Energy Outlook and Energy Saving Potential in East Asia

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June 2015

Economic Research Institute for ASEAN and East Asia

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.

The findings, interpretations, and conclusions expressed herein do not necessarily reflect the views and policies of the Economic Research Institute for ASEAN and East Asia, its Governing Board, Academic Advisory Council, or the institutions and governments they represent.

Preface

Energy security and climate change are very important issues in the world. At the 2nd 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 by 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). ECTF is responsible for supporting the efforts of the EAS and its Energy Ministers Meeting (EMM) to promote cooperation on policies to implement these countermeasures. ERIA is responsible for studying the potential impacts of the countermeasures and is focusing on 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 2014 to May 2015, including methodology, estimated impacts of current energy saving goals, and policy recommendations to the ECTF. This report extends and enhances the analysis of the Working Group undertaken annually from 2007 to 2013.

The structure of this report is similar to the previous versions 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 these 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 saving of a range of energy efficiency goals, action plans, and policies. A number of key insights for policy development are also discussed.

Mr Shigeru Kimura
Leader of the Working Group
2015

Acknowledgements

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

Special acknowledgement also goes to Ms Cecilya L. Malik of Indonesia, Mr Danilo Vivar of the Philippines, and Mr Yanfei Li and Mr Phoumin Han of ERIA for their contributions in editing this report.

This study could not have been realised without the invaluable support and contribution provided by many people (please see details in the List of Project Members).

Special thanks go to Ms Maria Priscila del Rosario, chief editor and publication director of ERIA, and her team of editors and publishing staff for helping edit the report and prepare it for publication.

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Contents

List of Tables

Chapter 1

Chapter 2

List of Figures

Chapter 1

List of Abbreviations and Acronyms

ANRE	Agency for Natural Resources and Energy
APS	Alternative Policy Scenario
ASEAN	Association of Southeast Asian Nations
BAU	Business as Usual
BREE	Bureau of Resources and Energy Economics
CCS	carbon capture and storage
CCT	clean coal technology
CDM	Clean Development Mechanism
CNG	compressed natural gas
CO_2	carbon dioxide
EAS	East Asia Summit
ECTF	Energy Cooperation Task Force
EEC	energy efficiency and conservation
EAS	East Asia Summit
EMM	EAS Energy Ministers Meeting
ERIA	Economic Research Institute for ASEAN and East Asia
FiT	feed-in-tariff
GCV	gross calorific value
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
IEEJ	The Institute for Energy Economics, Japan
IPCC	Intergovernmental Panel for Climate Change
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LDV	light duty vehicles
LEAP	Long-range Energy Alternative Planning System
LEDS	Long-Term Energy Demand System
LET	low emission technologies

LPG	liquefied petroleum gas
METI	Ministry of Economy, Trade and Industry
Mtoe	million tonnes of oil equivalent (1 Mtoe = 41.868 PJ)
Mt C	million tonnes carbon (may be converted to million tonnes of CO_2 by multiplying by 44/12)
MW	megawatts
MWh	megawatt-hour
NCV	net calorific value
OECD	Organisation for Economic Co-operation and Development
RPS	Renewable Portfolio Standards
SWG	Sub-Working Group
toe	tonnes of oil equivalent
t C	tonnes of carbon
TPES	Total Primary Energy Supply
TWh	terawatt-hour
US$	United States dollar
WG	Working Group

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CHAPTER 1

Main Report on Energy Outlook and Saving Potential in the East Asia Region

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1. Introduction

Responding to the Cebu Declaration on East Asia Energy Security on 15 January 2007 announced by the leaders of the 16 countries of the East Asia Summit (EAS), the EAS Energy Cooperation Task Force (ECTF) was established and one of the agreed areas for cooperation was energy efficiency and conservation (EEC). Japan proposed to undertake a study on energy savings and CO_2 emission reduction potential in the EAS region. The study would quantify total potential savings under the individual energy efficiency goals, action plans, and policies of each country above and beyond Business As Usual.[1] The study would provide insights for national energy ministers to help them establish goals, action plans, and policies for improving energy efficiency in their respective countries. The first study was undertaken in 2007 and was updated annually to incorporate more recent information on member countries' energy saving potentials and energy efficiency goals, action plans, and policies. The 2013 study was updated again to undertake the following:

- Reflect the energy efficiency goals and actions plans submitted by the energy ministers during the 8th EAS Energy Minister's Meeting (EMM) held in Vientiane, Lao PDR on 24 September 2014 in the latest energy outlook until 2035; and
- Determine the impacts of various energy policies aimed at reducing energy demand and CO_2 emissions as follows:
    a. Improving energy efficiency in final energy consumption;
    b. Improving efficiency in thermal electricity generation;
    c. Increasing the utilisation of new and renewable energy in electricity generation and transportation sector; and
    d. Introduction or increasing the utilisation of nuclear power
- Carry out additional studies affecting energy consumption as follows:
    a. Pilot survey on road transport sector
    b. Impact of removal of energy subsidies
    c. Energy demand analyses in road transport and residential sectors using the bottom-up approach
    d. Cost–benefit analysis of clean coal technology (CCT)

[1] Ministry of Economy, Trade and Industry (METI) (2007), 'EAS Cooperation on Energy Efficiency and Conservation', submitted to the 3rd ECTF Meeting held in Tokyo in June 2007.

e. Study on renewable energy in electricity generation using optimisation analysis

This is the report of that study.

The Cebu Declaration outlined the potential energy challenges the region could face in the future driven by a number of factors including: the limited global reserves of fossil energy, fluctuating world fuel oil prices, worsening energy related environmental and health issues, and the urgent need to address climate change.[2]

For these reasons, the EAS leaders resolved to enhance regional cooperation in various areas to achieve: improved energy efficiency and environmental performance of fossil fuel use and reduced dependence on conventional fuels through intensified energy efficiency and conservation programmes; increase share of hydropower; and expansion of renewable energy, biofuels, and civilian nuclear power.

1.1. The East Asia Summit

The EAS is a collection of diverse countries, with wide variations amongst them in terms of per capita income, standards of living, population density, energy resource endowments, climate, and energy consumption per capita. It is composed of the 10 member countries of the Association of Southeast Asian Nations (ASEAN) – Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam, and six other countries – Australia, China, India, Japan, Republic of Korea (henceforth, South Korea), and New Zealand.[3]

Whereas some EAS countries have what might be called mature economies, the majority have developing economies. Several countries have a per capita gross domestic product (GDP) of less than US$1,000 (in 2005 prices[4]). 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 the latter countries still meet their energy needs mainly with traditional biomass fuels.

These differences partly explain why energy efficiency and conservation goals, action plans, and policies are assigned different priorities across countries. Countries with developed economies may be very keen to reduce energy consumption, developing countries tend to put more emphasis on economic growth and improving standards of living. However, as the economies of these countries grow, it should be expected that energy consumption per capita would grow as well.

Despite the differences amongst the 16 countries, the EAS leaders agreed that the EAS 'could play a significant role in community building', which could be an important cornerstone for the development of regional cooperation in the years to come[5].

[2] ASEAN Secretariat (2007), *Cebu Declaration on East Asian Energy Security 2007*. Jakarta: http://www.aseansec.org/19319.htm (accessed 27 February 2008).
[3] The Ministry of Foreign Affairs of Japan (2005), *Kuala Lumpur Declaration on the East Asia Summit, 2005*. Tokyo: http://www.mofa.go.jp/region/asia-paci/eas/joint0512.html (accessed 27 February 2008).
[4] All US$ (US dollars) in this document are stated at constant year 2005 values unless specified.
[5] The Ministry of Foreign Affairs of Japan (2005), '*Prime Minister Junichiro Koizumi Attends the EAS, ASEAN+3, and Japan-ASEAN Summit Meetings', (Overview and Preliminary Evaluation*), 2005. Tokyo: http://www.mofa.go.jp/region/asia-paci/eas/summary0512.html (accessed 28 February 2008)

Table 1-1 shows the geographic, demographic, and economic profiles of the 16 EAS countries. Table 1-2 shows their economic structure and energy consumption profiles.

Table 1-1. Geographic, Demographic, and Economic Profiles, 2012

	GDP (Billion 2005US$)	Share of Industry In GDP, %[1]	Share of Services in GDP, %[1]	Share of Agriculture in GDP, %[1]	Primary Energy Consumption (Mtoe)	Energy Consumption per Capita (toe/person)
Australia	845.9	28.2	69.3	2.4	128.3	5.7
Brunei Darussalam	10.3	71.1	28.2	0.7	2.9	7.0
Cambodia	10.0	24.4	40.1	35.6	5.8	0.4
China	4,523.6	45.3	44.6	10.1	2,894.3	2.1
India	1,394.5	31.9	50.0	18.0	788.1	0.6
Indonesia	427.6	46.8	38.7	14.5	219.5	0.9
Japan	4,708.6	25.6	73.2	1.2	452.3	3.5
Korea, Rep. of	1,077.9	38.1	59.5	2.5	263.4	5.3
Lao PDR	4.3	36.0	35.9	28.1	2.6	0.4
Malaysia	198.4	40.8	49.2	10.0	69.0	2.4
Myanmar	23.1	16.2	35.4	48.4	15.6	0.3
New Zealand	148.3	23.8	69.1	7.2	20.1	4.5
Philippines	145.2	31.2	56.9	11.8	42.3	0.4
Singapore	191.8	26.7	73.3	0.0	22.9	4.3
Thailand	226.4	43.6	44.2	12.3	117.7	1.8
Viet Nam	87.5	38.6	41.7	19.7	61.2	0.7

GDP = gross domestic product.

[1] Information on the land area of Cambodia, Indonesia, and Japan were provided by the Energy Saving Potential Working Group members from these countries.

Source: World Bank (2014), Washington, DC: World Bank. http://databank.worldbank.org/ddp/home.do (accessed November 2014); United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014) and Government of Cambodia.

Table 1-2. Economic Structure and Energy Consumption, 2012

	Land Area (thousand sq.km.)[1]	Population (million)	Population Density (persons/ sq.km.)	GDP (Billion 2005US$)	GDP per Capita (2005US$/ person)
Australia	7,682	22.6	2.9	845.9	37,368
Brunei Darussalam	5.3	0.4	78.2	10.3	24,951
Cambodia	181	14.9	82.1	10.0	672
China	9,327	1,350.7	144.8	4,523.6	3,349
India	2,973	1,236.7	415.9	1,394.5	1,128
Indonesia	1,911	246.9	129.2	427.6	1,732
Japan	378	127.8	338.1	4,708.6	36,838
Korea, Rep. of	97	50.0	515.0	1,077.9	21,556
Lao PDR	231	6.5	28.2	4.3	667
Malaysia	329	29.2	89.0	198.4	6,786
Myanmar	653	52.8	80.8	23.1	437
New Zealand	263	4.4	16.8	148.3	33,444
Philippines	298	96.7	324.3	145.2	1,501
Singapore	0.7	5.3	7,588.6	191.8	36,107
Thailand	511	66.8	130.7	226.4	3,390
Viet Nam	310	87.5	282.3	87.5	1,000

GDP = gross domestic product.
Note: [1] Sectoral shares to GDP of Myanmar and New Zealand are 2004 and 2009 values, respectively.
Source: World Bank (2014), World Databank. Washington, DC: World Bank. http://databank.worldbank.org/ddp/home.do (accessed November 2014); International Energy Agency (IEA) (2014), Energy Balances of Organisation for Economic Co-operation and Development (OECD) Countries 2012 and Energy Balances of Non-OECD Countries 2012, Paris; and United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

1.2. Rationale

The rationale of this study is derived from the Cebu Declaration[6], which highlighted a number of goals including the following:

- improving the efficiency and environmental performance of fossil fuel use;
- reducing the dependence on conventional fuels through intensified energy efficiency and conservation programmes, increase share of hydropower, expansion of renewable energy systems and biofuel production/utilisation, and for interested parties, civilian nuclear power; and
- mitigating greenhouse gas emissions through effective policies and measures, thus contributing to global climate change abatement.

To be able to design an action plan or policy measures to reduce energy consumption, projections of energy consumption by sector are required. Hence, Japan suggested the preparation of an energy outlook for the EAS region, including an estimate of the energy savings and CO_2 emission reduction potential if current and proposed national energy efficiency and conservation goals, action plans, and policies could be implemented as planned by the EAS countries.

The Economic Research Institute for ASEAN and East Asia (ERIA) approved the proposal of the Japanese government to conduct a study on energy saving and CO_2 emission reduction potentials in the East Asia Region. As a result, the Working Group for the Analysis of Energy Savings Potential was convened. Members from all of the 16 EAS countries are represented in the Working Group, with Mr. Shigeru Kimura of the Institute of Energy Economics, Japan (IEEJ) as the leader of the group.

1.3. Objective

The objective of this study is to analyse the potential impacts of proposed additional energy saving goals, action plans, and policies in the East Asia Summit region on energy consumption by fuel and sector and greenhouse gas emissions.

Specifically, a Business-as-Usual (BAU) scenario was developed for each country outlining future sectoral and economy-wide energy consumption assuming no significant changes to government policies. An Alternative Policy Scenario (APS) was also designed to examine the potential impacts if additional energy efficiency goals, action plans, or policies were developed that are currently, or likely to be, under consideration. Increased

[6] ASEAN Secretariat (2007), *Cebu Declaration on East Asian Energy Security (2007).* Jakarta: http://www.aseansec.org/19319.htm (accessed 27 February 2008).

uptake of renewable energy sources – including liquid biofuels – and nuclear energy as well as utilisation of more efficient thermal power plant technologies were also considered in the APS. The difference between the BAU scenario and the APS in both final and primary energy consumption represents potential energy savings. The difference in CO_2 emissions between the two scenarios represents the greenhouse gas emission reduction potential.

In addition, collaboration between EAS countries on energy modelling and policy development was a key objective of the Working Group.

1.4. Working Group Activities in 2014

In 2014, the Working Group continued to assess energy saving potentials in the EAS region, using the goals, action plans, and policies reported at the 7th EAS Energy Ministers Meeting (EAS–EMM7). The Working Group in 2014 enhanced and extended the analysis that had been undertaken from 2007 to 2013. The Working Group conducted three meetings – one in Chiang Mai on 15–17 October 2014, one in Phnom Penh on 13–15 January 2015, and another one in Jakarta on 26–27 March 2015.

During the first meeting, the Working Group discussed and developed the 2014 research plan and provided updates on revised energy saving goals, action plans, and policies that each EAS country reported in 2014 as well as each of the countries' economic development plans. The research plan included additional studies that were undertaken by Working Group volunteers as follows:

- Impact of removal of energy subsidies;
- Energy demand analyses in road transport in Thailand and residential sectors in Cambodia and Viet Nam using the bottom-up approach;
- Cost–benefit analysis of clean coal technology (CCT); and
- A study on renewable energy in electricity generation using optimisation analysis.

During the second meeting, the agenda mainly covered the review of energy outlook models of each of the 16 EAS countries. The progress of the analyses on the additional studies was also reported.

During the third meeting, the Working Group discussed the preliminary energy outlook of each country and the policy implications that could be derived from the outlook results. The Working Group also discussed the reports of additional studies carried out by volunteer Working Group members in 2014.

2. Data and Methodology

2.1. Scenarios Examined

The study continued to examine two scenarios, as in the studies conducted annually from 2007 to 2013 – a BAU scenario reflecting each country's current goals, action plans, and policies; and an APS. The APS included additional goals, action plans, and policies reported at the EAS–EMM7 held in September 2014 in Vientiane, Lao PDR or those that are currently, or likely to be, under consideration.

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. There are still many potential EEC policies and technological options that have not been examined or incorporated in the APS.

In 2014, the APS assumptions were grouped into four – a) more efficient final energy demand (APS1), b) more efficient thermal power generation (APS2), c) higher consumption of new and renewable energy (NRE) and bio-fuels (APS3), and d) introduction or higher utilisation of nuclear energy (APS4). The energy models are able to estimate the individual impacts of these assumptions on both primary energy demand and CO_2 emissions. The combination of these assumptions constitutes the assumptions of the APS.

The assumptions in APS1 are the reduction targets in sectoral final energy demand assuming that 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 emission in proportion to the reduction in final energy demand.

In APS2, the utilisation of more efficient thermal power plant technologies in the power sector is assumed. This assumption resulted in lower primary energy consumption and CO_2 emission in proportion to the efficiency improvement in the thermal power generation. The most efficient coal and natural gas combined-cycle technologies are assumed to be utilised for new power plant construction in this scenario.

In APS3, higher contributions of NRE for electricity generation and utilisation of liquid biofuels in the transport sector are assumed. This resulted in lower CO_2 emission as NRE is considered carbon-neutral or would not emit additional CO_2 in the atmosphere. However, primary energy consumption may not decrease as NRE, like biomass and geothermal energy, are assumed to have lower efficiencies compared with fossil fuels-fired generation when converting electricity generated from these NRE sources into its primary energy equivalent.

APS4 assumes introduction of nuclear energy or a higher contribution of nuclear energy in countries that are already using this energy source. It is expected that this scenario would produce less CO_2 emission as nuclear energy has minimal CO_2 emission. However, as the assumption of thermal efficiency when converting nuclear energy output to primary energy is only 33 percent, primary energy consumption is not expected to be lower than the BAU in this scenario.

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

In every country, there is still a great deal to be learned from experience about what works and 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. The Definition of Energy Saving Potential and Its Limitations

There are many definitions of energy saving potential, including 'technical potential' (what might be possible with current technology) and 'economic potential' (what might be economic with current technology). However, the outputs of this study do not match any standard definition.

Perhaps the best way around the difficulties in defining 'energy saving potential' is to recognise that a definition is not really necessary. Despite the name given to the Working Group, this study does not really focus on measuring 'energy saving potential' in the abstract. Instead, the focus is on analysing additional energy savings that might be achieved through the energy efficiency and conservation goals, action plans, and policies of individual countries above and beyond BAU. The additional savings are measured as the difference between the BAU and APS scenarios.

2.3. Data

For consistency, the historical energy data used in this analysis came from the International Energy Agency's (IEA) energy balances for Organisation of Economic Co-operation and Development (OECD) and non-OECD countries, except for Australia and Lao PDR. Australian national energy data was converted from Gross Calorific Value (GCV) to Net Calorific Value (NCV) to be consistent with IEA energy balances. Estimations of national energy data from Lao PDR were made using the same methodology as used by the IEA. The socio-economic data for 15 countries were obtained from the World Bank's online World Databank – World Development Indicators (WDI) and Global Development Finance (GDF) – and the data of Myanmar were obtained from the United Nations Statistics Division (UNSD) Statistical Databases. Other data, such as those relating to transportation, buildings, and industrial production indices, were provided by the Working Group members from each EAS country where such data are available. Where official data were not available, estimates were obtained from other sources or developed by IEEJ.

2.4. Methodology

In 2007, the primary model used was the IEEJ World Energy Outlook Model, which is used by IEEJ in the preparation of their *Asia/World Energy Outlook.*[7] In 2014, all of the 10 ASEAN member countries utilised their own energy models. Australia used its own national model as well. The remaining countries provided key assumptions to IEEJ 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. In the next section, brief descriptions of the energy models in this study are provided.

Australia: Australian projections were developed using the country's E_4cast model,[8] a dynamic partial equilibrium framework that provides a detailed treatment of the Australian energy sector focusing on domestic energy use and supply. The Australian energy system is divided into 24 conversion and end use sectors, and fuels comprise 19

[7] Ito et al. (2014).
[8] E4cast is a partial equilibrium model of the Australian energy sector used by ABARE to project Australia's long term energy consumption, production and trade.

primary and secondary fuels with all states and territories represented. Energy demand for each fuel is modelled based on econometrically estimated price and income elasticities.

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 the ten member countries used the LEAP model.

Other countries: Other countries used the IEEJ model, which has a macro-economic module that calculates coefficients for various explanatory variables based on exogenously specified GDP growth rates. The macro-economic 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 the historical data and future parameters are projected using the explanatory variables from the macro-economic 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 is 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.

2.5. Enhancing the 2013 Study

From 2007 to 2013, a study was undertaken annually to assess the potential energy savings in the EAS region that could be achieved through the implementation of energy saving goals, action plans, and policies. Subsequently, this study was revised and extended in 2013 to incorporate more recent information and estimation procedures and incorporate further information about energy saving potentials and energy efficiency goals, action plans, and policies submitted during the EAS–EMM8 in Vientiane, Lao PDR. Specifically, the following new information is incorporated in this study:

- revised recent energy saving goals, action plans, and policies of each country;
- revised GDP growth projections;
- projected future oil prices; and
- results of the additional studies.

3. Socio-economic Indicators and Energy Policies: Assumptions

Growth in energy consumption and greenhouse gas (GHG) emissions is driven by a variety of socio-economic factors. In the EAS 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 EAS region. However, an increase in consumption of energy services is fundamental for achieving a range of socioeconomic development goals.

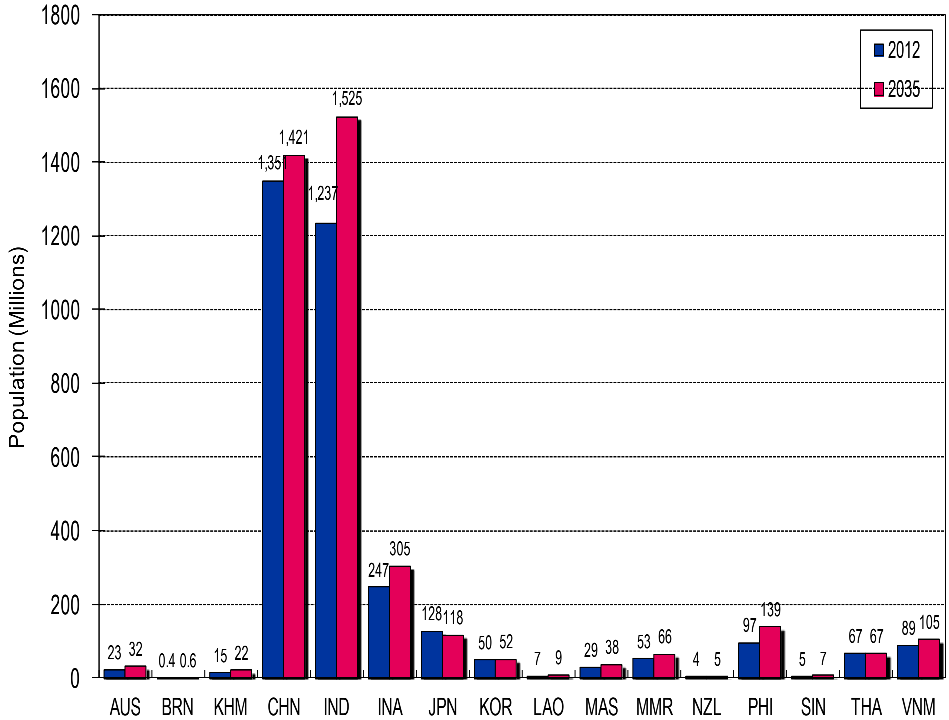
In this section, assumptions regarding key socioeconomic indicators and energy policies until 2035 are discussed for the EAS countries.

3.1. Population

In the models used for this study, changes in population to 2035 are set exogenously. It is assumed there is no difference in population between the BAU scenario and the APS. Assumed changes in population were submitted by the EAS countries, except China, for which the population projections from the United Nations were used.

In 2012, the total population in the EAS region was about 3.4 billion – around 49 percent of total world population. Based on the forecasts, the population in the EAS region is projected to increase at an average annual rate of about 0.6 percent, reaching about 3.91 billion in 2035. Figure-1 shows the 2012 and projected 2035 population by country.

Figure 1-1. Assumed Population in the EAS Region, 2012 and 2035

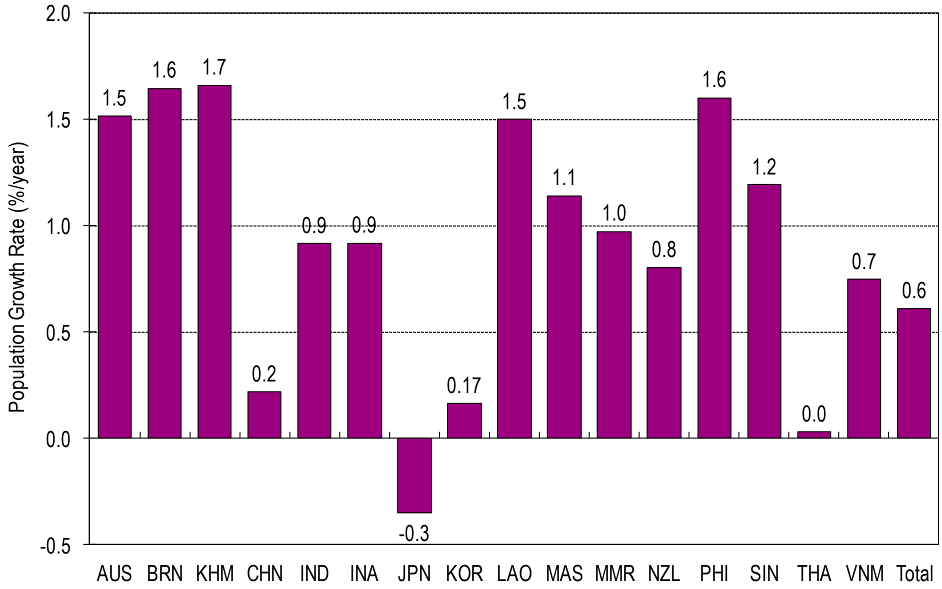


Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

As shown in Figure, population growth is generally assumed to be fastest in developing countries. China and Thailand are notable and significant exceptions, as they are expected to have relatively modest population growth. Nevertheless, by 2035, India and China are assumed to account for over 75 percent of the total population in the EAS region with populations of around 1.5 billion each.

Countries with more mature economies tend to have slower population growth. New Zealand and Singapore are assumed to have low, but still significant, population growth. South Korea's population 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 1-2. Assumed Average Annual Growth in Population, 2012 to 2035



Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

3.2. Economic Activity

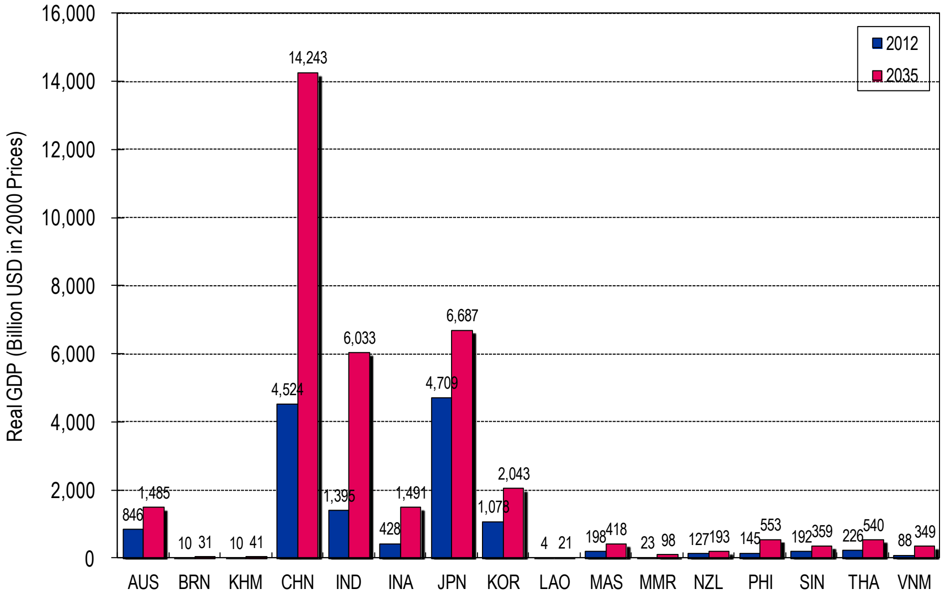
In the models used for this study, assumed changes in economic output to 2035 are set exogenously. GDP data (in 2005 US$) were obtained from the World Bank.[9] Assumed GDP growth rates to 2035 were submitted by all the EAS countries. In general, these assumptions took into account actual GDP growth rates from 2005 to 2012, which already reflect the economic recession and recovery in the United States and other countries in the world. No difference in growth rates was assumed between the BAU and APS scenarios.

In 2012, total GDP in the EAS region was about 14.0 trillion in 2005 US$ and it accounted for about 25 percent of global GDP. The GDP of the EAS region is assumed to grow at an average annual rate of about 4.0 percent from 2012 to 2035. This implies that by 2035 total GDP in the EAS region will reach about 34.6 trillion in 2005 US$.

In 2012, Japan was the largest economy by far in terms of total economic output: about 4.7 trillion 2005 US$. However, by 2035, China is projected to be the largest economy with an estimated GDP of about 14.2 trillion 2005 US$. Japan and India are projected to be the next largest economies with projected GDPs of about 6.7 trillion 2005 US$ and 6.0 trillion 2005 US$, respectively in 2035 (Figure 1-3Figure).

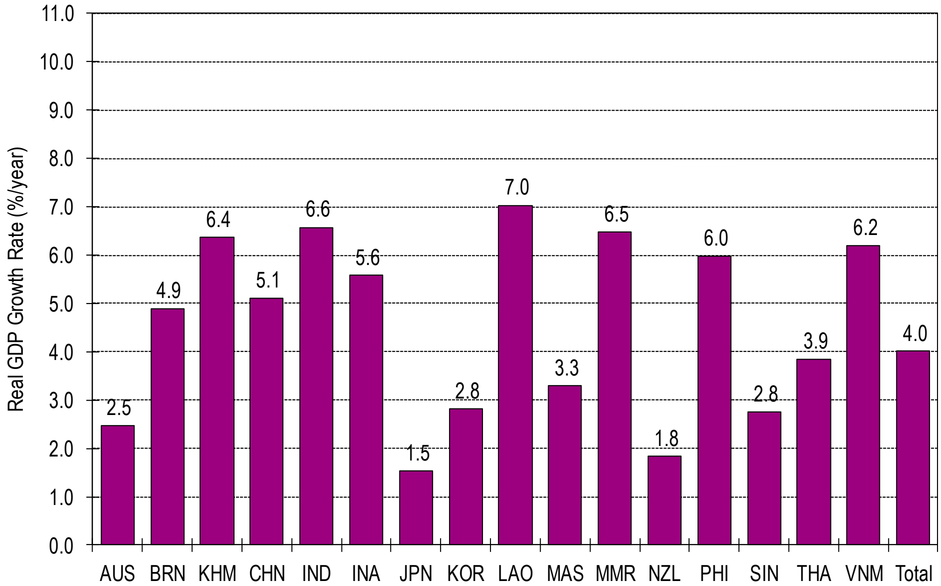
[9] World Bank (2014).

Figure 1-3. Assumed Economic Activity in the EAS Region 2012 and 2035



EAS = East Asian Summit Countries.
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

Figure 1-4. Assumed Average Annual Growth in GDP, 2012 to 2035

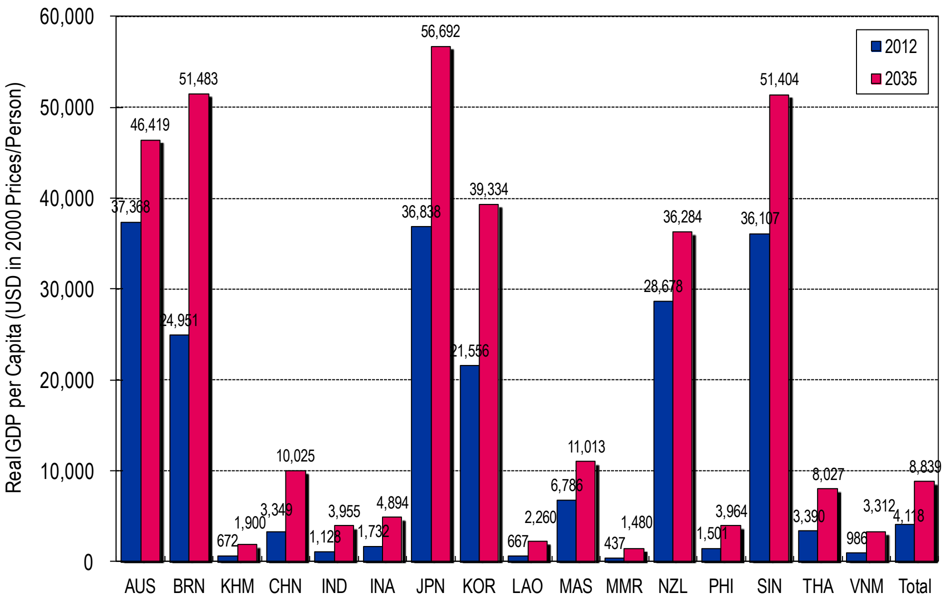


GDP = gross domestic product.
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

As shown in Figure 1-4, long-term economic growth rates are assumed to be quite high in the developing countries, with the highest growth rates in Cambodia, India, Lao PDR, Myanmar, Philippines, and Viet Nam. Economic growth in other developing countries is also assumed to be relatively rapid. Due to the large size of their economies, the rapid growth in China, India, and Indonesia is likely to be especially significant for energy demand. Countries with more mature economies – Australia, Brunei, Japan, South Korea, and New Zealand – are assumed to experience slower, but still significant, economic growth.

Average GDP per capita in the EAS region is assumed to increase from about US$4,100 in 2012 to about US$8,800 in 2035. However, as shown in Figure 1-5, there are, and will continue to be, significant differences in GDP per capita. In 2012, per capita GDP ranged from about US$450 in Myanmar to over US$36,000 in Australia, Japan, and Singapore. In 2035, per capita GDP is assumed to range from about US$1,500 in Myanmar to over US$56,000 in Japan.

Figure 1-5. Real GDP per Capita, 2012 and 2035



GDP = gross domestic product.

Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. New York: UN. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

3.3. Vehicle Ownership

Growth in the transport sector is one of the primary drivers of growth in energy consumption, and the major driver of oil consumption. In the model used in this study, energy demand by all forms of transport is modelled. However, road vehicle ownership is a key exogenous input. Assumed changes in road vehicle ownership were made for 14 countries with the exception of Lao PDR and Viet Nam. There is assumed to be no difference in road vehicle ownership between the BAU scenario and APS.

Strong population and economic growth is projected to drive significant increases in demand for transport services in India and China. By 2035, the number of road vehicles in China and India is projected to increase to about 312 million and 139 million, respectively. However, in both countries, despite the huge growth in road vehicles, rail is expected to meet an increasing share of total transport demand.

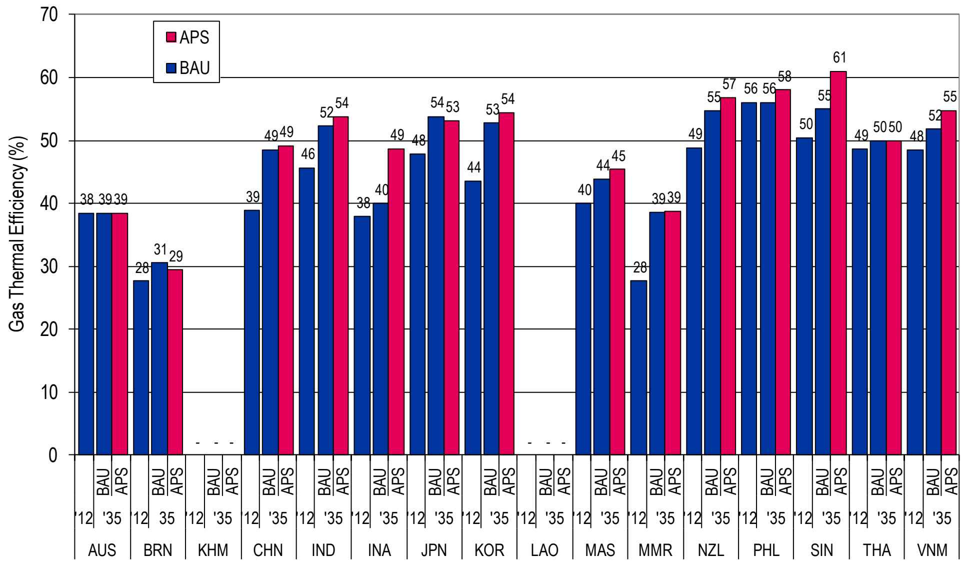
Per capita vehicle ownership is projected to increase in the EAS region. However, vehicle ownership on a per capita basis is projected to vary significantly amongst countries.

3.4. Electricity Generation

3.4.1. 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 2012 thermal efficiencies by fuel type (coal, gas, and oil) were derived from International Energy Agency data.[10] Thermal efficiencies by fuel (coal, gas, and oil) were projected by the following countries: Australia, Brunei Darussalam, Indonesia, Japan, Malaysia, 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 the IEEJ *Asia/World Energy Outlook 2014.*

Figure 1-6. Thermal Efficiencies of Gas Electricity Generation

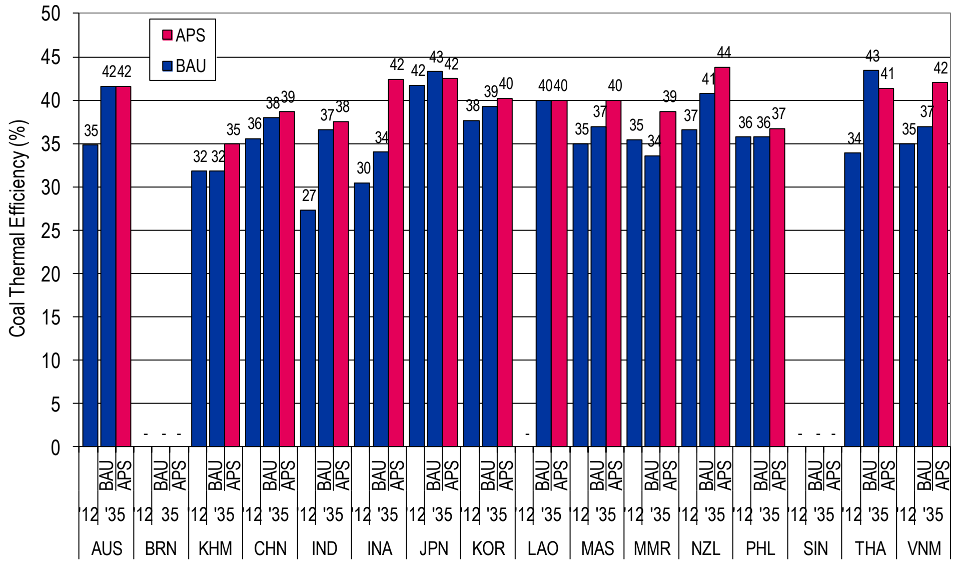


Source: Long-range Energy Alternatives Planning System (LEAP)'s database

Thermal efficiencies may differ significantly between countries due to differences in technological availability, age, cost of technology, temperatures, and the cost and availability of fuel inputs. Thermal efficiency in the EAS 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).

[10] IEA (2011).

Figure 1-7. Thermal Efficiencies of Coal Electricity Generation

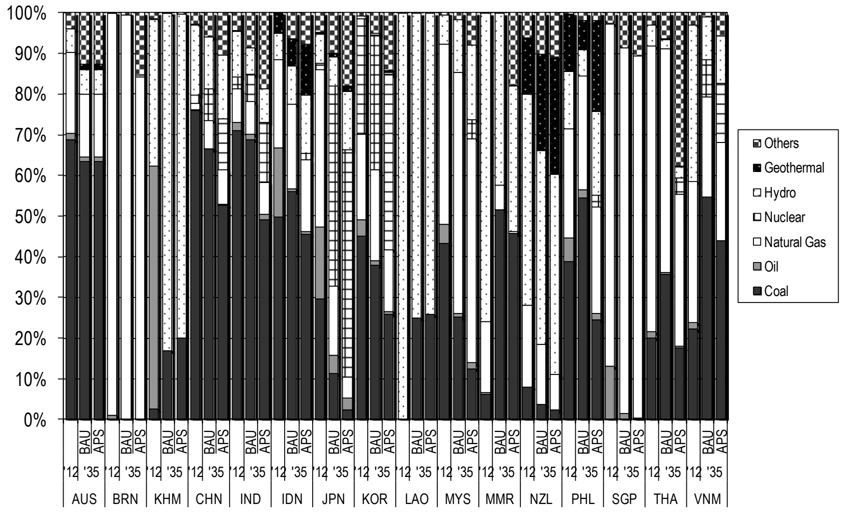


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Long-range Energy Alternatives Planning System (LEAP)'s database.

3.4.2. 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 greenhouse gas emissions. The projected electricity generation mix is shown in Figure 1-8.

Figure 1-8. Share of Fuel Type in the Electricity Generation Mix in the EAS Region



EAS = East Asian Summit.
Source: Country Energy Saving Potential Report_ sub report of this main report, 2015.

Coal is projected to remain the dominant source of electricity generation in the EAS region as a whole in both the BAU and APS. However, the share of coal in electricity generation in the EAS region is projected to decline from about 60.0 percent in the BAU scenario to about 45.0 percent in the APS by 2035, 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 in the EAS region. The use of oil in electricity generation is assumed to decline to almost negligible levels across the EAS region as a whole.

3.4.3 Access to Electricity

Currently, many households in developing countries lack access to electricity, and eliminating this situation is a major development goal. At the Working Group meetings, a number of the developing countries reported on initiatives to significantly expand access to electricity in their countries by 2035. Although this increasing access to electricity is another one of the drivers of increasing energy demand in the EAS region, it was 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 as a result of the relatively rapid GDP growth that is assumed to be experienced in these same countries.

3.5. Use of Biofuels

The Working Group members from each country were asked to include information regarding the potential use of biofuels in the BAU scenario and APS. Some, but not all, countries in the EAS region have plans 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 the IEEJ *Asia/World Energy Outlook 2014.* Table 1-3 summarises the assumptions regarding use of biofuels.

Table 1-3. 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 bio-diesel and bio-ethanol.
Indonesia	2025	Bioethanol: 15% blend from 3–7% in 2010 Bio-diesel: 20% blend from 1–5% in 2010
Japan	2005–2030	No biofuel targets submitted.
Republic of Korea	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 bio-fuels 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% bio-ethanol/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
Viet Nam	2020	10% ethanol blend in gasoline for road transport

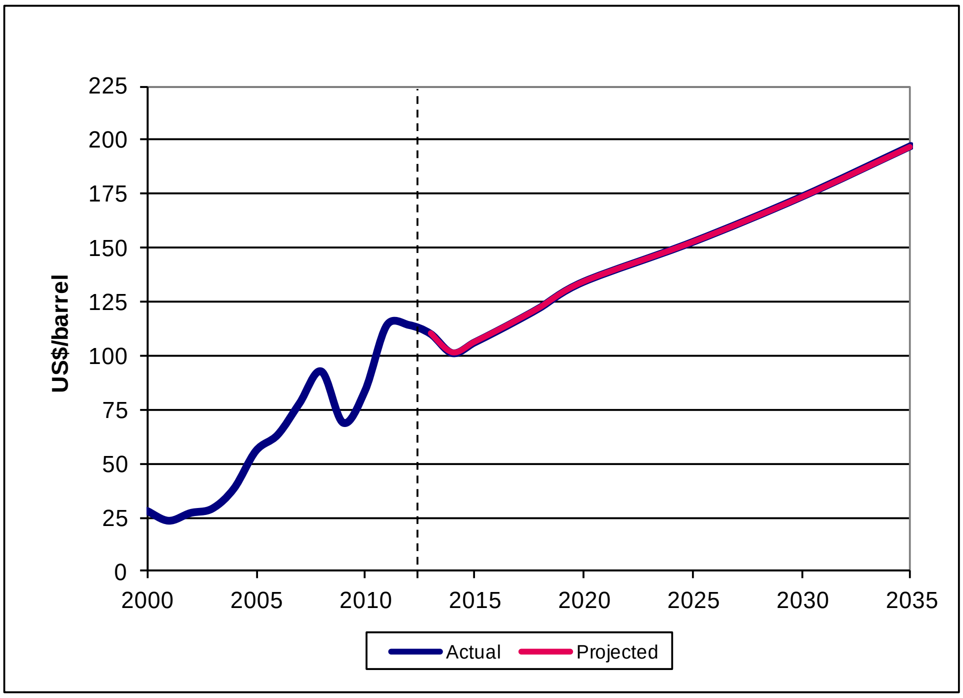
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Country Energy Saving Potential Report_ sub report of this main report, 2015.

The largest increases in consumption of biofuels in the APS are expected in India and China. In all countries, biofuels are expected to meet only a small portion of the transport fuel demand by 2035.

3.6. Crude Oil Price

Future changes in crude oil prices remain highly uncertain. In this modelling exercise the crude oil price, as measured by Japan's average import price (current US$), is assumed to increase from about US$88 a barrel in 2011 to US$197 a barrel in 2035 (Figure 1-). This projection is similar to the trend of the oil price assumption in Asia/World Energy Outlook 2014 of the Institute of Energy Economics, Japan.

Figure 1-9. Nominal Oil Price Assumptions to 2035



Source's Author's calculation in line with IEEJ's assumption of oil price assumptions.

3.7. Energy Saving Goals

Information about the potential energy savings achievable under specific policy initiatives to increase energy efficiency and reduce energy consumption was collected from each of the Working Group members from the 16 EAS countries. Each Working Group member specified which policy initiatives were existing policy, and should be applied to the BAU scenario, and which were proposed policies, and should apply only to the APS. Quantitative energy savings were estimated based on the country's own assumptions and modelling results. Table 4 shows the summary of energy saving goals, action plans, and policies collected from each EAS Working Group member in 2014.

Table 1-4. Summary of Energy Saving Goals, Action Plans, and Policies Collected from Each EAS Working Group Member

	Indicator	Goal
Australia	Carbon Pollution	5% reduction below 2000 level by 2020
Brunei Darussalam	Energy Intensity	45% improvement by 2035 from 2005 level
Cambodia	Final Energy Demand	10% reduction of BAU by 2030
China	Energy Intensity	16% improvement during the 12th 5-year plan (2011–2015)
India	Not submitted	•
Indonesia	Energy Intensity	Reduce by 1% /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 Demand	10% reduction from BAU by 2030
Malaysia	Final Energy Demand	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 Demand	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% saving from BAU until 2015 • 5%–8% saving from BAU after 2015

EAS = East Asian Summit; BAU = Business-as-Usual.
Source: Ito, K. et al (2014).

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 the 2012 to 2035 time period. This relatively strong economic growth and rising per capita incomes in the EAS countries could mean significant declines 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 greenhouse gas emissions and climate change challenges unless low emission technologies are used. Even if fossil fuel resources are sufficient, much of the fuel is likely to 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 as a result 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 greenhouse gases will be very challenging given such strong growth. However, as will be discussed in Section 4.3, sharp reductions in greenhouse gases are being called for by scientists. This huge 'headwind' working against energy efficiency and conservation and emission reductions poses a challenge to the EAS region that needs to be addressed.

4. Energy And Environmental Outlook for the EAS Region

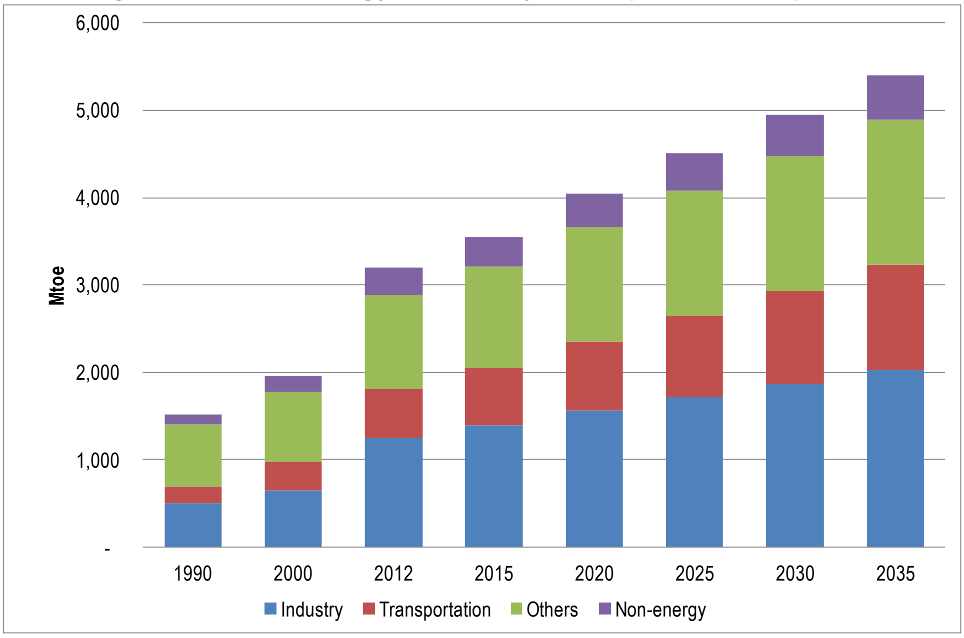
4.1. Business-as-Usual (BAU) Scenario

4.1.1. Final Energy Demand

Between 2012 and 2035, total final energy demand[11] in the 16 EAS countries is projected to grow at an average annual rate of 2.3 percent, reflecting the assumed 4.0 percent annual GDP growth and 0.6 percent population growth. Final energy demand is projected to increase from 3196 Mtoe in 2011 to 5405 Mtoe in 2035. Transport sector demand is projected to grow most rapidly, increasing by 3.4 percent per year, as a result of motorisation driven by increasing disposable income as EAS economies grow. The commercial and residential ('Others') sectors' demand will grow 1.9 percent per year slower than that of the industry sector. Energy demand in the industry sector is projected to grow at an average annual rate of 2.1 percent. Figure 1-10 shows final energy demand by sector under BAU in EAS, from 1990 to 2035.

[11] Refers to energy in the form in which it is actually consumed, that is, including electricity, but not including the fuels and/or energy sources used to generate electricity.

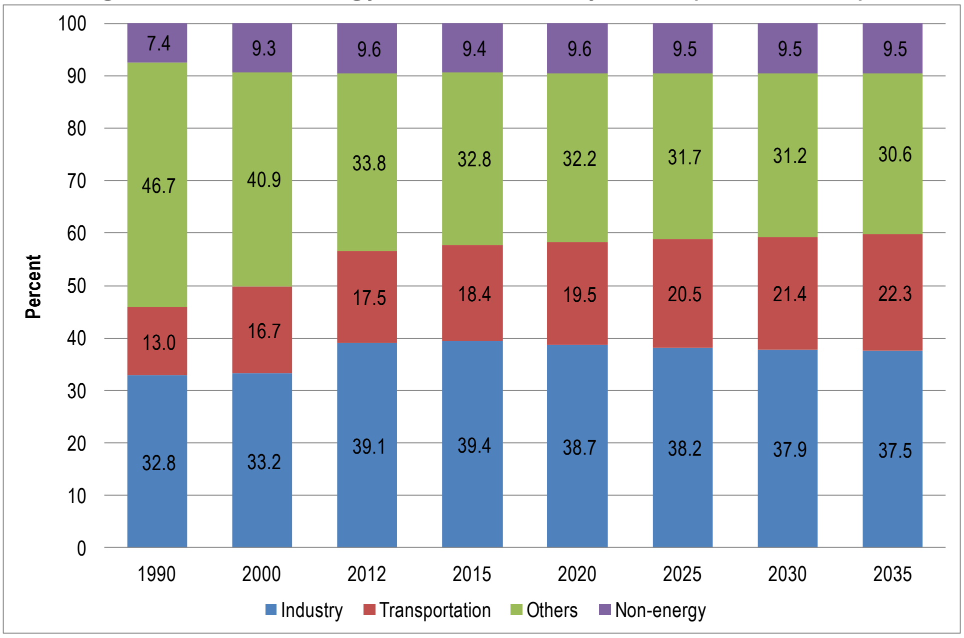
Figure 1-10. Final Energy Demand by Sector (1990 to 2035), BAU



BAU = Business-as-Usual.
Source: Author's calculation.

There will be a slight change in the shares of the sectors in final energy demand from 2012 to 2035, with the transport sector projected to have an increasing share and the industrial and other (largely residential and commercial) sectors decreasing shares. The industrial sector's share will decrease slightly, from 39.1 percent in 2012 to 37.5 percent in 2035. The other sectors' share will significantly decrease, from 33.8 percent to 30.6 percent during the same period. The share of transport sector, on the other hand, will increase from 17.5 percent to 22.3 percent from 2012 to 2035. The share of non-energy demand will remain at around 9.5 percent during the same period. The sectoral shares in final energy demand are shown in Figure 1-11.

Figure 1-11. Final Energy Demand Share by Sector (1990 to 2035)

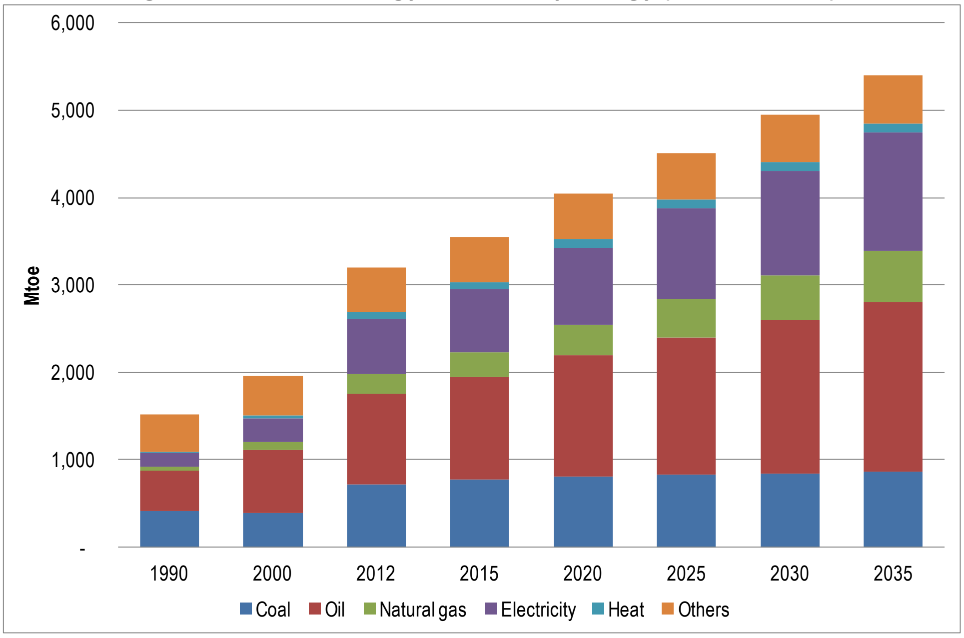


Source: Author's calculation.

For the energy sources, natural gas demand in the BAU scenario is projected to show the fastest growth, increasing by 4.3 percent per year, from 223 Mtoe in 2012 to 590 Mtoe in 2035. Although oil will retain the largest share of total final energy demand, it is projected to grow at a much lower rate of 2.7 percent per year, reaching 1942 Mtoe in 2035, compared with average annual growth of 3.8 percent over the last two decades. However, its share will still increase from 32.7 percent in 2012 to 35.9 percent in 2035. Demand for electricity will grow at a relatively fast rate of 3.4 percent per year. Its share will increase from 19.7 percent in 2012 to 25.0 percent in 2035, surpassing the share of coal. The growth in coal demand will grow at a slower rate of 0.8 percent per year on average. Other fuels, which are mostly solid and liquid biofuels, will have a slow annual growth rate of 0.4 percent on average, but consumption of liquid biofuels will grow rapidly. Consequently, the share of other fuels will decline from 15.8 percent in 2012 to 10.2 percent in 2035. 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.

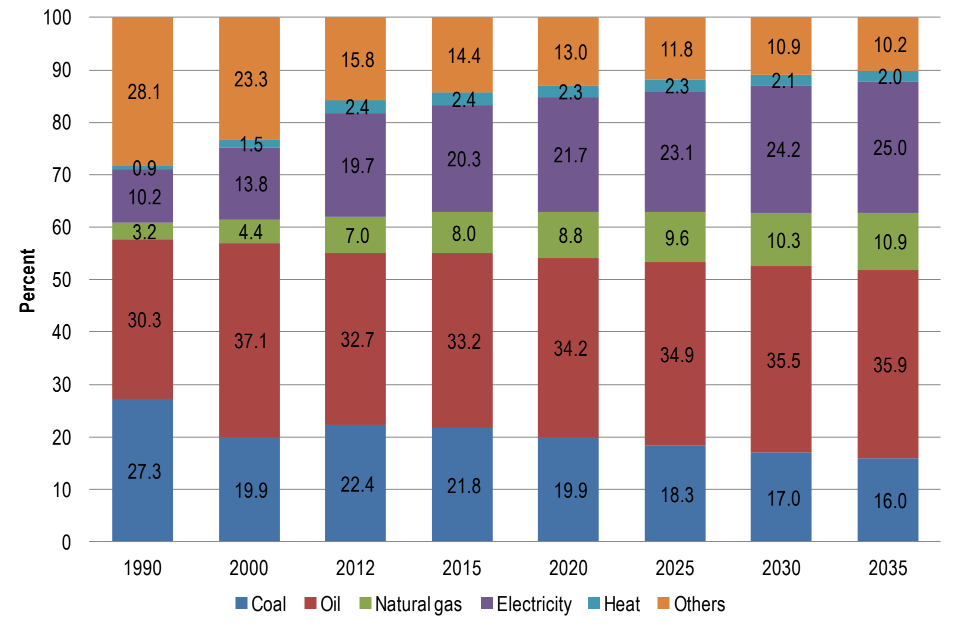
Figures 1-12 and 1-13 show the final energy demand and shares by energy in the EAS under the BAU from 1990 to 2035.

Figure 1-12. Final Energy Demand by Energy (1990 to 2035)



Source: Author’s calculation.

Figure 1-13. Final Energy Demand Share by Energy (1990 to 2035)



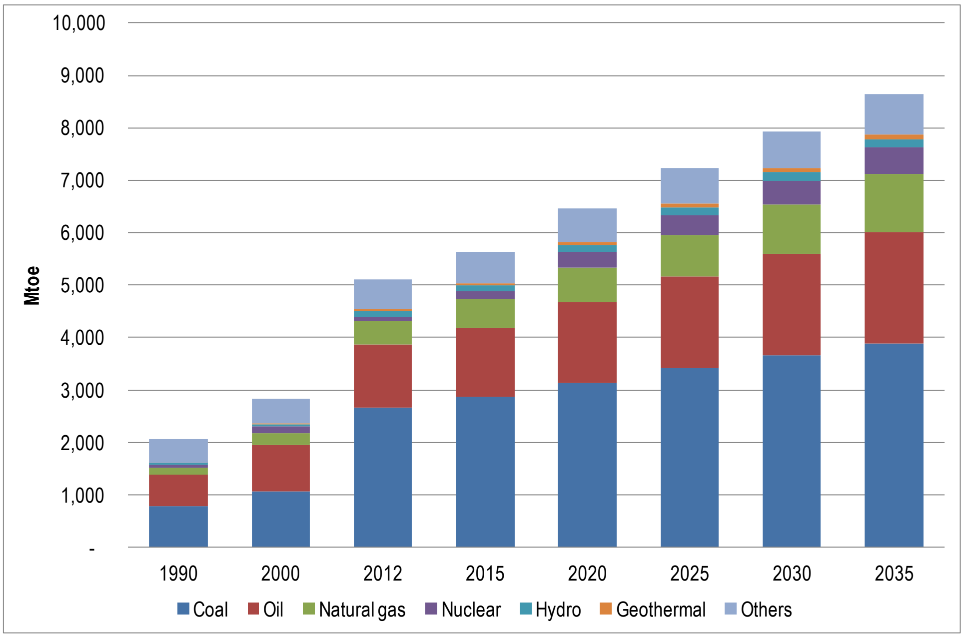
Source: Author's calculation.

4.1.2. Primary Energy Demand

Primary energy demand[12] in EAS is projected to grow at a similar pace, of 2.3 percent per year, as final energy demand. EAS primary energy demand is projected to increase from 5,106 Mtoe in 2012 to 8,635 Mtoe in 2035. Coal will remain the largest share of primary demand, but its growth is expected to be slower, increasing at 1.7 percent per year. Consequently, the share of coal in total primary energy demand is forecast to decline from 52 percent in 2012 to 44.9 percent in 2035. Figure 1-14 shows primary energy demand from 1990 to 2035.

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

Figure 1-14. Primary Energy Demand in EAS (1990 to 2035)

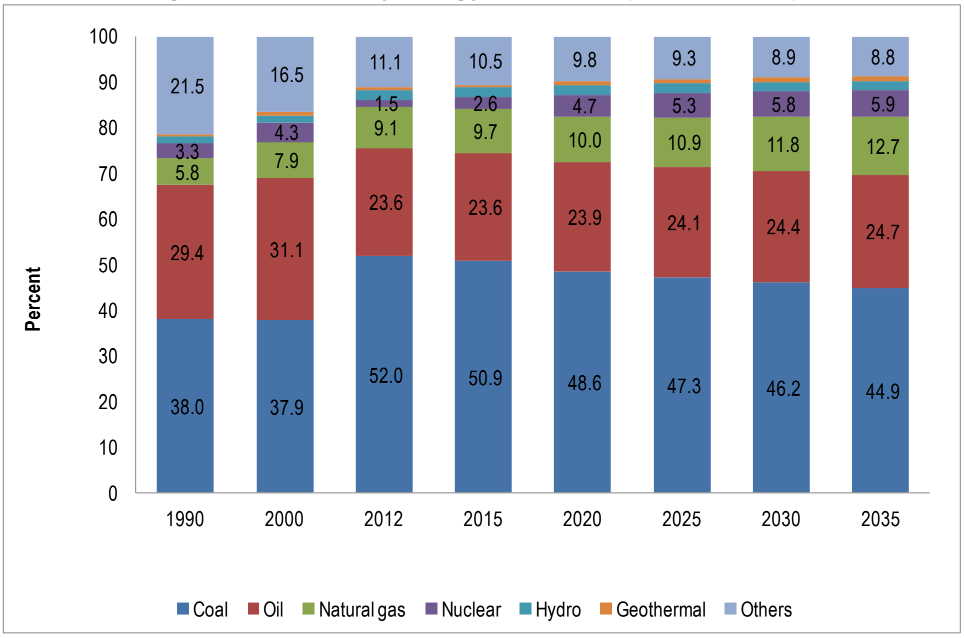


EAS = East Asian Summit.
Source: Author's calculation.

Amongst fossil sources of energy, natural gas is projected to show the fastest growth between 2012 and 2035, increasing at an annual average rate of 3.8 percent. Its share in the total will consequently increase from 9.1 percent in 2012 to 12.7 percent in 2035. Nuclear energy is also projected to increase at a rapid rate of 8.5 percent per year on average and its share will improve from 1.5 percent in 2012 to 5.9 percent in 2035. This is due to the assumed resumption of nuclear power generation in Japan, the expansion of power generation capacity in China and India, and the introduction of this energy source in Viet Nam.

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 percent. Consequently, the share of these other sources of energy will decrease from 11.1 percent in 2012 to 8.8 percent in 2035. Geothermal energy will increase at a rapid pace of 4.2 percent per year, but its share will remain low and will only reach 1.1 percent in 2035, a slight increase from 0.7 percent in 2012. The growth of hydro will be 2.0 percent per year and its share will remain low, at around 2.0 percent from 2012 to 2035. Figure 1-15 shows the shares of each energy source in the total primary energy mix from 1990 to 2035.

Figure 1-15. Primary Energy Mix in EAS (1990 to 2035)

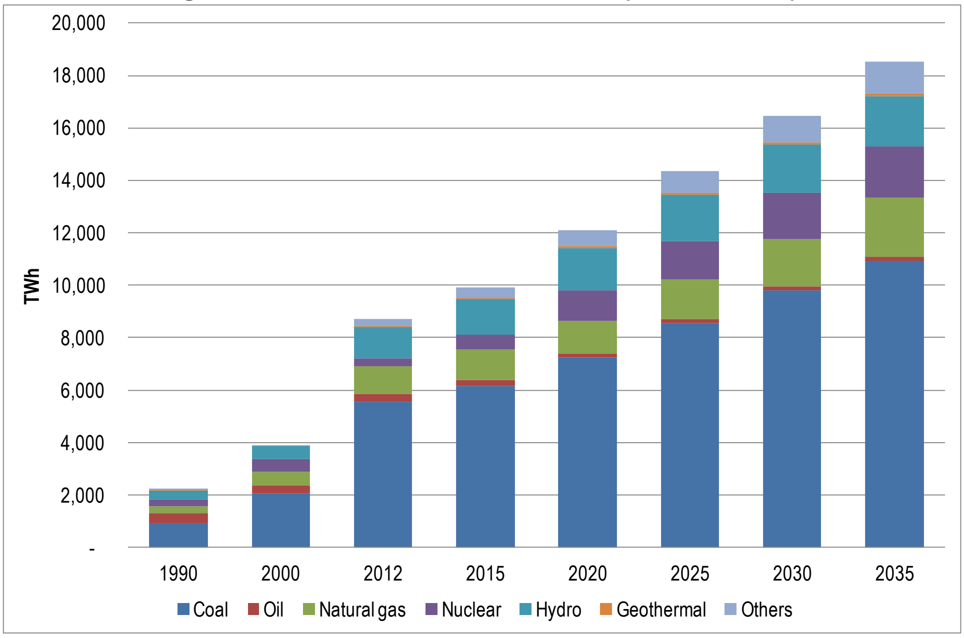


EAS = East Asian Summit.
Source: Author's calculation.

4.1.3. Power Generation

Power generation in EAS is projected to grow at 3.3 percent per year on average from 2012 (8,717 TWh) to 2035 (18,530 TWh), slower than the 6.5 percent annual rate of growth from 1990 to 2012 (Figure 1-16).

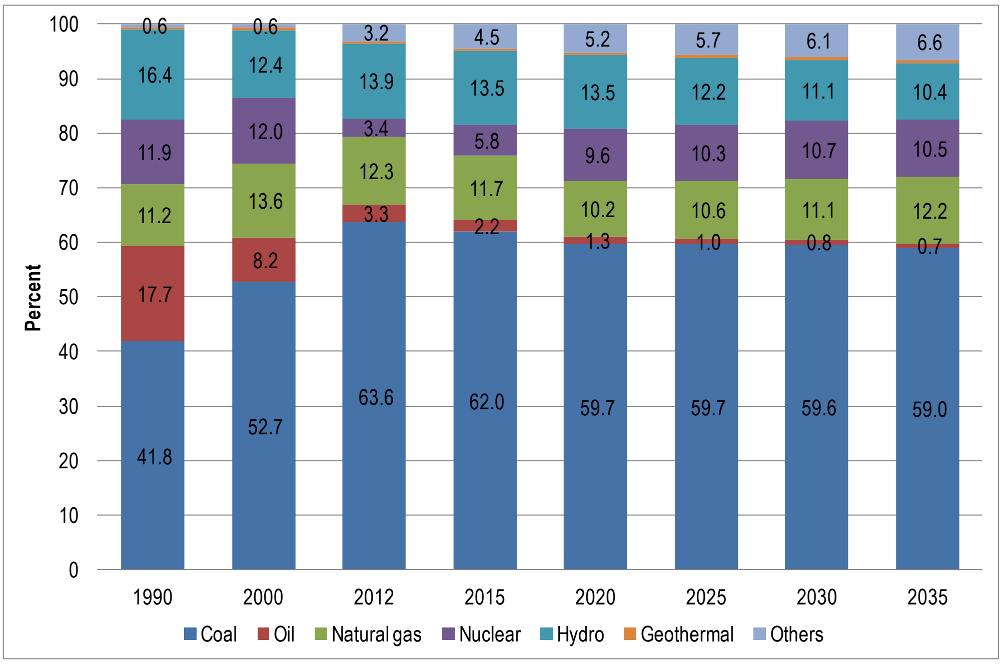
Figure 1-16. Power Generation in EAS (1990 to 2035)



EAS = East Asian Summit.
Source: Author's calculation.

The share of coal–fired generation is projected to continue to be the largest and will remain about 60 percent of the total until 2035. The share of natural gas is projected to be stable at around 12.0 percent from 2012 to 2035. The nuclear share (3.4 percent in 2012) is forecast to increase to 10.5 percent in 2035, in the assumption that nuclear power plants in Japan will resume operation, and due to an increase in generating capacities in China and the introduction of nuclear energy in Viet Nam. Geothermal (0.3 percent in 2012) and other (wind, solar, biomass, etc., at 3.2 percent) shares will also increase, to 0.6 percent and 6.6 percent in 2035, respectively. The shares of oil and hydro are projected to decrease slightly, from 3.3 percent to 0.7 percent, and from 13.9 percent to 10.4 percent, respectively, during the same period. Figure 1-17 shows the shares of each energy source in electricity generation from 1990 to 2035.

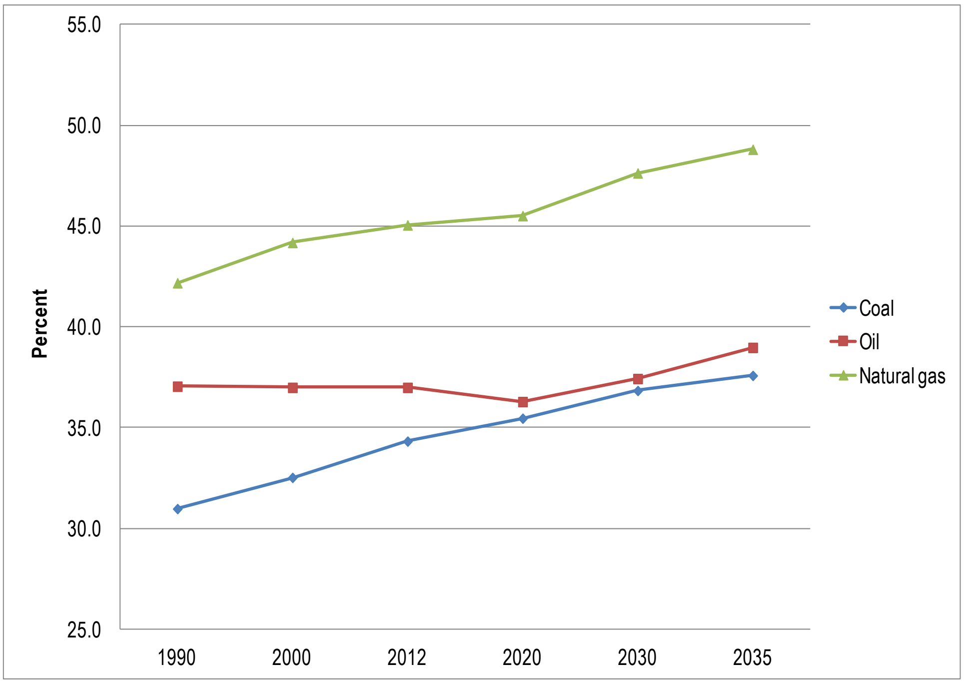
Figure 1-17. Power Generation Mix in EAS (1990 to 2035)



EAS = East Asian Summit.
Source: Author's calculation.

Thermal efficiency is projected to grow in EAS from 2012 to 2035 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 from 34.3 percent in 2012 to 37.6 percent in 2035. The efficiency of natural gas power plants will also increase, from 45.1 percent in 2012 to 48.8 percent in 2035. Even oil power plants, which will not be used significantly in the future, will see an improvement in efficiency, from 37.0 percent in 2012 to 39.0 percent in 2035. Figure 1-18 shows the thermal efficiency of coal-, oil-, and natural gas-fired power plants from 1990 to 2035.

Figure 1-18. Thermal Efficiency by Fuel, BAU (1990 to 2035)

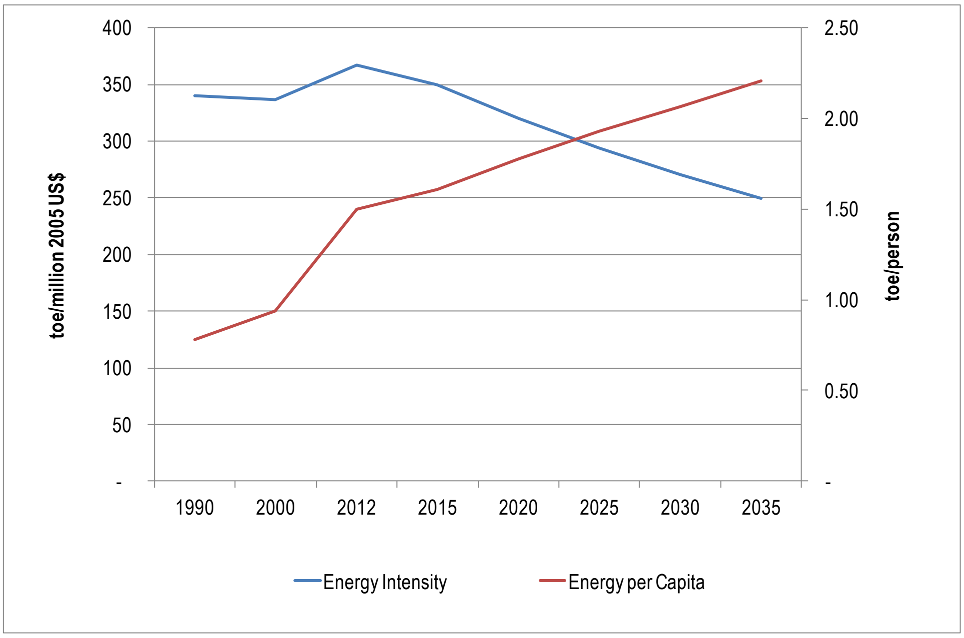


BAU = Business-as-Usual.
Source: Author's calculation.

4.1.4. Primary Energy Intensity and Per Capita Energy Demand

Even in the BAU, energy intensity in EAS is projected to decline, from 365 toe/million US$ (constant 2005) in 2012 to 250 toe/million US$ in 2035. In contrast, energy demand per capita is projected to continue to increase, from 1.5 toe per person in 2012 to 2.2 toe per person in 2035. 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 as disposable income increases. Figure 1-19 shows the energy intensity and energy per capita from 1990 to 2035.

Figure 1-19. Energy Intensity and Per Capita Energy Demand in EAS

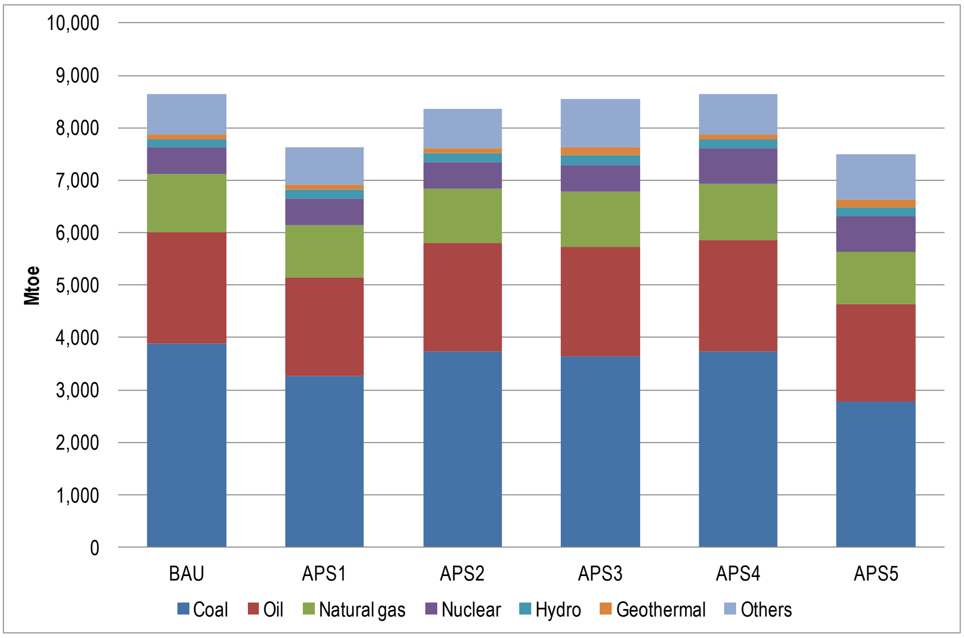


EAS = East Asian Summit.
Source: Author's calculation.

4.2. Alternative Policy Scenario (APS)

As mentioned above, the assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions (APS or APS5). Figure 1-20 shows the total primary energy supply in all the scenarios.

Figure 1-20. Total Primary Energy Supply in EAS in 2035 (All Scenarios)



EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

APS1 and APS5 have the largest reduction in total primary energy supply due to the energy efficiency assumptions on the demand-side. Energy efficiency assumptions in APS1 could reduce total primary energy supply in BAU by as much as 973 Mtoe or 11.3 percent. This energy saving is more than two times the consumption of Japan in 2012.

APS2, which assumes higher efficiency in thermal electricity generation, has a lower impact than APS1. This is due to the assumptions that only the newly constructed power plants will have higher efficiency. It is expected that existing power plants will continue to operate until the end of their lifetimes. This is why, only 268 Mtoe or 3.1 percent of the total primary energy supply in the BAU could be saved in this scenario. This energy saving is almost equal to the total primary energy consumption of South Korea in 2012.

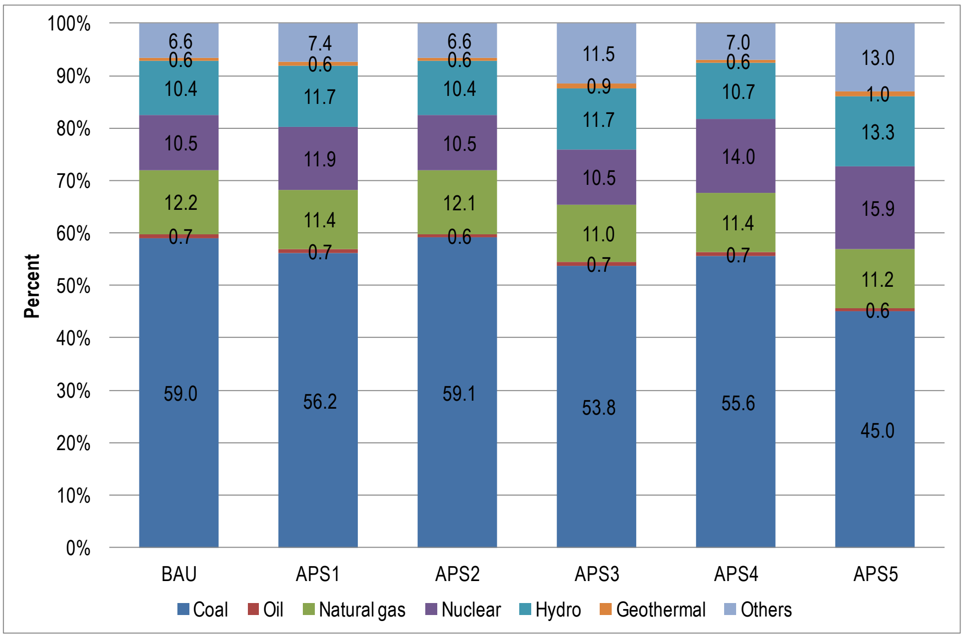
APS3 assumes higher penetration of renewable energy in electricity generation and higher consumption of biofuels in the transportation sector. Like APS2, there is only a small reduction in the BAU value of 255 Mtoe or a 3.0 percent reduction. Although hydro, solar, and wind energy are assumed to have 100 percent thermal efficiency when converted to primary energy, the contributions of these energy sources were dwarfed by the contribution of biomass and geothermal energy, which have lower thermal efficiency than the fossil-fired electricity generation that was replaced in this scenario. However, this 3.0 percent reduction in primary energy consumption can result in a 5.1 percent reduction in BAU CO_2 emission.

APS4 assumes a higher contribution of nuclear energy in power generation. In this scenario, the total primary energy supply is just 6.4 Mtoe or 0.01 percent lower than the total primary energy supply in the BAU. This is due to the relatively lower thermal efficiency of nuclear power generation (33 percent) compared with new coal- and natural gas-fired power plants. However, due to the reduction in fossil fuels that would be replaced by nuclear energy, there could be a 2.9 percent reduction in the BAU CO_2 emission in this scenario.

Figure 1-21 shows the total electricity generation mix in EAS in 2035 in all scenarios. In APS1, due to lower electricity demand, the shares of fossil-fired electricity generation could be lower than in the BAU scenario. In APS2, the shares are almost the same as those of the BAU. In APS3, due to the assumption of more renewable energy, fossil fuel-fired generation could be reduced by 9.1 percent whereas in APS4, nuclear energy could reduce fossil fuel share by 5.9 percent. In APS5, reduction in fossil energy-based generation could be reduced by as much as 30.6 percent.

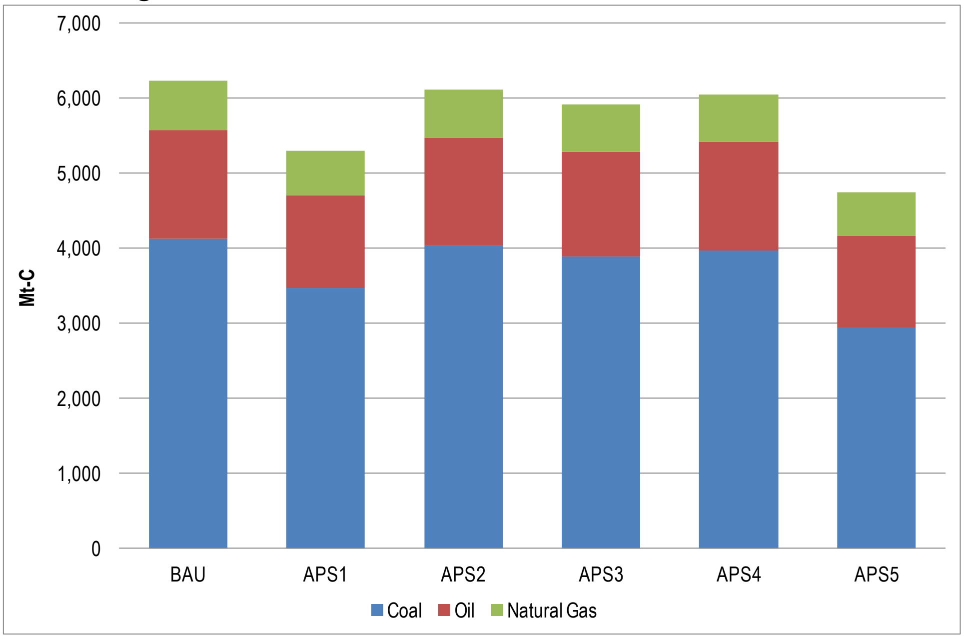
In terms of CO_2 emission reduction, the energy efficiency assumption in APS1 could reduce emissions in the BAU by 15.0 percent in 2035. In APS2, the installation of more efficient new power plants is able to reduce emissions by 1.9 percent. Higher contributions from renewable energy could reduce emissions by 5.1 percent whereas a higher contribution from nuclear energy could result in an emission reduction of 2.9 percent. All these assumptions combined could reduce BAU CO_2 emissions by 23.8 percent in 2035. Figure 1-22 shows the estimated CO_2 emissions in all the analysed scenarios.

Figure 1-21. Electricity Generation in 2035 in EAS in All Scenarios



EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 1-22. Total EAS CO_2 Emissions in 2035 in All Scenarios



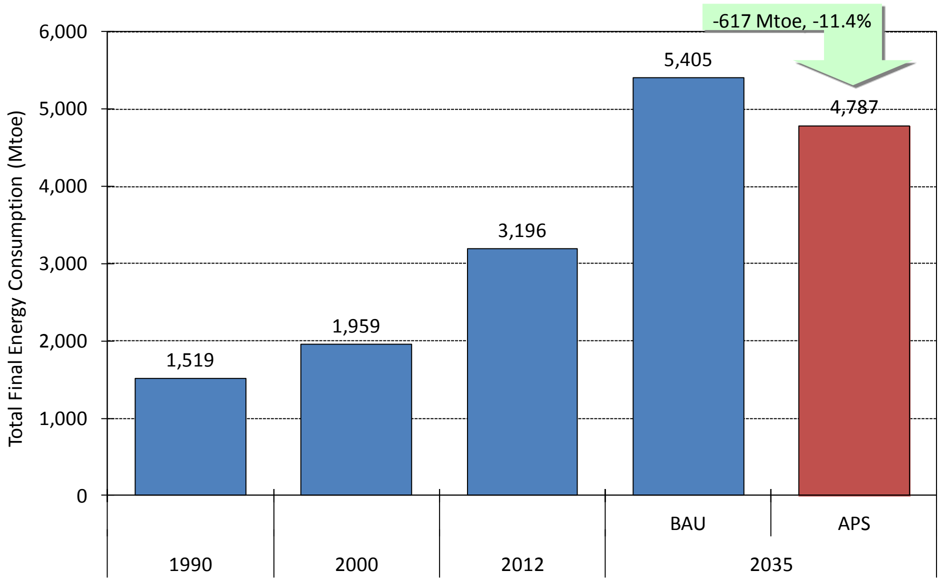
EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

The more detailed analysis of the differences between the BAU and the APS follows below.

4.2.1. Total Final Energy Demand

In the APS case, final energy demand is projected to rise to 4,787 Mtoe, 617 Mtoe or 11.4 percent lower than in the BAU case in 2035. This is due to the various energy efficiency plans and programmes, presented in Section 3 above, in both the supply and demand sides that are to be implemented by EAS countries. Figure 1-23 shows the evolution of final energy demand from 1990 to 2035 in both the BAU and APS scenarios.

Figure 1-23. Total Final Energy Demand, BAU and APS

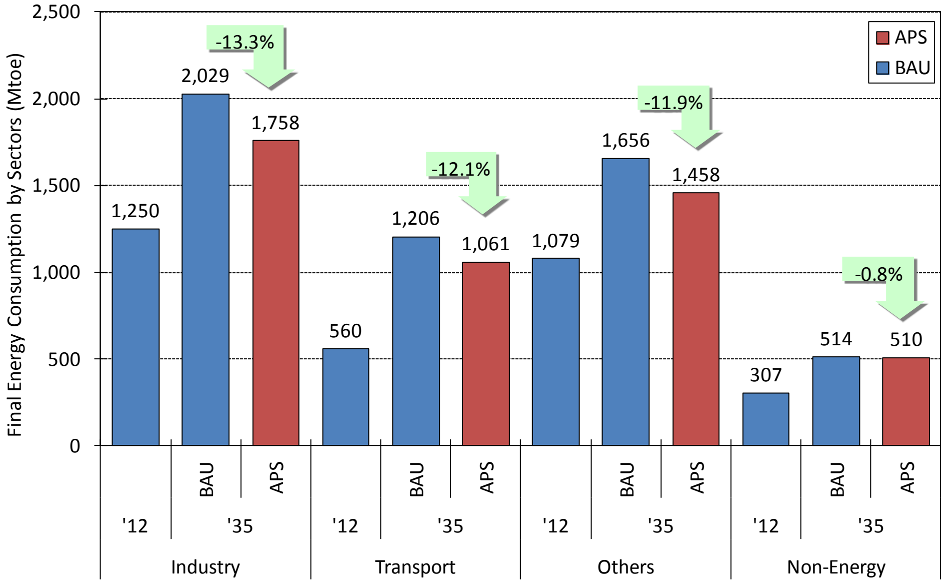


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author’s calculation.

