# Energy Outlook and Energy Saving Potential in East Asia

edited by

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This report was prepared by the Working Group for Analysis of Energy Saving Potential in East Asia under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the Working Group, who represent the participating countries of the East Asia Summit (EAS) region, discussed and agreed to certain key assumptions and modelling approaches to enable harmonisation of the forecasting techniques. These assumptions and modelling approaches may differ from those normally used in each country. Therefore, the projections presented here should not be viewed as official national projections of the participating countries.

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# Preface

Energy security and climate change are very important issues in the world. At the 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 2015 to May 2016, including methodology, estimated impacts of current energy saving goals, and policy recommendations to the ECTF.

The structure of this report is 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

2016

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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.

The Authors

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# List of Abbreviations and Acronyms

| | |
|---|---|
| AAGR | annual average growth rate |
| ANRE | Agency for Natural Resources and Energy |
| APS | Alternative Policy Scenario(s) |
| ASEAN | Association of Southeast Asian Nations |
| BAU | Business-as-Usual scenario |
| BREE | Bureau of Resources and Energy Economics |
| CCS | carbon capture and storage |
| CCT | clean coal technology |
| CNG | compressed natural gas |
| $CO_2$ | carbon dioxide |
| DOE | Department of Energy (Philippines) |
| EAS | East Asia Summit |
| ECTF | Energy Cooperation Task Force |
| EEC | energy efficiency and conservation |
| 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 |
| IEA | International Energy Agency |
| IEEJ | The Institute for Energy Economics, Japan |
| INDC | Intended Nationally Determined Contribution |
| IPCC | Intergovernmental Panel for Climate Change |
| ktoe | thousand tons 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 |
| LRET | Large-scale Renewable Energy Target |
| Mtoe | million tons of oil equivalent (1 Mtoe = 41.868 PJ) |
| Mt C | million tons carbon (may be converted to million tons of $CO_2$ by multiplying by 44/12) |
| MW | megawatts |
| MWh | megawatt-hour |
| NCV | net calorific value |
| NRE | new and renewable energy |
| OECD | Organisation for Economic Co-operation and Development |
| PV | photovoltaic |
| RET | renewable energy target |
| RPS | Renewable Portfolio Standards |
| toe | tons of oil equivalent |
| tC | tons of carbon |
| TPES | total primary energy supply |
| TWh | terawatt-hour |
| US$ | United States dollar |
| WG | Working Group |

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# Executive Summary

The Economic Research Institute for ASEAN and East Asia (ERIA) East Asia Summit (EAS) Energy Outlook has been updated in 2015–2016 by revising the macro assumptions, such as economic and population growth as well as crude oil price under the current lower scenario. In addition, this outlook incorporates more recent information on the EAS 16 member countries' energy saving potential and energy efficiency goals, action plans, and policies, including power development plans such as renewable electricity.

The outlook still focuses on analysing the additional energy savings that might be achieved by the individual countries above and beyond the Business-as-Usual scenario (BAU) projection. It continues to examine two scenarios, the BAU and the Alternative Policy Scenario (APS), but it is extended from 2035 to 2040. The APS includes not only more ambitious energy saving targets but also rapid advances in low-carbon energy technologies and renewable energy.

The ERIA EAS Energy Outlook results of both primary and final energy consumption of 2015–2016 are slightly higher than the results in 2014–2015. This is due to the changes in gross domestic product (GDP) assumption in countries estimated. Accordingly, the energy saving potential and carbon dioxide ($CO_2$) reduction potential defined as BAU–APS in terms of energy demand and $CO_2$ emissions will also be higher.

Under the BAU, the sustained population and economic growth will significantly increase Total Final Energy Consumption (TFEC) by 1.8 times from 2013 to 2040. Total Primary Energy Supply (TPES) will also increase by 1.8 times over the same period. Although energy demand will continue to increase, GDP elasticity, defined as the growth rate of energy demand as a share of the growth rate of GDP, is expected to improve from 1.06 in 1990–2013 to 0.56 in 2013–2040. In other words, there will be a significant reduction in energy intensity, defined as energy demand as a share of GDP, in the EAS region.

