 88.5% and reached 94.8% in 2017. The government expected all households to have access to electricity by 2020.

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



Source: Author's calculations.

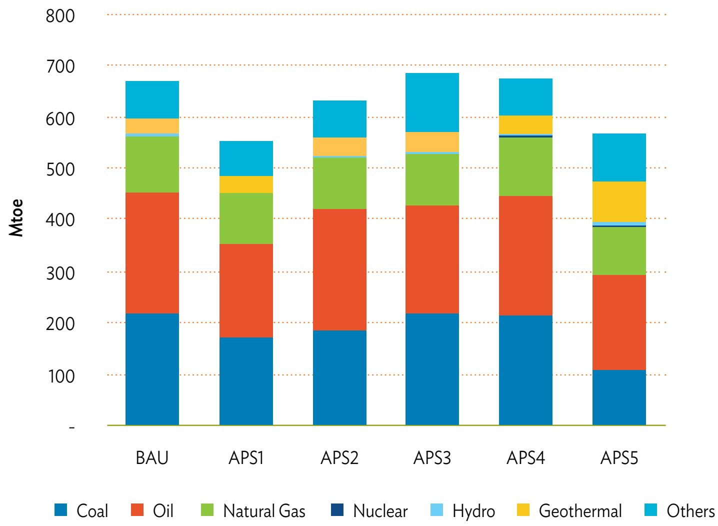
Under the BAU scenario, energy consumption per capita will continue to increase and will reach 2.1 toe per person in 2040. This result is in accordance with the existing national energy policy (2014), which targeted a level of 1.4 toe in 2025 and 3.2 toe in 2050.

In the BAU scenario, the elasticity of final energy consumption is expected to continue declining and will reach 0.8 in 2040. Elasticity lesser than 1 indicates that growth in final energy consumption will be slower than growth in GDP over the period 2015–2040.

3.2. Energy Savings and CO_2 Reduction Potential

The assumptions in the APS were analysed separately to determine the individual impact of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions, APS5. Figure 7.8 shows the changes in the TPES for all the scenarios.

Figure 7.8: Comparison of Scenarios of Total Primary Energy Supply by 2040



Mtoe = million tons of oil equivalent.

Source: Author's calculations.

Figure 7.8 illustrates that APS1 and APS5 have the largest reduction in primary energy supply in 2040 due to the energy efficiency assumptions on the demand side. Energy efficiency assumptions in APS1 could reduce the TPES in the BAU scenario by as much as 118 Mtoe or 17.6%. For APS5, the reduction will amount to 104 Mtoe or 15.5%.

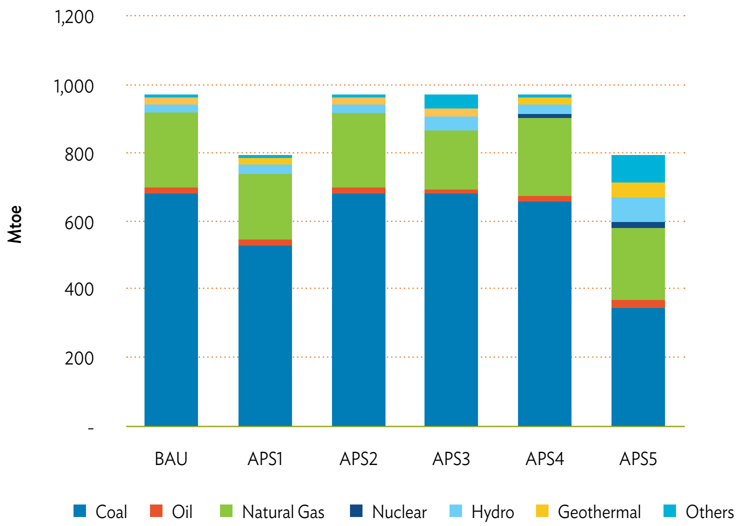
APS2, which assumes higher efficiency in thermal electricity generation, will also reduce the TPES in 2040 by 42 Mtoe or 6.2% compared to the BAU scenario. Since APS2 does not assume efficiency measures for the final sector, it will have a lower impact than APS1. Therefore, the reduction is due mainly to the use of more efficient power generation while some conventional plants ceased operation after reaching their technical lifetime.

For APS3, the TPES increased slightly as more renewable energy for power generation started operation and more biofuels were being consumed by the transport sector. The difference between APS3 and the BAU scenario for 2040 is only around 11.5 Mtoe or 1.7%.

The introduction of nuclear power generation after 2020 (APS4) will also increase the total primary energy mix of 2040 by only 1.4 Mtoe or 0.2% compared to the BAU scenario. The result indicates that the introduction of nuclear plants will reduce the consumption of fossil fuels (coal, oil, gas) in generating power. However, since the efficiency of nuclear plants is slightly lower than the average thermal efficiency of fossil fuel plants, then there can be no savings relative to the BAU scenario results.

Figure 7.9 shows the total electricity generation in 2040 in all scenarios. In APS1, due to the lower electricity demand, the shares of fossil-fired electricity generation will be lower than in the BAU scenario, 93% compared to 95%. In APS2, the share is the same as that of the BAU scenario. In APS3, due to the assumption of more renewable energy, the shares of fossil fuel–fired generation could be reduced by 5% while in APS4, nuclear energy could reduce fossil fuel share by almost 2%. In APS5, where all scenarios were combined, the reduction in the shares of fossil energy–based generation will be significant; i.e. almost 22% lower than the BAU scenario.

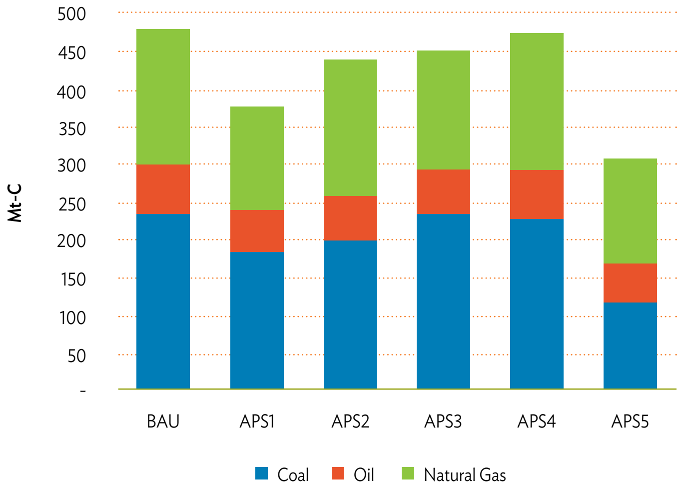
Figure 7.9: Comparison of Scenarios to Electricity Generation by 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.
Source: Author's calculations.

In terms of CO_2 emissions reduction, energy efficiency assumptions in APS1 could reduce emissions by 22% in 2040 compared to the BAU scenario. In APS2, the installation of more efficient new power plants could reduce emissions by 9%. Higher contributions from renewable energy could reduce emissions by 6% while nuclear energy could reduce emissions by 1%. All these assumptions combined (APS5) could reduce BAU scenario CO_2 emissions by 36% in 2040.

Figure 7.10: Comparison of Scenarios to CO_2 Emissions by 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons carbon.

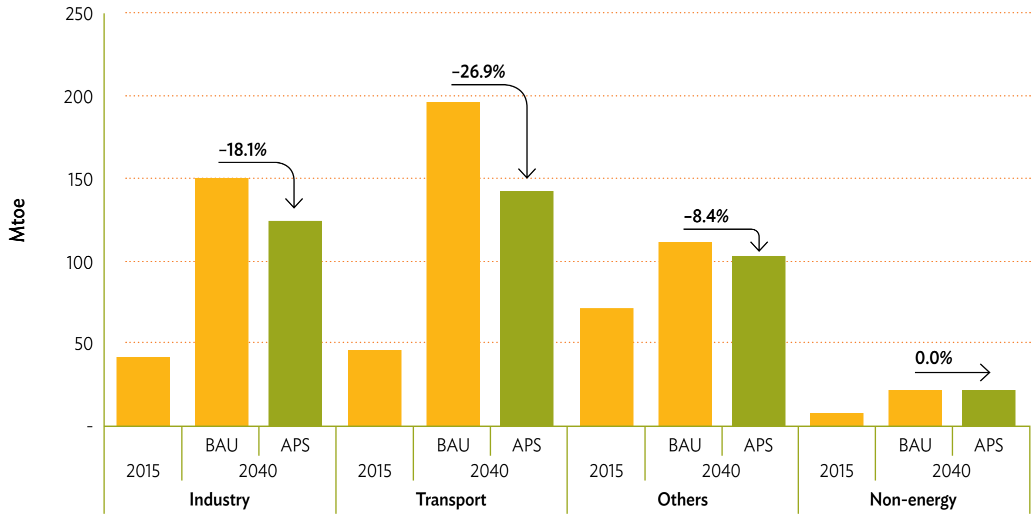
Source: Author's calculations.

3.2.1. Final energy consumption

In the combined APS (APS5), the TFEC is projected to increase at a slower rate than in the BAU scenario, increasing at an average rate of 3.5% per year from 162 Mtoe in 2015 to 388 Mtoe in 2040. Slower growth under the APS, relative to the BAU scenario, is projected across all sectors as a result of the government's EEC programme, particularly in the transport sector. The growth rate of energy demand in the transport sector is projected to increase by 4.8% per year compared with 6.1% per year in the BAU scenario. Figure 7.11 shows the TFEC by sector in 2015 and 2040 in both the BAU scenario and the APS.

Final energy consumption savings are estimated to be 27 Mtoe in the industry sector, 52 Mtoe in the transport sector, and 9.3 Mtoe in the residential/commercial ('others') sector by 2040 under the APS, relative to the BAU scenario.

Figure 7.11: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

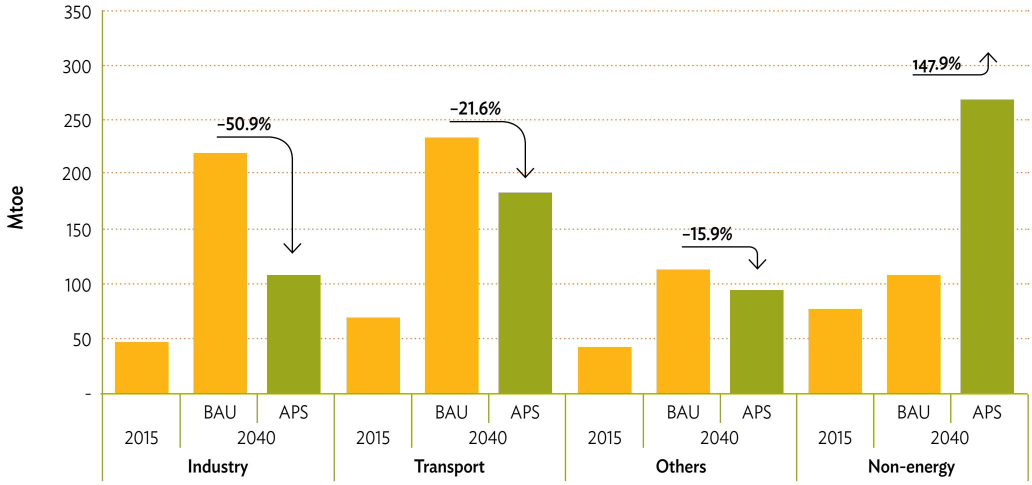
Source: Author's calculation.

3.2.2. Primary energy supply

In the combined APS (APS5), the TPES is projected to increase at a slower rate, relative to the BAU scenario, 3.7% per year to 567 Mtoe in 2040. All energy sources are projected to experience positive AAGRs. However, some will be slower than in the BAU scenario. The lower TPES relative to the BAU scenario reflects EEC measures on the demand and supply sides, with the use of more efficient technology for power generation.

In terms of fuel type, there are estimated savings of almost 111 Mtoe for coal, 50 Mtoe for oil, and 18 Mtoe for natural gas by 2040 under the APS, relative to the BAU scenario. In case of other resources (new and renewable resources, nuclear, and 'others'), the TPES in the APS in 2040 is 159 Mtoe higher than that in the BAU scenario.

Figure 7.12: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



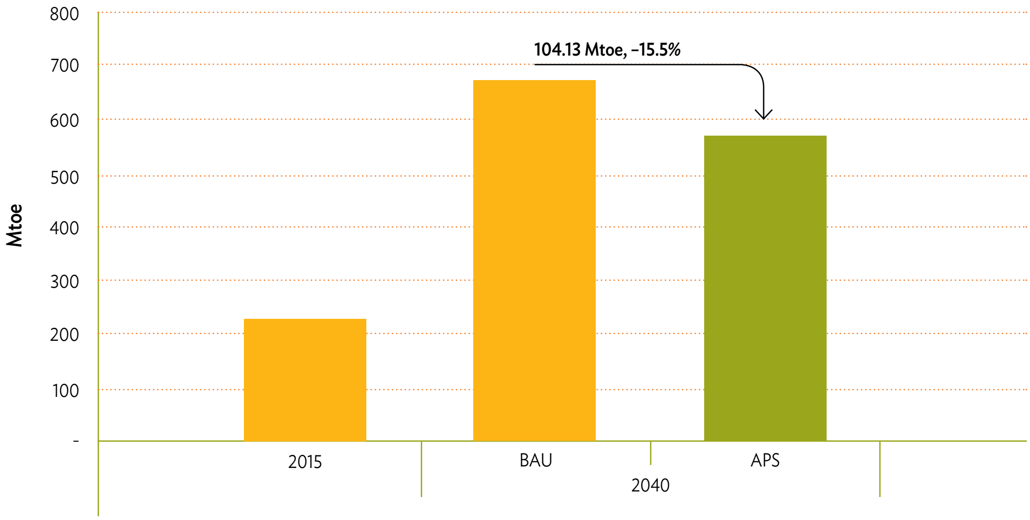
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

3.2.3. Projected energy savings

Total energy savings (the difference between the TPES in the BAU scenario and the APS) are 104 Mtoe in 2040. These could be achieved through the implementation of EEC and renewable energy targets and action plans of Indonesia, improved power plant efficiency, and introduction of nuclear energy. These are more than half of Indonesia's TPES in 2015, which is around 230 Mtoe.

Figure 7.13: Total Primary Energy Supply, BAU and APS (2015 and 2040)



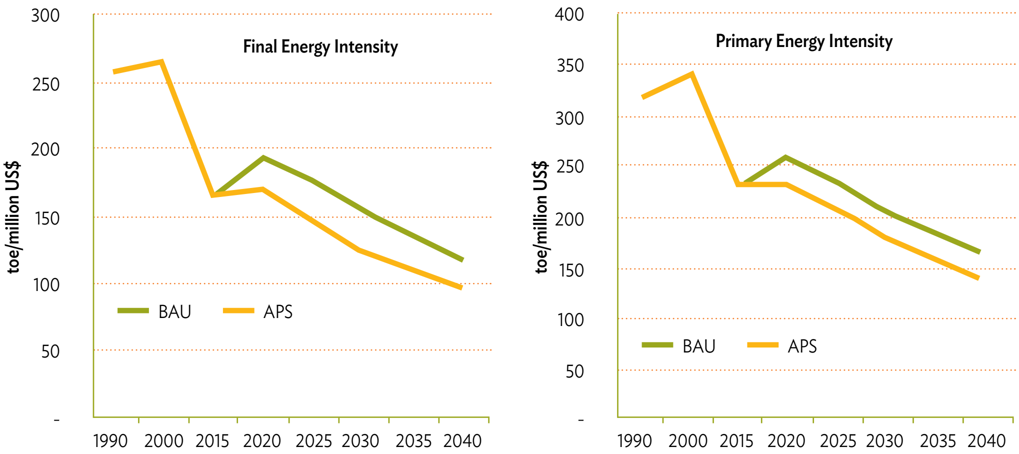
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2.4. Energy intensities

The 2014 National Energy Policy emphasised the target of 1% per year reduction in final energy intensity up to 2025. Under the BAU scenario, the final energy intensity has been (and will be) on the decline at an average rate of 1.3 per year over 2015–2040. Implementation of the sectoral EEC targets under the APS will result in a faster declining rate for the final energy intensity, 2% per year over the projection period.

Figure 7.14: Energy Intensity, BAU and APS (1990–2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, toe = tons of oil equivalent.

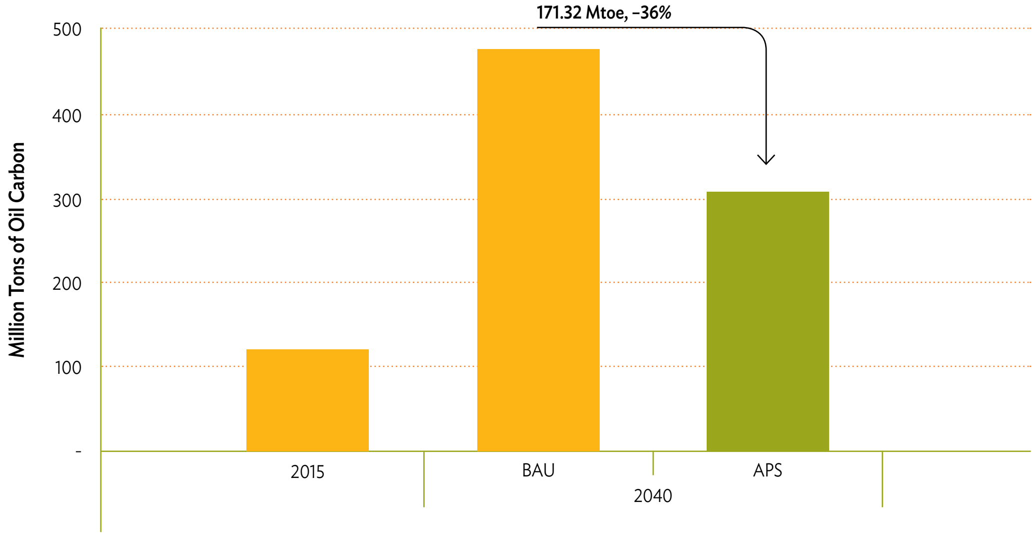
Source: Author's calculations.

In terms of primary energy intensity, the annual reduction will be similar, 1.3% under the BAU scenario. In the APS, the annual reduction in primary energy intensity will also be 2% under extensive implementation of the sectoral EEC targets.

3.2.5. CO_2 emissions from energy consumption

CO_2 emissions from energy consumption are projected to increase at an average annual rate of 5.6% from around 122 million tons of carbon (Mt-C) in 2015 to 476 Mt-C in 2040 in the BAU scenario. This is driven by the increasing use of carbon-intensive fuels, particularly the use of coal for power generation and industry, as well as oil in the transport sector.

Figure 7.15: CO_2 Emissions from Energy Consumption, BAU and APS (2015–2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

In the combined APS (APS5), the CO_2 emissions in 2015–2040 are expected to be 36% lower than in the BAU scenario. The inclusion of more energy conservation measures, higher efficiency, elevated renewable targets, and the inclusion of nuclear energy after 2020 would contribute to the reduced emissions. The government has committed to reduce CO_2 emissions in 2030 by 29% without international assistance, and 41% with international assistance. This study's result, which is 36% reduction, is above the committed target of 29%. However, to achieve the committed CO_2 reduction target of 41%, the combined target and action plan specified under APS5 must be more aggressive.

3.2.6. Review of Indonesia's Nationally Determined Contributions and APS results

Regarding climate change, Indonesia ratified the Paris Agreement through Law Number 16, year of 2016, which was submitted to the United Nations Framework Convention on Climate Change on 6 November 2016. This is a commitment amongst countries across the globe to reduce greenhouse gas (GHG) emissions. The commitment in Indonesia's NDC was to unconditionally reduce 29% of GHG emissions by 2030, and conditionally reduce up to 41% through international support. The percentage value is the sectors' reduction compared to the total BAU value of 2030. Table 7.1 shows the GHG emissions reduction target under the NDC. The CM1 is the countermeasure under the unconditional mitigation scenario, and CM2 is the countermeasure under the conditional mitigation scenario.

Table 7.1: NDC Emissions Reduction Targets for GHG

No	Sector	GHG Emissions Level 2010* MtCO2e	GHG Emissions Level 2030, (MtCO2e)			GHG Emissions Reduction (MtCO2e)		GHG Emissions Reduction % of Total BAU	
			BAU	CM1	CM2	CM1	CM2	CM1	CM2
1	Energy*	453.2	1,669	1,355	1,271	314	398	11.0%	13.9%
2	Waste	88.0	296	285	270	11	26	0.4%	0.9%
3	IPPU	36.0	70	67	66	3	3	0.1%	0.1%
4	Agriculture	110.5	120	110	116	9	4	0.3%	0.1%
5	Forestry**	647.0	714	217	64	497	650	17.2%	23.0%
	TOTAL	**1,334.0**	**2,869**	**2,034**	**1,787**	**834**	**1,081**	**29.0%**	**38.0%**

BAU = Business-As-Usual, CM = countermeasure, GHG = greenhouse gases, IPPU = Industrial Processes and Product Use, $MtCO_2e$ = metric tons of equivalent carbon dioxide, NDC = Nationally Determined Contributions.

*Including fugitive, ** including peat fire

Source: Indonesia NDC and the Way Forward, Webinar NDC on 20 July 2017.

Based on the NDC, the energy sector is projected to emit GHG almost four times the 2010 level by 2030 if no countermeasures are taken (CM1). The sources of emissions are fuel combustion and fugitive emissions from fuel production. The industry and power generation will be the major emitters of GHG emissions in 2030. These sectors are the major consumers of coal in the country.

Based on the NDC emissions reduction target, the estimated GHG emissions reduction from energy (fuel combustion and including fugitive) will be 314 Mt-CO_2e under the CM1 condition (unconditional) and 398 Mt-CO_2e under the CM2 condition (conditional). This will be around 19% reduction and 23% reduction, respectively, from the BAU scenario emissions of the sector.

The CO_2 emissions in the current outlook will also increase almost four times over the planning period, from around 122 Mt-C (447 Mt-CO_2) in 2015 to 476 Mt-C (1,745 Mt-CO_2) in 2040 under the BAU scenario. Although slightly higher, the trend is like the NDC projection for 2010 to 2030. The CO_2 emissions under the APS for 2040 will be 1,117 Mt-CO_2, which is 12% lower than the projected level for the CM2 in the NDC. Compared to BAU, the APS will reduce the CO_2 emission by 628 Mt-CO_2, or 36% (Table 7.2). By implementing the efforts assumed under the APS (which is a combination of APS1, APS2, APS3, and APS4), the reduction in CO_2 emissions will be higher than the NDC target. These are promoting energy efficiency efforts in all final sectors, improving thermal efficiency of fossil power plants, increasing renewable shares in the transport and power sectors, and installing two units of 1,100 MW nuclear plants by 2040.

Table 7.2: CO_2 Emissions in 2030 and 2040 for BAU and APS

Fuel Type	GHG Emissions Level (Mt-CO_2)					GHG Emissions Reduction			
	2015	2030 BAU	2030 APS	2040 BAU	2040 APS	2030 (Mt-CO_2)	2040 (Mt-CO_2)	2030 (%)	2040 (%)
Coal	181	553	261	850	418	292	432	52.9	50.9
Gas	87	137	119	237	194	18	43	13.3	18.1
Oil	179	540	411	658	505	129	153	23.9	23.2
TOTAL	**447**	**1,230**	**790**	**1,745**	**1,117**	**440**	**628**	**35.8**	**36.0**

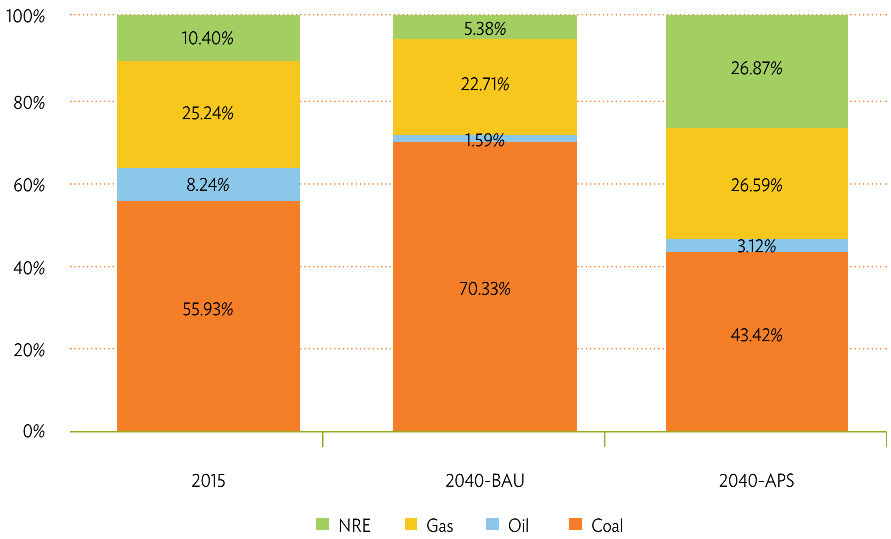
BAU = Business-As-Usual, CM = countermeasure, GHG = greenhouse gases, Mt-CO2 = metric tons of carbon dioxide.

Source: Author's calculation.

In 2030, the total CO_2 emission under the BAU scenario is around 1,230 Mt-CO_2, which is slightly below the CM2 level of the NDC. Thus, under the current outlook, the CO_2 emission level assumed for the CM2 will be achievable in 2030 under the BAU scenario assumption which are economic growth on average at 5.8% per year, average population growth of 0.8% per year, and implementation of the current energy policy which already assumed 1.3% reduction in energy intensity, and increased share of renewables including biofuels both in the transport and the power sectors as outlined in the biofuel road map.

The CO_2 emissions reduction is highest in the case of coal compared to oil and gas. Oil is mostly consumed by the transport sector and will remain dominant, despite the introduction of other alternatives to oil. Coal is mainly used in the power sector. The increasing share of NRE as outlined in the current energy policy will reduce the coal share significantly. Figure 7.16 shows the share of the different sources of energy in total electricity generation in 2040. The figure shows that the growth of electricity production from coal-fired power plants in the APS is slower than that of the NRE- and gas-based power plants. In the case of NRE-based power plants, solar- and biomass-based power generation will grow fastest, considering it was very small in 2015.

Figure 7.16: Power Generation Mix, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, NRE = new and renewable energy.

Source: Author's calculation.

4. Implications and Policy Recommendations

Indonesia's primary energy intensity (TPES/GDP) and final energy intensity (TFEC/GDP) have been declining as a result of greater utilisation of efficient energy technologies by both energy producers and consumers. Under the BAU scenario, the primary energy intensity declined at 1.3% per year over the projection period. Further adaptation of the sectoral target combined with the renewables' portfolio, efficient power plant technology, and introduction of nuclear energy, will enable the country's energy intensity to decline even more at 2.1% per year. The elasticity of primary energy supply is also projected to decrease to below 1.0 under the BAU scenario (0.8) and furthermore to 0.6 under the assumptions that the sectoral saving target and the other policy interventions under APS2, APS3, and APS4 are implemented fully as indicated in the combined APS (APS5) scenario.

The primary energy supply per capita is in the range of 1.7 to 2.2 toe/person for all scenarios by 2040. This is still below that of neighbouring countries like Thailand and Malaysia. The development of energy infrastructure, particularly in the remote and small island areas, will improve the electrification ratio and, hence, increase accessibility to energy.

Oil will still have the largest share in the total primary energy mix. The 2014 National Energy Policy sets the target of less than 25% in 2025, and of less than 20% in 2050. The transport sector, which is the main consumer of oil in the country, will be crucial for achieving these energy-saving targets. Government should further encourage the transport sector programme by improving the public transport system and promoting the use of alternative fuels and more efficient vehicles.

The current analysis which assumed increased use of alternative fuels and more efficient vehicles in the transport sector and efficient boilers in the industries resulted in oil consumption savings between the BAU scenario and the APS of as high as 23% in 2040.

The combined APSs (APS5) assumed implementation of programmes to achieve the sectoral energy-saving targets such as

- Promoting industrial energy efficiency through mandatory energy management for industries consuming more than 6,000 toe as mandated by Government Regulation no. 70/2009, through a system optimisation approach, and by adapting the ISO50001 as the reference for the national competent standard on energy managers.
- Saving 10% of electricity consumption through national campaigns and through regulations in the case of government buildings.
- Implementing 'Green Building' in existing and new buildings by formulating stricter legislation to improve the environment quality of buildings , and encouraging green buildings by adopting the standards in Regulation No. 02/PRT/M/2015 on Green Building issued by the Minister of Public Works and Public Housing. Both the governor of DKI Jakarta and the mayor of Bandung had already issued regulations on green buildings, Regulation No. 38/2012 and Regulation no. 1023/2016, respectively.
- Promoting the labelling and performance standards on electrical appliances in the residential sector through regulations that mandate energy efficiency labelling and minimum energy performance standards (MEPS) for appliances. Regulations are in place for compact fluorescent lamps or CFL and for air conditioning. MEPS and labelling for refrigerators, rice cookers, washing machines, water pumps, and LED lights will soon be finalised.
- Formulating funding mechanisms (private, public, or a combination of both) to promote efficient technologies and equipment. The main issue is the lack of financial support from commercial banks and other financial institutions. Provision of policies that will increase investment amounts and reduce strict collateral requirements of banks and other financial institutions is currently ongoing. In addition, policies and regulations to facilitate and support the establishment of energy-saving companies will also support funding for EEC projects.

Pursuing EEC programmes is one measure of reducing CO_2 emissions to achieve the committed target in the NDC of 29% (without international support) and 41% (with international support). Increasing the share of renewable energy sources in the supply mix, increased thermal efficiency of fossil fuel plants, and the introduction of nuclear energy, as implied in the APS, would further reduce CO_2 emissions. The assumptions in the APS will slow down CO_2 emissions compared to the BAU scenario. The reduction level is more than that targeted in the NDC for the energy sector; i.e. more than 440 Mt-CO_2 in 2030 compared to 392 Mt-CO_2 under CM2 of the NDC. Most of the reductions will come from reducing the use of coal, particularly in the power sector, and replacing it with renewable energy such as solar, hydro, and geothermal.

Both the BAU scenario and the combined APS (APS5) projected that renewable energy will play a major role in the country's energy mix. The government has implemented programmes and issued regulations to accelerate the development of renewable energy in Indonesia. The recent Ministry of Energy and Mineral Resources (MEMR) Regulation No. 50 Year 2017 provide more opportunities for the private sector to enhance the development of hydro, geothermal, PV, wind, municipal waste, biomass (agriculture estates), biogas, and ocean energy for on-grid electricity. MEMR Regulation no. 38 of 2016 provides opportunities for the private sector and local state-owned companies to develop small-scale power supply (off-grid/mini-grid) from renewable energy (mini/micro hydro, PV, etc.) to accelerate electrification in undeveloped rural, remote, border, and populated small island areas.

Through the Biodiesel Mandatory Roadmap (MEMR Regulation No. 12 of 2015), the government promotes biofuel use for non-electricity purposes, such as in the transport sector, as alternative for diesel fuel. Indonesia started Biodiesel Blending in 2008 with B2.5 then gradually increased to B5, B10, B15, and reached B20 in 2016. This mandate opens opportunities for the private sector to produce cleaner biofuel.

Further measures still need to be undertaken to attract increased private sector involvement. Examples are improving the transparency and awareness of government support mechanisms, enhancing financial institutions to participate in renewable energy projects, improving the mechanism for providing incentives to promote NRE sources, further collaborating with developed countries to promote low-carbon technologies, etc.

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CHAPTER 8

JAPAN COUNTRY REPORT

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1. Background

Japan is a small island-nation in Eastern Asia. It consists of several thousand islands spanning a land area of approximately 377,960 square kilometres; most of its land area is mountainous and thickly forested. Until 2009, it was the world's second-largest economy after the United States. In 2010, however, China surpassed Japan as the world's second-largest economy. Japan's real gross domestic product (GDP) in 2015 was about US$5,986 billion (constant 2010 prices) (World Bank, 2017), and the population is currently about 127 million.

1.1. Energy Situation

Japan possesses limited indigenous energy resources and imports almost all its crude oil, coal, and natural gas requirements to sustain economic activity. In 2015, Japan's primary energy supply was 429.8 million tons of oil equivalent (Mtoe). By energy type, oil represented the largest share at 43.0%, coal was second at 27.3%, followed by natural gas at 23.3%. Nuclear energy accounted for 0.6%. Others, such as hydro, geothermal, wind, and solar, represented the remainder of 5.8%. In 2015, net imports of energy accounted for about 99% of net primary energy supply. With limited indigenous energy sources, Japan imported almost 100% of oil and coal, and 98% of gas.

Japan is a large importer of coal: steam coal for power generation, pulp and paper, and cement production; and coking coal for steel production. Domestic demand for natural gas is met almost entirely by imports of liquefied natural gas. Natural gas is mainly used for electricity generation, followed by reticulated city gas and industrial fuels. In 2015, primary natural gas consumption was 100 Mtoe.

Japan's final energy consumption experienced a slight growth of 0.1% per year from 287.0 Mtoe in 1990 to 291.4 Mtoe in 2015. The residential/commercial ('others') sector had the highest growth rate during this period at 1.1% per year, followed by the transport sector with 0.2%. Consumption in the industry sector decreased at a rate of 1.1% per year on average over the period 1990–2015. Oil was the most-consumed product, having a share of 59.5% in 1990; it decreased to 52.3% in 2015. Electricity was the second most-consumed product.

Japan's primary energy supply decreased at the rate of 0.1% per year from 438.6 Mtoe in 1990 to 429.8 Mtoe in 2015. Amongst the major energy sources, the fastest-growing fuels were natural gas and coal. Natural gas and coal consumption grew at an average annual rate of 3.3% and 1.7%, respectively, while nuclear energy declined at 11.5% in 1990–2015 due to the Great East Japan earthquake. Oil consumption declined by 1.2% per year over the same period.

In Japan, 292 gigawatts (GW) of power generation capacity was installed and generated about 1,035 terawatt-hours (TWh) of electricity in 2015. The generation by energy type is broken down as thermal (coal, natural gas, and oil) at 82.6%; nuclear, 0.9%; hydro, 8.2%; and geothermal, solar, and wind taking up the remaining 8.0%.

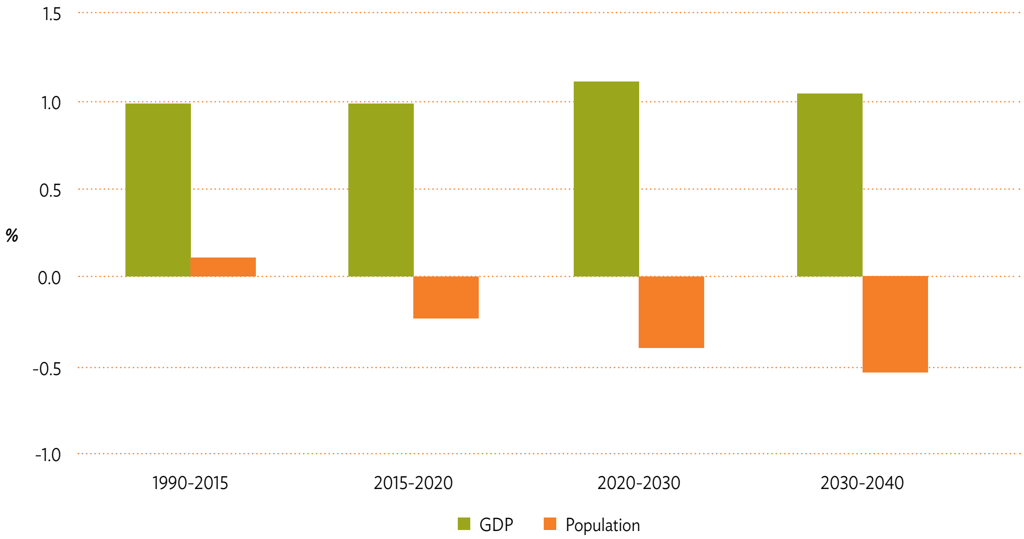
2. Modelling Assumptions

In this outlook, Japan's real GDP is assumed to grow at an average annual rate of 1% from 2015 to 2040. With the maturing of Japanese society and economy, the industry structure will become increasingly oriented towards the service industry.

Population growth, on the other hand, will decline by about 0.4% per year from 2015 to 2040 due to the decreasing birth rate. Japan's population is projected to decrease from 127 million in 2013 to 114 million in 2040. Figure 8.1 shows the assumptions of GDP and population growth in this study.

The development of Japan's infrastructure and the expansion of its manufacturing industry will be saturated over the outlook period, and production of crude steel, cement, and ethylene will gradually decline. The number of automobiles will decline as the population shrinks.

Figure 8.1: Annual Growth Rate of GDP and Population



GDP = gross domestic product.

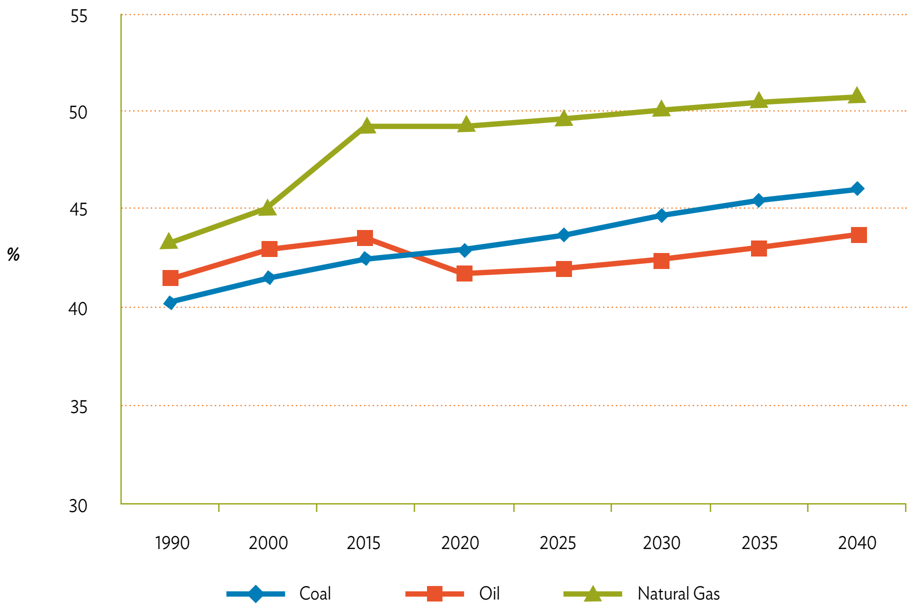
Source: Author's assumption.

The New Strategic Energy Plan was approved by the Cabinet in April 2014. Based on this plan, the Ministry of Economy, Trade and Industry (METI) approved the Long-term Energy Supply and Demand Outlook in July 2015. According to the Outlook, the share of nuclear power will be reduced from about 30% before the Great East Japan Earthquake to about 20%–22% in 2030. The share of renewable energy will be about 22% to 24% in 2030, which was 11% before the earthquake. Also, the share of baseload power (hydropower, coal-fired thermal power, nuclear power, etc.) will be approximately 56%.

Japan's energy savings goal will be attained through the implementation of national energy efficiency programmes in all energy-consuming sectors. For the industry sector, energy savings are expected from improvements in manufacturing technologies. In the residential/commercial sector, the 'Top Runner Programme'[1] is projected to induce huge savings in addition to programmes on energy management systems, improvements in adiabatic efficiency, lighting systems, and heat pump systems. In the transport sector, efficiency improvements will be achieved from improvements in vehicle fuel efficiency, including increases in the stock of hybrid vehicles and structural changes in vehicles. Figure 8.2 shows the assumed thermal efficiencies of thermal power plants in the Business-As-Usual (BAU) scenario.

[1] This is Japan's energy efficiency programme that 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.

Figure 8.2: Thermal Efficiency, BAU



BAU= Business-As-Usual.

Source: Author's calculation.

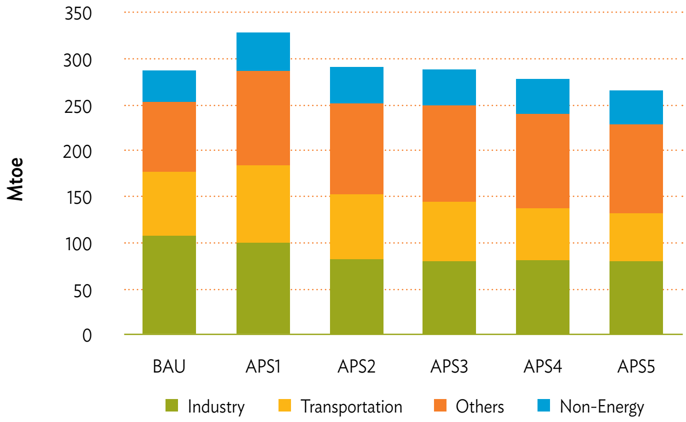
3. Simulation Results

3.1. Business-As-Usual Scenario

3.1.1. Final Energy Consumption

With the projected relatively low economic growth and declining population, Japan's final energy demand from 2015 to 2040 is projected to decline at an average rate of 0.4% per year in the BAU scenario. This is also driven by improved energy efficiency in the transport sector. The final energy consumption of the transport sector is projected to decrease at an annual average rate of 1.3% from 2015 to 2040. This is mainly due to improvements in the fuel economy of conventional internal combustion engine vehicles, and the penetration of hybrid vehicles. Figure 8.3 shows the projected final energy consumption by sector from 1990 to 2040 under the BAU scenario.

Figure 8.3: Final Energy Consumption by Sector, BAU

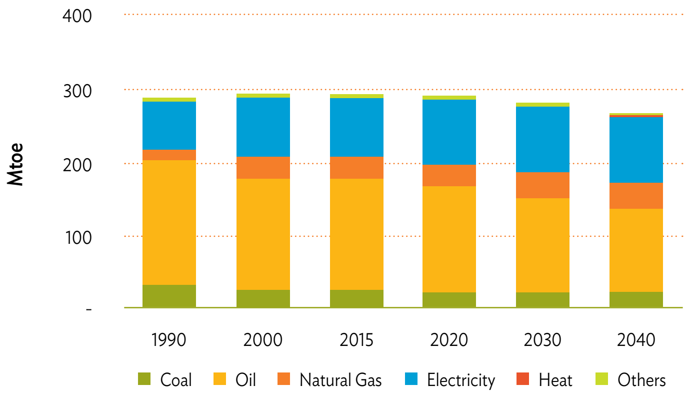


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

By fuel type, the consumption of coal and oil is projected to decrease at an average annual rate of 0.4% and 1.1%, respectively, between 2015 and 2040. On the other hand, consumption of natural gas and electricity is projected to increase at 0.6% and 0.4% per year, respectively, over the period. Figure 8.4 shows the projected final energy consumption by source from 1990 to 2040 under the BAU scenario.

Figure 8.4: Final Energy Consumption by Source, BAU



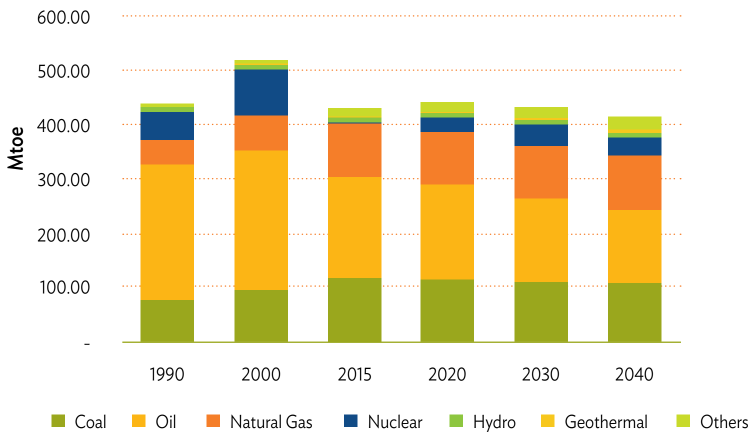
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.1.2. Primary energy supply

Under the BAU scenario, Japan's net primary energy supply is projected to decrease at an average annual rate of 0.1% per year from 429.8 Mtoe in 2015 to 414.3 Mtoe in 2040 (Figure 8.5). This decrease is due mainly to the decreasing use of oil at an average annual growth rate (AAGR) of 1.5% between 2015 and 2040. On the other hand, nuclear and renewable energy including hydro will have increased AAGRs of 10.9% and 1.7%, respectively. The share of nuclear between 2015 and 2040 is projected to increase from 0.6% to 7.9%. The self-sufficiency rate of primary energy will reach 26.3% in 2040, from 7.0% in 2015, after the restart of nuclear power plants and penetration of renewable energy.

Figure 8.5: Primary Energy Supply, BAU



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

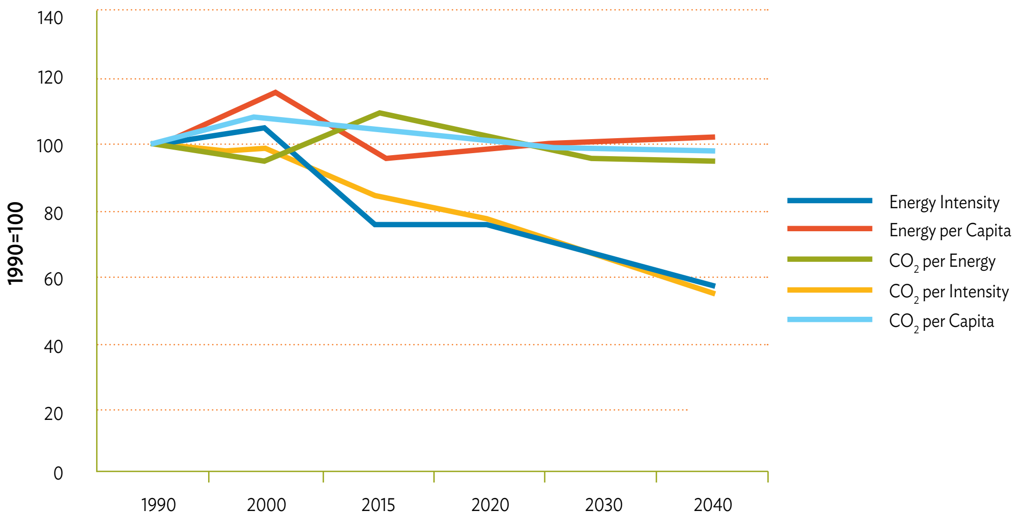
3.1.3. Energy indicators

The energy consumption per capita towards 2040 will increase during the projection period. Income elasticity[2] between 2015 and 2040 is expected to decline because the growth rate in energy consumption will be negative while the GDP growth rate is assumed to be positive.

Except for energy consumption per capita, all other energy indicators will exhibit decreases from the 2015 levels by 2040. CO_2 intensity carbonisation rate (CO_2 emissions per unit of energy consumption) will be about 46% lower than the 1990 levels and about 44% lower than the 2015 levels. Figure 8.6 shows the evolution of several kinds of indicators of energy consumption in Japan from 1990 to 2040 under the BAU scenario.

2 Growth rate of energy consumption divided by growth rate of GDP.

Figure 8.6: Indices of Energy and CO_2 Intensities, Energy per Capita, and Carbonisation Rate, BAU (1990–2040)



BAU = Business-As-Usual.

Source: Author's calculation.

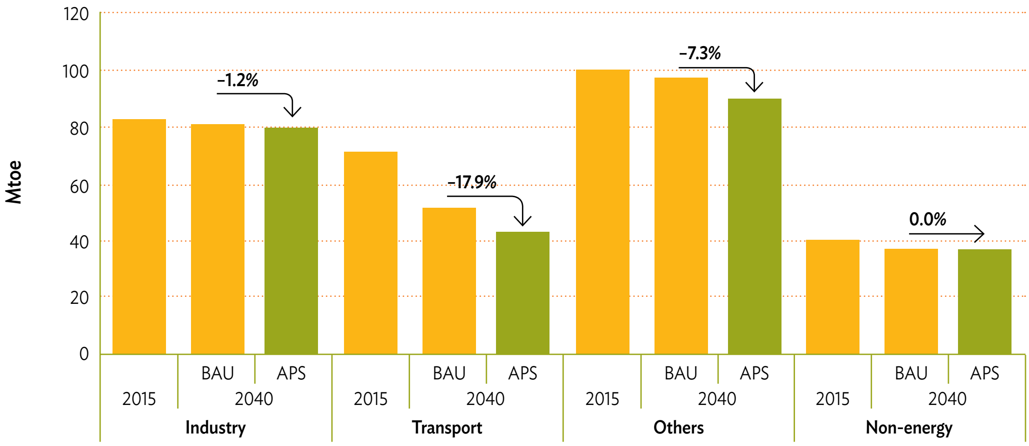
3.2. Energy Savings and CO_2 Reduction Potential

3.2.1. Final energy consumption

In the Alternative Policy Scenario (APS), final energy consumption is projected to decline at the faster rate of 0.6% per year, from 291.4 Mtoe in 2015 to 248.8 Mtoe in 2040. In all final sectors (industry, transport, 'others'), energy consumption will continue to decrease due to improved energy efficiency. The transport sector especially will achieve a remarkable savings of 1.3% per year due to the Top Runner Programme and more aggressive energy management systems. Japan will implement continuous efforts to improve energy efficiency, especially regarding the penetration of energy-efficient automobiles, such as hybrid vehicles, electric vehicles, and plug-in hybrid electric vehicles.

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 actions in those sectors have already been done so far. Figure 8.7 shows the final energy consumption by sector in the BAU scenario and the APS.

Figure 8.7: Final Energy Consumption by Sectors, BAU and APS (2015 and 2040)



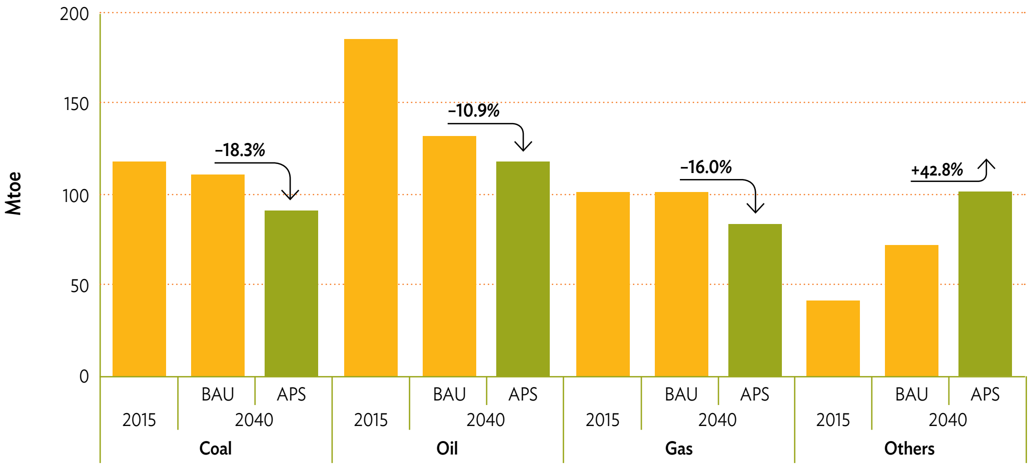
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2.2. Primary energy supply

In the APS, the projected primary energy supply of Japan will decline at a rate of 0.3% per year to 394.1 Mtoe in 2040, 35.7 Mtoe lower than that in 2015. Coal, oil, and natural gas will have decreasing AAGRs of 1.1%, 1.8%, and 0.7%, respectively. Nuclear and biomass will partially substitute fossil fuels. Figure 8.8 shows the primary energy supply by source under the BAU scenario and the APS.

Figure 8.8: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

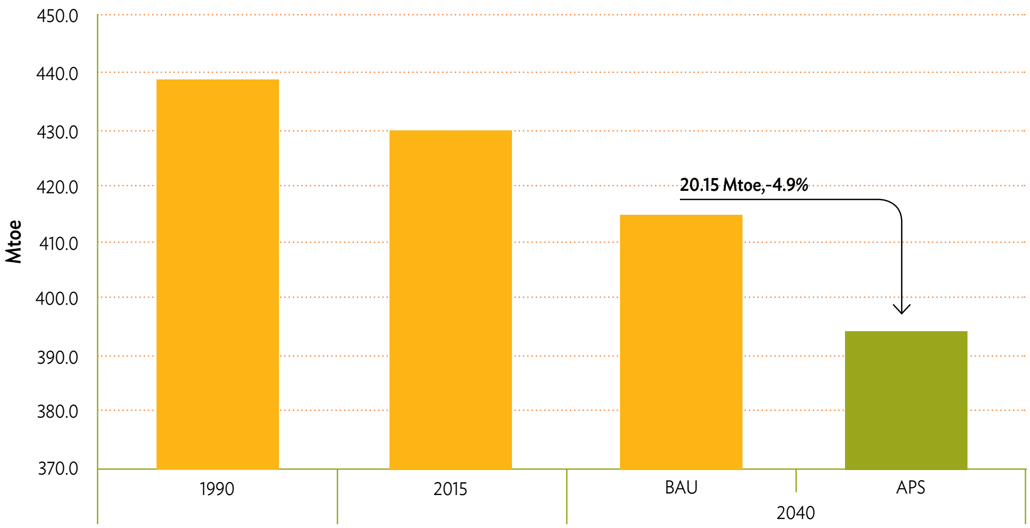
Source: Author's calculation.

3.2.3. Projected energy savings

Energy savings that could be derived from action plans of Japan amount to 20.15 Mtoe, the difference between the primary energy demand of the BAU scenario and the APS (Figure 8.9). This is equivalent to 4.9% reduction of Japan's consumption under the BAU scenario in 2040.

Estimated savings in final energy consumption in the residential/commercial sector will amount to 7.11 Mtoe and 9.25 Mtoe in the transport sector in 2040 in the APS. The projected decreases in the consumption of the transport sector in 2015–2040 are 25.3 Mtoe in the BAU scenario and 42.6 Mtoe in the APS. This is attributable to the increase of more efficient vehicles.

Figure 8.9: Total Primary Energy Supply, BAU and APS (1990, 2015, and 2040)



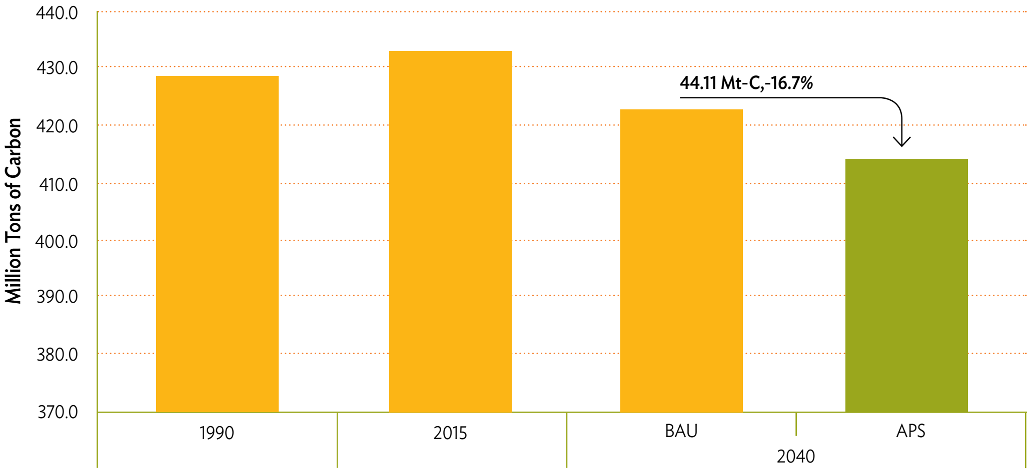
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2.4. CO_2 emissions from energy consumption

Under the BAU scenario, CO_2 emissions from energy consumption are projected to decrease at an average annual rate of 0.7% from 312.9 million tons of carbon (Mt-C) in 2015 to 219.2 Mt-C in 2040 (Figure 8.10). Under the APS, CO_2 emissions are projected to decline at average annual rate of 1.4% between 2015 and 2040.

Figure 8.10: CO_2 Emissions from Fossil Fuel Combustion, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Author's calculation.

4. Japan's Intended Nationally Determined Contributions

Japan's Intended Nationally Determined Contributions towards reduced greenhouse gas emissions after 2020 is 26.6% by fiscal year (FY) 2030, compared to that of FY2013 (25.4% reduction compared to FY2005, approximately 1.042 billion tons of carbon dioxide equivalent (t-CO_2e). That target is consistent with METI's Long-term Energy Supply and Demand Outlook of Japan's quantitative policy target for energy mix in 2030. Japan is expected to achieve this target in the APS.

5. Implications and Policy Recommendations

Japan's primary energy intensity has been declining since 1980, and it is the lowest worldwide. This could be due to the enormous improvements in energy efficiencies in both supply- and demand-side technologies that have been developed and implemented in the country. The fact that Japan imports most of its energy requirements is another reason the country is very aggressive in improving energy efficiency.

The Cabinet approved the Strategic Energy Plan in April 2014 (Government of Japan, 2014). The plan was the basis for METI's approval in July 2015 of the Long-term Energy Supply and Demand Outlook (METI, 2015), which presents the ideal structure of energy supply and demand. This can be realised if appropriate measures are taken based on the fundamental direction of energy policies. Japan's objectives are safety, energy security, economic efficiency, and environment, which are the basic concepts of the policies.

CO_2 emissions in 2040 are projected to be much lower than those of the 1990 level in the APS, based on METI's Outlook, and even in the BAU scenario. However, to achieve the 26% reduction target for 2030, Japan should effectively implement its policies on low-carbon technology, including energy efficiency and zero emissions energy.

For energy efficiency, the APS requires a 1% improvement per year for companies that consume large amounts of energy, and a target of 50% share in sales for hybrid vehicles. Renewable and nuclear energy play a key role in decarbonising power generation. To achieve intensive renewable energy penetration, like in the APS, it is necessary to significantly reduce the capital cost, invest in grids to cope with fluctuations of power from photovoltaic and wind, and implement effective grid rules. As for nuclear energy, mature safety measures and sufficient communication with local communities for restart are required.

In addition, as the leader in energy efficiency, Japan's government and companies should share best practices of policies, services, and products with other countries. By doing this, Japan can contribute to reducing world energy consumption. This is beneficial to Japan as well since such activity helps with the global expansion of its market.

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CHAPTER 9

REPUBLIC OF KOREA COUNTRY REPORT

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1. Background

The Republic of Korea (henceforth, Korea) is in the southern half of the Korean Peninsula and shares a 238-kilometre border with the Democratic People's Republic of Korea (North Korea). It occupies 100,188 square kilometres and includes about 3,000 mostly small, uninhabited islands. Korea is a mountainous country with lowlands accounting for only 30% of the total land area. The climate is temperate, with heavy rainfall in summer. As of 2015, Korea had a population of 51.069 million, over 90% of whom live in urban areas. Korea has recorded tremendous economic growth over the past half century, overcoming the Asian financial crisis in 1998 and the global economic crisis in 2008. However, due to the global financial crisis of 2007–2008, growth has slowed down. The Korean economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals.

Korea has no domestic oil resources and has produced only a small amount of anthracite coal, but imports most of its coal, which is bituminous coal. Consequently, Korea must import nearly all of its needed energy and is the fifth-largest oil importer and the second-largest importer of liquefied natural gas (LNG) in the world. The total primary consumption in 2015 was 272.7 million tons of oil equivalent (Mtoe), increasing by 4.4% a year since 1990. Although primary energy consumption is dominated by oil and coal, nuclear power and LNG also supply a significant share of the country's primary energy. The strongest growth occurred in natural gas (11.3% per year), followed by renewable energy (9.1% per year), coal (4.7% per year), and nuclear (4.7% per year). Oil has increased at a relatively slower 2.9% per year.

The total final energy consumption in 2015 was 174.2 Mtoe, increasing at an average annual rate of 4% from that in 1990. The industry sector accounted for 28.2% of final energy consumption in 2015, followed by non-energy (27.2%) and transport (19.2%).

While consumption of coal and oil has gradually decreased, natural gas in the final energy consumption rapidly grew at a rate of 14.9% per year between 1990 and 2015.

In 2015, electric power generation in Korea amounted to 549.2 terawatt-hours (TWh), with coal and nuclear combined providing nearly three-fourths of the country's electricity, followed by natural gas, sharing 22.4% of generation. Total electricity consumption has grown at an average annual growth rate (AAGR) of 6.8% between 1990 and 2015. When broken down by fuel, coal, natural gas, and nuclear grew by an average annual rate of 10.9%, 10.7%, and 4.7%, respectively, between 1990 and 2015. Over the same period, oil and hydro, however, recorded negative annual growth rates of -1.6% and -4.3%, respectively. Meanwhile, other energy sources such as new and renewable energy (NRE) rapidly grew at an annual rate of 44.7%.

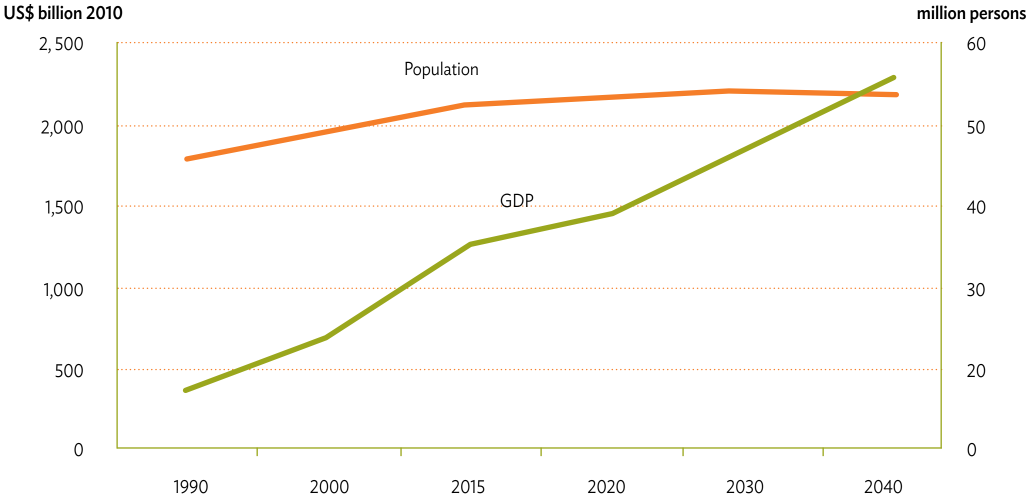
Since the 1990s, the Korean government has established five, Basic Plans for Rational Energy Use, which are being revised every 5 years and contain various policy tools and programmes developed and implemented under the auspices of the Ministry of Trade, Industry, and Energy. Several energy savings measures were announced to encourage the public to voluntarily conserve energy. As part of the measures, voluntary energy conservation campaigns were launched to reduce heating and fuel consumption. Furthermore, the government 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 current 'Fifth Basic Plan for Rational Energy Use (2013–2017)' encompasses various key policy tools and programmes to attain the country's energy savings target. Amongst them are voluntary agreements, energy audits, energy service companies, appliance labelling and standards, fuel economy, and public transit and mode shifting. These policy tools have played and will continue to play important roles in energy savings.

2. Modelling Assumptions

Korea's GDP grew at an average annual rate of 5% between 1990 and 2015. In this report, Korea's GDP is assumed to grow at an AAGR of 2.4% from 2015 to 2040 as shown in figure 9.1. Affected by the 2008–2009 global economic slowdown, the Korean economy has been a bit shaken. However, the economy is still in good shape and its economic growth is expected to recover to 2.9% per year from 2015 to 2020, slowing down to 2.2% per year between 2020 and 2040.

Figure 9.1: Assumptions for GDP and Population (1990–2040)



GDP = gross domestic product.

Source: Author.

Korea is expected to continue to rely heavily on coal and nuclear energy for power generation to meet the baseload. Gas-fired power generation is projected to increase from 2013 to 2040, while oil-fired generation is projected to decline. Generation from hydro sources is projected to remain relatively stable. Also projected is a strong growth in electricity generation from wind power and solar photovoltaics driven by renewable portfolio standards, which were launched in January 2012.

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

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

3. Outlook Results

3.1. Final Energy Consumption

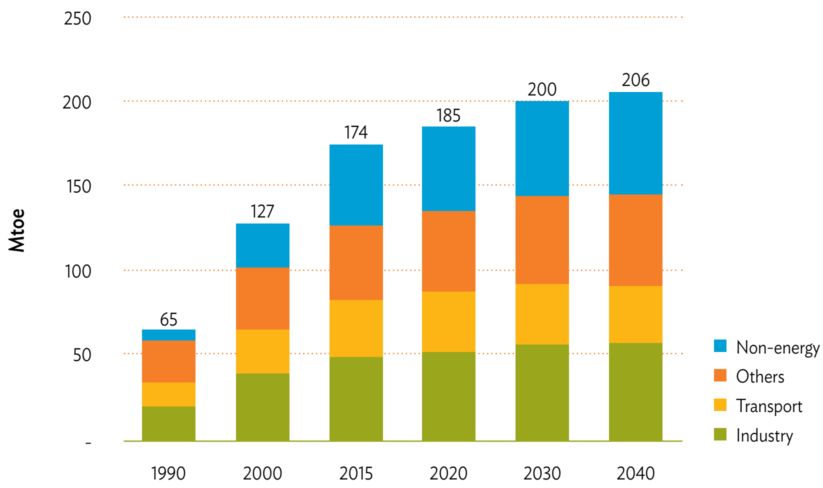
Korea's final energy consumption grew 4.4% per year, from 64.9 Mtoe in 1990 to 174.2 Mtoe in 2015.[2] The non-energy sector had the highest growth rate during this period at 8.1% per year, followed by the industry sector with 4.0%. Energy consumption in the residential/commercial/public ('others') sector had grown at a relatively slow pace of 2.4% per year. Oil was the most consumed product, with a share of 67.3% in 1990, declining to 51.8% in 2015. The share of coal in the final energy consumption declined by 11.3% between 1990 and 2015 whereas the energy share of electricity had doubled to be the second-largest consumed product.

Business-As-Usual Scenario

With an assumption of low economic and population growth, final energy consumption in Korea is projected to increase at a low average rate of 0.7% a year between 2015 and 2040 under the Business-As-Usual (BAU) scenario as shown in figure 9.2. This is largely due to the negative growth in energy consumption in the transport sector, which is projected to decrease at an AAGR of -0.01% between 2015 and 2040. The growth in final energy consumption is expected to be led by the 'others' and industry sectors up to 2020 at 1.4% and 1.2% per year, respectively, then be taken over by the non-energy sectors such as the residential/commercial, and public sectors at 1.0% thereafter up to 2040. Nevertheless, all sectors are expected to slow down at a rate less than 0.8%, or a negative average growth rate per year except for the 'others' sectors.

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

Figure 9.2: Final Energy Consumption by Sector, BAU (1990–2040)

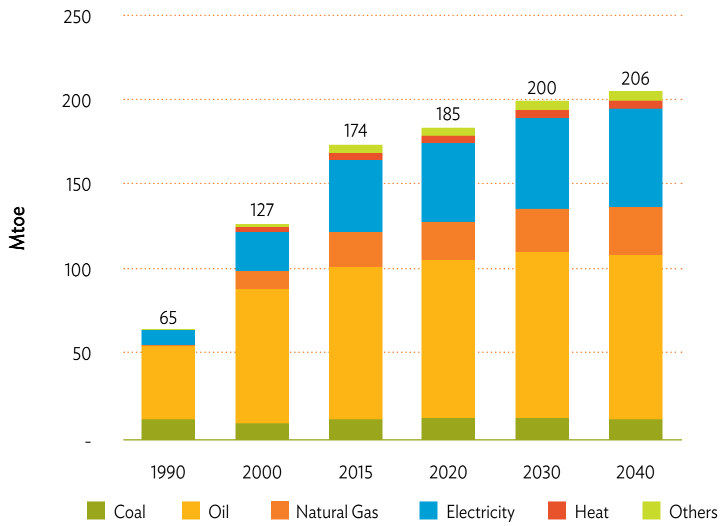


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Final energy consumption by energy type is expected to be patterned after energy consumption by sector as shown in figure 9.3. The AAGR shows -0.1% for coal, 0.3% for oil, 1.3% for natural gas, 1.2% for electricity, and 0.3% for heat over the 2015–2040 period. Coal and oil consumption is expected to peak around 2020, then gradually decrease thereafter, showing a negative growth rate. Heat energy consumption is anticipated to follow the same pattern as oil because of the expected decrease in population and the changing lifestyle oriented towards using more electricity for heating. The case of oil is more like due to the decreasing energy consumption in the transport sector caused by an increasing deployment of electrical vehicles. Other energy types, including NRE, show a growth rate of 1.8% a year, faster than natural gas, electricity, and heat. The use of renewable energy, in addition to natural gas, will increase as clean and green energy will considerably contribute to reduced CO_2 emissions.

Figure 9.3: Final Energy Consumption by Energy Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

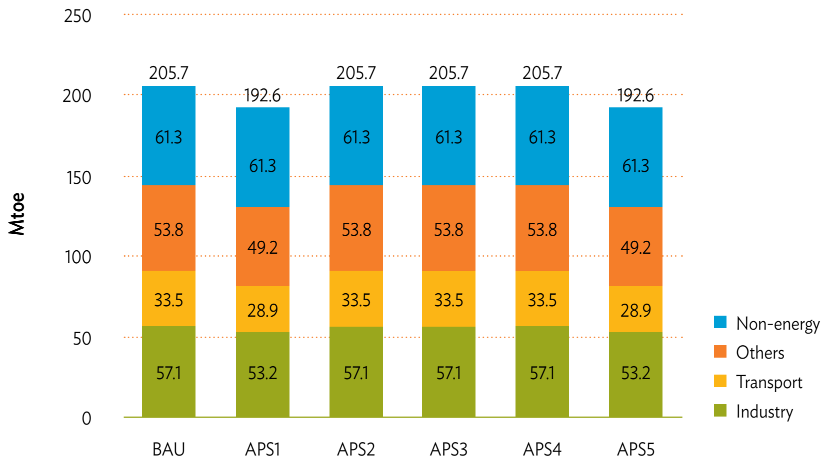
Source: Author's calculation.

Alternative Policy Scenarios

This section discusses the five alternative scenarios developed based on the focus of policy options: (i) improved efficiency of final energy demand (APS1), (ii) more efficient thermal power generation (APS2), (iii) higher contribution of renewable energy to total supply (APS3), (iv) contribution of nuclear energy to total supply (APS4), and (v) combined effects of APS1 to APS4 (APS5).

Figure 9.4 shows final energy demand by sector in each APS. Total final energy demand is to be reduced in the case of APS1 (improved efficiency) and APS5 (combined effects of APS1 to APS 4) at 192.6 Mtoe, 13.1 Mtoe or 5.2% lower than that in BAU. APS2, APS3, and APS4 show 205.7 Mtoe. The total amount and share of final energy demand by sector are the same as those of the BAU scenario. Accordingly, APS5 which is a combination of all APSs shows 192.6 Mtoe, 19.7 Mtoe or 9.5% lower than in the BAU scenario, the same as in APS1.

Figure 9.4: Final Energy Consumption by Sector, BAU and APS



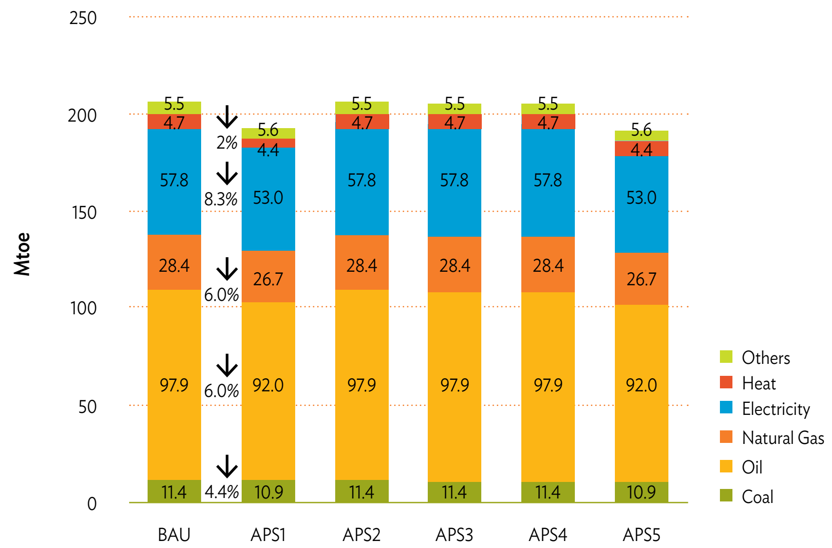
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Final energy demand by energy type is shown in Figure 9.5. In APS1 (improved efficiency), oil accounts for 5.9 Mtoe of energy savings, the largest energy savings, followed by electricity (4.8 Mtoe) and natural gas (1.7 Mtoe). In terms of percentage, electricity shows the largest (8.3%), followed by oil and natural gas, both at 6.0%. APS2, APS3, and APS4 are identical in terms of energy demand by energy source, and APS1 and APS5 are identical in terms of total energy demand, share of energy demand by sector, and energy source.

In APS5, final energy consumption is projected to increase at an AAGR of 0.4%, from 174.2 Mtoe in 2015 to 192.6 Mtoe in 2040. Energy demand in the transport sector is projected to decrease at an AAGR of -2.7% over the same period, whereas other sectors have increased energy consumption over the same period. The rate of growth is much slower across all sectors, except for the industry sector, compared to the BAU scenario (Figure 9.6). The non-energy sector shows an AAGR of 1.0%, followed by the 'others' sector at 0.4%, and the industry sector at 0.3%.

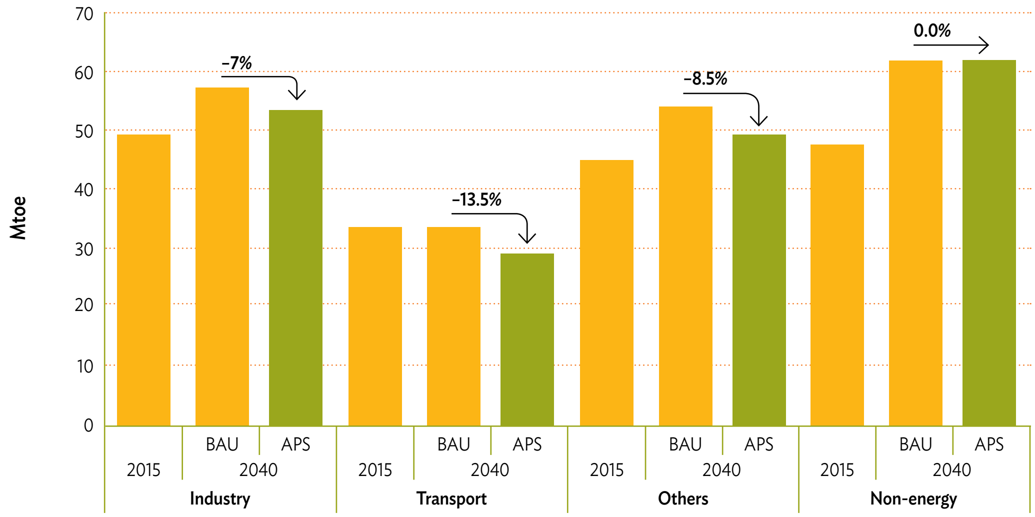
Figure 9.5: Final Energy Consumption by Energy, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Figure 9.6: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



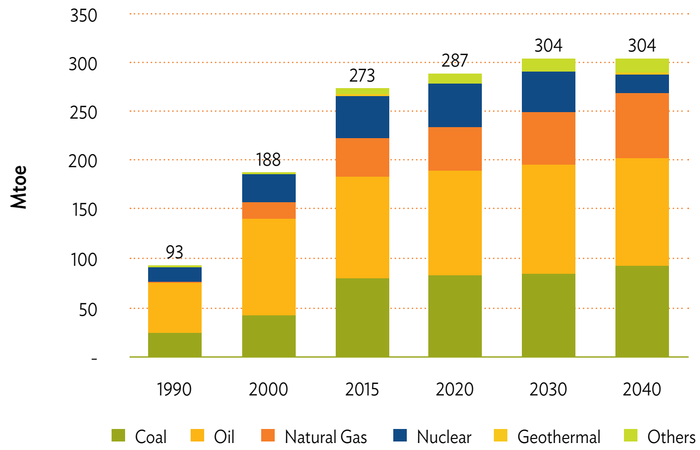
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2. Primary Energy Demand

The primary energy demand in Korea had increased at an average rate of 4.4%, from 92.9 Mtoe in 1990 to 272.7 Mtoe in 2015. Amongst the major energy sources, natural gas grew the fastest at an average annual rate of 11.3%. The next was coal (4.7%), followed by oil (29%) and nuclear (4.7%) over the same period. Other energy sources, mainly renewable energy such as solar, wind, biomass, and ocean energy, have been rapidly growing at a rate of 9.1% over the same period. This indicates that the Korean government has been successfully implementing its 'Low Carbon Green Growth' and, Energy New Industry' policies initiated by previous administrations.

Figure 9.7: Primary Energy Supply by Energy Type, BAU and APS (1990–2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

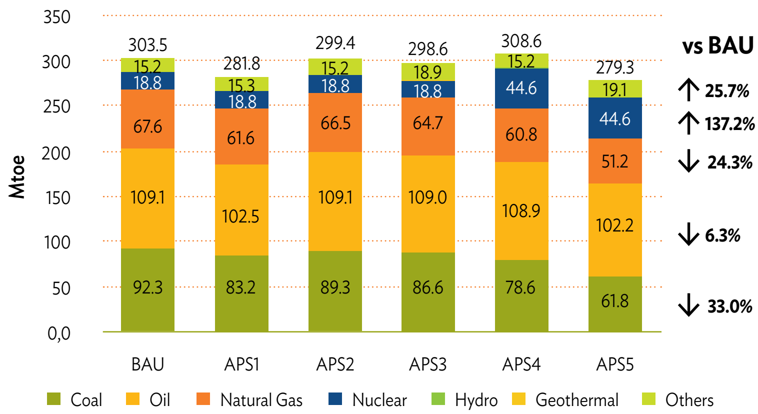
Business-As-Usual Scenario

In the BAU scenario, the primary energy demand in Korea is projected to increase at an average annual rate of 0.4%, from 272.7 Mtoe in 2015 to 303.5 Mtoe in 2040. Growth in all energy sources is projected to slow down. While the consumption of natural gas shows the fastest growth with a rate of 2.2% per year, coal and oil show much slower AAGRs of 0.5% and 0.2%, respectively, over the period 2015–2040. The growth in natural gas will largely be at the expense of nuclear, with the share of nuclear declining from 15.7% in 2015 to 6.2% in 2040.

Alternative Policy Scenario

Based on the projection and analysis in the final energy demand by sector and by energy source, primary energy demand is projected in figure 9.8 for all five scenarios. Unlike in final energy demand, each APS has a different amount and share by energy source depending on a specific policy focus of each APS. Except for APS4 (contribution of nuclear energy to total supply), APS1, APS2, and APS3 have primary energy demand less than the BAU scenario. Amongst those APSs, APS1 (improved efficiency of final energy demand) is the lowest, 281.8 Mtoe, 7.1% lower than that in the BAU scenario, APS3 (higher contribution of renewable energy to total supply) follows at 298.6 Mtoe; and APS2 (more efficient thermal power generation), at 299.4 Mtoe. In APS1, the largest reduction is in the demand for coal, 9.9%, followed by natural gas (8.9%), and oil (6.0%). Nuclear is to be the same as in the BAU scenario, but others (renewable energy) are to increase by 6.6%.

Figure 9.8: Total Primary Energy Supply, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

In APS5, which combines APS1 to APS4, primary energy demand is projected to increase at a lower rate of 0.1% per year, from 272.7 Mtoe in 2015 to 279.3 Mtoe in 2040. The consumption of fossil fuels, such as coal and oil, will gradually decrease in 2015–2040 whereas that of clean energy such as natural gas, nuclear, and others (NRE) will increase by 1.1%, 0.2%, and 4.4% per year, respectively, over the projection period (Figure 9.7). 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 reduced consumption of fossil fuels.

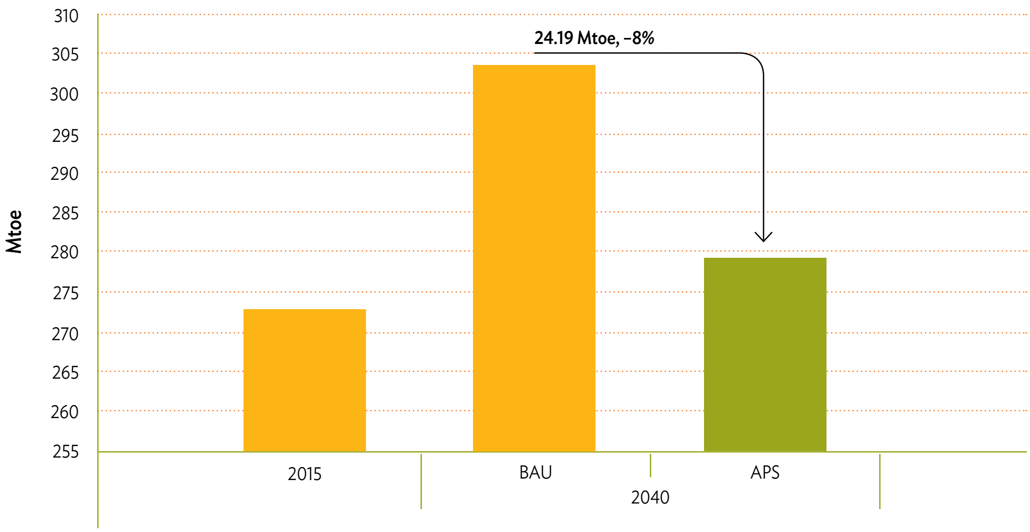
Projected Energy Savings

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

1. Shift of energy policy from a supply-oriented approach to a demand-oriented one. More than anything else, reform in energy pricing and energy taxation is a most pressing issue. In this context, market mechanisms should be introduced in energy pricing where rational energy use is induced by sharing information on the full cost of energy production and consumption.
2. Transformation of industrial structure into a less energy-intensive one, currently under way, should be accelerated towards knowledge-based, service, and green industries, which consume less and clean energies.
3. Application of energy efficiency standards and codes in product design and production processes as well as in designing and constructing a system such as factories, buildings, and plants. Under these policy directions, the Korean government should develop and implement an action plan that contains milestones and strategies with specific and cost-effective policy tools.

The energy savings that could be derived from the energy saving targets, action plans, and policy tools in Korea briefly mentioned in the previous paragraph is 24.19 Mtoe, the difference between primary energy demand in the BAU scenario and the APS in 2040 (Figure 9.9). This is equivalent to only 2.4% increase compared to the primary energy consumption in 2015. Figure 9.10 shows the energy savings potential by energy source. Amongst energy sources, coal has the largest reduction in energy demand, -33.1%, followed by natural gas (-24.3%) and oil (-6.4%). In contrast, other energy sources, such as nuclear and renewable energy, will increase by 86.2% than in the BAU scenario, whose major contributor is renewable energy.

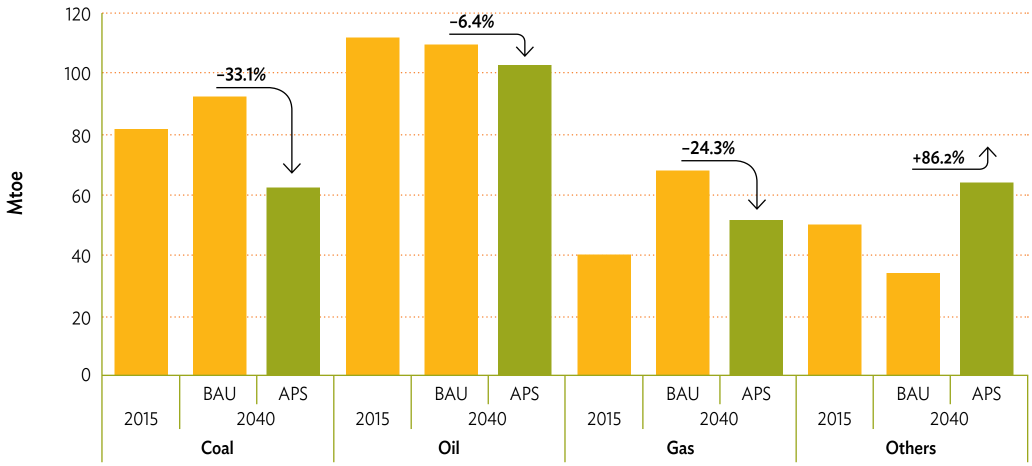
Figure 9.9: Total Primary Energy Supply, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Figure 9.10: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

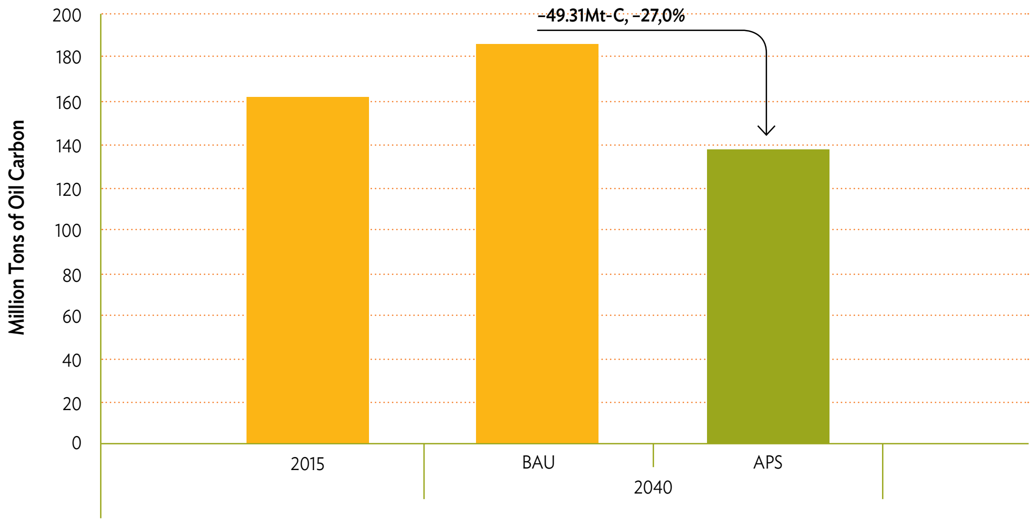
Source: Author's calculation.

3.3. CO_2 Emissions from Energy Consumption

Carbon dioxide (CO_2) emissions from energy consumption are projected to increase at an AAGR of 0.4%, from 158.7 million tons of carbon (Mt-C) in 2015 to 176.7 Mt-C in 2040 based on the BAU scenario. Such a growth rate is slower than that in primary energy consumption. This indicates that Korea will be using less carbon-intensive fuels – such as nuclear, natural gas, and renewable energy – and employing more energy-efficient green technologies.

In the APS, CO_2 emissions are projected to decline at an AAGR of -0.7% between 2015 and 2040. The difference in CO_2 emissions between the BAU scenario and the APS is 49.31 Mt-C or -27.0% (Figure 9.11). To attain such an ambitious target, the government must develop and implement cost-effective and consensus-based action plans to save energy and reduce CO_2 emissions.

Figure 9.11: CO_2 Emissions from Energy Consumption, BAU and APS (2015 and 2040)



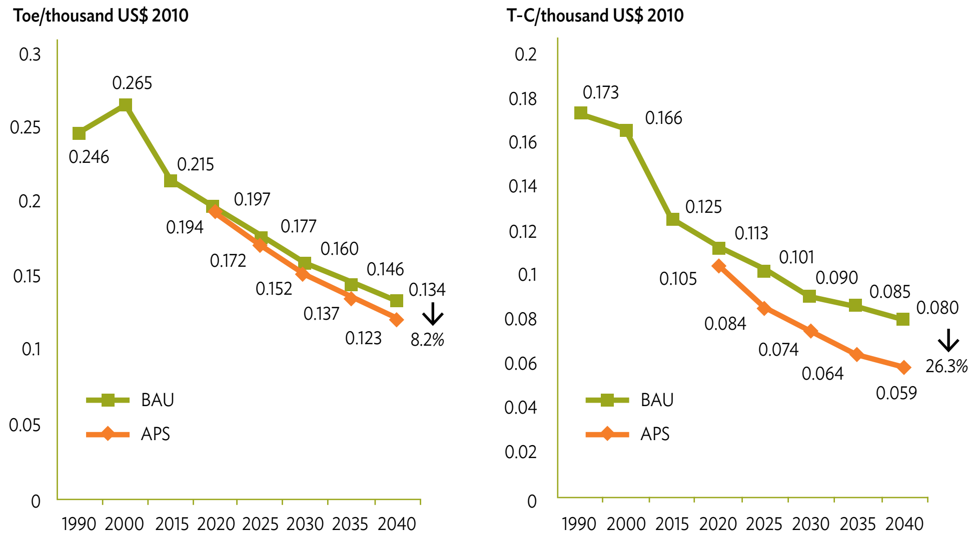
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Author's calculation.

3.4. Energy and Carbon Intensity

As a result of energy savings, the energy intensity of GDP is projected to improve (Figure 9.12). In the BAU scenario, energy consumption per unit of GDP (toe/thousand 2010 US$) is projected to be reduced from 0.197 down to 0.123, indicating a 37.7% improvement. In the APS, it was accelerated by 42.8%. Energy intensity in the APS is 8.2% below that in the BAU scenario. Carbon intensity is also projected to improve in both the BAU scenario and the APS mainly due to the reduction in primary energy consumption in terms of energy intensity. Improvement in carbon intensity, CO_2 emissions per unit of GDP (t-C/thousand 2010 US$), is more salient than that in energy intensity. It is projected to be reduced from 0.113 down to 0.080 and 0.059 t-C/thousand 2010 US$ for the BAU scenario and APS, 36.0% and 52.8%, respectively. Carbon intensity in the APS is 26.3% below that in the BAU scenario.

Figure 9.12: Energy and Carbon Intensities (1990–2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Author's calculation.

4. Implications and Policy Recommendations

Without any domestic energy resources economically available, Korea has been importing 97% of the energy needed for economic growth. Thus, Korea's top policy agenda on energy is energy security, that is, how to maintain a stable energy supply to keep the economy going. However, on entering the 21st century, the Korean government shifted its energy policy into a sustainable, efficient, and energy-saving approach, which was to some extent reflected in the first (2009) and second (2014) National Energy Basic Plan.

Korea's total primary and final energy consumption in the 1990s had rapidly increased at a rate faster than that of GDP whose growth 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, the shift to a less energy-intensive industrial structure takes time, indicating that energy-intensive industries will prevail in the short to medium term. However, Korea will and must transform its industrial structure into a less energy-intensive one in the longer term.

The Second National Energy Basic Plan[3] released in 2014 sets the policy approach of completely shifting the industrial structure from a supply-oriented into a demand-oriented one. Its basic policy direction consists of six major agendas with demand-oriented energy policy as a priority. Five other key agendas are to build a distributed generation system, an improved sustainable energy policy, to strengthen energy security, an enhanced stable energy supply, and to implement an energy policy with people's support.

As regards the priority of an energy policy shift to a demand-oriented approach, the target is to save 13% of the total primary energy consumption along with 15% of electric power consumption. Under this agenda, four policy tasks are proposed: (i) reform of energy-related taxation, (ii) reform of energy pricing, (iii) information and communications technology–based demand management, and (iv) strengthen programmes by sector. The reform of energy-related taxation as well as energy pricing are intended to induce a rational use of electricity by coordinating relative prices between electricity and non-electricity energy. Additionally, it was proposed that social costs such as nuclear safety, reinforcement of transmission lines, and a reduction in greenhouse gas (GHG) emissions should be reflected.

[3] The Korean government worked on the Second National Energy Basic Plan in 2013, releasing its report in early 2014.

Another policy agenda includes an approach from the environmental side, namely, setting a target of for reduced GHG emissions in response to global climate change. The Korean government announced an ambitious, aggressive target to reduce its GHG emissions by 37% from that of the BAU scenario (850.6 $MtCO_2e$) by 2030 across all economic sectors. Out of this target of 37%, 25.7% will be met by domestic activities and the rest, 11.3%, will be attained by emissions trade in the international market. It is a proactive response to and a fulfilment of its international responsibility for the new climate regime established as a follow-up action to the Paris Agreement in December 2015.

Throughout the past 3 decades, the Korean government has been mostly concerned with energy security, energy efficiency, and environmental preservation. The energy security issue has been dealt with by promoting foreign resource development imports and renewable energy development. Energy efficiency improvement has been addressed through programmes supported by a series of the Five-Year Basic Plans of Rational Energy Use. Relevant offices of the Ministry of Environment have approached the environmental issue caused by the consumption of fossil fuels and nuclear energy. Now is the time for Korea to synergise those efforts exerted so far by the selection and concentration of policy tools and programmes through coordination amongst 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, announcing a new energy policy direction, 'Energy Transition', which has completely shaken up the existing national energy policy. Energy Transition rests on two major energy policy agendas: (i) step-wise reduction of nuclear power plants and coal-fired plants ('de-nuclearisation' and 'de-coalisation' policies), and (ii) expansion of renewable energy with the share of renewable electricity raised to 20% by 2030 (RE 3020). These policy agendas will be reflected in subsequent energy plans: the Eighth Electricity Demand and Supply Basic Plan (completed and announced) and the Third National Energy Master Plan (under way).

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

The impacts and implications of the reform in the energy mix remain to be seen. Such reform calls for a vast amount of investment in rebuilding infrastructure, hardware, and software, along with institutional arrangements. It also entails a change not only in the energy sector per se but also in the cultural, political, and social domains. Having successfully gone through several energy transitions in the past, the Korean government is highly confident to go ahead with the current policy goals of transforming into 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 transform the Korean economy into a less energy-intensive and greener one in terms of energy savings and reduced CO_2 emissions. Such an achievement will position Korea as one of the leading global nations in terms of low-carbon green growth.

CHAPTER 10

LAO PDR COUNTRY REPORT

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1. Background

1.1. Socio-economic Situation

The Lao People's Democratic Republic (Lao PDR) is in the middle of the Southeast Asian peninsula. It is bounded by 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 (km^2), about 70% of which is covered by mountains. In 2015, the country had a population of 6,663,967, with an average population density of 27 persons/km2. It comprises 18 provinces, with Vientiane as the capital.

Since the country shifted to an open-door economic policy in 1986, its economy has been progressing and expanding rapidly. Gross domestic product (GDP) in 2015 increased 7.56% from the previous year (Lao Statistics Bureau, 2015), increasing to KN 39,647 billion at 2002 constant prices. This is equivalent to US$140,814 million, bringing the per capita income to US$1,628. The economy has been gradually changing from agriculture-oriented activities to a wider range of activities such as services and industry. For example, in 2013, the services sector had a share of 37.9% of the total GDP, while the agriculture sector had only 23.5%. The share of the industry sector to GDP was 33.2% in 2013; it is expected to have a bigger share in the coming years due to large investments in the mineral and hydropower sectors.

1.2. Energy Supply–Demand Situation

The Lao PDR is well endowed with renewable energy resources, especially hydropower and biomass. Since 1990 hydropower resources are being intensively developed to provide electricity for the requirements of the country and its neighbours. Every year the Lao PDR receives a significant amount of hard currencies from those power exports, widely considered as a driving force to boost socio-economic development and the energy security of the country.

Lao PDR's total primary energy consumption (TPEC) in 2013 was 2.47 Mtoe. The energy mix consisted of hydro, oil, coal, and biomass. Many power plants in the country generate electricity for export, with the export figure reaching 11,548 gigawatt-hours (GWh) in 2013, equivalent to 1.18 million tons of oil equivalent (Mtoe), and accounting for more than half of the total power consumed in the country and 73.2% of total hydropower generation. Biomass continues to be an important energy source, and is mostly consumed in the country. In places where modern energy is inaccessible, Lao people use it as a main source for cooking, heating, and many other activities because it is abundant, obtainable everywhere, and free. In 2015, 1.30 Mtoe of biomass, representing 13.7% of the TPEC, was used. Consumption of oil products was the second largest after biomass. The Lao PDR does not have oil refineries; thus, the supply of all oil products has been met by imports from Thailand and Viet Nam. In 2015, the Lao PDR imported 0.99 Mtoe of oil products to supply the demand of the transport and the residential/commercial ('others') sectors. In the same year, 6.49 Mtoe of coal was consumed, mainly by the industry sector, i.e. the Hongsa Thermal Power Plant, which is the first and largest coal-fired power plant that started operation in 2015. Therefore, from 2015 onwards, coal demand is expected to increase sharply.

Due to its geographic advantage and its many rivers, the Lao PDR is a rich country in terms of hydropower resources. According to the Mekong River Commission Study in 1995, the potential of the country's hydropower resources is 26,000 megawatt-hours (MW). However, until 2015, only 3,894 MW (Department of Energy Policy and Planning, 2015) or 15% of total potential had been realised. In 2015, it produced around 16,501 GWh of electricity (Department of Energy Policy and Planning, 2015). Out of this, 65.7% (equivalent to 10,842 GWh) was exported to Thailand, Viet Nam, and Cambodia; the remaining was consumed domestically. Power exports are projected to increase sharply because of the government's agreements with neighbouring countries that, by 2020, the Lao PDR should export 7,000 MW to Thailand and 5,000 MW to Viet Nam. The power sources for export are mainly from hydropower. However, one thermal power plant, the Hongsa Thermal Power Plant, which has 1,878 MW of installed capacity and three hydropower projects in 2018 are being constructed for export purposes. All projects for export purposes are being developed by foreign private investors through the built-operate-transfer scheme.

The power sector plays a major role in the energy sector, as well as in the country's economy, as it generates substantial revenues for the country. The revenues may not be significant in the short to medium terms, but for the long term, they will be high or will increase manyfold because the ownership of private power plants will be transferred to the government. The electrification ratio in the Lao PDR is 88.94% in 2015 (Department of Energy Policy and Planning, 2015). The government plans to raise the country's electrification ratio to 90% by 2020. This plan is amongst the government priorities to eradicate poverty in the country. Considering the increase of electricity demand in the Lao PDR and power production for export, optimisation of the power sector will be necessary for future electricity supply.

1.3. Energy Policies

Since the establishment of the Ministry of Energy and Mines in 2006, energy infrastructure and legislation have been developed and expanded. Also, the energy policies are developing and gaining public attention and support. The policies gradually evolved from just the power sector policy to broader energy policies towards the development of a sustainable and environment-friendly energy sector. The improvement of the energy policies could be credited to the strong support from the Association of Southeast Asian Nations (ASEAN) and other international organisations, especially the Economic Research Institute for ASEAN and East Asia for its continuous cooperation and support on energy policies of Cambodia, the Lao PDR, Myanmar, and Viet Nam to catch up with other ASEAN countries.

The Lao PDR is a landlocked country in the middle of the Mekong subregion. It is surrounded by the three big economies of China, Thailand, and Viet Nam and the two medium economies of Myanmar and Cambodia. Thus, the Lao PDR can promote itself as a land-linked country to take advantage of its geography. Based on the energy policies exchanged in the platform of ASEAN+3[1] energy cooperation, evidence shows that those countries have high energy demand and support the energy trade and power integration in this region because it can raise regional energy security and sustainable development. At the same time, the Lao PDR has been trading electricity with Thailand for many decades; now it expands this policy to other neighbouring countries to support regional energy cooperation. Particularly, the country will increase power exports to 15,000 MW by 2030 – 10,000 MW to Thailand and 5,000 MW to Viet Nam, Cambodia, and Myanmar.

Apart from international cooperation, the Lao PDR also aims to:

- Increase access to electricity by grid extensions and off-grid rural electrification.
- Maintain an affordable tariff to promote economic and social development.
- Increase electrification ratio to more than 95% by 2020.
- Promote energy efficiency and conservation.
- Make modern energy more affordable and accessible for every Lao citizen even in remote areas.
- Increase the share of renewable energy in total energy supply by 30% in 2030, including to blend 10% of biofuels in the oil supply for the transport sector.