4.2.2. Final Energy Demand by Sector

Figure 1-24 shows the composition of final energy demand by sector in both the BAU and APS. Final energy demand in most sectors is significantly reduced in the APS case compared with the BAU case. In percentage terms, the reduction is largest in the industry sector (13.3 percent), followed by the transport sector (12.1 percent), and the others sector (11.9 percent). Non-energy demand will not be significantly different from the BAU.

Figure 1-24. Final Energy Demand by Sector, BAU and APS

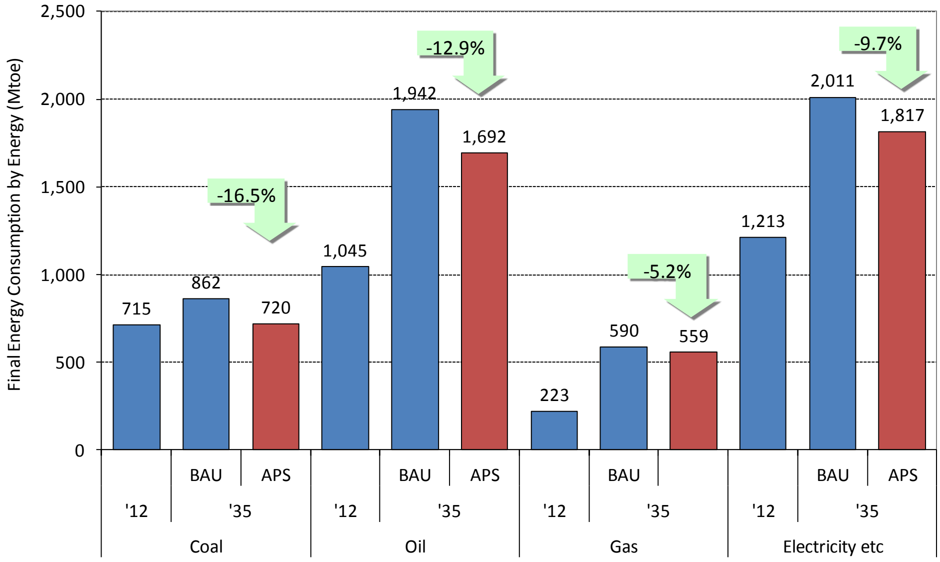


EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4.2.3. Final Energy Demand by Fuel

Figure 1-25 shows final energy demand by type of fuel. In the APS case, growth in final demand for all fuels is lower compared with the BAU case. The growth rate of 1.8 percent per year on average is lower than the BAU's 2.3 percent growth rate. The largest reduction will be in oil demand, at 250 Mtoe or 12.6 percent from the BAU's 1,942 Mtoe to 1,692 Mtoe in the APS. This potential saving in oil is equivalent to 59 percent of China's final oil demand in 2012. The saving potential in other fuels, which includes electricity and heat, is the second largest at 194 Mtoe, equivalent to a reduction of 9.7 percent from BAU. This is to be brought about by improvement in the efficiencies of household appliances and more efficient building designs. The saving potential for coal is 142 Mtoe and this will come mostly from energy efficiency in the industrial sector. The saving potential for natural gas is around 31 Mtoe or 5.2 percent from the BAU demand.

Figure 1-25. Final Energy Demand by Fuel, BAU and APS

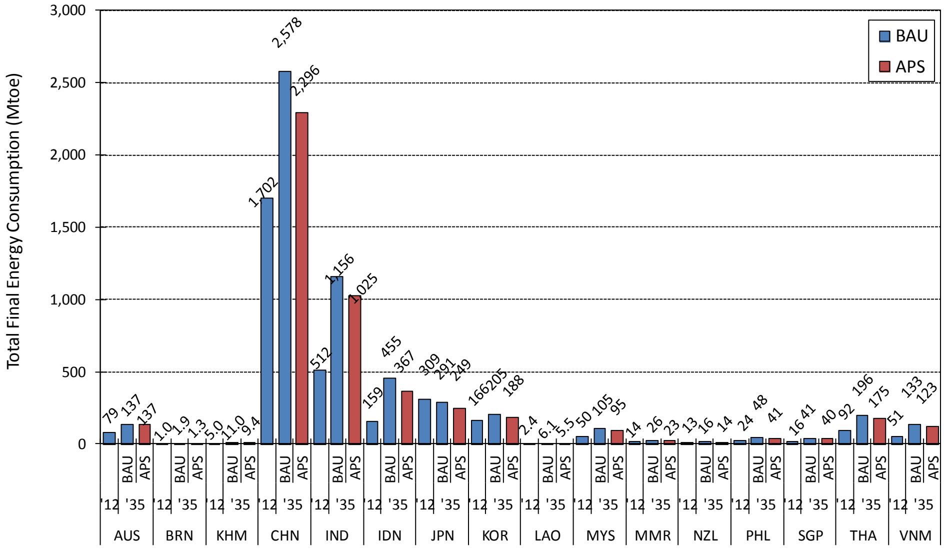


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4.2.4. Final Energy Demand by Country

Figure 1-26 shows final energy demand by country. The most striking result is that China is projected to continue to dominate the EAS region's final energy demand until 2035. China is projected to account for about 48.0 percent of the EAS region's final energy demand in 2035, down from about 53.3 percent in 2012. Just five countries – China, India, Indonesia, Japan, and South Korea – are projected to account for 86.7 percent of the EAS region's final energy demand in 2035, with the growth in final energy demand concentrated in just three countries: China, India, and Indonesia. In fact, these 'big three' countries are projected to account for 82.2 percent of the growth in energy demand for the entire EAS region between 2012 and 2035. In the APS case, growth in most countries, including the 'big three', is significantly lower relative to the BAU scenario. However, the 'big three' are still projected to account for 82.6 percent of the growth in energy demand in the EAS region between 2012 and 2035.

Figure 1-26. Total Final Energy Demand by Country, BAU and APS

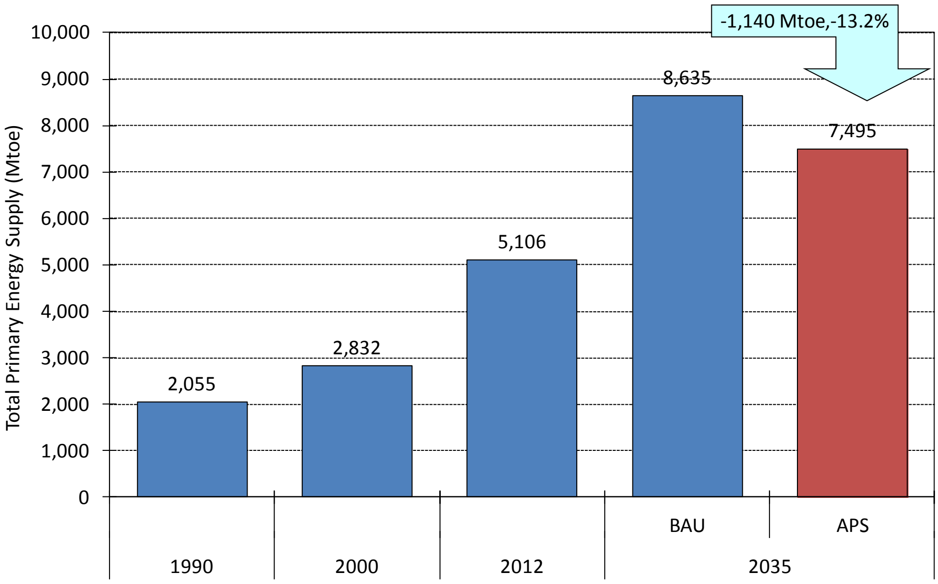


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4.2.5. Total Primary Energy Demand

The pattern followed by primary energy demand is, as one would expect, similar to final energy demand. Figure 1-27 shows that total primary energy demand is projected to increase from 5,106 Mtoe in 2012 to 8,635 Mtoe in 2035 in the BAU case, an increase on average of 2.3 percent per year. In the APS case, demand is projected to grow to 7,495 Mtoe by 2035, 13.2 percent lower than in the BAU case. The reduction in 2035 primary energy demand in the APS case compared with the BAU case of 1,140 Mtoe is roughly equivalent to 40 percent of China's demand in 2012.

Figure 1-27. Total Primary Energy Demand, BAU and APS



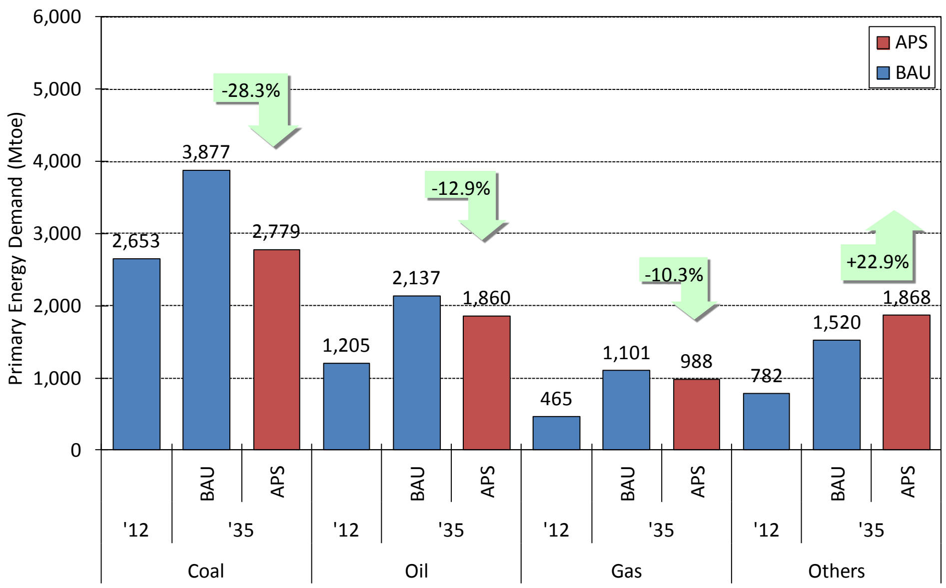
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4.2.6. Primary Energy Demand by Source

In the APS scenario, growth in coal, oil, and natural gas primary demand is projected to be considerably lower than the BAU. Coal demand for example, will be 28.3 percent lower in the APS or equivalent to 1,098 Mtoe, 41.4 percent of EAS coal demand of 2,653 Mtoe in 2012. This reflects a shift from coal-fired electricity generation to nuclear and renewable energy in the APS case. Demand for oil will also be lower in the APS, by 277 Mtoe or 12.9 percent. This is due to the combined effect of more efficient vehicles and the utilisation of alternative fuels in the transport sector, such as natural gas, electricity, and biofuels. The demand for natural gas will also be lower in the APS, at 10.3 percent of the BAU, equivalent to 113 Mtoe. This is mainly due to reduced electricity demand in the APS and the introduction of more efficient power generation technologies and alternative fuels such as nuclear, solar, and wind energy. Other fuels, which include these alternative energy sources, on the other hand, will be 22.9 percent higher in the APS than in BAU.

Figure 1-28 shows primary energy demand by energy source in both scenarios.

Figure 1-28. Primary Energy Demand by Source, BAU and APS

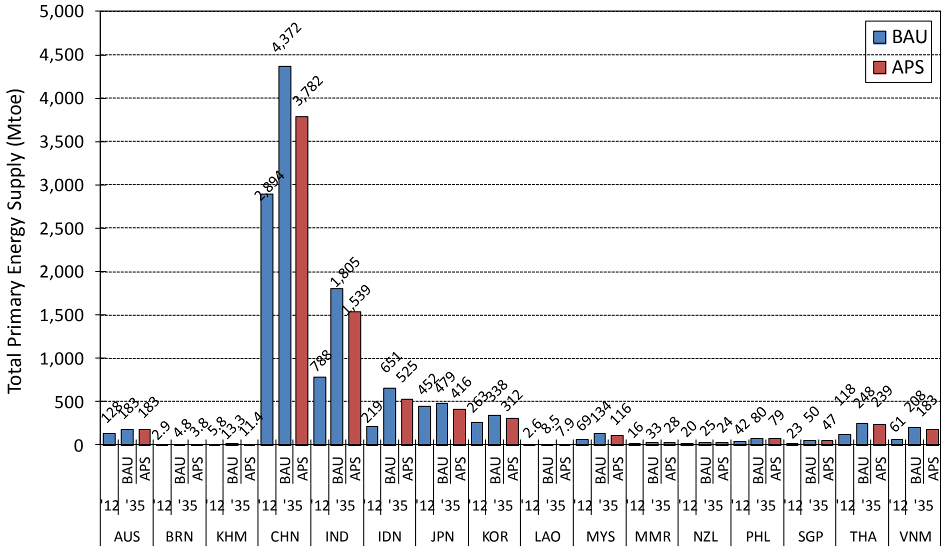


EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author’s calculation.

4.2.7. Primary Energy Demand by Country

Figure 1-29 shows primary energy demand by country, which is similar to the pattern for final energy demand by country shown in Figure 1-. Five countries – China, India, Indonesia, Japan, and South Korea – are projected to account for 88.6 percent of the EAS region’s primary energy in 2035. The ‘big three’ – China, India, and Indonesia – will dominate the growth in the EAS region’s primary energy, accounting for 83.0 percent of growth between 2012 and 2035. In the APS case, growth in primary energy demand in most countries is significantly lower, but the dominance of demand by five countries and the relative importance of the growth in three countries remain unchanged.

Figure 1-29 Primary Energy Demand by Country, BAU and APS



EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4.2.8. Primary Energy Intensity by Country

In Table 1-5, the impacts of the energy saving goals and policies submitted by each Working Group member on energy intensities are summarised. It should be noted that these results are illustrative of the potential energy savings that can be achieved and should not be interpreted as official country projections.

Table 1-5. Quantitative Impact of Energy Saving Goals and Policies: Illustrative Impacts

	2012	2035		Variance		
		BAU	APS	APS/BAU	2012/2035 BAU	2012/2035 APS
	(toe/million 2005 US$)	(toe/million 2005 US$)	(toe/million 2005 US$)	%	%	%
Australia	152	123	123	0.0	-18.8	-18.8
Brunei Darussalam	282	156	123	-21.2	-44.6	-56.3
Cambodia	579	324	277	-14.3	-44.1	-52.1
China	640	307	266	-13.5	-52.0	-58.5
India	565	299	255	-14.8	-47.0	-54.9
Indonesia	513	437	352	-19.4	-14.9	-31.4
Japan	98	72	62	-13.2	-26.8	-36.4
Korea	244	166	153	-7.7	-32.3	-37.5
Lao PDR	605	412	382	-7.4	-31.8	-36.9
Malaysia	348	321	277	-13.8	-7.7	-20.4
Myanmar	676	335	285	-15.0	-50.4	-57.8
New Zealand	158	132	124	-5.9	-16.7	-21.6
Philippines	292	144	142	-1.4	-50.5	-51.2
Singapore	119	138	131	-5.1	15.8	9.9
Thailand	520	460	443	-3.8	-11.5	-14.9
Viet Nam	699	597	524	-12.2	-14.7	-25.1
Total	367	250	217	-13.2	-32.0	-40.9

BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

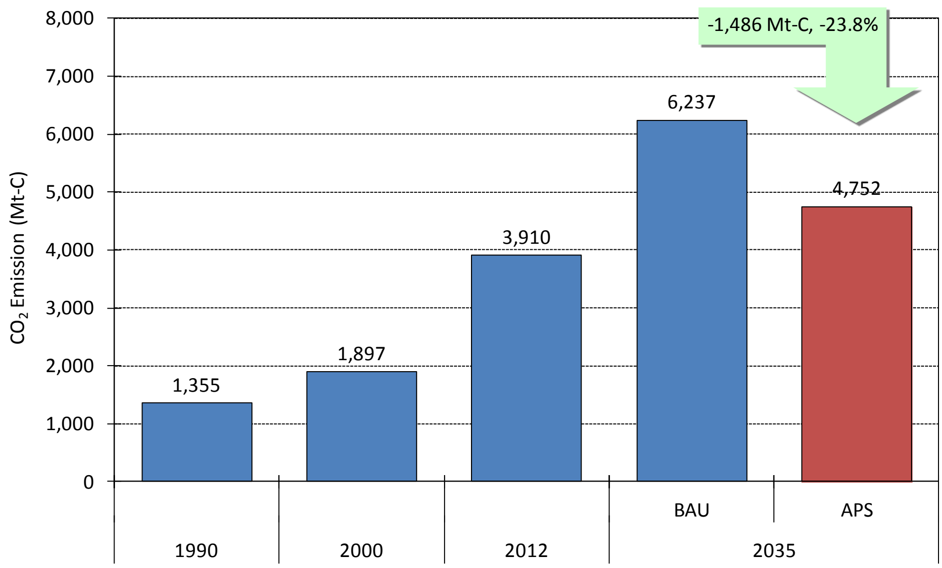
4.3. Carbon Dioxide (CO_2) Emissions from Energy Consumption

4.3.1. CO_2 Emissions

As shown in Figure 1-30, CO_2 emissions from energy consumption in the BAU case are projected to increase from 3,910 million tonnes of Carbon (Mt–C) in 2012 to 6,237 Mt–C in 2035, implying an average annual growth rate of 2.1 percent. This is slightly lower than growth in total primary energy demand of 2.3 percent per year. In the APS case, CO_2 emissions are projected to be 4,752 Mt–C in 2035, 23.8 percent lower than under the BAU scenario.

Although the emission reductions under the APS are significant, CO_2 emissions from energy demand in the APS case in 2035 will still be above 2012 levels and more than three 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 (IPCC) suggests that to keep the increase in global mean temperature to not more than 2^{o}C compared with pre-industrial levels, global CO_2 emissions would need to peak between 2000 and 2015 and be reduced to between 15 and 50 percent of the levels in 2000 (that is, a reduction of between 50 and 85 percent) by 2050. To keep temperature rises in the 3^{o}C range, CO_2 emissions would need to peak between 2010 and 2030 and be at 70 to 105 percent of the levels in 2000 by 2050.[13]

Figure 1-30. Total CO_2 Emissions, BAU and APS



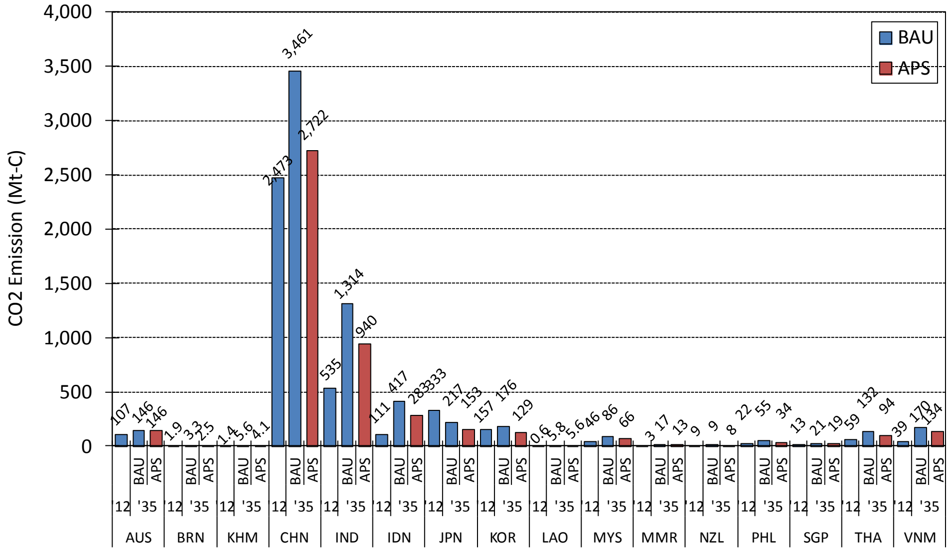
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

[13] See 'Summary for Policymakers' in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Table SPM.5.

Although much depends on the mitigation achieved in other regions, it would appear unlikely that global emissions could meet either of these profiles given the contribution of the EAS region to global total emissions under the APS results. Yet the consequences of insufficient reductions in emissions could be severe. For example, at 2°C above pre-industrial levels, up to 30 percent of species become at increasing risk of extinction, most corals become bleached, and droughts and water availability become an increasing problem worldwide. At 3°C, millions of people could experience coastal flooding each year.[14]

As shown in Figure 1-31, emissions and emission growth in the EAS region are projected to be dominated by China and India. In fact, China and India will account for 989 Mt–C and 779 Mt–C, respectively, of the projected 2,328 Mt–C increase in the EAS region's emissions from 2012 to 2035 under the BAU case, or 75.9 percent of total growth in the EAS region. Adding Indonesia's growth of 306 Mt–C, these three countries account for 2,073 Mt–C or 89.1 percent of total growth in the EAS region. No other country will account for growth of more than 132 Mt–C. Japan is the only country in the EAS region whose emissions are projected to decline under the BAU case as a result of improved energy efficiency and increased utilisation of renewable energy.

Figure 1-31. CO_2 Emissions by Country, BAU and APS



EAS = East Asian Summit; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

[14] These examples are taken from 'Summary for Policymakers' in *Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Figure SPM.7. The examples assume that 1° C of temperature increase has already occurred, as per this same report, Figure SPM.1.

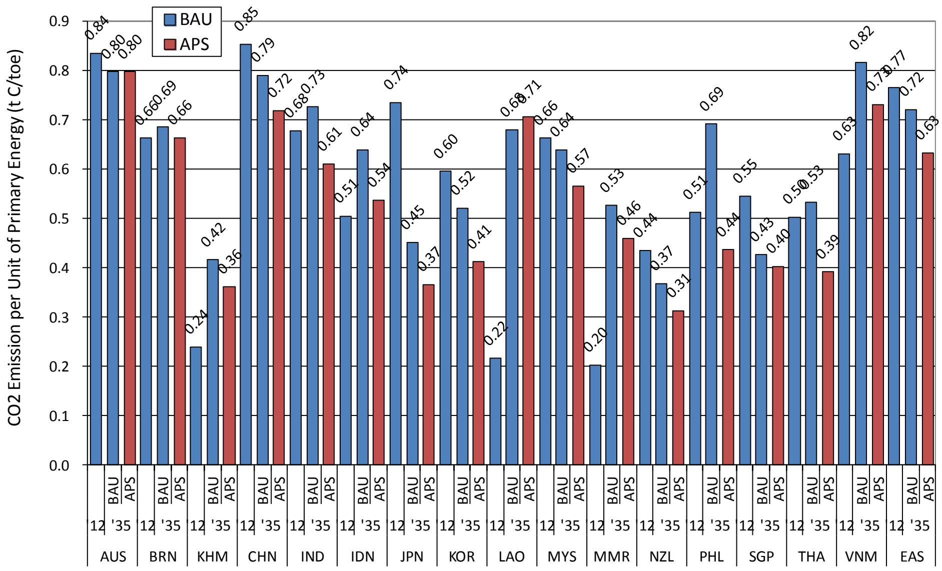
In the APS case, China and India remain dominant, accounting for 249 and 405 Mt–C, respectively, of the projected 842 Mt–C growth in emissions in the EAS region between 2012 and 2035, or 77.8 percent. Adding 171 Mt–C from Indonesia, these three countries account for 826 Mt–C or 98.1 percent of the EAS region total. No other country will account for a growth of more than 96 Mt–C. Emissions from Japan, South Korea, and New Zealand are expected to decline in the APS case relative to 2012 levels, due to effective mitigation policies.

4.3.2. Fundamental Drivers of CO_2 Emissions from Energy Demand

The CO_2 emissions discussed above may be viewed as the net result of four drivers, two of which are moving in a direction favourable to CO_2 emission reductions, and two of which are moving in an unfavourable direction.

i) Emissions per unit of primary energy are projected to decline to 0.72 t–C/toe in 2035 from 0.77 t–C/toe in 2012 under the BAU scenario. In the APS case, this will decline to 0.63 t–C/toe in 2035, equivalent to a decline of 17.2 percent from 2012 (Figure 1-32). The reduction under the APS case reflects a shift away from coal and oil, the two most emission-intensive fuels.

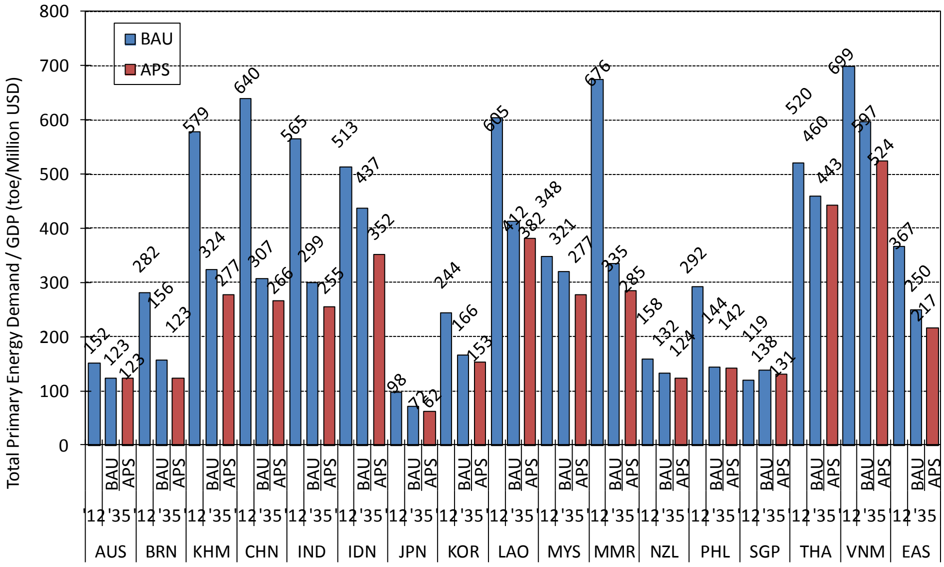
Figure 1-32. Emissions per Unit of Primary Energy, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

ii) Primary energy per unit of GDP is projected to decline from 365 toe/million US$ in 2012 to 250 toe/million US$ in 2035 under the BAU scenario, or by 31.5 percent (Figure 1-33). In the APS case, this will decline to 217 toe/million US$ in 2035, or by 40.6 percent. The lower emissions under the APS case reflects projected improvements in energy intensity. Looking at (i) and (ii) in combination, emissions per unit of GDP will decrease from 279 t–C/million US$ in 2012 to 180 t–C/million US$ in 2035 under the BAU scenario, or by 35.4 percent. Under the APS, this will decline to 137 t–C/million US$ in 2035, 50.8 percent lower than in 2012.

Figure 1-33. Primary Energy Demand per Unit of GDP, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

iii) Working against these declines in emissions per unit of primary energy and primary energy per unit of GDP is the projected significant increase in GDP per person in the EAS region, from around US$4,100/person in 2012 to 8,800 US$/person in 2035, an increase of 114.7 percent. Looking at (i), (ii), and (iii) in combination, emissions per person are projected to increase from 1.1 t–C/person in 2012 to 1.6 t–C/person in 2035 under the BAU scenario, or by 38.7 percent. Under the APS, emissions rise to only 1.2 t–C/person in 2035, or will be 5.6 percent higher than 2012. However, the rising emissions per capita are associated with increases in GDP per capita and improvements in living standards.

iv) Finally, the population in the EAS region is expected to grow from 3,401 million in 2012 to 3,913 million in 2035, or by 15.1 percent. Combined, all these drivers lead to growth in emissions from 3,910 Mt–C in 2012 to 6,237 Mt C in 2035 under the BAU scenario, or a rise of 59.5 percent. Under the APS, emissions grow to 4,752 Mt–C in 2035, or by 21.5 percent.

5. Pilot Survey on Road Transport Sector

5.1. Survey Objective

The objective of the survey was to determine the distance travelled and the fuel economy of each vehicle. From this information, the total fuel consumption can be calculated as follows:

$$FC_i = \Sigma FE_i * ML_i * NV_i$$

Where: FC_i = Fuel consumption of fuel i

FE_i = Fuel economy of vehicle using fuel i (litre/km)

ML_i = distance travelled of vehicle using fuel i (km/vehicle)

NV_i = Number of vehicles using fuel i

i = type of fuel (gasoline, diesel, LPG, CNG, etc.)

5.2. Survey Questionnaire

To obtain the required information, IEEJ designed the questionnaire patterned to the questionnaire used by the Ministry of Land, Infrastructure and Transport of Japan in its monthly survey on road transportation. The questionnaire asks the respondent to record the daily trips of each vehicle and consolidate the total trips in one month. Figure 34 shows the survey questionnaire.

5.3. Survey Methodology

The survey was to be carried out by the members of the ERIA Working Group on the Analysis of Energy Saving Potential in East Asia. The Working Group members were requested to survey colleagues and/or relatives that use personal vehicles. The questionnaires were distributed by the Working Group members to their co-workers and friends.

Figure 1-34. Pilot Survey on Road Transport Questionnaire

Pilot Survey on Road Transport Sector

(This questionnaire should contain the sums of the daily record of trips)

Respondent's Name (optional):	____________________	
Month and Year	__________	
Type of Motor Vehicle	☐ Car	☐ Motorcycle
Engine Displacement/Size (cc, liter, etc.)	__________	__________
Type of Fuel (Gasoline, Diesel, LPG, etc)	__________	__________
Maker (Toyota, Hyundai, Peugeot, etc.)	__________	__________
Model	__________	__________
Odometer Readings:		
Before the first trip of the month	__________	__________
After the last trip of the month	__________	__________
Total Distance Travelled (last trip - first trip)	__________	__________
Amount of fuel Loaded (liters)	__________	__________
Number of days used:	__________	__________
Did you use theExpressway?	☐ Yes ☐ No	
Main Purpose of Travel:	☐ going to work ☐ delivering goods ☐ liesure ☐ shopping ☐ Others	☐ going to work ☐ delivering good ☐ liesure ☐ shopping ☐ Others
	__________ __________ __________ __________ __________	__________ __________ __________ __________ __________

Working Group members reported that the respondents complained of the amount of data being collected in the survey. Some respondents do not have data on the odometer readings as the odometers were intentionally disabled for unspecified reasons.

5.4. Results of the Survey

The pilot survey produced some results, as shown in the Table 1-6 below:

Table 1-6. Results of Pilot Road Transport Survey and Similar Data Obtained from National Surveys of Japan and Thailand

Country	Cars			Motorcycles		
	Number of Samples	Average distance travelled (km)	Fuel Economy (km/litre)	Number of Samples	Average distance travelled (km)	Fuel Economy (km/litre)
Brunei Darussalam	28	1,442	11.8	-	-	-
Cambodia	10	948	11.7	10	716	39.8
Indonesia	13	2,660	7.9	25	1,013	27.6
Lao PDR	6	166	8.8	5	141	38.8
Malaysia	6	1,843	13.8	10	1,253	39.7
Myanmar	6	1,461	10.6	10	1,180	27.9
Philippines	12	746	7.5	5	442	27.6
Singapore	5	-	14.5	-	-	-
Viet Nam	10	426	11.5	10	310	43.1
Japan*	-	1,814	11.1	-	-	-
Korea*	-	1,091	9.5	-	-	-
Small	-	967	11.8	-	-	-
Medium	-	1,092	9.2	-	-	-
Large	-	1,293	6.3	-	-	-
Thailand*	-	2,331	13.2	-	-	-

* Based on government survey

Source: Survey conducted by the Working Group of this Energy Outlook and Saving Potential Study (2014).

Nine countries submitted reports on the pilot survey, whereas three countries (Japan, South Korea, and Thailand) provided information obtained from national surveys. It should be noted that the numbers collected in the pilot survey are taken from a biased survey as the selection of the samples is not random. Likewise, the size of the sample is too small relative to the population. In addition, although the engine displacements of vehicles and types of fuel were reported, the analysis did not calculate the fuel economy by size of vehicle or type of fuel.

Nevertheless, based on the results on passenger cars, Singapore showed the highest fuel economy at 14.5 km/litre followed by Malaysia at 13.8 km/litre. The result of the national survey in Thailand of 13.2 km/litre is close to this range. Brunei Darussalam, Cambodia, Myanmar, and Viet Nam had fuel economies ranging from 10.6 km/litre to 11.8 km/litre. This range is very close to the average fuel economy of cars in Japan of 11.1 km/litre and small cars in South Korea at 11.8 m/litre. Indonesia, Lao PDR, and the Philippines had lower fuel economies, ranging from 7.5 km/litre to 8.8 km/litre. For comparison, medium cars in South Korea have fuels economies of 92 km/litre and large cars 6.3 km/litre.

For motorcycles, Viet Nam had the highest fuel economy, of 43.1 km/litre. Cambodia, Lao PDR, and Malaysia had fuel economies ranging from 38.8 km/litre to 39.8 km/litre, whereas Indonesia, Myanmar, and the Philippines registered low fuel economies of 27.6 km/litre to 27.9 km/litre.

As regards distance travelled by cars, Indonesia registered the highest, at 2,660 km/car/month, and Viet Nam the lowest, at 426 km/car/month. Again, these numbers do not represent the national figures due to biased sampling.

5.5. Lessons Learned

Although it was quite challenging, the pilot survey showed that it is possible to carry out a survey on private vehicles using questionnaires. However, the questionnaire should be improved by addressing the complaints of the respondents. In the analysis of the results, it would also be ideal if the income levels of vehicle owners are included in the questionnaire as it is possible that the travelling behaviour of vehicle owners is influenced by their purchasing power.

To collect more useful information, like passenger-kilometres, the questionnaire should also ask for the average number of passengers (including the driver) in the private cars.

In the analysis of the data, it would be better if the fuel economies of vehicles are further classified into types of fuel and size of vehicles (engine displacement) like the national data of South Korea. This may hardly be applicable to a small survey like this pilot survey, but it should be considered when a national survey is carried out.

This survey provided a good example for energy analysts in Southeast Asia. To further enhance the knowledge gained from this survey, it should be repeated next year with an improved questionnaire and, if possible, a bigger sample size.

6. Conclusions and Recommendation

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

6.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and carbon dioxide 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. TFEC in 2035 will increase 1.7 times from 2012 with electricity increasing 2.1 times during the same period. Oil will increase 1.9 times, but will retain its highest fuel share in final consumption at

1,942 Mtoe. Transportation sector consumption – which is dominated by road transport – will increase 2.2 times, to 1,206 Mtoe in 2035.

2. Electricity generation in 2035 will increase 2.1 times, to 18,530 GWh from 2012, with coal increasing 2.0 times. Although nuclear will increase 6.6 times and NRE 2.1 times during the same period, coal will continue to have the largest share at 59 percent in 2035. Electricity generation will be the source of 64.6 percent of the 3,877 Mtoe of primary demand for coal.
3. Total Primary Energy Supply (TPES) in 2035 will increase 1.7 times from 2012. However, even in the BAU, the EAS region's energy elasticity, which is defined as the growth rate of primary energy demand divided by the growth rate of GDP from 2012 to 2030, is projected to improve to 0.58 (2.3/4.0), compared with 1.08 (4.2/3.9) from 1990 to 2011.
4. The continuing reliance on fossil fuels to meet increasing energy demand will also be associated with significant increases in CO_2 emissions. However, even in the BAU, CO_2 elasticity, which is defined as the growth rate of CO_2 emissions divided by the growth rate of GDP from 2012 to 2035, will be 0.51 lower than energy elasticity. There are two reasons for this. The first is diversification amongst fossil energy from coal to gas. Coal's share of the total primary energy mix is forecast to decline from 52.0 percent in 2010 to 44.9 percent in 2035. On the other hand, the share of gas is projected to increase to 9.1 percent from 12.8 percent during the same period. The second reason is the increased use of carbon-neutral energy, such as nuclear power, hydro power, geothermal power, and new and renewable energy (NRE). The share of carbon neutral energy in 2012 was 15.3 percent, but is forecast to increase to 17.6 percent in 2035.
5. The EAS energy mix in the BAU scenario will change from 2012 to 2035. The share of coal and oil will fall from 75.6 percent to 69.6 percent. The diversification of the regional energy mix, which increases the share of low-carbon and carbon-neutral energy, will contribute to improvements in carbon intensity.
6. Industry remains as a major consumer of energy, but the transport sector continues to increase rapidly. These two sectors are challenging sectors in terms of improving energy efficiency and reducing CO_2 emissions. Hence, appropriate energy efficiency and conservation programmes and low emission technologies are needed in these sectors.
7. Throughout the region there is strong potential to increase energy efficiency to reduce growth in energy consumption and CO_2 emissions. The results of this analysis indicate that by 2035 the implementation of currently proposed energy efficiency goals, action plans, and policies across the EAS region could lead to the following reductions:
    - 13.2 percent in primary energy demand;
    - 13.2 percent in energy intensity; and
    - 23.8 percent in energy derived CO_2 emissions.

6.2. Policy Implications

Based on the above key findings, the Working Group members identified a number of policy implications, which were 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.

a. *Energy Efficiency Action Plans in Final Consumption Sectors*

The industry sector would be a major source of energy savings because it will still be the largest energy-consuming sector by 2035. There are several EEC action plans to be implemented, which include replacement of existing facilities and equipment with more efficient ones. In addition, the Working Group had the following recommendations:

- Change the industrial structure from heavy to light industries – a shift of energy intensive industry to less energy intensive industries would surely reduce energy consumption per unit of GDP output.

In the road transport sector, the following are measures that are considered to definitely reduce energy consumption per unit of transport activities:

- Improve fuel economy;
- Shift from personal to mass transportation mode;
- Shift to more efficient technologies such as hybrid vehicles and clean alternative fuels.

In other sectors, the following measures were identified to improve energy efficiency:

- Use demand management systems such as household energy management systems (HEMS) and building energy management systems (BEMS);
- Improve thermal efficiency in the power generation sector by constructing or replacing existing facilities with new and more efficient generation technologies.

b. *Need for Consistent EEC Policies*

To further promote energy efficiency, effective and consistent energy efficiency policies will be needed:

- Demand side
    - Establishment of energy management system
    - Promotion of energy efficiency in small and medium enterprises (SMEs)
- Supply side
    - Strong support for energy technology development such as smart grids
    - Planning of best energy mix in both power generation and primary energy supply
    - Use of more efficient thermal power generation technologies
- Financial side

- Provision of financial incentives on EEC such as soft loans, tax credits, and other incentives that would support energy efficiency and conservation

c. *Shift from Fossil to Non-fossil Fuels to Curb CO_2 Emissions*

To curb the increasing CO_2 emissions, there is a need to shift from fossil to non-fossil fuels. This could be attained by increasing the share of new and renewable energy as well as nuclear energy in the energy mix of each country. Joint research amongst industries, governments, and academics should be carried out to determine the economic potential of NRE and the safe use of nuclear energy.

Various analyses show that the intermittent nature of renewable energy sources poses significant challenges in integrating renewable-energy generation with existing electricity grids. Governments should look into this integration problem, as increasing share of renewable electricity would entail significant costs. Government investment in electricity storage technologies, especially for solar and wind power, might be needed.

Even in the APS, the carbonisation ratio is still projected to increase in view of the inevitable continuing use of fossil fuels to meet increasing demand in both the final consumption and electricity generation sectors. This implies that the development of carbon capture and storage (CCS) technology will be very important in controlling the release of greenhouse gases into the atmosphere.

Likewise, carbon sinks such as forests should also be increased to lessen the impact of emitted CO_2 on the environment.

In most cases, RE technologies are not as competitive as thermal power generation technologies using fossil fuel. Supportive RE policies are needed, therefore, and they can be categorised as energy policies and financial policies. The former mainly include policies such as Feed-in-Tariff (FIT), Renewable Portfolio Standard (RPS), net metering, carbon tax, or carbon cap and trade. Financial policies include public financing, carbon financing, and banking regulations with sustainability requirements. The key to incentivise private investment in renewable energy is to lower the risks related to renewable energy projects and improve the profitability prospects.

d. *Rationalising Energy Pricing Mechanism*

The Working Group members recognised that distorted energy pricing is a barrier to the effective implementation of energy efficiency policies. It was suggested, therefore, that energy prices should be rationalised to reflect the real cost of energy while ensuring that the most vulnerable sectors of society are still able to use energy. Rationalising energy prices is considered to be an important policy that would help to improve more efficient use of energy. Furthermore, government incentives would be necessary for consumers to choose the best energy mix.

e. *End-use Energy Statistics*

The Working Group also recognised the need for end-use energy statistics in all energy-consuming sectors. Currently, only a few countries collect this information and databases containing such information are scarce. End-use energy statistics are important for the formulation and assessment of the effectiveness of energy saving policies and monitoring of actual energy savings.

6.3. Recommendations

The analysis in this report indicates that there is significant potential for countries in the EAS region to reduce growth in energy consumption and CO_2 emissions by implementing policies across all sectors of the economy that encourage improvements in energy efficiency and conservation and increase the use of lower emission technologies and fuels.

It is clear that many EAS countries already have a variety of policies aimed at achieving energy saving goals. However, it is recommended that detailed action plans which outline in a broad sense how these energy savings will be achieved should also be developed, especially in industry and road transport sectors. Energy management is one of the important action plans in the industry sector. On the other hand, improvement of fuel economy and a shift from personal to mass transport modes are essential in the road transport sector. Rationalising the current pricing mechanism is a key policy to advance energy efficiency and conservation activities, expand the use of renewable energy, provide consumers with the best energy mix, and reduce the burden on national government budgets. However, assistance for low-income households is required to help them cope with higher prices.

A lack of reliable end-use energy statistics will be barriers to monitoring and evaluating energy saving targets and action plans of EAS countries. The pilot survey on end-use energy consumption in the residential sector, which covered both urban and rural areas, has contributed to improving the capability to collect energy consumption statistics. It is recommended that a national energy consumption survey be conducted in all sectors in EAS countries, applying the experience and know-how obtained through the pilot survey.

The projected level of energy savings and reduction in CO_2 emissions will be significant if all of the energy saving and low emission fuel policies proposed at the 6th Energy Ministers Meeting in September 2012 were implemented in EAS countries. Although enhanced energy efficiency and an increase in the share of low emission and renewable fuels in the energy mix may also have other benefits, such as increasing energy supply diversity and enhancing energy security, these measures are not sufficient to mitigate all of the challenges posed by climate change. Therefore, more aggressive saving goals, advanced technologies to reduce CO_2 emissions directly, such as clean coal technologies along with carbon capture storage, and enhanced uptake of low emission fuels are recommended to further reduce CO_2 emissions.

Concrete action is required to facilitate inter-regional collaboration on technology development, technology transfer, and technology policy implementation within the EAS and between the EAS and the rest of the world. It was also noted that financial schemes to support the inter-regional collaboration on technology transfer may be associated with implementing more energy efficient technologies and increasing the share of renewable energy sources.

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CHAPTER 2

Australian Government Energy Projections to 2050

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Executive Summary

Australian energy projections were derived using the *E4cast* model, a dynamic partial equilibrium model of the Australian energy sector. The *E4cast* modelling framework incorporates domestic as well as international trade in energy sources. It provides a complete treatment of the Australian energy sector, representing energy production, trade, and consumption at a detailed level. As a result, the model can be used to produce a full range of results, including Australian energy balance tables.

Key results in the latest Australian energy projections worth highlighting and reported in this paper are in terms of energy supply and demand. In the policy scenario, electricity generation is projected to grow by 30 percent over the period (0.08 percent per year) to total 332 terawatt hours (tW) in 2050. Coal's share of this production is projected to remain at 64 percent in 2050, whereas the share of gas declines to 14 percent, from the current 19 percent, due to the assumed rising gas prices over the projection period. About one-fifth of Australia's electricity is projected to be generated by renewable sources by 2049–2050.

Primary energy consumption is projected to grow by 42 percent, at a rate of growth of 1 percent per year. This compares with average annual growth in primary energy consumption in Australia of 1.5 percent per year recorded from 2001–2002 to 2011–2012.

The projections include existing government policies, including the Renewable Energy Target and the repeal of carbon pricing ('no carbon pricing' has been included). They also incorporate the latest estimates of electricity generation technology costs from the Australian Energy Technology Assessment (Syed, 2013).

The Business-as-Usual scenario (BAU) has not been included, since the projections represent the Australian government's official estimates of energy consumption and production to 2050 in light of present and known future energy policies.

1. Introduction

1.1. Historical Australian Energy Context

1.1.1. Energy Resources

Australia is endowed with abundant, high-quality and diverse energy resources (Map 1). Australia has around 34 percent of the world's uranium resources, 14 percent of the world's black coal resources, and almost 2 percent of world gas resources. It has only a small proportion of the world's crude oil resources. Australia also has large, widely distributed wind, solar, geothermal, hydroelectricity, ocean energy, and bioenergy resources.

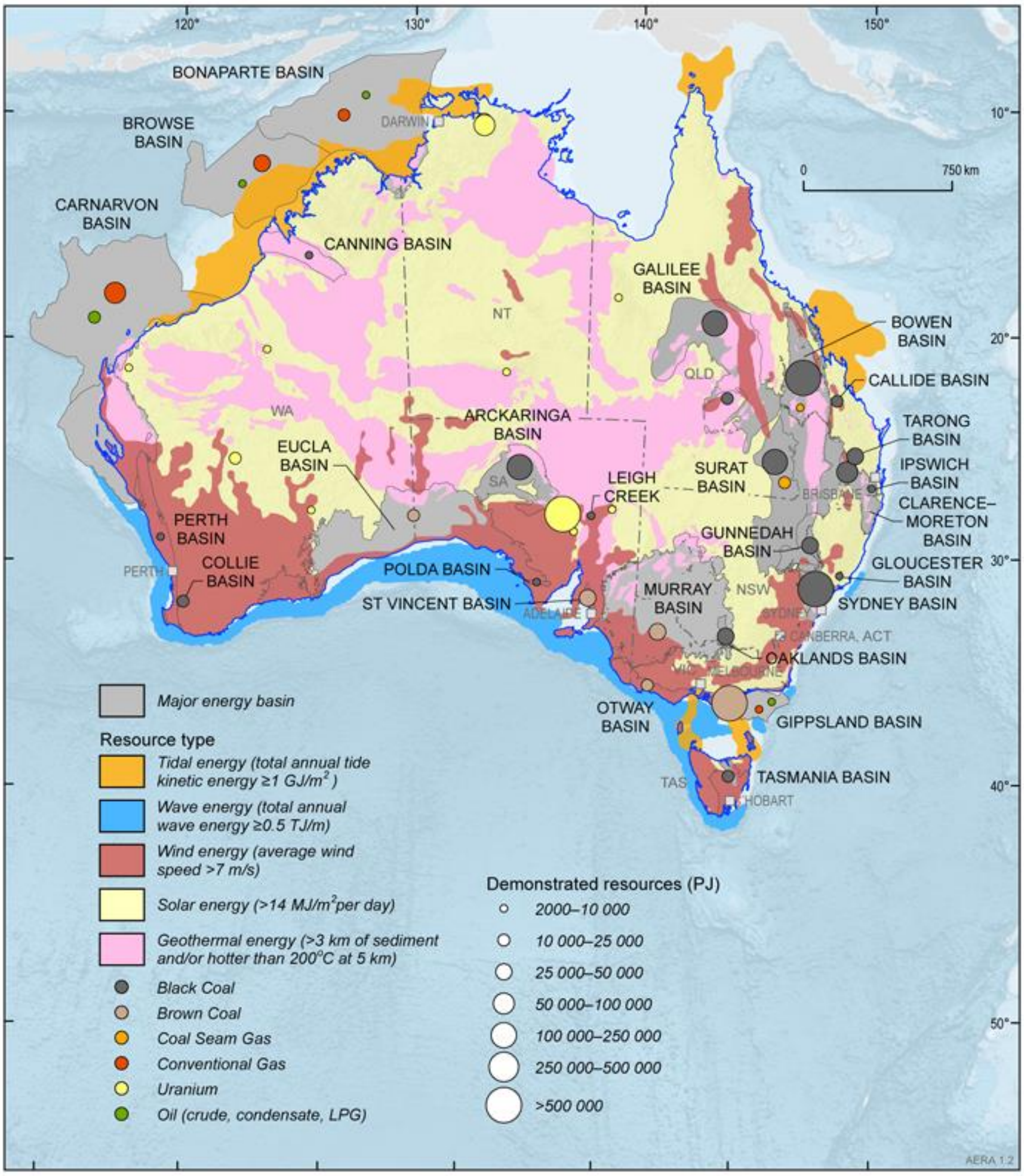
Geoscience Australia (GA) and the Bureau of Resources and Energy Economics (BREE) published *Australian Energy Resource Assessment* (AERA) in June 2014 (GA and BREE, 2014), which has informed the present section of this report. Australia's energy resources are a key contributor to Australia's economic prosperity. Its estimated total demonstrated non-renewable energy resources, with the exception of oil, have increased since 2010.

Australia's diverse energy resource base includes substantial coal resources that support domestic consumption and sizeable energy exports around the world.

Australia is endowed with renewable energy resources (wind, solar, geothermal, ocean, and bioenergy). Wind and solar energy resources are being increasingly exploited, whereas geothermal and ocean energy remain largely undeveloped.

Since uranium is not consumed domestically, it is not included in the energy balance projections presented in the following text. In this section, uranium is included in production and exports to provide a historical description of Australian energy. Therefore, the numbers in this section are not strictly comparable to the numbers in the following sections that exclude uranium.

Map 2.1. Distribution of Australia's Energy Resources

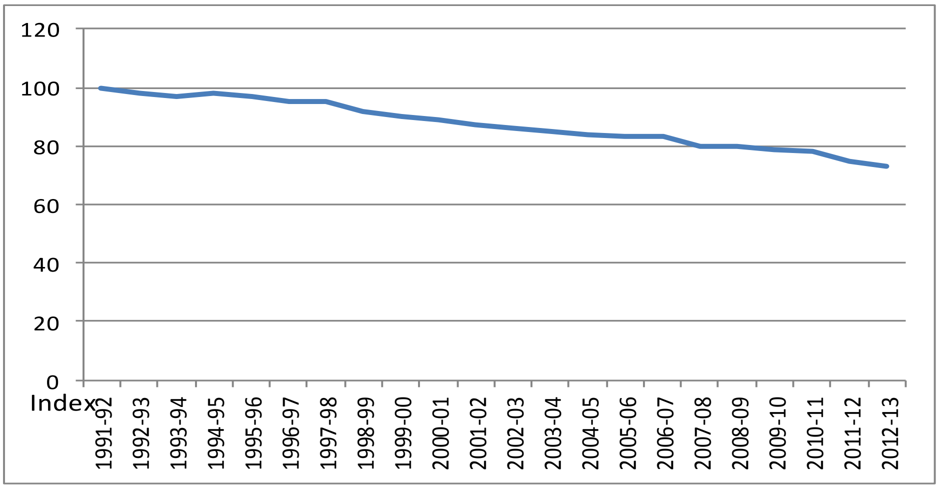


Source: GA and BREE (2014).

1.1.2. Energy Consumption

Primary energy consumption measures the total amount of energy used within the Australian economy. It is the total of the consumption of each fuel in both the conversion and end-use sectors. Over the past three decades, growth in energy consumption has generally remained below the rate of economic growth. This indicates a longer-term decline in the ratio of primary energy use to gross domestic product (GDP), or energy intensity (Figure 2-1) in the Australian economy. This can be attributed to two key factors: improvements in energy efficiency associated with technological advancement; and a shift in industry structure towards less energy-intensive sectors such as the commercial and services sectors.

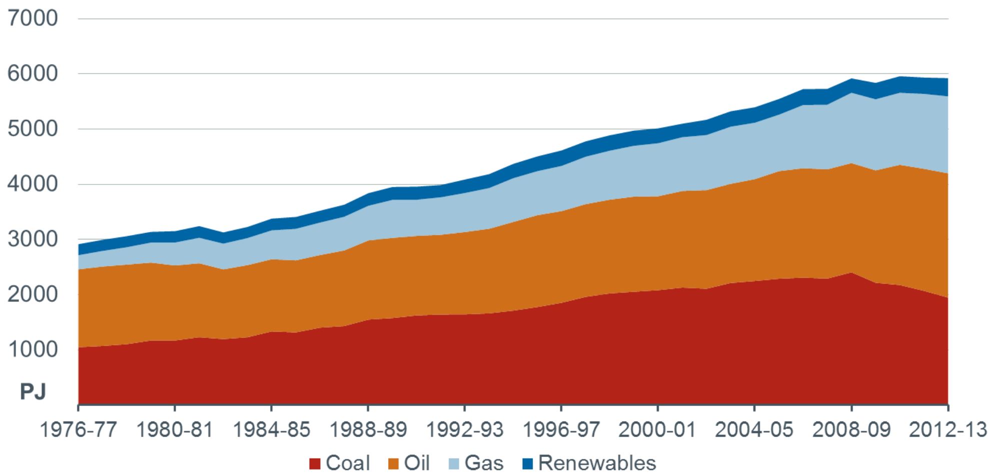
Figure 2-1. Australian Energy Intensity



Source: BREE (2014a), Table B.

In 2012–2013, black and brown coal together accounted for 33 percent of total energy consumption, its lowest share since the early 1970s. Coal consumption fell by 6 percent in 2012–2013, underpinned by falling coal use in the electricity generation and iron and steel sectors.

Figure 2-2. Australian Energy Consumption, by Fuel Type



Source: BREE (2014a), Table C.

The share of natural gas in Australia's energy mix has increased in recent years, supported by greater uptake in the electricity generation sector and growth in industrial use, particularly in the non-ferrous metals sector. Gas consumption rose by 2 percent in 2012–2013, supported by an expansion in alumina output and additional gas-fired electricity generation capacity.

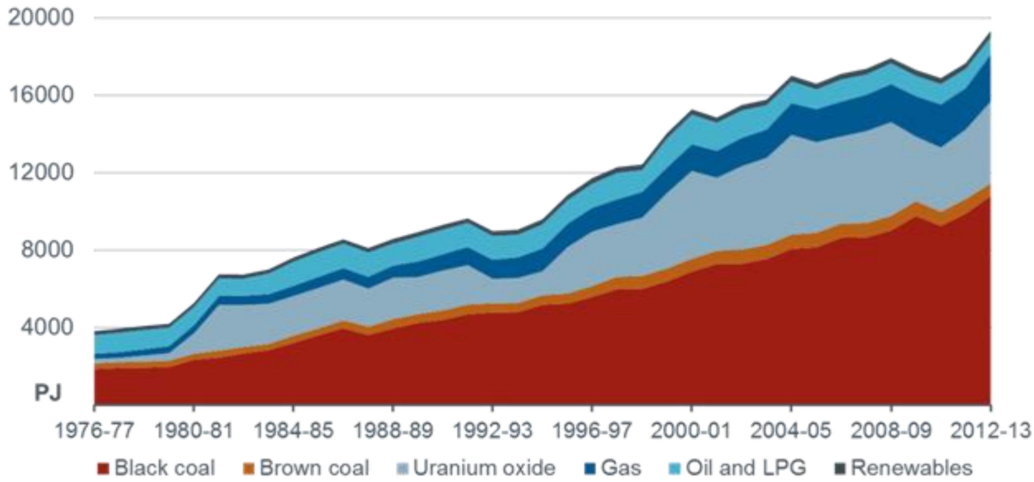
Hydro energy has been another significant contributor to energy consumption in Australia, with other renewables (solar, wind, and bioenergy) representing a much lower proportion of the total primary energy consumption.

1.1.3. Energy Production

Energy production is defined as the total amount of primary energy produced in the Australian economy, as measured before consumption or transformation. Australia is the world's ninth largest energy producer, accounting for around 2.4 percent of the world's energy production (IEA, 2012a). The main fuels produced in Australia are coal, uranium, and gas (Figure 2-3). Although Australia produces uranium, it is not consumed domestically and all output is exported. Coal accounted for around 59.3 percent of total energy production in energy content terms in 2012–2013, followed by uranium (22 percent) and gas (12.7 percent). Crude oil, condensate, and naturally occurring liquefied petroleum gas (LPG) represented 4.6 percent of total energy production in that year, and renewable energy the remaining 1.7 percent.

Australian production of renewable energy is dominated by bagasse, wood and wood waste, and hydroelectricity, which together accounted for around 80 percent of renewable energy production in 2012–2013. Wind and solar energy accounted for the remainder of Australia's renewable energy production, and their production has been increasing strongly.

Figure 2-3. Australian Energy Production, by Fuel Type



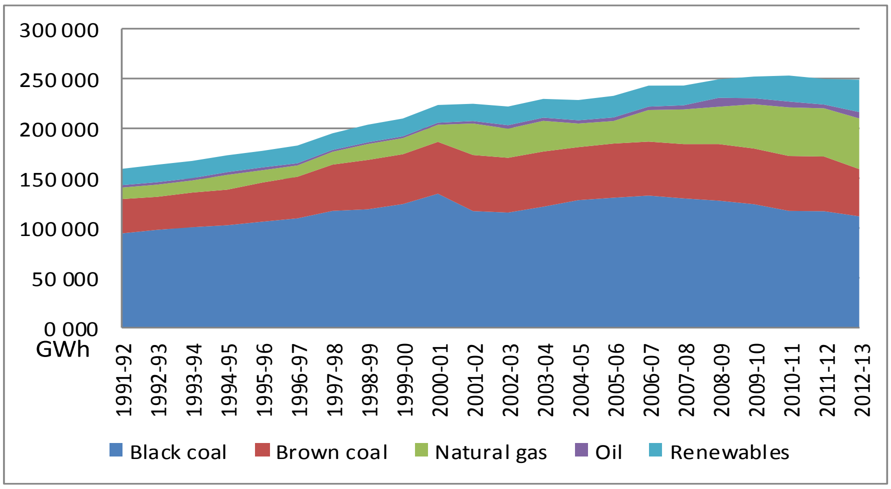
Source: BREE (2014a), Table J.

1.1.4. Electricity Generation

Electricity generation has grown at an average annual rate of 3.5 percent per year from 1991–1992 to 2001–2002. However, there has been a gradual decline in generation over the past few years (Figure 4), from 253 tW (around 911 petajoules) in 2010–2011 to 249 tW (897 petajoules) in 2012–2013. Electricity generation grew at an average rate of 1.2 percent from 2002–2003 to 2012–2013 (Figure 2-4).

Coal continues to be the major fuel source for electricity generation, although its share in total production fell from 77 percent in 2003–2004 to around 66 percent in 2012–2013. In contrast, natural gas-fired generation continued to rise in 2012–2013, supported by new capacity coming on line in Victoria.

Figure 2-4. Australian Electricity Generation, by Fuel Type



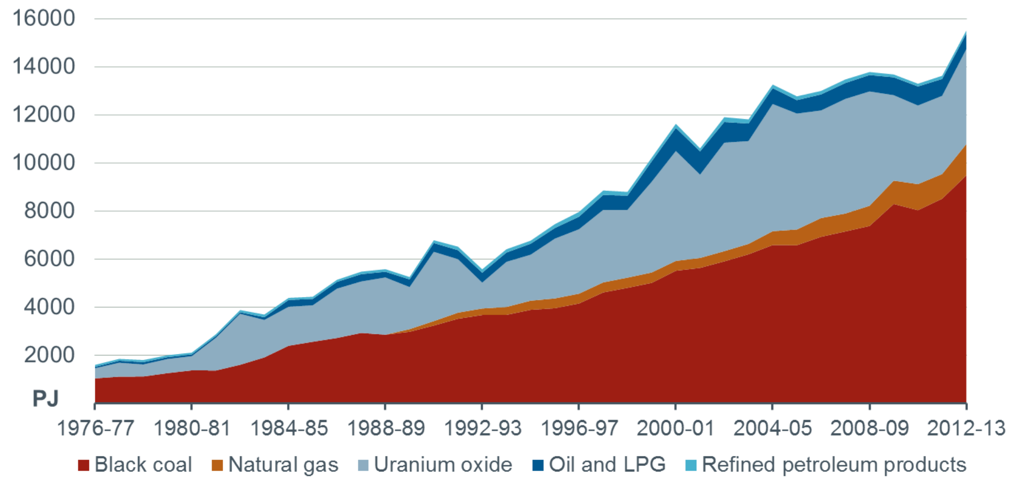
Source: BREE (2014a), Table O.

The share of renewables in Australian electricity generation has risen from approximately 8 percent in 2003–2004 to around 13 percent in 2012–2013.

1.1.5. Energy Trade

Australia's energy exports grew by 14 percent in 2012–2013 in energy content terms, to reach 15,504 petajoules, which is equal to around 80 percent of total energy production. This strong growth was led by Australia's three largest energy exports: black coal, uranium oxide, and liquefied natural gas (LNG) (Figure 2-5).

Figure 2-5. Australian Energy Exports, by Fuel Type



Source: BREE (2014a), Table J.

Total export earnings for mineral and energy commodities for 2013–2014 are forecast to be around US$196 billion, supported by robust growth in both mineral and energy commodity export volumes. These predictions are in spite of tighter international commodity market conditions and lower margins for domestic producers.

In 2013–2014, LNG exports reached 1,303 petajoules (around 23.9 million tonnes). Over the past decade, two new LNG trains built at NWS (in 2004 and 2008), and the start-up of Darwin LNG in 2006 and Pluto in 2012 have been responsible for sustained LNG export growth of 13 percent per year (BREE, 2014b).

Australia is a net importer of liquid hydrocarbons, including crude oil and most petroleum products.

1.1.6. Energy Policy

Energy related policy responsibilities are shared across the different levels of government in Australia. Much of Australia's energy policy is developed and implemented through cooperative action between the Australian and state and territory governments.

The government has prioritised a new Energy White Paper to address the challenges facing Australia's energy sector and to provide industry and consumers with certainty in government policy.

The Energy White Paper articulates a coherent and integrated national energy policy, addressing the issues of reliable and competitively priced energy supply, streamlining regulation, and driving a commercially driven energy market that provides transparent prices and investment signals across all sources of energy and proven energy technologies.

Further information is available on the Energy White Paper website www.ewp.industry.gov.au

1.1.7. Renewable Energy Target

The objective of the Renewable Energy Target (RET) is to advance the development and employment of renewable energy resources over the medium term and to assist in moving Australia to a lower-carbon economy. The Renewable Energy Target legislation requires that the scheme is reviewed every two years.

From 1 January 2011, the RET has operated as two parts:

1. Large-scale Renewable Energy Target (LRET), and
2. Small-scale Renewable Energy Scheme (SRES).

The LRET encourages the deployment of large-scale renewable energy projects such as wind farms, whereas the SRES supports the installation of small-scale systems, including rooftop solar panels and solar water heaters. The LRET is set in annual gigawatt hour targets, rising to 41,000 GWh in 2020. The LRET target remains at 41,000 GWh from 2021 to 2030.

Small businesses and households are anticipated to provide more than the additional 4,000 gigawatt hours through the SRES. The Clean Energy Regulator (CER) oversees the RET. The LRET targets are presented in Table 2-1 (CER, 2014).

Table 2-1. Renewable Electricity Generation Target (excluding existing renewable generation)

Year ending	TWh
2014	16.9
2015	18.8
2016	21.4
2017	26.1
2018	30.6
2019	35.3
2020 and onwards	41.0

Source: CER (2014).

In *E⁴cast*, the renewable energy target is modelled as a constraint on electricity generation – renewable energy must be greater than or equal to the interim target in any given year. In the model, the large-scale grid renewable generation is modelled by a subsidy to renewables that is funded by a charge on non-renewable generators. This is endogenously modelled so that total renewable generation meets the target.

The RET includes compulsory targets, such as 41 TWh LRET by 2020 that is maintained to 2030, and 15 TWh existing renewable generation below baseline. Thus, the compulsory RET target equates to a total of 56 TWh renewable electricity generation from large grid-based plants.

In *E4cast*, only grid generation is modelled (excluding rooftop solar, or non-grid small generation plants).

1.1.8. Energy Efficiency

Over the last two decades there has been a significant coordinated effort between Australian Commonwealth and state and territory governments to ensure that energy efficiency opportunities are recognised and realised. In particular, governments have sought to act where market failures have limited the take up of cost-effective energy efficiency activities. In 2009, Australian governments entered into a partnership agreement and developed a National Strategy on Energy Efficiency (NSEE) to accelerate energy efficiency efforts.

These activities – in particular, improved efficiency of refrigeration, air conditioning and electronics, minimum performance standards for a range of common household appliances, and energy efficiency requirements in the Building Code – are beginning to show up in Australia's energy use trends. Together with the growth in rooftop solar PV and a decline in some energy intensive industries, improved energy efficiency has reduced demand in the national electricity market, although this trend may be reversing since the repeal of the carbon price (Sadler, 2014). Moreover, energy efficiency measures can also reduce the need for costly upgrades to electricity infrastructure, if they are targeted at reducing peak demand.

2. Key Assumptions

A number of economic drivers will shape the Australian energy sector over the next two decades. These include

- Population growth;
- Economic growth;
- Energy prices;
- Electricity generation technologies;
- End-use energy technologies; and
- Government policies.

The assumptions relating to these key drivers are presented below.

2.1. Population Growth

Population growth affects the size and pattern of energy demand. Projections for the Australian population are taken from the Australian Bureau of Statistics publication (ABS, 2013) and are presented in Table 2-4.

Table 2-2. Australian Population Assumptions

Year	Population Millions
2015	23.94
2020	26.03
2030	30.11
2040	33.92
2050	37.59

Source: ABS (2013).

2.2. Economic Growth

Sector-level energy demand within *E4cast* is primarily determined by the value of the 'activity' variable used in each sector's fuel demand equation, along with fuel prices; that is, direct and cross price, and income elasticities, as well as energy efficiency improvements.

Since *E4cast* is a bottom-up model, the activity variable used for all non-energy-intensive sectors is gross state product (GSP), which represents income or business activity at the state level. However, for energy-intensive industries (aluminium, other basic nonferrous metals, and iron and steel manufacturing) projected industry output is considered as a more relevant indicator of activity than GSP because of the lumpy nature of investment.

The long-term projections of the GDP and GSP assumptions (Table 2-3) are provided by the Australian Treasury.

Table 2-3. Australian Economic Growth, by Region

Annual Growth Rate 2014–15 to 2049–50	%
New South Wales	2.6
Victoria	2.5
Queensland	3.2
South Australia	1.5
Western Australia	3.3
Tasmania	1.8
Northern Territory	2.6
Australia	**2.7**

Source: Australian Treasury provided assumptions on GSP and gross domestic product (GDP).

2.3. Real Energy Prices

Domestic fuel costs, such as gas, black and brown coal, biomass and biogas, are based on the fuel price projections to 2050 used in Syed 2013.

2.4. Electricity Generation Technologies

The *Australian Energy Technology Assessment* (AETA) provides insights on 40 market-ready and prospective electricity generation technologies in Australia (Syed, 2013). AETA provides latest levelised cost of energy (LCOE) estimates and projections to 2050. Although other similar cost estimates have been conducted internationally, these studies are not directly applicable to Australian conditions due to differences in domestic costs (e.g. labour), differences in the quality of domestic energy resources, technology performance, and other local conditions. The LCOE estimates provided in Syed 2012, and 2013 were used in the present projections.

2.5. Government Policies

The key policies that have been modelled explicitly in *E4cast* included the repeal of carbon tax and the Minerals Resource Rent. Noting that government policy is to introduce the direct action plan to mitigate carbon emissions, there is no direct or indirect pricing of carbon emissions in the projections. The existing renewable energy target has been retained. Direct action plan was not modelled directly given the capacity of the model.

3. Energy Projection Results in Alternative Policy Scenarios

Australian energy projections in the Alternative Policy Scenarios (APS) from 2015 to 2050 on energy consumption, electricity generation, and production are provided in Tables 2-4 to 2-8 below.

3.1. Energy Consumption

Total primary energy consumption is projected to grow by nearly 42 percent (or 1 percent per year) over the projection period (Table 2-4). This compares with average annual growth in primary energy consumption in Australia of 1.5 percent per year from 2001–2002 to 2011–2012.

Coal and gas will continue to supply Australia's energy needs, although their share in the energy mix is expected to decline.

The use of gas (conventional and unconventional natural gas) in industries is expected to grow over the outlook period, with projected falls in gas-fired electricity generation offset by growth in the consumption of gas in LNG production.

Renewable energy consumption is projected to increase moderately at a rate of 0.9 percent per year over the projection period. The growth in renewable energy is mainly driven by strong growth in wind and solar energy, at 2 and 1.7 percent, respectively.

The higher growth rates in energy consumption projected for Queensland, Northern Territory, and Western Australia, compared with other states, are underpinned by higher gross state product assumptions, combined with the high share of mining in economic output and the significant projected expansion of the gas sector, in particular LNG.

The electricity generation sector and the transport sector are expected to remain the two main users of primary energy over the outlook period.

The mining sector accounts for 8.7 percent of primary energy consumption in 2014–2015 and is projected to have the highest energy consumption growth rate over the outlook period. This reflects the expected ongoing moderate global demand for energy and mineral commodities and the large number of mineral and energy projects (including LNG and coal seam gas) assumed to come on stream over the next few years.

Table 2-4. Primary Energy Consumption, by Energy Type

	2014–15 (PJ)	2034–35 (PJ)	2049–50 (PJ)	% share 2014–15	% share 2049–50	Average Annual Growth 2014–15 to 2049–50
Non-renewables	**5,675**	**7,220**	**8,078**	**94**	**95**	**1.0**
Coal	1,635	1,871	1,945	27	23	0.5
black coal	1,171	1,407	1,436	19	17	0.6
brown coal	464	464	509	8	6	0.3
Oil	2,431	3,304	3,879	40	45	1.3
Gas	1,610	2,045	2,253	27	26	1.0
Renewables	**341**	**441**	**463**	**6**	**5**	**0.9**
Hydro	68	68	66	1	1	-0.1
Wind	59	116	118	1	1	2.0
Bioenergy	195	220	231	3	3	0.5
Solar	19	23	34	<1	<1	1.7
Geothermal	0	14	14	0	<1	
Total[a]	**6,016**	**7,661**	**8,541**	**100**	**100**	**1.0**

a/ Numbers in the table may not add up to their totals due to rounding.
Source: Author's calculation.

Oil consumption in the transport sector is expected to grow steadily over the projection period at an average rate of 1.3 percent per year, driven largely by economic growth. Within the transport sector, road transport is the largest contributor to energy consumption. Energy use in the road transport sector is projected to grow by 0.65 percent per year on average over the period to 2049–2050.

Primary energy consumption, by sector

At the sectoral level, the main drivers of primary energy consumption are the electricity generation sector, the transport sector, and the manufacturing sector. These sectors are projected to account for 64 percent of the increase in primary energy consumption from 2014–2015 to 2049–2050 (Table 2-5).

The electricity generation sector accounted for the largest share (34 percent) of primary energy consumption in 2014–2015. Total primary energy consumption in the power generation sector is projected to grow at only 0.3 percent per year, to increase from 2,054 petajoules in 2014–2015 to 2,278 petajoules in 2049–2050 (Table 2-8). Further details about the electricity generation sector projections are provided below.

Table 2-5. Primary Energy Consumption, by Sector

Sector	2014–15 (PJ)	2034–35 (PJ)	2049–50 (PJ)	% share 2014–15	% share 2049–50	% Average Annual Growth 2014–15 to 2049–50
Electricity generation	2,054	2,268	2,278	34	27	0.3
Agriculture	103	133	157	2	2	1.2
Mining	523	1,051	1,211	9	14	2.4
Manufacturing	1,244	1,456	1,618	21	19	0.8
Transport	1,752	2,325	2,723	29	32	1.3
Commercial & Residential	339	427	554	6	6	1.4
Australia[a]	**6,016**	**7,661**	**8,541**	**100**	**100**	**1.0**

a/ Numbers in the table may not add up to their totals due to rounding.
Source: Author's calculation.

The transport sector (excluding electricity used in rail transport) is expected to account for 29 percent of primary energy consumption in 2014–2015 and continues to rely heavily on oil. Consumption of oil and petroleum products in the transport sector is expected to grow steadily over the projection period at an average rate of 1.3 percent per year, driven largely by economic growth (Table 2-8). Also, the share of the transport sector in primary energy consumption is projected to increase marginally from 29 percent to 32 percent over the period to 2049–2050. This effect is evident due to the slow growth in two main fuel-consuming sectors in the economy – electricity generation and manufacturing.

The manufacturing sector is the third largest user of primary energy in Australia, accounting for a share of 21 percent in 2014–2015. This sector covers a number of relatively energy-intensive sub-sectors such as petroleum refining, iron and steel, aluminium smelting, and minerals processing. Whereas energy consumption in the manufacturing sector is projected to increase at an average annual rate of 0.8 percent over the outlook period, the share of the sector in total primary energy consumption is expected to decline, which reflects a progressive structural shift toward less energy-intensive sectors.

The mining sector, which contributed only 9 percent of primary energy consumption in 2014–2015, is projected to have the highest energy consumption growth rate (2.4 percent per year) over the outlook period. This reflects the continuation of global demand for energy and mineral commodities and the large number of mineral and energy projects (including LNG and coal seam gas) assumed to come on stream over the outlook period. The considerable volume of investment is a major driver of the expected expansion in the mining sector and the associated growth in primary energy consumption. In 2049–2050, the sector is projected to account for 14 percent of Australian primary energy consumption.

3.2. Electricity Generation

- Gross electricity generation is projected to grow by nearly 30 percent (or 0.8 percent per year) from 255 tW hours in 2014–2015 to 332 tW hours in 2049–2050 (Table 2-6). Coal is expected to remain the dominant source of electricity generation. The share of coal in electricity generation is projected to remain broadly constant (64 percent in 2014–2015 and 65 percent in 2049–2050), growing at 0.8 percent per year.

- Due to the declining cost of renewable generation (mostly wind and solar) over the projection period, as shown in the latest Australian Energy Technology Assessment report (Syed, 2013), electricity production from renewables is expected to grow by 1.5 percent per year, with wind and solar growing at a rate of 2 percent and 3 percent, respectively, over the projection period. The share of renewables is expected to increase from 15.3 percent in 2014–2015 to 22 percent in 2020, and then fall slightly, to 20.1 percent, by 2049–2050.

Table 2-6. Electricity Generation, by Energy Type (TWh)

Energy Type	2014–15	2034–35	2049–50	% share 2014–15	% share 2049–50	% Average Annual Growth 2014–15 to 2049–50
Non-renewables	**216**	**252**	**265**	**85**	**80**	**0.6**
Coal	163	200	214	64	65	0.8
black coal	117	153	163	46	49	1.0
brown coal	47	47	51	18	15	0.3
Gas	50	49	48	19	14	-0.1
Oil	3	3	3	1	1	0.0
Renewables	**39**	**63**	**67**	**15**	**20**	**1.5**
Hydro	19	19	18	7	6	-0.1
Wind	16	32	33	6	10	2.0
Bioenergy	2	5	6	1	2	3.7
Solar	2	3	6	1	2	3.0
Geothermal	0	4	4	0	1	
Total[a]	**255**	**315**	**332**	**100**	**100**	**0.8**

a/ Numbers in the table may not add up to their totals due to rounding.
Source: Author's calculation.

3.3. Final Energy Consumption, By Energy Type

Total final energy consumption in Australia is projected to increase from 4,399 petajoules in 2014–2015 to 6,582 petajoules in 2049–2050, a rise of 50 percent over the projection period and an average annual rate of increase of 1.2 percent (Table 2-7).

This compares with an average annual growth rate of 1.7 percent in the 10 years to 2014–2015. Electricity is projected to continue to grow strongly to meet energy demand in end-use sectors. This will reduce the relative share of gas in final energy consumption by 2050, although the amount of gas consumption is projected to increase by 35 percent between 2014–2015 and 2049–2050. Petroleum products are projected to see the fastest growth rate, with an average rate of 1.4 percent per year over the projection period. Since the share of petroleum products in total final energy consumption increases from 53 percent to 57 percent from the beginning to the end of the outlook period, the shares of gas, electricity, and coal fall accordingly. The decline in the share of gas is predominantly due to rising prices to 2049–2050. The demand for petroleum products increases from growing mining and residential sectors. The consumption of renewables is projected to grow moderately, at a rate of 0.7 percent per year, in the absence of carbon pricing.

Table 2-7. Final Energy Consumption, by Energy Type

Energy Type	2014–15 (PJ)	2034–35 (PJ)	2049–50 (PJ)	% share 2014–15	% share 2049–50	% Average Annual Growth 2014–15 to 2049–50
Coal	119	139	152	3	2	0.7
Petroleum products	2312	3169	3734	53	57	1.4
Gas	999	1159	1346	23	20	0.9
Renewables	186	220	240	4	4	0.7
Electricity	784	1037	1111	18	17	1.0
Total[a]	**4399**	**5725**	**6582**	**100**	**100**	**1.2**

a/ Numbers in the table may not add up to their totals due to rounding.
Source: Author's calculation.

3.4. Energy Production and Trade

Total production of non-uranium energy in Australia is projected to grow by 59 percent (or 1.3 percent per year) (Table 8) over the projection period, driven by strong growth in gas, to reach 27,567 petajoules in 2049–2050.

Although coal production is expected to continue to increase, with projected growth of 1.2 percent per year, its share in total energy production is expected to fall from 75 percent in 2014–2015 to 71 percent by the end of the projection period.

The production of gas (conventional and unconventional natural gas) is expected to grow at a rate of 2.5 percent per year over the projection period, and its share in total Australian energy production is forecast to increase from 18 percent to 27 percent from the beginning to the end of the projection period.

Australia's exports of energy are expected to grow over the projection period. In 2014–2015, the ratio of Australia's primary energy consumption to energy production (excluding uranium) is estimated to be 35 percent. By 2049–2050, this ratio is projected to have fallen to 31 percent.

Black coal, which includes both thermal and metallurgical coal, is projected to remain Australia's dominant energy export. The projected average annual growth rate of 1.2 percent is based on expectations that global demand for coal will continue to increase in the period to 2049–2050 as a result of increased demand for electricity and steel-making raw materials, particularly in emerging market economies in Asia.

LNG exports are also projected to increase significantly. By 2049–2050, LNG exports from the western market have the potential to reach 44 million tonnes (2,838 petajoules), which reflects an average annual growth rate over the projection period of 2.6 percent. LNG growth is higher in Eastern Gas Market and Northern Gas Market exports, at 6.7 and 4 percent per year, respectively, over the projection period. It may be noted that LNG exports are included as exogenous variables, using the data to 2020 from BREE's internal database. International Energy Agency (IEA) projections for growth in LNG supply in Australia are used (IEA, 2013) as well.

With declining oil production and limited prospects for an expansion of refinery capacity, coupled with recent refinery closures, Australia's net trade position for crude oil and refined petroleum products is expected to deteriorate over the outlook period. Australia's net imports of liquid fuels are projected to increase by 2.4 percent per year on average.

The main sources of energy produced in Australia on an energy content basis are coal, uranium, and gas. With the exception of crude oil and refined petroleum products, Australia is a net exporter of energy commodities. In 2014–2015, production of coal is expected to be 13,021 petajoules, or 75 percent of total energy production (excluding uranium). In physical terms, total coal production is expected to be 570 million tonnes. Gas is expected to account for 18 percent of total energy production, followed by crude oil and condensate and naturally occurring LPG (5 percent) and renewables (hydroelectricity, wind energy, bioenergy, and solar energy) at 2 percent. Although Australia is a significant producer of uranium oxide, it is not included in the projections as it is not consumed as a fuel in Australia and, therefore, does not affect the domestic energy balance.

Table 2-8. Energy Production, by Source

	2014–15 (PJ)	2034–35 (PJ)	2049–50 (PJ)	% share 2014–15	% share 2049–50	% Average Annual Growth 2014–15 to 2049–50
Non-renewables	**17009**	**26492**	**27104**	**98**	**98**	**1.3**
Coal	13021	19299	19441	75	71	1.2
black coal	12557	18834	18932	72	69	1.2
brown coal	464	464	509	3	2	0.3
Oil	786	348	161	5	1	-4.4
LPG	93	98	104	1	0	0.3
Gas	3109	6748	7398	18	27	2.5
Renewables	**341**	**441**	**463**	**2**	**2**	**0.9**
Hydro	68	68	66	0	0	-0.1
Wind	59	116	118	0	0	2.0
Bioenergy	195	220	231	1	1	0.5
Solar	19	23	34	<1	<1	1.7
Geothermal	0	14	14	0	<1	
Total	**17350**	**26933**	**27567**	**100**	**100**	**1.3**

Note: Numbers in the table may not add up to their totals due to rounding.
Source: Author's calculation.

Total production of energy in Australia (excluding uranium) is projected to grow at an average rate of 1.3 percent per year to 2049–2050. At this rate, Australian production of energy is projected to increase by 59 percent to reach 27,567 petajoules in 2049–2050 (Table 8). Gas production is projected to increase from 3,109 petajoules (57 million tonnes) in 2014–2015 to 7,398 petajoules (136 million tonnes) in 2049–2050, or 27 percent of total energy production. At the same time, the combined share of crude oil and naturally occurring LPG is projected to be around 1 percent of total energy production (at 265 petajoules) in 2049–2050. The share of coal in total energy production is projected to fall slightly, from 75 percent in 2014–2015 to 71 percent by 2049–2050.

4. Conclusions

The energy sector projections presented in this report are derived using the *E4cast* model. *E4cast* is a dynamic partial equilibrium model of the Australian energy sector. It is used to project energy consumption by fuel type, industry, and state and territory to 2050, on an annual basis.

The current projections show that Australian energy consumption will continue to grow over the next 40 years, albeit at a much lower rate than in the past 20 years. This is because of the substitution of renewables for fossil fuels in electricity generation – which require much less energy use to generate electricity – and because of expected energy efficiency improvements, and higher energy prices.

Gross electricity generation is projected to grow at a rate of 0.8 percent per year over the outlook period. This growth is dominated by coal-fired electricity generation. Coal and oil will continue to supply the bulk of Australia's energy needs, although their share in the energy mix is expected to decline. The use of gas (natural gas and coal seam gas) as final energy consumption in industries is expected to grow by 1 percent per year over the outlook period. This moderate growth is driven primarily by negative gas-fired electricity generation growth, but positive consumption of gas in liquefied natural gas (LNG) production. Black coal is projected to remain Australia's dominant energy export. LNG exports are also projected to increase significantly.

The share of renewable energy is projected to increase moderately at a rate of 0.9 percent per year over the projection period. The growth in renewable energy is mainly driven by strong growth in wind and solar energy. Transition to a low carbon economy will require long-term structural adjustment in the Australian energy sector. Although Australia has an abundance of energy resources, this transformation will need to be underpinned by significant investment in energy supply chains to allow for better integration of renewable energy sources and emerging technologies into our energy systems. It will be critical to ensure that the broader energy policy framework continues to support cost-effective investment in Australia's energy future, and timely adjustments to market settings in response to emerging pressures, and market developments.

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CHAPTER 3

Brunei Darussalam Country Report

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1. Background

Brunei Darussalam is a sovereign state located on the north-west coast of the island of Borneo in Southeast Asia. Its land area consists of two unconnected parts with a total area of 5,765 square kilometres on the island of Borneo. The country is divided into four administrative districts – Belait, Tutong, Brunei–Muara, and Temburong. The capital city, Bandar Seri Begawan, is located in the Brunei–Muara district where the country's government operations and major business activities take place. The total population of Brunei was approximately 399,800 as of 2012, of which one-third live in the capital city. Other major towns are the port town of Muara, the oil-producing town of Seria, and its neighbouring town, Kuala Belait. In Belait District, the Panaga area is home to large numbers of Europeans expatriates, due to Royal Dutch Shell and British Army housing.

In 2012, Brunei's gross domestic product (GDP) amounted to US$10.3 billion at constant 2005 US$, reflecting a GDP per capita of US$25,000 in constant 2005 US$. The energy sector was mainly driven by crude oil and LNG exporting activity, which has been the primary driver of overall economic activity of the country. It contributes more than 60 percent of the country's GDP and the sector accounts for about 90 percent of Brunei's total exports.

The country supports the implementation of energy security strategies such as diversification of energy sources and energy efficiency and conservation. The government is currently actively working to achieve the country's economic development target through strengthening upstream and downstream activities for oil and gas, including corresponding energy services, while exploring plans to diversify its energy mix.

2. Energy Supply and Consumption

Natural gas and oil remained the primary sources of energy for Brunei. The country's total primary energy supply was 2.9 Mtoe in 2012, with natural gas contributing the biggest share, of 74.2 percent, followed by oil at 25.8 percent, and a very small part was contributed by solar energy as one of the sources of electricity. As a major oil and gas exporter, Brunei exported 84.2 percent of its oil and gas production in 2012.

Brunei has a total installed capacity of 806.2 MW for power generation, which recorded output of 3.9 TWh in 2012. On top of oil and gas as sources of power, the country has a 1.2 MW solar photovoltaic plant. Likewise, as part of total installed capacity, auto producers' capacity reached a total of 108.9 MW and produced 406 GWh of electricity during the period.

Table 3-1. Energy Supply and Consumption 2012 (Mtoe)

Supply and Consumption	Oil	Gas	Electricity	Total
Primary Energy Supplies				
Indigenous Production	8.00	10.45	-	18.45
Net Import and Others	-7.26	-8.28	-	-15.54
Total Primary Energy Supplies	**0.74**	**2.17**	**-**	**2.91**
Final Energy Consumption				
Industrial Sector	0.20	-	0.02	0.22
Transport Sector	0.45	-	-	0.45
Other Sectors	0.04	0.02	0.26	0.32
Total Final Energy Consumption	**0.69**	**0.02**	**0.28**	**0.99**

Source: EDMC, 2015.

Total final energy consumption (TFEC) of Brunei in 2012 amounted to 0.98 Mtoe. The transport sector had the highest energy consumption at 0.5 Mtoe or 46.0 percent of the TFEC. 'Other' sectors, covering residential and commercial, consumed 30.4 percent of total energy used, and the industrial sector's energy demand accounted for 22.2 percent in the TFEC. In terms of energy demand by fuel type, oil accounted for 69.7 percent of final consumption, followed by electricity and natural gas at 28.3 percent and 2.0 percent, respectively (Table 3-1).

3. Energy Policies

3.1. Supply

Brunei's energy sector is entering an era of new challenges as the country needs to boost upstream production by maximising the potential of its matured fields and venturing into further exploration and development activities. Aligned with the National Vision known as Wawasan Brunei 2035, there is a need to go further in downstream development to maximise the added value creation potential of its upstream assets. In this regard, Brunei has devised the following strategies to strengthen and improve upstream and downstream activities for oil and gas:

1. Sustaining a reserve replacement ratio greater than 1 to ensure Brunei will continue to benefit from oil and gas production in the long term;
2. Improving oil and gas production to more than 650 kboe (kilo barrel of oil equivalent) per day in 2035 and continuously monitoring not only internal but also external variables that could require target refinement;
3. Raising revenue from domestic downstream industries to reach BN$5 billion in 2035 through the development of energy related downstream sub-industries, which cover refinery, chemical, and petrochemical plants.

In addition to the energy supply targets, Brunei has also started to develop renewable energy resources in the country that cover solar and waste-to-energy projects. To support the development of renewable energy sources, the government will implement renewable energy policy and regulatory frameworks to stimulate not only public but also private sector investment in renewable energy development.