Fossil fuel energy consisting of coal, oil, and gas will still be dominant in 2040 and its share under the BAU will be 84 percent. If EAS countries remain dedicated to implementing their energy efficiency and conservation (EEC) policies and increase low-carbon energy technologies such as nuclear power generation and solar photovoltaic (PV)/wind (APS), the EAS region could achieve fossil fuel savings of 23 percent and the fossil fuel share could fall to 76 percent. $CO_2$ emissions would be reduced significantly as a consequence. In view of this, EAS countries need to implement their EEC and renewable energy polices (energy saving targets and action plans) as scheduled. The targets and action plans that will be applied across sectors – industry, transport, residential, and commercial – should be appropriate and feasible. Government support for EEC service companies' activities is also essential.

Renewable energy such as hydro, geothermal, solar PV, and wind and biomass will also contribute to the expected reduction of fossil fuel consumption, which will result in a mitigation of $CO_2$ emissions. To increase the share of renewable energy in the primary energy mix, appropriate government policies will be crucial. Policies such as renewable energy targets, Renewable Portfolio Standards (RPS), and Feed-in-Tariff (FiT) have been implemented in some of the EAS member countries and have accelerated the deployment of renewable energy domestically.

Energy supply security has become a top priority energy issue for the EAS region implementing EEC measures, and increasing renewable energy shares will certainly contribute to maintaining regional energy security through the reduction of fossil fuel consumption and increasing the use of domestic energy. Regional energy networks such as the Trans-ASEAN Gas Pipeline and the ASEAN Power Grid, a liquefied natural gas (LNG) receiving terminal, and oil stockpiling through the ASEAN Petroleum Security Agreement are recommended to diversify energy supply sources. Nuclear power generation is another option for securing the energy supply in this region.

According to the Energy Outlook 2016, coal power generation will be still dominant in the EAS region by 2040. Increasing the use of clean coal technology (CCT) and development of carbon capture storage (CCS) technology will be critical for the coal power plants in this region to become carbon free. Hydrogen technology will also play a key role as an alternative to fossil fuels, and can be applied across sectors such as power generation, industry, and residential.

This year the Energy Outlook includes an estimation of the investment cost required for power generation. The analysis results indicate that the EAS region will need about US$4 trillion for the construction of power plants to meet the additional capacity requirements. By region, ASEAN will need US$600 billion and the ‘Plus 6’ countries will need US$3.4 trillion for power generation facilities. The share of investment cost by power plants will be quite different between the BAU and the APS. Under the BAU, most of the investment will be allocated to coal power plants, whereas under the APS most of the allocation will be to renewable energy electricity such as hydro and solar PV/wind in ASEAN and renewable energy electricity and nuclear power plants in the ‘Plus 6’ countries. If EAS countries want to implement their ambitious low-carbon energy policies (APS), they will need to allocate significant amounts of money to developing nuclear, hydro, and solar PV/wind power plants.

Chapter 1

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

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## 1. Introduction

Sustained population and economic growth in the East Asia Summit (EAS) region have nearly doubled energy demand for both primary and final energy consumption. The increasing energy demand poses a threat to the region's energy security. Hence, potential energy saving is key to reducing energy demand and carbon dioxide ($CO_2$) emissions.

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

This study shows energy saving potential using both the Business-as-Usual scenario (BAU) and Alternative Policy Scenarios (APS). The BAU was developed for each EAS economy, outlining future sectoral and economy-wide energy consumption assuming no significant changes to government policies. APS were set out to examine the potential impacts if additional energy efficiency goals, action plans, or policies that are currently, or likely to be, under considered were developed. The difference between the BAU and the APS in both final and primary energy supply represents potential energy savings. The difference in $CO_2$ emissions between the two scenarios represents the potential for reducing greenhouse gas (GhG) emissions.

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

## 1.1. The East Asia Summit

The EAS is a collection of diverse countries, with wide variations among 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 ASEAN member countries – Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam, and six other countries – Australia, China, India, Japan, Republic of Korea (henceforth, Korea), and New Zealand (The Ministry of Foreign Affairs of Japan, 2005).

Whereas some EAS countries are what might be called mature economies, the majority are regarded as developing economies. Several countries have a per capita gross domestic product (GDP) of less than US$1,000 (in 2005 prices[1]). Countries with mature economies have higher energy consumption per capita, whereas developing countries generally have lower energy consumption per capita. A large percentage of the people in the latter countries still meet their energy needs mainly with traditional biomass fuels.

[1] All US$ (US dollars) in this document are 2005 constant prices unless specified.

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

Despite the differences among 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 (Ministry of Foreign Affairs of Japan, 2005).