[1] ASEAN countries plus China, Japan, and the Republic of Korea.

2. Modelling Assumptions

This study aims to forecast the Lao PDR's energy growth and demand from a base year of 2015 to 2040 and to see its energy saving and CO_2 emissions reduction potential if it uses or implements some Alternative Policy Scenarios (APSs). This study, therefore, uses four scenarios as described below:

- Business-As-Usual (BAU) – a scenario calculated based on the assuming growth of GDP, population, and oil price (Table 10.1);
- APS 1 – a scenario in which the Lao PDR is implementing energy saving and conservation programmes, i. e. reducing energy consumption by 10% during the study period (2015–2040);
- APS 3 – a scenario in which the Lao PDR is implementing the biofuel programme, i. e. blending 10% of biofuel with all oil to be consumed in the country during the study period;
- APS 5 – a scenario that combines APS 1 and APS 3 into one scenario.

Table 10.1: Assumption of Annual Average Growth of GDP and Population

Projection Period	GDP Growth, %	Population Growth, %
2015–2020	7.0	1.5
2020–2030	6.5	1.3
2030–2040	6.0	1.2
2013–2040	6.0	1.2

GDP = gross domestic product.

Source: Author's assumptions based on consultation with relevant ministries;

3. Outlook Results

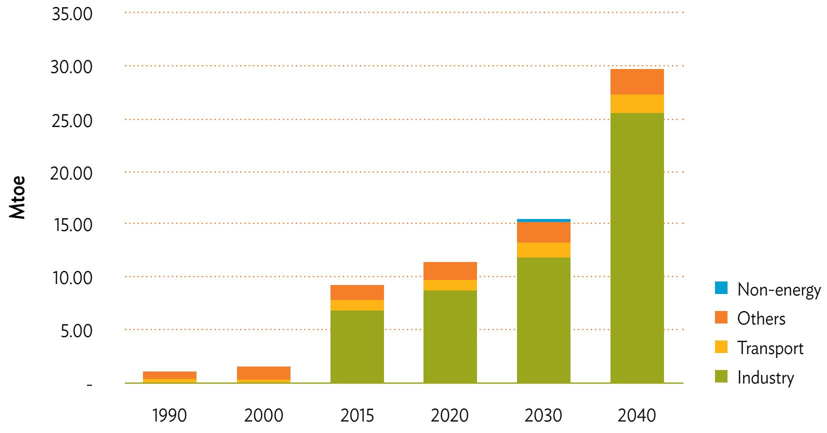
3.1 Business-As-Usual Scenario

3.1.1 Final energy demand

In the Lao PDR, final energy consists of coal, oil, electricity, and others. Its total final energy consumption (TFEC) increased at an average annual rate of 8.6%, from 1.09 Mtoe in 1990 to 9.12 Mtoe in 2015 (Figure 10.1). The growth will continue at a faster rate of 3% per year and 6.9% per year in 2015–2020 and 2020–2030, respectively. Then after 2040, the TFEC will grow at a slower rate of 4.8% per year.

For the final energy consumption by sector, the Lao PDR, like other Southeast Asian countries, has four sectors that use energy: industry, transport, 'others', and non-energy. The 'others' sector covers sub-sectors like residential, agriculture, services, and commerce. Between 1990 and 2015, the industry sector registered the highest energy use at 22.9% per year, followed by the transport sector which grew at 7.5% per year, while the 'others' sector grew at the lowest rate of 1.9% per year. The highest growth rate of the industry sector continues until 2040. In 1990-2040, the transport sector grew at an average annual rate of 2.2%, followed by the 'others' (21%) and non-energy (0.9%) sectors. The share of final energy consumption by sectors is shown in Figure 10.2.

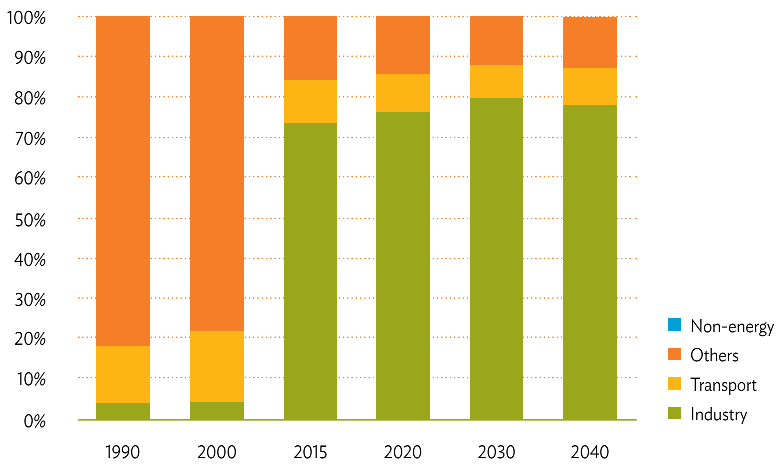
Figure 10.1: Final Energy Consumption by Sector (1990–2040)



Mtoe = million tons of oil equivalent.

Source: Author's calculation.

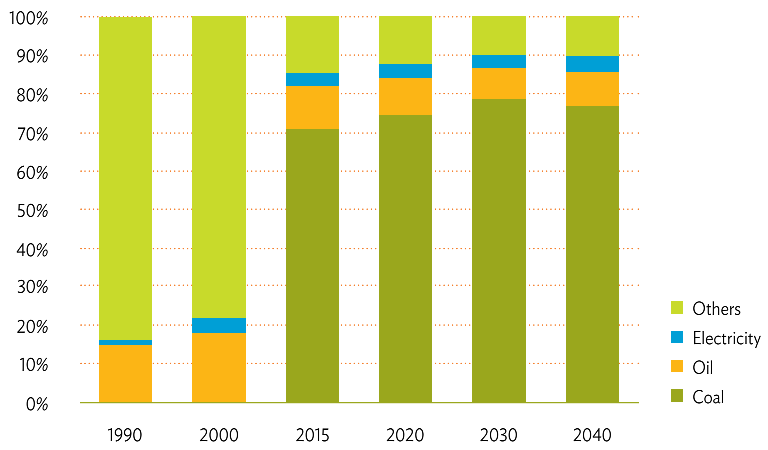
Figure 10.2: Sectors' Share in Final Energy Consumption (1990–2040)



Source: Author's calculation.

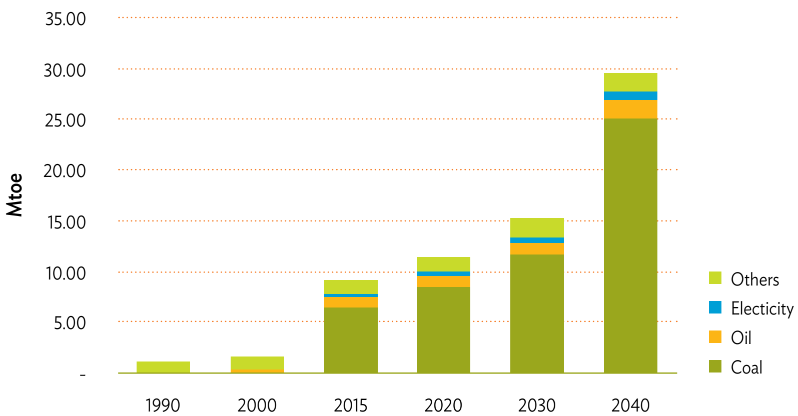
In terms of energy type, coal was mostly used in 2015; it stood at 6.49 Mtoe and shared 71.1% in the total final energy demand. It is expected to have more than 71% share until the end of the study period. For example, coal's share in the TFEC will be 74.5% in 2020, 78.5% in 2025, 76.9% in 2030, 75.0% in 2035, and 85.3% in 2040 (Figure 10.3 and Figure 10.4). The year 2015 was a turning point for the TFEC of the Lao PDR. In 1990–2000, Others included the residential and commercial sectors and always had the biggest share, 83.8% in 1990 and 78.2% in 2000. However, in 2015, coal had the biggest share because the Hongsa Thermal Power Plant started operation. Other coal-fired power plants are also expected to be developed after 2025. From 1990 to 2000, the 'others' sector used biomass, which consists of fuelwood and charcoal, the most because a majority of Lao people still live in rural areas and rely on fuelwood as a main fuel for their cooking. Although using fuelwood is inconvenient compared to other energy types like electricity and liquefied petroleum gas, which are mostly used for cooking in urban areas, fuelwood costs less.

Figure 10.3: Fuels' Share in Total Final Energy Consumption



Source: Author's calculation.

Figure 10.4: Final Energy Consumption by Fuel Type (1990–2040)



Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Oil is an important energy source for the Lao PDR because the whole transport sector relies solely on this fuel. The oil price directly affects the country's socio-economic development because it is part of living and of doing business in the country. However, unlike electricity and coal, oil is the only energy that is not produced domestically; it is imported either from Thailand or Viet Nam. Therefore, it is worthwhile to closely observe and monitor its trend during this study. In 2015, 0.99 Mtoe was consumed and it is projected to grow at an average annual rate of 2.1% in 2015–2040. Oil demand is expected to rise from 0.99 Mtoe in 2015 to 1.09 Mtoe in 2020, 1.21 Mtoe in 2025, 1.35 Mtoe in 2030, 1.50 Mtoe in 2035, and 1.68 Mtoe in 2040. In terms of average annual growth rate (AAGR), oil is projected to increase at a rate of 2.0% in 2015–2020, 2.1% in 2020–2030, 2.2% in 2030–2040, and 2.1% in 2015–2040. Compared with coal, electricity, and biomass, coal will rank third in 2015–2040.

3.1.2 Primary energy supply

The country's primary energy supply consists of coal, oil, hydro, and others. Others cover biomass, biofuels, and exported electricity. The Lao PDR's total primary energy consumption (TPEC) increased at an average annual rate of 8.6%, from 1.20 Mtoe in 1990 to 9.49 Mtoe in 2015 (Figure 10.5). The growth is expected to continue at a faster rate of 7.2% per year in 2015–2020 because a big amount of coal has been used since 2015 for a thermal power plant. The TPEC growth rate is then projected to continue at a slower rate of 3.3% per year during 2020–2030 and at a faster rate again of 7.1% in 2030–2040. However, primary energy is forecasted to grow at a rate of 5.6% per year in 2015–2040.

In 2015, coal was the energy used the most (7.04 Mtoe), followed by hydro (1.33 Mtoe) and biomass (1.3 Mtoe). The reason for coal being used the most is the beginning of the operation of the Hongsa Thermal Power Plant. This plant will also increase coal consumption at a high rate of 10.6% in 2015–2020, and its share in the TPEC will increase from 74.3% in 2015 to 86.8% in 2020. Coal's share is projected to continuously have a higher percentage of more than 86% until 2040.

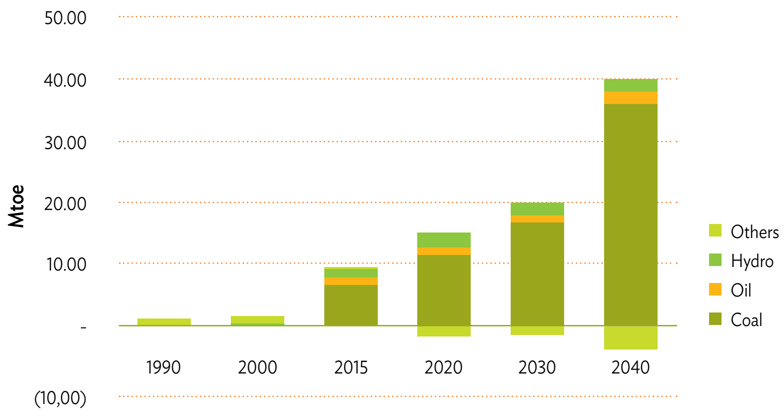
In 2015, 1.33 Mtoe of hydro with a 14.1% share in the TPEC was used; it is expected to increase to 2.42 Mtoe at 18% TPEC share in 2020. Its AAGR is forecast to reach 2.2% in between 2015 and 2040, so hydro demand will increase to 2.30 Mtoe by 2040. The increase in hydro is due to the country's intensive development of hydropower projects to meet increasing domestic demand and to export 7,000 MW to Thailand by 2025 and 5,000 MW to Viet Nam by 2030 per agreement.

Biomass is also used a lot in the Lao PDR because it is a cheaper fuel for cooking and is the main fuel for most rural people. In 1990, 1.01 Mtoe of biomass was used and this increased to 1.30 Mtoe in 2015. It is projected to increase to 1.39 Mtoe in 2020, 1.48 Mtoe in 2025, 1.56 Mtoe in 2030, 1.66 Mtoe in 2035, and 1.75 Mtoe in 2040. In terms of its growth rate, like the projection of biomass in final energy, it is also estimated to grow at 1.2% between 2015 and 2040.

The demand for oil has been experiencing a high growth in the Lao PDR. Many people can afford to buy private cars for their daily commute, thus, significantly increasing the number of vehicles. Until 2015, the country did not have any refinery, and all oil products were imported. More than 20 oil companies did business in the Lao PDR, and they were authorised to import and sell oil in the country. In 1990, only 0.16 Mtoe of oil was used. Oil usage increased at an AAGR of 7.5% in 1990–2015 and with a 13.6% share in the TPEC in 1990. It increased from 0.28 Mtoe in 2000 to 0.99 Mtoe in 2015. Its share in the TPEC also went down from 17.2% in 2000 to 10.4% in 2015; it is projected to have shares of 8.1% in 2020, 6.7% in 2025, 7.3% in 2030, 7.9% in 2035, and 4.6% in 2040 (Figure 10.6). However, in terms of the AAGR, oil, being the fourth energy source, is expected to have a rate of 2.1% per year after those of coal, electricity (exported), and hydro between 2015 and 2040.

Apart from the primary energy described above that are related to those that could be produced domestically and imported from its neighbours, the Lao PDR still exports a significant amount of electricity to Viet Nam, Cambodia, and mostly to Thailand. Figure 10.5 shows that 'others' show negative signs from 1990 onwards because the exported electricity is greater than biomass. The Lao PDR has been exporting power to Thailand since Nam Ngum Dam started operation in 1971; later, many power plants followed suit. The exported figures increased from 0.05 Mtoe in 1990 to 1.18 Mtoe in 2015. Exported electricity is also projected to increase to 3.12 Mtoe in 2020, 2.38 Mtoe in 2025, 3.02 Mtoe in 2030, 2.88 Mtoe in 2035, and 5.24 Mtoe in 2040. Although the AAGR of electricity for export showed a high rate of 21.4% per year in 1990–2020, it is forecasted to grow only at a rate of 6.1% per year in 2015–2020.

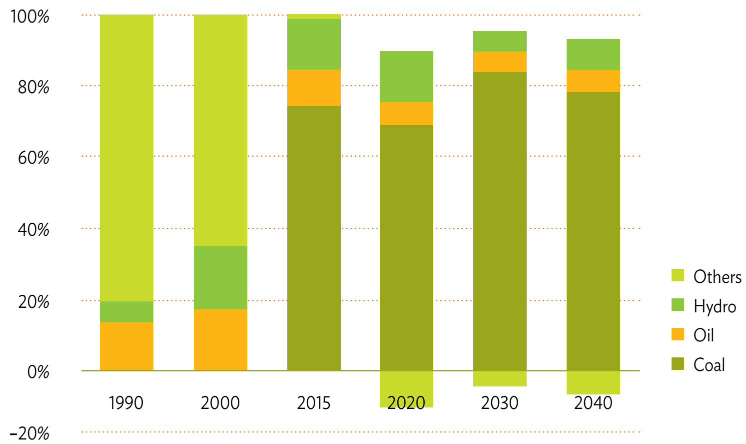
Figure 10.5: Primary Energy Supply by Source



Mtoe = million tons of oil equivalent.

Source: Author's calculation

Figure 10.6: Fuels' Share in Primary Energy Supply

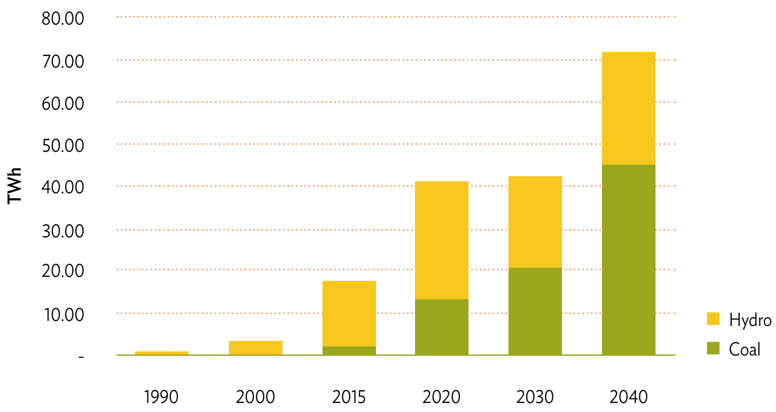


Source: Author's calculation.

3.1.3 Power generation

The history of Lao PDR's power generation can be divided into periods. The first period is 1970–2015, during which all power is generated from one source like hydropower. The second period is after 2015, during which the country has both hydro and thermal power plants because the Hongsa Lignite Power Plant started operation in 2015. In 1990, the Lao PDR produced only 0.82 TWh of electricity, then increased to 3.44 TWh in 2000 and to 17.76 TWh in 2015. Its generation is forecasted to increase to 41.12 TWh in 2020. The outputs of power generation are estimated to go up dramatically from 2015 to 2040; they are forecasted to reach 33.63 TWh in 2025, 42.32 TWh in 2030, 42.32 TWh in 2035, and 71.86 TWh in 2040 (Figure 10.7). All power generated before 2015 was from hydropower sources. Over that period, power generation grew at an AAGR of 13.1%. This rate is then expected to be greater than 18.3% in 2015–2020, at 0.3% in 2020–2030, and at 5.4% in 2030–2040. Because of the first thermal power plant being put into operation in 2015, the power generation mix in the Lao PDR has changed since 2015 (Figures 10.7 and 10.8). For example, in 2015, out of the output of power generation, hydropower plants are projected to share 87.3%, while the thermal power plant will share 12.7% of total generation. Hydropower plants are forecasted to continue to have the bigger share over the thermal power plant until 2020.

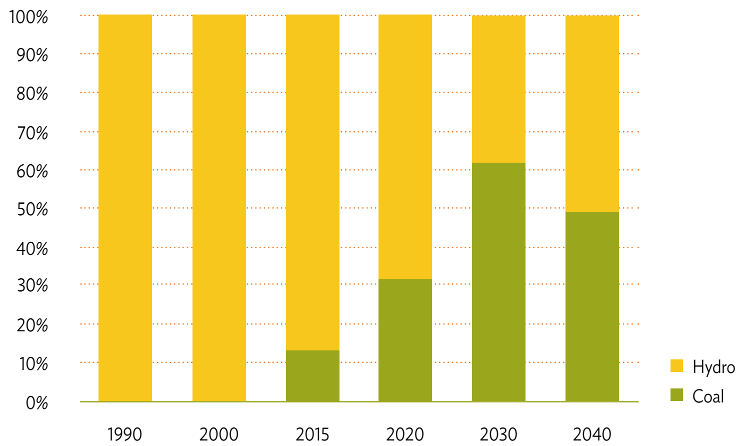
Figure 10.7: Electricity Generation in 2040



TWh = terawatt-hour.

Source: Author's calculation

Figure 10.8: Technologies' Share in Electricity Generation (1990–2040)

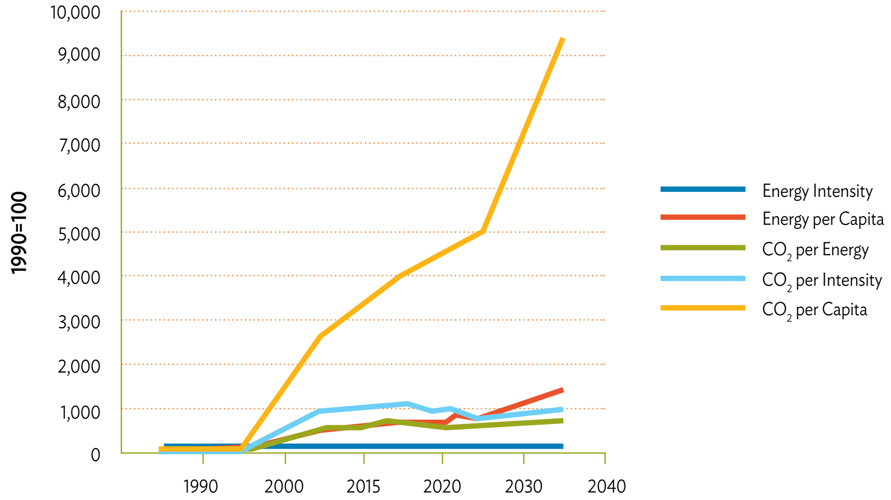


Source: Author's calculation.

3.1.4 Energy indicators

In 2020, the Lao PDR's primary energy intensity (TPES/GDP) will reach the highest level of 1,872 toe/million 2010 US$ and is expected to decline to 1,076 toe/million 2010 US$ in 2035 (Figure 10.9). Similarly, final energy intensity will decline even lower; from 1,791 toe/million 2010 US$ in 2020, it will decrease to 888 toe/million 2010 US$ in 2035. This indicates that energy consumers are implementing energy efficiency and conservation (EEC) programmes.

Figure 10.9: Energy Intensity and Other Energy Indicators (1990–2040)

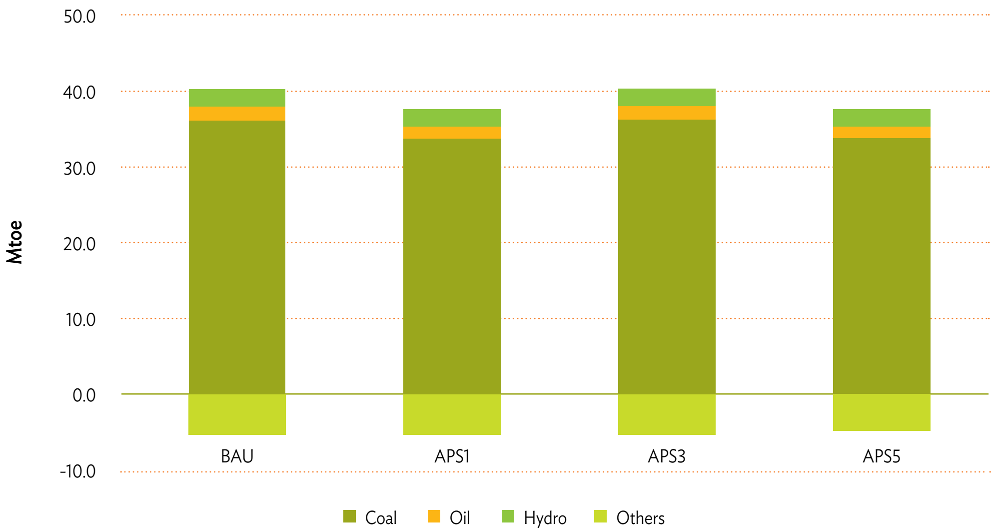


Source: Author's calculations.

3.2 Energy Saving and CO_2 Reduction Potential (APS)

For this study, the Lao PDR uses three APSs for its energy saving and CO_2 reduction potential: (i) EEC scenario (APS1), (ii) development of renewable energy (APS3), and (iii) APS5 that combines APS1 and APS3. These three APSs yield the following changes. First, the TPEC of APS1 amounting to 2.76 Mtoe has decreased; compared with the BAU scenario, it declined from 35.055 Mtoe in the BAU scenario to 32.289 Mtoe in APS1. Second, there is no change in primary energy consumption of APS3. Third, primary energy consumption of APS5 has been reduced to the same amount as APS1. The 10% reduction in the TPEC mainly comes from the implementation of EEC programmes. All existing primary energies such as coal, oil, hydro, and others are reduced (Figure 10.10).

Figure 10.10: Comparison of Scenarios to Total Primary Energy Supply in 2040

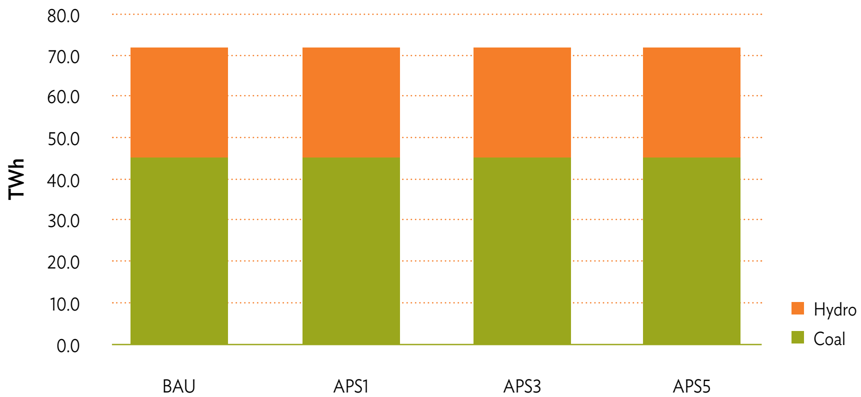


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Figure 10.11 shows no change in power generation from the BAU scenario to APS1, APS3, and APS5.

Figure 10.11: Comparison of Scenarios to Electricity Generation in 2040

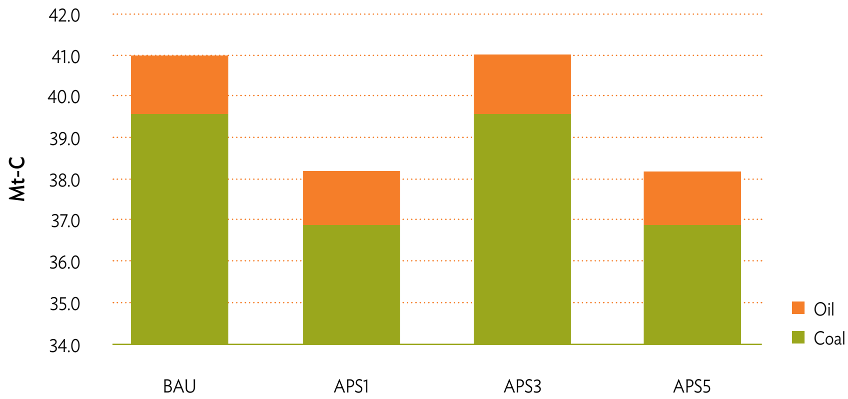


APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation

Figure 10.12 illustrates energy saving potential amounting to 2.797 million tons of carbon (Mt-C) in APS1 and APS5. CO_2 emissions declined from 40.943 Mt-C in the BAU scenario to 38.146 Mt-C in APS1 and to 38.146 Mt-C in APS5. This reduction is a result of the EEC programmes.

Figure 10.12: Comparison of Scenarios to Carbon Emissions in 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Author's calculation.

3.2.1 Final energy consumption

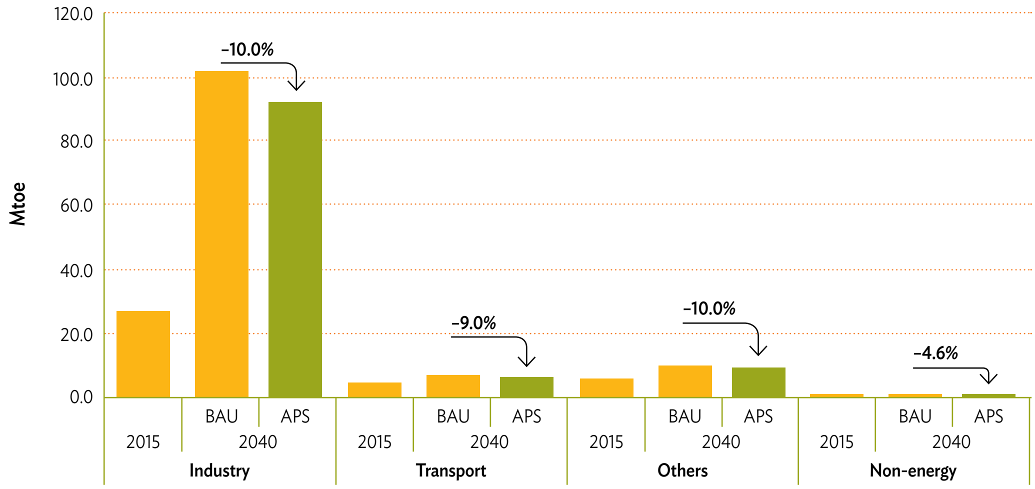
For trends of final energy demand of the BAU scenario and the APS in each sector, the model shows that, in APS1, final energy demand is expected to increase from 9.19 Mtoe in 2015 to 26.65 Mtoe in 2040. Industry demonstrates the highest trends both in consumption and share in the TFEC in 2015–2040. This dominance of industry in the TFEC is due to the high use of coal in the Hongsa Thermal Power Plant and other coal-fired power plants that have operated since 2015. In APS1, industry consumed 6.70 Mtoe of energy in 2015, and is forecast to consume 7.80 Mtoe in 2020, 10.72 Mtoe in 2025, 10.76 Mtoe in 2030, 10.78 Mtoe in 2035, and 22.94 Mtoe in 2040. Likewise, it always keeps larger shares throughout the study period, i.e. 73.5% in 2015, 76.4% in 2020, 80.0% in 2025, 78.3% in 2030, 76.5% in 2035, and 86.1% in 2040. Industry also shows the highest growth rate per year in 2015–2040 during which it is expected to grow at 5% per year. After industry, the 'others' sector is forecast to use the most energy for the study period: 1.44 Mtoe in 2020, 1.59 Mtoe in 2025, 1.76 Mtoe in 2030, 1.96 Mtoe in 2035, and 2.20 Mtoe in 2040 (Figure 10.13).

For the AAGR, APS1 is expected to grow more slowly than in the BAU scenario in 2015–2040. The growth rate is forecast to be 4.8% per year in the BAU scenario and 4.4% in APS1.

For final energy demand by fuel, similar to the BAU scenario, in APS1 coal also showed a majority share of 71.1% in 2015. It is forecast to increase gradually to 78.4% in 2025, decline gradually to 76.8% in 2030 and to 74.9% in 2035, then go up again to 85.2% in 2040.

Figure 10.13 shows that, in 2040, the final energy demand in industry is expected to be reduced from the BAU scenario to the APS at 10.0%; in transport, 9.0%; 'others', 10.0%; and non-energy, 4.6%.

Figure 10.13: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

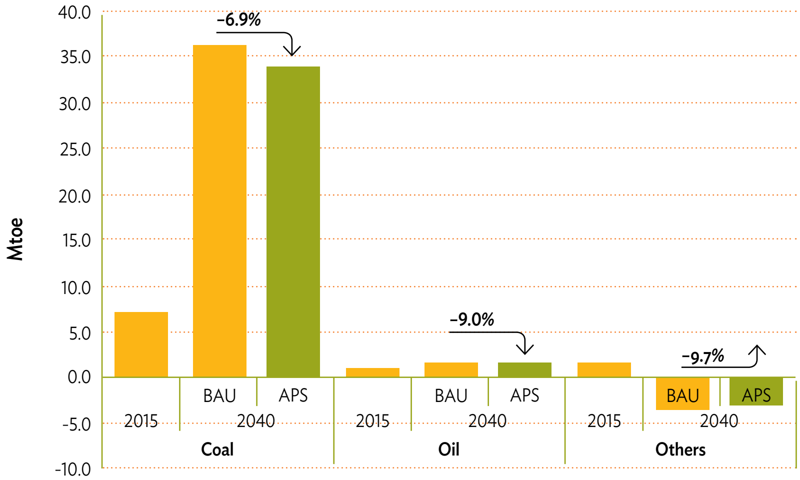
Source: Author's calculation.

3.2.2 Primary energy consumption

In APS1, 9.49 Mtoe of primary energy was consumed in 2015; it is expected to increase to 12.30 Mtoe in 2020, 17.05 Mtoe in 2030, and 33.87 Mtoe in 2040. In terms of the AAGR, primary energy grew at 8.6% per year between 1990 and 2015. It is expected to grow at 5.3% in 2015–2020, 3.3% in 2020–2030, and 7.1% in 2030–2040. But for 2015–2040, primary energy is expected to increase at 5.2%.

Figure 10.14 shows that, by comparing the BAU scenario and the APS in 2040, coal and oil are expected to decrease by 6.9% and 9.0, respectively. However, 'others' is forecast to increase by 9.7% because of the increase in power exports to Lao PDR's neighbours.

Figure 10.14: Primary Energy Demand by Source, BAU and APS (2015 and 2040)



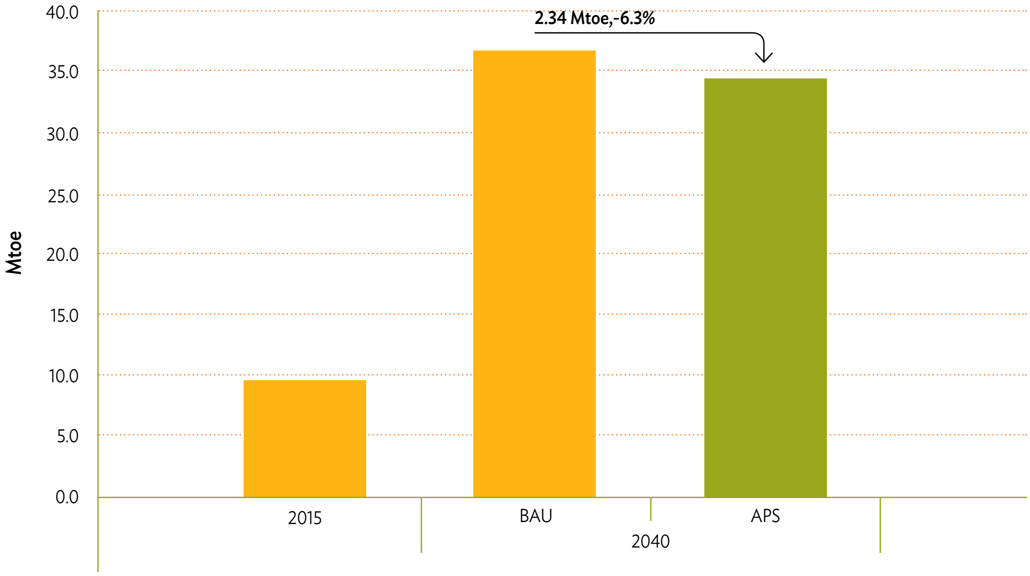
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2.3 Projected energy savings

Figure 10.15 shows that, in 2040, primary energy is expected to decrease from the BAU scenario to the APS by 2.34 Mtoe or 6.3%. This decrease in the TPEC is due to implementation of the 10% reduction in energy consumption from 2015 to 2030.

Figure 10.15: Total Primary Energy Supply, BAU and APS (2015 and 2040)



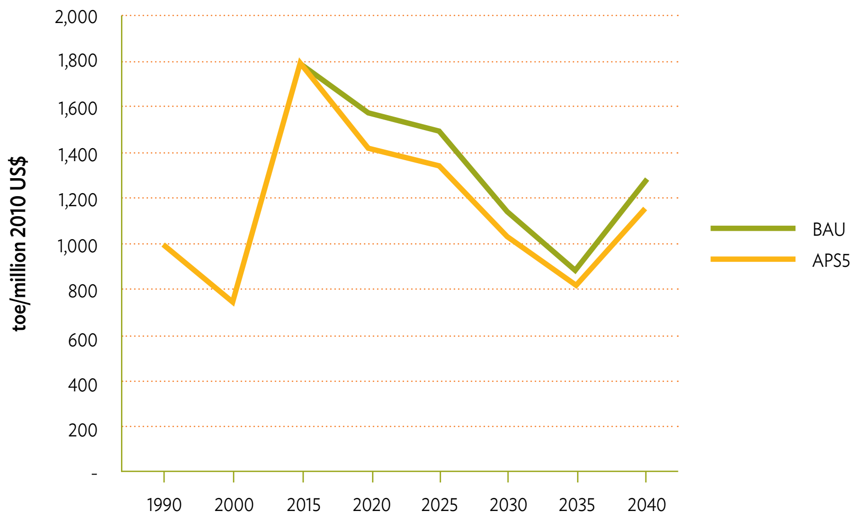
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.2.4 Energy intensities

As the Lao PDR endeavours to move towards an efficient and competitive economy and promote sustainable development, energy intensity for both final and primary energy has been reduced significantly. Final energy intensity is projected to decrease from 1,791 toe/million 2010 US$ in 2015 to 1,279.2 toe/million 2010 US$ in 2040. Primary energy intensity is expected to decline from 1,862.1 toe/million 2010 US$ in 2015 to 1,591.7 toe/million 2010 US$ in 2040. Figures 10.16 and 10.17 show that energy intensity in APS5 is less than that in the BAU scenario. This is due to the implementation of the 10% energy saving from 2015 to 2030. However, Figure 10.17 shows an increase in energy intensity between 2035 and 2040 because of the end of the energy savings programme.

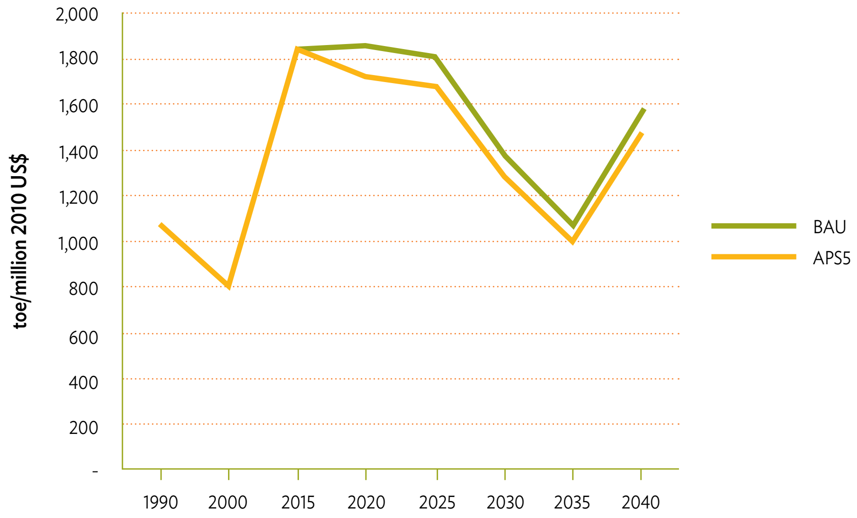
Figure 10.16: Final Energy Intensity, BAU and APS (1990–2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, toe = tons of oil.

Source: Author's calculation.

Figure 10.17: Primary Energy Intensity, BAU and APS (1990–2040)



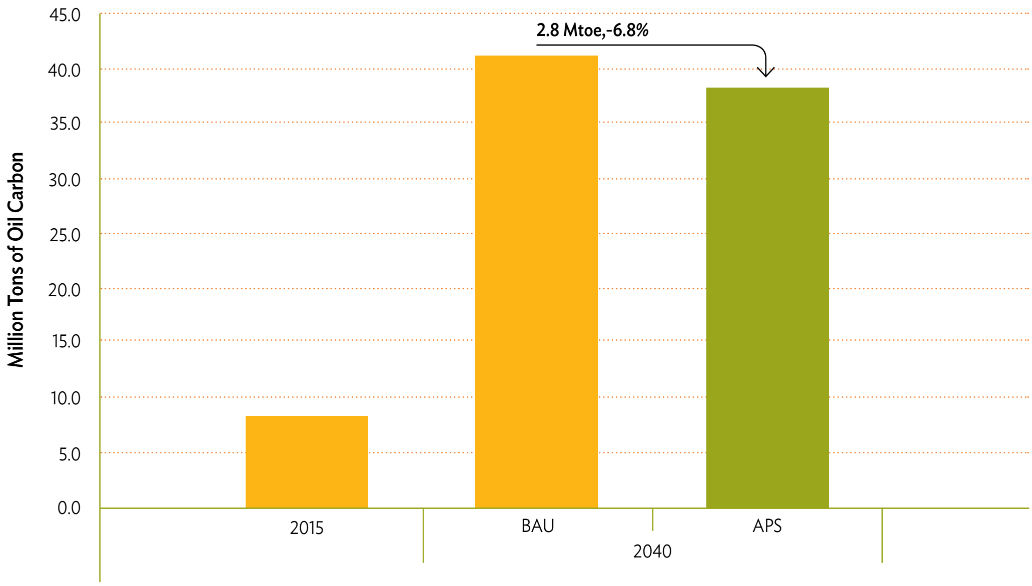
APS = Alternative Policy Scenario, BAU = Business-As-Usual, toe = tons of oil.

Source: Author's calculation.

3.2.5 CO_2 emissions from energy consumption

By reducing energy consumption by 10%, the Lao PDR can reduce CO_2 emissions by 2.8 Mt-C (or 6.8%) in the APS in 2040 (Figure 10.18).

Figure 10.18: CO_2 Emissions from Energy Combustion, BAU vs. APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4. Implications and Policy Recommendations

In this study, the Lao PDR will achieve energy savings mainly through the implementation of the government's renewable EEC programmes. The programmes consist of an increase of the renewable energy share in total energy supply by 30% by 2025, 10% of biofuels in oil supply for the transport sector, and the reduction of 10% in energy consumption in all sectors.

To reduce both the TPEC and the TFEC, as well as CO_2 emissions, the Lao PDR should extend the implementation of the renewable EEC programmes until 2040. As these programmes are most important in reducing energy, these should be proposed as a national policy. At the same time, it should implement sound projects and programmes. The industry sector should implement an energy management system, develop and implement its own energy saving or reduction plans, cooperate with the government on energy security, and regularly conduct seminars on energy-saving measures. The transport sector should increase public transport in big cities and conduct campaigns to promote the use of public transport. The 'others' sector should raise public awareness in energy conservation and implement energy management systems in the building sector. In addition, a study on the correlation between GDP and energy consumption should be carried out and energy statistics should be improved accordingly. The government should also consider the following:

1. Implement EEC programmes in all sectors.
2. Establish an EEC fund (like that of Thailand) to support EEC programmes and energy-saving companies.
3. Increase public transport and use electric vehicles (including public buses and tuk-tuks) to reduce oil imports, CO_2 emissions, and worsening traffic congestion.
4. Reform electricity tariff to encourage more EEC activities, e.g. time of use pricing.
5. Increase the share of coal thermal power generation in the power generation mix by using local coal and clean coal technology to stabilise electricity supply.
6. Promote power trade within ASEAN.

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CHAPTER 11

MALAYSIA COUNTRY REPORT

Zaharin Zulkifli, *Energy Commission of Malaysia*

1. Introduction

Malaysia is in Southeast Asia. Its 329,847 square kilometres of territory comprise Peninsular Malaysia and the Sabah and Sarawak States on the island of Borneo. Malaysia has a tropical, humid climate with temperatures averaging 30°C. Its gross domestic product (GDP) grew steadily over the last 26 years, growing at an average of 5.7% per year from 1990 to 2016, except for sluggish growth in 1998 due to the Asian financial crisis and in 2001 due to slow growth of export demand for electronic products. The country also experienced the latest downward economy trend in 2009 due to the world economic crisis.

Malaysia is well endowed with conventional energy resources such as oil, gas, and coal, as well as renewables such as hydro, biomass, and solar energy. Crude oil and condensates reserves in the country stood at 5.03 billion barrels or 21 years of lifespan as of 1 January 2016, supported by the rising reserves from the deep-water discoveries in offshore Sabah. Meanwhile, natural gas reserves are at 87.76 trillion standard cubic feet (Tscf), enough to cover 37 years of gas output at current production levels. As of January 2015, reserves of coal stood at 1,983.37 million tons. In terms of energy equivalent, Malaysia's gas reserves are four times the size of its crude oil reserves. Natural gas reserves off the east coast of Peninsular Malaysia are dedicated for domestic consumption while those in Sarawak are allocated as revenue earner in the form of liquefied natural gas (LNG) exports. Malaysia is a net energy exporter.

During the last 10 years, some of the barriers to the uptake of energy efficiency and renewable energy have been removed. But there is room for further improvement and progress. The challenge would be to give renewable energy the necessary lift to greater heights in the next 5 years. Efforts to promote energy efficiency should be intensified. In addition, climate change, which is inextricably linked with energy use, has become increasingly important, as people begin to appreciate the implications of an increased risk of unpredictable, severe weather and rapid changes to the ecosystem. Thus, the need to work towards a truly sustainable energy future becomes more compelling. A sustainable energy system is central to meeting the economic goals of Malaysia. Malaysia's levels of energy use per unit of production (intensity) are high compared to other nations. A national strategy aimed at reducing energy intensity must be drawn up. Energy planning must recognise that the place to begin is not only with supply but also the management of demand for energy services, by increasing energy efficiency and the use of renewable energy sources to meet any remaining demand. To pursue the green growth stated in the Eleventh Malaysia Plan, KeTTHA[1] launched the Green Technology Master Plan (GTMP) in 2017 to earmark green growth as one of the six game changers that would alter the trajectory of the economy's growth. The GTMP creates a framework for facilitating the mainstreaming of green technology into the planned development of Malaysia while encompassing the four pillars set out in the plan.

Throughout the years, the government of Malaysia has formulated some policies and programmes on energy to ensure the long-term reliability and security of energy supply for sustainable socio-economic development in the country. The major energy policies implemented in the country are:

- Petroleum Development Act (1974)
- National Petroleum Policy (1975)
- National Energy Policy (1979)
- National Depletion Policy (1980)
- Four-Fuel Diversification Policy (1981)
- Fifth Fuel Policy (2000)
- Biofuel Policy (2006)
- National Green Technology Policy (2009)
- National Renewable Energy Policy and Action Plan (2010)
- New Energy Policy and 10th Malaysia Plan (2010)
- Eleventh Malaysia Plan (2015)
- Green Technology Master Plan (2017)

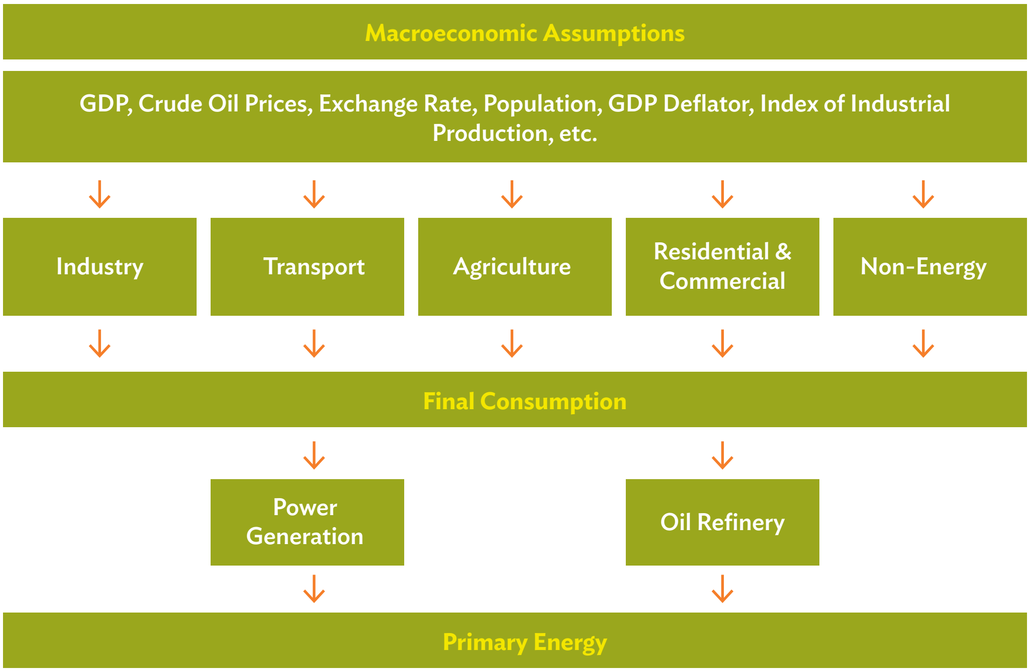
2. Modelling Assumptions

The energy demand projections up to 2040 were estimated using the econometric approach. Historical energy demand data were taken from the National Energy Balance published by the Energy Commission of Malaysia. The economic indicators used in

[1] Formerly the Ministry of Energy, Green Technology and Water. Now it is the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC).

energy modelling such as GDP were taken from the World Bank's World Development Indicators. Energy modelling involved the estimation of final energy consumption and the corresponding primary energy requirements or supply. Figure 11.1 shows the model structure for final energy demand projection and estimation of transformation inputs to arrive at the primary energy requirements.

Figure 11.1: Modelling Structure



GDP = gross domestic product.
Source: Author.

The econometric approach is the method applied in forecasting final energy demand. The historical correlation between energy demand as well as macroeconomic and activity indicators were derived by regression analysis using Microfit. Microfit is an interactive software package written for microcomputers and is 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 were 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 for 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, floor area of buildings, etc. 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 arrears, private consumption, and other factors that encourage commercial activities. However, due to unavailable information on the activity indicators, macroeconomic data, which is GDP, was the best variable to search for the relationship with the energy demand trend. GDP information was broken down into industry GDP, commercial 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 due to insufficiency of data or there is failure to derive a statistically sound equation, other methods such as share of percentage approach are used.

One of the main drivers of the modelling assumption is GDP growth rates. The GDP growth rates assumption forecast was based on IHS[2] data from a study conducted by the Economic Planning Unit (EPU) of Malaysia (IHS Energy Insight, 2014). Most of the energy demand equations for Malaysia use GDP as the key factor in determining future projections. This is due to the high correlation between energy demand and GDP. Table 11.1 shows the assumptions of GDP growth rates by sector.

Table 11.1: GDP Growth Assumptions by Sector to 2040 (% per year)

GDP Growth Rate, %	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040
Agriculture	2.16	2.26	2.09	1.91	1.74
Mining & Quarrying	0.01	1.01	3.03	3.74	5.17
Manufacturing	3.55	3.16	2.77	2.47	2.3
Construction	3.44	3.01	2.54	2.26	2.09
Services	4.41	4.42	3.67	3.07	2.67
Total GDP	**3.88**	**3.77**	**3.19**	**2.74**	**2.43**

GDP = gross domestic product.

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

[2] IHS Markit Ltd is a London-based global information provider that was formed in 2016 when IHS Inc. and Markit Ltd. merged.

Besides future GDP growth rates, the annual average population growth was also a key driver for future energy growth. In 2015, Malaysia's population was 31.0 million; it is projected to increase by 10.5 million (33.9%) to 41.5 million in 2040. However, annual population growth rate would be decreasing from 1.15% in 2016–2020 to 1.02% in 2021–2025, 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 rate and international migration. The assumption of future growth rates of population was obtained from the Department of Statistics Malaysia (Table 11.2).

Table 11.2: Population Growth Assumption to 2040

	2016–2020	2021–2025	2026–2030	2031–2035	2036–2040
Population (million)	33.8	36.0	38.1	39.9	41.5
Population growth (%)	1.15	1.02	0.87	0.74	0.63

Source: Department of Statistics (2016).

In accelerating its socio-economic development, supported by its current position as a net energy exporter, Malaysia subsidises energy use for various users. The energy subsidies offered to various energy users in the country have been growing from year to year, corresponding with the volatility of global energy prices and growing demand for energy. The subsidies have reached a worrisome level that the government expenditure capacity has been stretched beyond its ability and has taken the share of other developmental budget allocations. This situation has prompted the Malaysian government to review its policies related to energy subsidies and to act to mitigate growing energy subsidies. In this regard, energy efficiency offers a sound solution to mitigate the effects of the gradual removal of energy subsidies.

In promoting energy efficiency, the Ministry of Energy, Green Technology and Water (MEGTW) had enacted several legal instruments. The main legal instrument on energy efficiency promotion is the Electricity Supply Act (Amendment) 2001, or Act A1116. This empowers the MEGTW, under Sections 23A to 23C, to promote efficient use of electricity in the country. Deriving from Act 1116, the MEGTW issued the Efficient Management of Electrical Energy Regulation 2008. Under this regulation, all installations that consume or generate 3 million kilowatt-hours (KWh) or more of electricity over 6 months will be required to engage an electrical energy manager who shall, amongst others, be responsible to analyse the total consumption of electrical energy, advise on the development and implementation of measures to ensure efficient management of electrical energy, and monitor the effectiveness of the measures taken. The Energy Commission is empowered to enforce the energy efficiency regulations.

A lack of holistic and long-term policy for demand-side management (DSM) has been identified as a main barrier in implementing energy efficiency initiatives in Malaysia, even though it is an important element in the country's energy plan and policy. Energy efficiency initiatives are set to receive renewed attention under the Eleventh Malaysia Plan through a reinvigoration of the DSM. This is intended to be achieved by formulating a comprehensive DSM master plan. The EPU will initiate a study on DSM, which covers the whole spectrum of the energy sector.

Malaysia has developed a reasonably well-designed renewable support mechanism that includes a set of legislation: published feed-in tariffs (FiT) with annual digression rates from 2013 onwards, quota mechanisms, a Renewable Energy Master Plan, and an implementing agency (the Sustainable Energy Development Authority or SEDA). Malaysia has opted for FiT to drive the development of renewable capacity. FiT is guaranteed by the Renewable Energy Act 2011 and the levels are set by SEDA. The scheme is intended to provide a reasonable level of return for investors over a fixed period to give a level of certainty. FiTs are available for biogas, biomass, solar photovoltaic (PV), and small hydro. Support of 16 years is given for biomass and biogas and 21 years for small hydropower and solar PV. A capacity quota system is in place to manage the new capacity added to the system. This mechanism enables Malaysia to shape the amount of new capacity to be added to the system from the different technologies and make it economically sustainable. Similar systems have been applied, for example, for solar PV in deregulated markets, including Italy and Spain, in response to a rush for new installations. FiT levels adjust to the cost of the technology. Except for small hydro, FiTs have been revised every year per different digression rates from 2013 onwards. This system is used in countries like Germany to adjust the level of remuneration to technology cost evolutions. However, these digression rates must be correctly calculated to avoid a slowdown in capacity buildup. Such a mechanism has proven to work well only in relatively experienced markets, with more track records and know-how.

To complement the current FiT mechanism, a new instrument termed net energy metering (NEM) will be implemented in the Eleventh Malaysia Plan. NEM aims to promote and encourage more solar PV generation by prioritising internal consumption before any excess electricity generated is fed to the grid. NEM is expected to encourage manufacturing facilities and the public to generate clean electricity. This will further assist the government's effort to increase the contribution of renewable energy in the generation mix. NEM, which was started on 1 November 2016, is regulated by the Energy

Commission and implemented by SEDA. The total quota allocated for the 5-year period (2016–2020) is 500 megawatts (MW).[3]

The new NEM scheme is only applicable to Peninsular Malaysia and applicants must be a registered TNB customers. NEM is executed by the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), regulated by the Energy Commission (EC), with Sustainable Energy Development Authority (SEDA) Malaysia as the implementing agency.

As a continuation of the government's effort to boost solar PV market in the economy, the EC has been tasked with implementing the large-scale solar (LSS) programme, which is based on a bidding process. The total quota allocated for the LSS from 2017 to 2020 is 1,250 MW. Of this, 250 MW was granted direct award under the fast-track programme. As of 2018, there are 91.5 MW solar operated from five LSS projects from an open bidding exercise. While in Sabah, there are 50 MW solar operated from direct award projects. The remaining 1,000 MW fall under the bidding mechanism. In August 2017, the Energy Commission announced the bid open price for LSS PV plants for 2019–2020. The bid was divided into three categories based on capacity: 1 MW–5.99 MW; 6.00 MW–9.99 MW; and 10 MW–30 MW. The results showed that the lowest bid received was in the 10 MW–30.00 MW category, with a tariff of RM0.3398/kWh (US$0.079/kWh).

The implementation of the Nuclear Power Infrastructure Development Plan and the Nuclear Power Regulatory Infrastructure Development Plan would be an important step in developing nuclear power to supply electricity in the future. This will support the multiple goals of improving energy security, spurring economic development, and reducing greenhouse gas (GHG) emissions. A new independent atomic energy regulatory commission will be established. The 10-Year Comprehensive Communication Plan and Strategies on Nuclear Power for electricity will be continued to increase awareness and public acceptance.

[3] The Ministry has introduced several solar PV initiatives to encourage Malaysia's renewable energy (RE) uptake. From the RE townhall held on 12 July 2018, one of the key issues highlighted by the PV industry is the need to change the concept of NEM from the existing net billing to true net energy metering. This is will help improve the return of investment of solar PV under NEM.

Effective from 1 January 2019, NEM will be improved by adopting the true net energy metering concept and this will allow excess solar PV generated energy to be exported back to the grid on a 'one-on-one' offset basis. This means that every 1kWh exported to the grid will be offset against 1kWh consumed from the grid, instead of at the Displaced Cost previously.

The quota allocation for NEM is 500 MW up to year 2020. Quota allocation will be divided into domestic and non-domestic category. Agriculture will be a new category to be added to the NEM scheme. The NEM category has been divided into four categories – Residential, Commercial, Industrial, and Agriculture.

In setting up the scenarios for this project, several assumptions or scenarios have been identified (Table 11.3).

Table 11.3: Potential Mitigation Scenarios

Scenario	Mitigation Actions
Energy Efficiency and Conservation	**1. Improve final energy consumption of all energy types by 8% in 2016 and reach 16% by 2040.**
Renewable Energy	**1. Implement renewable energy in the power sector by 2036:**
	a. Hydro: 8,543 MW
	b. Solar: 2,679 MW
	c. Biomass: 916 MW
	d. Biogas: 194 MW
	e. MSW: 39 MW
	Total: 12,372 MW
	2. Increase the share of biodiesel from 5% to 7% from 2020
Energy Efficiency in the Power Sector (EEP)	1. Improve the efficiency of power plants:
	a. Natural gas at 55% by 2040
	b. Coal at 45% by 2040
Nuclear (NUC)	**Commission 2,000 MW of nuclear in 2036**
Alternative Policy Scenario	**Combination of all scenarios:**
	APS = EEC + RE + EEP + NUC

MSW = Municipal Sold Waste, MW = megawatt.

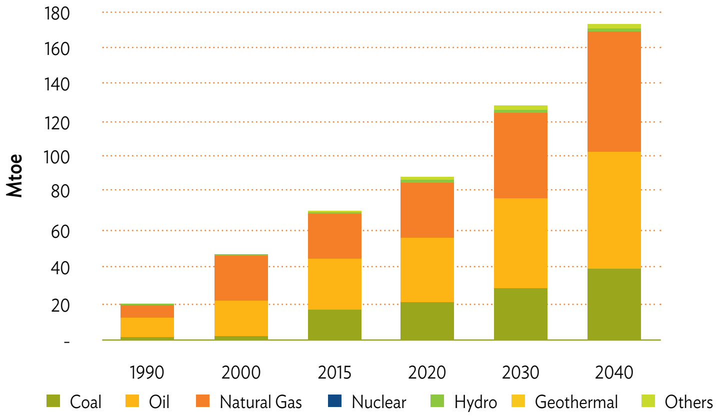
Source: Author's assumptions.

3. Outlook Results

3.1. Business-As-Usual Scenario

Total primary energy consumption (TPEC) in the Business-As-Usual (BAU) scenario registered a growth at 5.2% per year from 1990 until 2015. The outlook results showed that the TPEC is projected to increase by 3.6% per year from 2015 until 2040. Hydro will increase from 1.22 million tons of oil equivalent (Mtoe) in 2015 to 2.05 Mtoe with average annual growth rate (AAGR) of 2.1%. Oil supply will increase at 3.5% per year in 2015–2040. The supply of coal consumed mainly by the power sector is expected to increase by 3.3% per year in 2015–2040. Natural gas will experience an increase from 24.60 Mtoe in 2015 to 66.11 Mtoe in 2040, or an AAGR of 4%. Biomass for power generation will increase at an average annual rate of 8% in 2015–2040 while biofuel use for land transportation will increase at 1% per year (Figure 11.2).

Figure 11.2: Primary Energy Consumption by Fuel Type, BAU (1990–2040)

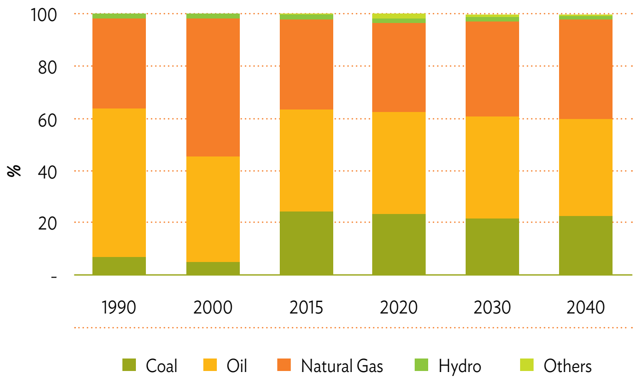


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

In terms of share by fuel type, oil share will decrease from 38.7% in 2015 to 37.2% in 2040. However, the share of natural gas will increase from 34.9% in 2015 to 38.3% in 2040. Coal will have a decreasing share over the projection period, from 24.6% in 2015 to 22.6% in 2040. The share of hydro will decrease from 1.7% in 2015 to 1.2% in 2040 (Figure 11.3).

Figure 11.3: Share of Primary Energy Supply by Fuel Type, BAU (1990–2040)

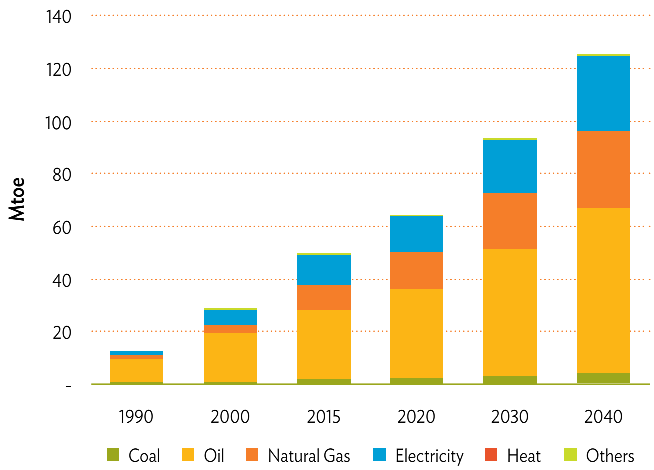


BAU = Business-As-Usual.

Source: Author's calculation.

Total final energy demand in the BAU scenario will increase from 49.52 Mtoe in 2015 to 125.14 Mtoe in 2040, illustrating an AAGR of 3.8% per year. Final demand of natural gas and electricity will experience the highest AAGR of 4.6% and 3.7% per year, from 2015 to 2040, respectively. Oil demand will grow from 26.39 Mtoe in 2015 to 62.52 Mtoe in 2040, or 3.5% per year. Coal demand will increase 3.5% per year from 2015 until 2040 and other fuels will grow from 0.39 Mtoe in 2015 to 0.50 Mtoe in 2040, or 1% per year (Figure 11.4)

Figure 11.4: Final Energy Consumption by Fuel Type, BAU (1990–2040)

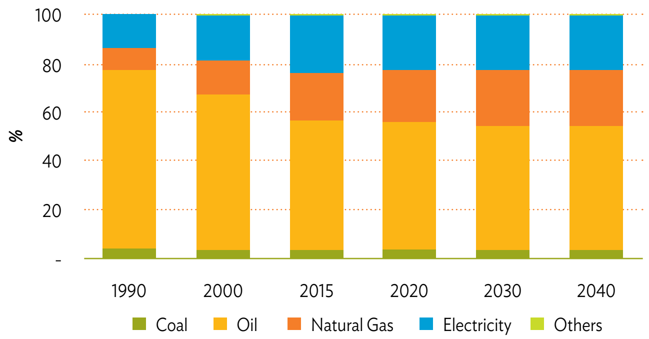


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Analysis by share showed that oil, with 50%, will still dominate in 2040, slightly lower than that in 2015 (53.3%). This will be followed by natural gas (23.4%) and electricity (22.8%) in 2040. Share of coal will decrease from 3.6% in 2015 to 3.4% in 2040 (Figure 11.5).

Figure 11.5: Share of Final Energy Consumption by Fuel Type, BAU (1990–2040)

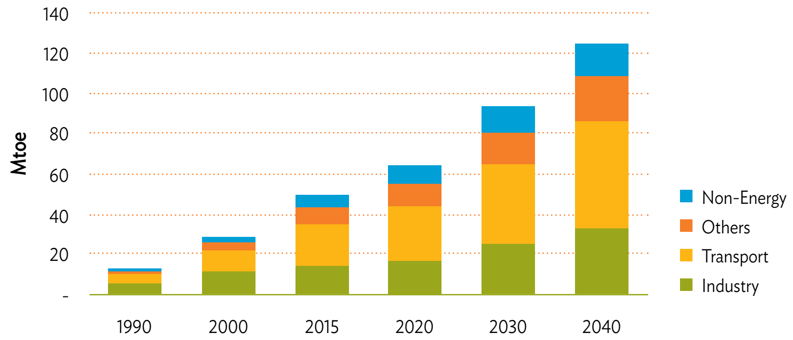


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Final energy demand by sector showed that the non-energy use sector will lead the growth with 4.2% per year from 2015 until 2040. This will be followed by the 'others' sector growing from 8.53 Mtoe in 2015 until 22.29 Mtoe in 2040 or 3.9% per year. The transport sector is expected to increase from 21.10 Mtoe in 2015 to 53.03 Mtoe in 2040, or 3.8% per year. The industry sector will have an average annual growth of 3.5% per year from 2015 until 2040 (Figure 11.6).

Figure 11.6: Final Energy Consumption by Sector, BAU (1990–2040)

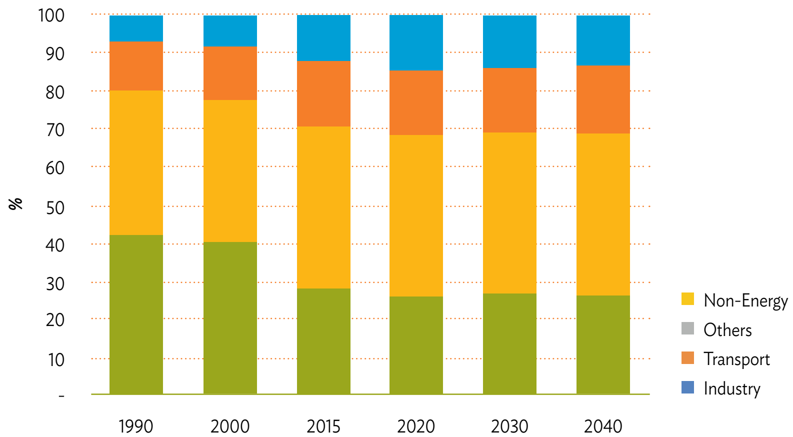


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Analysis by share showed that the transport sector will still dominate energy use in 2040, with 42.4% compared to 42.6% in 2015. This will be followed by the industry sector with 26.6% share in 2040 compared to 28.2% in 2015. The share of non-energy use is 13.2% of total final energy demand in 2040, to increase in 2015 at 12%. The share of the 'others' sector is expected to be at 17.8% in 2040 (Figure 11.7).

Figure 11.7: Share of Final Energy Consumption by Sectors, BAU (1990–2040)

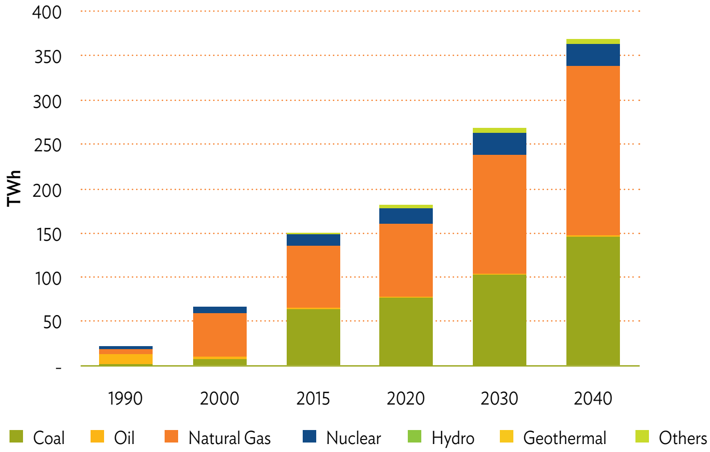


BAU = Business-As-Usual.

Source: Author's calculation.

In the BAU scenario, total power generation is expected to grow around 3.6% per year from 2015 until 2040, reaching 368.13 terawatt-hours (TWh). Power generation from other types of fuel (others) will have the fastest growth at 7% per year during the same period. Power generation from natural gas is projected to increase to 191.40 TWh in 2040 from 69.96 TWh in 2015. Power generation from coal will grow 3.4% per year from 63.47 TWh in 2015 to 145.83 TWh in 2040. Electricity generation from hydro will increase by 2.1% per year during the same period. Power generation from oil is expected to decline by 0.3% per year to register at 1.60 TWh in 2040 compared to 1.74 TWh in 2015 (Figure 11.8).

Figure 11.8: Power Generation by Fuel Type, BAU (1990–2040)

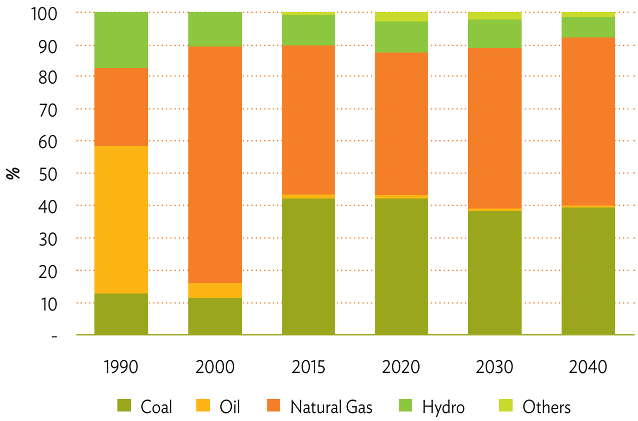


BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

In terms of share, power generation mix will be dominated by natural gas and coal in 2040 with share of 52.0% and 39.6%, respectively, followed by hydro with a share of 6.5% in 2040 compared to 9.4% in 2015. Share of others will be at 1.5% of the total power generation in 2040. Oil share will be at 0.4% in 2040 compared to 1.2% share in 2015.

Figure 11.9: Share of Power Generation by Fuel Type, BAU (1990–2040)

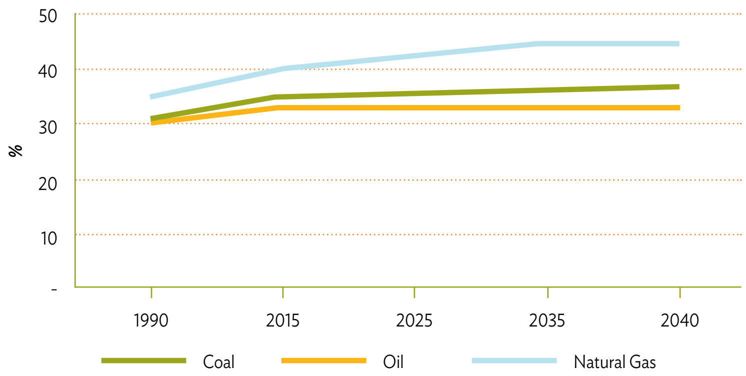


BAU = Business-As-Usual.

Source: Author's calculation.

In the BAU scenario, the thermal efficiency of coal power plants is expected to improve to 36.1% in 2040 from 35.0% in 2015. That of oil power plants is projected to remain the same over the same period at around 33%. Thermal efficiency of natural gas power plants will further improve to almost 44.8% by 2040 from the 2015 level of 40.0% (Figure 11.10).

Figure 11.10: Thermal Efficiency by Fuel Type, BAU (1990–2040)

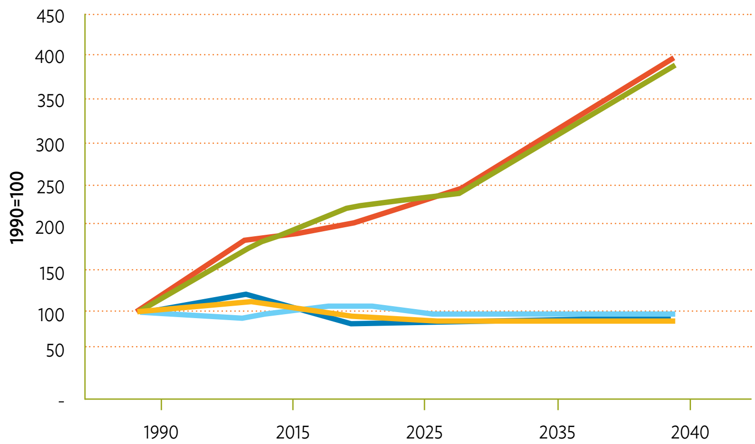


BAU = Business-As-Usual.

Source: Author's calculation.

Malaysia's primary energy intensity is expected to increase to 223 toe/million US$ in 2040 from 214 toe/million US$ in 2015, while final energy intensity is expected to increase to 161 toe/million US$ in 2040 compared to 150 toe/million US$ in 2015. Primary energy per capita is projected to increase to 4.37 toe/person in 2040 compared to 2.30 toe/person in 2015.

Figure 11.11: Energy Indicators, BAU (1990–2040)



BAU = Business-As-Usual.

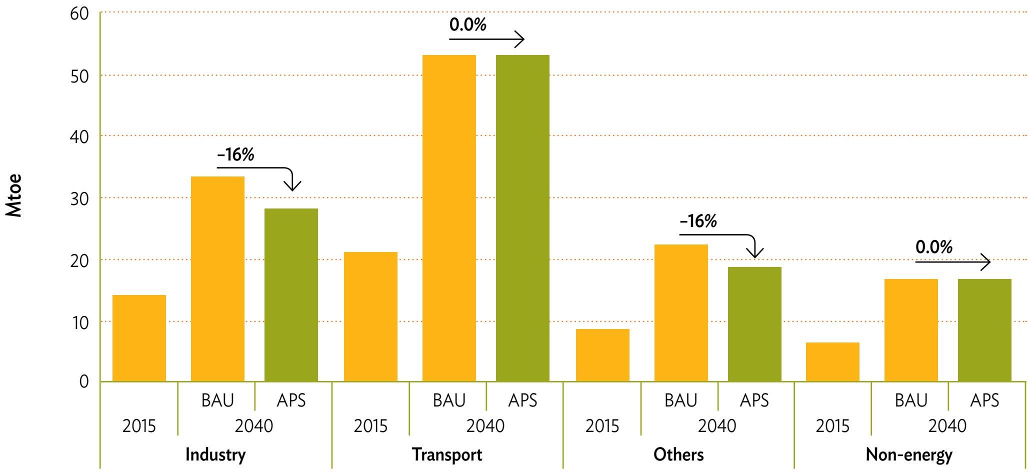
Source: Author's calculation.

Carbon dioxide (CO_2) intensity is expected to decrease to 150 t-C/million US$ in 2040 from 157 t-C/million US$ in 2015. CO_2 per primary energy would slightly decrease in 2040 at 0.67 t-C/toe from 0.74 t-C/toe in 2015.

3.2. Alternative Policy Scenario

In the Alternative Policy Scenario (APS), growth in final energy demand will be at 3.5% from 2015 until 2040, slightly lower than that of the BAU scenario. The slower rate of increase in the APS is projected to be the result of improvements in manufacturing technologies as well as efforts to improve energy efficiency, particularly in the industry and the 'others' sectors. Thus, savings of 16% in the industry sector in 2040 could be expected. In the 'others' sector, the growth rate of energy consumption is projected to be slower than the BAU scenario at 3.2% per year compared to 3.9% per year in the BAU scenario. The potential saving of 16% in 2040 can be achieved through the implementation of energy efficiency measures (Figure 11.12).

Figure 11.12: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)

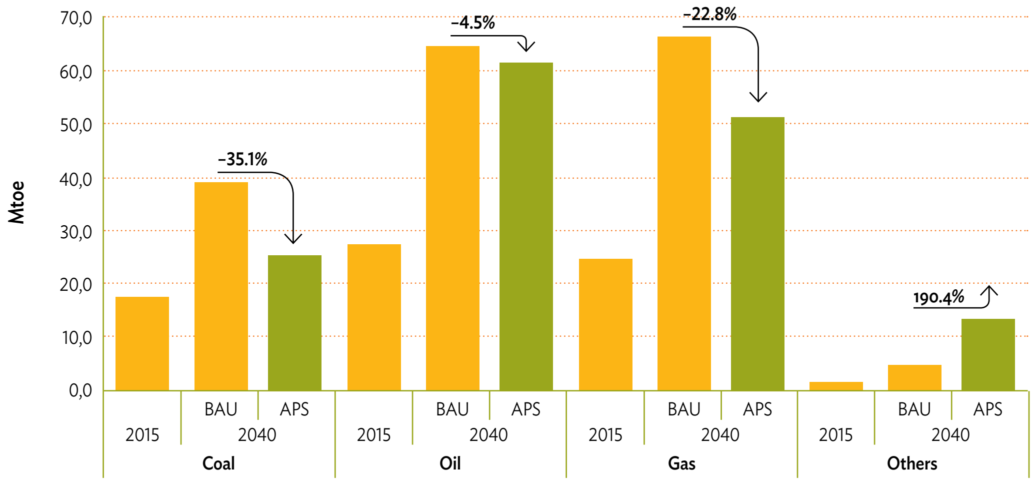


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

In the APS, primary energy consumption is projected to increase at a slower rate than in the BAU scenario at 2.9% per year from 70.58 Mtoe in 2015 to 145.21 Mtoe in 2040 (Figure 11.13). Solar and biomass will be growing the fastest at average rates of 12.1% per year and 8.7% per year, respectively. This is due to the implementation of FiT, NEM, and LSS in power generation that largely impact on primary energy consumption in 2040 as more renewable energy for power generation is expected to be commissioned. Hydro will also increase fast but at a slower rate of 2.4% per year between 2015 and 2040. Oil will have slower growth rates of 3.3% per year in 2015–2040 from the BAU scenario. Natural gas and coal are projected to increase at 3.0% per year and 1.5% per year, respectively. Nuclear power as a future energy option will be introduced after 2036 (Figure 11.13).

Figure 11.13: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



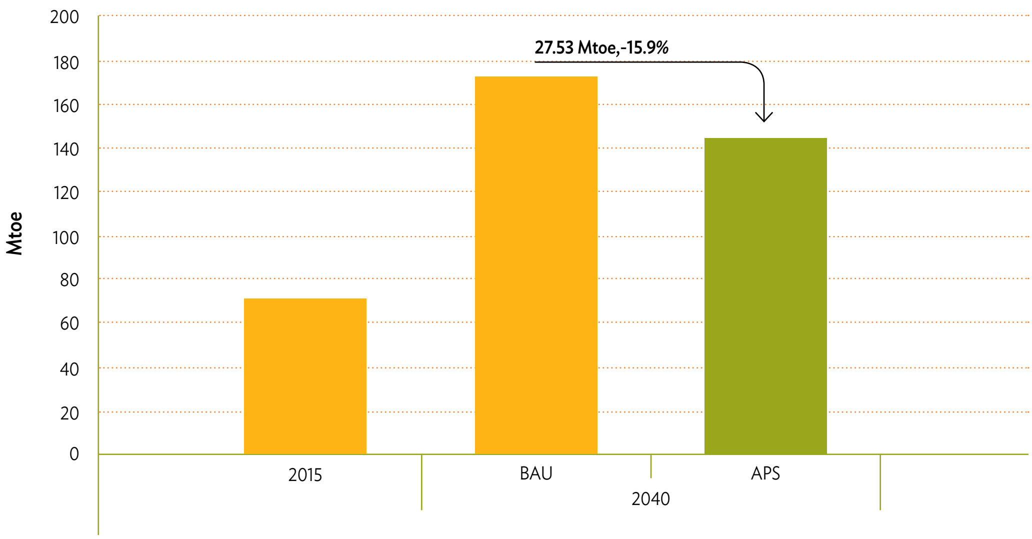
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.3. Projected Energy Savings

The energy savings that could be achieved under the APS because of energy efficiency efforts in the industry and the 'others' sectors, more efficient thermal power supply, and higher contribution from renewable energy are estimated at 27.53 Mtoe in 2040 or 15.9% (Figure 11.14).

Figure 11.14: Total Primary Energy Supply, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

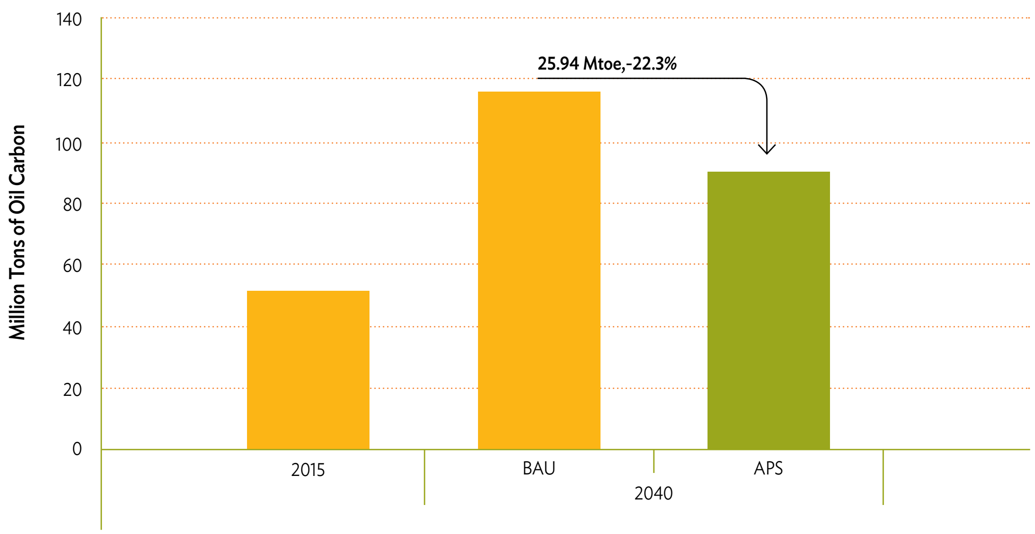
Major savings can be achieved by switching from coal or natural gas to renewable energy and nuclear power. While for final energy demand, savings of 8.9 Mtoe – comprising savings of 5.3 Mtoe in the industry sector and 3.6 Mtoe in the 'others' sector – can be achieved in 2040.

3.4. CO_2 Emissions from Energy Consumption

In the BAU scenario, total CO_2 emissions from energy consumption are projected to increase by 3.3% per year in 2015–2040. In 2015, the CO_2 level was at 52.0 million tons of carbon (Mt-C) and was expected to increase to 116.3 Mt-C in 2040 under the BAU scenario.

In the APS, the annual increase in CO_2 emissions from 2015 to 2040 will be lower than in the BAU scenario at 2.2% per year, which is consistent with the growth in primary energy consumption. Reduced CO_2 emissions in the APS of 25.94 Mt-C or 22.3% relative to the BAU scenario is also due to a significant decrease in coal consumption for power generation in the APS. This is because coal consumption is being replaced by natural gas and other clean energy sources such as nuclear and renewable energy. Furthermore, the lower energy usage in the industry and the 'others' sectors has also contributed to the reduction. This indicates that Malaysia's energy-saving efforts and renewable energy action plan would be effective in reducing CO_2 emissions (Figure 11.15).

Figure 11.15: CO_2 Emissions from Energy Combustion, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.5. Review of Intended Nationally Determined Contributions of Malaysia

In 2013, parties to the United Nations Framework Convention on Climate Change (UNFCCC) were invited to initiate domestic preparations for and submit their Intended Nationally Determined Contributions (INDC) by 2015. The INDC submission aimed to facilitate the UNFCCC negotiations for adopting relevant instruments under the convention that are applicable to all parties towards achieving the objectives of the convention as per Article 2. Countries were expected to outline in their INDC the post-2020 climate actions they intend to take under an international agreement. During the 21st Conference of the Parties (COP21) of the UNFCCC in Paris in December 2015, the parties adopted the Paris Agreement, a historic international climate agreement aimed to keep the global average temperature to well below 2°C. It also aimed to pursue efforts to limit the increase to 1.5°C, and to achieve net zero emissions in the second half of this century.

Malaysia submitted its INDC to the UNFCCC in November 2015. Its INDC stipulates that Malaysia intends to reduce its GHG emissions intensity of GDP by 45% by 2030 relative to that in 2005. This consists of 35% on an unconditional basis and a further 10% conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries. Malaysia's INDC was developed by a participatory process through an inter-ministerial and government agencies working group. A stakeholders' workshop was conducted in 2015 to obtain inputs on possible measures to reduce GHG emissions.

Based on results calculated from the APS, Malaysia already achieved its unconditional target of 35% of GHG emissions intensity of GDP by 2030 relative to that in 2005 by 40.8% (Table 11.4).

Table 11.4: Current Results of Key Indicators from APS

	2016–2020	2021–2025
GDP (billions of 2010 US$)	204.862	582.879
CO_2 emissions (Mt-C)	42.400	71.391
Carbon intensity	0.207	0.122
Total reduction (%)	(40.82)	

APS = Alternative Policy Scenario, GDP = gross domestic product, Mt-C = million tons of carbon.

Source: Author.

To achieve the 45% conditional target upon receipt of climate finance, technology transfer, and capacity building from developed countries, Malaysia needs to exert further efforts to reduce its carbon emissions. New targets under the EEC scenario have been identified as the best solution to achieve this target (Table 11-5).

Table 11.5: Newly Proposed Mitigation Scenario

Scenario	Mitigation Actions
Energy Efficiency and Conservation (EEC)	**1. Improve final energy consumption of all energy types by 8% in 2016 and reach 17% by 2040.**
Renewable Energy (RE)	**1. Implement RE in the power sector by 2036:**
	a. Hydro: 8,543 MW
	b. Solar: 2,679 MW
	c. Biomass: 916 MW
	d. Biogas: 194 MW
	e. MSW: 39 MW
	Total: 12,372 MW
	2. Increase the share of biodiesel from 5% to 7% from 2020
Energy Efficiency in the Power Sector (EEP)	1. Improve the efficiency of power plants:
	a. Natural gas at 55% by 2040
	b. Coal at 45% by 2040
Nuclear (NUC)	**Commission 2,000 MW of nuclear in 2036**
Alternative Policy Scenario (APS)	**Combination of all scenarios:**
	APS = EEC + RE + EEP + NUC

MSW = Municipal Sold Waste, MW = megawatt.

Source: Author.

Table 11.5 shows that the new target for EEC is improvement of final energy consumption in all energy types by 8% in 2016 and reach 17% by 2040. The old target of 16% under the APS will be reached by 2040. Table 11.6 shows the INDC results.

Table 11.6: Results for INDC Scenario

	2005	2030
GDP (billions of 2010 US$)	204.862	582.879
CO2 emissions (Mt-C)	42.400	63.800
Carbon intensity	0.207	0.109
Total Reduction (%)	(47.11)	

GDP = gross domestic product, INDC = Intended Nationally Determined Contributions.

Source: Malaysia INDC Report.

4. Conclusions

The TPEC in the BAU scenario registered a growth at 5.2% per year from 1990 until 2015. The outlook results showed that the TPEC is projected to increase by 3.6% per year from 2015 until 2040. In the APS, primary energy consumption is projected to increase at a slower rate than in the BAU scenario at 2.9% per year, from 70.58 Mtoe in 2015 to 145.21 Mtoe in 2040. Total final energy demand in the BAU scenario will increase from 49.52 Mtoe in 2015 to 125.14 Mtoe in 2040. This illustrates an AAGR of 3.8% per year. In the APS, growth in final energy demand will be at 3.5% in 2015–2040, slightly lower compared to that of the BAU scenario. The slower rate of increase in the APS is projected to be the result of improvements in manufacturing technologies as well as efforts to improve energy efficiency, particularly in the industry and the 'others' sectors.

There is still room for improvement in reducing energy in Malaysia. The potential of reducing energy in the industry sector should consider not only electricity but also other fuels, such as oil and gas, especially for heating purposes. Potential saving or target for the transport sector in Malaysia still cannot be quantified due to lack of information. Malaysia needs to collect energy data on the transport sector to identify accurate potential savings. It also needs to develop a comprehensive policy study to identify potential energy savings in the transport sector. The power sector should continuously use renewable energy to minimise carbon emissions. Introduction of new technology that can generate electricity more efficiently can contribute to potential savings. Nuclear power is a possible energy option in Malaysia.

Clear action plans and targets for each sector will help formulate energy potential savings in Malaysia. Government policy in terms of laws and regulations is needed to ensure that all related initiatives in reducing energy is moving forward. Furthermore, financial support from developed countries will speed up the whole process in meeting the target of reducing energy. Since climate change has become a global issue, identifying the potential energy saving will be very important. This effort needs cooperation from all stakeholders such as policymakers, the private sector, and others.

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CHAPTER 12

MYANMAR COUNTRY REPORT

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1. Background

1.1. Country Profile

Myanmar is the largest country in mainland Southeast Asia. It covers 676,577 square kilometres (km) and shares a border of 5,858 km with Bangladesh and India to the northwest, China to the northeast, and Thailand to the southeast. About 48% of the total land area is covered with forest, and most of the land is used for agriculture. Myanmar had a population of 52.4 million in 2015, with an average annual growth rate (AAGR) of 1% per year from 1990 to 2015.

Myanmar is located in Southeast Asia and has three distinct seasons. It enjoys 3 to 4 months of heavy monsoon and abundant sunshine all year round, which makes it ideal for accumulating water for hydropower and for agriculture. Its topographic features favour the existence of numerous rivers, mountain ranges, and sedimentary basins where mineral deposits and energy resources have abundantly accumulated. The delta regions where the two major river systems (N'mail and Mali rivers) enter the Bay of Bengal and the 2,832 km coastal strip along the southern part are also a good area for the development of marine ecosystems and an abundant source for marine products and chemicals.

Myanmar is endowed with rich natural resources for the production of commercial energy. Its current sources of energy are crude oil, natural gas, hydroelectricity, biomass, and coal. Besides these, wind, solar, geothermal, bioethanol, biodiesel, and biogas are potential energy sources found in the country.

Myanmar's proven energy reserves in 2017 comprised 105 million barrels of oil, 6.58 trillion cubic feet of gas, and 542.56 million metric tons of coal. The country is a net exporter of energy, exporting substantial amounts of natural gas and coal to neighbouring countries. However, it imports around 90% of its total oil requirements.

1.2. Socio-economic Status

The population of Myanmar grew at 1% per year between 1990 and 2015 to 52.4 million in 2015. Myanmar's gross domestic product (GDP) was US$[1] 70.5 billion (constant 2010) in 2015, and its GDP per capita grew from around US$200 in 1990 to US$1,300 in 2015. Aiming to enhance economic development, Myanmar formulated and implemented 5-year short-term plans in 1992 to 2013. The first (1992–1995), second (1996–2000), third (2001–2005), and fourth plans (2006–2010) achieved AAGRs in GDP of 7.5%, 8.5%, 12.8%, and 12.0%, respectively. The last 5-year plan (2011–2016) was formulated to achieve an AAGR of 7% in GDP.

1.3. Energy Consumption in the Base Year

Myanmar's total primary energy supply was 19.8 million tons of oil equivalent (Mtoe) in 2015. Natural gas is mainly used to generate electricity and in industry. Currently, Myanmar has 5,235 megawatts (MW) of installed generation capacity and produced almost 16 terawatt-hours (TWh) of electricity in 2015 (Table 12.1). During the same year, thermal (coal, natural gas, and oil) and hydro accounted for 41% and 59% of total electricity generation, respectively.

Table 12.1: Installed Capacity and Power Generation by Fuel Type (2015–2016)

No.	Type of Fuel	2015-2016	
		Installed (MW)	Generation (GWh)
1	Hydro	3,215	9,399
2	Gas + Steam	1,695	6,511
3	Coal	120	
4	Diesel	95	55
Total Reduction (%)		5,125	15,965

GWh = gigwatt-hour, MW = megawatt.

Source: Myanmar Ministry of Electricity and Energy (2018a).

[1] All US$ in this report are in constant 2010 values unless specified.

2. Modelling Assumptions

2.1. GDP and Population Growth

In this publication, Myanmar's GDP is assumed to grow at an average annual rate of around 6.2% from 2015 to 2040, slowing from the 9.1% growth of 1990–2015. The population is assumed to increase by about 0.71% per year from 2015 to 2040. The assumption is based on data from the Ministry of Labour, Immigration and Population.

2.2. Energy Consumption and Electricity Generation

Hydro and natural gas dominated electricity generation in Myanmar. Other fuels such as oil and coal also contributed to the country's generation mix but was only less than 13% in total in 1990. The government's plan is to increase further the share of natural gas, coal, hydro, and other renewables in the total generation mix and decrease oil share. Myanmar also has plans to export electricity to neighbouring countries, such as Thailand and China, from its hydropower plants.

Based on the yearly plan for the construction of power plants in 2018–2022 (Table 12.2), majority of the projects are gas-based power plants, including liquefied natural gas (LNG). Others are hydro and solar power plants. The yearly plan excludes coal-based power plants, currently at 120 MW installed capacity.

In this masterplan, the shares between scenarios differ. The lowest is the Power Resource Balance scenario (Scenario 3), under which total installed capacity will reach 23,594 MW by 2030 with hydro share amounting to 38%; coal, 33%; gas, 20%; and the remaining which are renewables (solar, wind, etc.), 8%. Both installed capacity in the yearly plan and the power supply scenario 3 are included in the current outlook model under the Reference scenario.

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) LNG to Power (Zhefu)				1390		
11	Kanbauk LNG to Power (Total & Siemens)				820	410	
12	Ywama (W.B.) (Gas)				150	75	
13	Upper KyaingTaung (Hydro)				51		
14	Upper Yeywa (Hydro)				280		
15	Middle PaungLaung (Energize)					152	
16	Dee Dote (Andritz)					60	
	Total	343	265	563	2731	747	4649

MW = megawatt.

Source: Department of Electric Power Planning, Myanmar Ministry of Electricity and Energy (2018b).

The Energy Masterplan of Myanmar considers three scenarios (Table 12.3).

Table 12.3: Installed Capacity and Power Supply in Scenarios for 2030

No	Energy Resources	Scenario 1 (Domestic Energy Consumption) Installed Capacity (MW)	%	Scenario 2 (Least Cost) Installed Capacity (MW)	%	Scenario 3 (Power Resources Balance) Installed Capacity (MW)	%
1	Hydro (large)	12,147	42	12147	43	1412	6
2	Hydro (small and medium)	6,891	24	6,891	24	7,484	32
3	Gas	4,986	17	2,484	9	4,758	20
4	Coal	2,760	10	5,030	18	7,940	34
5	Renewable	2,000	7	2,000	7	2,000	8
	Total	28,784		28,552		23,594	

MW = megawatt.

Source: Myanmar Energy Master Plan (2015).

2.3. Energy and Climate Change/Environmental Policies

Myanmar's energy policy in general 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 use of water resources, a renewable energy resource for generating electricity to save non-renewable sources of energy such as fossil fuels for alternative and future use. It also emphasises energy efficiency and conservation (EEC) to save energy through effective energy management and to reduce energy consumption to minimise harmful environmental impacts. It further encourages the use of new and renewable energy (NRE) sources, especially solar and wind which are abundant under Myanmar's climatic condition. It also recognises that traditional energy sources, such as fuelwood and charcoal, still need to be used. Regulations and anticipatory actions are necessary for the sustained harvesting of this primary energy source.

Savings in Myanmar's energy consumption can be attained through the implementation of energy efficiency programmes in all energy-consuming sectors. In the industry sector, energy savings of at least 14% from Business-As-Usual (BAU) scenario levels are expected by 2020 from improved manufacturing technologies. In the residential and commercial ('others') sectors, efficient end-use technologies and energy management systems are also projected to induce significant savings. In the transport sector, efficiency improvements will be achieved by improved vehicle fuel economy and more effective traffic management.

Myanmar still lacks a national strategy and action plan for mitigating and adapting to climate change, but several ministries have been implementing sector-specific initiatives relevant to climate change. The government is encouraging the use of biofuel in the transport and agriculture sectors to reduce oil dependency and curb carbon dioxide (CO_2) emissions. These efforts are already in place, although the amount of biofuel used in the country is still small for the time being. The government, through the Ministry of Electricity and Energy, has initiated the Clean Fuel Programme to reduce CO_2 emissions by increasing the use of natural gas in the industry sector 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 (MONREC), the designated national authority for clean development mechanism, 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 MONREC, formerly the Ministry of Forestry, and its members come from 19 ministries.
The Environmental Conservation Law was enacted in March 2012. The law provides the legal basis for implementing a range of enhanced environmental management measures. Simultaneously, the draft Environmental Conservation Rule, which embodies regulations and technical guidelines and creates the enabling conditions for their effective implementation, is being drawn up and submitted to the authorised body.

2.4. The National Efficiency Policy

The National Energy Efficiency and Conservation Policy, Strategy and Roadmap for Myanmar (ADB, 2015) mandates the following:

> *The National Energy Efficiency and Conservation Policy, Strategy and Roadmap for Myanmar 2015 was supported by the Asian Development Bank and the Japan Fund for Poverty Reduction. Based on the calculated potential energy savings, the National Energy Efficiency Policy targets the following objectives by 2020, using 2012 as a baseline: (i) to reduce national electricity demand by 12%, (ii) to reduce biomass consumption by 2.3%, and (iii) to reduce national carbon dioxide emissions by 78,690 tonnes. To reach the overall energy efficiency objective, it is necessary to develop a strategy to save energy for all important energy-intensive sectors such as the industry, transport, commercial, and residential sectors.*

Specifically, the following strategies could achieve the goals:

For the residential sector: (i) introduction of energy efficiency performance standards and labelling for appliances, (ii) establishment of testing and certification facilities for appliances, (iii) introduction of incentives for energy-efficient equipment, (iv) phasing out of inefficient appliances from the market, (v) promotion of efficient biomass cook stoves, (vi) increasing consumer awareness on the benefits of LPG for cooking, (vii) introduction of energy efficiency labelling scheme for LPG cook stoves, and (viii) conduct of regular energy efficiency awareness campaigns in national media.

For the commercial sector: (i) conduct of energy audits; (ii) formulation of energy performance standards (for appliances); (iii) incorporation of energy efficiency in new building design, energy building code, and refurbishments; and (iv) preparation of energy efficiency guidelines for commercial buildings.

Action Plan 2018–2021 provides for a step-by-step implementation of activities to harmonise energy efficiency performance standards for air conditioning and lighting.

In addition, the following measures are considered important in achieving the goals:

- Residential: high efficiency lighting and refrigeration, LPG cooking
- Industry: cogeneration, energy efficiency (boiler, kilns, motor), waste heat recovery
- Commercial: high efficiency lighting and air conditioning, LPG cooking, solar water heating, standard labelling equipment of appliances, LED

2.5. Intended Nationally Determined Contributions/Nationally Determined Contributions (INDC/NDC)

Mitigation actions and policies in the energy sector:

- Energy – 30% renewable in rural electrification (mini hydropower; biomass; solar, wind, and solar mini-grid technologies)
- Clean cooking and heating – distribute approximately 260,000 energy-efficient cooking stoves between 2016 and 2031
- Renewable energy (hydropower) – 9.4 GW hydroelectric generation by 2030
- Energy efficiency – 20% electricity-saving potential of the total forecast electricity consumption by 2030.

Government plans to achieve by 2030 a 27% share of renewable energy to the national energy mix. To fulfil this goal, the share of these four types of renewable energy sources should be allocated as follows: hydropower (1.3%), solar (on-grid, 17.8%) (off-gird, 3.7%), biomass (1%), bio-gasification (0.02%), and biofuel (5%).This higher share of renewable targets in the energy mix could be achieved if the government has clear policy support to scale up renewables such as feed-in-tariff or any other policy to attract investment in renewable power generation.

