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 km^2)1	Population (million)	Population Density (persons/km^2)	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

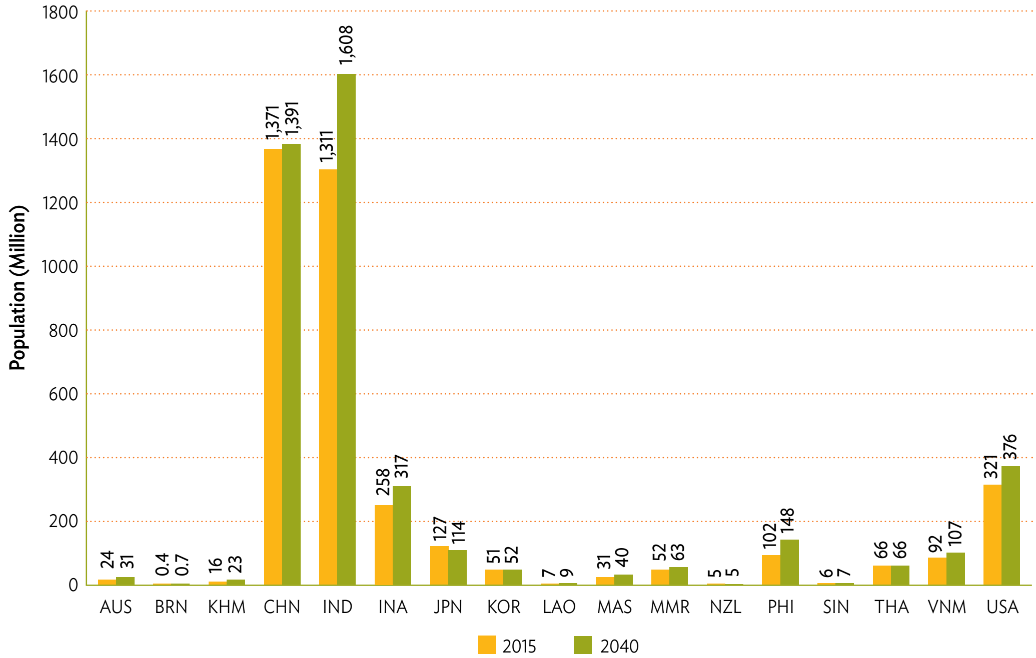
In the models used for this study, changes in population to 2040 are set exogenously. No difference in population between the BAU scenario and the APS is assumed. The EAS17 countries, except China, submitted assumed changes in population based on the population projections from the United Nations.

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.

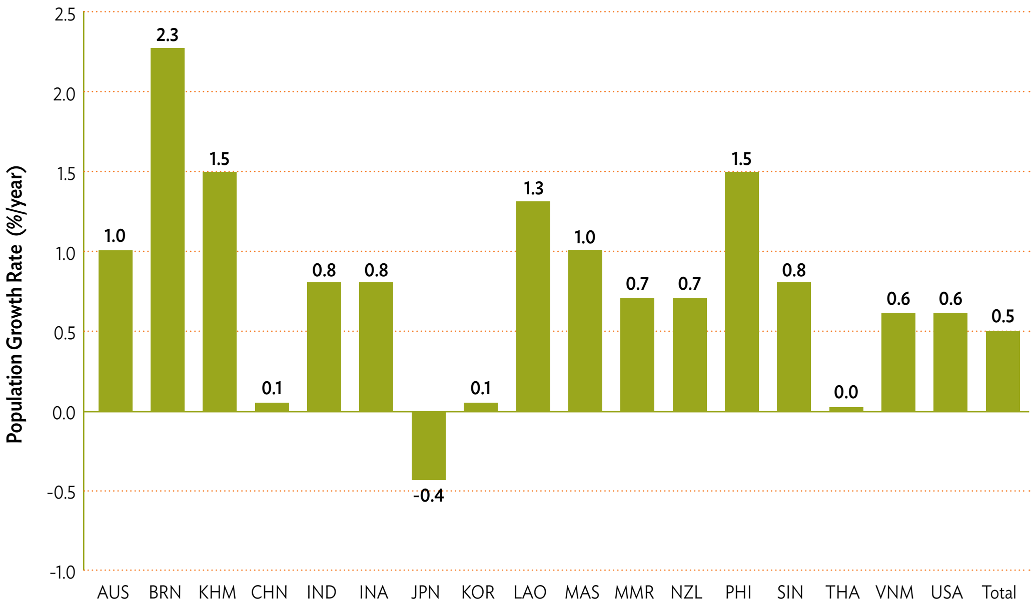
Figure 1.1: Assumed Population in the EAS17 Region, 2015 and 2040



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



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Source: World Bank (2018).