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, 2013**

| | Land Area (thousand sq. km.)* | Population (million) | Population Density (persons/ sq. km.) | GDP (billion 2005 US$) | GDP per Capita (2005 US$/ person) |
|---|---|---|---|---|---|
| **Australia** | 7,682 | 23.13 | 3.01 | 867.09 | 37,489 |
| **Brunei Darussalam** | 5.3 | 0.41 | 77.08 | 10.10 | 24,874 |
| **Cambodia** | 181 | 15.08 | 83.31 | 10.72 | 711 |
| **China** | 9,327 | 1,360.72 | 145.88 | 4,912.96 | 3,611 |
| **India** | 2,973 | 1,252.14 | 421.14 | 1,489.78 | 1,190 |
| **Indonesia** | 1,812 | 246.86 | 136.27 | 449.14 | 1,819 |
| **Japan** | 365 | 127.34 | 349.35 | 4,685.52 | 36,796 |
| **Korea, Rep. of** | 97 | 50.22 | 517.20 | 1,199.01 | 23,875 |
| **Lao PDR** | 231 | 6.58 | 28.51 | 5.09 | 774 |
| **Malaysia** | 329 | 29.47 | 89.68 | 207.95 | 7,057 |
| **Myanmar** | 653 | 52.98 | 81.10 | 24.93 | 471 |
| **New Zealand** | 263 | 4.44 | 16.87 | 120.14 | 27,046 |
| **Philippines** | 298 | 98.20 | 329.34 | 155.61 | 1,585 |
| **Singapore** | 0.7 | 5.40 | 7,713.14 | 202.42 | 37,491 |
| **Thailand** | 511 | 67.45 | 132.03 | 230.37 | 3,415 |
| **Viet Nam** | 310 | 89.71 | 289.32 | 92.28 | 1,029 |

sq. km. = square kilometres; GDP = gross domestic product.
Note: * Information on the land area data of Cambodia was provided by the Government of Cambodia.
Source: World Development Indicators, World Bank Database, November 2013.

**Table 1-2. Economic Structure and Energy Consumption, 2013**

| | GDP (billion 2005 US$) | Share of Industry in GDP, percent* | Share of Services in GDP, percent* | Share of Agriculture in GDP, percent* | Primary Energy Supply (Mtoe) | Energy Consumption per Capita (toe/person) |
|---|---|---|---|---|---|---|
| **Australia** | 867.1 | 28.2 | 69.2 | 2.6 | 129.1 | 5.6 |
| **Brunei Darussalam** | 10.1 | 60.9 | 38.3 | 0.8 | 2.9 | 7.1 |
| **Cambodia** | 10.7 | 29.9 | 43.0 | 27.1 | 6.8 | 0.5 |
| **China** | 4,913.0 | 48.8 | 43.5 | 7.7 | 3,021.9 | 2.2 |
| **India** | 1,489.8 | 33.5 | 52.0 | 14.5 | 775.4 | 0.6 |
| **Indonesia** | 449.1 | 39.7 | 49.7 | 10.6 | 223.9 | 0.9 |
| **Japan** | 4,685.5 | 28.1 | 70.7 | 1.3 | 454.7 | 3.6 |
| **Korea, Rep. of** | 1,199.0 | 39.6 | 57.8 | 2.6 | 263.8 | 5.3 |
| **Lao PDR** | 5.1 | 31.5 | 42.7 | 25.8 | 2.5 | 0.4 |
| **Malaysia** | 208.0 | 39.4 | 53.4 | 7.2 | 74.5 | 2.5 |
| **Myanmar** | 24.9 | 25.9 | 41.8 | 32.3 | 16.5 | 0.3 |
| **New Zealand** | 120.1 | 23.7 | 71.9 | 4.4 | 19.5 | 4.4 |
| **Philippines** | 155.6 | 33.8 | 56.4 | 9.9 | 44.5 | 0.5 |
| **Singapore** | 202.4 | 32.7 | 67.2 | 0.0 | 28.7 | 5.3 |
| **Thailand** | 230.4 | 37.4 | 54.4 | 8.2 | 132.3 | 2.0 |
| **Viet Nam** | 92.3 | 42.0 | 40.9 | 17.1 | 60.1 | 0.7 |

Note: * Sectoral shares to GDP of Myanmar and New Zealand are 2004 and 2009 values, respectively.
Source: World Development Indicators, World Bank Database, November 2013; International Energy Agency (IEA) (2014), Energy Balances of Organisation for Economic Co-operation and Development (OECD) countries 2013.