2.6. Alternative Policy Scenarios

In previous studies, two scenarios were formulated to analyse the impact of policy interventions to the energy sector. The BAU scenario serves as the reference case to project energy demand and CO_2 emissions, and the Alternative Policy Scenario (APS), to evaluate the impacts of policy interventions in the development and utilisation of energy resources in the country. The APS as such can include policies to increase EEC targets, expedite penetration of NRE and introduction of cleaner technology, including options for a nuclear power plant. To understand further the impact of individual policy interventions, this year's study formulated five APSs as follows:

- APS1 – Improved energy efficiency of final energy demand
- APS2 – Higher efficiency of thermal electricity generation
- APS3 – Higher contribution of NRE (here, NRE for electricity generation and biofuels in the transport sector are assumed)
- APS4 – Introduction or higher contribution of nuclear energy
- APS5 – Combined impact of scenarios APS1 to APS4

Myanmar does not have an existing plan to introduce nuclear energy for power generation. As such, APS4 has not been considered in the analysis. Thus, APS5 would consist only of APS1, APS2, and APS3.

APS3 includes more renewables in the power generation mix of Myanmar. As such, for APS3, the additional installed capacity for coal-based and gas-based power plant for 2030 is replaced by renewable energy capacity, including hydro plants.

Beside the APS, this 2018 study also considers the emissions plan and target of East Asia Summit member countries under the INDC/NDC of the energy sector.

3. Outlook Results

3.1. Business-As-Usual Scenario

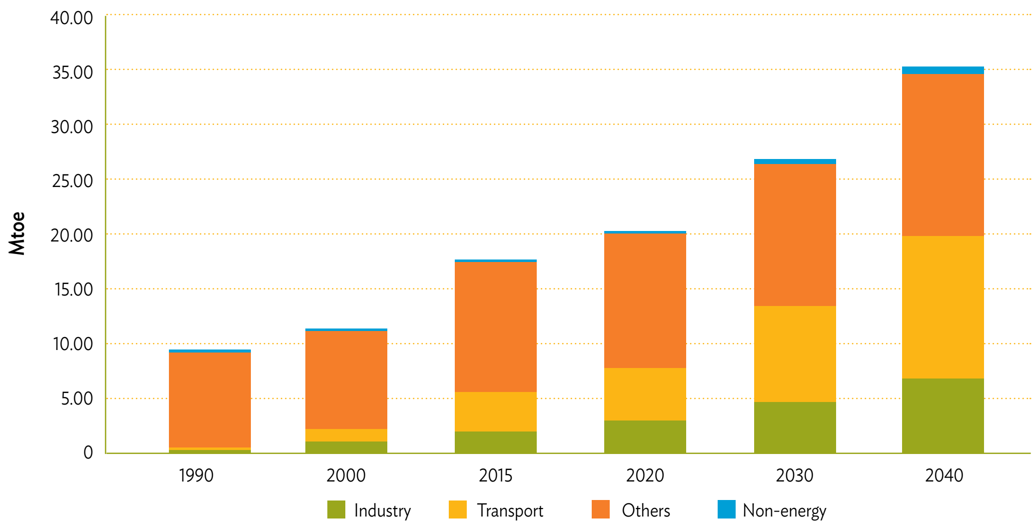
Final Energy Consumption

The total final energy consumption in Myanmar increased by about 2.6% per year, from 9.4 Mtoe in 1990 to 17.73 Mtoe in 2015.The transport sector was the fastest-growing sector with an average annual growth of 8.6% in 1990–2015. Consequently, the share of this sector in the total final energy demand increased from around 4.7% in 1990 to almost 19.9% in 2015. The industry sector was the second-fastest growing sector with an AAGR of 7.1% over the same period; the share of this sector in the total final energy demand increased from 4.2% in 1990 to 12.3% in 2015.

The 'others' sector, which comprises the commercial, residential, and agriculture sectors, was the major contributor to total final energy consumption. The shares of this sector, however, has been declining from 90.1% in 1990 to 66.3% in 2015. This indicates that the annual growth of demand for this sector was slower than that of the industry and transport sectors. The AAGR of the demand of the 'others' sector was 1.3% in 1990–2015. Non-energy consumption grew gradually at an average annual rate of 4.2% over the same period, from almost 0.09 Mtoe in 1990 to 0.27 Mtoe in 2015. Although the share of this sector demand was only 1.0% in 1990, it increased slightly to 1.5% in 2015.

Using the socio-economic assumptions stated above, final energy demand in Myanmar is projected to grow at an annual rate of 2.8% under the BAU scenario, reaching 35.29 Mtoe in 2040. The transport sector will still experience the fastest growth in final energy demand in 2015–2040. Its growth rate, however, is lower than that of 1990–2015. Final energy demand of the transport sector will increase at an average rate of 5.3% per year while that of the industry sector will grow at 4.8% per year. Final energy demand of the 'others' sector (mainly the residential and commercial sectors) is projected to grow at an annual average rate of 0.9%, slower than in the past. This is mainly because of the reduction in biomass demand, which represents majority of the fuel consumed by the sector. Figure 12.1 shows the final energy demand by sector to 2040 under the BAU scenario.

Figure 12.1: Final Energy Demand by Sector, BAU (1990-2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

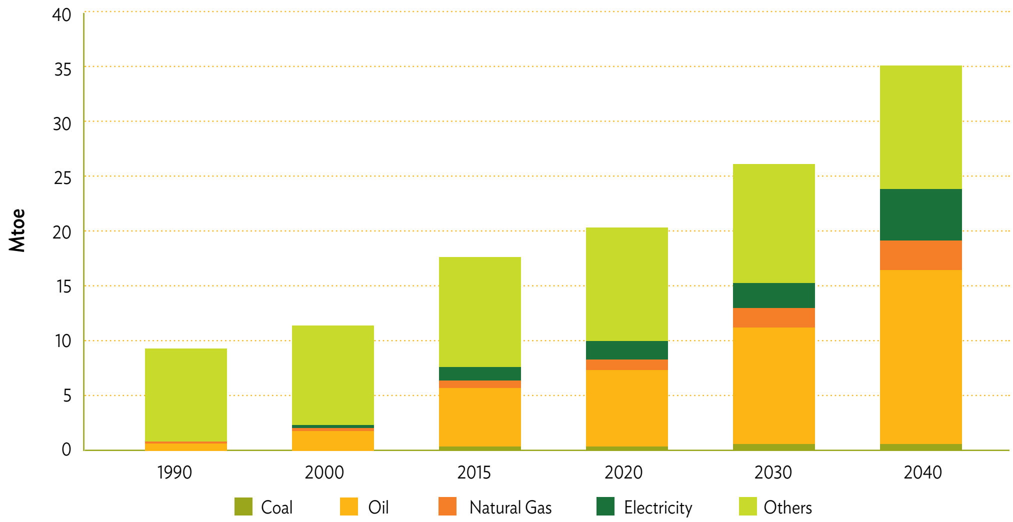
Source: Study outcome.

The growth of the respective sectors under BAU will result in a continuous increase of the transport, industry, and non-energy sector shares in the total final energy demand and a decline in the share of the 'others' sector. The share of the transport, industry, and non-energy sectors is projected to increase to 36.4%, 19.9 %, and 2.0%, respectively, in 2040. That of the 'others' sector will decline to around 41.7% from 66.3 % in 2015.

By fuel type, others, which are mostly biomass, were the most consumed fuel in 1990 with a share of 89.2% in the country's total final energy demand. Its share decreased to 56.8% in 2015 due to the higher growth of other fuels. The demand of natural gas increased from 0.23 Mtoe in 1990 to 0.71 Mtoe in 2015 while that for oil increased from 0.59 Mtoe to 5.43 Mtoe over the same period. Oil demand grew the fastest at an average rate of 9.3% per year in 1990–2015.

Under the BAU scenario, the share of other fuels will decline to 31.7% in 2040, indicating that its future use will grow slower than the other fuels. In contrast, oil share will continue to increase and will reach 44.9% in 2040 from 30.6% in 2015 with an average growth of 4.4% per year. This is due to the rapid increase of transport sector activities in 2015-2040. Figure 12.2 shows the final energy demand by fuel type to 2040 under the BAU scenario.

Figure 12.2: Final Energy Consumption by Fuel Type, BAU (1990-2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Study outcome.

Coal is projected to have an AAGR of 3.2% in 2015–2040, still slower than natural gas (5.2%). Electricity demand will still grow the fastest at an AAGR of 6% per year during the same period. Its share will increase from 6.5% in 2015 to 14.0% in 2040.

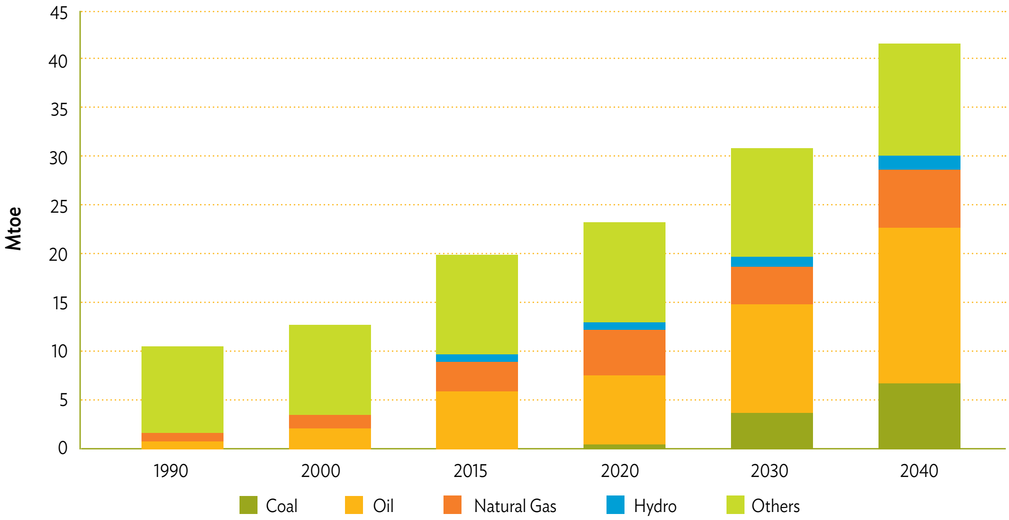
Primary Energy Consumption

The primary energy consumption in Myanmar grew at an average annual rate of 2.5%, from 10.68 Mtoe in 1990 to 19.85 Mtoe in 2015 (Figure 12.3). Amongst the major energy sources, hydro and oil grew the fastest, with AAGRs of 8.6% and 8.4%, respectively. Natural gas consumption grew at an average annual rate of 5.8% over the same period. Coal consumption increased at 7.1% per year on the average over the same period. Others, such as biomass, dominate the primary energy consumption mix in 2015, with a 50.9% share. Oil (27.6%) and natural gas (15.5%) had the next largest shares amongst the major fuels over the same period.

In the BAU scenario, Myanmar's primary energy consumption is projected to increase at an annual average rate of 3% per year to 41.79 Mtoe in 2040. Hydro and natural gas are expected to grow at average annual rates of 2.7% and 2.5%, respectively. Coal will grow fastest at 12.3% over the period 2015–2040. Oil will grow at 4.4% per year.

The share of oil and hydro in the total primary energy mix of Myanmar will increase to 38.3% and 3.8%, respectively, in 2040. Coal share will also increase from 1.9% in 2015 to 16.4% in 2040. Natural gas shares will increase to 13.8% over the projection period. Notably, the share of biomass will decrease due to its slow growth that is driven just by the growth of the rural population. From 50.9% in 2015, its share will decline to 27.6% in 2040.

Figure 12.3: Primary Energy Supply by Source, BAU (1990-2040)



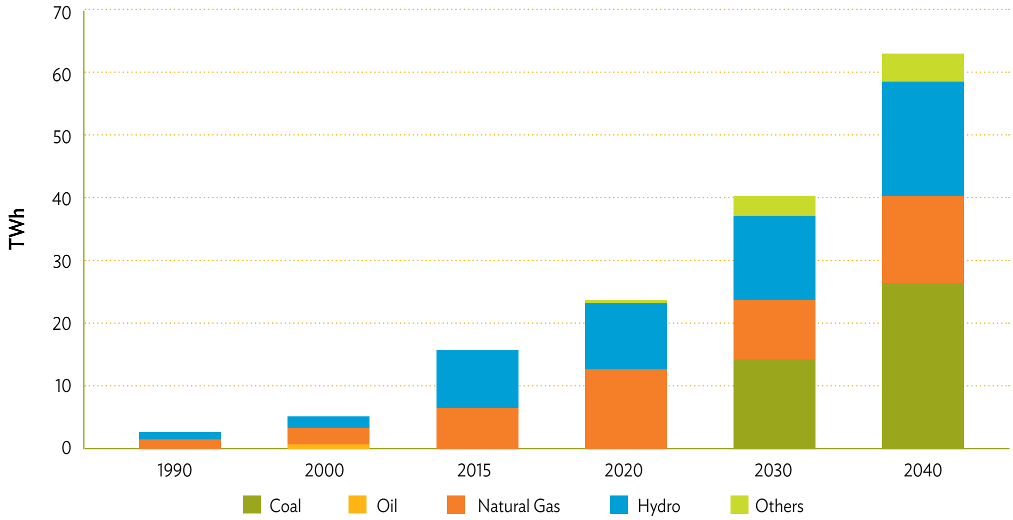
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Study outcome.

Power Generation

Hydro and natural gas dominated the power sector fuel mix in Myanmar (Figure 12.4). In 2015, the share of hydro in the power generation mix reached 58.9%, while that of natural gas was 40.8%. The remaining fuel (coal and oil) accounted for only 0.3% of the total generation mix.

Figure 12.4: Power Generation Mix, BAU (1990-2040)



BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Study outcome.

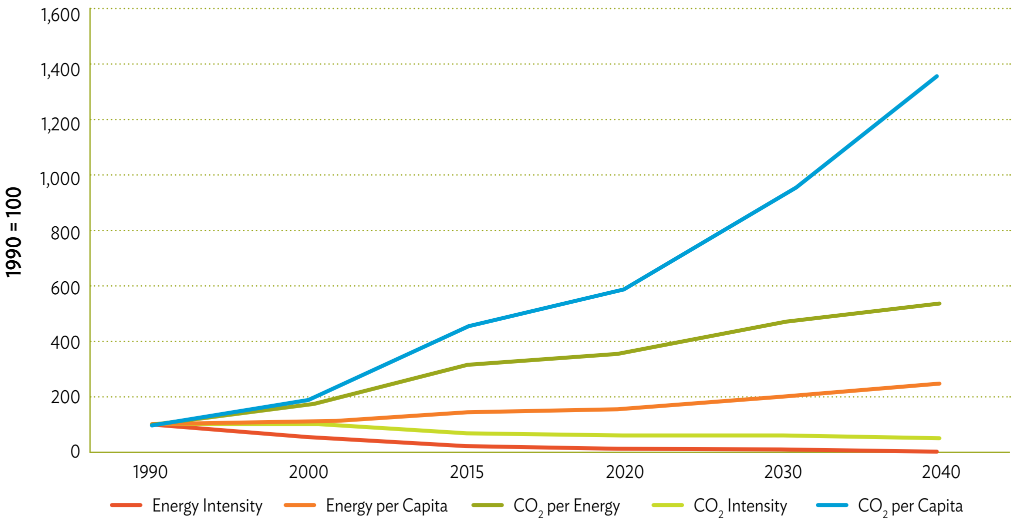
Under the BAU scenario, oil-based power plants will cease operation by 2030 while hydro and natural gas still have shares in the power sector mix of Myanmar in 2040. The share, however, has changed. Hydro-based power plants will have a 29.1% share while that of natural gas will be 21.8%.

The remaining fuel will have an increasing role in the future. Coal-based power generation share in the total fuel mix will increase to 42.2% in 2040, becoming the dominant power generation sector while other renewable shares (solar, wind, and biomass) will reach 6.8%. Total electricity generation from the different plants will grow at an average annual rate of 5.6% in 2015–2040, with natural gas–based power plants growing at an average annual rate of 3.0%. Hydropower generation will increase but at a slower average annual rate of 2.7% during the same period.

Energy Intensity, Energy per Capita, and Energy Elasticity

Myanmar's primary energy intensity (TPES/GDP) has been declining since 1990. In 2015, the primary energy intensity was 281 toe/million 2010 US$, lower than what it was in 1990 which was 1,333 toe/million 2010 US$. The intensity is projected to continue to decrease to 132 toe/million 2010 US$ by 2040 at an average rate of 3% per year. Energy consumption per capita grew from 0.3 toe in 1990 to 0.4 toe in 2015 and will increase to 0.67 toe by 2040, at an AAGR of 2.3%. CO_2 intensity was 140t-C/million 2010 US$ in 1990 and decreased to 93t-C/million 2010 US$ in 2015. CO_2 intensity is projected to continue to decrease to 74 t-C/million 2010 US$ in 2040 at an AAGR of 0.9%. Figure 12.5 shows the evolution of these energy indicators from 1990 to 2040.

Figure 12.5: Energy Intensity, CO_2 Intensity, and Energy per Capita (1990–2040)



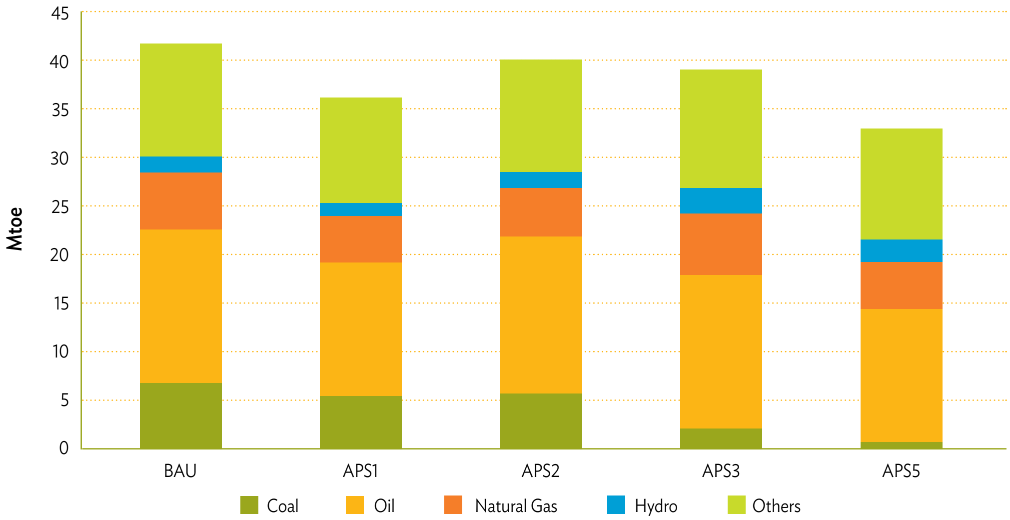
CO_2 = carbon dioxide.

Source: Study outcome.

3.2. Energy Savings Potential (APS)

The APS was analysed separately to determine the individual impacts of the policy interventions assumed in APS1, APS2, and APS3. The combination of all these policy interventions was further analysed in APS5. Figure 12.6 shows the changes in total primary energy consumption (TPEC) in all scenarios.

Figure 12.6: Comparison of Scenarios to Total Primary Energy Supply in 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Study outcome.

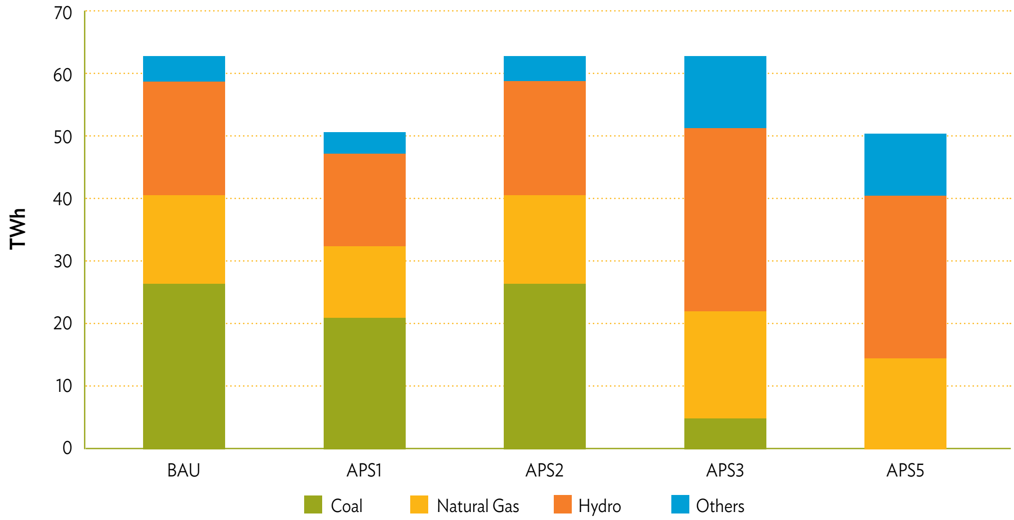
Figure 12.6 shows that APS5 has the largest reduction in the TPEC due to the implementation of EEC action plans, improvement of thermal efficiency of fossil-fuelled power plants, and higher penetration of NRE in the country's supply mix. The AAGR of the TPEC under APS5 will be around 2.1% over the projection period. In 2040, the reduction of primary energy consumption in APS5 compared to the BAU scenario will be 8.64 Mtoe or 20.7%. Individually, implementation of energy efficiency targets and masterplan as defined in APS1 will reduce the TPEC of Myanmar by 5.49 Mtoe or 13.1% in 2040 compared to the BAU scenario. The AAGR of primary energy consumption in APS1 will be 2.4%, slightly higher than APS5. APS2, which assumes higher efficiency in thermal electricity generation, will reduce the TPES by 1.53 Mtoe or 3.7% compared to the BAU scenario. The country's TPES under APS2 will grow at an annual average rate of 2.9%, slightly slower than the BAU scenario. Since no final energy demand efficiency measures were assumed for APS2, the impact on primary energy supply will be lower than APS1 or APS5. Of all the fossil fuels considered, implementation of this higher efficiency in thermal power generation policy intervention will reduce the use of coal and natural gas for power generation. A highly efficient power generation could lead to higher reduction in coal use by almost 14% in 2040.

If a policy for higher penetration of NRE is implemented, then the TPEC will decrease, compared to the BAU scenario, by 2.63 Mtoe or 6.3%. By fuel type, coal consumption will decrease but the use of renewable energy will increase by 12% (1.60 Mtoe).

The impact of implementing policy interventions will also be reflected in the power generation of the country. Figure 12.7 shows total electricity generation in 2040 in all scenarios. In both APS1 and APS5, due to lower electricity demand, power generation will be reduced by 11.47 Mtoe or 20% compared to the BAU scenario. The reduction in power generation will be from natural gas, coal, and hydro plants; highest reduction will be in coal power plants (5.32 Mtoe in APS1 and 26.1 Mtoe in APS5).

Under APS2 and APS3, the total amount of electricity generated will be similar to the BAU scenario because no efficiency measures were imposed on the final sector. The differences, however, lie in the fuel mix for power generation under APS3. More 'others' renewable power plants such as solar, wind, biomass, etc. will be in operation over the projection period, replacing coal-based power plants, which are supposed to be in operation up to 2040.

Figure 12.7: Comparison of Scenarios of Electricity Generation in 2040

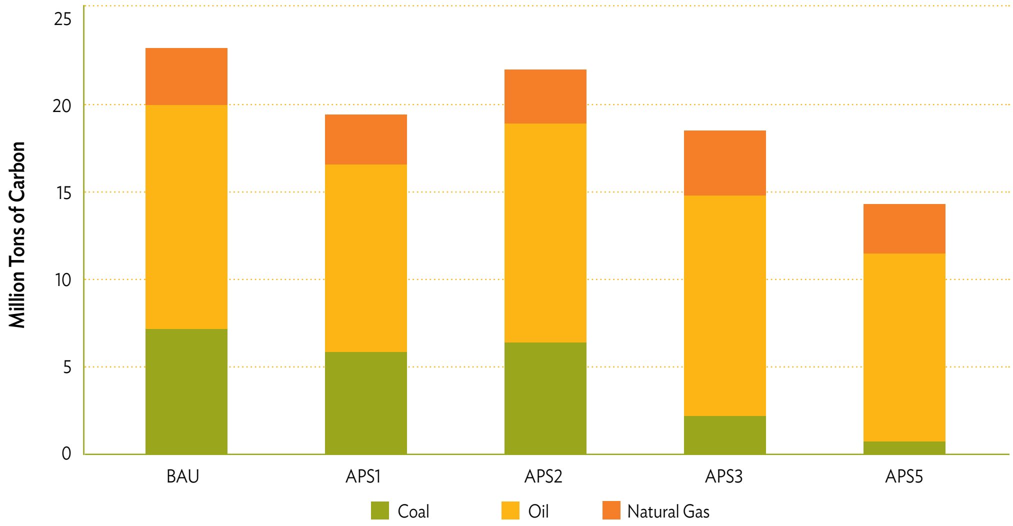


APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Study outcome.

In terms of CO_2 emissions reduction, the energy efficiency assumption in APS5 is expected to reduce emissions at the largest by around 8.9 million metric tons of carbon (Mt-C) or 38% lower than the BAU scenario. The decrease in CO_2 indicates that the energy-saving goals, action plans, and policies in the promotion of programmes, and switching to less carbon-intensive technologies such as renewable sources in the supply mix will be effective in reducing CO_2 emissions. Figure 12.8 shows the projected CO_2 emissions in 2040 in all scenarios.

Figure 12.8: Comparison of Scenarios to CO_2 Emissions in 2040



APS = Alternative Policy Scenario, BAU = Business-As-Usual.

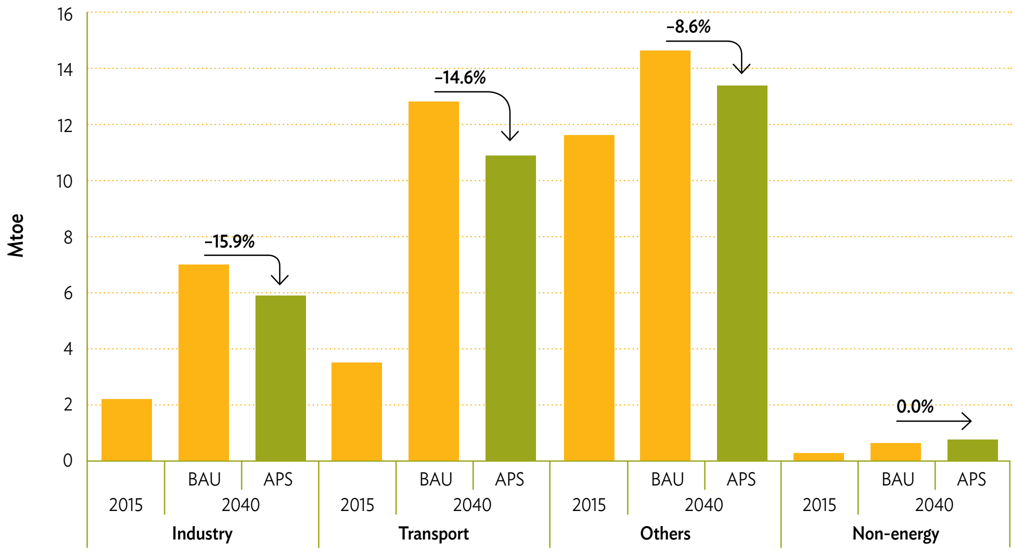
Source: Study outcome.

In APS1, total final energy demand will be lower so that CO_2 emissions from energy consumption will also be lower, reaching 19.50 Mt-C. This is a reduction of CO_2 emissions by around 3.9 Mt-C, which is about 17% lower than the BAU scenario. In APS3, higher contributions from renewable energy could reduce emissions by 21% compared to the BAU scenario. Total CO_2 emissions under APS3 will be around 18.6 Mt-C. The decrease in CO_2 indicates that increasing renewable energy shares in the total supply will reduce further CO_2 emissions.

3.2.1 Final energy consumption in the APS

In APS5, the growth in final energy demand is projected to grow at a lower average annual rate of 2.3% compared to the 2.8% annual growth in the BAU scenario. The reason for the slower growth rate is the result of technological improvement in manufacturing processes and the reduction of final energy demand of electricity and oil in the residential and commercial ('others') sectors. Figure 12.9 shows the differences in final energy demand in 2040 by sector in the BAU scenario and the APS.

Figure 12.9: Final Energy Consumption by Sector, BAU and APS (2015–2040)



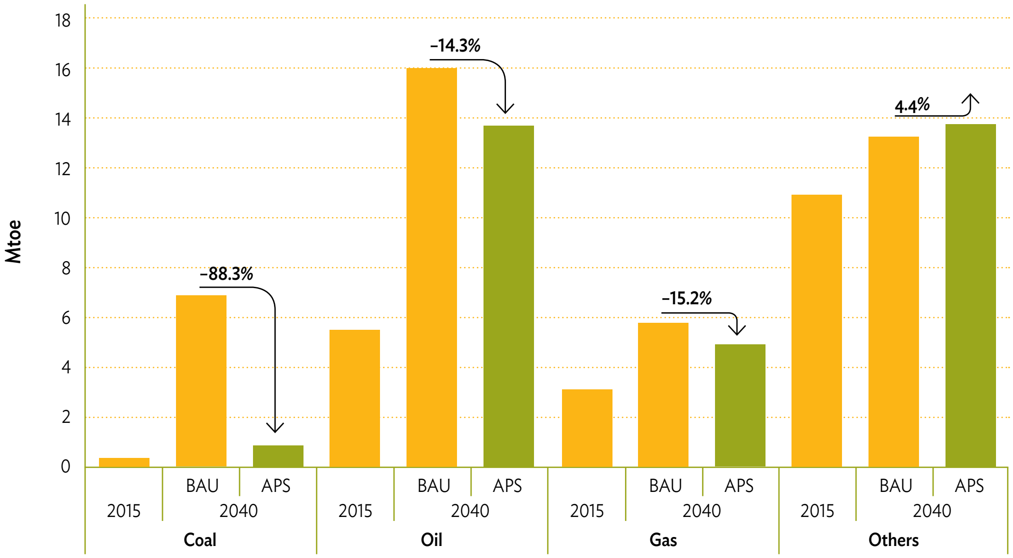
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Study outcome.

Primary Energy Supply

In the APS, Myanmar's primary energy supply is projected to increase at a slightly lower rate than the BAU scenario's at 2.1% per year, from 19.85 Mtoe in 2015 to 33.15 Mtoe in 2040. Hydro will be the fastest growing at 4.3% per year, followed by oil at 3.7% per year in 2015–2040. Coal is expected to grow at an average annual rate of 3.1% over the same period and natural gas, at 1.9% per year. Figure 12.10 shows the primary energy consumption by source in 2040 under the BAU scenario and the APS.

Figure 12.10: Primary Energy Supply by Source, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

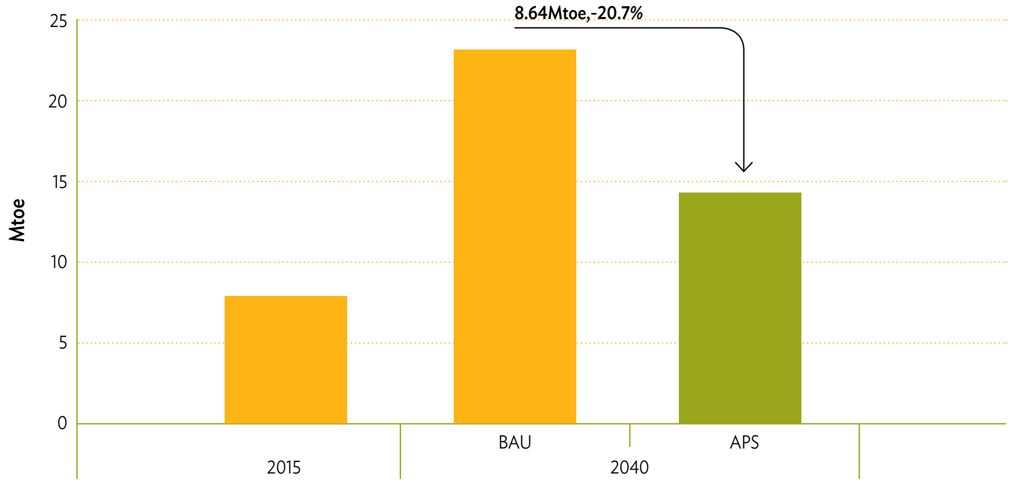
Source: Study outcome.

Projected Energy Savings

In Myanmar, commercial energy consumption is projected based on the energy requirements of the major sectors (industry, transport, agriculture, and households). The choice of fuel type is determined by available supply, since energy demand must be met mainly by domestic sources. Obviously, there is a gap between demand and supply, but the demand is much higher than the actual requirement. Due to these constraints, coefficients, derived by time series regression, have been applied to allocate energy. These allocations are made according to the priority of state organisations and enterprises. For the private sector, allocations are made according to the registered licensed capacity of the firm.

Future savings in energy could be due to savings in primary energy consumption in the residential, commercial, transport, and industry sectors. In this regard, Myanmar has implemented a range of EEC goals and action plans which target energy savings in all sectors of the economy and in cooperation with the private and the public sectors. There is an estimated saving of 8.64 Mtoe in 2040 in the APS relative to the BAU scenario. This is equivalent to 20.7% saving of the primary energy consumption in 2040 of the BAU scenario (Figure 12.11). Myanmar has plans to decrease the growth in primary energy consumption by implementing a range of EEC measures on the demand side.

Figure 12.11: Evolution of Primary Energy Supply, BAU and APS (2015 and 2040)



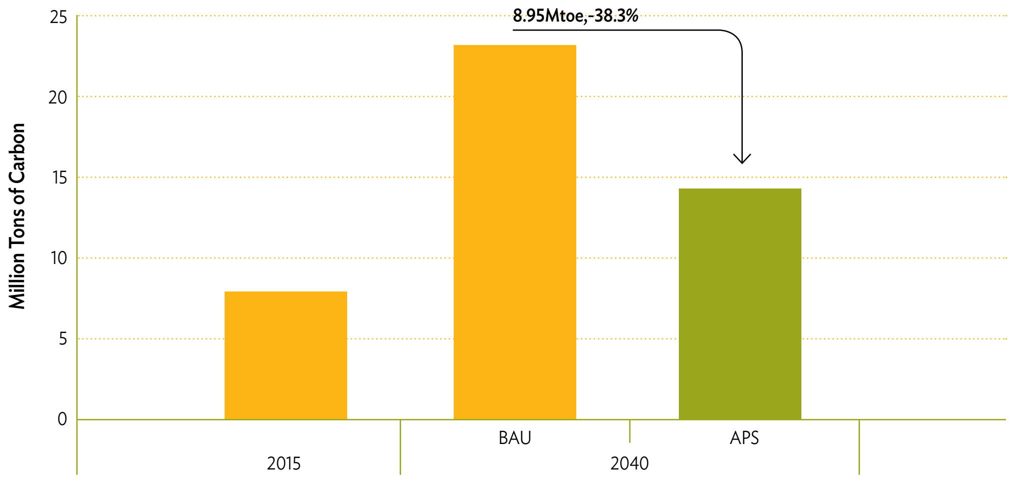
APS = Alternative Policy Scenario, BAU = Business-As-Usual scenario, Mtoe = million tons of oil equivalent.

Source: Study outcome.

CO_2 Reduction Potential

In the APS, the energy efficiency policy of Myanmar is projected to reduce growth in CO_2 emissions from energy consumption. In 2040, in the APS, CO_2 emissions from energy consumption are projected to reach about 14.4 million tons of carbon (Mt-C) which is about 38% below the the BAU scenario level (Figure 12.12).

Figure 12.12: CO_2 Emissions from Energy Consumption, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Study outcome.

3.3. Intended Nationally Determined Contributions/Nationally Determined Contributions

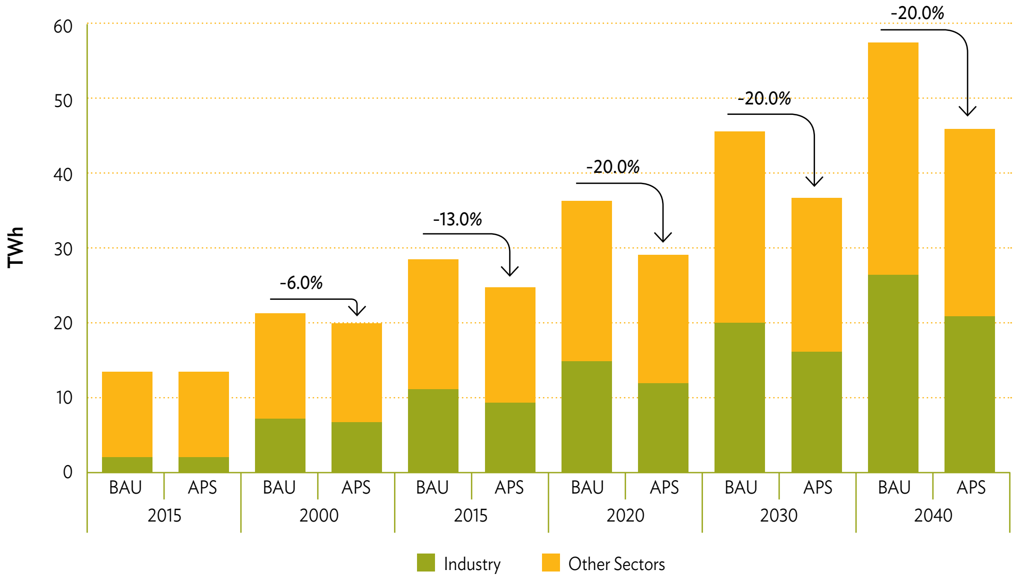
The current energy outlook model considered the Mitigation Actions and Policies of Myanmar in the Energy Sector as specified above in section 2.5 on INDC/NDC. These are the 20% electricity saving potential by 2030 and the 9.4 GW hydroelectricity generation by 2030. The 30% renewable in rural electrification (mini hydropower; biomass; solar, wind, and solar mini-grid technologies) is considered in the share of renewable in the total power supply mix of Myanmar.

The energy sector mitigation actions and policies are represented in the APS scenario since the scenario includes:

- Energy savings (APS1) in the different final sectors (industry, transport, residential, commercial, and others) as a result of introducing more efficient technologies. The assumptions were:
  - Electricity: 20% reduction of demand compared to the BAU scenario
  - Oil: 15% saving from the BAU scenario
  - Others (biomass): 5% reduction compared to the BAU scenario
- Introduction of highly efficient technologies for fossil fuel use in the power sector (APS2)
- Increasing renewable energy share in the electricity-generating capacity (APS3):
  - Hydro-installed capacity of 9.4 GW by 2030 (including mini- and micro-hydro)
  - Other renewables such as wind, solar, and biomass with total capacity of 3 GW by 2030.

Electricity demand reached 36 TWh in 2030 under the BAU scenario. Under the APS, electricity demand was expected to be reduced by 20% compared to the BAU scenario. As a result, electricity demand in the APS will be only 29 TWh in 2030. The electricity saving of 20% has been assumed to continue to 2040 as no additional target is available after 2030. Figure 12.13 shows the electricity demand of the final sectors over the projection period. 'Others' comprises the residential, commercial, agriculture, construction, and other sectors. Electricity demand in the transport sector has been excluded in the current outlook.

Figure 12.13: Electricity Demand, BAU and APS (2015 and 2040)

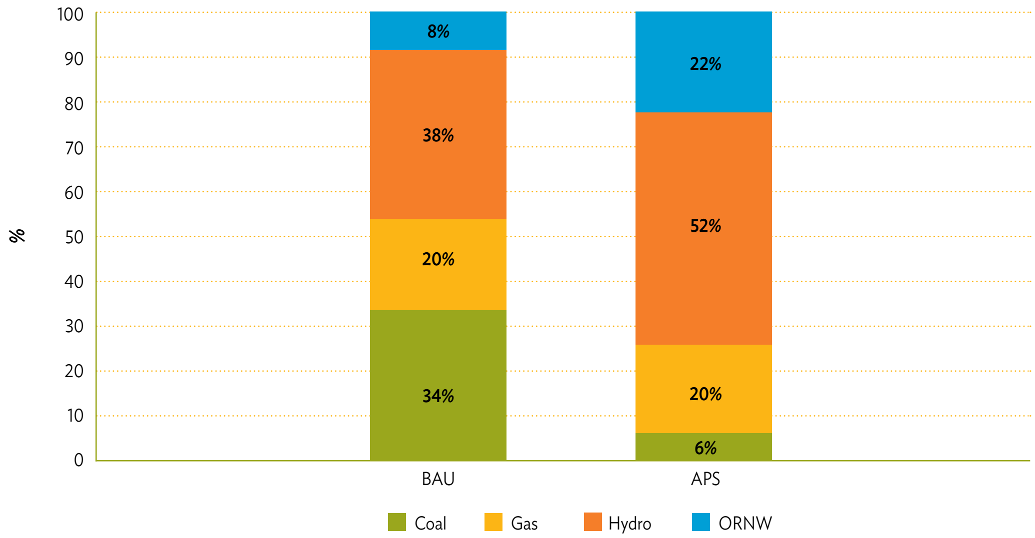


APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Sources: Study outcome.

The APS generation capacity will be more towards renewable energy compared to the BAU scenario (Figure 12.14). As explained earlier in the modelling assumption, the APS excludes some of the additional capacity for the coal-based and natural gas capacity after 2025. More capacity will be made available from renewable energy sources. Hydro resources will reach the 9.4 GW capacity by 2030 as stipulated in the mitigation actions and policies for the energy sector of Myanmar. These include not only the large hydro but also the mini- and micro-hydro plants. Hydro share reached 52% under the APS compared to 38% under the BAU scenario while other renewable sources such as solar, wind, and biomass will also have increasing share compared to the BAU scenario (22% compared to 8%).

Figure 12.14: Power Generation Capacity in 2030, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual scenario, ORNW = other renewable sources.
Source: Study outcome.

Considering lower final energy demand and more renewable share under the APS, the impact of the APS to the environment would be a lower CO_2 emissions. The total CO_2 emissions under the BAU scenario in 2030 will be 55.2 Mt-CO_2e (or 15.1 Mt-C). Under the APS, CO_2 emissions will be around 36.4 Mt-CO_2e (or 9.9 Mt-C) in 2030. This is a reduction of CO_2 emissions by 18.8 Mt-CO_2e (or 5.1 Mt-C) compared to the BAU scenario, which is approximately around 34%.

As previously shown, the CO_2 emission reductions in the APS will be 38% by 2040, which is around 32.8 Mt-CO_2e (or 8.9 Mt-C).

4. Conclusions and Policy Implications

Although energy intensity will decline, energy consumption will still increase due to economic, population, and vehicle growth. Myanmar should increase adoption of energy-efficient technologies to mitigate growth in energy consumption; it 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 due to the scarcity of technical and financial resources needed first to reverse the decline and then to accelerate natural gas and oil development and production.

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 and more financial and technical assistance in each energy subsector to secure the national energy supply.

To increase electricity production, Myanmar should rehabilitate existing electricity transmission and distribution, expand rural electrification, build coal- or gas-fired power plants, and promote renewable energy in the country's fuel mix as secure energy sources. The framework should list all potential renewable energy projects in the area, outlining priorities and sequencing, along with funding requirements which would be based on completed studies.

In this regard, the following actions are proposed to be considered:

- The Ministry of Electricity and Energy should formulate an integrated national energy policy, including on energy efficiency.
- Adopt a coordination mechanism and institutional arrangement and legal framework.
- Improve energy statistics for better analysis of energy saving potential in Myanmar.
- Conduct a demand-side survey for energy consumption, which can be done by combining this survey with existing ones.
- Due to the continuous dominance of the transport sector in final energy consumption, set an energy efficiency target for the transport sector in addition to those that have been calculated for the industry, commercial, and household sectors.
- Create 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 offer experiences, advanced technologies, new markets, and investment.
- Improve energy management practices of the industrial and commercial sectors.
- Establish a dedicated energy efficiency body to oversee the energy efficiency programme of Myanmar.
- Refine the current energy efficiency target to include the numerical targets and detailed action plans of all sectors.
- Establish a comprehensive integrated energy plan to guide the development of the sector, including an energy efficiency labelling programme for energy service companies and appliances.
- Since the electrification rate is still low, formulate schemes to enhance private participation, including foreign companies, to accelerate power sector development, including transmission and distribution system to ensure reliable electricity supply to the consumers.

- The Ministry of Industry should set specific targets for each sector on energy efficiency and government should implement to achieve these targets.
- Consider the import of LNG in floating terminals in the short term to meet the projected rapid growth of electricity demand while exploration of new domestic natural gas resources is still being undertaken.
- Consider civilian nuclear energy policy and exploration of geothermal energy potential to generate electricity.
- Remove taxes in LPG and kerosene to reduce biomass consumption, which is increasing continuously, in the residential sector.
- Encourage private companies to invest in new refinery capacities to meet domestic petroleum products demand.

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CHAPTER 13

NEW ZEALAND COUNTRY REPORT

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Seiya Endo, *The Institute of Energy Economics, Japan*

1. Background

New Zealand is an island country in the southwestern Pacific Ocean. It is located some 1,500 kilometres (km) east of Australia and consists of three main islands (the North Island, the South Island, and Stewart Island), and several smaller, mostly uninhabited outer islands. The land area is approximately 269,000 km^2, making it 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 4.6 million at the end of 2015. Although there are some light and heavy industries, foreign trade is heavily dependent on agriculture, tourism, forestry, and fishing. In 2015, New Zealand had a nominal gross domestic product (GDP) of about US$169.1 billion, or about US$36,800 per capita. Although the latter figure is near the average of countries of the Organisation for Economic Co-operation and Development, New Zealand tends to be ranked highly in international quality-of-life surveys.

The country possesses significant indigenous energy resources, including hydro, geothermal, wind, natural gas, and coal. New Zealand is self-sufficient in natural gas and electricity and is a net exporter of coal. It has locally produced crude oil, which is generally exported because of its high quality and, therefore, has a high value on the international market. To meet its oil demand, over half of all imported oil to New Zealand in 2015 was produced in the Middle East. Remaining energy reserves as of 1 January 2018 include 71.1 million barrels of oil (2P[1]) and 50.1 billion cubic metres of natural gas, as well as in-ground resources of over 15 billion tons of coal, 80% of which are South Island lignite.

[1] 2P values may be totalled safely using arithmetic summation since they are the midpoint of the probability distribution.

In 2015, New Zealand's total primary energy supply (TPES) was around 20.6 million tons of oil equivalent (Mtoe). By source, oil represented the largest share at about 33%. Natural gas and geothermal energy were second largest, contributing around 20% and 24%, respectively. The remainder of the primary energy supply were hydro (10%), coal (7%), biomass (5%), and a smaller percentage of other renewables such as wind, solar photovoltaic (PV), and biofuels.

Final energy consumption was about 14.1 Mtoe in 2015. By sector, transport accounted for the largest share at around 34% because New Zealand heavily depends on private road vehicles, road freight, and air transport. The share of the industry sector was the second largest at about 31%, whereas the total of agricultural, residential, and commercial sectors was 25%. The non-energy sector consumes the balance of 10%.

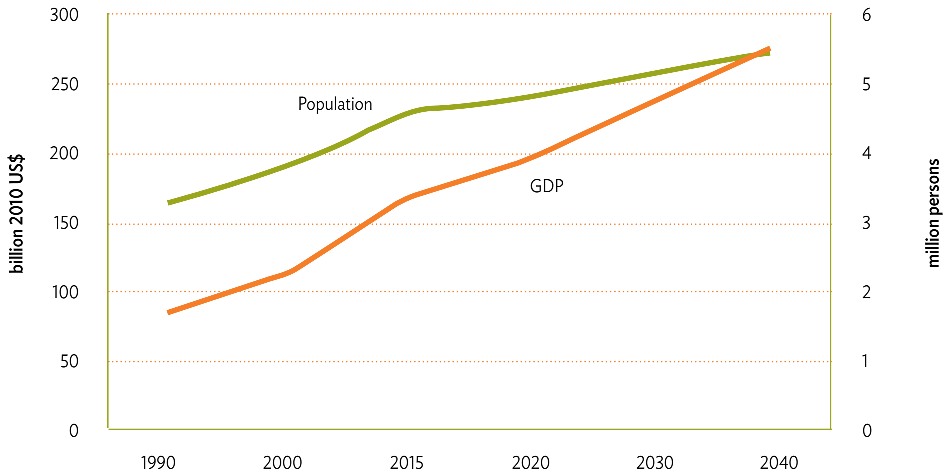
Total gross power generation output in 2015 was about 44.2 terawatt-hours (TWh). Hydro accounted for about 56% as the most utilised source, whereas geothermal represented the second most utilised source at about 18%, followed by natural gas (15%), coal (4%), and other renewables (7%). Oil is used in electricity generation only as a minor source for peaking and emergency supply (IEA, 2017).

2. Modelling Assumptions

In this outlook, New Zealand's GDP is assumed to grow at an average annual rate of 2% between 2015 and 2040. Its population will increase by about 19% to 5.5 million by 2040, from 4.6 million in 2015 (Figure 13.1).

In the Business-As-Usual (BAU) scenario, hydro use in power generation will remain constant, as most hydro sites have already been developed. Generation from natural gas-based plants is projected to increase slightly, at an annual average rate of 1.1%. Geothermal power generation will increase at an average annual growth rate of 2.6% and wind generation will continue to grow, but it will contribute only a small share of New Zealand's electricity by 2040. In contrast, coal-fired power generation will disappear (Figure 13.2). Thermal efficiency of gas- and oil-fired power plants may not increase so much in the future because new large fossil fuel–based plants are not planned. Moreover, Genesis Energy (New Zealand's largest energy company) has decided to decommission its coal-fired power plants by 2023.

Figure 13.1: GDP and Population (1990–2040)

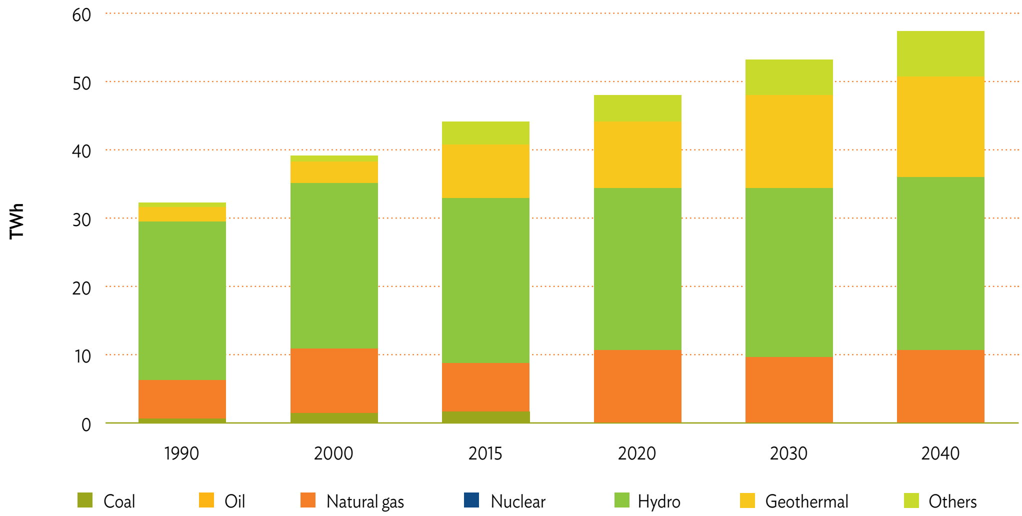


GDP = gross domestic product at 2010 constant prices.

Source: Authors' calculations.

In terms of primary energy consumption, the overall energy intensity of the economy improved in real terms at an annual average rate of 0.9% in 1990–2015.

Figure 13.2: Power Generation by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Authors' calculations.

The government implemented an emissions trading scheme in 2010 and is currently reviewing that scheme to determine how it can best support the country in meeting its climate change targets and transitioning to a low-emissions economy. New Zealand, through its Energy and Energy Efficiency and Conservation Strategies, has also 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, at work, and in transport, as well as the development and deployment of sustainable energy technologies.

3. Outlook Results

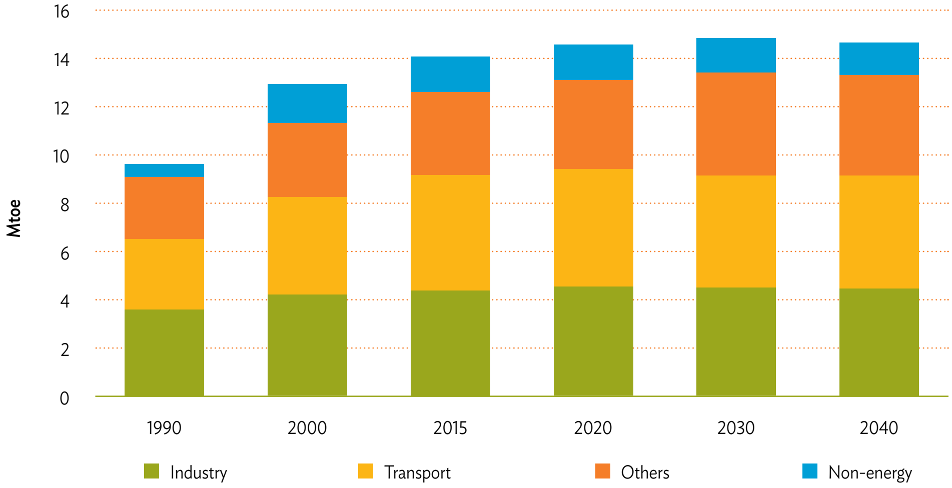
3.1. Final Energy Consumption

New Zealand's final energy consumption grew by 1.5% per year from 9.7 Mtoe in 1990 to 14.1 Mtoe in 2015. During the same period, oil increased from 4.0 Mtoe to 6.2 Mtoe; electricity, from 2.4 Mtoe to 3.4 Mtoe; and natural gas, from 1.8 Mtoe to 2.7 Mtoe. On the other hand, coal declined from 0.7 Mtoe to 0.6 Mtoe.

3.1.1. Business-As-Usual scenario

In the BAU scenario, final energy consumption in 2015–2040 is projected to grow by 0.6 Mtoe at an average rate of 0.2% per year. The 'others' sector (agricultural, residential, and commercial) will have the largest increase of 0.6 Mtoe during this period, growing at an average annual rate of 0.6%. Transport sector consumption is projected to decrease by 0.1 Mtoe at an annual rate of 0.1%, but that of the industry sector is projected to increase by 0.2 Mtoe in 2040. Non-energy sector consumption will remain constant in 2015–2040 (Figure 13.3).

Figure 13.3: Final Energy Consumption by Sector, BAU (1990–2040)



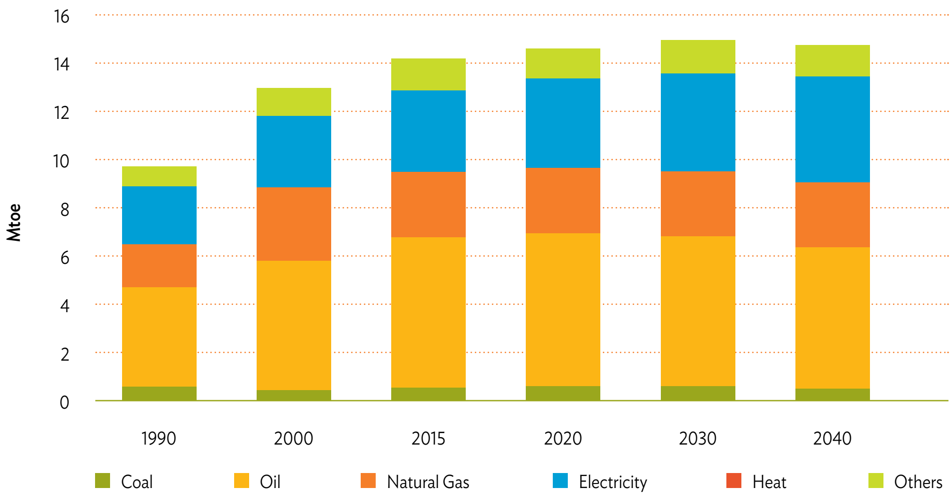
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Note: The 'others' sector includes the agricultural, residential, and commercial sectors.

Source: Authors' calculations.

By source, final demand of electricity will steadily increase by 1.0 Mtoe between 2015 and 2040 at an average rate of 1.1% per year. Final demand of other renewable energy – which includes geothermal, solar, biogas, and woody biomass used for direct-use heat applications – will increase slightly in 2015–2040 at an average rate of 0.1% per year. By 2040, final demand for oil will decrease by 0.3 Mtoe at an average rate of 0.2%; coal demand, by 0.1 Mtoe at an average rate of 0.4%; and natural gas, by 0.1 Mtoe at an average rate of 0.1% per year (Figure 13.4).

Figure 13.4: Final Energy Consumption by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Note: The 'others' sector includes geothermal, solar, biogas, and woody biomass.

Source: Authors' calculations.

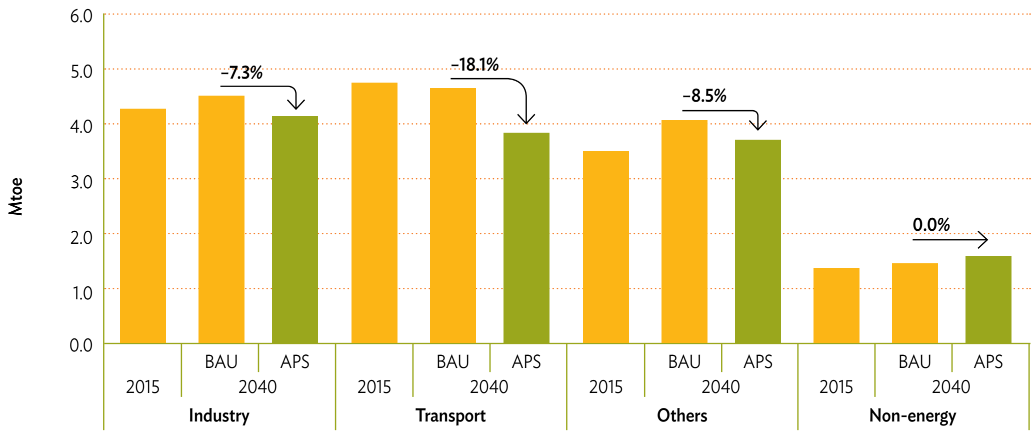
3.1.2. Alternative Policy Scenario

In the Alternative Policy Scenario (APS), final energy consumption will be slightly lower at 0.9 Mtoe between 2015 and 2040. Energy use in the 'others' sector will increase at an average rate of 0.2% per year, reflecting increasing use of efficient appliances in the residential and commercial sectors. Energy use in the industry sector is projected to decrease at an annual average rate of 0.2%. Energy use in the transport sector will decrease slightly, reflecting a shift to more energy-efficient vehicles, particularly electric vehicles. The sectoral final energy consumption in 2015 and 2040 in the BAU scenario and the APS is shown in Figure 13.5.

3.2. Primary Energy Supply

Primary energy supply in New Zealand grew at a rate of 1.9% per year, from 12.8 Mtoe in 1990 to 20.6 Mtoe in 2015. The fastest-growing primary fuel in absolute terms was oil, rising from 3.5 Mtoe in 1990 to 6.8 Mtoe in 2015. The increase in oil consumption was due to the rapid growth in transport energy demand.

Figure 13.5: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

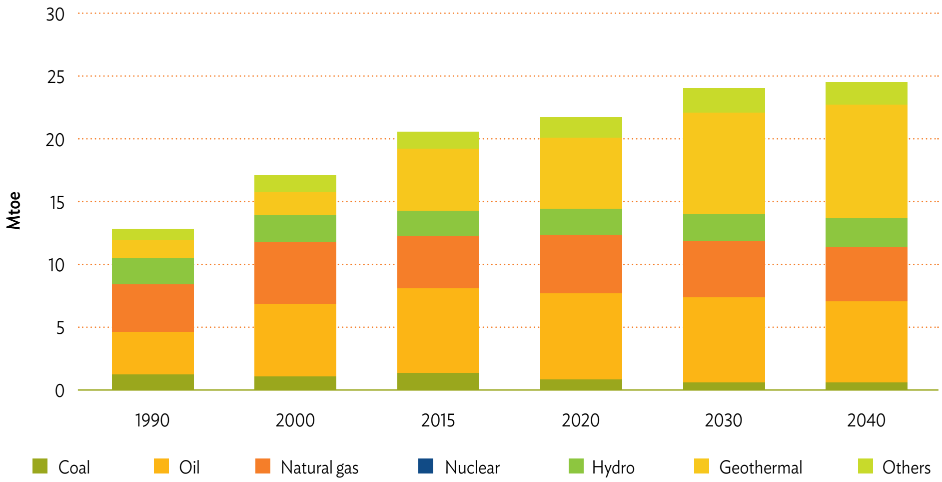
Source: Authors' calculations.

Between 1990 and 2015, natural gas and coal consumption increased at an annual average rate of 0.2% and 0.6%, respectively. Geothermal energy use grew from 1.5 Mtoe in 1990 to 4.9 Mtoe in 2015 at an annual rate of 4.9% for electricity generation, while hydro demand for electricity production slightly increased from 2.0 Mtoe in 1990 to 2.1 Mtoe in 2015. 'Other' energy sources, which include biomass, solar, wind, liquid biofuels, and biogas, increased by 2.3% per year.

3.2.1. Business-As-Usual scenario

In the BAU scenario, New Zealand's primary energy supply will grow at an average annual rate of 0.7% to 24.6 Mtoe in 2040 from 20.6 Mtoe in 2015. Geothermal energy is projected to contribute most to the incremental growth of primary energy supply between 2015 and 2040 and will account for 37% of total primary energy supply in 2040. Primary energy of 'others' will grow by 1% per year, reflecting mainly the expected growth in wind power. The share of 'others' will account for 7.4% of total primary energy supply in 2040. In contrast, primary fossil fuel will slightly decrease at an average rate of 0.2%. Its share of the total will account for 46.7% in 2040, down from 59.3% in 2015. The remaining 8.9% of the total share in 2040 will be hydro for electricity generation, increasing at an average annual growth rate of 0.2% (Figure 13.6).

Figure 13.6: Primary Energy Supply by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

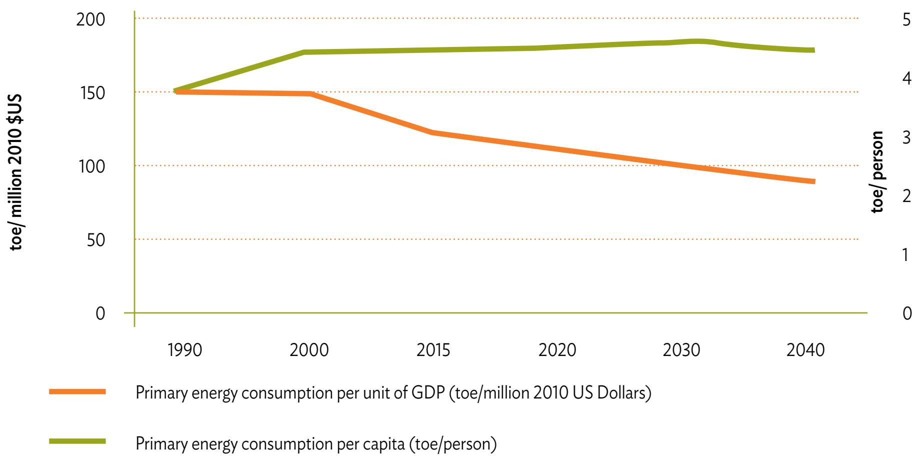
Source: Authors' calculations.

The lower growth of primary energy supply relative to GDP growth will result in lower energy intensity in the future. From 122 toe/million US$ in 2015, energy intensity will improve to 89 toe/million US$ in 2040. Primary energy supply per capita will remain constant at 4.5 toe per person in 2015–2040. Figure 13.7 shows primary energy intensity and energy per capita as indicators.

3.2.1. Alternative Policy Scenario (APS)

In the APS, primary energy supply is projected to grow at a lower rate of 0.5% per year to 23.2 Mtoe in 2040. Coal, oil, and gas are expected to show significant declines of 3.2%, 1.0%, and 0.7% per year, respectively. Geothermal primary energy is expected to grow by 2.9% per year. 'Others' primary energy, which includes biomass, solar, wind, liquid biofuels, and biogas, is expected to grow by 1.3% per year (Figure 13.8).

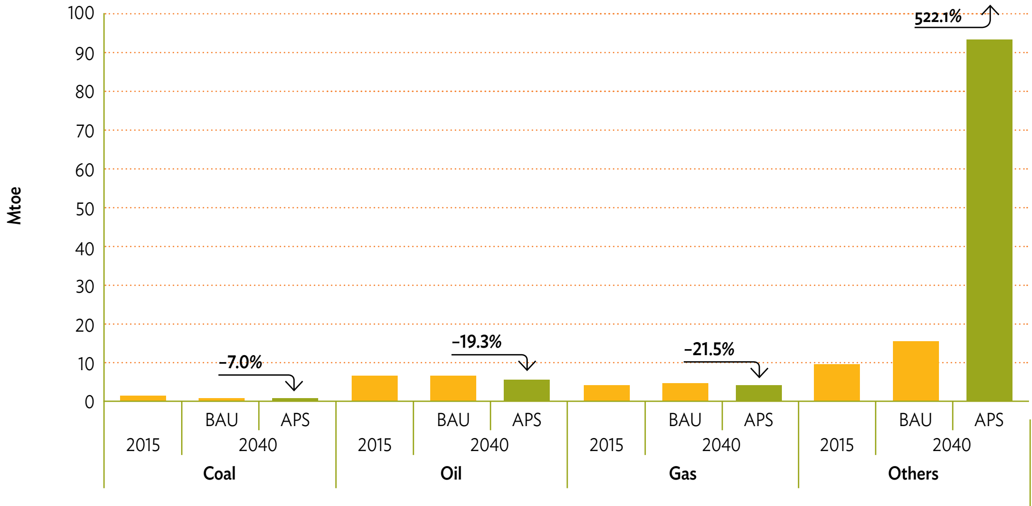
Figure 13.7: Primary Energy Intensity and Energy per Capita Indicator, BAU (1990–2040)



BAU = Business-As-Usual, GDP = gross domestic product, toe = tons of oil equivalent.

Source: Authors' calculations.

Figure 13.8: Primary Energy Supply by Fuel Type, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

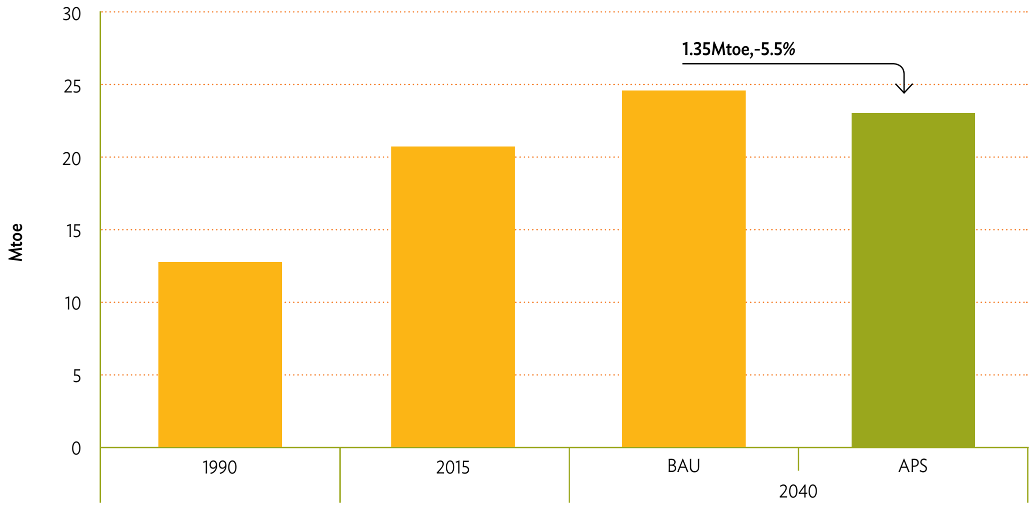
Note: The 'others' sector includes biomass, solar, wind, liquid biofuels, biogas, hydro, and geothermal.

Source: Authors' calculations.

3.3. Projected Energy Savings

Under the APS, energy savings could amount to 1.35 Mtoe or 5.5% less than under the BAU scenario in 2040. Energy savings is the difference between the primary energy supply in the BAU scenario and the APS (Figure 13.9).

Figure 13.9: Total Primary Energy Supply, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

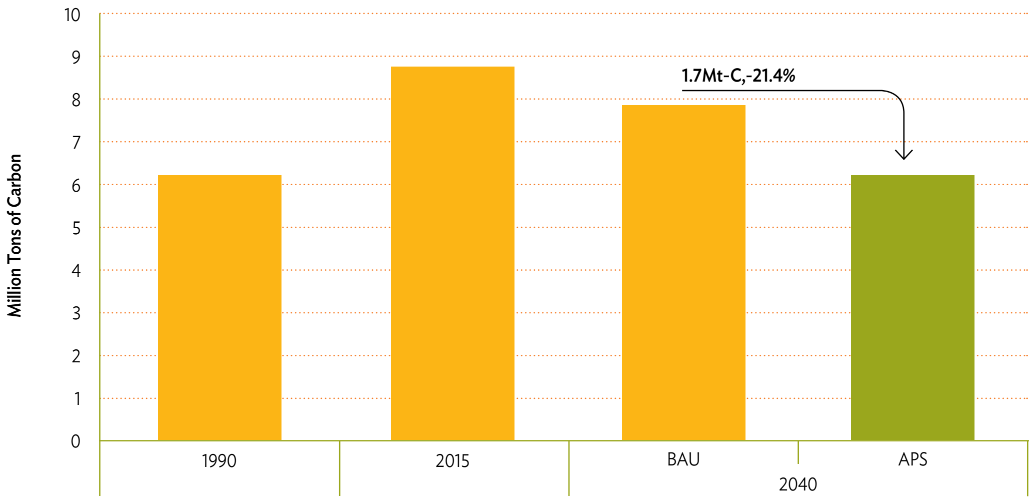
Source: Authors' calculations.

The above savings in primary energy are mainly due to a switch to more efficient vehicles, particularly electric vehicles, in the transport sector, along with improved insulation and more efficient appliances in the residential and commercial sectors.

3.4. Carbon Dioxide Emissions

Carbon dioxide (CO_2) emissions in the BAU scenario will decrease slightly, from 8.8 million tons of carbon (Mt-C) in 2015 to 7.9 Mt-C in 2040. In the APS, CO_2 emissions will decrease from 2015 to 2040 by 1.4% per year. The decrease reflects the switch to renewable energy in electricity generation, and the switch to electric vehicles in the transport sector. Figure 13.10 shows the difference of CO_2 emissions from energy consumption between the BAU scenario and the APS in 2040, compared with 1990 and 2015, in New Zealand.

Figure 13.10: CO_2 Emissions from Energy Consumption, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Authors' calculations.

4. Implications and Policy Recommendations

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 a high proportion of its electricity from renewable sources, particularly hydro, although CO_2 emissions from this sector have grown with large investment in fossil fuel–based generation in the 1990s and 2000s.

Trading of carbon credits will incentivise investment into new renewable generation technologies, with geothermal and wind as prospective options, provided CO_2 trading prices rise above the current levels. As the Acting Minister of Energy and Resources announced on 30 August 2011, New Zealand's ambitious goal is for 90% of electricity generation to be from renewable sources by 2025. New Zealand's large base of renewable generation, however, limits the room for CO_2 emissions reduction in the electricity generation sector. In March 2016, the minister announced that the targets will be developed and the New Zealand Energy Efficiency and Conservation Strategy (NZEECS) 2011–2016 will be replaced by mid-2019. The NZEECS's successor will have a carbon reduction focus.

New Zealand has some other opportunities to improve energy efficiency, for example, through improving the efficiency of vehicles, improving the insulation of buildings, and improving the efficiency of heat production in industry, or switching to lower-carbon fuels. The largest potential energy and carbon savings are in the transport sector. 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. Furthermore, reduction in emissions from the transport sector is possible through a switch to electric vehicles and increased use of biofuels. Electric vehicles are a good match for New Zealand, given the high proportion of electricity generated from renewables and the relatively short distances of average trips. Also, charging infrastructure already exists in most residential dwellings. In early 2018, the government announced a package of measures designed to encourage the use of electric vehicles. The target is to double the number of electric vehicles every year through to 2021 and to do so by removing barriers that have until now prevented households and businesses from choosing electric cars. Current barriers include the limited selection of models available, a lack of widespread public charging infrastructure, and lack of awareness about electric vehicles.

In the building sector, the government should consider formulating and implementing stronger regulations to enhance the energy efficiency of new and existing buildings in the residential and commercial sectors. New Zealand should also consider a package of measures (including regulatory instruments) to improve the energy efficiency of industrial heat plants.

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CHAPTER 14

PHILIPPINES COUNTRY REPORT

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1. Background

1.1. Socio-economic Background

The Philippines, officially known as the Republic of the Philippines, is amidst Southeast Asia's main water bodies, namely, the South China Sea on the west, Philippine Sea on the east, and Sulu and Celebes Sea on the southwest. The country comprises more than 7,000 islands, situated in the western Pacific Ocean, and is composed of three main geographical divisions: Luzon, Visayas, and Mindanao. The country's capital, officially known as the National Capital Region and commonly known as Metro Manila, is in Luzon. It is composed of 16 cities, namely, Caloocan, Las Piñas, Makati, Malabon, Mandaluyong, Manila, Marikina, Muntinlupa, Navotas, Parañaque, Pasay, Pasig, Quezon City (the country's most populous city), San Juan, Taguig, and Valenzuela.

In 2015, the Philippine economy sustained its 6.1% growth rate from the previous year. This was largely due to the vigorous economic activities in the industry and the services sectors during the period, which posted an annual growth rate of 6.4% and 6.9%, respectively. The increase in the industry sector was driven by the 5.7% growth in the manufacturing sector, as well as the double-digit hike of 11.6% in the construction sector. The increase in the services sector is attributed to the robust domestic trade and services and the boom in real estate businesses. Meanwhile, agriculture, hunting, forestry, and fishing posted a small 0.1% increase during the period, a slowdown from its 1.7% growth registered for 2014. Gross domestic product (GDP) per capita[1] of the country was recorded at US$2,616 per person in 2015.

[1] In constant 2010 US$ (World Bank ICP database/World Development Indicators).

1.2. Policy

The Philippine Department of Energy (DOE) has set forth strategic directions and energy agenda to assist President Duterte's administration in attaining its development goals as envisioned in Ambisyon 2040, the blueprint of a long-term, collective vision, and aspirations of Filipinos, and supported by national economic strategies that will provide opportunities for inclusive growth. Within Ambisyon 2040, the Philippine energy sector plays a vital role as an indispensable factor for economic growth. Foremost amongst the focus of the DOE is consumer-first policies, reliability of energy supply, and affordability of tariffs.

To achieve security and reliability of supply, as well as the vision of a low-carbon future, the DOE is adopting a technology-neutral policy in coming up with an optimal energy mix, especially for the power sector, for the baseload (70%), mid-merit (20%), and peaking (10%) requirements that match the peak demand and the required 25% reserve requirements on a per regional grid basis to meet the 43,765 MW additional capacity required by 2040. In addition, efforts on the development and promotion of indigenous energy, such as renewable energy (RE) and hydrocarbon fuels (oil, gas, and coal) and tapping into clean and smart technologies, have been on the priority list to augment the country's long-term energy needs. A Nuclear Energy Implementing Organization, created within the DOE, has recommended a firm national policy on nuclear. The country's liquefied natural gas (LNG) capacities and capabilities shall be harnessed through the development of the ₱100 billion[2] Batangas integrated LNG by 2020, with an initial 5 million tons per year throughput and initial reserve capacity of 200 MW.

The DOE is also pushing for greater energy access thru a 100% national and regional electrification rate by facilitating the completion of transmission projects, such as the Visayas–Mindanao Interconnection Project by 2020 and the Semirara–Mindoro–Panay Interconnection, by 2019 in support of our country's goal of a One-Grid Philippines. Consistent with its drive for consumer empowerment, the DOE is implementing a Pro-Consumer Distribution Framework for energy affordability, choice, and transparency. On the other hand, the finalisation of the Implementing Rules and Regulations of Executive Order No. 30,[3] which President Duterte signed in June 2017, tags energy projects amounting to at least US$70 million as projects of 'national significance', while creating the Energy Investment Coordinating Council mandated to fast-track the permitting process of such energy projects. Aside from this, the DOE is working towards drafting guidelines that will assist energy stakeholders and industry participants in coming up with

[2] Philippine peso.

[3] Full title: 'Creating the Energy Investment Coordinating Council In Order to Streamline the Regulatory Procedures Affecting Energy Projects'.

an Energy Sector Resiliency Compliance Plan (RCP). The RCP shall contain adaptation measures, both engineering and non-engineering options, to gauge infrastructure and human resource preparedness during and in the aftermath of disruptive events.

Below are some of the highlights of the energy sector's plans and programmes:

Renewable Energy

The passage of Republic Act (RA) No. 9513, or Renewable Energy Act of 2008, legally supports the policy and programme framework to promote the utilisation of RE resources and technologies. On 14 June 2011, the government unveiled the National Renewable Energy Program (NREP) or the 'Green Energy Roadmap' of the Philippines. NREP is anchored on the DOE's Energy Reform Agenda, which aims to ensure greater energy supply security for the country. It established the policy and programme framework for the promotion of RE and a road map to guide efforts in realising the market penetration targets of each RE resource in the country. Under the updated RE road map, the target of 15,304 megawatts (MW) installed RE capacity by 2030 is envisioned to be increased to 20,000 by 2040. To achieve this, NREP also provides for policy mechanisms to support the implementation of the RE Act. These policy mechanisms include the Renewable Portfolio Standards (RPS), feed-in tariffs (FiT), Green Energy Option Program, and Net-Metering for Renewable Energy.

The RPS sets the minimum percentage of generation from eligible RE resources, provided by generators, distribution utilities, and electric suppliers. Initially, an installation target of 760 megawatts (MW) from RE was set for the first 3 years, from 2013 to 2015, broken down as follows: biomass (250 MW), run-of-river hydro (250 MW), solar (50 MW), wind (200 MW), and ocean (10 MW).

On the other hand, FiT provides guaranteed payments on a fixed rate per kilowatt-hour for RE generation, excluding generation for own use. Effective October 2015, the Energy Regulatory Commission has approved FiT rates, which will apply to generation from RE sources, particularly run-of-river hydro, biomass, wind, and solar. Effective October 2015, the approved FiT rates for biomass, hydropower, solar, and wind are ₱6.63, ₱5.90, ₱8.69, and ₱7.40 per kilowatt-hour, respectively. Currently, there is no FiT rate for ocean energy since the technology is still for further study and not yet available in the country.

Alternative Fuels

Biofuels

The DOE is aggressively implementing RA 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 the country's goal of achieving energy security, as well as augmenting farmers' income, generating rural employment, and reducing 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 gasoline retailers. The DOE, together with the National Biofuels Board, is embarking on revisiting and/or re-evaluating the blending requirement with due consideration on the availability of feedstock and to facilitate the scheduled blending of biofuels in compliance with RA 9367.

In terms of research and development, the DOE initiated a partnership with the academe to implement biofuel projects using alternative feedstocks, such as sweet sorghum, cassava, and macro-algae. Four projects were implemented in 2016 to introduce and develop alternative feedstocks of biofuels in the country:

1. Village Scale Production of MMSU[4] Hydrous Ethanol as Feedstock for R&D in Biofuel Trials and Anhydrous Ethanol Production, which has been completed.
2. Establishment of a Community-Based Bioethanol Industry and Continued Research and Development on the Feasibility of Hydrous Bioethanol as Biofuel Blend, whose implementation started only in 2015. These projects are being implemented by the Mariano Marcos State University.
3. Bioethanol Production from Macro-algae and Socio-ecological Implications, which is being implemented by the University of the Philippines-Visayas Foundation Inc.
4. Bioethanol Production Potential of Different Cassava Varieties under Northern Mindanao Condition and Development of a Pilot-Scale Cassava Bioethanol Plant, which is being implemented by Xavier University.

[4] Mariano Marcos State University.

Compressed Natural Gas (CNG)

The DOE is keen to pursue the implementation of the Natural Gas Vehicle Program for Public Transport by engaging a third party to evaluate the feasibility of its project's implementation. To date, the DOE is coordinating with the Department of Transportation – Land Transportation Franchising and Regulatory Board – on the confirmation of franchise availability for the targeted 200 compressed natural gas (CNG) buses, of which 176 franchises were declared available for the CNG buses in March 2015. Accordingly, the DOE mandated the Philippine National Oil Company Exploration Corporation to take over the operation and maintenance of CNG refilling stations. However, the procurement of two modular CNG stations for Biñan, Laguna and Port Area, Batangas City has yet to be finalised; the issue of securing CNG supply and the negative impact of the current volatility of diesel prices on the economic viability of operating the CNG delivery system.

AutoLPG

In terms of using liquefied petroleum gas (LPG) as an alternative fuel for transport, the total number of commercial autoLPG-fuelled taxis nationwide stood at 9,718 units complemented by 192 refilling stations in 2015. In 2016, the total number of converted taxi units decreased to about 8,415, but the total number of refilling stations remained at 192. The decline of taxi units was brought about by various issues that hampered the programme's implementation.

Despite the setback, the DOE is exerting all efforts within its mandate to make autoLPG a viable option as a fuel for public transport. To sustain the programme, the DOE, in coordination with concerned national government agencies, promotes the mainstreaming of autoLPG in the transport sector through policy recommendations. In June 2016, the interim inter-agency AutoLPG Technical Working Group (TWG) was officially institutionalised through the adoption of Joint Administrative Order No. 1, Series of 2016, entitled 'Creating the Technical Working Group (TWG) on the Use of AutoLPG as Fuel for Public Transport and for Other Related Purposes'. The TWG is to be created in key areas in Luzon, Visayas, and Mindanao to harmonise all autoLPG-related policies, rules, and guidelines and develop a mechanism for collaboration, cooperation, and coordination amongst member national government agencies for the effective implementation of the AutoLPG Program (DOE, 2017).

E-vehicles

As of the end of 2015, 10 new companies were engaged in the manufacture of e-trikes and were registered under the Board of Investments' Investment Priority Projects. This has translated to about ₱500 million of fresh investments and generated more than 500 local jobs. For electric and hybrid vehicles, the Government of Japan coordinated with the Department of Foreign Affairs and the DOE for the Japan Non-Project Grant Aid for the Introduction of Japanese Advance Products and its System (Next-Generation Vehicle Package) for the Philippines. Under the terms of the grant aid, next-generation vehicles such as hybrid vehicles, plug-in hybrid electric vehicles, and electric vehicles, including charging stations, will be procured by the Government of Japan and delivered to the Philippines through the DOE for deployment to identified beneficiaries. Target beneficiaries of this grant aid include Philippine National Police stations in Leyte and Samar which were devastated by typhoon 'Yolanda', government agencies in Region 8 that are instrumental to emergency response operations and rehabilitation. Vehicles were also allocated to non-government agencies that could assist in conducting research, performance testing, and promoting alternative fuel vehicles.

Household Electrification

The provision of electricity access is now focused on households throughout the country. Household electrification levels increased from 89.6% in 2015 to 90.7% in 2016. This increase corresponds to a 3% growth in the number of households energised – from 19,994,430 in 2015 to 20,597,320 in 2016. It also implies that 20,597,320 out of the potential 22,721,430 households are reaping the benefits of electricity access. On a grid level, Luzon has the highest electrification and this increased from 94.6% in 2015 to 95.5% in 2016. Visayas and Mindanao posted electrification levels of 94.0% and 74.1% in 2016, respectively. Aside from these are various grid and off-grid programmes 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

The country's total primary energy supply (TPES) in 2015 reached 51.3 million tons of oil equivalent (Mtoe). Oil accounted for the biggest share of 33.6% in the total energy supply, followed by coal (22.7%) and geothermal (18.5%). Total primary production reached 26.9 Mtoe, bringing the country's energy self-sufficiency level at 52.4% during the period.
Meanwhile, the country's total electricity generation in 2015 reached 82.4 terawatt-hours (TWh). Coal-fired power plants remained the major source for power generation, with total installed capacity of 5,963 megawatts (MW) during the period. Coal contributed 44.5% or 36.7 TWh in the total power generation mix of the country. Meanwhile, natural gas–fired power plants accounted for 22.9% or 18.9 TWh in the power mix, as the country's three existing natural gas power plants had a combined installed capacity of 2,862 MW. On the other hand, the combined share of renewable energy in the total power generation mix was registered at 25.4% during the period.

2. Modelling Assumptions

Five scenarios, aside from the Business-as-Usual (BAU) scenario, were developed to assess the energy savings potential of the country. the BAU scenario serves as the reference case in the projection of energy demand and carbon dioxide (CO_2) emissions of the energy sector. the BAU scenario incorporates the energy sector's existing energy policies, plans, and programmes which are being implemented and will be pursued within the forecast period.

Alternative Policy Scenario (APS) 1 assessed the impact of possible policy interventions in terms of possible utilisation of energy efficiency technologies for future energy use, together with their corresponding reductions in CO_2 emissions. This assumes that the energy saving goals of 10% in 2024, 25% in 2025, and 20% in 2035 from annual final energy demand of the country will be achieved through a range of measures, including intensified energy utilisation management programmes in the commercial and industry sectors as well as the continuous use of alternative fuels and technologies. The Information and Education Campaign Program of the DOE will also contribute to the energy-saving goals of the country. In the residential and commercial sectors, the use of more efficient electrical appliances is projected to induce savings. Energy labelling and ratings on major electrical appliances will also help consumers choose more efficient electrical products.

APS2 assessed the effect of more efficient thermal power generation, particularly for future coal and natural gas power plant technologies.

APS3 measured the results of combined contribution of renewable energy and alternative fuels to the total energy supply. As part of the government's initiative 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 their impact on the TPES. The NREP lays down the foundation for developing the country's RE resources, stimulating investments in the RE sector, developing technologies, and providing the impetus for national and local renewable utilisation. It sets out indicative interim targets for the delivery of RE within the time frame. In this scenario, the aggregated 20 GW RE capacity is assumed in 2040.

Although the Philippines currently has no firm policy direction on the use of nuclear energy in power generation, APS4 considered additional capacity from nuclear power to determine the impact of possible long-term nuclear option in the country. Lastly, APS5 will focus on the combined effects of the four scenarios: APS1, APS2, APS3, and APS4.

In the model, GDP is projected to grow at an annual rate of around 6% between 2015 and 2040. The population of the country is expected to grow at the rate of 1.5% 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.

Additional scenarios were simulated in the energy outlook model to investigate the feasibility of the 70% Intended Nationally Determined Contributions (INDC) of the country as a commitment to international environmental agreements for the planning period 2010–2030. INDC1 reflects the possibility of reducing CO_2 emissions according to the level of INDC submission of the country, which is 70% CO_2 reduction by 2030 from the BAU scenario level of the same period. The model for INDC1 sets the target of 70% CO_2 reduction by 2030. On the other hand, INDC2 was simulated to look for a more suitable level of CO_2 reduction at the end of the planning period in terms of realistic policy interventions and assumptions.

3. Outlook Results

3.1. Business-As-Usual Scenario

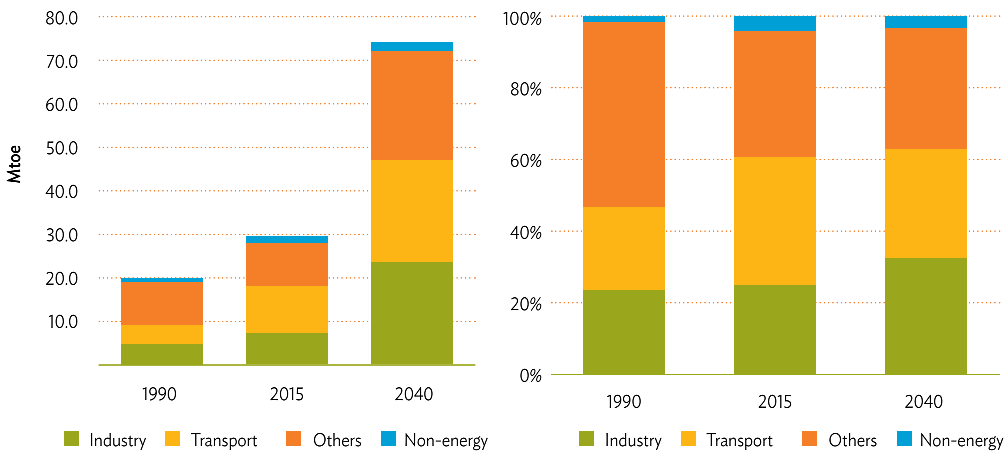
3.1.1 Total final energy consumption (TFEC)

3.1.1.1. TFEC by sector

The Philippines' final energy consumption grew from 19.7 Mtoe in 1990 to 29.6 Mtoe in 2015 at an average annual growth rate of about 1.7%. During this period, energy consumption in the transport sector grew the fastest at an average annual rate of 3.5%, followed by the industry sector with 1.9%. The 'others' sector (residential and commercial, and agriculture, fishery, and forestry) posted a sluggish average annual growth of 0.1% per year.

Final energy consumption is expected to grow at an average annual rate of 3.7% in the BAU scenario over 2015–2040. The transport sector will grow at an average rate of 3.1% per year. On the other hand, the industry and 'others' sectors are expected to grow faster at an average rate of 4.8% and 3.6% per year, respectively (Figure 14.1).

Figure 14.1: Final Energy Consumption by Sector, BAU (1990, 2015, and 2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

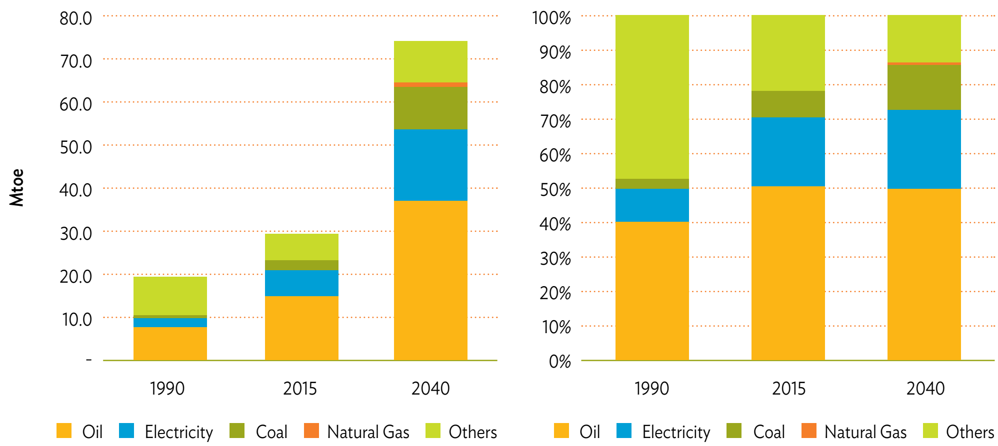
Source: Author's calculations.

Despite the sluggish growth of the aggregated energy consumption of the 'others' (such as residential and commercial) sector in 1990–2015, it continued to account for the biggest share in the total consumption mix for the period – albeit declining from 52.1% in 1990 to 35.6% by 2015. In the same period, the share of the transport sector in the demand mix increased from its level of 23.0% to 35.8%. However, across the planning period, 2015–2040, the share of transport in the demand mix is declining and will drop to 30.9% by 2040. On the other hand, as the energy requirement in the industry sector is expected to increase the fastest, its share to the demand mix is on a continuous uptrend from 23.7% in 1990 to 25.1% in 2015 and to 32.5% by 2040. Meanwhile, the combined consumption of other sectors will recover from its sluggish growth to sustain its share in the consumption mix at an average of 36.3% across the planning horizon.

3.1.1.2. TFEC by fuel

By fuel type, the consumption of natural gas is projected to grow the fastest at an average of 11.5% per year between 2015 and 2040. Increased requirements from industry, particularly in cement and other energy-intensive manufacturing sub-sectors, will contribute to the average hike in coal demand of 6.0% per year, while electricity is expected to maintain its steady pace with an average increment in demand of 4.3% for the next 25 years. On the other hand, demand for oil, mainly from the transport sector, is expected to grow by 3.7% during the period (Figure 14.2).

Figure 14.2: Final Energy Consumption by Fuel Type, BAU (1990, 2015, and 2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

Oil will remain as the most-consumed fuel throughout the planning period, with a share of 49.7% in 2040 in the total demand mix, slightly lower from its 2015 level of 50.7%. Electricity will contribute an average share of 22.7% by 2040, making it the second-most consumed energy source after oil. Coal is expected to increase its share of total demand by almost twice its 2015 share of 7.7% to 13.3% in 2040. On the other hand, the consumption of other fuels such as biomass and other RE, despite their projected lacklustre growth of 1.7% per year, will account for 13.3% of the demand mix in 2040.

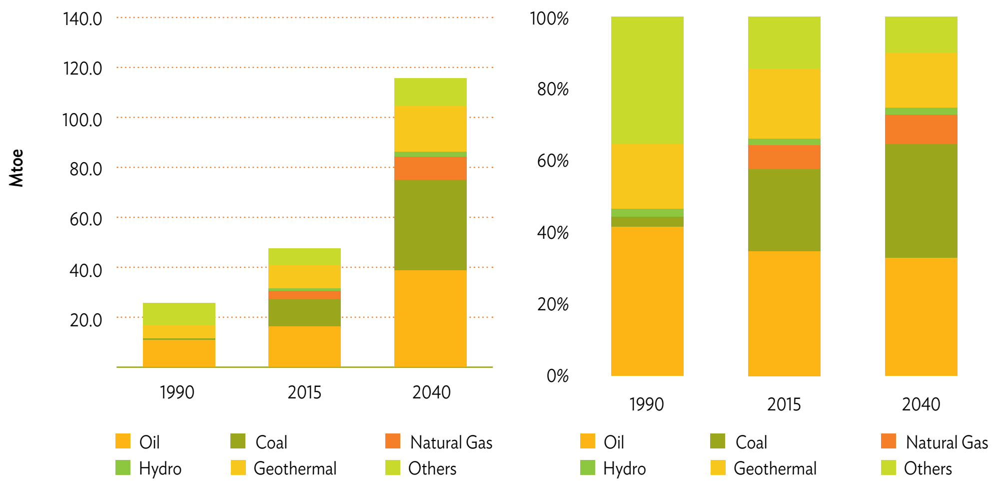
3.1.2. Total primary energy supply (TPES) by fuel type

Primary energy supply in the Philippines grew at an average annual rate of 2.4%, from 26.0 Mtoe in 1990 to 47.5 Mtoe in 2015. Amongst the major energy sources, coal grew the fastest at 11.5% per year. Geothermal, oil, and hydro each registered average increments of 2.9%, 1.7%, and 1.4%, respectively. On the other hand, primary energy supply of other fuels went down by 1.3 % per year.

For 2015–2040, the country's primary energy supply is expected to increase by 3.6% per year from its 2015 level to 115.8 Mtoe in 2040. Consumption of all major energy sources are projected to increase during the period, with coal growing the fastest at 4.9% per year. Natural gas is also expected to expand with a growth rate of 4.7% per year, while oil growth rate is estimated at 3.5% for the period in review. On the other hand, major RE consumption from geothermal and hydro will have an average growth rate of 2.9% and 2.7%, respectively, for the planning period, while other fuels' aggregated consumption level is expected to rise the slowest at 2.1%.

Oil will account for the largest share in the total energy supply of the country at 33.2%, on average, over the planning period. Coal and natural gas, being part of the country's major energy requirements, are projected to register the shares of 31.5% and 8.2%, respectively, by the end of 2040. During the same year, geothermal and hydro, which are mainly used for power generation, will register shares of 15.9% and 1.3%, respectively. Meanwhile, the requirement for other fuels in 2040 will contribute 9.6% to the supply mix (Figure 14.3).

Figure 14.3: Primary Energy Supply by Fuel Type, BAU (1990, 2015, and 2040)



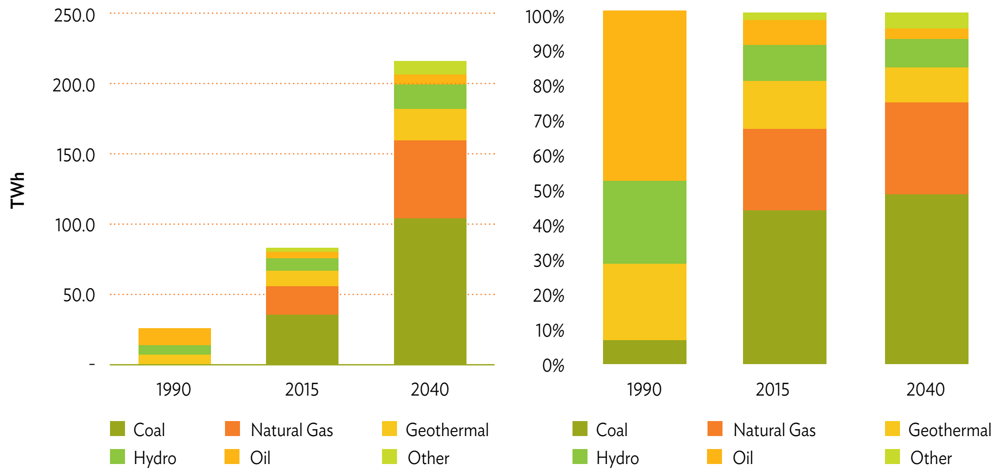
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

3.1.3. Power generation

Total power generation in 2015 reached 82.4 TWh, more than thrice the country's level in 1990. Coal maintains its spot as the major source of power generation, accounting for a 44.5% share in 2015. With total power generation expected to increase by 3.9% yearly to 215.3 TWh by 2040, the share of coal in the generation mix will likewise increase to 48.7% for the period to reflect an average annual growth rate of 4.3% and reach the level of 105.0 TWh by 2040. Natural gas–fired power plants are also expected to follow the same trend as coal, with their generation levels rising by as much as three times its 2015 level of 18.9 TWh to 55.8 TWh in 2040, about one-fourth of total generation during the same year. Major RE sources, such as hydro and geothermal, are expected to contribute an aggregate share of 18.1% (8.2% share for hydro and 9.9% share for geothermal) to the country's generation mix in 2040, as output grows at an average annual rate of 2.9% and 2.7%, respectively. Generation from other energy (solar, wind, and biomass) is expected to increase at an average annual rate of 7.7%. Meanwhile, declining use of oil in the power sector is evident in its paltry average growth of 0.9% for the planning period (Figure 14.4).

Figure 14.4: Power Generation by Fuel Type, BAU (1990, 2015, and 2040)

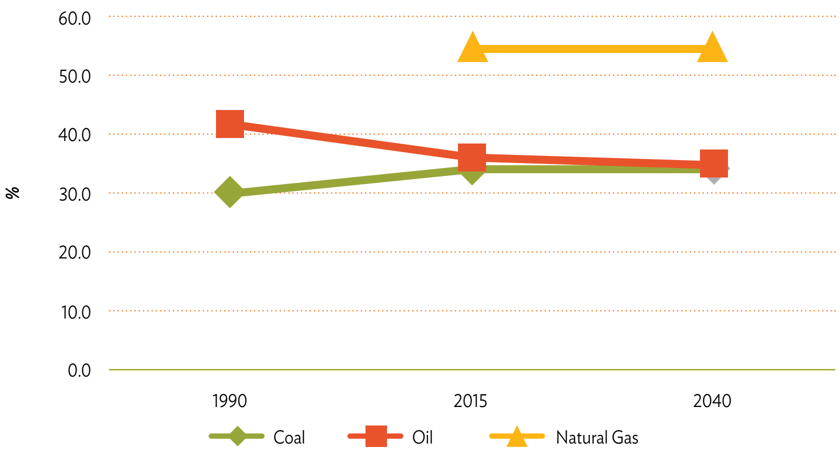


BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculations.