3.2. Consumption

Brunei is actively working on energy efficiency and conservation towards a 45 percent energy intensity reduction goal by 2035. In achieving the energy intensity target, relevant government agencies, industry, and other energy stakeholders are collaborating in evaluating legislative, financial, and fiscal policy measures to promote energy efficiency and low-energy intensive industries. Industry's role includes the identification of technical levers that may lead to a reduction of energy usage over time. Other energy stakeholders, such as individuals and households, may shift their consumption behaviour towards the use of more energy-efficient appliances and equipment and take energy efficiency and conservation measures.

4. Outlook Result

4.1. Total Final Energy Consumption (TFEC)

Business-As-Usual (BAU) Scenario

Energy consumption of Brunei has been increasing over the years along with an increase in the country's economic activities. The TFEC increased by 4.8 percent from 0.35 Mtoe in 1990 to 0.98 Mtoe in 2012. Under the BAU scenario, the projected average annual increase of the TFEC is projected to be 2.9 percent from its 2012 level, to reach 1.88 Mtoe in 2035. The projection is linked to a 4.9 percent annual average GDP growth rate in the model. The high rate of GDP growth is supported by the country's aspiration to strengthen its economic structure towards the development of the commercial and service sectors, along with the industrial sector. The highest rate of increase in TFEC by sector is forecast to come from the industrial sector, at 4.8 percent per year. Aggregate demand of the residential and commercial sectors is estimated to increase by 2.7 percent per year, which corresponds to projected population growth of 1.6 percent per year for the period 2012 to 2035 and is also in line with a projected increase in economic activities of the commercial sector. The transport and non-energy sectors are projected to increase by 1.8 percent and 1.6 percent, respectively.

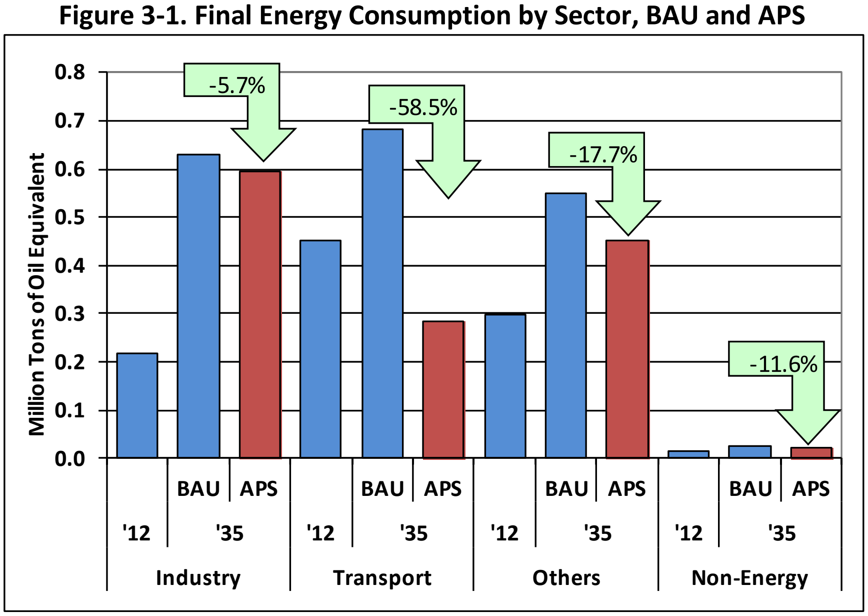
In 2035, the share of oil in the TFEC is forecast at 69.5 percent and will be consumed mainly by the transport sector. The TFEC for oil in 2012 was 0.68 Mtoe and is projected to increase to 1.31 Mtoe in 2035. Demand for electricity is expected to increase by an average 2.9 percent per year from 0.28 Mtoe in 2012 to 0.53 Mtoe in 2035.

Alternative Policy Scenario (APS)

Under the Alternative Policy Scenario (APS), the goal is to reduce energy intensity by 45.0 by 2035 from the 2005 level, and average annual TFEC will increase moderately by 1.4 percent, or from 0.98 Mtoe in 2012 to 1.35 Mtoe in 2035. At the end of the planning period, the industrial sector's share TFEC will be the highest, at 44.1 percent. The combined share of 'other' sectors such as residential and commercial of TFEC is projected at 33.4 percent in 2035, and the transport sector's TFEC will account for 21.0 percent.

A future improvement in vehicle efficiency will be the result of fuel economy regulation. This could be the main factor behind an expected decline in the growth rate of demand in the transport sector of 2.0 percent per year throughout the planning period. Referring to the result of the forecasting model for energy outlook, the TFEC under APS will fall by 28.4 percent compared with the BAU level. The transport sector will contribute the biggest energy savings with a decrease in its demand by 58.5 percent, followed by a 17.7 percent reduction for 'other' sectors, and a 5.7 percent decrease for the industrial sector.

Figure 3-1. Final Energy Consumption by Sector, BAU and APS



Source: Author's calculation
BAU = Business-as-Usual; APS = Alternative Policy Scenario.

4.2. Total Primary Energy Supply (TPES)

Business-As-Usual Scenario

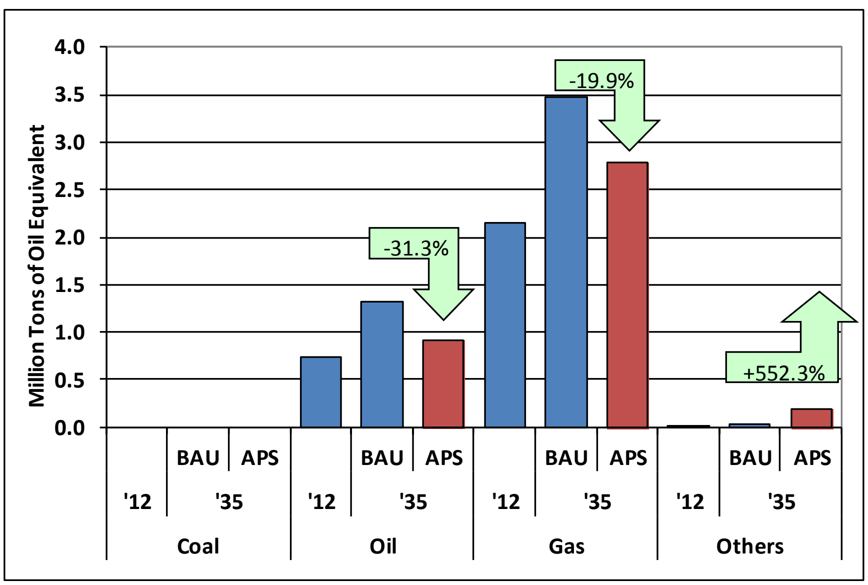
Based on the model projection for BAU, Total Primary Energy Supply (TPES) will increase by 2.2 percent per year, from 2.90 Mtoe in 2012 to 4.82 Mtoe in 2035.

TPES for oil will grow by 2.5 percent per year, from 0.8 Mtoe in 2012 to 1.3 Mtoe in 2035, and natural gas is expected to increase by 2.1 percent per year, from 2.2 Mtoe to 3.5 Mtoe. The figures show that Brunei will continue to be a net exporter of energy in the future. The energy balance table for 2035 indicates that Brunei will be exporting 20.6 Mtoe of natural gas and oil or 84.5 percent of total oil and gas production.

Alternative Policy Scenario

A significant decrease in TPES for oil and natural gas is projected for the APS compared with the BAU scenario in 2035. Oil supply under APS is projected to be 31.3 percent lower than the BAU level, and natural gas supply under APS 19.9 percent lower. But renewable energy is significantly higher under the APS, particularly from solar and waste-to-energy sources, as shown in Figure 3-2.

Figure 3-2. Primary Energy Supply by Source, BAU and APS



Source: Author's calculation
BAU = Business-as-Usual; APS = Alternative Policy Scenario.

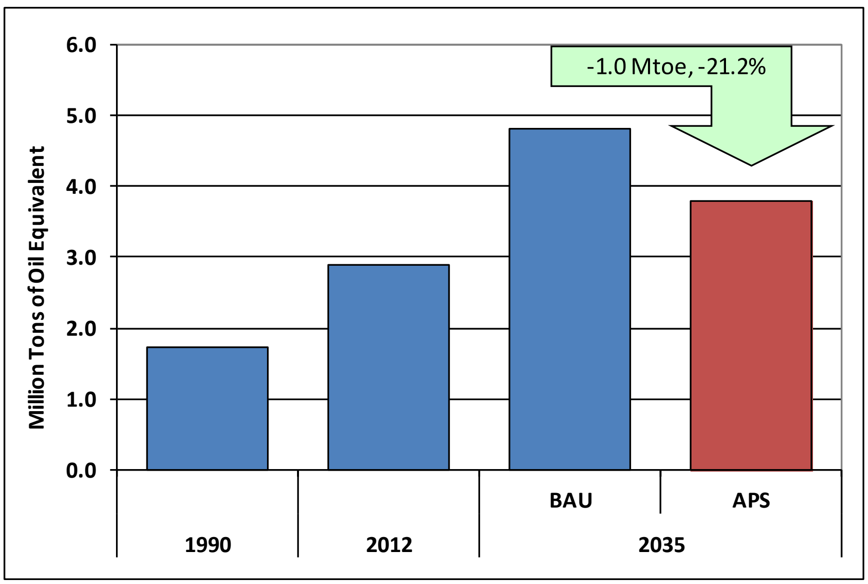
4.3. Power Generation

Power generation capacity for public utilities is dominated by natural gas power plants in Brunei. Of the total installed capacity of 806.2 MW, 1.2 MW is Solar PV and 12.0 MW is diesel power plants. Based on the model's projection, about 7.4 TWh of electricity will be generated in 2035, which means an average annual increase of 2.8 percent over the planning period. Under the BAU scenario, diesel power plants will have been decommissioned by 2018. In future, all new thermal power plants will be use Combined Cycle Gas Turbine technology with an efficiency improvement of 45 percent. Solar PV power plant will be maintained at 1.2 MW capacity throughout the planning period and a 10 MW Municipal Waste-to-Energy plant will be developed as additional capacity.

4.4. Projected Energy Savings

The energy savings potential, derived from the difference between primary energy consumption in the BAU scenario and the APS at the end of the planning period, is projected at 21.2 percent or 1.0 Mtoe. This could be achieved through the implementation of legislative measures on energy efficiency and conservation as well as the development of renewable energy in Brunei (Figure 3-3).

Figure 3-3. Reduction of Primary Energy Consumption, BAU and APS



Source: Author's calculation
BAU = Business-as-Usual; APS = Alternative Policy Scenario.

4.5. Carbon Dioxide (CO_2) Emissions

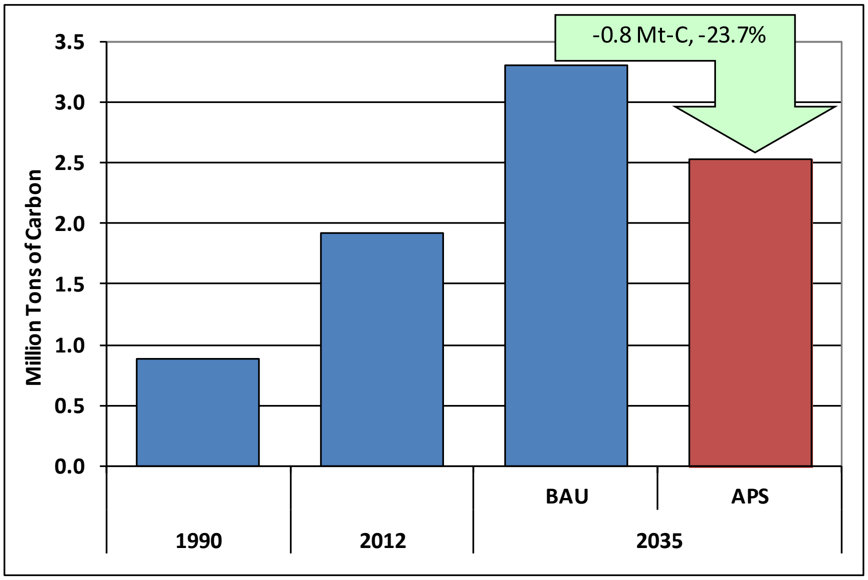
Business-As-Usual

The percentage increase in the CO_2 emission correlates with the increase of the TPES. This is expected because the energy mix of Brunei is 99 percent dependent on fossil fuel. In 2012, the level of CO_2 emission from the energy sector's activity reached 1.9 Mt-C. This level will increase by an average 2.3 percent per year to reach 3.3 Mt-C in 2035.

Alternative Policy Scenario

In the APS, CO_2 emission is projected at a lower level, of 2.5 Mt-C, than under the BAU scenario at the end of the planning period. The decrease in CO_2 emission by 23.7 percent from the BAU scenario to APS could be attained trough greater energy efficiency and use of renewable energy.

Figure 3-4. CO_2 Emission from Energy Consumption, BAU and APS



Source: Author's calculation
BAU = Business-as-Usual; APS = Alternative Policy Scenario.

5. Findings and Policy Implications

5.1. Findings

Achieving the objectives of the National Vision – Wawasan Brunei 2035 – will require a significant increase in the activity level of all economic sectors, including the energy sector. Despite the efforts to focus on energy efficiency and sustainability measures, demand for energy will continue to grow for the next 20 years and fossil fuels will remain the primary source of energy to meet future requirements. The results of the model used in the study show that the improvement in energy efficiency and the development of renewable energy are critical to the reduction of energy demand to realise the country's significant energy savings potential.

5.2. Policy Implications

The projected increase in final energy consumption requires the government to work in close coordination with relevant energy stakeholders to make concerted efforts to continuously promote energy efficiency and conservation. This should be done in collaboration with concerned government and private sector, industries and other energy stakeholders, including individuals.

To realise this, the government should pursue the following objectives:

1. Introduce a policy framework on Public Private Partnerships to accommodate collaboration with the private sector to accelerate the development of renewable energy resources in Brunei.
2. Replace simple cycle power plant with a more efficient combined cycle or cogeneration plant, and put in place an appropriate maintenance programme. This could improve overall power generation efficiency by more than 45 percent by 2020.
3. Evaluate the feasibility of altering the tariff structure to promote desired consumption behaviour and, if appropriate, apply the current progressive electricity tariff of the residential sector to other sectors.
4. Develop a National Standard and Labelling Order for electrical appliances with a view to restricting imports of non-efficient electrical appliances and products.
5. Ensure compliance with EEC Building Guidelines for Non-Residential Buildings that was developed to establish energy efficiency and conservation standards and a regulatory mechanism for buildings in Brunei.
6. Develop a policy initiative for the implementation of Fuel Economy Regulation. To support this policy, hybrid cars, fuel-efficient vehicles, and electric vehicles will have to be introduced.
7. Conduct awareness programmes at all community levels.

CHAPTER 4

Cambodia Country Report

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Ministry of Mines and Energy (MME), Cambodia

1. Background

The Kingdom of Cambodia is located in the Lower Mekong region of Southeast Asia. It has an 800 km border with Thailand in the west, with Lao PDR in the north, and Viet Nam in the east. The physical landscape is dominated by lowland plains around the Mekong River and the Tonle Sap Lake. Of the country's area of 181,035 square kilometres, approximately 49 percent remains covered by forest. There are about 2.5 million hectares of arable land and over 0.5 million hectares of pasture land. The country's gross domestic product (GDP) in 2011 was about US$9.3 billion at constant 2005 prices, with a substantial agriculture share of 34 percent. The population in the same year was 14.5 million.

Cambodia's total primary energy supply (TPES) in 2012 stood at 5.78 Mtoe – oil represented the second largest share of Cambodia's TPES at 28.9 percent; hydro was third at 0.8 percent, followed by coal (0.2 percent), whereas others (mostly biomass) had the bulk of 67.3 percent. Imported electricity accounted for the remaining 2.8 percent.

Final energy consumption stood at 5.03 Mtoe. It is dependent on imports of petroleum products having no crude oil production or oil refining facilities. Its electricity supply is dominated by oil, at 59.8 percent, with hydro, coal, biomass, and solar energy accounting for the rest.

Cambodia has 10,000 MW of hydropower potential, of which 4,931 MW will be developed by 2020. Coal-fired power generation will have a capacity of 380 MW by 2015.

2. Modelling Assumptions

2.1. GDP and Population

In forecasting energy demand to 2035, it is assumed that the GDP of Cambodia will grow at an annual rate of 6.4 percent. With its population projected to grow at 1.7 percent per year, GDP per capita is forecast to grow by 4.6 percent per year up to 2035.

2.2. Electricity Generation

With regard to the future electricity supply, hydro is expected to dominate Cambodia's fuel mix in 2035, 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 3173.2 MW, 900 MW of which will come from coal power plants to be installed from 2010 to 2018. Hydro will make up 1873.2 MW of the total.

From 2020 to 2035, the additional electricity generation capacity requirements will be met by hydro. The gross electricity generation also assumes net export of electricity to neighbouring countries of 2,600 GWh in 2020, and this is projected to gradually increase to 3,080 GWh by 2035.

2.3. Energy Efficiency and Conservation Policies

Cambodia's energy efficiency and conservation programmes aim to achieve an integrated and sustainable programme that will facilitate energy efficiency improvements in the major energy consuming sectors and help prevent wasteful fuel consumption. To achieve these aims, the country realises the need for market transformation 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 the provision of decentralised rural energy services through a new generation of rural energy entrepreneurs.
- Assisting in market transformation for home and office electrical appliances through bulk purchase and dissemination of high performance lamps, showcasing of energy efficient products, support for 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 importance of energy efficiency and conservation.
- Improving energy efficiency in buildings and public facilities.
- Improving energy efficiency in industries in cooperation with United Nations Industrial Development Organization (UNIDO) and the Ministry of Industry, Mines and Energy (MIME) (now changed to Ministry of Mines and Energy, MME) to be implemented in four sectors – rice mill, brick kiln, rubber refinery, and garment.

Cambodia has also embarked on preparing an action plan for energy efficiency and conservation in cooperation with the Energy Efficiency Design sub-working group. Specific actions plans are being drafted for the industrial, transportation, and other sectors. The initial estimates of sector demand reduction of existing consumers from these actions plans are 10 percent by 2015 and 15 percent by 2035 relative to the Business-as-Usual (BAU) scenario. These initial estimates were used in forecasting energy demand under the Alternative Policy Scenario (APS).

In a close consultation process between the former MIME and European Union Energy Initiative Partnership Dialogue Facility (EUEI–PDF) that started in July 2011, it was decided to launch a project to support the Royal Government of Cambodia (RGC) in the elaboration of a National Energy Efficiency Policy, Strategy and Action Plan. The project started with an inception phase in August 2012 and was concluded in April 2013 with a final workshop, which elaborated the recommendations and conclusions of the plan.

Five sectors were identified as priority areas for the National Energy Efficiency Policy, Strategy and Action Plan:

1) Energy efficiency in industry;

2) Energy efficiency of end-user products;
3) Energy efficiency in buildings;
4) Energy efficiency of rural electricity generation and distribution; and
5) Efficient use of biomass resources for residential and industrial purposes.

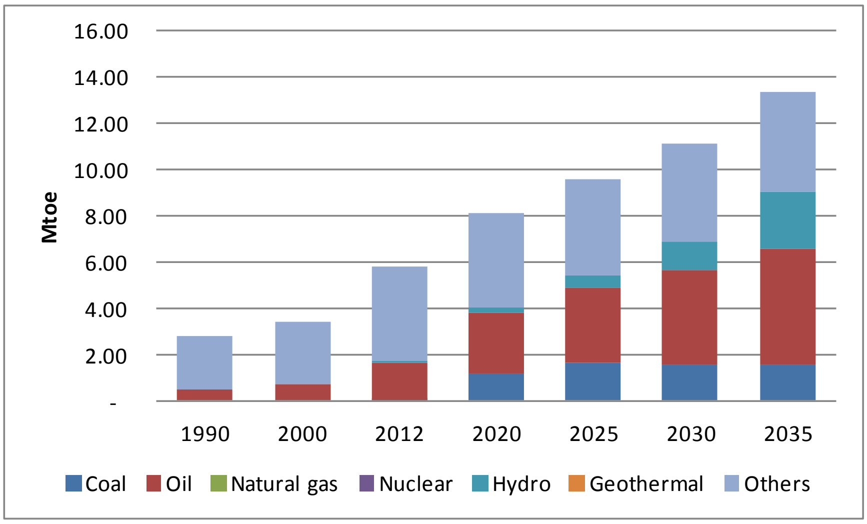
3. Outlook Results

3.1. Business-as-Usual (BAU) Scenario

3.1.1. Total Primary Energy Demand

Primary energy supply in Cambodia grew at 3.3 percent per year, which is a faster rate than final energy consumption or 2.0 times from 2.84 Mtoe in 1995 to 5.78 Mtoe in 2012. Amongst the major energy sources, the fastest growing was oil. Oil consumption grew at an average annual rate of 5.5 percent between 1995 and 2012 (Figure 4-1).

Figure 4-1. Total Primary Energy Supply in BAU



BAU = Business-as-Usual.
Source: Author's calculation.

In the Business-as-Usual (BAU) scenario, Cambodia's primary energy demand is projected to increase at an annual rate of 3.7 percent per year or 2.3 times from 5.78 Mtoe in 2012 to 13.35 Mtoe in 2035. The faster growth is expected in coal, increasing at annual average rate 24.5 percent between 2012 and 2035, followed by hydro, oil, and others (including biomass and imported electricity) at 19.0 percent, 4.9 percent, and 0.3 percent, respectively. The share of hydro is projected to increase from 0.8 percent in 2012 to 18.1 percent in 2035. This growth in the share is at the expense of biomass, the share of which is projected to decline from 67.3 percent to 32.4 percent. The share of coal is projected to increase from 0.2 percent to 11.7 percent over the same period.

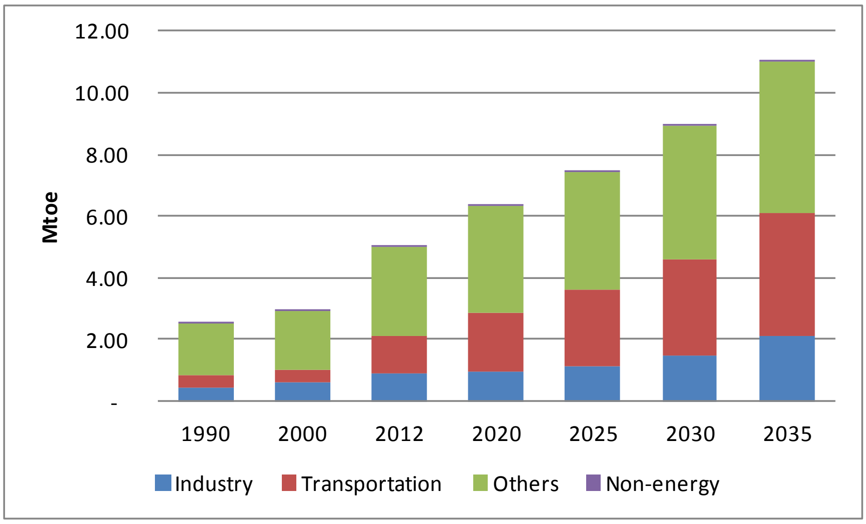
3.1.2. Total Final Energy Consumption

3.1.2.1. By Sector

Cambodia's final energy consumption grew at an average annual rate of 3.1 percent per year from 2.54 Mtoe in 1995 to 5.03 Mtoe in 2012.

In the BAU scenario, driven by assumed strong economic growth and a rising population, final energy consumption is projected to increase at an annual average rate of 3.5 percent, or more than two times from 5.03 Mtoe in 2012 to 11.04 Mtoe in 2035 (Figure 4-2).

Figure 4-2. Total Final Energy Consumption by Sector in BAU



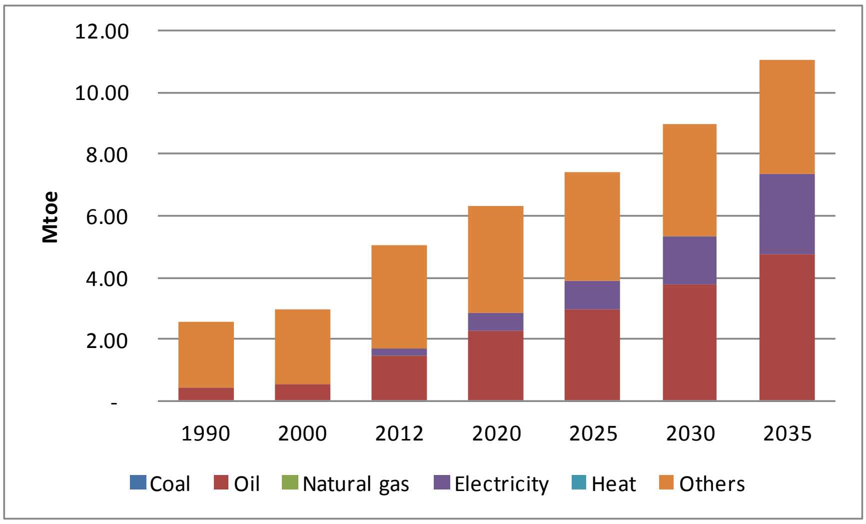
BAU = Business-as-Usual.
Source: Author's calculation.

Amongst the sectors, the strongest growth in consumption is projected to occur in the transportation sector, which increases at annual average rate of 5.3 percent between 2012 and 2035. Industry, non-energy, and others sector are projected to grow at 3.9 percent, 2.3 percent, and 4.0 percent per year, respectively.

3.1.2.2. By Fuel

Electricity is projected to exhibit the fastest growth in final energy consumption, growing at 10.6 percent per year or 10 times from 0.26 Mtoe in 2012 to 2.62 Mtoe in 2035. Oil is projected to see the second highest growth rate, of 5.3 percent per year or 3.3 times from 1.44 Mtoe in 2012 to 4.75 Mtoe in 2035. Others, which mainly include solid and liquid biofuels, will increase at 0.4 percent per year from 3.32 Mtoe in 2012 to 3.67 Mtoe in 2035 (Figure 4-3).

Figure 4-3. Final Energy Consumption by Fuel in BAU



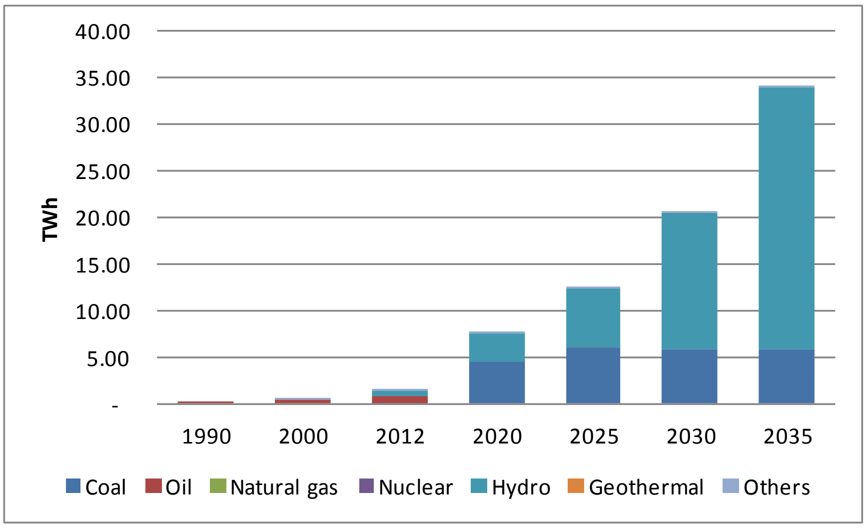
BAU = Business-as-Usual.
Source: Author's calculation.

3.1.2.3. Electricity Generation

Electricity generation increased by 9.4 percent per year from 0.2 TWh in 1995 to 1.43 TWh in 2012. From 1995 to 2001, 100 percent of electricity generated came from oil-fired power plants. In 2002, a hydropower power plant started operation in Cambodia and by 2012 its share in the power generation mix increased to 36.1 percent. Coal power generation was introduced quite late in Cambodia, in 2009. By 2012, the share of coal in the power generation mix had reached 2.6 percent.

In the BAU scenario, to meet the demand for electricity, power generation is projected to increase at an average rate of 14.7 percent per year between 2012 and 2035. The fastest growth in electricity generation will be in coal (24.5 percent per year), followed by hydro (19.0 percent per year), and others (0.2 percent per year) (Figure 4-4). Generation from oil-fired power plants will decrease considerably, due to high fuel cost.

Figure 4-4. Electricity Supply in Cambodia, 1995 to 2035 in BAU



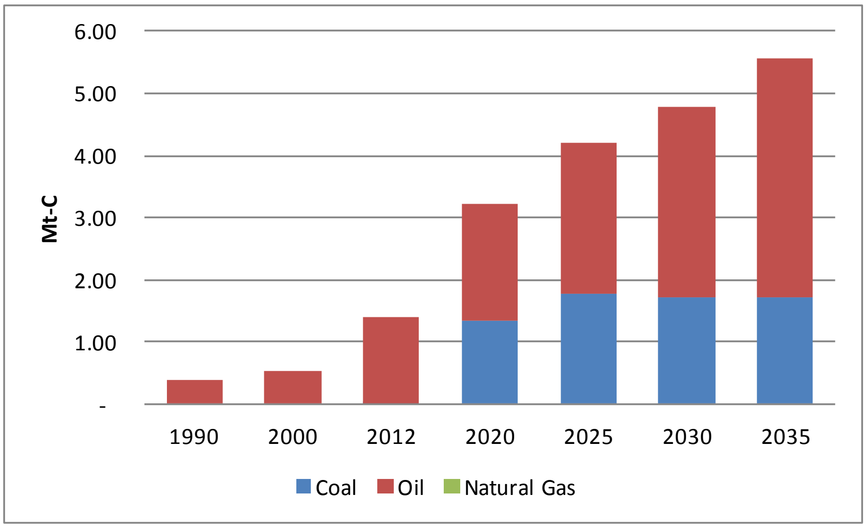
BAU = Business-as-Usual.
Source: Author's calculation.

3.1.2.4. CO_2 Emissions

CO_2 emissions from energy consumption are projected to increase by 6.2 percent per year, from 1.4 Mt-C in 2012 to 5.6 Mt-C in 2035 under the BAU scenario.

Oil is the largest source of carbon emissions, which will increase from 1.4 Mt-C in 2012 to 3.5 Mt-C in 2035. Emission from coal is expected to see the fastest growth rate, at 24.5 percent per year from 0.01 Mt-C in 2012 to 1.7 Mt-C in 2035 (Figure 4-5).

Figure 4-5. CO_2 Emissions from Energy Combustion in Cambodia, BAU



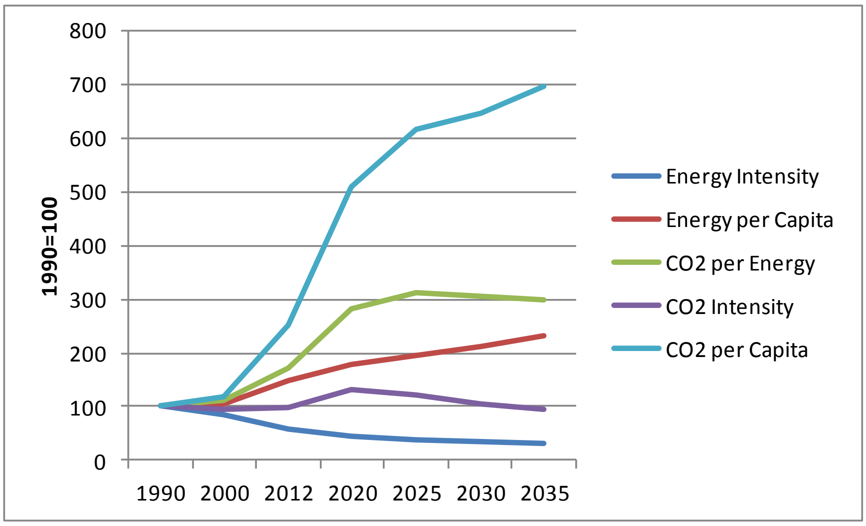
BAU = Business-as-Usual.
Source: Author's calculation.

3.1.2.5. Energy Indicators

Energy intensity had a decreasing trend from 1,002 toe/million US$ in 1995 to 579 toe/million US$ in 2012. In the BAU scenario, energy intensity will further decrease, to 324 toe/million US$ in 2035. This indicates that energy will be used more efficiently in economic development. This will be mainly the result of the dominance of conventional biomass use in the rural areas of the country and the future growth of it will be slower than GDP growth.

Energy per capita had been increasing from 0.26 toe/person in 1995 to 0.39 toe/person in 2012. In the BAU scenario, energy per capita will further increase, to 0.61 toe/person in 2035. This indicates that people's 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.

On the one hand, CO_2 per energy in the BAU case is projected to increase from 0.24 metric tons of Carbon per toe (t-C/toe) in 2012 to 0.42 t-C/toe in 2035, implying faster growth of fossil fuels than total energy consumption.

However, CO_2 intensity had been decreasing from 140 t-C/million US$ in 1995 decreasing to 139 t-C/million US$ in 2012. It will drop further, to 135 t-C/million US$ in 2035.

4. Scenario Analysis

4.1. Alternative Policy Scenario (APS)

The Alternative Policy Scenario (APS) consists of scenarios such as energy efficiency and conservation (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 scenario 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:
  - All sectors' demand to be reduced by 10 percent in 2015 and 15 percent by 2035 relative to BAU.
  - Using efficient motorbikes in road transport.
  - Replacing inefficient devices with efficient ones in commercial and residential sectors like cooking, lighting, refrigeration, and air conditioning.
- APS2: Improvement of energy efficiency in thermal power plants. It is assumed that energy efficiency of coal and fuel oil thermal power plants will stay constant at 32 until 2035 under BAU. In the APS, new coal power plants are assumed to have thermal efficiencies of 35 percent.

- APS3: Additional 50MW of biomass gasified power plants by 2030 and solar PV with capacity gradually increasing to 50MW by 2035 are assumed in this scenario.
- APS5 or APS: Combination of APS1 to APS3

4.2. Energy Saving Potential and CO_2 Emissions Reduction

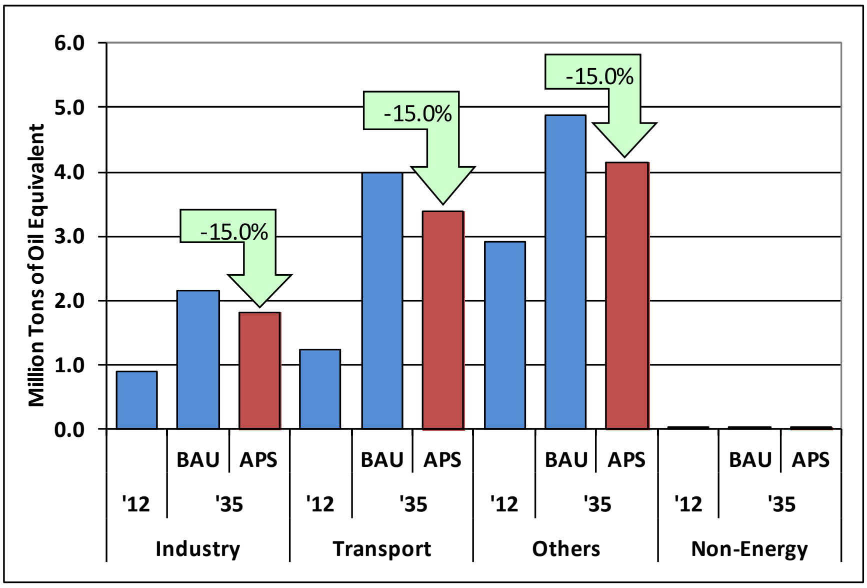
4.2.1. Final Energy Consumption

In the APS, final energy consumption is projected to increase at a slower rate of 2.8 percent (compared with 3.5 percent in BAU) from 5.03 Mtoe in 2012 to 9.39 Mtoe in 2035 because of EEC measures APS1 in industrial, transportation, residential, and commercial (others) sectors.

Savings in final energy consumption amount to 1.7 Mtoe. The bulk of the savings are expected to occur in the others sector (0.7 Mtoe), followed by the transportation sector (0.6 Mtoe), and the industry sector (0.3 Mtoe).

An improvement in end-user technologies and the introduction of energy management systems is expected to contribute to the slower rate of consumption growth, particularly in the other sectors (residential and commercial), industry, and transportation (Figure 4-7).

Figure 4-7. Final Energy Consumption by Sector in BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

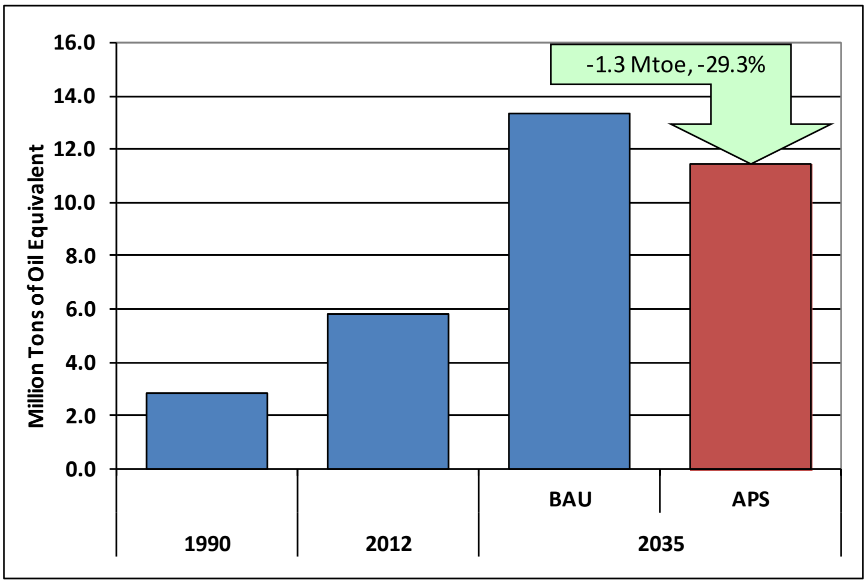
4.2.2. Total Primary Energy Demand

In the APS, total primary energy demand is projected to increase at a slower rate of 3.0 percent per year from 5.78 Mtoe in 2012 to 11.44 Mtoe in 2035. The savings could mostly be derived from EEC Scenarios on the demand side and development of renewable energy technology (APS3).

In the APS, coal is projected to grow at an average annual rate 24.0 percent compared with 24.5 percent in the BAU, followed by oil with 4.2 percent compared with 4.9 percent in the BAU, respectively, over the same period.

The total saving amounts to 1.9 Mtoe, which is equivalent to 14.3 percent of Cambodia's total primary energy consumption in 2035 (Figure 4-8).

Figure 4-8. Total Primary Energy Demand by Fuel in BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

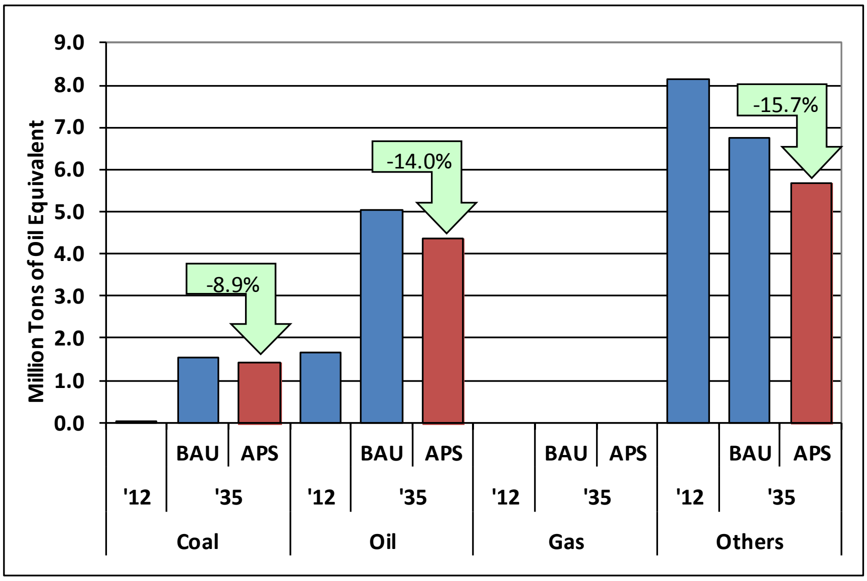
The slower growth in consumption, relative to the BAU scenario, comes from EEC measures on the demand side (APS1), more aggressive uptake of energy efficiency in thermal power plants (APS2), and adoption of renewable energy (APS3) on the supply side. Accordingly, the coal saving potential would be 8.9 percent, followed by oil at 14.0 percent, and others at 15.7 percent (Figure 4-9).

4.2.3. CO_2 Emission Reduction Potential

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 6.2 percent per year from 1.4 million metric tons of carbon (Mt-C) in 2012 to 5.6 Mt-C in 2035 Under the APS, the annual increase in CO_2 emissions between 2012 and 2035 is projected to be 4.9 percent per year, which is 1.3 percent lower than the BAU.

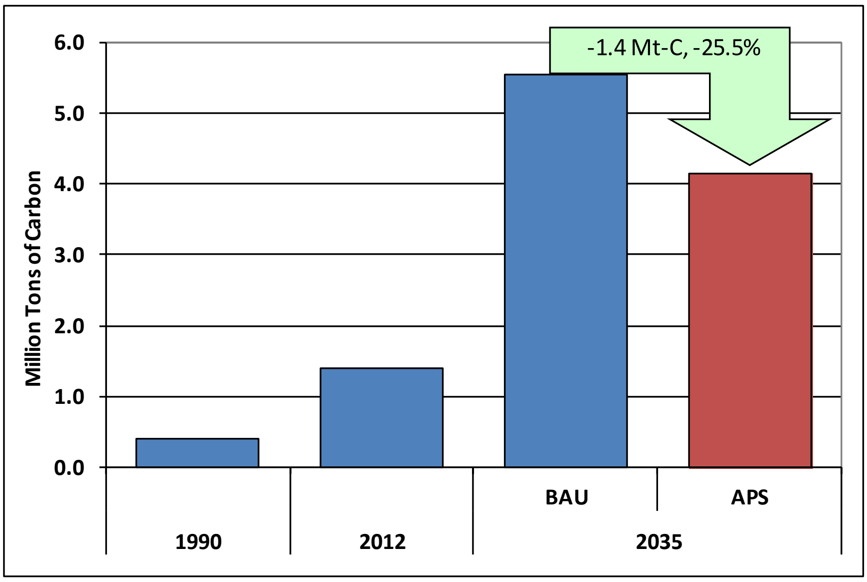
The CO_2 emission reduction would be mostly derived from EEC measures on the demand side (APS1). Improvement of energy efficiency in thermal power plants (APS2) and development of renewable energy technologies (APS3) can also contribute significantly to CO_2 reduction (Figure 4-10).

Figure 4-9. Total Primary Energy Saving Potential by Fuel, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 4-10. CO_2 Emission by Fuel, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

5. Key Findings and Policy Implications

From the above analysis on energy saving potential, the following are the key findings:

- Energy demand in Cambodia is expected to continue to grow at a significant rate, driven by robust economic growth, industrialisation, urbanisation, and population growth. Energy efficiency and conservation is the 'new source' of energy and measures reflected in the APS scenario are estimated to have significant potential to help meet future demand in a sustainable manner.

- Cambodia's energy intensity will be further reduced, reflecting efficient use of energy.
- The annual growth of energy demand in the transportation sector is projected to be 5.3 percent, the highest in BAU, and its share is projected to continuously increase, from 24.3 percent in 2012 to 36.0 percent in 2035. This shows that the transportation sector has a large potential for saving on energy.
- Electricity demand is increasing with the highest annual growth rate of 10.6 percent in BAU and is projected to be lower at 9.8 percent under the APS.
- Hydro power plants will be the major source of power generation in Cambodia in the coming years. Its share in total power generation output is projected to increase continuously, from 36.1 percent in 2012 to a dominating share of 83.0 percent in 2035.
- Coal thermal power plants will be the second major power generation source in Cambodia in the coming years. Its share in total power generation output is expected to increase continuously, from 2.6 percent in 2012 to 17.0 percent in 2035. This is also the area with the largest energy saving as well as the highest greenhouse gas (GHG) mitigation potential in Cambodia.

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

- Promotion for establishment of targets and roadmap for EEC implementation: The targets for EEC in Cambodia should be set up for the short-, medium-, and long-term periods and focused on the buildings and industries sectors. The long-term should be set up based on an assessment of energy saving potential for all energy sectors, including residential and commercial sectors, which have large potential on energy saving up to 2035.
- Compulsory energy labelling for electrical appliances: Annual growth of electricity demand in residential and commercial (other) sectors is projected to be substantial compared to other sectors. Compulsory energy labelling for electrical appliances could be an effective management measure for generation of energy savings.
- Priority for 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 2035. Therefore, advanced technologies for both types of resources should be prioritised for development from the stage of project design.
- Priority for renewable energy development: Renewable energy is an important resource for energy independence, energy security and GHG emissions abatement. This is necessary to build up the strategy and mechanisms to support renewable energy development.

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CHAPTER 5

People's Republic of China Country Report

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1. Background

1.1. Natural Condition and History

The People's Republic of China has a land area of 9.6 million square kilometres and is situated in eastern Asia on the western shore of the Pacific Ocean. China's continental coastline extends for about 18,000 kilometres, and its vast sea surface has more than 5,000 islands. Due to its size, China's climate is very diverse, with temperatures ranging from 48ºC in the northwest during summer to -40ºC in the far north in winter.

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

1.2. Economy and Population

China's gross domestic product (GDP) in 2014 was around US$6.92 trillion, which translates into a per capita income of around US$5,055 (in 2005 US$ terms).[1] China is currently the world's most populous country. It had a population of about 1.37 billion in 2014.[2] To mitigate population growth, China has implemented a family planning policy since the 1970s. China has been experiencing a fast urbanisation process at an annual growth rate of approximately 1 percent since 1978 when China's reforms and opening up started. At the end of 2013, around 53.7 percent of the population was living 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 reserves of 236.3 billion tonnes in 2014. In 2013, China produced 2.57 billion tonnes of raw coal. The country is still a major crude oil producer,

[1] The source of the GDP data is the China National Bureau of Statistics (NBS). The author calculated the constant 2005 value using GDP Deflator and exchange rate in 2005.
[2] China National Bureau of Statistics.

with output of 302.6 million tonnes of crude oil in 2013. However, driven by very fast increases in China's oil demand, it became an oil importer in the 1990s. In 2014, net imports of oil reached 290 million, with a growth rate of 8.2 percent. China is also a large producer and exporter of energy-intensive items. In 2014, it produced 1.13 billion tonnes of finished steel and 2.48 billion tonnes of cement, and exported 0.94 billion tonnes of finished steel.

China's per-capita energy reserve is considerably lower than the world average. The per-capita average of both coal and hydropower resources is at present only about 50 percent of the world average, whereas 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 percent of the world average, which hinders the development of biomass energy.

In 1990, coal accounted for 60.6 percent of primary energy consumption, oil made up 13.6 percent, natural gas just below 1.5 percent, and hydro 1.3 percent. In 2014, coal was still a major fuel, with a higher share of about 66.0 percent.[3] As for the share of other energy sources, oil increased from 1990 levels to 17.1 percent, and gas and electricity reached 5.7 percent and 9.8 percent, respectively. Primary energy consumption in China increased at an average annual rate of around 5.6 percent, from 870.7 Mtoe in 1990 to 2,982 Mtoe in 2014. Energy intensity (primary energy demand per unit of GDP) declined from 1,656 tonnes of oil equivalent per million US$ (toe/million US$) in 1990 to 272.9 toe/million US$ in 2013.[4]

Final energy consumption in China increased at a lower annual average rate of 4.4 percent from 664.2 Mtoe in 1990 to 2,115.2 Mtoe in 2014. Coal accounted for 47.9 percent of final energy consumption in 1990 and 43.1 percent in 2014. In 1990, oil accounted for 12.7 percent of total final energy consumption. Oil consumption has increased rapidly at 7.6 percent per year between 1990 and 2014, leading to a significant increase in its share, to 23.3 percent, in 2014. Electricity consumption also increased markedly, with growth of 11.5 percent between 1990 and 2014, which was higher than any of the other final energy sources. The share of electricity in final energy consumption increased from 5.9 percent in 1990 to 25.2 percent in 2014.[5]

Industry is the major energy-consuming sector in China, followed by the residential and commercial sectors (the 'Others' sector). The share of industry consumption increased from 36.7 percent in 1990 to 47.6 percent in 2012, whereas the share of energy consumption in 'others' declined from 51.8 percent in 1990 to 30.4 percent in 2012, because of faster growth in the industry and transport sectors.

In China, coal-fired power generation accounted for around 71.3 percent of total electricity generation in 1990. By 2014, this share had increased to 74.9 percent. The share of hydro was 20.4 percent in 1990, but declined to 18.8 percent in 2014. Gas and oil, collectively, accounted for about 1.5 percent of total generation in 2014 and the share of nuclear power increased to about 2.3 percent in 2014.[6]

The Chinese government is pushing for the development of a modern energy

[3] Ibid.
[4] Calculate by the author based on NBS data.
[5] China National Energy Administration (2014), *Handbook of Energy Data Analysis.*
[6] Ibid.

industry. The government takes resource conservation and environmental protection as 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 were developed by the Institute of Energy Economics, Japan. China's population increased from 1.135 billion in 1990 to 1.351 billion in 2012. Over the projection period, China's population growth is assumed to slow down as a result of the one child policy. China's population is assumed to increase at an average rate of 0.2 percent per year and reach 1.421 billion by 2035.

China's economy grew at an average annual rate of 10.3 percent from US$526 billion in 1990 to about US$4.52 trillion in 2012 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.8 percent per year from 2012 to 2020, 4.2 percent per year from 2020 to 2035, and 5.1 percent per year from 2012 to 2035. It is calculated to reach US$14.24 trillion by 2035. Given the GDP and population assumptions, GDP per capita in China is projected to increase from around US$3,349 per person in 2012 to US$10,000 per person in 2035.

2.2. Energy and Climate Change Policies

Although China is still a developing country and has a GDP per capita less than one-seventh of that of the United States (according to nominal exchange rate) in 2014, the government has set aggressive goals on energy intensity reduction and addressing climate change issues.

According to the official governmental source, in the last five years, China has achieved significant energy conservation and remarkable progress in environmental protection. In 2013, China's CO_2 emissions per unit of GDP dropped by 4.3 percent compared with the 2012 level. By the end of 2015, output of China's energy saving and environmental protection industry is expected to reach US$725.8 billion. China's current capacity in hydropower, wind power, and plantation areas all rank first in the world, which has made a positive contribution to addressing the problem of global climate change. After the evaluation in 2014, China eliminated obsolete production capacity in the following industries: steel production, 31.1 million tonnes; cement (clinker and mill), 81 million tonnes; plate glass, 37.6 million weight cases. By the end of 2014, the share of thermal power units was 67.3 percent, a year-on-year growth of 5.9 percent.

To develop non-fossil fuel, China continues to increase investment in renewable energy. It invested US$15.6 billion in hydropower stations, US$9.2 billion in nuclear power plants, and US$16.1 billion in wind power in 2014. By the end of 2013, power generation capacity had reached 1,257 GW – the capacity of hydropower, which ranked first globally, reached 280 GW, registering a year-on-year growth of 12.4 percent; nuclear power plants, 14.66 GW; on-grid wind power capacity, which was the largest in the world, amounted to 76.52 GW, increasing 24.6 percent year-on-year; on-grid solar power reached 15.89 GW, growing 366 percent from a year earlier. The installed electricity capacity of non-fossil fuel, including, hydro, nuclear, wind, and solar energies, in 2014 took up 32.8 percent of the whole, 6.2 percentage points higher than the 2010 figure. The electricity generated from non-fossil fuel accounted for 25.1 percent of total on-grid electricity in 2014.

In China's Outline of the 12th Five-Year Plan (2012–2015) for National Economic and Social Development, it is stipulated that by 2015 energy consumption per unit of GDP will drop by 16 percent from 2010. To achieve this goal, the government has already implemented administrative measures, market based measures, and legal measures to promote energy conservation, and it will continue to implement new policies. Energy intensity reduction goals will be assigned to provincial governments and progress will be announced publicly every year. In addition to energy intensity targets, controlling total energy consumption has been proposed.

The development of renewable energy has also been accelerated. The People's Congress of China 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 percent by 2020 (measured in coal-equivalent). Subsidisation policies have also been developed to encourage development of wind power, solar photovoltaic, and biomass.

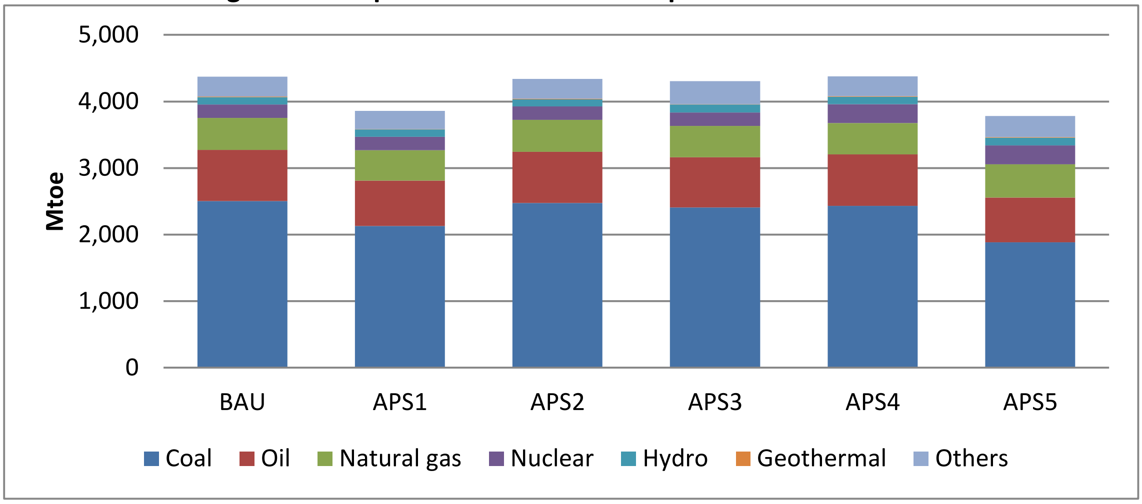
China announced its goal of reducing CO_2 emissions per GDP (carbon intensity) by 40–45 percent from the 2005 level by 2020. To meet the target, China will implement ambitious energy efficiency and fuel switching policies. Moreover, the government has announced its goal of cultivating 40 million hectares of forested land to mitigate greenhouse gas (GHG) emissions.

In our 2014 scenario analyses, we have set five APS scenarios, which are listed as APS1–5 and the meanings of these scenarios are as follows: APS1 – energy efficiency and conservation (EEC) in final consumptions sector; APS2 – EEC in thermal efficiency in coal, oil and gas fired power generations; APS3 – Increase of hydro, geothermal and NRE; APS4 – Increase of nuclear; APS5 – Implement all of the APS1 to APS4. If not specifically declared, all results that we show in this chapter under APS refer to APS5.

3. Outlook Results

As mentioned above, the assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions. Figure 5-1 shows the changes in total primary energy consumption (TPEC) in all the scenarios.

Figure 5-1. Impacts of Scenario Assumptions on TPEC in 2035



TPEC = total primary energy consumption; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

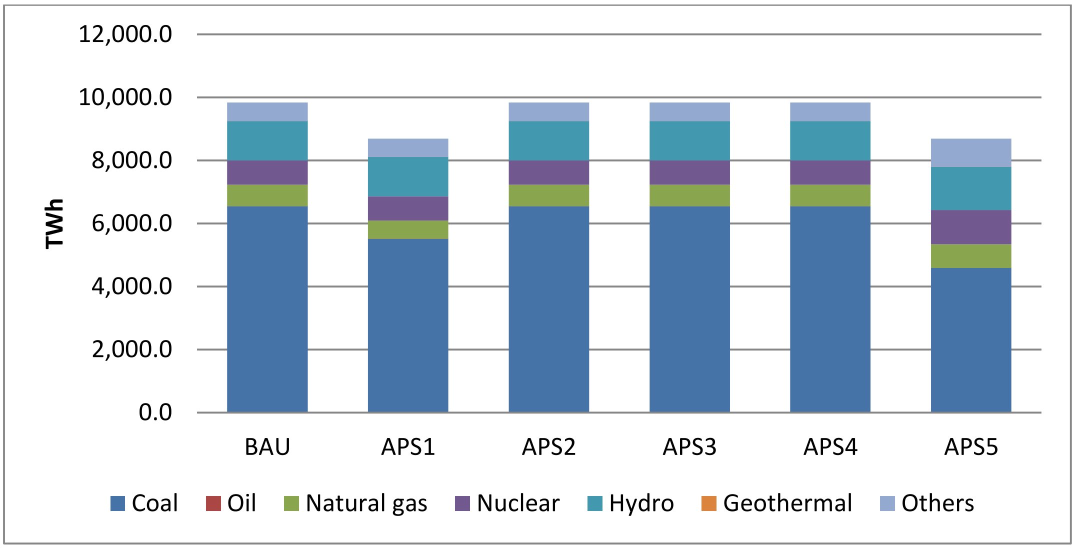
In Figure 5-1 above, APS1 and APS5 have the largest reduction in total primary energy consumption due to the energy efficiency assumptions on the demand-side. Energy efficiency assumptions in APS1 could reduce total primary energy consumption in the Business-as-Usual (BAU) scenario by as much as 513.0 Mtoe or 11.7 percent in 2035.

APS2, which assumes higher efficiency in thermal electricity generation, has a lower impact than APS1. This is due to the assumption that only the newly constructed power plants will have higher efficiency. It is expected that existing power plants will continue to operate until the end of their lifetimes. This is why only 32.3 Mtoe or 0.8 percent of total primary energy consumption is saved under the BAU scenario in 2035.

APS3 assumes higher penetration of renewable energy in electricity generation and higher consumption of biofuels in the transportation sector. Like APS2, there is only a 65.2 Mtoe reduction in total primary energy consumption in BAU in 2035. Although hydropower, solar energy, and wind energy are assumed to have 100 percent thermal efficiency when converted to primary energy, the contributions of these energy sources were dwarfed by the contributions of biomass and geothermal energy, which have lower thermal efficiencies than the fossil-fired electricity generation that were replaced in this scenario. However, a sizeable reduction in CO_2 emission is expected under this scenario.

APS4 assumes a higher contribution of nuclear energy to power generation. There is a small increase of 4.4 Mtoe in total primary energy consumption in this scenario compared with the BAU scenario in 2035. This is due to the lower thermal efficiency of nuclear power generation (33 percent) compared with new coal and natural gas-fired power plants. However, the shift to nuclear achieves a greater carbon emissions reduction.

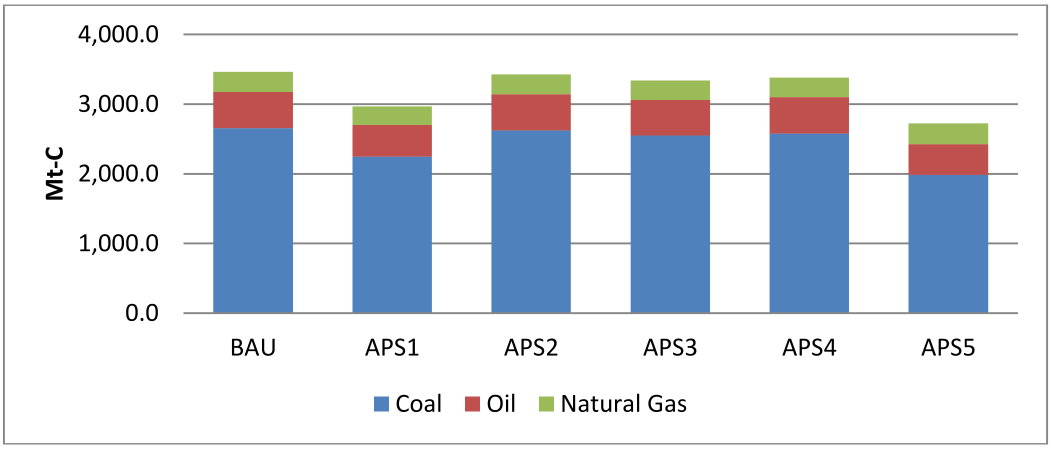
Figure 5-2. Electricity Generation in 2035 in All Scenarios



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 5-2 shows total electricity generation in East Asia Summit Region (EAS) in 2035 under all scenarios. In APS1, due to lower electricity demand, the shares of fossil-fired electricity generation were lower than in the BAU scenario. In APS2, the shares are the same as those for BAU. In APS5, fossil energy-based generation could be reduced by as much as 26.2 percent.

Figure 5-3. CO_2 Emissions in 2035 in All Scenarios



Source: Author's calculation.

In terms of CO_2 emissions reduction, as shown in Figure 5-3, the energy efficiency assumption in APS1 could reduce emissions in the BAU scenario by 14.2 percent in 2035. In APS2, the installation of more efficient new power plants allows a reduction in emissions of 1.0 percent. Higher contributions from renewable energy in APS3 could reduce emissions by 3.6 percent, and higher contribution from nuclear energy in APS4 could result in an emission reduction of 2.3 percent. All these assumptions combined, as in APS5, could reduce BAU CO_2 emissions by 21.4 percent in 2035.

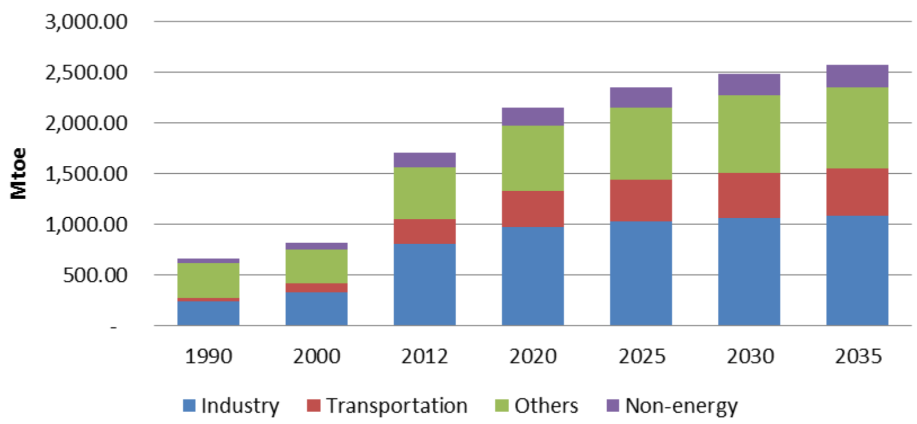
3.1. Total Final Energy Demand

Between 2012 and 2035, growth in China's final energy demand is projected to slow, reflecting lower projected economic and population growth.

Business-as-Usual (BAU) Scenario

Final energy consumption is projected to increase at an average rate of 1.8 percent per year between 2012 and 2035. Transportation sector consumption is projected to see the fastest growth, increasing by 3.0 percent a year, followed by the non-energy sector at 2.3 percent per year. Energy consumption in the industry sector is projected to grow at an average annual rate of 1.3 percent. Figure 5-4 shows China's final energy consumption by sector under the BAU scenario.

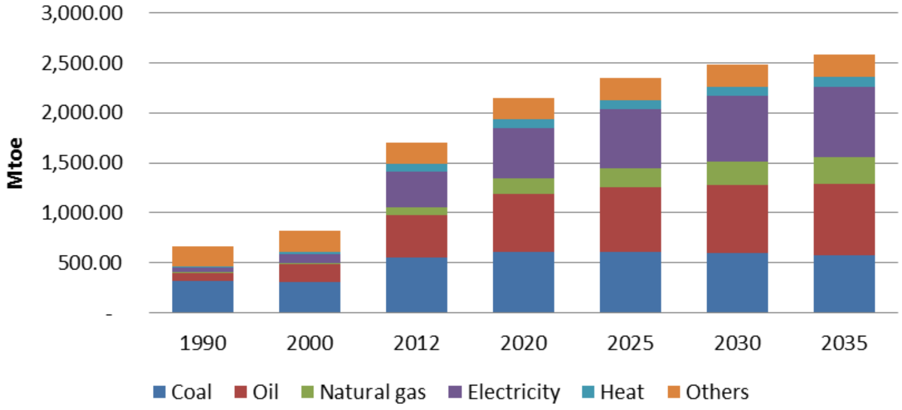
Figure 5-4. Final Energy Consumption by Sector in BAU



BAU = Business-as-Usual.
Source: Author's calculation.

Amongst energy sources, natural gas consumption in the BAU scenario is projected to exhibit the fastest growth, increasing by 5.4 percent per year, from 80.7 Mtoe in 2012 to 272.3 Mtoe in 2035. Although coal still accounts for a large share of total final energy consumption, it is projected to grow at a lower rate, of 0.1 percent per year, reaching 577.0 Mtoe in 2035, compared with a 2.6 percent average annual growth rate over last two decades. Consumption of electricity and heat are projected to increase at average annual rates of 3.0 percent and 1.4 percent, respectively, over the same period, reaching 701.0 Mtoe and 96.5 Mtoe in 2035. Oil is projected to grow by 2.3 percent annually, to around 710.0 Mtoe in 2035. Figure 5-5 shows China's final energy consumption by fuel type under the BAU scenario.

Figure 5-5. Final Energy Consumption by Fuel in BAU

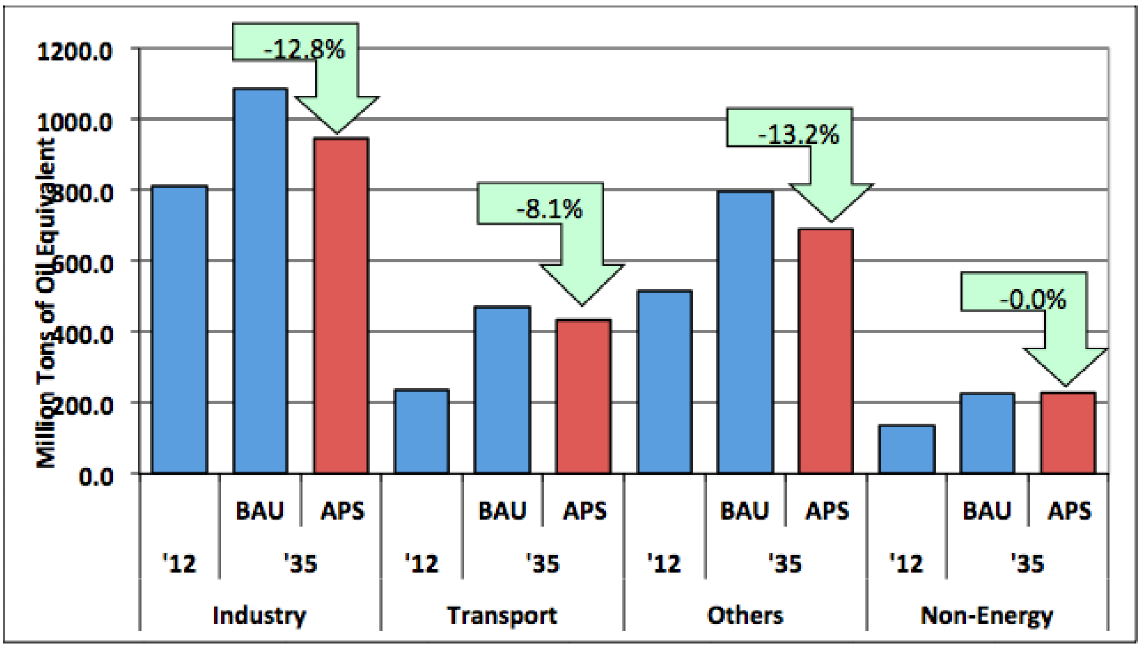


BAU = Business-as-Usual
Source: Author's calculation.

Alternative Policy Scenario (APS)

In the APS, final energy consumption is projected to increase by 1.3 percent per year, from 1,701.9 Mtoe in 2012 to 2,295.7 Mtoe in 2035, as a result of energy efficiency and conservation programmes, as well as further adoption of clean energy technologies. An improvement in end-use technologies and the introduction of energy management systems is expected to contribute to slower energy growth in all sectors, particularly in the commercial, residential, and transportation sectors. Figure 5-6 shows final energy consumption in China in 2012 and 2035 in both the BAU scenario and APS.

Figure 5-6. Final Energy Consumption: BAU and APS



BAU = Business-as-Usual.
Source: Author's calculation.

3.2. Primary Energy Consumption

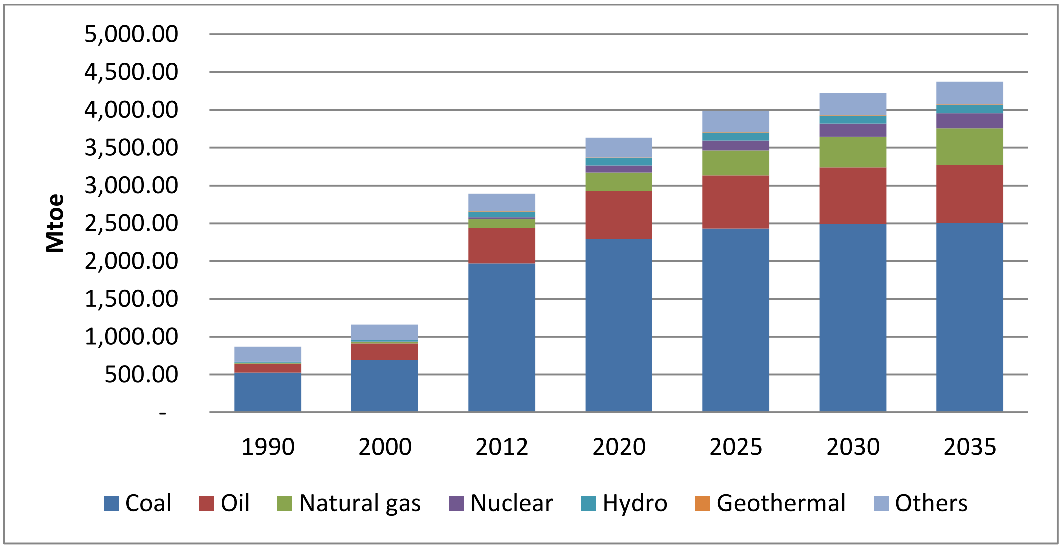
Primary energy consumption in China is projected to grow at a slower pace than in the past decades. It is also expected that growth in primary energy demand will be slightly slower than final energy consumption, because of improved efficiency in the energy transformation sector.

Business-as-Usual Scenario

In the BAU scenario, China's primary energy consumption is projected to increase at an annual average rate of 1.8 percent to 4,372.1 Mtoe in 2035. Coal will still constitute the largest share in total primary energy consumption, but its growth is expected to be slower, increasing by 1.0 percent per year. Consequently, the share of coal in total primary energy is projected to decline from 68.0 percent in 2012 to 57.3 percent in 2035.

Biofuels is projected to exhibit the fastest growth between 2012 and 2035, increasing at an annual average rate of 12.3 percent, followed by nuclear energy at 9.4 percent. Oil and hydro are projected to grow at lower rates of 2.2 and 1.6 percent per year, respectively. The share of natural gas is projected to increase from 4.2 percent in 2012 to 11.0 percent in 2035, and the share of nuclear will increase from 0.9 percent to 4.6 percent. The share of oil is projected to increase from 16.0 percent in 2012 to 17.6 percent in 2035 and hydro is projected to decline from 2.6 percent in 2012 to 2.5 percent in 2035. Figure 5-7 shows China's primary energy consumption by energy type under the BAU scenario.

Figure 5-7. Primary Energy Consumption by Energy, BAU

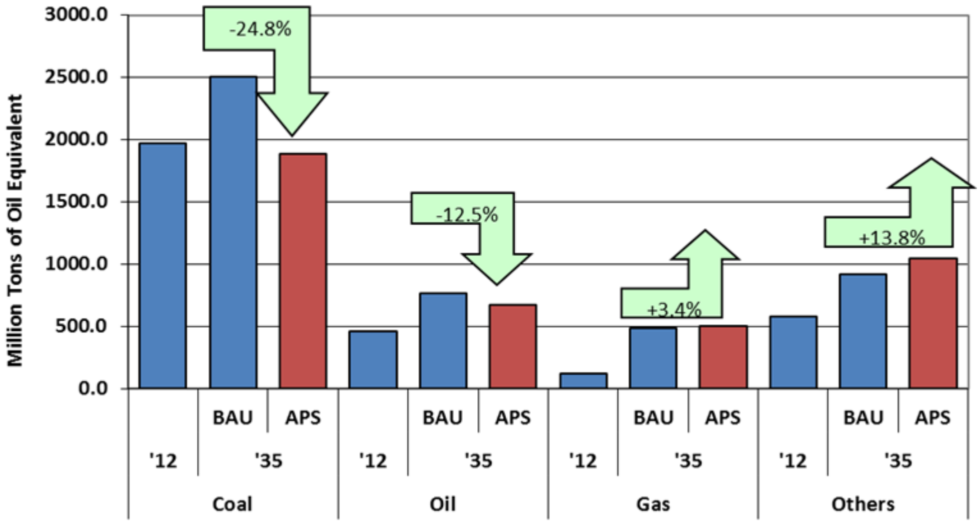


BAU = Business-as-Usual.
Source: Author's calculation.

Alternative Policy Scenario

In the APS, primary energy consumption is projected to increase by 1.2 percent per year between 2012 and 2035. By 2035, primary energy consumption is projected to have reached 3,782.0 Mtoe. The growth in primary energy consumption is projected to be slower under the APS than under the BAU scenario (Figure 5-8). Coal is projected to decline by 0.2 percent per year, and oil is projected to increase by 1.6 percent per year and natural gas by 6.4 percent per year. For nuclear, the annual average growth rate will be higher than the BAU, increasing by 11.1 percent per year between 2012 and 2035. The growth rate of hydro in the APS is expected to be higher than the BAU, increasing by 2.0 percent per year. Mitigated consumption under the APS is mainly achieved through energy efficiency and conservation measures on the demand side.

Figure 5-8. Primary Energy Demand by Source, BAU and APS



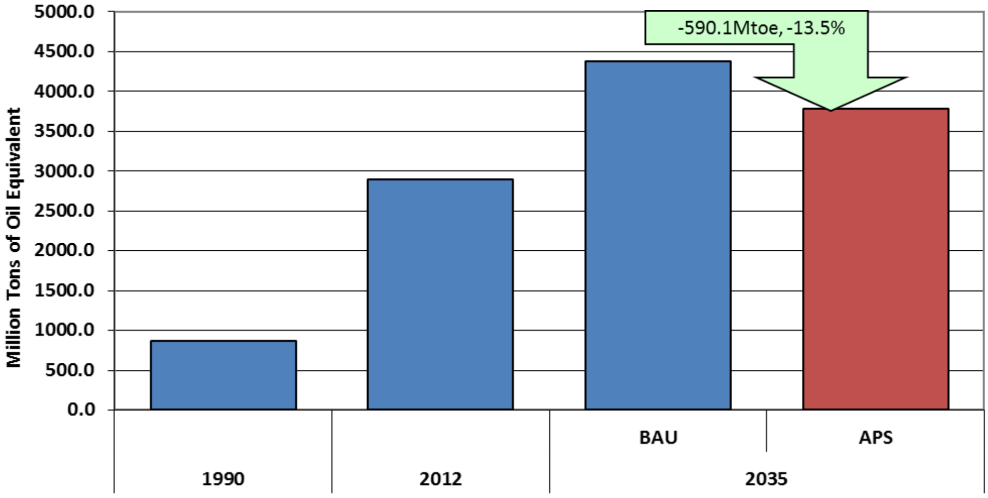
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.3. Projected Energy Savings

It is estimated that the implementation of energy efficiency and conservation goals and action plans in China could reduce primary energy demand in 2035 by about 590.1 Mtoe under the APS, relative to the BAU scenario. In other words, in the APS, China's primary energy demand is around 13.5 percent lower than under the BAU scenario (see Figure 5-9).

In terms of final energy consumption, there is an estimated saving of 139.1 Mtoe in the industry sector, 38.4 Mtoe in the transportation sector, and 104.6 Mtoe in the 'others' sector in 2035 under the APS, relative to the BAU scenario.

Figure 5-9. Total Primary Energy Demand, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.4. CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 1.5 percent per year from 2,472.8 Mt-C in 2012 to 3,461.5 Mt-C in 2035 under the BAU scenario. This annual growth rate is lower than that for primary energy demand (1.8 percent) over the same period, indicating a reduction in the emissions intensity of the Chinese economy.

In the APS, the annual increase in CO_2 emissions between 2012 and 2035 is projected to be 0.4 percent. This rate is also lower than the average annual growth rate in primary energy demand over the same period. The difference between the APS and the BAU CO_2 emissions growth rates indicates that the energy saving goals and action plans of China are effective in reducing CO_2 emissions (Figure 5-10).

3.5. Power Generation

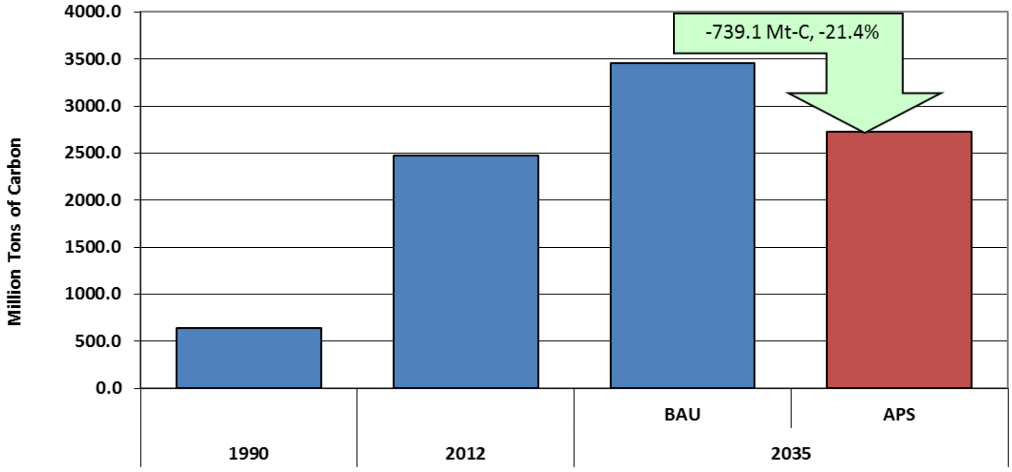
Power generation in China is projected to grow more slowly between 2012 and 2035 than in the last decade.

Business-as-Usual (BAU) Scenario

In the BAU scenario, power generation in China is projected to grow at 3.0 percent per year on average from 4,984.8 TWh in 2012 to 9,842.1 TWh in 2035 (Figure 5-11).

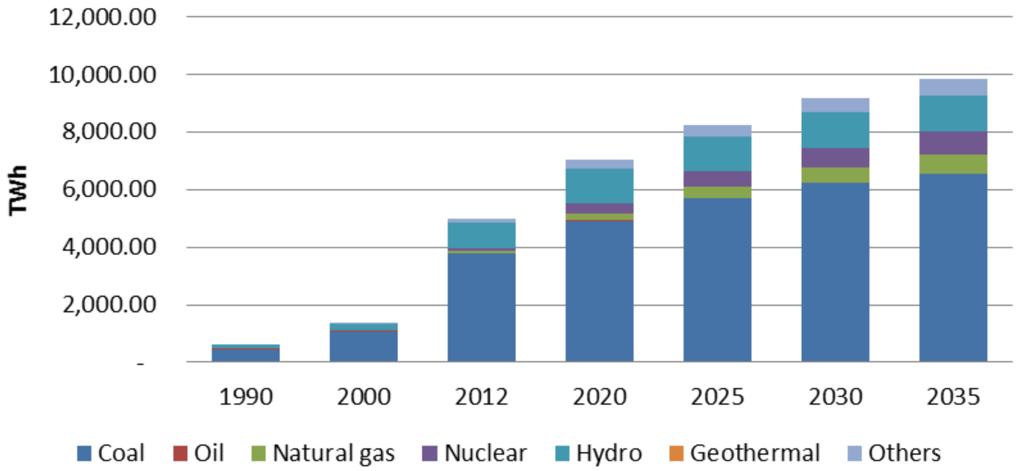
The share of coal-fired power under BAU is projected to experience a decreasing trend, from 75.9 percent in 2012 to 66.5 percent in 2035. Conversely, as the cleaner forms of generation, the share of natural gas-fired and nuclear power are both projected to grow from 1.7 and 2.0 percent in 2012 to 6.9 percent and 7.9 percent in 2035, respectively. The share of oil is projected to decrease slightly, whereas other sources of power generation are projected to increase. The fast development of photovoltaic power generation in China is a typical example, reflecting China's switching to clean power generation. China's thermal efficiency by fuel under BAU is projected to increase between 2012 and 2035, as presented in Figure 5-12.

Figure 5-10. CO_2 Emission from Energy Consumption, BAU and APS



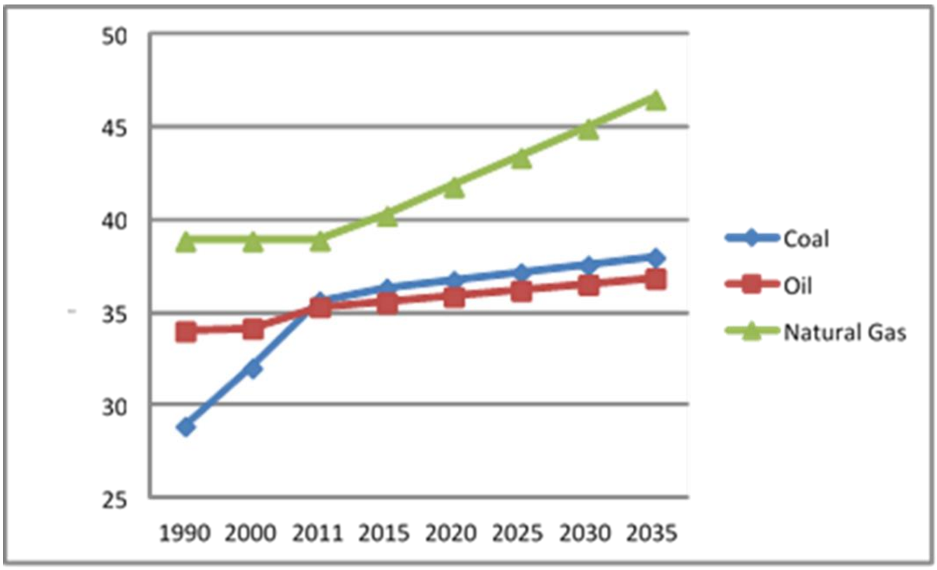
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 5- 11. Power Generation in BAU



Source: Author's calculation.

Figure 5-12. Thermal Efficiency by Fuel in BAU



BAU = Business-as-Usual.
Source: Author's calculation.

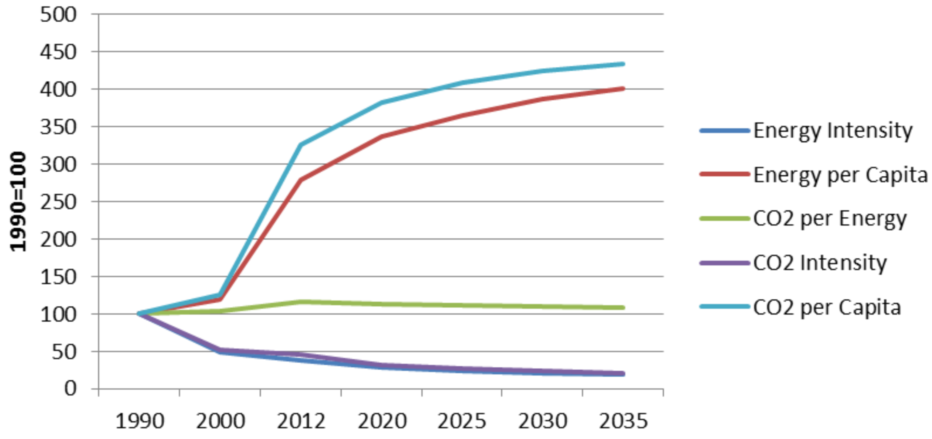
Alternative Policy Scenario (APS)

In the APS, total power generation will increase by 2.4 percent per year between 2012 and 2035. By 2035, total power generation output is projected to have reached 8,697.5 TWh. Except for coal-fired power, the annual growth rate per year between 2012 and 2035 of all fuel power types under APS are projected to grow faster than in the BAU scenario. In 2035, hydropower, geothermal power, and 'others', are projected to increase by an annual average of 2.0 percent, 4.0 percent, and 8.2 percent, respectively under APS between 2012 and 2035.

3.6. Energy Intensity and Other Energy Indicators

According to the assumed economic and population growth along with the projected energy information of China, energy intensity defined as TPES/GDP and energy per capita in the BAU scenario are illustrated in Figure 5-13. From 1990 to 2012, it shows that China's energy intensity saw a remarkable drop as a result of efforts on energy efficiency. In 2035, primary energy intensity in China is projected to drop to around 307.0 toe/million 2005 US$, or an annual average decrease of 3.1 percent per year. With the improvement of living standards in China, energy per capita under the BAU scenario is projected to reach 3.08 TOE per person in 2035. Compared with the energy intensity in BAU, primary energy intensity in the APS is projected to show a faster rate of decrease, of 3.8 percent, from 2012 to 2035.

Figure 5-13. Energy Indicators, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

4. Implications and Policy Recommendations

As the world's largest developing country, it is paramount for China to eradicate poverty and improve quality of life. China is in a fast growth phase and its urbanisation rate is low. If China maintains fast GDP growth, its energy demand and CO_2 emissions will increase in the long run. In the past three decades, China has made great efforts on energy conservation and achieved great success. The latest effort was made during the 2014 APEC summits, when China and the United States issued a Joint Announcement on Climate Change. According to the announcement, China vowed CO_2 emissions would peak and the share of non-fossil fuels in primary energy consumption would increase to around 20 percent by 2030. Besides, Chinese metropolises such as Beijing and Shanghai have shown great ambition trying to limit energy-intensive and pollution-intensive industries, including steel and cement productions, to improve urban air quality.

Although China's energy demand and CO_2 emissions are expected to increase in the foreseeable future, energy intensity (energy demand per GDP) and emission intensity (CO_2 emission per GDP) would continue to decrease as the GDP growth rate stays relatively high. If sound energy efficiency and conservation policies are implemented, China could reduce its total primary energy consumption by around 13.5 percent and CO_2 emissions by about 21.4 percent by 2035. There is a great potential for energy saving in China, with around 50 percent of this achievable through structural change of the economy. The rapid development of the tertiary industry may also reduce China's energy demand.