### 1.2. Objective and Rationale

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

The study supports the Cebu Declaration, which highlights 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 EEC programmes, increasing the share of hydropower, expanding renewable energy systems and biofuel production/utilisation, and, for interested parties, civilian nuclear power; and
- mitigating GhG emissions through effective policies and measures, thus contributing to global climate change abatement.

The Government of Japan asked ERIA to conduct a study on energy saving and potential on $CO_2$ emission reduction in the East Asia region. As a result, the Working Group for this study on the Analysis of Energy Saving Potential was convened. Members from all 16 EAS countries are represented in the Working Group to support this study.

## 2. Data and Methodology

### 2.1. The Scenarios

The study continues to examine two scenarios, as in the studies conducted annually from 2007 to the present – a BAU reflecting each country's current goals, action plans, and policies; and an APS.

The APS includes additional goals, action plans, and policies reported every year to the East Asia Energy Ministers Meeting (EAS–EMM). The latest updated policies were reported at the 9th EAS–EMM held on 8 October 2015 in Kuala Lumpur, Malaysia.

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 – (i) more efficient final energy consumption (APS1), (ii) more efficient thermal power generation (APS2), (iii) higher consumption of new and renewable energy (NRE) and biofuels (APS3), and (iv) introduction or higher utilisation of nuclear energy (APS4). The energy models are able to estimate the individual impacts of these assumptions on both primary energy supply and $CO_2$ emissions. The combination of these assumptions constitutes the assumptions of the APS. The main report highlights only the BAU and APS. However, each country report will analyse all the APS scenarios from APS1 to APS4.

Detailed assumptions for each APS are follows:

- The assumptions in APS1 are the reduction targets in sectoral final energy consumption, assuming that more efficient technologies are utilised and energy saving practices 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 consumption.
- In APS2, the utilisation of more efficient thermal power plant technologies in the power sector is assumed. This assumption resulted in lower primary energy supply and $CO_2$ emission in proportion to the efficiency improvement in thermal power generation. The most efficient coal and natural gas combined–cycle technologies are assumed to be utilised for the construction of new power

plants 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 supply may not decrease as NRE, like biomass and geothermal energy, are assumed to have lower efficiencies compared with fossil fuel–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. This scenario is expected to emit less $CO_2$ because of nuclear energy's minimal $CO_2$ emission. However, as the assumption of thermal efficiency when converting nuclear energy output into primary energy is only 33 percent, primary energy supply is not expected to be lower than for the BAU in this scenario.

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

## 2.2. Data

For consistency, the historical energy data used in this analysis came from the 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) into 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 the Institute of Energy Economics, Japan (IEEJ).

## 2.3. Methodology

In 2007, the primary model used was the IEEJ World Energy Outlook Model, which is used by IEEJ in preparing their Asia/World Energy Outlook (Ito et al., 2014). In 2014, all 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 $E_4$cast model,[2] 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 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.

[2] $E_4$cast is a partial equilibrium model of the Australian energy sector used to project Australia's long-term energy consumption, production, and trade.

*ASEAN countries*: The energy models of ASEAN countries were developed using the Long-range Energy Alternative Planning System (LEAP) software, an accounting system used to develop projections of energy balance tables based on final energy consumption and energy input/output in the transformation sector. Final energy consumption is forecast using energy demand equations by energy and sector and future macroeconomic assumptions. For this study, all 10 member countries used the LEAP model.

*Other countries:* Other countries used the IEEJ model, which has a 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 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 are treated exogenously. For electricity generation, the Working Group members were asked to specify assumptions about the future electricity generation mix in their respective countries by energy source. These assumptions were used to determine the future electricity generation mix.

## 3. Assumptions of the Study

Growth in energy consumption and GhG emissions is driven by 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 socio-economic development goals.