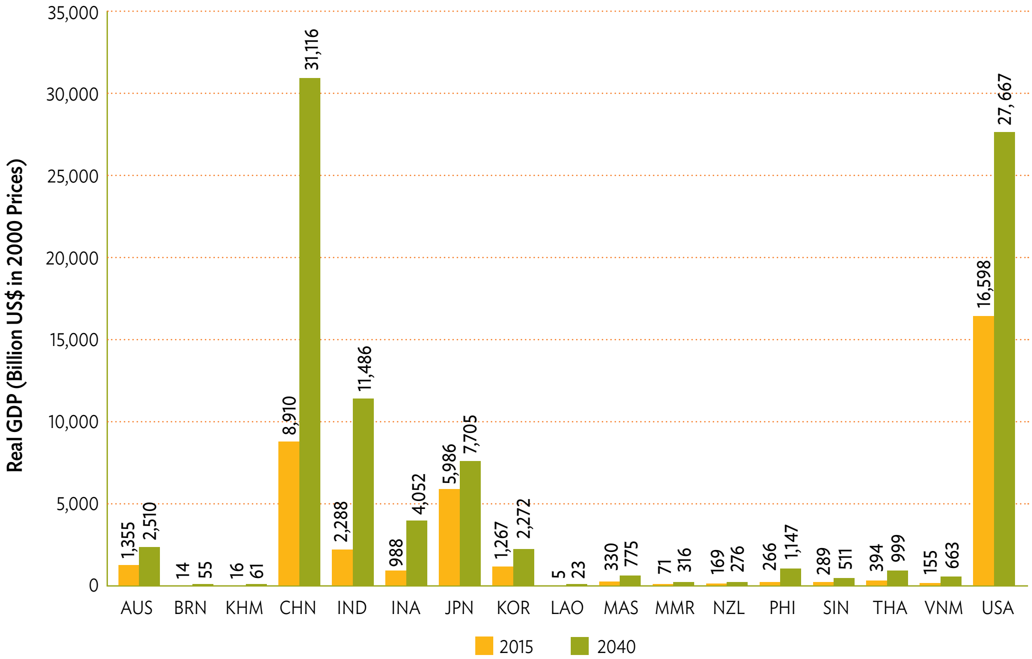
3.2. Economic Activity

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

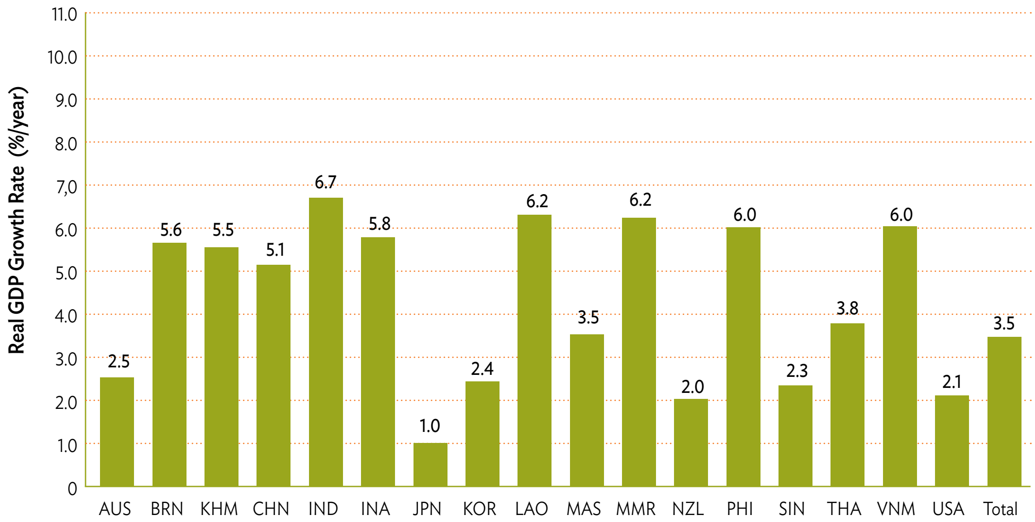


AUS = Australia, BRN = Brunei, KHM = Cambodia, CHN = China, EAS = East Asia Summit, GDP = gross domestic product, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam,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

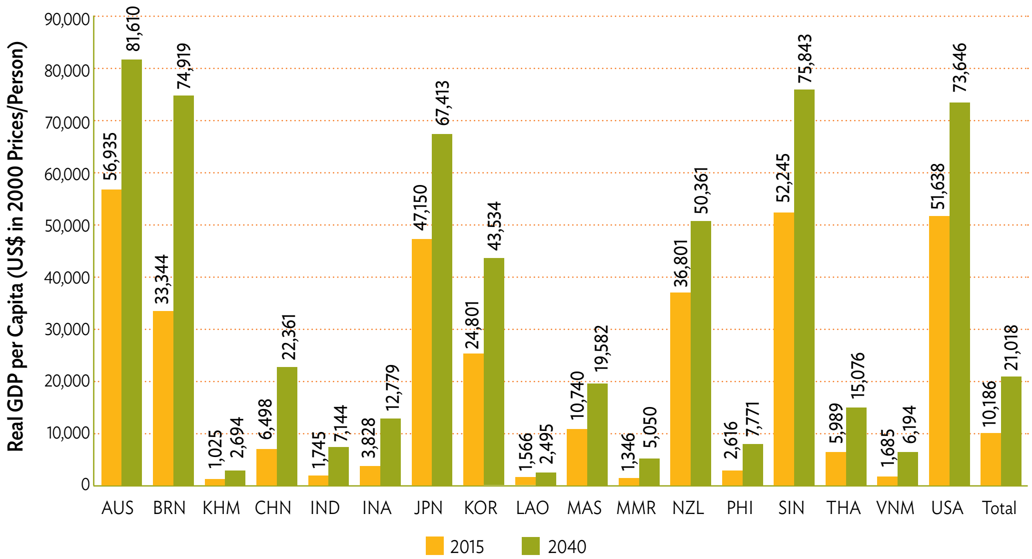


AUS = Australia, BRN = Brunei, KHM = Cambodia, CHN = China, GDP = gross domestic product, IND = India, INA = Indonesia, JPN = Japan, KOR = Korea, LAO = Lao PDR, MAS = Malaysia, MMR = Myanmar, NZL = New Zealand, PHI = Philippines, SIN = Singapore, THA = Thailand, VNM = Viet Nam, USA = United States of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



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Source: World Bank (2018).

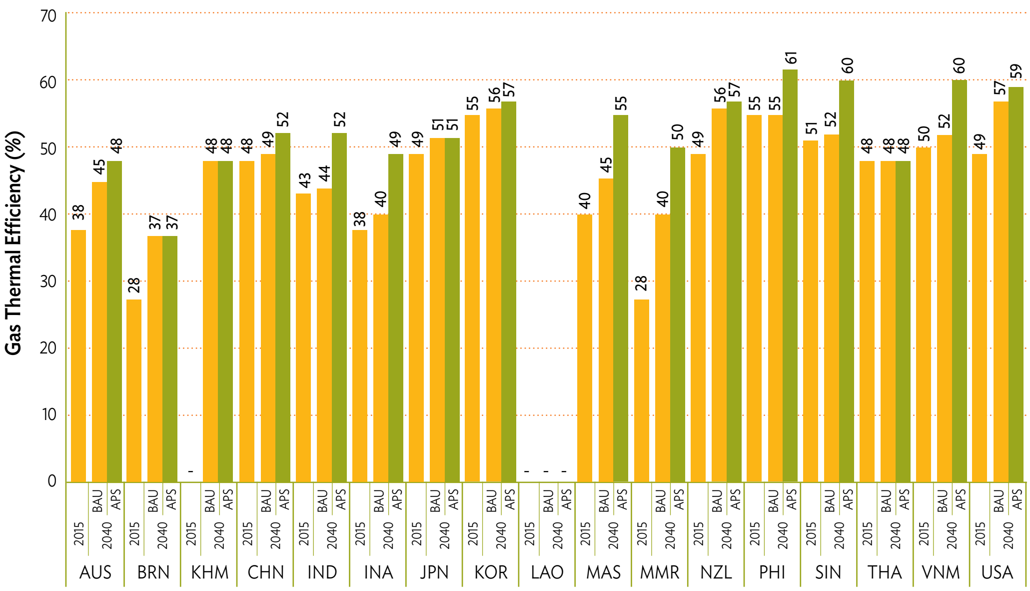
3.3. Electricity Generation

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).