Energy saving and energy efficiency improvement in industry will be important during the next 10 years. It is noteworthy that in 2014 coal consumption decreased for the first time since 2000, by 2.9 percent. Considering the fact that China has entered the 'new normal', in which the economic growth rate would be moderately high, and because Beijing has begun to make efforts in controlling air pollution, the relatively low growth rate of coal consumption may persist in the coming years. The scheduled closure of small and inefficient power plants, coal mines, and small energy-intensive plants in industries like cement and steel could greatly improve China's energy intensity and carbon emission intensity. But in the long run it is more important to enhance energy efficiency in the residential, commercial, and transportation sectors for efficient energy saving. Moreover, the development of non-fossil and renewable energy resources promoted by future market demand is vital for an environment-friendly energy supply structure in future.

The Chinese government could also formulate more market-based measures to motivate enterprises to take action. Specifically, energy pricing reforms, energy taxes, and carbon taxes should be implemented gradually. China should also develop more energy efficiency standards and labelling to facilitate the development of an energy-efficient electrical appliances market. Reduction of energy subsidies would also help to incentivise more efficient use of energy.

There is also a need for a change in China's industrial structure (heavy to light industries or industry to services) and to accelerate the development of non-fossil energy including hydro, wind, and nuclear power. China also needs to urgently lengthen the lifecycle of buildings and infrastructure, which would reduce excessive consumption of energy intensive products such as steel and cement.

CHAPTER 6

INDIA COUNTRY REPORT[1]

LU ZHENG[2] AND SAPTARSHI DAS[3]

1. Background

India is located in South Asia and has a land area of three million square kilometres. India has the second largest population in the world – it was around 869 million in 1990 and grew at an average annual rate of 1.6 percent to reach 1.24 billion in 2012. India's gross domestic product (GDP)) increased at an average annual rate of 6.5 percent from US$ 352 billion in 1990 to US$ 1.395 trillion (2005 constant price) in 2012, which meant it ranked as the 10th largest economy globally. The services sector and the industry sector are the largest contributors to India's GDP.

1.1. Energy Situation

India's total primary energy consumption increased by 4.2 percent per year, from around 317 Mtoe in 1990 to 788 Mtoe in 2012. In 2012, coal, mainly consumed for power generation and by industry, accounted for the largest share of primary energy, at 44.9 percent. 'Others',[4] most of which is the non-commercial biomass used by the residential sector, had the second largest share at 23.4 percent, followed by oil at 22.5 percent. The remaining shares were natural gas (6.2 percent), hydro (1.4 percent), and nuclear (1.1 percent). Compared with 1990, the share of non-commercial biomass energy decreased marginally, but the share of fossil energy including coal, oil, and natural gas increased. Amongst the major energy sources, the fastest growing were natural gas and nuclear energy – natural gas grew at an average annual rate of 7.2 percent and nuclear by 7.9 percent per year. Coal, oil, and hydro consumption increased, but at slower annual average rates, of 5.8 percent, 5.0 percent, and 2.6 percent, respectively.

India generated 1,128 TWh of electricity in 2012. Average annual growth in electricity generation between 1990 and 2012 was 6.3 percent, almost as high as the growth in GDP. The shares of generation by fuel type in 2011 were: coal, 71.1 percent; hydro, 11.2 percent; natural gas, 8.3 percent; nuclear, 2.9 percent; oil, 2.0 percent; and others (wind, solar PV, and other renewable energy sources), 4.5 percent.

India's final energy demand grew by 3.3 percent per year, from 250 Mtoe in 1990 to 512 Mtoe in 2012. Between 1990 and 2012, the industry sector grew by 4.1 percent per year, the transport sector by 5.9 percent per year, and the residential and commercial

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[1] Based on Model run and broad assumptions by the Institute of Energy Economics, Japan (IEEJ).
[2] Energy Data and Modelling Center (EDMC), The Institute of Energy Economics, Japan (IEEJ).
[3] Modelling and Scenario Building Area (MSB), The Energy and Resources Institute, India (TERI).
[4] Others constitute non-commercial biomass, wind, solar, solid and liquid biomass, and other renewable energy sources as well as electricity imports or exports.

(others) sectors by 2.2 percent per year. Non-energy use[5] saw fast growth of 4.6 percent a year.

In terms of commercial energy consumption, the share of oil was the highest, at 20.1 percent of total final energy demand in 1990, and 29 percent in 2012. The share of coal increased from 16.8 percent in 1990 to 17.3 percent in 2012, that of electricity from 7.4 percent to 14.6 percent, and that of natural gas from 2.3 percent to 5.1 percent. The share of other energy, most of which is the non-commercial biomass, dropped from 53.0 percent in 1990 to 34 percent in 2012.

2. Modelling Assumptions

India's GDP is assumed to grow at an average annual rate of 6.6 percent from 2012 to 2035, and its population is assumed to increase by an average 0.9 percent per year.

Concerning future electricity supply, the share of coal in electricity generation will continue to be the largest. The shares of nuclear power and others, especially wind and solar, are projected to increase to 2035, whereas the shares of oil and hydro are expected to fall.

Implementation of energy efficiency programmes in power generation and energy end-use sectors are expected to allow India to attain its energy saving goals. Improvements in highly energy-intensive industries and in inefficient small plants are some of the planned measures to achieve energy savings in the industrial 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 achieve efficiency improvements.

3. Outlook Results

3.1. Business-as-Usual (BAU) Scenario

Total Final Energy Consumption

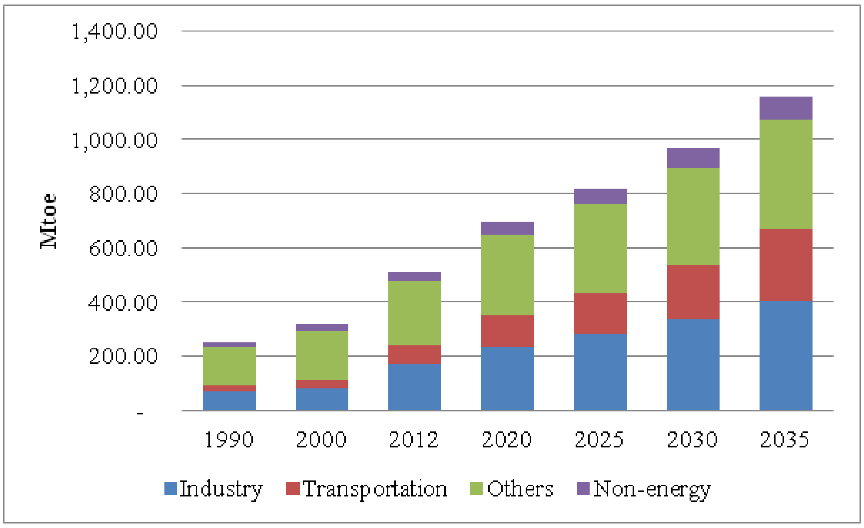
Under the BAU scenario, with assumed strong economic growth and a rising population, India's final energy demand is projected to increase at an average rate of 3.6 percent per year from 512 Mtoe in 2012 to 1156 Mtoe in 2035 (Figure 6-1). The strongest growth is expected to occur in the transport sector, increasing at 5.8 percent a year between 2012 and 2035. Strong growth is also expected in the industry sector (3.9 percent a year) and non-energy consumption (3.7 percent a year). Due to the large share of non-commercial energy in final energy demand, the growth rate of the 'others' sector that includes the residential and commercial sectors, is projected to be modest, at 2.4 percent per year. But the consumption of commercial energy, especially electricity, will increase

[5] Non-energy use refers to consumption of energy products for non-energy purposes, such as feedstock for the petrochemical industry for the production of ethylene and lubricants in the transportation and industrial sector.

rapidly in the residential and commercial sectors.

The share of 'others', which is the largest at 45.8 percent in 2012, will drop to 34.9 percent in 2035, that of industry will increase from 32.8 percent in 2012 to 34.8 percent in 2035, and that of transport from 14.4 percent to 23.2 percent.

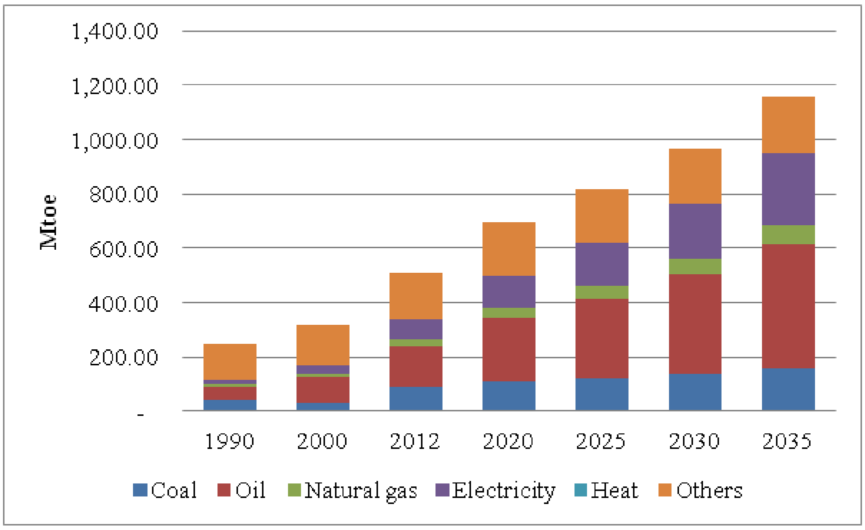
Figure 6-1. Final Energy Demand by Sector



Source: Author's calculation.

In final energy demand by source, electricity is expected to see the fastest growth, increasing by 5.6 percent per year from 2012 to 2035 (Figure 6-2). Oil demand will increase at the second highest rate, of 5.0 percent per year, followed by natural gas (4.5 percent), and coal (2.5 percent).

Figure 6-2. Final Energy Demand by Source



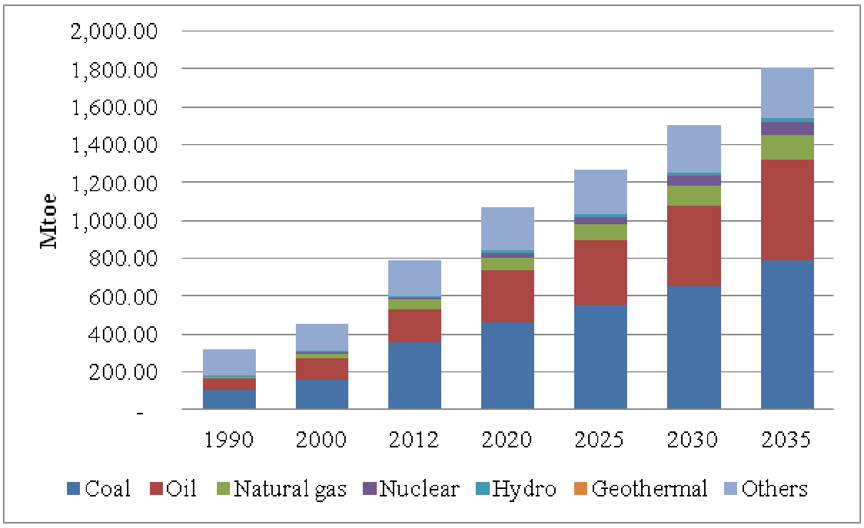
Source: Author's calculation.

Primary Energy Demand

Under the Business-as-Usual (BAU) scenario, India's primary energy demand will increase at an average annual rate of 3.7 percent to 1,805 Mtoe in 2035 from 788 Mtoe in 2012. Coal demand, driven by the demand of power generation, is projected to grow at 3.5 percent per year and reach 787 Mtoe in 2035, from 354 Mtoe in 2012, maintaining the largest share at 43.6 percent in 2035 (44.9 percent in 2012). Due to rapid motorisation, oil is expected to increase to 529 Mtoe and would have the second largest share at 29.3 percent in 2035. The average annual growth rate for oil demand from 2012 to 2035 is assumed to be 4.9 percent. Natural gas consumption is expected to increase by 4.5 percent per year between 2012 and 2035 and its share will be 7.4 percent in 2035 (6.2 percent in 2012). Figure 6-3 shows projected primary energy demand in India from 1990 to 2035 under the BAU scenario.

Nuclear energy is expected to grow fastest, at an average annual rate of 9.2 percent, with its share increasing from 1.1 percent in 2012 to 3.6 percent in 2035. Of the 'others', solar and wind will increase significantly, but due to the slow growth of non-commercial biomass which has the largest portion, 'others' as a whole is projected to increase by only 1.6 percent per year through to 2035, with its share dropping to 14.9 percent from 23.9 percent in 2012.

Figure 6-3. Primary Energy Demand by Source



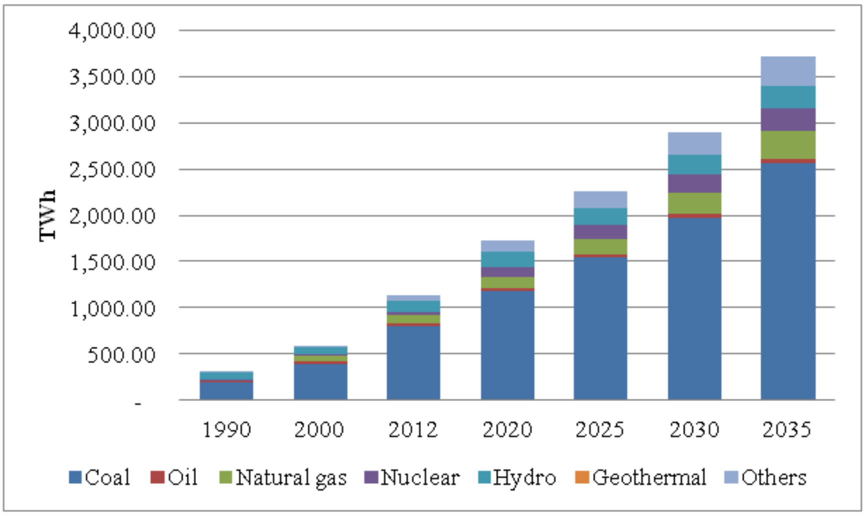
Source: Author's calculation.

Power Generation

In 2012, power generation in India was 1,128 TWh. Under the BAU scenario, India's power generation will increase at an annual rate of 5.3 percent per year to 3,721 TWh in 2035. Coal will continue to dominate India's power generation mix, maintaining its share at above 65 percent. Hydro's share in India's power generation mix will decline from 11.2 percent in 2012 to 6.5 percent in 2035, and oil's share will decline from 2 percent in 2012 to 1.3 percent in 2035. In contrast, the share of nuclear power will increase from 2.9 percent to 6.7 percent, and new energy including wind and solar power will increase from

4.5 percent to 8.7 percent. The share of natural gas-fired generation will decrease until 2020, but increase when the barriers to supply and utilisation of natural gas are cleared. The share of natural gas will be 8 percent in 2035, and the average growth rate from 2012 to 2035 is expected to be 5.1 percent per year. Figure 6-4 shows the projected power generation in India from 1990 to 2035 under the BAU scenario.

Figure 6-4. Power Generation, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

3.2. Energy Saving and CO_2 Reduction Potential

3.2.1 Final Energy Demand

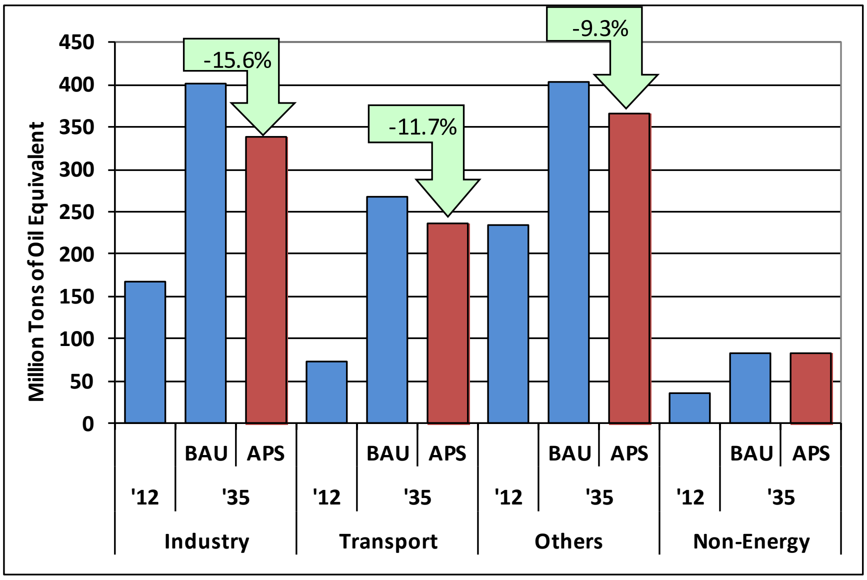
Under the Alternative Policy Scenario (APS), final energy demand is projected to increase at a slower rate, of 3.1 percent per year from 512 Mtoe in 2012 to 1,025 Mtoe in 2035. This is 132 Mtoe or 11.4 percent lower than under the BAU scenario. The slower growth in demand is expected to occur across all end-use sectors, reflecting improvements in end-use technologies and the introduction of energy management systems (Figure 6-5).

In 2035, under the APS relative to the BAU scenario, there is an estimated saving of 62.9 Mtoe (15.6 percent) in the industry sector, 31.4 Mtoe (11.7 percent) in the transport sector, and 37.5 Mtoe (9.3 percent) in the 'others' sector.

3.2.2 Primary Energy Demand

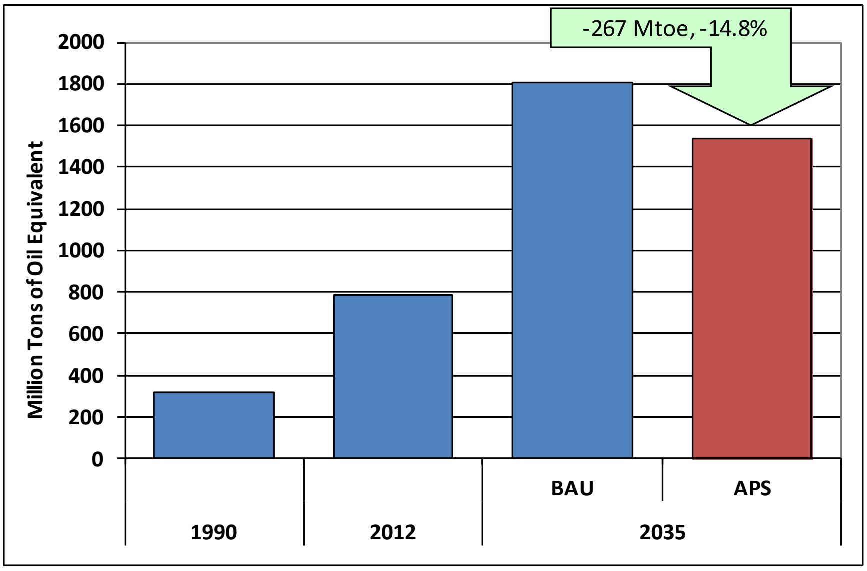
Under the APS relative to the BAU scenario, India's primary energy demand is projected to increase at a slower rate, of 3 percent per year to 1,539 Mtoe in 2035. The difference between primary energy demand under the BAU scenario versus the APS in 2035 is 266.8 Mtoe or 14.8 percent (Figure 6-6).

Figure 6-5. Final Energy Demand by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

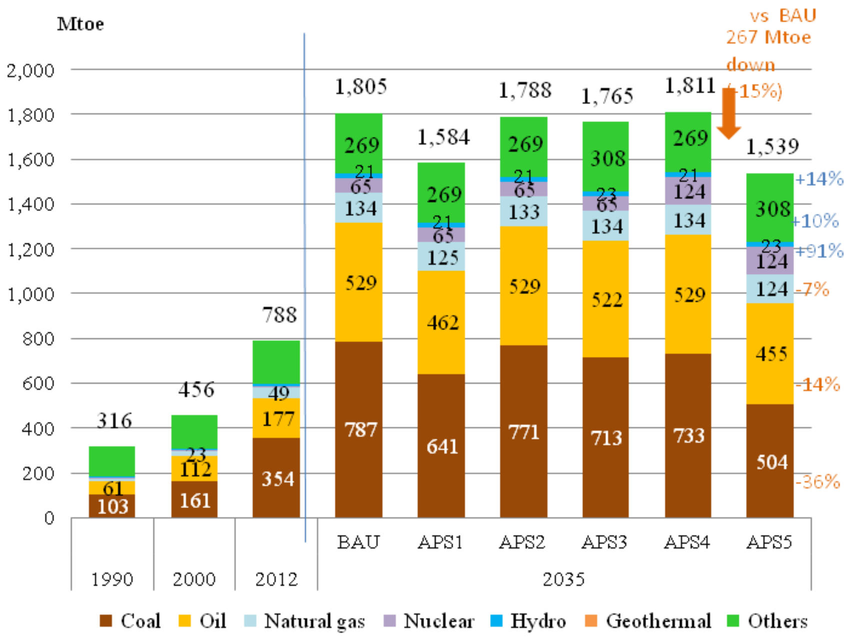
Figure 6-6. Net Primary Energy Supply, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In the APS, nuclear will be the fastest growing energy source, increasing at 12.3 percent per year, to reach 124.4 Mtoe in 2035, 91 percent higher than under the BAU scenario. Hydro and 'others' will grow at 3.3 percent and 2.2 percent per year, increasing to 22.9 Mtoe and 307.84 Mtoe, or 10 percent and 14 percent higher than the BAU scenario, respectively (Figure 6-7).

Figure 6-7. Primary Energy Demand by Source, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

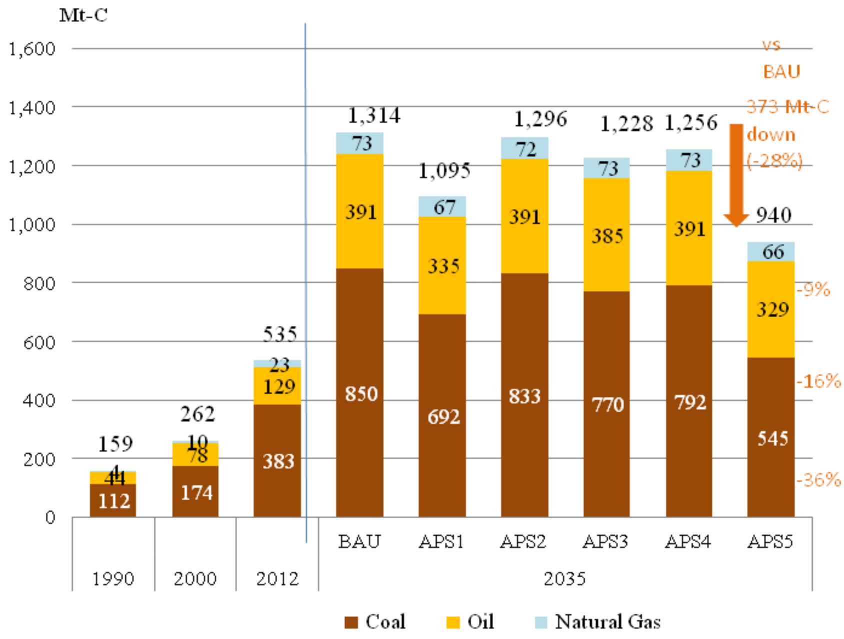
Natural gas, oil, and coal will grow at slower annual rates of 4.1 percent, 4.2 percent, and 1.5 percent, respectively, increasing to 124 Mtoe, 455 Mtoe, and 504 Mtoe, respectively, in 2035, meaning they will be 7.7 percent, 14.0 percent, and 35.9 percent lower, respectively, than under the BAU scenario.

3.3. CO_2 Emissions from Energy Consumption

Under the BAU scenario, CO_2 emissions from energy consumption will increase by 4.0 percent per year, from 535 Mt-C in 2012 to 1314 Mt-C in 2035. The projected growth in emissions is less than the projected growth in primary energy consumption, reflecting the expected increase in the use of less carbon intensive energy sources in India.

In the APS, the annual increase in CO_2 emissions from 2012 to 2035 will be 2.5 percent slower than under the BAU scenario – CO_2 emissions in 2035 will be 940 Mt-C, 28.4 percent lower than under the BAU scenario. Lower demand for coal in final demand and in power generation and for oil in the transport sector contribute most to the expected reduction in CO_2 emissions. Figure 6-8 shows the CO_2 emission in 2035 under the various scenarios analysed in this energy outlook.

Figure 6-8. CO_2 Emissions from Energy Combustion, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Implications

- Energy security and access to energy are key challenges for 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 in the APS. Use of domestic coal for secure supply as well as more efficient coal technologies such as integrated gasification combined-cycle (IGCC), ultra-supercritical (USC), etc. would be necessary. In the long term and medium term, R&D 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, it is necessary to enhance the infrastructure for importation, domestic transportation, and utilisation.
- Energy efficiency and demand side management are important.
  - Industry will account for 39 percent of the incremental energy use to 2035; energy efficiency programmes should be focused on this sector. Broadening the scope of the PAT (Perform, Achieve, Trade) scheme will be an important way of achieving this.
  - There are huge potential savings in the power sector. Advanced technologies for power generation should be used as much as possible.
  - 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.

CHAPTER 7

Indonesia Country Report

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1. Background

Indonesia is the largest archipelagic state in Southeast Asia comprising of 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, East Timor, and Malaysia. Other neighbouring countries include Singapore, the Philippines, Australia, and the Indian territories of Andaman and Nicobar Islands.

Indonesia covers an area of nearly two million square kilometres and is the world's 16th largest country in terms of land area. According to the 2010 population census, Indonesia had 237.6 million people, making it the world's fourth most populous country. Its average population density in 2010 was 124 people per square kilometre. The population continued to increase after 2010, reaching 245.4 million in 2012, resulting in a population density of 128 people per square kilometre, and by the end of 2013 the population had reached nearly 250 million.

Indonesia's economic growth from 2010 to 2013 was around 6 percent per year. In 2012, its real GDP increased by 6.2 percent, year-on-year, reaching US$427.6 billion (constant 2005 US$), and in 2013 it reached US$452.3 billion (constant 2005 US$), growing by 5.8 percent, year-on-year.

From 1990 to 2012, GDP growth registered an average 4.9 percent per year. GDP per capita in 2012 was around US$1,730 (constant 2005 US$), a considerable improvement from 1990, when it was only US$840 (constant 2005 US$).

Indonesia is richly endowed with natural resources. It had previously been a member of the Organization of Petroleum Exporting Countries (OPEC), but the increasing demand for oil products made the country a net importer of oil. Indonesian crude oil proven reserves have declined sharply, particularly in the late 1980s – they amounted to 11.6 billion barrels in 1980, 9 billion barrels in 1988, 5.4 billion barrels in 1990, and 4.2 billion barrels in 2009, and as of January 2014 were estimated at around 3.7 billion barrels.

Indonesia is the world's largest liquefied natural gas (LNG) exporter. Its natural gas proven reserves were 2.9 trillion cubic metres (TCM) in 1990, declined slightly to 2.5 TCM in 2005, but increased to 2.9 TCM (around 103.35 trillion cubic feet) in 2012. Indonesia is also a coal exporter with proven coal reserves of around 31.4 billion tonnes at the end of 2013.

In addition to its 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 GW and the estimated geothermal potential is more than 28 GW.

Indonesia's total primary energy consumption was almost 219 Mtoe in 2012. Oil represented the largest share of primary energy consumption in 2012 at around 34.8 percent, followed by 'others' (mainly biomass) at 24.5 percent, natural gas at 18.1 percent, and coal at 14.7 percent, with the remaining share of 7.9 percent representing hydro and geothermal.

Indonesia had around 45 GW of installed electricity generating capacity and generated around 196 TWh of electricity in 2012. The state electricity company of Indonesia, PT PLN PERSERO, owns and operates generation plants with a combined capacity of about 33 GW in 2012, composed of: 27 percent oil, 35 percent coal, 25 percent gas, 11 percent hydro, and 2 percent geothermal. There are also wind and solar power plants, but the total capacity of these resources is still small.

2. Modelling Assumptions

The government expects GDP growth of 5.7 percent in 2015 and assumes it will continue to increase, to 6.6 percent in 2016 and 8 percent in 2019. The National Energy Council (DEN) assumes average annual growth of 8 percent from 2015 to 2025, and that it will slow to 7.25 percent in 2035 and 6.5 percent in 2050. Official projections are for average annual growth of around 7.6 percent from 2012 and 2035.

However, for the purpose of this study we use the projections of the International Monetary Fund and the World Bank, which assume an average annual growth rate of 5.6 percent from 2012 to 2035 period for Indonesia.

Population growth is assumed to increase at an average 0.9 percent per year between 2012 and 2035. This is based on the assumptions of the revised population projection of the Central Bureau of Statistic (BPS) and is lower than the assumption used in the previous study (1 percent per year).

The scenarios will basically be similar to those used in last year's report, i.e. the Business-as-Usual (BAU) scenario and the five Alternative Policy Scenarios (APS). These APS reflected the additional policy interventions likely to be implemented, such as energy efficiency and conservation (EEC) targets and action plans; efficiency improvements in power generation plants; more aggressive adoption of renewable energy; and introduction of nuclear energy. The current study will also analyse the impacts of these policy interventions, not only combined, but also separately.

In the case of Indonesia, the five APS considered are as follow:

a) More efficient final energy demand (APS1), with specific energy saving targets by sector (Table 7-1), were considered as the basis for analysis.

Table 7-1. Energy Conservation Potential to 2025

Sector	Energy Consumption Per Sector Year 2012 (Million BOE) *)	Potential of EC	Target of Energy Conservation Sectoral (2025)
Industry	305 (39,7%)	10 – 30%	17%
Transportation	311 (40,4%)	15 – 35%	20%
Household	92 (12%)	15 – 30%	15%
Commercial	34 (4,4%)	10 – 30%	15%
Others (Agriculture, Construction, and Mining)	26 (3,4%)	25%	-

source: Draft National Energy Conservation Master Plan (RIKEN) 2011

Note:
- exclude biomass and non-energy used
- *) temporarily data on December 2013

Source: Harris (2014), 'Energy Efficiency Implementation To Reduce GHG Emission', paper presented at the Workshop on Technology Transfer for Low Carbon Technology in Indonesia, Directorate Energy Conservation, DGNREEC, MEMR.

In addition, Article 9 of the 2014 National Energy Policy (KEN) stated that energy elasticity achievement shall be less than 1 (one) in 2025 and that the reduction in final energy intensity of 1 percent per year will be achieved up to 2025. These goals and targets have also been considered as the energy saving target for this year's study.

b) More efficient thermal power generation (APS2), where higher improvement of existing coal power plants and the introduction of cleaner coal technologies have been considered in the analysis. In addition, more efficient natural gas combined-cycle technologies were also considered for this scenario.
c) 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 are assumed compared with the BAU scenario.
d) Introduction or higher utilisation of nuclear energy (APS4), where the assumption was it will be in operation after 2020, similar to the previous study. This is in line with the current plan, which involves construction of two units after 2020, each with a capacity of 1,000 MW.
e) The combination of APS1 to APS4 constitutes the assumptions of the APS (APS5).

3. Outlook Results

3.1 Business-as-Usual Scenario (BAU)

3.1.1. Final Energy Demand

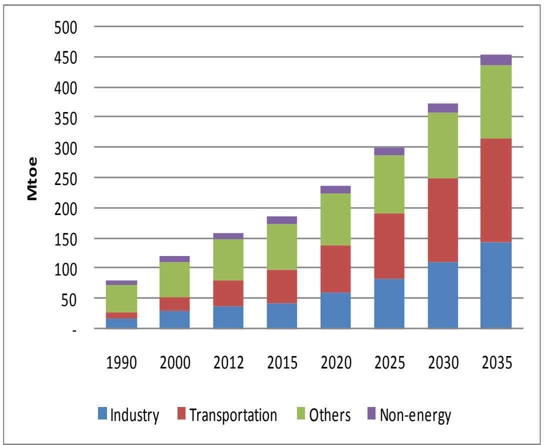
Indonesia's final energy demand increased at an average annual rate of 3.2 percent between 1990 and 2012, increasing from around 80 Mtoe to 159 Mtoe. Given the assumed economic and population growth, the growth in final energy consumption will continue, but at a faster rate of 4.7 percent per year between 2012 and 2035 in the BAU scenario.

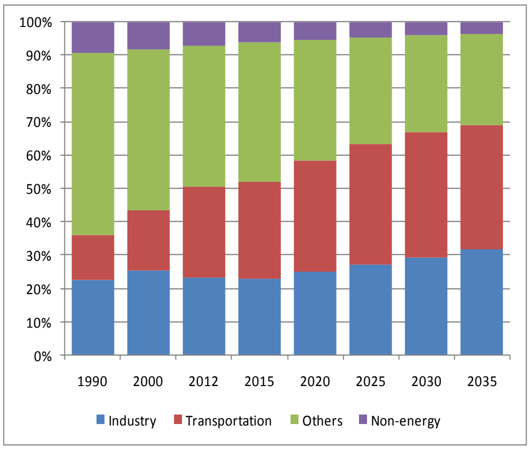
This growth stems from the rapid increase of energy consumed in the transportation and industrial sectors. The transportation sector is still heavily dependent on oil. From 1990 to 2012, final energy demand of the transport sector grew at an average rate of 6.6 percent per year, which made it the sector with the highest growth. It is expected it will continue to grow up to 2035 under the BAU scenario, but at a slightly lower rate of 6.1 percent per year.

Final energy consumption in the industrial and other sectors (mainly consisting of the residential and commercial sectors), grew at an average rate of 3.3 percent and 2.0 percent per year, respectively from 1990 to 2012. Final energy demand of these sectors for 2012 to 2035 is projected to increase more rapidly under the BAU scenario, at an average annual growth rate of 6.06 percent and 2.7 percent, respectively.

The 'others' sector had the highest share in total final energy demand from 1990 to 2012, because of the high consumption of biomass mainly in the residential sector, but the share fell from around 55 percent in 1990 to 42 percent in 2012. It is expected that the share will continue decline as household appliances become more efficient and households increasingly use alternatives such as natural gas and LPG. The sector's share in total final energy demand will fall to 27 percent in 2035.

Figure 7-1. Final Energy Demand by Sector





Source: Author's calculation.

The transportation sector's share in total final energy demand increased from 13.4 percent in 1990 to 27.4 percent in 2012. This share will continue to increase and is expected to reach 37.5 percent in 2035. The combined share of oil and alternative fuels for transport will contribute more to the increase of the transport sector's share in total final energy demand. Oil was the main fuel used in the transport sector, and oil consumption of the sector is expected to grow at an average rate of around 6.0 percent per year. Alternatives for oil such as biofuel will also contribute significantly, growing at an average 15.0 percent per year from 2012 to 2035.

The industrial sector's share in total final energy demand amounted to 23 percent on average from 1990 to 2012, and its share is projected to increase to 31.8 percent by 2035, in line with an expected growth in industrial activities.

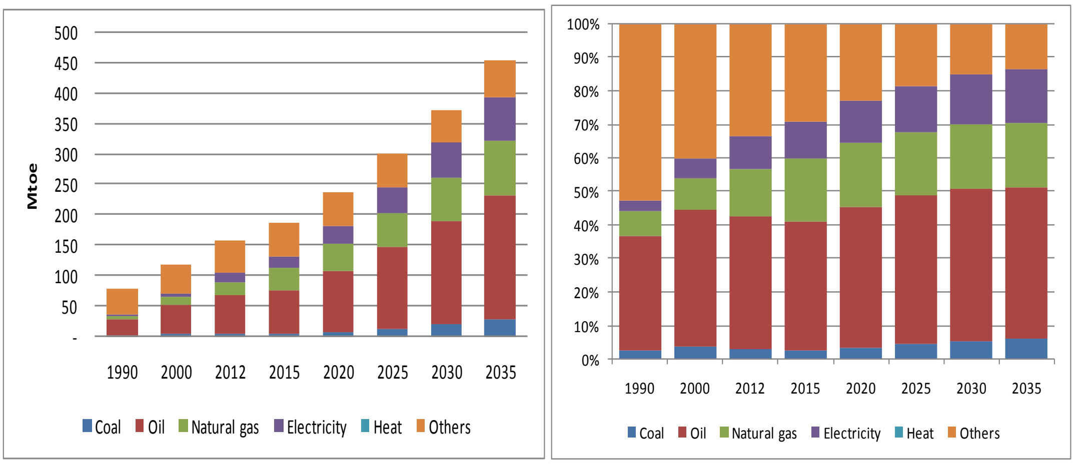
By fuel type, electricity experienced the fastest growth from 1990 to 2012, increasing at an average rate of 8.6 percent per year. This rapid growth of electricity demand was due to the significant increase in consumption of the industrial and residential sectors, from 2.4 Mtoe in 1990 to 15.1 Mtoe in 2012. The electrification ratio improved from 28 percent in 1990 to 77 percent in 2012. Coal also increased significantly over the same period as industry expanded, particularly the cement industry. Total coal demand increased from 2.1 Mtoe in 1990 to 4.7 Mtoe in 2012, growing at an average rate of 3.7 percent per year.

As for natural gas and oil, average annual growth of these fuels from 1990 to 2012 period was 6.3 percent and 3.9 percent, respectively. Demand for other fuels (mostly biomass for households) increased by around 11 Mtoe, at an average rate of 1.1 percent per year.

Demand for all fuels is projected to continue to increase. Demand for coal will grow fastest, at an average rate of 8.3 percent per year, to 29.1 Mtoe in 2035. Electricity is also expected to grow, but at a slower rate than in the past. The average annual growth rate for electricity demand is expected to be 7.1 percent per year from 2012 to 2035.

Natural gas and oil demand will grow at an average rate of 6.0 percent per year and 5.2 percent per year, respectively, between 2012 and 2035. Demand for 'other' fuels will see the slowest increase over the same period, growing at an average 0.5 percent per year. This is mainly due to a fall in the growth rate of the residential sector's biomass consumption.

Figure 7-2. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

In terms of fuel, oil will continue to play a major role in the country's final energy demand, although more alternatives fuels will be consumed by the end-use sectors. It is expected that the share of oil will be around 45 percent in 2035, increasing from 39.7 percent in 2012. The remaining shares will be coal (6.4 percent), natural gas (19.3 percent), electricity (16.1 percent), and others (13.2 percent).

3.1.2. Primary Energy Consumption

Primary energy consumption in Indonesia grew faster than final energy demand, at about 3.7 percent per year, from 99 Mtoe in 1990 to 219 Mtoe in 2012. Amongst the major energy sources, the fastest growing fuels between 1990 and 2012 were coal and geothermal energy. Coal consumption grew at an average annual rate of 10.5 percent and geothermal energy increased at 10.1 percent a year. Gas consumption increased at a slower rate, of 4.3 percent per year, and oil consumption rose slightly more slowly, at 3.8 percent per year.

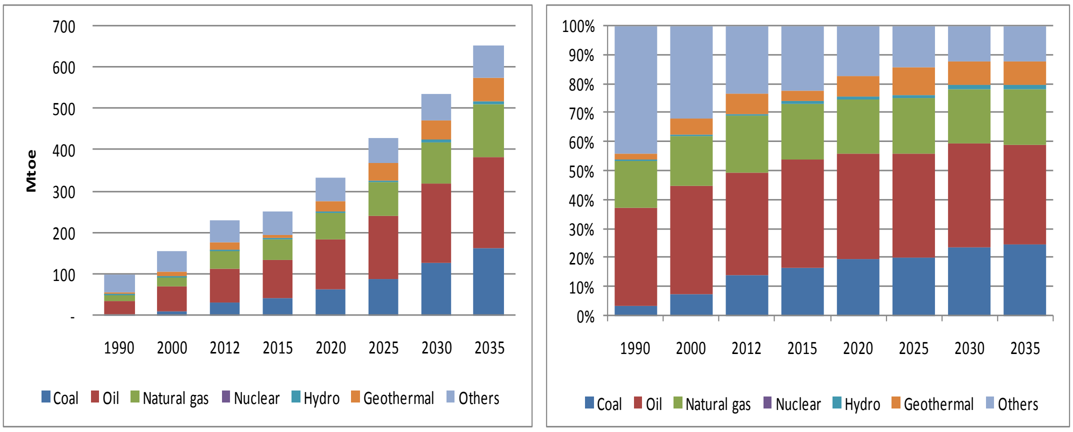
In the BAU scenario, Indonesia's primary energy consumption is projected to increase at an average annual rate of 4.8 percent, reaching 652 Mtoe in 2035. Coal is projected to continue to grow, but at a slower rate of 7.3 percent per year over the projection period. Geothermal energy is also expected to increase over the projection period, but more slowly than over the past two decades because of the difficulties of expanding exploration in protected forest areas. Exploration will also become more expensive as the areas to be explored become smaller and are increasingly located in difficult terrains, such as those in the eastern part of Indonesia. The projected growth rate of geothermal energy until 2035 is projected to be 5.4 percent per year.

Hydro, on the other hand, will increase at a faster rate, of 8.7 percent per year between 2012 and 2035, compared with the period from 1990 to 2012, as more hydro plants will be built, such as in East Kalimantan. Consideration is being given to building more run-of-the-river type hydroelectricity, rather than the reservoir type.

Oil consumption is projected to increase at an average annual rate of 4.6 percent from 2012 to 2035, and natural gas consumption is expected to increase slightly faster, at an average rate of 5.5 percent per year.

It is assumed that there will be no uptake of nuclear energy 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 7-3. Primary Energy Consumption, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

From 1990 to 2012, oil constituted the largest share of total primary energy consumption, increasing from 33.8 percent to 34.8 percent. The share of natural gas in the total mix also increased slightly, from 16.0 percent in 1990 to 18.1 percent in 2012.

Since both coal and geothermal experienced rapid growth from 1990 to 2012, the shares of these energy sources in the total fuel mix increased significantly. Coal's share in the total primary energy mix increased from 3.6 percent to 14.7 percent and that of geothermal from 2.0 percent to 7.4 percent. Hydro's share remained constant. Since the 'others' – which include biomass, solar, wind, ocean, biofuels, and electricity – grew slower than the other fuels, its share declined from 44.1 percent in 1990 to 24.5 percent in 2012.

In the BAU scenario, oil's share will continue to be dominant throughout the 2012–2035 period and the share of oil in the total primary energy mix will still be just below 33 percent in 2035. The share of natural gas share will increase to 20.7 percent by the end of the projection period.

Hydro's share in the total primary energy mix will remain below 2 percent, even though hydro is projected to grow faster than geothermal.

3.1.3. Power Generation

Power generation output increased at an average rate of 8.5 percent per year over the past two decades, from 32.7 TWh in 1990 to almost 195.9 TWh in 2012. The fastest growth occurred in the production of electricity from natural gas plants, at 20.3 percent per year. This was due to the increase in gas turbine and combined cycle capacities as natural gas became increasingly more available.

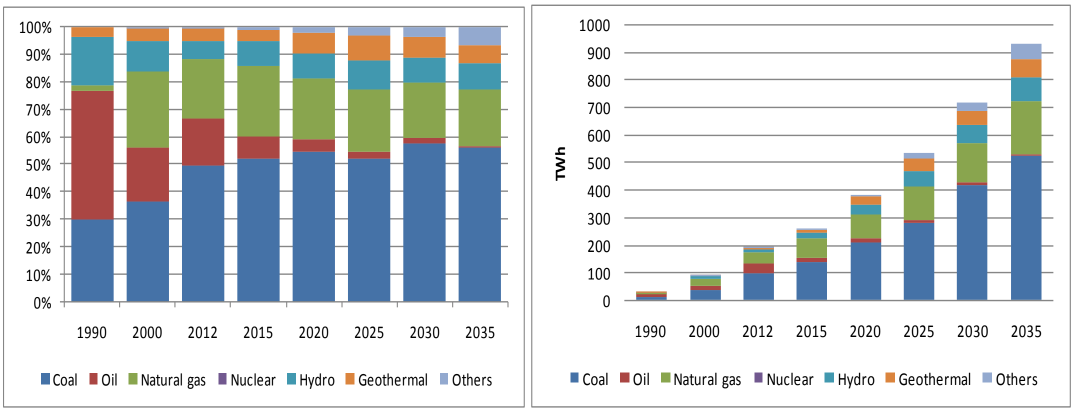
In the BAU scenario, to meet the demand for electricity, power generation is projected to increase at a slower rate, of 7 percent per year, reaching 936 TWh in 2035. This study included the electricity imports of PT PLN as implied in the General Plan of Electricity Development (RUPTL) 2015–2024. Electricity imports will increase from 758 GWh in 2015 to 1,503 GWh in 2024, and it is assumed they will remain at this level until 2035.

By type of fuel, generation from 'others' will see the fastest growth, at an average rate of 25.9 percent per year. The main reason for this very rapid growth is that generation from these other sources was very small in 2012, but is expected to increase significantly as a result of the government's policy to increase the use of new and renewable energy sources including solar PV, wind, and biomass, which are classified as 'others'.

Generation from geothermal and hydro are also growing fast, but much slower than 'others', at 8.6 percent per year and 8.7 percent per year, respectively.

Power generation from natural gas will continue to increase, but at a much slower rate, of 6.8 percent per year, and coal based power generation is projected to grow at an average annual rate of 7.6 percent. No nuclear plant is considered under the BAU scenario.

Figure 7-4. Power Generation by Type of Fuel (TWh)



Source: Author's calculation.

The share of coal will remain dominant in Indonesia's total power generation. The share of coal in total power generation was lower than oil in 1990 (29.9 percent), but it increased after that as more coal power plants were constructed, and by 2012 the share had increased to 49.9 percent, higher than that of oil. Under the BAU scenario, this share is expected to continue to increase, and by 2035 the share of coal in total power generation will be 56.1 percent.

Oil had the largest share in power generation in 1990 (46.9 percent), but by 2012 it had declined to 16.8 percent, as production from coal and natural gas plants increased rapidly. The share of natural gas reached 21.8 percent in 2012, but will decrease slightly, to 20.8 percent in 2035 under the BAU scenario.

Hydro also an important role in Indonesia's overall electricity production, its share amounting to 17.5 percent in 1990, but by 2012 it had declined to 6.5 percent. Under the BAU scenario, hydro's share is expected to increase to 9.4 percent in 2035.

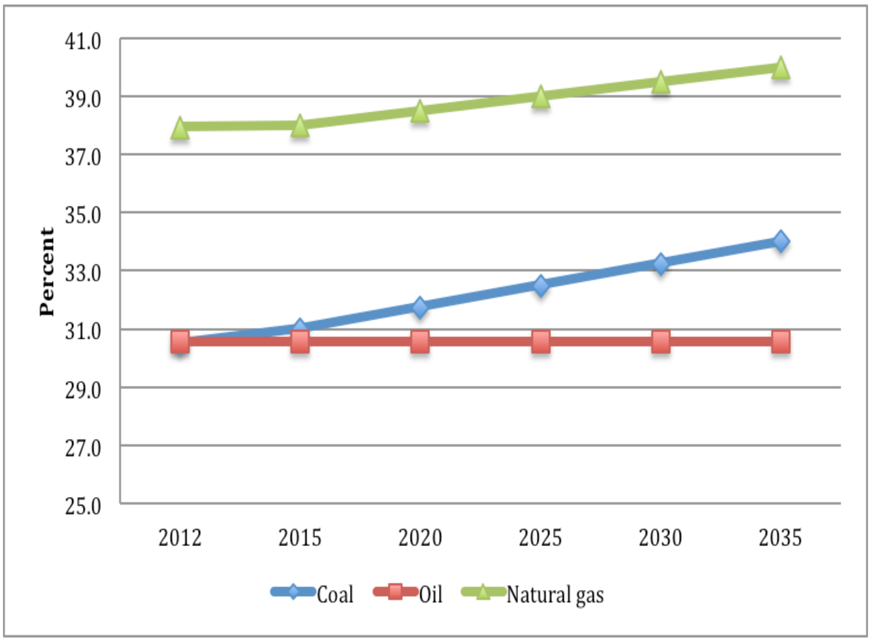
The shares of geothermal and other renewables together constituted about 5 percent of total power generation in 2012. The role of these renewables is expected to increase significantly and their combined share is projected to increase to 13.2 percent by 2035.

The average thermal efficiency of fossil fuel-based power plants was 32.1 percent in 2012. In the BAU scenario, it was assumed that the efficiency of coal and natural gas power plants will increase to 35.4 percent in 2035.

By fuel, coal power plants' thermal efficiency is projected to increase from 30.5

percent in 2012 to 34 percent in 2035 and natural gas is assumed to increase from 37.9 percent to 40.0 percent. Oil will remain below 31 percent over the 2012–2035 period.

Figure 7-5. Thermal Efficiency, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

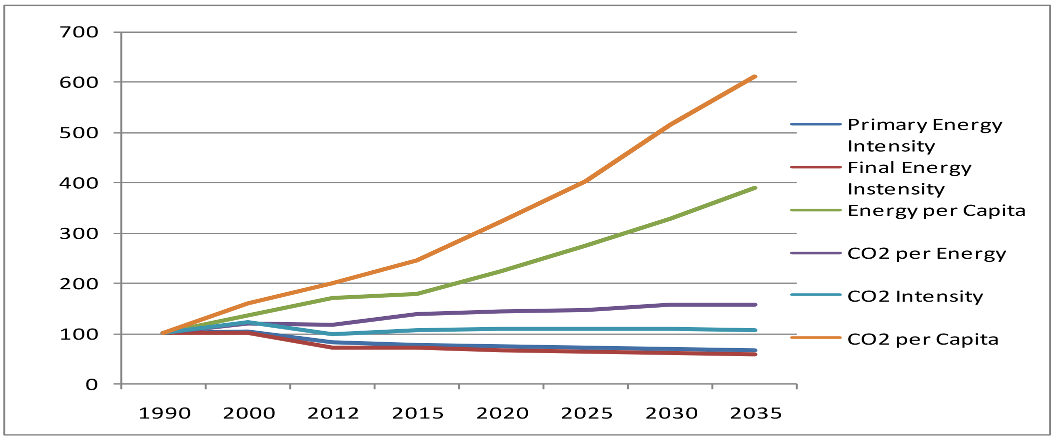
3.1.4. Energy Indicators

As a developing country, Indonesia's primary energy intensity (TPES/GDP) had been increasing up until 2000. Since then, it has declined and reached a level of 513 toe/million 2005 US$ in 2012. Similarly, final energy intensity declined and reached a level of 372 toe/million 2005 US$ in 2012. These figures are an indication that energy producers and consumers have started to use energy more effectively through the implementation of energy conservation measures and greater utilisation of efficient energy technologies.

In the BAU scenario, primary and final energy intensity are projected to decline at an average annual rate of 0.7 and 0.9 percent, respectively, from 2012 to 2035. Primary energy intensity in 2035 is expected to be around 437 toe/million 2005 US$ and final energy intensity 305 toe/million 2005 US$. Thus, the energy intensity ratio is expected to improve by almost 19 percent (primary) and 18 percent (final) in 2035 compared with 2012.

Per capita energy consumption, measured as the ratio of total primary energy consumption to total population, increased from 0.55 in 1990 to 0.89 in 2012. This level of energy consumption per capita is an indication that people's energy access improved. The electrification ratio was around 77 percent in 2012 and increased to 84.3 percent in 2014, indicating that around 16 percent of households still have no access to electricity. The main reason is that there is still a lack of energy infrastructure development, particularly in the remote areas and the outer islands due to the high investment cost.

Figure 7-6. Energy Intensity and Other Energy Indicators (1990=100)



Source: Author's calculation.

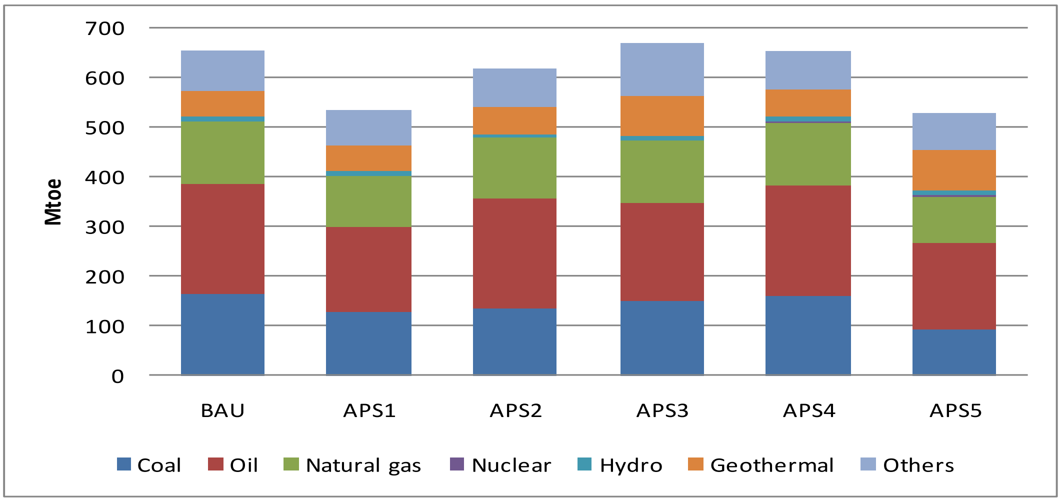
Under the BAU scenario, energy consumption per capita will continue to increase and will reach 2.14 toe per person in 2035. This result is in accordance with the existing national energy policy (2014), which targeted a level of 1.4 TOE in 2025 and 3.2 TOE in 2050.

In the BAU scenario, the elasticity of final energy consumption is expected to continue to decline and reach 0.84 in 2035. Elasticity below 1.0 is an indicator that growth in final energy consumption will be slower than growth in GDP from 2012 to 2035.

3.2. Energy Saving and CO_2 Reduction Potential (APS)

As mentioned above, the assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions, APS5. Figure 7-7 shows the changes in total primary energy supply in all the scenarios.

Figure 7-7. Total Primary Energy Supply, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In Figure 7-7, APS1 and APS5 have the largest reduction in total primary energy supply due to the energy efficiency assumptions on the demand-side. Energy efficiency assumptions in APS1 could reduce total primary energy supply in BAU by nearly as much as 119 Mtoe or 18.2 percent.

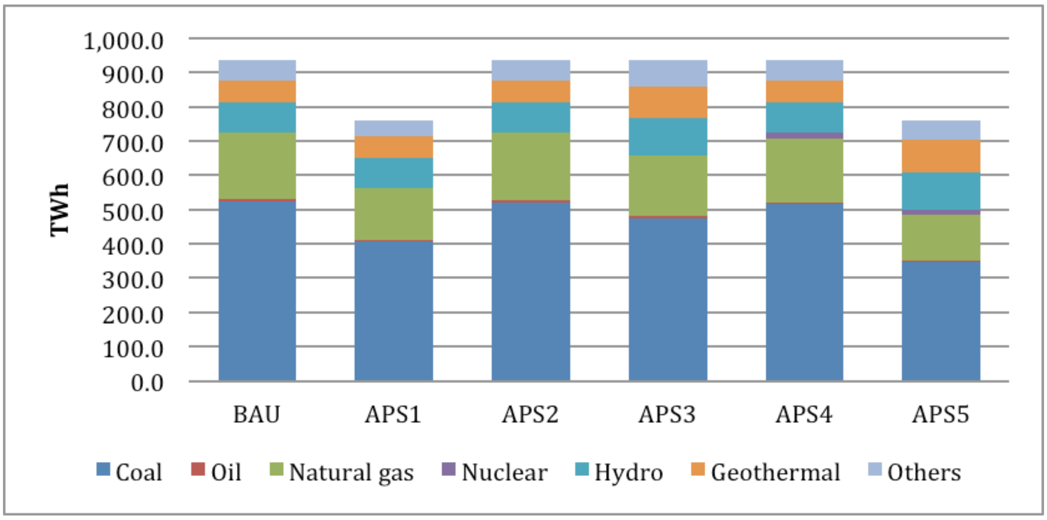
APS2, which assumes higher efficiency in thermal electricity generation, will also reduce total primary energy supply in 2035 by 31.7 Mtoe or 4.9 percent, as compared with the BAU scenario. Under APS2, no efficiency measures were assumed for the final sector, so its impact will be lower than APS1. Therefore, the reduction is due mainly to the use of more efficient power generation, with some of the conventional plants ceasing operations having reached the end of their technical lifetime.

For APS3, the total primary energy supply will increase slightly as more renewable energy for power generation will be used and more biofuels will be consumed in the transportation sector. The difference between APS3 and the BAU scenario for 2035 is 17.4 Mtoe or 2.7 percent.

The introduction of nuclear power generation after 2020 (APS4) will increase the total primary energy mix in 2035, but only by 2.7 Mtoe or 0.4 percent compared with BAU. The result indicates that the introduction of nuclear plants will reduce consumption of fossil fuels (coal, oil, gas) in generating power. However, considering the efficiency of nuclear plants is slightly lower than the average thermal efficiency of fossil plants, there may be no savings relative to the BAU results.

Figure 7-8 shows total electricity generation in 2035 in all scenarios. In APS1, due to the lower electricity demand, the shares of fossil-fired electricity generation were lower than in the BAU scenario – 74.0 percent compared with 77.6 percent. In APS2, the share is the same as that of BAU. In APS3, due to the assumption of more renewable energy, the shares of fossil fuel-fired generation could be reduced by 7.5 percent, and in APS4 nuclear energy could reduce the fossil fuel share by 2 percent. In APS5, where all scenarios are combined, the reduction in the shares of fossil energy-based generation will be significant, i.e. almost 13.8 percent lower than under the BAU scenario.

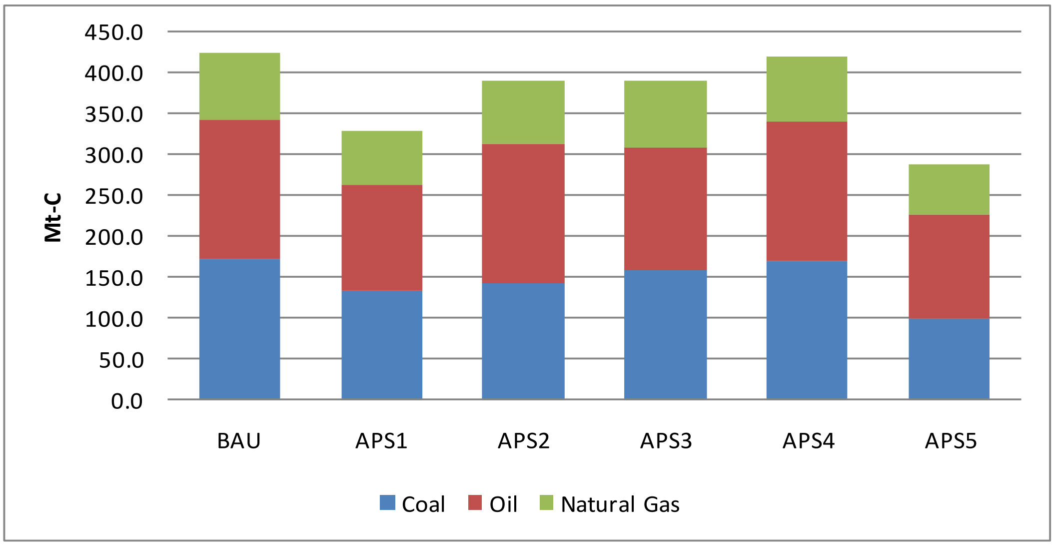
Figure 7-8. Electricity Generation, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author’s calculation.

In terms of CO_2 emission reduction, the energy efficiency assumption in APS1 could reduce emissions by 22.7 percent in 2035 compared with the BAU scenario. In APS2, the installation of more efficient new power plants reduces emissions by 7.9 percent. Higher contributions from renewable energy could reduce emissions by 8.4 percent and nuclear energy could reduce emissions by 0.9 percent. All these assumptions combined (APS5) could reduce BAU CO_2 emissions by 32.3 percent in 2035.

Figure 7-9. CO_2 Emission, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.2.1. Final Energy Demand

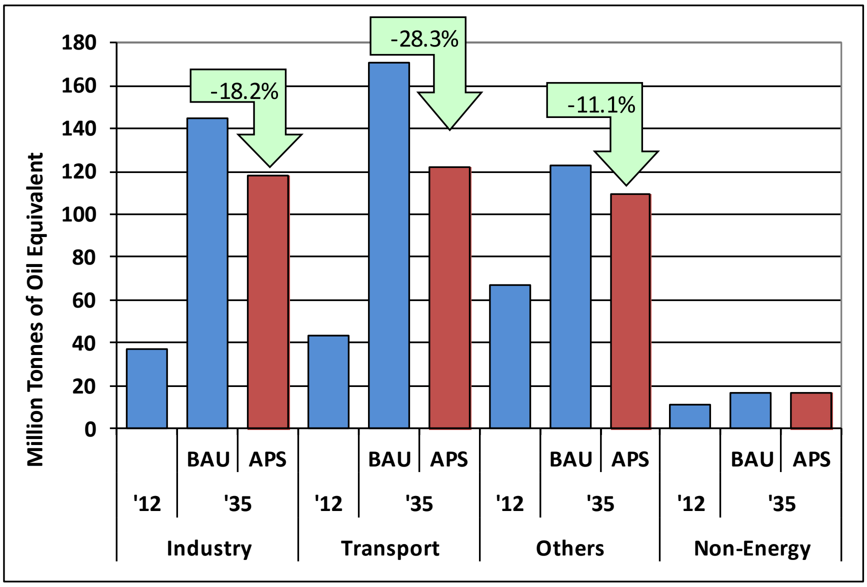
In the combined APS (APS5), final energy demand is projected to increase at a slower rate than in the BAU scenario, increasing at an average rate of 3.7 percent per year from 159 Mtoe in 2012 to 367 Mtoe in 2035. Slower growth under the APS, relative to the BAU scenario, is projected across all sectors as a result of the government programme for energy efficiency and conservation, particularly in the transport sector. Growth of energy demand in the transport sector is projected to increase by 4.6 percent per year compared with 6.1 percent per year under the BAU scenario. Figure 7-10 shows final energy demand by sector in 2012 and 2035 under the BAU scenario and APS.

In terms of final energy consumption savings, saving of almost 26 Mtoe are expected in the industry sector, savings of nearly 48 Mtoe in the transport sector, and of around 14 Mtoe in the residential/commercial (other) sector by 2035 under the APS, relative to the BAU scenario.

3.2.2. Primary Energy Consumption

In the combined APS (APS5), primary energy consumption is projected to increase at a slower rate relative to the BAU scenario, at 3.9 percent per year, to 525.2 Mtoe in 2035. All energy sources are projected to experience positive average annual growth rates, but some of these will be lower than under the BAU scenario. The lower consumption relative to the BAU scenario reflects energy efficiency and conservation measures on the demand side and the supply, with the use of more efficient technology for power generation.

Figure 7-10. Final Energy Demand by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In terms of the fuel type, a saving of 68.1 Mtoe is estimated for coal, a saving of almost 51.6 Mtoe for oil, and around 31.6 Mtoe for natural gas by 2035 under the APS, relative to the BAU scenario. In case of other resources (new and renewable resources, nuclear, and others) the APS consumption in 2035 is 17.8 Mtoe higher than under the BAU scenario.

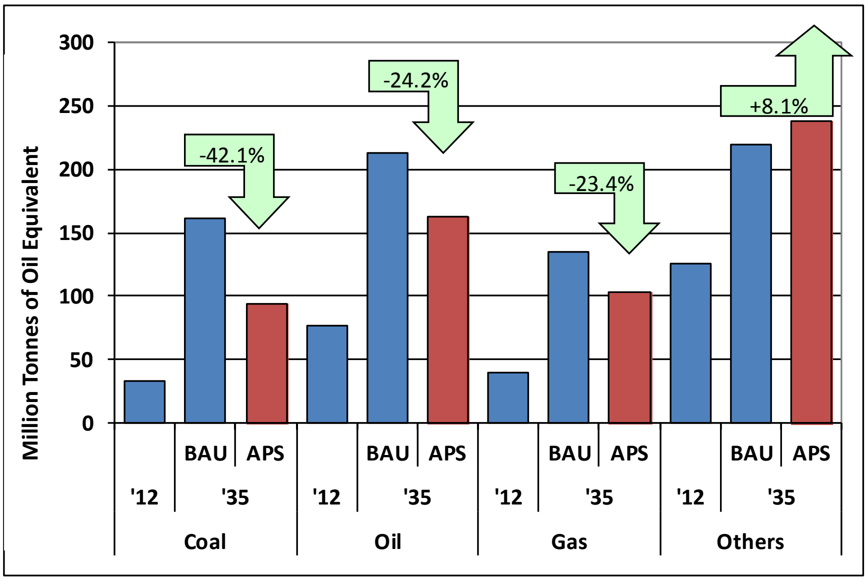
3.2.3. Projected Energy Savings

The total energy savings (the difference between primary energy demand in the BAU scenario and the APS) that could be achieved through the implementation of EEC and renewable energy targets and action plans of Indonesia, improved power plant efficiency, and the introduction of nuclear energy, amount to 126.4 Mtoe in 2035. This is more than a half of Indonesia's primary energy consumption in 2012, which was around 219 Mtoe.

3.2.4. Energy Intensities

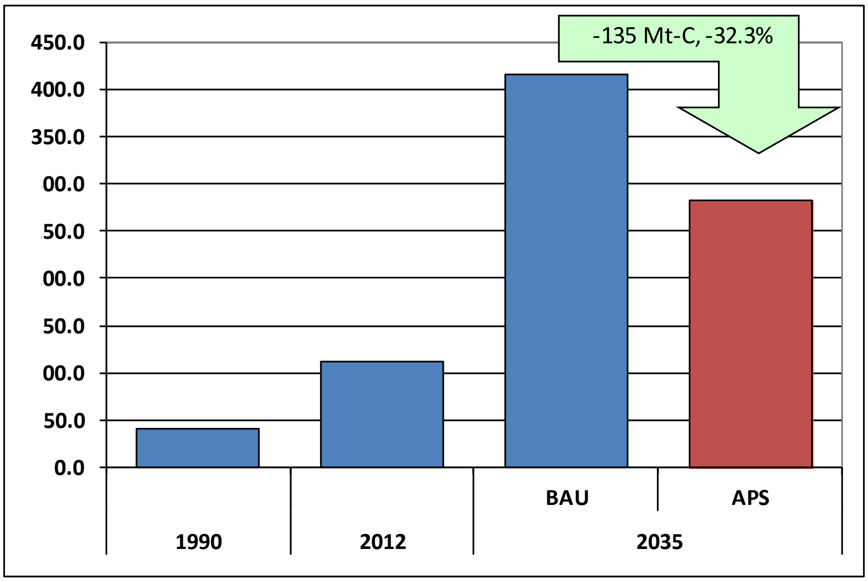
The 2014 national energy policy emphasised the target of a 1 percent annual reduction in final energy intensity up to 2025. Under the BAU scenario, the final energy intensity will decline at an average rate of 0.86 per year from 2012 to 2035. This indicates that further extensive implementation of the sectoral EEC targets under the APS will result in a faster declining of final energy intensity – 1.8 percent per year over the projection period.

Figure 7-11. Primary Energy Demand by Source, BAU and APS



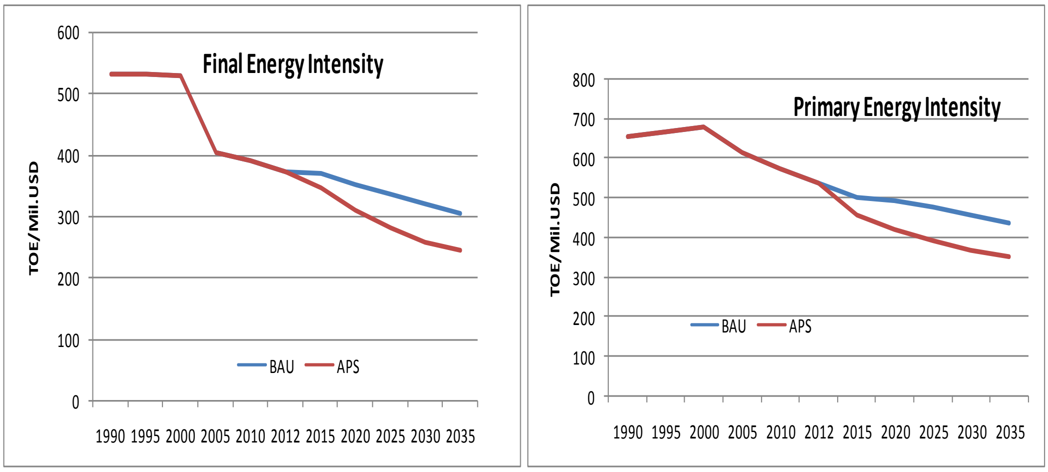
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 7-12. Total Primary Energy Demand, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 7-13. Energy Intensity, BAU and APS



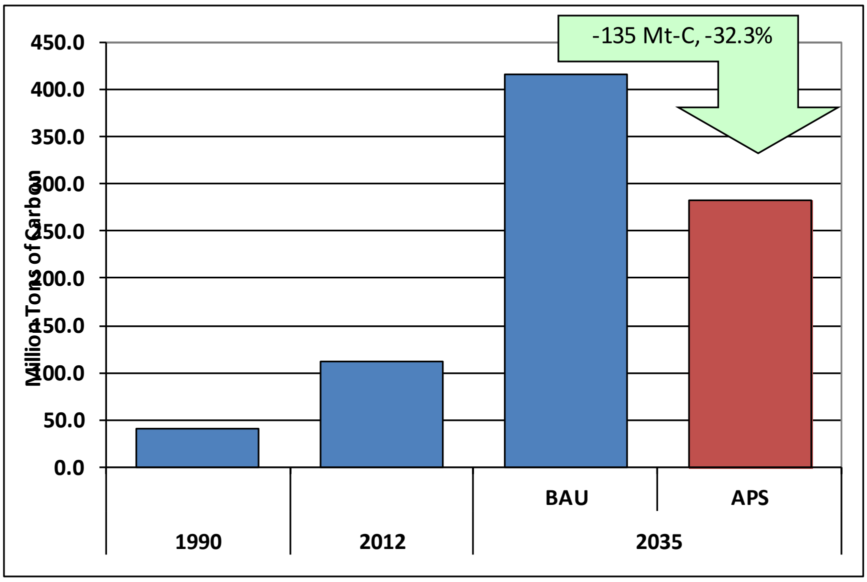
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In terms of primary energy intensity, the annual reduction will be 0.7 percent under the BAU scenario and 1.6 percent in the APS, due to extensive implementation of the sectoral EEC targets under the latter scenario.

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 5.9 percent, from around 111.1 Mt-C in 2012 to 417.2 Mt-C in 2035 in the BAU scenario. This will be driven by an 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 7-14. CO_2 Emissions from Energy Combustion, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In the combined APS (APS5), CO_2 emissions from 2012 to 2035 are expected to be 32.3 percent lower than under the BAU scenario. Contributory factors to this reduction of CO_2 are more energy conservation, higher efficiency, and elevated renewable targets assumed in the APS, and the inclusion of nuclear energy after 2020. The government has committed to reduce CO_2 emissions by 2025 by 26 percent without international assistance and by 41 percent with international assistance. This study result is above the committed target of 26 percent. However, to achieve the committed CO_2 reduction targets of 41 percent, the combined target and action plan specified under APS5 would not be sufficient, and must be more aggressive, therefore.

4. Implications and Policy Recommendations

Indonesia's primary energy intensity, total primary energy supply per unit of dollar GDP (TPES/GDP), and final energy intensity, total final energy consumption per unit of dollar GDP (TFEC/GDP), have been declining as a result of greater utilisation of efficient energy technologies both by energy producers and consumers. Under the BAU scenario, final energy intensity declined at an average 0.86 percent per year over the projection period, which nearly achieved the 1 percent goal stated in the 2014 National Energy Policy. Adopting the sectoral target under APS1 combined with the renewable portfolio, efficient power plant technology, and introduction of nuclear, will allow the country's energy intensity to decline further, at 1.8 percent per year. The elasticity of final energy consumption is also projected to decrease to below 1.0 under the BAU scenario (0.84), and further, to 0.7, 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).

Primary energy consumption per capita is in the range of 1.7 to 2.2 toe/person for all scenarios by 2035. This is still lower than neighbouring countries like Thailand and Malaysia, and there are still people without access to energy, as indicated by the electrification ratio of 84.3 percent in 2014. Development of energy infrastructure, particularly in the remote and small island areas will improve the electrification ratio, and hence increase access to energy.

Oil will continue to have the largest share in the total primary energy mix. The 2014 National Energy Policy sets a target of less than 25 percent in 2025 and less than 20 percent in 2050. The transport sector, which is the main consumer of oil in Indonesia, will be crucial for achieving these energy saving targets. The government should further encourage the transport sector programme through:

- Removing oil subsidy;
- 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, more efficient vehicles in the transport sector, and more efficient boilers in the industrial sector, resulted in savings of oil consumption between the BAU scenario and the APS as high as 27 percent in 2035. Developed countries in the region, such as Japan and Australia, should increase efforts to introduce newly improved technologies to developing countries as early as possible.

The combined APS (APS5) assumed implementation of programmes for achieving the sectoral energy saving targets. In this regards, the following measures will be necessary:

- Enhance policy to move away from subsidies, but with the option of assisting low-income households. This includes restructuring of electricity tariffs towards a more market-based electricity pricing mechanism.
- Better enforcement of regulations on EEC in the industrial sector.
- Encourage revitalisation programmes of industries to improve performance of boilers, burners, etc.
- Expand labelling and performance standards on appliances in the residential sector.
- Develop a regulatory framework to increase participation of the private sector and Energy Service Companies (ESCOs) in EEC.
- Formulate a funding mechanism to develop efficient technologies and equipment.
- Increase public awareness of EEC.

Pursuing energy efficiency and conservation programmes are some of the measures needed to reduce CO_2 emission to achieve the committed target of 26 percent (without international support) and 41 percent (with international support). Increasing the share of renewable energy sources in the supply mix, increasing thermal efficiency of fossil fuel plants, and introduction of nuclear energy, would result in further reductions in CO_2 emissions.

Both the BAU scenario and the combined APS (APS5) projected that renewable energy will have a major part in the country's energy mix. Efforts to enhance renewable energy have been undertaken by the government, such as inclusion of geothermal and hydro resources in the second crash programme for the acceleration of a 10,000 MW power development; domestic obligation (DMO) on biofuels; provision of Feed-in-Tariff (FIT) for geothermal, solar, hydro, and biomass power generation; finalisation of the FIT for wind energy sources; and fiscal incentives to promote renewable energy development, etc. Nonetheless, further measures, also to attract greater private sector involvement, need to be taken, such as increasing the transparency and awareness of government support mechanisms, enhancing financial institutions to participate in renewable energy projects, and further improving the existing revolving fund for geothermal and expand it to other renewable energy sources.

CHAPTER 8

Japan Country Report

SOHEI IWATA
The Institute of Energy Economics, Japan (IEEJ)

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 and most of its land area is mountainous and thickly forested. Until 2009, it was the world's second largest economy after the United States, but in 2010 Japan was overtaken by China. Japan's real gross domestic product (GDP) in 2012 was US$4,622 (constant 2005 prices), and the population is currently about 128 million.

1.1. Energy Situation

Japan possesses limited indigenous energy resources and imports almost all of its crude oil, coal, and natural gas requirements to sustain economic activity.

In 2012, Japan's net primary energy consumption was 452.3 Mtoe. By energy type, oil represented the largest share, at 46.5 percent, coal was second at 24.8 percent, followed by natural gas (23.3 percent), and nuclear energy (0.9 percent). Others, such as hydro, geothermal, wind, and solar, represented the remainder of 4.5 percent. In 2012, net imports of energy accounted for about 99 percent of the net primary energy supply. With limited indigenous energy sources, Japan imported almost 100 percent of oil, 100 percent of coal, and 97 percent 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 (LNG). Natural gas is mainly used for electricity generation, followed by reticulated city gas and industrial fuels. In 2012, primary natural gas consumption was 105.3 Mtoe.

Japan's final energy grew slowly, at 0.2 percent per year on average, from 297.8 Mtoe in 1990 to 308.8 Mtoe in 2012. The residential/commercial ('Other') sector had the highest growth rate during this period, at 1.1 percent per year, followed by the transport sector with 0.2 percent. Consumption in the industry sector decreased at a rate of 0.9

percent per year on average from 1990 to 2012. Oil was the most consumed product, with a share of 61.2 percent in 1990 and 53.0 percent in 2012. Electricity was the second most consumed product.

Japan's primary energy demand grew at a rate of 0.1 percent per year from 439.2 Mtoe in 1990 to 452.3 Mtoe in 2012. 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 4.0 percent and 1.7 percent, respectively, and nuclear energy declined by 10.9 percent from 1990 to 2012, due to the Great East Japan Earthquake. Oil consumption declined by 0.8 percent per year over the same period.

Japan has 281 GW of installed electricity generating capacity and generated about 1,026 TWh of electricity in 2012. Generation by energy type is broken-down as follows: thermal (coal, natural gas, and oil) at 85.9 percent; nuclear (1.6 percent); hydro (7.4 percent); and geothermal, solar, and wind taking up the remainder of 5.2 percent.

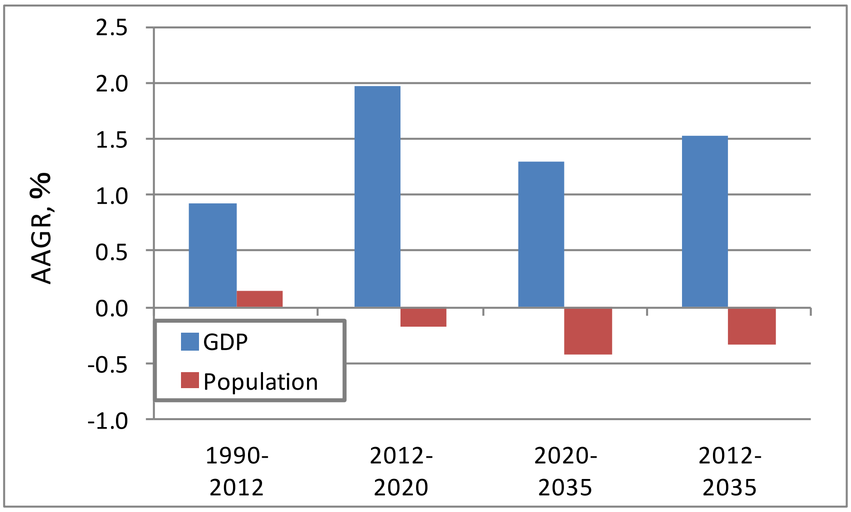
2. Modelling Assumptions

In this outlook, Japan's real gross domestic product (GDP) is assumed to grow at an annual average rate of 1.6 percent from 2012 to 2035, projecting recovery from economic recession. In 2014, Abenomics[1] is estimated to have strongly increased GDP The industry structure, with the maturing of Japanese society and Japan's economy, will become increasingly oriented toward services. Population growth, on the other hand, will decline by about 0.3 percent per year from 2012 to 2035 due to the declining birth rate. Japan's population is projected to decrease from 128 million in 2012 to 118 million in 2035. Figure 8-1 shows the assumptions of GDP and population growth used 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 with the decline in population.

[1] An economic programme introduced by Shinzo Abe upon starting his second term as Prime Minister of Japan in December 2012.

Figure 8-1. Growth Rate of GDP and Population

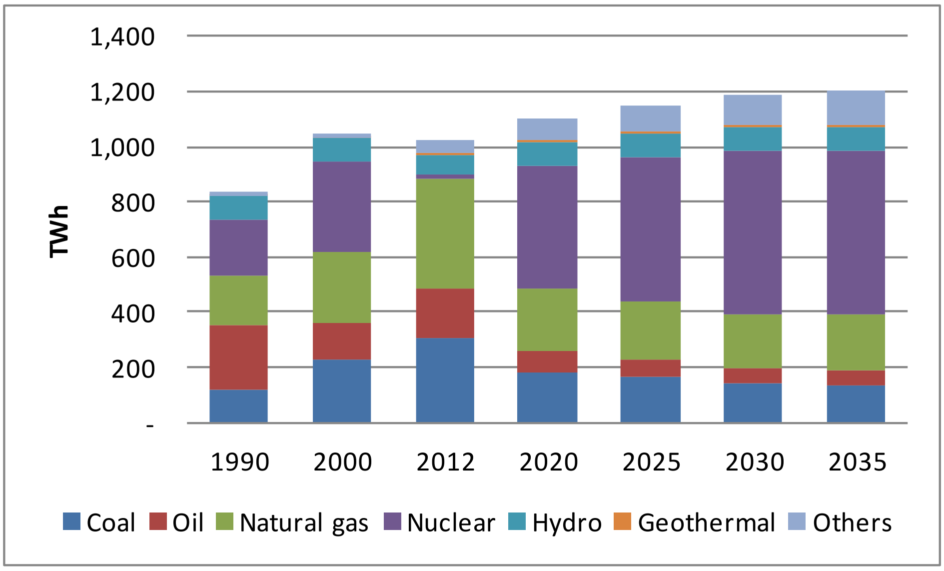


GDP = gross domestic product.

Source: Author's calculation.

The Strategic Energy Plan approved by the Cabinet in June 2010 highlighted that the share of zero emission power generation, including nuclear and renewable energy, will increase to 67 percent in 2030. It also assumed fourteen additional nuclear power plants would be constructed by 2030 and the capacity utilisation rate was expected to grow through to 2035. The capacity of hydro power plants would be around 70 percent of the resource potential, which would translate to an increase in capacity by 2035. On the other hand, supply from fossil fuel–fired power generation was projected to decrease.

Figure 8-2. Power Generation, BAU

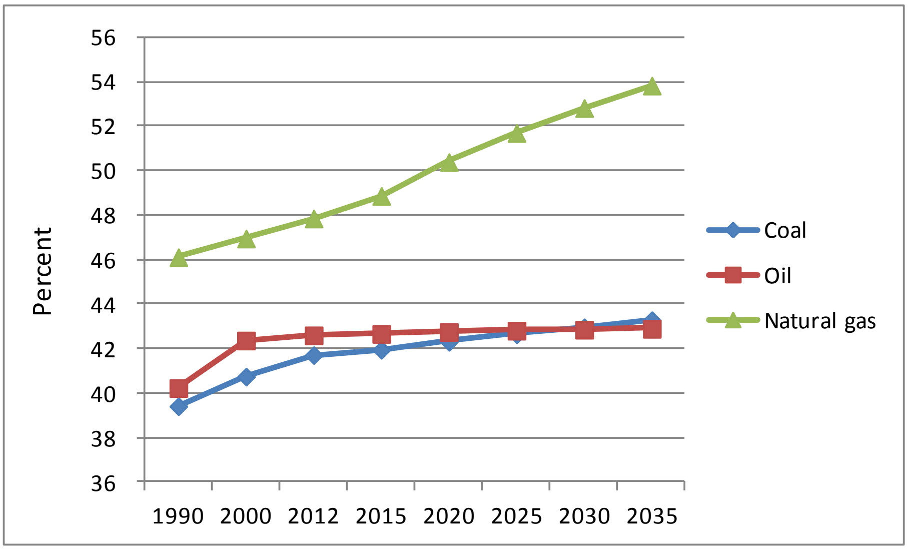


BAU = Business-as-Usual.

Source: Author's calculation.

Figure 8-2 shows the projected power generation mix in Japan to 2035 under the Business-as-Usual (BAU) scenario and Figure 8-3 shows the assumed thermal efficiencies of thermal power plants in the BAU scenario.

Figure 8-3. Thermal Efficiency, BAU



Source: Author's calculation.

Japan's energy saving goals will be attained through the implementation of national energy efficiency programmes in all energy consuming sectors. In the industry sector, energy savings are expected from improvements in manufacturing technologies. In the residential and commercial sectors, the 'Top Runner Program' 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 by improvements in vehicle fuel efficiency, including increases in the stock of hybrid cars and structural changes in vehicles.

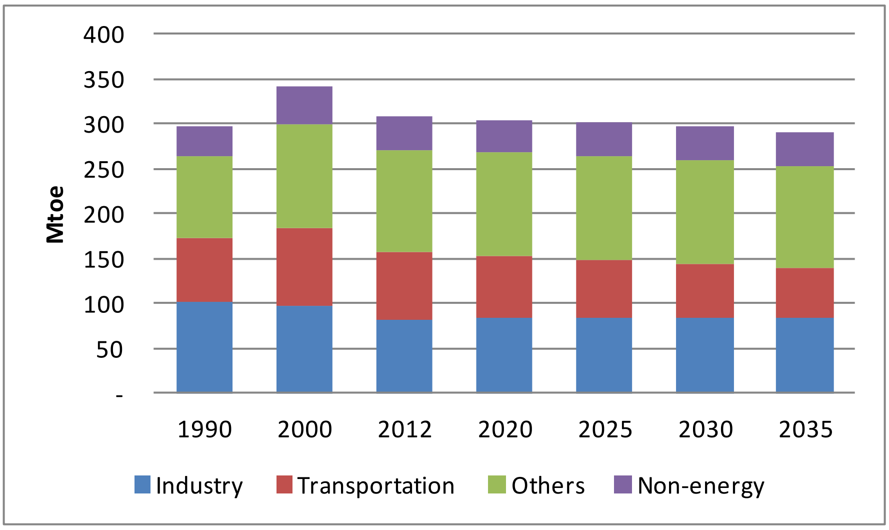
3. Outlook Results

3.1. Business-as-Usual Scenario (BAU)

3.1.1. Final Energy Demand

With relatively low projected economic growth and a declining population, Japan's final energy demand from 2012 to 2035 is projected to decrease at an average rate of 0.3 percent per year in the BAU scenario. This is also driven by a projected decline in the consumption of the transportation as a result of improvements in energy efficiency. Final energy demand of the industrial sector is projected to increase at an annual average rate of 0.1 percent from 2012 to 2035. Figure 8-4 shows projected final energy demand by sector from 1990 to 2035 under the BAU.

Figure 8-4. Final Energy Demand by Sector, BAU

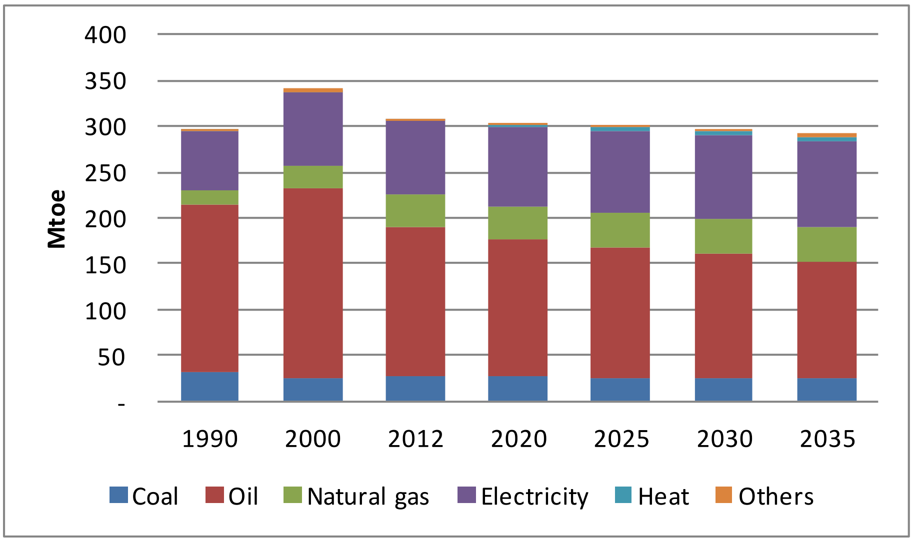


BAU = Business-as-Usual.