The thermal efficiencies of coal, oil, and natural gas under the BAU scenario are projected to be constant for the whole planning period. Coal thermal efficiency is set at 34%, while oil and natural gas power plant efficiencies are set at around 35% and 55%, respectively (Figure 14.5).

Figure 14.5: Thermal Efficiency by Fuel Type, BAU (1990, 2015, and 2040)



BAU = Business-As-Usual.

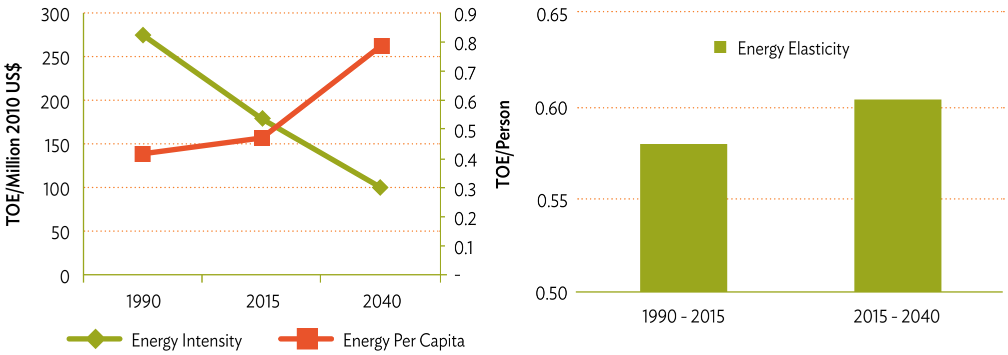
Source: Author's calculations.

3.1.4. Energy indicators

Under the BAU scenario, the energy intensity of the country tends to decrease at a rate of 2.3% for the period 2015–2040. 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 0.47 toe/person in 2015 to 0.78 toe/person in 2040, due to the improvement in the standard of living and income of the people.

Income elasticity of energy is the relationship between changes in the primary energy supply and the changes in GDP. The income elasticity for 2015–2040 is expected to be at approximately 0.6, indicating that energy demand is rising less than proportionately to income.

Figure 14.6: Energy Intensity, Energy Per Capita, and Income Elasticity of Energy (1990, 2015, and 2040)



Source: Author's calculations.

3.2 Alternative Policy Scenario

As mentioned, the assumptions in the APS were analysed separately to determine the individual impact of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions (APS5).

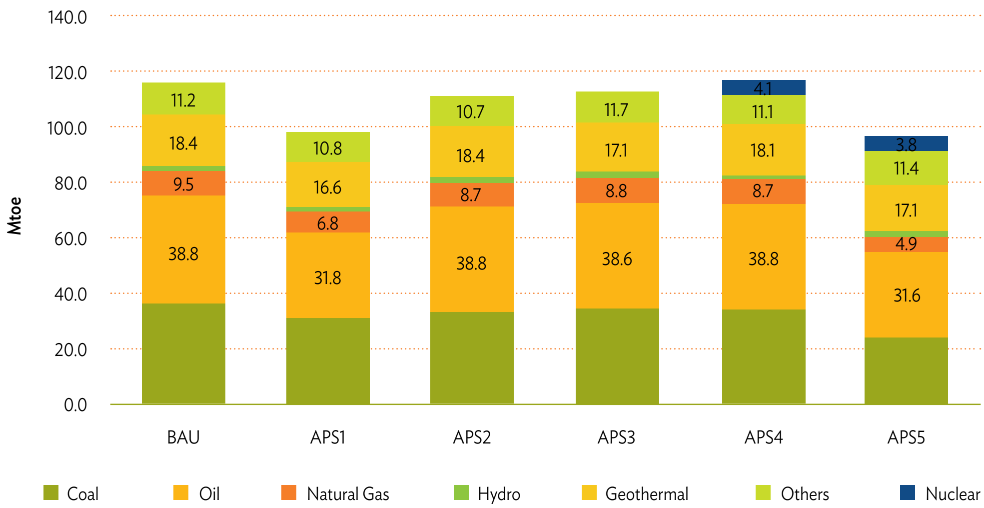
3.2.1. TPES

Figure 14.7 shows the changes in the TPES in all the scenarios. APS1, which assumes improved efficiency of final energy consumption, is projected to increase at a rate of 3% per year as levels reach 98.4 Mtoe by 2040. Compared to the BAU scenario, APS1 is lower by 17.4 Mtoe, or 15%, indicating the effectiveness of energy efficiency measures implemented in various sectors of the economy.

Based on the assumption of more efficient thermal power generation, APS2's TPES will be lower by 4.7 Mtoe or 4% compared to the BAU scenario as it will reach 111.06 Mtoe in 2040. The bulk of the reduction would be from coal as more efficient power plants are assumed to be used to generate power in this scenario.

Under APS3, where the bulk of the increase in the contribution of RE will be in the form of variable RE (solar and wind), TPES is lower by 3 Mtoe or 2.6% compared to BAU. This is mainly due to the slowdown in the use of geothermal energy in power generation vis-à-vis hydro and other RE. Under APS3, aggregate generation output from other RE (solar, wind, biomass, etc.) alone is expected to increase by as much as 10.5% per year, outpacing the 2.4% annual growth in geothermal generation output. This brings the TPES levels under APS3 to 112.8 Mtoe by 2040.

Figure 14.7: Comparison of Scenarios to Total Primary Energy Supply (2040)



Mtoe = million tons of oil equivalent.

Source: Author's calculations.

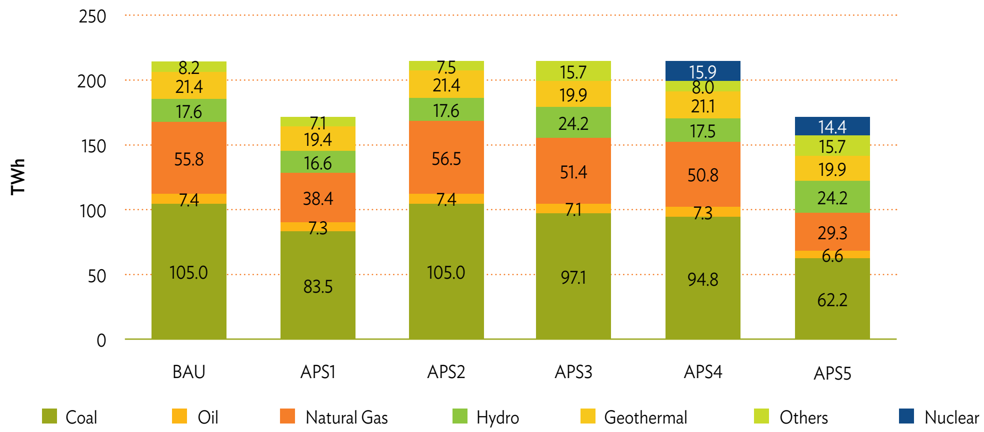
With the entry of nuclear in the energy mix, APS4 is the only scenario where the TPES is slightly higher than the BAU scenario by about 0.5 Mtoe, or 0.4%. This is due to the assumption that the thermal efficiency of nuclear power plants is 33% lower than the efficiencies of natural gas and coal power plants at 35.0% and 55.0%, respectively.

Combining all scenarios, the country's TPES under APS5 will grow at an average annual rate of 2.8% to reach 95.05 Mtoe in 2040. The combined effects of APS1 to APS4 is expected to yield the biggest reduction of 20.8 Mtoe, making the level of energy supply under APS5 17.9% lower than under the BAU scenario. This indicates the effectiveness of combining various energy assumptions – improved efficiency in the energy demand and thermal power generation, as well as higher contribution of RE and entry of nuclear in the supply mix – to achieve the feasible level of the TPES by 2040.

3.2.2. Total electricity generation

Figure 14.8 shows the total electricity generation in 2040 in all scenarios. Due to the efficiency measures resulting in lower electricity demand, APS1's total generation output was at 172.3 TWh as all fuels register reduced generation output vis-à-vis the BAU scenario. This makes APS1's level at 43.1 TWh or 20% less than 215.3 TWh under the BAU scenario, with lower shares for fossil-fired power plants, particularly for natural gas and coal.

Figure 14.8: Comparison of Scenarios to Electricity Generation (2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hours.

Source: Author's calculations.

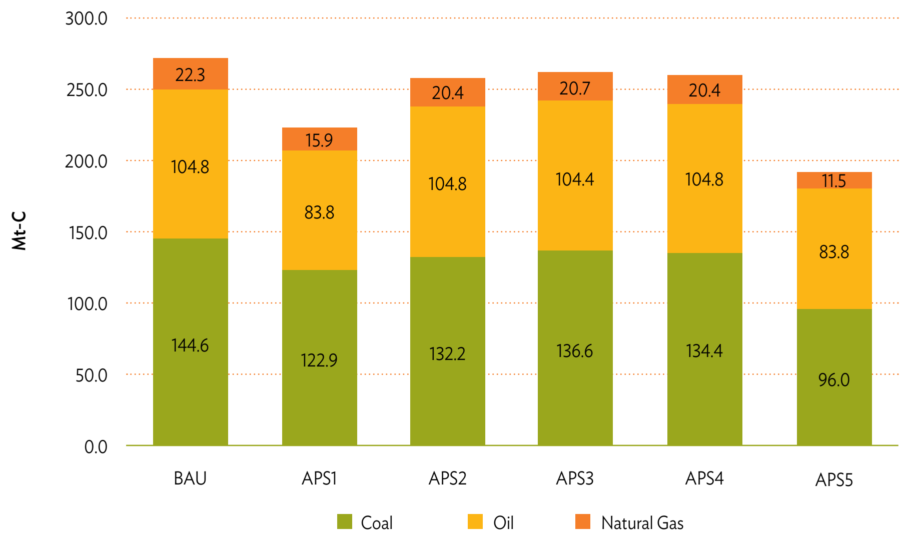
APS2, APS3, and APS4 yield the same total generation output with the BAU scenario. However, under APS2, coal share will increase slightly by less than a TWh compared with the BAU scenario level. This is because of the entry of highly efficient coal-fired power plants, which, although operating with higher thermal efficiency by 2% compared with conventional coal plants, will contribute significantly to the generation mix. Power generation from coal is projected to reach 105.0 TWh level by 2040 for APS2, slightly higher compared with its level in the BAU scenario. This is the same case with the power generation from natural gas that will also increase slightly in APS2 from the BAU scenario. On the total account, the effect of higher thermal efficiencies of fossil fuel plants is a slight reduction on the aggregated variable RE generation output for APS2. On the other hand, the shares of generation from fossil fuels are lower for the two other scenarios, as they are displaced by RE for APS3 and entry of nuclear in the generation mix for APS4.

While APS5's total generation output is equal to that of APS1 for 2040 at 172.3 TWh, there is a significant reduction in the aggregate level of fossil fuels' power output from the BAU scenario to APS5 at 41.7 %, or from 168.1 TWh to 98.02 TWh.

3.2.3. Total CO_2 emissions

In terms of reduction of CO_2 emissions, the energy efficiency assumption in APS1 will generate 222.6 million metric tons of carbon (Mt-C), which is 49.0 Mt-C or 18.0% lower than BAU for 2040. The decrease in CO_2 indicates that the energy-saving goals, action plans, and policies in the promotion of the energy efficiency and conservation programme will be effective in reducing CO_2 emissions (Figure 14.9).

Figure 14.9: Comparison of Scenarios to CO_2 Emissions (2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Author's calculations.

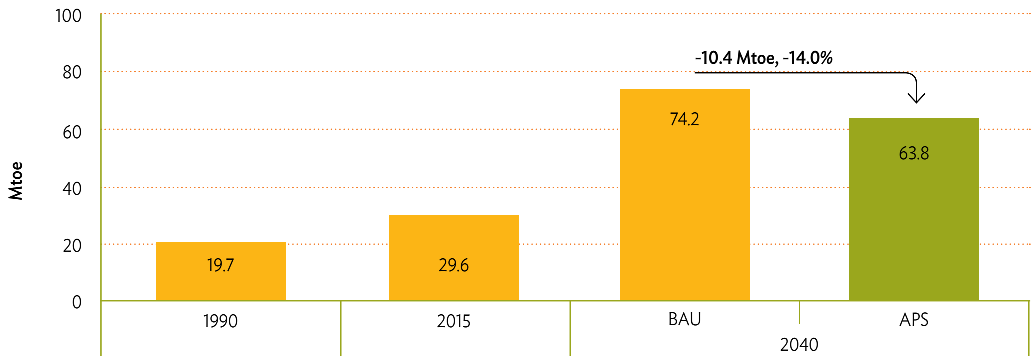
Under APS2, total CO_2 emissions are lower by 14.2 Mt-C or 5.2% relative to the BAU scenario's 271.6 Mt-C. In APS3, the reduction is the least amongst all alternative scenarios at 10 Mt-C. In APS4, the reduction will account for the level of 12.1 Mt-C or 4.4% compared with the BAU scenario.

Combining all the assumptions in APS1, APS2, APS3, and APS4 (APS5) will give the aggregate reduction of CO_2 emissions from the BAU scenario at 80.3 Mt-C or 29.6%.

3.2.4. Final energy consumption

Figures 14.10 to 14.12 show the levels of the TFEC in 2040 between the BAU scenario and the APS (APS5), by sector and by fuel. Due to the improved economy-wide energy efficiency that will yield higher energy savings on the demand side under the APS, final energy demand is at 63.8 Mtoe, which is 10.4 Mtoe or 14% lower than the BAU scenario.

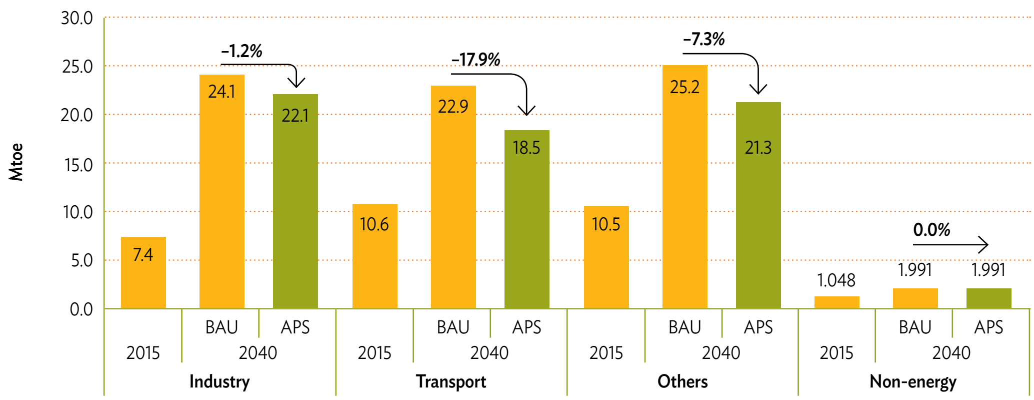
Figure 14.10: Comparison of Total Final Energy Consumption in 2040, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of oil equivalent.

Source: Author's calculations.

Figure 14.11: Comparison of Final Energy Consumption in 2040, BAU and APS



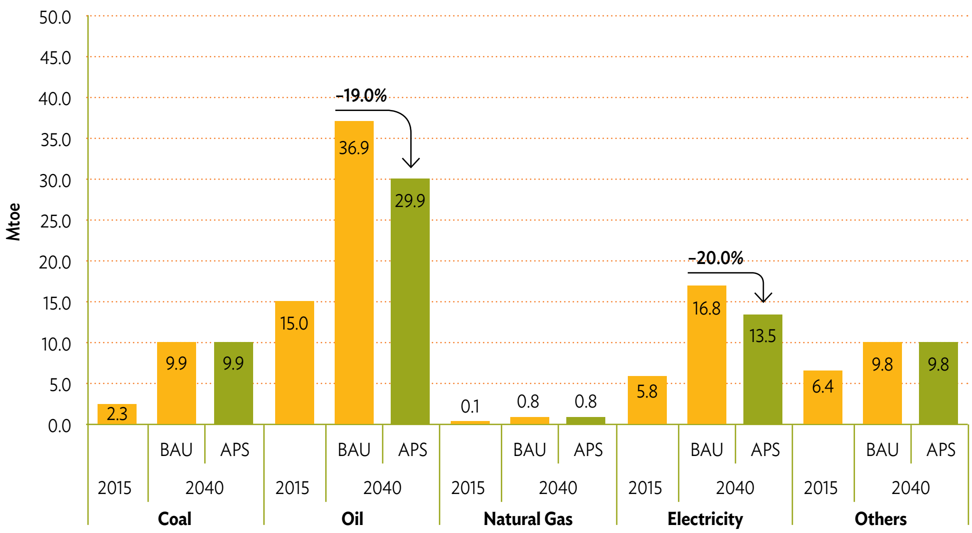
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of oil equivalent.

Source: Author's calculations.

All economic sectors are expected to contribute to the aggregate reduction in energy demand under the APS. The transport sector will cut its demand by as much 19.5% to reach 18.5 Mtoe, from 22.9 Mtoe in the BAU scenario. Energy demand from the 'others' sector (residential, commercial, agriculture, fishery, and forestry) at 21.3 Mtoe is 15.4% lower than its BAU level of 25.2 Mtoe. The industry sector will also contribute 8.5% reduction – from 24.1 Mtoe under the BAU scenario to 22.1 Mtoe in the APS.

The impact of improved efficiency is evident in the 19% and 20% decline in the consumption of oil and electricity under the APS (APS5) vis-à-vis BAU (Figure 14.12).

Figure 14.12: Comparison of Final Energy Consumption by Fuel Type in 2040, BAU and APS



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of oil equivalent.

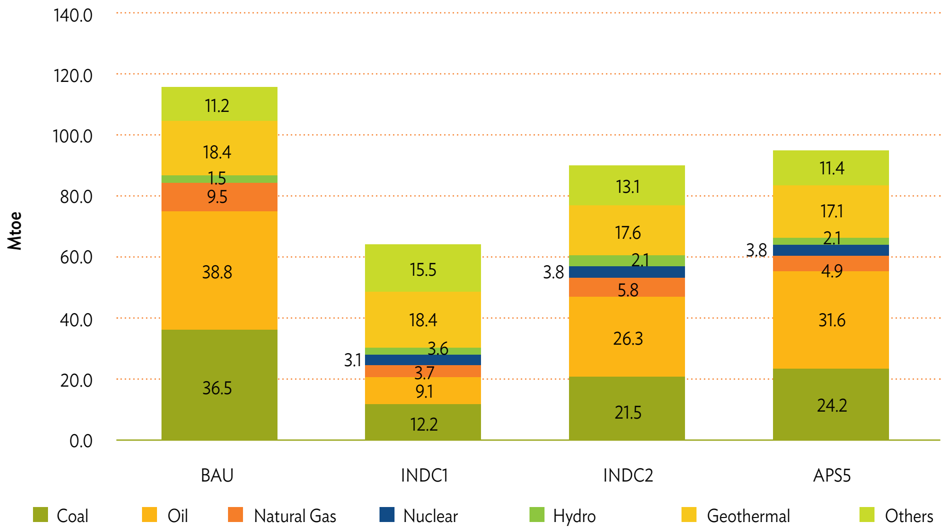
Source: Author's calculations.

3.3 Intended Nationally Determined Contributions Scenario

Aside from the assumptions set forth under the APSs, the country's commitment to international environmental agreements in terms of its INDC was likewise studied. Two simulations were done for this purpose: INDC1 seeks to determine the effect of a 70% reduction in CO_2 emissions by 2030 from BAU, while INDC2 looks into more considerable CO_2 emissions reduction targets by 2040. In INDC1, to be able to reduce CO_2 emissions by 70% in 2030, fuel substitution, such as from fossil fuels to electricity and biomass, was assumed from 2025 to 2035 in the demand sectors. On the other hand, more considerable assumptions were made in INDC2, such as 25%–30% energy efficiency target from 2025 to 2035 and 10% electricity use in the transport, industry, and services sectors to substitute gasoline and diesel demand. For INDC2 power generation, it was assumed that all additional capacities from coal and natural gas power plants by 2022 until 2040 will be of highly efficient technologies and more contribution of RE generation output to compensate for the significant increase in electricity demand. At the end, the energy savings potential of INDC2 at 25.5 Mtoe is higher by 4 percentage points compared with APS5 (20.8 Mtoe) but with much higher CO_2 reduction from the BAU scenario by 38.2% in 2040 compared with APS5 with 29.6% CO_2 reduction at the same period.

3.3.1 TPES

Figure 14.13: Comparison of Total Primary Energy Supply in 2040 (BAU, INDC, and APS5)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, INDC = Intended Nationally Determined Contributions, Mtoe = million tons of oil equivalent.

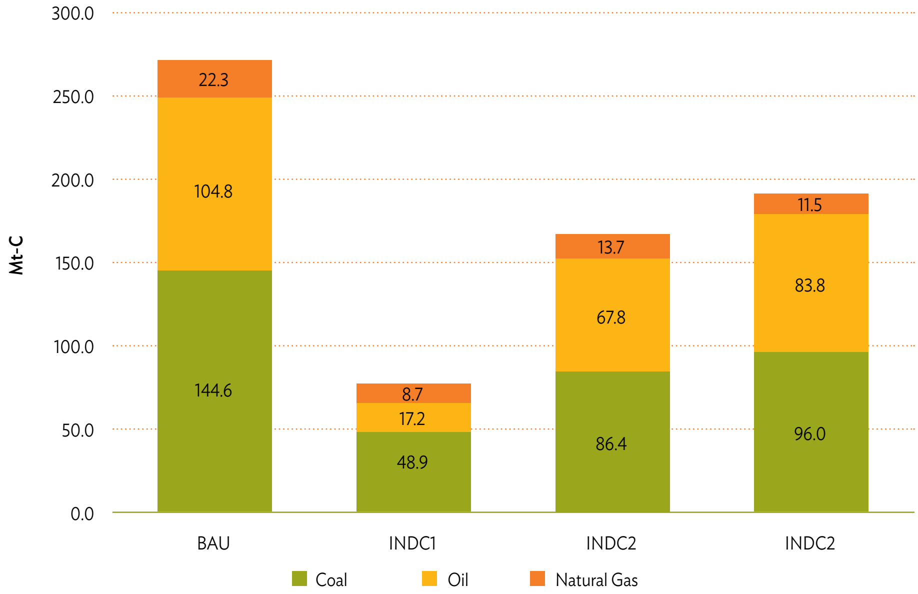
Source: Author's calculations.

INDC1 yields a TPES level of 64.5 Mtoe, 44.3% (51.3 Mtoe) less than that of the BAU scenario. Under INDC1, supply of fossil fuels will significantly decline by 70.6% from the BAU level. On the other hand, the reduction on INDC2 supply level compared with the BAU scenario is projected at 22%. Comparing also the supply level between INDC2 and the APS, the difference is only 4.8 Mtoe, with INDC2 lower by 5% at the 90.3 Mtoe level of energy supply. Despite the significant reduction in the aggregate supply of fossil fuels in INDC2 at 37%, this was compensated by the higher production of RE compared with the BAU scenario and APS5.

3.3.2 Total CO_2 Emissions

INDC1 will produce the least amount of CO_2 emissions at 74.7 Mt-C amongst the four scenarios. This will reflect 70% reduction of CO_2 emissions by 2030 and 72.5 CO2 emission by 2040 from BAU. On the other hand, INDC2's CO_2 emissions reduction at 167.9 Mt-C in 2040 is lesser by 55.4% compared with that of INDC1 during the period, while only 12.2% higher reduction from APS5. The CO_2 emissions reduction of INDC1, INDC2, and APS5 from the BAU scenario will register at 72.5%, 38.2%, and 29.6%, respectively, by 2040.

Figure 14.14: Comparison of Total CO_2 in 2040 (BAU, INDC, and APS5)



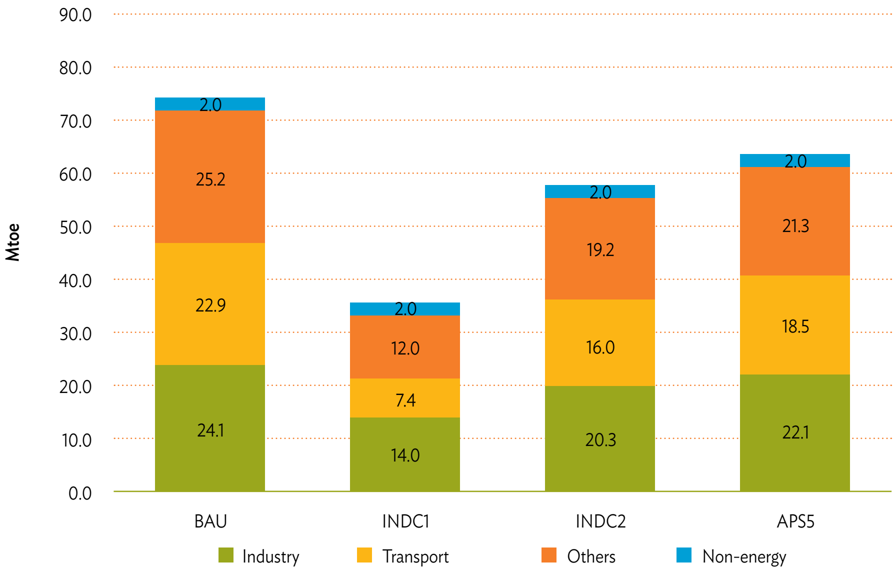
APS = Alternative Policy Scenario, BAU = Business-As-Usual, INDC = Intended Nationally Determined Contributions, Mt-C = million tons of carbon.

Source: Author's calculations.

3.3.3 Final energy demand

The CO_2 emissions reduction targets for both INDC1 and INDC2 put a cap on final energy demand, resulting in lower levels compared to APS5. However, energy demand in transport, which has been the primary source of CO_2 emissions amongst end-use sectors, has been reduced to 7.4 Mtoe under INDC1, which is considerably lower compared to the sector's historical consumption levels. This contributes to the halving of final energy demand for INDC1 at 35.4 Mtoe from the BAU scenario's 74.2 Mtoe. On the other hand, the demand mix of INDC2, which totals 57.6 Mtoe, is almost similar with the levels of each end-use sector from that of the BAU scenario and APS5.

Figure 14.15: Comparison of Final Energy Consumption by Sector in 2040 (BAU, INDC, and APS5)

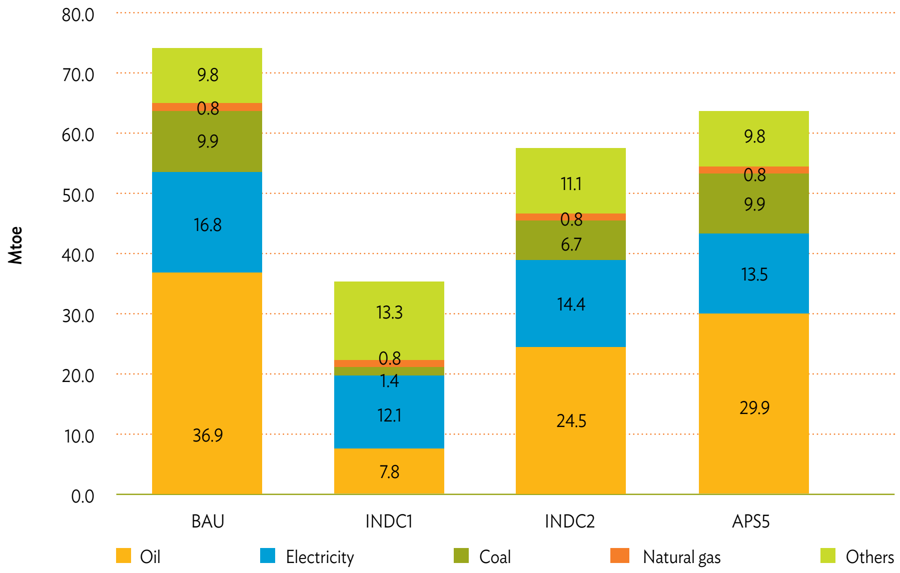


APS = Alternative Policy Scenario, BAU = Business-As-Usual, INDC = Intended Nationally Determined Contributions, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

In Figure 14.16, the effect of 70% CO_2 reduction in INDC1 will bring down the aggregate consumption of oil and coal by 80.3% from its BAU scenario level. The scenario may not be possible without other fuels to substitute this aggregate level of consumption of oil and coal. In particular, coal consumption in INDC1 will be reduced to a mere 1.4 Mtoe by 2040 or an almost sevenfold reduction from the BAU scenario, while oil will account for an almost fivefold reduction. For INDC2, an assumption to substitute smaller reduction of fossil fuels in the demand sectors will bring down the coal and oil demands by 32% to 33% from the BAU scenario. INDC2's electricity demand is higher by 6.5% compared with the APS5 level to compensate reduction in fossil-fuel demand. Meanwhile, oil demand in INDC2 will be reduced significantly compared with the BAU scenario and APS5 but will still be the most dominant fuel in the demand sector as could also be observed in the BAU scenario and APS5.

Figure 14.16: Comparison of Final Energy Consumption by Fuel Type in 2040 (BAU, INDC, and APS5)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, INDC = Intended Nationally Determined Contributions, Mtoe = million tons of oil equivalent.

Source: Authors' calculations.

4. Implications and Policy Recommendations

Amongst the fossil fuels under the BAU scenario, coal supply will register the fastest growth rate at 4.9% throughout the planning period. This is due to the significant contribution of coal in power generation, which corresponds to the increasing demand for electricity at 4.3% average annual rate. Towards 2040, coal supply level will almost be at equal level with the country's most dominant fuel, oil, that is mainly used in the transport sector. The aggregated share of RE at 26.8% is behind by 14.8% of the projected contribution of coal in the supply mix. The result of the study indicates that the significant use of coal during the planning period is inevitable. Given the current policy of the government to fully support the attainment of its development goals as envisioned in Ambisyon 2040, which covers the country's industrialisation and urbanisation goal within the framework of the long-term Philippine Development Plan, the DOE is focused on achieving security and reliability of energy supply in anticipation of the long-term economic development of the country. This is to support the vision of a low-carbon future and adopting a technology-neutral policy in coming up with an optimal energy mix. At this point, a reliable source of energy for power generation such as coal is indispensable; in fact, majority of the committed capacities from the private power projects are coal power projects (more than 70% of the committed capacities). Consistent with the results of the study, the share of coal in power generation by 2040 will account for almost half of the total generation output. Natural gas will comprise one-fourth of the generation output while the remaining shares will be sourced from oil and RE. Thus, it is important for the government to push for more diversification of energy sources in a feasible manner to achieve an ideal energy mix that would be consistent with the goal of the energy sector on energy security. Coal-fired power plants provide reliable baseload capacity given their dominant share in power generation, while avoiding or controlling their increased capacity in power generation will hamper the stability of electricity supply. The government still needs to safeguard the environment through policy interventions such as promoting the use of highly efficient and clean coal technologies in power generation and non-power industries. In fact, coal demand in the industry sector will be the third highest in utilisation level by 2040 after oil and electricity at 13.3% share of the total demand mix. However, there is an issue in implementing the policy, considering the power sector is a deregulated industry. Under this condition, the government has limited control in choosing the type of power plants to be built since the power industry is already deregulated and led by private investment. It can be addressed somehow by formulating a fuel mix policy for power generation to guide and inform investors and other key players of the industry on the preferred power mix of the country for long-term sustainability of the country's power sector. This policy might have been in conflict with technology-neutral policies. However, the role of the government here is only to provide a check-and-balance on the share of fuel types in the power mix. Each fuel should not be more than the required level that it could dictate the price of electricity and disrupt supply that will more likely cause a total power crisis.

On the demand side, oil will register the biggest share in the final energy consumption by almost half of the demand mix at the end of the planning period. This will happen despite the current effort of the government to promote 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 constantly at around 50% across different scenarios. It would be appropriate for the government to focus on the promotion of alternative fuels in the transport sector to substitute partly and directly the use of oil in the sector with the extended implementation of alternative fuels in the transport programme.

Moreover, the use of alternative technologies and fuels such as electric vehicles, compressed natural gas (CNG), autogas (LPG for transportation), and biofuels for transport will temper the utilisation of oil in the country in the future, thus, reducing the negative impacts of oil price volatility in the world market. The government's efforts in the promotion of alternative fuels in the transport sector will help not only in reducing the energy requirements but also in lessening GHG emissions that mostly come from the transport sector.

On the other hand, under the APS, energy and CO_2 intensity will continue to decline from 2015 to 2040, although CO_2 emissions per energy consumption will increase corresponding to the increased share of fossil fuels. In this regard, the government should strictly implement plans and/or programmes for energy efficiency and conservation that will address volatile oil prices and their inflationary effect on the prices of basic commodities, and change the economic structure of the country to rely more on its services sector rather than on energy-intensive industries. This is also consistent with the target of the Asia-Pacific Economic Cooperation (APEC) to reduce its aggregate energy intensity (energy demand per unit of GDP) by 45% by 2035, with 2005 as the base year. Improvement in the energy intensity of the Philippines is expected to be driven in part by the country's changing economic structure, relying more on its service sector than on energy-intensive industries.

In response to the results of this study, the government should pursue its programmes and projects that will further increase and enhance the use of indigenous, clean, and efficient alternative fuels. The full implementation of the Renewable Energy Act of 2008 to expand the utilisation and development of indigenous energy, such as geothermal, hydro, solar, wind, and other clean energy, will not only promote the use of sustainable energy but will also lessen the country's need for energy imports. FiT, RPS, and other policy mechanisms provided under the law will boost the use of RE.

Special attention should also be given to the industry sector since its energy demand is growing more than the transport sector and could have high potential energy savings. In fact, based on the study results, the demand of the industry sector will surpass that of the transport sector as early as 2035 across different scenarios.

Currently, the Philippines has a specific quantitative energy-saving requirement as provided under Administrative Order (AO) No. 110, Directing the Institutionalisation of a Government Energy Management Program. The AO requires the reduction of at least 10% in the cost of fuel and electricity consumption, amongst others, in the government. This can be duplicated or expanded to other sectors if an existing energy conservation law will require strict regulation and implementation.

In addition, there is a need to pass the Energy Conservation Law to realise the targets set by the government. The law will institutionalise energy conservation and enhance the efficient use of energy in the country.

Moreover, looking at the integration of all the scenarios, the result is effective in reducing the carbonisation ratio. This indicates that the government should set the enabling environment to ensure that policies will strictly be implemented.

Finally, it is important to ratify commitment to international environmental agreements like the INDC and Nationally Determined Contributions that will direct member countries to pursue reduction of CO_2 emissions under a certain framework. Based on the results of the study, nearly 35% could be a suitable level of CO_2 emissions reduction in the country by 2040.

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CHAPTER 15

SINGAPORE COUNTRY REPORT

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1. Background

Singapore is a small island-state in Southeast Asia, located along the Strait 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 $52,200 (in constant 2010 US$) in 2015. Singapore submitted its Intended Nationally Determined Contributions (INDC) to the Secretariat of the United Nations Framework Convention on Climate Change on 3 July 2015 (NCCS, 2015) and has signed off to the Paris Agreement as of 22 April 2016 (Ministry of Foreign Affairs, 2016). Singapore's INDC highlights its intentions to reduce its emissions intensity by 36% from 2005 levels by 2030. In addition to emissions intensity targets, Singapore also intends to stabilise emissions with the aim of peaking around 2030. Under the Copenhagen Accord, Singapore also has a voluntary target of reducing carbon dioxide (CO_2) emissions by 7%–11% below Business-As-Usual (BAU) scenario levels in 2020 (NCCS, 2012), which will be increased to 16% if there is a global agreement on climate change.

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 Teo Chee Hean, Deputy Prime Minister and Co-ordinating Minister for National Security and Minister of Home Affairs, the committee was attended by the ministers for the environment and water resources, finance, foreign affairs, national development, trade and industry, as well as transport, to provide an 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 multipronged objectives of achieving economic competitiveness, energy security, and environmental sustainability (Ministry of Trade and Industry, 2007) all at the same time.

2.1. Fuel Switch

Singapore started switching from oil to natural gas as a source for power generation in the early 2000s. Today, natural gas remains a key component of the country's power generation mix. Imports into Singapore increased by 2.4% in 2016 and, in 2017, natural gas represented 95.2% of the fuel mix for electricity generation in Singapore (Energy Market Authority, 2018). Petroleum products, coal, and others accounted for the remaining 0.7%, 1.2%, and 2.9%, respectively (Energy Market Authority, 2018). In a consultation paper released by the Energy Market Authority in 2015, natural gas is expected to remain dominant in Singapore's power sector in the foreseeable future.

To expand the country's import capability and sourcing options for liquefied natural gas (LNG), Singapore has already commenced commercial operations with its newly constructed LNG terminal in May 2013. This currently has a throughput capacity of 6 million tons per year (Boon, 2013) and 9 million metric tons per annum (Mtpa) thereafter in 2017 with a fourth storage tank to be constructed. The current aims are to increase the targeted annual capacity to 11 Mtpa by 2018 (Veras, 2016).

2.2. Promoting Solar Energy

Singapore has been active in promoting solar energy as the only alternative renewable source of energy to meet its needs. Although solar technology is not subsidised, there is policy support for the deployment of solar resources in the form of removal of non-market barriers; system support in terms of facilitating system integration of the intermittency of solar energy without compromising grid stability; and continued support for research, development, and demonstration efforts aimed at reducing costs and improving efficiency of solar modules. As part of the policy objective of accelerating the scale of solar deployment in Singapore, the Housing and Development Board (HDB) awarded in 2015 a public tender for the installation and management of 76 megawatt-peak (MWp) of solar photovoltaic (PV) panels under the SolarNova programme (HDB, 2015a). The SolarNova programme, led by the Economic Development Board (EBD), is a government-led programme that aims to promote solar deployment through aggregating solar demand across the public sector (Ministry of Trade and Industry, 2014). The EDB and the Public Utilities Board have also partnered to install floating PV platforms in reservoirs (Channel News Asia, 2015). Future initiatives will involve the installation of solar-ready roofs on all HDB flats with at least 400 square metres of open roof space, with the HDB committing to install at least 220 MWp of solar panels at about 5,500 HDB flats by 2020 (HDB, 2017). Beyond these forms of support, Singapore also has a national target of deploying 350 MWp of solar PV by 2020 and extending the share of solar PV to 8% of the country's peak electricity demand by 2030 (NCCS, 2016a).

In 2010, Singapore had explored the nuclear option with a nuclear energy pre-feasibility study. The results of the study, which was confirmed in a 2012 statement from the Ministry of Trade and Industry, was that nuclear energy was not suitable for deployment, given that the high risks associated with the dense urban population of Singapore outweigh the benefits (Ministry of Trade and Industry, 2012). However, Singapore will continue to monitor technological developments and may revisit the option in the future. In the meantime, it shall cooperate with international and regional players to actively tackle issues regarding nuclear safety and emergency planning.

2.3. Energy Efficiency Improvements

Energy efficiency is another integral part of Singapore's mitigation effort. An inter-agency Energy Efficiency Programme Office, led by the National Environment Agency and the Energy Market Authority, was established in May 2007 to help promote and facilitate the adoption of energy efficiency across sectors in Singapore (Energy Efficiency Programme Office, 2013a). 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

Households account for about one-sixth of the electricity consumed in Singapore (NCCS, 2016b) and are, thus, 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 was imposed on all registrable air conditioners and refrigerators, as well as smaller appliances such as television sets, clothes dryers, and lighting. MELS serves to inform consumers and help them identify, and thereby purchase, more energy-efficient appliances. MEPS is a supply-side policy that complements MELS by prohibiting the sale of appliance models that do not meet the minimum specified energy efficiency levels. 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 MELS and MEPS are constantly evaluated and revised to ensure policy efficacy and efficiency.

In addition to MELS and MEPS, various public messaging campaigns aimed at 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 improves consumer awareness during the purchasing stage, while the Home Energy Auditor motivates energy efficiency behavioural change when consuming electricity at home. Recent public messaging campaigns have also began targeting residential interior design with the Resource Efficiency Guide for New Home Owners.

Since the early 2010s, the relevant ministries are studying the feasibility and cost–benefit of utilising smart home technologies, such as the home energy management systems, to reduce residential energy consumption. Residents in the Yuhua estate in the west of Singapore will be the first as a pilot estate to experience such technologies, where smart features will be progressively implemented until 2018 (HDB, 2015b). Subsequently, the rollout of full retail contestability, where residential consumers can choose their own electricity supplier in the second half of 2018 (Tang See Kit, 2018), could provide further support for conservation efforts should consumers become more aware of their own electricity load profiles (Loi, Owen, and Ke, 2017).

Transport

Energy efficiency in the transport sector is governed by three complementary policy objectives: (i) reducing private transport (ii) promoting public transport ridership, and (iii) promoting non-motorised transport.

The Vehicle Quota System regulates the growth of vehicle population in Singapore. Under this system, 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 (Land Transport Authority, 2014a). In view of the land constraints on road expansion, the annual vehicle population growth rate has decreased to 0% effectively from February 2018 onwards (Land Transport Authority, 2017a). Since 2012, the Fuel Economy Labelling Scheme has mandated fuel economy labels to be affixed to vehicles at the point of sale. This was complemented by the Carbon Emissions-based Vehicle

Scheme, introduced in 2013 (Land Transport Authority, n.d.), and was in place until December 2017. This scheme qualified all new cars and imported used cars with low carbon emissions of less than or equal to 135 g carbon emissions per kilometre (CO_2/km) for vehicle tax rebates of S$5,000–S$30,000. Cars with high carbon emissions of more than 185g CO2/km also incurred a corresponding registration surcharge between S$5,000 and S$20,000. Taxis were imposed higher surcharges to adopt lower emission models for their fleet (Land Transport Authority, 2015). This scheme was replaced in January 2018 by the new Vehicular Emissions Label, which offers rebates and surcharges based on the worst-performing pollutant out of five. These charges range from S$30,000 (rebates) to S$30,000 (surcharge), depending on the band category in which the new car or taxi is being purchased (Land Transport Authority, 2017b).

Public transport is the most energy-efficient mode of travel. Under the Land Transport Masterplan, Singapore targets to achieve a 75% public transport modal share during peak hours by 2030, up from 66% in 2014. In a nutshell, the promotion of public transport ridership is achieved by ensuring the efficiency and reliability of public transport services. In addition to constantly upgrading and expanding the current fleet of public transport vehicles, actions were also taken to expand existing metro lines and outreach. Mandatory give-way operations also ensure bus priority on the roads. The Park & Ride scheme was also initiated to ensure a seamless switch between private and public transport.

The government will create more connections through the construction of two new rail lines and three new extensions. By 2030, the rail network would have doubled from the existing 178 km in 2013 to about 360 km, and 8 in 10 homes would be located within a 10-minute walk from a train station. Public buses would connect commuters to even more places, with new bus routes added to the bus network. Singapore is adding about 80 new bus services under the Bus Service Enhancement Programme.

To improve the overall experience of commuters, especially in the first and last miles of their journeys, the government will also build more than 200 km of sheltered walkways. 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. Specifically, the intra-town cycling programme launched by the Land Transport Authority promotes cycling through designated specialised road cycling paths. The island-wide cycling path network will eventually be well over 700 km in length. In addition, the electric vehicle pilot car-sharing programme is in progress, which will see the introduction of possibly 1,000 electric vehicles and charging infrastructure by (2020) to promote their use (Land Transport Authority, 2014b).

Buildings

At the design stage, energy efficiency in buildings is governed by the Building and Construction Authority (BCA) of Singapore's Green Mark Scheme. Launched in January 2005 to promote environment sustainability in the construction and real estate sectors, the Green Mark Scheme targets environment-friendly designs in buildings, with a focus on energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green features focusing on landlord's contributions in 'going green' (E2 Singapore, 2016). Since April 2008, all new buildings and existing buildings undergoing major retrofitting works with a gross floor area above 2,000 square metres must meet Green Mark certified standards. The BCA Green Mark Scheme promotes the adoption of green building technologies and reduces the use of electricity in the commercial sector via efficiency improvements and conservation. Buildings exceeding the minimum requirements are also awarded higher accreditations, such as the Platinum Green Mark, which serves to promote exceptional performance. Technical and financial support mechanisms are also provided to motivate continued energy efficiency upgrades. The Building Energy Efficiency Roadmap, published jointly by the National Climate Change Secretariat and the National Research Foundation in 2014, evaluates existing energy efficiency technologies for buildings, hence, providing technical expertise in the area. Various financial support mechanisms, such as Green Mark Incentive Scheme for Existing Buildings and Premises and the Building Retrofit Energy Efficiency Financing scheme, are available to provide co-financing for retrofitting and energy efficiency upgrades. The target is for at least 80% of the buildings in Singapore to achieve BCA Green Mark certified rating by 2030 (BCA, 2013). The most recent updates for the Green Mark Assessment Criteria are in 2016 for residential buildings (BCA, 2016), and an ongoing pilot for non-residential buildings (BCA, 2017).

Since a 2012 survey by the Development Authority of Singapore revealed that the 10 largest data centre operators in Singapore consumed as much energy as 130,000 households, data centres became a key sector for policymakers. Data centres have been included in the BCA Green Mark Scheme since 2012. A similar technology roadmap has been prepared for data centres, which highlights strong growth prospects for improving energy efficiency in the sector. This was in line with estimates from the 2012 survey which posited that there is an energy efficiency potential of 20%. The Development Authority of Singapore also launched a new Green Data Centre Innovation Programme aimed at promoting innovative technological approaches to improving energy efficiency in data centres.

Since 2006, the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) initiative has placed the public sector at the front of building energy efficiency. Under the PSTLES, all existing public sector buildings must meet a minimum Gold Mark rating, as determined by the type of building. Moreover, the Guaranteed Energy Savings Performance (GESP) contracts initiative was introduced to ensure reaping the expected energy savings. Under the GESP contract structure, the 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 a 3- to 5-year contract period (E2 Singapore, n.d.). The efficacy of this initiative could be proved with the average electricity savings of 15% across 14 projects by March 2015 (E2 Singapore, 2015a), contributing to annual monetary savings of S$6 million.

Industry

The industry-focused Energy Efficiency National Partnership is a voluntary programme which started in 2010 that helps companies put in place energy management systems and implement projects to improve energy efficiency. Mandatory energy management requirements for energy-intensive companies in the industry sector were later introduced in April 2013 under the Energy Conservation Act . Energy-intensive companies consuming more than 15 GWh (electricity) or 54 terajoules (fuel or steam) each year are required to appoint an energy manager, monitor and report energy use and greenhouse gas emissions, and submit energy efficiency improvement plans (National Environment Agency, 2014). Beside legislation enforcing mandatory energy management practices, policies were also introduced to incentivise energy efficiency investments. The ESCO (energy services company) Accreditation Scheme supports the Energy Conservation Act by ensuring professionalism in energy-related services. As of mid-2018, 29 qualified energy services specialists are from 19 accredited ESCOs.

Incentives and grants, such as the Design for Efficiency Scheme, Energy Efficiency Improvement Assistance Scheme, and the Grant for Energy Efficiency Technologies, were also put in place as co-financing schemes to reduce initial costs of energy efficiency upgrades. The One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology is another example of a tax incentive to encourage energy efficiency upgrades in industries (E2 Singapore, 2015b). Knowledge-sharing is also promoted through industry-focused seminars and provision of energy management training and resources.

3. Modelling Assumptions

3.1. Power Generation Sector

For the BAU scenario, the generation efficiency of combined-cycle gas turbine plants is assumed to improve from 50.5% in 2015 to 52% in 2040, registering an increase of 2.9% due to progression towards a competitive electricity market. Single-cycle thermal plants are expected to improve marginally as well from 34.7% to 42% in 2040. The use of solar generation capacity is assumed to grow from 3% in 2015 to around 9% of aggregate demand for electricity in 2040, as part of public efforts towards promoting renewable energies.

With respect to Alternative Policy Scenario (APS2), which considers greater potential for efficiency in the power generation sector, combined-cycle gas turbine plants will reach 60% efficiency by 2040, whilst single-cycle thermal plants could reach 45%. APS3 allows for the share of solar to reach 30% of Singapore total electricity needs in 2040.

3.2. Transport Sector

The demand for gasoline, natural gas, and diesel for Singapore's road vehicles is assumed to be dependent primarily on vehicle growth. Consistent with vehicle quota targets set by the Land Transport Authority, vehicle growth would remain at 0.25% from 2015 to 2017, before going down to 0% from 2018 thereafter 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 around 200 km in 2015 to 344 km by 2040, an annual average growth rate (AAGR) of 2.2% per year. APS1 is like the BAU scenario here, as no further vehicle growth reductions or railway efficiency improvements have been assumed.

3.3. Residential Sector

In the BAU scenario, electricity demand growth is assumed to follow an AAGR of 6.9% from 2015 to 2040. Electricity demand growth can be further reduced to an AAGR of 6.7% in APS1. Demand for natural gas and oil products remains like the BAU scenario.

3.4. Commercial Sector

In the BAU scenario, electricity demand is assumed to slow down at an AAGR of 0.8% from 2015 to 2040, which will eventually end up below the baseline econometric forecasts in 2040. APS1 will lead to a further reduction in AAGR for electricity demand to -0.9%. No reduction is expected from natural gas and oil consumption.

3.5. Industry/Petrochemicals Sector

For industry, the BAU scenario assumes that natural gas, electricity, diesel, kerosene, residual fuel oil, as well as refinery gas demand will grow at an AAGR of 1.2% in 2015–2040. The demand growth will slow further to 1% in APS1, which is also 10% below econometric estimates in 2040. the BAU scenario and APS1 remain similar for the other fuels in the industry sector.

The production of ethylene is supposedly tied to policy targets to grow linearly to reach 6 million tons per year by 2020, which translates to 22.2 Mtoe of naphtha produced (EDB, 2012) in the BAU scenario. Naphtha is used as an intermediary fuel to produce petrochemicals mainly stockpiled for exports from Singapore to other countries. Here, we assume that naphtha demand remains constant at 6,099.53 Mtoe on the observation that production figures remain like 2008, having just recovered from a large decline after the financial recession.

4. Outlook Results

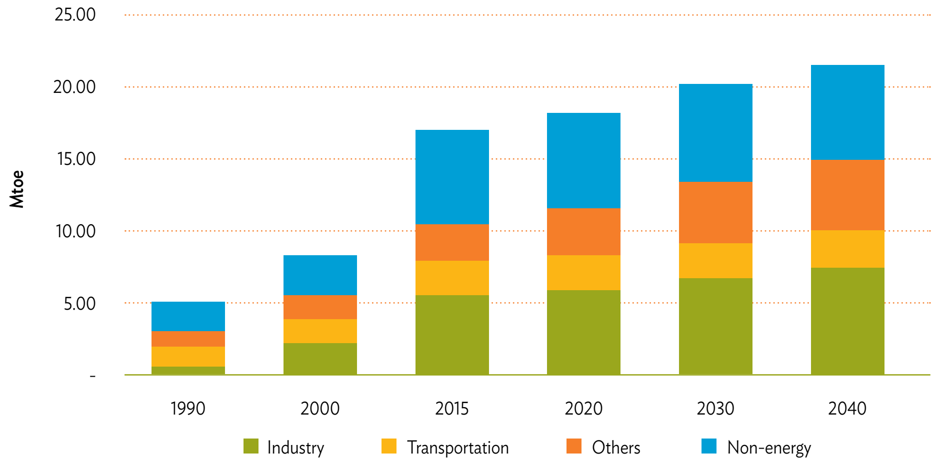
4.1. Business-As-Usual Scenario

4.1.1. Final energy consumption

Singapore's total final energy consumption (TFEC) grew at an annual rate of 5%, from 5.01 Mtoe in 1990 to 17.07 Mtoe in 2015. During the same period, oil was the dominant energy source, with 3.8 Mtoe and 11.59 Mtoe consumed in 1990 and 2015, respectively. About 38.8% of the country's final energy is consumed for non-energy uses in 2015, particularly as feedstock for petrochemical production. In 1990, 27.1% of the TFEC was used in the transport sector although its share declined by almost 50%, reaching around 13.8% only in 2015.

Under the BAU scenario, the TFEC is projected to grow by 0.9% a year between 2015 and 2040. The petrochemical sector is expected to remain stagnant in terms of growth (Figure 15.1). The industry sector's consumption will increase on average by 1.2% per year. The transport sector is projected to grow by 0.3% per year while the 'others' (residential and commercial) sector is projected to grow by 2.7% per year.

Figure 15.1: Final Energy Consumption by Sector, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Under the BAU scenario, industry and non-energy consumption will be dominant in the TFEC. By the end of 2040, non-energy share in the TFEC will decline to 30.9% while the industry sector's share will increase from 32.7% in 2015 to around 34.7% in 2040.

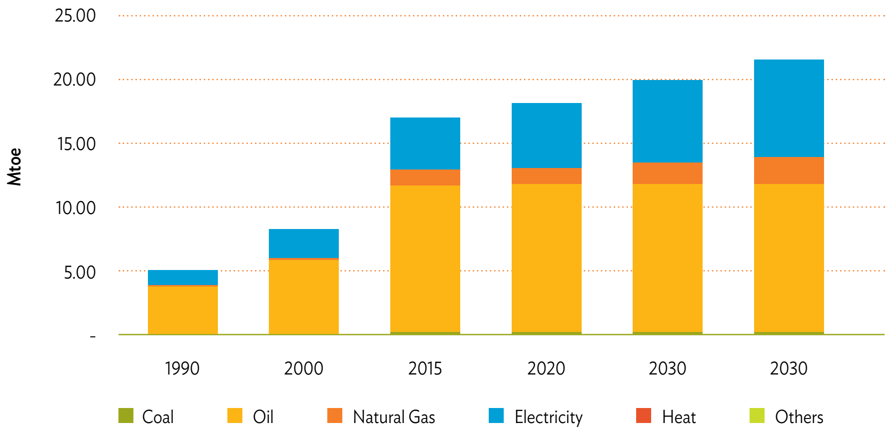
The transport sector's share in the TFEC in 2015–2040 is expected to decrease to 11.7% from its 27.1% share in 1990. This decrease stems from the country's national policies advocating for more efficient automobile technology and the promotion of public transport as the main means of transportation. 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 in 1990–2015 at an average rate of 12.7% per year. The growth of natural gas was due to the increasing demand in its use mainly in the rapidly expanding industry sector. Also, in 1990–2015, electricity consumption grew at an average annual rate of 5.1%.

Under the BAU scenario, the demand for natural gas is expected to continue expanding but at a slower average growth of 2% per year until 2040. Meanwhile, electricity demand will be growing at an average rate of 2.5% per year.

Oil is still expected to play a major role in the country's TFEC. For the past 2 decades, that is, from 1990 to 2015, the share of oil fell from 76.1% to around 67.9%. Under the BAU scenario, oil's share to the TFEC will fall to 64.1% in 2020 before falling further to 54.3% in 2040. This decline is mainly due to the high growth in natural gas use, which will increase from its share of 7.3% in 2015 to 9.5% in 2040. Meanwhile, the share of electricity in the TFEC will increase to around 27.7% starting 2020 before rising further to 35.5% until 2040. Figure 15.2 shows the final energy consumption by fuel.

Figure 15.2: Final Energy Consumption by Fuel Type, BAU (1990–2040)



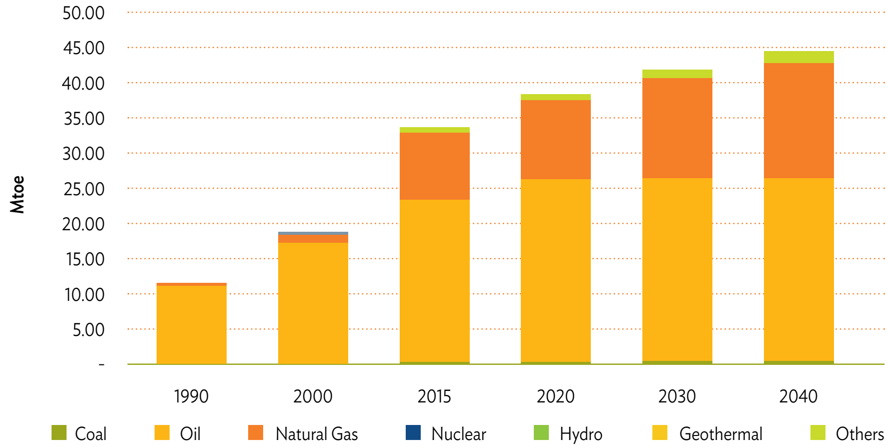
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.1.2. Primary energy supply

Total primary energy supply (TPES) grew by 4.4% per year, from 11.53 Mtoe in 1990 to 33.63 Mtoe in 2015. Singapore's dominant source of energy in 1990 was oil, and its supply increased by 2.9% yearly from 11.44 Mtoe in 1990 to 23.15 Mtoe in 2015. 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 0.4 Mtoe in 1992 to 9.39 Mtoe in 2015.

Figure 15.3: Primary Energy Supply, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Primary energy supply in the BAU scenario is projected to grow by 1.1% per year during 2015–2040 (Figure 15.3). Amongst the energy sources, solar energy is expected to grow the fastest at 3.9% a year, followed by biomass (2.5% per year) and natural gas (2.2% per year). Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

Singapore's net generation capacity has already increased by more than 2,000 megawatts (MW) or about 20% of current installed capacity with more efficient combined-cycle gas turbines (Ministry of Trade and Industry, 2013). Nevertheless, oil is expected to remain the primary energy source, accounting for 58.2% of primary energy supply in 2040, followed by natural gas at 36.4%.

4.1.3. Power generation

Electricity generation grew by 4.8% per year from 15.7 terawatt-hours (TWh) to 50.41 TWh in 1990–2015. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 28% of electricity generation in Singapore in 2001, grew rapidly to supply 95% of Singapore's electricity in 2015. Thermal power generation from fuel oil was around 0.35 TWh in 2015. In the same period, biomass and solar took up a small proportion of the mix, totalling around 3.1%.

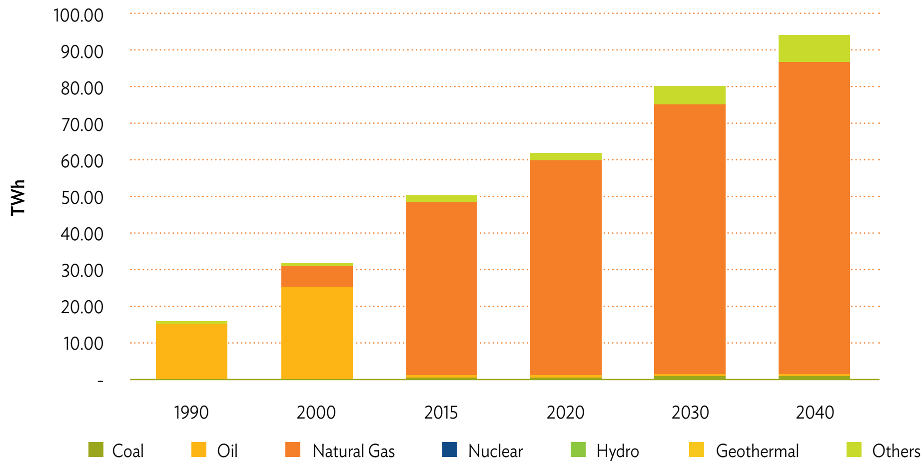
In the BAU scenario, power generation is projected to increase at 2.5% per year as well, reaching 94.54 TWh in 2040. By type of fuel, generation from others, which comprise biomass and solar power, will have the fastest growth at an average rate of almost 6.6%

per year. Power generation of others is expected to increase its share from a minimal share of 3.1% in 2015 to 8.1% in 2040. Coal started to be utilised in 2013 as a substitute for hydrogen and carbon monoxide as feedstock for the energy and petrochemical sectors. It is projected to grow only marginally at 2.5% per year.

After 2015, at least 90% of the country's power generation mix will come from natural gas under the BAU scenario. Its share of the generation mix will gradually decline over time – from 95.0% in 2015 to 90.5% in 2040 – as more solar power is utilised. On the other hand, the share of oil will decline to 0.2% over the same period.

The average thermal efficiency of Singapore's fossil-fuelled power plants was around 30.3% in 1990 and improved to 49.5% in 2015 as more natural gas–fired power plants operated. In the BAU scenario, the thermal efficiency of fossil plants is expected to improve further to around 50.9% in 2040. That of natural gas plants will be 52% in 2040, and that of oil, 42%.

Figure 15.4: Electricity Generation, BAU (1990–2040)



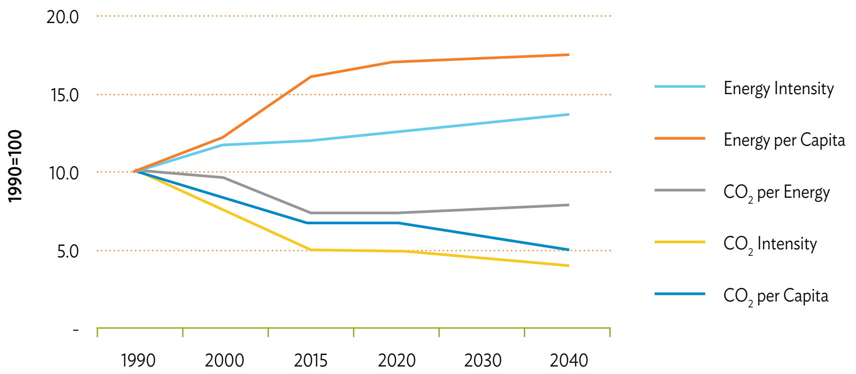
BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

4.1.4. Energy indicators

Primary energy intensity, which is computed as the ratio of primary energy supply over GDP, is expected to decrease. Similarly, final energy intensity of Singapore (ratio of final energy consumption over GDP) will also be declining in 2015–2040. This decrease in energy intensity indicates that Singapore is moving towards a highly economically productive country; that is, less energy will be used to produce each unit of output. Energy and CO_2 per capita increases as population growth is expected to remain lower than fossil fuel demand growth (Figure 15.5).

Figure 15.5: Energy Indicators, BAU (1990–2040)



BAU = Business-As-Usual, CO_2 = carbon dioxide.

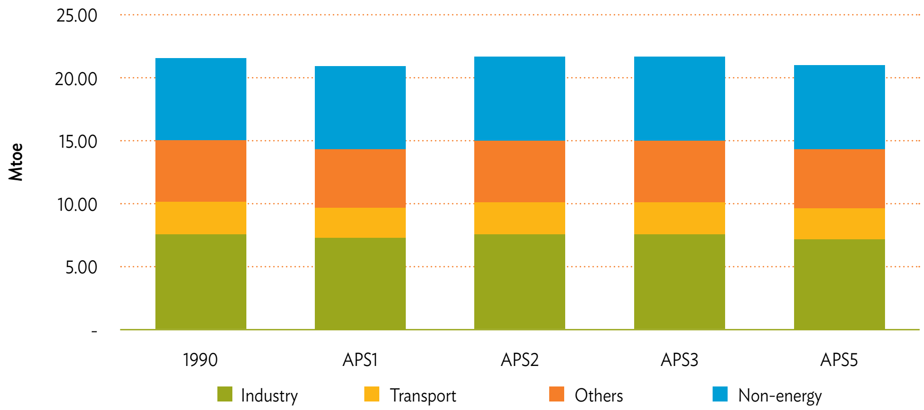
Source: Author's calculation.

4.2. Energy Saving and CO_2 Reduction Potential

4.2.1. Final energy consumption

The TFEC under APS1 is projected to increase by 0.8% from 2015 to 2040. Like the BAU scenario, the non-energy sector grows at 0% per year. The 'others' (residential and commercial) sector grows at 2.5%; this is followed by the industry sector at 1.0% and the transport sector at 0.3%. APS2 and APS3 do not include energy conservation policies for end-demand and, hence, are like the BAU scenario. APS5, a combination of all APS, will have the same final energy consumption as that of APS1 (Figure 15.6).

Figure 15.6: Final Energy Consumption by Sector, BAU and APSs



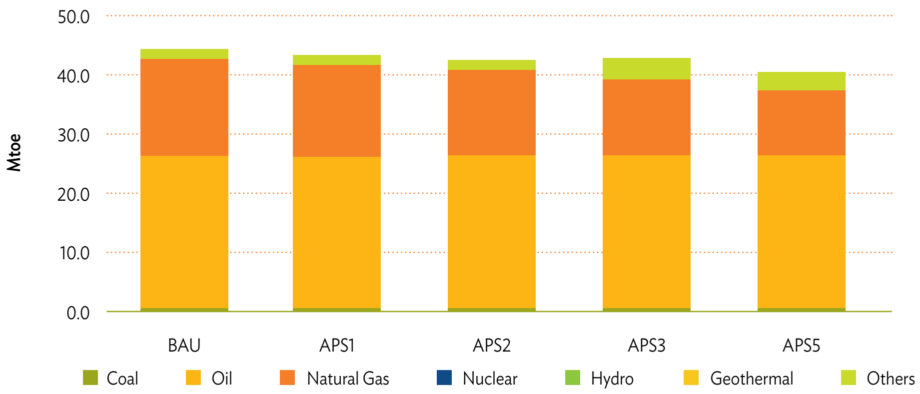
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.2.2. Primary energy supply

Results from APS2 show that the primary energy supply for 2015–2040 will increase at an average annual rate of 0.9%, a 1.89 Mtoe decrease from the BAU scenario (Figure 15.7) in 2040. This translates to a reduction of 4.2% from the BAU scenario in 2040. APS1 and APS3 will help lower primary energy supply by 1.01 Mtoe and 1.5 Mtoe, respectively, in 2040. This illustrates that policies targeting end-user energy efficiency and renewables still play only a secondary role to power generation efficiency policies in reducing primary energy supply.

Figure 15.7: Total Primary Energy Supply by Fuel Type, BAU and APSs

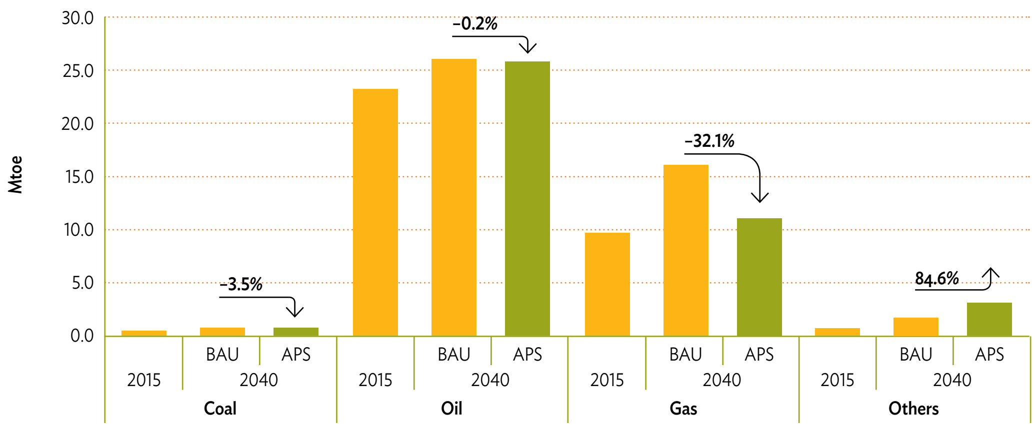


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

Most of the reduction in primary energy supply will come from natural gas at 1.89 Mtoe, which is a drop of 11.7% from the BAU scenario (Figure 15.8). Oil falls only by 0.14% as it is limited by the already-declining the BAU scenario consumption for power generation, as well as the large consumption in petrochemical non-energy use. Biomass consumption will remain relatively constant, whereas solar power progresses significantly but is still small in magnitude. Hence, this leads to increased consumption of others by 84.6%.

Figure 15.8: Primary Energy Supply by Fuel Type, BAU and APS5 (2015 and 2040)



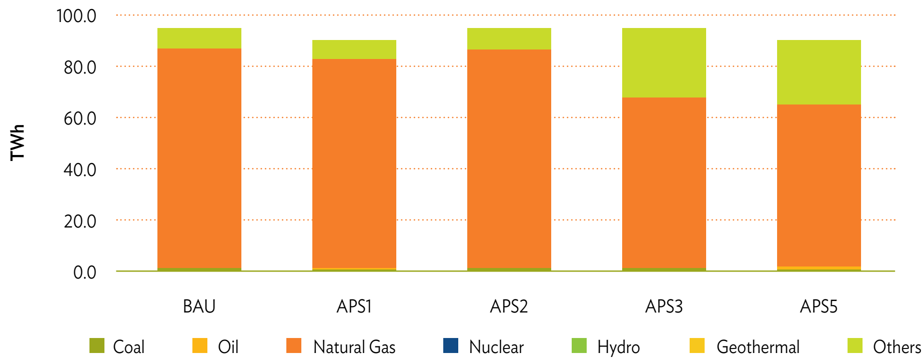
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

4.2.3. Power generation

Results from APS1 and APS5 show decreased electricity generation, registering a drop of 4.4 TWh or 4.7% from the BAU scenario. APS2 and APS3 assume the same generation as the BAU scenario since these do not have energy-saving measures (Figure 15.9).

Figure 15.9: Electricity Generation, BAU and APSs



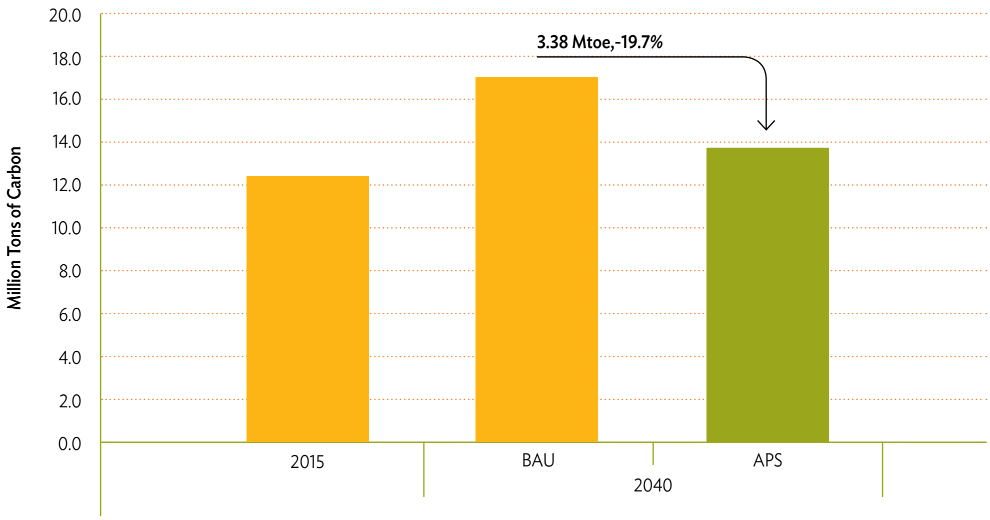
APS = Alternative Policy Scenario, BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculation.

4.2.4. CO_2 reduction potential

Under the BAU scenario, CO_2 emissions from energy demand are projected to increase at an average annual rate of 1.3%, from 12.4 Mt-C in 2015 to around 17.2 Mt-C in 2040 (Figure 15.10).

Figure 15.10: CO_2 Emissions from Energy Supply, BAU and APS5 (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculation.

CO_2 emissions reduction potential comes mainly from improvements in thermal efficiency for power generation (APS2), with savings of 1.21 Mt-C in 2040, equivalent to a 7.1% decrease from the BAU scenario. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with APS1 registering emissions reduction of 0.59 Mt-C in the same period (a 3.4% reduction from the BAU scenario). Increased use of solar power offers large emissions reduction of 2 Mt-C (a 11.7% reduction from BAU). Overall, APS5 will contribute to emissions reduction of 3.38 Mt-C, which is a 19.7% reduction from the BAU scenario. Under this scenario, carbon emissions will increase at an AAGR of 0.4% from 2015 to 2040, compared with 1.3% under the BAU scenario.

5. Implications and Policy Recommendations

The Singapore government has been progressively implementing new strategies to help incentivise and advocate the adoption of clean energy technologies and conservation behaviour amongst industries and households. These programmes include several funding schemes, including the Clean Development Mechanism, Documentation Grant that help provide companies with financial assistance to engage carbon consultancy services, and Grant for Energy Efficient Technologies to help encourage industry investments in energy-efficient equipment or technologies (Energy Efficiency Programme Office, 2013b). Zero-Capex (Capital Expenditure) or similar commercial contracts can also be actively promoted to increase the involvement of energy service companies to help conserve energy.

Solar adoption, an electric vehicle car-sharing programme, as well as smart technologies pave the way to further reduce carbon in industries and households in the future. There is also an initiative to improve the petrochemical industry's energy efficiency and competitiveness by way of a 'heat-integration' plan (Lim, 2013).

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 Singapore transits towards using more natural gas to power its electricity needs. Currently, Singapore plans to increase LNG import storage facilities, and is appointing one or two companies to import LNG for Singapore in the short-term future. Coal use for co-generation, as well as the greater adoption of solar energy, shows efforts made towards fuel mix diversification.

As shown in the forecast results for the BAU scenario with 2015 as the base year, Singapore is already on track to meet its projected 2020 targets of hitting 77.2 million tons of MT-CO_2, (NCCS, 2016c) where estimations show the potential to go as low as 13.42 Mt-C or approximately 50 million tons of MT-CO_2 if much greater efforts are taken to reduce emissions.

Despite the limitations posed by its small size and the paucity of renewable energy sources, Singapore's long-term commitment to building a sustainable city will ensure that the efforts of using energy efficiently and in an environmentally viable manner will continue to receive broad support.

Notes

APS 1 to APS5 are results from an academic exercise and should not be taken to reflect Singapore's national position for climate policies.

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CHAPTER 16

THAILAND COUNTRY REPORT

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1. Background

Thailand is in the middle of Southeast Asia, with the Pacific Ocean on the southeast coast and the Indian Ocean on the southwest coast. Its land area is approximately 513,115 square kilometres, with great plains in the centre, mountainous areas in the north, and highlands in the northeast. Its gross domestic product (GDP) in 2015 was about US$393.7 billion (in constant 2010 US$ terms). In 2015, its population was 65.7 million and income per capita was around US$5,989.

Thailand is an energy importer, especially of crude oil, because of very limited domestic resources. Its indigenous energy resources include natural gas, coal (only lignite), and biomass. In 2015, proven reserves were 0.2 billion barrels (26.1 million cubic metres) of oil, and 7.3 trillion cubic feet (0.21 trillion cubic metres) of natural gas. Proven reserves of lignite amounted to 1,181 million tons but this number was published in 2013.

Thailand's total primary energy supply (TPES) reached 135 million tons of oil equivalent (Mtoe) in 2015. Oil accounted for the largest share at around 38.7%, followed by natural gas (28.1%) and coal (12.5%). 'Others' accounted for the remaining 20.7%. In 2015, net imports of energy accounted for 46.5% of the TPES. Due to very limited indigenous oil resources, Thailand imported around 83.6% of its oil and most of its bituminous coal. Although the country produces large quantities of natural gas, about 29.9% of its use was imported from Myanmar and other countries.

In Thailand, natural gas is used as a major energy source for power generation. In 2015, primary natural gas supply registered at 37.9 Mtoe; around 75.3% of this level was sourced from domestic supply and the rest was imported from neighbouring countries. Liquefied natural gas was also sourced from other countries. Coal was mainly consumed in power generation and industry. It was also heavily used in cement and paper production.

Thailand generated about 165.7 terawatt-hours (TWh) of power in 2015. The majority of the country's power generation used thermal sources (coal, natural gas, and oil), accounting for 91.5% of generation. It is followed by hydro at 3.5% while geothermal, solar, small hydro, and biomass made up the remainder.

2. Modelling Assumptions

GDP growth in 1990–2015 was a moderate 4.2% per year. Thailand's GDP is assumed to grow at an average rate of 3.8% per year in 2015–2040. Population growth is also projected to be reasonably slow at around 0.03% per year in 2015–2040, compared with average growth of about 0.6% per year in 1990–2015.

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 constant. Nuclear power and renewable energy are projected to increase their shares in the power generation mix in the Alternative Policy Scenario (APS).

Thailand expects its energy-saving goals to be achieved through the implementation of energy efficiency programmes in all sectors. In the industry sector, improvements in technology development in manufacturing processes should help improve energy efficiency. In the residential and commercial ('others') sectors, large energy savings are projected, driven by programmes to promote public awareness of energy efficiency and energy efficiency labelling. In the transport sector, further developments 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 phase 2.

Government policies will continue to encourage the increased use of alternative fuels, especially biofuels. Growth of CO_2 emissions is also expected to be reduced through the increased adoption of more energy-efficient and lower-emissions technologies. In particular, in the APS, nuclear power and renewable energy sources are expected to help reduce CO_2 emissions from electricity generation. Gasohol and biodiesel as oil alternatives are also expected to help curb CO_2 emissions from transportation.

3. Outlook Results

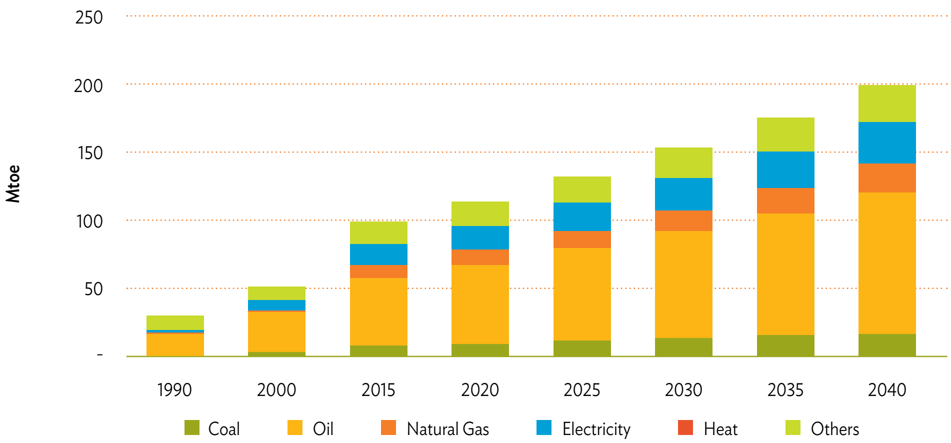
3.1. Business-As-Usual Scenario

In 1990–2015, Thailand's final energy consumption grew at a high rate of 5% per year, from 28.9 Mtoe in 1990 to 98.0 Mtoe in 2015. Given moderate economic growth and low population growth rate, final energy consumption is projected to grow moderately at around 2.9% per year between 2015 and 2040.

Oil was the dominant energy source in final energy consumption, accounting for 49.3 Mtoe, or a 50.2% share, in 2015. Electricity was the second-largest energy source, accounting for 15 Mtoe, or a 15.3% share, in 2015.

Oil is expected to remain the largest final energy source throughout the projection period. Its share is projected to increase from 2015 level to 52% in 2040. In 2040, the shares of electricity will remain the same at the current level, 15.3%, but natural gas and coal in final energy consumption are projected to slightly increase to 10.7% and 8.5%, respectively (Figure 16.1).

Figure 16.1: Final Energy Consumption by Fuel Type, BAU (1990–2040)

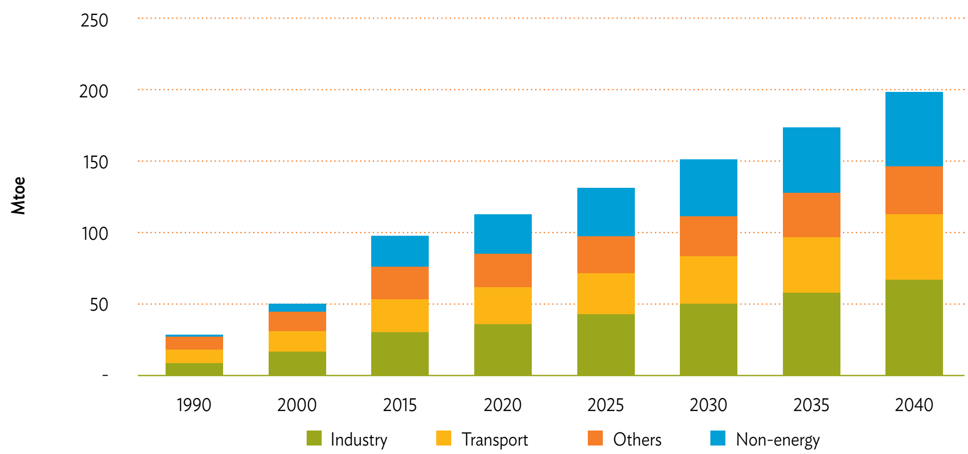


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

The industry sector has the smallest share, 8.7 Mtoe, in the total final energy in 1990. While consumption in the sector highly increased at an average rate of 5.2% a year in 1990–2015, the share of industry increased from 30.0% in 1990 to 31.2% in 2015, making it the largest consuming sector. The industry sector is projected to remain the largest consumer, accounting for 34.1% in the final energy consumption in 2040. In addition, non-energy use, which consists mainly of naphtha, will also increase its consumption like the industry sector. As a result, the 'others' (residential and commercial) sector, will account for the smallest proportion of final energy consumption at 17.2% in 2040, showing the declining trend of its share as has been observed since 1990.

Figure 16.2: Final Energy Consumption by Sector, BAU (1990–2040)



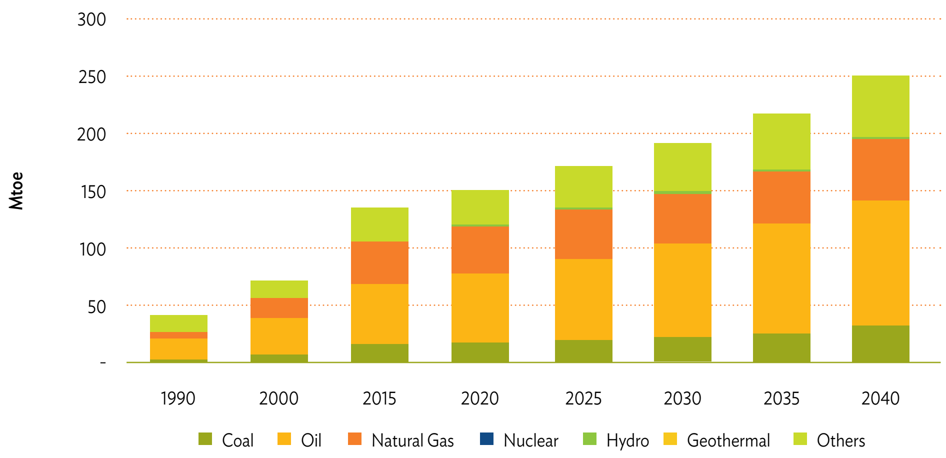
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

Primary energy supply grew at an average annual rate of 4.7%, from 42.6 Mtoe in 1990 to 135.0 Mtoe in 2015, driven largely by fast economic development between 1990 and 1996 and moderate economic growth after 1997. This growth in primary energy supply was achieved despite the severe economic crisis in 1997–1998 and the world economic crisis in 2008. In 2015, the major sources of primary energy were oil, natural gas, and coal with shares of 38.7% (52.3 Mtoe), 28.1% (37.9 Mtoe), and 12.5% (16.8 Mtoe), respectively. Although oil remained the largest source in 1990–2015, its share in primary energy demand declined a little from 42.1% in 1990 to 38.7% in 2015. Natural gas, which is mainly consumed in the power generation sector, became an important source of energy with its share in primary energy demand increasing significantly from 11.7% in 1990 to 28.1% in 2015. Contrastingly, the share of hydropower declined from 1.0% in 1990 to only 0.4% in 2015 (Figure 16.2).

In the Business-As-Usual (BAU) scenario, primary energy demand is projected to grow at about 2.5% per year from 2015 to 2040, reaching 250.8 Mtoe in 2040. The highest average annual growth rate is expected in oil (3%), with consumption expected to reach 109.1 Mtoe in 2040, followed by coal and natural gas. The growth rate of coal is expected to be around 2.8% in 2015–2040. Natural gas growth is expected to be slower than that of primary energy demand. Its average growth rate is about 1.4% per year between 2015 and 2040.

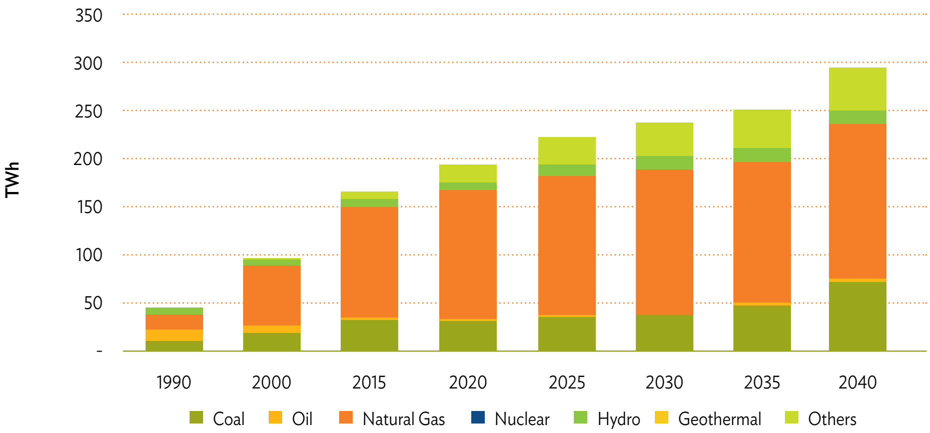
Figure 16.3: Primary Energy Supply by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.
Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

In 1990, total power generation registered at 44.2 TWh and reached 167.7 TWh in 2015 with an average growth rate of 5.4% per year. Figure 16.4 shows that natural gas has been a major fuel for power generation since 1990. Natural gas power generation grew with a robust rate of 7.8% per year from 17.8 TWh (40.2% share) in 1990 to 117.0 TWh (70.6% share) in 2015. Coal has the second-largest share at 25.0% in 1990, but its share shrank to 19.9% in 2015. Power generation by oil was the smallest, with only 1.7 TWh in 2015.

Figure 16.4: Power Generation by Fuel Type, BAU (1990–2040)



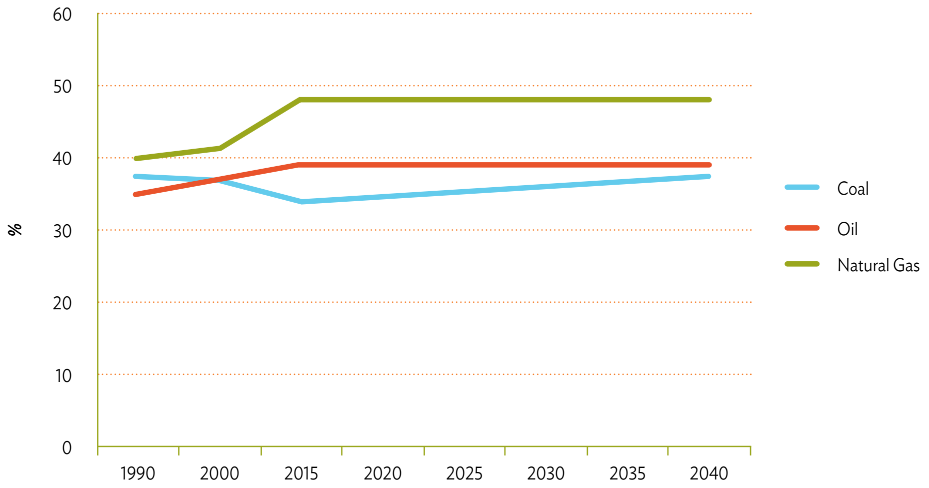
BAU = Business-As-Usual, TWh = terawatt-hours.

Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

In the BAU scenario, power generation is expected to grow at around 2.3% per year in 2015–2040 and will reach 294.6 TWh in 2040. In 2040, natural gas will remain to be a dominant fuel in power generation, with the highest share of 54.6% or 161.0 TWh. Coal will still be the second-largest source of power with 24.4% share, or 71.8 TWh during the period. Power generation from hydro will increase slightly by 3.8% per year, from 5.8 TWh in 2015 to 14.6 TWh in 2040 (Figure 16.4).

Thermal efficiency of natural gas improved the highest improvement as combined cycle gas turbines technology was applied. The 40.0% efficiency of natural gas in 1990 jumped to 47.9% in 2015 and is expected to remain unchanged until 2040. Coal thermal efficiency declined almost 4.0% from 1990 to 2015, but the efficiency is also assumed to improve from 33.9% in 2015 to 37.3% in 2040 (Figure 16.5).

Figure 16.5: Thermal Efficiency by Fuel Type, BAU (1990–2040)

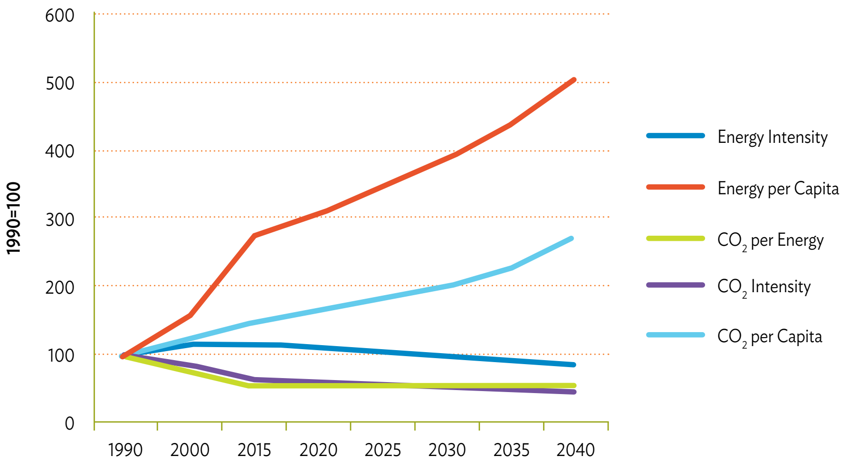


BAU = Business-As-Usual.

Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

Energy intensity reached 343 toe/million at 2010 US$ in 2015. In the BAU scenario, energy intensity is projected to decline by 1.2% per year to reach 251 toe/million 2010 US$ in 2040. Energy per capita will move upward from 2.1 toe per person in 2015 to 3.8 toe per person in 2040 (Figure 16.6).

Figure 16.6: Energy Indicators (1990–2040)



Sources: 1990–2015 compiled by IEA (2017), 2020–2040 compiled by author.

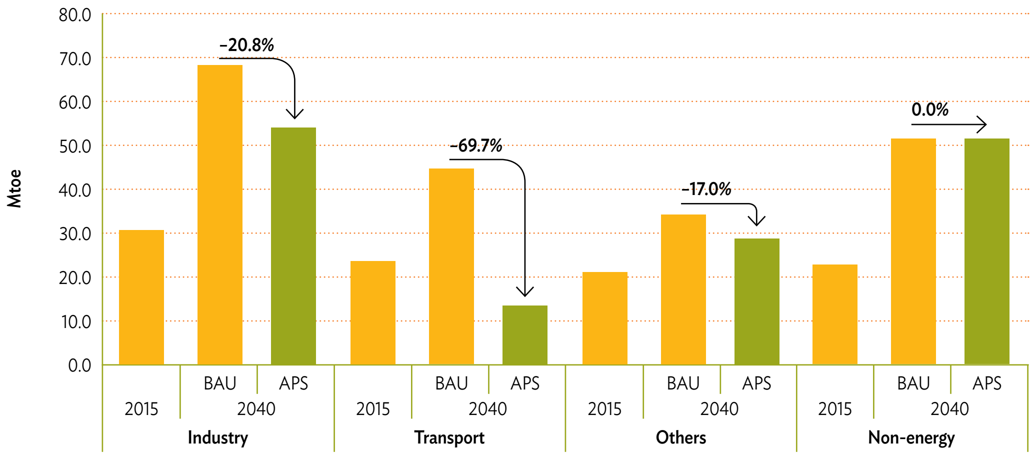
Energy elasticity in 1990–2015 was 1.2, indicating that energy demand rose faster than economic growth. In the BAU scenario, energy elasticity is projected at 0.8 between 2015 and 2040. It means that energy demand will grow at a slower rate than economic output.

3.2 Energy Saving and CO_2 Reduction Potential

3.2.1 Final Demand

In the APS (APS5), final energy consumption is projected to grow at 1.6% per year, from 98.0 Mtoe in 2015 to 147.2 Mtoe in 2040. This is lower by 25.8% than the BAU scenario, which will grow at an average annual rate of 2.9% in 2040. The majority of energy savings will be achieved through energy efficiency improvement programmes implemented in the industry (20.8%) and the transport (69.7%) sectors. Improvements will also be achieved in the 'others' sector (17%) (Figure 16.7).

Figure 16.7: Final Energy Consumption by Sector, BAU and APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

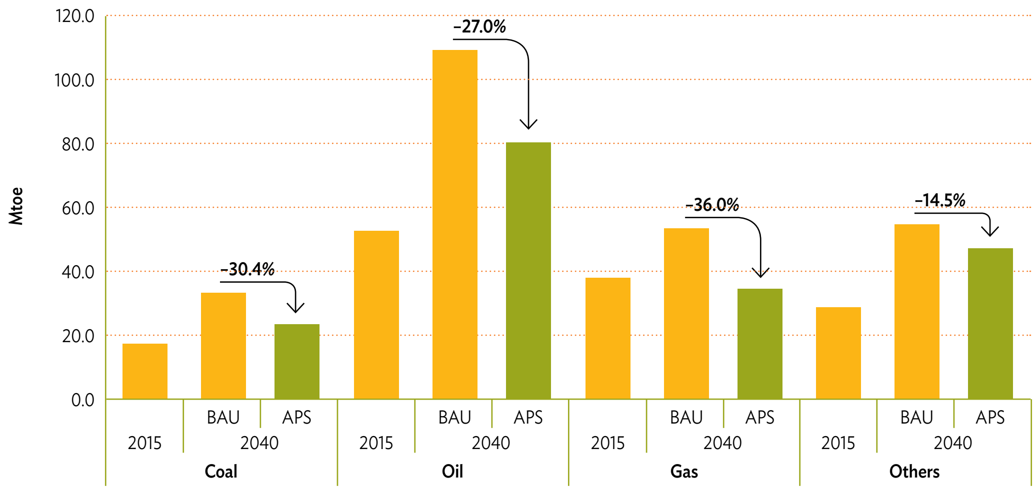
Sources: 2015 compiled by IEA (2017), 2040 compiled by author.

3.2.2 Primary Energy Supply

In the APS, growth in primary energy supply is projected to be much slower than in BAU, increasing at 1.2% per year (compared with 2.5% in the BAU scenario) to reach 184 Mtoe in 2040. Primary energy supply is expected to be about 26.6% lower than in the BAU scenario in 2040, an energy saving of about 66.8 Mtoe.

Oil and coal are projected to increase at slower average annual rates of 1.7% and 1.3%, respectively (3.0% and 2.8% in the BAU scenario). Natural gas is projected to decrease at an average annual rate of -0.4% (1.4% in the BAU scenario) from 53.4 Mtoe in 2015 to 34.2 Mtoe in 2040. The lower growth rates compared to the BAU scenario 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 Demand by Source, BAU and APS (2015 and 2040)



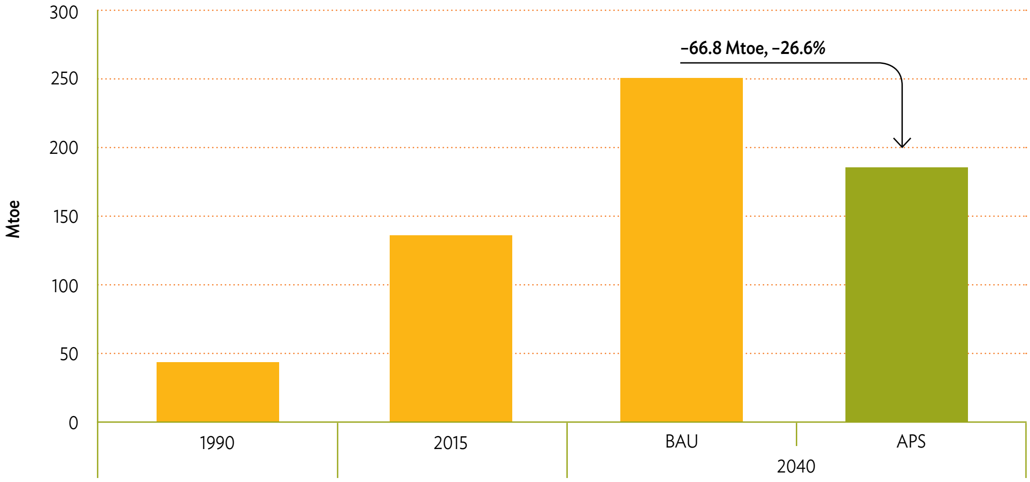
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Sources: 2015 compiled by IEA (2017), 2040 compiled by author.

3.3 Projected Energy Savings

The difference between primary energy supply in BAU and the APS in 2040 is 66.8 Mtoe (Figure 16.9). This represents the potential energy savings that could be achieved if energy efficiency and conservation goals and action plans were implemented. Oil will contribute the largest energy savings at 29.4 Mtoe. Meanwhile, energy savings from natural gas and coal will reach 19.2 Mtoe and 10.1 Mtoe, respectively, in 2040. However, the contribution of non-fossil energy sources will also be 10.6 Mtoe lower than in the BAU scenario.

Figure 16.9: Total Primary Energy Supply, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Sources: 1990 and 2015 compiled by IEA (2017), 2040 compiled by author.

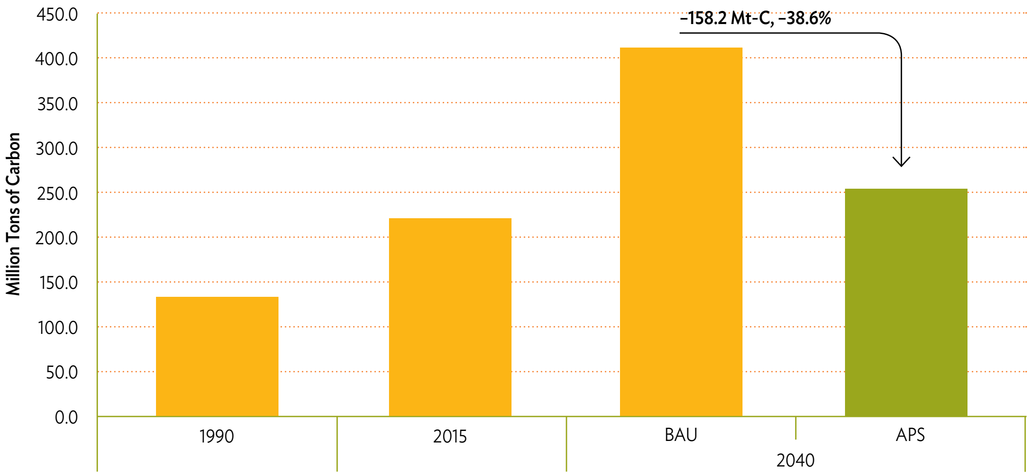
In final energy consumption, the savings in the APS in 2040 will reach 51.1 Mtoe. The largest savings are expected to be achieved in the transport sector at 31.3 Mtoe. On the other hand, the industry and the 'others' sectors are expected to save 14.1 Mtoe and 5.8 Mtoe of energy, respectively.

3.4 CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 2.5% per year on average, from 220.6 million tons of carbon (Mt-C) in 2015 to 410.1 Mt-C in 2040 under the BAU scenario.