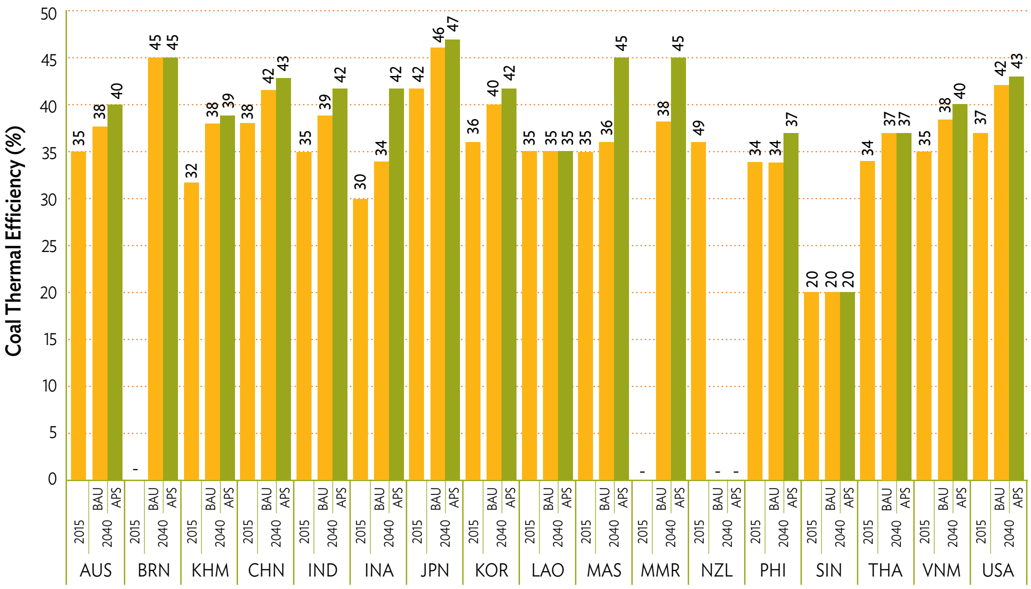
Figure 1.6: Thermal Efficiencies of Gas Electricity Generation



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



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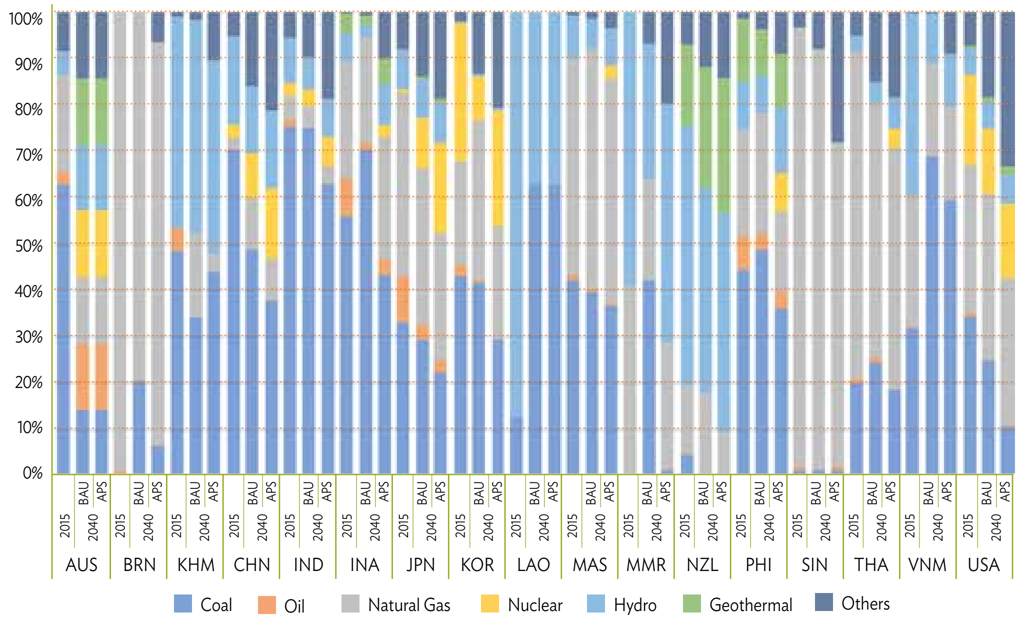
Source: Long-range Energy Alternatives Planning System (LEAP)'s database.

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



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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.

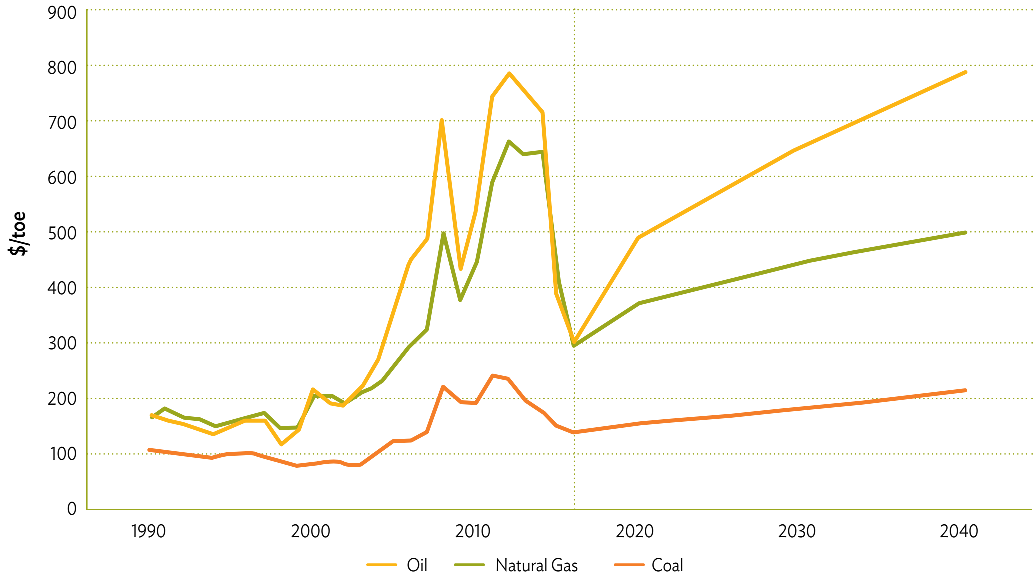
Source: Country Energy Saving Potential Report, sub-report of this main report (2018).

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

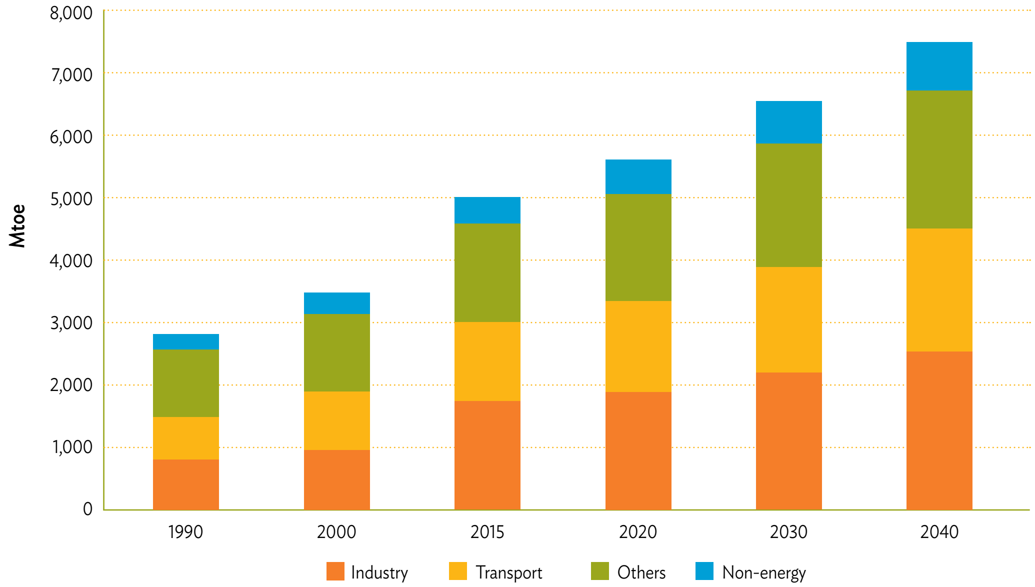
4.1. Business-As-Usual Scenario

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.