Source: Author's calculation.

By fuel type, consumption of coal and oil is projected to decrease at an average annual rate of 0.4 and 1.1 percent, respectively, from 2012 to 2035, whereas consumption of natural gas and electricity are projected to increase, at a rate of 0.4 and 0.7 percent per year, respectively, over this period. Figure 8-5 shows projected final energy demand by source from 1990 to 2035 under the BAU.

Figure 8-5. Final Energy Demand by Source, BAU



BAU = Business-as-Usual.

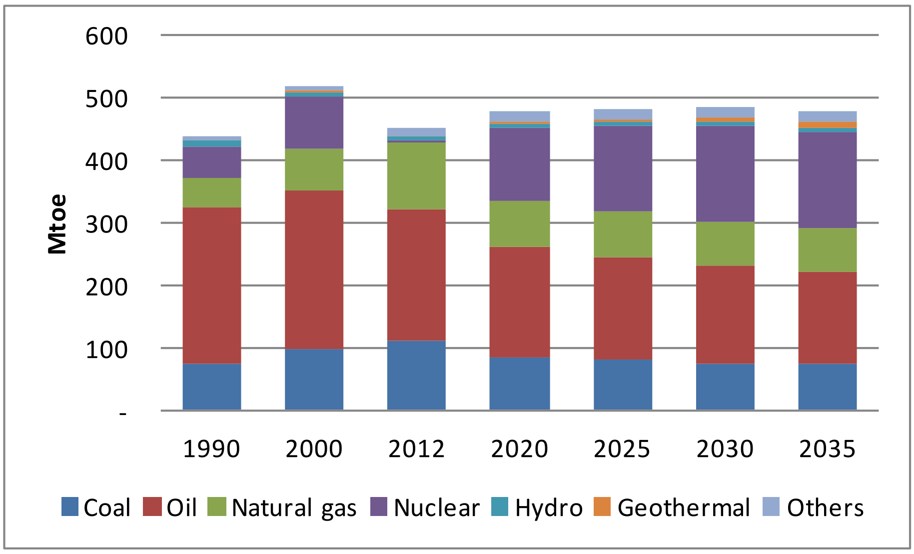
Source: Author's calculation.

3.1.2. Primary Energy Demand

Under the BAU scenario, Japan's net primary energy supply is projected to increase at an average annual rate of 0.3 percent per year, from 452.3 Mtoe in 2012 to 479.3 Mtoe in 2035 (Figure 8-6). This increase is mainly due to an expected increase in the use of nuclear energy, which is projected to grow at annual average rate of 17.0 percent from 2012 to 2035. The share of nuclear energy is projected to increase from 0.9 percent to 32.2 percent over this period. The Strategic Energy Plan of 2010 highlighted that the self-sufficiency rates of primary energy consumption, including renewable energy, will increase to 40 percent in 2030.

Consumption of coal, oil, and natural gas is expected to decrease at average annual rates of 1.8 percent, 1.5 percent, and 1.8 percent, respectively, from 2012 to 2035, due to the projected increase in consumption of nuclear and renewable energy.

Figure 8-6. Net Primary Energy Supply, BAU



BAU = Business-as-Usual.

Source: Author's calculation.

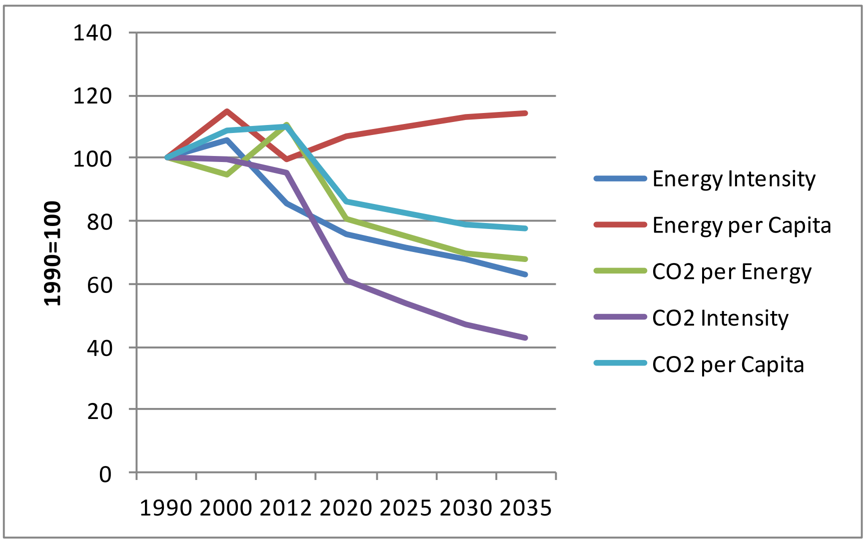
3.1.3. Energy Indicators

Energy consumption per capita up to 2035 will increase at a faster rate than in recent decades. The elasticity[2] between 2012 and 2035 is expected to be negative due to further energy intensity improvements and the decrease in population.

[2] Growth rate of GDP divided by the growth rate of energy consumption. For Japan, elasticity will be negative in the future as the growth rate of energy consumption will be negative whereas the growth rate of GDP is assumed to be positive.

Except for energy consumption per capita, all energy indicators will decrease from 2012 levels to 2035. CO_2 emission per person and the CO_2 intensity carbonisation rate (CO_2 emission per unit of energy consumption) will be about 60 percent lower than 1990 levels and about 20 percent lower than 2012 levels. Figure 8-7 shows the projected trends in various indicators of energy consumption in Japan from 1990 to 2035 under the BAU scenario.

Figure 8-7. Indices of Energy and CO_2 Intensities, Energy per Capita, and Carbonisation Rate, BAU



BAU = Business-as-Usual.

Source: Author's calculation.

3.2. Energy Saving and CO_2 Reduction Potential

3.2.1. Final Energy Demand

Under the Alternative Policy Scenario (APS), final energy demand is projected to decline at a faster rate, of 0.9 percent per year, from 308.8 Mtoe in 2012 to 248.8 Mtoe in 2035. A rapid decline of 2.0 percent per year is expected in the transport sector due to the Top Runner Program[3] and more aggressive energy management systems. Japan will implement continuous efforts to improve energy efficiency, especially with regard to

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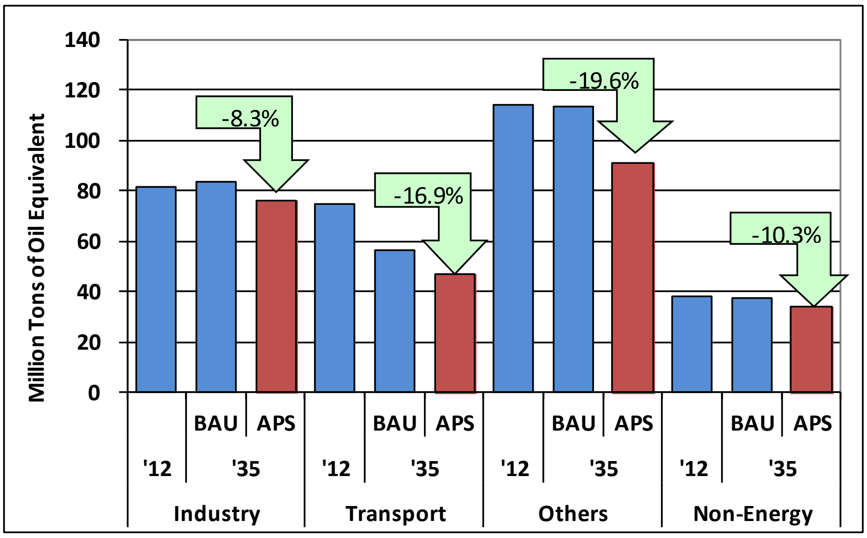
[3] The 'Top Runner Program' is Japan's energy efficiency programme that aims to improve the energy efficiency of household and office appliances as well as vehicles by setting the end-use energy performance of the best technology available on the market as the standard for each product category.

introducing energy efficient automobiles such as hybrid vehicles (HV), electric vehicles (EV), and plug-in hybrid electric vehicles (PHEV).

The industry sector and service sector will also improve their energy efficiency, but, despite their efforts, the steel and cement sectors will see a decline in energy efficiency. It will be difficult for these sectors to improve their energy efficiency drastically, because their capacity factors will be decreasing and they will use more renewable energy. Final energy demand by sector in the BAU scenario and APS are shown in Figure 8-8.

Figure 8-8. Final Energy Demand by Sector, BAU and APS

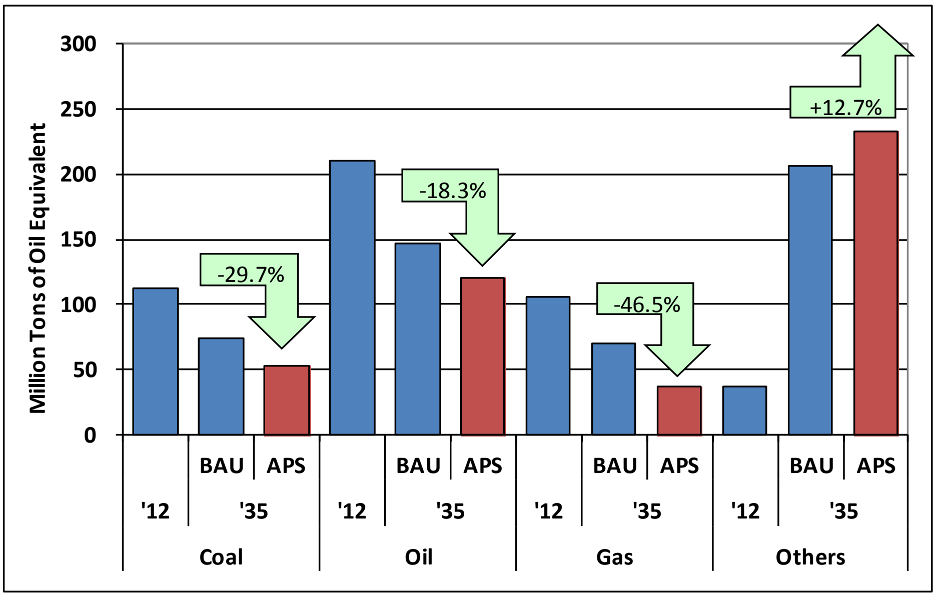


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.2.2. Primary Energy Consumption

In the APS, projected primary energy consumption of Japan will decline at a rate of 0.4 percent per year to 415.8 Mtoe in 2035, which is 36.4 Mtoe lower than primary demand in 2012. Coal, oil, and natural gas are expected to see decreasing annual average growth rates of 3.3 percent, 2.4 percent, and 4.4 percent, respectively, mainly due to the increase of nuclear energy, which is expected to grow at an annual average rate of 17.0 percent. Figure 8-9 shows primary energy supply by source under the BAU scenario and the APS.

Figure 8-9. Net Primary Energy Consumption by Source, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.

Source: Author's calculation.

3.2.3. Projected Energy Saving

The energy savings that could be derived from the energy efficiency and conservation (EEC) goals and action plans of Japan are 63.5 Mtoe, the difference between the primary energy demand of the BAU scenario and the APS (Figure 8-10). This is equivalent to a 13.2 percent reduction in Japan's BAU consumption in 2035.

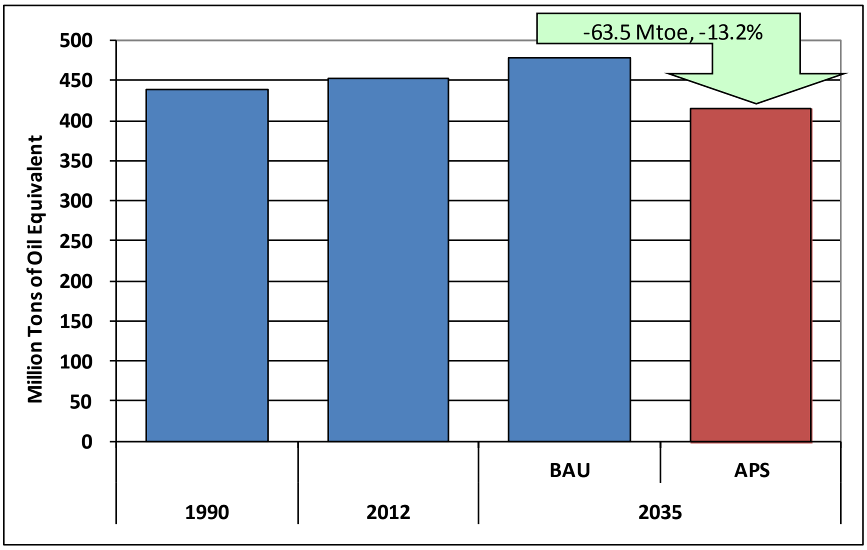
In terms of savings in final energy demand, an estimated saving of 22.3 Mtoe is expected in the residential/commercial sector and 9.6 Mtoe in the transportation sector in 2035 in the APS, relative to BAU. The projected decreases in consumption of the transportation sector from 2012 to 2035 are 17.8 Mtoe in the BAU scenario and 27.4 Mtoe in the APS. This can be attributed to an increase in the use of more efficient vehicles.

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 1.9 percent from 332.8 Mt-C in 2012 to 216.6 Mt-C in 2035 (Figure 8-11).

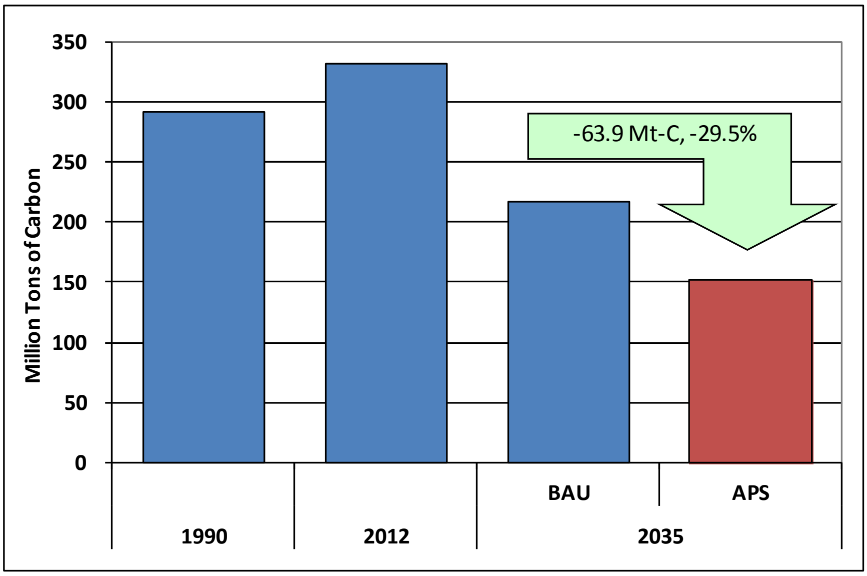
Under the APS, the annual decrease in CO_2 emissions from 2012 to 2035 is projected to decline at a faster average annual rate, of 3.3 percent. This rate of decrease is higher than that in primary energy demand, which is 0.4 percent. CO_2 emissions in 2035 are projected to be about half of emissions in 1990. This indicates that Japan's energy saving goals and action plans are very effective in reducing CO_2 emissions.

Figure 8-10. Primary Energy Demand, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 8-11. CO_2 Emissions from Fossil Fuel Combustion, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.

Source: Author's calculation.

4. Implications and Policy Recommendations

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

In the APS and even under the BAU scenario, CO_2 emissions in 2035 are projected to be much lower than the 1990 level. This indicates that Japan could achieve its target of reducing greenhouse gas (GHG) emissions by half from 2005 to 2050. But to achieve the final target, Japan should effectively implement its policies on low carbon technology, including energy efficiency and zero emission energy, such as the Top Runner Program and on renewable energy.

Moreover, as the world leader in energy efficiency, Japan should introduce such successful policies to other countries as early as possible as doing so would enable Japan to contribute to reducing world energy consumption. This would benefit Japan not only economically, but also in that there would be more available energy in the market.

Therefore, Japan should not only look at its own market but also to the world market as a whole when developing energy efficiency policies and low carbon energy policies. Reduced energy consumption of the world would mean more available energy for years to come.

The New Basic Energy Plan had been finally approved by the cabinet in April 2014. Nuclear energy is referred to as 'an important base load power source' with no concrete figures, while renewables are written with strong expression of the additional introduction. That is, the introduction of renewables should be accelerated as much as possible, followed by continuous active promotion. Although new specific numerical targets are being discussed under the New Basic Energy Plan, nuclear and renewable energy must be a great progress for Japan to be able to create a realistically qualitative energy plan.

CHAPTER 9

Republic of Korea Country Report

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College of Engineering, Seoul National University

1. Background

The Republic of South Korea (henceforth, South Korea) is located in the southern half of the South Korean Peninsula and shares a 238 km border with North Korea. It occupies just over 100,000 square kilometres and includes about 3,000, mostly small, uninhabited islands. South Korea is a mountainous country with lowlands accounting for only 30 percent of the total land area. The climate is temperate, with heavy rainfall in summer. As of 2014, South Korea had a population of 50,424, over 90 percent of which lives in urban areas. South Korea has recorded tremendous economic growth over the past half century. Gross domestic product (GDP) plunged by 7 percent in 1998 due to the financial crisis, but has since rebounded. Another recent global economic crisis in 2008 could not keep South Korea from continuing economic growth. Due to the recent deterioration in the global economy, growth has slowed down, recording 2.0 percent in 2012, but is projected to reach around 2.6 percent in 2013 and 3.8 percent in 2014.[1] The South Korean economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals. Agriculture, forestry, and fishing made up only 2.5 percent of total GDP in 2012.

South Korea has no domestic oil resources and has produced only a small amount of anthracite coal. The country imports most of its coal supply, which is bituminous coal. Consequently, South Korea has to import 96 percent of its energy needs and is the fifth largest oil importer and the second largest importer of liquefied natural gas (LNG) in the world.

Although total primary energy consumption is dominated by oil and coal, nuclear power and LNG also supply a significant share of the country's primary energy. Total primary energy consumption increased by 4.9 percent per year on average between 1990 and 2012. The strongest growth occurred in natural gas (13.6 percent), coal (5.2 percent), and nuclear (4.9 percent). Oil use increased at a slower rate of 3.1 percent a year.

Total final energy consumption (TFEC) in 2012 was 166.4 Mtoe, increasing at an average annual rate of 4.4 percent from 1990. The industry sector accounted for 28.4 percent of final energy consumption in 2012, followed by 'Others' (27.3 percent), and transportation (18.2 percent). Consumption of natural gas in the industry sector increased eightfold in the last decade and oil accounts for a relatively large share of industry consumption.

[1] Bank of Korea (2013).

In 2012, electric power generators in South Korea produced 531.0 TWh of electricity, with coal and nuclear combined providing almost three-quarters of South Korea's electricity. Natural gas accounted for 21.1 percent of generation in 2012. Total electricity consumption grew at an average annual rate of 7.7 percent from 1990 to 2012. When broken down by fuel, coal, natural gas, and nuclear increased at an average annual rate of 12.6 percent, 11.8 percent, and 4.9 percent, respectively, over this period.

Since the 1990s, the South Korean government established three Basic Plans for Rational Energy Utilization in a row, which were revised at the end of each five-year period and contain a variety of policy tools and programmes developed and implemented under the auspice of the Ministry of Trade, Industry, and Energy (MOTIE). Several energy savings measures were announced to encourage the general public to voluntarily conserve energy. As part of the measures, 'Voluntary Energy Conservation Campaigns,' were launched to reduce heating fuel consumption. Furthermore, the government urged energy-intensive industries to enhance energy efficiency of their products. In addition, MOTIE and the Board of Audit and Inspection of South Korea formed a task force to examine 660 public and private organisations to measure their progress in implementing voluntary energy saving plans

The current Basic Plan for Rational Energy Utilization has a variety of key policy tools and programmes to attain the energy savings target. Amongst them are Voluntary Agreements (VAs), Energy Audits, Energy Service Companies (ESCOs), Appliance Labelling and Standards, Fuel Economy, and Public Transit and Mode Shifting. These policy tools have been and will continue to play important roles in energy savings.

2. Modelling Assumptions

South Korea's GDP had grown at an average annual rate of 4.9 percent between 1990 and 2012. In this report, South Korea's GDP is assumed to grow at an average annual growth rate of 2.8 percent from 2012 to 2035. Following the global recession in 2009, the South Korean economy has been a little bit shaken. However, the South Korean economy is still in a good shape and its economic growth is expected to recover to 3.5 percent per year from 2012 to 2020, slowing down to 2.5 percent per year from 2020 to 2035.

South Korea is expected to continue to rely heavily on coal and nuclear energy for power generation to meet the base load electricity demand. Gas-fired power generation is projected to increase between 2012 and 2035, whereas oil-fired generation is projected to decline. Generation from hydro sources is projected to remain relatively stable. There is projected to be a strong growth in electricity generation from wind power and solar PVs driven by the renewable portfolio standards (RPS), which was launched in January 2012.

South Korea's energy saving goal can be attained through implementing energy efficiency improvement programmes in all energy sectors. In the industrial sector, energy saving is expected from the expansion of Voluntary Agreement (VA), the highly efficient equipment programme, 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 transportation, and improving the fuel economy of vehicles. In the residential and commercial (Other) sector, a minimum efficiency standards programme is projected to induce huge savings in addition to 'e-Standby Korea 2010'.

3. Outlook Results

3.1. Total Final Energy Consumption

South Korea's final energy consumption registered growth of 4.4 percent per year from 64.9 Mtoe in 1990 to 166.4 Mtoe in 2012.[2] The non-energy sector had the highest growth rate during this period, at 8.8 percent per year, followed by the industry sector with 4.2 percent. Energy consumption in the residential/commercial/public (Other) sector grew at a relatively slow pace of 2.9 percent per year. Oil was the most consumed product with a share of 67.3 percent in 1990, declining to 50.7 percent in 2012. The share of coal in final energy consumption declined by 12 percent a year between 1990 and 2012, whereas the share of electricity doubled to become the second most consumed product.

3.2. Business-as-Usual (BAU) Scenario

With an assumption of low economic and population growth, final energy consumption in South Korea is projected to increase at a low average rate of 0.9 percent a year between 2012 and 2035 under the Business-as-Usual (BAU) scenario. This is due largely to negative growth in energy consumption in the transportation sector, which is projected to decrease at an annual average rate of 0.3 percent between 2012 and 2035. Growth in final energy consumption is expected to be led by industrial and non-energy, with an identical increase at an average annual rate of 1.2 percent during the same period. Other sectors, such as the residential, commercial, and public sectors, are projected to increase at a rate of 1.0 percent per annum.

For each type of energy, the projected increases at average annual growth rates are 0.5 percent for coal, 0.2 percent for oil, 1.2 percent for natural gas, 2.1 percent for electricity, and 0.2 percent for heat from 2010 to 2035. Other energy types, including renewable energies, are estimated to grow at a rate of 1.8 percent per annum, which is faster than any other type of energy. Increasing use of renewable energy in addition to natural gas as clean and green energy will contribute to a considerable reduction in CO_2 emissions.

3.3. Alternative Policy Scenario (APS)

In this section, five alternative scenarios (APS) are developed based on varying focuses of policy options: improved efficiency of final energy demand (APS1); more efficient thermal power generation (APS2); higher contribution of renewable energy to total supply (APS3); contribution of nuclear energy to total supply (APS4); combined effects of APS 1–4 (APS5). Final energy demand by sector in each APS is shown in Figure 9-1. Total final energy demand is to be reduced only in the case of APS1 (improved efficiency), showing 187.9 Mtoe. Other alternative policy scenarios are the same with 204.6 Mtoe for APS2–4. Total and share of final energy demand by sector is the same as in the case of BAU. Accordingly, APS5, which combines all APS, shows 187.9 Mtoe, 16.7 Mtoe (8.2 percent) lower than in the BAU scenario, the same as in APS1.

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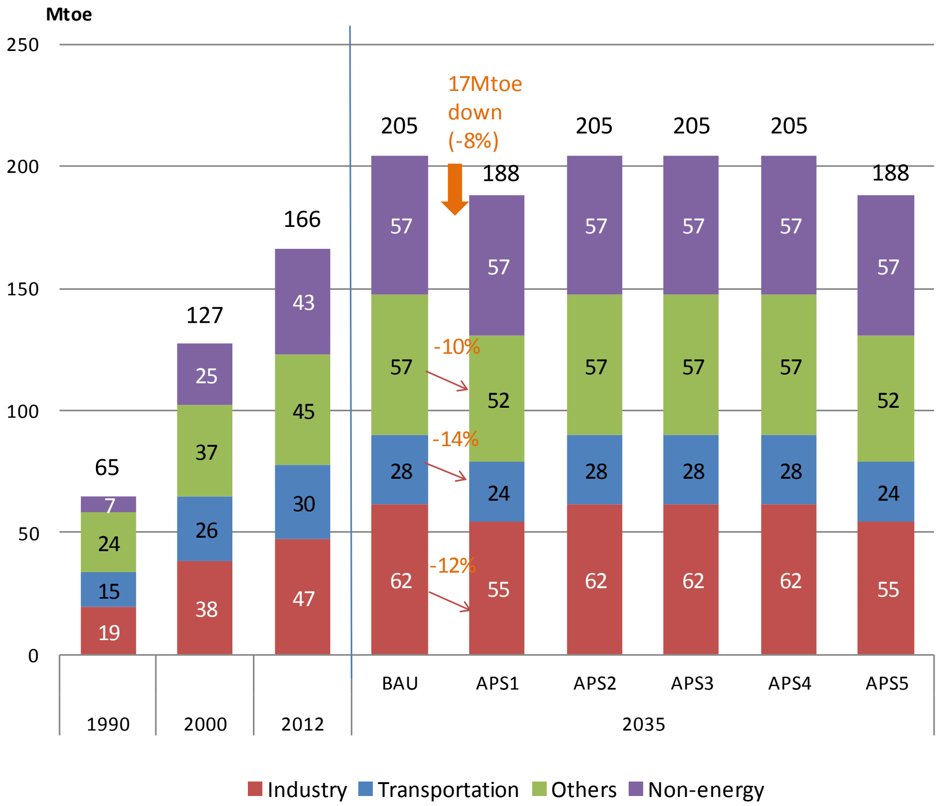
[2] Energy consumption is calculated based on the net calorific values as converted by IEEJ from original data submitted by the Republic of Korea.

Figure 9-1. Final Energy Demand by Sector

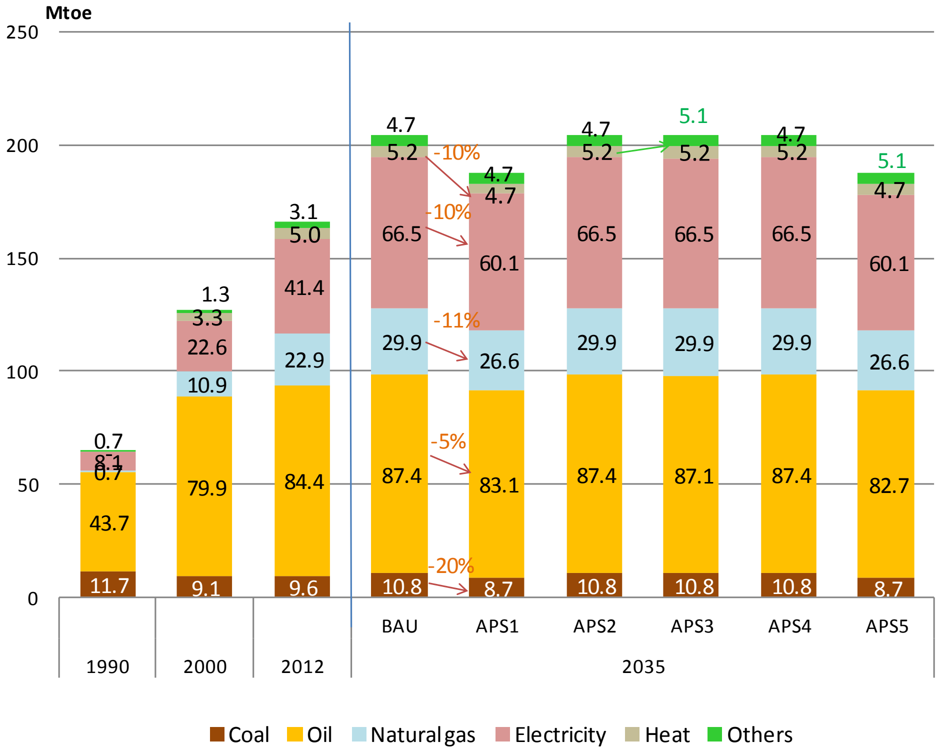


Source: Author's calculation.

Final energy demand by energy source is shown in Figure 9-2. In APS1 (improved efficiency) electricity accounts for the largest portion of energy saving, followed by oil and natural gas. Unlike in the case of final energy demand by sector, energy demand by energy source shows some change depending on the specific policy approach of each scenario. In APS3 (higher contribution of renewable energy to total supply), 'other' energy sources, including renewable energy, are to be increased by 0.4 Mtoe compared with all other APS. Other than that, APS1 and APS5 are identical in terms of total energy demand, share of energy demand by sector, and energy source.

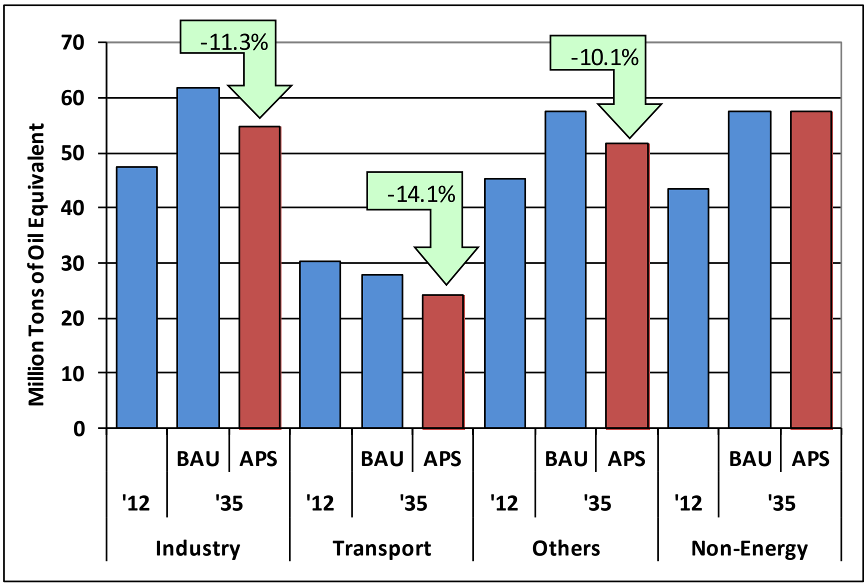
In APS5, which combines APS1, APS2, APS3, and APS4, final energy consumption is projected to increase at an average annual growth rate of 0.5 percent, from 166.4 Mtoe in 2012 to 187.9 Mtoe in 2035. Energy demand in the transport sector is projected to decrease at an annual average growth rate of 1.0 percent over the same period. The rate of growth is much slower across all sectors compared with the BAU scenario (Figure 9-3).

Figure 9-2. Final Energy Demand by Energy Source



Source: Author's calculation.

Figure 9-3. Final Energy Consumption by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.4. Primary Energy Demand

Primary energy demand in South Korea grew at an average annual rate of 4.9 percent from 92.9 Mtoe in 1990 to 263.4 Mtoe in 2012. Amongst the major energy sources, natural gas was the fastest growing at an average annual rate of 13.6 percent. Coal increased at a rate of 5.2 percent a year, followed by nuclear and oil at 4.9 percent and 3.1 percent, respectively, over the same period. Other energy sources, mainly renewable energies such as solar and wind showed rapid growth, at a rate of 8.6 percent, during the same period, which indicates that the South Korean government has been successfully implementing its 'Low Carbon Green Growth' policy.

Business-as-Usual Scenario

In the BAU scenario, primary energy demand in South Korea is projected to increase at an annual average rate of 1.1 percent, from 263.4 Mtoe in 2012 to 338.2 Mtoe in 2035. Growth in all the energy sources is projected to slow. Consumption of nuclear shows the fastest growth, increasing at a rate of 2.7 percent per year. Natural gas and coal are projected to grow at much slower average annual rates, of 1.0 percent and 1.3 percent, respectively, from 2010 to 2035. Growth of nuclear will largely be at the expense of oil, with the share of oil projected to decline from 36.9 percent in 2012 to 28.7 percent in 2035.

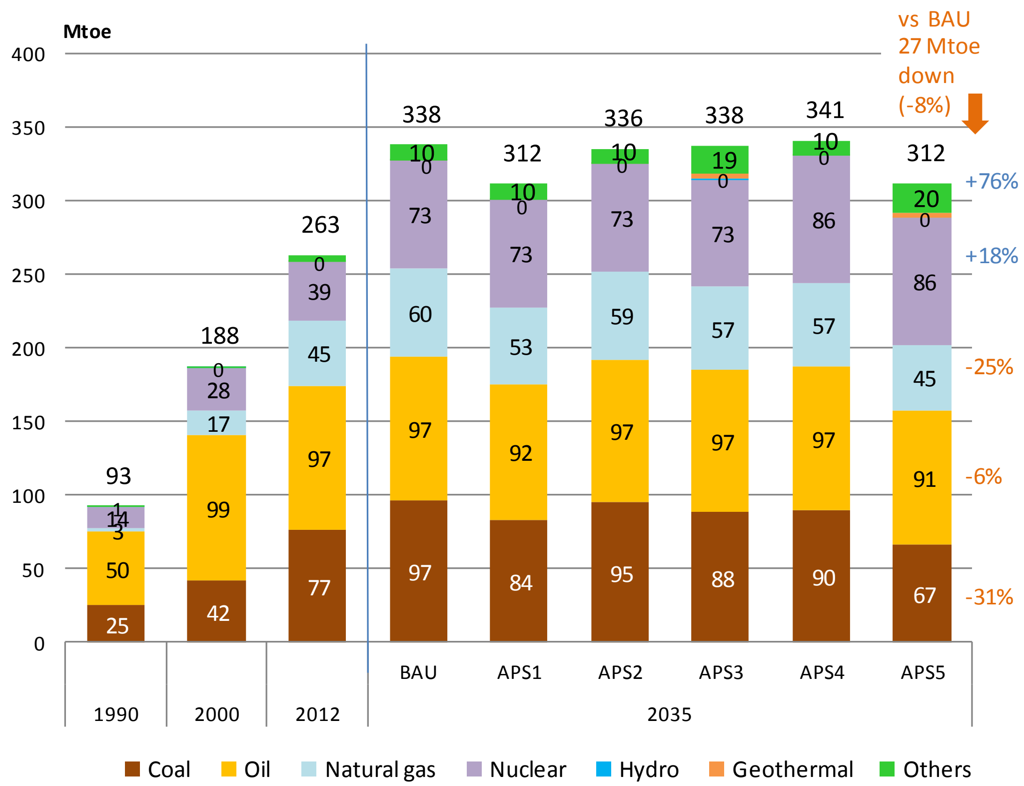
Alternative Policy Scenario

Based on the projections and analysis of final energy demand by sector and energy source, primary energy demand is projected for each of the five alternative scenarios. Unlike in the case of final energy demand, each APS has a different amount and share by energy source, depending on the specific policy focus of each APS. Except for APS3, APS5 has more demand for renewable energy – 19.8 Mtoe, which is 9.4 Mtoe more than in the other APS. The largest reduction is in the demand for coal (31.3 percent), followed by natural gas, and oil. Nuclear and 'others' (renewable energies) are projected to increase by 17.6 percent and 90.8 percent, respectively.

In APS5, which combines all other APS, primary energy demand is projected to increase at a lower annual average rate of 0.7 percent, from 263.4 Mtoe in 2012 to 312.0 Mtoe in 2035. Consumption of fossil fuels such as coal, oil, and natural gas will gradually decrease from 2012 to 2035, whereas nuclear and renewable energies will increase by 3.5 percent and 6.6 percent per year, respectively, over the same period (Figure 9-4). Energy efficiency and conservation measures on the demand side will be the main contributors to the reduction in consumption growth.

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

Figure 9-4. Primary Energy Demand in South Korea



Source: Author's calculation.

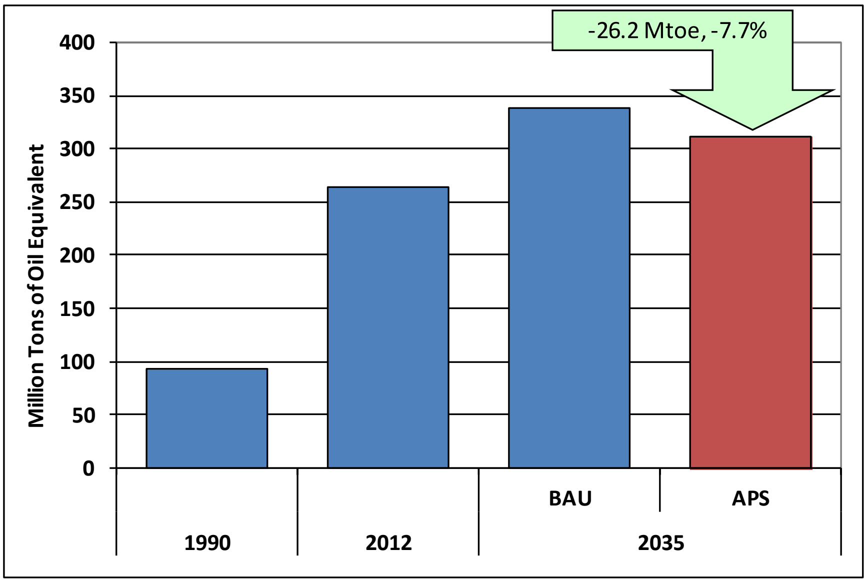
First, energy policy should be shifted from a supply-oriented approach to a demand-oriented one. Reform of energy pricing and energy taxation are the most pressing issues. In this context, market mechanism should be introduced in energy pricing, by which rational energy use is induced through sharing information on the full cost of energy production and consumption. Second, transformation of the industrial structure into a less energy-intensive one, which is currently underway, should be accelerated towards knowledge-based, service, and green industries (which consume less), and clean energies. Third, energy efficiency standards and codes should be applied in product designing and production processes, as well as in designing and constructing a system such as factory, building and plant. Based on these policy directions, the South Korean government should develop and implement an action plan containing milestones and strategies with specific and cost-effective policy tools.

Projected Energy Saving

The energy savings that could be derived from the energy saving targets, action plans, and policy tools in South Korea is 26.2 Mtoe, i.e. the difference between primary energy demand in the BAU scenario and the APS in 2035 (Figure 9-5). This is equivalent to 9.9 percent of South Korea's consumption in 2012.

In terms of final energy consumption savings in 2035, savings are estimated at 7.0 Mtoe in the industry sector, 5.8 Mtoe in the residential/commercial (other) sector, and 4.0 Mtoe in the transportation sector

Figure 9-5. Total Primary Energy Demand to 2030, BAU and APS



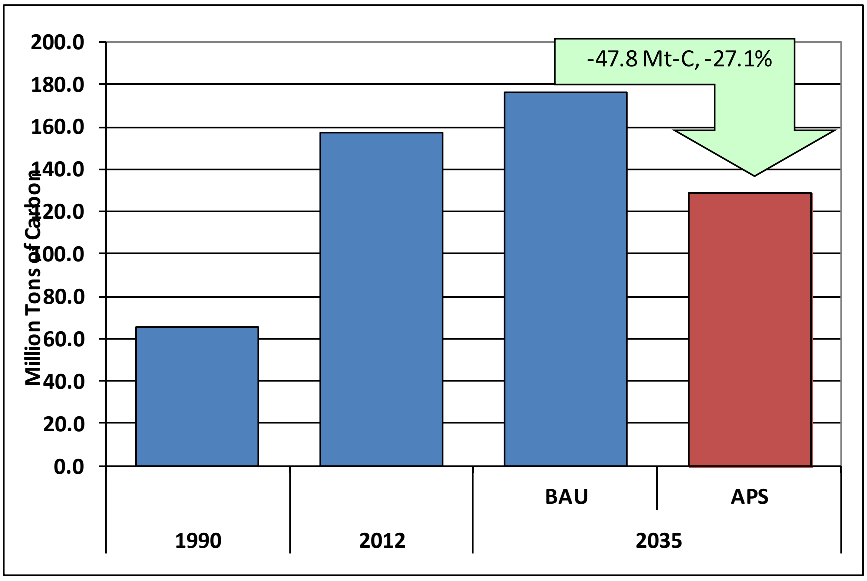
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.5. CO_2 Emissions from Energy Consumption

Carbon dioxide (CO_2) emissions from energy consumption are projected to increase at an annual average rate of 0.5 percent, from 157.0 Mt C in 2012 to 176.5 Mt C in 2035, based on the BAU scenario. This growth rate is slower than that of primary energy consumption, indicating that South Korea will be using less-carbon intensive fuels such as nuclear, natural gas, and renewable energies and employing more energy efficient, green technologies.

In the APS, CO_2 emissions are projected to decline at an annual average rate of 0.9 percent between 2012 and 2035. The difference in CO_2 emissions between BAU and APS is 47.8 Mt C or 27.1 percent (Figure 9-5). To attain such an ambitious target, the South Korean government has to develop and implement cost-effective and consensus-based action plans for energy saving and CO_2 emissions reduction.

Figure 9-6. CO_2 Emission from Energy Consumption, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Implications and Policy Recommendations

South Korea, even without any economically available domestic energy resources, has been making great strides in economic growth. Such very high economic growth would not have been possible without a stable and continuous supply of energy, which is a basic element in modern economic activities. This nexus between economic development and energy consumption had been accepted as inseparable until the end of the 20th century. But at the beginning of the 21st century, the South Korean government shifted its energy policy to a sustainable, efficient, and energy saving approach, which was to some extent reflected in the first (2008) and second (2013) National Energy Basic Plan.

South Korea's total primary and final energy consumption in the 1990s rapidly increased at a rate faster than that of GDP, growth of which had been driven by energy-intensive industries such as the petrochemical, steel, and cement industries. Since 1997, the contribution of these industries to South Korea's GDP has gradually declined, resulting in reduced energy intensity. But the shift to a less energy–intensive industrial structure takes time, so energy-intensive industry will prevail in the short term and medium term. In the longer term, however, South Korea has to and will transform its industrial structure into a less energy-intensive one.

As mentioned above, the South Korean government has recently released the second National Energy Basic Plan.[3] Its approach shifted from a supply-oriented one to a demand-oriented one. Its basic policy direction consists of six major agendas, with demand-oriented energy policy as the first priority. The other five key agendas are: building a distributed generation, harmonisation of the environment and safety, strengthened energy security and more stable energy supply, implementation of energy policy with people's support.

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

As regards the first priority, a shift in energy policy to a demand-oriented approach, the target is to save 13 percent of total primary energy consumption along with 15 percent of electric power consumption. Under this agenda, four policy tasks are proposed: 1) reform of energy-related taxation; 2) reform of energy pricing; 3) ICT-based demand management; and 4) strengthening programmes by sector. Reform of energy-related taxation as well as energy pricing are intended to induce 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 line, reduction in GHG emissions. Concerning the ICT-based demand management,

Throughout the past three decades, some major concerns of the South Korean government have been energy security, energy efficiency, and environmental preservation. The energy security issue has been dealt with by promoting foreign resource development importation and renewable energy development. The issue of energy efficiency improvement has been addressed through programmes supported by consecutive editions of the Five Year Basic Plan of Rational Energy Use. The environmental issue caused by consumption of fossil and nuclear energy has been approached in the relevant offices of Ministry of Environment. Now is the time for South Korea to synergise those efforts exerted so far, by selection and concentration of policy tools and programmes through better coordination between relevant ministries, as clearly specified in the Second National Energy Basic Plan.

We recommend that South Korea sticks to its current policy goals of transforming the economy into one with a less energy-intensive, greener economic structure and implementing policies to decouple the long-cherished nexus of economic growth and energy consumption by implementing its current policy agenda and its policy tools and programmes. Such nation-wide efforts and campaigns should eventually transform the South Korean economy into a less energy-intensive and greener one in terms of energy savings as well as reduced CO_2 emissions. This would make South Korea one of the leading nations globally in terms of low-carbon green growth.

CHAPTER 10

Lao PDR Country Report

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1. Background

1.1. Socio-Economic Situation

Lao People's Democratic Republic (Lao PDR) is a landlocked country located in the middle of the Southeast Asian peninsula. It has a border with five countries – China in the north, Viet Nam in the east, Cambodia in the south, and Thailand and Myanmar in the west. Lao PDR has a total area of 236,800 square kilometres, about 70 percent of which is covered by mountains. Its population was 6,514,432 as of 2012, and the average population density is 27 persons per square kilometre. Lao PDR consists of 17 provinces, and its capital city is Vientiane with a population of 783,032.

Since Lao PDR had changed its economic policy to an 'open door' policy in 1986, the economy has been progressing and expanding rapidly. Gross domestic product (GDP) growth in 2012 was 8.0 percent, year-on-year, increasing to 36,659 billion kip at 2002 constant prices.[1] This is equivalent to US$9.36 billion and amounts to a per capita income of US$1,408. The economy has been changing gradually changing from agriculture-oriented activities to a wider range of activities such as services and industry. In 2012, the service sector had a share of 37.1 percent and the agriculture sector a share of 26.0 percent of total GDP. The share of the industry sector to GDP was 31.2 percent in 2012, and its share is expected to rise in the coming years due to large investments in mineral and hydropower sectors.

1.2. Energy Supply–Demand Situation

Laos PDR's Total Primary Energy Consumption (TPEC) in 2012 was 2.63 Mtoe. The country's primary energy mix consists of four types of energy – oil, hydro, coal, and biomass. In 2012, electricity exports amounted to 0.47 Mtoe and accounted for more than half of total power consumed and 82.2 percent of total hydropower generation. The main fuel consumed in Lao PDR is biomass, because it is abundant and does not need to be purchased as a commercial commodity. Biomass remains an important energy source for cooking and for small industries, for which in 2012 it has accounted 1.5 Mtoe representing 65.6 percent of the TPEC. Consumption of oil products was the second largest after biomass. Lao PDR does not have any oil refineries and all consumption of oil products has

[1] The World Bank (2015), *World Development Indicators*.
ttp://databank.worldbank.org/data/views/reports/tableview.aspx (accessed June 2015).

been met by imports from Thailand and Viet Nam. In 2012, Lao PDR imported 0.54 Mtoe of oil products to supply the demand of the transport and other sectors. In 2012, 0.11 Mtoe of coal was consumed in Lao PDR, mainly in the industrial sector. In the near future, coal demand is expected to increase sharply as the first large coal power plant will start operating in 2015.

The power sector plays a major role in the country's economy. Electricity became a source of revenue from abroad and at the same time a source of energy for economic activities. The electrification ratio in Lao PDR was 80 percent in 2012. According to the Government of Lao PDR's plan, the country will strive to raise the electrification ratio to 90 percent in 2020. This plan is amongst the priorities of the government to eradicate the country's poverty. Considering the increase of electricity demand in Lao PDR and the power production for export, optimisation of the power sector will be necessary for the future supply of electricity.

Due to its geographic advantage, Lao PDR is known as a rich country in terms of hydropower resources, because it has many rivers. According to the Mekong River Commission Study in 1995, Lao PDR has a potential hydropower resource of 23,000 MW. However, up until 2012, only 2,966 MW of installed capacity or 12 percent of its total potentials had been realised. In 2012, Lao PDR produced around 12,760 GWh of electricity, of which 81 percent (equivalent to 10,319 GWh) was exported to Thailand and the remainder consumed domestically. Power export is projected to increase sharply because the government has made a commitment to help Lao PDR's neighbouring countries to meet their power demand. By 2020, it has agreed to export 7,000 MW to Thailand and 5,000 MW to Viet Nam. The power source for export is mainly from hydropower. One thermal power plant with 1,800 MW installed capacity named Hongsa Lignite Power Project, however, is being constructed for export purposes. More than 50 hydropower sites have been planned to meet the 2020 export target. Most hydropower projects for electricity export purposes are being developed by private foreign investors through the Build-Operate-Transfer (BOT) scheme.

2. Energy Policies

Since the establishment of the Ministry of Energy and Mines in 2006, energy policy has gained much public attention and support in Lao PDR. The policy gradually evolved from just the power sector policy to broader energy policies towards development of sustainable and environmentally friendly energy sector. The improvement of energy policy could be credited to ASEAN for its close cooperation with its members.

1.3.1. Supply (Fossil, NRE, Nuclear, Biofuels, etc.)

On the energy supply side, Lao PDR's government has taken a number of measures and devised strategies to ensure greater security of energy supply and promote sustainable development in the energy sector. For economic and social development, the government's aim is to provide energy security with sufficient energy supply at affordable prices without shortage or disruption. At the same time, the government attempts to reduce dependence on energy imports and gradually diversify its energy supply. Now the renewable energy policy has been approved as a government decree. It aims to increase the share of renewable energy in total energy supply by 30 percent by 2020. This policy also targets a 10 percent blending of biofuels in the oil supply for the transportation sector and it is expected to help the country to reduce oil imports. As part of the energy mix, although there is no plan to construct a nuclear power plant in the medium term, the government is attempting to build its personal capacity to be ready to cooperate with other countries and develop nuclear power plants in the long term when it considers it to be necessary.

1.3.2. Total Primary Energy Consumption (Energy Efficiency and Conservation)

Lao PDR's Total Primary Energy Consumption (TPEC) increased significantly, from1.20 Mtoe in 1990 to 2.63 Mtoe in 2012, and is projected to grow to 8.55 Mtoe by 2035. To meet this increase in demand, large investments will be required in the energy sector and the country will need to both to exploit more of its natural resources and import more oil from abroad. These can have a negative impact on the environment and increase greenhouse gas emissions. Therefore Lao PDR's government, through the Ministry of Energy and Mines (MoEM), is trying to tackle this energy issue, as reflected in its energy policy. For instance, one of the most effective measures and policies to minimise the associated issues, which the government is currently promoting, is the Energy Efficiency and Conservation programme. In it, a 10 percent reduction in energy consumption by 2020 in all sectors is being proposed to the government.

1.3.3. Creation of New Department

To promote greater security and sustainable development in energy supply, the government has frequently reviewed and improved energy organisation structures. Based on new developments in the country, suitable energy organisations are needed to efficiently manage the energy sector. For example, the Department of Electricity has been split into Department of Energy Policy and Planning, Department of Energy Management and Institute of Renewable Energy Promotion. The change aims to increase mandated responsibilities to accommodate a wide range of energy activities. Moreover, the energy market has been opened up to local and international investors. This strategy is aiming to promote competition and more investments in the energy industry. As a result, many new independent power producers (IPPs) have emerged to produce electricity for domestic and export requirements. Recently, Electricité du Laos (EdL), the state-owned power utility has been also divided into two companies: Electricité du Laos and Electricité du Laos–Generation (EdL–Gen).

2. Modelling Assumption

Lao PDR's GDP is projected to grow at an average annual rate of 7.0 percent from 2012 to 2035 and its population is projected to grow at an average annual rate of 1.5 percent. Since there are no national projections of growth rates up to 2035, the previous workshops recommended Lao PDR use growth rates of 7 percent for GDP and 1.5 percent for population, for the purpose of this study.

3. Energy and CO_2 Emission Outlook

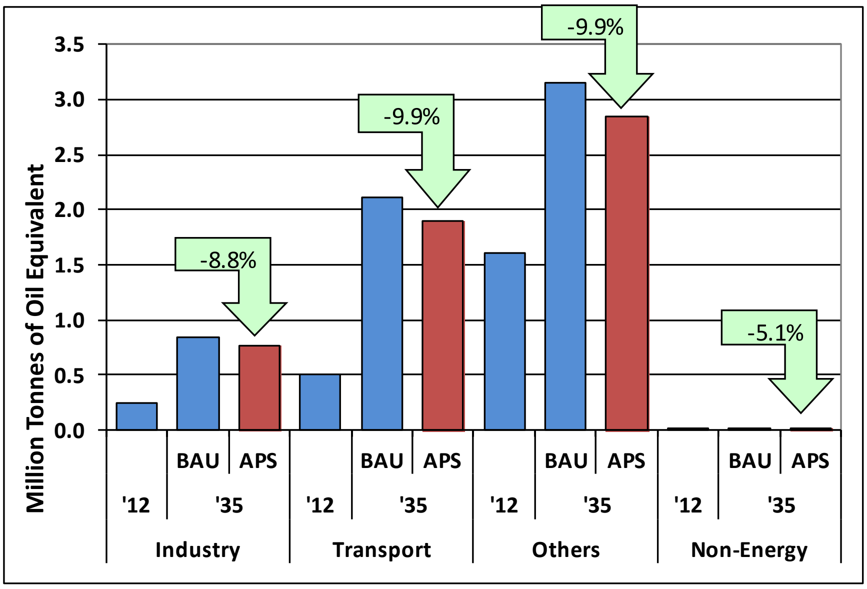
3.1. Total Final Energy Consumption

Lao PDR's Total Final Energy Consumption (TFEC) grew at 3.6 percent from 1.09 Mtoe in 1990 to 2.36 Mtoe in 2012. The industry sector had the highest growth rate during this period, at 8.7 percent per year, followed by the transportation sector, at 5.4 percent per year. The share of other sectors remains large and accounted for 68.2 percent of TFEC in 2012. In terms of energy types, biomass was the most consumed in 2012, with a share of 63.5 percent, followed by oil, which accounted for 22.7 percent.

TFEC in Business as Usual (BAU)

From 2012 to 2035, Lao PDR will experience high growth in TFEC at 4.2 percent per year on average. The transportation sector will have the highest growth rate of 6.4 percent followed by the industry sector at 5.6 percent. The others sector will have a slower growth rate of 3 percent.

Figure 10-1. Final Energy Consumption by Sector, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

TFEC in Alternative Policy Scenario (APS)

In the APS, the growth of TFEC from 2012–2035 will be 3.8 percent slightly lower than the 4.2 percent in the BAU scenario. This is due to the energy policy of the Government of Lao PDR that is to be implemented in the near future. The policy includes an increase of the renewable energy share in total energy supply by 30 percent by 2025, 10 percent blend of biofuels in oil supply for the transportation sector and the reduction of 10 percent in energy consumption in all sectors. By implementing these measures, the TFEC is estimated to reduce from 6.12 Mtoe in BAU to 5.52 MTOE in APS.

3.2. Total Primary Energy Consumption

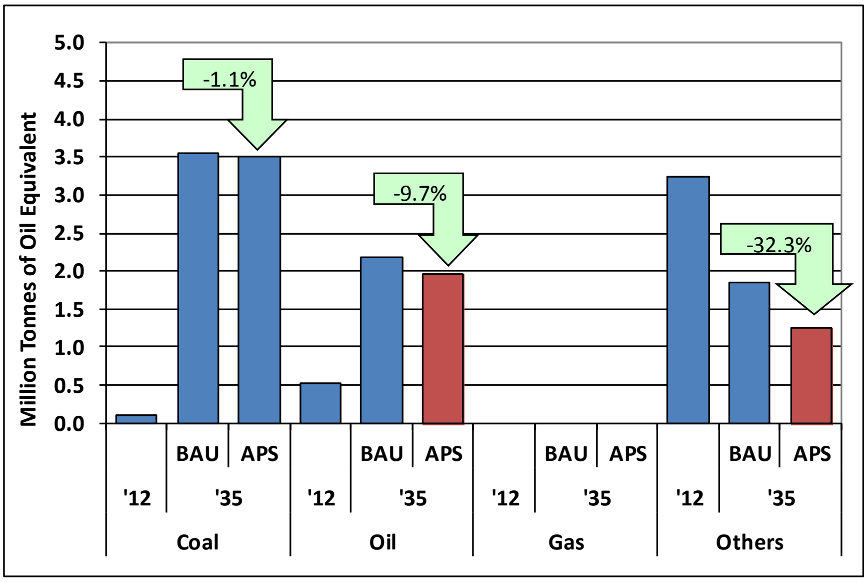
The TPEC in Lao PDR increased from 1.20 Mtoe in 1990 to 2.63 Mtoe in 2012 at an average annual growth rate of 3.6 percent. Oil consumption increased at an annual average growth rate of 5.6 percent, and hydro electricity production increased by 11.2 percent. Coal started to figure in the primary energy mix in the late 2000's and had a 4.3 percent share in 2012.

TPEC in the BAU

The TPEC of Lao PDR will grow at an average annual rate of 5.3 percent from 2012 to 2035 under the BAU scenario, reaching 8.55 Mtoe by 2035. Coal will grow at the fastest rate of 16.2 percent during the same period due to development of the first ever coal-fired power plant in the country, the Hongsa Lignite Power Plant, which will be operated from 2015 onwards.

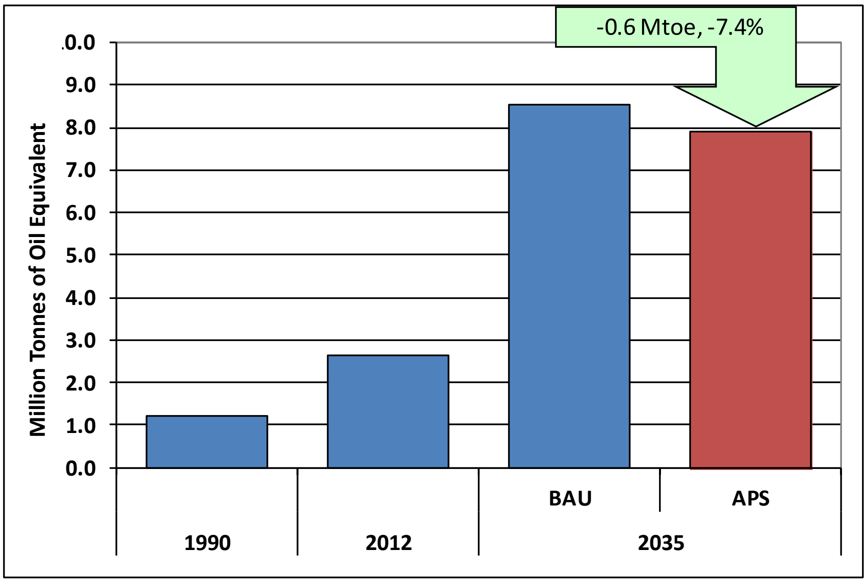
Hydropower will also increase at an average annual growth rate of 7.5 percent but at a lower rate compared with that of coal for the period 2012–2035. In absolute amount, hydropower production will increase from 0.72 Mtoe in 2012 to 3.81 Mtoe in 2035. Oil demand will rise at 6.3 percent per year on average, from 0.54 Mtoe in 2012 to 2.18 Mtoe in 2035.

Figure 10-2. Total Primary Energy Consumption, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 10-3. Evolution of Total Primary Energy Consumption, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Scenario Analysis

The APS consists of scenarios such as energy efficiency and conservation (EEC) scenario (APS1), improvement of Energy Efficiency in power generation (APS2), development of renewable energy (APS3). The scenarios were individually modelled to determine the impact of each scenario to 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 reduction 10 percent of final energy consumption in all sectors up to 2025.
- APS2: focus on installation of more efficient thermal power plants. However this APS2 has been not practical for this study.
- APS3: focus on an increase 10 percent of biofuels blending with total fuel used by the country by 2025.
- APS4: focus on installation of Nuclear Power Plants. However this APS4 has been not practical in the power plan of Lao PDR, therefore this scenario is not used in the study.
- APS5: Combination with APS1 and APS3.

Result of TPEC in Alternative Policy Scenario (APS)

In the APS, the TPEC will increase at an average rate of 4.9 percent throughout the projection period between 2012 and 2035. It is projected to increase from 2.63 Mtoe in 2012 to 7.92 Mtoe in 2035. If compared with BAU, the TPES in APS will be 7.4 percent lower or equivalent to 0.63 MTOE. The reduction in TPES will result from the implementation of a number of energy strategies and measures as mentioned above.

3.3. CO_2 Emissions

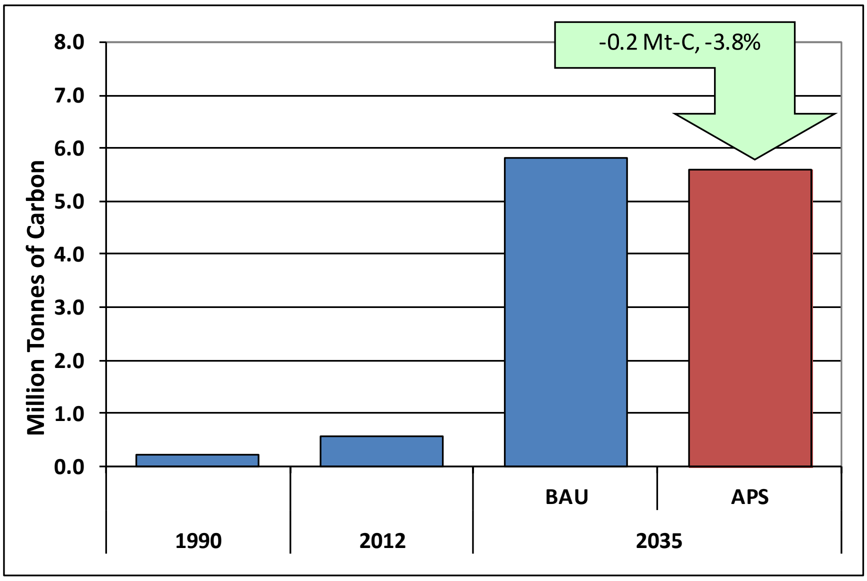
CO_2 in Business-as-Usual (BAU)

In the Business-as-Usual (BAU) scenario, CO_2 emissions are projected to increase from 0.6 Mt-C in 2012 to 5.8 Mt-C in 2035 at an average annual growth rate of 10.6 percent per annum. The high increase of CO_2 emission is due to the operation of a lignite power plant. Before the operation of this coal power plant, almost 100 percent of electricity generation in Lao PDR is from hydropower.

Alternative Policy Scenario (APS)

In the APS, the CO_2 emissions will be increasing but at a slower rate than the BAU case. The average annual growth rate of CO_2 emission in the APS will be 10.5 percent for the period 2012–2015, reducing the total CO_2 emission to 0.2 Mt-C, roughly 3.8 percent lower than BAU.

Figure 10-4. CO_2 Emission from Energy Combustion, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Findings and Policy Implications

4.1 Findings

In this energy outlook, the GDP of Lao PDR is assumed to grow at an average annual growth rate of 7.0 percent from 2012 to 2035 and population growth is assumed to grow at an average annual growth rate of 1.5 percent. By the year 2035, if the three energy measures of the government are implemented, the total primary energy consumption will decrease from 8.55 Mtoe in the BAU to 7.92 Mtoe in APS.

In the APS, the primary energy intensity and the final energy intensity in 2035 will be at 382 and 266 toe/million 2005 US$, and they are smaller than the BAU (412 and 295 toe/million 2005 US$, respectively). The primary energy consumption per capita of Lao PDR in 2035 will be 0.86 toe/person in the APS – lower than the BAU's 0.93 toe/person.

The CO_2 intensity will increase over the 2012–2035 period for both BAU and APS. However, in 2035 the CO2 intensity of the APS will reach 270 t-C/million 2005 US$, and it is lower as compared to the BAU (281 t-C/ million 2005 US$).

4.2 Policy Implications

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

In order to have energy reduction both in TPEC and TFEC, as well as the reduction in CO_2 emissions, Lao PDR should extend the implementation of the renewable energy and energy conservation programmes until 2035. As the energy conservation programmes are the most important in achieving the energy reduction, it should be proposed to be a national policy. At the same time, there should be sound projects and programmes to be implemented. Industry sector should implement the energy management system, develop and implement its own energy saving or reduction plans, to cooperate with the government energy security and regularly conduct seminars on energy saving measures; Transport sector should increase the public transport in the big cities and conduct campaign to promote the use of that transportation; And other sector should raise a public awareness on energy conservation and implement energy management in building sector. In addition, the study on correlation between GDP and energy consumption should be carried out and energy statistics should be improved accordingly. In addition, the government should consider implementing the following:

1. Implement EEC programmes in all sectors
2. Establish EEC fund (similar to that of Thailand) to support EEC programmes and ESCOs;
3. Increase the public transport and use electric vehicles (including public buses and tuk-tuk) which can reduce not only the oil import and CO2, but also traffic congestion which is getting worse and worse.
4. Reform electricity tariff to encourage more EEC activities, e.g. time of use (ToU) pricing
5. Increase a share of coal thermal power generation in power generation mix by using local coals and Clean Coal Technology (CCT) to secure the stable supply of electricity.
6. Promote power trade within ASEAN.

CHAPTER 11

Malaysia Country Report

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1. Background

Malaysia is located in Southeast Asia. Its 329,847 square kilometres of territory consist of Peninsular Malaysia and the Sabah and Sarawak States on the island of Borneo. Malaysia has a tropical, humid climate with temperatures averaging 30^{o}C. Malaysia's gross domestic product (GDP) grew steadily over the last 23 years, at an average of 5.8 percent per year from 1990 to 2012. However, growth was sluggish in 1998, due to the Asian Financial Crisis, and in 2001 due to slow growth of export demand for electronic products. Malaysia was also negatively affected by the world economic crisis in 2009.

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. As of January 2012, reserves included 6.0 billion barrels of crude oil and condensates, 92.1 trillion cubic feet of natural gas and 1483.1 million tonnes of coal. In terms of energy equivalent, Malaysia's gas reserves are four times as large as its crude oil reserves. Natural gas reserves off the east coast of Peninsular Malaysia are dedicated for domestic consumption and those in Sarawak are allocated for exports in the form of liquefied natural gas (LNG). Malaysia is a net energy exporter. Mineral fuels, lubricants, etc., contributed 20.4 percent of the economy's export earnings in 2012, or RM[1] 143,388 million.

The country's current energy policy was formulated in 1979. Since then, not only has the Malaysian economy undergone fundamental structural changes, but more importantly, the energy landscape, both domestic and international, has changed significantly. A review of the existing core policy has to be conducted and a more comprehensive energy policy and a master plan for the implementation of the energy policy have to be formulated.

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 considerably increase renewable energy (RE) use in the next five years. Efforts to promote Energy Efficiency (EE) need to be intensified. Moreover, 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 has become more urgent. A sustainable energy system is central to meeting the economic goals of Malaysia. Its levels of energy

[1] Malaysian ringgit.

use per unit of production (intensity) are high compared with other nations. A national strategy aimed at reducing energy intensity has to be drawn up. Energy planning has to recognise that the place to begin is not just 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.

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 social-economic development in the country. The major energy policies implemented in the country are as follows:

(a) Petroleum Development Act (1974)
(b) National Petroleum Policy (1975)
(c) National Energy Policy (1979)
(d) National Depletion Policy (1980)
(e) Four-Fuel Diversification Policy (1981)
(f) Fifth Fuel Policy (2000)
(g) Biofuel Policy (2006)
(h) National Green Technology Policy (2009)
(i) National Renewable Energy Policy and Action Plan (2010)
(j) New Energy Policy and 10th Malaysia Plan (2010)

2. Modelling Assumptions

In determining the forecast of final energy demand, an econometric approach was applied by using the historical correlation between energy demand as well as macroeconomic and activity indicators. Final energy demand equations were derived by using regression analysis.

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 their 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 areas, private consumption, and other factors that encourage commercial activities. However, due to unavailability of information on the activity indicators, macroeconomic parameters, i.e. gross domestic product (GDP), were the best variables to use in establishing the relationship with the energy demand trend. These macroeconomic indicators were mainly used to generate the model equations. In some cases, where regression analysis was not applicable due to insufficiency of data, or failure to derive a statistically sound equation, other methods, such as share or percentage approaches, were used.

One of the main drivers of the modelling assumption is the GDP growth rate. The GDP growth rates assumption forecast was based on a study carried out by Economic Planning Unit (EPU) under the Prime Minister’s Office. Most of the energy demand equations for Malaysia used GDP as the key factor to determine future projections, because of a high correlation between energy demand and GDP. The GDP growth assumptions are listed in Table 11-1.

Table 11-1. GDP Growth Assumptions by Sector to 2035

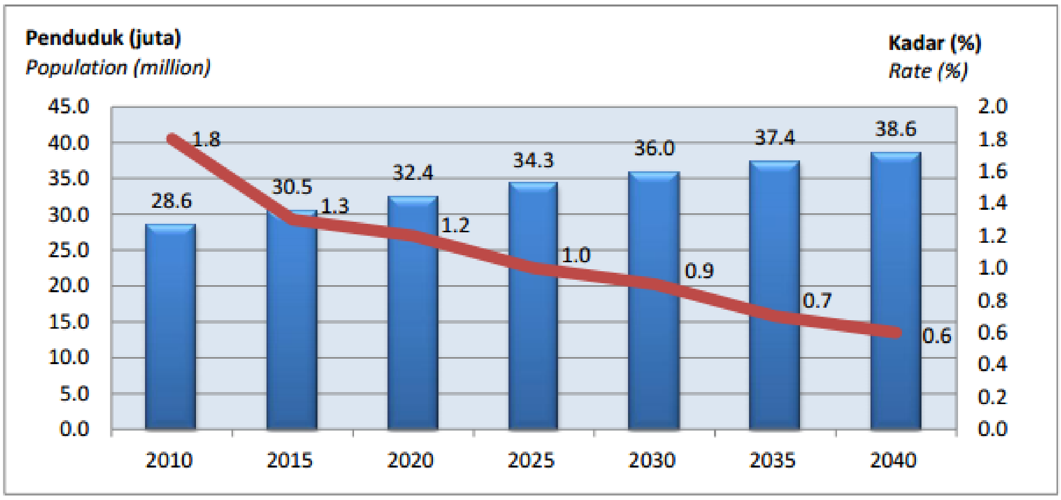
in % year-on-year

	Agriculture	Manufacturing	Services	Total GDP
2012–2013	2.06	4.78	5.88	4.74
2013–2014	2.55	6.19	6.35	6.02
2014–2015	0.30	4.90	5.60	5.00
2015–2020	1.44	2.95	4.13	3.30
2020–2025	1.37	2.95	3.72	3.02
2025–2030	1.37	2.95	3.88	3.02
2030–2035	1.37	2.95	3.67	3.02

GDP = gross domestic product.
Source: Economic Planning Unit, Prime Minister Department and ERIA.

Another important parameter in projecting future energy demand is the population growth rate. Besides future GDP growth rates, annual average population growth was also considered as one of main key drivers for future energy growth. In 2012, Malaysia's population was 29.2 million and it is projected to increase by 8.7 million (29.9 percent) to 38.0 million in 2035. However, the annual population growth rate is projected to decrease from 1.4 per cent from 2012 to 2020, to 1.0 percent from 2020 to 2035. This is a reflection of a targeted decline in the fertility rate and international migration. The assumptions of future population growth rates were obtained from the Department of Statistics Malaysia (Figure 11-1).

Figure 11-1. Population Growth Assumption to 2035



Source: Department of Statistics Malaysia.

To accelerate its economic and social development, supported by its current position as a net energy exporter, Malaysia provides subsidises energy use for various users. Due to the volatility of global energy prices and growing demand for energy, the total amount of energy subsidies offered to various energy users in the country has been growing from year to year. It has reached very high levels, placing a strain on government expenditure and taking away funds from other developmental budgets. This has led the government to review its energy subsidy policies and take action to manage energy subsidies with proper mitigation actions. In this regard, energy efficiency offers a sound solution to mitigate the effects of the gradual removal of energy subsidies.

To promote energy efficiency, the Ministry of Energy, Green Technology and Water (MEGTW) enacted a number of legal instruments. The main legal instrument on energy efficiency promotion is the Electricity Supply Act (Amendment) 2001, also known as Act A1116. The act empowers the MEGTW, under Sections 23A, 23B, and 23C, to promote efficient use of electricity in the country. Based on this, MEGTW issued the Efficient Management of Electrical Energy Regulation 2008, under which all installations that consume or generate 3 million kWh or more of electricity over a period of six months will be required to engage an electrical energy manager who shall, amongst others, be responsible for analysing the total consumption of electrical energy, to advise on the development and implementation of measures to ensure efficient management of electrical energy, and to monitor the effectiveness of the measures taken. The Energy Commission (EC) is empowered to enforce the Energy Efficiency Regulations.

The latest regulatory instrument to promote energy efficiency improvement is the Electricity Regulations (Amendment) 2013. The regulation was amended to allow for the implementation of Minimum Energy Performance Standards (MEPS) regarding selected electrical appliances and lighting. Under the new regulation, refrigerators, air-conditioners, televisions, fans, and lamps (Fluorescent, Compact Fluorescent, Light Emitting Diode, and Incandescent) that enter the Malaysian market or are sold to consumers must meet the minimum energy performance standards as prescribed in the regulation. Furthermore, information related to MEPS of those products must be made available to consumers by labelling. Labelling of appliances covered by MEPS will became a mandatory requirement. The regulation will pave the way for the phasing-out of inefficient electrical appliances and lighting.

Malaysia has developed a reasonably well-designed renewable support mechanism that includes a set of legislation, published Feed-in-Tariff (FiT) with annual digression rates from 2013 onwards, developed a quota mechanism, and created a Renewable Energy Master Plan and an implementing agency (SEDA, the Sustainable Energy Development Authority). 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 provide a level of certainty. FiTs are available for biogas, biomass, solar PV, and small hydro. Support duration is16 years 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 in 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. Feed-in-Tariff (FiT) has been used to adjust to the cost of the technology. With the exception of small hydro, FiTs are revised every year according to different digression rates from 2013 onwards. This system is used in countries like Germany as a way to adjust the level of remuneration to technology cost evolutions. However, as these digression rates have to be correctly calculated to avoid a slowdown in capacity build out, such mechanisms have proven to work well only in relatively mature markets, with long track records and know-how.

The Malaysian government is seeking to promote the wider use of public transport through the development of mass transit systems. The current focus is on Kuala Lumpur and the Klang Valley, where around 7.6 million people live (about a third of the population). The existing light transit rail (LRT) system was developed in the late 1990s/early 2000s and consists of 124 km of track carrying 150 million passengers per year, around 1.2 billion passenger-km (0.5 percent of Peninsular Malaysia's total transport demand in passenger-km). The current plans call for an expansion of the LRT system with an additional 150 km of track to be developed between 2016 and 2022. The new network will transport around 330 million passengers a year and account for around 1 percent of the Peninsula's total transport passenger-km. In addition to the LRT, there are plans to develop the East Coast rail route. This would serve around 3.3 million people in Kelantan, Terengganu, Pahang, and Selangor via a 620 km line. It is also anticipated that it will carry 37 million tonnes of freight annually.

Under the Economic Transformation Programme (ETP), formulated as part of Malaysia's National Transformation Programme, the government is studying the possibility of deploying nuclear energy to meet future demand to further diversify the energy mix for Peninsular Malaysia. To spearhead the initiative, the Malaysia Nuclear Power Corporation (MNPC) has been formed to lead the planning based on the current development timeline of 11 to 12 years, from pre-project to commissioning.

In setting up the scenarios for this project, several assumptions or scenarios have been identified:

1) APS1 Improved efficiency of final energy demand

2) APS2 Higher efficiency of thermal electricity generation

3) APS3 Higher contribution of NRE (here NRE for electricity generation and biofuels for the transport sector are assumed)

4) APS4 Introduction of nuclear energy

5) APS5 Combined impact of scenarios APS1 to APS4

The details of future assumptions based on their respective scenarios are mentioned in Table 11-2:

Table 11-2. Energy Efficiency Assumptions

Scenarios	Assumptions
APS1	1. Electricity Demand in Industrial Sector (INEL)
	Potential reduction of electricity demand in industrial sector from the year 2015 until 2035 by 1.6 percent per year
	2. Total Energy Demand in Industrial Sector (INTT)
	Potential reduction of total energy demand (electricity + petroleum products + coal + natural gas) in industrial sector by 1 percent per year from 2015 until 2035
	3. Total Energy Demand in Commercial Sector
	Potential reduction of total energy demand in commercial sector by 1 percent per year from 2015 until 2035

APS = Alternative Policy Scenario.

Table 11-3. Higher Efficiency of Thermal Electricity Generation

Scenarios	Assumptions
APS2	1.Higher efficiency of coal power plant by 40 percent in 2035
	2. Higher efficiency of natural gas power plant by 45.9 percent in 2035

Table 11-4. Renewable Energy Assumptions

Scenarios	Assumptions						
APS2	1. By 2030, Malaysia will be expected to have the following renewable energy (RE) capacities in power generation. The breakdown of the capacity based on type of fuels type are showed below:						
	Cumulative Capacity (MW)						
	Year	Biomass	Biogas	Mini-Hydro	Solar PV	Solid Waste	Total
	2015	330	100	290	55	200	975
	2020	800	240	490	175	360	2,065
	2025	1,190	350	490	399	380	2,809
	2030	1,340	410	490	854	390	3,484
	2. In 2020, 7 percent of Malaysia's share of diesel consumption in transport sector will come from biodiesel.						

APS = Alternative Policy Scenario.

Table 11-5. Nuclear Energy Assumptions

Scenarios	Assumptions
APS4	1. By 2025, a 2000 MW nuclear plant is expected to have been commissioned.

APS = Alternative Policy Scenario(s).

Table 11-6. APS Assumptions

Scenarios	Assumptions
APS5	APS1 + APS2 + APS3 + APS4

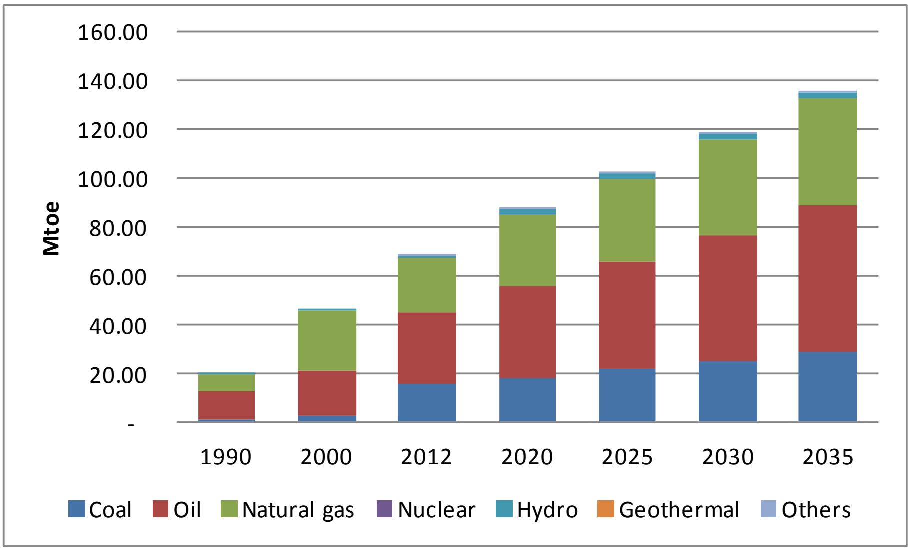
APS = Alternative Policy Scenario.

3. Outlook Results

3.1. Business-as-Usual (BAU) Scenario

Total primary energy consumption under the BAU scenario registered average annual growth of 5.8 percent from 1990 to 2012 and is projected to increase by 2.9 percent per year from 2012 to 2035. Hydro is expected to increase from 0.78 Mtoe in 2012 to 2.75 Mtoe in 2035, at an average annual growth rate of 5.6 percent, oil supply by 3.1 percent, and supply of coal mainly consumed by the power sector by 0.8 percent. Natural gas is projected to increase from 22.48 Mtoe in 2012 to 52.74 Mtoe in 2035, or grow at an average annual rate of 3.8 percent, biomass for power generation at 7.4 percent, and biofuel use for land transportation at 1.2 percent.

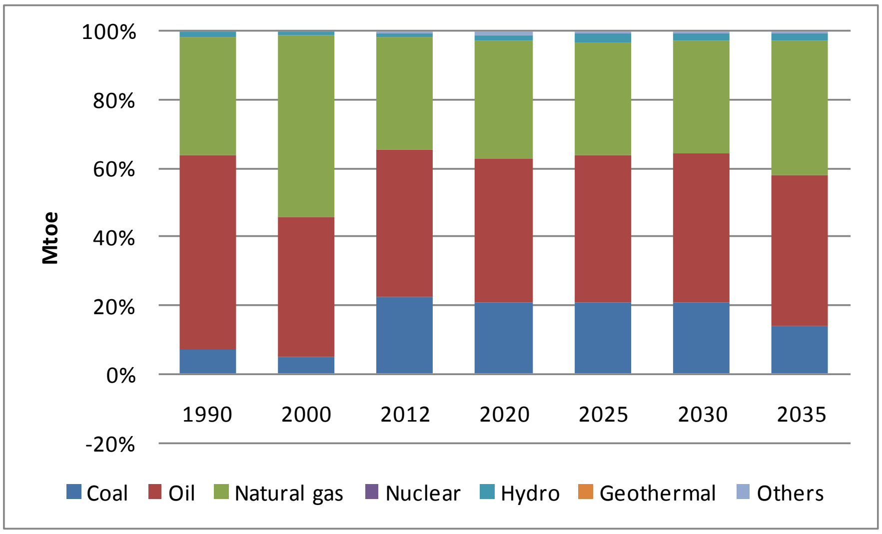
Figure 11-2. Primary Energy Consumption by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

In terms of shares by fuel type, the share of oil is projected to increase from 43.2 percent in 2012 to 44.4 percent in 2035 and the share of natural gas will increase from 32.6 percent in 2012 to 39.3 percent in 2035. The share of coal is expected to decrease over the projection period, from 22.4 percent in 2012 to 13.9 percent in 2035, and the share of hydro will increase from 1.1 percent in 2012 to 2.0 percent in 2035.

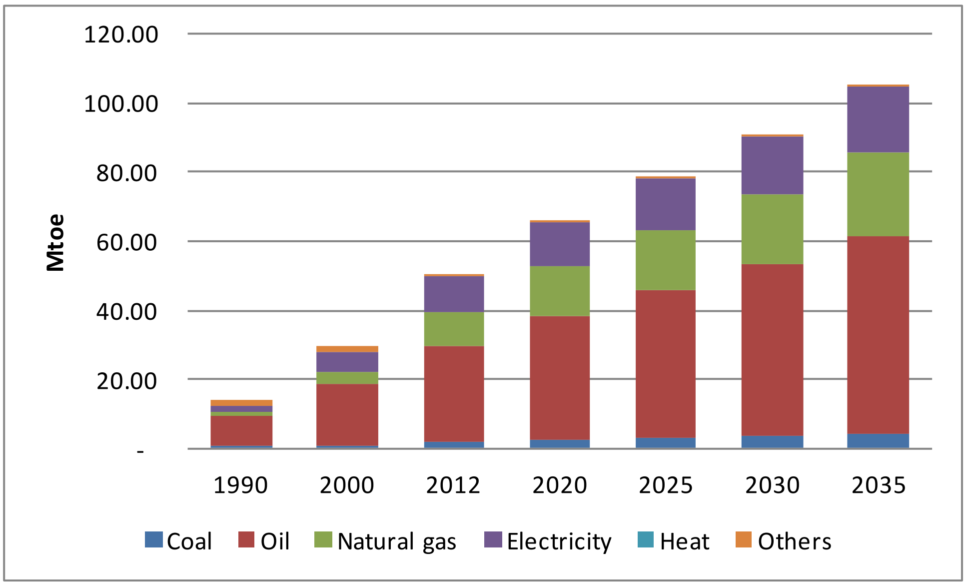
Figure 11-3. Share of Primary Energy Consumption by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

Total final energy demand in the BAU scenario is projected to increase from 50.2 Mtoe in 2012 to 104.7 Mtoe in 2035, or at an average annual growth rate of 3.2 percent per year. Final demand of coal and natural gas are expected to see the highest average annual growth rates, of 3.8 percent and 4.2 percent, respectively from 2012 level to 2035. Oil demand will grow from 27.7 Mtoe in 2012 to 57.6 Mtoe in 2035, or at 3.2 percent per year. Electricity demand will increase by 2.6 percent per year from 2012 to 2035 and other fuels will grow from 0.11 Mtoe in 2012 to 0.15 Mtoe in 2035, or by 1.2 percent per year.

Figure 11-4. Final Energy Demand by Fuel, BAU

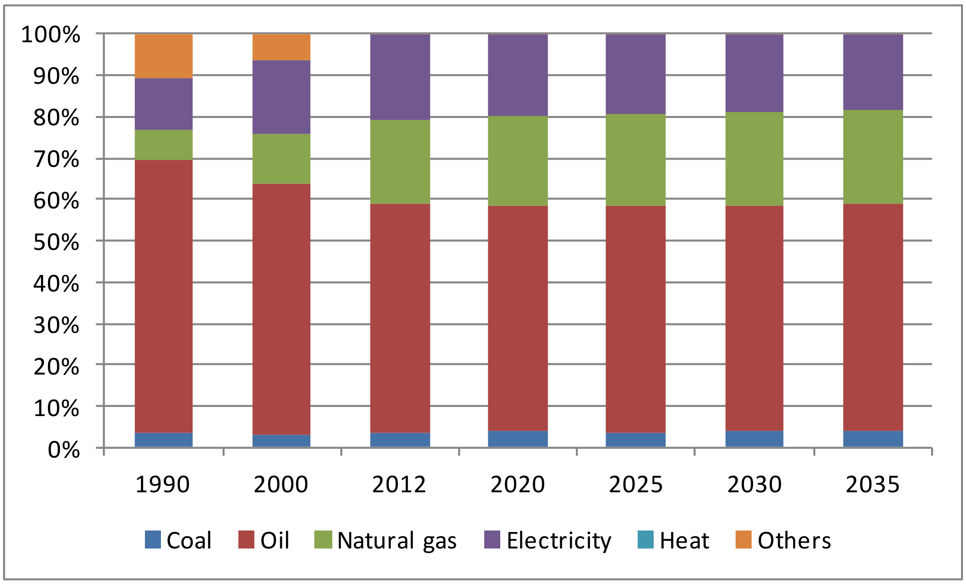


BAU = Business-as-Usual.
Source: Author’s calculation.

Analysis by fuel type shows that the share of oil will remain the largest, at 55.1 percent, in 2035, nearly the same as in 2012 (55.3 percent), followed by natural gas with 23.9 percent in 2035. The share of electricity is projected to fall to 18.1 percent from 20.7 percent in 2012, whereas the share of coal is expected to increase slightly, from 3.5 percent in 2012 to 3.9 percent in 2035.