Under the APS, the average annual growth in CO_2 emissions in 2013–2040 is projected to be 0.5%, with emissions level of 252 Mt-C in 2040. The difference in the CO_2 emissions between the BAU scenario and the APS is 158.2 Mt-C or 38.6%. This reduction in CO_2 emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans as well as shifting to lower carbon energy (Figure 16.10).

Figure 16.10: CO_2 Emissions from Energy Consumption, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Sources: 1990 and 2015 compiled by IEA (2017), 2040 compiled by author.

3.5 Thailand's Intended Nationally Determined Contributions (INDC)

3.5.1 Thailand's INDC in Greenhouse Gases

Thailand submitted its INDC in greenhouse gas to the United Nations Framework Convention on Climate Change on 1 October 2015. The target of greenhouse gas reduction, according to its INDC, would be 20% off from BAU by 2030; this was forecast nationally in 2005. CO_2 emissions in the BAU scenario were estimated at 555 Mt-C in 2030. Consequently, the INDC also targets reduced CO_2 of 113 Mt-C in the energy sector.

3.5.2 INDC Achievement and the APS

Under the APS, carbon emission reduction in 2030 was estimated at 80 Mt-C, about 227 Mt-C lower than 307 Mt-C of the BAU scenario (East Asia Summit outlook). This reduction amount of 80 Mt-C is equal to 288 Mt-C. In this regard, the APS's CO_2 reduction targets can be achieved through the INDC targets (reduction of 113 Mt-C) in the energy sector. Thailand's policy on energy savings should be satisfied adequately based on the target of CO_2 reduction commitment described in its INDC.

4. Implications and Policy Recommendations

Strong economic growth before the 1997 Asian financial crisis contributed to relatively high energy intensity in Thailand in 1990–2011. However, energy intensity has declined since the economy recovered from the 1997 crisis. Furthermore, Thailand's energy efficiency programmes in a wide range of areas (including the industry, transport, and building sectors) and higher oil prices in the world market will contribute to a continued decline in energy intensity.

Improving energy efficiency will also help Thailand (which is an oil importer) address the challenges posed by high world oil prices. Thailand is committed to reduce the intensity of energy consumption, particularly oil consumption, and is looking for more sustainable energy sources and environment-friendly fuels. The more Thailand saves energy, the less sensitive it will be to fluctuations in world energy prices and supply. Furthermore, Thailand has realised that energy savings is important; thus, the country should put more effort into it.

Although the country has an alternative policy for the next 23 years, oil will remain a major energy source. Oil is one of the most sensitive energy sources in terms of price and security. Thailand should focus more on saving oil to be less dependent on this fuel. Furthermore, energy use in the transport sector will become the smallest in the future compared to other sectors. Nonetheless, this sector is also less productive than the others. It means that it consumes more energy, but adds less value. The more energy saving effort in the transport sector, the more benefit it will be for the economy as a whole.

CHAPTER 17

VIET NAM COUNTRY REPORT

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1. Background

Viet Nam has a total land area of about 331,111 square kilometres and lies in Southeast Asia. In 2015, its population was 91.7 million and its gross domestic product (GDP) was $154.5 billion in 2010 US$ terms. The commercial sector contributes the most to Viet Nam's GDP (38.3%), followed by the industry sector (34.2%), agriculture (16.1%), and 'others' (11.4%). GDP per capita was US$1,685 in 2015.

Viet Nam possesses considerable indigenous energy resources. It has 3,390 million tons of proven recoverable reserves of coal, 460 million cubic metres of crude oil reserves, and 610 billion cubic metres of gas reserves.

Viet Nam's total primary energy supply (TPES) was 70.1 million tons of oil equivalent (Mtoe) in 2015. Coal represented the largest share of the country's TPES at 35.9%; oil was second at 22.2%, followed by natural gas (13.7%), hydro (7.8%), and others (20.3%). Viet Nam is a net exporter of crude oil and coal but is an importer of petroleum products because of limited capacity at the Dung Quat oil refinery (6.5 million tons a year) that could meet around 45% of domestic demand.

Coal is mainly used in the industry sector with consumption of 25.2 Mtoe in 2015, while natural gas is largely used to generate electricity.

Viet Nam had around 38.5 gigawatts (GW) of installed generating capacity and produced 159.8 terawatt-hours (TWh) of electricity in 2015. Most of its electricity generation comes from thermal sources (coal, natural gas, and oil), accounting for 60.2% of total generation; the remaining is hydro (39.5%) and others (around 0.3%).

2. Modelling Assumptions

In this outlook, Viet Nam's GDP is assumed to grow at an average annual rate of 6.0% from 2015 to 2040. Growth is projected to be faster in the first outlook period, increasing at 7% per year between 2015 and 2020. For the remaining periods of 2020–2030 and 2030–2040, the country's economic growth will moderate to an annual rate of 6.2% and 5.2%, respectively. Population growth is projected to increase at a much slower rate, increasing by 0.6% per year between 2015 and 2040.

The share of electricity generated from coal-fired power plants is projected to increase considerably because of the expense of other energy types (natural gas and hydro). 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 3%–5% of total energy consumption, equivalent to 5 Mtoe, between 2006 and 2010, and 5%–8% of total energy consumption, equivalent to 13.1 Mtoe between 2010 and 2015, in line with the national target on energy efficiency and conservation (EEC).

In 2010, the Law on Energy Efficiency and Conservation, approved by the National Assembly, focused on priority policies, such as (i) increasing the use of renewable energy in line with Viet Nam's potential and conditions, (ii) contributing to energy security and environmental protection, and (iii) promoting energy efficiency in production and residential areas through regulations and technological measures on energy efficiency and renewable energy.

In November 2015, the Renewable Energy Development Strategy of Viet Nam was approved by the Prime Minister's Decision[1] to accelerate the expansion and use of renewable energy sources; gradually increase renewable energy share in national energy production and consumption and ensure less dependence on fossil sources; and contribute to better energy security, mitigating climate change, environmental protection, and sustainable socio-economic development.

[1] Decision No. 2068/QD-TTg issued on 25 November 2015 to approve the Vietnam Renewable Energy Development Strategy to 2030 outlook up to 2050 (in Vietnamese).

The strategic targets are:

- Increase the share of renewable energy-based electricity to 4.5% in 2020, 15% in 2030, and 33.1% in 2050.
- Increase the proportion of households using solar water-heating devices to 12% in 2020, 26% in 2030, and 50% in 2050.
- Scale up the application of biogas technologies with a construction volume of from about 4 million cubic metres (m^3) in 2015 to 8 million m^3 in 2020, to approximately 60 million m^3 in 2030, and 100 million m^3 in 2050.
- Increase the production of biofuels to meet the transport sector's fuel demand: 5% in 2020, 13% in 2030, and 25% in 2050.

From the above analysis, in this study, Alternative Policy Scenarios (APSs) are proposed: EEC scenarios (APS1), improvement of energy efficiencies in power generation (APS2), and development of renewable energy (APS3).

- **APS1:** Develop EEC scenarios in potential sectors on the demand side, including:
    - o **Industry:** Improve technologies in making cement, bricks, non-baked bricks, iron, and steel. For the remaining other industries, EEC measures are assumed to be implemented to reduce energy consumption by around 15% by 2040.
    - o **Transport:** Implement EEC measures such as passenger transport mode shift from private to public, freight transport switch from road, and increased penetration of electric vehicles.
    - o **Residential:** Replace inefficient devices with efficient ones, such as high-efficient lamps in lighting, efficient refrigerators, and air conditioners in cooling homes.
    - o **Commercial:** Use EEC measures in the commercial sector to reduce 12% of energy consumption by 2040.

- **APS2:** Improve energy efficiency in thermal power plants
  The efficiency of coal-fired thermal power plants is assumed to increase to 40% by 2040 compared with 38% in the Business-As-Usual (BAU) scenario, while natural gas with combined cycle gas turbines technologies will increase to 60% by 2040 compared with 52% in the BAU scenario.

- **APS3:** Develop renewable energy technologies
  Installed electricity generating capacity from renewable energy is assumed to reach 40,200 megawatts (MW) in 2040 with solar photovoltaic contributing 20,000 MW; wind,10,000 MW; small hydro, 5,000 MW; biomass,5,000 MW; and biogas, 200 MW.

  Moreover, the Renewable Energy Development Strategy has set the targets for using biofuels in the transport sector, solar water heaters in the residential sector, and biogas cook stoves in rural areas to reduce dependency on oil and curb CO_2 emissions. Therefore, it is assumed that by 2040, the share of households using solar water-heating devices in urban and rural areas would reach 60% and 25%, respectively, biogas cook stoves in rural areas would reach 15%; and the substitution of ethanol for gasoline in the transport sector would reach around 20%.

- **APS5:** Combining from APS1 to APS3.

3. Outlook Results

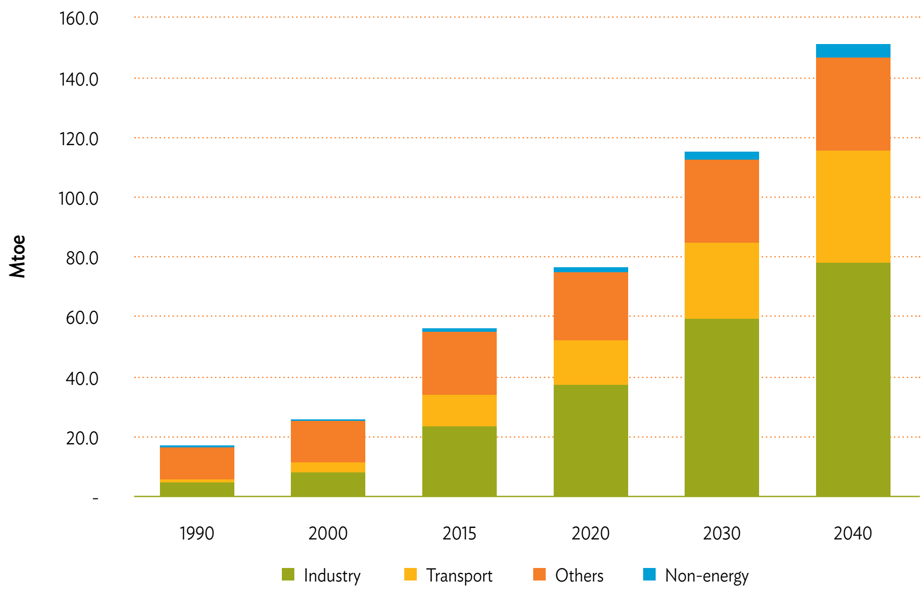
3.1. Business-As-Usual Scenario

3.1.1. Total final energy consumption

Viet Nam's total final energy consumption (TFEC) in 2015 was 56.3 Mtoe, which has increased at 5.1% per year, 3.5 times more than its 1990 level of 16.1 Mtoe. On a per sector basis, the fastest growth occurred in the transport sector (8.4% per year), followed by the industry sector (6.8%), and the residential/commercial ('others') sector (3.0% per year). Non-energy use is expected to grow at 16.3% per year.

For 2015–2040, the TFEC is projected to increase at an average rate of 4% per year under the BAU scenario. Growth is driven by strong economic growth, which is assumed to be at an average annual growth rate of 6.0%, and the rising population at an average annual growth rate of 0.6%. On a per sector basis, the strongest growth in consumption is projected to occur in transport, increasing by 5.2% per year. This is followed by the industry sector (4.9% per year) and the residential/commercial ('others') sector (1.6% per year). Non-energy use is expected to grow at 5.1% per year. Figure 17.1 shows the final energy consumption by sector from 1990 to 2040.

Figure 17.1: Final Energy Consumption by Sector, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons 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 will decrease from 37.2% in 2015 to 20.7% by 2040 due to the substitution of biomass fuels by commercial fuels with higher efficiency. The decreasing share of the sector is due to the growing economy. Economic growth will translate to improvements in the standard of living, thus, increasing the transition from biomass to modern fuels.

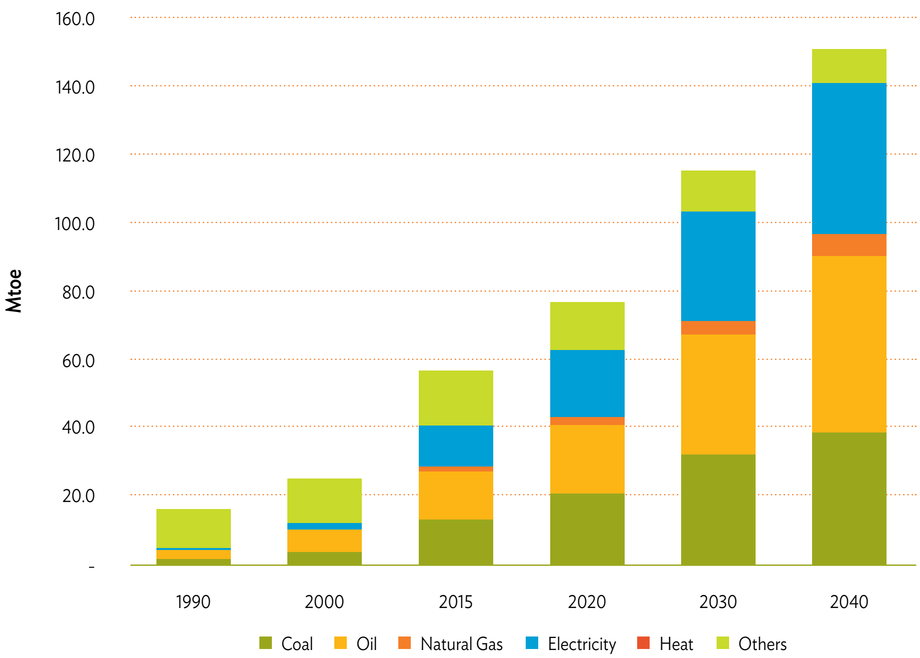
Starting from 2015 up to 2040, the industry sector will be the largest consuming sector in Viet Nam. The share of energy consumption in the industry sector will increase from 42.0% in 2015 to 51.6% in 2040. The smaller consumer is the transport sector although its share will increase slowly from 18.6% in 2015 to 24.9% in 2040.

Meanwhile, other fuels (mostly biomass) are the most-consumed product, accounting for 73.9% of the TFEC in 1990; however, this declined to 28.1% in 2015. Oil was the second most-consumed product, accounting for 14.5% of the TFEC in 1990 and increasing to 25.3% in 2015. The share of coal consumed from 1990 to 2015 increased from 8.3% to 22.5%. Electricity had a small share of 3.3% in 1990 but increased significantly to 21.6% in 2015.

On a per fuel basis under the BAU scenario, natural gas is projected to exhibit the fastest growth in final energy consumption, increasing at 6.1% per year between 2015 and 2040. Electricity and oil are projected to have the second-highest growth rate of 5.3% per year, followed by coal at 4.5%. Other fuels (mostly biomass) are projected to decrease at an annual rate of 1.8% due to the transition from biomass to modern fuels.

Other fuels (dominated by biomass) had the largest share at 28.1% in 2015 but this share will reduce significantly to 6.7% in 2040. Oil products had the second-largest share of 25.3% in 2015; this share is projected to increase to 34.3% in 2040. The third-largest share of demand is coal, which is projected to increase from 22.5% in 2015 to 25.4% in 2040. On the other hand, electricity and natural gas were used primarily in the industry sector with shares of 21.6% and 2.6% in 2015, respectively. In 2040, the shares of electricity and natural gas will increase up to 29.2% and 4.3%, respectively (Figure 17.2).

Figure 17.2: Final Energy Consumption by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

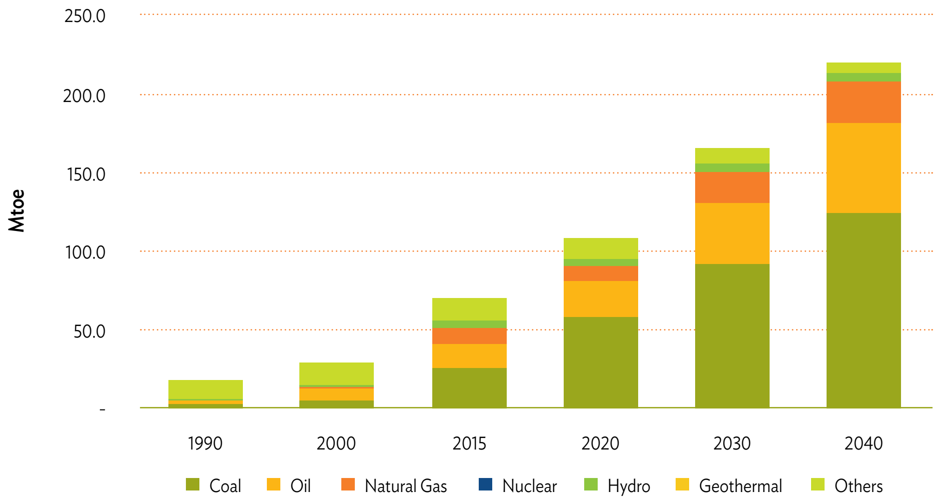
Source: Author's calculations.

3.1.2. Total primary energy supply

Viet Nam's total primary energy supply (TPES) grew at a higher rate than final energy consumption; it increased at 5.6% per year or 3.9 times, from 17.9 Mtoe in 1990 to 70.1 Mtoe in 2015. Amongst the major energy sources, the fastest-growing were natural gas, hydro, coal, and oil. Natural gas consumption grew at an average annual rate of 38.1% between 1990 and 2015 while hydro, coal, and oil grew at 10.4%, 10.2%, and 7.2% per year, respectively.

In the BAU scenario, Viet Nam's TPES is projected to increase at an annual rate of 4.7% or 3.1 times, from 70.1 Mtoe in 2015 to 219.9 Mtoe in 2040. The fastest growth is expected in coal, increasing at an annual average rate of 6.6% between 2015 and 2040, followed by oil (5.4%) and natural gas (4.1%) while hydro and other fuels (mostly biomass) will decrease slightly and strongly at 0.2% and 2.9% per year, respectively. Figure 17.3 shows the primary energy supply by source in 1990–2040.

Figure 17.3: Primary Energy Supply, BAU (1990–2040)



BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

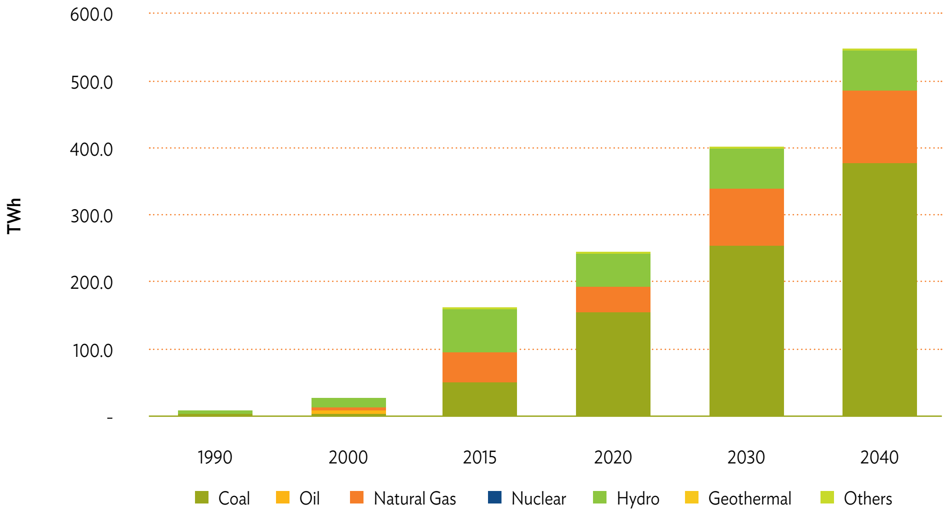
Coal accounted for the largest share of 35.9% of the TPES in 2015 and will increase to 56.2% in 2040. The share of oil was 22.2% in 2015 and will increase to 26.3% in 2040. This growth is due to the projected decline of natural gas (from 13.7% to 12.1%), hydro (from 7.8% to 2.3%), and others (from 20.3% to 3.1%).

3.1.3. Power generation

Power generation output increased at 12.4% per year or 18.4 times, from 8.7 TWh in 1990 to 159.8 TWh in 2015. The fastest growth occurred in natural gas power generation (42.9% per year), followed by coal (13.8%) and hydropower (10.4% per year). This fast growth is due to the 5.8% decrease of oil.

Power generation is projected to increase at an average rate of 5% per year, or 3.4 times between 2015 and 2040, to meet electricity demand under the BAU scenario. The fastest growth will be in coal power generation (8.3% per year), followed by natural gas (3.6% per year). This fast growth is due to the decrease of hydro, oil, and other (mostly small hydropower). Figure 17.4 shows the power generation output by the type of fuel under the BAU scenario from 1990 to 2040.

Figure 17.4: Power Generation by Fuel Type, BAU (1990–2040)



BAU = Business-As-Usual, TWh = terawatt-hour.

Source: Author's calculations.

By the end of 2015, the majority of the country's power came from hydropower, which comprised about 39.5% of the total power generation mix. The share of coal-fired power generation was around 31.9% while the rest were from natural gas (28.1%), oil (0.2%), and other power generation (around 0.3%).

In the BAU scenario, coal will be the major fuel used for power generationbetween 2020 and 2040, with its share increasing from 64.0% in 2020 to 68.9% in 2040. On the other hand, the share of hydro in the total power generation will decline from 20.4% in 2020 to around 11.0% in 2040.

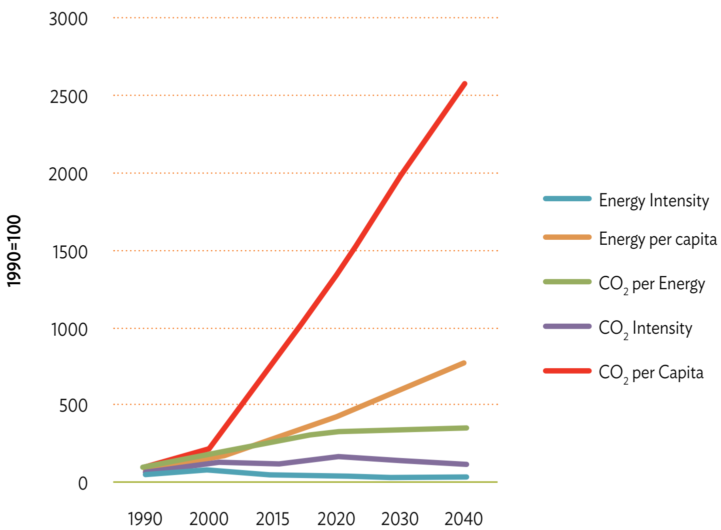
3.1.4. Energy indicators

From 1990 to 2015, Viet Nam's energy intensity showed a decreasing trend. Both primary and final energy intensities of the country decreased from 1,006 toe/million and 905 toe/million 2010 US$ in 1990 to 453 toe/million and 364 toe/million 2010 US$ in 2015. This was due to the high economic growth, which significantly reduced the use of biomass fuels in the residential sector, although the energy requirement in the industry and the transport sectors had been increasing in recent years. The final energy intensity under the BAU scenario is estimated to continue the decreasing trend from 364 toe/million to 228toe/million 2010 US$ by 2040. This decreasing trend indicates that energy will be used efficiently for economic development.

Meanwhile, the primary energy per capita increased from 0.27 toe/person in 1990 to 0.76 toe/person in 2015; it will continue to increase to 2.06 toe/person by 2040. This indicates that, in the future, living standards and people's incomes will increase, resulting in rising total primary energy consumption (TPEC) per capita.

Regarding greenhouse gas (GHG) emissions, CO_2 intensity and CO_2 per energy increased from 265 t-C/million 2010 US$ and 0.26 t-C/toe in 1990 to 317 t-C/million 2010 US$ and 0.7 t-C/toe in 2015, respectively. In the BAU scenario, CO_2 intensity and CO_2 per energy will also slightly increase by 2020 at 417 t-C/million 2010 US$ and 0.84 t-C/toe. Beyond 2020, CO_2 intensity will decline until 2040 at 295 t-C/million 2010 US$, while CO_2 per energy will slightly increase at around 0.89 t-C/toe. CO_2 per capita will continuously increase due to energy demand rising faster than population growth. (Figure 17.5).

Figure 17.5: Energy Indicators (1990–2040)



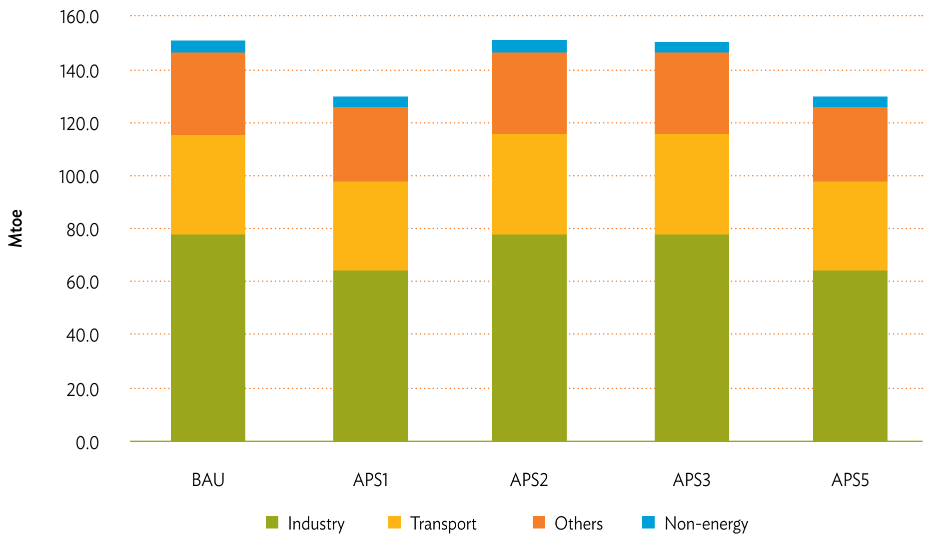
Source: Author's calculations.

3.2. Energy Savings and CO_2 Reduction Potential

3.2.1. Total final energy consumption

In the Alternative Policy Scenario (or APS5, the TFEC is projected to increase at a slower rate of 3.4% per year (compared with 4.0% in the BAU scenario), from 56.3 Mtoe in 2015 to 130.2 Mtoe in 2040 because of EEC measures (APS1) in the industry, transport, and 'others' sectors. The total final consumption by sector in APSs compared to the BAU scenario is presented in Figure 17.6.

Figure 17.6: Total Final Energy Consumption by Sector in BAU and APSs



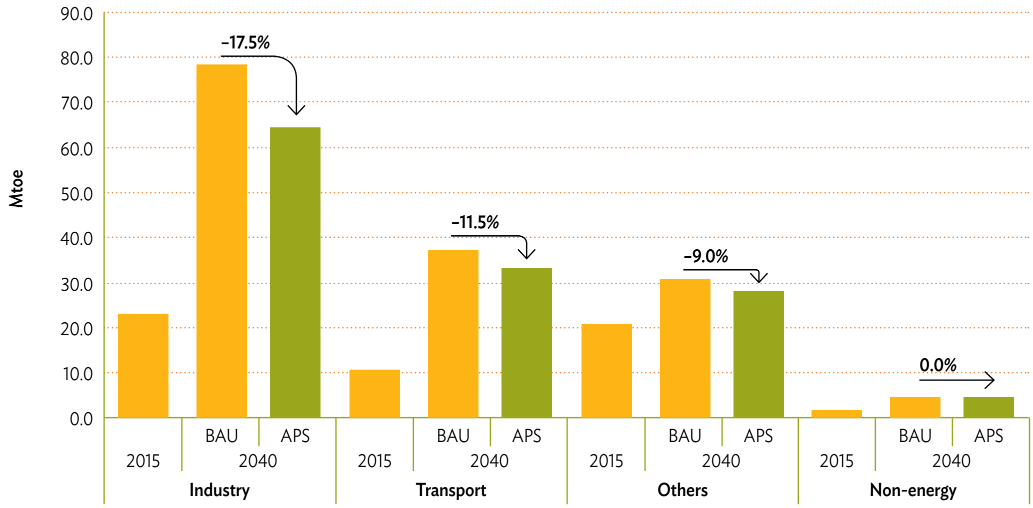
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

The bulk of the savings are expected to occur in the industry sector with 13.7 Mtoe (equivalent to 17.5% reduction), followed by the transport sector with 4.3 Mtoe (equivalent to 11.5% reduction), and the 'others' sector with 2.8 Mtoe (equivalent to 9.0% reduction).

An improvement in end-use technologies and the introduction of energy management systems are expected to contribute to the slower rate of consumption growth, particularly in the industry, transport, and 'others' sectors (Figure 17.7).

Figure 17.7: Final Energy Consumption, BAU vs APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

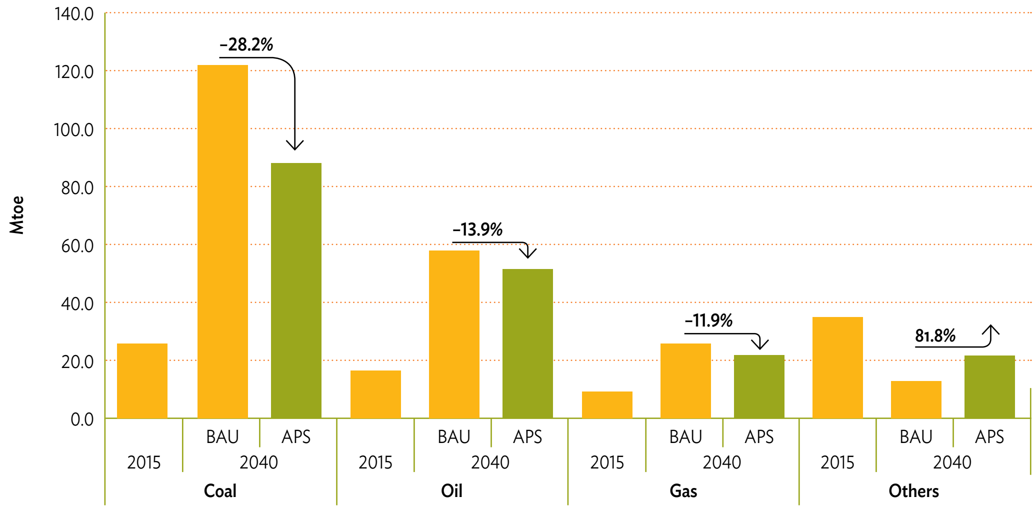
Source: Author's calculations.

3.2.2. Total primary energy supply

In APS5, the TPES is projected to increase at a slower rate of 3.9% per year, from 70.1 Mtoe in 2015 to 183.7 Mtoe in 2040. Coal is projected to grow at the highest average annual rate of 5.2% compared with 6.6% in the BAU scenario. This is followed by oil (4.8%) and natural gas (3.6%), compared with 5.4% and 4.1% in the BAU scenario, respectively, over the same period.

The slower growth in consumption, compared to the BAU scenario, 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. Coal has the highest energy savings potential with 28.2%, followed by oil (13.9%) and natural gas (11.9%). Figure 17.8 shows the primary energy saving potential by fuel under the BAU scenario and APS.

Figure 17.8: Primary Energy Saving Potential by Fuel Type, BAU and APS (2015 and 2040)

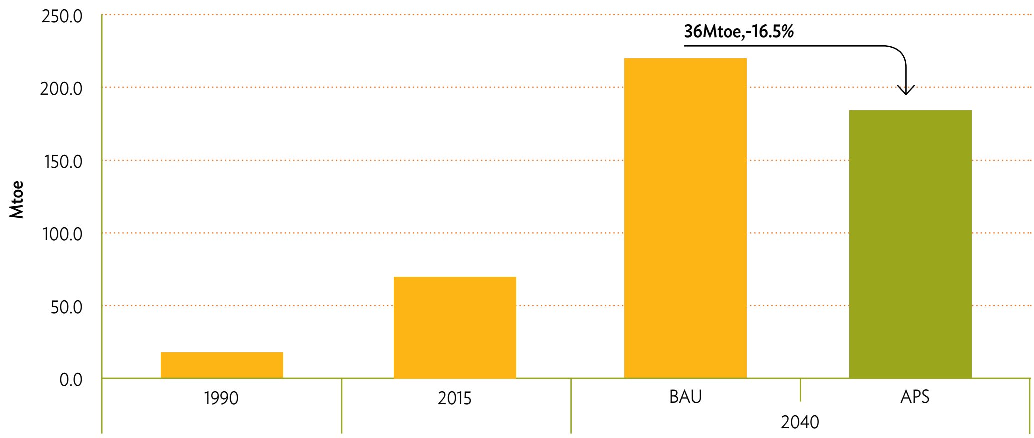


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Author's calculations.

The total savings amount to 36.3 Mtoe, equivalent to 16.5% of Viet Nam's TPEC in 2040. (see Figure 17.9).

Figure 17.9: Evolution of Primary Energy Supply, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

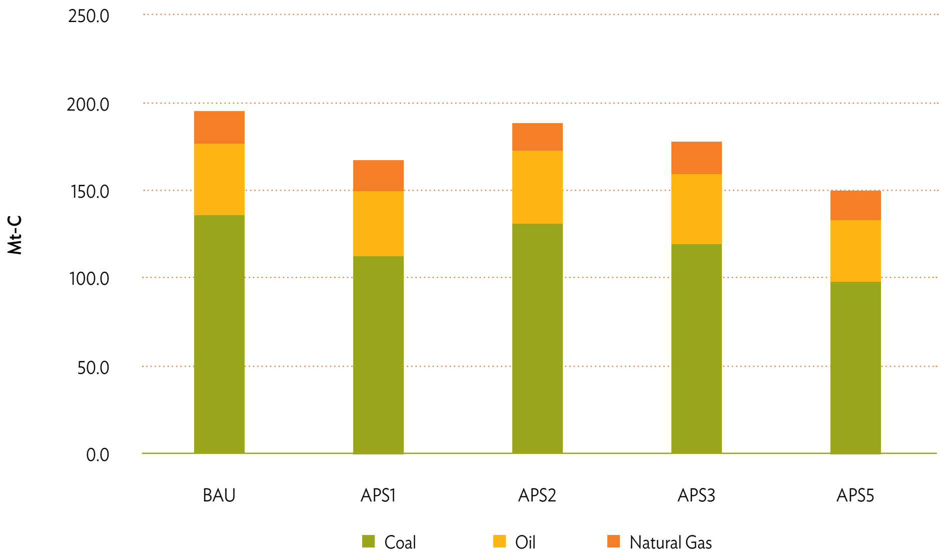
Source: Author's calculations.

3.2.3. CO_2 reduction potential

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 5.7% per year from 49.0 million metric tons of carbon (Mt-C) in 2015 to 195.2 Mt-C in 2040. Meanwhile, under APS5, the annual increase in CO_2 emissions between 2015 and 2040 is projected to be 4.6% yearly, which is 1.1 percentage points lower than the BAU scenario.

Reduced CO_2 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 renewable energy technologies (APS3) also contributed significantly to CO_2 reduction (Figure 17.10).

Figure 17.10: CO_2 Emissions by Fuel Type, BAU and APSs

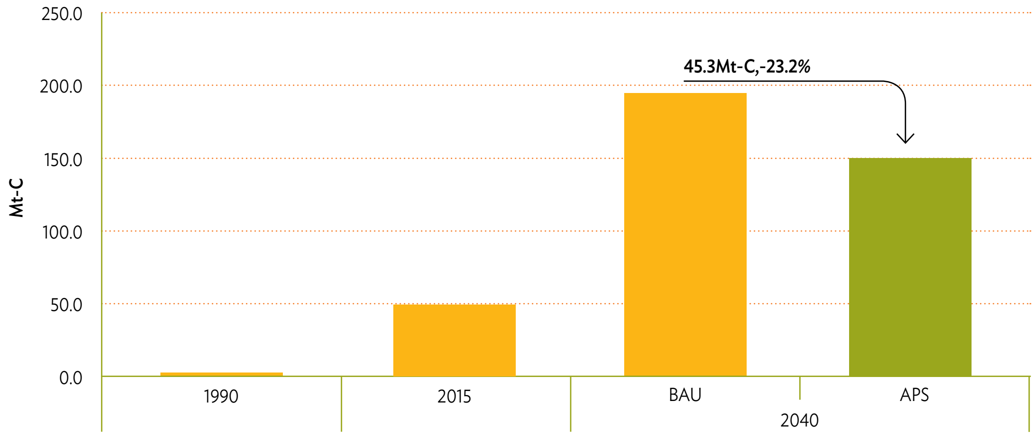


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-c = million tons of carbon.

Source: Author's calculations.

Improvements on CO_2 emissions under the APSs will be around 45.3 Mt-C lower, equal to 23.2% reduction in 2040. This indicates that the energy saving goals and action plans of Viet Nam are effective in reducing CO_2 emissions (see Figure 17.11).

Figure 17.11: Evolution of CO_2 Emissions, BAU and APS (1990, 2015, and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-c = million tons of carbon.

Source: Author's calculations.

4. Review of Viet Nam's INDC and APS5 Results

In September 2015, Viet Nam submitted its Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change. Viet Nam's INDC includes mitigation and adaptation components and covers the entire economy, including the energy; agriculture; land use, land use change, and forestry; and waste sectors. The mitigation component includes both unconditional and conditional contributions. Unconditional contributions are measures implemented using domestic resources, while conditional contributions are those that could be implemented if new and additional international financial support, technology transfer, and capacity building are received.

With domestic resources, by 2030, Viet Nam will reduce GHG emissions by 8% compared to the BAU scenario, equal to around 63 million tons of carbon dioxide equivalent (tCO_2e). The contribution of the energy sector on GHG emissions reduction by 2030 will be 29.5 million tCO_2e, accounting for 46.8% of total GHG emissions reduction under unconditional contribution.

The above-mentioned 8% contribution could be increased to 25%, with international support, equal to around 197 million tCO_2e. The contribution of the energy sector on GHG emissions reduction by 2030 will be 65.9 million tCO_2e, accounting for 33.5% of total GHG emissions reduction under conditional contribution.

GHG mitigation goals in the energy sector are expected to be attained through the potential mitigation options in the industry, transport, and 'others' sectors on the demand side and the development of renewable energy technologies, particularly solar, wind, and biomass for power generation, on the supply side.

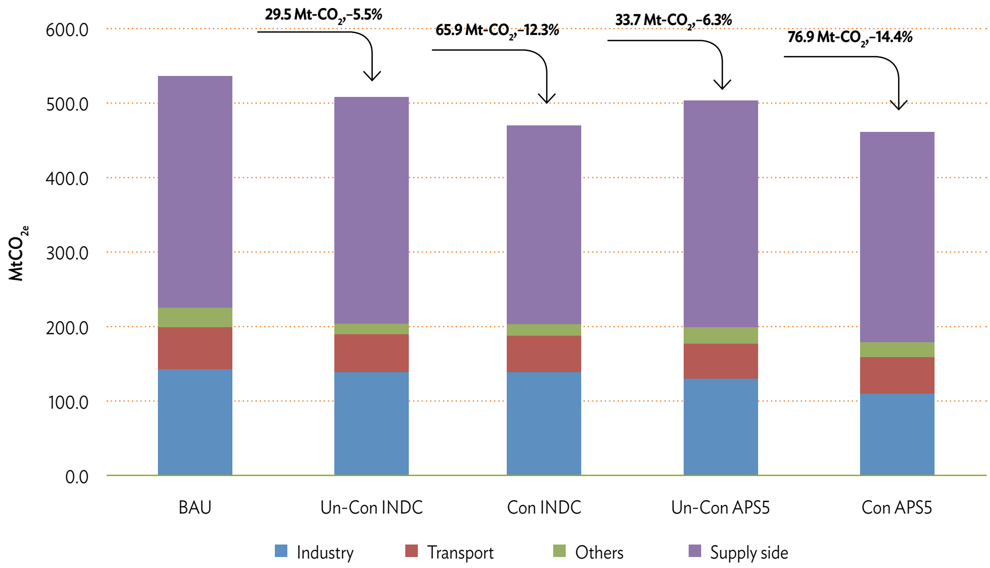
These options were proposed and selected based on the following criteria: government prioritisation, GHG reduction potential, cost-effectiveness, and the maturity of technology development, which can be classified by unconditional and conditional contributions as follows:

- Prioritised mitigation options: GHG reduction potential, alignment with government policies, cost-effectiveness, and maturity of technologies
- Unconditional: low abatement costs, already implemented in Viet Nam, aligned with sectoral plans for 2021–2030
- Conditional: higher abatement costs and new technologies currently implemented in developed countries.

To evaluate and compare GHG emissions reduction potential and targets with Viet Nam's INDC, the author classified the mitigation technologies in APS5 and based on the above criteria to compare APS5 of this study with INDC on GHG emissions reduction.

Under APS5, with domestic resources, Viet Nam will reduce by 2030 33.7 million tCO_2e (or 6.3% reduction) compared to 29.5 million tCO_2e (or 5.5% reduction) in the INDC. These GHG emissions will further decrease to 76.9 million tCO_2e (or 14.4% reduction) compared to 65.9 million tCO_2e (or 12.3% reduction) in the INDC under conditional contribution with international support.

Figure 17.12: GHG Reduction Targets, APS5 vs INDC



APS = Alternative Policy Scenario, BAU = Business-As-Usual Scenario, GHG = greenhouse gases,
INDC = Intended Nationally Determined Contributions, Mt-CO_2 = million tons of carbon dioxide equivalent.

Source: Author's calculations.

In both the INDC and APS5, the power generation and industry sectors have high potential in reducing GHG. Compared to Viet Nam's INDC on GHG emissions reduction targets, those in APS5 look similar but seem to be more ambitious due to new policies and technologies being updated. These also prove that if APS5 were implemented, Viet Nam's INDC would be achieved.

5. Key Findings and Policy Implications

The following are some key findings from the above analysis on energy savings potential:

- Energy demand in Viet Nam is expected to continue to grow significantly, driven by robust economic growth, industrialisation, urbanisation, and population growth. EEC measures can potentially contribute to meeting higher demand in a sustainable manner.
- Viet Nam's energy intensity, which is amongst the highest in the world, indicates high savings potential.
- Electricity demand is increasing with highest annual growth rate of 5.3% in the BAU scenario and is projected to decline to 4.7% in the APS. This decline proves that the EEC measures are effective in electricity demand.

- EEC scenarios on the demand side are most effective compared with other proposed scenarios, which are APS2 and APS3.
- Coal-fired thermal power plants will be the major power source in Viet Nam in the coming years. Their share in the total power generation output is increasing continuously from 31.9% in 2015 to 68.9% in 2040 in the BAU scenario. This is the area with the largest energy savings and GHG mitigation potential in both Viet Nam's INDC and APS5.
- GHG mitigation technologies in APS5 will be developed to conform with Viet Nam's INDC and government policies.

The following policies are recommended to effectively implement EEC activities in Viet Nam:

- **Establishment of new targets and a roadmap for EEC implementation:** Energy demand in Viet Nam in the BAU scenario is expected to continue to grow significantly in the coming years. EEC scenarios on the demand side are most effective compared to other proposed scenarios (APS2 and APS3). Therefore, Viet Nam needs to strengthen EEC activities by updating and setting new targets globally and specifically in each sector for the next periods and by preparing specific road maps or action plans to achieve these targets.
- **Compulsory energy standards and labelling for electrical appliances:** The annual growth of electricity demand, especially in the 'others' sector, is projected to be the second highest (5.3%) in the BAU scenario. Therefore, compulsory energy standards and labelling for electrical appliances is an effective management measure in energy savings.
- **Priority for development of advanced coal-fired thermal power technology:** Coal-fired thermal power plants will be the major source of power generation in Viet Nam up to 2040. Therefore, Viet Nam needs to retrofit the existing thermal power plants to improve the efficiency of power generation and to prioritise energy-effective technologies (clean coal technologies) for the development of new coal-fired thermal power plants.
- **Priority for renewable energy development:** Coal-fired power generation is projected to have a dominant share in the future, which will result in the country's reliance on coal imports for power generation. The development of renewable energy technologies to replace coal for power generation is an important factor for energy independence, energy security, and GHG abatement. This is necessary in setting up policy support and mechanisms to promote renewable energy development.

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CHAPTER 18

UNITED STATES COUNTRY REPORT

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1. Introduction

The United States (US) is the fourth-largest country in the world by total area and the third largest by population. Since 1990, its population has grown at an average annual rate of 2.4%, reaching approximately 321 million in 2015.[1] As of 2018, 82.3% of its total population lives in urban areas, with the trend towards increased urbanisation expected to continue at an average annual rate of change of 0.95% throughout the current 2015–2020 period (CIA, 2018).

The US is also the world's second-largest economy, with a gross domestic product (GDP) of $16.9 trillion and per capita income of $51,640 in 2015 (both in constant 2010 US$ values). By sector of origin, 80.2% of its GDP can be linked to services, while 18.9% is linked to industrial output, including motor vehicles, aerospace, chemicals, and consumer goods. Agriculture, including wheat, corn, beef, dairy, and forest products, makes up the remaining 0.9% (CIA, 2018). 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] Unless otherwise cited, all data in this report can be attributed to economic modelling results for the United States of The Institute of Energy Economics, Japan, which are included in full as an annex to this publication.

1.1. Energy Situation

The US is the world's second-largest consumer of energy and the second-largest emitter of CO_2, though by per capita measures, it ranks first in both categories. In 1990, its final energy consumption was 1,294 million tons of oil equivalent (Mtoe). Over the following decade, consumption increased to 1,546 Mtoe in 2000, and then experienced a modest overall decline in 2000 to 2015 so that consumption was 1,520 Mtoe as of the end of 2015. Different studies have contested whether this indicates that US consumption has peaked, or if a gradual recovery in economic activity following the 2007–2008 global economic crisis may have ultimately reversed this trend. Periodically cited as evidence is that between 1990 and 2015, only industry sector consumption declined overall (though non-energy sector consumption has also declined in the period since 2000). Meanwhile, energy consumption in the 'others' (residential/commercial/public) sector and transport grew steadily.

During this period, coal consumption also declined sharply from 56 Mtoe to 20 Mtoe, but growth in consumption of natural gas and renewables more than offset this decline. A key contributor to this is the major shift under way in the US's domestic energy supply outlook. While the country 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 favourable conditions for wind and solar energy – up until recently, significant portions of this potential were not considered technically or economically viable. However, since the 2000s, breakthroughs in technology, declining production costs, and favourable environments for development and investment have contributed to a growing abundance in 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 (Richardson-Barlow et al., 2014). The International Energy Agency estimates that the US will be the world's largest oil producer by 2023. Natural gas production also increased twelvefold during a similar period, resulting in the US becoming a top producer of natural gas (Richardson-Barlow et al., 2014).

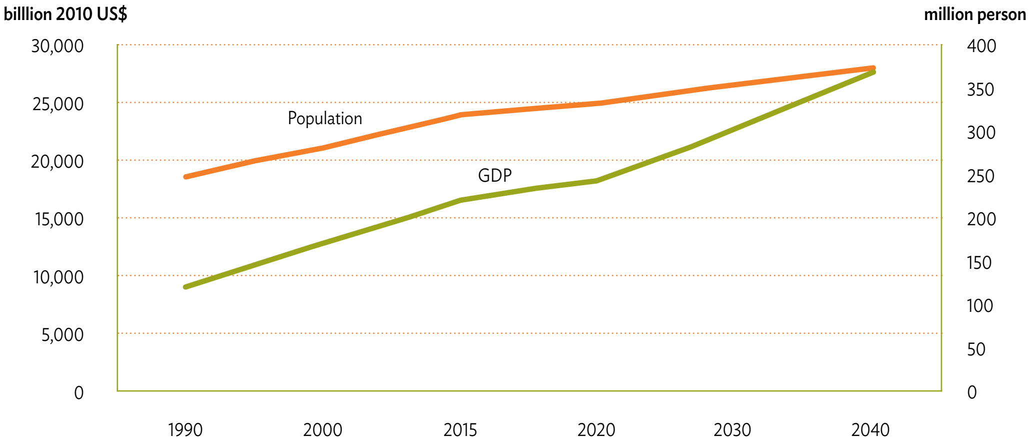
As has been well documented, such developments are now having a crucial, transformative impact on reshaping US energy outlooks. Rises in production levels of oil and natural gas are contributing to reducing or backing out of import requirements from Canada and other country sources. Combined with other market and policy factors, energy independence is also contributing to accelerating trends in transforming the US power generation mix. In 2014, for the first time ever, natural gas surpassed coal as the single largest share of US power generation. Meanwhile, increasingly favourable economics, coupled with supportive domestic policy environments, also contributed to significant increases in consumption levels for wind and solar, which grew at the largest rates of increase of any fuel source in between 1990 and 2015. In some states of the US, including Texas and Iowa, wind energy is considered cost competitive with traditional fuel sources, which may further incentivise further consumption (Gillespie, Johnson, and Schwartz, 2017).

Expanded production and reduced requirements for domestic consumption (particularly of abundant, high-quality indigenous coal resources) have also opened the door for the US to play an increasingly important role as a key exporter to the Asia-Pacific region. To date, US liquefied natural gas exports have been delivered to several major economies in Asia, including Japan, Taiwan, India, the Republic of Korea, and China, and frequency and volumes are anticipated to grow exponentially in the coming decades (EIA, 2018a). The US is also becoming an increasingly important supplier of crude oil to Asia. It is also an important global exporter of coal, with India, the Republic of Korea, and Japan representing three of the top five recipients of US steam coal exports in 2017 (EIA, 2018b). Going forward, while each of these fuel sources may potentially contribute immensely to strengthening regional energy security outlooks, factors such as overall competitiveness of US supplies, social licence considerations in both the US and Asian countries, and the need to overcome current bottlenecks in US transport infrastructure may limit the overall potential of US export growth.

2. Modelling Assumptions

Over this study's outlook period of 2015–2040, 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 (Figures 18.1 and 18.2). While US birth rates are projected to remain below replacement levels during the outlook window, its population continues to grow overall due to sustained immigration and improvements in life expectancies. However, at 0.6% per year, population growth rate for the outlook period is still at a notably slower pace than the 1% of the previous 25-year period (CIA, 2018).

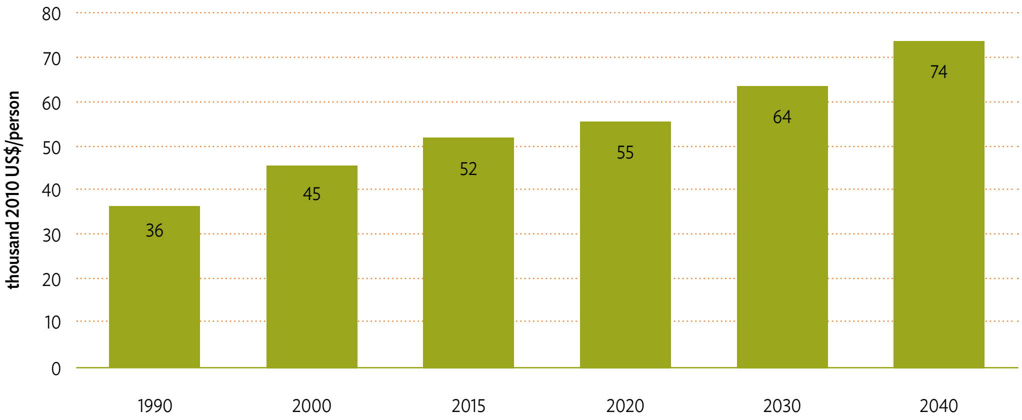
Figure 18.1: GDP and Population (1990–2040)



GDP = gross domestic product.

Source: Authors' assumptions.

Figure 18.2: Per Capita GDP (1990–2040)



GDP = gross domestic product.

Source: Calculation based on authors' assumptions.

Between 1990 and 2015, US GDP grew at an average annual rate of 2.4%. Despite significant disruption in this overarching trend during the 2007–2008 global economic crisis, the US economic outlook appears to have now recovered dramatically by several measures. However, ongoing questions about job creation rates and challenges in increasing productivity remain looming challenges to realising new gains in GDP growth. This model projects that GDP growth rates will re-stabilise over the outlook period at rates comparable, though modestly lower, than the prior 25 years. Between 2015 and 2040, average annual growth will continue at 2.1% per year, and each decade snapshot will relatively closely mirror this overall trend (with the 2030–2040 period being the sole outlier at the slightly slower pace of 2%). This estimate aligns with expectations of continued efficiency and productivity gains alongside the above modest but sustained population growth, as well as continued US leadership and commitment to innovation in emerging fields.

In terms of overall total final energy consumption (TFEC), oil is anticipated to retain its dominance through the outlook period, reflecting that by sector, transport also remains the single largest driver of the TFEC. In electricity generation, while coal, nuclear energy, and hydropower are each anticipated to remain critical components of the overall US mix, each of these sources is anticipated to decline in terms of their overall share between 2015 and 2040. This is primarily due to unfavourable economics and domestic policy and social licence factors when compared with the outlooks for non-hydro renewables and natural gas. Investments in cleaner consumption technologies as well as the retirement of ageing coal-fired power fleets are also anticipated to boost overall efficiency of generation. However, uncertainties about the pace and scale of retirement of existing nuclear power plants weigh on the overall trajectory for reducing CO_2 emissions.

The Alternative Policy Scenarios (APSs) assume progress towards the full implementation and realisation of a range of established efforts to strengthen a country's energy-saving potential. For the US, these include efforts to strengthen efficiency of final energy demand, 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 levels. This study then reviews the results of the APSs to determine cumulative impact in promoting CO_2 emissions reductions and encouraging energy savings beyond business-as-usual.

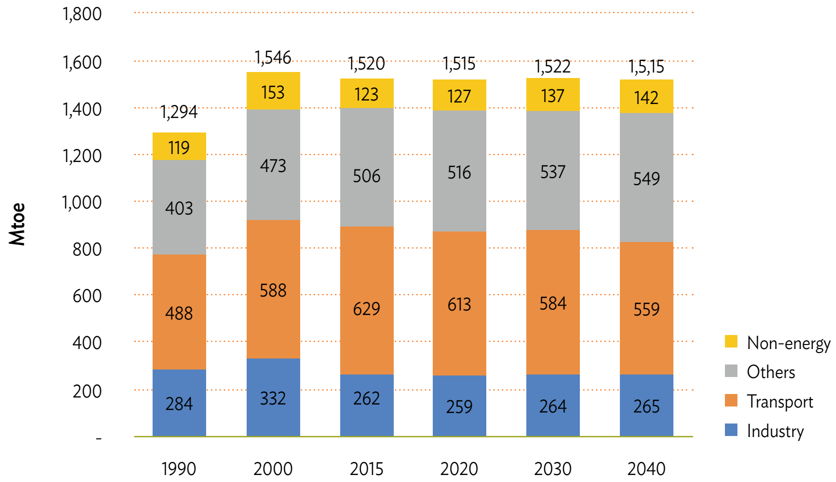
3. Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final energy consumption

Under the Business-As-Usual (BAU) scenario, the TFEC is anticipated to decline slightly between 2015 and 2040, though at 1,515 Mtoe, it remains well above 1990 levels (Figure 18.3). The transport sector is the only sector whose consumption is anticipated to decline, with efficiency improvements and other structural changes within the sector offsetting prospects for additional consumption despite continued growth in vehicle ownership. Meanwhile, consumption by industry, non-energy, and 'others' (residential/commercial) sector grows. The largest growth is experienced in the 'others' sector, though non-energy sector consumption grows at the fastest rate.

Figure 18.3: Final Energy Consumption by Sector, BAU (1990–2040)

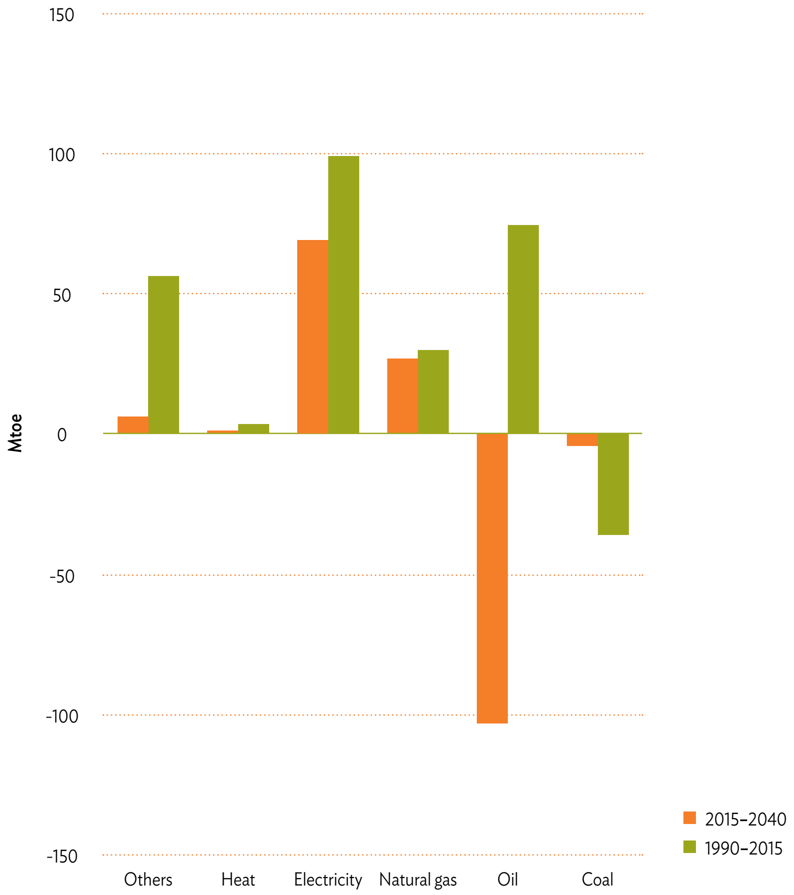


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

During this same period, electricity consumption is anticipated to grow from 325 Mtoe to 376 Mtoe. Non-hydropower renewables, primarily wind and solar but also geothermal, will experience the most dramatic growth during this period. Natural gas consumption remains relatively stable up to 2030 but is anticipated to modestly decline through the end of the outlook period. Coal consumption declines throughout the entire 2015–2040 period, although at a much slower pace than in the previous 25 years. Oil consumption experiences the most dramatic decline, given robust expectations for continued efficiency gains as well as switching in the transport sector to natural gas, biofuels, and other sources as well as increased deployment of electric vehicles (Figure 18.4).

Figure 18.4: Changes in Final Energy Consumption by Fuel Type, BAU



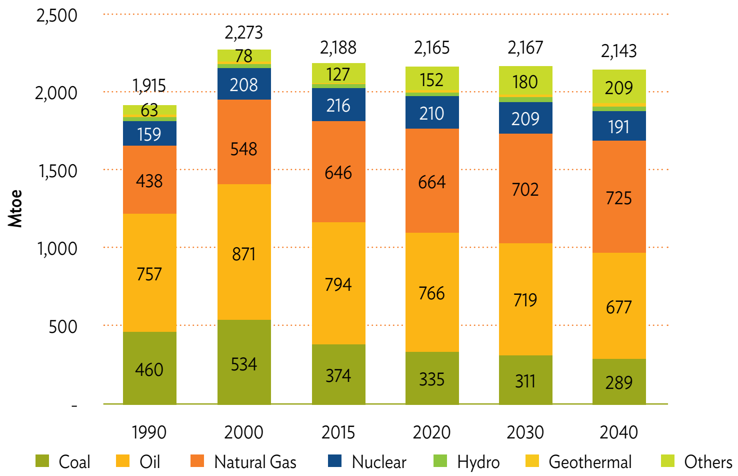
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.1.2. Primary energy consumption

Under the BAU scenario, total primary energy consumption is anticipated to decline from 2,188.3 Mtoe in 2015 to 2,143 Mtoe in 2040, with an average annual rate of decline of 0.1%. Of note, much of this overall decline is also anticipated to already have occurred by 2020. Coal consumption is anticipated to decline at a rate of 1.0% during this period, while nuclear declines by 0.5%. In contrast, non-hydropower renewables experience the largest growth in consumption during this period at 5.3%, closely followed by geothermal at 4.4% (Figure 18.5).

Figure 18.5: Final Energy Consumption by Fuel Type, BAU (1990–2040)

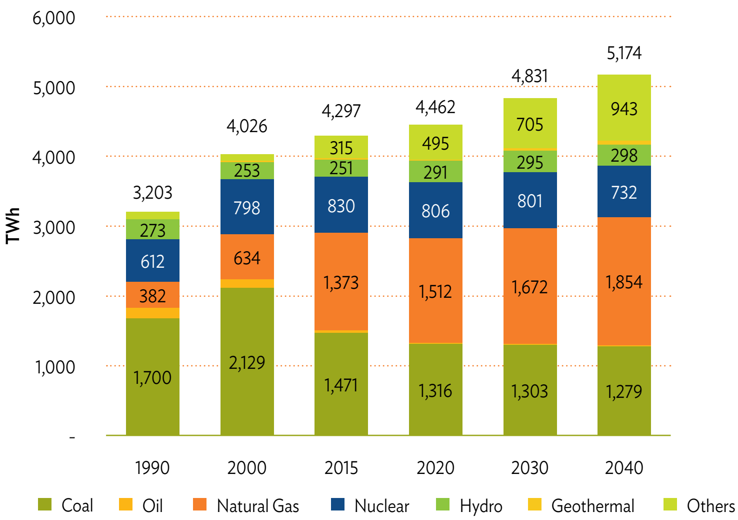


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.1.3. Power generation

Figure 18.6: Power Generation under BAU (1990–2040)



BAU = Business-As-Usual, TWh = terawatt-hour.

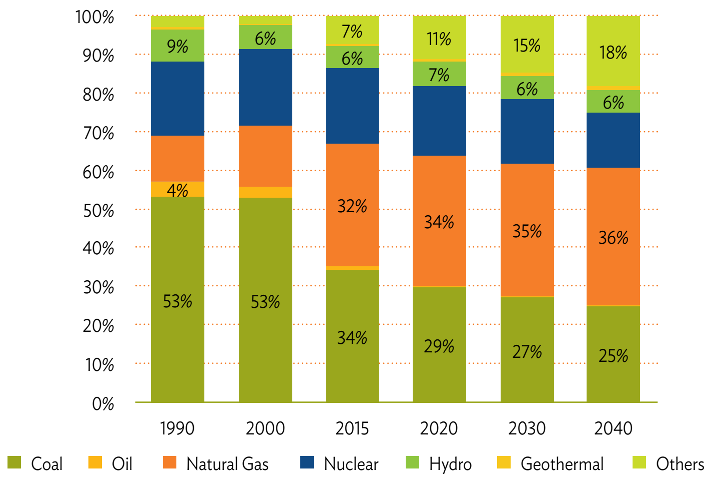
Source: Authors' calculation.

Electricity generation in the US, under the BAU scenario, is projected to increase over the outlook period, though at a comparatively slower pace than in the previous 25 years. Generation output increases from 4,297.0 terawatt hours (TWh) to 5,173.8 TWh between 2015 and 2040, for an average annual growth rate of 0.7%.

After surpassing coal as the single largest share of the US's power generation mix in 2014, natural gas retains its number one rank through 2040, representing 35.8% 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. Improved economics alongside other considerations could also contribute to incentivising higher levels of consumption of wind and solar though, as aptly noted by the Energy Information Administration, many existing tax credits will begin to expire in the early 2020s, potentially raising questions for the road ahead (Figure 18.6).

The retirement of older, less-efficient coal-fired plants and 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 continues its decline at 0.6% a year, though it is still anticipated to account for roughly one-quarter of all US power generation in 2040. Uncertainties in investments and progress towards strengthening existing, ageing grid infrastructure may also challenge efforts to bring new generation online in ways that promote energy savings and CO_2 reductions (Figure 18.7).

Figure 18.7: Share of Power Generation Mix under BAU (1990–2040)



BAU = Business-As-Usual.

Source: Authors' calculation.

3.2 Energy Savings in the APS and CO_2 Reduction Potential

3.2.1. Final energy consumption

Under the APS, this study projects that early signs of declining TFEC in the US will be affirmed and that the overall rate of decline will also be accelerated. Under the APS, this study anticipates that in 2015–2040, consumption will decline from 1,520 Mtoe to 1,379 Mtoe. When compared with the BAU scenario, this shows an energy savings of 135.8 Mtoe or 9% during the period. Transportation realises a savings of 57.6 Mtoe (10.3%); industry, 21.8 Mtoe (8.2%); and residential and commercial, 56.4 Mtoe (10.3%). Meanwhile, in contrast to expectations under the BAU scenario, all sectors save for non-energy now realise some level of declining overall consumption (Figure 18.8).

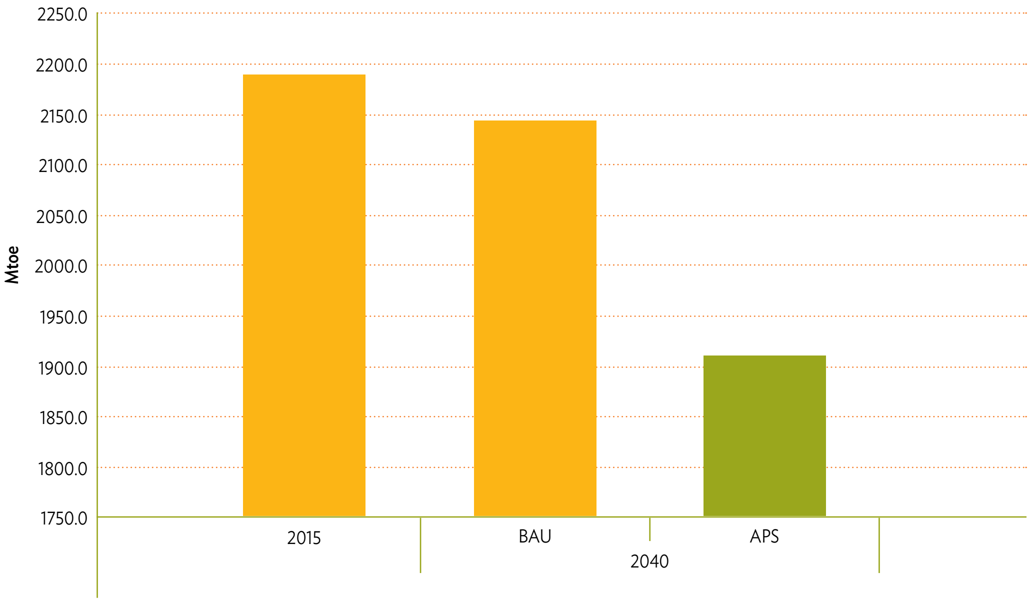
Figure 18.8: Final Energy Consumption by Sector in BAU vs. APS

APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

3.2.2. Primary energy supply

Figure 18.9: Total Primary Energy Supply in BAU vs APS (2015 and 2040)

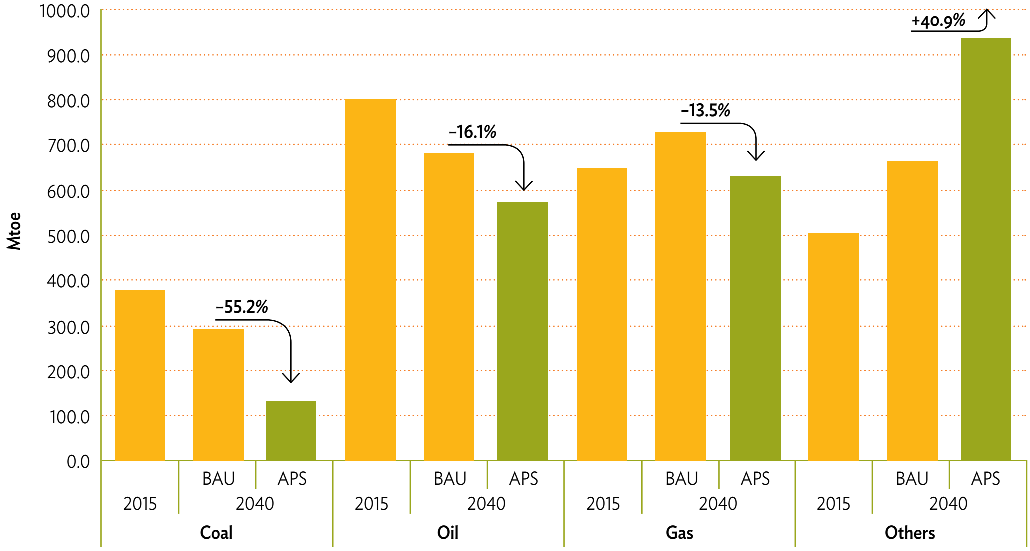


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Under the APS, US primary energy consumption is anticipated to decrease from 2,188.3 Mtoe in 2015 from 1,910.2 Mtoe in 2050. This implies that, in 2040, under the APS, savings of primary energy consumption will be around 232.73 Mtoe or 10.9% lower compared with the BAU scenario (Figure 18.9).

Coal in the primary energy demand in the APS is expected to decline to 129.7 Mtoe. This represents a total energy saving of 159.6 Mtoe in 2040 compared with the BAU scenario. Oil consumption is also anticipated to decline compared to the BAU scenario, with a potential saving of 109.3 Mtoe (or 16.1%) by 2040, while natural gas is also anticipated to see a similar level of decline. In contrast, the demand for others (renewables) is anticipated to increase to about 270.35 Mtoe (40.9%) compared to the BAU scenario in 2040 (Figure 18.10).

Figure 18.10: Total Primary Energy Supply by Fuel in BAU vs APS (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

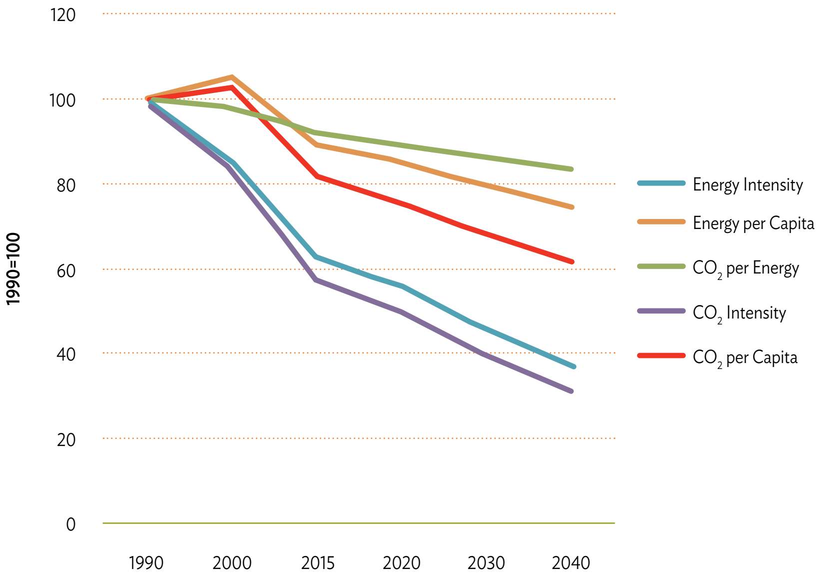
3.3. CO_2 Emissions

CO_2 emissions from energy consumption, under the BAU scenario, are anticipated to decline modestly – from 1,382.9 million tons of carbon (Mt-C) in 2015 to 1,228.9 Mt-C in 2040. This is equivalent to a decrease in average annual rate of 0.5%. Key drivers of this shift is due to continued fuel switching in the electricity mix of the US. Decreased consumption of coal and oil and increased consumption of natural gas and non-fossil sources contribute to modest improvements in the country's overall emissions profile.

In the APS, CO_2 emissions are projected to decrease at an average annual rate of 1.7%, from 1,382.9 Mt-C in 2015 to 902.2 Mt-C in 2040. Emissions savings in the APS are thus 26.6% compared to the BAU scenario in 2040. The most dramatic shifts in primary energy consumption between the BAU scenario and the APS are linked to the acceleration of trends in reducing coal – a difference of 55.2% by 2040 – while oil consumption is reduced by an additional 16.1% and gas by an additional 13.5% (Figure 18.11).

In the official submission of its Intended Nationally Determined Contribution (INDC), the US pledged to reduce CO_2 emissions from their 2005 levels by 26%–28% by 2025. While the current US (Trump) administration has raised the prospects of revising or abandoning its current INDC pledge, this study suggests that the US has already made substantial progress towards this goal. However, even under the APS, more robust actions may be necessary to achieve this target by 2025.

Figure 18.11: CO_2 Emissions Trends under APS (1990–2040)



Source: Authors' calculation.

4. Policy Implications

Based on the results and discussions presented above, the following policy implications could be derived:

- Coal, oil, and natural gas will continue to dominate the US energy mix in both the BAU scenario and the APS.
- Natural gas will remain as the single greatest share of the US electricity generation mix in 2015–2040, although non-hydro renewables such as wind and solar are anticipated to experience the largest growth rates.
- Improved economics alongside sustained breakthroughs in renewable energy technologies could also contribute to incentivising higher levels of consumption in ways that further accelerate CO_2 emissions and promote energy savings. However, as the Energy Information Administration notes, substantial uncertainties lie ahead, including determining the implications and desirable responses to expiring tax credits and fiscal incentives for renewable energy in the 2020s.
- Continued efforts to strengthen the transport sector are being envisioned as a critical opportunity to save energy under both the BAU scenario and the 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.

- Growing potential for US energy exports to Asia could contribute immensely to strengthening regional energy security outlooks. However, factors such as overall competitiveness, social licence considerations on both sides of the Pacific, and the need to overcome current bottlenecks in US transport infrastructure may limit overall US export growth potential.

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ANNEX

RESULTS SUMMARY TABLES

EAS17 (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3,955**	**5,049**	**7,488**	**8,249**	**8,928**	**9,595**	**10,255**	**10,943**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**2.0**	**1.5**	**1.3**	**1.5**
Coal	1,230	1,558	3,103	3,297	3,511	3,754	4,002	4,254	31.1	30.9	41.4	40.0	39.3	39.1	39.0	38.9	3.8	1.2	1.3	1.3	1.3
Oil	1,361	1,751	2,082	2,320	2,488	2,652	2,801	2,981	34.4	34.7	27.8	28.1	27.9	27.6	27.3	27.2	1.7	2.2	1.3	1.2	1.4
Natural gas	557	772	1,155	1,296	1,444	1,607	1,785	1,972	14.1	15.3	15.4	15.7	16.2	16.8	17.4	18.0	3.0	2.3	2.2	2.1	2.2
Nuclear	227	329	316	404	473	520	526	543	5.8	6.5	4.2	4.9	5.3	5.4	5.1	5.0	1.3	5.0	2.5	0.4	2.2
Hydro	54	63	151	172	183	193	202	209	1.4	1.2	2.0	2.1	2.1	2.0	2.0	1.9	4.2	2.6	1.1	0.8	1.3
Geothermal	24	38	48	50	66	72	94	103	0.6	0.8	0.6	0.6	0.7	0.7	0.9	0.9	2.9	0.6	3.7	3.7	3.1
Others	501	537	632	710	762	798	845	881	12.7	10.6	8.4	8.6	8.5	8.3	8.2	8.1	0.9	2.4	1.2	1.0	1.3
Biomass	497	523	498	511	504	489	477	464	12.6	10.4	6.7	6.2	5.6	5.1	4.6	4.2	0.0	0.5	-0.4	-0.5	-0.3
Solar, Wind, Ocean	2	4	75	130	176	224	269	314	0.0	0.1	1.0	1.6	2.0	2.3	2.6	2.9	15.9	11.6	5.5	3.4	5.9
Biofuels	1	7	54	66	76	80	91	96	0.0	0.1	0.7	0.8	0.9	0.8	0.9	0.9	18.2	4.1	1.9	1.9	2.4
Electricity	0	2	5	4	5	6	9	7	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	10.1	-4.8	5.3	0.5	1.3

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2,785**	**3,453**	**5,020**	**5,565**	**6,025**	**6,479**	**6,926**	**7,410**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**2.1**	**1.5**	**1.4**	**1.6**
Industry	779	957	1,717	1,865	2,011	2,165	2,333	2,529	28.0	27.7	34.2	33.5	33.4	33.4	33.7	34.1	3.2	1.7	1.5	1.6	1.6
Transportation	681	910	1,275	1,466	1,596	1,712	1,817	1,936	24.5	26.4	25.4	26.3	26.5	26.4	26.2	26.1	2.5	2.8	1.6	1.2	1.7
Others	1,093	1,253	1,557	1,697	1,825	1,950	2,068	2,177	39.3	36.3	31.0	30.5	30.3	30.1	29.9	29.4	1.4	1.7	1.4	1.1	1.3
Non-energy	231	333	471	538	593	652	708	768	8.3	9.7	9.4	9.7	9.8	10.1	10.2	10.4	2.9	2.7	1.9	1.7	2.0
Total	**2,785**	**3,453**	**5,020**	**5,565**	**6,025**	**6,479**	**6,926**	**7,410**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**2.1**	**1.5**	**1.4**	**1.6**
Coal	456	393	908	963	1,024	1,083	1,141	1,218	16.4	11.4	18.1	17.3	17.0	16.7	16.5	16.4	2.8	1.2	1.2	1.2	1.2
Oil	1,132	1,506	1,894	2,128	2,295	2,458	2,605	2,779	40.7	43.6	37.7	38.2	38.1	37.9	37.6	37.5	2.1	2.4	1.5	1.2	1.5
Natural gas	351	446	581	658	733	814	893	976	12.6	12.9	11.6	11.8	12.2	12.6	12.9	13.2	2.0	2.5	2.1	1.8	2.1
Electricity	383	574	1,047	1,206	1,359	1,524	1,693	1,858	13.8	16.6	20.8	21.7	22.6	23.5	24.4	25.1	4.1	2.9	2.4	2.0	2.3
Heat	16	35	94	101	107	113	118	122	0.6	1.0	1.9	1.8	1.8	1.7	1.7	1.6	7.4	1.6	1.1	0.7	1.1
Others	446	499	497	509	505	487	475	458	16.0	14.5	9.9	9.2	8.4	7.5	6.9	6.2	0.4	0.5	-0.5	-0.6	-0.3

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5,436**	**7,948**	**14,290**	**16,499**	**18,573**	**20,752**	**22,912**	**25,030**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.9**	**2.9**	**2.3**	**1.9**	**2.3**
Coal	2,618	4,180	7,681	8,379	9,159	10,094	11,095	12,024	48.2	52.6	53.8	50.8	49.3	48.6	48.4	48.0	4.4	1.8	1.9	1.8	1.8
Oil	566	482	223	171	152	130	108	94	10.4	6.1	1.6	1.0	0.8	0.6	0.5	0.4	-3.7	-5.2	-2.7	-3.2	-3.4
Natural gas	621	1,157	2,546	2,916	3,296	3,748	4,289	4,846	11.4	14.6	17.8	17.7	17.7	18.1	18.7	19.4	5.8	2.8	2.5	2.6	2.6
Nuclear	873	1,262	1,213	1,550	1,816	1,994	2,019	2,084	16.1	15.9	8.5	9.4	9.8	9.6	8.8	8.3	1.3	5.0	2.5	0.4	2.2
Hydro	630	731	1,761	2,004	2,133	2,240	2,344	2,425	11.6	9.2	12.3	12.1	11.5	10.8	10.2	9.7	4.2	2.6	1.1	0.8	1.3
Geothermal	27	37	50	61	82	91	110	120	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	2.6	3.8	4.1	2.8	3.5
Others	101	98	815	1,418	1,935	2,455	2,948	3,436	1.9	1.2	5.7	8.6	10.4	11.8	12.9	13.7	8.7	11.7	5.6	3.4	5.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**910**	**1,377**	**2,274**	**2,440**	**2,643**	**2,884**	**3,150**	**3,412**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.7**	**1.4**	**1.7**	**1.7**	**1.6**
Coal	643	1,024	1,764	1,890	2,038	2,216	2,403	2,577	70.7	74.3	77.6	77.5	77.1	76.8	76.3	75.5	4.1	1.4	1.6	1.5	1.5
Oil	126	112	53	41	36	30	24	21	13.8	8.1	2.3	1.7	1.4	1.1	0.8	0.6	-3.4	-5.2	-2.8	-3.5	-3.5
Natural gas	141	241	457	510	569	637	722	813	15.5	17.5	20.1	20.9	21.5	22.1	22.9	23.8	4.8	2.2	2.3	2.5	2.3

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**36.0**	**36.3**	**39.5**	**40.4**	**41.0**	**41.7**	**42.3**	**42.8**									**0.4**	**0.4**	**0.3**	**0.3**	**0.3**
Coal	35.0	35.1	37.5	38.1	38.7	39.2	39.7	40.1									0.3	0.4	0.3	0.2	0.3
Oil	38.7	37.0	36.3	36.3	36.1	36.8	38.0	37.7									-0.3	0.0	0.1	0.3	0.2
Natural gas	37.9	41.2	47.9	49.2	49.8	50.6	51.0	51.3									0.9	0.5	0.3	0.1	0.3

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2,762**	**3,534**	**5,660**	**6,132**	**6,604**	**7,108**	**7,621**	**8,189**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**1.6**	**1.5**	**1.4**	**1.5**
Coal	1,349	1,719	3,369	3,577	3,824	4,096	4,378	4,673	48.8	48.6	59.5	58.3	57.9	57.6	57.4	57.1	3.7	1.2	1.4	1.3	1.3
Oil	1,033	1,306	1,514	1,645	1,751	1,866	1,987	2,140	37.4	36.9	26.7	26.8	26.5	26.2	26.1	26.1	1.5	1.7	1.3	1.4	1.4
Natural gas	380	509	776	910	1,029	1,147	1,257	1,377	13.8	14.4	13.7	14.8	15.6	16.1	16.5	16.8	2.9	3.2	2.3	1.8	2.3

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	16,861	23,941	39,023	46,476	55,279	65,967	78,166	91,534	3.4	3.6	3.6	3.3	3.5
Population (millions of people)	2,881	3,313	3,839	3,987	4,114	4,218	4,298	4,357	1.2	0.8	0.6	0.3	0.5
GDP per capita (thousands of 2010 US$/person)	5.85	7.23	10.17	11.66	13.4	15.6	18.2	21.0	2.2	2.8	3.0	3.0	2.9
Primary energy consumption per capita (toe/person)	1.37	1.52	1.95	2.07	2.17	2.27	2.39	2.51	1.4	1.2	1.0	1.0	1.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	235	211	192	177	162	145	131	120	-0.8	-1.5	-2.0	-1.9	-1.9
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	165	144	129	120	109	98	89	81	-1.0	-1.4	-2.0	-1.9	-1.8
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	164	148	145	132	119	108	98	89	-0.5	-1.9	-2.0	-1.8	-1.9
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.70	0.70	0.76	0.74	0.74	0.74	0.74	0.75	0.3	-0.3	0.0	0.1	0.0

EAS17 (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3,955**	**5,049**	**7,487**	**8,072**	**8,486**	**8,857**	**9,182**	**9,512**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**1.5**	**0.9**	**0.7**	**1.0**
Coal	1,230	1,558	3,103	3,149	3,138	3,144	3,115	3,100	31.1	30.9	41.4	39.0	37.0	35.5	33.9	32.6	3.8	0.3	0.0	-0.1	0.0
Oil	1,361	1,751	2,082	2,285	2,372	2,439	2,492	2,573	34.4	34.7	27.8	28.3	27.9	27.5	27.1	27.0	1.7	1.9	0.7	0.5	0.9
Natural gas	557	772	1,155	1,252	1,343	1,441	1,531	1,620	14.1	15.3	15.4	15.5	15.8	16.3	16.7	17.0	3.0	1.6	1.4	1.2	1.4
Nuclear	227	329	316	416	522	603	677	752	5.8	6.5	4.2	5.2	6.2	6.8	7.4	7.9	1.3	5.6	3.8	2.2	3.5
Hydro	54	63	151	175	188	201	212	222	1.4	1.2	2.0	2.2	2.2	2.3	2.3	2.3	4.2	2.9	1.4	1.0	1.5
Geothermal	24	38	48	72	109	144	165	166	0.6	0.8	0.6	0.9	1.3	1.6	1.8	1.7	2.9	8.3	7.2	1.5	5.1
Others	501	537	632	724	814	886	990	1,078	12.7	10.6	8.4	9.0	9.6	10.0	10.8	11.3	0.9	2.8	2.0	2.0	2.2
Biomass	497	523	498	514	509	495	497	486	12.6	10.4	6.7	6.4	6.0	5.6	5.4	5.1	0.0	0.6	-0.4	-0.2	-0.1
Solar, Wind, Ocean	2	4	75	139	212	282	364	445	0.0	0.1	1.0	1.7	2.5	3.2	4.0	4.7	15.9	13.0	7.3	4.7	7.4
Biofuels	1	7	54	68	89	104	123	142	0.0	0.1	0.7	0.8	1.1	1.2	1.3	1.5	18.2	4.8	4.3	3.2	4.0
Electricity	0	2	5	4	5	6	7	5	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	10.1	-5.1	3.9	-0.6	0.2

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2,785**	**3,453**	**5,020**	**5,457**	**5,775**	**6,058**	**6,324**	**6,615**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**1.7**	**1.1**	**0.9**	**1.1**
Industry	779	957	1,717	1,821	1,922	2,024	2,127	2,240	28.0	27.7	34.2	33.4	33.3	33.4	33.6	33.9	3.2	1.2	1.1	1.0	1.1
Transportation	681	910	1,275	1,427	1,504	1,552	1,594	1,653	24.5	26.4	25.4	26.2	26.0	25.6	25.2	25.0	2.5	2.3	0.8	0.6	1.0
Others	1,093	1,253	1,557	1,670	1,756	1,830	1,896	1,954	39.3	36.3	31.0	30.6	30.4	30.2	30.0	29.5	1.4	1.4	0.9	0.7	0.9
Non-energy	231	333	471	538	593	652	708	768	8.3	9.7	9.4	9.9	10.3	10.8	11.2	11.6	2.9	2.7	1.9	1.7	2.0
Total	**2,785**	**3,453**	**5,020**	**5,457**	**5,775**	**6,058**	**6,324**	**6,615**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**1.7**	**1.1**	**0.9**	**1.1**
Coal	456	393	908	947	991	1,029	1,060	1,102	16.4	11.4	18.1	17.3	17.2	17.0	16.8	16.7	2.8	0.8	0.8	0.7	0.8
Oil	1,132	1,506	1,894	2,087	2,180	2,252	2,311	2,391	40.7	43.6	37.7	38.2	37.8	37.2	36.5	36.1	2.1	2.0	0.8	0.6	0.9
Natural gas	351	446	581	645	703	761	816	871	12.6	12.9	11.6	11.8	12.2	12.6	12.9	13.2	2.0	2.1	1.7	1.4	1.6
Electricity	383	574	1,047	1,182	1,304	1,433	1,563	1,688	13.8	16.6	20.8	21.7	22.6	23.7	24.7	25.5	4.1	2.5	1.9	1.7	1.9
Heat	16	35	94	99	102	106	108	108	0.6	1.0	1.9	1.8	1.8	1.7	1.7	1.6	7.4	1.1	0.7	0.2	0.6
Others	446	499	497	497	495	478	466	455	16.0	14.5	9.9	9.1	8.6	7.9	7.4	6.9	0.4	0.0	-0.4	-0.5	-0.3

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5,436**	**7,948**	**14,289**	**16,176**	**17,811**	**19,498**	**21,144**	**22,709**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.9**	**2.5**	**1.9**	**1.5**	**1.9**
Coal	2,618	4,180	7,681	7,915	7,947	8,086	8,111	8,126	48.2	52.6	53.8	48.9	44.6	41.5	38.4	35.8	4.4	0.6	0.2	0.0	0.2
Oil	566	482	223	196	163	134	103	89	10.4	6.1	1.6	1.2	0.9	0.7	0.5	0.4	-3.7	-2.6	-3.7	-4.0	-3.6
Natural gas	621	1,157	2,546	2,790	3,013	3,293	3,561	3,802	11.4	14.6	17.8	17.2	16.9	16.9	16.8	16.7	5.8	1.8	1.7	1.4	1.6
Nuclear	873	1,262	1,213	1,596	2,003	2,314	2,598	2,885	16.1	15.9	8.5	9.9	11.2	11.9	12.3	12.7	1.3	5.6	3.8	2.2	3.5
Hydro	630	731	1,761	2,034	2,181	2,332	2,468	2,586	11.6	9.2	12.3	12.6	12.2	12.0	11.7	11.4	4.2	2.9	1.4	1.0	1.5
Geothermal	27	37	50	75	121	154	175	185	0.5	0.5	0.4	0.5	0.7	0.8	0.8	0.8	2.6	8.3	7.5	1.8	5.3
Others	101	98	815	1,569	2,384	3,183	4,128	5,036	1.9	1.2	5.7	9.7	13.4	16.3	19.5	22.2	8.7	14.0	7.3	4.7	7.6

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**910**	**1,377**	**2,274**	**2,300**	**2,278**	**2,285**	**2,269**	**2,260**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.7**	**0.2**	**-0.1**	**-0.1**	**0.0**
Coal	643	1,024	1,764	1,771	1,731	1,714	1,675	1,640	70.7	74.3	77.6	77.0	76.0	75.0	73.8	72.6	4.1	0.1	-0.3	-0.4	-0.3
Oil	126	112	53	47	39	32	24	21	13.8	8.1	2.3	2.1	1.7	1.4	1.0	0.9	-3.4	-2.1	-3.9	-4.2	-3.7
Natural gas	141	241	457	481	508	540	570	599	15.5	17.5	20.1	20.9	22.3	23.6	25.1	26.5	4.8	1.0	1.2	1.1	1.1

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**36.0**	**36.3**	**39.5**	**40.8**	**42.0**	**43.3**	**44.6**	**45.7**									**0.4**	**0.6**	**0.6**	**0.5**	**0.6**
Coal	35.0	35.1	37.5	38.4	39.5	40.6	41.6	42.6									0.3	0.5	0.5	0.5	0.5
Oil	38.7	37.0	36.3	35.5	35.8	36.4	37.5	37.2									-0.3	-0.4	0.3	0.2	0.1
Natural gas	37.9	41.2	47.9	49.9	51.0	52.5	53.7	54.6									0.9	0.8	0.5	0.4	0.5

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2,762**	**3,534**	**5,660**	**5,884**	**5,963**	**6,067**	**6,118**	**6,207**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**0.8**	**0.3**	**0.2**	**0.4**
Coal	1,349	1,719	3,369	3,406	3,388	3,401	3,379	3,365	48.8	48.6	59.5	57.9	56.8	56.1	55.2	54.2	3.7	0.2	0.0	-0.1	0.0
Oil	1,033	1,306	1,514	1,615	1,644	1,672	1,695	1,748	37.4	36.9	26.8	27.5	27.6	27.6	27.7	28.2	1.5	1.3	0.3	0.4	0.6
Natural gas	380	509	776	863	931	995	1,044	1,094	13.8	14.4	13.7	14.7	15.6	16.4	17.1	17.6	2.9	2.1	1.4	1.0	1.4

Energy and economic indicators

	1990	2000	2015	2020	2025	2030	2035	2040	AAGR(%) 1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	16,861	23,941	39,023	46,477	55,281	65,971	78,168	91,534	3.4	3.6	3.6	3.3	3.5
Population (millions of people)	2,881	3,313	3,839	3,990	4,117	4,222	4,303	4,360	1.2	0.8	0.6	0.3	0.5
GDP per capita (thousands of 2010 US$/person)	5.85	7.23	10.17	11.65	13.4	15.6	18.2	21.0	2.2	2.8	3.0	3.0	2.9
Primary energy consumption per capita (toe/person)	1.37	1.52	1.95	2.02	2.06	2.10	2.13	2.18	1.4	0.7	0.4	0.4	0.4
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	235	211	192	174	154	134	117	104	-0.8	-2.0	-2.5	-2.5	-2.4
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	165	144	129	117	104	92	81	72	-1.0	-1.8	-2.4	-2.4	-2.3
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	164	148	145	127	108	92	78	68	-0.5	-2.7	-3.1	-3.0	-3.0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.70	0.70	0.76	0.73	0.70	0.69	0.67	0.65	0.3	-0.7	-0.6	-0.5	-0.6

Australia (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**86.4**	**103.1**	**125.3**	**128.7**	**133.5**	**136.7**	**138.7**	**140.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.5**	**0.6**	**0.2**	**0.4**
Coal	35.1	43.1	42.9	41.0	40.7	39.5	37.6	35.4	40.7	41.8	34.2	31.8	30.5	28.9	27.1	25.3	0.8	-0.9	-0.4	-1.1	-0.8
Oil	31.2	34.2	41.9	42.6	42.8	42.8	42.7	42.3	36.1	33.1	33.4	33.1	32.1	31.4	30.8	30.2	1.2	0.4	0.0	-0.1	0.0
Natural gas	14.8	19.3	32.2	35.1	38.8	41.8	44.5	46.9	17.1	18.7	25.7	27.2	29.0	30.6	32.1	33.5	3.2	1.7	1.8	1.1	1.5
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	1.2	1.4	1.1	1.5	1.5	1.5	1.5	1.5	1.4	1.4	0.9	1.2	1.1	1.1	1.1	1.1	-0.2	5.8	0.0	0.0	1.1
Geothermal	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	0.0	0.0	-	111.9	1.1	1.0	17.2
Others	4.0	5.1	7.1	8.5	9.7	11.0	12.4	13.8	4.7	5.0	5.7	6.6	7.3	8.0	9.0	9.9	2.3	3.5	2.6	2.4	2.7
Biomass	4.0	4.9	4.6	4.8	4.9	5.0	5.1	5.1	4.6	4.7	3.7	3.7	3.7	3.7	3.7	3.7	0.6	0.9	0.4	0.2	0.4
Solar, Wind, Ocean	0.1	0.1	1.9	2.9	4.0	5.1	6.4	7.8	0.1	0.1	1.5	2.3	3.0	3.7	4.6	5.6	13.3	9.5	5.7	4.4	5.9
Biofuels	0.0	0.1	0.7	0.8	0.8	0.9	0.9	0.9	0.0	0.1	0.6	0.6	0.6	0.6	0.6	0.7	-	1.9	1.0	0.9	1.1
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**56.7**	**69.6**	**81.3**	**84.4**	**87.1**	**89.7**	**92.0**	**94.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.8**	**0.6**	**0.5**	**0.6**
Industry	19.3	23.8	24.0	25.1	25.8	26.5	27.0	27.5	34.1	34.2	29.5	29.7	29.6	29.5	29.4	29.2	0.9	0.9	0.6	0.4	0.5
Transportation	21.1	25.7	32.5	33.0	33.1	33.3	33.4	33.5	37.3	36.9	40.0	39.1	38.1	37.1	36.3	35.6	1.7	0.3	0.1	0.1	0.1
Others	12.3	15.7	20.7	22.2	23.9	25.6	27.2	28.7	21.7	22.6	25.5	26.3	27.5	28.6	29.6	30.5	2.1	1.4	1.4	1.1	1.3
Non-energy	4.0	4.4	4.1	4.2	4.2	4.3	4.4	4.4	7.0	6.4	5.0	4.9	4.9	4.8	4.7	4.7	0.1	0.5	0.3	0.2	0.3
Total	**56.7**	**69.6**	**81.3**	**84.4**	**87.1**	**89.7**	**92.0**	**94.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.8**	**0.6**	**0.5**	**0.6**
Coal	4.6	4.2	2.3	2.3	2.2	2.1	2.0	1.9	8.0	6.0	2.9	2.7	2.5	2.3	2.1	2.0	-2.6	-0.5	-0.9	-1.2	-0.9
Oil	29.0	34.7	42.6	43.2	43.4	43.5	43.4	43.2	51.2	49.9	52.4	51.2	49.8	48.5	47.2	46.0	1.5	0.3	0.1	-0.1	0.1
Natural gas	8.7	11.4	13.5	14.2	14.7	15.3	15.7	16.1	15.3	16.4	16.6	16.8	16.9	17.0	17.1	17.1	1.8	1.0	0.8	0.5	0.7
Electricity	11.1	14.9	18.2	19.8	21.7	23.6	25.6	27.5	19.6	21.4	22.4	23.5	24.9	26.3	27.8	29.2	2.0	1.8	1.8	1.5	1.7
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	3.3	4.4	4.7	4.9	5.1	5.2	5.3	5.4	5.9	6.4	5.8	5.9	5.8	5.8	5.8	5.7	1.4	1.0	0.6	0.3	0.6

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**154.3**	**209.9**	**252.3**	**274.9**	**299.7**	**325.1**	**350.0**	**373.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.0**	**1.7**	**1.7**	**1.4**	**1.6**
Coal	121.5	174.2	158.6	154.1	153.2	151.8	147.3	141.4	78.7	83.0	62.9	56.0	51.1	46.7	42.1	37.8	1.1	-0.6	-0.1	-0.7	-0.5
Oil	3.6	1.8	6.8	6.7	6.8	6.8	6.7	6.6	2.3	0.9	2.7	2.4	2.3	2.1	1.9	1.8	2.6	-0.3	0.2	-0.3	-0.1
Natural gas	14.4	16.2	52.5	63.0	76.1	90.5	104.4	118.6	9.3	7.7	20.8	22.9	25.4	27.8	29.8	31.7	5.3	3.7	3.7	2.7	3.3
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	14.1	16.4	13.4	17.7	17.7	17.7	17.7	17.7	9.2	7.8	5.3	6.4	5.9	5.4	5.1	4.7	-0.2	5.8	0.0	0.0	1.1
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	111.9	1.1	1.0	17.2
Others	0.8	1.2	21.0	33.4	45.8	58.2	73.8	89.4	0.5	0.6	8.3	12.2	15.3	17.9	21.1	23.9	14.3	9.7	5.7	4.4	6.0

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**33.3**	**45.8**	**52.0**	**52.2**	**54.8**	**56.0**	**56.2**	**56.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.8**	**0.1**	**0.7**	**0.0**	**0.3**
Coal	28.9	41.2	38.8	36.9	36.7	35.6	33.9	31.9	86.8	90.0	74.5	70.8	66.9	63.6	60.3	56.9	1.2	-1.0	-0.4	-1.1	-0.8
Oil	0.9	0.5	1.4	1.5	1.6	1.6	1.6	1.6	2.8	1.1	2.6	2.9	2.8	2.8	2.8	2.8	1.5	2.4	0.3	-0.1	0.5
Natural gas	3.5	4.1	11.9	13.7	16.6	18.8	20.7	22.6	10.4	8.9	22.9	26.3	30.2	33.5	36.9	40.3	5.0	2.9	3.2	1.8	2.6

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**36.0**	**36.1**	**36.0**	**36.9**	**37.0**	**38.3**	**39.6**	**40.9**									**0.0**	**0.5**	**0.4**	**0.7**	**0.5**
Coal	36.1	36.4	35.2	35.9	35.9	36.7	37.4	38.1									-0.1	0.4	0.2	0.4	0.3
Oil	32.3	29.2	42.9	37.5	37.2	36.9	36.6	36.3									1.1	-2.7	-0.1	-0.2	-0.7
Natural gas	35.6	34.4	38.0	39.5	39.5	41.4	43.3	45.2									0.3	0.8	0.5	0.9	0.7

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**70.3**	**83.9**	**98.8**	**99.1**	**101.2**	**101.9**	**101.3**	**100.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.4**	**0.1**	**0.3**	**-0.2**	**0.1**
Coal	37.9	46.6	46.3	44.3	43.9	42.6	40.6	38.3	54.0	55.5	46.9	44.7	43.4	41.8	40.0	38.2	0.8	-0.9	-0.4	-1.1	-0.8
Oil	23.2	25.2	32.3	32.9	33.0	33.0	32.9	32.6	33.0	30.0	32.7	33.2	32.6	32.4	32.4	32.5	1.3	0.4	0.0	-0.1	0.0
Natural gas	9.2	12.1	20.1	21.9	24.3	26.2	27.9	29.4	13.1	14.5	20.4	22.1	24.0	25.7	27.5	29.3	3.2	1.7	1.8	1.2	1.5