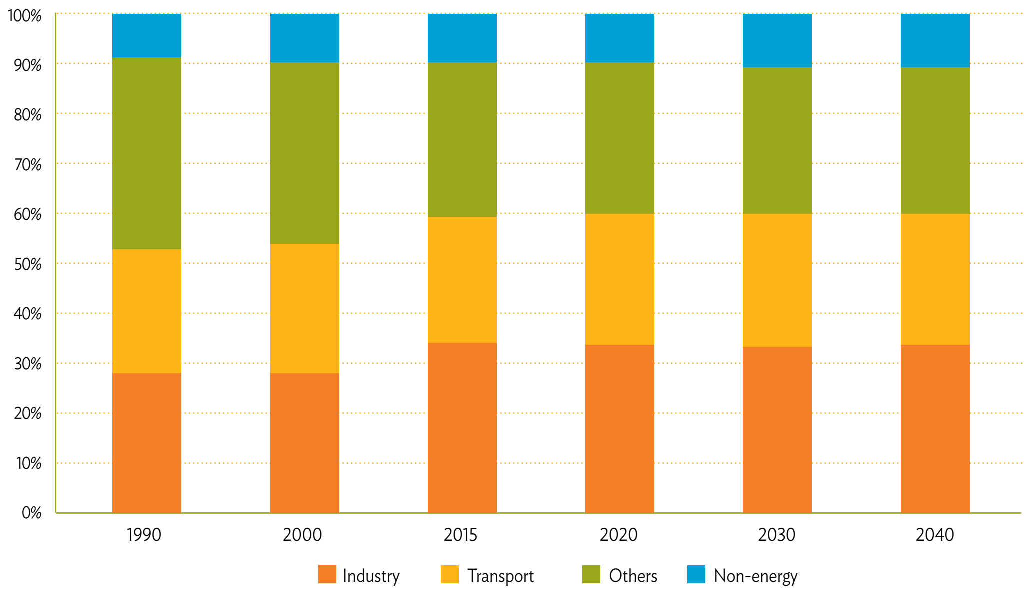
Figure 1.10: Final Energy Consumption by Sector, BAU (1990–2040)



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

Source: Authors' calculation.

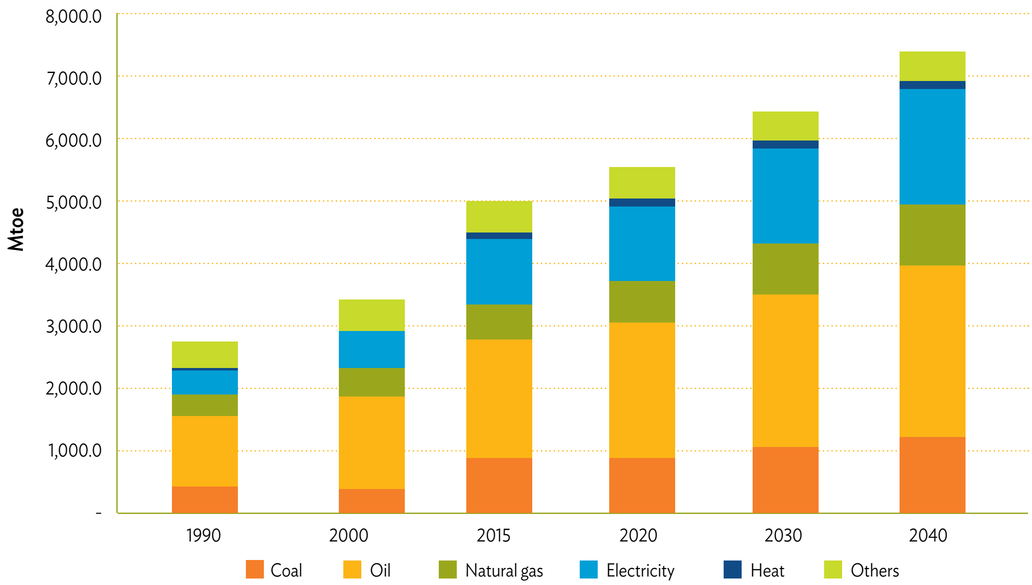
Figure 1.11: Final Energy Consumption Share by Sector (1990–2040)



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.

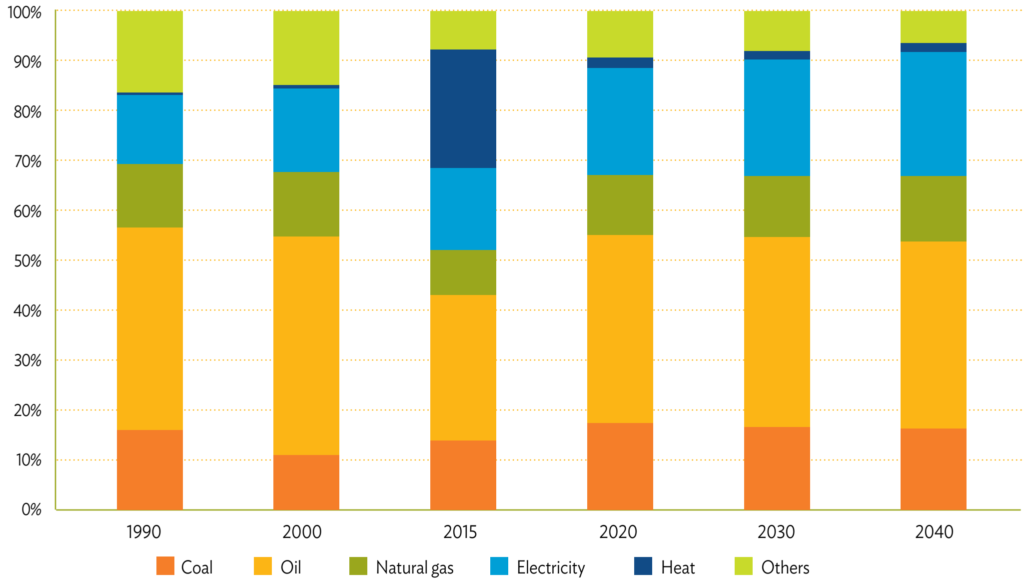
Figure 1.12: Final Energy Consumption by Fuel Type (1990–2040)



Mtoe = million tons of oil equivalent.

Source: Authors' calculation.