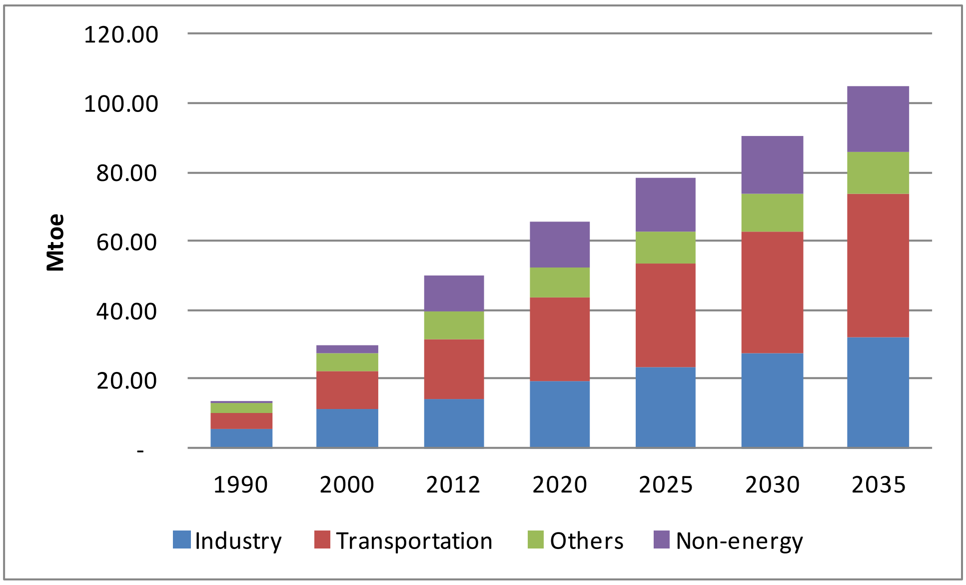
Final energy demand by sector shows that the transportation sector will see the highest growth, at 3.9 percent per year, from 2012 until 2035, followed by industrial sector which is projected to grow from 14.3 Mtoe in 2012 to 32.2 Mtoe in 2035, or at 3.6 percent per year. The ‘Others’ sector is expected to see an annual average increase of 1.7 percent from 2012 until 2035. The non-energy use is expected to increase from 10.7 Mtoe in 2012 to 19.1 Mtoe in 2035, or at an average annual growth rate of 2.6 percent.

Figure 11-5. Share of Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

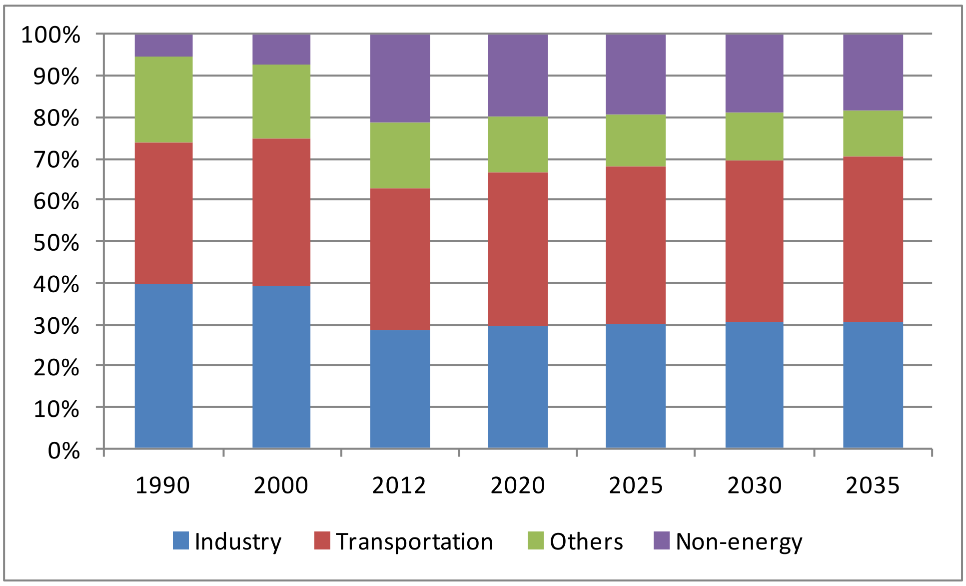
Figure 11-6. Final Energy Demand by Sector, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

The transport sector is projected to maintain its highest share of energy usage in 2035, at 39.8 percent, compared with 34.2 percent in 2012, followed by the industry sector at 30.8 percent share in 2035, compared with 28.5 percent in 2012. The share of non-energy use is expected to be 18.2 percent of total final energy demand in 2035, a decrease from 21.3 percent share in 2012. The share of the 'others' sector is expected to be 11.2 percent in 2035.

Figure 11-7. Share of Final Energy Demand by Sector, BAU



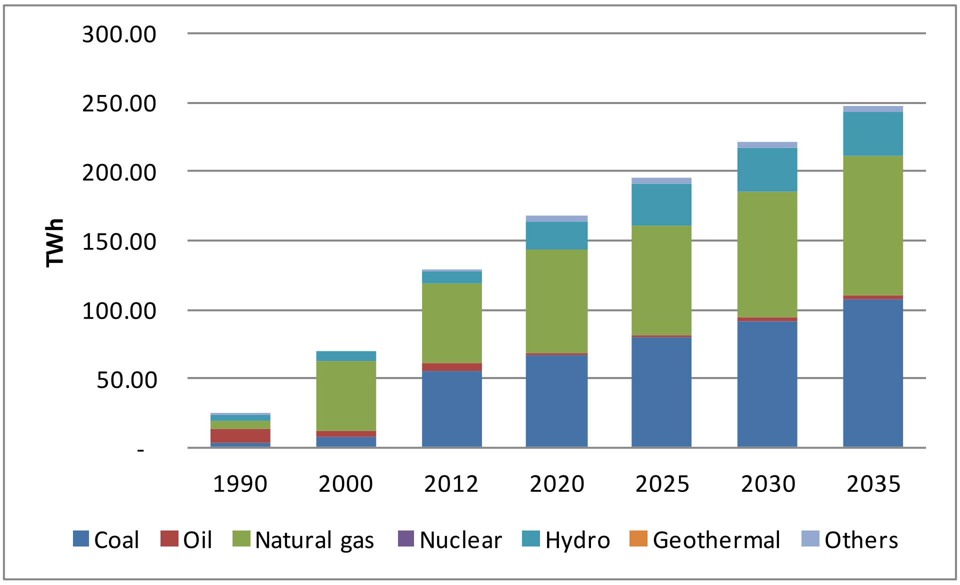
BAU = Business-as-Usual.
Source: Author's calculation.

In the BAU scenario, total power generation is expected to grow at around 2.9 percent per year on average from 2012 to 2035, reaching 248.3 TWh. Power generation from others is expected to see the fastest growth, at 7.1 percent per year from 2012 until 2035. This is followed by power generation from hydro, which is projected to increase to almost 32 TWh in 2035, compared with 9.1 TWh in 2012. Power generation from coal is projected to grow at an annual average rate of only 0.5 percent from 2012 to 2035, from 55.8 TWh in 2012 to 62.4 TWh in 2035. Power generation from oil is expected to decline by an average 3.5 percent per year, to 2.6 TWh in 2035 compared with 5.9 TWh in 2012.

The power generation mix will in 2035 will be dominated by natural gas and coal, with shares of 59.3 percent and 25.1 percent, respectively. Hydro follows with a share of 12.9 percent in 2035 compared with 7.0 percent in 2012. The share of others will be 1.7 percent of total power generation in 2035 and that of oil share 1.0 percent in 2035, compared with 4.6 percent in 2012.

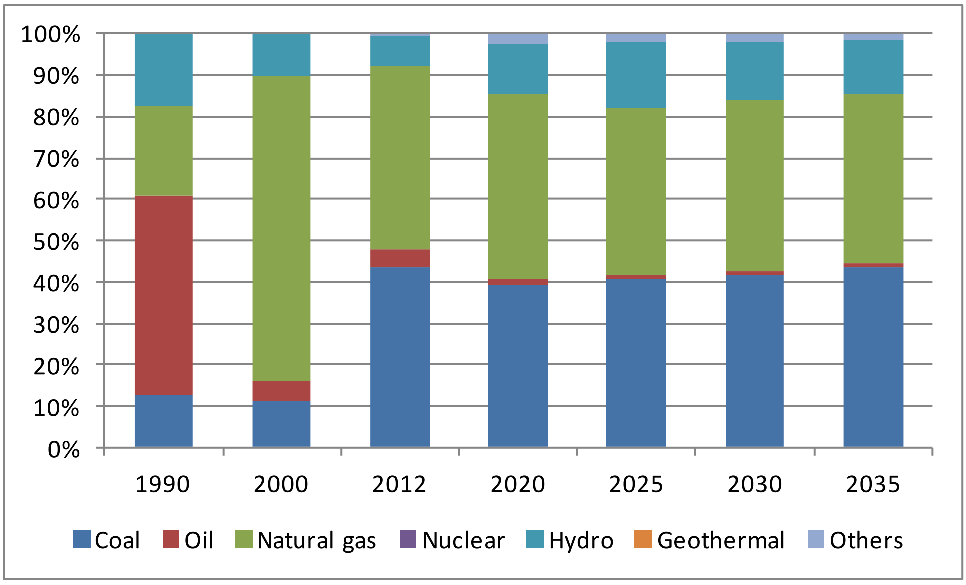
In the BAU scenario, thermal efficiency of coal power plants is expected to improve to 37.0 percent in 2035 from 35.0 percent in 2012, and that of oil power plants is projected to remain more or less the same over the projection period at around 33.0 percent. Thermal efficiency of natural gas power plants will further improve, to almost 44 percent by 2035, from 40 percent in 2012.

Figure 11-8. Power Generation by Fuel, BAU



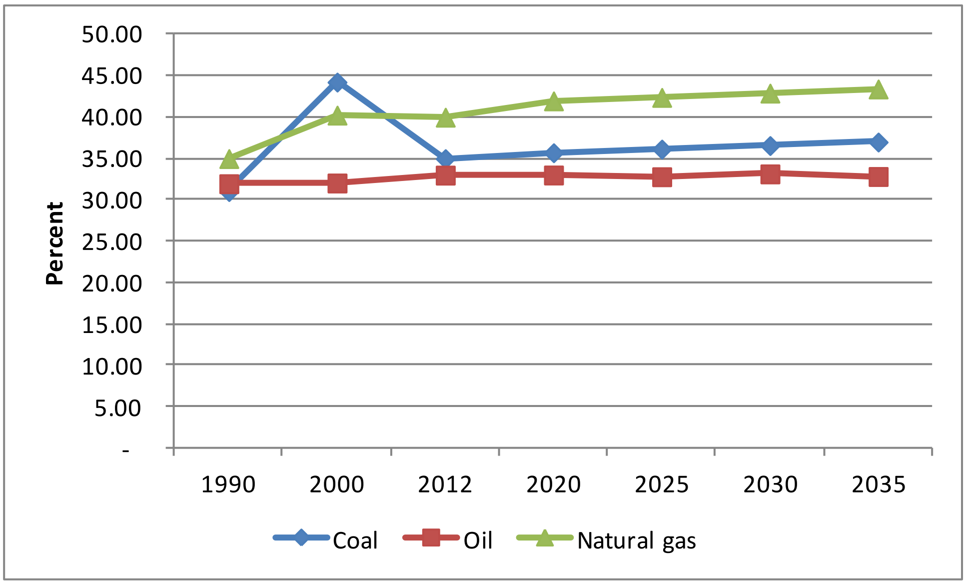
BAU = Business-as-Usual.
Source: Author's calculation.

Figure 11-9. Share of Power Generation by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

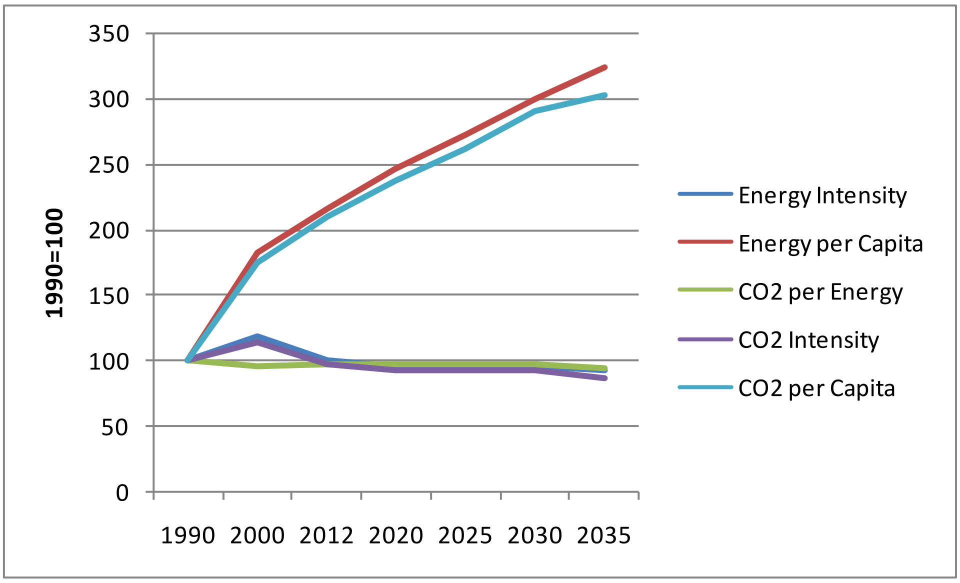
Figure 11-10. Thermal Efficiency by Fuel, BAU



Source: Author's calculation.

Malaysia primary energy intensity is expected to decline to 321 toe/million US$ in 2035 from 348 toe/million US$ in 2012, and final energy intensity is projected to decline to 250 toe/million US$ in 2035 compare with 253 toe/million US$ in 2012. However, primary energy per capita is projected to increase to 3.53 toe/person in 2035 compared with 2.36 toe/person in 2012.

Figure 11-11. Energy Indicators, BAU



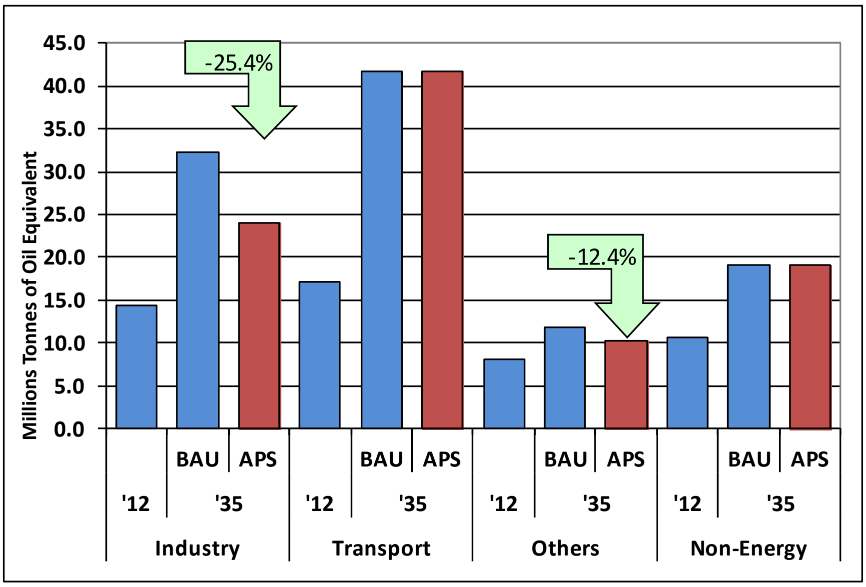
BAU = Business-as-Usual.
Source: Author's calculation.

CO_2 intensity is expected to decrease to 205 t-C/million US$ in 2035 from 231 t-C/million US$ in 2012. CO_2 per primary energy is projected to decrease slightly, from 0.66 t-C/toe in 2012 to 0.64 t-C/toe in 2035.

3.2. Alternative Policy Scenario (APS)

In the APS, growth in final energy demand will be 2.8 percent from 2012 to 2035, slightly lower than under the BAU scenario. The slower rate of growth 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 industrial and commercial sectors. As a result, savings of 25.4 percent in the industry sector can be expected by 2035. In the 'others' sector, the growth rate of energy consumption is projected to be slower than under the BAU scenario, growing at an average rate of 1.1 percent per year compared with 1.7 percent per year in the BAU scenario. The potential saving of 12.4 percent in 2035 can be achieved through the implementation of energy efficiency measures (Figure 11-12).

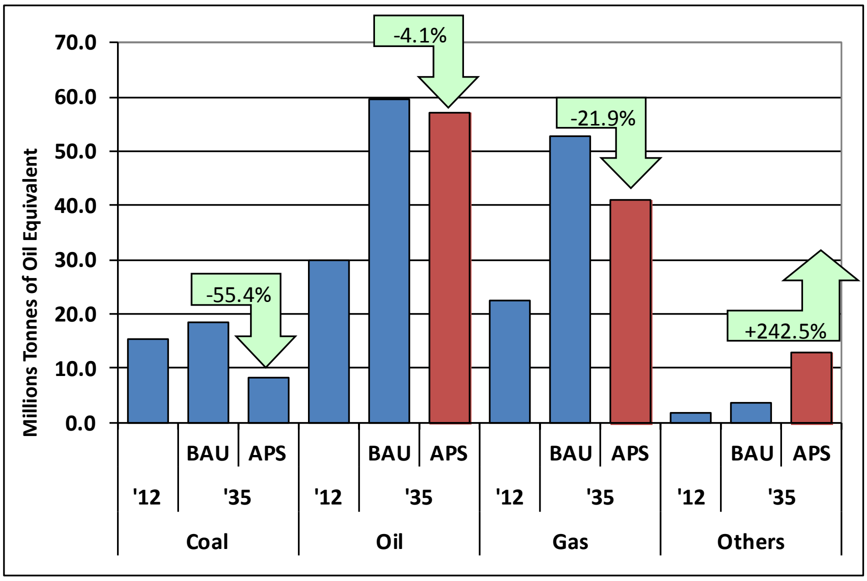
Figure 11-12. Final Energy Demand by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In the APS, primary energy consumption is projected to increase at a slower rate than in the BAU scenario, at 2.3 percent per year, from 69.0 Mtoe in 2012 to 115.8 Mtoe in 2035. Biomass and biofuels will be growing fastest, at annual average rates of 13.1 percent and 10.4 percent, respectively. This is due to the implementation of FiT in power generation, which is expected to have a big impact on primary energy consumption in 2035, as more renewable energy for power generation is expected to be commissioned. Hydro will also increase steadily, but at a slower rate of 5.9 percent per year from 2012 to 2035. Oil is expected to grow at 2.9 percent per year from 2012 until 2035 and natural gas at 2.7 percent. Coal is projected to decrease by an annual average 2.7 percent from 2012 to 2035 (Figure 11-13), mainly as a result of energy efficiency and conservation measures on the demand side as well as a reduced dependency on fossil fuels. Nuclear power will be introduced as another energy option after 2025.

Figure 11-13. Primary Energy Consumption by Source, BAU and APS5

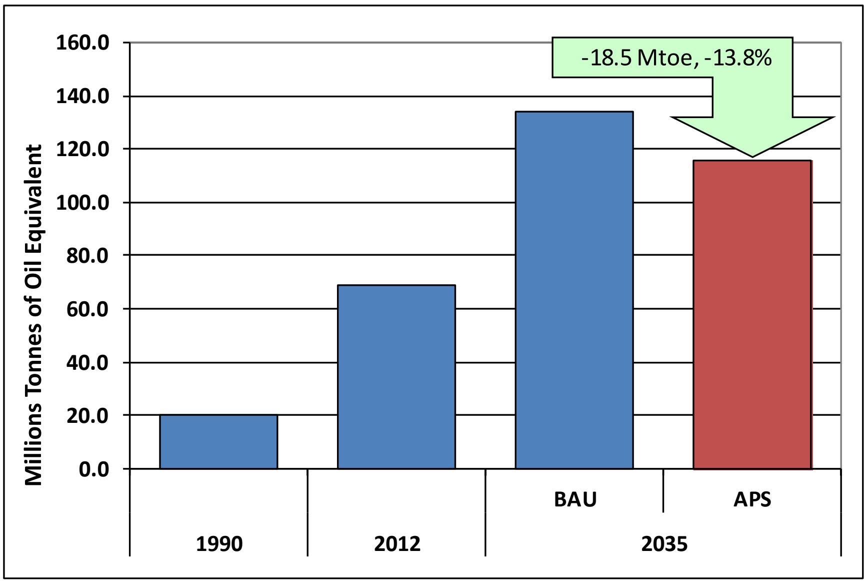


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.3. Projected Energy Savings

The energy savings that could be achieved under the APS, relative to the BAU scenario, are a result of energy efficiency efforts in the industrial and commercial sectors, a more efficient thermal power supply, and a higher contribution from renewable energy, and are estimated at about 18.5 Mtoe in 2035 (Figure).

Figure 11-14. Total Primary Energy Consumption, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

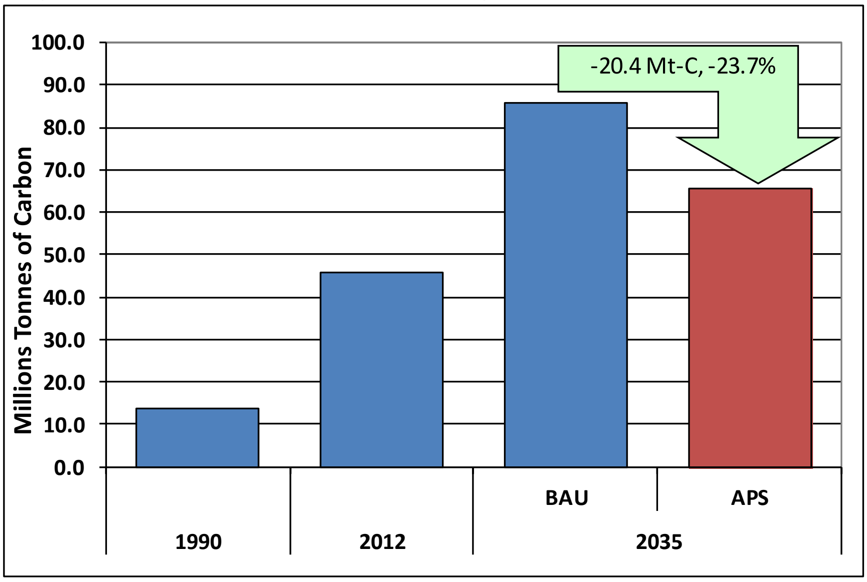
Most of the savings can be achieved by switching from coal to renewable energy and nuclear power. In terms of final energy demand, the saving of 9.6 Mtoe that can be achieved in 2035 consist of savings of 8.2 Mtoe in the industrial sector and savings of 1.5 Mtoe in the commercial sector.

3.4. CO_2 Emissions from Energy Consumption

In the BAU scenario, total carbon dioxide (CO_2) emissions from energy consumption are projected to increase by 2.8 percent per year from 2012 to 2035. In 2012, the CO_2 level was at 45.8 million tonnes of carbon (Mt-C) and this is expected to increase to 86.0 Mt-C in 2035 under the BAU scenario.

In the APS, the annual increase in CO_2 emissions from 2012 to 2035 will be lower than in the BAU scenario, at 1.6 percent per year, which is fairly consistent with the projected growth in primary energy consumption. The reduction in CO_2 emissions in the APS of 20.4 Mt-C or 23.7 percent relative to the BAU scenario is also due to a significant decrease in coal consumption for power generation in the APS, relative to the BAU scenario, as 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 industrial sector and the commercial sector and fuel switching in the transport sector have also contributed to the reduction. This indicates that Malaysia's energy saving effort and renewable energy action plan would be effective in reducing CO_2 emissions.

Figure 11-15. CO_2 Emissions from Energy Combustion, BAU and APS5



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Conclusions

Malaysia's primary energy intensity in the APS is projected to be 13.8 percent lower in 2035 than under the BAU scenario. The reduction of primary energy intensity will be due to Malaysia's energy saving measures, promoting energy efficiency and renewable energy. A contribution is expected to be made by programmes and activities under the Economic Transformation Programme (ETP) to increase diversification of the energy industry, step up exploration for new oil and gas resources, enhance production from known reserves, and encourage the use of alternative energy sources such as solar, hydro-electric, and nuclear.

Malaysia faces several energy issues and challenges, which can be addressed in holistic manner. The entire need of reformulation of the sustainable energy plan can help to achieve future economic targets. Some major challenges are the depletion of fossil fuel, global warming, and the volatility of energy prices. Successfully tackling the increase in energy demand depends on many issues. These issues can be addressed by utilising a large proportion of renewable sources, even though these sources are costlier than fossil fuels. However, hastening technology learning and subsidies can help improve technology competitiveness. Renewable subsidies should be well targeted and not burdensome to consumers.

For its Economic Transformation Programme (ETP), Malaysia needs more energy and continuous economic growth. Faced with rising demand for electricity, Malaysia is also exploring the nuclear energy option to meet future demand. The increase in energy consumption has also resulted in high levels of greenhouse gas (GHG) emissions. Alternative energy sources like nuclear and solar are needed to reduce GHG emissions.

Malaysia should continue with and enhance energy efficiency programmes and activities, as the results so far have been a large reduction in total final energy consumption compared with the BAU scenario. There is potential for savings in the industry, commercial, and residential sectors. Besides the industry sector, the transportation sector is expected to become one of the largest energy consumers in 2035. Programmes or activities to reduce energy demand – such as enhancing the public transportation network, introducing hybrid and Electric Vehicle (EV), and substituting private vehicles with Natural Gas Vehicle (NGV) – should be implemented and organised. To mitigate CO_2 emission in the power sector, cleaner, better, and more efficient thermal technologies should be used for electricity generation in the country. The FiT programme should also be continued to promote the utilisation of RE to minimise CO_2 emissions.

CHAPTER 12

Myanmar Country Report

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1. Background

1.1. Country Profile

Myanmar is the largest country in mainland Southeast Asia. Its territorial area covers 676,577 square kilometres and it shares a border of 5,858 km with Bangladesh and India to the northwest, China to the northeast, and Thailand to the southeast. Approximately 48 percent of its total land area is covered with forest, and most of the land area is utilised for agriculture. Myanmar had a population of 52.8 million in 2012 with an average annual growth rate of 1.0 percent per year from 1990 to 2012.

Myanmar is geographically located at the tip of the Southeast Asia Peninsula and has three distinct seasons. It enjoys three to four months of heavy monsoon and abundant sunshine all year round, which makes it ideal for accumulating water resource for hydropower and 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 enter the Bay of Bengal and the 2,832 kilometre coastal strip along the southern part is 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 production of commercial energy. The available current sources of energy found in Myanmar are crude oil, natural gas, hydroelectricity, biomass, and coal. Besides these, wind energy, solar, geothermal, bio-ethanol, biodiesel, and biogas are the potential energy sources found in Myanmar.

Myanmar's proven energy reserves comprise of 136 million barrels of oil, 10 trillion cubic feet of gas, and 466 million metric tonnes of coal. The country is a net exporter of energy, exporting substantial amounts of natural gas and coal to neighbouring countries. However, it imports around 50 percent of its total oil requirements.

1.2. Socio-economic Status

The population of Myanmar grew at 1.0 percent per year between 1990 and 2012, to 52.8 million in 2012. Myanmar's gross domestic product (GDP) was US$[1] 23.1 billion (constant 2005) in 2012 and its GDP per capita grew from around US$0.1 thousand in 1990

[1] All US$ in this report are in constant 2005 values unless otherwise specified.

to US$0.44 thousand in 2012. With the objectives of enhancing economic development in Myanmar, five-year short-term plans were formulated and implemented from 1992 to 2012. The first (1992–1995), second (1996–2000), and third plans (2001–2005) achieved average annual GDP growth rates of 7.5 percent, 8.5 percent, and 12.8 percent respectively. The last five-year plan (2006–2010) was formulated to achieve an average annual GDP growth rate of 12 percent.

1.3. Energy Consumption in the Base Year

Myanmar's total primary energy consumption was 15.6 million tonnes of oil equivalent (Mtoe) in 2012. Natural gas is mainly used for electricity generation and in industry. Myanmar has 4,041 megawatts (MW) of installed generation capacity and produced about 12.4 terawatt-hours (TWh) of electricity in 2012. During the same year, thermal (coal, natural gas, and oil) and hydro accounted for 23.9 percent and 76.1 percent of total electricity generation, respectively.

2. Modelling Assumptions

2.1. GDP and Population Growth

In this report, Myanmar's GDP is assumed to grow at an average annual rate of around 6.5 percent from 2012 to 2035, slowing from the 9.3 percent growth seen from 1990 to 2012. The population is assumed to increase by about 1.0 percent per year on average from 2012 to 2035.

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 less than 13 percent of the total in 1990. It is assumed that the share of coal in the generation mix will be more than 50 percent in 2035. The government's plan is to further increase the share of natural gas, coal, hydro, and other renewables in the total generation mix and reduce the share of oil. Myanmar has also plans to export electricity from its hydro power plants to neighbouring countries such as Thailand and China.

2.3. Energy and Climate Change/Environmental Policies

Myanmar's energy policy in general strives towards maintaining the status of 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 it in terms of volume, density, and reliability. It also advocates the utilisation 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. Energy efficiency and conservation (EEC) is emphasised to save energy through effective energy management and to reduce energy consumption so as to minimise harmful environmental impacts. Utilisation of new and renewable energy sources is encouraged, especially solar and wind, which are abundantly available thanks to Myanmar's climatic condition. Myanmar's energy policy also accepts the fact that utilisation of traditional energy sources such as fuel-wood and charcoal still needs to be practiced. 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 percent from Business-as-Usual (BAU) levels are expected from improvements in manufacturing technologies by 2020. In the residential and commercial ('others') sector, efficient end-use technologies and energy management systems are also projected to induce significant savings. In the transport sector, efficiency increases 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 remains small for the time being. The government through the Ministry of Energy has initiated the Clean Fuel Program to reduce carbon dioxide emissions by increasing the use of natural gas in the industrial sector and for power generation; this includes converting gasoline, diesel, and liquefied petroleum gas (LPG) vehicles to compressed natural gas (CNG) vehicles.

The Ministry of Environmental Conservation and Forestry (MOECAF), the designated national authority for clean development mechanism (CDM) has submitted one hydro power project to UNFCCC for consideration. The National Environmental Conservation Committee was formed in 2004 and re-formed in April 2011, replacing NCEA, and now serves as the focal organisation for environmental matters. It is chaired by MOECAF, formerly the Ministry of Forestry. The Committee's membership includes 19 ministries.

The Environmental Conservation Law was enacted by the government 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 an authorised body.

Myanmar's primary energy saving goal is to reduce energy consumption by 5 percent in 2020 and 10 percent in 2030, relative to the BAU scenario. Specifically, the goals could be achieved by implementing the following strategies:

- In the industrial sector, improve energy efficiency by 10 percent against BAU and reduce energy related greenhouse gases by 2020.
- In the transport sector, have biofuel (E85, biodiesel) substitution of at least 8 percent by 2020.
- Increase the total installed power capacity of renewable energy to 15 percent by 2020.
- Improve energy efficiency in the commercial/residential sector by 8 percent by

2020.

In addition, the following measures are considered important in achieving the goals:

- To develop energy statistics and support systems to help improve energy efficiency in all sectors by encouraging information dissemination and cooperation between the public and private sectors.
- To develop voluntary action plans for the private sector by 2010–2015.
- To develop labelling systems for appliances and buildings by 2015.
- To increase research and development.
- To develop an energy management system through the ASEAN Energy Manager Accreditation Scheme (AEMAS) Program by 2010–2015.

On a sectoral basis, the energy efficiency and conservation measures in Myanmar are listed below:

- In industry, gradual replacement of low efficiency equipment with higher efficiency alternatives will be encouraged.
- In the transportation sector, the state will encourage fuel switching in the transport sector to biofuels and natural gas as alternative fuels. The state also aims to achieve energy saving through exploiting more efficient transportation networks, including road, waterways, rail, air, and seaway and develop high-capacity transportation with greater volume capacity for freight and passengers. Improvement of fuel efficiency in the transport sector is also considered.
- In the residential and commercial sectors, the following measures will be implemented:
    - Encourage the use of alternative energy and improve energy efficiency in existing buildings in the public and private sectors.
    - Promote the use of more energy efficient appliances and energy saving equipment in the residential and commercial sectors.
    - Launch the use of biodiesel (B 100) in rural communities.
- In the electricity sector, the following measures will be implemented:
    - Develop and expand the energy mix and supply sources through utilisation of the full energy potential of the country, including frontier exploration and development and intensive research on oil, natural gas, coal, hydropower, geothermal, energy efficiency and conservation, and new and renewable sources of energy.
    - Replace transformers and install capacitor banks in the main sub-stations. Optimise the voltage, conductor size, and loading of transformers.

2.4. The National Efficiency Policies

To reach a National Target for EEC plans and programmes, the government should implement the following actions:

- Disseminate knowledge about EEC to communities and encourage the use of local renewable energy resources instead of fossil fuels.
- Conduct workshops and seminars regarding EEC to increase public awareness.

- Market promotion of energy efficient equipment and labelling of energy saving appliances such as air-conditioners, motors and pumps, and electric appliances.
- Encourage the private sector to implement EEC programmes on a voluntary basis through recognition programmes.
- Provide financial assistance for transferring advanced technology.
- Adoption of best practices is an effective action plan for energy saving in the transport, residential, and commercial sectors.
- Consider EEC on both the demand and supply sides of electricity.
- Design proper policy measures and action plans to achieve energy savings targets.

2.5. Action Plan

The energy efficiency initiatives of Myanmar cover buildings, households, and the industrial and transport sectors. They are as follows:

Table 12-1. Energy Efficiency Initiatives

Sectors	Energy Efficiency Initiatives
Industrial	Promote the introduction of equipment and facilities with high-energy conservation capacity. Develop energy statistics Develop goals for voluntary action plans Develop R & D and AEMAS Program
Transportation	Raise fuel efficiency in terms of passenger-km, and km/litre, and Fuel substitution with biofuels
Electricity	Develop technology transfer and renewable energy, knowledge in rural areas Assist sustainable, renewable energy application in electricity generation
Household	Labelling systems for buildings and appliances Develop demand side management programmes Thorough management of energy and other resources

AEMAS = ASEAN Energy Manager Accreditation Scheme, R & D = Research and Development.
Source: Author's collection from various sources.

2.6. Alternative Policy Scenarios (APS)

In previous studies, two scenarios were formulated to analyse the impact of policy interventions on the energy sector. The BAU scenario, which serves as the reference case to project energy demand and CO_2 emission, 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 energy efficiency and conservation targets, expedite penetration of new and renewable energy and introduction of cleaner technology, including the option of using nuclear power plant. To better understand the impact of individual policy interventions, this year's study formulated five alternative policy scenarios:

1) APS1: Improved energy efficiency of final energy demand
2) APS2: Higher efficiency of thermal electricity generation
3) APS3: Higher contribution of new and renewable energy (NRE) (here NRE for electricity generation and biofuels in the transport sector are assumed)

4) APS4: Introduction or higher contribution of nuclear energy
5) APS5: Combined impact of scenarios APS1 to APS4.

In the case of Myanmar, there is no existing plan to introduce nuclear energy for power generation. As such, APS4 has not been considered in the analysis. Therefore, APS5 would consist only of APS1, APS2, and APS3.

3. Outlook Results

3.1. Business-as-Usual (BAU) Scenario

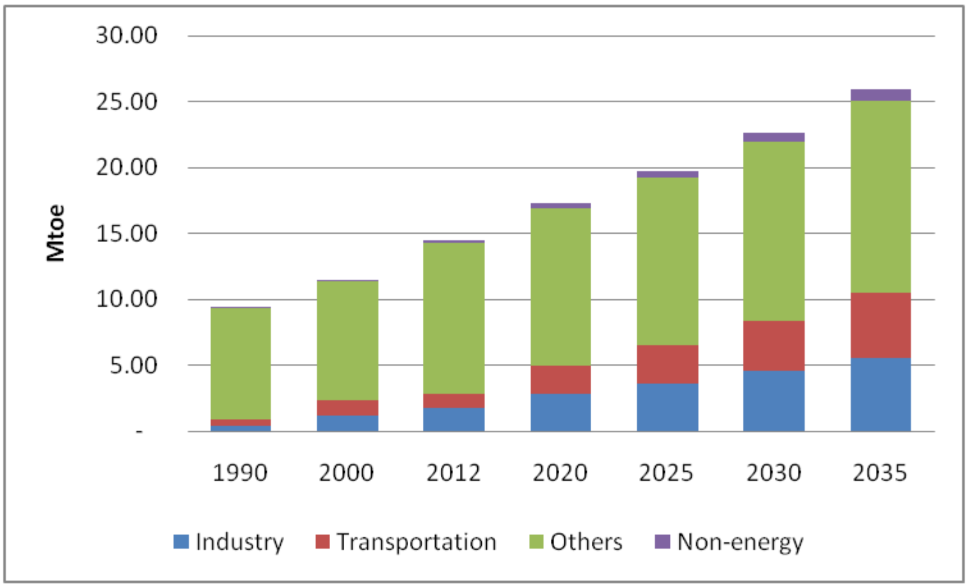
3.1.1. Final Energy Demand

Total final energy demand in Myanmar increased by about 2.0 percent per year on average, from 9.4 Mtoe in 1990 to 14.5 Mtoe in 2012. The industrial sector was the fastest growing sector with an average annual growth of 7.1 percent between 1990 and 2012. Consequently, the share of this sector in total final energy demand increased from around 4.2 percent in 1990 to 12.2 percent in 2012. The transport sector was the second fastest growing sector with an average annual growth rate of 4.1 percent over the same period and the share of this sector in total final energy demand increased from 4.7 percent in 1990 to 7.4 percent in 2012.

The others sector, which comprises the commercial, residential, and agricultural sectors, was the major contributor to total final energy consumption. The shares of this sector, however, declined, from 90.1 percent in 1990 to 78.8 percent in 2012. This indicates that annual growth of demand in this sector was slower than in the industry and transport sectors. The average annual growth rate of demand in the others sector was 1.4 percent between 1990 and 2012. Non-energy consumption grew gradually, at an average annual growth rate of 4.4 percent over the same period, from almost 0.1 Mtoe in 1990 to 0.24 Mtoe in 2012. Although the share of this sector in total demand was only 1 percent in 1990, it increased slightly, to 1.7 percent, in 2012.

Using the socio-economic assumptions stated above, final energy demand in Myanmar is projected to grow at an annual average rate of 2.6 percent under the BAU scenario, reaching 25.9 Mtoe in 2035. Final energy demand is projected to grow fastest in the transportation sector, at an annual average growth rate of 6.9 percent. In the industry and others sectors, energy demand is projected to grow at an annual average rate of 5.1 percent and 1.1 percent, respectively. The non-energy sector will grow at an average annual rate of 6.0 percent. Figure 12-1 shows final energy demand by sector to 2035 under the BAU scenario.

Figure 12-1. Final Energy Demand by Sector, BAU



Source: Author's calculation.

The respective growth of the sectors under the BAU scenario will result in a continuous increase in the shares of the transport, industrial, and non-energy sectors in total final energy demand and a decline in the others sector's share. The transport, industrial, and non-energy sector shares are projected to increase to 19.0 percent, 21.5 percent, and 3.6 percent, respectively, in 2035. The others sector's share will decline to 56.0 percent from 78.8 percent in 2012.

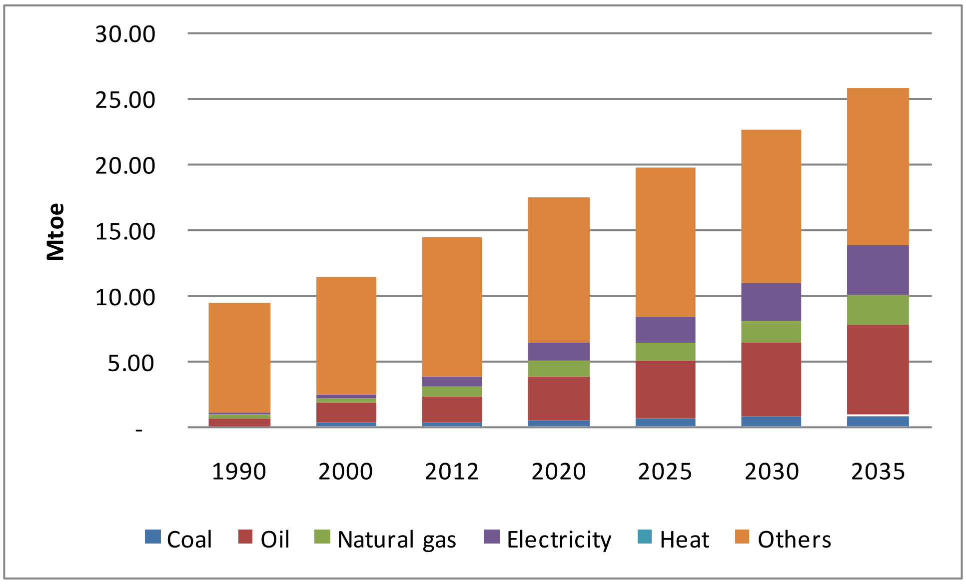
By fuel type, others, which is mostly biomass, consumed most fuel in 1990, having a share of 89.2 percent in Myanmar's total final energy demand. Its share decreased to 73.9 percent in 2012 due to higher growth of the other fuels. The demand for natural gas increased from 0.23 Mtoe in 1990 to 0.72 Mtoe in 2012, and that for electricity increased from 0.15 Mtoe to 0.71 Mtoe over the same period. Coal demand increased fastest, at an average growth rate of 8.4 percent per year from 1990 to 2012.

Under the BAU scenario, the share of other fuels is projected to decline to 46.7 percent in 2035, indicating that its future use will grow more slowly than the other fuels. In contrast, the share of oil will continue to increase and is expected to reach 26.8 percent in 2035 from 14.2 percent in 2012, with an average growth of 5.4 percent per year. This is due to the rapid increase of the transport sector's activities from 2012 to 2035. Figure 12-2 shows final energy demand by fuel type to 2035 under the BAU scenario. Coal and natural gas are projected to grow at an average annual growth rate of 4.9 percent and 5.0 percent, respectively, from 2012 to 2035; not as fast as oil (5.4 percent). Electricity demand will grow fastest, at an average annual growth rate of 7.5 percent during the same period. Its share will increase from 4.9 percent in 2012 to 14.6 percent in 2035.

3.1.2. Primary Energy Consumption

Primary energy Consumption in Myanmar grew at an average annual rate of 1.7 percent, from 10.7 Mtoe in 1990 to 15.6 Mtoe in 2012. Amongst the major energy sources, the fastest growing were hydro and coal with average annual growth rates of 9.8 percent and 9.4 percent, respectively.

Figure 12-2. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

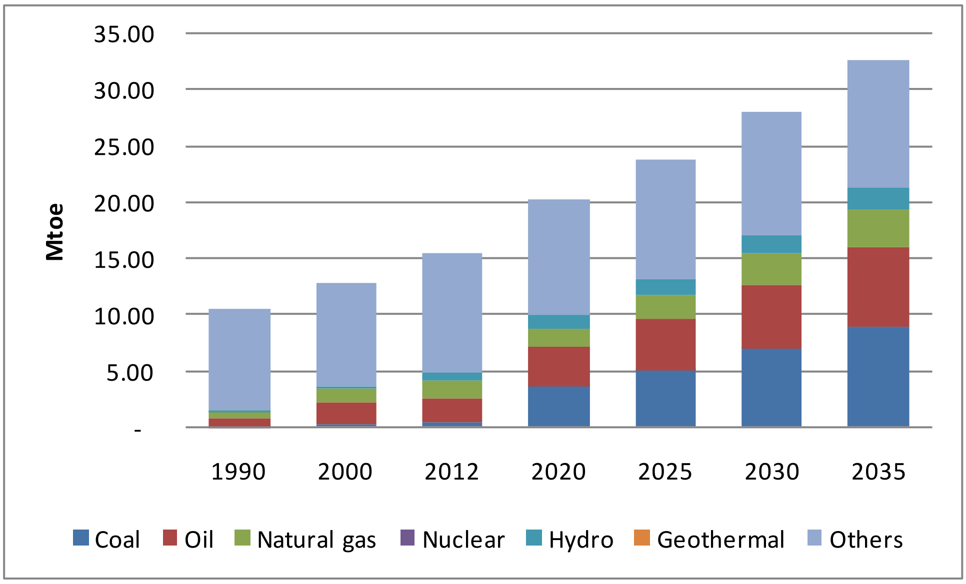
Natural gas consumption grew at an average annual rate of 3.5 percent over the same period and oil consumption at 4.9 percent. Others, such as biomass, dominated the primary energy consumption mix in 2012, with a share of 68.8 percent. Oil and natural gas, with respective shares of 13.4 percent and 10.3 percent, had the next largest shares of 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 3.3 percent per year to 32.8 Mtoe in 2035. Hydro and natural gas are expected to grow at average annual rates of 4.2 percent and 3.2 percent, respectively. Coal will grow faster, at 13.6 percent over the period 2012–2035 and oil will grow at 5.4 percent per year.

The share of oil and hydro in the total primary energy mix of Myanmar are projected to increase, to 21.4 percent and 6.4 percent, respectively in 2035. The share of coal will also increase, from 3.1 percent in 2012 to 27.5 percent in 2035. The share of natural gas will remain more or less the same at around 10 percent in over the projection period. Notably, the share of biomass is expected to decrease due to its slow growth driven only by the growth of the rural population – from 68.8 percent in 2012, its share will decline to 37.1 percent in 2035.

Under the BAU scenario, oil-based power plants will cease operation by 2035 and natural gas-based power plants' share will decrease to around 6 percent during the same year. Consequently, the role of coal-based power plants will grow – the share of electricity generated from coal-based power plants will increase to 51.6 percent in 2035. Hydro will continue to dominate the power sector fuel mix, but with a reduced share of 42.5 percent in 2035, from 76.1 percent in 2012.

Figure 12-3. Primary Energy Consumption by Source, BAU

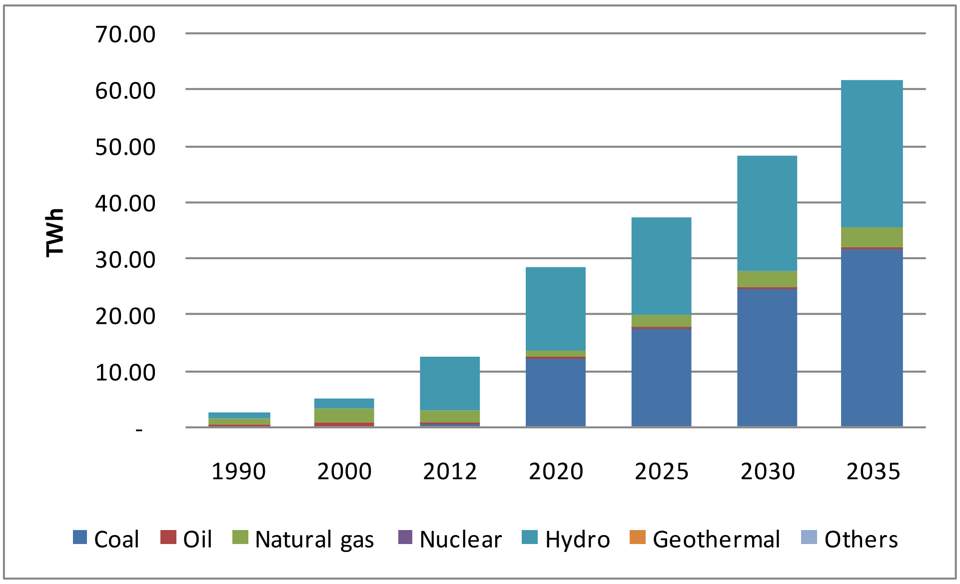


BAU = Business-as-Usual.
Source: Author's calculation.

3.1.3. Power Generation

Hydro and natural gas dominated the power sector fuel mix in Myanmar. In 2012, the share of hydro in the power generation mix reached 76.1 percent and the share of natural gas was 17.3 percent. The remaining fuels (coal and oil) accounted for only 6.6 percent of the total generation mix.

Figure 12-4. Power Generation Mix-BAU Case



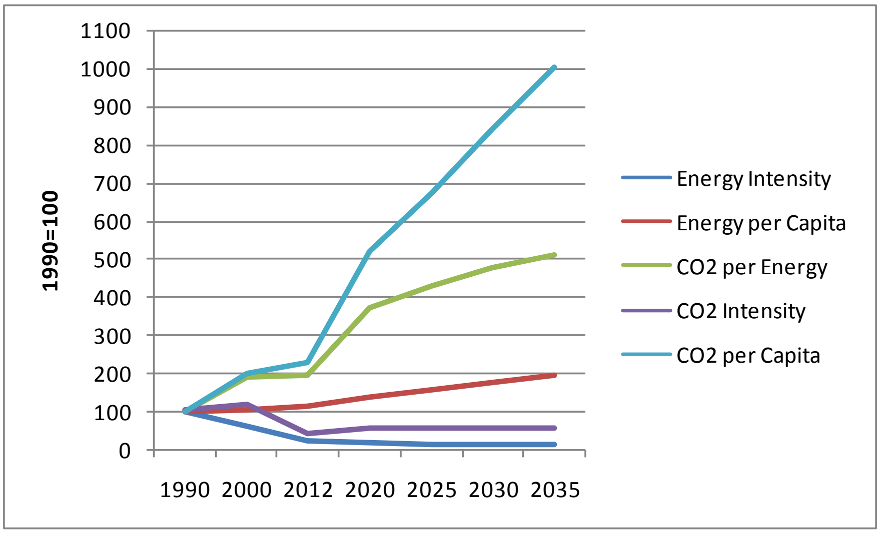
BAU = Business-as-Usual.
Source: Author's calculation.

Total electricity generation from the different plants is projected to grow at an average annual rate of 7.2 percent and coal-based power plants will grow at an average annual rate of 17.6 percent. Hydro power generation will also increase, at an average annual rate of 4.5 percent from 2012 to 2035, and natural gas based power plants are expected to grow at 2.3 percent.

3.1.4. Energy Intensity, Energy per Capita, and Energy Elasticity

Myanmar's primary energy intensity (TPES/GDP) has been declining since 1990. In 2012, primary energy intensity was 676 toe/million 2005 US$, lower than in 1990 when it was 3,243 toe/million 2005 US$. The intensity is projected to continue to decrease, to 335 toe/million 2005 US$ by 2035, at an average rate of 3.0 percent per year. Energy consumption per capita grew from 0.25 toe in 1990 to 0.30 toe in 2012, and will increase to 0.50 by 2035, at an average annual growth rate of 2.3 percent. CO_2 intensity was 334 t-C/million 2005 US$ in 1990 and decreased to 137 t-C/million 2005 US$ in 2012. CO_2 intensity is projected to increase to 177 t-C/million 2005 US$ in 2035, at an average annual growth rate of 1.1 percent. Figure 12-5 shows the evolution of these energy indicators from 1990 to 2035.

Figure 12-5. Energy Intensity, CO_2 Intensity, and Energy per Capita



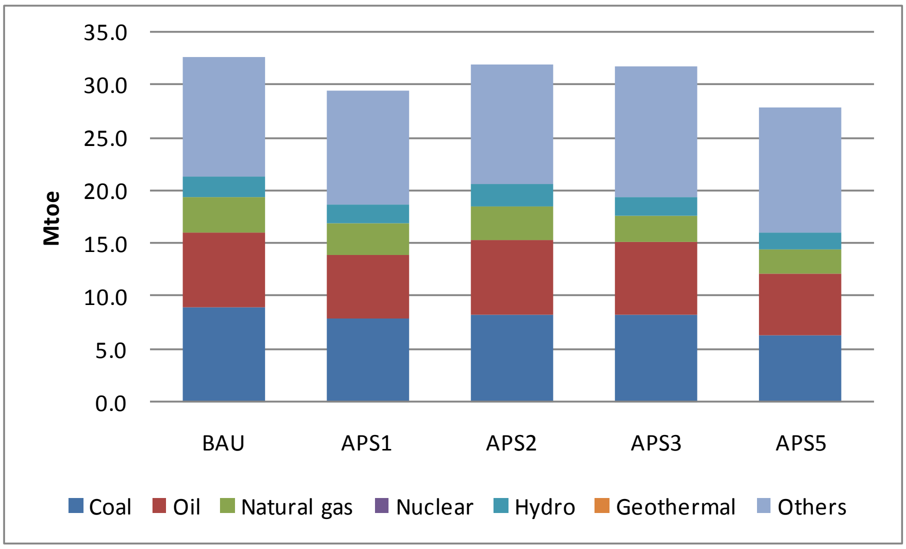
Source: Author's calculation.

3.2. Energy Saving 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 supply in all the scenarios.

In Figure 12-6, APS5 has the largest reduction in total primary energy consumption due to the implementation of energy efficiency and conservation (EC) action plans, improvement of thermal efficiency of fossil-fuelled power plants, and higher penetration of new and renewable energy in the country's supply mix.

Figure 12-6. Total Primary Energy Supply, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

The average annual growth rate of total primary energy supply under the APS5 will be around 2.6 percent over the projection period and coal will see the fastest growth, at 11.9 percent. In 2035, the reduction of primary energy consumption in APS5 as compared with the BAU scenario will be 4.9 Mtoe, or 15.0 percent. This reduction will be mainly due to a reduction in the use of coal (29.2 percent). Individually, implementation of only the energy efficiency targets and masterplan as defined in APS1, will reduce Myanmar's total primary energy consumption by only 3.3 Mtoe (10.1 percent) in 2035 compared with the BAU scenario. By fuel type, the main contributor to this reduction will also be the use of coal (almost 12 percent). The average annual growth rate of primary energy consumption in APS1 will be 2.8 percent, slightly faster than APS5, and with coal also seeing the fastest growth.

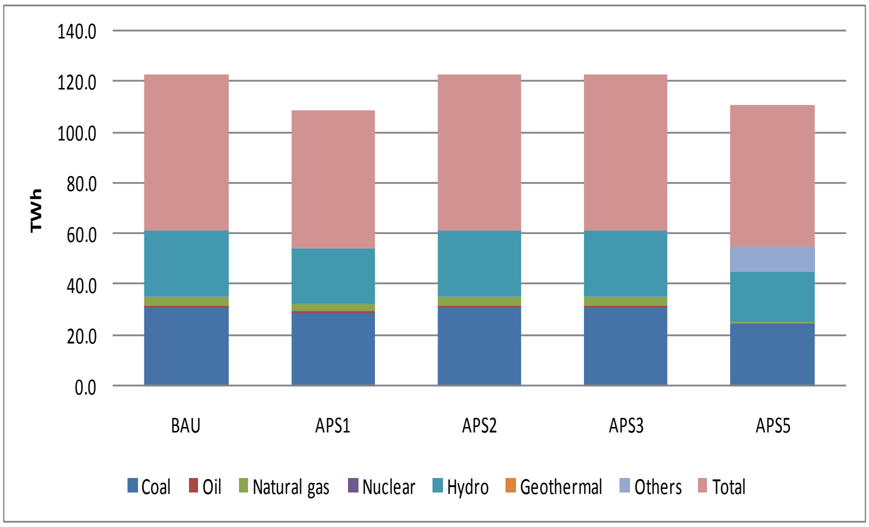
APS2, which assumes higher efficiency in thermal electricity generation, will reduce total primary energy supply by 0.7 Mtoe or 2.2 percent compared with the BAU scenario. The country's total primary energy supply under APS2 will grow at an annual average rate of 3.2 percent, reaching 32 Mtoe in 2035. Since no final energy demand efficiency measures were assumed for APS2, the impact on the primary energy supply will be lower than under 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, resulting in a higher reduction of coal use by almost 8 percent in 2035.

If policy for higher penetration of new and renewable energy (NRE) is implemented, there will also be a reduction in total primary energy consumption compared with BAU, but only by 0.89 Mtoe or 2.7 percent. By fuel type, coal and natural gas consumption will decline, but the use of 'others' fuel, consisting of biofuels and other NRE, is projected to increase (9 percent).

The impacts of implementing policy intervention APS3 will also be reflected in Myanmar's power generation. Figure 12-7 shows total electricity generation in 2035 in all scenarios. Under APS1, due to lower electricity demand, power generation will also be reduced, by 7 Mtoe or 11 percent compared with BAU. The reduction will be from natural gas, coal, and hydro plants; with the highest reduction expected for hydro power plants (16.3 percent).

Under APS3, the total amount of electricity generated will be similar to the BAU scenario because no efficiency measures was also imposed on the final sector. The differences, however, lie in the fuel mix for power generation. More 'others' renewable power plants such as solar, wind, biomass, etc., will be in operation over the projection period, replacing the fossil-fuelled power plants, (natural gas–fuelled plants), which are supposed to be in operation up to 2035.

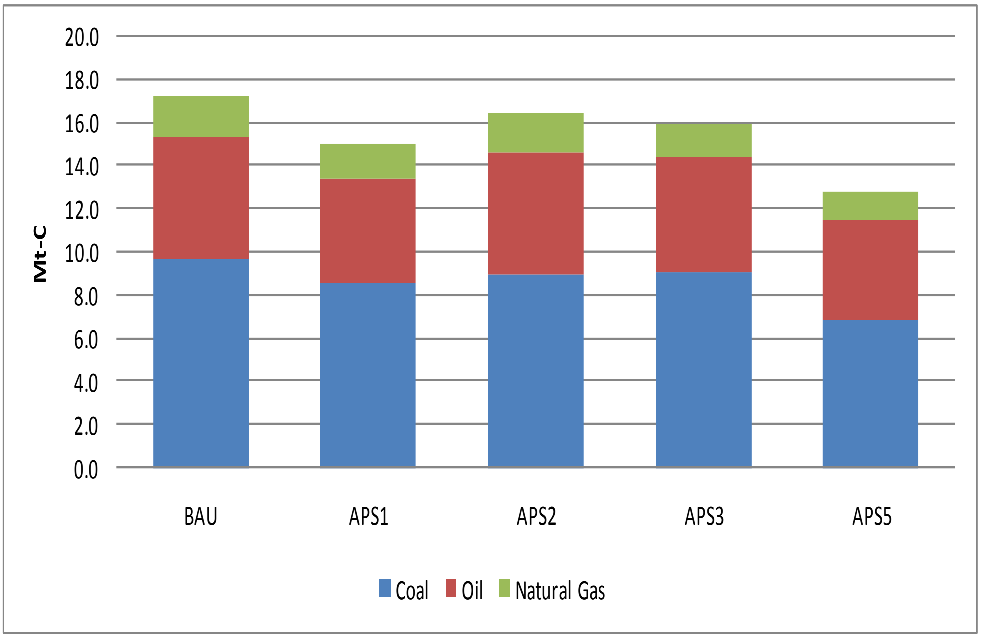
Figure 12-7. Electricity Generation, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In terms of CO_2 emission reduction, the energy efficiency assumption in APS5 is expected to reduce emissions most, by around 4.4 million metric tonnes of carbon (Mt-C), or 25.7 percent lower than under the BAU scenario. The decrease in CO_2 indicates that the energy saving goals, action plans and policies to promote the government's programmes, 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 2035 under all scenarios.

Figure 12-8. CO_2 Emission, All Scenarios, 2035



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In APS1, total final energy demand will be lower, so that CO_2 emissions from energy consumption will also be lower, reaching around 15 Mt-C. This is a reduction of CO_2 emission by around 2.2 Mt-C, which is 13.0 percent lower than under the BAU scenario. In APS3, higher contributions from renewable energy could reduce emissions by 8.0 percent compared with the BAU scenario. Total CO_2 emissions under APS3 will be around 15.9 Mt-C, which is around 1.3 Mt-C lower than for BAU. The decrease in CO_2 indicates that increasing renewable energy shares in total supply will reduce CO_2 emissions, although not by as much as under APS1 or APS5.

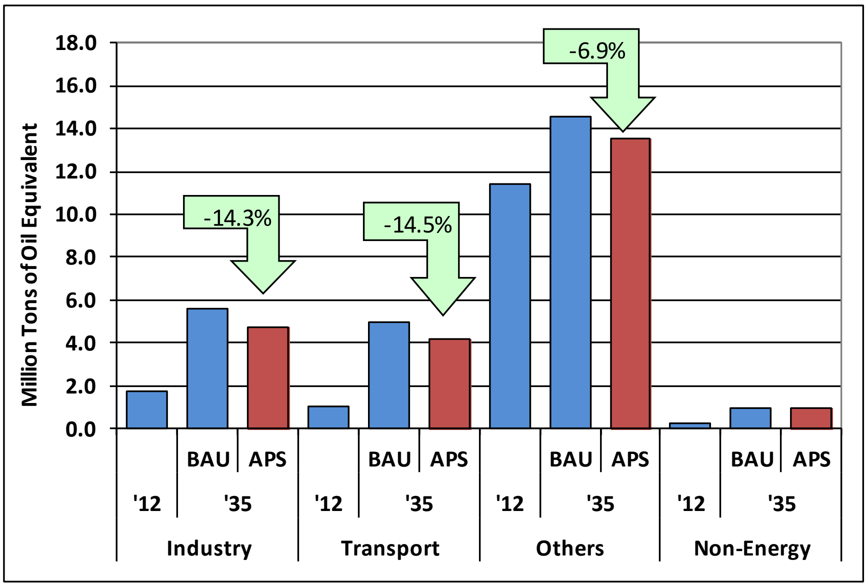
3.2.1. Final Energy Demand

In the APS, which is the combined APS (APS5), growth in final energy demand is projected to be lower, at an average annual rate of 2.1 percent compared with the 2.6 percent annual growth under the BAU scenario. The reason for the slower growth rate is technological improvements in manufacturing processes and the reduction in final energy demand of electricity and oil in the residential and commercial (other) sector. Figure 12-9 shows the differences in final energy demand in 2035 by sector in the BAU scenario and the APS.

Primary Energy Consumption

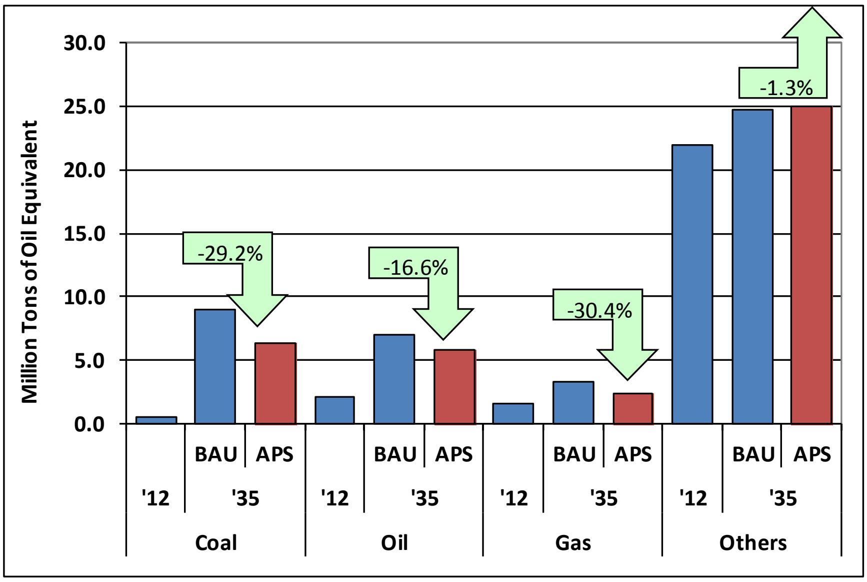
In the APS, Myanmar's primary energy consumption is projected to increase at a slightly lower rate than under the BAU scenario, at 2.6 percent per year, from 15.3 Mtoe in 2012 to 27.8 Mtoe in 2035. Coal will be the fastest growing, at 11.9 percent per year, followed by oil at 4.6 percent per year, between 2012 and 2035. Natural gas is expected to grow at an average annual rate of 1.6 percent over the same period, lower than hydro, which is expected to grow at 2.9 percent per year. Figure 12-10 shows primary energy consumption by source in 2035 under the BAU scenario and APS.

Figure 12-9. Final Energy Demand by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 12-10. Primary Energy Consumption by Source, BAU and APS



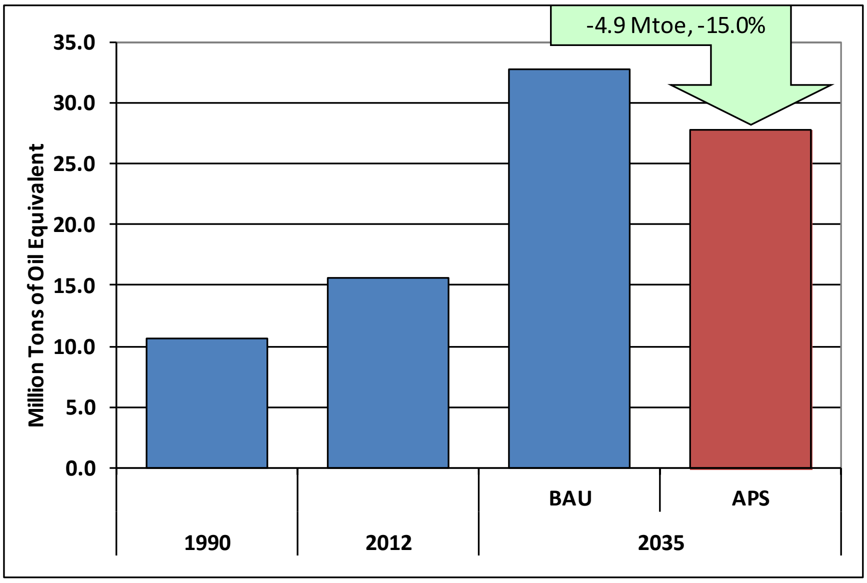
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Projected Energy Savings

In Myanmar, commercial energy consumption is projected on the basis of energy requirements of the major sectors (industry, transport, agriculture, and households). The choice of fuel type is determined by available supply, since energy demand has to be met mainly from domestic sources. Obviously, there is a gap between demand and supply, but on the other hand, demand is much higher than the actual requirement. Due to these constraints, coefficients, derived from time series regression, had been applied to allocate energy. These allocations are made in accordance with the priority of the State organisations and enterprises. For the private sector, allocations are made in accordance with the registered licensed capacity of the firm in question.

Future energy savings could result from savings in primary energy consumption in the residential, commercial, transportation, and industrial sectors. In this regard, Myanmar has implemented a range of energy efficiency and conservation goals and action plans, which target energy savings in all sectors of the economy and in cooperation with both the private and public sectors. There is an estimated saving of 4.9 Mtoe in 2035 in the APS, relative to the BAU scenario. This is equivalent to a 15 percent saving on primary energy consumption in 2035 under the BAU scenario (Figure 12-11). Myanmar has plans to decrease the growth in primary energy consumption by implementing a range of energy efficiency and conservation measures on the demand side.

Figure 12-11. Evolution of Primary Energy Consumption, BAU and APS

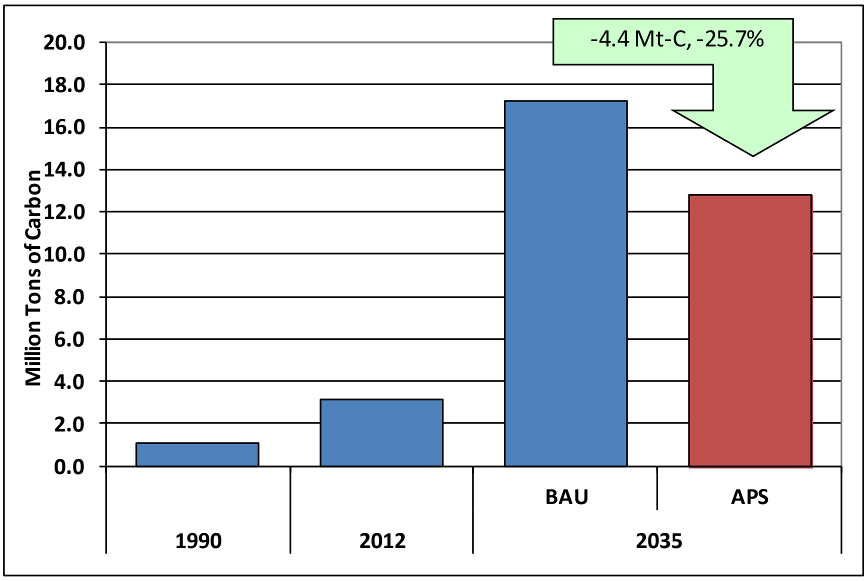


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

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 2035, in the APS, CO_2 emissions from energy consumption are projected to reach about 4.4 million tonnes of carbon (Mt-C), which is about 25.7 percent below the BAU level (Figure 12-12).

Figure 12-12. CO_2 Emission from Energy Consumption, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Conclusions and Policy Implications

Although energy intensity will decline, energy consumption is still increasing due to economic, population, and vehicle population growth. Myanmar should increase adoption of energy efficient technologies to mitigate growth in energy consumption and should also diversify energy availability. The energy saving programme will target the residential, commercial, transport, and industry sectors.

In this regard, the following proposed actions could be considered:

- An integrated national energy policy including energy efficiency should be formulated by the National Energy Management Committee (NEMC).
- Coordination mechanisms, institutional arrangements, and a legal framework need to be adopted.
- Better energy statistics would be needed for better analysis of energy saving potential in Myanmar.
- Myanmar needs to conduct a demand-side survey on energy consumption, which can be done by combining this survey with existing surveys.
- Given the continuing dominance of the transport sector in final energy consumption, an energy efficiency target should be set for the transport sector in addition to those that have already been set for the industrial, commercial, and household sectors.
- A detailed policy mechanism for the renewable energy sector should be established to implement the potential programmes and projects. This mechanism should be developed and planned in conjunction with external stakeholders, who can offer experience, advanced technologies, new markets, and investment.
- Energy management practices in the industrial and commercial sectors should be

improved.

- A dedicated energy efficiency body needs to be established to oversee Myanmar's EE programme.
- The current EE targets need to be refined to include all sectors' numerical targets and detailed action plans.
- Myanmar needs to 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.
- As the electrification rate remains low, the government needs to formulate schemes to increase private participation, including by foreign companies, to accelerate power sector development including transmission and distribution system to ensure a reliable electricity supply to consumers.
- The National Energy Management Committee (NEMC) should formulate a renewable energy policy to encourage the private sector and foreign investors to invest in renewable energy.
- NEMC should set specific targets for each sector on energy efficiency and the government should enforce implementation to achieve these targets.
- Consider the import of LNG in floating terminals for the short-term to meet the projected rapid growth of electricity demand while new domestic natural gas resources are being undertaken.
- Consider a civilian nuclear energy policy and exploration of geothermal energy potential for electricity generation.
- As biomass consumption is increasing continuously, the government should remove taxes on LPG and kerosene to reduce expenses in the residential sector.
- Encourage private companies to invest in new refinery capacities to meet domestic demand for petroleum products.

CHAPTER 13

New Zealand Country Report

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1. Background

New Zealand is an island country in the south-western Pacific Ocean. It is located some 1,500 km east of Australia. It consists of two main islands (the North Island and the South Island), and a number of smaller, mostly uninhabited outer islands. The land area is approximately 269,000 square kilometres, 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 4.47 million at the end of 2013. Although there is some light and heavy industry, foreign trade is heavily dependent on agriculture, tourism, forestry, and fishing. In 2013, New Zealand had a nominal gross domestic product (GDP) of about US$171.0 billion, or about US$38,200 per capita. Whereas the latter figure is near the average of Organisation for Economic Co-operation and Development (OECD) countries, New Zealand tends to be ranked highly in international quality-of-life surveys.

New Zealand 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, but it meets most of its oil demand through imports. Energy remaining reserves include 116.6 million barrels of oil (P90) and 56.4 billion cubic metres (BCM) of natural gas (P90), as well as in-ground resources of over 15 billion tonnes of coal, 80 percent of which are South Island lignites.

In 2012, New Zealand's total primary energy demand was around 20.1 million tonnes of oil equivalent (Mtoe). By source, oil represented the largest share at about 33 percent. Natural gas and geothermal energy were second largest, contributing around 21 percent and 19 percent, respectively. The remainder of demand were hydro at 10 percent, coal at 8 percent, biomass with 8 percent, and a smaller percentage of other renewables such as wind and solar PV.

Final energy demand was about 13.9 Mtoe in 2012. By sector, the transport sector had the largest share at around 35 percent because New Zealand heavily depends on private road vehicles, road freight, and air transport. The share of the industrial sector was the second largest at about 33 percent, whereas the agricultural, residential, and commercial sectors had a joint share of 25 percent. The balance of 7 percent was consumed by the non-energy sector.

Total gross power generation output in 2012 was about 44.3 TWh. Hydro accounted for about 52 percent as the most utilised source, whereas natural gas represented the second most utilised source at over 20 percent. The third most utilised source was geothermal power at about 14 percent and the remainder were coal at 8 percent and other renewables at 6 percent. Oil is used in electricity generation only as a minor source peaking supply.

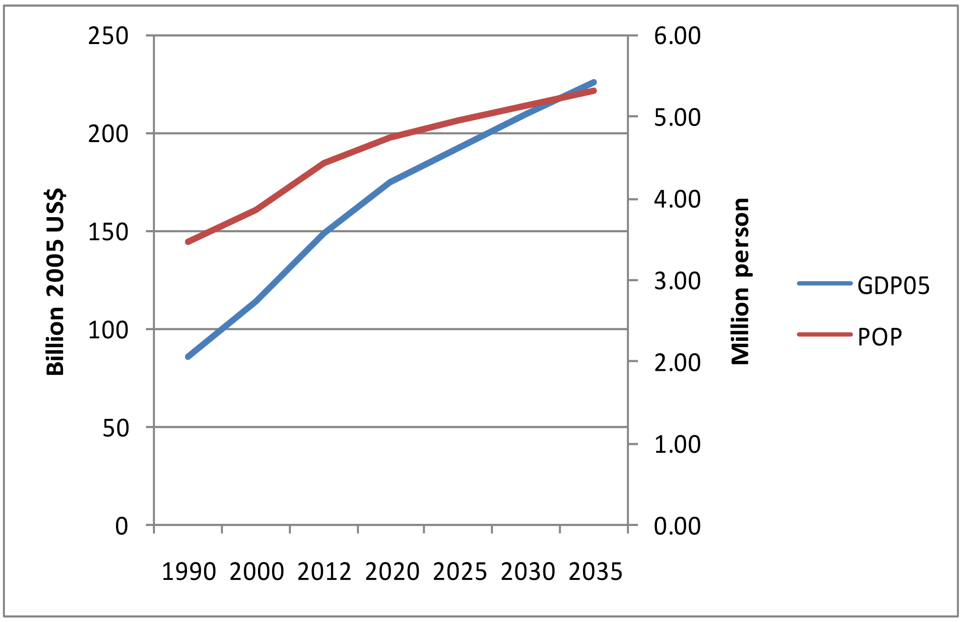
2. Modelling Assumptions

In this outlook, New Zealand's GDP is assumed to grow at an average annual rate of 1.8 percent between 2012 and 2035. The population is projected to increase by about 20 percent to 5.33 million by 2035, from 4.47 million in 2012. See Figure 13-1.

In the Business-as-Usual (BAU) scenario, hydro use in power generation will remain constant, although most hydro sites have already been developed. Generation from coal- and natural gas–based plants will decrease at an annual average rate of 2.1 percent and 0.2 percent, respectively. In contrast, geothermal power generation will increase at an annual average growth rate of 3.5 percent and wind generation will continue to grow, but it will still contribute only a small share on New Zealand's electricity by 2035 (Figure 13-2).

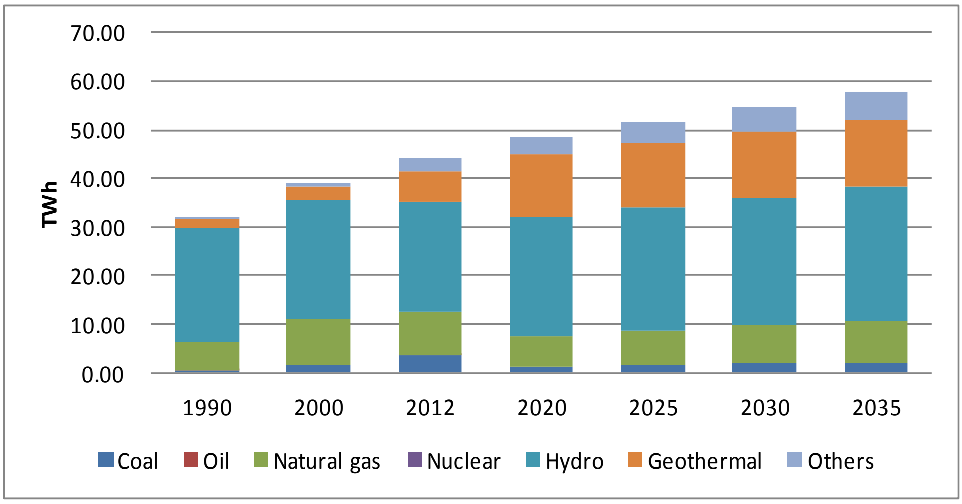
Thermal efficiency for coal-, gas-, and oil-fired power plants may not increase so much in the future, because new large fossil-fuelled plants are not planned.

Figure 13-1. GDP and Population



GDP = gross domestic product; POP = population.

Figure 13-2. Power Generation – BAU



BAU = Business-as-Usual.

In terms of energy demand, the overall energy intensity of the economy improved in real terms by an annual average rate of 0.8 percent from 1990 to 2012.

On the supply side, new gas discoveries are assumed at an average of 60 petajoules per year (PJ/year) – about 1.6 BCM – with production from new discoveries starting in 2012.

The New Zealand government implemented an emissions trading scheme in 2010 and has set a target for 90 percent 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 for the development and deployment of sustainable energy technologies.

3. Outlook Results

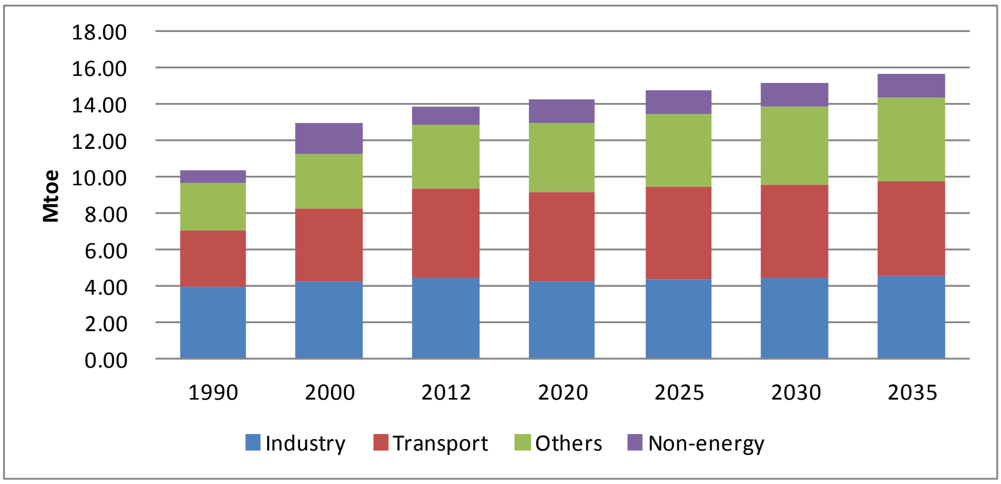
3.1. Total Final Energy Consumption

New Zealand's final energy consumption grew at an annual average rate of 1.3 percent per year from 10.4 Mtoe in 1990 to 13.9 Mtoe in 2012. Oil increased from 3.91 Mtoe to 5.87 Mtoe and electricity rose from 2.48 Mtoe to 3.37 Mtoe over the same period. But coal declined from 0.70 Mtoe to 0.59 Mtoe and natural gas decreased from 1.62 Mtoe to 1.45 Mtoe from 1990 to 2012.

3.1.1. Business-as-Usual (BAU) Scenario

In the BAU scenario, final energy consumption from 2012 to 2035 is projected to grow by 1.8 Mtoe at an average annual rate of 0.5 percent. The 'others' sector (agricultural, residential, and commercial) is projected to see the largest rise, of 1.0 Mtoe, between 2012 and 2035, at an average annual growth rate of 1.1 percent. Transport sector consumption is projected to increase by 0.4 Mtoe at an annual average rate of 0.4 percent and the industry sector is projected to increase slightly, by 0.1 Mtoe in 2035. Non-energy sector consumption will rise by 0.3 Mtoe, at an average annual rate of 1.1 percent (Figure 13-3).

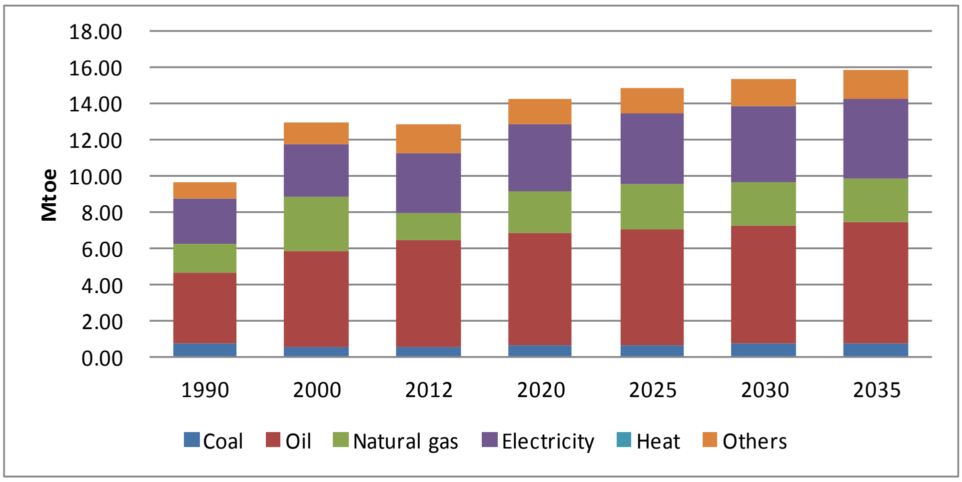
Figure 13-3: Final Energy Consumption by Sector – BAU



BAU = Business-as-Usual.
Note: 'Others' sector includes the agricultural, residential, and commercial sectors.
Source: Author's calculation.

By source, final consumption of electricity will steadily increase, by 1.0 Mtoe between 2012 and 2035, at an average rate of 1.1 percent per year. Final consumption of oil will also rise, by 0.8 Mtoe, at an average rate of 0.6 percent. Natural gas and coal will increase by 1.0 Mtoe and 0.2 Mtoe at 2.3 percent and 1.2 percent, respectively, whereas other renewables such as wind and biomass will decrease slightly from 2102 to 2035 (Figure 13-4).

Figure 13-4. Final Energy Consumption by Source – BAU

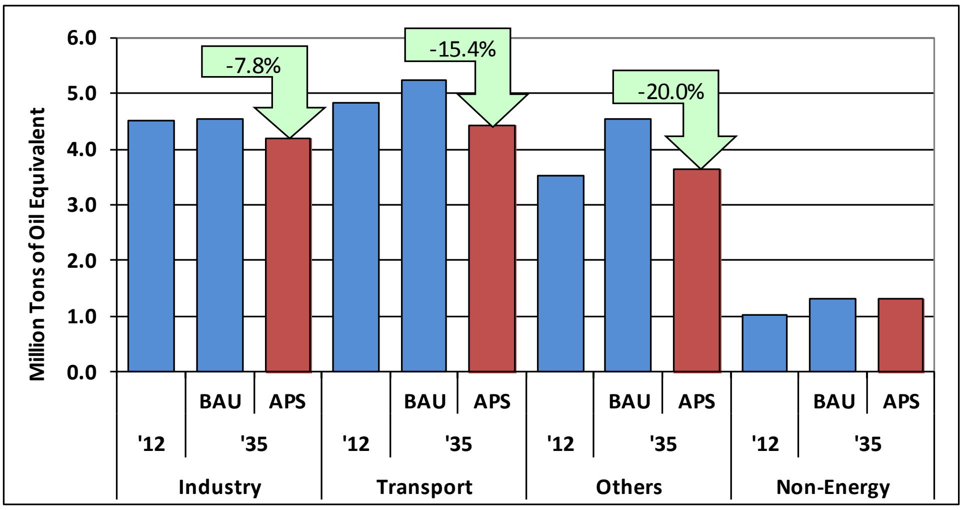


BAU = Business-as-Usual.
Source: Author's calculation.

3.1.2. Alternative Policy Scenario (APS)

In the Alternative Policy Scenario (APS), final energy consumption will decrease slightly in 2035. The projected decrease in final energy consumption will be 0.3 Mtoe between 2012 and 2035. Energy use in the 'others' sector will increase at an average rate of 0.1 percent per year, reflecting increased use of efficient appliances in the residential and commercial sectors. Energy use in the industrial sector will decrease at an annual average rate of 0.3 percent. Furthermore, energy use in the transport sector will decline at an average of 0.4 percent, reflecting a shift to more energy efficient vehicles, particularly electric vehicles. Sectoral final energy consumption in 2012 and 2035 in the BAU scenario and the APS is shown in Figure 13-5.

Figure 13-5. Final Energy Consumption by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Alternative Policy Scenario of the Institute of Energy Economics, Japan (IEEJ).

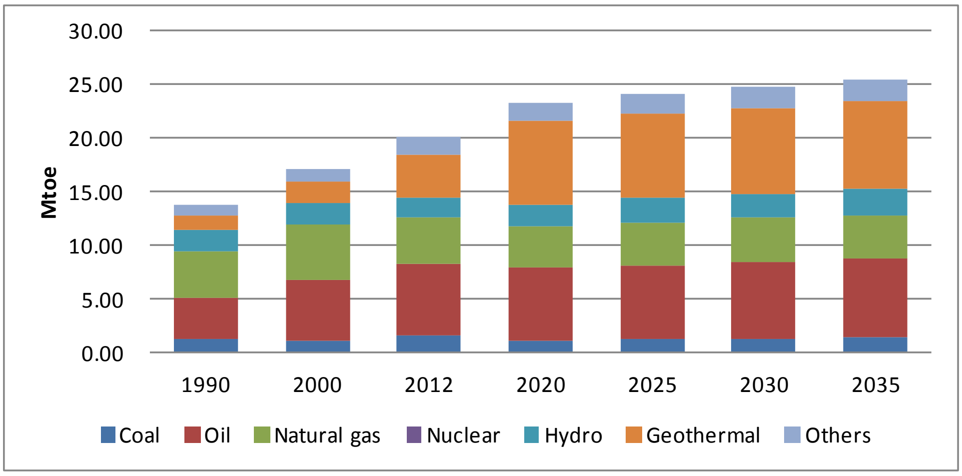
3.2. Primary Energy Demand

Primary energy demand in New Zealand grew at a rate of 1.7 percent per year from 13.8 Mtoe in 1990 to 20.1 Mtoe in 2012. The fastest growing primary fuel in absolute terms was oil, rising from 3.8 Mtoe in 1990 to 6.6 Mtoe in 2012. The increase in oil demand is due to rapid growth in transport energy demand. Coal demand also increased, at an annual average growth rate of 1.3 percent, whereas natural gas demand was almost unchanged from 1990 to 2012, reflecting a decrease in gas production from the Maui gas field. Geothermal energy use grew from 1.5 Mtoe in 1990 to 3.9 Mtoe in 2012, at an average annual rate of 4.5 percent for electricity generation, whereas hydro demand for electricity production decreased slightly, at an average rate of 0.1 percent per year. 'Others' energy sources, which include biomass, solar, and wind, increased at 2.6 percent per year.