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	636	881	1,355	1,561	1,782	2,016	2,260	2,510	3.1	2.9	2.6	2.2	2.5
Population (millions of people)	17	19	24	25	27	28	30	31	1.3	1.3	1.1	0.9	1.0
GDP per capita (thousands of 2010 US$/person)	37.30	46.01	56.95	61.49	66.4	71.4	76.6	81.6	1.7	1.5	1.5	1.3	1.4
Primary energy consumption per capita (toe/person)	5.06	5.38	5.27	5.07	4.97	4.84	4.70	4.55	0.2	-0.8	-0.5	-0.6	-0.6
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	136	117	92	82	75	68	61	56	-1.5	-2.3	-1.9	-1.9	-2.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	89	79	60	54	49	44	41	37	-1.6	-2.1	-1.9	-1.7	-1.9
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	110	95	73	63	57	51	45	40	-1.6	-2.7	-2.3	-2.3	-2.4
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.81	0.81	0.79	0.77	0.76	0.75	0.73	0.72	-0.1	-0.5	-0.3	-0.4	-0.4
Automobile ownership volume (millions of vehicles)	10	12	17	19	20	22	23	24	2.3	1.7	1.4	1.2	1.4
Automobile ownership volume per capita (vehicles per person)	0.573	0.642	0.721	0.734	0.748	0.762	0.776	0.789	0.9	0.4	0.4	0.3	0.4

Australia (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**86.4**	**103.1**	**125.3**	**125.5**	**125.0**	**124.1**	**122.3**	**119.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.0**	**-0.1**	**-0.3**	**-0.2**
Coal	35.1	43.1	42.9	38.8	35.9	33.2	30.2	27.2	40.7	41.8	34.2	30.9	28.7	26.7	24.7	22.7	0.8	-2.0	-1.6	-2.0	-1.8
Oil	31.2	34.2	41.9	41.8	40.7	39.1	37.2	35.2	36.1	33.1	33.4	33.3	32.6	31.5	30.4	29.4	1.2	0.0	-0.7	-1.0	-0.7
Natural gas	14.8	19.3	32.2	33.9	35.4	36.9	37.9	38.5	17.1	18.7	25.7	27.0	28.3	29.7	31.0	32.1	3.2	1.0	0.8	0.4	0.7
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	1.2	1.4	1.1	1.5	1.5	1.5	1.5	1.5	1.4	1.4	0.9	1.2	1.2	1.2	1.2	1.3	-0.2	5.8	0.0	0.0	1.1
Geothermal	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	0.0	0.0	-	112.6	3.0	1.1	18.2
Others	4.0	5.1	7.1	9.4	11.4	13.4	15.5	17.5	4.7	5.0	5.7	7.5	9.1	10.8	12.7	14.6	2.3	5.6	3.6	2.7	3.7
Biomass	4.0	4.9	4.6	4.9	5.0	5.0	5.0	5.0	4.6	4.7	3.7	3.9	4.0	4.0	4.1	4.1	0.6	1.2	0.2	-0.1	0.3
Solar, Wind, Ocean	0.1	0.1	1.9	3.5	5.1	6.7	8.5	10.3	0.1	0.1	1.5	2.8	4.1	5.4	7.0	8.6	13.3	13.5	6.8	4.3	7.1
Biofuels	0.0	0.1	0.7	1.0	1.3	1.6	2.0	2.3	0.0	0.1	0.6	0.8	1.1	1.3	1.6	1.9	-	7.6	4.8	3.5	4.8
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**56.7**	**69.6**	**81.3**	**83.6**	**84.6**	**85.0**	**84.8**	**84.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.6**	**0.2**	**-0.1**	**0.2**
Industry	19.3	23.8	24.0	24.9	25.3	25.6	25.7	25.5	34.1	34.2	29.5	29.8	30.0	30.2	30.3	30.2	0.9	0.7	0.3	-0.1	0.2
Transportation	21.1	25.7	32.5	32.7	32.0	31.0	29.9	29.0	37.3	36.9	40.0	39.1	37.8	36.5	35.3	34.3	1.7	0.1	-0.5	-0.7	-0.5
Others	12.3	15.7	20.7	21.8	23.0	24.0	24.9	25.6	21.7	22.6	25.5	26.1	27.2	28.3	29.4	30.3	2.1	1.1	1.0	0.6	0.9
Non-energy	4.0	4.4	4.1	4.2	4.2	4.3	4.4	4.4	7.0	6.4	5.0	5.0	5.0	5.1	5.1	5.2	0.1	0.5	0.3	0.2	0.3
Total	**56.7**	**69.6**	**81.3**	**83.6**	**84.6**	**85.0**	**84.8**	**84.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.6**	**0.2**	**-0.1**	**0.2**
Coal	4.6	4.2	2.3	2.3	2.1	2.0	1.9	1.7	8.0	6.0	2.9	2.7	2.5	2.4	2.2	2.0	-2.6	-0.6	-1.2	-1.7	-1.3
Oil	29.0	34.7	42.6	42.6	41.6	39.9	38.1	36.2	51.2	49.9	52.4	51.0	49.1	47.0	44.9	42.8	1.5	0.0	-0.7	-1.0	-0.6
Natural gas	8.7	11.4	13.5	14.0	14.4	14.6	14.7	14.7	15.3	16.4	16.6	16.8	17.0	17.2	17.3	17.4	1.8	0.8	0.4	0.0	0.3
Electricity	11.1	14.9	18.2	19.6	21.2	22.8	24.4	25.9	19.6	21.4	22.4	23.5	25.0	26.8	28.7	30.6	2.0	1.5	1.5	1.3	1.4
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	3.3	4.4	4.7	5.0	5.4	5.6	5.9	6.0	5.9	6.4	5.8	6.0	6.3	6.6	6.9	7.2	1.4	1.4	1.1	0.7	1.0

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**154.3**	**209.9**	**252.3**	**272.0**	**292.6**	**313.5**	**333.7**	**352.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.0**	**1.5**	**1.4**	**1.2**	**1.3**
Coal	121.5	174.2	158.6	146.8	139.3	131.9	122.9	113.0	78.7	83.0	62.9	54.0	47.6	42.1	36.8	32.1	1.1	-1.5	-1.1	-1.5	-1.3
Oil	3.6	1.8	6.8	6.4	6.1	5.9	5.6	5.3	2.3	0.9	2.7	2.3	2.1	1.9	1.7	1.5	2.6	-1.3	-0.7	-1.1	-1.0
Natural gas	14.4	16.2	52.5	60.0	69.2	78.6	87.1	94.8	9.3	7.7	20.8	22.1	23.7	25.1	26.1	26.9	5.3	2.7	2.7	1.9	2.4
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	14.1	16.4	13.4	17.7	17.7	17.7	17.7	17.7	9.2	7.8	5.3	6.5	6.0	5.6	5.3	5.0	-0.2	5.8	0.0	0.0	1.1
Geothermal	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	112.6	3.0	1.1	18.2
Others	0.8	1.2	21.0	41.1	60.2	79.2	100.3	121.4	0.5	0.6	8.3	15.1	20.6	25.3	30.1	34.5	14.3	14.3	6.8	4.4	7.3

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**33.3**	**45.8**	**52.0**	**49.1**	**47.7**	**46.3**	**44.4**	**42.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.8**	**-1.2**	**-0.6**	**-0.9**	**-0.8**
Coal	28.9	41.2	38.8	34.9	32.2	29.7	27.0	24.2	86.8	90.0	74.5	71.1	67.6	64.1	60.7	57.2	1.2	-2.1	-1.6	-2.0	-1.9
Oil	0.9	0.5	1.4	1.3	1.2	1.2	1.1	1.1	2.8	1.1	2.6	2.6	2.6	2.6	2.5	2.5	1.5	-1.3	-0.7	-1.1	-1.0
Natural gas	3.5	4.1	11.9	12.9	14.2	15.4	16.3	17.0	10.4	8.9	22.9	26.3	29.8	33.3	36.8	40.3	5.0	1.7	1.8	1.0	1.5

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**36.0**	**36.1**	**36.0**	**37.4**	**38.7**	**40.2**	**41.7**	**43.3**									**0.0**	**0.7**	**0.7**	**0.8**	**0.7**
Coal	36.1	36.4	35.2	36.2	37.2	38.2	39.2	40.2									-0.1	0.6	0.5	0.5	0.5
Oil	32.3	29.2	42.9	42.9	42.9	42.9	42.9	42.9									1.1	0.0	0.0	0.0	0.0
Natural gas	35.6	34.4	38.0	39.9	41.9	43.9	45.8	47.8									0.3	1.0	0.9	0.9	0.9

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**70.3**	**83.9**	**98.8**	**95.4**	**92.2**	**88.8**	**84.6**	**80.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.4**	**-0.7**	**-0.7**	**-1.0**	**-0.8**
Coal	37.9	46.6	46.3	41.9	38.8	35.8	32.6	29.3	54.0	55.5	46.9	44.0	42.1	40.4	38.6	36.7	0.8	-2.0	-1.6	-2.0	-1.8
Oil	23.2	25.2	32.3	32.3	31.3	29.9	28.3	26.6	33.0	30.0	32.7	33.8	33.9	33.7	33.4	33.3	1.3	-0.1	-0.8	-1.1	-0.8
Natural gas	9.2	12.1	20.1	21.2	22.1	23.0	23.6	24.0	13.1	14.5	20.4	22.2	24.0	25.9	28.0	30.0	3.2	1.0	0.8	0.4	0.7

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	636	881	1,355	1,561	1,782	2,016	2,260	2,510	3.1	2.9	2.6	2.2	2.5
Population (millions of people)	17	19	24	25	27	28	30	31	1.3	1.3	1.1	0.9	1.0
GDP per capita (thousands of 2010 US$/person)	37.30	46.01	56.95	61.49	66.4	71.4	76.6	81.6	1.7	1.5	1.5	1.3	1.4
Primary energy consumption per capita (toe/person)	5.06	5.38	5.27	4.94	4.66	4.40	4.14	3.90	0.2	-1.3	-1.2	-1.2	-1.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	136	117	92	80	70	62	54	48	-1.5	-2.8	-2.6	-2.5	-2.6
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	89	79	60	54	47	42	38	34	-1.6	-2.3	-2.4	-2.2	-2.3
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	110	95	73	61	52	44	37	32	-1.6	-3.5	-3.2	-3.2	-3.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.81	0.81	0.79	0.76	0.74	0.72	0.69	0.67	-0.1	-0.7	-0.6	-0.7	-0.7
Automobile ownership volume (millions of vehicles)	10	12	17	19	20	22	23	24	2.3	1.7	1.4	1.2	1.4
Automobile ownership volume per capita (vehicles per person)	0.573	0.642	0.721	0.734	0.748	0.762	0.776	0.789	0.9	0.4	0.4	0.3	0.4

Brunei Darussalam (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.70**	**2.40**	**3.26**	**6.18**	**7.32**	**8.00**	**9.01**	**9.39**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**13.7**	**2.6**	**1.6**	**4.3**
Coal	0.00	0.00	0.00	0.16	0.70	0.70	0.70	0.70	0.0	0.0	0.0	2.6	9.5	8.7	7.7	7.4	-	-	15.8	0.0	-
Oil	0.00	0.50	0.19	0.97	1.16	1.43	1.83	1.84	0.0	20.8	5.7	15.8	15.8	17.9	20.4	19.6	-	39.2	3.9	2.5	9.6
Natural gas	1.70	1.90	3.07	5.04	5.47	5.87	6.48	6.86	100.0	79.2	94.3	81.6	74.7	73.4	71.9	73.0	2.4	10.4	1.5	1.6	3.3
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Biomass	0.00	0.00							0.0	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	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	10.2	0.0	0.0	2.0
Biofuels									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.36**	**0.56**	**0.80**	**3.15**	**3.65**	**4.04**	**4.62**	**4.78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.3**	**31.4**	**2.5**	**1.7**	**7.4**
Industry	0.06	0.07	0.20	0.32	0.66	0.84	1.13	1.13	16.7	12.5	25.1	10.0	18.1	20.8	24.5	23.7	5.0	9.3	10.3	3.0	7.1
Transportation	0.19	0.26	0.31	0.76	0.82	0.89	0.96	0.96	52.8	46.4	38.2	24.2	22.5	21.9	20.7	20.1	1.9	19.9	1.5	0.8	4.7
Others	0.09	0.21	0.28	0.33	0.43	0.57	0.79	0.94	25.0	37.5	34.3	10.6	11.7	14.1	17.1	19.7	4.6	3.8	5.6	5.1	5.0
Non-energy	0.02	0.02	0.02	1.74	1.74	1.74	1.74	1.75	5.6	3.6	2.4	55.3	47.8	43.1	37.7	36.5	-0.2	146.8	0.0	0.0	19.8
Total	**0.35**	**0.57**	**0.80**	**3.15**	**3.65**	**4.04**	**4.62**	**4.78**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**31.4**	**2.5**	**1.7**	**7.4**
Coal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Oil	0.26	0.36	0.52	1.00	1.16	1.40	1.74	1.75	74.3	63.2	64.5	31.7	31.7	34.5	37.6	36.5	2.8	14.0	3.4	2.3	5.0
Natural gas	0.00	0.00	0.03	1.74	1.75	1.75	1.76	1.77	0.0	0.0	3.6	55.4	48.0	43.4	38.1	37.0	-	127.3	0.1	0.1	17.9
Electricity	0.09	0.21	0.26	0.41	0.74	0.89	1.12	1.26	25.7	36.8	31.9	12.9	20.3	22.1	24.3	26.5	4.3	9.6	8.2	3.6	6.6
Heat	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.17**	**2.54**	**3.78**	**5.83**	**10.98**	**12.93**	**15.94**	**17.74**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.8**	**9.1**	**8.3**	**3.2**	**6.4**
Coal	0.00	0.00	0.00	0.84	3.64	3.64	3.64	3.64	0.0	0.0	0.0	14.4	33.2	28.2	22.9	20.5	-	-	15.8	0.0	-
Oil	0.01	0.02	0.04	0.03	0.03	0.03	0.03	0.03	0.9	0.8	1.0	0.5	0.2	0.2	0.2	0.2	5.5	-5.9	-0.6	0.6	-1.2
Natural gas	1.16	2.52	3.74	4.96	7.31	9.26	12.26	14.06	99.1	99.2	99.0	85.1	66.6	71.6	77.0	79.3	4.8	5.8	6.4	4.3	5.4
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	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	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	10.2	0.0	0.0	2.0

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.46**	**0.87**	**1.23**	**1.68**	**2.63**	**3.01**	**3.59**	**3.96**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**6.5**	**6.0**	**2.8**	**4.8**
Coal	0.00	0.00	0.00	0.16	0.70	0.70	0.70	0.70	0.0	0.0	0.0	9.5	26.5	23.1	19.4	17.6	-	-	15.8	0.0	-
Oil	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0	1.1	0.9	0.5	0.3	0.3	0.2	0.2	-	-5.9	-0.6	0.6	-1.2
Natural gas	0.46	0.86	1.22	1.51	1.92	2.31	2.89	3.26	100.0	98.9	99.1	90.0	73.2	76.7	80.4	82.2	4.0	4.5	4.3	3.5	4.0

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**22**	**25**	**26**	**30**	**36**	**37**	**38**	**39**									**0.8**	**2.4**	**2.2**	**0.4**	**1.5**
Coal	-	-	-	45	45	45	45	45									-	-	0.0	0.0	-
Oil	-	17	30	30	30	30	30	30									-	0.0	0.0	0.0	0.0
Natural gas	22	25	26	28	33	34	36	37									0.8	1.3	2.0	0.7	1.4

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.9**	**1.4**	**6.7**	**9.4**	**10.9**	**12.6**	**15.0**	**16.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.3**	**7.2**	**2.9**	**2.4**	**3.6**
Coal			0.0	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	6.9	5.9	5.1	4.3	4.1	-	-	0.0	0.0	-
Oil	0.2	0.5	1.6	3.0	3.5	4.3	5.3	5.3	22.2	35.7	23.6	32.2	32.3	33.8	35.3	33.4	8.6	14.1	3.4	2.3	5.0
Natural gas	0.7	0.9	5.1	5.8	6.7	7.7	9.1	10.0	77.8	64.3	76.4	60.9	61.8	61.0	60.4	62.5	8.3	2.4	2.9	2.6	2.7

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	6.9	8.6	13.9	17.6	25.5	36.4	51.8	54.5	2.8	4.9	7.5	4.1	5.6
Population (millions of people)	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	1.3	2.1	2.3	2.3	2.3
GDP per capita (thousands of 2010 US$/person)	23.0	28.7	33.3	38.09	49.3	62.7	79.7	74.9	1.5	2.7	5.1	1.8	3.3
Primary energy consumption per capita (toe/person)	5.7	8.0	7.8	13.35	14.13	13.79	13.86	12.90	1.3	11.3	0.3	-0.7	2.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	246	279	235	350	287	220	174	172	-0.2	8.4	-4.5	-2.4	-1.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	52	65	58	179	143	111	89	88	0.4	25.3	-4.6	-2.4	1.7
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	130	163	480	535	427	346	291	293	5.4	2.2	-4.3	-1.7	-2.0
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.5	0.6	2.0	1.53	1.49	1.57	1.67	1.70	5.6	-5.7	0.3	0.8	-0.7
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Brunei Darussalam (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.70**	**2.40**	**3.26**	**5.90**	**6.87**	**7.09**	**7.23**	**7.63**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**12.6**	**1.9**	**0.7**	**3.5**
Coal	0.0	0.0	0.00	0.16	0.16	0.16	0.16	0.16	0.0	0.0	0.0	2.7	2.3	2.3	2.2	2.1	-	-	0.0	0.0	-
Oil	0.0	0.5	0.19	0.93	0.99	1.06	1.25	1.25	0.0	20.8	5.7	15.7	14.4	15.0	17.3	16.4	-	37.8	1.4	1.7	7.9
Natural gas	1.7	1.9	3.07	4.81	5.73	5.87	5.82	6.22	100.0	79.2	94.3	81.6	83.3	82.8	80.5	81.5	2.4	9.4	2.0	0.6	2.9
Nuclear	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Biomass	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Solar, Wind, Ocean	0.0	0.0	0.00	0.02	0.03	0.05	0.07	0.07	0.0	0.0	0.0	0.3	0.5	0.6	1.0	1.0	-	194.7	8.8	5.1	30.9
Biofuels	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.36**	**0.56**	**0.80**	**3.06**	**3.42**	**3.54**	**3.71**	**3.86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.3**	**30.7**	**1.5**	**0.9**	**6.5**
Industry	0.1	0.1	0.20	0.29	0.63	0.76	0.94	0.94	16.7	12.5	25.1	9.5	18.3	21.6	25.3	24.3	5.0	7.7	10.1	2.1	6.3
Transportation	0.2	0.3	0.31	0.74	0.69	0.61	0.60	0.60	52.8	46.4	38.2	24.2	20.2	17.3	16.3	15.7	1.9	19.3	-1.9	-0.2	2.7
Others	0.1	0.2	0.28	0.29	0.36	0.42	0.42	0.57	25.0	37.5	34.3	9.4	10.6	11.9	11.3	14.8	4.6	0.9	3.8	3.1	3.0
Non-energy	0.0	0.0	0.02	1.74	1.74	1.74	1.74	1.74	5.6	3.6	2.4	56.8	50.9	49.2	47.0	45.2	-0.2	146.8	0.0	0.0	19.8
Total	**0.35**	**0.57**	**0.80**	**3.06**	**3.42**	**3.54**	**3.71**	**3.86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**30.7**	**1.5**	**0.9**	**6.5**
Coal	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Oil	0.3	0.4	0.52	0.96	1.00	1.04	1.19	1.20	74.3	63.2	64.5	31.2	29.1	29.5	32.1	31.0	2.8	13.0	0.9	1.4	3.4
Natural gas	0.0	0.0	0.03	1.74	1.75	1.75	1.76	1.77	0.0	0.0	3.6	57.0	51.1	49.6	47.5	45.8	-	127.3	0.1	0.1	17.9
Electricity	0.1	0.2	0.26	0.36	0.68	0.74	0.75	0.89	25.7	36.8	31.9	11.8	19.8	20.9	20.4	23.2	4.3	7.2	7.4	1.9	5.1
Heat	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.17**	**2.54**	**3.78**	**5.37**	**10.28**	**11.10**	**11.28**	**13.08**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.8**	**7.3**	**7.5**	**1.7**	**5.1**
Coal	0.0	0.0	0.00	0.84	0.84	0.84	0.84	0.84	0.0	0.0	0.0	15.7	8.2	7.6	7.5	6.4	-	-	0.0	0.0	-
Oil	0.0	0.0	0.04	0.02	0.02	0.02	0.02	0.02	0.9	0.8	1.0	0.4	0.2	0.2	0.2	0.2	5.5	-10.6	0.8	0.2	-1.8
Natural gas	1.2	2.5	3.74	4.29	9.07	9.71	9.57	11.36	99.1	99.2	99.0	79.8	88.2	87.5	84.8	86.8	4.8	2.8	8.5	1.6	4.5
Nuclear	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.0	0.0							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.0	0.0	0.00	0.22	0.35	0.52	0.85	0.86	0.0	0.0	0.0	4.2	3.4	4.7	7.5	6.6	-	193.6	8.7	5.2	30.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.46**	**0.87**	**1.23**	**1.46**	**2.36**	**2.49**	**2.43**	**2.81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**3.5**	**5.5**	**1.2**	**3.4**
Coal	0.0	0.0	0.00	0.16	0.16	0.16	0.16	0.16	0.0	0.0	0.0	11.0	6.8	6.5	6.6	5.7	-	-	0.0	0.0	-
Oil	0.0	0.0	0.01	0.01	0.01	0.01	0.01	0.01	0.0	1.1	0.9	0.4	0.3	0.3	0.3	0.2	-	-10.6	0.8	0.2	-1.8
Natural gas	0.5	0.9	1.22	1.29	2.19	2.32	2.26	2.64	100.0	98.9	99.1	88.5	92.9	93.3	93.1	94.0	4.0	1.2	6.0	1.3	3.1

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**21.9**	**25.1**	**26.5**	**30.4**	**36.3**	**36.6**	**37.0**	**37.4**									**0.8**	**2.8**	**1.9**	**0.2**	**1.4**
Coal	-	-	-	45.0	45.0	45.0	45.0	45.0									-	-	0.0	0.0	-
Oil	-	17.2	30.0	30.0	30.0	30.0	30.0	30.0									-	0.0	0.0	0.0	0.0
Natural gas	21.7	25.2	26.4	28.6	35.6	36.0	36.4	37.0									0.8	1.6	2.3	0.3	1.4

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.9**	**1.4**	**6.7**	**8.8**	**9.8**	**10.2**	**10.6**	**11.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.3**	**5.6**	**1.6**	**1.2**	**2.2**
Coal	0.0	0.0	0.0	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	7.4	6.6	6.3	6.1	5.6	-	-	0.0	0.0	-
Oil	0.2	0.5	1.6	2.9	3.0	3.2	3.6	3.6	22.2	35.7	23.6	33.1	31.0	31.0	34.4	31.7	8.6	13.0	0.9	1.4	3.4
Natural gas	0.7	0.9	5.1	5.2	6.1	6.4	6.3	7.2	77.8	64.3	76.4	59.5	62.4	62.6	59.5	62.7	8.3	0.5	2.1	1.2	1.4

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	6.9	8.6	13.9	17.6	25.5	36.4	51.8	54.5	2.8	4.9	7.5	4.1	5.6
Population (millions of people)	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	1.3	2.1	2.3	2.3	2.3
GDP per capita (thousands of 2010 US$/person)	23.0	28.7	33.3	38.09	49.3	62.7	79.7	74.9	1.5	2.7	5.1	1.8	3.3
Primary energy consumption per capita (toe/person)	5.7	8.0	7.8	12.75	13.26	12.22	11.12	10.49	1.3	10.3	-0.4	-1.5	1.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	246	279	235	335	269	195	140	140	-0.2	7.4	-5.3	-3.3	-2.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	52	65	58	174	134	97	72	71	0.4	24.6	-5.6	-3.1	0.8
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	130	163	480	497	382	282	204	211	5.4	0.7	-5.5	-2.8	-3.2
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.5	0.6	2.0	1.49	1.42	1.44	1.46	1.51	5.6	-6.2	-0.3	0.4	-1.2
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Cambodia (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.84**	**3.42**	**7.04**	**8.94**	**9.90**	**11.24**	**12.86**	**15.24**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.7**	**4.9**	**2.3**	**3.1**	**3.1**
Coal	0.00	0.00	0.59	1.23	1.44	1.66	2.24	2.97	0.0	0.0	8.3	13.7	14.5	14.8	17.4	19.5	-	16.0	3.0	6.0	6.7
Oil	0.51	0.70	1.93	2.65	3.17	3.64	4.14	4.75	18.0	20.5	27.4	29.7	32.0	32.4	32.2	31.2	5.4	6.6	3.2	2.7	3.7
Natural gas			0.00	0.00	0.00	0.43	0.56	1.25	0.0	0.0	0.0	0.0	0.0	3.9	4.4	8.2	-	-	-	11.2	-
Nuclear									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00	0.17	0.49	0.67	0.82	1.12	1.51	0.0	0.0	2.4	5.5	6.8	7.3	8.7	9.9	-	23.5	5.2	6.2	9.1
Geothermal									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	2.33	2.72	4.35	4.57	4.62	4.69	4.80	4.76	82.0	79.5	61.8	51.1	46.7	41.7	37.3	31.2	2.5	1.0	0.3	0.2	0.4
Biomass	2.33	2.72	4.22	4.41	4.46	4.53	4.62	4.57	82.0	79.5	60.0	49.3	45.1	40.3	35.9	30.0	2.4	0.9	0.3	0.1	0.3
Solar, Wind, Ocean	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	-	33.7	-5.0	46.5	21.0
Biofuels			0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.00	0.00	0.13	0.16	0.16	0.16	0.16	0.16	0.0	0.0	1.9	1.8	1.6	1.4	1.2	1.0	-	3.6	0.0	0.0	0.7

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.543**	**2.950**	**5.925**	**7.350**	**8.196**	**9.123**	**10.272**	**11.770**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**4.4**	**2.2**	**2.6**	**2.8**
Industry	0.44	0.61	1.03	1.14	1.25	1.45	1.80	2.41	17.2	20.7	17.4	15.5	15.3	15.9	17.5	20.5	3.5	2.0	2.5	5.2	3.5
Transportation	0.38	0.43	1.39	1.91	2.29	2.66	3.08	3.59	15.0	14.6	23.5	26.0	27.9	29.2	29.9	30.5	5.3	6.5	3.4	3.0	3.9
Others	1.72	1.90	3.45	4.25	4.59	4.94	5.32	5.67	67.5	64.4	58.3	57.8	56.1	54.2	51.8	48.1	2.8	4.2	1.5	1.4	2.0
Non-energy	0.01	0.01	0.05	0.05	0.06	0.07	0.08	0.10	0.3	0.3	0.8	0.7	0.7	0.7	0.8	0.9	7.8	3.3	2.3	4.0	3.2
Total	**2.54**	**2.95**	**5.93**	**7.35**	**8.20**	**9.12**	**10.27**	**11.77**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**4.4**	**2.2**	**2.6**	**2.8**
Coal	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	-	2.0	2.0	2.0	2.0
Oil	0.44	0.54	1.87	2.65	3.17	3.64	4.14	4.75	17.3	18.1	31.5	36.1	38.6	39.9	40.3	40.3	6.0	7.3	3.2	2.7	3.8
Natural gas			-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.01	0.03	0.43	1.01	1.29	1.70	2.30	3.24	0.4	1.0	7.2	13.8	15.7	18.6	22.4	27.6	15.8	18.8	5.3	6.7	8.4
Heat			-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	2.09	2.39	3.62	3.67	3.72	3.77	3.81	3.76	82.3	80.8	61.1	50.0	45.4	41.3	37.1	31.9	2.2	0.3	0.3	0.0	0.2

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.20**	**0.45**	**4.40**	**10.61**	**14.03**	**19.05**	**26.57**	**38.20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**13.2**	**19.3**	**6.0**	**7.2**	**9.0**
Coal	0.00	0.00	2.13	4.52	5.95	6.87	9.82	13.04	0.0	0.0	48.4	42.6	42.4	36.1	37.0	34.1	-	16.3	4.3	6.6	7.5
Oil	0.20	0.45	0.23	0.00	0.00	0.00	0.00	0.00	100.0	100.0	5.2	0.0	0.0	0.0	0.0	0.0	0.6	-100.0	-	-	-100.0
Natural gas	0.00	0.00	0.00	0.00	0.00	2.42	3.15	7.00	0.0	0.0	0.0	0.0	0.0	12.7	11.8	18.3	-	-	-	11.2	-
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00	2.00	5.74	7.83	9.55	13.05	17.51	0.0	0.0	45.5	54.1	55.8	50.1	49.1	45.8	-	23.5	5.2	6.2	9.1
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.00	0.00	0.04	0.34	0.26	0.21	0.56	0.65	0.0	0.0	0.9	3.2	1.8	1.1	2.1	1.7	-	53.1	-5.0	12.2	11.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.10**	**0.09**	**0.63**	**1.22**	**1.42**	**2.08**	**2.79**	**4.20**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**13.9**	**5.5**	**7.3**	**7.9**
Coal	0.00	0.00	0.57	1.22	1.42	1.64	2.22	2.95	0.0	0.0	90.5	100.0	100.0	79.1	79.8	70.2	-	16.2	3.1	6.0	6.8
Oil	0.10	0.09	0.06	0.00	0.00	0.00	0.00	0.00	100.0	100.0	9.5	0.0	0.0	0.0	0.0	0.0	-2.0	-100.0	-	-	-100.0
Natural gas	-	-	0.00	0.00	0.00	0.43	0.56	1.25	0.0	0.0	0.0	0.0	0.0	20.9	20.2	29.8	-	-	-	11.2	-

Thermal efficiency

	%								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**17.2**	**43.0**	**31.9**	**32.0**	**36.0**	**38.5**	**40.0**	**41.0**	**2.5**	**0.0**	**1.9**	**0.6**	**1.0**
Coal	-	-	31.9	32.0	36.0	36.0	38.0	38.0	-	0.1	1.2	0.5	0.7
Oil	17.2	43.0	32.5	-	-	-	-	-	2.6	-	-	-	-
Natural gas	-	-	-	-	-	48.0	48.0	48.0	-	-	-	0.0	-

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.40**	**0.50**	**2.02**	**3.27**	**3.90**	**4.78**	**5.89**	**7.60**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.7**	**10.1**	**3.9**	**4.7**	**5.4**
Coal	0.00	0.00	0.63	1.33	1.56	1.80	2.44	3.24	0.0	0.0	31.2	40.8	40.0	37.7	41.5	42.7	-	16.2	3.1	6.0	6.8
Oil	0.40	0.50	1.39	1.94	2.34	2.70	3.08	3.55	100.0	100.0	68.8	59.2	60.0	56.5	52.4	46.8	5.1	6.9	3.4	2.8	3.8
Natural gas	0.00	0.00	0.00	0.00	0.00	0.28	0.36	0.80	0.0	0.0	0.0	0.0	0.0	5.8	6.1	10.6	-	-	-	11.2	-

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	4	5	15.9	20.8	27.2	35.5	46.4	60.6	7.6	5.5	5.5	5.5	5.5
Population (millions of people)	9	12	15.5	16.7	18.0	19.4	20.9	22.5	2.8	1.5	1.5	1.5	1.5
GDP per capita (thousands of 2010 US$/person)	0.4	0.4	1.0	1.24	1.5	1.8	2.2	2.7	4.7	3.9	3.9	3.9	3.9
Primary energy consumption per capita (toe/person)	0.3	0.3	0.5	0.53	0.55	0.58	0.62	0.68	1.8	3.4	0.8	1.6	1.6
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	775	657	442	430	364	316	277	251	-2.8	-0.6	-3.0	-2.3	-2.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	695	567	373	354	302	257	221	194	-3.1	-1.0	-3.1	-2.8	-2.6
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	108	96	127	158	143	135	127	125	0.8	4.4	-1.6	-0.7	-0.1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.1	0.1	0.3	0.37	0.39	0.43	0.46	0.50	3.7	5.0	1.5	1.6	2.2
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Cambodia (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.84**	**3.42**	**7.04**	**8.54**	**9.55**	**10.08**	**10.76**	**13.04**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.7**	**4.0**	**1.7**	**2.6**	**2.5**
Coal	0.00	0.00	0.59	0.88	1.22	1.14	1.10	2.49	0.0	0.0	8.3	10.3	12.7	11.3	10.2	19.1	-	8.6	2.6	8.1	5.9
Oil	0.51	0.70	1.93	2.55	3.23	3.54	3.83	4.35	18.0	20.5	27.4	29.9	33.9	35.1	35.6	33.4	5.4	5.8	3.3	2.1	3.3
Natural gas	0.00	0.00	0.00	0.20	0.17	0.14	0.15	0.19	0.0	0.0	0.0	2.3	1.8	1.4	1.4	1.4	-	-	-3.2	2.8	-
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00	0.17	0.35	0.31	0.53	0.83	0.93	0.0	0.0	2.4	4.1	3.3	5.3	7.7	7.1	-	15.5	4.2	5.7	7.0
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	2.33	2.72	4.35	4.55	4.62	4.73	4.86	5.09	82.0	79.5	61.8	53.3	48.3	46.9	45.1	39.0	2.5	0.9	0.4	0.7	0.6
Biomass	2.33	2.72	4.22	4.30	4.24	4.23	4.23	4.32	82.0	79.5	60.0	50.3	44.4	42.0	39.3	33.1	2.4	0.4	-0.2	0.2	0.1
Solar, Wind, Ocean	0.00	0.00	0.00	0.01	0.03	0.05	0.07	0.09	0.0	0.0	0.0	0.1	0.4	0.5	0.6	0.7	-	107.2	17.3	6.7	26.6
Biofuels	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.00	0.00	0.13	0.24	0.34	0.45	0.56	0.68	0.0	0.0	1.9	2.9	3.5	4.5	5.2	5.2	-	13.3	6.3	4.1	6.8

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.54**	**2.95**	**5.93**	**7.08**	**7.59**	**8.11**	**8.75**	**10.02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**3.6**	**1.4**	**2.1**	**2.1**
Industry	0.44	0.61	1.03	1.10	1.16	1.29	1.53	2.05	17.2	20.7	17.4	15.5	15.3	15.9	17.5	20.5	3.5	1.2	1.6	4.8	2.8
Transportation	0.38	0.43	1.39	1.84	2.12	2.36	2.61	3.05	15.0	14.6	23.5	26.0	27.9	29.2	29.9	30.4	5.3	5.7	2.5	2.6	3.2
Others	1.72	1.90	3.45	4.09	4.25	4.39	4.52	4.82	67.5	64.4	58.3	57.7	56.0	54.1	51.7	48.1	2.8	3.4	0.7	0.9	1.3
Non-energy	0.01	0.01	0.05	0.05	0.06	0.07	0.08	0.10	0.3	0.3	0.8	0.8	0.8	0.8	0.9	1.0	7.8	3.3	2.3	4.0	3.2
Total	**2.54**	**2.95**	**5.93**	**7.08**	**7.59**	**8.11**	**8.75**	**10.02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**3.6**	**1.4**	**2.1**	**2.1**
Coal	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	-	2.0	2.0	2.0	2.0
Oil	0.44	0.54	1.87	2.55	2.93	3.24	3.53	4.05	17.3	18.1	31.5	36.1	38.7	39.9	40.3	40.4	6.0	6.5	2.4	2.3	3.1
Natural gas	0.00	0.00	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.01	0.03	0.43	0.98	1.19	1.51	1.96	2.76	0.4	1.0	7.2	13.8	15.7	18.6	22.4	27.5	15.8	17.9	4.4	6.2	7.7
Heat	0.00	0.00	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	2.09	2.39	3.62	3.53	3.44	3.35	3.24	3.19	82.3	80.8	61.1	49.9	45.4	41.3	37.1	31.9	2.2	-0.5	-0.5	-0.5	-0.5

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.20**	**0.45**	**4.40**	**9.05**	**10.58**	**13.04**	**17.24**	**25.73**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**13.2**	**15.5**	**3.7**	**7.0**	**7.3**
Coal	0.00	0.00	2.13	3.24	5.03	4.70	4.86	11.29	0.0	0.0	48.4	35.8	47.5	36.1	28.2	43.9	-	8.8	3.8	9.2	6.9
Oil	0.20	0.45	0.23	0.00	0.00	0.00	0.00	0.00	100.0	100.0	5.2	0.0	0.0	0.0	0.0	0.0	0.6	-100.0	-	-	-100.0
Natural gas	0.00	0.00	0.00	1.10	0.97	0.79	0.82	1.04	0.0	0.0	0.0	12.2	9.2	6.1	4.8	4.1	-	-	-3.2	2.8	-
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00	2.00	4.11	3.61	6.19	9.69	10.79	0.0	0.0	45.5	45.4	34.2	47.4	56.2	41.9	-	15.5	4.2	5.7	7.0
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.00	0.00	0.04	0.60	0.97	1.36	1.87	2.61	0.0	0.0	0.9	6.6	9.2	10.4	10.9	10.1	-	70.8	8.6	6.7	18.1

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.10**	**0.09**	**0.63**	**1.07**	**1.37**	**1.27**	**1.22**	**2.65**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**11.0**	**1.7**	**7.7**	**5.9**
Coal	0.00	0.00	0.57	0.87	1.20	1.12	1.08	2.47	0.0	0.0	90.5	81.5	87.4	88.8	88.0	93.0	-	8.7	2.6	8.2	6.0
Oil	0.10	0.09	0.06	0.00	0.00	0.00	0.00	0.00	100.0	100.0	9.5	0.0	0.0	0.0	0.0	0.0	-2.0	-100.0	-	-	-100.0
Natural gas	-	-	0.00	0.20	0.17	0.14	0.15	0.19	0.0	0.0	0.0	18.5	12.6	11.2	12.0	7.0	-	-	-3.2	2.8	-

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**17.2**	**43.0**	**31.9**	**35.0**	**37.5**	**37.4**	**39.9**	**40.0**									**2.5**	**1.8**	**0.7**	**0.7**	**0.9**
Coal	-	-	31.9	32.0	36.0	36.0	38.8	39.4									-	0.1	1.2	0.9	0.8
Oil	17.2	43.0	32.5	-	-	-	-	-									2.6	-	-	-	-
Natural gas	-	-	-	48.0	48.0	48.0	48.0	48.0									-	-	0.0	0.0	-

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.4**	**0.5**	**2.0**	**2.9**	**3.6**	**3.7**	**3.9**	**5.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.7**	**7.8**	**2.3**	**2.9**	**3.7**
Coal	0.0	0.0	0.63	0.96	1.32	1.23	1.18	1.83	0.0	0.0	31.2	32.4	36.7	33.2	30.4	36.9	-	8.7	2.6	4.0	4.4
Oil	0.4	0.5	1.39	1.87	2.16	2.39	2.62	3.02	100.0	100.0	68.8	63.3	60.2	64.4	67.2	60.7	5.1	6.0	2.5	2.3	3.1
Natural gas	0.0	0.0	0.00	0.13	0.11	0.09	0.09	0.12	0.0	0.0	0.0	4.3	3.1	2.4	2.4	2.4	-	-	-3.2	2.8	-

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	3.7	5.2	15.9	20.8	27.2	35.5	46.4	60.6	7.6	5.5	5.5	5.5	5.5
Population (millions of people)	9.0	12.2	15.5	16.7	18.0	19.4	20.9	22.5	2.8	1.5	1.5	1.5	1.5
GDP per capita (thousands of 2010 US$/person)	0.4	0.4	1.0	1.24	1.5	1.8	2.2	2.7	4.7	3.9	3.9	3.9	3.9
Primary energy consumption per capita (toe/person)	0.3	0.3	0.5	0.51	0.53	0.52	0.51	0.58	1.8	2.4	0.2	1.1	1.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	775	657	442	411	352	284	232	215	-2.8	-1.5	-3.6	-2.7	-2.8
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	695	567	373	340	279	228	188	165	-3.1	-1.8	-3.9	-3.2	-3.2
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	108	96	127	142	132	105	84	82	0.8	2.2	-3.0	-2.4	-1.7
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.1	0.1	0.3	0.35	0.38	0.37	0.36	0.38	3.7	3.7	0.7	0.3	1.1
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

China (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**870.7**	**1,129.8**	**2,973.3**	**3,293.5**	**3,525.8**	**3,734.5**	**3,899.2**	**4,014.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**2.1**	**1.3**	**0.7**	**1.2**
Coal	527.6	664.7	1,982.0	2,005.6	2,013.0	2,006.6	1,992.1	1,938.6	60.6	58.8	66.7	60.9	57.1	53.7	51.1	48.3	5.4	0.2	0.0	-0.3	-0.1
Oil	118.8	220.8	533.7	652.6	729.2	788.9	825.5	853.4	13.6	19.5	18.0	19.8	20.7	21.1	21.2	21.3	6.2	4.1	1.9	0.8	1.9
Natural gas	12.8	20.8	158.5	236.2	313.1	392.7	475.2	556.5	1.5	1.8	5.3	7.2	8.9	10.5	12.2	13.9	10.6	8.3	5.2	3.5	5.2
Nuclear	0.0	4.4	44.5	106.2	151.9	197.5	224.9	252.3	0.0	0.4	1.5	3.2	4.3	5.3	5.8	6.3	-	19.0	6.4	2.5	7.2
Hydro	10.9	19.1	95.8	107.9	113.5	118.5	123.0	125.6	1.3	1.7	3.2	3.3	3.2	3.2	3.2	3.1	9.1	2.4	0.9	0.6	1.1
Geothermal	0.0	1.7	5.1	6.0	6.6	7.3	8.0	8.6	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	-	3.3	2.1	1.6	2.1
Others	200.6	198.4	153.6	179.0	198.5	222.9	250.5	280.0	23.0	17.6	5.2	5.4	5.6	6.0	6.4	7.0	-1.1	3.1	2.2	2.3	2.4
Biomass	200.4	197.0	104.0	101.3	93.7	90.2	93.6	98.9	23.0	17.4	3.5	3.1	2.7	2.4	2.4	2.5	-2.6	-0.5	-1.2	0.9	-0.2
Solar, Wind, Ocean	0.0	1.0	41.2	66.9	92.2	118.0	139.6	161.1	0.0	0.1	1.4	2.0	2.6	3.2	3.6	4.0	33.0	10.2	5.8	3.2	5.6
Biofuels	0.0	1.1	9.5	11.7	13.6	15.8	18.2	21.0	0.0	0.1	0.3	0.4	0.4	0.4	0.5	0.5	-	4.3	3.0	2.9	3.2
Electricity	0.2	-0.7	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-207.9	-1.7	0.0	0.0	-0.3

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**654.3**	**781.2**	**1,905.7**	**2,133.7**	**2,286.6**	**2,421.5**	**2,524.1**	**2,602.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**2.3**	**1.3**	**0.7**	**1.3**
Industry	233.9	299.0	966.1	1,001.9	1,016.9	1,026.8	1,027.1	1,016.6	35.7	38.3	50.7	47.0	44.5	42.4	40.7	39.1	5.8	0.7	0.2	-0.1	0.2
Transportation	33.5	87.3	298.6	403.4	473.0	524.1	556.6	581.1	5.1	11.2	15.7	18.9	20.7	21.6	22.1	22.3	9.2	6.2	2.7	1.0	2.7
Others	344.1	334.7	483.2	548.2	599.2	653.5	706.7	751.2	52.6	42.8	25.4	25.7	26.2	27.0	28.0	28.9	1.4	2.6	1.8	1.4	1.8
Non-energy	42.9	60.2	157.7	180.2	197.5	217.1	233.7	253.0	6.6	7.7	8.3	8.4	8.6	9.0	9.3	9.7	5.3	2.7	1.9	1.5	1.9
Total	**654.3**	**781.2**	**1,905.7**	**2,133.7**	**2,286.6**	**2,421.5**	**2,524.1**	**2,602.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**2.3**	**1.3**	**0.7**	**1.3**
Coal	308.2	274.5	700.8	697.6	678.3	656.7	625.9	588.0	47.1	35.1	36.8	32.7	29.7	27.1	24.8	22.6	3.3	-0.1	-0.6	-1.1	-0.7
Oil	84.6	180.4	480.4	592.1	667.6	723.8	759.0	786.6	12.9	23.1	25.2	27.8	29.2	29.9	30.1	30.2	7.2	4.3	2.0	0.8	2.0
Natural gas	8.9	12.4	105.4	144.0	178.6	212.7	245.2	277.2	1.4	1.6	5.5	6.7	7.8	8.8	9.7	10.7	10.4	6.4	4.0	2.7	3.9
Electricity	39.0	89.1	419.4	495.4	561.1	625.8	687.1	737.6	6.0	11.4	22.0	23.2	24.5	25.8	27.2	28.3	10.0	3.4	2.4	1.7	2.3
Heat	13.2	25.5	83.3	90.4	95.9	101.4	106.2	110.0	2.0	3.3	4.4	4.2	4.2	4.2	4.2	4.2	7.6	1.7	1.2	0.8	1.1
Others	200.4	199.3	116.4	114.2	105.0	101.0	100.6	102.5	30.6	25.5	6.1	5.4	4.6	4.2	4.0	3.9	-2.2	-0.4	-1.2	0.1	-0.5

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**621.3**	**1,355.7**	**5,844.2**	**6,890.9**	**7,781.0**	**8,638.0**	**9,427.9**	**10,054.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.4**	**3.4**	**2.3**	**1.5**	**2.2**
Coal	441.3	1,060.4	4,109.0	4,345.4	4,540.1	4,690.2	4,858.6	4,889.0	71.0	78.2	70.3	63.1	58.3	54.3	51.5	48.6	9.3	1.1	0.8	0.4	0.7
Oil	50.4	47.3	9.7	9.6	9.3	8.8	8.2	7.2	8.1	3.5	0.2	0.1	0.1	0.1	0.1	0.1	-6.4	-0.2	-0.9	-1.9	-1.1
Natural gas	2.8	5.8	145.3	302.9	482.9	682.9	912.1	1,139.3	0.4	0.4	2.5	4.4	6.2	7.9	9.7	11.3	17.2	15.8	8.5	5.3	8.6
Nuclear	0.0	16.7	170.8	407.5	582.7	758.0	863.2	968.3	0.0	1.2	2.9	5.9	7.5	8.8	9.2	9.6	-	19.0	6.4	2.5	7.2
Hydro	126.7	222.4	1,114.5	1,254.3	1,320.3	1,378.0	1,430.7	1,460.2	20.4	16.4	19.1	18.2	17.0	16.0	15.2	14.5	9.1	2.4	0.9	0.6	1.1
Geothermal	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	14.3	4.5	1.4	5.1
Others	0.0	3.1	294.8	571.1	845.4	1,119.7	1,354.8	1,590.0	0.0	0.2	5.0	8.3	10.9	13.0	14.4	15.8	50.4	14.1	7.0	3.6	7.0

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**144.7**	**297.2**	**948.5**	**1,000.1**	**1,061.7**	**1,116.2**	**1,178.9**	**1,211.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.8**	**1.1**	**1.1**	**0.8**	**1.0**
Coal	131.7	284.3	920.1	943.7	973.7	993.5	1,016.6	1,010.7	91.0	95.7	97.0	94.4	91.7	89.0	86.2	83.4	8.1	0.5	0.5	0.2	0.4
Oil	12.4	11.6	2.4	2.4	2.3	2.2	2.0	1.8	8.5	3.9	0.3	0.2	0.2	0.2	0.2	0.1	-6.4	-0.2	-0.9	-1.9	-1.1
Natural gas	0.6	1.3	26.1	54.0	85.7	120.6	160.3	199.2	0.4	0.4	2.7	5.4	8.1	10.8	13.6	16.4	16.2	15.7	8.4	5.1	8.5

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**29.4**	**32.2**	**38.7**	**40.1**	**40.8**	**41.5**	**42.2**	**42.8**									**1.1**	**0.7**	**0.3**	**0.3**	**0.4**
Coal	28.8	32.1	38.4	39.6	40.1	40.6	41.1	41.6									1.2	0.6	0.2	0.2	0.3
Oil	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0									0.0	0.0	0.0	0.0	0.0
Natural gas	39.0	39.0	47.9	48.2	48.4	48.7	48.9	49.2									0.8	0.1	0.1	0.1	0.1

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**637.8**	**862.8**	**2,545.4**	**2,699.1**	**2,803.8**	**2,879.4**	**2,931.4**	**2,930.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**1.2**	**0.6**	**0.2**	**0.6**
Coal	549.0	700.9	2,080.5	2,094.7	2,092.8	2,075.8	2,051.3	1,984.0	86.1	81.2	81.7	77.6	74.6	72.1	70.0	67.7	5.5	0.1	-0.1	-0.5	-0.2
Oil	83.5	151.7	369.7	459.9	517.5	559.5	583.5	598.7	13.1	17.6	14.5	17.0	18.5	19.4	19.9	20.4	6.1	4.5	2.0	0.7	1.9
Natural gas	5.3	10.2	95.2	144.5	193.5	244.1	296.7	348.2	0.8	1.2	3.7	5.4	6.9	8.5	10.1	11.9	12.3	8.7	5.4	3.6	5.3

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	830	2,237	8,910	12,206	16,005	20,546	25,701	31,116	10.0	6.5	5.3	4.2	5.1
Population (millions of people)	1,135	1,263	1,371	1,398	1,412	1,415	1,407	1,391	0.8	0.4	0.1	-0.2	0.1
GDP per capita (thousands of 2010 US$/person)	0.73	1.77	6.50	8.73	11.3	14.5	18.3	22.4	9.1	6.1	5.2	4.4	5.1
Primary energy consumption per capita (toe/person)	0.77	0.89	2.17	2.36	2.50	2.64	2.77	2.89	4.2	1.7	1.1	0.9	1.1
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,050	505	334	270	220	182	152	129	-4.5	-4.2	-3.9	-3.4	-3.7
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	789	349	214	175	143	118	98	84	-5.1	-4.0	-3.9	-3.4	-3.7
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	769	386	286	221	175	140	114	94	-3.9	-5.0	-4.5	-3.9	-4.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.73	0.76	0.86	0.82	0.80	0.77	0.75	0.73	0.6	-0.9	-0.6	-0.5	-0.6
Automobile ownership volume (millions of vehicles)	5	16	163	250	312	366	405	438	14.7	8.9	3.9	1.8	4.0
Automobile ownership volume per capita (vehicles per person)	0.005	0.012	0.119	0.179	0.221	0.258	0.288	0.315	13.8	8.5	3.8	2.0	4.0

China (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**870.7**	**1,129.8**	**2,973.3**	**3,232.7**	**3,357.4**	**3,452.5**	**3,494.6**	**3,494.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**1.7**	**0.7**	**0.1**	**0.6**
Coal	527.6	664.7	1,982.0	1,952.8	1,865.0	1,771.8	1,650.6	1,503.0	60.6	58.8	66.7	60.4	55.5	51.3	47.2	43.0	5.4	-0.3	-1.0	-1.6	-1.1
Oil	118.8	220.8	533.7	649.5	708.4	742.6	751.4	752.1	13.6	19.5	18.0	20.1	21.1	21.5	21.5	21.5	6.2	4.0	1.3	0.1	1.4
Natural gas	12.8	20.8	158.5	228.6	289.7	346.4	395.1	435.0	1.5	1.8	5.3	7.1	8.6	10.0	11.3	12.4	10.6	7.6	4.2	2.3	4.1
Nuclear	0.0	4.4	44.5	106.2	170.1	234.1	298.0	362.0	0.0	0.4	1.5	3.3	5.1	6.8	8.5	10.4	-	19.0	8.2	4.5	8.7
Hydro	10.9	19.1	95.8	108.4	115.2	121.6	127.6	131.7	1.3	1.7	3.2	3.4	3.4	3.5	3.7	3.8	9.1	2.5	1.1	0.8	1.3
Geothermal	0.0	1.7	5.1	6.2	6.5	7.5	8.3	9.0	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.3	-	4.2	1.8	2.0	2.4
Others	200.6	198.4	153.6	181.1	202.5	228.7	263.6	302.2	23.0	17.6	5.2	5.6	6.0	6.6	7.5	8.6	-1.1	3.3	2.4	2.8	2.7
Biomass	200.4	197.0	104.0	98.9	89.4	83.8	85.5	90.0	23.0	17.4	3.5	3.1	2.7	2.4	2.4	2.6	-2.6	-1.0	-1.6	0.7	-0.6
Solar, Wind, Ocean	0.0	1.0	41.2	70.0	98.2	126.4	155.0	183.1	0.0	0.1	1.4	2.2	2.9	3.7	4.4	5.2	33.0	11.2	6.1	3.8	6.2
Biofuels	0.0	1.1	9.5	13.1	15.9	19.5	24.1	30.0	0.0	0.1	0.3	0.4	0.5	0.6	0.7	0.9	-	6.7	4.1	4.4	4.7
Electricity	0.2	-0.7	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-207.9	-1.7	0.0	0.0	-0.3

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**654.3**	**781.2**	**1,905.7**	**2,097.3**	**2,201.3**	**2,278.4**	**2,318.8**	**2,334.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**1.9**	**0.8**	**0.2**	**0.8**
Industry	233.9	299.0	966.1	977.9	970.2	959.4	938.7	906.0	35.7	38.3	50.7	46.6	44.1	42.1	40.5	38.8	5.8	0.2	-0.2	-0.6	-0.3
Transportation	33.5	87.3	298.6	398.3	455.8	488.2	501.5	509.6	5.1	11.2	15.7	19.0	20.7	21.4	21.6	21.8	9.2	5.9	2.1	0.4	2.2
Others	344.1	334.7	483.2	541.0	577.8	613.6	645.0	666.2	52.6	42.8	25.4	25.8	26.2	26.9	27.8	28.5	1.4	2.3	1.3	0.8	1.3
Non-energy	42.9	60.2	157.7	180.2	197.5	217.1	233.7	253.0	6.6	7.7	8.3	8.6	9.0	9.5	10.1	10.8	5.3	2.7	1.9	1.5	1.9
Total	**654.3**	**781.2**	**1,905.7**	**2,097.3**	**2,201.3**	**2,278.4**	**2,318.8**	**2,334.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**1.9**	**0.8**	**0.2**	**0.8**
Coal	308.2	274.5	700.8	687.2	660.0	631.2	593.1	548.0	47.1	35.1	36.8	32.8	30.0	27.7	25.6	23.5	3.3	-0.4	-0.8	-1.4	-1.0
Oil	84.6	180.4	480.4	589.4	648.7	681.5	691.3	693.6	12.9	23.1	25.2	28.1	29.5	29.9	29.8	29.7	7.2	4.2	1.5	0.2	1.5
Natural gas	8.9	12.4	105.4	140.2	169.1	195.0	217.4	237.5	1.4	1.6	5.5	6.7	7.7	8.6	9.4	10.2	10.4	5.9	3.4	2.0	3.3
Electricity	39.0	89.1	419.4	486.4	538.1	588.4	634.3	669.8	6.0	11.4	22.0	23.2	24.4	25.8	27.4	28.7	10.0	3.0	1.9	1.3	1.9
Heat	13.2	25.5	83.3	88.0	91.4	94.5	96.5	97.1	2.0	3.3	4.4	4.2	4.2	4.1	4.2	4.2	7.6	1.1	0.7	0.3	0.6
Others	200.4	199.3	116.4	106.1	94.0	87.7	86.1	88.6	30.6	25.5	6.1	5.1	4.3	3.9	3.7	3.8	-2.2	-1.8	-1.9	0.1	-1.1

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**621.3**	**1,355.7**	**5,844.2**	**6,766.3**	**7,461.5**	**8,121.6**	**8,704.3**	**9,129.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.4**	**3.0**	**1.8**	**1.2**	**1.8**
Coal	441.3	1,060.4	4,109.0	4,167.4	4,077.7	3,958.8	3,764.6	3,465.5	71.0	78.2	70.3	61.6	54.6	48.7	43.2	38.0	9.3	0.3	-0.5	-1.3	-0.7
Oil	50.4	47.3	9.7	9.2	8.3	7.4	6.3	5.1	8.1	3.5	0.2	0.1	0.1	0.1	0.1	0.1	-6.4	-1.0	-2.1	-3.6	-2.5
Natural gas	2.8	5.8	145.3	290.5	433.7	576.4	706.7	807.6	0.4	0.4	2.5	4.3	5.8	7.1	8.1	8.8	17.2	14.9	7.1	3.4	7.1
Nuclear	0.0	16.7	170.8	407.5	652.8	898.2	1,143.6	1,388.9	0.0	1.2	2.9	6.0	8.7	11.1	13.1	15.2	-	19.0	8.2	4.5	8.7
Hydro	126.7	222.4	1,114.5	1,260.9	1,339.6	1,413.5	1,483.9	1,531.2	20.4	16.4	19.1	18.6	18.0	17.4	17.0	16.8	9.1	2.5	1.1	0.8	1.3
Geothermal	0.1	0.1	0.1	0.3	0.4	0.5	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	19.1	4.8	2.6	6.6
Others	0.0	3.1	294.8	630.6	948.9	1,266.7	1,598.7	1,930.6	0.0	0.2	5.0	9.3	12.7	15.6	18.4	21.1	50.4	16.4	7.2	4.3	7.8

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**144.7**	**297.2**	**948.5**	**964.4**	**948.1**	**926.6**	**889.0**	**827.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.8**	**0.3**	**-0.4**	**-1.1**	**-0.5**
Coal	131.7	284.3	920.1	910.9	870.5	825.9	767.9	691.5	91.0	95.7	97.0	94.4	91.8	89.1	86.4	83.6	8.1	-0.2	-1.0	-1.8	-1.1
Oil	12.4	11.6	2.4	2.2	2.0	1.8	1.5	1.2	8.5	3.9	0.3	0.2	0.2	0.2	0.2	0.1	-6.4	-1.3	-2.4	-3.8	-2.7
Natural gas	0.6	1.3	26.1	51.3	75.6	99.0	119.7	134.9	0.4	0.4	2.7	5.3	8.0	10.7	13.5	16.3	16.2	14.5	6.8	3.1	6.8

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**29.4**	**32.2**	**38.7**	**39.8**	**41.0**	**42.2**	**43.3**	**44.5**									**1.1**	**0.6**	**0.6**	**0.5**	**0.6**
Coal	28.8	32.1	38.4	39.3	40.3	41.2	42.2	43.1									1.2	0.5	0.5	0.4	0.5
Oil	35.0	35.0	35.0	35.4	35.8	36.2	36.6	37.0									0.0	0.2	0.2	0.2	0.2
Natural gas	39.0	39.0	47.9	48.7	49.4	50.1	50.8	51.5									0.8	0.3	0.3	0.3	0.3

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**637.8**	**862.8**	**2,545.4**	**2,634.5**	**2,611.5**	**2,557.3**	**2,449.2**	**2,297.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**0.7**	**-0.3**	**-1.1**	**-0.4**
Coal	549.0	700.9	2,080.5	2,037.6	1,933.0	1,822.2	1,682.4	1,513.6	86.1	81.2	81.7	77.3	74.0	71.3	68.7	65.9	5.5	-0.4	-1.1	-1.8	-1.3
Oil	83.5	151.7	369.7	457.3	500.0	520.7	521.5	513.9	13.1	17.6	14.5	17.4	19.1	20.4	21.3	22.4	6.1	4.3	1.3	-0.1	1.3
Natural gas	5.3	10.2	95.2	139.6	178.5	214.4	245.3	270.4	0.8	1.2	3.7	5.3	6.8	8.4	10.0	11.8	12.3	7.9	4.4	2.3	4.3

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	830	2,237	8,910	12,206	16,005	20,546	25,701	31,116	10.0	6.5	5.3	4.2	5.1
Population (millions of people)	1,135	1,263	1,371	1,398	1,412	1,415	1,407	1,391	0.8	0.4	0.1	-0.2	0.1
GDP per capita (thousands of 2010 US$/person)	0.73	1.77	6.50	8.73	11.3	14.5	18.3	22.4	9.1	6.1	5.2	4.4	5.1
Primary energy consumption per capita (toe/person)	0.77	0.89	2.17	2.31	2.38	2.44	2.48	2.51	4.2	1.3	0.5	0.3	0.6
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,050	505	334	265	210	168	136	112	-4.5	-4.5	-4.4	-3.9	-4.3
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	789	349	214	172	138	111	90	75	-5.1	-4.3	-4.3	-3.8	-4.1
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	769	386	286	216	163	124	95	74	-3.9	-5.5	-5.4	-5.1	-5.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.73	0.76	0.86	0.81	0.78	0.74	0.70	0.66	0.6	-1.0	-1.0	-1.2	-1.1
Automobile ownership volume (millions of vehicles)	5	16	163	250	312	366	405	438	14.7	8.9	3.9	1.8	4.0
Automobile ownership volume per capita (vehicles per person)	0.005	0.012	0.119	0.179	0.221	0.258	0.288	0.315	13.8	8.5	3.8	2.0	4.0

India (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**305.7**	**440.9**	**851.1**	**1,068.7**	**1,335.8**	**1,623.6**	**1,944.1**	**2,312.46**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.2**	**4.7**	**4.3**	**3.6**	**4.1**
Coal	92.7	145.9	378.9	505.6	675.2	864.8	1,070.0	1,290.0	30.3	33.1	44.5	47.3	50.5	53.3	55.0	55.8	5.8	5.9	5.5	4.1	5.0
Oil	61.1	112.0	206.2	254.7	316.5	386.2	474.1	592.1	20.0	25.4	24.2	23.8	23.7	23.8	24.4	25.6	5.0	4.3	4.3	4.4	4.3
Natural gas	10.6	23.1	43.2	60.7	83.0	108.8	139.4	175.6	3.5	5.2	5.1	5.7	6.2	6.7	7.2	7.6	5.8	7.0	6.0	4.9	5.8
Nuclear	1.6	4.4	9.8	17.5	25.8	34.7	41.6	48.6	0.5	1.0	1.1	1.6	1.9	2.1	2.1	2.1	7.5	12.4	7.1	3.4	6.6
Hydro	6.2	6.4	11.9	16.0	18.9	21.8	24.7	27.5	2.0	1.5	1.4	1.5	1.4	1.3	1.3	1.2	2.7	6.2	3.1	2.4	3.4
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	133.6	149.1	201.2	214.2	216.5	207.4	194.3	178.6	43.7	33.8	23.6	20.0	16.2	12.8	10.0	7.7	1.7	1.3	-0.3	-1.5	-0.5
Biomass	133.5	148.8	195.5	200.5	195.5	178.9	158.2	134.9	43.7	33.7	23.0	18.8	14.6	11.0	8.1	5.8	1.5	0.5	-1.1	-2.8	-1.5
Solar, Wind, Ocean	0.0	0.2	4.8	12.5	19.7	27.1	34.6	42.1	0.0	0.0	0.6	1.2	1.5	1.7	1.8	1.8	27.8	21.0	8.0	4.5	9.1
Biofuels	0.0	0.1	0.82	0.8	0.8	0.9	1.0	1.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	-	-1.3	1.9	2.2	1.4
Electricity	0.1	0.1	0.0	0.4	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-10.2	121.5	0.0	0.0	17.2

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**243.2**	**315.3**	**577.7**	**719.8**	**896.2**	**1,081.9**	**1,299.5**	**1,560.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.5**	**4.5**	**4.2**	**3.7**	**4.1**
Industry	66.7	83.4	195.3	260.3	341.9	432.8	542.6	673.0	27.4	26.5	33.8	36.2	38.1	40.0	41.8	43.1	4.4	5.9	5.2	4.5	5.1
Transportation	20.8	31.9	86.0	109.9	139.8	176.7	227.6	297.4	8.6	10.1	14.9	15.3	15.6	16.3	17.5	19.1	5.8	5.0	4.9	5.3	5.1
Others	142.3	173.2	249.9	287.3	332.8	370.8	405.2	441.6	58.5	54.9	43.3	39.9	37.1	34.3	31.2	28.3	2.3	2.8	2.6	1.8	2.3
Non-energy	13.3	26.8	46.5	62.3	81.7	101.7	124.1	148.4	5.5	8.5	8.0	8.7	9.1	9.4	9.5	9.5	5.1	6.0	5.0	3.8	4.8
Total	**243.2**	**315.3**	**577.7**	**719.8**	**896.2**	**1,081.9**	**1,299.5**	**1,560.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.5**	**4.5**	**4.2**	**3.7**	**4.1**
Coal	38.6	34.5	108.2	151.0	215.0	281.3	355.0	438.3	15.9	10.9	18.7	21.0	24.0	26.0	27.3	28.1	4.2	6.9	6.4	4.5	5.8
Oil	50.2	94.4	174.4	219.9	278.5	345.9	431.9	542.5	20.6	29.9	30.2	30.6	31.1	32.0	33.2	34.8	5.1	4.7	4.6	4.6	4.6
Natural gas	5.6	9.7	28.9	41.6	57.7	76.4	99.6	127.7	2.3	3.1	5.0	5.8	6.4	7.1	7.7	8.2	6.8	7.5	6.3	5.3	6.1
Electricity	18.5	32.4	88.3	124.0	165.7	215.1	269.9	331.3	7.6	10.3	15.3	17.2	18.5	19.9	20.8	21.2	6.5	7.0	5.7	4.4	5.4
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	130.3	144.4	177.8	183.4	179.2	163.3	143.2	120.5	53.6	45.8	30.8	25.5	20.0	15.1	11.0	7.7	1.3	0.6	-1.2	-3.0	-1.5

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**292.7**	**569.7**	**1,383.0**	**1,926.1**	**2,548.9**	**3,255.4**	**4,003.6**	**4,809.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.4**	**6.8**	**5.4**	**4.0**	**5.1**
Coal	191.6	390.2	1,041.5	1,400.9	1,854.6	2,388.5	2,972.4	3,598.9	65.5	68.5	75.3	72.7	72.8	73.4	74.2	74.8	7.0	6.1	5.5	4.2	5.1
Oil	13.3	29.2	23.0	23.4	20.9	13.9	1.4	0.0	4.5	5.1	1.7	1.2	0.8	0.4	0.0	0.0	2.2	0.4	-5.1	-44.6	-22.6
Natural gas	10.0	56.0	68.1	91.1	120.0	153.7	190.2	230.2	3.4	9.8	4.9	4.7	4.7	4.7	4.8	4.8	8.0	6.0	5.4	4.1	5.0
Nuclear	6.1	16.9	37.4	67.1	99.0	133.1	159.7	186.3	2.1	3.0	2.7	3.5	3.9	4.1	4.0	3.9	7.5	12.4	7.1	3.4	6.6
Hydro	71.7	74.5	138.1	186.4	219.8	253.3	286.7	320.2	24.5	13.1	10.0	9.7	8.6	7.8	7.2	6.7	2.7	6.2	3.1	2.4	3.4
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	0.0	3.0	75.0	157.2	234.6	312.9	393.1	473.4	0.0	0.5	5.4	8.2	9.2	9.6	9.8	9.8	36.4	16.0	7.1	4.2	7.6

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**56.8**	**121.4**	**275.5**	**357.4**	**458.6**	**576.7**	**700.5**	**832.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.5**	**5.3**	**4.9**	**3.7**	**4.5**
Coal	48.4	103.2	254.0	331.7	427.9	541.7	662.5	787.5	85.1	85.0	92.2	92.8	93.3	93.9	94.6	94.6	6.9	5.5	5.0	3.8	4.6
Oil	5.0	9.0	7.8	7.5	6.6	4.4	0.5	0.0	8.8	7.4	2.8	2.1	1.4	0.8	0.1	0.0	1.8	-0.8	-5.2	-44.6	-22.9
Natural gas	3.5	9.3	13.6	18.2	24.0	30.6	37.6	45.0	6.1	7.6	4.9	5.1	5.2	5.3	5.4	5.4	5.6	6.0	5.3	3.9	4.9

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.5**	**33.7**	**35.4**	**36.5**	**37.4**	**38.1**	**38.8**	**39.6**									**0.3**	**0.6**	**0.4**	**0.4**	**0.4**
Coal	34.1	32.5	35.3	36.3	37.3	37.9	38.6	39.3									0.1	0.6	0.4	0.4	0.4
Oil	22.8	28.0	25.2	26.8	27.1	27.3	27.5	27.7									0.4	1.2	0.2	0.2	0.4
Natural gas	24.7	52.0	43.0	43.0	43.0	43.1	43.5	44.0									2.2	0.0	0.0	0.2	0.1

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**147.9**	**245.2**	**574.7**	**751.7**	**986.8**	**1,252.2**	**1,551.1**	**1,893.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.6**	**5.5**	**5.2**	**4.2**	**4.9**
Coal	100.1	157.6	409.2	546.0	729.2	934.0	1,155.6	1,393.2	67.7	64.3	71.2	72.6	73.9	74.6	74.5	73.6	5.8	5.9	5.5	4.1	5.0
Oil	44.2	77.7	150.8	185.4	230.2	282.1	349.0	441.2	29.9	31.7	26.2	24.7	23.3	22.5	22.5	23.3	5.0	4.2	4.3	4.6	4.4
Natural gas	3.6	9.9	14.6	20.3	27.5	36.1	46.5	59.3	2.4	4.0	2.5	2.7	2.8	2.9	3.0	3.1	5.8	6.7	5.9	5.1	5.8

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	470	809	2,288	3,282	4,710	6,425	8,655	11,486	6.5	7.5	6.9	6.0	6.7
Population (millions of people)	871	1,053	1,311	1,385	1,454	1,515	1,567	1,608	1.7	1.1	0.9	0.6	0.8
GDP per capita (thousands of 2010 US$/person)	0.54	0.77	1.75	2.37	3.2	4.2	5.5	7.1	4.8	6.3	6.0	5.4	5.8
Primary energy consumption per capita (toe/person)	0.35	0.42	0.65	0.77	0.92	1.07	1.24	1.44	2.5	3.5	3.3	3.0	3.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	651	545	372	326	284	253	225	201	-2.2	-2.6	-2.5	-2.2	-2.4
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	517	390	252	219	190	168	150	136	-2.8	-2.8	-2.6	-2.1	-2.4
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	315	303	251	229	209	195	179	165	-0.9	-1.8	-1.6	-1.7	-1.7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.48	0.56	0.68	0.70	0.74	0.77	0.80	0.82	1.3	0.8	0.9	0.6	0.8
Automobile ownership volume (millions of vehicles)	4	9	42	60	91	131	192	284	9.5	7.5	8.1	8.0	8.0
Automobile ownership volume per capita (vehicles per person)	0.005	0.009	0.032	0.043	0.062	0.086	0.122	0.176	7.7	6.4	7.1	7.4	7.1

India (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**305.7**	**440.9**	**851.1**	**1,051.8**	**1,276.6**	**1,492.4**	**1,718.2**	**1,973.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.2**	**4.3**	**3.6**	**2.8**	**3.4**
Coal	92.7	145.9	378.9	489.1	618.2	741.2	858.1	981.6	30.3	33.1	44.5	46.5	48.4	49.7	49.9	49.7	5.8	5.2	4.2	2.8	3.9
Oil	61.1	112.0	206.2	252.2	307.8	367.0	437.6	526.1	20.0	25.4	24.2	24.0	24.1	24.6	25.5	26.7	5.0	4.1	3.8	3.7	3.8
Natural gas	10.6	23.1	43.2	59.2	78.3	98.9	122.4	149.6	3.5	5.2	5.1	5.6	6.1	6.6	7.1	7.6	5.8	6.5	5.3	4.2	5.1
Nuclear	1.6	4.4	9.8	17.5	27.7	41.6	55.5	69.4	0.5	1.0	1.1	1.7	2.2	2.8	3.2	3.5	7.5	12.4	9.1	5.2	8.2
Hydro	6.2	6.4	11.9	16.9	20.5	24.1	27.7	31.3	2.0	1.5	1.4	1.6	1.6	1.6	1.6	1.6	2.7	7.3	3.6	2.6	4.0
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	133.6	149.1	201.2	216.9	224.0	219.7	217.0	215.1	43.7	33.8	23.6	20.6	17.6	14.7	12.6	10.9	1.7	1.5	0.1	-0.2	0.3
Biomass	133.5	148.8	195.5	202.6	197.6	180.4	159.5	136.7	43.7	33.7	23.0	19.3	15.5	12.1	9.3	6.9	1.5	0.7	-1.1	-2.7	-1.4
Solar, Wind, Ocean	0.0	0.2	4.8	12.7	24.1	35.5	51.1	66.8	0.0	0.0	0.6	1.2	1.9	2.4	3.0	3.4	27.8	21.3	10.8	6.5	11.1
Biofuels	0.0	0.1	0.82	1.2	2.0	3.3	6.0	11.1	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.6	-	8.1	10.7	12.8	11.0
Electricity	0.1	0.1	0.0	0.4	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-10.2	121.5	0.0	0.0	17.2

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**243.2**	**315.3**	**577.7**	**713.3**	**872.9**	**1,027.7**	**1,200.9**	**1,400.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.5**	**4.3**	**3.7**	**3.1**	**3.6**
Industry	66.7	83.4	195.3	258.9	334.0	410.9	496.9	590.7	27.4	26.5	33.8	36.3	38.3	40.0	41.4	42.2	4.4	5.8	4.7	3.7	4.5
Transportation	20.8	31.9	86.0	108.4	134.4	164.5	204.5	257.4	8.6	10.1	14.9	15.2	15.4	16.0	17.0	18.4	5.8	4.7	4.3	4.6	4.5
Others	142.3	173.2	249.9	283.8	322.8	350.6	375.5	403.9	58.5	54.9	43.3	39.8	37.0	34.1	31.3	28.8	2.3	2.6	2.1	1.4	1.9
Non-energy	13.3	26.8	46.5	62.3	81.7	101.7	124.1	148.4	5.5	8.5	8.0	8.7	9.4	9.9	10.3	10.6	5.1	6.0	5.0	3.8	4.8
Total	**243.2**	**315.3**	**577.7**	**713.3**	**872.9**	**1,027.7**	**1,200.9**	**1,400.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.5**	**4.3**	**3.7**	**3.1**	**3.6**
Coal	38.6	34.5	108.2	150.0	209.9	267.7	327.7	390.3	15.9	10.9	18.7	21.0	24.0	26.0	27.3	27.9	4.2	6.7	6.0	3.8	5.3
Oil	50.2	94.4	174.4	217.8	271.4	329.3	398.7	482.1	20.6	29.9	30.2	30.5	31.1	32.0	33.2	34.4	5.1	4.6	4.2	3.9	4.2
Natural gas	5.6	9.7	28.9	41.5	57.0	74.4	95.1	119.0	2.3	3.1	5.0	5.8	6.5	7.2	7.9	8.5	6.8	7.5	6.0	4.8	5.8
Electricity	18.5	32.4	88.3	121.8	159.3	199.7	244.0	293.7	7.6	10.3	15.3	17.1	18.3	19.4	20.3	21.0	6.5	6.6	5.1	3.9	4.9
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	130.3	144.4	177.8	182.3	175.2	156.6	135.5	115.3	53.6	45.8	30.8	25.6	20.1	15.2	11.3	8.2	1.3	0.5	-1.5	-3.0	-1.7

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**292.7**	**569.7**	**1,383.0**	**1,892.4**	**2,449.9**	**3,022.7**	**3,619.7**	**4,262.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.4**	**6.5**	**4.8**	**3.5**	**4.6**
Coal	191.6	390.2	1,041.5	1,352.3	1,679.3	2,012.1	2,326.3	2,674.4	65.5	68.5	75.3	71.5	68.5	66.6	64.3	62.7	7.0	5.4	4.1	2.9	3.8
Oil	13.3	29.2	23.0	22.6	18.9	11.7	1.1	0.0	4.5	5.1	1.7	1.2	0.8	0.4	0.0	0.0	2.2	-0.3	-6.3	-45.2	-23.5
Natural gas	10.0	56.0	68.1	87.9	108.6	129.5	148.9	171.1	3.4	9.8	4.9	4.6	4.4	4.3	4.1	4.0	8.0	5.3	3.9	2.8	3.8
Nuclear	6.1	16.9	37.4	67.1	106.5	159.7	212.9	266.2	2.1	3.0	2.7	3.5	4.3	5.3	5.9	6.2	7.5	12.4	9.1	5.2	8.2
Hydro	71.7	74.5	138.1	196.4	238.2	280.1	321.9	363.7	24.5	13.1	10.0	10.4	9.7	9.3	8.9	8.5	2.7	7.3	3.6	2.6	4.0
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	0.0	3.0	75.0	166.1	298.5	429.6	608.6	787.5	0.0	0.5	5.4	8.8	12.2	14.2	16.8	18.5	36.4	17.2	10.0	6.2	9.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**56.8**	**121.4**	**275.5**	**341.2**	**404.8**	**464.1**	**514.0**	**570.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.5**	**4.4**	**3.1**	**2.1**	**3.0**
Coal	48.4	103.2	254.0	317.0	378.9	437.6	488.3	542.4	85.1	85.0	92.2	92.9	93.6	94.3	95.0	95.1	6.9	4.5	3.3	2.2	3.1
Oil	5.0	9.0	7.8	7.4	6.0	3.6	0.3	0.0	8.8	7.4	2.8	2.2	1.5	0.8	0.1	0.0	1.8	-1.1	-7.1	-45.6	-24.1
Natural gas	3.5	9.3	13.6	16.9	20.0	22.9	25.4	28.1	6.1	7.6	4.9	4.9	4.9	4.9	4.9	4.9	5.6	4.4	3.1	2.1	2.9

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.5**	**33.7**	**35.4**	**36.9**	**38.4**	**39.9**	**41.4**	**42.9**									**0.3**	**0.8**	**0.8**	**0.7**	**0.8**
Coal	34.1	32.5	35.3	36.7	38.1	39.5	41.0	42.4									0.1	0.8	0.8	0.7	0.7
Oil	22.8	28.0	25.2	26.2	27.3	28.4	29.4	30.5									0.4	0.8	0.8	0.7	0.8
Natural gas	24.7	52.0	43.0	44.8	46.7	48.6	50.4	52.3									2.2	0.9	0.8	0.7	0.8

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**147.9**	**245.2**	**574.7**	**730.9**	**915.0**	**1,096.2**	**1,280.8**	**1,488.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.6**	**4.9**	**4.1**	**3.1**	**3.9**
Coal	100.1	157.6	409.2	528.2	667.7	800.4	926.7	1,060.1	67.7	64.3	71.2	72.3	73.0	73.0	72.4	71.2	5.8	5.2	4.2	2.8	3.9
Oil	44.2	77.7	150.8	183.4	222.9	266.0	318.4	385.9	29.9	31.7	26.2	25.1	24.4	24.3	24.9	25.9	5.0	4.0	3.8	3.8	3.8
Natural gas	3.6	9.9	14.6	19.3	24.4	29.8	35.6	42.6	2.4	4.0	2.5	2.6	2.7	2.7	2.8	2.9	5.8	5.7	4.4	3.6	4.4

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	470	809	2,288	3,282	4,710	6,425	8,655	11,486	6.5	7.5	6.9	6.0	6.7
Population (millions of people)	871	1,053	1,311	1,385	1,454	1,515	1,567	1,608	1.7	1.1	0.9	0.6	0.8
GDP per capita (thousands of 2010 US$/person)	0.54	0.77	1.75	2.37	3.2	4.2	5.5	7.1	4.8	6.3	6.0	5.4	5.8
Primary energy consumption per capita (toe/person)	0.35	0.42	0.65	0.76	0.88	0.98	1.10	1.23	2.5	3.2	2.6	2.2	2.6
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	651	545	372	320	271	232	199	172	-2.2	-2.9	-3.2	-3.0	-3.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	517	390	252	217	185	160	139	122	-2.8	-3.0	-3.0	-2.7	-2.9
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	315	303	251	223	194	171	148	130	-0.9	-2.4	-2.6	-2.7	-2.6
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.48	0.56	0.68	0.69	0.72	0.73	0.75	0.75	1.3	0.6	0.6	0.3	0.4
Automobile ownership volume (millions of vehicles)	4	9	42	60	91	131	192	284	9.5	7.5	8.1	8.0	8.0
Automobile ownership volume per capita (vehicles per person)	0.005	0.009	0.032	0.043	0.062	0.086	0.122	0.176	7.7	6.4	7.1	7.4	7.1

Indonesia (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**98.62**	**154.77**	**229.46**	**337.80**	**410.03**	**478.58**	**571.54**	**671.41**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**8.0**	**3.5**	**3.4**	**4.4**
Coal	3.55	12.01	46.41	84.65	105.99	141.89	174.66	217.96	3.6	7.8	20.2	25.1	25.8	29.6	30.6	32.5	10.8	12.8	5.3	4.4	6.4
Oil	33.35	57.86	67.70	133.75	168.40	193.36	210.79	234.40	33.8	37.4	29.5	39.6	41.1	40.4	36.9	34.9	2.9	14.6	3.8	1.9	5.1
Natural gas	15.80	26.54	40.23	47.83	55.72	64.17	82.73	111.41	16.0	17.1	17.5	14.2	13.6	13.4	14.5	16.6	3.8	3.5	3.0	5.7	4.2
Nuclear			0.00	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	-	-	-	-	-
Hydro	0.49	0.86	1.18	0.80	1.64	1.55	2.08	2.27	0.5	0.6	0.5	0.2	0.4	0.3	0.4	0.3	3.6	-7.5	6.8	3.9	2.6
Geothermal	1.93	8.37	17.28	9.46	14.81	13.66	30.18	32.97	2.0	5.4	7.5	2.8	3.6	2.9	5.3	4.9	9.2	-11.3	3.7	9.2	2.6
Others	43.50	49.12	56.66	61.31	63.46	63.95	71.10	72.40	44.1	31.7	24.7	18.2	15.5	13.4	12.4	10.8	1.1	1.6	0.4	1.2	1.0
Biomass	43.50	49.12	55.66	55.45	54.56	53.81	54.23	54.60	44.1	31.7	24.3	16.4	13.3	11.2	9.5	8.1	1.0	-0.1	-0.3	0.1	-0.1
Solar, Wind, Ocean	-	-	0.00	0.03	0.05	0.05	0.19	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	67.8	4.8	14.5	19.3
Biofuels	-	-	0.99	5.75	8.86	10.09	16.68	17.59	0.0	0.0	0.4	1.7	2.2	2.1	2.9	2.6	-	42.0	5.8	5.7	12.2
Electricity	-	-	0.00	0.08	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	133.8	-100.0	-	-100.0

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**79.817**	**120.322**	**162.772**	**252.265**	**306.720**	**357.205**	**412.712**	**476.771**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**9.2**	**3.5**	**2.9**	**4.4**
Industry	18.09	30.65	41.55	59.09	72.52	91.63	117.66	150.60	22.7	25.5	25.5	23.4	23.6	25.7	28.5	31.6	3.4	7.3	4.5	5.1	5.3
Transportation	10.71	21.87	44.17	108.87	142.28	163.50	179.54	194.09	13.4	18.2	27.1	43.2	46.4	45.8	43.5	40.7	5.8	19.8	4.2	1.7	6.1
Others	43.66	58.01	69.86	75.88	81.44	88.85	98.67	110.80	54.7	48.2	42.9	30.1	26.6	24.9	23.9	23.2	1.9	1.7	1.6	2.2	1.9
Non-energy	7.35	9.80	7.19	8.43	10.48	13.23	16.84	21.28	9.2	8.1	4.4	3.3	3.4	3.7	4.1	4.5	-0.1	3.2	4.6	4.9	4.4
Total	**79.82**	**120.32**	**162.77**	**252.27**	**306.72**	**357.21**	**412.71**	**476.77**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**9.2**	**3.5**	**2.9**	**4.4**
Coal	2.13	4.65	9.60	13.56	17.56	24.06	33.45	45.63	2.7	3.9	5.9	5.4	5.7	6.7	8.1	9.6	6.2	7.1	5.9	6.6	6.4
Oil	27.24	49.01	56.19	119.97	153.99	179.60	196.64	219.88	34.1	40.7	34.5	47.6	50.2	50.3	47.6	46.1	2.9	16.4	4.1	2.0	5.6
Natural gas	6.02	11.55	24.24	31.31	37.20	44.41	53.34	64.13	7.5	9.6	14.9	12.4	12.1	12.4	12.9	13.5	5.7	5.2	3.6	3.7	4.0
Electricity	2.43	6.81	17.22	27.26	35.55	46.18	60.22	77.48	3.0	5.7	10.6	10.8	11.6	12.9	14.6	16.3	8.1	9.6	5.4	5.3	6.2
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	41.99	48.31	55.52	60.18	62.42	62.96	69.06	69.65	52.6	40.1	34.1	23.9	20.4	17.6	16.7	14.6	1.1	1.6	0.5	1.0	0.9

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.67**	**93.33**	**233.33**	**357.09**	**454.25**	**577.40**	**752.99**	**968.73**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.2**	**8.9**	**4.9**	**5.3**	**5.9**
Coal	9.77	34.00	130.51	264.51	334.19	452.14	558.28	681.30	29.9	36.4	55.9	74.1	73.6	78.3	74.1	70.3	10.9	15.2	5.5	4.2	6.8
Oil	15.33	18.34	19.65	13.04	15.00	12.69	14.06	15.36	46.9	19.7	8.4	3.7	3.3	2.2	1.9	1.6	1.0	-7.9	-0.3	1.9	-1.0
Natural gas	0.73	26.09	58.89	64.07	76.46	85.71	134.19	220.00	2.2	28.0	25.2	17.9	16.8	14.8	17.8	22.7	19.2	1.7	3.0	9.9	5.4
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	5.71	10.02	13.74	9.29	19.09	17.99	24.17	26.41	17.5	10.7	5.9	2.6	4.2	3.1	3.2	2.7	3.6	-7.5	6.8	3.9	2.6
Geothermal	1.13	4.87	10.05	5.50	8.61	7.95	17.55	19.18	3.4	5.2	4.3	1.5	1.9	1.4	2.3	2.0	9.2	-11.3	3.7	9.2	2.6
Others	0.00	0.01	0.49	0.68	0.90	0.92	4.74	6.48	0.0	0.0	0.2	0.2	0.2	0.2	0.6	0.7	-	6.9	3.0	21.6	10.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**6.50**	**17.00**	**55.68**	**89.07**	**109.51**	**140.06**	**174.02**	**223.95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.0**	**9.8**	**4.6**	**4.8**	**5.7**
Coal	2.32	6.90	36.81	71.09	88.43	117.83	141.21	172.33	35.7	40.6	66.1	79.8	80.8	84.1	81.1	77.0	11.7	14.1	5.2	3.9	6.4
Oil	3.97	4.45	5.53	3.67	4.22	3.57	3.95	4.32	61.0	26.2	9.9	4.1	3.9	2.5	2.3	1.9	1.3	-7.9	-0.3	1.9	-1.0
Natural gas	0.21	5.65	13.35	14.31	16.86	18.66	28.85	47.30	3.2	33.2	24.0	16.1	15.4	13.3	16.6	21.1	18.1	1.4	2.7	9.7	5.2

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**34.2**	**39.7**	**32.3**	**33.0**	**33.4**	**33.8**	**34.9**	**35.2**									**-0.2**	**0.4**	**0.2**	**0.4**	**0.3**
Coal	36.1	42.4	30.5	32.0	32.5	33.0	34.0	34.0									-0.7	1.0	0.3	0.3	0.4
Oil	33.2	35.4	30.6	30.6	30.6	30.6	30.6	30.6									-0.3	0.0	0.0	0.0	0.0
Natural gas	30.1	39.7	37.9	38.5	39.0	39.5	40.0	40.0									0.9	0.3	0.3	0.1	0.2

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**40.9**	**75.8**	**122.0**	**218.0**	**273.1**	**335.8**	**394.8**	**476.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.5**	**12.3**	**4.4**	**3.6**	**5.6**
Coal	8.4	15.1	49.4	90.1	112.8	151.0	185.8	231.9	20.5	19.9	40.5	41.3	41.3	45.0	47.1	48.7	7.4	12.8	5.3	4.4	6.4
Oil	27.2	46.1	23.9	28.5	32.9	37.4	48.0	64.7	66.6	60.9	19.6	13.1	12.0	11.1	12.2	13.6	-0.5	3.6	2.8	5.6	4.1
Natural gas	5.3	14.6	48.7	99.4	127.5	147.4	161.0	179.5	12.9	19.2	40.0	45.6	46.7	43.9	40.8	37.7	9.3	15.3	4.0	2.0	5.4

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	310	453	988	1,300	1,740	2,328	3,101	4,052	4.7	5.6	6.0	5.7	5.8
Population (millions of people)	179	209	258	274	287	298	307	317	1.5	1.2	0.9	0.6	0.8
GDP per capita (thousands of 2010 US$/person)	1.7	2.2	3.8	4.75	6.1	7.8	10.1	12.8	3.2	4.4	5.1	5.0	4.9
Primary energy consumption per capita (toe/person)	0.6	0.7	0.9	1.23	1.43	1.61	1.86	2.12	1.9	6.8	2.7	2.8	3.5
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	318	341	232	260	236	206	184	166	-1.3	2.3	-2.3	-2.1	-1.3
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	258	265	165	194	176	153	133	118	-1.8	3.3	-2.3	-2.6	-1.3
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	132	167	123	168	157	144	127	118	-0.3	6.3	-1.5	-2.0	-0.2
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.4	0.5	0.5	0.65	0.67	0.70	0.69	0.71	1.0	4.0	0.8	0.1	1.2
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Indonesia (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**99**	**155**	**229**	**302**	**362**	**421**	**500**	**567**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.4**	**5.6**	**3.4**	**3.0**	**3.7**
Coal	4	12	46.41	46.17	52.91	66.86	82.27	107.09	3.6	7.8	20.2	15.3	14.6	15.9	16.5	18.9	10.8	-0.1	3.8	4.8	3.4
Oil	33	58	67.70	116.15	137.96	150.54	164.04	183.88	33.8	37.4	29.5	38.5	38.1	35.7	32.8	32.4	2.9	11.4	2.6	2.0	4.1
Natural gas	16	27	40.23	46.00	51.48	56.95	69.30	93.70	16.0	17.1	17.5	15.2	14.2	13.5	13.9	16.5	3.8	2.7	2.2	5.1	3.4
Nuclear	0	0	0.00	0.00	2.44	2.46	4.42	4.92	0.0	0.0	0.0	0.0	0.7	0.6	0.9	0.9	-	-	-	7.2	-
Hydro	0	1	1.18	2.07	3.12	4.35	5.42	6.04	0.5	0.6	0.5	0.7	0.9	1.0	1.1	1.1	3.6	11.9	7.7	3.3	6.7
Geothermal	2	8	17.28	29.25	47.31	70.27	83.23	77.29	2.0	5.4	7.5	9.7	13.1	16.7	16.7	13.6	9.2	11.1	9.2	1.0	6.2
Others	43	49	56.66	62.23	66.56	69.79	90.90	94.36	44.1	31.7	24.7	20.6	18.4	16.6	18.2	16.6	1.1	1.9	1.2	3.1	2.1
Biomass	43	49	55.66	57.45	59.75	62.42	78.33	81.06	44.1	31.7	24.3	19.0	16.5	14.8	15.7	14.3	1.0	0.6	0.8	2.6	1.5
Solar, Wind, Ocean	-	-	0.00	0.10	0.17	0.32	0.89	0.98	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	-	112.3	11.9	12.0	27.2
Biofuels	-	-	0.99	4.60	6.64	7.06	11.68	12.32	0.0	0.0	0.4	1.5	1.8	1.7	2.3	2.2	-	35.8	4.4	5.7	10.6
Electricity	-	-	0.00	0.08	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	133.8	-100.0	-	-100.0

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**80**	**120**	**163**	**221**	**257**	**289**	**334**	**388**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**6.3**	**2.7**	**3.0**	**3.5**
Industry	18	31	41.55	51.04	61.04	75.05	96.35	123.28	22.7	25.5	25.5	23.1	23.7	26.0	28.8	31.8	3.4	4.2	3.9	5.1	4.4
Transportation	11	22	44.17	88.36	108.89	117.93	130.24	141.79	13.4	18.2	27.1	40.0	42.3	40.8	38.9	36.6	5.8	14.9	2.9	1.9	4.8
Others	44	58	69.86	72.84	77.05	82.60	91.04	101.49	54.7	48.2	42.9	33.0	29.9	28.6	27.2	26.2	1.9	0.8	1.3	2.1	1.5
Non-energy	7	10	7.19	8.43	10.48	13.23	16.84	21.28	9.2	8.1	4.4	3.8	4.1	4.6	5.0	5.5	-0.1	3.2	4.6	4.9	4.4
Total	**80**	**120**	**163**	**221**	**257**	**289**	**334**	**388**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.9**	**6.3**	**2.7**	**3.0**	**3.5**
Coal	2.13	4.65	9.60	11.56	14.54	19.32	26.85	36.63	2.7	3.9	5.9	5.2	5.6	6.7	8.0	9.4	6.2	3.8	5.3	6.6	5.5
Oil	27.24	49.01	56.19	98.88	120.34	133.40	147.60	166.73	34.1	40.7	34.5	44.8	46.7	46.2	44.1	43.0	2.9	12.0	3.0	2.3	4.4
Natural gas	6.02	11.55	24.24	28.20	33.04	38.96	47.10	56.95	7.5	9.6	14.9	12.8	12.8	13.5	14.1	14.7	5.7	3.1	3.3	3.9	3.5
Electricity	2.43	6.81	17.22	23.87	30.22	38.08	49.65	63.86	3.0	5.7	10.6	10.8	11.7	13.2	14.8	16.5	8.1	6.7	4.8	5.3	5.4
Heat	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	41.99	48.31	55.52	58.16	59.32	59.04	63.27	63.68	52.6	40.1	34.1	26.4	23.0	20.4	18.9	16.4	1.1	0.9	0.1	0.8	0.5

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.67**	**93.33**	**233.33**	**310.96**	**384.26**	**472.61**	**616.11**	**792.47**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.2**	**5.9**	**4.3**	**5.3**	**5.0**
Coal	9.77	34.00	130.51	152.90	178.48	226.65	270.64	344.12	29.9	36.4	55.9	49.2	46.4	48.0	43.9	43.4	10.9	3.2	4.0	4.3	4.0
Oil	15.33	18.34	19.65	25.44	26.41	24.69	22.18	24.71	46.9	19.7	8.4	8.2	6.9	5.2	3.6	3.1	1.0	5.3	-0.3	0.0	0.9
Natural gas	0.73	26.09	58.89	83.37	89.74	94.31	124.00	210.71	2.2	28.0	25.2	26.8	23.4	20.0	20.1	26.6	19.2	7.2	1.2	8.4	5.2
Nuclear	0.00	0.00	0.00	0.00	9.38	9.43	16.94	18.88	0.0	0.0	0.0	0.0	2.4	2.0	2.8	2.4	-	-	-	7.2	-
Hydro	5.71	10.02	13.74	24.06	36.29	50.52	63.03	70.24	17.5	10.7	5.9	7.7	9.4	10.7	10.2	8.9	3.6	11.9	7.7	3.3	6.7
Geothermal	1.13	4.87	10.05	17.01	27.51	40.87	48.41	44.95	3.4	5.2	4.3	5.5	7.2	8.6	7.9	5.7	9.2	11.1	9.2	1.0	6.2
Others	0.00	0.01	0.49	8.18	16.45	26.14	70.90	78.84	0.0	0.0	0.2	2.6	4.3	5.5	11.5	9.9	-	75.7	12.3	11.7	22.5

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**6.50**	**17.00**	**55.68**	**57.34**	**62.58**	**71.38**	**83.32**	**114.19**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.0**	**0.6**	**2.2**	**4.8**	**2.9**
Coal	2.32	6.90	36.81	34.60	38.37	47.54	55.42	70.46	35.7	40.6	66.1	60.3	61.3	66.6	66.5	61.7	11.7	-1.2	3.2	4.0	2.6
Oil	3.97	4.45	5.53	7.16	7.43	6.94	6.24	6.95	61.0	26.2	9.9	12.5	11.9	9.7	7.5	6.1	1.3	5.3	-0.3	0.0	0.9
Natural gas	0.21	5.65	13.35	15.59	16.78	16.90	21.66	36.78	3.2	33.2	24.0	27.2	26.8	23.7	26.0	32.2	18.1	3.1	0.8	8.1	4.1

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**34.2**	**39.7**	**32.3**	**39.2**	**40.5**	**41.6**	**43.0**	**43.6**									**-0.2**	**4.0**	**0.6**	**0.5**	**1.2**
Coal	36.1	42.4	30.5	38.0	40.0	41.0	42.0	42.0									-0.7	4.5	0.8	0.2	1.3
Oil	33.2	35.4	30.6	30.6	30.6	30.6	30.6	30.6									-0.3	0.0	0.0	0.0	0.0
Natural gas	30.1	39.7	37.9	46.0	46.0	48.0	49.2	49.3									0.9	3.9	0.4	0.3	1.1