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



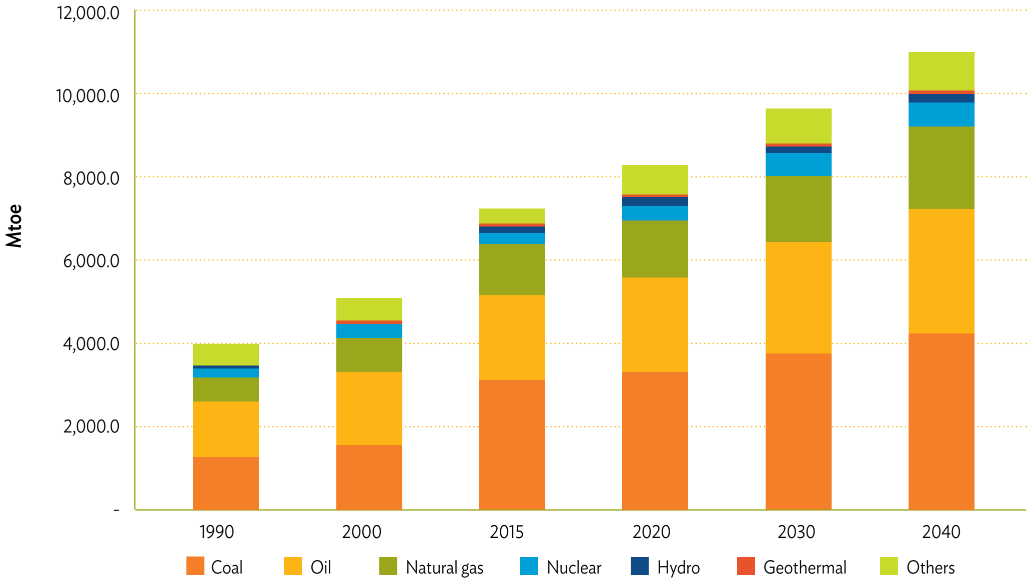
Source: Authors' calculation.

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)



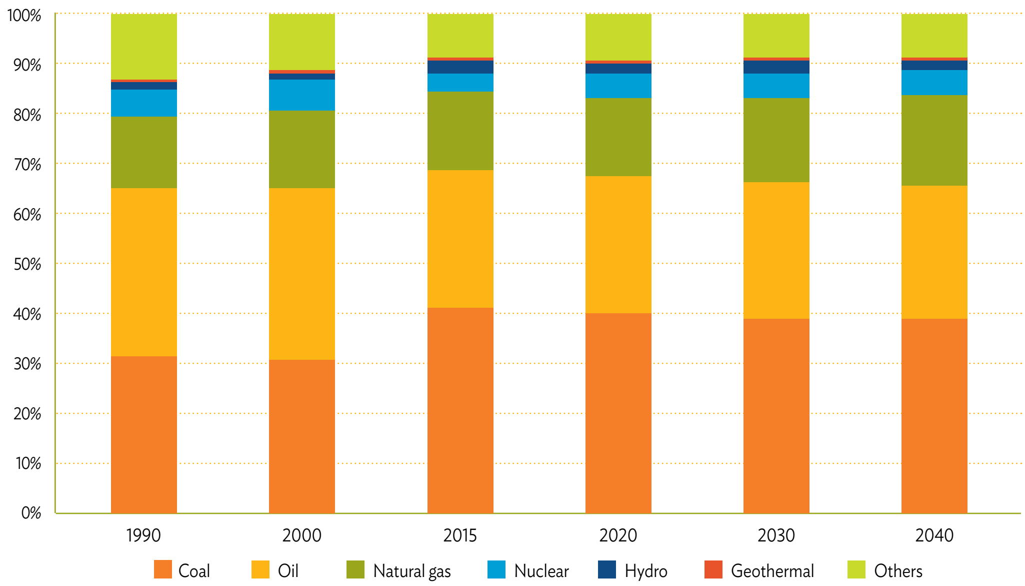
EAS = East Asia Summit , Mtoe = million tons of oil equivalent.

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)

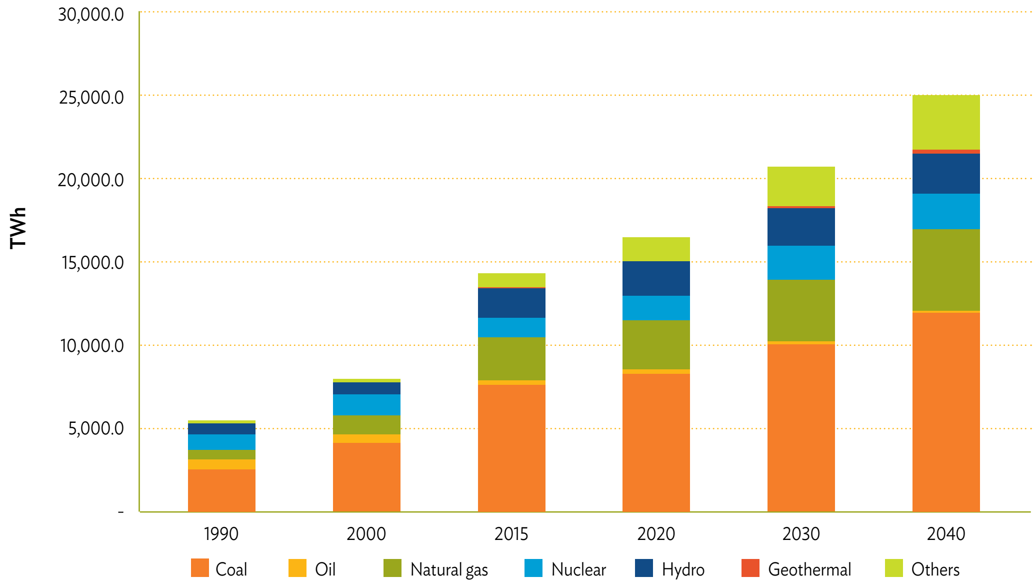


Source: Authors' calculation.

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)

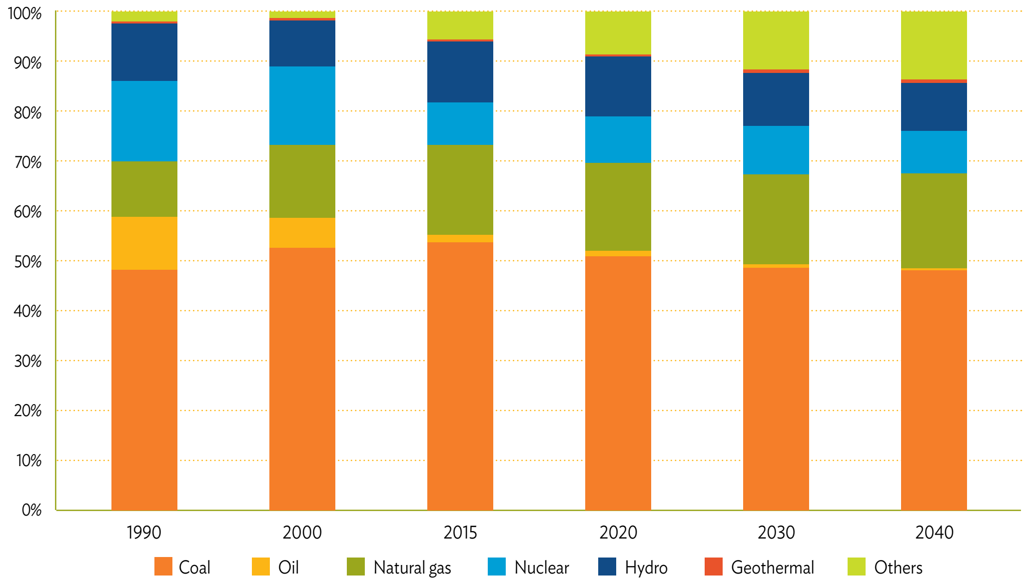


EAS = East Asia Summit, TWh = terawatt-hour.