3.2.1. Business-as-Usual (BAU) Scenario

In the BAU scenario, New Zealand's primary energy demand is projected to grow at an average annual rate of 1.0 percent per year, to 25.5 Mtoe in 2035 from 20.1 Mtoe in 2012. To the incremental growth of primary energy demand between 2012 and 2035, geothermal energy contributes the most, and is estimated to account for 32.5 percent of total primary energy demand in 2035. 'Others' primary energy will grow by 0.6 percent per year on average, mainly reflecting an expected growth in wind power, so it will account for 7.8 percent of the total. Primary fossil fuel will slightly increase, at an average annual rate of 0.1 percent, and its share of the total will account for 50.4 percent in 2035, down from a 62.4 percent share in 2012. The remaining 9.3 percent of the total share in 2035 will be hydro for electricity generation, increasing at annual average growth rate of 0.8 percent over the projection period (Figure 13-6).

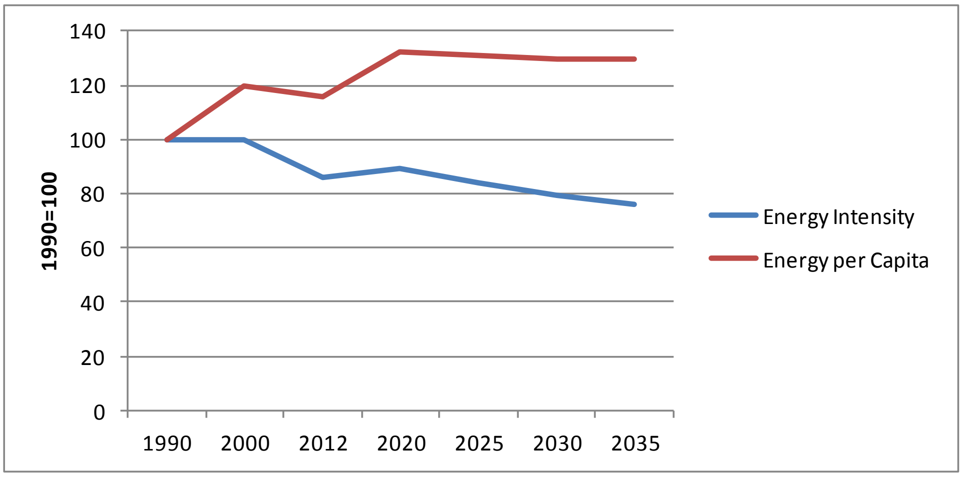
Figure 13-6. Total Primary Energy Demand and its Composition – BAU



BAU = Business-as-Usual.
Source: Author's calculation.

The lower projected growth of primary energy demand relative to GDP growth will result in lower energy intensity in the future. From 136 toe/million US$ in 2012, energy intensity will improve to 113 toe/million US$ in 2035. Primary energy demand per capita, however, is expected to increase from 4.54 toe per person in 2012 to 4.78 toe per person in 2035. Figure 13-7 shows primary energy intensity and energy per capita as indicators.

Figure 13-7. Primary Energy Intensity & Energy per Capita Indicators – BAU

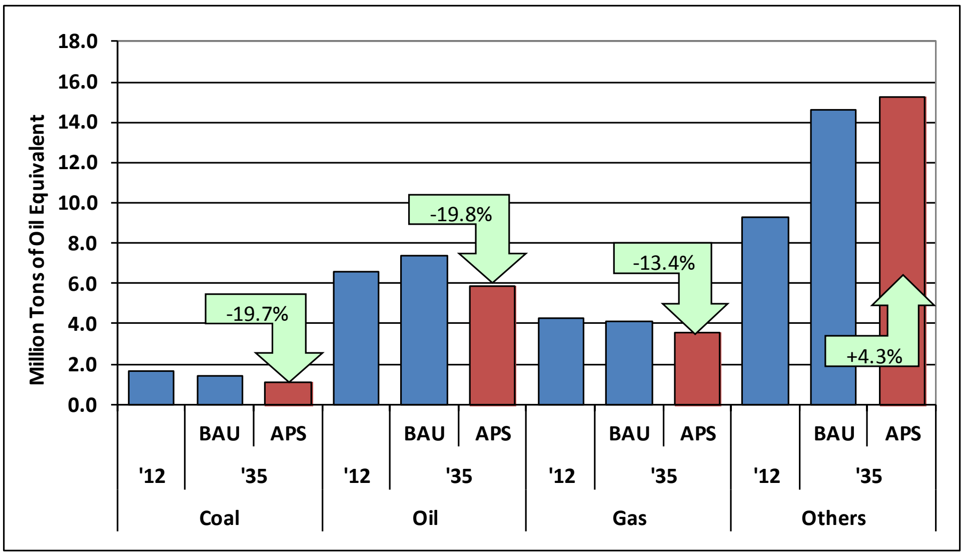


BAU = Business-as-Usual.

3.2.2. Alternative Policy Scenario (APS)

In the APS, primary energy demand is projected to grow at a lower rate of 0.8 percent per year to 24.0 Mtoe in 2035. Coal, oil, and gas are expected to show significant declines, of 1.7 percent, 0.5 percent, and 0.8 percent per year, respectively. Whereas geothermal primary energy is expected to grow by 3.9 percent per year (like in the BAU), 'Others' primary energy, which includes wind and biomass, is expected to grow by only 0.3 percent per year (Figure 13-8).

Figure 13-8. Primary Energy Demand by Source, BAU and APS



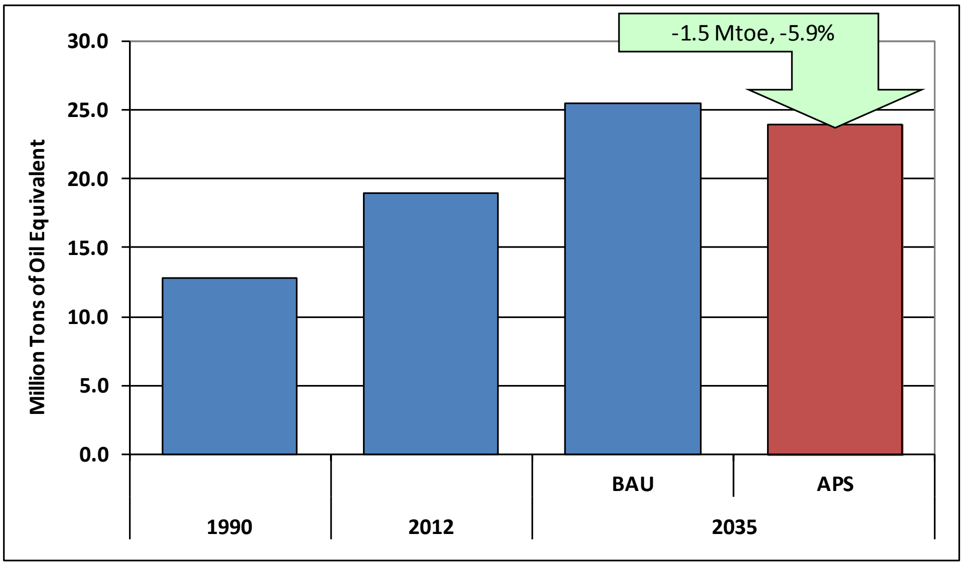
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Note: 'Others' source includes hydro and geothermal.
Source: Alternative Policy Scenario of the Institute of Energy Economics, Japan (IEEJ).

3.3. Projected Energy Savings

Under the APS, energy savings could amount to 1.5 Mtoe in 2035, the difference between primary energy demand under the BAU scenario and the APS, which is 5.9 percent less under the APS in 2035 (Figure 13-9).

The savings in primary energy are mainly due to a switch in automobiles 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.

Figure 13-9. Total Primary Energy, BAU and APS



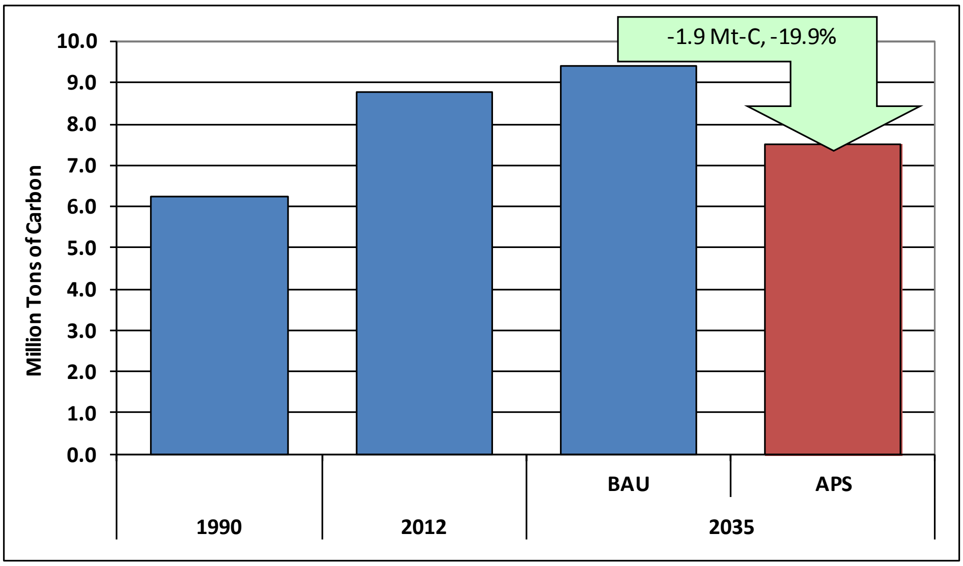
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Alternative Policy Scenario of the Institute of Energy Economics, Japan (IEEJ).

3.4. CO_2 Emissions

Carbon dioxide (CO_2) emissions in the BAU scenario will increase by 0.3 percent on average per year, from 8.8 million tonnes of carbon (Mt-C) in 2012 to 9.4 Mt-C in 2035.

In the APS, CO_2 emissions will decrease from 2012 to 2035, or by 0.7 percent per year. Since primary energy demand, excluding geothermal, is expected to be more or less stable over this period, the decrease reflects a switch to renewable energy in electricity generation, and the switch in automobiles to electric vehicles in the transport sector. Figure 13-10 shows the difference in CO_2 emissions from energy consumption between the BAU scenario and the APS in 2035 compared with 1990 and 2012.

Figure 13-10. CO_2 Emissions as Carbon from Energy Consumption, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Alternative Policy Scenario of the Institute of Energy Economics, Japan (IEEJ).

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 still grown 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-fuelled generation. Their trading will incentivise investment in new renewable generation technologies, with geothermal and wind particularly as prospective options, provided CO_2 trading prices rise above current levels. As the Acting Minister of Energy and Resources released on the 30th of August in 2011, New Zealand's ambitious goal of achieving its target of 90 percent of electricity generation from renewable sources by 2025 would be achieved if the power generation companies and operators stop using fossil fuels and replace them with renewables. New Zealand's large base of renewable generation, however, limits the room for CO_2 emissions reduction in the electricity generation sector.

New Zealand has some other opportunities to improve energy efficiency, for example, through upgrading inefficient vehicles, reducing the amount of poorly-insulated buildings, and extending biomass use in industry. Actually, there are significant potential energy savings in the transport sector. Growth in energy consumption in the transport sector slowed in recent years, mainly because of high fuel prices and a shift to smaller vehicles. Furthermore, reductions in emissions from the transport sector are 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 relatively short average trips. Also charging infrastructure already exists in most residential dwellings. Stronger regulation of new buildings in the residential and commercial sectors, to enhance their energy efficiency, should also be considered. Some of the regulations might also be applied to existing buildings along with some remedies to reduce CO_2 emissions, such as subsidies for installing wind or solar PV, where the economics make good fiscal sense.

CHAPTER 14

Country Report of the Philippines

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1. Background

1.1. Socio-economic Background

The Philippines, officially known as The Republic of the Philippines, with Manila as its capital city, is an archipelago comprising 7,107 islands. The country is located in the midst of Southeast Asia's main water bodies, namely, the South China Sea, the Philippine Sea, the Sulu Sea, and the Celebes Sea.

In 2012, the Philippine economy posted a 6.8 percent growth rate, year-on-year, up from 3.6 percent in 2011. The growth of the economy was largely due to vigorous economic activity in the services and industrial sectors during this period, which posted annual growth rates of 7.6 percent and 6.8 percent, respectively. The increase in service sector activity could be attributed to robust domestic trade and a boom in real estate businesses. The increase in the industrial sector was driven by double digit growth in the construction business, at 15.7 percent. Meanwhile, agriculture, hunting, forestry, and fishing registered a 2.8 percent increased during the period. Gross domestic product (GDP) per capita was US$1,500 in 2012.

1.2. Policy

Notwithstanding the fact that fossil fuels contribute significantly to the country's primary energy supply, the Department of Energy (DOE) of the Philippines is adopting use of clean, green, and sustainable sources of energy for its long-term energy security strategy. The country's long-term national energy plan ensured that the immediate need for energy is met while making sure that it will not cause damage to people and the environment. A target of a 60 percent self-sufficiency level as part of the country's energy security goal will ensure the development of indigenous energy such as renewable energy and hydrocarbon fuels (oil, gas, and coal). In particular, renewable energy sources like geothermal, wind, biomass, ocean, and alternative fuels like biofuels and compressed natural gas (CNG), are expected to augment the country's energy requirement.

Another key component of the country's energy security strategy is to take full advantage of opportunities in energy efficiency and conservation. The launching of the National Energy Efficiency and Conservation Program (NEECP) in August 2004 is evidence of the energy sector's commitment to work continuously on the development and promotion of new technologies and the practice of good energy habits in the household, business, and transport sectors. In line with the NEECP, the DOE has a goal of 10.0 percent energy savings from the total annual energy demand. The DOE has pursued its efforts to minimise demand for energy while ensuring the energy requirement to support economic growth by taking the lead on increasing public interest in the use of energy-efficient technologies and conservation practices.

As the DOE walks the path towards energy development, it will continue to implement reforms in the power industry and the downstream oil industry to address socially sensitive issues such as stability of supply and high cost of electricity and petroleum products.

Below are the highlights of the energy sector's plans and programmes:

Renewable Energy (RE)

The passage of Republic Act No. 9513 or Renewable Energy Act of 2008 legally support the policy and programme framework to promote the utilisation of renewable energy (RE) resources and technologies. On 14 June 2011, the government unveiled the National Renewable Energy Program (NREP) or the 'Green Energy Roadmap' for the Philippines. The NREP is anchored in the DOE's Energy Reform Agenda, which aims to ensure greater energy supply security for the country. It has established a policy and programme framework for the promotion of renewable energy and a roadmap to guide efforts in realising market penetration targets for each renewable energy resource in the country. The roadmap is targeting 15,304 MW installed RE capacity by 2030. The NREP also provides for policy mechanisms to support the implementation of the RE Act. These policy mechanisms include: Renewable Portfolio Standards (RPS), Feed-in Tariff (FIT), Green Energy Option Program, and Net-Metering for Renewable Energy.

The RPS sets the minimum percentage of generation from eligible RE resources, provided by the generators, distribution utilities, and electricity suppliers. Initially, an installation target of 760 megawatts (MW) from RE is set for the first three 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).

Moreover, the FIT provides guaranteed payments on a fixed rate per kWh for RE generation, excluding generation for own use. On 27 July 2012, the Energy Regulatory Commission (ERC) approved the initial FIT rates, which will apply to generation from renewable energy (RE) sources, particularly run-of-river hydro, biomass, wind, and solar. Approved FIT rates for biomass, hydropower, solar, and wind are PhP[1]6.63, PhP5.90, 9.68PhP, and PhP8.53 per kilowatt-hour (kWh), respectively. Currently, there is no FIT rate for ocean energy since the technology is still being researched and not yet available in the Philippines.

Alternative Fuels

<u>Biofuels</u>

The DOE is aggressively implementing Republic Act No. 9367 or the Biofuels Act of 2006. The law intends to tap the country's indigenous agricultural resources as potential feedstock for biofuels.

[1] Philippine peso.

The mandatory 1.0 percent biodiesel blend in all diesel fuel sold in the country since May 2007 was increased to 2.0 percent in February 2009 on a voluntary basis. Moreover, the Philippines now enjoys an accelerated use of E10 (10 percent) bioethanol blend as supplied by most of the country's gasoline retailers.

To serve the technical requirements for the biofuels programme and ensure its continuous research and development, the DOE provided counterpart funding of PhP50 million for the establishment of a vehicle testing facility located at the Department of Mechanical Engineering Laboratory, University of the Philippines in Diliman, Quezon City. Roundtable discussions with stakeholders on technical verification and relevance of emerging biofuel technologies also forms part of the DOE's initiatives on research and development.

As part of its continuing effort to diversify the country's energy mix, a biofuel project with the University of the Philippines – Visayas Foundation Inc. (UPVFI) titled 'Bioethanol Production from Macroalgae and Socio-ecological Implications' was launched in September 2013. And the 'B5 Testing on Public Utility Jeepneys' project between the Philippine Coconut Authority (PCA) and UP–National Center for Transportation Studies (UP–NCTS) was launched in July 2013.

Compressed Natural Gas (CNG)

Currently, there are 61 compressed natural gas (CNG) buses in the Philippines, of which 41 are being commercially run. The CNG buses are plying the Manila–Batangas–Laguna routes. In addition, there are 20 CNG buses that had completed technical evaluation and testing. As of June 2012, seven bus operators were accredited for CNG bus operation. The CNG Mother-refueling Station and the Daughter Station are operating in Batangas and Biñan, Laguna, respectively.

Auto-LPG

In terms of using LPG as an alternative fuel for transport, over 19,052 taxis nationwide are now running on LPG, which is complemented by 219 auto-LPG dispensing stations. To date, 31 auto-LPG conversion shops with Philippine National Standard (PNS) licenses are being monitored by the DOE to ensure safe operation and standards compliant conversion of gasoline fed motor vehicles to auto-LPG.

In support of the government's Auto-LPG programme, the Development Bank of the Philippines (DBP) has included auto-LPG initiative in its 'Clean Alternative Transport Fuel Financing Program,' which provides reasonable financing packages for auto-LPG related activities such as acquisition of auto-LPG vehicles. The LTFRB also extended the number of years of franchise for taxis that converted to auto-LPG within two years. These schemes promoted large-scale conversion of taxi fleets and encourage new player participation in the programme. And to validate the technical viability on the use of alternative fuel for public transport, the UP–National Center for Transportation Studies (UP–NCTS) and the UP Vehicle Research and Testing Laboratory (UP–VRTL) were commissioned to conduct two performance tests for Alternative Fuel Vehicles – specifically the Auto-LPG-fuelled Jeepney and the Electric-Powered Jeepney – that were completed in October 2013.[2]

[2] Energy Sector Accomplishment Report 2013

E-Vehicle

To date, 623 electric vehicles (EV) of various types have been in use in various cities and municipalities (Makati, Taguig, Mandaluyong, Quezon, Puerto Princesa, Davao, and Surigao del Norte) of the country. The E-vehicle Program is one of the government's initiative towards sustainable, energy efficient, and low-carbon transport future. In relation to the E-vehicle Program, the DOE launched in January 2012 its 'Bright Now! Do Right. Be Bright. Go E-trike!' design-an-electric tricycle contest to encourage and promote the creativity and innovativeness of young Filipinos in crafting the Philippine version of the so called 'Green Vehicle.'

Barangay Electrification

Rural electrification has been one of the government's priority thrust. The goal is to achieve total barangay[3] electrification by end of 2010. As of August 2012, the country's total electrification level had reached 99.98 percent, with 41,965 barangays out of 41,974 (formerly 41,980) already enjoying access to electricity. Given the importance of electricity in the economic development of the country, the electrification programme of the government is being extended up to household level. The government is targeting to achieve 90.0 percent household electrification by 2017.

As of 30 December 2013, household electrification was 79.5 percent, meaning that 17.0 million out of the 21.4 million households had an electricity connection.[4]

1.3. Energy

The country's total primary energy supply in 2012 reached 42.3 million tonnes of oil equivalent (MTOE). Oil accounted for the biggest share – 32.1 percent – in the total energy supply, followed by geothermal and coal, which both had shares of about 21.0 percent in the mix. Total production reached 24.3 MTOE in 2012, bringing the energy self-sufficiency level of the country to 57.4 percent.

The Philippines' total electricity generation in 2012 amounted to 72.9 terawatt-hours (TWh). Coal-fired power plants remained the major source of power generation, with an installed capacity of 5,568 megawatt (MW). Coal accounted for 38.8 percent or 28.3 TWh of the country's total electricity requirement in 2012 and natural gas-fired power plants accounted for 26.9 percent or 19.6 TWh in the power mix. The Philippines currently has three natural gas power plants with a combined installed capacity of 2,861 MW. The combined share of renewable energy in the total power generation mix was 28.5 percent in 2012.

2. Modelling Assumptions

Five scenarios were developed to assess the energy savings potential of the country aside from the Business-as-Usual (BAU) scenario, which serves as the reference case in the projection of energy demand and carbon dioxide (CO_2) emission of the energy sector. The BAU scenario incorporates the energy sector's existing energy policies, plans,

[3] Filipino term for a village, district, or ward and is the smallest administrative division in the Philippines.
[4] Status of Household Electrification as of 31 December 2013.

and programmes, which are being implemented and will be pursued over the forecast period. The virtue of this scenario rests on assessing the effects of such measures, which may evolve either as a consequence of need (energy security) or the commercialisation of energy technologies (economics) given the interaction of market forces.

Alternative Policy Scenario (APS) 1 will test the impact of possible policy interventions in terms of possible utilisation of efficient and environment-friendly technologies for future energy use together with its corresponding CO_2 emission reduction. The extended energy saving goals of 15.0 percent of the country's annual final energy demand is expected to be achieved through a range of measures, including intensified energy utilisation management programmes in the commercial and industrial sectors, power plants, and distribution utilities, as well as the continuous use of alternative fuels and technologies. The information and education campaign being conducted by the Department of Energy (DOE) and the 'Palit Ilaw'[5] Program also contribute to the country's energy saving goals. In the residential and commercial sectors, the utilisation of more efficient electrical appliances is projected to induce savings. Energy labelling and ratings of major electrical appliance will help consumers to choose more efficient electrical products.

APS2 will assess the effect of more efficient thermal power generation, particularly as a result of new technologies to be used in coal and natural gas power plants.

The APS3 will measure the result of the combined contribution of renewable energy and alternative fuels to the total energy supply. As part of the government's initiatives to ensure security of energy supply and at the same time protect the environment and promote green technology, the targets set under the NREP were incorporated in the model, particularly in APS3, to test their impact on the total primary energy supply. The NREP lays down the foundation for developing the country's renewable energy 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 renewable energy within the timeframe of 2011 to 2030. The intensified development and utilisation of alternative fuels for transport such as compressed natural gas (CNG) and electric vehicles, as part of a continuing strategy to reduce the country's dependence on imported oil, were also part of the APS3 simulation.

Although the Philippines at present has no clear policy direction on the use of nuclear energy in power generation, APS4 considered additional capacity from nuclear power to determine the impact of a possible long-term nuclear option in the country. And lastly, APS5 will focus on the combined effects of the four scenarios (APS1, APS2, APS3, and APS4).

In the model, GDP is assumed to grow at an average annual rate of 6.3 percent[6] from 2011 to 2035 and the projected population growth of the country is 1.6 percent per year for the same period. Population growth is based on the adjusted 2000 census-based medium population projections using the results of the 2007 population census of including the population level of 93.3 million for 2010.

[5] Filipino term for 'change lamps' wherein the DOE distributes CFL lamps for free to consumers in exchange of their incandescent bulbs.
[6] IMF World Economic Outlook (2014).

3. Outlook Results

3.1. Business as Usual (BAU) Scenario

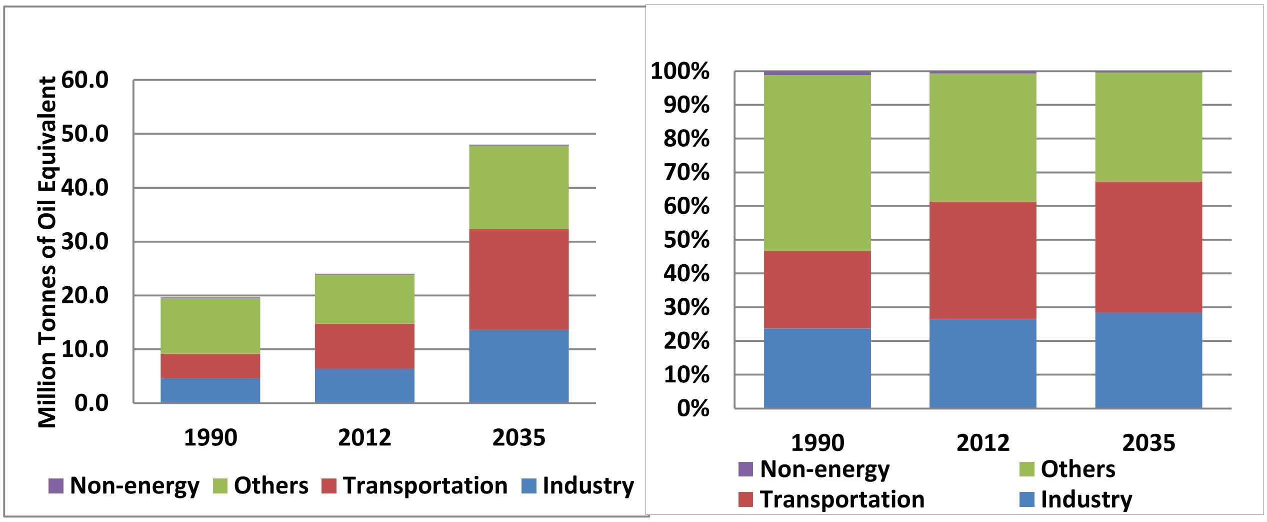
3.1.1. Total Final Energy Demand

Total Final Energy Demand by Sector

The Philippines' final energy demand grew from 19.7 MTOE in 1990 to 24.0 MTOE in 2012, at an average annual growth rate of 1.09 percent. From 1990 to 2012, energy demand in the transport sector grew fastest, at an average annual rate of 2.8 percent, followed by the industrial sector with 1.4 percent. Final energy demand in the 'Others' sector (residential/commercial) decreased by an average 0.5 percent per year over the same period.

Final energy demand is projected to grow at an annual average rate of 3.1 percent in the BAU scenario from 2012 to 2035, the transport sector will grow at an average annual rate of 3.6 percent per year, and the industrial and other sectors are expected to grow at an average rate of 3.4 percent and 2.3 percent per year, respectively (Figure 14-1).

Figure 14-1. Final Energy Demand by Sector, BAU



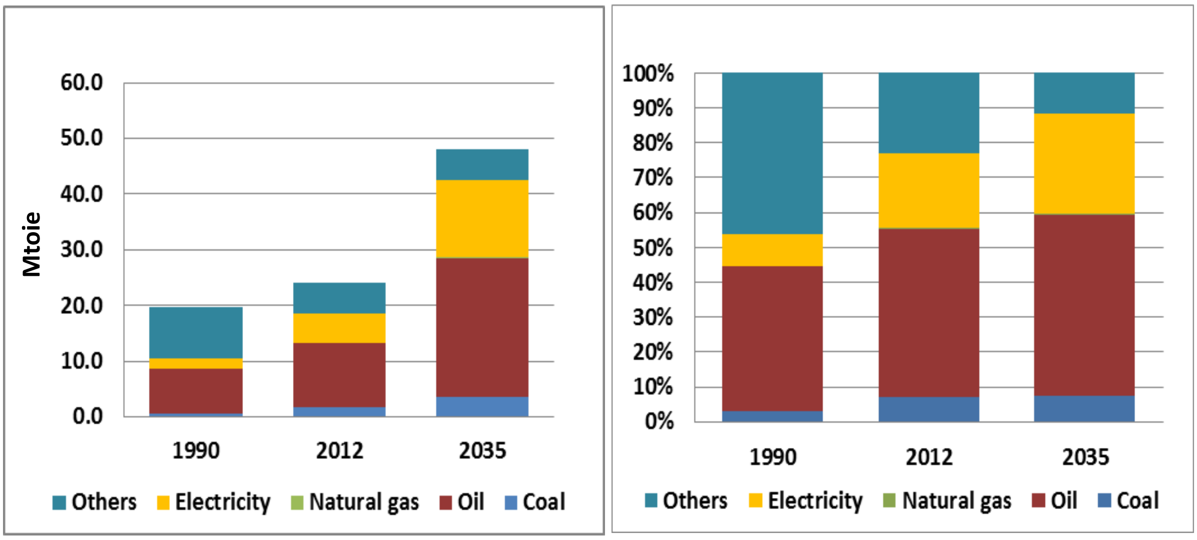
Source: Author's calculation.

Aggregate energy demand of other sectors, such as residential and commercial, although decreasing from 52.2 percent to 38.0 percent between 1990 and 2012, comprised the biggest share in the total demand mix during that period. The share of the transport sector increased from 23.0 percent to 34.8 percent during the same period, and is projected to further increase its share, to 39.0 percent of the demand mix by the end of the planning period in 2035. The demand of the 'others' sector is projected to be 32.3 percent in 2035. The share of energy demand of industry in the demand mix rose from 23.7 percent in 1990 to 26.5 percent in 2012, and is projected to rise to 28.3 percent at the end of the planning period.

Total Final Energy Demand by Fuel

By fuel type, demand for natural gas and electricity is projected to grow at almost the same rate of an annual average 4.4 percent from 2012 to 2035. Oil demand is expected to grow by 3.4 percent over the same period, to be used mainly for the transport sector. Demand for coal for non-power applications will grow at an average annual rate of 3.3 percent over the same period, with the bulk of its end-use demand coming from the cement industry (Figure 14-2).

Figure 14-2. Final Energy Consumption by Fuel, BAU



Source: Author's calculation.

Oil will remain the most consumed fuel throughout the planning period, despite a fall in its share in the total demand mix from 48.2 percent in 2012 to 51.9 percent in 2035.

Electricity will contribute an average share of 28.6 percent at the end of the planning period, making it the second-most consumed energy source after oil. Demand for other fuels such as biomass and other renewable energy (RE), although projected to decline, will account for 11.6 percent of the demand mix in 2035. The share of coal in the industry sector is expected to decrease to 7.5 percent in 2035.

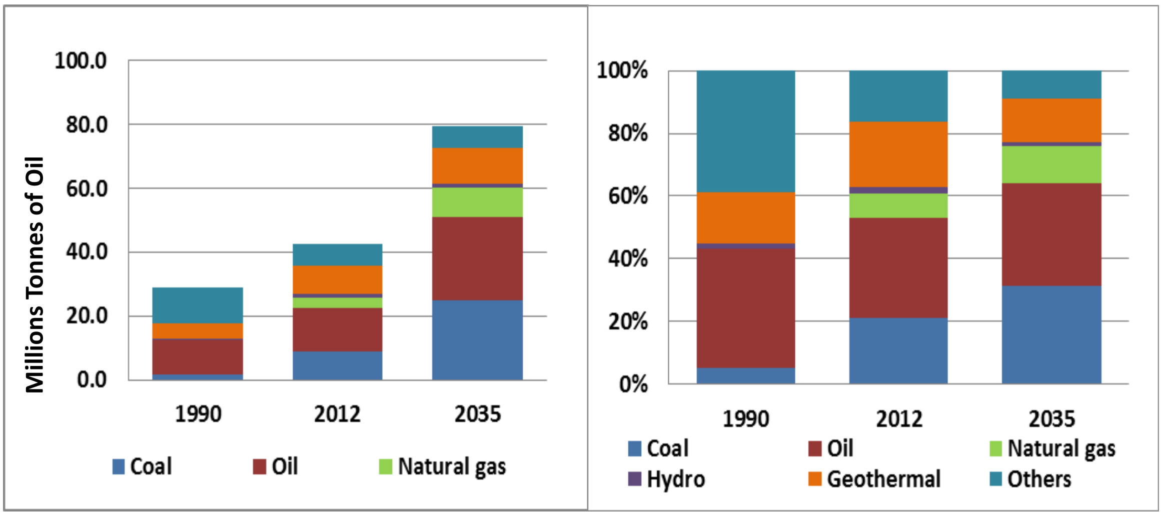
Total Primary Energy Consumption by Fuel

Primary energy consumption in the Philippines grew at an annual average rate of 1.8 percent, from 28.7 Mtoe in 1990 to 42.3 Mtoe in 2012. Amongst the major energy sources, consumption of coal grew the fastest, at 8.3 percent per year, followed by geothermal and hydro, with 2.9 percent and 2.4 percent, respectively. Oil grew at an average annual rate of just 1.0 percent per year from 1990 to 2012 and primary energy consumption of other fuels declined by an average annual 2.1 percent over the same period.

From 2012 to 2035, the country's primary energy consumption is expected to increase by 2.8 percent per year from its 2012 level, to 79.8 Mtoe in 2035. Consumption of all major energy sources is projected to increase during the period with coal growing fastest at 5.0 percent per year. Natural gas is also expected to expand, at a growth rate of 3.8 percent per year during the same period, and oil is projected to grow at 2.9 percent. Major RE consumption from geothermal and hydro is projected to grow at an average annual rate of 0.9 percent and 0.4 percent, respectively, from 2012 to 2035, and aggregate consumption of other fuels is expected to grow at a meagre 0.1 percent over the projection period.

Coal will account for the largest share in the total energy supply of the country at 33.5 percent at the end of the planning period. Oil and natural gas being part of the country's major energy requirement are projected to account for shares of 33 percent and 9.7 percent, respectively, in 2035. Geothermal and hydro, which are mainly used for power generation, are expected to have shares of 13.7 percent and 1.2 percent, respectively, and the requirements for other fuels in 2035 will amount to a share of 8.9 percent in the supply mix at the end of the projection period (Figure 14-3).

Figure 14-3. Primary Energy Consumption by Sector, BAU

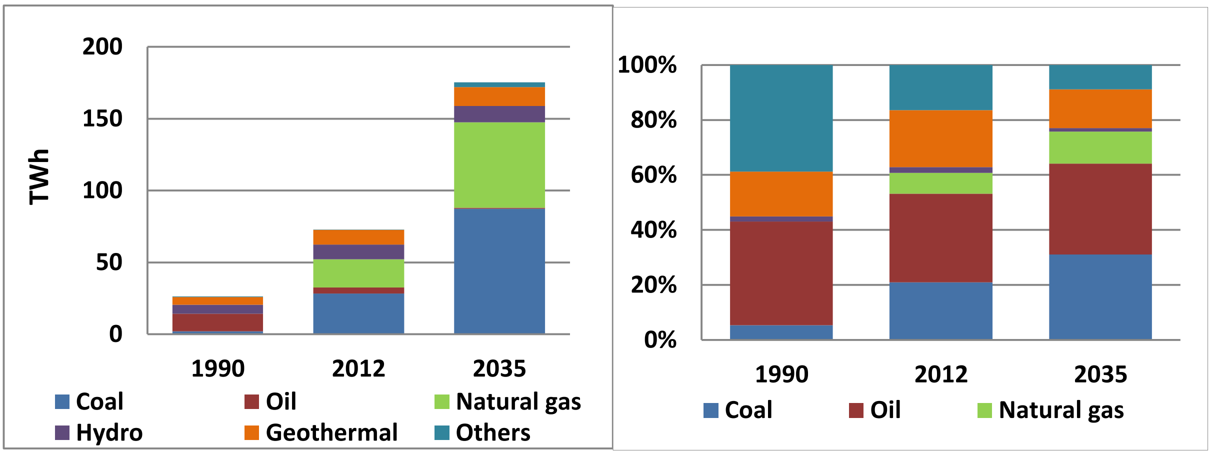


Source: Author's calculation.

Power Generation

Total power generation in 2012 reached 72.9 terawatt-hours (TWh), nearly a threefold increase on 1990. Power generation is expected to increase at an average annual rate of 3.9 percent over the planning period. Coal remained the major source of power generation, accounting for a share of 38.8 percent in 2012. It is expected to grow at an average annual rate of 5.4 percent, from 28.3 TWh in 2012 to 95.6 TWh in 2035, which increases its share to 54.5 percent. Natural gas followed with output projected to grow from 19.6 TWh in 2012 to 49.2 TWh in 2035, at an average rate of 4.1 percent per year. Oil will decrease at an annual average 0.8 percent over the planning period. Power generation from hydro and geothermal are expected to grow at average annual rates of 0.4 percent and 0.9 percent, respectively. The contribution of other fuel (solar, wind, and biomass) to power generation is expected to increase at an average annual rate of 11.6 percent (Figure 14-4).

Figure 14-4: Power Generation by Fuel, BAU



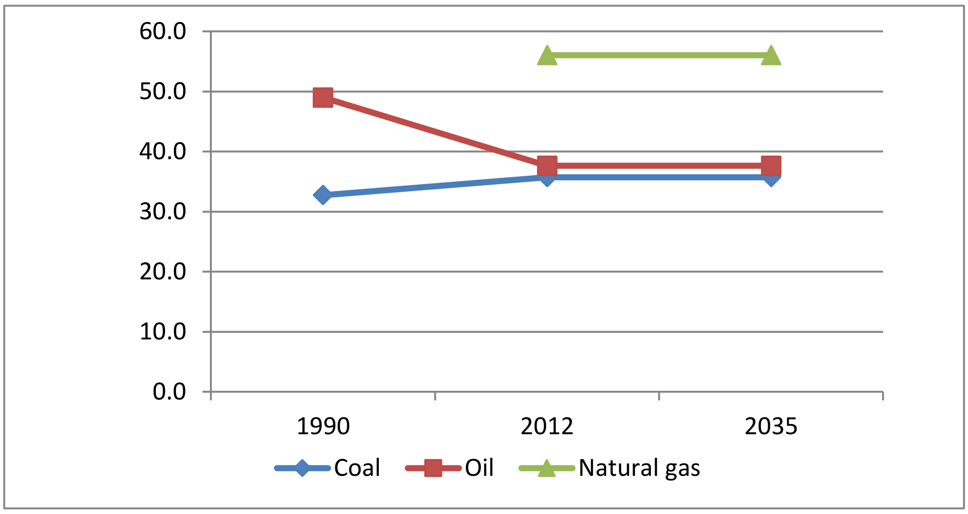
Source: Author's calculation.

The thermal efficiencies of coal, oil, and natural gas under the BAU scenario are projected to be fairly constant over the planning period. By the end of the projection period, coal thermal efficiency is expected to be about 36.0 percent, and oil and natural gas power plants' efficiencies are estimated at around 40.0 percent and 56.0 percent, respectively.

3.1.2. Energy Indicators

Under the BAU scenario, energy intensity of the Philippines is expected to decrease at an average annual rate of 3.0 percent from 2012 to 2035. Energy intensity is the ratio of total primary energy over GDP. The significant reduction in energy intensity is attributable to the government's efforts in promoting energy conservation and efficiency in the different sectors of the economy. Energy per capita is projected to increase from 0.44 toe/person in 2012 to 0.57 toe/person in 2035, due to improvements in people's living standards and income.

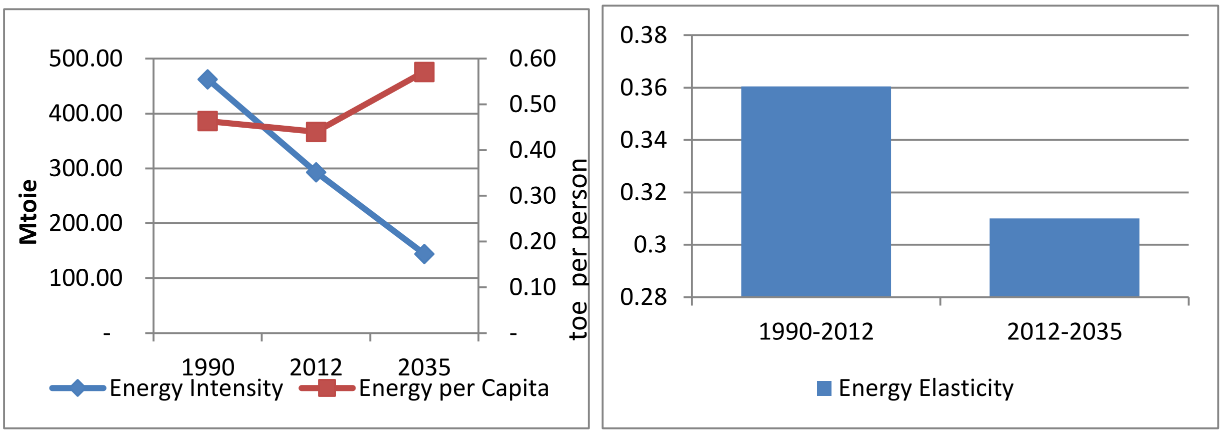
Figure 14-5. Thermal Efficiency by Fuel, BAU



Source: Author's calculation.

Energy elasticity is the relationship between changes in primary energy demand and changes in GDP. It is projected at approximately 0.3 from 2012 to 2035, indicating that energy demand is rising less slowly than income.

Figure 14-6. Energy Intensity, Energy Per Capita, and Energy Elasticity

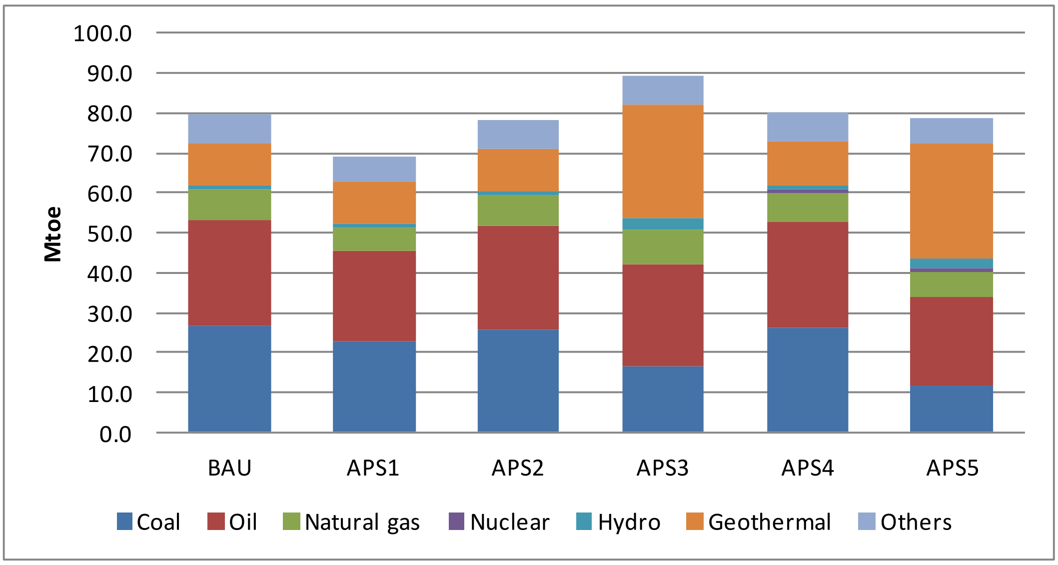


Source: Author's calculation.

3.2. Alternative Policy Scenario (APS)

As mentioned above, the assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, APS4 and the combination of all these assumptions (APS5 or APS). Figure 14-7 shows the changes in total primary energy supply in all the scenarios.

Figure 14-7: Primary Energy Supply for All Scenarios in 2035



Source: Author's calculation.

In Figure 14-7 above, APS1 has the largest reduction in total primary energy supply due to its energy efficiency assumptions on the demand-side. The country's total primary energy supply under the APS1 will grow at an annual average rate of 2.1 percent, reaching 69.0 Mtoe in 2035. This is lower than under the BAU scenario, indicating the effectiveness of energy efficiency measures implemented in the various sectors of the economy. The projected total primary energy supply reduction under APS1 will be 10.8 Mtoe or 13.5 percent.

APS2, which assumes higher efficiency in thermal electricity generation will have lower total primary energy supply of 1.5 Mtoe or 1.9 percent than the BAU scenario. The country's total primary energy supply under APS2 is projected to reach 78.3 Mtoe in 2035. Most of the reduction would be due to coal and natural gas being used at more efficient plants to generate power in this scenario.

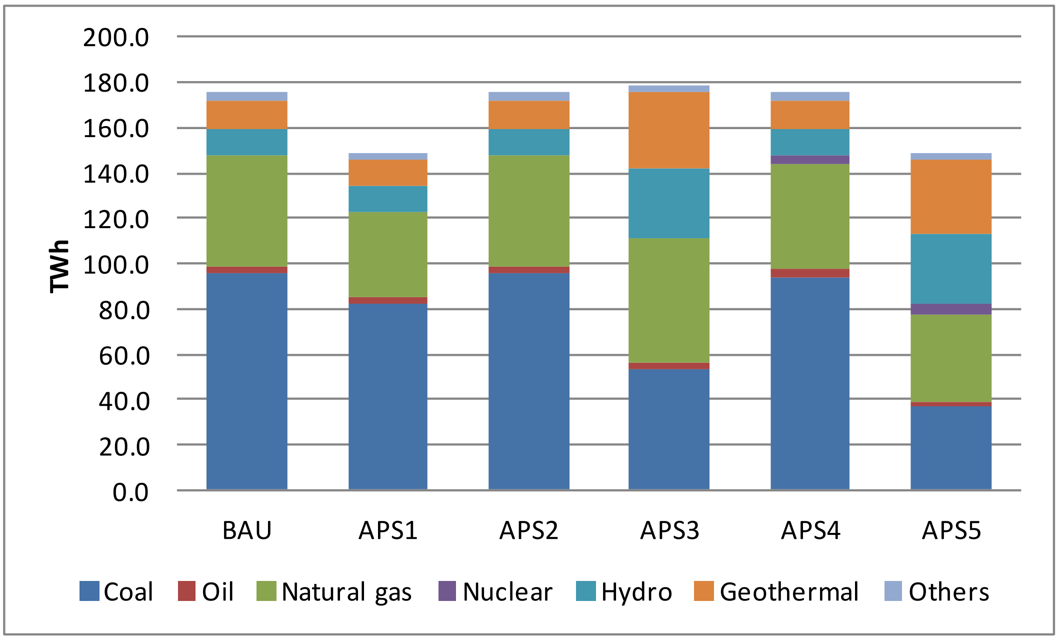
For APS3, total primary energy supply is projected to be almost 9.6 Mtoe higher than under the BAU scenario. This is mainly due to the increased use of geothermal energy in power generation. With the exception of hydro, wind, and solar energy, the efficiency of non-renewable energy (NRE) plants is usually lower than that of fossil-fuelled power plants.

In APS4, total primary energy supply will be 0.3 Mtoe higher than in the BAU scenario. This is due to the assumption that nuclear power plants are only 33 percent efficient, lower than natural gas and coal power plants, which have efficiencies of 35.7 percent and 56.1 percent, respectively.

The combined effect of APS1, APS2, APS3, and APS4, or APS5 will be lower total primary energy supply of only 1.1 Mtoe, or a 1.4 percent saving in primary energy supply.

Figure 14-8 shows total electricity generation in 2035 in all scenarios. In APS1, due to lower electricity demand, the shares of fossil-fired electricity generation were lower than in the BAU scenario – 82.5 percent compared with 84.5 percent in the BAU scenario.

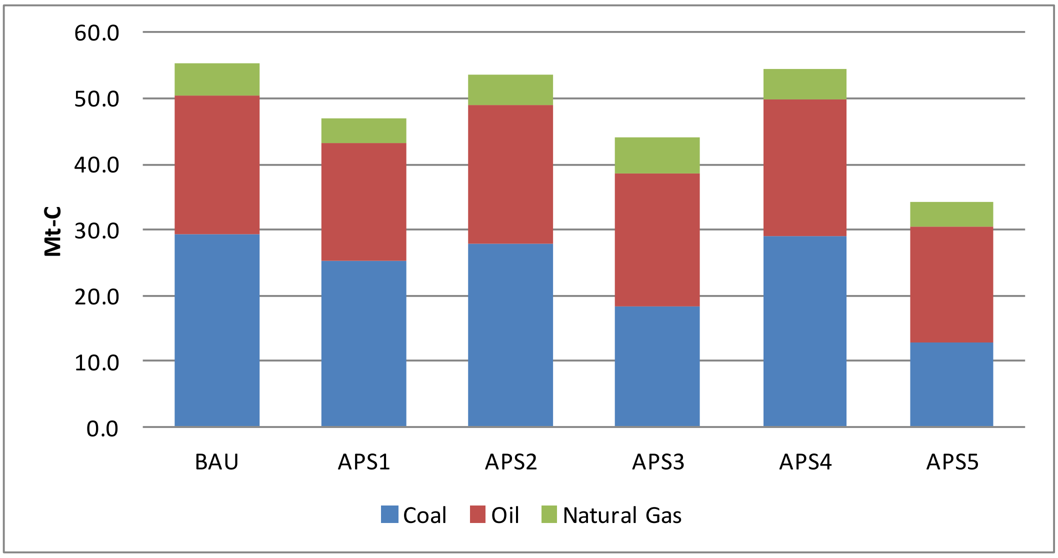
Figure 14-8. Electricity Generation for All Scenarios in 2035



Source: Author's calculation.

In APS2, the shares are the same as those for BAU. In APS3, due to the assumption of more renewable energy, the shares of fossil fuel-fired generation will only be 62.5 percent compared with the BAU scenario's 84.5 percent. In APS4, fossil fuel-fired electricity generation is expected to make up 82.0 percent of the total, indicating that nuclear displaced the other 2.5 percent. In APS5, where all scenarios were combined, the shares of fossil energy-based generation will be reduced further to 52.2 percent.

Figure 14-9. CO_2 Emission for All Scenarios in 2035



Source: Author's calculation.

In terms of CO_2 emission reduction, the energy efficiency assumption in APS1 is expected to reduce emissions by around 8.3 million metric tonnes of carbon (Mt-C), which is 15.1 percent lower than for BAU. The reduction in CO_2 indicates that the energy saving goals, action plans, and policies related to the promotion of energy efficiency and the conservation programme will be effective in reducing CO_2 emissions.

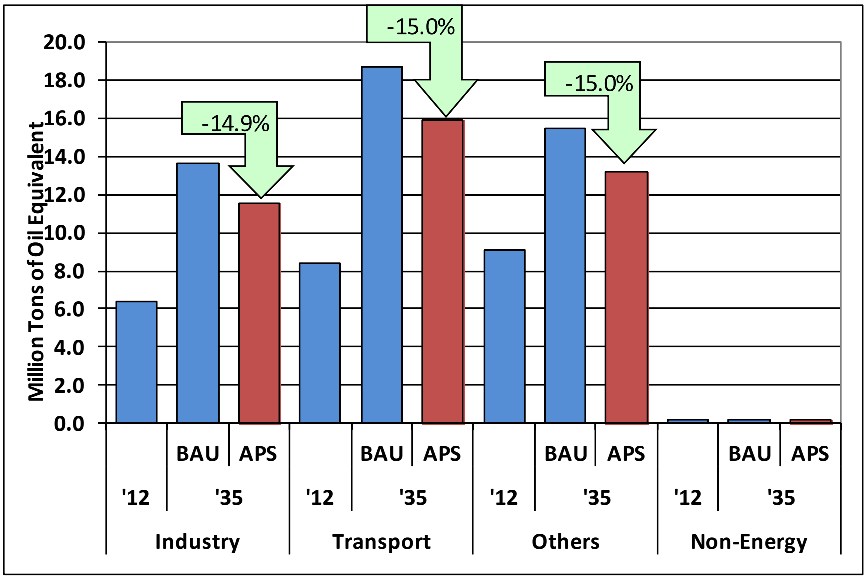
In APS2, total CO_2 emissions could be reduced by 1.5 Mt-C or 2.8 percent relative to BAU. In APS3, the reduction could be 11.1 Mt-C, which is 20.2 percent lower than for BAU. In APS4, the reduction could be 0.7 Mt-C or 1.2 percent relative to BAU, as only 620 MW of nuclear power was assumed in this scenario.

Combining all the assumptions in APS1, APS2, APS3, and APS4 (APS5), is expected to reduce BAU CO_2 emissions by 20.8 Mt-C or 37.7 percent.

3.2.1. Final Energy Demand

In the APS (APS5), final energy demand is projected to increase at a slower rate than in the BAU scenario, increasing at an average rate of 2.3 percent per year, from 24.0 Mtoe in 2012 to 40.9 Mtoe in 2035. Slower growth under the APS, relative to the BAU scenario, is projected across all sectors as a result of the government's programme for energy efficiency and conservation. The transport sector is expected to see the highest growth, at 2.8 percent per year, followed by the industrial sector at 2.6 percent per year. Figure 14-10 shows final energy demand by sector in 2012 and 2035 in both the BAU scenario and the APS. The reduction of final energy demand will be 15 percent in 2035 in all sectors except for the non-energy sector.

Figure 14-10: Final Energy Demand by Sector, BAU and APS



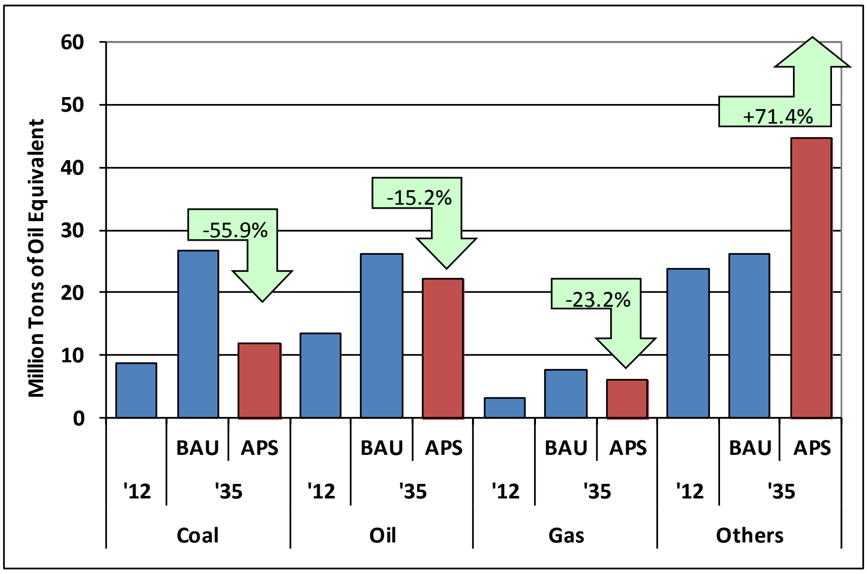
Source: Author's calculation.

Primary Energy Supply

Over the projection period, the relative share of each form of energy is expected to change significantly in response to changes in economic structure and policy environment. The country's total primary energy supply under the APS will grow at an average annual rate of 2.7 percent, increasing from 42.3 Mtoe in 2012 to 78.6 Mtoe in 2035. Compared with the BAU scenario, the APS will see a 1.4 percent lower energy supply level in 2035 (Figure 14-16).

Renewable energy sources such as geothermal, hydro, and 'other RE' (solar, wind, and biofuels) are expected to see the fastest growth over the projection period, increasing by 5.3 percent, 4.3 percent, and 5.1 percent per year, respectively. Energy supply from fossil fuels such as coal, oil, and natural gas, is projected to increase more moderately, by 1.3 percent, 2.2 percent, and 2.7 percent per year, respectively, under this scenario.

Figure 14-11. Total Primary Energy Supply by Fuel, BAU and APS

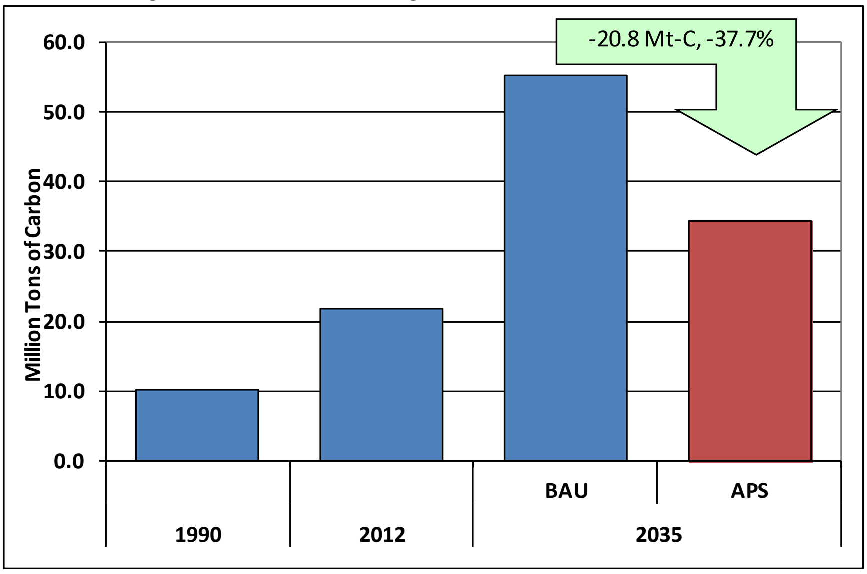


Source: Author's calculation.

CO_2 Reduction Potential

Total CO_2 emissions from energy consumption will reach 34.4 Mt-C in 2035. The CO_2 emission reduction is expected to be 20.8 Mt-C, which is 37.7 percent lower than the BAU level. The reduction in CO_2 indicates that applying all the assumptions for energy saving goals to increase renewable energy and alternative fuels in total supply and improve thermal efficiency in power generation will meet the CO_2 emissions reduction target (Figure 14-12).

Figure 14-12: CO_2 Savings Potential, BAU and APS5



Source: Author's calculation.

4. Implications and Policy Recommendations

Under the BAU scenario, on the supply side, primary energy consumption of coal is projected to grow fastest, at an annual average rate of 5 percent, throughout the planning period. This is due to the significant expected contribution of coal fuel in power generation, which corresponds to an expected increase in demand for electricity at an annual average rate of 4.4 percent. Coal supply is projected to surpass the Philippine's requirement for oil, which is mainly utilised in the transport sector. The aggregate share of RE at 23.8 percent for this most likely energy scenario is also behind by around 41.0 percent compared with the projected contribution of coal in the supply mix. Thus, it is imperative for the government to temper the utilisation of this fuel through the strict implementation of its energy security policy in adopting the use of clean, green, and sustainable sources of energy, particularly in the power sector. However, the government's policy options are limited as the power sector is a deregulated industry, so its control over what power plants are to be built is limited. It can exert some influence by formulating a fuel mix policy for power generation, to guide and inform investors and other key players in the industry on the preferred national power mix for the benefit of the long-term sustainability of the country's power sector. Further, the government should find a way to encourage the stake holders to invest and support the government's thrusts on good governance and initiatives to further enhance operational efficiency and data transparency and exchanges amongst stakeholders.

On the demand side, oil will register the biggest share in the final energy demand by more than 50.0 percent towards the end of the planning period. This is despite of the current effort of the government to implement the promotion of energy efficiency and conservation programme and alternative fuel and technology development. The results of the model indicated that the share of oil in the total demand is constant across different scenarios. This is because oil is the major fuel of the transport sector, which is the biggest user of energy currently and in the future. As indicated by the outlook model results, transport sector will be the biggest user of energy across different scenario throughout the planning period. 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 transport programme.

Moreover, the use of alternative technologies and fuels such as electric vehicle, 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 prices 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 energy requirement but also lessen GHG emission coming from the transport sector.

On the other hand, under the APS, energy intensity and CO_2 intensity will continue to decline from 2012 to 2035, although CO_2 emission per energy consumption will increase corresponds to the increase share of fossil fuels. In this regard, the government should implement strictly the energy plans and programmes for energy efficiency and conservation to address; responses to volatile oil prices and their inflationary effects on the prices of basic commodities; and changing economic structure of the country to rely more on its service sector rather more than on energy intensive industries. This is also consistent with the Asia-Pacific Economic Cooperation's (APEC) target to reduce APEC's aggregate energy intensity (energy demand per unit of GDP) by forty-five (45 percent) percent 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 to rely more on its service sector rather than on energy intensive industries.

In response to the result of the study, the government should pursue its programmes and projects that will further increase and enhance the utilisation 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. The FIT, RPS and other policy mechanism provided under the law will boost the utilisation of RE.

Special attention should also be given to the industrial sector since it is growing almost at the same rate as the transport sector and could have high potential energy savings.

Furthermore, the country must establish a quantitative sectoral energy savings target for easy evaluation and monitoring and to institutionalise energy efficiency and conservation, incentives towards greater participation is needed. Currently, the Philippines has a specific quantitative energy saving requirement as provided under Administrative Order (AO) No. 110, 'Directing the Institutionalization of a Government Energy Management Program'. The AO requires the reduction of at least ten percent (10 percent) in the cost of the consumption of fuel and electricity amongst others in the government. This can be duplicated or expanded to other sectors if there is an existing energy conservation law which 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 necessary environment to ensure that the policies will strictly be implemented.

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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 Straits of Malacca between Malaysia and Indonesia. It is the most urbanised and industrialised country in the Association of Southeast Asian Nations (ASEAN), with an annual gross domestic product (GDP) per capita of S$ 71,318 in 2014[1] and is fully electrified. It has a national policy framework to maintain a balance amongst the policy objectives of economic competitiveness, energy security, and environmental sustainability.[2] Singapore has a national target of reducing energy intensity by 20 percent by 2020 and 35 percent by 2030 compared with 2005[3]. It also has a voluntary target of reducing carbon dioxide (CO_2) emissions by 7–11 percent below business-as-usual levels in 2020,[4] which will be increased to 16 percent if there is a global agreement on climate change.

1.1. Singapore's Policy Initiatives

An inter-agency Energy Efficiency Programme Office (EEPO), led by the National Environment Agency (NEA) and the Energy Market Authority (EMA), was established in May 2007 to help promote and facilitate the adoption of energy efficiency in Singapore.[5]

1.1.1. Households

Households account for about one-sixth of electricity consumed in Singapore[6] and thus is a key sector for energy efficiency policies. The Mandatory Energy Labelling Scheme (MELS), introduced in 2008, imposes compulsory display of energy labels on relevant household appliances. Initially only levied on all registrable air-conditioners and refrigerators, the requirement has progressively expanded over the years to include television sets and clothes dryers. The MELS serves to inform consumers and helps them identify, and thereby purchase, more energy efficient appliances. The Minimum Energy Performance Standards (MEPS) is a supply-side policy that complements the MELS by

[1] Singapore Department of Statistics (2015), *National Accounts*, from http://www.singstat.gov.sg/statistics/browse-by-theme/national-accounts
[2] Ministry of Trade and Industry of Singapore (2007). National Energy Policy Report–Energy for Growth, from http://app.mti.gov.sg/data/pages/2546/doc/NEPR.pdf
[3] Singapore Government (2009). The Sustainable Development Blueprint 2009, from http://app.mewr.gov.sg/data/ImgCont/1292/sustainbleblueprint_forweb.pdf; Singapore Government (2014). The Sustainable Development Blueprint, fromhttp://www.mewr.gov.sg/ssb/files/ssb2015.pdf
[4] National Climate Change Secretariat (2012). Speech on Climate Change by Mr Teo Chee Hean, Deputy Prime Minister, Coordinating Minister for National Security and Minister for Home Affairs, at the Committee of Supply Debate, from http://app.nccs.gov.sg/news_details.aspx?nid=642&pageid=97
[5] Energy Efficiency Programme Office (2013), http://app.e2singapore.gov.sg/About_Esup2/supPO/Objective_and_Members.aspx
[6] https://www.nccs.gov.sg/climate-change-and-singapore/domestic-actions/reducing-emissions/households

prohibiting 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 bring more energy-efficient appliances to the market as technology improves.

Both the MELS and MEPS are constantly evaluated and revised to ensure policy efficacy and efficiency. Although both policies are limited in coverage at the existing stage, it is expected that these initiatives will be extended to include other energy intensive appliances, through a continuing assessment process. In particular, general lighting, such as incandescent lamps, CFL, and LED lamps, will be covered under the scheme from July 2015. Given that the efficacy of existing labelling standards in facilitating energy conservation and efficiency improvements will depend on how responsive end-users are to these initiatives, the MELS is constantly evaluated. In September 2014, new ratings systems and designs of the MELS were introduced to improve consumer readability and understanding. The revised label also included a component on estimated annual energy cost aimed at helping consumers better understand how the energy performance of the appliance they buy will translate into cost savings.

In addition to the initiatives targeting the purchase of electrical appliances, NEA also aims to affect energy consumption behaviour through the '10 Percent Energy Challenge' national campaign. Launched in 2008, the campaign aims to increase consumer understanding of residential energy consumption by providing energy savings tips and incentivising households to reduce energy consumption. In conjunction with the campaign, NEA has launched various interactive mobile communication applications, such as Life Cycle Calculator and Home Energy Auditor mobile application. Currently, NEA is also looking at rolling out additional public messaging initiatives in 2015 and the possibility of utilising smart home technologies, such as the Home Energy Management Systems (HEMS), to reduce residential energy consumption.

For the transport sector, the Vehicle Quota System (VQS) regulates the growth of the vehicle population in Singapore. Under the VQS, anyone who wishes to register or buy a new vehicle in Singapore must first obtain a Certificate of Entitlement (COE), which represents a right to vehicle ownership for 10 years.[7] In view of the land constraints on road expansion, the annual vehicle population growth rate has been reduced from 3 percent in 1990 to 1.5 percent in 2009, to 1 percent in August 2012, to 0.5 percent in 2013, and 0.25 percent since 2015.[8] The Fuel Economy Labelling Scheme (FELS) has mandated fuel economy labels to be affixed to vehicles at the point of sale since 2012.[9] This is complemented by the Carbon Emissions-based Vehicle Scheme (CEVS), which was introduced in 2013. The CEVS will be revised in July 2015 to reflect improvements in emission standards. Rebates and surcharges will also be increased for very low- and high-carbon emission vehicles, respectively, to further encourage vehicle buyers to shift to low-carbon emission models. All new cars and imported used cars with low carbon emissions

[7] Land Transport Authority (2014), 'Overview of Vehicle Quota System', http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/vehicle-quota-system/overview-of-vehicle-quota-system.html
[8] Land Transport Authority (2015), 'Vehicle Quota System', http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/vehicle-quota-system.html
[9] Land Transport Authority (n.d.), 'Fuel Economy Labeling Scheme (FELS)', http://www.onemotoring.com.sg/publish/onemotoring/en/lta_information_guidelines/buy_a_new_vehicle/fuel_economy.html

of less than 136g carbon emissions per kilometre (CO_2/km) will qualify for vehicle tax rebates of between S$5,000 and S$30,000. Cars with high carbon emissions more than 185g CO_2/km, will incur a corresponding registration surcharge between S$5,000 and S$20,000. Cars with carbon emissions between 136 and 185g CO_2/km receive neither a rebate nor will they have to pay a surcharge. To encourage taxi companies to adopt lower emission models for their fleet, the CEVS rebate and registration surcharge for taxis is set 50 percent higher than for cars – between S$7,500 and S$30,000.[10]

1.1.2. Buildings

The Building and Construction Authority (BCA) of Singapore launched the BCA Green Mark Scheme in January 2005 to promote environmental sustainability in the construction and real estate sectors. 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 National Climate Change Secretariat (NCCS) and the National Research Foundation (NRF) in 2014, evaluates existing energy efficiency technologies for building providing technical expertise in the area. A variety of financial support mechanisms, such as the Green Mark Incentive Scheme for Existing Buildings and Premises (GMIS–EBP) and the Building Retrofit Energy Efficiency Financing (BREEF) scheme are available to provide co-financing for retrofitting and energy efficiency upgrades. The target is for at least 80 percent of the buildings in Singapore to achieve BCA Green Mark Certified rating by 2030.[11]

In its recently launched Third Green Building Masterplan, BCA announced its intention to engage building tenants and occupants with a view to inducing energy consumption behavioural change.

Since a 2012 survey by Development Authority of Singapore (IDA) 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, which was in line with estimates from the 2012 survey, which posits that there is an energy efficiency potential of 20 percent. IDA also launched a new Green Data Centre Innovation Programme (GDCIP) aimed at promoting innovative technological approaches to improving data centre energy efficiency.

[10] Land Transport Authority (2015), 'Revised Carbon Emissions-based Vehicle Scheme (CEVS) from 1 July 2015', *Press Release*, 23 February, http://www.lta.gov.sg/apps/news/page.aspx?c=2&id=8aa03b88-409f-4852-b2df-09077e101468
[11] Building Construction Authority (2013), 'R&D Framework', Build Green Magazine, Issue 02/13 https://www.bca.gov.sg/greenmark/others/BGreen2013.pdf

1.1.3. Industry

The industry-focused Energy Efficiency National Partnership (EENP) 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 (ECA). Energy intensive companies consuming more than 15GWh (electricity) or 54TJ (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.[12] Besides legislation enforcing mandatory energy management practices, policies were also introduced to incentivise energy efficiency investments. A recent document released by NCCS made references to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which includes forecasts that the deployment of best-available technology could reduce energy intensity from current levels by 25 percent across the industrial sector. Incentives and grants, such as the Design for Efficiency Scheme (DfE), Energy Efficiency Improvement Assistance Scheme (EASe), and the Grant for Energy Efficiency Technologies (GREET), were put in place as co-financing schemes to reduce initial costs of energy efficiency upgrades. Knowledge sharing is also promoted through industry-focused seminars and provision of energy management training and resources.

The industry-focused Energy Efficiency National Partnership (EENP) is a voluntary programme that started in 2010 and 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 (ECA). Energy intensive companies consuming more than 15GWh (electricity) or 54TJ (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.[13] In the same year, the SME (small and medium enterprise) Energy Efficiency Initiative was conceptualised with the goal of helping 300 SMEs achieve at least 10 percent savings over three years. The government has set aside S$17 million for this initiative and four areas of support were emphasised – Energy Audit, Energy Monitoring System, Energy Efficiency Project Implementation, and Energy Efficiency Thought Leadership.[14]

2. Modelling Assumptions

Five scenarios were developed to assess the energy saving potential of the energy efficiency and conservations policies in Singapore. The 'Business As Usual' (BAU) scenario forecasts energy demand and CO_2 emissions by incorporating energy policies implemented up until the end of 2013. Three Alternative Policy Scenarios (APS) project energy use and CO_2 emissions with higher uptakes of energy efficiency and conservation

[12] National Environment Agency, (2014), http://app.e2singapore.gov.sg/Programmes/Energy_Efficiency_National_Partnership.aspx
[13] National Environment Agency, (2014), http://app.e2singapore.gov.sg/Programmes/Energy_Efficiency_National_Partnership.aspx
[14] SPRING Singapore (2013), 'Government Sets Aside $17 Million to Boost Energy Efficiency in SMEs', *Press Release*, 10 July. http://www.spring.gov.sg/NewsEvents/PR/Pages/Government-Sets-Aside-17-million-to-Boost-Energy-Efficiency-in-SMEs-20130710.aspx

policies – lower end-user energy demand, more efficient power generation, and increased share of renewable in the energy mix for APS1, APS2, and APS3, respectively. Unlike some other ASEAN countries, Singapore does not have a nuclear policy and hence APS4 is not considered. Finally, APS5 aggregates the effects of all three APS.

2.1. Power Generation Sector

In 2012, the overall efficiency of gas-fired power plants in Singapore was 51 percent and it was 39 percent for thermal plants. According to the International Energy Agency (IEA), the average thermal efficiency of combined cycle gas turbine (CCGT) generators was 57.0 percent and that of conventional power plants was 41.1 percent.[15] By 2035 under BAU, it is assumed that the efficiency of gas power plants will attain 55 percent efficiency and thermal power plants will attain an efficiency of 41 percent. The share of electricity contributed by solar power reaches 6 percent by 2035. The government aims to boost the adoption of solar power in Singapore's system to 350 megawatt-peak (MWp) by 2020, which is about 5 percent of peak electricity demand in 2020, a significant increase from Singapore's existing 15 MWp of solar power capacity.[16]

APS2 projects higher efficiencies and a larger share of solar power. It is assumed under APS2 that by 2035 gas-fired turbines will attain 61.0 percent efficiency and that thermal power plants will attain an efficiency of approximately 45.0 percent. The share of electricity contributed by solar power reaches 10 percent by 2035 under APS3. According to an estimate provided by the Sustainable Energy Association of Singapore (SEAS) in its White Paper, Singapore has enough space to accommodate 6GWp of solar PV, which can generate 7.2 TWh of electricity each year, or approximately 17 percent of Singapore's current electricity demand.[17] However, this projection could be too optimistic in view of the government's announcement to nearly double the cap for power generation from renewable sources to 600MW from 350MW. These and other measures are expected to help enable renewable energy sources (without the aid of government subsidies) meet 8 percent of Singapore's electricity needs by 2025, up from less than 1 percent now.[18]

2.2. Transport Sector

For the transport sector in all scenarios, both gasoline and diesel demand are linked to assumptions in the annual vehicle population growth rate. Following the caps on annual vehicle population growth rate announced by the government, the vehicle population is projected to grow by 1.5 percent from 2011, reducing to 0.5 percent from 2013 and to 0.25 percent from 2015 and assumed as such thereafter. Fuel efficiency improvements are also expected to further reduce fuel demand in APS1, which is fed into the model as an equivalent of 0.1 percent less vehicle growth in 2013, and 0.05 percent less vehicle growth in 2015.

[15] International Energy Agency (2010), *Projected costs of generation electricity*, p 102.
[16] Chia, Y.M. (2014), 'Boost for electricity retail market and solar power use', *The Straits Times*, 7 March.
[17] Sustainable Energy Association of Singapore (2014), 'A case for sustainability: Accelerating the adoption of Renewable Energy in Singapore', White Paper.
[18] Leong, G. (2013). 'Electricity market revolution on the way', *Business Times*, 23 November.

2.3. Residential Sector

It is assumed that energy efficiency measures targeted at the residential sector, such as energy labelling, minimum energy efficiency standards, and educational campaigns (e.g. '10 Percent Energy Challenge'), will reduce residential energy demand by 5 percent under the BAU scenario, and by 7.5 percent in APS1 by 2035.

2.4. Commercial Sector

A joint study conducted by the Building and Construction Authority (BCA) and the National University of Singapore (NUS) demonstrated that retrofitting to achieve the standard BCA Green Mark certification can result in a 17.0 percent reduction in energy demand.[19] If measured by the area of the buildings where owners are responsible for paying for the utilities, the average savings are even higher at nearly 30.0 percent. In 2005, the total number of buildings awarded the Green Mark Scheme was 17. By September 2014, there were more than 2,200 Green Mark building projects in Singapore.[20] At this pace, Singapore should be on track to achieve its target of having 80.0 percent of its existing and future buildings Green-Mark-certified by 2030.[21] Given our understanding of the vintage of building stock in Singapore and building stock replacement rates, a 10.0 percent reduction in electricity demand by the commercial sector is assumed for BAU and a 20.0 percent reduction in APS1.

2.5. Industry/Petrochemicals Sector

With reference to the IEA's Energy Technology Transitions for Industry 2009, the application of Best Available Technology (BAT) could reduce energy use in the industry sector by 13–29 percent.[22] Hence, the energy saving potential in the industry sector by 2030 is assumed to be 5.0 percent in the BAU scenario and 10.0 percent in APS1.

Singapore has a long-term aim of expanding ethylene production to a range of 6–8 million tonnes per year by 2020. [23] Over the last few years, its naphtha has doubled to 4 million tonnes per annum[24]. Singapore's petrochemical complex primarily uses liquefied petroleum gas (LPG) and naphtha to produce olefins, ethylene, and propylene. Most ethylene plants in Singapore are naphtha-based; therefore, capacity additions in the petrochemical sector will affect naphtha demand. In 2010, naphtha accounted for 99.0 percent of the petrochemical feedstock in Singapore and LPG 1.0 percent.[25] In December

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[19] Yu, S.M., Y. Tu, C.X. Luo, (2011), 'Green Retrofitting Costs and Benefits: A New Research Agenda, Institute of Real Estate Studies 2011-022', available at: http://www.ires.nus.edu.sg/workingpapers/IRES2011-022.pdf

[20] Building and Construction Authority Singapore (2015), 'Green Mark Projects', available at: http://www.bca.gov.sg/greenmark/green_mark_projects.html

[21] Building and Construction Authority Singapore (2009). '2nd Green Building Masterplan', available at http://www.bca.gov.sg/GreenMark/others/gbmp2.pdf

[22] International Energy Agency (2009), *Energy Technology Transitions for Industry*, p 31.

[23] Economic Development Board (2007), 'ExxonMobil's second steam cracker brings chemical industry to the next lap', available at http://www.edb.gov.sg/edb/sg/en_uk/index/news/articles/exxonmobil_s_second.html

[24] Lim, R. (2013), 'Petrochem-refining sector in 'digesting' phase', *Business Times*, 19 December.

[25] International Energy Agency (2012), *Energy Balances of Non-OECD Countries*.

2012, a new 220 megawatt petrochemical co-generation plant was added to ExxonMobil's existing petrochemical operations, adding 2.6 million tonnes per year to its finished product capacity.[26] According to the IEA, 155.0 GJ of naphtha is required to produce one tonne of ethylene. If the share of naphtha in the production of ethylene increases to 100.0 percent by 2020 and the above conversion factor is used, the production of 6.0 million tonnes of ethylene implies the demand of 22.2 Mtoe of naphtha in the non-energy sector.

There are also plans for the sharing of excess heat and steam for greater efficiency in the petrochemical plants on Jurong Island.[27] The carbon emissions reduction from these measures could be expected to go up to 13 percent by 2025, which is assumed to be about half of what IEA had assumed (24 percent) if current best practices are adopted.[28]

3. Outlook Results

3.1. Business-as-Usual (BAU)

3.1.1. Total Final Energy Demand

Singapore's total final energy demand grew at an annual rate of 5.4 percent from 5.0 Mtoe in 1990 to 16.0 Mtoe in 2012. During the same period, oil was the dominant energy source, with 3.8 Mtoe and 11.1 Mtoe consumed in 1990 and 2012 respectively. More than 37.0 percent of the country's final energy is consumed for non-energy uses, particularly as feedstock for petrochemical production. In 1990, 27.1 percent of total final energy demand was used in the transport sector, although its share in total final energy demand declined by more than 40 percent, reaching around 15.7 percent in 2012.

Under the BAU scenario, total final energy demand is projected to grow by an average 4.2 percent per year between 2012 and 2035. The fastest growth is expected to occur in the petrochemical sector, at 6 percent per year. This is followed by the industry sector, which is projected to grow by an average annual 3.6 percent (Figure 15-1). The transport sector is projected to grow by 0.9 percent per year and the 'others' (residential and commercial) sector by 1.7 percent.

Under the BAU scenario, non-energy consumption will still comprise the highest share in total final energy demand, followed by the industrial sector. By the end of 2020, non-energy use will exceed 60.0 percent of Singapore's total final energy demand, before declining slightly, to 56.1 percent, in 2035. The industrial sector's share will also fall, from a 32.3 percent share in 2012 to around 28.1 percent in 2035.

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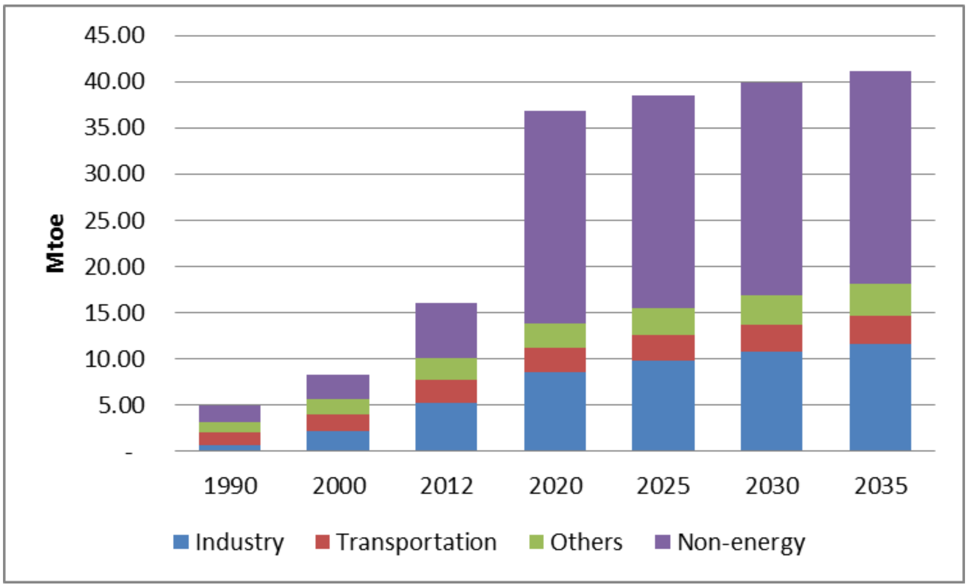
[26] ExxonMobil Chemical (2012), 'ExxonMobil Commissions Singapore Petrochemical Plant Expansion', available at: http://news.exxonmobilchemical.com/pressrelease/english/exxonmobil-commissions-singapore-petrochemical-plantexpansion

[27] Lim, R. (2013), 'In the pipeline: Heat exchange on Jurong Island: Plans for plants to share excess heat, steam for efficiency'. *The Straits Times*, 19 December.

[28] International Energy Agency (2014), 'Energy Technology Perspectives 2014 – Harnessing Electricity's Potential'.

Figure 15-1. Final Energy Demand by Sector, BAU

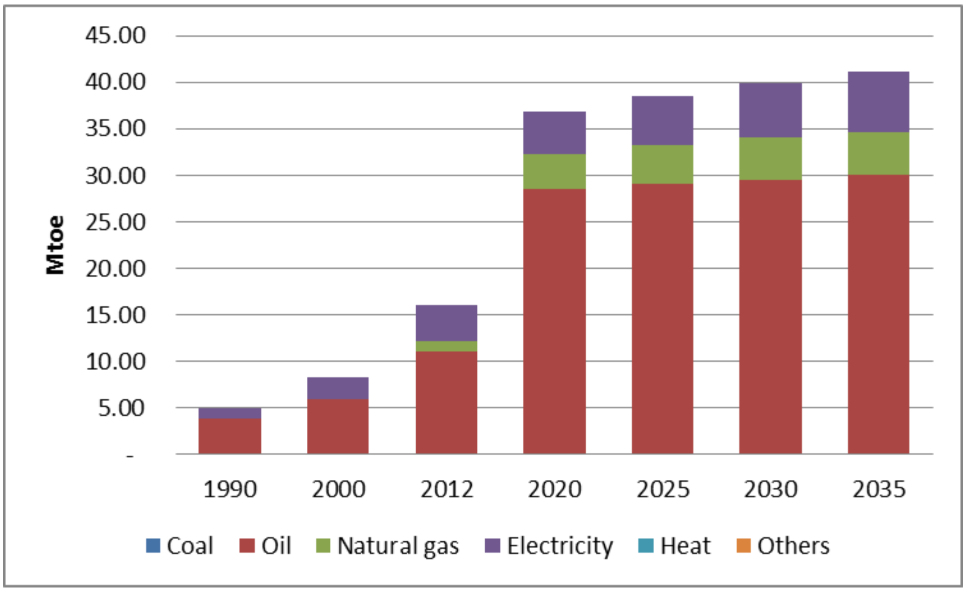


BAU = Business-as-Usual.
Source: Author's calculation.

The transport sector's share in total final energy demand from 2012 to 2035 is expected to decrease to 7.5 percent from its 27.1 percent share in 1990. The decrease is due to the country's active promotion of more efficient automobile technology and the increased use of mass transit for personal transport. Moreover, COE quotas are also expected to remain effective in curbing vehicle growth.

By fuel type, natural gas saw the fastest growth from 1990 to 2012, increasing at an average annual rate of 14.1 percent.

Figure 15.2. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

The rapid growth of natural gas was due to the increasing demand in its use mainly in the rapidly expanding industry sector. From 1990 to 2012, demand for electricity grew at an average annual rate of 5.7 percent.

Under the BAU scenario, demand for natural gas is expected to continue to expand, but at a slower average growth rate of 6.3 percent per year. Electricity demand is projected to grow at an average annual rate of only 2.3 percent per year.

Oil is expected to continue to play a major role in Singapore's final energy demand. From 1990 to 2012, the share of oil fell from 76.1 percent to 69.1 percent. Under the BAU scenario, oil's share in total final energy demand is projected to rise to 77 percent in 2020 before falling to 73 percent in 2035. Natural gas usage will increase from its share of 7.1 percent in 2012 to 11.1 percent in 2035. And the share of electricity in final energy demand will decrease to around 12.4 percent in 2020 and rise to 15.8 percent in 2035. Figure 15-2 shows final energy demand by fuel type.

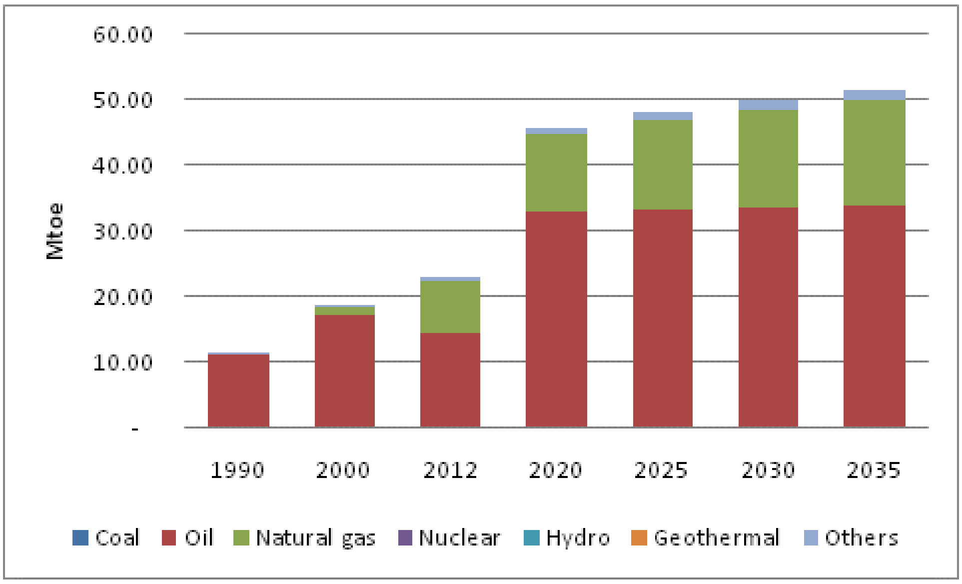
3.1.2. Total Primary Energy Consumption

Total primary energy consumption grew by 3.2 percent per year, from 11.53 Mtoe in 1990 to 22.91 Mtoe in 2012. Singapore's dominant source of energy in 1990 was oil, of which consumption increased by an average annual 3.2 percent, from 11.4 Mtoe in 1990 to 14.43 Mtoe in 2012. 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 increased. Natural gas consumption increased rapidly from 0.4 Mtoe in 1992 to 7.87 Mtoe in 2012. To expand the country's import capability and sourcing options, Singapore has commenced commercial operations with its newly constructed LNG terminal in May 2013, which currently has a throughput capacity of 6.0 million tonnes per year,[29] and an expected 9 million metric tonnes per year in 2017, with a fourth storage tank to be constructed.[30]

Primary energy demand in the BAU scenario is projected to grow by 3.6 percent per year between 2012 and 2035 (Figure 15-3). Amongst the energy sources, solar energy is expected to grow fastest, at 32.3 percent a year, followed by oil at 3.8 percent. Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

[29] Boon (2013).
[30] *ChannelNewsAsia, Singapore Opens First LNG Terminal, Plans for Second Terminal, 25 February 2014.*

Figure 15-3. Total Primary Energy Consumption, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

Over the next few years, Singapore's net generation capacity will increase by more than 2,000 MW or about 20.0 percent of current installed capacity and will consist of more efficient Combined Cycle Gas Turbines (CCGTs)[31]. Nevertheless, oil is expected to remain the primary energy source, accounting for 66 percent of primary energy demand in 2035, followed by natural gas at 30.7 percent.