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**40.9**	**75.8**	**122.0**	**161.1**	**188.6**	**215.7**	**249.1**	**304.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.5**	**5.7**	**3.0**	**3.5**	**3.7**
Coal	8.4	15.1	49.4	49.1	56.3	71.2	87.6	114.0	20.5	19.9	40.5	30.5	29.9	33.0	35.2	37.4	7.4	-0.1	3.8	4.8	3.4
Oil	27.2	46.1	23.9	27.1	29.9	32.4	39.0	53.0	66.6	60.9	19.6	16.8	15.8	15.0	15.7	17.4	-0.5	2.5	1.8	5.0	3.2
Natural gas	5.3	14.6	48.7	85.0	102.4	112.2	122.5	137.8	12.9	19.2	40.0	52.7	54.3	52.0	49.2	45.2	9.3	11.8	2.8	2.1	4.2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	309.8	453.4	988.1	1,300	1,740	2,328	3,101	4,052	4.7	5.6	6.0	5.7	5.8
Population (millions of people)	178.6	208.9	258.2	273.6	287.0	298.1	307.5	317.1	1.5	1.2	0.9	0.6	0.8
GDP per capita (thousands of 2010 US$/person)	1.7	2.2	3.8	4.75	6.1	7.8	10.1	12.8	3.2	4.4	5.1	5.0	4.9
Primary energy consumption per capita (toe/person)	0.6	0.7	0.9	1.10	1.26	1.41	1.62	1.79	1.9	4.4	2.5	2.4	2.8
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	318	341	232	232	208	181	161	140	-1.3	0.0	-2.5	-2.5	-2.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	258	265	165	170	148	124	108	96	-1.8	0.6	-3.1	-2.6	-2.1
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	132	167	123	124	108	93	80	75	-0.3	0.1	-2.9	-2.1	-2.0
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.4	0.5	0.5	0.53	0.52	0.51	0.50	0.54	1.0	0.1	-0.4	0.5	0.0
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Japan (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**438.6**	**517.9**	**429.8**	**440.5**	**439.6**	**432.9**	**423.7**	**414.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0.1**	**0.5**	**-0.2**	**-0.4**	**-0.1**
Coal	76.5	97.2	117.5	116.2	110.1	111.8	112.5	110.4	17.4	18.8	27.3	26.4	25.1	25.8	26.5	26.6	1.7	-0.2	-0.4	-0.1	-0.2
Oil	250.3	255.1	184.9	172.9	160.6	151.5	142.0	132.7	57.1	49.3	43.0	39.2	36.5	35.0	33.5	32.0	-1.2	-1.3	-1.3	-1.3	-1.3
Natural gas	44.2	65.7	100.0	98.8	95.4	98.4	100.4	99.9	10.1	12.7	23.3	22.4	21.7	22.7	23.7	24.1	3.3	-0.2	0.0	0.2	0.0
Nuclear	52.7	83.9	2.5	25.2	42.9	37.9	32.7	32.7	12.0	16.2	0.6	5.7	9.8	8.8	7.7	7.9	-11.5	59.3	4.1	-1.5	10.9
Hydro	7.5	7.3	7.3	7.3	7.6	7.9	8.0	8.1	1.7	1.4	1.7	1.7	1.7	1.8	1.9	2.0	-0.1	0.0	0.7	0.3	0.4
Geothermal	1.6	3.1	2.4	3.0	4.2	5.4	6.4	7.4	0.4	0.6	0.6	0.7	1.0	1.3	1.5	1.8	1.7	4.6	6.2	3.2	4.6
Others	5.9	5.7	15.3	17.1	18.7	20.1	21.7	23.1	1.3	1.1	3.5	3.9	4.3	4.6	5.1	5.6	3.9	2.3	1.6	1.4	1.7
Biomass	4.5	4.7	11.4	11.9	12.2	12.4	12.9	13.3	1.0	0.9	2.7	2.7	2.8	2.9	3.0	3.2	3.8	0.9	0.5	0.6	0.6
Solar, Wind, Ocean	1.4	0.9	3.9	4.8	5.9	6.9	8.0	9.0	0.3	0.2	0.9	1.1	1.3	1.6	1.9	2.2	4.2	4.7	3.7	2.7	3.5
Biofuels	0.0	0.0	0.0	0.4	0.7	0.7	0.8	0.8	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	-100.0	-	6.0	1.7	-
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**287.0**	**328.2**	**291.4**	**288.3**	**283.2**	**278.8**	**272.9**	**266.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.1**	**-0.2**	**-0.3**	**-0.5**	**-0.4**
Industry	109.6	99.7	82.1	80.4	80.3	81.0	81.0	80.6	38.2	30.4	28.2	27.9	28.4	29.0	29.7	30.3	-1.1	-0.4	0.1	0.0	-0.1
Transportation	68.1	84.4	71.3	65.5	60.8	57.4	54.4	51.7	23.7	25.7	24.5	22.7	21.5	20.6	19.9	19.4	0.2	-1.7	-1.3	-1.0	-1.3
Others	75.7	102.7	98.8	103.9	104.0	102.6	100.0	96.8	26.4	31.3	33.9	36.0	36.7	36.8	36.6	36.4	1.1	1.0	-0.1	-0.6	-0.1
Non-energy	33.7	41.4	39.2	38.5	38.1	37.8	37.4	36.9	11.8	12.6	13.4	13.4	13.5	13.6	13.7	13.9	0.6	-0.3	-0.2	-0.2	-0.2
Total	**287.0**	**328.2**	**291.4**	**288.3**	**283.2**	**278.8**	**272.9**	**266.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.1**	**-0.2**	**-0.3**	**-0.5**	**-0.4**
Coal	30.5	24.4	23.6	22.9	22.6	22.4	21.9	21.3	10.6	7.4	8.1	8.0	8.0	8.0	8.0	8.0	-1.0	-0.6	-0.2	-0.5	-0.4
Oil	170.7	194.5	152.3	143.4	135.1	128.2	121.3	114.7	59.5	59.3	52.3	49.8	47.7	46.0	44.4	43.1	-0.5	-1.2	-1.1	-1.1	-1.1
Natural gas	15.2	21.7	29.5	31.5	32.7	33.6	34.1	34.3	5.3	6.6	10.1	10.9	11.5	12.1	12.5	12.9	2.7	1.3	0.7	0.2	0.6
Electricity	66.3	83.3	81.6	85.8	87.9	89.7	90.7	91.0	23.1	25.4	28.0	29.7	31.0	32.2	33.2	34.2	0.8	1.0	0.4	0.2	0.4
Heat	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3.8	0.3	-0.4	-1.0	-0.5
Others	4.1	3.8	3.8	4.1	4.4	4.3	4.4	4.3	1.4	1.2	1.3	1.4	1.5	1.6	1.6	1.6	-0.2	1.5	0.5	-0.1	0.4

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**872.6**	**1,088.1**	**1,035.3**	**1,087.5**	**1,113.8**	**1,135.9**	**1,147.7**	**1,151.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.7**	**1.0**	**0.4**	**0.1**	**0.4**
Coal	117.7	233.8	343.2	329.4	310.1	325.6	337.4	337.4	13.5	21.5	33.2	30.3	27.8	28.7	29.4	29.3	4.4	-0.8	-0.1	0.4	-0.1
Oil	283.7	179.3	102.5	84.9	67.6	58.7	48.4	36.5	32.5	16.5	9.9	7.8	6.1	5.2	4.2	3.2	-4.0	-3.7	-3.6	-4.6	-4.0
Natural gas	170.6	253.6	409.8	390.7	365.4	381.3	392.6	390.4	19.6	23.3	39.6	35.9	32.8	33.6	34.2	33.9	3.6	-1.0	-0.2	0.2	-0.2
Nuclear	202.3	322.0	9.4	96.9	164.8	145.4	125.5	125.5	23.2	29.6	0.9	8.9	14.8	12.8	10.9	10.9	-11.5	59.3	4.1	-1.5	10.9
Hydro	86.9	85.2	85.2	85.0	88.9	91.5	93.2	94.2	10.0	7.8	8.2	7.8	8.0	8.1	8.1	8.2	-0.1	0.0	0.7	0.3	0.4
Geothermal	1.7	3.3	2.6	3.3	4.7	6.1	7.3	8.5	0.2	0.3	0.2	0.3	0.4	0.5	0.6	0.7	1.6	4.9	6.4	3.3	4.9
Others	9.6	10.7	82.5	97.3	112.4	127.4	143.4	159.3	1.1	1.0	8.0	8.9	10.1	11.2	12.5	13.8	9.0	3.4	2.7	2.3	2.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**117.9**	**132.8**	**161.6**	**151.8**	**138.3**	**140.0**	**140.5**	**136.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.3**	**-1.2**	**-0.8**	**-0.3**	**-0.7**
Coal	25.2	48.5	69.6	66.0	61.0	62.7	64.0	63.0	21.4	36.5	43.1	43.5	44.1	44.8	45.5	46.2	4.2	-1.0	-0.5	0.0	-0.4
Oil	58.8	35.9	20.3	17.5	13.9	11.9	9.7	7.2	49.9	27.0	12.5	11.5	10.0	8.5	6.9	5.3	-4.2	-2.9	-3.8	-4.9	-4.1
Natural gas	33.9	48.5	71.8	68.3	63.4	65.4	66.9	66.1	28.7	36.5	44.4	45.0	45.9	46.7	47.6	48.5	3.0	-1.0	-0.4	0.1	-0.3

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**41.7**	**43.2**	**45.5**	**45.6**	**46.2**	**47.0**	**47.6**	**48.2**									**0.3**	**0.0**	**0.3**	**0.2**	**0.2**
Coal	40.2	41.5	42.4	42.9	43.7	44.7	45.4	46.1									0.2	0.2	0.4	0.3	0.3
Oil	41.5	42.9	43.5	41.7	42.0	42.4	43.0	43.7									0.2	-0.9	0.2	0.3	0.0
Natural gas	43.3	45.0	49.1	49.2	49.5	50.1	50.5	50.7									0.5	0.1	0.2	0.1	0.1

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**292.1**	**325.9**	**312.9**	**301.3**	**282.6**	**278.9**	**273.4**	**263.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.3**	**-0.8**	**-0.8**	**-0.6**	**-0.7**
Coal	82.0	104.5	126.5	125.1	118.5	120.3	121.1	118.8	28.1	32.1	40.4	41.5	41.9	43.1	44.3	45.1	1.7	-0.2	-0.4	-0.1	-0.3
Oil	182.0	179.4	122.5	113.0	103.2	95.8	88.2	80.8	62.3	55.0	39.2	37.5	36.5	34.3	32.3	30.7	-1.6	-1.6	-1.6	-1.7	-1.7
Natural gas	28.1	42.0	63.9	63.1	60.9	62.8	64.1	63.8	9.6	12.9	20.4	21.0	21.6	22.5	23.5	24.2	3.3	-0.2	0.0	0.1	0.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	4,683	5,349	5,986	6,222	6,533	6,948	7,342	7,705	1.0	0.8	1.1	1.0	1.0
Population (millions of people)	124	127	127	125	123	121	118	114	0.1	-0.2	-0.4	-0.5	-0.4
GDP per capita (thousands of 2010 US$/person)	37.91	42.17	47.15	49.58	53.0	57.6	62.5	67.4	0.9	1.0	1.5	1.6	1.4
Primary energy consumption per capita (toe/person)	3.55	4.08	3.39	3.51	3.56	3.59	3.60	3.62	-0.2	0.7	0.2	0.1	0.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	94	97	72	71	67	62	58	54	-1.1	-0.3	-1.3	-1.5	-1.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	61	61	49	46	43	40	37	35	-0.9	-1.0	-1.4	-1.5	-1.4
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	62	61	52	48	43	40	37	34	-0.7	-1.5	-1.9	-1.6	-1.7
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.67	0.63	0.73	0.68	0.64	0.64	0.65	0.64	0.4	-1.2	-0.6	-0.1	-0.5
Automobile ownership volume (millions of vehicles)	58	72	77	77	77	76	74	72	1.2	0.1	-0.2	-0.4	-0.3
Automobile ownership volume per capita (vehicles per person)	0.467	0.571	0.608	0.617	0.623	0.627	0.630	0.633	1.1	0.3	0.2	0.1	0.2

Japan (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**438.6**	**517.9**	**429.8**	**438.1**	**431.7**	**422.5**	**409.8**	**394.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**-0.1**	**0.4**	**-0.4**	**-0.7**	**-0.3**
Coal	76.5	97.2	117.5	115.3	108.0	104.2	95.7	90.2	17.4	18.8	27.3	26.3	25.0	24.7	23.4	22.9	1.7	-0.4	-1.0	-1.4	-1.1
Oil	250.3	255.1	184.9	170.5	154.4	140.6	128.4	118.2	57.1	49.3	43.0	38.9	35.8	33.3	31.3	30.0	-1.2	-1.6	-1.9	-1.7	-1.8
Natural gas	44.2	65.7	100.0	95.0	87.5	82.9	82.4	84.0	10.1	12.7	23.3	21.7	20.3	19.6	20.1	21.3	3.3	-1.0	-1.4	0.1	-0.7
Nuclear	52.7	83.9	2.5	28.9	49.1	58.4	62.1	55.9	12.0	16.2	0.6	6.6	11.4	13.8	15.2	14.2	-11.5	63.6	7.3	-0.4	13.3
Hydro	7.5	7.3	7.3	7.3	7.6	7.9	8.0	8.1	1.7	1.4	1.7	1.7	1.8	1.9	2.0	2.1	-0.1	0.0	0.7	0.3	0.4
Geothermal	1.6	3.1	2.4	3.7	5.2	6.7	8.3	9.9	0.4	0.6	0.6	0.8	1.2	1.6	2.0	2.5	1.7	9.2	6.1	4.0	5.9
Others	5.9	5.7	15.3	17.5	19.8	21.9	24.9	27.8	1.3	1.1	3.5	4.0	4.6	5.2	6.1	7.1	3.9	2.7	2.3	2.4	2.4
Biomass	4.5	4.7	11.4	12.1	12.7	13.2	14.0	14.8	1.0	0.9	2.7	2.8	2.9	3.1	3.4	3.8	3.8	1.2	0.9	1.2	1.1
Solar, Wind, Ocean	1.4	0.9	3.9	5.0	6.5	8.0	10.1	12.2	0.3	0.2	0.9	1.1	1.5	1.9	2.5	3.1	4.2	5.2	4.9	4.3	4.7
Biofuels	0.0	0.0	0.0	0.4	0.7	0.7	0.8	0.8	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	-100.0	-	6.0	1.7	-
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**287.0**	**328.2**	**291.4**	**285.7**	**276.2**	**267.1**	**257.8**	**248.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.1**	**-0.4**	**-0.7**	**-0.7**	**-0.6**
Industry	109.6	99.7	82.1	80.4	80.1	80.5	80.3	79.6	38.2	30.4	28.2	28.1	29.0	30.2	31.2	32.0	-1.1	-0.4	0.0	-0.1	-0.1
Transportation	68.1	84.4	71.3	64.1	56.9	50.8	46.1	42.5	23.7	25.7	24.5	22.4	20.6	19.0	17.9	17.1	0.2	-2.1	-2.3	-1.8	-2.1
Others	75.7	102.7	98.8	102.7	101.1	97.9	94.0	89.7	26.4	31.3	33.9	36.0	36.6	36.7	36.4	36.1	1.1	0.8	-0.5	-0.9	-0.4
Non-energy	33.7	41.4	39.2	38.5	38.1	37.8	37.4	36.9	11.8	12.6	13.4	13.5	13.8	14.2	14.5	14.9	0.6	-0.3	-0.2	-0.2	-0.2
Total	**287.0**	**328.2**	**291.4**	**285.7**	**276.2**	**267.1**	**257.8**	**248.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.1**	**-0.4**	**-0.7**	**-0.7**	**-0.6**
Coal	30.5	24.4	23.6	22.9	22.5	22.3	21.7	21.0	10.6	7.4	8.1	8.0	8.2	8.3	8.4	8.4	-1.0	-0.6	-0.3	-0.6	-0.5
Oil	170.7	194.5	152.3	141.7	130.2	119.8	110.4	102.5	59.5	59.3	52.3	49.6	47.1	44.8	42.8	41.2	-0.5	-1.4	-1.7	-1.5	-1.6
Natural gas	15.2	21.7	29.5	31.3	32.1	32.7	32.9	32.8	5.3	6.6	10.1	11.0	11.6	12.2	12.8	13.2	2.7	1.2	0.4	0.0	0.4
Electricity	66.3	83.3	81.6	85.1	86.5	87.6	87.9	87.7	23.1	25.4	28.0	29.8	31.3	32.8	34.1	35.3	0.8	0.8	0.3	0.0	0.3
Heat	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3.8	0.1	-0.7	-1.2	-0.7
Others	4.1	3.8	3.8	4.1	4.4	4.3	4.4	4.3	1.4	1.2	1.3	1.4	1.6	1.6	1.7	1.7	-0.2	1.5	0.4	-0.1	0.4

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**872.6**	**1,088.1**	**1,035.3**	**1,079.5**	**1,095.9**	**1,109.1**	**1,112.9**	**1,109.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.7**	**0.8**	**0.3**	**0.0**	**0.3**
Coal	117.7	233.8	343.2	326.2	302.5	293.5	262.7	246.5	13.5	21.5	33.2	30.2	27.6	26.5	23.6	22.2	4.4	-1.0	-1.1	-1.7	-1.3
Oil	283.7	179.3	102.5	82.2	62.8	49.1	37.1	27.9	32.5	16.5	9.9	7.6	5.7	4.4	3.3	2.5	-4.0	-4.3	-5.0	-5.5	-5.1
Natural gas	170.6	253.6	409.8	371.2	325.1	298.5	296.9	308.8	19.6	23.3	39.6	34.4	29.7	26.9	26.7	27.8	3.6	-2.0	-2.2	0.3	-1.1
Nuclear	202.3	322.0	9.4	110.7	188.3	224.1	238.2	214.6	23.2	29.6	0.9	10.3	17.2	20.2	21.4	19.4	-11.5	63.6	7.3	-0.4	13.3
Hydro	86.9	85.2	85.2	85.0	88.9	91.5	93.2	94.2	10.0	7.8	8.2	7.9	8.1	8.3	8.4	8.5	-0.1	0.0	0.7	0.3	0.4
Geothermal	1.7	3.3	2.6	4.1	5.9	7.6	9.5	11.4	0.2	0.3	0.2	0.4	0.5	0.7	0.9	1.0	1.6	9.8	6.3	4.1	6.1
Others	9.6	10.7	82.5	100.1	122.4	144.7	175.2	205.7	1.1	1.0	8.0	9.3	11.2	13.0	15.7	18.5	9.0	4.0	3.8	3.6	3.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**117.9**	**132.8**	**161.6**	**146.9**	**128.3**	**116.9**	**106.9**	**102.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.3**	**-1.9**	**-2.3**	**-1.3**	**-1.8**
Coal	25.2	48.5	69.6	65.3	59.2	56.1	49.4	45.5	21.4	36.5	43.1	44.4	46.2	48.0	46.2	44.3	4.2	-1.3	-1.5	-2.1	-1.7
Oil	58.8	35.9	20.3	16.9	12.8	9.9	7.4	5.4	49.9	27.0	12.5	11.5	10.0	8.5	6.9	5.3	-4.2	-3.5	-5.2	-5.8	-5.1
Natural gas	33.9	48.5	71.8	64.7	56.2	50.9	50.2	51.8	28.7	36.5	44.4	44.1	43.8	43.5	46.9	50.4	3.0	-2.1	-2.4	0.2	-1.3

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**41.7**	**43.2**	**45.5**	**45.6**	**46.3**	**47.1**	**48.0**	**48.8**									**0.3**	**0.0**	**0.3**	**0.3**	**0.3**
Coal	40.2	41.5	42.4	43.0	43.9	45.0	45.8	46.6									0.2	0.3	0.4	0.4	0.4
Oil	41.5	42.9	43.5	41.8	42.2	42.7	43.4	44.2									0.2	-0.8	0.2	0.3	0.1
Natural gas	43.3	45.0	49.1	49.3	49.7	50.4	50.9	51.2									0.5	0.1	0.2	0.2	0.2

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**292.1**	**325.9**	**312.9**	**295.9**	**270.1**	**251.7**	**232.3**	**219.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.3**	**-1.1**	**-1.6**	**-1.4**	**-1.4**
Coal	82.0	104.5	126.5	124.1	116.3	112.1	102.9	97.0	28.1	32.1	40.4	41.9	43.0	44.5	44.3	44.3	1.7	-0.4	-1.0	-1.4	-1.1
Oil	182.0	179.4	122.5	111.1	97.9	86.7	76.8	68.7	62.3	55.0	39.2	37.5	36.3	34.4	33.1	31.3	-1.6	-1.9	-2.4	-2.3	-2.3
Natural gas	28.1	42.0	63.9	60.7	55.9	52.9	52.6	53.6	9.6	12.9	20.4	20.5	20.7	21.0	22.6	24.4	3.3	-1.0	-1.4	0.1	-0.7

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	4,683	5,349	5,986	6,222	6,533	6,948	7,342	7,705	1.0	0.8	1.1	1.0	1.0
Population (millions of people)	124	127	127	125	123	121	118	114	0.1	-0.2	-0.4	-0.5	-0.4
GDP per capita (thousands of 2010 US$/person)	37.91	42.17	47.15	49.58	53.0	57.6	62.5	67.4	0.9	1.0	1.5	1.6	1.4
Primary energy consumption per capita (toe/person)	3.55	4.08	3.39	3.49	3.50	3.50	3.49	3.45	-0.2	0.6	0.0	-0.2	0.1
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	94	97	72	70	66	61	56	51	-1.1	-0.4	-1.5	-1.7	-1.3
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	61	61	49	46	42	38	35	32	-0.9	-1.2	-1.8	-1.7	-1.6
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	62	61	52	48	41	36	32	28	-0.7	-1.9	-2.7	-2.4	-2.4
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.67	0.63	0.73	0.68	0.63	0.60	0.57	0.56	0.4	-1.5	-1.2	-0.7	-1.1
Automobile ownership volume (millions of vehicles)	58	72	77	77	77	76	74	72	1.2	0.1	-0.2	-0.4	-0.3
Automobile ownership volume per capita (vehicles per person)	0.467	0.571	0.608	0.617	0.623	0.627	0.630	0.633	1.1	0.3	0.2	0.1	0.2

Republic of Korea (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**92.9**	**188.2**	**272.7**	**287.2**	**297.6**	**303.8**	**307.2**	**303.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**1.0**	**0.6**	**0.0**	**0.4**
Coal	25.4	41.9	80.8	83.9	86.3	85.6	90.3	92.3	27.3	22.3	29.6	29.2	29.0	28.2	29.4	30.4	4.7	0.8	0.2	0.8	0.5
Oil	49.7	99.0	102.7	105.0	108.3	110.0	110.5	109.1	53.5	52.6	37.7	36.6	36.4	36.2	36.0	35.9	2.9	0.4	0.5	-0.1	0.2
Natural gas	2.7	17.0	39.3	44.1	49.5	54.1	61.0	67.6	2.9	9.0	14.4	15.4	16.6	17.8	19.9	22.3	11.3	2.3	2.1	2.2	2.2
Nuclear	13.8	28.4	42.9	45.0	42.3	40.8	31.0	18.8	14.8	15.1	15.7	15.7	14.2	13.4	10.1	6.2	4.7	0.9	-1.0	-7.5	-3.3
Hydro	0.5	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-4.3	11.8	0.0	0.0	2.3
Geothermal	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	2.2	1.8	1.1	1.6
Others	0.7	1.4	6.6	8.6	10.7	12.8	14.0	15.2	0.8	0.8	2.4	3.0	3.6	4.2	4.6	5.0	9.1	5.6	4.0	1.7	3.4
Biomass	0.7	1.3	5.0	5.4	5.7	5.9	6.0	5.9	0.8	0.7	1.8	1.9	1.9	1.9	1.9	2.0	8.1	1.8	0.8	0.1	0.7
Solar, Wind, Ocean	0.0	0.0	0.6	2.1	3.8	5.7	6.8	8.0	0.0	0.0	0.2	0.7	1.3	1.9	2.2	2.6	18.1	26.9	10.5	3.4	10.6
Biofuels	0.0	0.0	0.9	1.1	1.1	1.2	1.2	1.2	0.0	0.0	0.3	0.4	0.4	0.4	0.4	0.4	17.1	3.0	0.9	0.2	1.1
Electricity	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**64.9**	**127.1**	**174.2**	**184.8**	**193.7**	**200.3**	**204.6**	**205.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**1.2**	**0.8**	**0.3**	**0.7**
Industry	19.3	38.5	49.1	52.3	54.7	56.2	57.1	57.1	29.7	30.3	28.2	28.3	28.2	28.1	27.9	27.8	3.8	1.2	0.7	0.2	0.6
Transportation	14.6	26.3	33.4	35.1	35.8	35.8	35.1	33.5	22.5	20.7	19.2	19.0	18.5	17.9	17.1	16.3	3.4	1.0	0.2	-0.7	0.0
Others	24.3	37.3	44.3	47.4	49.7	51.7	53.2	53.8	37.5	29.4	25.4	25.7	25.6	25.8	26.0	26.1	2.4	1.4	0.9	0.4	0.8
Non-energy	6.7	25.0	47.3	50.0	53.5	56.6	59.3	61.3	10.4	19.7	27.2	27.1	27.6	28.3	29.0	29.8	8.1	1.1	1.2	0.8	1.0
Total	**64.9**	**127.1**	**174.2**	**184.8**	**193.7**	**200.3**	**204.6**	**205.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**1.2**	**0.8**	**0.3**	**0.7**
Coal	11.7	9.1	11.8	12.4	12.4	12.2	11.9	11.4	18.1	7.1	6.8	6.7	6.4	6.1	5.8	5.6	0.0	1.0	-0.1	-0.6	-0.1
Oil	43.7	79.9	90.3	93.7	96.8	98.5	98.9	97.9	67.3	62.8	51.8	50.7	50.0	49.2	48.4	47.6	2.9	0.7	0.5	-0.1	0.3
Natural gas	0.7	10.9	20.5	22.9	24.7	26.3	27.6	28.4	1.0	8.6	11.8	12.4	12.8	13.1	13.5	13.8	14.6	2.3	1.4	0.8	1.3
Electricity	8.1	22.6	42.6	46.2	49.8	53.0	55.9	57.8	12.5	17.8	24.5	25.0	25.7	26.5	27.3	28.1	6.9	1.6	1.4	0.9	1.2
Heat	0.0	3.3	4.4	4.7	4.9	4.9	4.9	4.7	0.0	2.6	2.5	2.5	2.5	2.5	2.4	2.3	-	1.4	0.6	-0.5	0.3
Others	0.7	1.3	4.7	5.0	5.2	5.4	5.4	5.5	1.1	1.0	2.7	2.7	2.7	2.7	2.7	2.7	7.6	1.3	0.8	0.2	0.6

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**105.4**	**288.5**	**549.2**	**595.4**	**641.6**	**682.9**	**719.0**	**743.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.8**	**1.6**	**1.4**	**0.9**	**1.2**
Coal	17.7	111.4	236.6	241.1	255.4	261.8	287.0	308.6	16.8	38.6	43.1	40.5	39.8	38.3	39.9	41.5	10.9	0.4	0.8	1.7	1.1
Oil	18.9	34.6	12.5	11.2	10.2	8.5	7.2	5.2	17.9	12.0	2.3	1.9	1.6	1.3	1.0	0.7	-1.6	-2.2	-2.7	-4.9	-3.5
Natural gas	9.6	29.5	122.9	138.3	161.2	181.3	217.6	255.6	9.1	10.2	22.4	23.2	25.1	26.6	30.3	34.4	10.7	2.4	2.7	3.5	3.0
Nuclear	52.9	109.0	164.8	172.7	162.5	156.4	118.8	72.1	50.2	37.8	30.0	29.0	25.3	22.9	16.5	9.7	4.7	0.9	-1.0	-7.5	-3.3
Hydro	6.4	4.0	2.1	3.7	3.7	3.7	3.7	3.7	6.0	1.4	0.4	0.6	0.6	0.5	0.5	0.5	-4.3	11.8	0.0	0.0	2.3
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	0.0	0.1	10.4	28.4	48.5	71.1	84.6	98.1	0.0	0.0	1.9	4.8	7.6	10.4	11.8	13.2	44.7	22.3	9.6	3.3	9.4

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.5**	**40.4**	**79.6**	**81.4**	**86.7**	**88.9**	**98.7**	**106.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**0.4**	**0.9**	**1.8**	**1.2**
Coal	6.0	27.1	56.4	57.3	59.4	58.9	63.4	65.9	47.7	66.9	70.8	70.4	68.5	66.2	64.3	61.9	9.4	0.3	0.3	1.1	0.6
Oil	4.5	7.6	4.1	2.6	2.3	2.0	1.6	1.2	36.0	18.9	5.2	3.2	2.7	2.2	1.7	1.1	-0.4	-8.7	-2.8	-5.0	-4.9
Natural gas	2.0	5.8	19.1	21.5	25.0	28.1	33.6	39.4	16.3	14.2	24.0	26.4	28.8	31.6	34.1	37.0	9.4	2.4	2.7	3.5	2.9

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**31.7**	**37.3**	**40.2**	**41.3**	**42.3**	**43.7**	**44.6**	**46.0**									**1.0**	**0.5**	**0.6**	**0.5**	**0.5**
Coal	25.4	35.4	36.1	36.2	37.0	38.2	38.9	40.3									1.4	0.0	0.6	0.5	0.4
Oil	35.9	39.0	26.1	37.0	37.2	37.5	37.7	37.8									-1.3	7.2	0.1	0.1	1.5
Natural gas	40.6	44.0	55.3	55.4	55.5	55.6	55.7	55.8									1.2	0.0	0.0	0.0	0.0

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**65.2**	**118.2**	**158.7**	**164.8**	**170.6**	**171.7**	**179.2**	**182.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.6**	**0.7**	**0.4**	**0.6**	**0.6**
Coal	27.4	45.3	86.7	89.9	92.4	91.5	96.3	98.4	42.1	38.3	54.6	54.6	54.2	53.3	53.8	53.8	4.7	0.7	0.2	0.7	0.5
Oil	36.0	62.0	46.8	46.5	46.5	45.5	43.8	41.1	55.3	52.4	29.5	28.2	27.3	26.5	24.4	22.5	1.1	-0.1	-0.2	-1.0	-0.5
Natural gas	1.7	10.9	25.2	28.3	31.7	34.7	39.1	43.3	2.7	9.2	15.9	17.2	18.6	20.2	21.8	23.7	11.3	2.3	2.1	2.2	2.2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	377	710	1,267	1,460	1,683	1,898	2,101	2,272	5.0	2.9	2.7	1.8	2.4
Population (millions of people)	42.9	47.0	51.1	52.0	52.6	52.9	52.8	52.2	0.7	0.4	0.2	-0.1	0.1
GDP per capita (thousands of 2010 US$/person)	8.80	15.09	24.80	28.09	32.0	35.8	39.8	43.5	4.2	2.5	2.5	2.0	2.3
Primary energy consumption per capita (toe/person)	2.17	4.00	5.34	5.53	5.66	5.74	5.82	5.81	3.7	0.7	0.4	0.1	0.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	246	265	215	197	177	160	146	134	-0.5	-1.8	-2.0	-1.8	-1.9
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	172	179	138	127	115	106	97	91	-0.9	-1.7	-1.8	-1.5	-1.7
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	173	166	125	113	101	90	85	80	-1.3	-2.1	-2.2	-1.2	-1.8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.70	0.63	0.58	0.57	0.57	0.57	0.58	0.60	-0.7	-0.3	-0.2	0.6	0.1
Automobile ownership volume (millions of vehicles)	3	12	21	24	26	28	29	29	7.6	2.6	1.5	0.5	1.3
Automobile ownership volume per capita (vehicles per person)	0.079	0.256	0.411	0.460	0.496	0.523	0.546	0.560	6.8	2.3	1.3	0.7	1.2

Republic of Korea (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**92.9**	**188.2**	**272.7**	**283.4**	**288.7**	**288.9**	**287.5**	**279.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**0.8**	**0.2**	**-0.3**	**0.1**
Coal	25.4	41.9	80.8	74.4	65.9	65.0	61.0	61.8	27.3	22.3	29.6	26.2	22.8	22.5	21.2	22.1	4.7	-1.6	-1.3	-0.5	-1.1
Oil	49.7	99.0	102.7	104.9	106.0	106.1	104.7	102.2	53.5	52.6	37.7	37.0	36.7	36.7	36.4	36.6	2.9	0.4	0.1	-0.4	0.0
Natural gas	2.7	17.0	39.3	41.4	42.3	45.5	47.4	51.2	2.9	9.0	14.4	14.6	14.7	15.7	16.5	18.3	11.3	1.0	0.9	1.2	1.1
Nuclear	13.8	28.4	42.9	53.4	61.9	56.8	56.8	44.6	14.8	15.1	15.7	18.8	21.4	19.7	19.7	16.0	4.7	4.5	0.6	-2.4	0.2
Hydro	0.5	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-4.3	11.8	0.0	0.0	2.3
Geothermal	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	-	2.0	1.6	1.0	1.4
Others	0.7	1.4	6.6	8.9	12.0	15.0	17.1	19.1	0.8	0.8	2.4	3.1	4.2	5.2	5.9	6.8	9.1	6.2	5.3	2.5	4.4
Biomass	0.7	1.3	5.0	5.4	5.7	5.9	5.9	5.9	0.8	0.7	1.8	1.9	2.0	2.0	2.1	2.1	8.1	1.8	0.8	0.0	0.7
Solar, Wind, Ocean	0.0	0.0	0.6	2.3	4.8	7.4	9.4	11.5	0.0	0.0	0.2	0.8	1.6	2.6	3.3	4.1	18.1	28.7	12.7	4.5	12.3
Biofuels	0.0	0.0	0.9	1.1	1.5	1.6	1.6	1.6	0.0	0.0	0.3	0.4	0.5	0.5	0.6	0.6	17.1	4.4	3.4	0.4	2.4
Electricity	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**64.9**	**127.1**	**174.2**	**183.3**	**189.6**	**193.1**	**194.3**	**192.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**1.0**	**0.5**	**0.0**	**0.4**
Industry	19.3	38.5	49.1	51.8	53.5	54.3	54.3	53.2	29.7	30.3	28.2	28.3	28.2	28.1	27.9	27.6	3.8	1.1	0.5	-0.2	0.3
Transportation	14.6	26.3	33.4	34.7	34.6	33.5	31.4	28.9	22.5	20.7	19.2	18.9	18.3	17.3	16.2	15.0	3.4	0.8	-0.4	-1.4	-0.6
Others	24.3	37.3	44.3	46.7	47.9	48.8	49.4	49.2	37.5	29.4	25.4	25.5	25.3	25.2	25.4	25.6	2.4	1.1	0.4	0.1	0.4
Non-energy	6.7	25.0	47.3	50.0	53.5	56.6	59.3	61.3	10.4	19.7	27.2	27.3	28.2	29.3	30.5	31.8	8.1	1.1	1.2	0.8	1.0
Total	**64.9**	**127.1**	**174.2**	**183.3**	**189.6**	**193.1**	**194.3**	**192.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.0**	**1.0**	**0.5**	**0.0**	**0.4**
Coal	11.7	9.1	11.8	12.3	12.2	12.0	11.5	10.9	18.1	7.1	6.8	6.7	6.4	6.2	5.9	5.7	0.0	0.9	-0.3	-0.9	-0.3
Oil	43.7	79.9	90.3	93.2	94.9	95.2	94.2	92.0	67.3	62.8	51.8	50.8	50.1	49.3	48.5	47.7	2.9	0.6	0.2	-0.3	0.1
Natural gas	0.7	10.9	20.5	22.7	24.1	25.3	26.3	26.7	1.0	8.6	11.8	12.4	12.7	13.1	13.5	13.9	14.6	2.1	1.1	0.5	1.1
Electricity	8.1	22.6	42.6	45.4	48.0	50.2	52.1	53.0	12.5	17.8	24.5	24.8	25.3	26.0	26.8	27.5	6.9	1.3	1.0	0.5	0.9
Heat	0.0	3.3	4.4	4.6	4.8	4.8	4.6	4.4	0.0	2.6	2.5	2.5	2.5	2.5	2.4	2.3	-	1.2	0.3	-0.8	0.1
Others	0.7	1.3	4.7	5.0	5.5	5.6	5.6	5.6	1.1	1.0	2.7	2.7	2.9	2.9	2.9	2.9	7.6	1.4	1.1	0.0	0.7

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**105.4**	**288.5**	**549.2**	**585.8**	**619.1**	**647.1**	**670.1**	**681.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.8**	**1.3**	**1.0**	**0.5**	**0.9**
Coal	17.7	111.4	236.6	214.1	190.0	193.4	186.6	198.8	16.8	38.6	43.1	36.5	30.7	29.9	27.8	29.2	10.9	-2.0	-1.0	0.3	-0.7
Oil	18.9	34.6	12.5	10.0	7.6	6.3	4.7	3.3	17.9	12.0	2.3	1.7	1.2	1.0	0.7	0.5	-1.6	-4.5	-4.5	-6.2	-5.2
Natural gas	9.6	29.5	122.9	122.8	120.0	134.0	141.5	164.7	9.1	10.2	22.4	21.0	19.4	20.7	21.1	24.2	10.7	0.0	0.9	2.1	1.2
Nuclear	52.9	109.0	164.8	204.9	237.6	217.8	217.8	171.1	50.2	37.8	30.0	35.0	38.4	33.7	32.5	25.1	4.7	4.5	0.6	-2.4	0.2
Hydro	6.4	4.0	2.1	3.7	3.7	3.7	3.7	3.7	6.0	1.4	0.4	0.6	0.6	0.6	0.6	0.6	-4.3	11.8	0.0	0.0	2.3
Geothermal	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	0.0	0.0	-	-	-	-	-
Others	0.0	0.1	10.4	30.3	60.2	91.8	115.8	139.8	0.0	0.0	1.9	5.2	9.7	14.2	17.3	20.5	44.7	24.0	11.7	4.3	11.0

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.5**	**40.4**	**79.6**	**71.4**	**63.1**	**64.1**	**61.9**	**66.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**-2.2**	**-1.1**	**0.3**	**-0.7**
Coal	6.0	27.1	56.4	49.4	42.5	42.0	39.4	40.8	47.7	66.9	70.8	69.2	67.5	65.6	63.6	61.6	9.4	-2.6	-1.6	-0.3	-1.3
Oil	4.5	7.6	4.1	3.0	2.1	1.7	1.1	0.8	36.0	18.9	5.2	4.2	3.4	2.6	1.9	1.2	-0.4	-6.0	-5.8	-7.4	-6.5
Natural gas	2.0	5.8	19.1	19.0	18.4	20.4	21.4	24.7	16.3	14.2	24.0	26.6	29.2	31.8	34.5	37.2	9.4	-0.2	0.7	1.9	1.0

Thermal efficiency

	%								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**31.7**	**37.3**	**40.2**	**41.8**	**43.3**	**44.8**	**46.2**	**47.6**	**1.0**	**0.8**	**0.7**	**0.6**	**0.7**
Coal	25.4	35.4	36.1	37.3	38.4	39.6	40.7	41.9	1.4	0.6	0.6	0.6	0.6
Oil	35.9	39.0	26.1	28.3	30.5	32.6	34.8	37.0	-1.3	1.6	1.4	1.3	1.4
Natural gas	40.6	44.0	55.3	55.7	56.1	56.5	57.0	57.4	1.2	0.2	0.2	0.2	0.2

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**65.2**	**118.2**	**158.7**	**152.6**	**142.1**	**140.6**	**134.1**	**133.5**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**3.6**	**-0.8**	**-0.8**	**-0.5**	**-0.7**
Coal	27.4	45.3	86.7	79.6	70.3	69.2	64.7	65.4	42.1	38.3	54.6	52.2	49.5	49.2	48.3	49.0	4.7	-1.7	-1.4	-0.6	-1.1
Oil	36.0	62.0	46.8	46.5	44.6	42.2	38.9	35.2	55.3	52.4	29.5	30.4	31.4	30.0	29.0	26.4	1.1	-0.2	-1.0	-1.8	-1.1
Natural gas	1.7	10.9	25.2	26.6	27.1	29.2	30.4	32.8	2.7	9.2	15.9	17.4	19.1	20.7	22.7	24.6	11.3	1.0	0.9	1.2	1.1

Energy and economic indicators

	1990	2000	2015	2020	2025	2030	2035	2040	AAGR(%) 1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	377	710	1,267	1,460	1,683	1,898	2,101	2,272	5.0	2.9	2.7	1.8	2.4
Population (millions of people)	42.9	47.0	51.1	52.0	52.6	52.9	52.8	52.2	0.7	0.4	0.2	-0.1	0.1
GDP per capita (thousands of 2010 US$/person)	8.80	15.09	24.80	28.09	32.0	35.8	39.8	43.5	4.2	2.5	2.5	2.0	2.3
Primary energy consumption per capita (toe/person)	2.17	4.00	5.34	5.45	5.49	5.46	5.44	5.35	3.7	0.4	0.0	-0.2	0.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	246	265	215	194	172	152	137	123	-0.5	-2.0	-2.4	-2.1	-2.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	172	179	138	126	113	102	92	85	-0.9	-1.8	-2.1	-1.8	-1.9
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	173	166	125	105	84	74	64	59	-1.3	-3.6	-3.4	-2.3	-3.0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.70	0.63	0.58	0.54	0.49	0.49	0.47	0.48	-0.7	-1.5	-1.0	-0.2	-0.8
Automobile ownership volume (millions of vehicles)	3	12	21	24	26	28	29	29	7.6	2.6	1.5	0.5	1.3
Automobile ownership volume per capita (vehicles per person)	0.079	0.256	0.411	0.460	0.496	0.523	0.546	0.560	6.8	2.3	1.3	0.7	1.2

Lao People's Democratic Republic (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.20**	**1.65**	**9.49**	**13.42**	**18.18**	**18.55**	**18.95**	**36.81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.6**	**7.2**	**3.3**	**7.1**	**5.6**
Coal	0.00	0.00	7.04	11.64	16.76	16.80	16.82	36.32	0.0	0.0	74.3	86.8	92.2	90.6	88.7	98.7	-	10.6	3.7	8.0	6.8
Oil	0.16	0.28	0.99	1.09	1.21	1.35	1.50	1.68	13.6	17.2	10.4	8.1	6.7	7.3	7.9	4.6	7.5	2.0	2.1	2.2	2.1
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	0.07	0.30	1.33	2.42	1.11	1.86	1.86	2.30	5.9	17.9	14.1	18.0	6.1	10.0	9.8	6.2	12.5	12.6	-2.6	2.1	2.2
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.97	1.07	0.12	-1.73	-0.91	-1.46	-1.22	-3.49	80.5	65.0	1.3	-12.9	-5.0	-7.9	-6.5	-9.5	-8.0	-270.3	-1.7	9.1	-214.4
Biomass	1.01	1.30	1.30	1.39	1.48	1.56	1.66	1.75	84.6	78.5	13.7	10.4	8.1	8.4	8.7	4.8	1.0	1.3	1.2	1.1	1.2
Solar, Wind, Ocean	0.00	0.00	0.00	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	-	-	-	-	-
Biofuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	-0.05	-0.22	-1.18	-3.12	-2.38	-3.02	-2.88	-5.24	-4.1	-13.6	-12.5	-23.3	-13.1	-16.3	-15.2	-14.2	13.6	21.4	-0.3	5.7	6.1

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.09**	**1.50**	**9.12**	**11.34**	**14.87**	**15.24**	**15.64**	**29.58**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.9**	**4.4**	**3.0**	**6.9**	**4.8**
Industry	0.04	0.06	6.70	8.66	11.90	11.95	11.97	25.47	3.6	4.2	73.5	76.4	80.0	78.4	76.5	86.1	22.9	5.3	3.3	7.9	5.5
Transportation	0.16	0.27	0.97	1.08	1.20	1.33	1.49	1.66	14.7	17.7	10.6	9.5	8.1	8.8	9.5	5.6	7.5	2.1	2.2	2.2	2.2
Others	0.89	1.17	1.44	1.59	1.77	1.96	2.18	2.44	81.7	78.1	15.8	14.1	11.9	12.8	13.9	8.2	1.9	2.0	2.1	2.2	2.1
Non-energy	0.00	0.00	0.00	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	-	0.9	0.9	0.9	0.9
Total	**1.09**	**1.50**	**9.12**	**11.34**	**14.87**	**15.24**	**15.64**	**29.58**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.9**	**4.4**	**3.0**	**6.9**	**4.8**
Coal	0.00	0.00	6.49	8.44	11.67	11.71	11.73	25.22	0.0	0.0	71.1	74.5	78.5	76.9	75.0	85.3	-	5.4	3.3	8.0	5.6
Oil	0.16	0.27	0.99	1.09	1.21	1.35	1.50	1.68	14.9	18.1	10.8	9.6	8.2	8.9	9.6	5.7	7.5	2.0	2.1	2.2	2.1
Natural gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.01	0.06	0.34	0.41	0.50	0.61	0.75	0.93	1.3	3.7	3.8	3.6	3.4	4.0	4.8	3.1	13.6	3.7	4.0	4.2	4.1
Heat	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.92	1.17	1.30	1.39	1.48	1.56	1.66	1.75	83.8	78.2	14.3	12.3	9.9	10.3	10.6	5.9	1.4	1.3	1.2	1.1	1.2

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.82**	**3.44**	**17.76**	**41.12**	**33.63**	**42.32**	**42.32**	**71.86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**13.1**	**18.3**	**0.3**	**5.4**	**5.7**
Coal	0.00	0.00	2.26	13.02	20.71	20.71	20.71	45.17	0.0	0.0	12.7	31.7	61.6	48.9	48.9	62.9	-	42.0	4.7	8.1	12.7
Oil	0.00	0.00	0.00	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	-	-	-	-	-
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	0.82	3.44	15.51	28.09	12.92	21.61	21.61	26.69	100.0	100.0	87.3	68.3	38.4	51.1	51.1	37.1	12.5	12.6	-2.6	2.1	2.2
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	0.00	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	-	-	-	-	-

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.00**	**0.00**	**0.56**	**3.20**	**5.09**	**5.09**	**5.09**	**11.10**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**42.0**	**4.7**	**8.1**	**12.7**
Coal	0.00	0.00	0.56	3.20	5.09	5.09	5.09	11.10	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	-	42.0	4.7	8.1	12.7
Oil	0.00	0.00	0.00	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	-	-	-	-	-
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**-**	**-**	**35.0**	**35.0**	**35.0**	**35.0**	**35.0**	**35.0**									**-**	**0.0**	**0.0**	**0.0**	**0.0**
Coal	-	-	35.0	35.0	35.0	35.0	35.0	35.0									-	0.0	0.0	0.0	0.0
Oil	-	-	-	-	-	-	-	-									-	-	-	-	-
Natural gas	-	-	-	-	-	-	-	-									-	-	-	-	-

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.2**	**0.3**	**8.3**	**13.6**	**19.3**	**19.4**	**19.6**	**40.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**16.1**	**10.2**	**3.7**	**7.7**	**6.6**
Coal	0.0	0.0	7.5	12.6	18.3	18.3	18.3	39.5	0.0	0.0	90.1	93.3	94.7	94.2	93.6	96.6	-	11.0	3.8	8.0	6.9
Oil	0.2	0.3	0.8	0.9	1.0	1.1	1.3	1.4	100.0	100.0	9.9	6.7	5.3	5.8	6.4	3.4	5.8	2.0	2.1	2.2	2.1
Natural gas	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	0.0	0.0	-	-	-	-	-

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	1.1	2.0	5.1	7.2	10.0	13.3	17.6	23.1	6.3	7.1	6.4	5.7	6.2
Population (millions of people)	4.2	5.4	6.7	7.2	7.7	8.2	8.7	9.3	1.8	1.5	1.3	1.2	1.3
GDP per capita (thousands of 2010 US$/person)	0.3	0.4	0.8	1.00	1.3	1.6	2.0	2.5	4.4	5.5	5.0	4.4	4.8
Primary energy consumption per capita (toe/person)	0.3	0.3	1.4	1.87	2.37	2.26	2.17	3.97	6.7	5.6	1.9	5.8	4.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,080	818	1,862	1,872	1,825	1,394	1,076	1,592	2.2	0.1	-2.9	1.3	-0.6
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	984	743	1,791	1,581	1,492	1,145	888	1,279	2.4	-2.5	-3.2	1.1	-1.3
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	180	148	1,636	1,890	1,933	1,459	1,111	1,771	9.2	2.9	-2.6	2.0	0.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.2	0.2	0.9	1.01	1.06	1.05	1.03	1.11	6.9	2.8	0.4	0.6	0.9
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Lao People's Democratic Republic (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.20**	**1.65**	**9.49**	**12.40**	**16.86**	**17.29**	**17.79**	**34.47**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.6**	**5.5**	**3.4**	**7.1**	**5.3**
Coal	0.00	0.00	7.04	10.80	15.60	15.63	15.64	33.80	0.0	0.0	74.3	87.1	92.5	90.4	87.9	98.1	-	8.9	3.8	8.0	6.5
Oil	0.16	0.28	0.99	0.99	1.10	1.23	1.37	1.53	13.6	17.2	10.4	8.0	6.5	7.1	7.7	4.4	7.5	0.0	2.2	2.2	1.8
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	0.07	0.30	1.33	2.47	1.11	1.86	1.86	2.30	5.9	17.9	14.1	19.9	6.6	10.7	10.4	6.7	12.5	13.1	-2.8	2.1	2.2
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.97	1.07	0.12	-1.86	-0.94	-1.43	-1.08	-3.15	80.5	65.0	1.3	-15.0	-5.6	-8.2	-6.1	-9.1	-8.0	-272.8	-2.6	8.3	-213.9
Biomass	1.01	1.30	1.30	1.26	1.34	1.42	1.50	1.58	84.6	78.5	13.7	10.1	7.9	8.2	8.4	4.6	1.0	-0.7	1.2	1.1	0.8
Solar, Wind, Ocean	0.00	0.00	0.00	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	-	-	-	-	-
Biofuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	-0.05	-0.22	-1.18	-3.12	-2.28	-2.84	-2.58	-4.74	-4.1	-13.6	-12.5	-25.2	-13.5	-16.4	-14.5	-13.7	13.6	21.4	-0.9	5.2	5.7

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.09**	**1.50**	**9.12**	**10.22**	**13.40**	**13.73**	**14.10**	**26.65**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.9**	**2.3**	**3.0**	**6.9**	**4.4**
Industry	0.04	0.06	6.70	7.80	10.72	10.76	10.78	22.94	3.6	4.2	73.5	76.4	80.0	78.3	76.5	86.1	22.9	3.1	3.3	7.9	5.0
Transportation	0.16	0.27	0.97	0.98	1.09	1.21	1.35	1.51	14.7	17.7	10.6	9.5	8.1	8.8	9.6	5.7	7.5	0.1	2.2	2.2	1.8
Others	0.89	1.17	1.44	1.44	1.59	1.76	1.96	2.20	81.7	78.1	15.8	14.0	11.9	12.8	13.9	8.2	1.9	-0.1	2.1	2.2	1.7
Non-energy	0.00	0.00	0.00	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	-	-0.1	0.9	0.9	0.7
Total	**1.09**	**1.50**	**9.12**	**10.22**	**13.40**	**13.73**	**14.10**	**26.65**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**8.9**	**2.3**	**3.0**	**6.9**	**4.4**
Coal	0.00	0.00	6.49	7.60	10.51	10.54	10.55	22.70	0.0	0.0	71.1	74.4	78.4	76.8	74.9	85.2	-	3.2	3.3	8.0	5.1
Oil	0.16	0.27	0.99	0.99	1.10	1.23	1.37	1.53	14.9	18.1	10.8	9.7	8.2	8.9	9.7	5.7	7.5	0.0	2.2	2.2	1.8
Natural gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.01	0.06	0.34	0.37	0.45	0.55	0.67	0.83	1.3	3.7	3.8	3.6	3.4	4.0	4.8	3.1	13.6	1.6	4.0	4.2	3.6
Heat	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.92	1.17	1.30	1.26	1.34	1.42	1.50	1.58	83.8	78.2	14.3	12.3	10.0	10.3	10.6	5.9	1.4	-0.7	1.2	1.1	0.8

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.82**	**3.44**	**17.76**	**41.77**	**33.63**	**42.32**	**42.32**	**71.86**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**13.1**	**18.6**	**0.1**	**5.4**	**5.7**
Coal	0.00	0.00	2.26	13.02	20.71	20.71	20.71	45.17	0.0	0.0	12.7	31.2	61.6	48.9	48.9	62.9	-	42.0	4.7	8.1	12.7
Oil	0.00	0.00	0.00	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	-	-	-	-	-
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	0.82	3.44	15.51	28.74	12.92	21.61	21.61	26.69	100.0	100.0	87.3	68.8	38.4	51.1	51.1	37.1	12.5	13.1	-2.8	2.1	2.2
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	0.00	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	-	-	-	-	-

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.00**	**0.00**	**0.56**	**3.20**	**5.09**	**5.09**	**5.09**	**11.10**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**-**	**42.0**	**4.7**	**8.1**	**12.7**
Coal	0.00	0.00	0.56	3.20	5.09	5.09	5.09	11.10	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	-	42.0	4.7	8.1	12.7
Oil	0.00	0.00	0.00	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	-	-	-	-	-
Natural gas	0.00	0.00	0.00	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	-	-	-	-	-

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**-**	**-**	**35.0**	**35.0**	**35.0**	**35.0**	**35.0**	**35.0**									**-**	**0.0**	**0.0**	**0.0**	**0.0**
Coal	-	-	35.0	35.0	35.0	35.0	35.0	35.0									-	0.0	0.0	0.0	0.0
Oil	-	-	-	-	-	-	-	-									-	-	-	-	-
Natural gas	-	-	-	-	-	-	-	-									-	-	-	-	-

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.2**	**0.3**	**8.3**	**12.6**	**17.9**	**18.1**	**18.2**	**38.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**16.1**	**8.6**	**3.7**	**7.8**	**6.3**
Coal	0.0	0.0	7.5	11.8	17.0	17.1	17.1	36.9	0.0	0.0	90.1	93.5	94.9	94.4	93.7	96.7	-	9.4	3.8	8.0	6.6
Oil	0.2	0.3	0.8	0.8	0.9	1.0	1.1	1.3	100.0	100.0	9.9	6.5	5.1	5.6	6.3	3.3	5.8	0.0	2.2	2.2	1.8
Natural gas	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	0.0	0.0	-	-	-	-	-

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	1.1	2.0	5.1	7.2	10.0	13.3	17.6	23.1	6.3	7.1	6.4	5.7	6.2
Population (millions of people)	4.2	5.4	6.7	7.2	7.7	8.2	8.7	9.3	1.8	1.5	1.3	1.2	1.3
GDP per capita (thousands of 2010 US$/person)	0.3	0.4	0.8	1.00	1.3	1.6	2.0	2.5	4.4	5.5	5.0	4.4	4.8
Primary energy consumption per capita (toe/person)	0.3	0.3	1.4	1.73	2.20	2.11	2.04	3.72	6.7	4.0	2.0	5.8	3.9
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,080	818	1,862	1,729	1,693	1,299	1,010	1,491	2.2	-1.5	-2.8	1.4	-0.9
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	984	743	1,791	1,425	1,345	1,032	800	1,152	2.4	-4.5	-3.2	1.1	-1.7
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	180	148	1,636	1,754	1,800	1,358	1,034	1,650	9.2	1.4	-2.5	2.0	0.0
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.2	0.2	0.9	1.01	1.06	1.05	1.02	1.11	6.9	2.9	0.3	0.6	0.9
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Malaysia (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**19.84**	**46.72**	**70.58**	**88.92**	**106.84**	**127.91**	**149.80**	**172.74**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.2**	**4.7**	**3.7**	**3.1**	**3.6**
Coal	1.36	2.31	17.37	20.72	23.76	27.92	32.59	39.00	6.8	4.9	24.6	23.3	22.2	21.8	21.8	22.6	10.7	3.6	3.0	3.4	3.3
Oil	11.35	19.09	27.34	35.03	41.84	49.60	57.01	64.26	57.2	40.9	38.7	39.4	39.2	38.8	38.1	37.2	3.6	5.1	3.5	2.6	3.5
Natural gas	6.80	24.72	24.60	30.34	37.96	47.07	56.87	66.11	34.3	52.9	34.9	34.1	35.5	36.8	38.0	38.3	5.3	4.3	4.5	3.5	4.0
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	0.34	0.60	1.22	1.45	2.01	2.05	2.05	2.05	1.7	1.3	1.7	1.6	1.9	1.6	1.4	1.2	5.2	3.6	3.5	0.0	2.1
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	-0.01	0.00	0.05	1.38	1.26	1.27	1.30	1.32	0.0	0.0	0.1	1.5	1.2	1.0	0.9	0.8	-209.3	97.4	-0.8	0.4	14.4
Biomass	0.00	0.00	0.21	1.42	1.42	1.42	1.42	1.42	0.0	0.0	0.3	1.6	1.3	1.1	0.9	0.8	-	46.8	0.0	0.0	8.0
Solar, Wind, Ocean	0.00	0.00	0.02	0.03	0.03	0.03	0.03	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	7.7	0.0	0.0	1.5
Biofuels	0.00	0.00	0.39	0.41	0.43	0.45	0.47	0.50	0.0	0.0	0.5	0.5	0.4	0.4	0.3	0.3	-	1.0	1.0	1.0	1.0
Electricity	-0.01	0.00	-0.57	-0.48	-0.62	-0.63	-0.63	-0.63	0.0	0.0	-0.8	-0.5	-0.6	-0.5	-0.4	-0.4	20.9	-3.4	2.7	0.0	0.4

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.52**	**28.13**	**49.52**	**64.30**	**77.93**	**93.48**	**109.31**	**125.14**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**5.4**	**3.8**	**3.0**	**3.8**
Industry	5.30	11.41	13.97	16.78	20.65	24.94	29.20	33.29	42.3	40.6	28.2	26.1	26.5	26.7	26.7	26.6	4.0	3.7	4.0	2.9	3.5
Transportation	4.76	10.50	21.10	27.34	33.10	39.73	46.38	53.03	38.0	37.3	42.6	42.5	42.5	42.5	42.4	42.4	6.1	5.3	3.8	2.9	3.8
Others	1.62	3.97	8.53	10.84	13.25	16.04	19.08	22.29	13.0	14.1	17.2	16.9	17.0	17.2	17.5	17.8	6.9	4.9	4.0	3.3	3.9
Non-energy	0.84	2.25	5.93	9.34	10.93	12.76	14.64	16.53	6.7	8.0	12.0	14.5	14.0	13.7	13.4	13.2	8.1	9.5	3.2	2.6	4.2
Total	**12.52**	**28.13**	**49.52**	**64.30**	**77.93**	**93.48**	**109.31**	**125.14**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**5.4**	**3.8**	**3.0**	**3.8**
Coal	0.51	0.99	1.78	2.28	2.76	3.25	3.73	4.22	4.1	3.5	3.6	3.5	3.5	3.5	3.4	3.4	5.1	5.1	3.6	2.7	3.5
Oil	9.19	18.01	26.39	33.74	40.36	47.87	55.26	62.52	73.5	64.0	53.3	52.5	51.8	51.2	50.6	50.0	4.3	5.0	3.6	2.7	3.5
Natural gas	1.09	3.86	9.56	13.86	17.29	21.29	25.36	29.33	8.7	13.7	19.3	21.6	22.2	22.8	23.2	23.4	9.1	7.7	4.4	3.3	4.6
Electricity	1.72	5.26	11.40	14.01	17.08	20.62	24.49	28.57	13.7	18.7	23.0	21.8	21.9	22.1	22.4	22.8	7.9	4.2	3.9	3.3	3.7
Heat	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	0.39	0.41	0.43	0.45	0.47	0.50	0.0	0.0	0.8	0.6	0.5	0.5	0.4	0.4	-	1.0	1.0	1.0	1.0

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**23.02**	**66.65**	**150.37**	**182.25**	**222.77**	**267.54**	**316.47**	**368.13**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.8**	**3.9**	**3.9**	**3.2**	**3.6**
Coal	2.93	7.69	63.47	76.93	87.34	102.95	121.73	145.83	12.7	11.5	42.2	42.2	39.2	38.5	38.5	39.6	13.1	3.9	3.0	3.5	3.4
Oil	10.56	3.01	1.74	1.84	1.56	1.54	1.61	1.60	45.9	4.5	1.2	1.0	0.7	0.6	0.5	0.4	-7.0	1.1	-1.8	0.4	-0.3
Natural gas	5.54	48.99	69.96	81.04	104.92	133.74	163.83	191.40	24.1	73.5	46.5	44.5	47.1	50.0	51.8	52.0	10.7	3.0	5.1	3.6	4.1
Nuclear	0.00	0.00	0.00	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	-	-	-	-	-
Hydro	3.99	6.97	14.17	16.92	23.43	23.81	23.79	23.79	17.3	10.5	9.4	9.3	10.5	8.9	7.5	6.5	5.2	3.6	3.5	0.0	2.1
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	1.02	5.51	5.51	5.51	5.51	5.51	0.0	0.0	0.7	3.0	2.5	2.1	1.7	1.5	-	40.0	0.0	0.0	7.0

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.16**	**13.86**	**31.09**	**35.39**	**42.07**	**50.85**	**60.79**	**71.98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.4**	**2.6**	**3.7**	**3.5**	**3.4**
Coal	0.81	1.50	15.59	18.44	21.00	24.67	28.86	34.78	15.7	10.8	50.2	52.1	49.9	48.5	47.5	48.3	12.5	3.4	3.0	3.5	3.3
Oil	2.99	0.78	0.45	0.48	0.41	0.40	0.42	0.42	57.9	5.7	1.5	1.4	1.0	0.8	0.7	0.6	-7.3	1.1	-1.8	0.4	-0.3
Natural gas	1.36	11.58	15.04	16.48	20.67	25.78	31.51	36.78	26.4	83.6	48.4	46.6	49.1	50.7	51.8	51.1	10.1	1.8	4.6	3.6	3.6

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**31.7**	**37.0**	**37.4**	**38.8**	**39.6**	**40.3**	**40.6**	**40.5**									**0.7**	**0.8**	**0.4**	**0.0**	**0.3**
Coal	31.0	44.2	35.0	35.9	35.8	35.9	36.3	36.1									0.5	0.5	0.0	0.0	0.1
Oil	30.4	33.0	33.0	33.0	33.0	33.0	33.0	33.0									0.3	0.0	0.0	0.0	0.0
Natural gas	35.0	36.4	40.0	42.3	43.7	44.6	44.7	44.8									0.5	1.1	0.5	0.0	0.4

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**13.6**	**30.7**	**52.0**	**59.5**	**72.0**	**86.0**	**98.8**	**116.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.5**	**2.8**	**3.7**	**3.1**	**3.3**
Coal	1.4	2.6	18.5	18.6	21.8	25.1	26.8	33.7	10.3	8.5	35.6	31.2	30.4	29.2	27.2	29.0	10.9	0.1	3.0	3.0	2.4
Oil	10.3	15.7	20.6	26.6	31.9	38.0	44.0	49.9	75.7	51.1	39.7	44.7	44.4	44.2	44.6	42.9	2.8	5.2	3.6	2.8	3.6
Natural gas	1.9	12.4	12.9	14.4	18.2	22.9	27.9	32.6	14.0	40.4	24.7	24.1	25.3	26.6	28.3	28.1	7.9	2.2	4.8	3.6	3.8

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	81.8	162.5	330.0	403.1	487.1	582.9	679.0	774.9	5.7	4.1	3.8	2.9	3.5
Population (millions of people)	18.0	23.2	30.7	33.0	34.9	36.6	38.2	39.6	2.2	1.4	1.1	0.8	1.0
GDP per capita (thousands of 2010 US$/person)	4.5	7.0	10.7	12.23	14.0	15.9	17.8	19.6	3.5	2.6	2.7	2.1	2.4
Primary energy consumption per capita (toe/person)	1.1	2.0	2.3	2.70	3.07	3.49	3.92	4.37	3.0	3.3	2.6	2.3	2.6
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	243	287	214	221	219	219	221	223	-0.5	0.6	-0.1	0.2	0.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	153	173	150	159	160	160	161	161	-0.1	1.2	0.1	0.1	0.3
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	166	189	157	148	148	147	146	150	-0.2	-1.3	0.0	0.2	-0.2
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.7	0.7	0.7	0.67	0.67	0.67	0.66	0.67	0.3	-1.9	0.0	0.0	-0.4
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Malaysia (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**19.84**	**46.72**	**70.58**	**82.26**	**96.05**	**112.34**	**128.61**	**145.21**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.2**	**3.1**	**3.2**	**2.6**	**2.9**
Coal	1.36	2.31	17.37	17.54	18.55	20.42	23.04	25.31	6.8	4.9	24.6	21.3	19.3	18.2	17.9	17.4	10.7	0.2	1.5	2.2	1.5
Oil	11.35	19.09	27.34	33.85	40.28	47.62	54.57	61.37	57.2	40.9	38.7	41.2	41.9	42.4	42.4	42.3	3.6	4.4	3.5	2.6	3.3
Natural gas	6.80	24.72	24.60	27.04	32.62	39.43	45.86	51.04	34.3	52.9	34.9	32.9	34.0	35.1	35.7	35.1	5.3	1.9	3.8	2.6	3.0
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	-	-	-	-	-
Hydro	0.34	0.60	1.22	1.51	2.12	2.16	2.18	2.18	1.7	1.3	1.7	1.8	2.2	1.9	1.7	1.5	5.2	4.4	3.7	0.1	2.4
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	-0.01	0.00	0.05	2.32	2.48	2.71	2.95	3.16	0.0	0.0	0.1	2.8	2.6	2.4	2.3	2.2	-209.3	119.0	1.6	1.5	18.4
Biomass	0.00	0.00	0.21	1.60	1.61	1.63	1.68	1.68	0.0	0.0	0.3	1.9	1.7	1.5	1.3	1.2	-	50.3	0.2	0.2	8.7
Solar, Wind, Ocean	0.00	0.00	0.02	0.20	0.36	0.39	0.40	0.40	0.0	0.0	0.0	0.2	0.4	0.4	0.3	0.3	-	54.0	6.9	0.2	12.1
Biofuels	0.00	0.00	0.39	1.07	1.25	1.45	1.65	1.85	0.0	0.0	0.5	1.3	1.3	1.3	1.3	1.3	-	22.5	3.1	2.5	6.5
Electricity	-0.01	0.00	-0.57	-0.55	-0.74	-0.77	-0.77	-0.78	0.0	0.0	-0.8	-0.7	-0.8	-0.7	-0.6	-0.5	20.9	-0.8	3.3	0.1	1.2

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.52**	**28.13**	**49.52**	**61.72**	**74.20**	**88.29**	**102.39**	**116.25**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**4.5**	**3.6**	**2.8**	**3.5**
Industry	5.30	11.41	13.97	15.22	18.38	21.78	25.02	27.96	42.3	40.6	28.2	24.7	24.8	24.7	24.4	24.1	4.0	1.7	3.7	2.5	2.8
Transportation	4.76	10.50	21.10	27.34	33.10	39.73	46.38	53.03	38.0	37.3	42.6	44.3	44.6	45.0	45.3	45.6	6.1	5.3	3.8	2.9	3.8
Others	1.62	3.97	8.53	9.83	11.80	14.01	16.35	18.73	13.0	14.1	17.2	15.9	15.9	15.9	16.0	16.1	6.9	2.9	3.6	2.9	3.2
Non-energy	0.84	2.25	5.93	9.34	10.93	12.76	14.64	16.53	6.7	8.0	12.0	15.1	14.7	14.5	14.3	14.2	8.1	9.5	3.2	2.6	4.2
Total	**12.52**	**28.13**	**49.52**	**61.72**	**74.20**	**88.29**	**102.39**	**116.25**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**4.5**	**3.6**	**2.8**	**3.5**
Coal	0.51	0.99	1.78	2.07	2.46	2.84	3.20	3.54	4.1	3.5	3.6	3.4	3.3	3.2	3.1	3.0	5.1	3.1	3.2	2.3	2.8
Oil	9.19	18.01	26.39	32.54	38.80	45.87	52.81	59.61	73.5	64.0	53.3	52.7	52.3	52.0	51.6	51.3	4.3	4.3	3.5	2.7	3.3
Natural gas	1.09	3.86	9.56	13.34	16.49	20.12	23.74	27.23	8.7	13.7	19.3	21.6	22.2	22.8	23.2	23.4	9.1	6.9	4.2	3.1	4.3
Electricity	1.72	5.26	11.40	12.70	15.21	18.01	20.99	24.02	13.7	18.7	23.0	20.6	20.5	20.4	20.5	20.7	7.9	2.2	3.6	2.9	3.0
Heat	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	0.39	1.07	1.25	1.45	1.65	1.85	0.0	0.0	0.8	1.7	1.7	1.6	1.6	1.6	-	22.5	3.1	2.5	6.5

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**23.02**	**66.65**	**150.37**	**166.57**	**200.49**	**236.20**	**273.90**	**312.18**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.8**	**2.1**	**3.6**	**2.8**	**3.0**
Coal	2.93	7.69	63.47	68.08	74.10	84.83	100.03	113.92	12.7	11.5	42.2	40.9	37.0	35.9	36.5	36.5	13.1	1.4	2.2	3.0	2.4
Oil	10.56	3.01	1.74	1.91	1.60	1.61	1.66	1.65	45.9	4.5	1.2	1.1	0.8	0.7	0.6	0.5	-7.0	1.9	-1.7	0.3	-0.2
Natural gas	5.54	48.99	69.96	70.89	90.18	114.12	136.18	152.28	24.1	73.5	46.5	42.6	45.0	48.3	49.7	48.8	10.7	0.3	4.9	2.9	3.2
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	-	-	-	-	-
Hydro	3.99	6.97	14.17	17.58	24.61	25.17	25.32	25.32	17.3	10.5	9.4	10.6	12.3	10.7	9.2	8.1	5.2	4.4	3.7	0.1	2.4
Geothermal	0.00	0.00	0.00	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	-	-	-	-	-
Others	0.00	0.00	1.02	8.12	10.00	10.48	10.71	10.73	0.0	0.0	0.7	4.9	5.0	4.4	3.9	3.4	-	51.3	2.6	0.2	9.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.16**	**13.86**	**31.09**	**29.66**	**32.64**	**37.31**	**42.40**	**46.00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.4**	**-0.9**	**2.3**	**2.1**	**1.6**
Coal	0.81	1.50	15.59	15.47	16.10	17.58	19.84	21.77	15.7	10.8	50.2	52.1	49.3	47.1	46.8	47.3	12.5	-0.2	1.3	2.2	1.3
Oil	2.99	0.78	0.45	0.50	0.42	0.42	0.43	0.43	57.9	5.7	1.5	1.7	1.3	1.1	1.0	0.9	-7.3	1.9	-1.7	0.3	-0.2
Natural gas	1.36	11.58	15.04	13.70	16.13	19.31	22.12	23.81	26.4	83.6	48.4	46.2	49.4	51.8	52.2	51.7	10.1	-1.8	3.5	2.1	1.9

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**31.7**	**37.0**	**37.4**	**40.8**	**43.7**	**46.2**	**48.3**	**50.1**									**0.7**	**1.8**	**1.2**	**0.8**	**1.2**
Coal	31.0	44.2	35.0	37.9	39.6	41.5	43.4	45.0									0.5	1.6	0.9	0.8	1.0
Oil	30.4	33.0	33.0	33.0	33.0	33.0	33.0	33.0									0.3	0.0	0.0	0.0	0.0
Natural gas	35.0	36.4	40.0	44.5	48.1	50.8	52.9	55.0									0.5	2.1	1.3	0.8	1.3

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**13.6**	**30.7**	**52.0**	**53.0**	**61.8**	**71.6**	**80.1**	**90.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.5**	**0.4**	**3.0**	**2.4**	**2.2**
Coal	1.4	2.6	18.5	15.2	16.4	17.2	17.2	19.8	10.3	8.5	35.6	28.6	26.5	24.1	21.4	21.9	10.9	-3.9	1.3	1.4	0.3
Oil	10.3	15.7	20.6	25.6	30.6	36.4	42.0	47.5	75.7	51.1	39.7	48.3	49.5	50.8	52.5	52.6	2.8	4.4	3.6	2.7	3.4
Natural gas	1.9	12.4	12.9	12.2	14.8	18.0	20.9	23.0	14.0	40.4	24.7	23.1	23.9	25.1	26.1	25.5	7.9	-1.0	3.9	2.5	2.4

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	81.8	162.5	330.0	403.1	487.1	582.9	679.0	774.9	5.7	4.1	3.8	2.9	3.5
Population (millions of people)	18.0	23.2	30.7	33.0	34.9	36.6	38.2	39.6	2.2	1.4	1.1	0.8	1.0
GDP per capita (thousands of 2010 US$/person)	4.5	7.0	10.7	12.23	14.0	15.9	17.8	19.6	3.5	2.6	2.7	2.1	2.4
Primary energy consumption per capita (toe/person)	1.1	2.0	2.3	2.50	2.76	3.07	3.37	3.67	3.0	1.7	2.1	1.8	1.9
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	243	287	214	204	197	193	189	187	-0.5	-0.9	-0.6	-0.3	-0.5
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	153	173	150	153	152	151	151	150	-0.1	0.4	-0.1	-0.1	0.0
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	166	189	157	132	127	123	118	117	-0.2	-3.5	-0.7	-0.5	-1.2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.7	0.7	0.7	0.64	0.64	0.64	0.62	0.62	0.3	-2.6	-0.1	-0.2	-0.7
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Myanmar (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**10.68**	**12.84**	**19.85**	**23.39**	**26.23**	**30.94**	**35.72**	**41.79**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.5**	**3.3**	**2.8**	**3.1**	**3.0**
Coal	0.07	0.32	0.38	0.48	0.59	3.92	4.77	6.84	0.6	2.5	1.9	2.1	2.2	12.7	13.4	16.4	7.1	5.3	23.2	5.7	12.3
Oil	0.73	1.97	5.47	7.11	8.87	10.85	13.18	16.00	6.8	15.4	27.6	30.4	33.8	35.1	36.9	38.3	8.4	5.4	4.3	4.0	4.4
Natural gas	0.76	1.20	3.08	4.48	4.59	3.84	4.92	5.77	7.1	9.3	15.5	19.1	17.5	12.4	13.8	13.8	5.8	7.8	-1.5	4.2	2.5
Nuclear	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.10	0.16	0.81	0.90	1.38	1.15	1.41	1.58	1.0	1.3	4.1	3.9	5.3	3.7	4.0	3.8	8.6	2.2	2.5	3.2	2.7
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.02	9.19	10.11	10.41	10.80	11.18	11.43	11.60	84.5	71.5	50.9	44.5	41.2	36.1	32.0	27.8	0.5	0.6	0.7	0.4	0.6
Biomass	9.02	9.19	10.11	10.40	10.76	11.12	11.36	11.51	84.5	71.5	50.9	44.5	41.0	35.9	31.8	27.6	0.5	0.6	0.7	0.4	0.5
Solar, Wind, Ocean	-	-	0.00	0.00	0.04	0.06	0.08	0.09	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	-	-	32.6	3.2	-
Biofuels	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	-	-	0.00	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	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**9.400**	**11.477**	**17.734**	**20.557**	**23.574**	**26.922**	**30.740**	**35.290**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**3.0**	**2.7**	**2.7**	**2.8**
Industry	0.39	1.15	2.17	3.05	3.86	4.76	5.79	7.01	4.2	10.0	12.3	14.8	16.4	17.7	18.8	19.9	7.1	7.0	4.6	3.9	4.8
Transportation	0.44	1.16	3.53	4.88	6.42	8.19	10.29	12.86	4.7	10.1	19.9	23.8	27.2	30.4	33.5	36.4	8.6	6.7	5.3	4.6	5.3
Others	8.47	9.08	11.76	12.33	12.92	13.50	14.09	14.71	90.1	79.1	66.3	60.0	54.8	50.2	45.8	41.7	1.3	0.9	0.9	0.9	0.9
Non-energy	0.09	0.09	0.27	0.30	0.37	0.46	0.57	0.71	1.0	0.8	1.5	1.4	1.6	1.7	1.9	2.0	4.2	2.2	4.6	4.4	4.0
Total	**9.40**	**11.48**	**17.73**	**20.56**	**23.57**	**26.92**	**30.74**	**35.29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**3.0**	**2.7**	**2.7**	**2.8**
Coal	0.05	0.32	0.38	0.46	0.54	0.63	0.72	0.82	0.5	2.8	2.1	2.2	2.3	2.3	2.3	2.3	8.3	4.0	3.3	2.7	3.2
Oil	0.59	1.53	5.43	7.02	8.76	10.74	13.05	15.85	6.2	13.3	30.6	34.2	37.2	39.9	42.4	44.9	9.3	5.3	4.3	4.0	4.4
Natural gas	0.23	0.32	0.71	0.92	1.21	1.57	1.99	2.51	2.4	2.8	4.0	4.5	5.1	5.8	6.5	7.1	4.7	5.4	5.5	4.8	5.2
Electricity	0.15	0.28	1.15	1.83	2.44	3.12	3.93	4.93	1.6	2.4	6.5	8.9	10.3	11.6	12.8	14.0	8.5	9.7	5.5	4.7	6.0
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	8.39	9.02	10.07	10.34	10.62	10.86	11.05	11.18	89.2	78.6	56.8	50.3	45.1	40.4	36.0	31.7	0.7	0.5	0.5	0.3	0.4

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.48**	**5.12**	**15.97**	**23.62**	**31.50**	**40.33**	**50.48**	**63.00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**8.2**	**5.5**	**4.6**	**5.6**
Coal	0.04	0.00	0.00	0.12	0.20	14.54	17.91	26.61	1.6	0.0	0.0	0.5	0.6	36.0	35.5	42.2	-100.0	-	61.6	6.2	-
Oil	0.27	0.69	0.06	0.10	0.06	0.00	0.00	0.00	10.9	13.5	0.3	0.4	0.2	0.0	0.0	0.0	-6.2	11.7	-100.0	-	-100.0
Natural gas	0.97	2.54	6.51	12.59	13.69	9.30	12.30	13.74	39.3	49.5	40.8	53.3	43.5	23.1	24.4	21.8	7.9	14.1	-3.0	4.0	3.0
Nuclear									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	1.19	1.89	9.40	10.49	16.02	13.37	16.43	18.35	48.1	37.0	58.9	44.4	50.8	33.2	32.5	29.1	8.6	2.2	2.5	3.2	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	0.0	-	-	-	-	-
Others	-	-	0.00	0.33	1.53	3.13	3.84	4.29	0.0	0.0	0.0	1.4	4.9	7.8	7.6	6.8	-	-	25.2	3.2	-

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.51**	**0.94**	**2.03**	**3.33**	**3.16**	**5.29**	**6.70**	**8.97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**10.4**	**4.7**	**5.4**	**6.1**
Coal	0.01	0.00	0.00	0.03	0.05	3.29	4.05	6.02	2.4	0.0	0.0	0.9	1.6	62.2	60.5	67.1	-100.0	-	60.3	6.2	-
Oil	0.06	0.19	0.01	0.03	0.01	0.00	0.00	0.00	12.5	20.6	0.7	0.8	0.5	0.0	0.0	0.0	-5.8	11.7	-100.0	-	-100.0
Natural gas	0.43	0.74	2.02	3.28	3.10	2.00	2.64	2.95	85.1	79.4	99.3	98.4	98.0	37.8	39.5	32.9	6.3	10.2	-4.8	4.0	1.5

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**21.7**	**29.6**	**27.8**	**33.0**	**37.9**	**38.8**	**38.8**	**38.7**									**1.0**	**3.5**	**1.6**	**0.0**	**1.3**
Coal	28.7	-	-	35.2	35.2	38.0	38.0	38.0									-	-	0.8	0.0	-
Oil	36.4	30.8	32.7	32.7	32.7	-	-	-									-0.4	0.0	-	-	-
Natural gas	19.3	29.3	27.7	33.0	38.0	40.0	40.0	40.0									1.5	3.5	1.9	0.0	1.5

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.1**	**2.4**	**6.6**	**8.9**	**10.4**	**15.1**	**18.5**	**23.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.3**	**6.3**	**5.4**	**4.5**	**5.2**
Coal	0.1	0.3	0.4067	0.5255	0.6389	4.2362	5.1606	7.3975	8.9	12.5	6.2	5.9	6.1	28.1	28.0	31.6	5.8	5.3	23.2	5.7	12.3
Oil	0.6	1.4	4.3403	5.6188	6.9917	8.5462	10.371	12.588	50.0	58.3	66.0	63.0	67.0	56.7	56.2	53.9	8.5	5.3	4.3	3.9	4.4
Natural gas	0.5	0.7	1.8262	2.7749	2.812	2.28	2.9211	3.3896	41.1	29.2	27.8	31.1	26.9	15.1	15.8	14.5	5.7	8.7	-1.9	4.0	2.5

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	8	16	71	100	139	185	242	316	9.1	7.2	6.3	5.5	6.2
Population (millions of people)	41	46	52	55	57	59	61	63	1.0	0.9	0.8	0.5	0.7
GDP per capita (thousands of 2010 US$/person)	0.2	0.3	1.3	1.83	2.4	3.1	4.0	5.1	8.0	6.3	5.5	4.9	5.4
Primary energy consumption per capita (toe/person)	0.3	0.3	0.4	0.43	0.46	0.52	0.58	0.67	1.5	2.4	2.0	2.5	2.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,333	803	281	234	189	167	148	132	-6.0	-3.6	-3.3	-2.3	-3.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	1,173	718	251	206	170	145	127	112	-6.0	-3.9	-3.4	-2.6	-3.2
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	140	150	93	89	75	81	76	74	-1.6	-0.9	-0.9	-1.0	-0.9
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.1	0.2	0.3	0.38	0.40	0.49	0.52	0.56	4.7	2.9	2.5	1.4	2.1
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Myanmar (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**10.68**	**12.84**	**19.85**	**22.77**	**24.35**	**25.70**	**29.35**	**33.15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.5**	**2.8**	**1.2**	**2.6**	**2.1**
Coal	0.07	0.32	0.38	0.46	0.53	0.59	0.68	0.80	0.6	2.5	1.9	2.0	2.2	2.3	2.3	2.4	7.1	4.3	2.4	3.1	3.1
Oil	0.73	1.97	5.47	6.83	8.06	9.31	11.30	13.70	6.8	15.4	27.6	30.0	33.1	36.2	38.5	41.3	8.4	4.5	3.2	3.9	3.7
Natural gas	0.76	1.20	3.08	4.27	4.01	3.39	4.33	4.89	7.1	9.3	15.5	18.7	16.5	13.2	14.7	14.7	5.8	6.8	-2.3	3.7	1.9
Nuclear	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.10	0.16	0.81	0.95	1.30	1.47	1.80	2.23	1.0	1.3	4.1	4.2	5.3	5.7	6.1	6.7	8.6	3.3	4.5	4.2	4.1
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.02	9.19	10.11	10.26	10.45	10.94	11.24	11.53	84.5	71.5	50.9	45.0	42.9	42.6	38.3	34.8	0.5	0.3	0.6	0.5	0.5
Biomass	9.02	9.19	10.11	10.25	10.41	10.74	11.00	11.23	84.5	71.5	50.9	45.0	42.8	41.8	37.5	33.9	0.5	0.3	0.5	0.5	0.4
Solar, Wind, Ocean	-	-	0.00	0.00	0.03	0.20	0.24	0.30	0.0	0.0	0.0	0.0	0.1	0.8	0.8	0.9	-	-	49.9	4.2	-
Biofuels	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	-	-	0.00	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	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**9.40**	**11.48**	**17.73**	**19.97**	**21.97**	**23.93**	**27.17**	**31.02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**2.4**	**1.8**	**2.6**	**2.3**
Industry	0.39	1.15	2.17	2.92	3.49	4.03	4.88	5.89	4.2	10.0	12.3	14.6	15.9	16.8	18.0	19.0	7.1	6.1	3.3	3.9	4.1
Transportation	0.44	1.16	3.53	4.69	5.83	7.01	8.79	10.98	4.7	10.1	19.9	23.5	26.5	29.3	32.3	35.4	8.6	5.8	4.1	4.6	4.6
Others	8.47	9.08	11.76	12.07	12.28	12.43	12.92	13.44	90.1	79.1	66.3	60.4	55.9	51.9	47.6	43.3	1.3	0.5	0.3	0.8	0.5
Non-energy	0.09	0.09	0.27	0.30	0.37	0.46	0.57	0.71	1.0	0.8	1.5	1.5	1.7	1.9	2.1	2.3	4.2	2.2	4.6	4.4	4.0
Total	**9.40**	**11.48**	**17.73**	**19.97**	**21.97**	**23.93**	**27.17**	**31.02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**2.4**	**1.8**	**2.6**	**2.3**
Coal	0.05	0.32	0.38	0.44	0.49	0.53	0.61	0.70	0.5	2.8	2.1	2.2	2.2	2.2	2.3	2.3	8.3	3.1	2.0	2.7	2.5
Oil	0.59	1.53	5.43	6.74	7.96	9.20	11.17	13.55	6.2	13.3	30.6	33.7	36.2	38.5	41.1	43.7	9.3	4.4	3.2	3.9	3.7
Natural gas	0.23	0.32	0.71	0.88	1.11	1.37	1.75	2.20	2.4	2.8	4.0	4.4	5.1	5.7	6.4	7.1	4.7	4.6	4.5	4.8	4.7
Electricity	0.15	0.28	1.15	1.72	2.12	2.50	3.14	3.94	1.6	2.4	6.5	8.6	9.7	10.4	11.6	12.7	8.5	8.4	3.8	4.7	5.0
Heat	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	8.39	9.02	10.07	10.19	10.28	10.32	10.50	10.62	89.2	78.6	56.8	51.0	46.8	43.1	38.7	34.2	0.7	0.2	0.1	0.3	0.2

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**2.48**	**5.12**	**15.97**	**23.48**	**28.40**	**32.62**	**40.61**	**50.40**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.7**	**8.0**	**3.3**	**4.4**	**4.7**
Coal	0.04	0.00	0.00	0.11	0.19	0.26	0.37	0.52	1.6	0.0	0.0	0.5	0.7	0.8	0.9	1.0	-100.0	-	8.6	7.3	-
Oil	0.27	0.69	0.06	0.09	0.05	0.00	0.00	0.00	10.9	13.5	0.3	0.4	0.2	0.0	0.0	0.0	-6.2	10.5	-100.0	-	-100.0
Natural gas	0.97	2.54	6.51	11.93	11.60	8.57	11.24	13.93	39.3	49.5	40.8	50.8	40.8	26.3	27.7	27.6	7.9	12.9	-3.3	5.0	3.1
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	1.19	1.89	9.40	11.04	15.11	17.14	20.88	25.89	48.1	37.0	58.9	47.0	53.2	52.5	51.4	51.4	8.6	3.3	4.5	4.2	4.1
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	0.0	-	-	-	-	-
Others	-	-	0.00	0.31	1.45	6.66	8.11	10.05	0.0	0.0	0.0	1.3	5.1	20.4	20.0	19.9	-	-	35.8	4.2	-

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**0.51**	**0.94**	**2.03**	**3.16**	**2.68**	**1.81**	**2.37**	**2.50**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.7**	**9.2**	**-5.4**	**3.3**	**0.8**
Coal	0.01	0.00	0.00	0.03	0.04	0.05	0.07	0.10	2.4	0.0	0.0	0.9	1.5	2.9	3.0	4.0	-100.0	-	6.7	6.5	-
Oil	0.06	0.19	0.01	0.02	0.01	0.00	0.00	0.00	12.5	20.6	0.7	0.8	0.5	0.0	0.0	0.0	-5.8	10.5	-100.0	-	-100.0
Natural gas	0.43	0.74	2.02	3.11	2.62	1.75	2.30	2.40	85.1	79.4	99.3	98.4	98.0	97.1	97.0	96.0	6.3	9.0	-5.6	3.2	0.7

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**21.7**	**29.6**	**27.8**	**33.0**	**38.0**	**42.0**	**42.1**	**49.8**									**1.0**	**3.5**	**2.4**	**1.7**	**2.4**
Coal	28.7	-	-	35.2	42.0	42.0	45.0	45.0									-	-	1.8	0.7	-
Oil	36.4	30.8	32.7	32.7	32.7	-	-	-									-0.4	0.0	-	-	-
Natural gas	19.3	29.3	27.7	33.0	38.0	42.0	42.0	50.0									1.5	3.5	2.4	1.8	2.4

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.1**	**2.4**	**6.6**	**8.5**	**9.4**	**9.9**	**12.1**	**14.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**7.3**	**5.4**	**1.5**	**3.8**	**3.2**
Coal	0.1	0.3	0.4	0.5	0.6	0.6	0.7	0.9	8.9	12.5	6.2	5.9	6.1	6.4	6.1	6.0	5.8	4.3	2.4	3.1	3.1
Oil	0.6	1.4	4.3	5.4	6.3	7.3	8.9	10.7	50.0	58.3	66.0	63.2	67.8	73.5	73.0	74.4	8.5	4.4	3.1	3.9	3.7
Natural gas	0.5	0.7	1.8	2.6	2.4	2.0	2.5	2.8	41.1	29.2	27.8	31.0	26.1	20.1	20.9	19.6	5.7	7.7	-2.8	3.5	1.8

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	8.0	16.0	70.5	101.2	140.8	188.6	244.2	316.2	9.1	7.5	6.4	5.3	6.2
Population (millions of people)	40.6	46.1	52.4	57.1	60.1	63.0	66.0	66.0	1.0	1.7	1.0	0.5	0.9
GDP per capita (thousands of 2010 US$/person)	0.2	0.3	1.3	1.77	2.3	3.0	3.7	4.8	8.0	5.6	5.4	4.8	5.2
Primary energy consumption per capita (toe/person)	0.3	0.3	0.4	0.40	0.41	0.41	0.44	0.50	1.5	1.0	0.2	2.1	1.1
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,333	803	281	225	173	136	120	105	-6.0	-4.4	-4.9	-2.6	-3.9
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	1,173	718	251	197	156	127	111	98	-6.0	-4.7	-4.3	-2.5	-3.7
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	140	150	93	84	66	53	50	46	-1.6	-2.0	-4.6	-1.4	-2.8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.1	0.2	0.3	0.37	0.38	0.39	0.41	0.44	4.7	2.5	0.3	1.2	1.1
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

New Zealand (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.8**	**17.1**	**20.6**	**21.8**	**23.0**	**24.0**	**24.3**	**24.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.9**	**1.1**	**1.0**	**0.2**	**0.7**
Coal	1.2	1.1	1.4	0.8	0.7	0.7	0.7	0.7	9.2	6.5	6.6	3.7	3.2	3.0	2.8	2.6	0.6	-10.3	-1.1	-0.9	-2.9
Oil	3.5	5.7	6.8	6.9	6.9	6.8	6.7	6.5	27.4	33.4	32.8	31.8	30.1	28.5	27.4	26.2	2.7	0.4	-0.1	-0.6	-0.2
Natural gas	3.9	5.1	4.1	4.6	4.6	4.4	4.4	4.4	30.2	29.6	19.8	21.2	19.9	18.3	18.1	17.8	0.2	2.5	-0.5	0.0	0.3
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	2.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	15.5	12.3	10.2	9.5	9.1	8.9	8.9	8.9	0.2	-0.4	0.3	0.3	0.2
Geothermal	1.5	1.9	4.9	5.8	7.0	8.2	8.7	9.1	11.5	11.4	23.6	26.8	30.5	34.3	35.6	37.0	4.9	3.7	3.5	1.0	2.5
Others	0.8	1.2	1.4	1.5	1.6	1.7	1.8	1.8	6.2	6.9	6.9	7.1	7.1	7.1	7.3	7.4	2.3	1.6	1.1	0.6	1.0
Biomass	0.7	1.1	1.1	1.2	1.2	1.2	1.2	1.2	5.6	6.4	5.3	5.4	5.3	5.0	4.9	4.8	1.7	1.5	0.2	-0.2	0.3
Solar, Wind, Ocean	0.0	0.1	0.3	0.3	0.3	0.4	0.4	0.5	0.3	0.3	1.2	1.2	1.4	1.6	1.8	2.0	7.2	1.2	3.9	2.3	2.7
Biofuels	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.4	0.4	0.4	0.5	0.5	0.6	2.6	4.7	2.1	2.0	2.6
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**9.7**	**12.9**	**14.1**	**14.6**	**14.8**	**14.9**	**14.8**	**14.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.7**	**0.2**	**-0.1**	**0.2**
Industry	3.6	4.3	4.3	4.5	4.6	4.6	4.5	4.5	37.0	32.9	30.8	31.1	30.9	30.7	30.6	30.5	0.8	0.9	0.1	-0.2	0.1
Transportation	3.0	4.1	4.8	4.9	4.9	4.9	4.8	4.7	30.4	31.4	34.2	33.7	33.3	32.9	32.5	32.0	2.0	0.4	0.0	-0.4	-0.1
Others	2.5	3.0	3.5	3.7	3.9	4.0	4.0	4.1	26.2	23.0	24.9	25.5	26.1	26.7	27.2	27.7	1.3	1.1	0.6	0.3	0.6
Non-energy	0.6	1.6	1.4	1.4	1.4	1.4	1.4	1.4	6.4	12.7	10.0	9.8	9.7	9.7	9.7	9.8	3.4	0.2	0.1	-0.1	0.0
Total	**9.7**	**12.9**	**14.1**	**14.6**	**14.8**	**14.9**	**14.8**	**14.7**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.7**	**0.2**	**-0.1**	**0.2**
Coal	0.7	0.5	0.6	0.6	0.6	0.6	0.6	0.5	6.9	4.0	4.3	4.3	4.2	4.1	3.9	3.7	-0.4	0.7	-0.3	-1.1	-0.4
Oil	4.0	5.3	6.2	6.4	6.4	6.3	6.1	5.9	41.4	41.0	44.1	43.6	43.0	42.2	41.2	40.2	1.8	0.5	-0.1	-0.6	-0.2
Natural gas	1.8	3.0	2.7	2.7	2.6	2.6	2.6	2.6	18.5	23.3	19.1	18.3	17.9	17.7	17.7	17.7	1.6	-0.1	-0.2	-0.1	-0.1
Electricity	2.4	2.9	3.4	3.7	3.9	4.1	4.3	4.4	25.0	22.8	23.9	25.1	26.3	27.4	28.7	30.0	1.3	1.7	1.1	0.8	1.1
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.8	1.2	1.204	1.3	1.3	1.3	1.3	1.221	8.1	9.0	8.6	8.7	8.7	8.6	8.5	8.3	1.7	1.1	0.0	-0.4	0.1

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.3**	**39.2**	**44.2**	**48.0**	**51.1**	**53.5**	**55.7**	**57.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.3**	**1.7**	**1.1**	**0.8**	**1.1**
Coal	0.7	1.5	1.9	0.2	0.0	0.0	0.0	0.0	2.1	3.9	4.3	0.4	0.0	0.0	0.0	0.0	4.3	-37.8	-100.0	-	-100.0
Oil	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	0.0	0.0	-8.8	4.1	-0.9	0.6	0.7
Natural gas	5.7	9.6	6.9	10.5	10.6	9.8	10.2	10.4	17.7	24.4	15.5	21.9	20.8	18.3	18.4	18.0	0.7	8.9	-0.7	0.6	1.7
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	23.2	24.4	24.5	24.1	24.4	24.8	25.2	25.5	71.9	62.3	55.5	50.1	47.8	46.4	45.2	44.3	0.2	-0.4	0.3	0.3	0.2
Geothermal	2.1	2.9	7.9	9.5	11.4	13.5	14.2	14.9	6.6	7.4	17.8	19.7	22.4	25.2	25.5	25.9	5.4	3.8	3.6	1.0	2.6
Others	0.6	0.8	3.1	3.8	4.6	5.4	6.1	6.8	1.8	2.0	6.9	7.9	9.0	10.1	10.9	11.7	7.0	4.3	3.6	2.3	3.2

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.4**	**2.3**	**1.7**	**1.8**	**1.7**	**1.6**	**1.6**	**1.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.7**	**1.7**	**-1.3**	**0.0**	**-0.2**
Coal	0.2	0.4	0.5	0.0	0.0	0.0	0.0	0.0	11.9	16.7	27.1	2.3	0.0	0.0	0.0	0.0	4.0	-37.7	-100.0	-	-100.0
Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-1.9	-1.0	-
Natural gas	1.2	1.9	1.2	1.8	1.7	1.6	1.6	1.6	87.7	83.3	72.9	97.6	100.0	100.0	100.0	100.0	-0.1	7.8	-1.1	0.0	1.1

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**38.8**	**42.0**	**45.2**	**50.9**	**52.5**	**53.2**	**54.9**	**56.2**									**0.6**	**2.4**	**0.4**	**0.6**	**0.9**
Coal	33.9	34.8	35.8	35.5	-	-	-	-									0.2	-0.1	-	-	-
Oil	14.1	-	-	25.5	26.9	28.2	30.8	33.0									-	-	1.0	1.6	-
Natural gas	39.6	43.4	48.7	51.3	52.5	53.2	54.9	56.2									0.8	1.0	0.4	0.6	0.6

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**6.2**	**8.1**	**8.8**	**8.6**	**8.5**	**8.3**	**8.1**	**7.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.4**	**-0.4**	**-0.4**	**-0.5**	**-0.4**
Coal	1.3	1.2	1.5	0.9	0.8	0.8	0.7	0.7	20.5	14.7	16.8	10.0	9.3	9.3	9.1	8.9	0.6	-10.3	-1.1	-0.9	-2.9
Oil	2.7	4.5	5.4	5.5	5.5	5.4	5.3	5.1	42.8	55.8	61.2	63.7	64.5	65.3	65.0	64.7	2.8	0.4	-0.1	-0.6	-0.2
Natural gas	2.3	2.4	1.9	2.3	2.2	2.1	2.1	2.1	36.7	29.4	21.9	26.3	26.2	25.4	26.0	26.5	-0.7	3.3	-0.7	-0.1	0.3

Energy and economic indicators

	1990	2000	2015	2020	2025	2030	2035	2040	AAGR(%) 1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	85	114	169	196	219	238	258	276	2.8	3.0	2.0	1.5	2.0
Population (millions of people)	3.3	3.9	4.6	4.8	5.0	5.2	5.3	5.5	1.3	0.9	0.8	0.5	0.7
GDP per capita (thousands of 2010 US$/person)	25.42	29.60	36.80	40.76	43.7	45.9	48.2	50.4	1.5	2.1	1.2	0.9	1.3
Primary energy consumption per capita (toe/person)	3.85	4.43	4.4881	4.53	4.59	4.63	4.55	4.4892	0.6	0.2	0.2	-0.3	0.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	152	150	122	111	105	101	95	89	-0.9	-1.9	-1.0	-1.2	-1.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	115	113	83	74	68	62	57	53	-1.3	-2.2	-1.7	-1.6	-1.8
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	74	71	52	44	39	35	32	29	-1.4	-3.3	-2.3	-1.9	-2.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.49	0.47	0.43	0.40	0.37	0.35	0.33	0.32	-0.5	-1.5	-1.3	-0.7	-1.1
Automobile ownership volume (millions of vehicles)	2	3	4	4	4	4	4	5	2.9	1.6	0.9	0.6	0.9
Automobile ownership volume per capita (vehicles per person)	0.538	0.672	0.799	0.827	0.836	0.838	0.840	0.842	1.6	0.7	0.1	0.0	0.2

New Zealand (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**12.8**	**17.1**	**20.6**	**22.2**	**23.0**	**23.5**	**23.4**	**23.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.9**	**1.4**	**0.6**	**-0.1**	**0.5**
Coal	1.2	1.1	1.4	0.8	0.7	0.7	0.7	0.6	9.2	6.5	6.6	3.5	3.1	2.9	2.8	2.6	0.6	-10.7	-1.1	-1.3	-3.2
Oil	3.5	5.7	6.8	6.8	6.6	6.2	5.7	5.2	27.4	33.4	32.8	30.8	28.8	26.5	24.5	22.4	2.7	0.2	-0.9	-1.8	-1.0
Natural gas	3.9	5.1	4.1	4.2	4.0	3.7	3.6	3.4	30.2	29.6	19.8	19.0	17.5	15.9	15.4	14.8	0.2	0.6	-1.1	-0.9	-0.7
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	2.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	15.5	12.3	10.2	9.3	9.1	9.1	9.3	9.4	0.2	-0.4	0.3	0.3	0.2
Geothermal	1.5	1.9	4.9	6.7	7.8	8.9	9.3	9.8	11.5	11.4	23.6	30.1	33.8	37.7	40.0	42.3	4.9	6.5	2.9	1.1	2.9
Others	0.8	1.2	1.4	1.6	1.7	1.8	1.9	2.0	6.2	6.9	6.9	7.3	7.6	7.8	8.1	8.5	2.3	2.6	1.2	0.7	1.3
Biomass	0.7	1.1	1.1	1.2	1.2	1.2	1.1	1.1	5.6	6.4	5.3	5.3	5.2	5.0	4.9	4.7	1.7	1.4	0.0	-0.7	0.0
Solar, Wind, Ocean	0.0	0.1	0.3	0.3	0.4	0.4	0.5	0.6	0.3	0.3	1.2	1.4	1.6	1.9	2.2	2.4	7.2	4.3	3.6	2.5	3.3
Biofuels	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.4	0.6	0.7	0.9	1.1	1.3	2.6	11.7	5.2	3.5	5.8
Electricity	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	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**9.7**	**12.9**	**14.1**	**14.5**	**14.4**	**14.1**	**13.7**	**13.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.5**	**-0.2**	**-0.7**	**-0.3**
Industry	3.6	4.3	4.3	4.5	4.5	4.4	4.3	4.1	37.0	32.9	30.8	31.2	31.2	31.3	31.5	31.5	0.8	0.7	-0.2	-0.6	-0.2
Transportation	3.0	4.1	4.8	4.9	4.7	4.5	4.2	3.9	30.4	31.4	34.2	33.6	32.8	31.8	30.5	29.3	2.0	0.2	-0.8	-1.5	-0.9
Others	2.5	3.0	3.5	3.7	3.8	3.8	3.8	3.7	26.2	23.0	24.9	25.4	26.0	26.7	27.5	28.3	1.3	0.9	0.3	-0.1	0.2
Non-energy	0.6	1.6	1.4	1.4	1.4	1.4	1.4	1.4	6.4	12.7	10.0	9.9	10.0	10.2	10.5	10.9	3.4	0.2	0.1	-0.1	0.0
Total	**9.7**	**12.9**	**14.1**	**14.5**	**14.4**	**14.1**	**13.7**	**13.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.5**	**0.5**	**-0.2**	**-0.7**	**-0.3**
Coal	0.7	0.5	0.6	0.6	0.6	0.6	0.5	0.5	6.9	4.0	4.3	4.3	4.2	4.2	4.0	3.8	-0.4	0.5	-0.6	-1.5	-0.7
Oil	4.0	5.3	6.2	6.3	6.1	5.7	5.2	4.7	41.4	41.0	44.1	43.3	42.1	40.4	38.2	35.9	1.8	0.2	-0.9	-1.9	-1.1
Natural gas	1.8	3.0	2.7	2.7	2.6	2.6	2.5	2.5	18.5	23.3	19.1	18.4	18.1	18.1	18.4	18.7	1.6	-0.2	-0.4	-0.4	-0.4
Electricity	2.4	2.9	3.4	3.6	3.8	4.0	4.1	4.2	25.0	22.8	23.9	25.1	26.4	28.0	29.9	31.9	1.3	1.5	0.9	0.6	0.9
Heat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.8	1.2	1.2	1.3	1.3	1.3	1.3	1.3	8.1	9.0	8.6	8.9	9.1	9.3	9.5	9.7	1.7	1.3	0.2	-0.3	0.2