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)

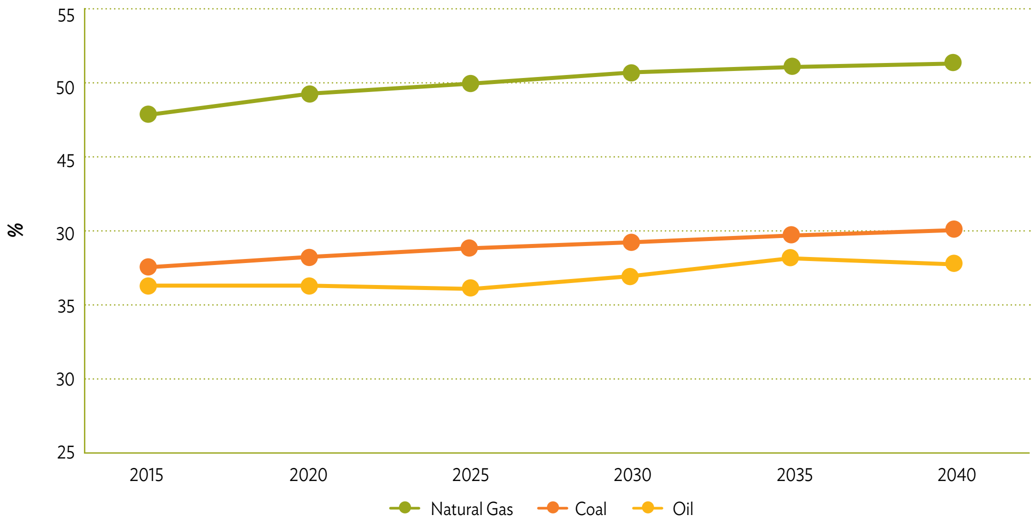


EAS = East Asia Summit.

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.

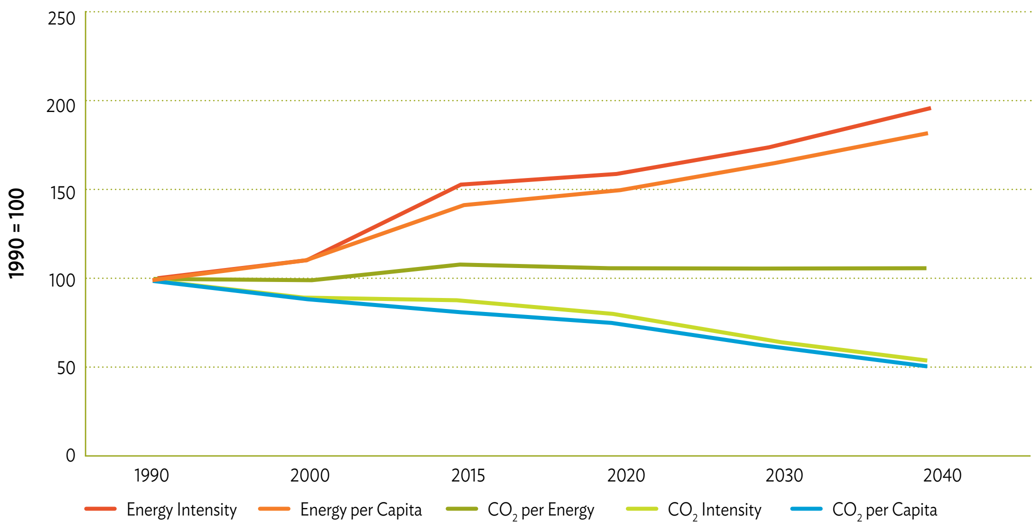
Source: Authors' calculation.

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.

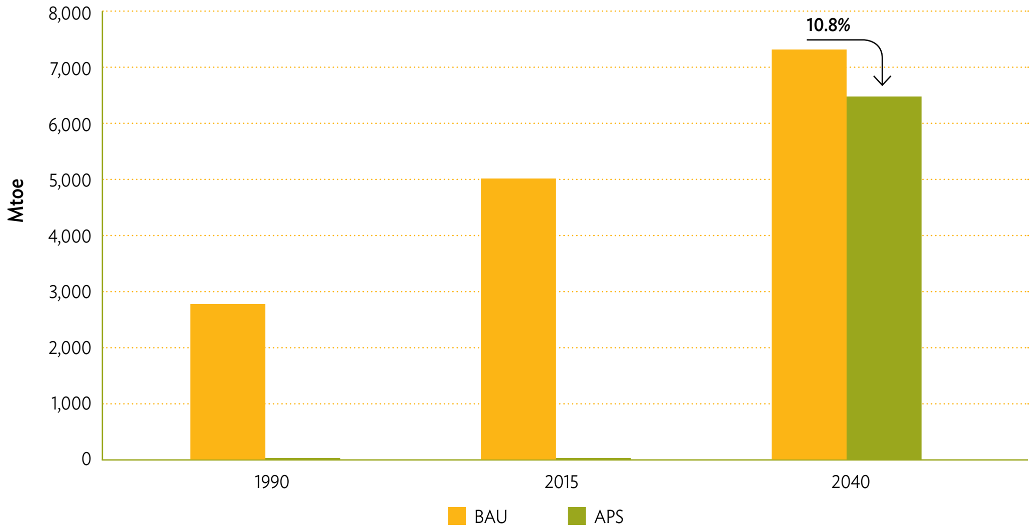
Source: Authors' calculation.

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

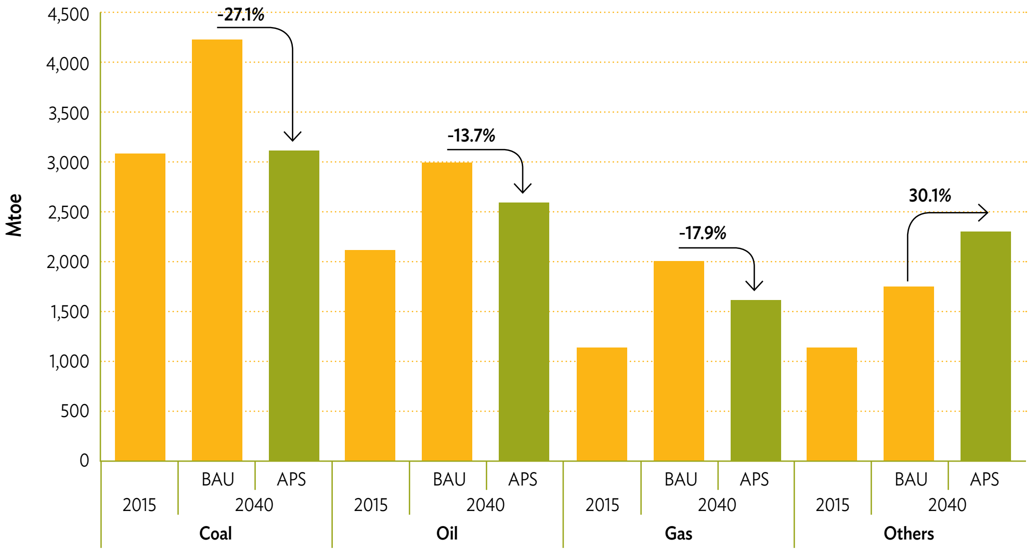
APS = Alternative Policy Scenario , BAU = Business-As-Usual .