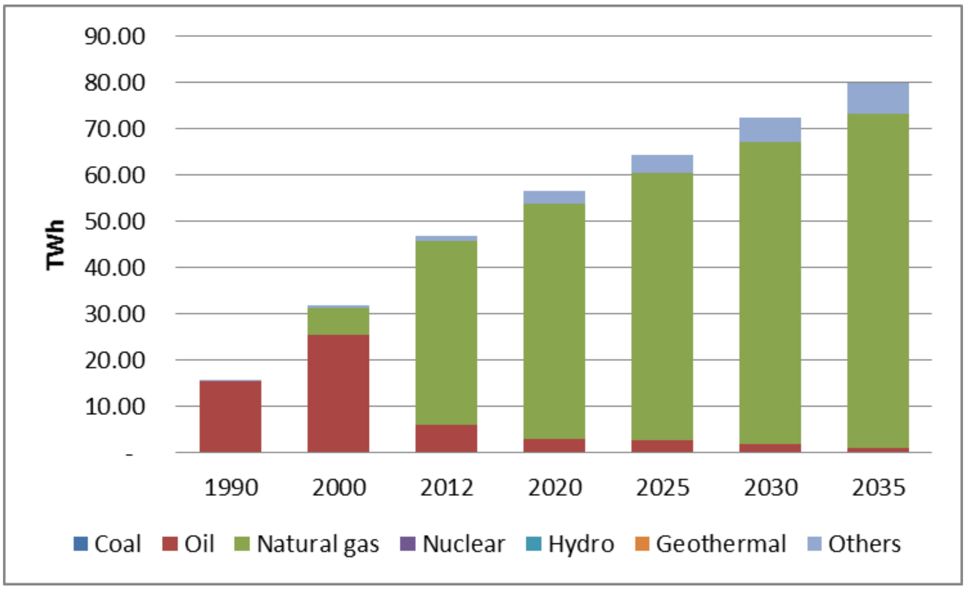
3.1.3. Power Generation

Electricity generation grew by 5.1 percent per year, from 15.7 TWh to 46.9 TWh, from 1990 to 2012. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 28 percent of electricity generation in Singapore in 2001, grew rapidly to supply 84.3 percent of Singapore's electricity in 2012. Fuel oil use for thermal power generation was around 13 percent[32] in 2012 and serves as a 'balancing' alternative to a total dependence on natural gas. Biomass takes up a small proportion of the mix, at around 2.7 percent.

In the BAU scenario, power generation is projected to increase at a slower rate of 2.3 percent per year, reaching 79.96 TWh in 2035. By type of fuel, generation from 'Others' will see the fastest growth, at an average rate of almost 7.7 percent per year. 'Others' power generation is expected to increase its share from a minimal share of 2.7 percent in 2012 to 8.6 percent in 2035.

[31] Ministry of Trade and Industry (2012).
[32] Energy Market Authority (2012).

Figure 15-4. Electricity Generation, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

By the end of 2013 and the years thereafter, at least 90.0 percent of the country's power generation mix will be made up of natural gas under the BAU scenario, whereas the share of oil will decline to 1.4 percent over the same period.

The average thermal efficiency of fossil power plants was around 30.3 percent in 1990 and improved to 48.7 percent in 2012, as natural gas-fired power plants came into operation. In the BAU scenario, thermal efficiency of fossil plants is expected to improve further, to around 55 percent in 2035.

By fuel, natural gas plants' thermal efficiency is projected to be 55.0 percent in 2035 and that of oil 41.0 percent.

3.1.4. Energy Indicators

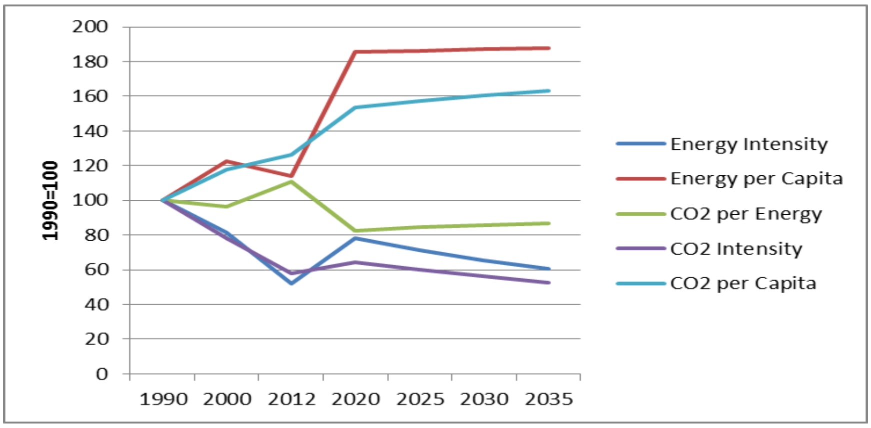
Total primary energy intensity, which is computed as the ratio of total primary energy demand over GDP is expected to increase over the projection period. Energy intensity continues to increase as Singapore's population will experience slower growth in the future.

3.2. Energy Saving and CO_2 Reduction Potential

3.2.1. Total Final Energy Demand

Final energy demand under APS1 is projected to increase by an annual average 4.1 percent from 2012 to 2035. Similar to the BAU case, the non-energy sector is expected to lead growth, at 6 percent per year, followed by the industry sector at 3.3 percent, and the other (residential and commercial) sector at 1.3 percent. APS2 and APS3 do not include energy conservation policies for end demand and hence are similar to the BAU scenario. APS5, as combination of all APS, will have the same final energy demand as APS1.

Figure 15-5. Energy Indicators, BAU

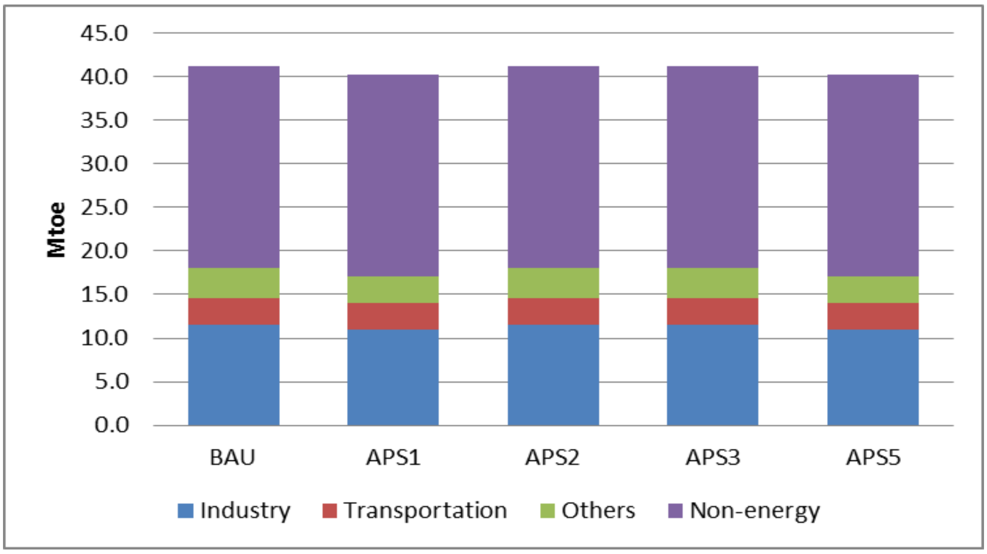


BAU = Business-as-Usual.
Source: Author's calculation.

3.2.2. Total Primary Energy Consumption

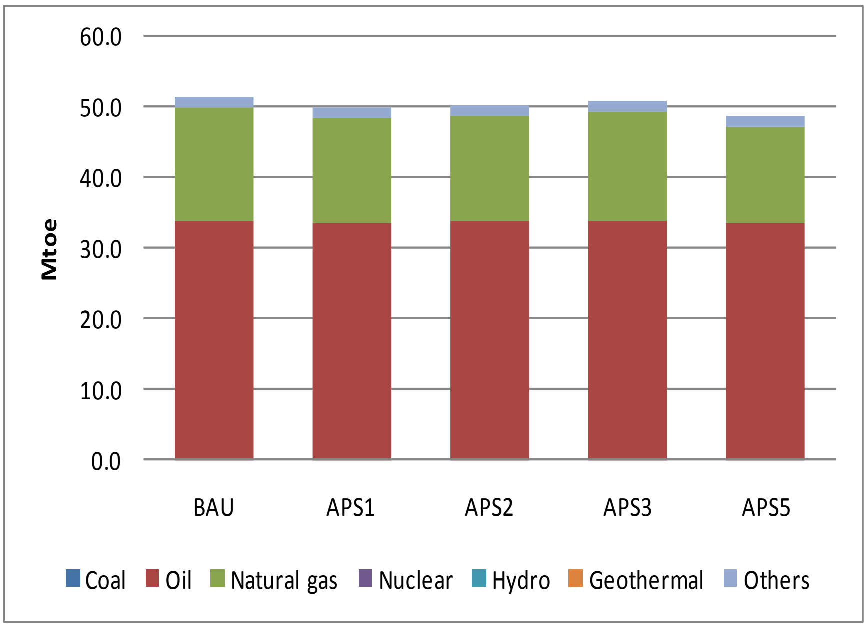
Results from APS1 show that primary energy demand from 2012 to 2035 will increase at an average annual rate of 3.4 percent, a marginal decrease from BAU (Figure 15-7). This translates to a reduction of 1.6 Mtoe from end-user energy efficiency policies. APS2 and APS3 will help to lower primary energy consumption by 1.4 Mtoe and 543 ktoe, respectively. This illustrates that solar policies play only a secondary role to end-user energy efficiency policies in reducing primary energy demand, whereas power generation can help provide sizeable consumption reductions.

Figure 15-6. Total Final Energy Demand by Sector, BAU and APS1–5



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

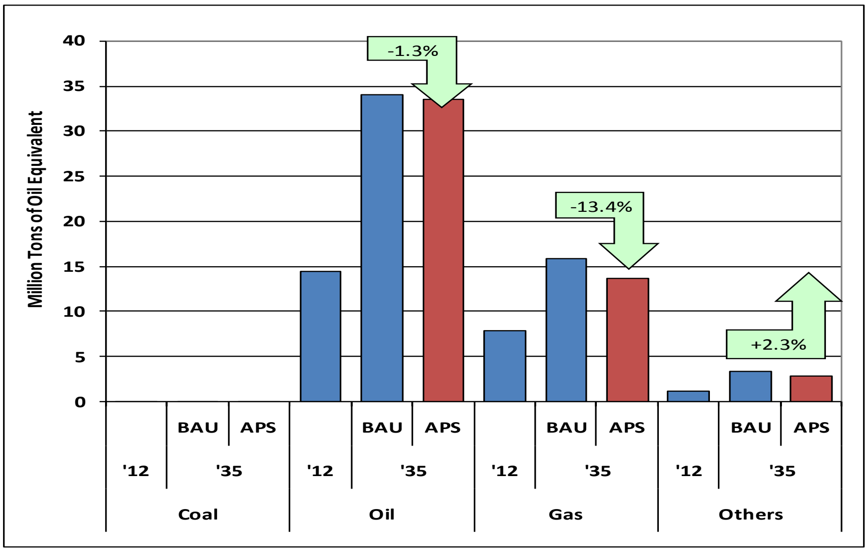
Figure 15-7. Total Primary Energy Consumption by Fuel, BAU and APS1–5



BAU = Business-as-Usual; APS = Alternative Policy Scenario
Source: Author's calculation.

Most of the reduction in primary energy consumption will come from natural gas, at 2.13 MTOE, which is a drop of 13.4 percent from BAU. Oil only falls by 1.3 percent as it is limited by the already declining BAU consumption for power generation, as well as the large consumption in petrochemical non-energy use. Biomass' consumption will remain relatively constant.

Figure 15-8. Total Primary Energy Consumption by Fuel, BAU and APS5

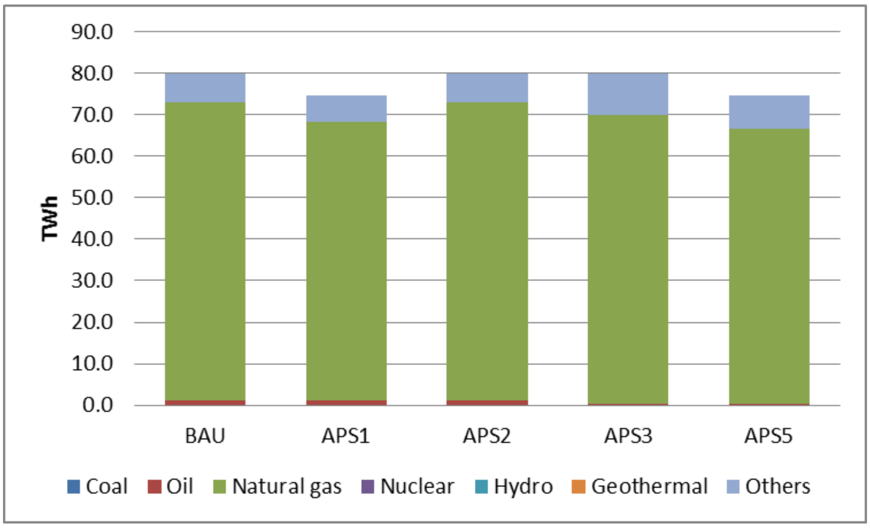


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.2.3. Power Generation

Results from APS1 and APS5 show a decrease in electricity generation, with a projected decrease of 5.38 TWh or 6.7 percent from BAU. APS2 and APS3 assume the same generation as BAU, since final energy demand does not decrease under these two scenarios.

Figure 15-9. Electricity Generation, TWh



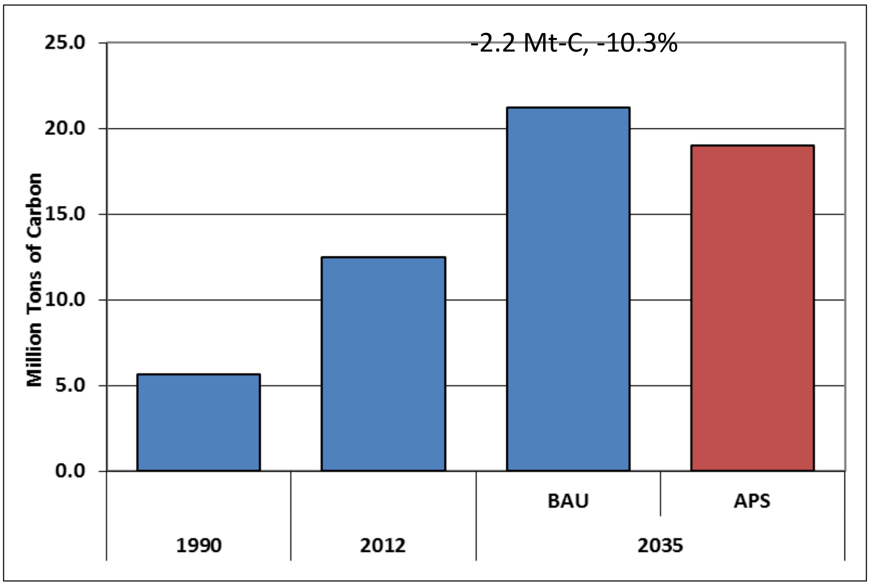
Source: Author's calculation.

3.2.4. CO_2 Reduction Potential

Carbon dioxide (CO_2) emissions from energy demand are projected to increase at an average annual rate of 2.3 percent, from 12.5 Mt-C in 2012 to around 21.2 Mt-C in 2035 (Figure 15-10).

The CO_2 emissions reduction potential comes mainly from power generation (APS2), with savings of 1.24 Mt-C in 2035, equivalent to a 5.8 percent decrease from BAU. This shows that further switching of power generation to cleaner sources greatly reduces emissions. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with a projected emissions reduction of 0.832 Mt-C (3.9 percent) under APS1. Utilisation of solar power and biomass accounts for the remainder of the carbon emissions, at 0.36 (1.7 percent) Mt-C. In total, all the energy efficiency policies (APS5) will contribute to reducing CO_2 to 2.29 Mt-C, which is a decrease of 10.3 percent from the BAU case from 2012 to 2035. This effectively translates to an annual average decrease of 1.8 percent.

Figure 15-10. CO_2 Emissions from Energy Consumption, BAU and APS5



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Implications and Policy Recommendations

The impetus for a reduction in energy use and emissions is provided by the host of programmes instituted by the government that seek to incentivise the use of less carbon-intensive fuels and to improve energy efficiency. These programmes includes a number of funding schemes, including the Clean Development Mechanism and the Documentation Grant that help provide companies with financial assistance for the engagement of carbon consultancy services, and the Grant for Energy Efficient Technologies (GREET) to help encourage industry investments in energy efficient equipment or technologies.[33] Zero-Capex (Capital Expenditure) or similar commercial contracts can also be actively promoted to increase the involvement of energy service companies (ESCOs) to help conserve energy. There is also an initiative to improve the petrochemical industry's energy efficiency and competitiveness by way of a 'heat-integration' plan.[34] Despite certain limitations due to Singapore's 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.

[33] Energy Efficiency Programme Office (2013), 'Incentives' available at: http://www.ema.gov.sg/info_directory/id:162/

[34] Lim Ronnie (2013), 'In The Pipeline: Heat Exchange on Jurong Island', *Business Times*, 19 December.

CHAPTER 16

Thailand Country Report

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1. Background

Thailand is in the middle of the South East Asian mainland, with the Pacific Ocean on the southeast coast and the Indian Ocean on the southwest coast. Its land area is approximately 513,115 square kilometres, with great plains in the centre, mountainous areas up north, and highlands in the northeast. Its gross domestic product in 2012 was US$226.4 billion (in constant 2005 US$ terms). In 2012, the population was 66.8 million and income per capita was US$3,390.

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 2012, proven reserves were 0.3 billion barrels (21.6 million cubic metres) of oil, 8.4 trillion cubic feet (0.24 trillion cubic metres) of natural gas, and 1,181 million tonnes of lignite.

Thailand's total primary energy supply (TPES) reached 117.7 Mtoe in 2012. Oil accounted for the largest share, at around 41.3 percent, followed by natural gas (22.8 percent), and coal (14.5 percent). 'Others' accounted for the remaining 20.8 percent. In 2012, net imports of energy accounted for 50.0 percent of TPES. Due to very limited indigenous oil resources, Thailand imported around 81.7 percent of its oil and most of its bituminous coal. Although Thailand produces large quantities of natural gas, about 19.2 percent of its use was imported from Myanmar and other countries, in terms of natural gas liquid (NGL).

Natural gas is used as a major energy source for power generation in Thailand. In 2012, primary natural gas supply registered at 26.8 Mtoe, around 80.7 percent of it sourced from domestic supply and the rest imported from neighbouring countries, while NGL was also sourced from countries. Coal was mainly consumed in power generation and industry, and was also heavily used in cement and paper production.

Thailand has 32.6 GW of installed electricity generation capacity and power generation was 166.6 TWh in 2012. The majority of Thailand's power generation used thermal sources (coal, natural gas, and oil), accounting for 91.8 percent of generation, followed by hydro at 5.3 percent, with geothermal, solar, small hydro, and biomass making up the remainder.

2. Modelling Assumptions

GDP growth from 1990 to 2012 was a moderate 4.3 percent per year. Thailand's GDP is assumed to grow at an average rate of 3.9 percent per year between 2012 and 2035. Population growth is also projected to be reasonably slow, at around 0.03 percent per year between 2012 and 2035, compared with average growth of about 0.8 percent per year between 1990 and 2012.

Coal and natural gas are projected to be the largest energy sources for power generation. The shares of fuel oil and diesel power plants are projected to decline. Nuclear power and renewable energy are projected to increase their shares in the power generation mix.

Thailand's energy saving goals are expected to be achieved through the implementation of energy efficiency programmes in all sectors. In the industrial sector, improvements in technology development in manufacturing processes should help improve energy efficiency. In the residential and commercial (other) sector, large energy savings are projected, driven by programmes to promote public awareness of energy efficiency and energy efficiency labelling. In the transportation sector, further development of the Bangkok metro area railway network will contribute to energy savings. Significant improvements in energy efficiency in passenger vehicles are also expected, in line with new developments in car technologies and the introduction of the next phase of the Eco Car Program II.

Government policies will continue to encourage the increased use of alternative fuels, especially biofuels. Reductions in the growth of CO_2 emissions are also expected to be achieved 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

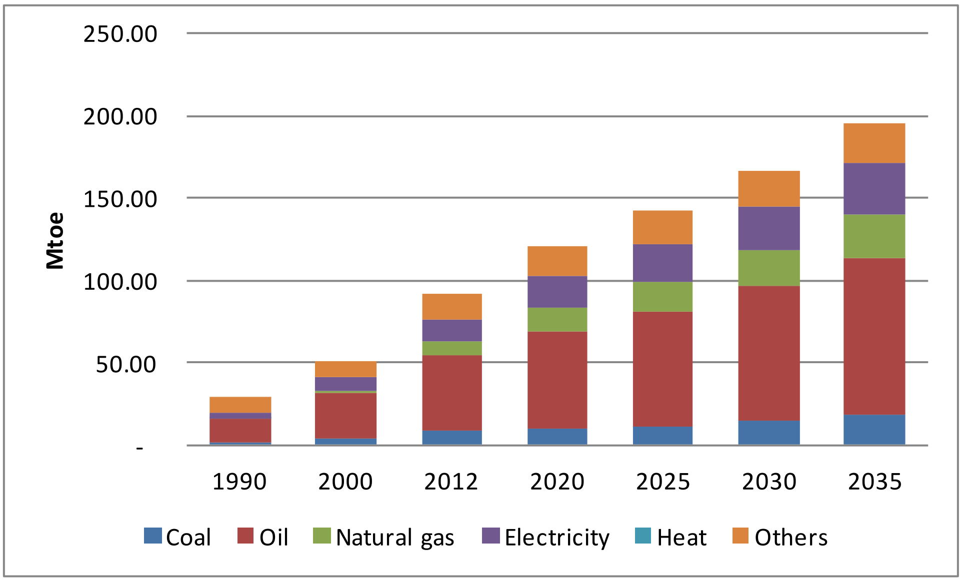
3.1. Business-as-Usual (BAU) Scenario

Between 1990 and 2012, Thailand's final energy consumption grew at quite a high rate, of 5.4 percent per year from 28.9 Mtoe in 1990 to 92.1 Mtoe in 2012. Given moderate economic growth and low population growth, final energy consumption is projected to grow at a moderate rate of around 3.3 percent per year between 2012 and 2035.

Oil has been the dominant energy source in final energy consumption, accounting for 45.5 Mtoe or a 49.4 percent share in 2012. Electricity was the second largest energy source, accounting for 13.9 Mtoe or a 15.1 percent share in 2012.

Oil is expected to remain the largest final energy source throughout the projection period. Its share is projected to decline a little from the 2012 level, to 48.4 percent in 2035. In 2035, the shares of electricity, natural gas, and coal in final energy consumption are projected to increase to 16.4 percent, 13.3 percent, and 9.6 percent, respectively.

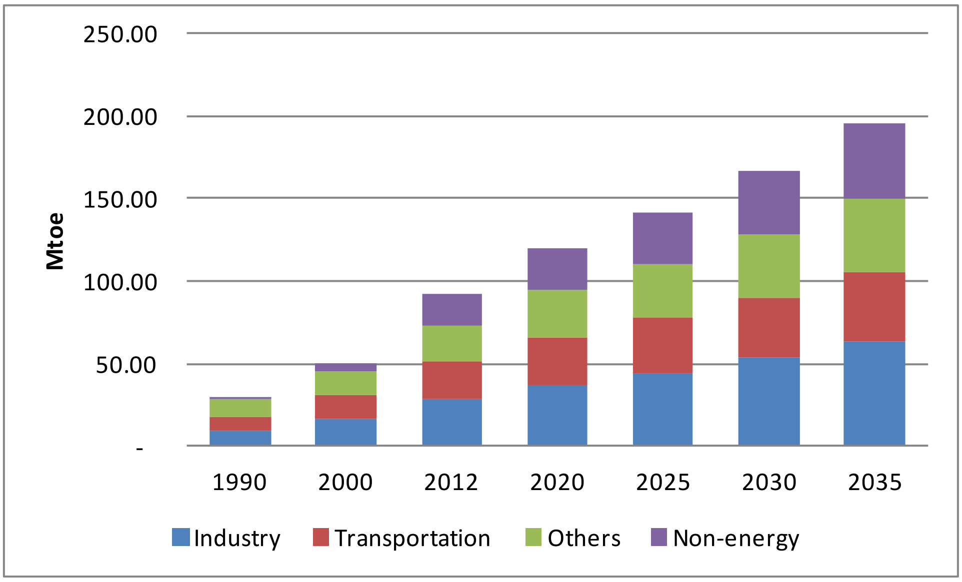
Figure 16-1. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

The industry sector had the smallest share in total final energy demand in 1990, at a level of 8.7 Mtoe. With consumption in the sector increasing at an average annual rate of 5.6 percent between 1990 and 2012, the share of industry increased from 30.0 percent in 1990 to 31.5 percent in 2012, becoming the largest consuming sector. The industry sector is projected to remain the largest consumer over the projection period, accounting for 32.4 percent of final energy consumption in 2035. The transportation sector is projected to have the smallest share of final energy consumption in 2035, at 21.5 percent, continuing the decline of its share since 1990.

Figure 16-2. Final Energy Demand by Sector, BAU

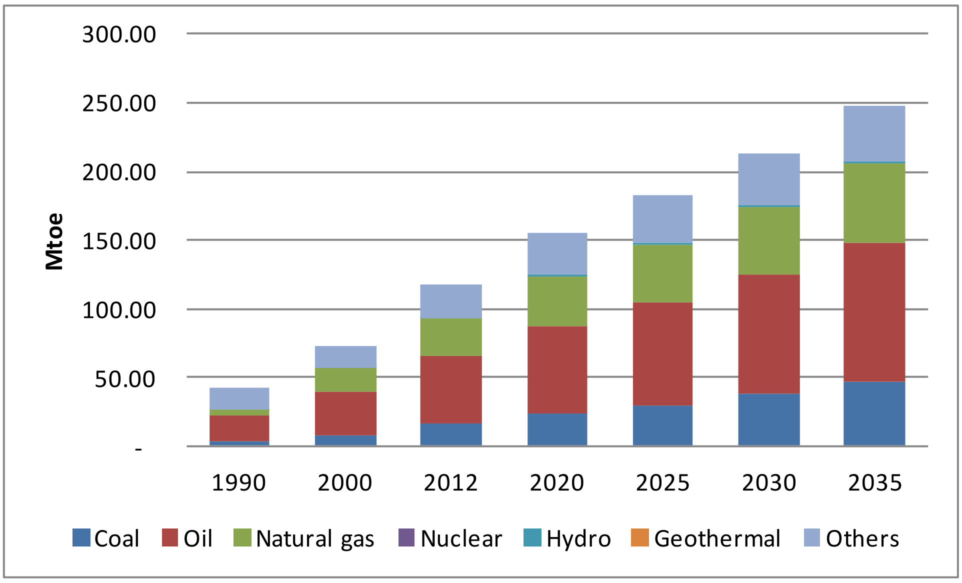


BAU = Business-as-Usual.
Source: Author's calculation.

Primary energy demand grew at an average annual rate of 4.7 percent, from 42.6 Mtoe in 1990 to 117.7 Mtoe in 2012, driven largely by fast economic development between 1990 and 1996. This growth in primary energy consumption was achieved despite the severe economic crisis in 1997–1998 and the world economic crisis in 2008. In 2012, the major sources of primary energy were oil, natural gas, and coal with shares of 41.3 percent (48.6 Mtoe), 22.8 percent (26.8 Mtoe), and 14.5 percent (17.1 Mtoe), respectively. Although oil remained the largest source between 1990 and 2012, its share in primary energy demand contracted slightly, from 42.1 percent in 1990 to 41.3 percent in 2012. 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 percent in 1990 to 22.8 percent in 2012. The share of hydropower declined from 1.0 percent in 1990 to just 0.6 percent in 2012.

In the BAU scenario, primary energy demand is projected to grow at about 3.3 percent per year from 2012 to 2035, reaching 248.4 Mtoe in 2035. The highest average annual growth rate is expected in coal (4.5 percent), with consumption expected to reach 47.1 Mtoe in 2035. Following very strong average annual growth in natural gas of 3.4 percent between 1990 and 2012, oil growth is expected to be slower than growth of primary energy demand. Although its average growth rate is projected at 3.2 percent per year between 2012 and 2035, its share in the total will remain above 40 percent.

Figure 16-3. Net Primary Energy Supply by Fuel, BAU

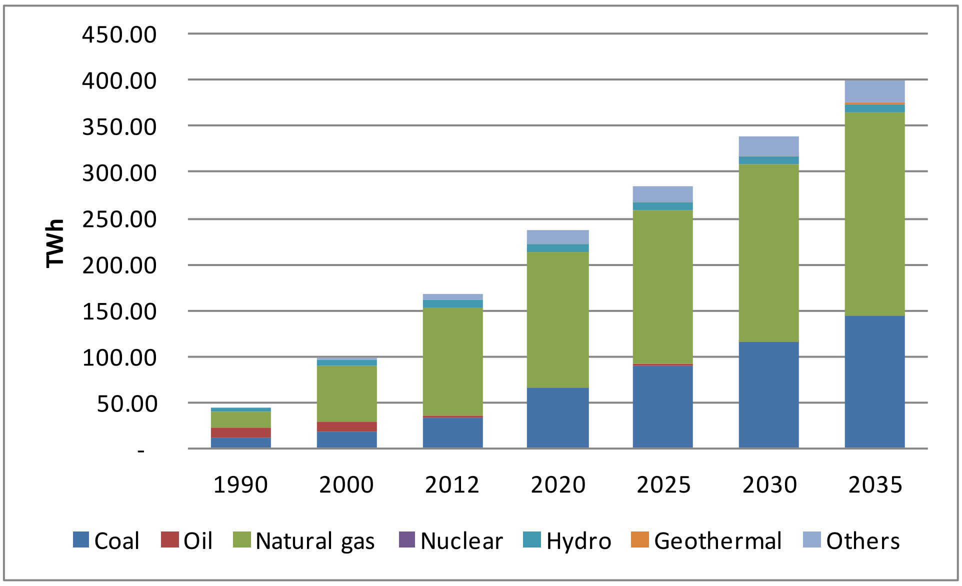


BAU = Business-as-Usual.
Source: Author’s calculation.

In 1990, total power generation registered at 44.2 TWh and reached 166.6 TWh in 2012, with an average annual growth rate of 6.2 percent. As shown in Figure 16-4, natural gas has been a major fuel for power generation since 1990. It grew at a robust rate of 8.9 percent per year from 17.8 TWh (40.2 percent share) in 1990 to 117.1 TWh (70.3 percent share) in 2012. Coal had the second largest share, at 25.0 percent, in 1990, and it shrank to 20.0 percent in 2012. Oil was the fuel least used in power generation, at just 2.4 TWh in 2012.

In the BAU scenario, power generation is expected to grow at around 3.9 percent per year from 2012 to 2035 and will reach 400.5 TWh in 2035. Natural gas is expected to remain the fuel most used in power generation, with a share of 55.1 percent, or 220.7 TWh, in 2035. Coal is expected to remain the second largest source of power, with a 35.8 percent share or a level of 143.3 TWh in 2035. Power generation from hydro will increase slightly, by 0.4 percent, from 8.8 TWh in 2012 to 9.5 TWh in 2035.

Figure 16-4. Power Generation by Fuel, BAU



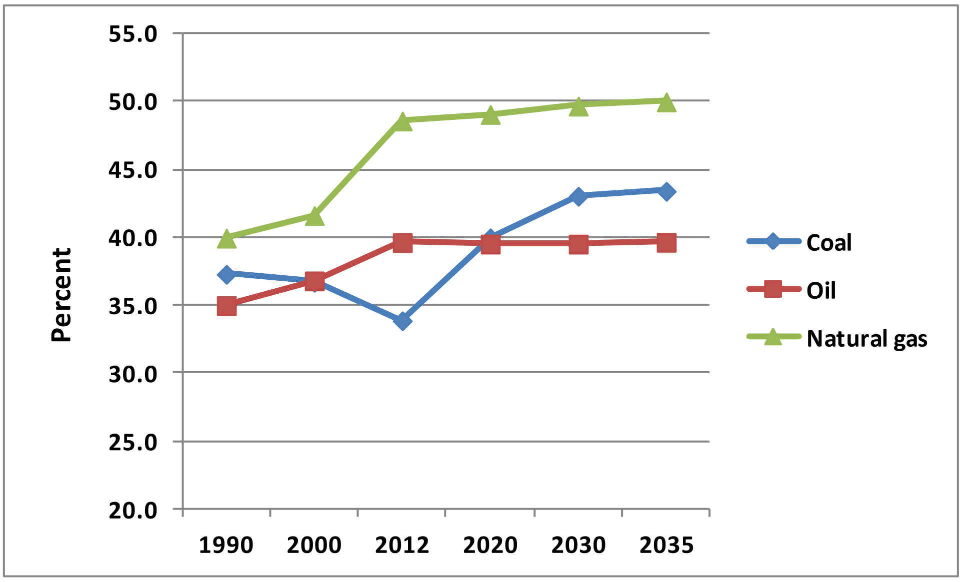
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Natural gas had the sharpest thermal efficiency improvement from 1990 to 2012, increasing from 40.0 percent efficiency in 1990 to 48.6 percent in 2012, and it is expected to increase to 50.0 percent by 2035. Coal thermal efficiency declined by 0.4 percent from 1990 to 2012, but is projected to improve from 33.9 percent in 2012 to 43.4 percent in 2035 (Figure 16-5).

Energy intensity reached 407.0 toe/million at 2005 US$ in 2012. In the BAU case, energy intensity is projected to decline by 0.5 percent per year to reach 363.0 toe/million 2005 US$ in 2035. Energy per capita is projected to increase from 1.8 toe per person in 2012 to 3.7 toe per person in 2035.

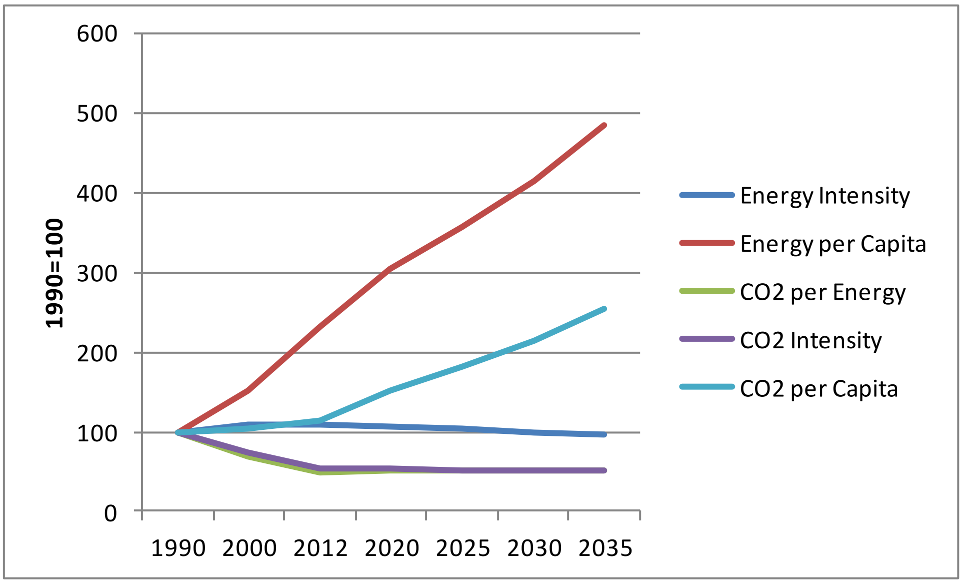
Energy elasticity between 1990 and 2012 registered at 1.1, which indicates that energy demand rose at a faster rate than economic output. In the BAU scenario, energy elasticity is projected at 0.8 from 2012 to 2035, meaning that energy demand will grow at a slower rate than economic output.

Figure 16-5. Thermal Efficiency by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

Figure 16-6. Energy Indicators



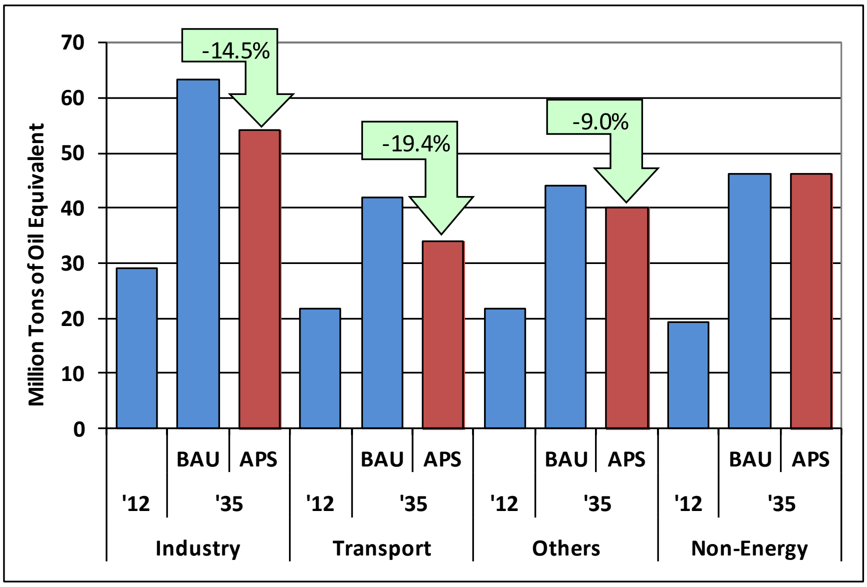
Source: Author's calculation.

3.2. Energy Saving and CO_2 Reduction Potential

Final Demand

In the APS, final energy consumption is projected to grow by 2.8 percent per year, from 92.1 Mtoe in 2012 to 174.5 Mtoe in 2035. This is 10.9 percent lower than the BAU scenario, in which growth is projected at an average annual rate of 3.3 percent from 2012 to 2035. The bulk of energy savings will be achieved through energy efficiency improvement programmes implemented in the industry (14.5 percent) and transportation (19.4 percent) sectors. Improvements will also be achieved in other sectors (9.0 percent), as shown in Figure 16-7.

Figure 16-7. Final Energy Consumption by Sector, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Primary Supply

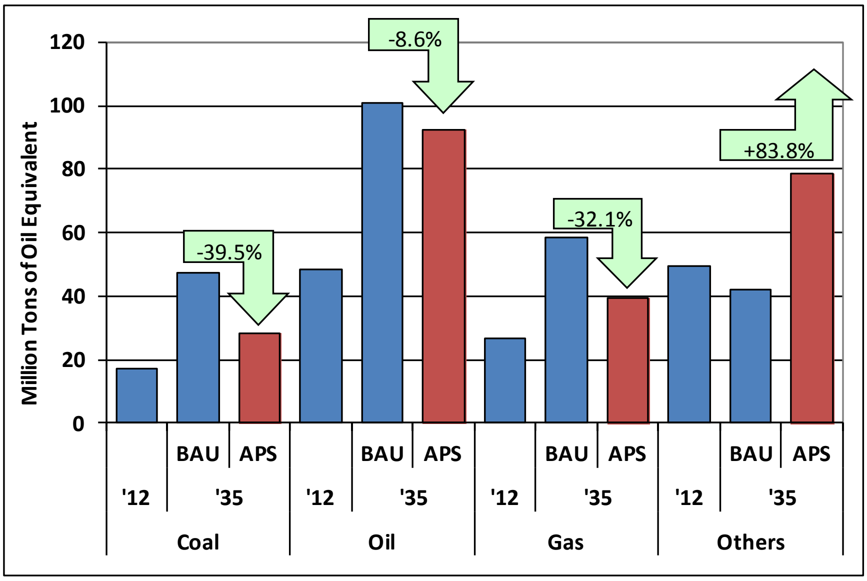
In the APS, growth in primary energy demand growth is projected to be much slower than in the BAU scenario, increasing at 3.1 percent per year (compared with 3.3 percent in BAU) to reach 238.9 Mtoe in 2035. Primary energy demand is expected to be about 3.8 percent lower in the APS than in the BAU scenario in 2035 – an energy saving of about 9.4 Mtoe.

Coal and oil are projected to increase at slower annual average rates of 2.2 percent and 2.8 percent, respectively (4.5 percent and 3.2 percent, respectively, in the BAU scenario). Natural gas use is projected to increase at an annual average rate of 1.7 percent (3.4 percent in the BAU scenario), from 26.8 Mtoe in 2012 to 39.6 Mtoe in 2035. The lower growth rates compared with the BAU scenario are mainly achieved through energy efficiency and conservation measures on the demand side. However, new and renewable energy are projected to grow at a faster rate, of 5.0 percent, in the APS compared with the 2.4 percent annual growth rate expected under the BAU scenario. This will result in 83.8 percent higher non-fossil energy in the APS compared with BAU. The differences in the projections between the two scenarios are shown in Figure 16-2.

3.3. Projected Energy Savings

The difference between primary energy demand in the BAU scenario and the APS in 2035 is 9.4 Mtoe (Figure). This represents the potential energy savings that could be achieved if energy efficiency and conservation goals and action plans were implemented. Natural gas and coal will contribute the largest energy savings at 18.7 Mtoe and 18.6 Mtoe, respectively, and energy saving from oil will reach 8.7 Mtoe in 2035. However, the contribution of non-fossil energy sources will be 36.5 Mtoe higher than in the BAU scenario.

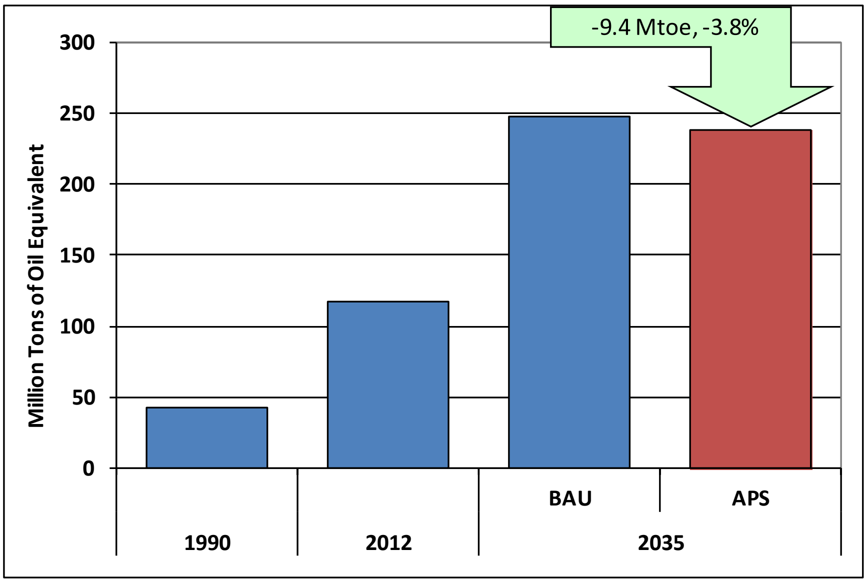
Figure 16-8. Primary Energy Demand by Source, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

In terms of final energy consumption, the savings in the APS compared with the BAU scenario in 2035 will reach 21.3 Mtoe. The largest savings are expected to be achieved in the industry sector, at 9.2 Mtoe. The transport and other sectors are expected to achieve energy savings of 8.2 Mtoe and 3.9 Mtoe, respectively.

Figure 16-9. Total Primary Energy Demand, BAU and APS



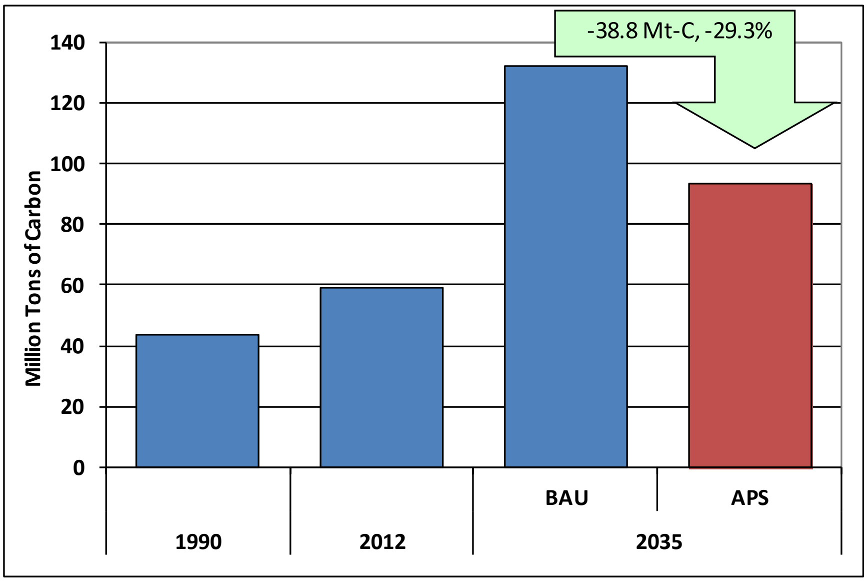
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.4. CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 3.6 percent per year on average, from 59.3 Mt-C in 2012 to 132.5 Mt-C in 2035 under the BAU scenario.

Under the APS, the average annual growth in CO_2 emissions from 2012 to 2035 is projected to be 2.0 percent, with an emissions level of 93.7 Mt-C in 2035. The difference the in CO_2 emissions between BAU and the APS is 38.8 Mt-C or 29.3 percent. This reduction in CO_2 emissions highlights the range of benefits that can be achieved through energy efficiency improvements and savings via action plans (Figure 16-4).

Figure 16-10. CO_2 Emissions from Energy Consumption, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Implications and Policy Recommendations

Strong economic growth prior to the Asian Financial Crisis in 1997 contributed to relatively high energy intensity in Thailand between 1990 and 2011. But since it recovered from the crisis, the energy intensity of the economy has declined. Thailand's energy efficiency programmes in a wide range of areas (including industry, transportation, and residential sectors) and high oil prices in the world market are projected to contribute to a continuing decline in the energy intensity of the Thai economy.

Improving energy efficiency will also help Thailand (an oil importer) address the challenges resulting from high world oil prices. Thailand is committed to reducing the intensity of energy consumption, particularly oil consumption, and to finding more sustainable energy sources and environmentally friendly fuels. It was recognised that the more Thailand saves energy, the less sensitive it will be to fluctuations in world energy prices and supply. In short, Thailand has realised the importance of energy savings and that it should make greater efforts to achieve them.

Although Thailand has an alternative policy for the next 23 years, oil will remain a major energy source for its economy. Oil is one of the most sensitive energy sources in terms of price and security. Thailand should focus more on oil savings in the future to become less dependent on this fuel. Energy use in the transportation sector will be lower than that in other sectors in future. This sector is also less productive than the others, meaning it consumes more energy but produces less value added. The greater the energy saving efforts in the transport sector, the more the Thai economy as a whole will benefit.

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 is located in the centre of Southeast Asia. In 2012, Viet Nam had a population of 88.8 million and a gross domestic product (GDP) of US$87.5 billion in 2005 US$ terms. The commercial sector contributed most to Viet Nam's GDP (41.7 percent), followed by the industry sector (38.6 percent), and agriculture (18.0 percent). GDP per capita was 986 US$ per person in 2012.

Viet Nam possesses considerable indigenous energy resources. It has 3.4 billion tonnes 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 60.4 Mtoe in 2012. Coal represented the largest share of Viet Nam's TPES at 29.0 percent; oil was second at 28.1 percent, followed by natural gas (12.8 percent), hydro (6.9 percent), and 'others' (23.2 percent). Viet Nam is a net exporter of crude oil and coal, but an importer of petroleum products because of capacity limitations at the Dung Quat oil refinery (6.5 million tonnes a year) that meets around 40 percent of domestic demand.

Coal is mainly used in the industry sector, with consumption of 17.5 million tonnes of oil equivalent (Mtoe) in 2012, and natural gas is largely used for electricity generation.

Viet Nam had around 26.5 GW of installed generating capacity and generated 117.6 TWh of electricity in 2012. Most of Viet Nam's electricity generation comes from thermal sources (coal, natural gas, and oil), accounting for 58.4 percent of total generation; the remainder is hydro (38.6 percent) and other (3.0 percent).

2. Modelling Assumptions

In this outlook, Viet Nam's GDP is assumed to grow at an average annual rate of 6.2 percent from 2012 to 2035. Growth is projected to be faster in the first half of the outlook period, increasing at an annual average 6.6 percent between 2012 and 2020. Economic growth is projected to be slightly lower from 2020 to 2035, at an annual rate of 6.0 percent. The population is projected to grow at 0.8 percent per year between 2012 and 2035.

The share of electricity generated from coal-fired power plants is projected to increase considerably, at the expense of other energy types (thermal and hydro). Viet Nam is expected to increase its imports of electricity, particularly from Lao PDR and China.

The use of nuclear energy is assumed to start in 2020 in line with Viet Nam's nuclear power development plan. In the Business-as-Usual (BAU) scenario, it is assumed that the first unit of nuclear power with a capacity of 1,000 MW will be installed in 2020 and followed by six units and ten of nuclear power with total capacity of 6,000 MW and 10,700 MW will be installed in 2030 and 2035 respectively.

Viet Nam's energy saving goals are assumed to be between 3 percent to 5 percent of total energy consumption, equivalent to 5 Mtoe, between 2006 and 2010, and 5 percent to 8 percent 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). Beyond 2015, Viet Nam's energy saving goals are assumed to follow the trend of earlier periods.

The energy savings goals are expected to be attained through the implementation of energy efficiency programmes in the industry, transport, residential, and commercial sectors on the demand side.

On the supply side, energy efficiency improvement in power generation, development of nuclear power and renewable energy technologies, particularly small hydro, wind, and biomass, are expected to come online intensively from 2013 in line with the master plan on renewable energy development.

From the above analysis, Alternative Policy Scenarios (APS) are proposed – EEC scenarios (APS1), improvement of energy efficiencies in power generation (APS2), development of renewable energy (APS3), and further development of nuclear power plants (APS4).

- **APS1:** EEC Scenarios on the demand side, including:
  - * EEC1: Using EEC measures in the industrial sector to achieve 5 percent to 8 percent energy reduction from 2012 to 2015, and 10 percent from 2016 onwards.
  - * EEC2: Switching from Diesel Oil (DO) to Compressed Natural Gas (CNG) in transportation and using efficient motorbikes in road transport.
  - * EEC3: Replacing inefficient devices with efficient devices in the residential sector, such as coal improved cooking stoves, Compact Fluorescent Lamp (CFL) in lighting, efficient refrigerators, and air conditioners for residential cooling.
  - * EEC4: Using EEC measures in the commercial sector to reduce electricity consumption by 10 percent by 2035.
- **APS2:** Improvement of energy efficiency in thermal power plants:

  It assumes that efficiencies of coal, natural gas, and residue fuel oil thermal power plants will increase to 42 percent, 45 percent, and 37 percent, respectively, by 2035 compared with 37 percent, 42 percent, and 31 percent, respectively, in the BAU scenario; natural gas with Combined Cycle Gas Turbine (CCGT) technologies will increase to 55 percent by 2035 compared with 52 percent in BAU.
- **APS3:** Development of renewable energy technologies:

  Installed electricity generating capacity from renewable energy is assumed to reach 13,400 MW in 2035, with wind contributing 6,200 MW, small hydro 5,200 MW, and biomass 2,000 MW.

Moreover, Viet Nam has considered the use of biofuels to reduce dependency on oil and curb CO_2 emissions. According to the Prime Minister's decision 177/2007/QD-TTg approving the master plan on biofuel development, Viet Nam is assumed to produce 250,000 tonnes of biofuels in 2015 (both ethanol and biodiesel, in which ethanol fuel accounts for around two-thirds of the total) and 1.8 million tonnes in 2025.

- **APS4:** Maximum nuclear power development:

  The installed capacity of nuclear power plants under the APS scenario is expected to reach 11,000 MW by 2030 and 15,000 MW by 2035 compared with 6,000 MW and 10,700 MW by 2030 and 2035, respectively, in the BAU scenario.

- **APS5:** Combines APS1, APS2, APS3, and APS4.

3. Outlook Results

3.1. Business-as-Usual (BAU) Scenario

3.1.1. Total Final Energy Consumption

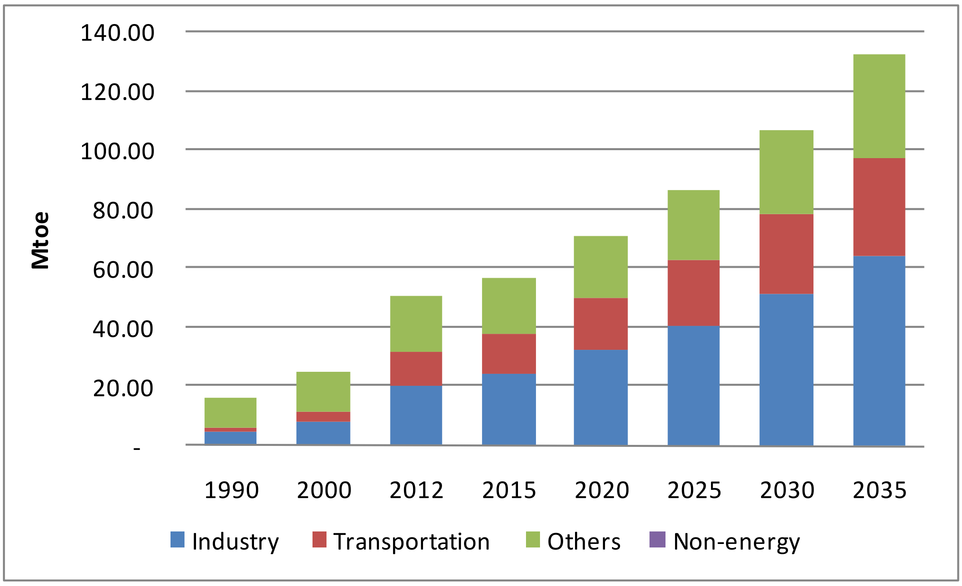
Viet Nam's Total Final Energy Consumption (TFEC) in 2012 was 50.8 Mtoe, 3.2 higher than its 1990 level of 16.0 Mtoe, an annual average increase of 5.4 percent. The fastest growth occurred in the transport sector (10.0 percent per year) followed by the industrial sector (7.1 percent), and the residential/commercial (others) sector (2.9 percent per year).

From 2012 to 2035, TFEC is projected to increase at an average rate of 4.3 percent per year under the BAU scenario, driven by strong economic growth, projected at an annual average rate of 6.2 percent, and average annual population growth of 0.7 percent. The strongest growth in consumption is projected to occur in the industry sector (5.1 percent per year), followed by the transportation sector (4.8 percent), and the residential/commercial (others) sector (2.7 percent per year).

The bulk of the country's energy consumption, or more than 63.1 percent, in 1990 was in the residential/commercial (others) sector, where biomass fuel used for residential cooking accounted for the major share. This share is projected to decline strongly, to 26.6 percent, by 2035 due to the substitution of biomass fuels by commercial fuels with higher efficiency. The decreasing share of the sector is due to an impact of the growing economy. The impact of economic growth will translate to improvement of standard of living, thus increasing the transition from biomass fuels to the model fuels.

The industrial sector is assumed to be the largest consuming sector in Viet Nam from 2012 to 2035. Its share of energy consumption is projected to increase from 40.1 percent in 2012 to 48.5 percent in 2035. The smallest consumer is the transport sector. Its share is expected to increase slightly, from 22.3 percent in 2012 to 24.9 percent in 2035.

Figure 17-1. Final Energy Demand by Sector, BAU



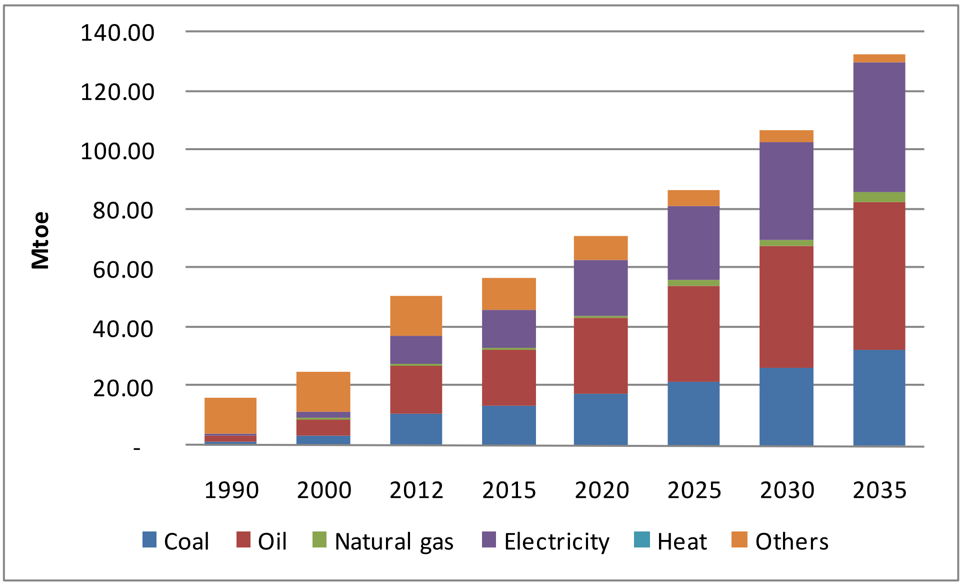
BAU = Business-as-Usual.
Source: Author's calculation.

Other fuels (mostly biomass) were the most consumed products in 1990, accounting for 73.9 percent of total final energy consumption, but this declined to 26.9 percent in 2012. Oil was the second most consumed product in 1990, accounting for 14.5 percent of total final energy consumption, and this increased to 31.7 percent in 2012. Over the same period, the share of coal consumed increased from 8.3 percent to 21.9 percent and that of electricity from 3.3 percent to 18.6 percent.

Under the BAU scenario, natural gas is projected to grow strongest in final energy consumption – it is projected to increase at an annual average rate of 8.1 percent from 2012 to 2035. Electricity is projected to have the second highest growth rate at 7.0 percent per year, followed by oil (5.1 percent), and coal (4.7 percent). Other fuels (mostly biomass) are projected to decrease strongly, at an average annual rate of 6.8 percent, due to the transition from biomass fuels to modern fuels.

Oil products had the largest share in final energy consumption in 2012, at 31.7 percent, and this share is projected to increase to 38.1 percent in 2035. Other fuels (biomass) accounted for the second largest share in 2012, at 26.9 percent, but this is projected to decrease to 2.0 percent in 2035. Coal, which is used primarily in the industry sector, was the country's third consumed fuel in 2012, with a share of 21.9 percent, and its share will increase to 24.2 percent in 2035. The largest increase will be in the share of demand for electricity; it is expected to rise from 18.6 percent in 2012 to 33.4 percent in 2035.

Figure 17-2. Final Energy Demand by Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

3.1.2. Total Primary Energy Consumption

Total Primary Energy Consumption (TPEC) in Viet Nam grew at a higher rate than final energy consumption, increasing at 5.8 percent per year, or 3.4 times, from 17.8 Mtoe in 1990 to 61.2 Mtoe in 2012. 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 42.9 percent between 1990 and 2012, and hydro, coal, and oil grew at 10.5 percent, 9.8 percent, and 8.9 percent per year, respectively.

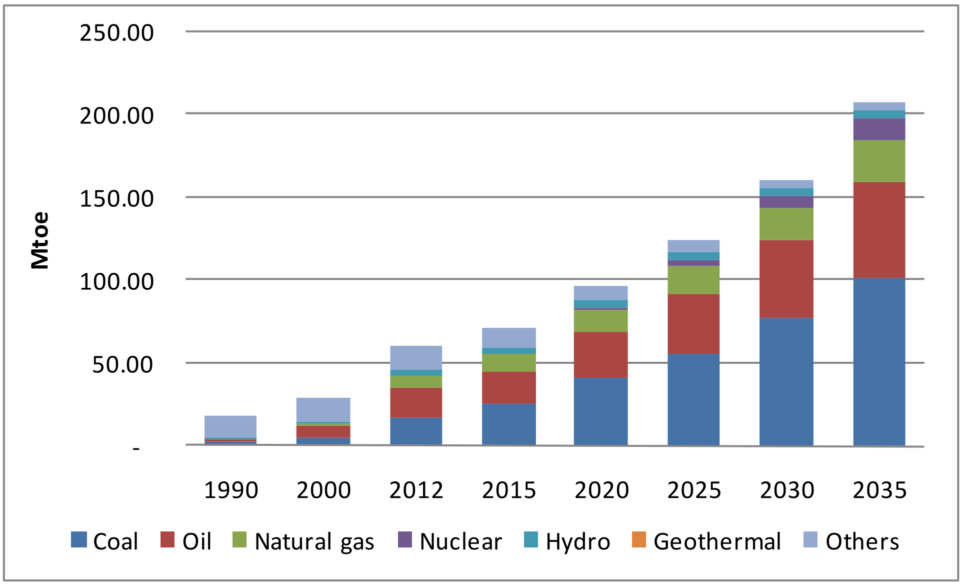
In the BAU scenario, Viet Nam's TPEC is projected to increase at an annual rate of 5.5 percent per year, or 3.4 times, from 61.2 Mtoe in 2012 to 208.2 Mtoe in 2035. The fastest growth is expected in coal, increasing at an annual average rate of 7.9 percent between 2012 and 2035, followed by oil, natural gas, and hydro at 5.4 percent, 5.3 percent, and 1.0 percent, respectively, whereas other fuels (mostly biomass) will decrease strongly, by 5.0 percent per year.

Coal accounted for a 28.6 percent share of TPEC in 2012 and is projected to increase strongly, to 48.6 percent in 2035. The share of oil was 29.1 percent in 2012 and will increase slightly, to 28.5 percent in 2035. The increases in the shares of coal and oil are a result of projected declines in the shares of natural gas, hydro, and others, which are expected to decrease from 12.6 percent to 12 percent, from 6.8 percent to 2.5 percent, and from 22.9 percent to 2.1 percent, respectively.

3.1.3. Power Generation

Power generation output increased at an average 12.6 percent per year from 8.7 TWh in 1990 to 117.6 TWh in 2012. The fastest growth occurred in natural gas power generation (49.3 percent), followed by coal (12.4 per cent), hydropower (10.2 percent), and oil (1.9 percent).

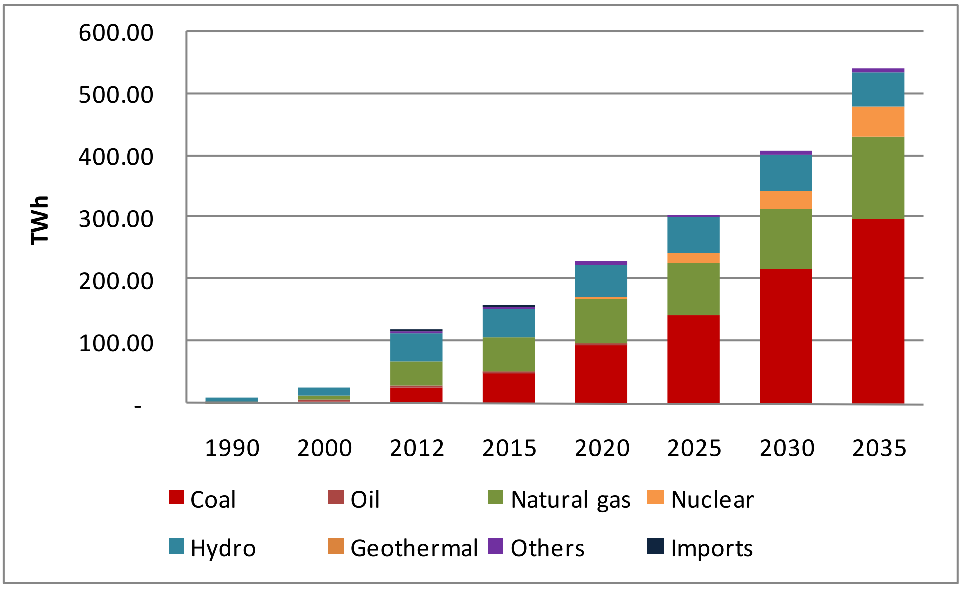
Figure 17-3. Primary Energy Demand, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

To meet electricity demand under the BAU scenario, power generation is projected to increase at an average rate of 6.9 percent per year, between 2012 and 2035. The fastest growth will be in coal power generation (11.2 percent), followed by natural gas (5.3 percent), 'others' (almost only small hydro power) generation (2.2 percent), and hydro power generation (0.9 percent).

Figure 17-4. Power Generation by Type of Fuel, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

At the end of 2012, most of Viet Nam's power requirement was met by hydropower, which accounted for 38.6 percent of the total power generation mix. The share of natural gas power generation was 34.6 percent, and coal and oil power generation accounted for the remainder.

In the BAU scenario, coal will be the major fuel for power generation from 2020 to 2035, with its share projected to increase from 42.5 percent to 54.8 percent. The share of natural gas in total power generation will decline from 34.6 percent in 2012 to 24.5 percent in 2035.

3.1.4. Energy Indicators

From 1990 to 2012, Viet Nam's energy intensity showed a decreasing trend. Both primary and final energy intensities of the country decreased, from 1,004 and 903 toe/million 2005 US$, respectively, in 1990 to 699 and 580 toe/million 2005 US$, respectively, in 2012. This was mainly due to strong economic growth, which resulted in a significant reduction in the use of biomass fuels for cooking in the residential sector, although the energy requirement in the industrial sector and transport sector increased strongly from 1990 to 2012. Final energy intensity under the BAU scenario is estimated to decrease from 597 to 380 toe/million 2005 US Dollars by 2035. This decreasing trend is a good indication that energy will be used efficiently for economic development.

Primary energy per capita increased from 0.27 toe/person in 1990 to 0.69 toe/person in 2012 and is projected to increase to 1.98 toe/person in 2035. This indicates that people's living standards and incomes will increase, resulting in an increase in total primary energy consumption per capita.

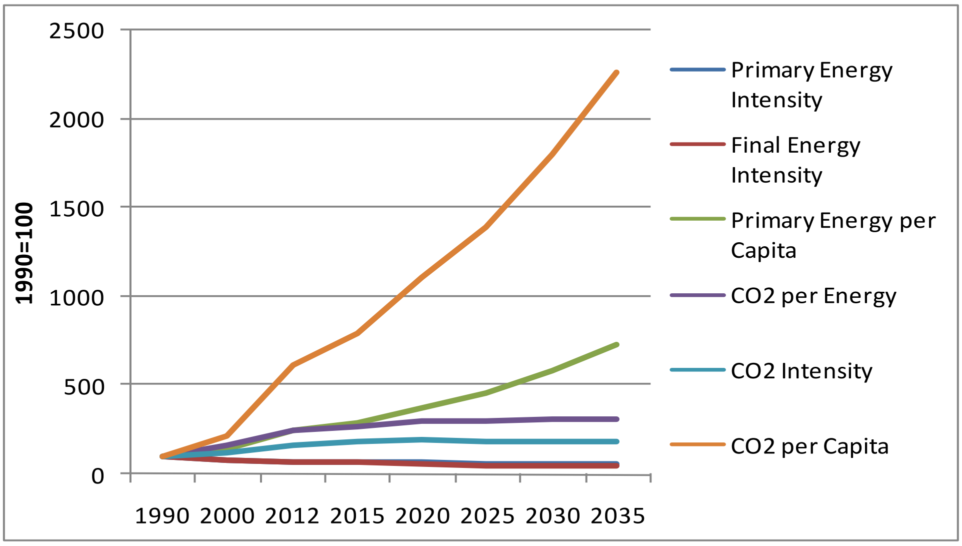
Regarding greenhouse gas (GHG) emissions, CO_2 intensity and CO_2 per energy increased from 265 t-C/million 2005 US$ and 0.26 t-C/toe, respectively, in 1990 to 442 t-C/million 2005 US$ and 0.63 t-C/toe, respectively, in 2012. In the BAU scenario, CO_2 intensity and CO_2 per energy are projected to increase slightly up to 2020, to 519 t-C/million 2005 US$ and 0.78 t-C/toe. From 2020 to 2035, CO_2 intensity will decline to 487 t-C/million 2005 US$, and CO_2 per energy will stay at around 0.82 t-C/toe. However, CO_2 per capita is projected to increase steadily, due to energy demand increasing faster than population growth rate (Figure 17-5).

3.2. Energy Savings and CO_2 Emissions Reduction Potential

3.2.1. Total Final Energy Consumption

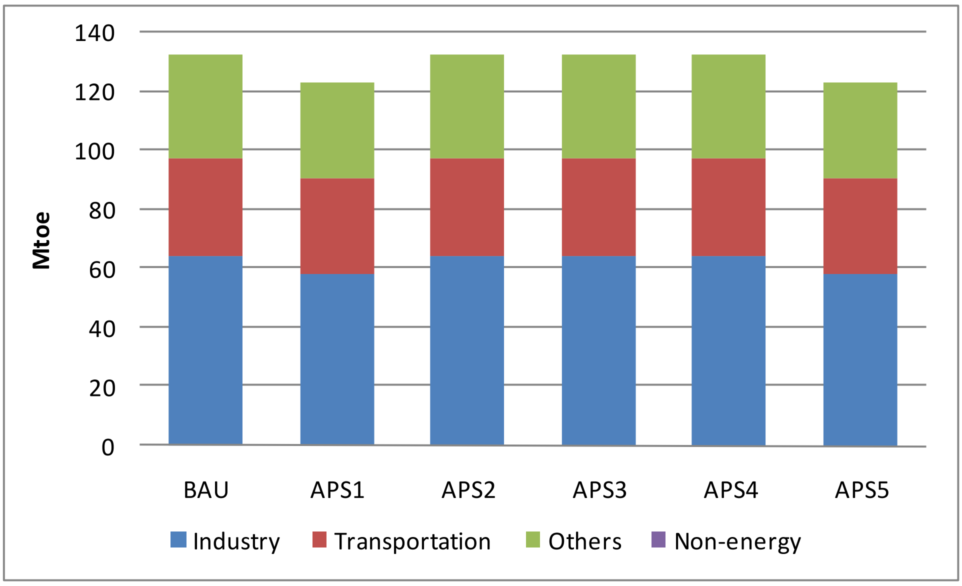
In APS5, Total Final Energy Consumption (TFEC) is projected to increase at a slower rate, of 3.9 percent per year (compared with 4.3 percent in the BAU scenario), from 50.8 Mtoe in 2012 to 123.1 Mtoe in 2035 because of EEC measures (APS1) in the industrial, transport, residential, and commercial (other) sectors.

Figure 17-5. Energy Indicators



Source: Author's calculation.

Figure 17-6. Total Final Energy Consumption by Sector in BAU and APS

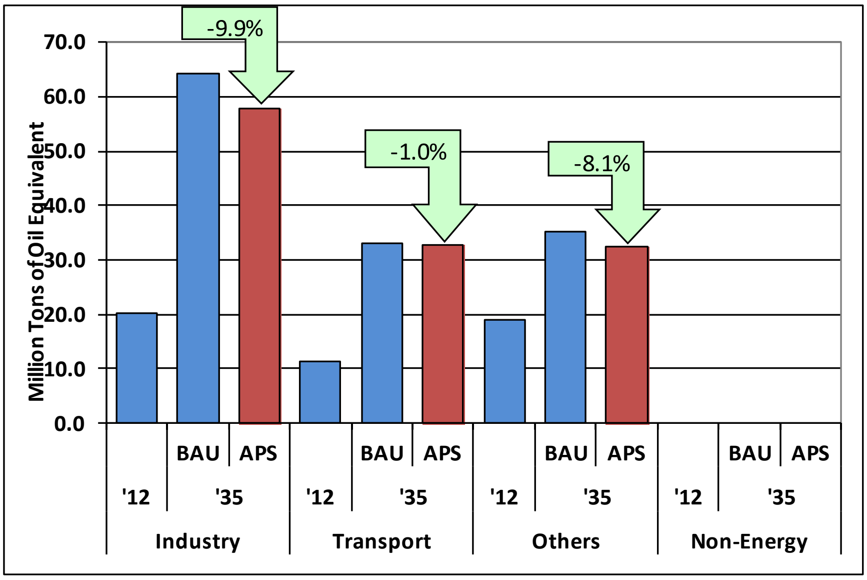


BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

The bulk of savings are expected to occur in the industry sector, with 6.4 Mtoe, equivalent to a 9.9 percent reduction, followed by the residential/commercial (others) sector, with 2.9 Mtoe, equivalent to a 8.1 percent reduction, and the transportation sector, with 0.3 Mtoe, equivalent to a 1.0 percent reduction.

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

Figure 17-7. Total Final Energy Consumption, BAU vs. APS



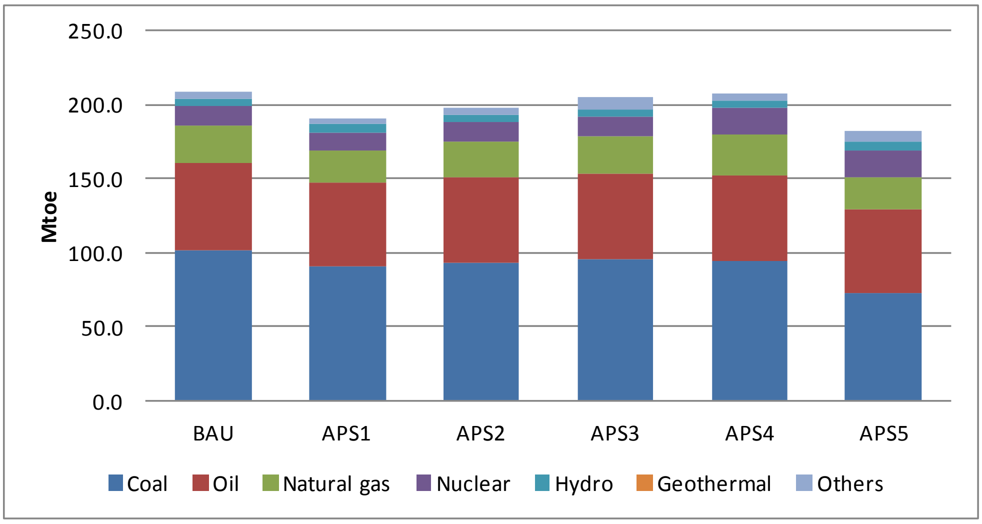
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.2.2. Total Primary Energy Consumption

In the APS5, Total Primary Energy Consumption (TPEC) is projected to increase at a slower rate, of 4.9 percent per year, from 61.2 Mtoe in 2012 to 182.9 Mtoe in 2035. Coal is projected to grow at the highest average annual rate, of 6.4 percent, compared with 7.9 percent in BAU, followed by oil and natural gas with 5.2 percent and 4.6 percent (compared with 5.4 percent and 5.3 percent in BAU), respectively, over the same period.

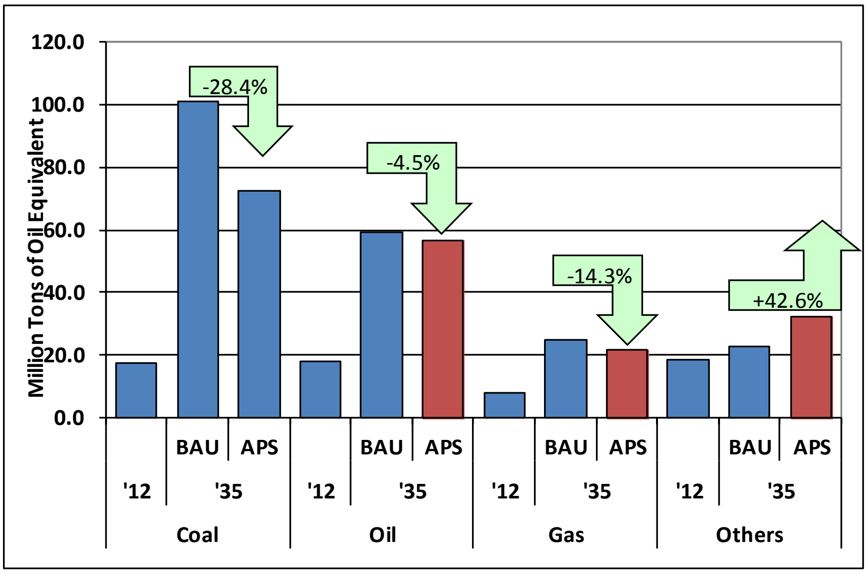
The slower growth in consumption, relative to the BAU scenario, stems from EEC measures on the demand side (APS1), and the more aggressive uptake of energy efficiency in thermal power plants (APS2), renewable (APS3) and nuclear energy (APS4) on the supply side. Coal has the highest energy saving potential, with 28.4 percent, followed by natural gas (14.3 percent), and oil (4.6 percent).

Figure 17-8. Primary Energy Demand by Fuel in BAU and APS



Source: Author's calculation.

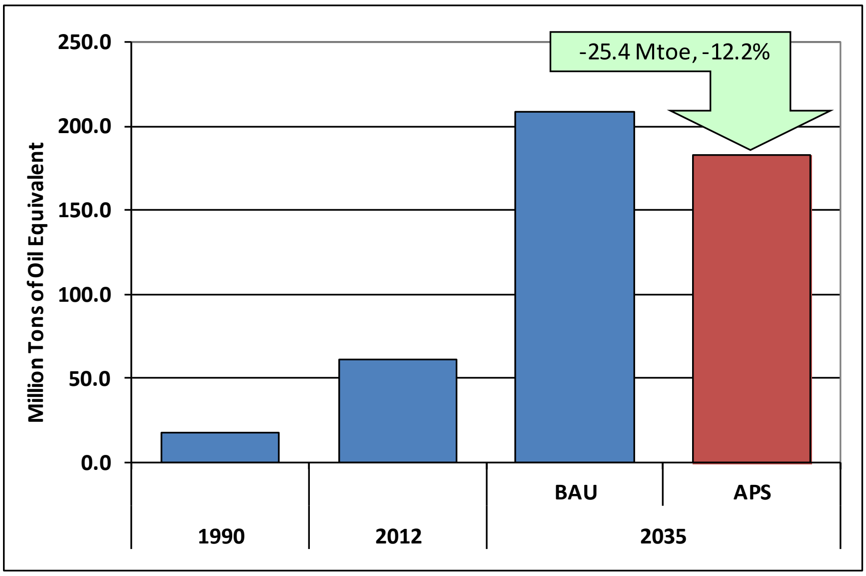
Figure 17-9. Primary Energy Saving Potential by Fuel, BAU vs. APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

The total savings amount to 25.4 Mtoe, or the equivalent to 12.2 percent of Viet Nam's projected total primary energy consumption in 2035 (Figure 17-10).

Figure 17-10. Evolution of Primary Energy Demand, BAU and APS



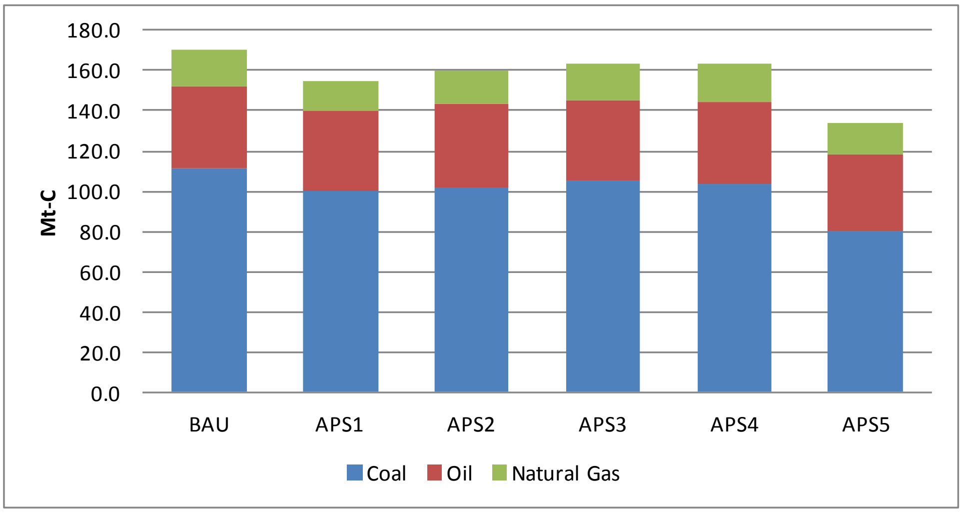
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.2.3. CO_2 Reduction Potential

CO_2 emissions from energy consumption under the BAU scenario are projected to increase by 6.6 percent per year, from 38.7 million metric tonne of carbon (Mt-C) in 2012 to 170.0 Mt-C in 2035. Under APS5, the annual increase in CO_2 emissions between 2012 and 2035 is projected to be 5.5 percent, which is 1.1 percentage points lower than in the BAU scenario.

The CO_2 emission reduction is mostly expected to result from EEC measures on the demand side (APS1). Moreover, improvement of energy efficiency in thermal power plants (APS2), development of renewable energy technologies (APS3), and maximum nuclear power development (APS4), also contributed significantly to CO_2 reduction (Figure 17-11).

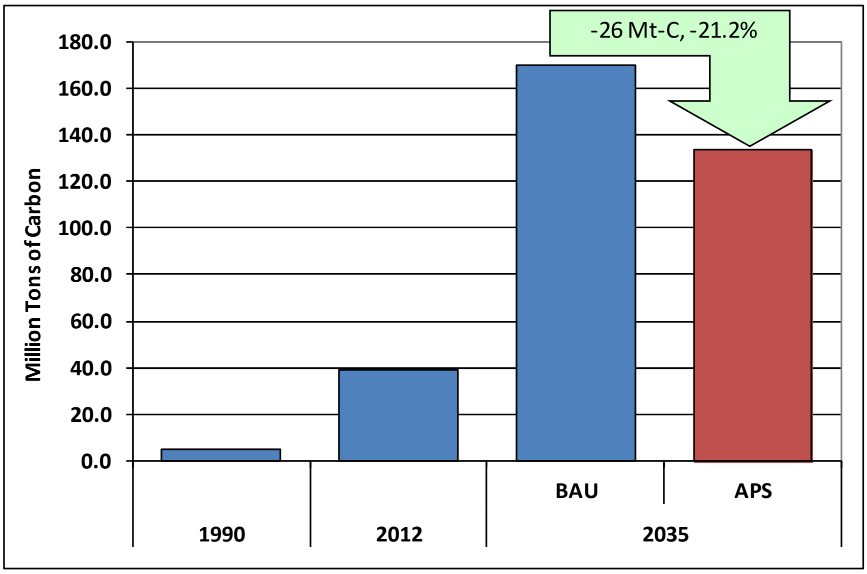
Figure 17-11. CO_2 Emissions by Fuel, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Reduction of CO_2 emissions under the APS will be around 36.1 Mt-C lower, equal to a 21.2 percent reduction in 2035, indicating that the energy saving goals and action plans of Viet Nam are very effective in reducing CO_2 emissions.

Figure 17-12. Evolution of CO_2 Emissions, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

4. Key Findings and Policy Implications

From the above analysis on energy saving potential, some keys findings are as follows:

- Energy demand in Viet Nam is expected to continue to grow at a significant rate, driven by robust economic growth, industrialisation, urbanisation, and population growth. Energy efficiency and conservation measures have the potential to contribute to meeting higher demand in a sustainable manner.
- Viet Nam's energy intensity, which is amongst the highest in the world, indicates high saving potential. However, the energy saving potential derived from the EEC goals of Viet Nam (25.4 Mtoe) seem to be modest (because energy efficiency goals focus heavily on the industry sector and buildings) compared with its potential.
- Annual growth of energy demand in the transportation sector is projected at the second highest rate, of 4.8 percent, in the BAU scenario, and its share is expected to increase from 22.3 percent in 2012 to 24.9 percent in 2035. This shows that the transportation sector has large energy saving potential.
- Electricity demand is increasing at the highest annual growth rate, of 7.0 percent, in the BAU scenario and is projected to decline by 6.5 percent in the APS. This decline proved that the EEC measures are effective in electricity demand. However, the electricity saving potential is still large, particularly in the residential and commercial sectors.
- Coal thermal power plants will be the major power generators in Viet Nam in the coming years. Its share in total power generation output is projected to increase steadily, from 22.2 percent in 2012 to a dominant share of 54.8 percent in 2035. This is the area with the largest energy saving and GHG mitigation potential in Viet Nam.
- EEC scenarios on the demand side are most effective compared with other proposed scenarios on energy saving as well as GHG emissions reduction.

Based on the above findings, we recommend the following actions to effectively implement EEC activities in Viet Nam:

- **Establishment of new targets and a roadmap for EEC implementation**: Targets for EEC in Viet Nam were set for a short-term period (2006–2015) and focused on the industry sector and buildings. New long-term targets should be set based on an assessment of the energy saving potential for all energy sectors, including transport and residential and commercial (other) sectors, which have a large potential for energy saving up to 2035.
- **Compulsory energy labelling for electrical appliances:** Annual growth of electricity demand is projected at second highest rate of 7.0 percent in BAU, especially demand on electricity use in residential and commercial (other) sectors. Therefore, compulsory energy labelling for electrical appliances is an effective management measure for energy saving.
- **Priority for development of advanced coal thermal power technology:** Coal thermal power plants will account for most of the power generation in Viet Nam up to 2035. Therefore, advanced coal thermal power or energy effective

technologies should be prioritised for coal thermal power plant development at the stage of project design.

- **Priority for renewable energy development:** Coal power generation is projected to have a dominant share in 2035, which will result in the country being reliant on coal imports for power generation. Renewable energy technology-based power generation is an important factor for energy independent, energy security and GHG abatement. Therefore, this is necessary to build up the strategy and mechanisms to support renewable energy development.

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Law on Energy Savings and Conservation, 2010.

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Decision 79/2006/QD-TTg dated 14 April 2006 of the Prime Minister Approving the National Target Program on Energy Savings and Conservation.

Decision 177/2007/QD-TTg dated 20 November 2007 of the Prime Minister Approving the Master Plan on Biofuel Development Until 2015 with Perspective of 2025.