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**32.3**	**39.2**	**44.2**	**47.6**	**50.0**	**51.7**	**53.4**	**54.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.3**	**1.5**	**0.8**	**0.6**	**0.9**
Coal	0.7	1.5	1.9	0.1	0.0	0.0	0.0	0.0	2.1	3.9	4.3	0.3	0.0	0.0	0.0	0.0	4.3	-40.9	-100.0	-	-100.0
Oil	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	0.0	0.0	-8.8	-1.2	-2.6	-1.7	-2.0
Natural gas	5.7	9.6	6.9	8.1	7.6	6.3	6.0	5.3	17.7	24.4	15.5	17.1	15.3	12.3	11.2	9.7	0.7	3.5	-2.5	-1.7	-1.0
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	23.2	24.4	24.5	24.1	24.4	24.8	25.2	25.5	71.9	62.3	55.5	50.6	48.9	47.9	47.1	46.6	0.2	-0.4	0.3	0.3	0.2
Geothermal	2.1	2.9	7.9	10.9	12.7	14.5	15.4	16.2	6.6	7.4	17.8	22.9	25.4	28.1	28.8	29.6	5.4	6.7	2.9	1.1	2.9
Others	0.6	0.8	3.1	4.3	5.2	6.1	6.9	7.7	1.8	2.0	6.9	9.1	10.4	11.8	12.9	14.0	7.0	7.2	3.4	2.4	3.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.4**	**2.3**	**1.7**	**1.4**	**1.2**	**1.0**	**0.9**	**0.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.7**	**-3.5**	**-3.1**	**-2.3**	**-2.9**
Coal	0.2	0.4	0.5	0.0	0.0	0.0	0.0	0.0	11.9	16.7	27.1	2.3	0.0	0.0	0.0	0.0	4.0	-40.9	-100.0	-	-100.0
Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-3.7	-3.3	-
Natural gas	1.2	1.9	1.2	1.4	1.2	1.0	0.9	0.8	87.7	83.3	72.9	97.6	100.0	100.0	100.0	100.0	-0.1	2.3	-2.9	-2.3	-1.6

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**38.8**	**42.0**	**45.2**	**51.1**	**52.9**	**53.7**	**55.6**	**57.2**									**0.6**	**2.5**	**0.5**	**0.6**	**0.9**
Coal	33.9	34.8	35.8	35.7	-	-	-	-									0.2	-0.1	-	-	-
Oil	14.1	-	-	25.6	27.0	28.5	31.2	33.5									-	-	1.1	1.6	-
Natural gas	39.6	43.4	48.7	51.4	52.9	53.7	55.6	57.2									0.8	1.1	0.4	0.6	0.6

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**6.2**	**8.1**	**8.8**	**8.3**	**7.9**	**7.4**	**6.8**	**6.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.4**	**-1.2**	**-1.1**	**-1.7**	**-1.4**
Coal	1.3	1.2	1.5	0.8	0.8	0.7	0.7	0.7	20.5	14.7	16.8	10.2	9.8	10.1	10.3	10.5	0.6	-10.7	-1.1	-1.3	-3.2
Oil	2.7	4.5	5.4	5.4	5.2	4.9	4.5	4.1	42.8	55.8	61.2	65.6	66.3	66.8	66.1	65.5	2.8	0.1	-0.9	-1.9	-1.1
Natural gas	2.3	2.4	1.9	2.0	1.9	1.7	1.6	1.5	36.7	29.4	21.9	24.3	23.9	23.1	23.6	24.0	-0.7	0.8	-1.6	-1.3	-1.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	85	114	169	196	219	238	258	276	2.8	3.0	2.0	1.5	2.0
Population (millions of people)	3	4	5	5	5	5	5	5	1.3	0.9	0.8	0.5	0.7
GDP per capita (thousands of 2010 US$/person)	25.42	29.60	36.80	40.76	43.7	45.9	48.2	50.4	1.5	2.1	1.2	0.9	1.3
Primary energy consumption per capita (toe/person)	3.85	4.43	4.49	4.60	4.59	4.53	4.37	4.24	0.6	0.5	-0.2	-0.6	-0.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	152	150	122	113	105	99	91	84	-0.9	-1.5	-1.4	-1.6	-1.5
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	115	113	83	74	66	59	53	48	-1.3	-2.4	-2.2	-2.1	-2.2
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	74	71	52	42	36	31	26	23	-1.4	-4.1	-3.0	-3.1	-3.3
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.49	0.47	0.43	0.37	0.34	0.31	0.29	0.27	-0.5	-2.7	-1.7	-1.6	-1.8
Automobile ownership volume (millions of vehicles)	2	3	4	4	4	4	4	5	2.9	1.6	0.9	0.6	0.9
Automobile ownership volume per capita (vehicles per person)	0.538	0.672	0.799	0.827	0.836	0.838	0.840	0.842	1.6	0.7	0.1	0.0	0.2

Philippines (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**25.95**	**37.42**	**47.49**	**59.09**	**74.03**	**86.64**	**100.49**	**115.81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**4.5**	**3.9**	**2.9**	**3.6**
Coal	0.73	4.11	11.11	14.50	20.88	26.19	31.52	36.45	2.8	11.0	23.4	24.5	28.2	30.2	31.4	31.5	11.5	5.5	6.1	3.4	4.9
Oil	10.92	15.73	16.55	20.34	23.75	27.68	32.56	38.82	42.1	42.0	34.8	34.4	32.1	31.9	32.4	33.5	1.7	4.2	3.1	3.4	3.5
Natural gas	-	0.01	3.00	2.92	3.92	5.42	7.01	9.49	0.0	0.0	6.3	4.9	5.3	6.3	7.0	8.2	-	-0.6	6.4	5.8	4.7
Nuclear	-	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.52	0.67	0.75	0.99	1.35	1.40	1.47	1.52	2.0	1.8	1.6	1.7	1.8	1.6	1.5	1.3	1.4	5.8	3.6	0.8	2.9
Geothermal	4.70	10.00	9.50	11.85	14.69	16.14	17.38	18.36	18.1	26.7	20.0	20.1	19.8	18.6	17.3	15.9	2.9	4.5	3.1	1.3	2.7
Others	9.08	6.90	6.59	8.48	9.43	9.81	10.54	11.17	35.0	18.4	13.9	14.4	12.7	11.3	10.5	9.6	-1.3	5.2	1.5	1.3	2.1
Biomass	9.07	6.89	6.07	7.63	8.43	8.73	9.35	9.87	34.9	18.4	12.8	12.9	11.4	10.1	9.3	8.5	-1.6	4.7	1.4	1.2	2.0
Solar, Wind, Ocean	-	-	0.08	0.30	0.40	0.42	0.45	0.47	0.0	0.0	0.2	0.5	0.5	0.5	0.4	0.4	-	31.9	3.3	1.1	7.5
Biofuels	0.01	0.01	0.45	0.55	0.60	0.66	0.74	0.84	0.0	0.0	0.9	0.9	0.8	0.8	0.7	0.7	15.8	4.2	1.8	2.5	2.5
Electricity	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**19.65**	**23.92**	**29.62**	**37.60**	**45.71**	**53.58**	**63.00**	**74.23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.7**	**4.9**	**3.6**	**3.3**	**3.7**
Industry	4.66	5.35	7.43	9.80	12.46	15.61	19.38	24.10	23.7	22.4	25.1	26.1	27.3	29.1	30.8	32.5	1.9	5.7	4.8	4.4	4.8
Transportation	4.52	8.10	10.61	12.68	14.33	16.53	19.37	22.95	23.0	33.9	35.8	33.7	31.4	30.9	30.7	30.9	3.5	3.6	2.7	3.3	3.1
Others	10.25	10.19	10.53	13.93	17.57	19.90	22.50	25.20	52.1	42.6	35.6	37.0	38.4	37.1	35.7	33.9	0.1	5.8	3.6	2.4	3.6
Non-energy	0.23	0.27	1.05	1.19	1.35	1.54	1.75	1.99	1.2	1.1	3.5	3.2	3.0	2.9	2.8	2.7	6.3	2.6	2.6	2.6	2.6
Total	**19.65**	**23.92**	**29.62**	**37.60**	**45.71**	**53.58**	**63.00**	**74.23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.7**	**4.9**	**3.6**	**3.3**	**3.7**
Coal	0.61	0.77	2.29	3.20	4.44	5.95	7.71	9.9	3.1	3.2	7.7	8.5	9.7	11.1	12.2	13.3	5.4	6.9	6.4	5.2	6.0
Oil	7.92	13.01	15.01	19.01	22.12	26.00	30.85	36.9	40.3	54.4	50.7	50.5	48.4	48.5	49.0	49.7	2.6	4.8	3.2	3.6	3.7
Natural gas	-	0.00	0.05	0.09	0.15	0.26	0.44	0.8	0.0	0.0	0.2	0.2	0.3	0.5	0.7	1.0	-	11.8	11.4	11.5	11.5
Electricity	1.82	3.14	5.83	7.71	10.54	12.63	14.68	16.8	9.3	13.1	19.7	20.5	23.0	23.6	23.3	22.7	4.8	5.7	5.1	2.9	4.3
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.30	7.00	6.44	7.60	8.46	8.73	9.32	9.8	47.3	29.3	21.7	20.2	18.5	16.3	14.8	13.3	-1.5	3.4	1.4	1.2	1.7

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**25.84**	**45.25**	**82.41**	**98.50**	**134.65**	**161.47**	**187.57**	**215.33**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.7**	**3.6**	**5.1**	**2.9**	**3.9**
Coal	1.93	16.66	36.69	44.71	65.02	80.03	94.15	105.0	7.5	36.8	44.5	45.4	48.3	49.6	50.2	48.7	12.5	4.0	6.0	2.7	4.3
Oil	12.38	9.14	5.86	5.04	6.17	6.34	6.46	7.4	47.9	20.2	7.1	5.1	4.6	3.9	3.4	3.4	-2.9	-3.0	2.3	1.5	0.9
Natural gas	-	0.02	18.88	18.09	24.14	32.99	42.01	55.8	0.0	0.0	22.9	18.4	17.9	20.4	22.4	25.9	-	-0.9	6.2	5.4	4.4
Nuclear	-	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	6.06	7.80	8.67	11.51	15.74	16.32	17.05	17.6	23.5	17.2	10.5	11.7	11.7	10.1	9.1	8.2	1.4	5.8	3.6	0.8	2.9
Geothermal	5.47	11.63	11.04	13.79	17.08	18.77	20.21	21.4	21.2	25.7	13.4	14.0	12.7	11.6	10.8	9.9	2.9	4.5	3.1	1.3	2.7
Others	0.00	0.00	1.28	5.36	6.49	7.02	7.67	8.2	0.0	0.0	1.6	5.4	4.8	4.3	4.1	3.8	-	33.2	2.7	1.6	7.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3.10**	**5.89**	**13.62**	**15.37**	**21.73**	**26.95**	**31.97**	**37.08**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.1**	**2.4**	**5.8**	**3.2**	**4.1**
Coal	0.56	3.78	9.26	11.31	16.44	20.24	23.81	26.5	18.0	64.3	68.0	73.6	75.7	75.1	74.5	71.6	11.9	4.1	6.0	2.7	4.3
Oil	2.54	2.10	1.41	1.24	1.52	1.56	1.59	1.8	82.0	35.6	10.3	8.1	7.0	5.8	5.0	4.9	-2.3	-2.5	2.3	1.5	1.0
Natural gas	-	0.01	2.95	2.83	3.77	5.16	6.57	8.7	0.0	0.1	21.7	18.4	17.4	19.1	20.5	23.5	-	-0.9	6.2	5.4	4.4

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**39.7**	**37.7**	**38.8**	**37.9**	**37.7**	**38.1**	**38.4**	**39.0**									**-0.1**	**-0.4**	**0.0**	**0.2**	**0.0**
Coal	29.8	37.9	34.1	34.0	34.0	34.0	34.0	34.0									0.5	0.0	0.0	0.0	0.0
Oil	41.9	37.5	35.8	35.0	35.0	35.0	35.0	35.0									-0.6	-0.5	0.0	0.0	-0.1
Natural gas	-	16.6	55.0	55.0	55.0	55.0	55.0	55.0									-	0.0	0.0	0.0	0.0

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**28.7**	**57.0**	**95.1**	**118.1**	**154.7**	**190.3**	**229.0**	**271.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.9**	**4.4**	**4.9**	**3.6**	**4.3**
Coal	4.4	18.0	45.9	57.6	82.9	104.0	125.1	144.6	15.3	31.5	48.3	48.8	53.6	54.6	54.6	53.2	9.8	4.6	6.1	3.4	4.7
Oil	24.3	39.0	42.2	53.6	62.5	73.6	87.5	104.8	84.7	68.4	44.3	45.4	40.4	38.7	38.2	38.6	2.2	4.9	3.2	3.6	3.7
Natural gas	-	0.0	7.0	6.8	9.2	12.7	16.5	22.3	0.0	0.0	7.4	5.8	6.0	6.7	7.2	8.2	-	-0.6	6.4	5.8	4.7

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	94.5	125.3	266.1	368.0	504.1	674.6	881.7	1,146.9	4.2	6.7	6.2	5.4	6.0
Population (millions of people)	61.9	78.0	101.7	109.6	118.0	127.2	137.0	147.6	2.0	1.5	1.5	1.5	1.5
GDP per capita (thousands of 2010 US$/person)	1.5	1.6	2.6	3.36	4.3	5.3	6.4	7.8	2.2	5.1	4.7	3.9	4.5
Primary energy consumption per capita (toe/person)	0.4	0.5	0.5	0.54	0.63	0.68	0.73	0.78	0.4	2.9	2.4	1.4	2.1
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	275	299	178	161	147	128	114	101	-1.7	-2.1	-2.2	-2.4	-2.3
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	208	191	111	102	91	79	71	65	-2.5	-1.7	-2.5	-2.0	-2.1
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	304	455	358	321	307	282	260	237	0.7	-2.1	-1.3	-1.7	-1.6
CO2 emissions per unit of primary energy consumption (t-C/toe)	1.1	1.5	2.0	2.00	2.09	2.20	2.28	2.35	2.4	0.0	0.9	0.7	0.6
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Philippines (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**25.95**	**37.42**	**47.49**	**54.11**	**60.10**	**71.16**	**83.44**	**95.05**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.4**	**2.6**	**2.8**	**2.9**	**2.8**
Coal	0.73	4.11	11.11	11.74	12.03	16.58	21.78	24.17	2.8	11.0	23.4	21.7	20.0	23.3	26.1	25.4	11.5	1.1	3.5	3.8	3.2
Oil	10.92	15.73	16.55	18.45	17.87	21.73	26.64	31.63	42.1	42.0	34.8	34.1	29.7	30.5	31.9	33.3	1.7	2.2	1.6	3.8	2.6
Natural gas	-	0.01	3.00	2.04	2.13	3.00	4.20	4.90	0.0	0.0	6.3	3.8	3.5	4.2	5.0	5.2	-	-7.4	3.9	5.0	2.0
Nuclear	-	-	-	0.00	0.42	1.12	1.49	3.76	0.0	0.0	0.0	0.0	0.7	1.6	1.8	4.0	-	-	106.4	12.8	-
Hydro	0.52	0.67	0.75	0.96	1.33	1.33	1.33	2.08	2.0	1.8	1.6	1.8	2.2	1.9	1.6	2.2	1.4	5.3	3.3	4.6	4.2
Geothermal	4.70	10.00	9.50	12.24	16.37	17.11	17.14	17.14	18.1	26.7	20.0	22.6	27.2	24.0	20.5	18.0	2.9	5.2	3.4	0.0	2.4
Others	9.08	6.90	6.59	8.67	9.95	10.28	10.87	11.38	35.0	18.4	13.9	16.0	16.6	14.5	13.0	12.0	-1.3	5.6	1.7	1.0	2.2
Biomass	9.07	6.89	6.07	7.45	8.27	8.48	8.97	9.39	34.9	18.4	12.8	13.8	13.8	11.9	10.8	9.9	-1.6	4.2	1.3	1.0	1.8
Solar, Wind, Ocean	-	-	0.08	0.63	1.13	1.18	1.18	1.18	0.0	0.0	0.2	1.2	1.9	1.7	1.4	1.2	-	52.7	6.4	0.0	11.6
Biofuels	0.01	0.01	0.45	0.59	0.55	0.62	0.71	0.81	0.0	0.0	0.9	1.1	0.9	0.9	0.9	0.9	15.8	5.8	0.5	2.7	2.4
Electricity	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**19.65**	**23.92**	**29.62**	**35.08**	**37.82**	**45.18**	**54.20**	**63.83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.7**	**3.4**	**2.6**	**3.5**	**3.1**
Industry	4.66	5.35	7.43	9.34	11.04	14.05	17.71	22.05	23.7	22.4	25.1	26.6	29.2	31.1	32.7	34.5	1.9	4.7	4.2	4.6	4.4
Transportation	4.52	8.10	10.61	11.50	10.85	12.92	15.61	18.48	23.0	33.9	35.8	32.8	28.7	28.6	28.8	29.0	3.5	1.6	1.2	3.6	2.2
Others	10.25	10.19	10.53	13.05	14.58	16.66	19.14	21.31	52.1	42.6	35.6	37.2	38.6	36.9	35.3	33.4	0.1	4.4	2.5	2.5	2.9
Non-energy	0.23	0.27	1.05	1.19	1.35	1.54	1.75	1.99	1.2	1.1	3.5	3.4	3.6	3.4	3.2	3.1	6.3	2.6	2.6	2.6	2.6
Total	**19.65**	**23.92**	**29.62**	**35.08**	**37.82**	**45.18**	**54.20**	**63.83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.7**	**3.4**	**2.6**	**3.5**	**3.1**
Coal	0.61	0.77	2.29	3.20	4.44	5.95	7.71	9.9	3.1	3.2	7.7	9.1	11.7	13.2	14.2	15.5	5.4	6.9	6.4	5.2	6.0
Oil	7.92	13.01	15.01	17.22	16.91	20.48	25.01	29.9	40.3	54.4	50.7	49.1	44.7	45.3	46.1	46.8	2.6	2.8	1.7	3.8	2.8
Natural gas	-	0.00	0.05	0.09	0.15	0.26	0.44	0.8	0.0	0.0	0.2	0.2	0.4	0.6	0.8	1.2	-	11.8	11.4	11.5	11.5
Electricity	1.82	3.14	5.83	6.94	7.90	9.79	11.74	13.5	9.3	13.1	19.7	19.8	20.9	21.7	21.7	21.1	4.8	3.5	3.5	3.2	3.4
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.30	7.00	6.44	7.65	8.42	8.70	9.30	9.8	47.3	29.3	21.7	21.8	22.3	19.3	17.2	15.4	-1.5	3.5	1.3	1.2	1.7

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**25.84**	**45.25**	**82.41**	**88.65**	**100.98**	**125.14**	**150.05**	**172.26**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.7**	**1.5**	**3.5**	**3.2**	**3.0**
Coal	1.93	16.66	36.69	35.75	32.51	45.90	60.71	62.2	7.5	36.8	44.5	40.3	32.2	36.7	40.5	36.1	12.5	-0.5	2.5	3.1	2.1
Oil	12.38	9.14	5.86	4.64	3.47	4.63	6.13	6.6	47.9	20.2	7.1	5.2	3.4	3.7	4.1	3.8	-2.9	-4.6	0.0	3.6	0.5
Natural gas	-	0.02	18.88	13.64	13.93	19.29	26.46	29.3	0.0	0.0	22.9	15.4	13.8	15.4	17.6	17.0	-	-6.3	3.5	4.3	1.8
Nuclear	-	-	-	-	1.61	4.31	5.70	14.4	0.0	0.0	0.0	0.0	1.6	3.4	3.8	8.4	-	-	-	12.8	-
Hydro	6.06	7.80	8.67	11.22	15.45	15.45	15.45	24.2	23.5	17.2	10.5	12.7	15.3	12.3	10.3	14.0	1.4	5.3	3.3	4.6	4.2
Geothermal	5.47	11.63	11.04	14.24	19.04	19.90	19.93	19.9	21.2	25.7	13.4	16.1	18.9	15.9	13.3	11.6	2.9	5.2	3.4	0.0	2.4
Others	0.00	0.00	1.28	9.15	14.97	15.65	15.67	15.7	0.0	0.0	1.6	10.3	14.8	12.5	10.4	9.1	-	48.2	5.5	0.0	10.5

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3.10**	**5.89**	**13.62**	**11.63**	**10.42**	**14.51**	**19.33**	**20.02**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.1**	**-3.1**	**2.2**	**3.3**	**1.6**
Coal	0.56	3.78	9.26	8.54	7.59	10.63	14.07	14.3	18.0	64.3	68.0	73.4	72.8	73.3	72.8	71.2	11.9	-1.6	2.2	3.0	1.7
Oil	2.54	2.10	1.41	1.14	0.85	1.14	1.51	1.6	82.0	35.6	10.3	9.8	8.2	7.8	7.8	8.1	-2.3	-4.1	0.0	3.6	0.6
Natural gas	-	0.01	2.95	1.96	1.98	2.74	3.75	4.1	0.0	0.1	21.7	16.8	19.0	18.9	19.4	20.7	-	-7.9	3.4	4.2	1.4

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**39.7**	**37.7**	**38.8**	**39.9**	**41.2**	**41.4**	**41.5**	**42.1**									**-0.1**	**0.6**	**0.4**	**0.2**	**0.3**
Coal	29.8	37.9	34.1	36.0	36.8	37.1	37.1	37.5									0.5	1.1	0.3	0.1	0.4
Oil	41.9	37.5	35.8	35.0	35.0	35.0	35.0	35.0									-0.6	-0.5	0.0	0.0	-0.1
Natural gas	-	16.6	55.0	60.0	60.5	60.6	60.6	60.8									-	1.8	0.1	0.0	0.4

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**28.7**	**57.0**	**95.1**	**99.6**	**99.6**	**130.0**	**166.4**	**191.3**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.9**	**0.9**	**2.7**	**3.9**	**2.8**
Coal	4.4	18.0	45.9	46.5	47.8	65.9	86.6	96.0	15.3	31.5	48.3	46.7	47.9	50.7	52.0	50.2	9.8	0.3	3.5	3.8	3.0
Oil	24.3	39.0	42.2	48.3	46.9	57.0	70.0	83.8	84.7	68.4	44.3	48.5	47.1	43.9	42.1	43.8	2.2	2.7	1.7	3.9	2.8
Natural gas	-	0.0	7.0	4.8	5.0	7.0	9.9	11.5	0.0	0.0	7.4	4.8	5.0	5.4	5.9	6.0	-	-7.4	3.9	5.0	2.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	94.5	125.3	266.1	368.0	504.1	674.6	881.7	1,146.9	4.2	6.7	6.2	5.4	6.0
Population (millions of people)	61.9	78.0	101.7	109.6	118.0	127.2	137.0	147.6	2.0	1.5	1.5	1.5	1.5
GDP per capita (thousands of 2010 US$/person)	1.5	1.6	2.6	3.36	4.3	5.3	6.4	7.8	2.2	5.1	4.7	3.9	4.5
Primary energy consumption per capita (toe/person)	0.4	0.5	0.5	0.49	0.51	0.56	0.61	0.64	0.4	1.1	1.3	1.4	1.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	275	299	178	147	119	105	95	83	-1.7	-3.8	-3.3	-2.4	-3.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	208	191	111	95	75	67	61	56	-2.5	-3.0	-3.5	-1.8	-2.7
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	304	455	358	271	198	193	189	167	0.7	-5.4	-3.3	-1.4	-3.0
CO2 emissions per unit of primary energy consumption (t-C/toe)	1.1	1.5	2.0	1.84	1.66	1.83	1.99	2.01	2.4	-1.7	-0.1	1.0	0.0
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Singapore (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**11.53**	**18.67**	**34.31**	**47.76**	**50.60**	**53.11**	**55.55**	**56.61**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.5**	**6.8**	**1.1**	**0.6**	**2.0**
Coal	0.02	0.00	0.27	0.29	0.31	0.33	0.35	0.36	0.2	0.0	0.8	0.6	0.6	0.6	0.6	0.6	10.6	1.5	1.3	0.8	1.1
Oil	11.44	17.35	23.81	35.33	36.41	37.42	38.57	39.18	99.2	92.9	69.4	74.0	72.0	70.5	69.4	69.2	3.0	8.2	0.6	0.5	2.0
Natural gas	0.00	1.12	9.84	11.65	13.26	14.63	15.78	16.12	0.0	6.0	28.7	24.4	26.2	27.5	28.4	28.5	-	3.4	2.3	1.0	2.0
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.07	0.20	0.39	0.49	0.61	0.73	0.85	0.95	0.6	1.1	1.1	1.0	1.2	1.4	1.5	1.7	7.1	4.9	4.0	2.7	3.7
Biomass	0.07	0.20	0.37	0.43	0.48	0.53	0.57	0.60	0.6	1.1	1.1	0.9	1.0	1.0	1.0	1.1	6.9	2.9	2.2	1.2	2.0
Solar, Wind, Ocean	0.00	0.00	0.02	0.07	0.13	0.20	0.28	0.35	0.0	0.0	0.1	0.1	0.3	0.4	0.5	0.6	-	30.6	11.5	6.0	12.8
Biofuels	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.01**	**8.31**	**25.66**	**38.54**	**40.83**	**42.93**	**45.06**	**45.88**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.8**	**8.5**	**1.1**	**0.7**	**2.4**
Industry	0.61	2.18	7.11	9.48	11.33	13.03	14.81	15.29	12.1	26.3	27.7	24.6	27.7	30.4	32.9	33.3	10.4	5.9	3.2	1.6	3.1
Transportation	1.36	1.75	2.99	3.09	3.25	3.44	3.66	3.89	27.1	21.1	11.6	8.0	8.0	8.0	8.1	8.5	3.2	0.7	1.1	1.2	1.1
Others	1.13	1.65	2.47	2.79	3.06	3.24	3.36	3.46	22.6	19.9	9.6	7.2	7.5	7.6	7.5	7.5	3.2	2.5	1.5	0.6	1.4
Non-energy	1.91	2.72	13.10	23.18	23.20	23.22	23.23	23.24	38.2	32.8	51.0	60.1	56.8	54.1	51.6	50.7	8.0	12.1	0.0	0.0	2.3
Total	**5.01**	**8.31**	**25.66**	**38.54**	**40.83**	**42.93**	**45.06**	**45.88**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.8**	**8.5**	**1.1**	**0.7**	**2.4**
Coal	0.02	0.00	0.13	0.13	0.13	0.13	0.13	0.13	0.4	0.0	0.5	0.3	0.3	0.3	0.3	0.3	7.5	0.0	0.0	0.0	0.0
Oil	3.81	5.86	19.84	31.37	32.45	33.48	34.64	35.27	76.1	70.5	77.3	81.4	79.5	78.0	76.9	76.9	6.8	9.6	0.7	0.5	2.3
Natural gas	0.06	0.11	1.51	2.23	2.80	3.32	3.80	3.71	1.2	1.3	5.9	5.8	6.8	7.7	8.4	8.1	13.6	8.1	4.1	1.1	3.7
Electricity	1.12	2.35	4.18	4.82	5.45	6.01	6.49	6.77	22.3	28.3	16.3	12.5	13.4	14.0	14.4	14.8	5.4	2.9	2.2	1.2	1.9
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**15.71**	**31.67**	**50.91**	**58.66**	**66.41**	**73.12**	**79.06**	**82.48**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.8**	**2.9**	**2.2**	**1.2**	**1.9**
Coal	0.00	0.00	0.42	0.48	0.54	0.60	0.64	0.67	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	-	2.9	2.2	1.2	1.9
Oil	15.54	25.32	0.56	0.56	0.53	0.48	0.40	0.29	98.9	80.0	1.1	1.0	0.8	0.7	0.5	0.4	-12.4	-0.1	-1.6	-4.9	-2.6
Natural gas	0.00	5.86	48.29	55.19	61.97	67.66	72.46	75.06	0.0	18.5	94.8	94.1	93.3	92.5	91.7	91.0	-	2.7	2.1	1.0	1.8
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.17	0.49	1.64	2.44	3.37	4.38	5.56	6.46	1.1	1.5	3.2	4.2	5.1	6.0	7.0	7.8	9.5	8.2	6.0	4.0	5.6

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**4.42**	**7.72**	**8.60**	**9.70**	**10.76**	**11.61**	**12.28**	**12.70**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.7**	**2.5**	**1.8**	**0.9**	**1.6**
Coal	0.00	0.00	0.14	0.16	0.19	0.20	0.22	0.23	0.0	0.0	1.7	1.7	1.7	1.8	1.8	1.8	-	2.9	2.2	1.2	1.9
Oil	4.42	6.60	0.12	0.12	0.11	0.10	0.08	0.06	100.0	85.5	1.4	1.2	1.0	0.9	0.7	0.5	-13.4	-0.3	-1.7	-4.9	-2.7
Natural gas	0.00	1.12	8.33	9.42	10.47	11.31	11.98	12.41	0.0	14.5	97.0	97.1	97.2	97.4	97.5	97.7	-	2.5	1.8	0.9	1.6

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**30.3**	**34.8**	**49.3**	**49.8**	**50.4**	**50.9**	**51.5**	**51.5**									**2.0**	**0.2**	**0.2**	**0.1**	**0.2**
Coal	-	-	25.1	25.1	25.0	25.1	25.1	25.1									-	-0.1	0.0	0.0	0.0
Oil	30.3	33.0	40.4	40.9	41.1	41.5	42.1	41.5									1.2	0.2	0.2	0.0	0.1
Natural gas	-	45.0	49.8	50.4	50.9	51.5	52.0	52.0									-	0.2	0.2	0.1	0.2

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.7**	**8.8**	**15.5**	**19.4**	**21.1**	**22.5**	**23.8**	**24.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.1**	**4.6**	**1.5**	**0.7**	**1.8**
Coal	0.1	0.0							1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-	-	-
Oil	5.6	8.0	9.2	12.0	12.6	13.1	13.7	13.7	98.8	90.4	59.4	61.6	59.7	58.3	57.4	57.1	2.0	5.3	0.9	0.5	1.6
Natural gas	0.0	0.9	6.3	7.5	8.5	9.4	10.1	10.3	0.0	9.6	40.6	38.4	40.3	41.7	42.6	42.9	-	3.4	2.3	1.0	2.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	50.4	100.4	212.9	248.7	288.7	326.7	364.6	402.5	5.9	3.2	2.8	2.1	2.6
Population (millions of people)	3.0	4.0	5.5	5.8	6.1	6.3	6.4	6.6	2.4	1.0	0.8	0.5	0.7
GDP per capita (thousands of 2010 US$/person)	16.55	24.92	38.58	42.8	47.6	52.1	56.6	60.9	3.4	2.1	2.0	1.6	1.8
Primary energy consumption per capita (toe/person)	3.78	4.63	6.22	8.23	8.35	8.47	8.62	8.56	2.0	5.8	0.3	0.1	1.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	229	186	161	192	175	163	152	141	-1.4	3.6	-1.7	-1.4	-0.5
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	99	83	121	155	141	131	124	114	0.8	5.2	-1.6	-1.4	-0.2
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	112	88	73	78	73	69	65	60	-1.7	1.4	-1.2	-1.4	-0.8
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.49	0.47	0.45	0.41	0.42	0.42	0.43	0.43	-0.3	-2.1	0.4	0.0	-0.2
Automobile ownership volume (millions of vehicles)			0.84	0.85	0.86	0.87	0.88	0.89	-	-	0.25	0.25	-
Automobile ownership volume per capita (vehicles per person)	-	-	0.151	0.146	0.141	0.138	0.136	0.134	-	-	-0.52	-0.28	-

Singapore (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**11.53**	**18.67**	**34.12**	**47.03**	**49.21**	**51.03**	**52.73**	**53.68**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.4**	**6.6**	**0.8**	**0.5**	**1.8**
Coal	0.02	0.00	0.27	0.29	0.31	0.33	0.34	0.35	0.2	0.0	0.8	0.6	0.6	0.6	0.6	0.7	10.6	1.4	1.2	0.7	1.0
Oil	11.44	17.35	23.78	35.23	36.22	37.13	38.16	38.76	99.2	92.9	69.7	74.9	73.6	72.8	72.4	72.2	3.0	8.2	0.5	0.4	2.0
Natural gas	0.00	1.12	9.68	10.98	12.01	12.76	13.28	13.48	0.0	6.0	28.4	23.3	24.4	25.0	25.2	25.1	-	2.6	1.5	0.5	1.3
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.07	0.20	0.40	0.52	0.67	0.81	0.95	1.09	0.6	1.1	1.2	1.1	1.4	1.6	1.8	2.0	7.2	5.8	4.5	3.0	4.1
Biomass	0.07	0.20	0.37	0.42	0.47	0.50	0.53	0.55	0.6	1.1	1.1	0.9	0.9	1.0	1.0	1.0	6.9	2.6	1.8	0.9	1.6
Solar, Wind, Ocean	0.00	0.00	0.03	0.10	0.20	0.31	0.42	0.54	0.0	0.0	0.1	0.2	0.4	0.6	0.8	1.0	-	30.9	11.4	5.9	12.7
Biofuels	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Electricity	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.01**	**8.31**	**25.62**	**38.36**	**40.46**	**42.33**	**44.18**	**45.00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.7**	**8.4**	**1.0**	**0.6**	**2.3**
Industry	0.61	2.18	7.08	9.33	11.02	12.54	14.09	14.57	12.1	26.3	27.6	24.3	27.2	29.6	31.9	32.4	10.3	5.7	3.0	1.5	2.9
Transportation	1.36	1.75	2.99	3.09	3.24	3.42	3.63	3.86	27.1	21.1	11.7	8.0	8.0	8.1	8.2	8.6	3.2	0.7	1.0	1.2	1.0
Others	1.13	1.65	2.46	2.76	3.00	3.15	3.23	3.33	22.6	19.9	9.6	7.2	7.4	7.5	7.3	7.4	3.2	2.3	1.4	0.5	1.2
Non-energy	1.91	2.72	13.09	23.18	23.20	23.22	23.23	23.24	38.2	32.8	51.1	60.4	57.3	54.8	52.6	51.7	8.0	12.1	0.0	0.0	2.3
Total	**5.01**	**8.31**	**25.62**	**38.36**	**40.46**	**42.33**	**44.18**	**45.00**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**6.7**	**8.4**	**1.0**	**0.6**	**2.3**
Coal	0.02	0.00	0.13	0.13	0.13	0.13	0.13	0.13	0.4	0.0	0.5	0.3	0.3	0.3	0.3	0.3	7.5	0.0	0.0	0.0	0.0
Oil	3.81	5.86	19.82	31.28	32.28	33.20	34.24	34.86	76.1	70.5	77.4	81.6	79.8	78.4	77.5	77.5	6.8	9.6	0.6	0.5	2.3
Natural gas	0.06	0.11	1.50	2.19	2.72	3.19	3.61	3.52	1.2	1.3	5.9	5.7	6.7	7.5	8.2	7.8	13.6	7.8	3.8	1.0	3.5
Electricity	1.12	2.35	4.17	4.75	5.33	5.81	6.20	6.48	22.3	28.3	16.3	12.4	13.2	13.7	14.0	14.4	5.4	2.7	2.0	1.1	1.8
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**15.71**	**31.67**	**50.73**	**57.90**	**64.89**	**70.70**	**75.54**	**78.95**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.8**	**2.7**	**2.0**	**1.1**	**1.8**
Coal	0.00	0.00	0.41	0.47	0.53	0.58	0.62	0.64	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	-	2.7	2.0	1.1	1.8
Oil	15.54	25.32	0.51	0.50	0.48	0.43	0.36	0.28	98.9	80.0	1.0	0.9	0.7	0.6	0.5	0.4	-12.8	-0.1	-1.5	-4.3	-2.4
Natural gas	0.00	5.86	48.06	54.07	59.73	64.13	67.49	69.47	0.0	18.5	94.7	93.4	92.0	90.7	89.3	88.0	-	2.4	1.7	0.8	1.5
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.17	0.49	1.75	2.86	4.16	5.56	7.07	8.55	1.1	1.5	3.5	4.9	6.4	7.9	9.4	10.8	9.8	10.2	6.9	4.4	6.5

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**4.42**	**7.72**	**8.42**	**9.05**	**9.57**	**9.85**	**9.95**	**10.23**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.6**	**1.4**	**0.8**	**0.4**	**0.8**
Coal	0.00	0.00	0.14	0.16	0.18	0.20	0.21	0.22	0.0	0.0	1.7	1.8	1.9	2.0	2.1	2.2	-	2.7	2.0	1.1	1.8
Oil	4.42	6.60	0.11	0.10	0.10	0.08	0.07	0.05	100.0	85.5	1.3	1.1	1.0	0.9	0.7	0.5	-13.8	-0.7	-2.0	-4.6	-2.8
Natural gas	0.00	1.12	8.17	8.79	9.29	9.57	9.67	9.96	0.0	14.5	97.0	97.1	97.1	97.1	97.2	97.3	-	1.5	0.9	0.4	0.8

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**30.3**	**34.8**	**50.0**	**52.3**	**54.6**	**56.9**	**59.2**	**59.2**									**2.0**	**0.9**	**0.8**	**0.4**	**0.7**
Coal	-	-	25.1	25.1	25.1	25.1	25.1	25.1									-	0.0	0.0	0.0	0.0
Oil	30.3	33.0	40.6	41.7	42.8	43.9	45.0	45.0									1.2	0.5	0.5	0.2	0.4
Natural gas	-	45.0	50.6	52.9	55.3	57.6	60.0	60.0									-	0.9	0.9	0.4	0.7

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**5.7**	**8.8**	**15.4**	**18.9**	**20.2**	**21.1**	**21.9**	**22.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.1**	**4.2**	**1.1**	**0.5**	**1.5**
Coal	0.1	0.0							1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-	-	-	-
Oil	5.6	8.0	9.2	11.9	12.5	12.9	13.4	13.5	98.8	90.4	59.7	62.8	61.8	61.2	61.1	60.9	2.0	5.2	0.8	0.4	1.5
Natural gas	0.0	0.9	6.2	7.0	7.7	8.2	8.5	8.6	0.0	9.6	40.3	37.2	38.2	38.8	38.9	39.1	-	2.6	1.5	0.5	1.3

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	50.4	100.4	212.9	248.7	288.7	326.7	364.6	402.5	5.9	3.2	2.8	2.1	2.6
Population (millions of people)	3.0	4.0	5.5	5.8	6.1	6.3	6.4	6.6	2.4	1.0	0.8	0.5	0.7
GDP per capita (thousands of 2010 US$/person)	16.55	24.92	38.58	42.8	47.6	52.1	56.6	60.9	3.4	2.1	2.0	1.6	1.8
Primary energy consumption per capita (toe/person)	3.78	4.63	6.18	8.10	8.12	8.13	8.19	8.12	2.0	5.5	0.0	0.0	1.1
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	229	186	160	189	170	156	145	133	-1.4	3.4	-1.9	-1.6	-0.7
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	99	83	120	154	140	130	121	112	0.8	5.1	-1.7	-1.5	-0.3
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	112	88	72	76	70	65	60	55	-1.7	1.0	-1.6	-1.6	-1.1
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.49	0.47	0.45	0.40	0.41	0.41	0.41	0.41	-0.3	-2.3	0.3	0.0	-0.4
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Thailand (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**42.63**	**72.27**	**134.97**	**151.42**	**171.76**	**191.92**	**217.11**	**250.81**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.7**	**2.3**	**2.4**	**2.7**	**2.5**
Coal	3.82	7.67	16.82	17.81	20.36	22.53	26.65	33.40	9.0	10.6	12.5	11.8	11.9	11.7	12.3	13.3	6.1	1.2	2.4	4.0	2.8
Oil	17.96	31.88	52.27	60.46	71.06	82.42	95.05	109.13	42.1	44.1	38.7	39.9	41.4	42.9	43.8	43.5	4.4	3.0	3.1	2.8	3.0
Natural gas	4.99	17.36	37.92	41.18	42.60	43.27	45.08	53.43	11.7	24.0	28.1	27.2	24.8	22.5	20.8	21.3	8.4	1.7	0.5	2.1	1.4
Nuclear									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.43	0.52	0.49	0.89	1.04	1.14	1.23	1.26	1.0	0.7	0.4	0.6	0.6	0.6	0.6	0.5	0.6	12.4	2.5	1.0	3.8
Geothermal									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	15.43	14.83	27.47	31.08	36.70	42.55	49.10	53.59	36.2	20.5	20.4	20.5	21.4	22.2	22.6	21.4	2.3	2.5	3.2	2.3	2.7
Biomass	14.69	14.59	23.27	25.79	29.70	32.97	36.60	40.39	34.4	20.2	17.2	17.0	17.3	17.2	16.9	16.1	1.9	2.1	2.5	2.0	2.2
Solar, Wind, Ocean			0.31	1.05	1.90	2.31	2.66	2.80	0.0	0.0	0.2	0.7	1.1	1.2	1.2	1.1	-	27.3	8.2	1.9	9.1
Biofuels			1.53	1.59	1.74	1.94	2.18	2.50	0.0	0.0	1.1	1.1	1.0	1.0	1.0	1.0	-	0.8	2.0	2.6	2.0
Electricity	0.05	0.24	2.35	2.65	3.35	5.32	7.65	7.90	0.1	0.3	1.7	1.7	2.0	2.8	3.5	3.1	16.4	2.4	7.2	4.0	5.0

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**28.87**	**50.57**	**98.04**	**113.33**	**132.00**	**152.16**	**174.02**	**198.30**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**2.9**	**3.0**	**2.7**	**2.9**
Industry	8.65	16.72	30.61	35.79	42.45	49.90	58.17	67.56	30.0	33.1	31.2	31.6	32.2	32.8	33.4	34.1	5.2	3.2	3.4	3.1	3.2
Transportation	9.01	14.61	23.72	25.88	29.42	33.71	38.78	44.92	31.2	28.9	24.2	22.8	22.3	22.2	22.3	22.7	3.9	1.8	2.7	2.9	2.6
Others	10.78	13.62	21.10	23.42	25.96	28.55	31.25	34.20	37.3	26.9	21.5	20.7	19.7	18.8	18.0	17.2	2.7	2.1	2.0	1.8	2.0
Non-energy	0.43	5.63	22.62	28.25	34.17	40.01	45.82	51.63	1.5	11.1	23.1	24.9	25.9	26.3	26.3	26.0	17.2	4.5	3.5	2.6	3.4
Total	**28.87**	**50.57**	**98.04**	**113.33**	**132.00**	**152.16**	**174.02**	**198.30**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**2.9**	**3.0**	**2.7**	**2.9**
Coal	1.31	3.54	8.16	9.84	11.60	13.35	15.09	16.85	4.5	7.0	8.3	8.7	8.8	8.8	8.7	8.5	7.6	3.8	3.1	2.4	2.9
Oil	14.93	28.77	49.25	57.26	67.25	78.09	89.93	103.21	51.7	56.9	50.2	50.5	50.9	51.3	51.7	52.0	4.9	3.1	3.1	2.8	3.0
Natural gas	0.14	1.11	9.63	11.02	13.14	15.53	18.16	21.16	0.5	2.2	9.8	9.7	10.0	10.2	10.4	10.7	18.5	2.7	3.5	3.1	3.2
Electricity	3.30	7.56	15.04	17.62	20.50	23.55	26.84	30.44	11.4	15.0	15.3	15.5	15.5	15.5	15.4	15.3	6.3	3.2	2.9	2.6	2.9
Heat									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.20	9.59	15.96	17.59	19.52	21.64	23.99	26.65	31.9	19.0	16.3	15.5	14.8	14.2	13.8	13.4	2.2	2.0	2.1	2.1	2.1

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**44.18**	**95.98**	**165.71**	**193.52**	**222.41**	**237.18**	**251.27**	**294.57**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.4**	**3.2**	**2.1**	**2.2**	**2.3**
Coal	11.05	17.77	32.92	31.89	35.66	38.11	49.01	71.82	25.0	18.5	19.9	16.5	16.0	16.1	19.5	24.4	4.5	-0.6	1.8	6.5	3.2
Oil	10.38	10.03	1.68	0.21	0.62	0.62	1.80	3.04	23.5	10.4	1.0	0.1	0.3	0.3	0.7	1.0	-7.0	-34.3	11.6	17.3	2.4
Natural gas	17.77	61.64	117.01	134.33	145.38	150.58	145.81	160.96	40.2	64.2	70.6	69.4	65.4	63.5	58.0	54.6	7.8	2.8	1.1	0.7	1.3
Nuclear			0.00	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	-	-	-	-	-
Hydro	4.98	6.03	5.75	10.30	12.05	13.24	14.29	14.61	11.3	6.3	3.5	5.3	5.4	5.6	5.7	5.0	0.6	12.4	2.5	1.0	3.8
Geothermal									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others		0.51	8.36	16.80	28.71	34.63	40.35	44.13	0.0	0.5	5.0	8.7	12.9	14.6	16.1	15.0	-	15.0	7.5	2.5	6.9

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**8.92**	**19.24**	**29.71**	**32.12**	**34.98**	**36.33**	**38.11**	**46.10**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.9**	**1.6**	**1.2**	**2.4**	**1.8**
Coal	2.55	4.16	8.35	7.98	8.76	9.18	11.55	16.56	28.6	21.6	28.1	24.8	25.1	25.3	30.3	35.9	4.9	-0.9	1.4	6.1	2.8
Oil	2.55	2.34	0.37	0.05	0.14	0.14	0.40	0.67	28.6	12.2	1.2	0.1	0.4	0.4	1.0	1.5	-7.4	-34.3	11.6	17.3	2.4
Natural gas	3.82	12.73	20.99	24.10	26.08	27.01	26.16	28.87	42.9	66.2	70.6	75.0	74.6	74.3	68.6	62.6	7.0	2.8	1.1	0.7	1.3

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**37.8**	**40.0**	**43.9**	**44.6**	**44.7**	**44.8**	**44.4**	**44.0**									**0.6**	**0.3**	**0.1**	**-0.2**	**0.0**
Coal	37.3	36.7	33.9	34.4	35.0	35.7	36.5	37.3									-0.4	0.3	0.4	0.4	0.4
Oil	35.0	36.8	38.8	38.8	38.8	38.8	38.8	38.8									0.4	0.0	0.0	0.0	0.0
Natural gas	40.0	41.6	47.9	47.9	47.9	47.9	47.9	47.9									0.7	0.0	0.0	0.0	0.0

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**131.5**	**169.2**	**220.6**	**242.7**	**275.2**	**307.0**	**346.6**	**410.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.1**	**1.9**	**2.4**	**2.9**	**2.5**
Coal	37.5	46.1	64.4	69.5	79.5	87.9	104.0	130.3	28.5	27.3	29.2	28.6	28.9	28.6	30.0	31.8	2.2	1.5	2.4	4.0	2.9
Oil	44.6	71.5	94.1	101.8	116.0	132.7	153.3	178.3	34.0	42.2	42.7	41.9	42.1	43.2	44.2	43.5	3.0	1.6	2.7	3.0	2.6
Natural gas	49.3	51.6	62.0	71.4	79.8	86.3	89.3	101.5	37.5	30.5	28.1	29.4	29.0	28.1	25.8	24.7	0.9	2.8	1.9	1.6	2.0

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	141.6	217.7	393.7	471.6	570.2	687.8	828.8	998.7	4.2	3.7	3.8	3.8	3.8
Population (millions of people)	56.6	61.9	65.7	65.8	65.9	66.0	66.1	66.2	0.6	0.0	0.0	0.0	0.0
GDP per capita (thousands of 2010 US$/person)	2.5	3.5	6.0	7.16	8.6	10.4	12.5	15.1	3.6	3.6	3.8	3.8	3.8
Primary energy consumption per capita (toe/person)	0.8	1.2	2.1	2.30	2.60	2.91	3.28	3.79	4.1	2.3	2.4	2.7	2.5
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	301	332	343	321	301	279	262	251	0.5	-1.3	-1.4	-1.0	-1.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	204	232	249	240	231	221	210	199	0.8	-0.7	-0.8	-1.1	-0.9
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	928	777	560	515	483	446	418	411	-2.0	-1.7	-1.4	-0.8	-1.2
CO_2 emissions per unit of primary energy consumption (t-C/toe)	3.1	2.3	1.6	1.60	1.60	1.60	1.60	1.64	-2.5	-0.4	0.0	0.2	0.0

Thailand (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**42.63**	**72.27**	**134.97**	**139.08**	**145.12**	**153.72**	**165.00**	**183.98**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.7**	**0.6**	**1.0**	**1.8**	**1.2**
Coal	3.82	7.67	16.82	16.31	17.45	18.65	21.10	23.25	9.0	10.6	12.5	11.7	12.0	12.1	12.8	12.6	6.1	-0.6	1.3	2.2	1.3
Oil	17.96	31.88	52.27	56.05	61.04	66.98	72.37	79.67	42.1	44.1	38.7	40.3	42.1	43.6	43.9	43.3	4.4	1.4	1.8	1.7	1.7
Natural gas	4.99	17.36	37.92	37.05	34.53	31.73	29.94	34.17	11.7	24.0	28.1	26.6	23.8	20.6	18.1	18.6	8.4	-0.5	-1.5	0.7	-0.4
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	1.18	2.56	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.4	-	-	-	-	-
Hydro	0.43	0.52	0.49	0.91	1.02	1.14	1.25	1.36	1.0	0.7	0.4	0.7	0.7	0.7	0.8	0.7	0.6	13.0	2.3	1.8	4.1
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	15.43	14.83	27.47	28.76	31.07	35.23	39.16	42.96	36.2	20.5	20.4	20.7	21.4	22.9	23.7	23.4	2.3	0.9	2.0	2.0	1.8
Biomass	14.69	14.59	23.27	24.12	25.99	28.41	30.94	34.02	34.4	20.2	17.2	17.3	17.9	18.5	18.7	18.5	1.9	0.7	1.7	1.8	1.5
Solar, Wind, Ocean	0.00	0.00	0.31	0.77	1.27	1.76	2.25	2.74	0.0	0.0	0.2	0.6	0.9	1.1	1.4	1.5	-	19.6	8.6	4.6	9.1
Biofuels	0.00	0.00	1.53	1.32	1.13	1.00	0.83	0.76	0.0	0.0	1.1	0.9	0.8	0.6	0.5	0.4	-	-3.0	-2.7	-2.7	-2.8
Electricity	0.05	0.24	2.35	2.56	2.67	4.06	5.15	5.44	0.1	0.3	1.7	1.8	1.8	2.6	3.1	3.0	16.4	1.7	4.7	3.0	3.4

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**28.87**	**50.57**	**98.04**	**104.66**	**112.65**	**123.63**	**133.52**	**147.17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**1.3**	**1.7**	**1.8**	**1.6**
Industry	8.65	16.72	30.61	32.63	36.08	41.35	46.47	53.51	30.0	33.1	31.2	31.2	32.0	33.4	34.8	36.4	5.2	1.3	2.4	2.6	2.3
Transportation	9.01	14.61	23.72	21.35	19.08	17.31	14.65	13.63	31.2	28.9	24.2	20.4	16.9	14.0	11.0	9.3	3.9	-2.1	-2.1	-2.4	-2.2
Others	10.78	13.62	21.10	22.43	23.33	24.96	26.58	28.40	37.3	26.9	21.5	21.4	20.7	20.2	19.9	19.3	2.7	1.2	1.1	1.3	1.2
Non-energy	0.43	5.63	22.62	28.25	34.17	40.01	45.82	51.63	1.5	11.1	23.1	27.0	30.3	32.4	34.3	35.1	17.2	4.5	3.5	2.6	3.4
Total	**28.87**	**50.57**	**98.04**	**104.66**	**112.65**	**123.63**	**133.52**	**147.17**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.0**	**1.3**	**1.7**	**1.8**	**1.6**
Coal	1.31	3.54	8.16	8.97	9.86	11.07	12.06	13.35	4.5	7.0	8.3	8.6	8.8	9.0	9.0	9.1	7.6	1.9	2.1	1.9	2.0
Oil	14.93	28.77	49.25	52.90	57.36	62.73	67.49	74.16	51.7	56.9	50.2	50.5	50.9	50.7	50.5	50.4	4.9	1.4	1.7	1.7	1.7
Natural gas	0.14	1.11	9.63	10.24	11.32	12.67	13.91	15.66	0.5	2.2	9.8	9.8	10.0	10.2	10.4	10.6	18.5	1.2	2.1	2.1	2.0
Electricity	3.30	7.56	15.04	16.26	17.37	19.30	21.15	23.48	11.4	15.0	15.3	15.5	15.4	15.6	15.8	16.0	6.3	1.6	1.7	2.0	1.8
Heat	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	9.20	9.59	15.96	16.29	16.74	17.87	18.91	20.52	31.9	19.0	16.3	15.6	14.9	14.5	14.2	13.9	2.2	0.4	0.9	1.4	1.0

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**44.18**	**95.98**	**165.71**	**177.00**	**189.94**	**196.96**	**206.74**	**233.22**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.4**	**1.3**	**1.1**	**1.7**	**1.4**
Coal	11.05	17.77	32.92	29.33	30.90	31.46	38.34	42.96	25.0	18.5	19.9	16.6	16.3	16.0	18.5	18.4	4.5	-2.3	0.7	3.2	1.1
Oil	10.38	10.03	1.68	0.00	0.00	0.00	0.00	0.91	23.5	10.4	1.0	0.0	0.0	0.0	0.0	0.4	-7.0	-100.0	-	-	-2.4
Natural gas	17.77	61.64	117.01	123.55	125.99	124.28	114.04	121.09	40.2	64.2	70.6	69.8	66.3	63.1	55.2	51.9	7.8	1.1	0.1	-0.3	0.1
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	4.53	9.82	0.0	0.0	0.0	0.0	0.0	0.0	2.2	4.2	-	-	-	-	-
Hydro	4.98	6.03	5.75	10.59	11.91	13.24	14.56	15.84	11.3	6.3	3.5	6.0	6.3	6.7	7.0	6.8	0.6	13.0	2.3	1.8	4.1
Geothermal	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	0.00	0.51	8.36	13.53	21.13	27.97	35.27	42.59	0.0	0.5	5.0	7.6	11.1	14.2	17.1	18.3	-	10.1	7.5	4.3	6.7

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**8.92**	**19.24**	**29.71**	**29.50**	**30.20**	**29.88**	**29.49**	**31.83**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**4.9**	**-0.1**	**0.1**	**0.6**	**0.3**
Coal	2.55	4.16	8.35	7.34	7.60	7.58	9.04	9.90	28.6	21.6	28.1	24.9	25.2	25.4	30.6	31.1	4.9	-2.6	0.3	2.7	0.7
Oil	2.55	2.34	0.37	0.00	0.00	0.00	0.00	0.20	28.6	12.2	1.2	0.0	0.0	0.0	0.0	0.6	-7.4	-100.0	-	-	-2.4
Natural gas	3.82	12.73	20.99	22.16	22.60	22.29	20.46	21.72	42.9	66.2	70.6	75.1	74.8	74.6	69.4	68.3	7.0	1.1	0.1	-0.3	0.1

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**37.8**	**40.0**	**43.9**	**44.6**	**44.7**	**44.8**	**44.4**	**44.6**									**0.6**	**0.3**	**0.1**	**-0.1**	**0.1**
Coal	37.3	36.7	33.9	34.4	35.0	35.7	36.5	37.3									-0.4	0.3	0.4	0.4	0.4
Oil	35.0	36.8	38.8	-	-	-	-	38.8									0.4	-	-	-	0.0
Natural gas	40.0	41.6	47.9	47.9	47.9	47.9	47.9	47.9									0.7	0.0	0.0	0.0	0.0

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**131.5**	**169.2**	**220.6**	**217.2**	**221.3**	**227.4**	**232.8**	**252.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**2.1**	**-0.3**	**0.5**	**1.0**	**0.5**
Coal	37.5	46.1	64.4	63.6	68.1	72.8	82.3	90.7	28.5	27.3	29.2	29.3	30.8	32.0	35.4	36.0	2.2	-0.3	1.3	2.2	1.4
Oil	44.6	71.5	94.1	88.5	85.8	86.1	84.6	89.5	34.0	42.2	42.7	40.8	38.8	37.8	36.3	35.5	3.0	-1.2	-0.3	0.4	-0.2
Natural gas	49.3	51.6	62.0	65.0	67.3	68.5	65.9	71.8	37.5	30.5	28.1	29.9	30.4	30.1	28.3	28.5	0.9	0.9	0.5	0.5	0.6

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	141.6	217.7	393.7	471.6	570.2	687.8	828.8	998.7	4.2	3.7	3.8	3.8	3.8
Population (millions of people)	56.6	61.9	65.7	65.8	65.9	66.0	66.1	66.2	0.6	0.0	0.0	0.0	0.0
GDP per capita (thousands of 2010 US$/person)	2.5	3.5	6.0	7.16	8.6	10.4	12.5	15.1	3.6	3.6	3.8	3.8	3.8
Primary energy consumption per capita (toe/person)	0.8	1.2	2.1	2.11	2.20	2.33	2.49	2.78	4.1	0.6	1.0	1.8	1.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	301	332	343	295	254	223	199	184	0.5	-3.0	-2.7	-1.9	-2.5
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	204	232	249	222	198	180	161	147	0.8	-2.3	-2.1	-2.0	-2.1
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	928	777	560	461	388	331	281	252	-2.0	-3.8	-3.3	-2.7	-3.1
CO_2 emissions per unit of primary energy consumption (t-C/toe)	3.1	2.3	1.6	1.56	1.52	1.48	1.41	1.37	-2.5	-0.9	-0.5	-0.8	-0.7

Viet Nam (BAU)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**17.86**	**28.74**	**70.06**	**107.36**	**136.84**	**165.63**	**191.56**	**219.92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.6**	**8.9**	**4.4**	**2.9**	**4.7**
Coal	2.21	4.37	25.18	57.90	74.65	91.31	107.22	123.54	12.4	15.2	35.9	53.9	54.6	55.1	56.0	56.2	10.2	18.1	4.7	3.1	6.6
Oil	2.71	7.81	15.58	22.50	30.25	38.94	47.63	57.87	15.2	27.2	22.2	21.0	22.1	23.5	24.9	26.3	7.2	7.6	5.6	4.0	5.4
Natural gas	0.00	1.12	9.62	9.63	15.42	20.22	23.25	26.57	0.0	3.9	13.7	9.0	11.3	12.2	12.1	12.1	38.1	0.0	7.7	2.8	4.1
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.46	1.25	5.43	4.26	4.95	5.17	5.12	5.14	2.6	4.4	7.8	4.0	3.6	3.1	2.7	2.3	10.4	-4.7	1.9	0.0	-0.2
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	12.47	14.19	14.25	13.08	11.57	10.00	8.34	6.80	69.8	49.4	20.3	12.2	8.5	6.0	4.4	3.1	0.5	-1.7	-2.6	-3.8	-2.9
Biomass	12.47	14.19	14.78	12.59	11.07	9.45	7.78	6.22	69.8	49.4	21.1	11.7	8.1	5.7	4.1	2.8	0.7	-3.2	-2.8	-4.1	-3.4
Solar, Wind, Ocean			0.02	0.02	0.02	0.03	0.04	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.3	5.1	4.1	3.7
Biofuels			0.00	0.00	0.00	0.00	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-100.0	-	-	9.1
Electricity			-0.55	0.47	0.47	0.51	0.51	0.51	0.0	0.0	-0.8	0.4	0.3	0.3	0.3	0.2	-	-196.8	0.9	0.0	-199.7

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**16.06**	**25.09**	**56.31**	**76.63**	**96.43**	**115.35**	**132.39**	**150.97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.1**	**6.4**	**4.2**	**2.7**	**4.0**
Industry	4.54	7.86	23.68	37.01	49.13	59.19	68.17	77.97	28.3	31.3	42.0	48.3	50.9	51.3	51.5	51.6	6.8	9.3	4.8	2.8	4.9
Transportation	1.38	3.50	10.46	14.91	19.89	25.79	31.54	37.56	8.6	13.9	18.6	19.5	20.6	22.4	23.8	24.9	8.4	7.3	5.6	3.8	5.2
Others	10.11	13.60	20.95	23.03	25.18	27.57	29.22	31.24	63.0	54.2	37.2	30.1	26.1	23.9	22.1	20.7	3.0	1.9	1.8	1.3	1.6
Non-energy	0.03	0.13	1.23	1.68	2.23	2.81	3.46	4.20	0.2	0.5	2.2	2.2	2.3	2.4	2.6	2.8	16.3	6.5	5.3	4.1	5.1
Total	**16.06**	**25.09**	**56.31**	**76.63**	**96.43**	**115.35**	**132.39**	**150.97**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.1**	**6.4**	**4.2**	**2.7**	**4.0**
Coal	1.33	3.22	12.65	20.39	27.08	32.10	35.22	38.37	8.3	12.8	22.5	26.6	28.1	27.8	26.6	25.4	9.4	10.0	4.6	1.8	4.5
Oil	2.33	6.51	14.23	19.96	26.74	34.73	42.92	51.82	14.5	26.0	25.3	26.0	27.7	30.1	32.4	34.3	7.5	7.0	5.7	4.1	5.3
Natural gas	0.00	0.02	1.49	2.57	3.46	4.34	5.37	6.53	0.0	0.1	2.6	3.4	3.6	3.8	4.1	4.3	-	11.5	5.4	4.2	6.1
Electricity	0.53	1.93	12.14	19.69	26.13	32.25	37.97	44.15	3.3	7.7	21.6	25.7	27.1	28.0	28.7	29.2	13.3	10.2	5.1	3.2	5.3
Heat	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	11.87	13.41	15.81	14.02	13.02	11.94	10.91	10.10	73.9	53.4	28.1	18.3	13.5	10.3	8.2	6.7	1.2	-2.4	-1.6	-1.7	-1.8

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**8.68**	**26.57**	**159.81**	**242.79**	**323.27**	**398.90**	**469.84**	**546.15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12.4**	**8.7**	**5.1**	**3.2**	**5.0**
Coal	2.00	3.14	51.00	155.30	200.30	253.42	313.14	376.39	23.1	11.8	31.9	64.0	62.0	63.5	66.6	68.9	13.8	24.9	5.0	4.0	8.3
Oil	1.31	4.52	0.30	0.00	0.00	0.00	0.00	0.00	15.0	17.0	0.2	0.0	0.0	0.0	0.0	0.0	-5.8	-100.0	-	-	-100.0
Natural gas	0.01	4.36	44.93	37.58	65.05	85.00	96.72	109.56	0.1	16.4	28.1	15.5	20.1	21.3	20.6	20.1	42.9	-3.5	8.5	2.6	3.6
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	5.37	14.55	63.19	49.56	57.57	60.11	59.60	59.82	61.8	54.8	39.5	20.4	17.8	15.1	12.7	11.0	10.4	-4.7	1.9	0.0	-0.2
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	-	-	0.39	0.35	0.36	0.38	0.37	0.37	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	-	-2.4	0.8	0.0	-0.2

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.27**	**3.56**	**20.35**	**43.92**	**58.59**	**73.49**	**88.11**	**103.29**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**11.7**	**16.6**	**5.3**	**3.5**	**6.7**
Coal	0.89	1.15	12.53	37.51	47.58	59.21	71.99	85.17	69.8	32.3	61.6	85.4	81.2	80.6	81.7	82.5	11.2	24.5	4.7	3.7	8.0
Oil	0.38	1.31	0.08	0.00	0.00	0.00	0.00	0.00	30.0	36.8	0.4	0.0	0.0	0.0	0.0	0.0	-6.1	-100.0	-	-	-100.0
Natural gas	0.00	1.10	7.74	6.41	11.01	14.28	16.12	18.12	0.2	30.9	38.0	14.6	18.8	19.4	18.3	17.5	36.9	-3.7	8.3	2.4	3.5

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**22.4**	**29.0**	**40.7**	**37.8**	**39.0**	**39.6**	**40.0**	**40.5**									**2.4**	**-1.5**	**0.5**	**0.2**	**0.0**
Coal	19.4	23.5	35.0	35.6	36.2	36.8	37.4	38.0									2.4	0.3	0.3	0.3	0.3
Oil	29.4	29.7	32.3	-	-	-	-	-									0.4	-	-	-	-
Natural gas	17.2	34.1	49.9	50.4	50.8	51.2	51.6	52.0									4.4	0.2	0.2	0.2	0.2

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**4.7**	**12.0**	**49.0**	**90.4**	**117.9**	**145.2**	**169.2**	**195.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.8**	**13.0**	**4.9**	**3.0**	**5.7**
Coal	2.5	4.7	28.0	63.9	82.7	101.2	118.3	135.7	53.2	39.2	57.2	70.7	70.1	69.7	69.9	69.5	10.1	17.9	4.7	3.0	6.5
Oil	2.2	6.4	13.9	19.4	24.4	30.3	35.3	41.7	46.8	53.3	28.5	21.5	20.7	20.9	20.9	21.4	7.7	6.8	4.6	3.2	4.5
Natural gas	0.0	0.9	7.0	7.1	10.8	13.6	15.7	17.9	0.0	7.5	14.3	7.8	9.2	9.4	9.3	9.1	-	0.2	6.8	2.7	3.8

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	17.8	36.8	154.5	216.7	296.9	397.3	519.3	662.8	9.0	7.0	6.2	5.2	6.0
Population (millions of people)	66.0	77.6	91.7	96.2	100.1	103.1	105.4	107.0	1.3	1.0	0.7	0.4	0.6
GDP per capita (thousands of 2010 US$/person)	0.3	0.5	1.7	2.25	3.0	3.9	4.9	6.2	7.6	6.0	5.5	4.9	5.3
Primary energy consumption per capita (toe/person)	0.3	0.4	0.8	1.12	1.37	1.61	1.82	2.06	4.2	7.9	3.7	2.5	4.0
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,006	780	453	495	461	417	369	332	-3.1	1.8	-1.7	-2.3	-1.2
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	905	681	364	354	325	290	255	228	-3.6	-0.6	-2.0	-2.4	-1.9
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	265	326	317	417	397	365	326	295	0.7	5.7	-1.3	-2.1	-0.3
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.3	0.4	0.7	0.84	0.86	0.88	0.88	0.89	4.0	3.8	0.4	0.1	1.0
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

Viet Nam (APS)

Primary energy supply

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**17.86**	**28.74**	**70.06**	**104.37**	**128.16**	**149.37**	**166.23**	**183.66**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.6**	**8.3**	**3.7**	**2.1**	**3.9**
Coal	2.21	4.37	25.18	54.63	65.11	74.30	81.81	88.71	12.4	15.2	35.9	52.3	50.8	49.7	49.2	48.3	10.2	16.8	3.1	1.8	5.2
Oil	2.71	7.81	15.58	21.66	28.23	35.30	42.05	49.81	15.2	27.2	22.2	20.8	22.0	23.6	25.3	27.1	7.2	6.8	5.0	3.5	4.8
Natural gas	0.00	1.12	9.62	9.37	14.66	18.63	20.98	23.42	0.0	3.9	13.7	9.0	11.4	12.5	12.6	12.8	38.1	-0.5	7.1	2.3	3.6
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	0.46	1.25	5.43	4.16	4.71	4.85	4.67	4.54	2.6	4.4	7.8	4.0	3.7	3.2	2.8	2.5	10.4	-5.2	1.6	-0.7	-0.7
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	12.47	14.19	14.25	14.55	15.46	16.29	16.72	17.18	69.8	49.4	20.3	13.9	12.1	10.9	10.1	9.4	0.5	0.4	1.1	0.5	0.8
Biomass	12.47	14.19	14.78	13.92	14.13	14.15	13.77	13.12	69.8	49.4	21.1	13.3	11.0	9.5	8.3	7.1	0.7	-1.2	0.2	-0.8	-0.5
Solar, Wind, Ocean			0.02	0.16	0.86	1.63	2.25	2.87	0.0	0.0	0.0	0.2	0.7	1.1	1.4	1.6	-	53.8	26.0	5.8	22.3
Biofuels			0.00	0.00	0.00	0.00	0.19	0.68	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	-	-100.0	-	-	24.0
Electricity			-0.55	0.47	0.47	0.51	0.51	0.51	0.0	0.0	-0.8	0.5	0.4	0.3	0.3	0.3	-	-196.8	0.9	0.0	-199.7

Final energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**16.06**	**25.09**	**56.31**	**74.36**	**90.90**	**105.61**	**117.66**	**130.15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.1**	**5.7**	**3.6**	**2.1**	**3.4**
Industry	4.54	7.86	23.68	35.47	45.37	52.62	58.39	64.29	28.3	31.3	42.0	47.7	49.9	49.8	49.6	49.4	6.8	8.4	4.0	2.0	4.1
Transportation	1.38	3.50	10.46	14.46	18.80	21.82	28.49	33.23	8.6	13.9	18.6	19.4	20.7	22.6	24.2	25.5	8.4	6.7	5.1	3.4	4.7
Others	10.11	13.60	20.95	22.75	24.50	26.36	27.31	28.43	63.0	54.2	37.2	30.6	27.0	25.0	23.2	21.8	3.0	1.7	1.5	0.8	1.2
Non-energy	0.03	0.13	1.23	1.68	2.23	2.81	3.46	4.20	0.2	0.5	2.2	2.3	2.5	2.7	2.9	3.2	16.3	6.5	5.3	4.1	5.1
Total	**16.06**	**25.09**	**56.31**	**74.36**	**90.90**	**105.61**	**117.66**	**130.15**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**5.1**	**5.7**	**3.6**	**2.1**	**3.4**
Coal	1.33	3.22	12.65	19.23	24.09	26.84	27.73	28.35	8.3	12.8	22.5	25.9	26.5	25.4	23.6	21.8	9.4	8.7	3.4	0.5	3.3
Oil	2.33	6.51	14.23	19.13	24.74	31.16	37.34	43.77	14.5	26.0	25.3	25.7	27.2	29.5	31.7	33.6	7.5	6.1	5.0	3.5	4.6
Natural gas	0.00	0.02	1.49	2.66	3.85	5.14	6.48	7.95	0.0	0.1	2.6	3.6	4.2	4.9	5.5	6.1	-	12.3	6.8	4.5	6.9
Electricity	0.53	1.93	12.14	19.17	24.75	29.68	33.88	38.13	3.3	7.7	21.6	25.8	27.2	28.1	28.8	29.3	13.3	9.6	4.5	2.5	4.7
Heat	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	11.87	13.41	15.81	14.18	13.48	12.80	12.23	11.95	73.9	53.4	28.1	19.1	14.8	12.1	10.4	9.2	1.2	-2.1	-1.0	-0.7	-1.1

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**8.68**	**26.57**	**159.81**	**236.17**	**305.82**	**366.66**	**418.57**	**470.84**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**12.4**	**8.1**	**4.5**	**2.5**	**4.4**
Coal	2.00	3.14	51.00	148.23	176.49	209.73	245.31	280.77	23.1	11.8	31.9	62.8	57.7	57.2	58.6	59.6	13.8	23.8	3.5	3.0	7.1
Oil	1.31	4.52	0.30	0.00	0.00	0.00	0.00	0.00	15.0	17.0	0.2	0.0	0.0	0.0	0.0	0.0	-5.8	-100.0	-	-	-100.0
Natural gas	0.01	4.36	44.93	36.66	61.89	77.44	85.86	94.51	0.1	16.4	28.1	15.5	20.2	21.1	20.5	20.1	42.9	-4.0	7.8	2.0	3.0
Nuclear	0.00	0.00							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Hydro	5.37	14.55	63.19	48.34	54.77	56.44	54.32	52.81	61.8	54.8	39.5	20.5	17.9	15.4	13.0	11.2	10.4	-5.2	1.6	-0.7	-0.7
Geothermal	-	-							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Others	-	-	0.39	2.94	12.67	23.05	33.07	42.74	0.0	0.0	0.2	1.2	4.1	6.3	7.9	9.1	-	49.6	22.9	6.4	20.6

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1.27**	**3.56**	**20.35**	**41.47**	**50.87**	**59.35**	**66.81**	**73.90**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**11.7**	**15.3**	**3.7**	**2.2**	**5.3**
Coal	0.89	1.15	12.53	35.41	41.01	47.46	54.08	60.36	69.8	32.3	61.6	85.4	80.6	80.0	80.9	81.7	11.2	23.1	3.0	2.4	6.5
Oil	0.38	1.31	0.08	0.00	0.00	0.00	0.00	0.00	30.0	36.8	0.4	0.0	0.0	0.0	0.0	0.0	-6.1	-100.0	-	-	-100.0
Natural gas	0.00	1.10	7.74	6.06	9.86	11.89	12.73	13.54	0.2	30.9	38.0	14.6	19.4	20.0	19.1	18.3	36.9	-4.8	7.0	1.3	2.3

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**22.4**	**29.0**	**40.7**	**38.3**	**40.3**	**41.6**	**42.6**	**43.7**									**2.4**	**-1.2**	**0.8**	**0.5**	**0.3**
Coal	19.4	23.5	35.0	36.0	37.0	38.0	39.0	40.0									2.4	0.6	0.5	0.5	0.5
Oil	29.4	29.7	32.3	-	-	-	-	-									0.4	-	-	-	-
Natural gas	17.2	34.1	49.9	52.0	54.0	56.0	58.0	60.0									4.4	0.8	0.7	0.7	0.7

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**4.7**	**12.0**	**49.0**	**86.1**	**105.6**	**123.2**	**136.4**	**149.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**9.8**	**11.9**	**3.7**	**2.0**	**4.6**
Coal	2.5	4.7	28.0	60.3	72.2	82.6	90.5	97.7	53.2	39.2	57.2	70.1	68.4	67.1	66.3	65.1	10.1	16.6	3.2	1.7	5.1
Oil	2.2	6.4	13.9	18.7	22.8	27.4	30.9	35.3	46.8	53.3	28.5	21.8	21.6	22.2	22.6	23.5	7.7	6.1	3.9	2.6	3.8
Natural gas	0.0	0.9	7.0	7.0	10.6	13.2	15.0	17.0	0.0	7.5	14.3	8.1	10.0	10.7	11.0	11.3	-	-0.1	6.5	2.6	3.6

Energy and economic indicators

	1990	2000	2015	2020	2025	2030	2035	2040	AAGR(%) 1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	17.8	36.8	154.5	216.7	296.9	397.3	519.3	662.8	9.0	7.0	6.2	5.2	6.0
Population (millions of people)	66.0	77.6	91.7	96.2	100.1	103.1	105.4	107.0	1.3	1.0	0.7	0.4	0.6
GDP per capita (thousands of 2010 US$/person)	0.3	0.5	1.7	2.25	3.0	3.9	4.9	6.2	7.6	6.0	5.5	4.9	5.3
Primary energy consumption per capita (toe/person)	0.3	0.4	0.8	1.09	1.28	1.45	1.58	1.72	4.2	7.3	2.9	1.7	3.3
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	1,006	780	453	482	432	376	320	277	-3.1	1.2	-2.4	-3.0	-2.0
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	905	681	364	343	306	266	227	196	-3.6	-1.2	-2.5	-3.0	-2.4
CO2 emissions per unit of GDP (t-C/million 2010 US dollars)	265	326	317	397	356	310	263	226	0.7	4.6	-2.4	-3.1	-1.3
CO2 emissions per unit of primary energy consumption (t-C/toe)	0.3	0.4	0.7	0.82	0.82	0.83	0.82	0.82	4.0	3.4	0.0	-0.1	0.6
Automobile ownership volume (millions of vehicles)									-	-	-	-	-
Automobile ownership volume per capita (vehicles per person)	-	-	-	-	-	-	-	-	-	-	-	-	-

United States (BAU)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,915.1**	**2,273.3**	**2,188.3**	**2,164.6**	**2,160.6**	**2,167.3**	**2,155.3**	**2,143.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.5**	**-0.2**	**0.0**	**-0.1**	**-0.1**
Coal	460.3	533.6	374.1	334.6	319.8	311.4	301.4	289.3	24.0	23.5	17.1	15.5	14.8	14.4	14.0	13.5	-0.8	-2.2	-0.7	-0.7	-1.0
Oil	756.8	871.1	794.0	765.7	737.3	719.0	697.3	676.9	39.5	38.3	36.3	35.4	34.1	33.2	32.4	31.6	0.2	-0.7	-0.6	-0.6	-0.6
Natural gas	438.2	547.6	646.4	663.6	681.0	702.4	717.1	724.6	22.9	24.1	29.5	30.7	31.5	32.4	33.3	33.8	1.6	0.5	0.6	0.3	0.5
Nuclear	159.4	207.9	216.4	210.0	210.2	208.7	195.9	190.7	8.3	9.1	9.9	9.7	9.7	9.6	9.1	8.9	1.2	-0.6	-0.1	-0.9	-0.5
Hydro	23.5	21.8	21.6	25.0	25.2	25.4	25.5	25.7	1.2	1.0	1.0	1.2	1.2	1.2	1.2	1.2	-0.3	3.0	0.2	0.1	0.7
Geothermal	14.1	13.1	9.0	13.5	18.8	20.8	23.6	26.3	0.7	0.6	0.4	0.6	0.9	1.0	1.1	1.2	-1.8	8.4	4.5	2.3	4.4
Others	62.7	78.2	126.9	152.2	168.2	179.6	194.4	209.5	3.3	3.4	5.8	7.0	7.8	8.3	9.0	9.8	2.9	3.7	1.7	1.6	2.0
Biomass	61.5	67.3	60.6	65.9	68.5	70.7	72.2	73.8	3.2	3.0	2.8	3.0	3.2	3.3	3.3	3.4	-0.1	1.7	0.7	0.4	0.8
Solar, Wind, Ocean	0.3	2.1	22.4	39.3	47.6	57.4	69.4	81.4	0.0	0.1	1.0	1.8	2.2	2.6	3.2	3.8	18.5	11.9	3.9	3.6	5.3
Biofuels	0.7	5.9	38.2	42.5	47.5	46.9	48.3	49.7	0.0	0.3	1.7	2.0	2.2	2.2	2.2	2.3	17.1	2.2	1.0	0.6	1.1
Electricity	0.2	2.9	5.7	4.6	4.6	4.6	4.6	4.6	0.0	0.1	0.3	0.2	0.2	0.2	0.2	0.2	15.1	-4.4	0.0	0.0	-0.9

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,293.5**	**1,546.2**	**1,520.1**	**1,514.8**	**1,513.1**	**1,521.6**	**1,519.9**	**1,514.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-0.1**	**0.0**	**0.0**	**0.0**
Industry	283.7	332.3	261.6	259.1	260.3	264.0	265.3	265.0	21.9	21.5	17.2	17.1	17.2	17.4	17.5	17.5	-0.3	-0.2	0.2	0.0	0.1
Transportation	487.6	588.2	629.0	612.6	595.6	583.6	569.8	559.0	37.7	38.0	41.4	40.4	39.4	38.4	37.5	36.9	1.0	-0.5	-0.5	-0.4	-0.5
Others	403.2	472.7	506.3	515.8	525.4	537.3	544.9	549.4	31.2	30.6	33.3	34.1	34.7	35.3	35.8	36.3	0.9	0.4	0.4	0.2	0.3
Non-energy	119.0	153.0	123.3	127.2	131.8	136.7	140.0	141.5	9.2	9.9	8.1	8.4	8.7	9.0	9.2	9.3	0.1	0.6	0.7	0.3	0.6
Total	**1,293.5**	**1,546.2**	**1,520.1**	**1,514.8**	**1,513.1**	**1,521.6**	**1,519.9**	**1,514.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-0.1**	**0.0**	**0.0**	**0.0**
Coal	55.7	32.6	19.5	18.3	17.5	16.8	16.0	15.1	4.3	2.1	1.3	1.2	1.2	1.1	1.1	1.0	-4.1	-1.3	-0.8	-1.1	-1.0
Oil	683.3	793.4	757.9	735.9	710.5	694.7	674.0	654.5	52.8	51.3	49.9	48.6	47.0	45.7	44.3	43.2	0.4	-0.6	-0.6	-0.6	-0.6
Natural gas	303.0	359.9	333.2	337.2	344.7	354.2	358.4	359.9	23.4	23.3	21.9	22.3	22.8	23.3	23.6	23.8	0.4	0.2	0.5	0.2	0.3
Electricity	226.5	301.0	325.2	336.6	349.1	365.6	380.6	393.9	17.5	19.5	21.4	22.2	23.1	24.0	25.0	26.0	1.5	0.7	0.8	0.7	0.8
Heat	2.2	5.3	5.5	5.6	5.8	6.1	6.3	6.5	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	3.8	0.4	0.9	0.6	0.7
Others	22.9	54.1	79.0	81.2	85.4	84.1	84.6	85.0	1.8	3.5	5.2	5.4	5.6	5.5	5.6	5.6	5.1	0.6	0.3	0.1	0.3

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3,202.8**	**4,025.9**	**4,297.0**	**4,462.4**	**4,622.7**	**4,831.2**	**5,016.1**	**5,173.8**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.2**	**0.8**	**0.8**	**0.7**	**0.7**
Coal	1,699.6	2,129.5	1,471.0	1,316.0	1,291.7	1,302.6	1,302.9	1,279.3	53.1	52.9	34.2	29.5	27.9	27.0	26.0	24.7	-0.6	-2.2	-0.1	-0.2	-0.6
Oil	130.6	118.5	38.8	14.8	13.8	11.9	11.5	10.8	4.1	2.9	0.9	0.3	0.3	0.2	0.2	0.2	-4.7	-17.5	-2.2	-1.0	-5.0
Natural gas	381.7	634.3	1,372.6	1,512.1	1,581.3	1,671.7	1,778.9	1,854.2	11.9	15.8	31.9	33.9	34.2	34.6	35.5	35.8	5.3	2.0	1.0	1.0	1.2
Nuclear	611.6	797.7	830.3	805.8	806.6	800.8	751.8	731.9	19.1	19.8	19.3	18.1	17.4	16.6	15.0	14.1	1.2	-0.6	-0.1	-0.9	-0.5
Hydro	273.2	253.2	251.0	290.5	293.2	295.4	297.1	298.4	8.5	6.3	5.8	6.5	6.3	6.1	5.9	5.8	-0.3	3.0	0.2	0.1	0.7
Geothermal	16.0	14.6	18.7	28.4	39.9	44.2	50.0	55.9	0.5	0.4	0.4	0.6	0.9	0.9	1.0	1.1	0.6	8.6	4.5	2.4	4.5
Others	90.1	78.1	314.6	494.8	596.2	704.6	824.0	943.3	2.8	1.9	7.3	11.1	12.9	14.6	16.4	18.2	5.1	9.5	3.6	3.0	4.5

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**513.0**	**668.0**	**591.4**	**560.4**	**551.2**	**549.9**	**550.0**	**544.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-1.1**	**-0.2**	**-0.1**	**-0.3**
Coal	396.0	501.6	340.8	303.1	289.3	281.8	272.9	262.0	77.2	75.1	57.6	54.1	52.5	51.2	49.6	48.2	-0.6	-2.3	-0.7	-0.7	-1.0
Oil	27.2	29.6	8.9	3.5	3.2	2.7	2.6	2.4	5.3	4.4	1.5	0.6	0.6	0.5	0.5	0.4	-4.4	-17.2	-2.3	-1.1	-5.1
Natural gas	89.7	136.9	241.7	253.8	258.7	265.4	274.5	279.6	17.5	20.5	40.9	45.3	46.9	48.3	49.9	51.4	4.0	1.0	0.4	0.5	0.6

Thermal efficiency

	%																AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040									1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**37.1**	**37.1**	**41.9**	**43.6**	**45.0**	**46.7**	**48.4**	**49.7**									**0.5**	**0.8**	**0.7**	**0.6**	**0.7**
Coal	36.9	36.5	37.1	37.3	38.4	39.8	41.1	42.0									0.0	0.1	0.6	0.5	0.5
Oil	41.2	34.5	37.5	36.9	37.2	37.5	37.9	38.2									-0.4	-0.3	0.2	0.2	0.1
Natural gas	36.6	39.9	48.8	51.2	52.6	54.2	55.7	57.0									1.2	1.0	0.6	0.5	0.6

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,314.7**	**1,532.0**	**1,382.9**	**1,324.4**	**1,292.2**	**1,277.6**	**1,255.4**	**1,228.9**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.2**	**-0.9**	**-0.4**	**-0.4**	**-0.5**
Coal	497.1	576.3	404.1	361.4	345.4	336.3	325.5	312.5	37.8	37.6	29.2	27.3	26.7	26.3	25.9	25.4	-0.8	-2.2	-0.7	-0.7	-1.0
Oil	545.6	615.8	574.4	548.0	521.3	502.6	482.2	464.1	41.5	40.2	41.5	41.4	40.3	39.3	38.4	37.8	0.2	-0.9	-0.9	-0.8	-0.8
Natural gas	272.0	339.8	404.4	415.0	425.5	438.7	447.7	452.3	20.7	22.2	29.2	31.3	32.9	34.3	35.7	36.8	1.6	0.5	0.6	0.3	0.4

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	9,064	12,713	16,598	18,394	20,260	22,629	25,118	27,677	2.4	2.1	2.1	2.0	2.1
Population (millions of people)	250	282	321	333	345	356	367	376	1.0	0.7	0.7	0.5	0.6
GDP per capita (thousands of 2010 US$/person)	36.31	45.06	51.64	55.24	58.8	63.5	68.5	73.6	1.4	1.4	1.4	1.5	1.4
Primary energy consumption per capita (toe/person)	7.67	8.06	6.81	6.50	6.27	6.08	5.88	5.70	-0.5	-0.9	-0.7	-0.6	-0.7
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	211	179	132	118	107	96	86	77	-1.9	-2.2	-2.0	-2.1	-2.1
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	143	122	92	82	75	67	61	55	-1.8	-2.1	-2.0	-2.0	-2.0
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	145	121	83	72	64	56	50	44	-2.2	-2.9	-2.4	-2.4	-2.5
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.69	0.67	0.63	0.61	0.60	0.59	0.58	0.57	-0.3	-0.6	-0.4	-0.3	-0.4
Automobile ownership volume (millions of vehicles)	189	221	255	267	278	292	306	319	1.2	0.9	0.9	0.9	0.9
Automobile ownership volume per capita (vehicles per person)	0.756	0.785	0.793	0.801	0.805	0.819	0.834	0.849	0.2	0.2	0.2	0.4	0.3

United States (APS)

Primary energy consumption

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,915.1**	**2,273.3**	**2,188.3**	**2,140.3**	**2,085.3**	**2,033.8**	**1,966.0**	**1,910.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.5**	**-0.4**	**-0.5**	**-0.6**	**-0.5**
Coal	460.3	533.6	374.1	319.4	259.9	213.7	171.3	129.7	24.0	23.5	17.1	14.9	12.5	10.5	8.7	6.8	-0.8	-3.1	-3.9	-4.9	-4.1
Oil	756.8	871.1	794.0	766.2	712.7	662.5	611.7	567.6	39.5	38.3	36.3	35.8	34.2	32.6	31.1	29.7	0.2	-0.7	-1.4	-1.5	-1.3
Natural gas	438.2	547.6	646.4	647.5	648.7	654.5	648.0	626.6	22.9	24.1	29.5	30.3	31.1	32.2	33.0	32.8	1.6	0.0	0.1	-0.4	-0.1
Nuclear	159.4	207.9	216.4	210.0	210.2	208.7	197.7	206.5	8.3	9.1	9.9	9.8	10.1	10.3	10.1	10.8	1.2	-0.6	-0.1	-0.1	-0.2
Hydro	23.5	21.8	21.6	25.0	25.2	25.4	25.5	25.7	1.2	1.0	1.0	1.2	1.2	1.2	1.3	1.3	-0.3	3.0	0.2	0.1	0.7
Geothermal	14.1	13.1	9.0	13.5	26.1	33.2	38.0	42.8	0.7	0.6	0.4	0.6	1.3	1.6	1.9	2.2	-1.8	8.4	9.4	2.6	6.4
Others	62.7	78.2	126.9	158.9	202.5	235.7	273.9	311.3	3.3	3.4	5.8	7.4	9.7	11.6	13.9	16.3	2.9	4.6	4.0	2.8	3.7
Biomass	61.5	67.3	60.6	67.7	70.8	73.3	74.6	76.0	3.2	3.0	2.8	3.2	3.4	3.6	3.8	4.0	-0.1	2.2	0.8	0.4	0.9
Solar, Wind, Ocean	0.3	2.1	22.4	43.3	68.7	91.3	121.4	151.4	0.0	0.1	1.0	2.0	3.3	4.5	6.2	7.9	18.5	14.1	7.7	5.2	8.0
Biofuels	0.7	5.9	38.2	43.3	58.4	66.6	73.3	79.3	0.0	0.3	1.7	2.0	2.8	3.3	3.7	4.2	17.1	2.5	4.4	1.8	3.0
Electricity	0.2	2.9	5.7	4.6	4.6	4.6	4.6	4.6	0.0	0.1	0.3	0.2	0.2	0.2	0.2	0.2	15.1	-4.4	0.0	0.0	-0.9

Final energy demand

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,293.5**	**1,546.2**	**1,520.1**	**1,503.9**	**1,476.4**	**1,449.7**	**1,413.7**	**1,379.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-0.2**	**-0.4**	**-0.5**	**-0.4**
Industry	283.7	332.3	261.6	257.5	255.5	254.8	250.3	243.2	21.9	21.5	17.2	17.1	17.3	17.6	17.7	17.6	-0.3	-0.3	-0.1	-0.5	-0.3
Transportation	487.6	588.2	629.0	610.0	582.2	553.3	523.6	501.4	37.7	38.0	41.4	40.6	39.4	38.2	37.0	36.4	1.0	-0.6	-1.0	-1.0	-0.9
Others	403.2	472.7	506.3	509.1	506.9	504.9	499.7	493.0	31.2	30.6	33.3	33.9	34.3	34.8	35.4	35.7	0.9	0.1	-0.1	-0.2	-0.1
Non-energy	119.0	153.0	123.3	127.2	131.8	136.7	140.0	141.5	9.2	9.9	8.1	8.5	8.9	9.4	9.9	10.3	0.1	0.6	0.7	0.3	0.6
Total	**1,293.5**	**1,546.2**	**1,520.1**	**1,503.9**	**1,476.4**	**1,449.7**	**1,413.7**	**1,379.0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-0.2**	**-0.4**	**-0.5**	**-0.4**
Coal	55.7	32.6	19.5	18.2	17.2	16.2	15.1	13.9	4.3	2.1	1.3	1.2	1.2	1.1	1.1	1.0	-4.1	-1.4	-1.1	-1.5	-1.3
Oil	683.3	793.4	757.9	732.3	684.2	638.9	591.6	550.9	52.8	51.3	49.9	48.7	46.3	44.1	41.9	39.9	0.4	-0.7	-1.4	-1.5	-1.3
Natural gas	303.0	359.9	333.2	333.4	332.9	332.4	327.9	321.4	23.4	23.3	21.9	22.2	22.5	22.9	23.2	23.3	0.4	0.0	0.0	-0.3	-0.1
Electricity	226.5	301.0	325.2	333.2	341.4	354.4	366.2	375.8	17.5	19.5	21.4	22.2	23.1	24.4	25.9	27.3	1.5	0.5	0.6	0.6	0.6
Heat	2.2	5.3	5.5	5.5	5.7	5.9	6.0	6.0	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	3.8	0.3	0.6	0.1	0.4
Others	22.9	54.1	79.0	81.3	94.9	101.7	106.8	111.0	1.8	3.5	5.2	5.4	6.4	7.0	7.6	8.1	5.1	0.6	2.3	0.9	1.4

Power generation output

	TWh								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**3,202.8**	**4,025.9**	**4,297.0**	**4,414.9**	**4,512.4**	**4,664.8**	**4,797.2**	**4,897.6**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**1.2**	**0.5**	**0.6**	**0.5**	**0.5**
Coal	1,699.6	2,129.5	1,471.0	1,256.6	1,038.3	870.9	705.2	525.6	53.1	52.9	34.2	28.5	23.0	18.7	14.7	10.7	-0.6	-3.1	-3.6	-4.9	-4.0
Oil	130.6	118.5	38.8	33.0	27.1	22.6	18.1	13.3	4.1	2.9	0.9	0.7	0.6	0.5	0.4	0.3	-4.7	-3.2	-3.7	-5.2	-4.2
Natural gas	381.7	634.3	1,372.6	1,449.8	1,485.3	1,556.8	1,598.1	1,545.6	11.9	15.8	31.9	32.8	32.9	33.4	33.3	31.6	5.3	1.1	0.7	-0.1	0.5
Nuclear	611.6	797.7	830.3	805.8	806.6	800.8	758.5	792.5	19.1	19.8	19.3	18.3	17.9	17.2	15.8	16.2	1.2	-0.6	-0.1	-0.1	-0.2
Hydro	273.2	253.2	251.0	290.5	293.2	295.4	297.1	298.4	8.5	6.3	5.8	6.6	6.5	6.3	6.2	6.1	-0.3	3.0	0.2	0.1	0.7
Geothermal	16.0	14.6	18.7	28.4	55.5	70.8	81.1	91.5	0.5	0.4	0.4	0.6	1.2	1.5	1.7	1.9	0.6	8.6	9.6	2.6	6.6
Others	90.1	78.1	314.6	550.9	806.3	1,047.5	1,339.1	1,630.7	2.8	1.9	7.3	12.5	17.9	22.5	27.9	33.3	5.1	11.9	6.6	4.5	6.8

Power generation input

	Mtoe								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**513.0**	**668.0**	**591.4**	**537.9**	**476.7**	**433.4**	**389.5**	**334.1**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.6**	**-1.9**	**-2.1**	**-2.6**	**-2.3**
Coal	396.0	501.6	340.8	288.0	230.1	185.3	144.4	104.6	77.2	75.1	57.6	53.5	48.3	42.7	37.1	31.3	-0.6	-3.3	-4.3	-5.6	-4.6
Oil	27.2	29.6	8.9	7.7	6.2	5.1	4.0	2.9	5.3	4.4	1.5	1.4	1.3	1.2	1.0	0.9	-4.4	-3.0	-4.0	-5.4	-4.4
Natural gas	89.7	136.9	241.7	242.2	240.4	243.1	241.1	226.5	17.5	20.5	40.9	45.0	50.4	56.1	61.9	67.8	4.0	0.0	0.0	-0.7	-0.3

Thermal efficiency

	%								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**37.1**	**37.1**	**41.9**	**43.8**	**46.0**	**48.6**	**51.3**	**53.7**	**0.5**	**0.9**	**1.0**	**1.0**	**1.0**
Coal	36.9	36.5	37.1	37.5	38.8	40.4	42.0	43.2	0.0	0.2	0.7	0.7	0.6
Oil	41.2	34.5	37.5	37.1	37.6	38.2	38.8	39.3	-0.4	-0.2	0.3	0.3	0.2
Natural gas	36.6	39.9	48.8	51.5	53.1	55.1	57.0	58.7	1.2	1.1	0.7	0.6	0.7

CO_2 Emissions

	Mt-C								Share, %								AAGR (%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
Total	**1,314.7**	**1,532.0**	**1,382.9**	**1,298.0**	**1,186.1**	**1,094.1**	**998.8**	**902.2**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**0.2**	**-1.3**	**-1.7**	**-1.9**	**-1.7**
Coal	497.1	576.3	404.1	344.9	280.7	230.8	185.0	140.1	37.8	37.6	29.2	26.6	23.7	21.1	18.5	15.5	-0.8	-3.1	-3.9	-4.9	-4.1
Oil	545.6	615.8	574.4	548.5	500.6	455.3	410.4	372.6	41.5	40.2	41.5	42.3	42.2	41.6	41.1	41.3	0.2	-0.9	-1.8	-2.0	-1.7
Natural gas	272.0	339.8	404.4	404.6	404.8	408.0	403.4	389.5	20.7	22.2	29.2	31.2	34.1	37.3	40.4	43.2	1.6	0.0	0.1	-0.5	-0.2

Energy and economic indicators

									AAGR(%)				
	1990	2000	2015	2020	2025	2030	2035	2040	1990-2015	2015-2020	2020-2030	2030-2040	2015-2040
GDP (billions of 2010 US dollars)	9,064	12,713	16,598	18,394	20,260	22,629	25,118	27,677	2.4	2.1	2.1	2.0	2.1
Population (millions of people)	250	282	321	333	345	356	367	376	1.0	0.7	0.7	0.5	0.6
GDP per capita (thousands of 2010 US$/person)	36.31	45.06	51.64	55.24	58.8	63.5	68.5	73.6	1.4	1.4	1.4	1.5	1.4
Primary energy consumption per capita (toe/person)	7.67	8.06	6.81	6.43	6.05	5.71	5.36	5.08	-0.5	-1.1	-1.2	-1.2	-1.2
Primary energy consumption per unit of GDP (toe/million 2010 US dollars)	211	179	132	116	103	90	78	69	-1.9	-2.5	-2.5	-2.6	-2.6
Final energy consumption per unit of GDP (toe/million 2010 US dollars)	143	122	92	82	73	64	56	50	-1.8	-2.2	-2.4	-2.5	-2.4
CO_2 emissions per unit of GDP (t-C/million 2010 US dollars)	145	121	83	71	59	48	40	33	-2.2	-3.3	-3.7	-3.9	-3.7
CO_2 emissions per unit of primary energy consumption (t-C/toe)	0.69	0.67	0.63	0.61	0.57	0.54	0.51	0.47	-0.3	-0.8	-1.2	-1.3	-1.2
Automobile ownership volume (millions of vehicles)	189	221	255	267	278	292	306	319	1.2	0.9	0.9	0.9	0.9
Automobile ownership volume per capita (vehicles per person)	0.756	0.785	0.793	0.801	0.805	0.819	0.834	0.849	0.2	0.2	0.2	0.4	0.3