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..

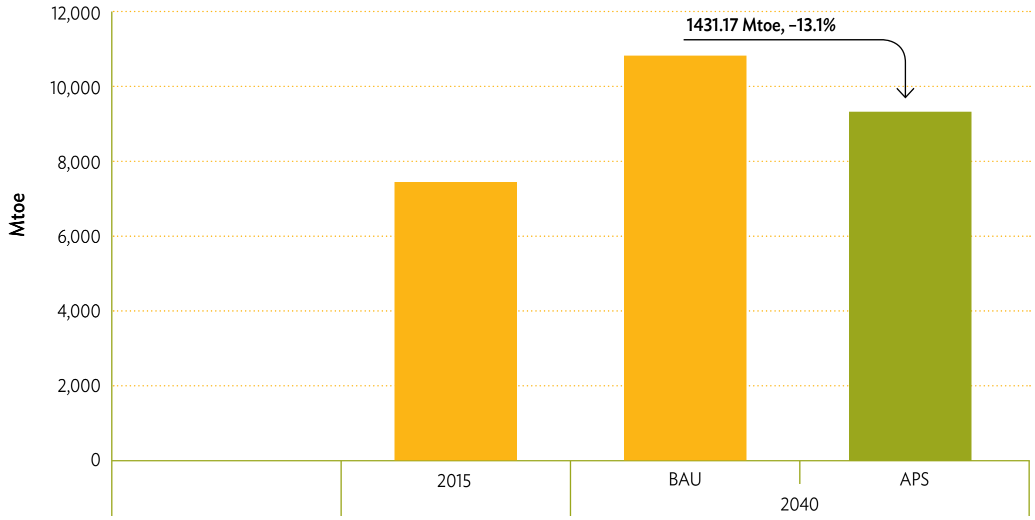
Source: Authors' calculation.

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

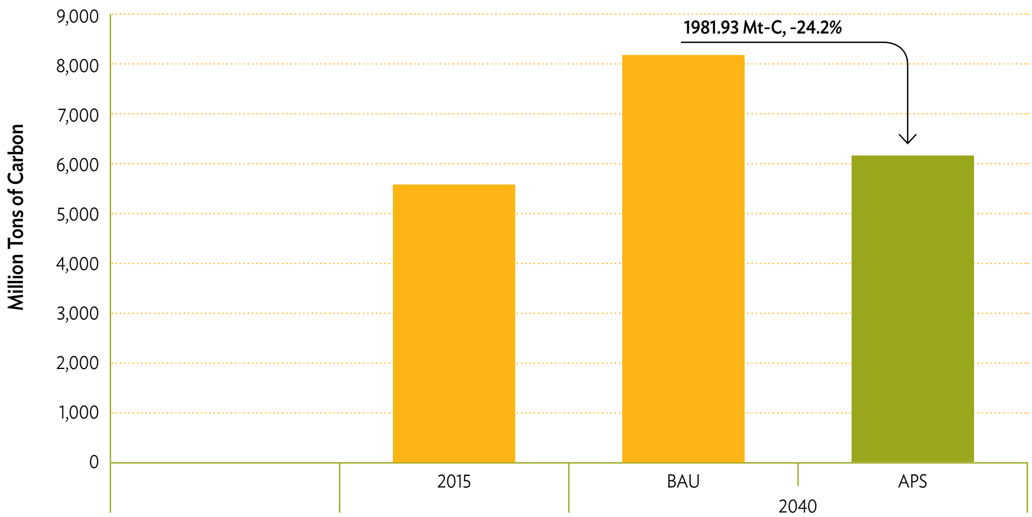
CO_2 emissions from energy consumption in the BAU scenario are projected to increase from 5,660 million tons of carbon (Mt-C) in 2015 to 8,189 Mt-C in 2040, implying an average annual growth rate of 1.5% (Figure 1.24). This is the same growth rate of TPES of 1.5% per year. In the APS, CO_2 emissions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

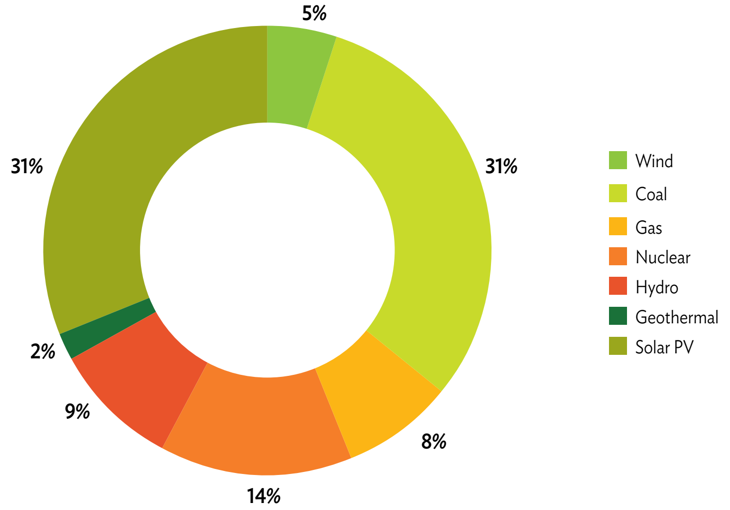
4.5. Necessary Investment Cost

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.

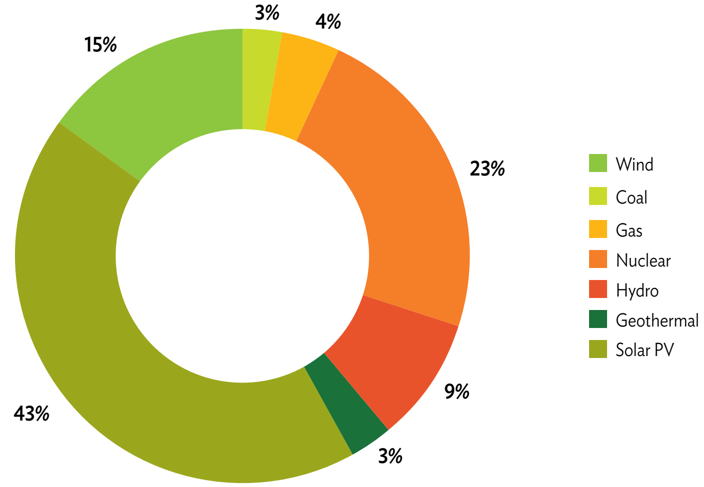
Figure 1.25: Investment Share by Power Source (EAS17-BAU)



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

Source: Authors' calculation.

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

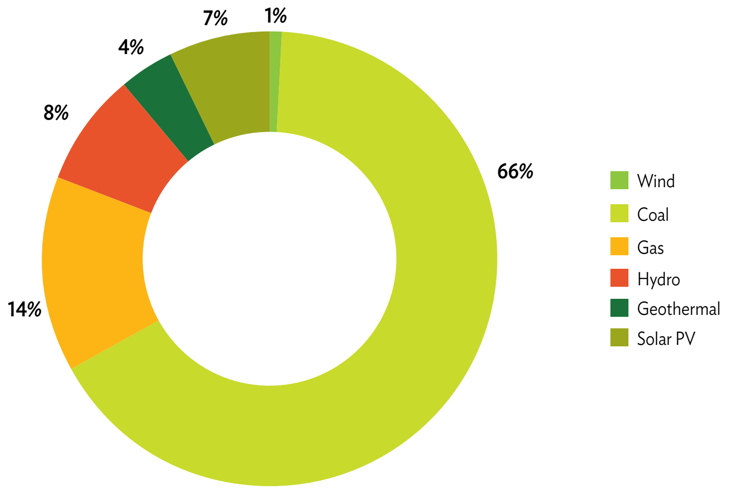


APS = Alternative Policy Scenario, EAS = East Asia Summit, PV = photovoltaic.

Source: Authors' calculation.

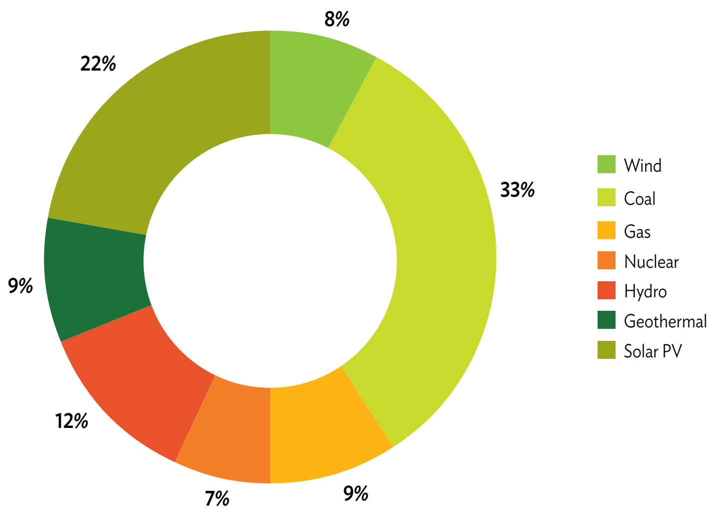
Figure 1.27 shows the investment needs of the 10 ASEAN Member States. ASEAN would account for about US$432 billion for the BAU scenario, and about US$440 billion in the APS. The investment shares by power generation source are different between the BAU scenario and the APS. Investment in coal and gas 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)

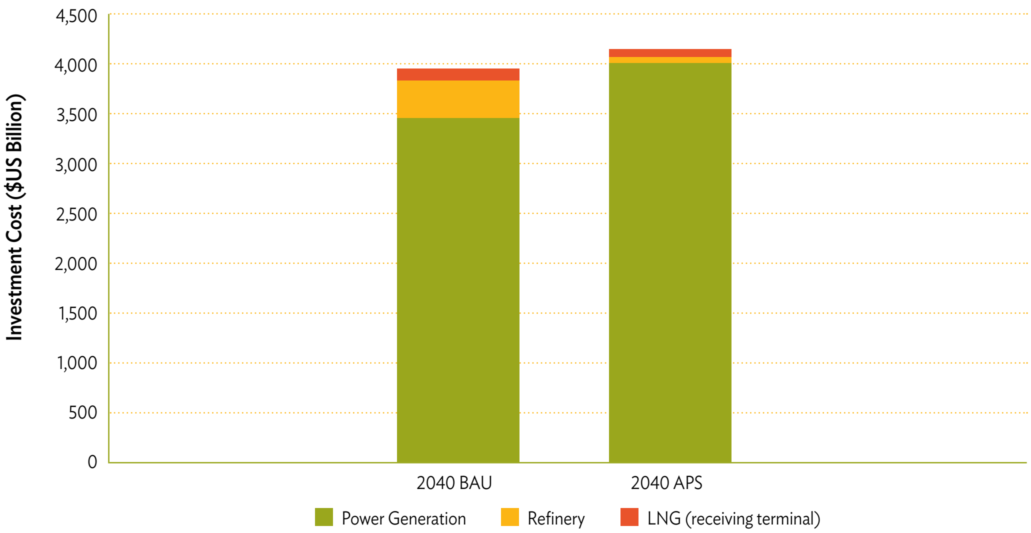


APS = Alternative Policy Scenario, ASEAN = Association of Southeast Asian Nations, PV = photovoltaic.
Source: Authors' calculation.

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)

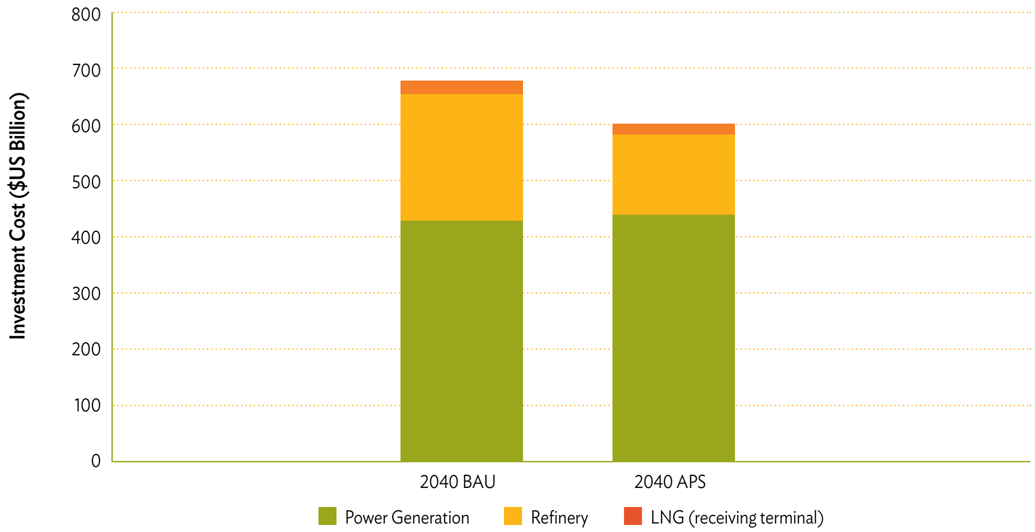


APS = Alternative Policy Scenario, BAU = Business-As-Usual, EAS = East Asia Summit, LNG = liquefied natural gas.

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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