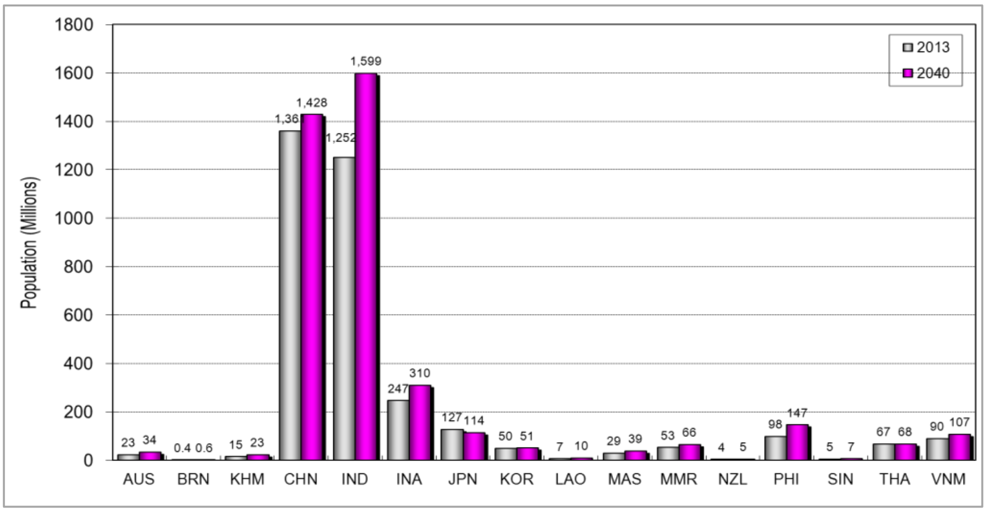
In this section, assumptions regarding key socio-economic indicators and energy policies until 2040 for EAS countries are discussed.

## 3.1. Population

In the models used for this study, changes in population to 2040 are set exogenously. It is assumed there is no difference in population between the BAU and the APS. Assumed changes in population were submitted by EAS countries, except China, for which the population projections from the United Nations were used.

In 2013, the total population of the EAS region was about 3.43 billion. Based on forecasts, it is projected to increase at an average annual rate of about 0.6 percent, reaching about 4 billion in 2040. **Error! Reference source not found.** 1-1 shows the 2013 and projected 2040 population by country.

**Figure 1-1. Assumed Population in the EAS Region, 2013 and 2040**

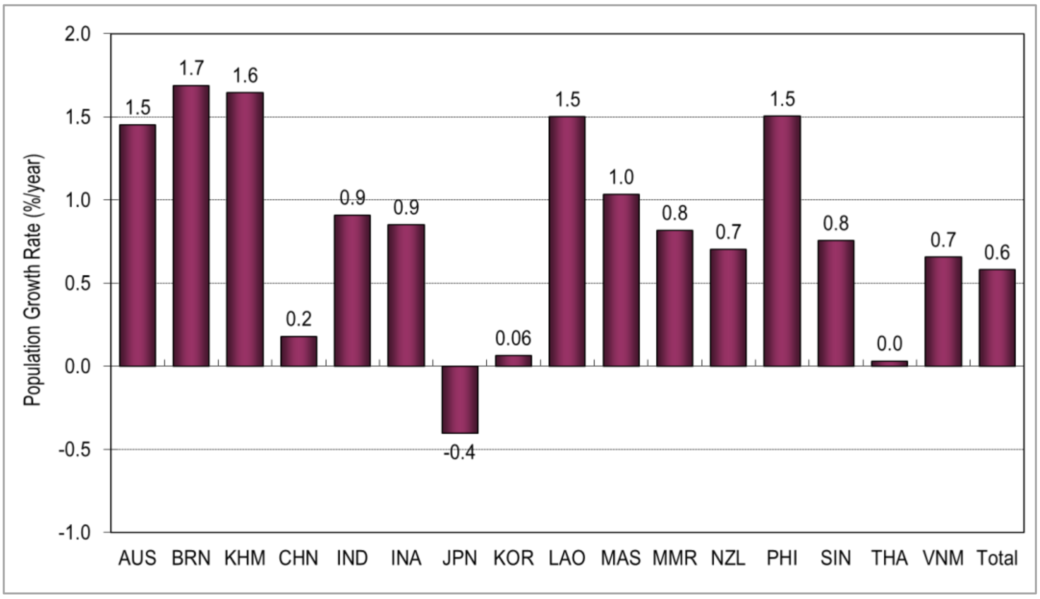



EAS = East Asia Summit (AUS = Australia; BRN = Brunei Darussalam; KHM = Cambodia; CHN = China; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam).
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. https://unstats.un.org/unsd/databases.htm (accessed June 2016).

As shown in Figure 1-2, 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 2040, India and China are assumed to account for over 80 percent of the total population in the EAS region with populations of around 1.42 billion for China and 1.59 billion for India.

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. 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, 2013–2040**




AUS = Australia; BRN = Brunei Darussalam; KHM = Cambodia; CHN = China; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam.
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. https://unstats.un.org/unsd/databases.htm (accessed June 2016).

### 3.2. Economic Activity

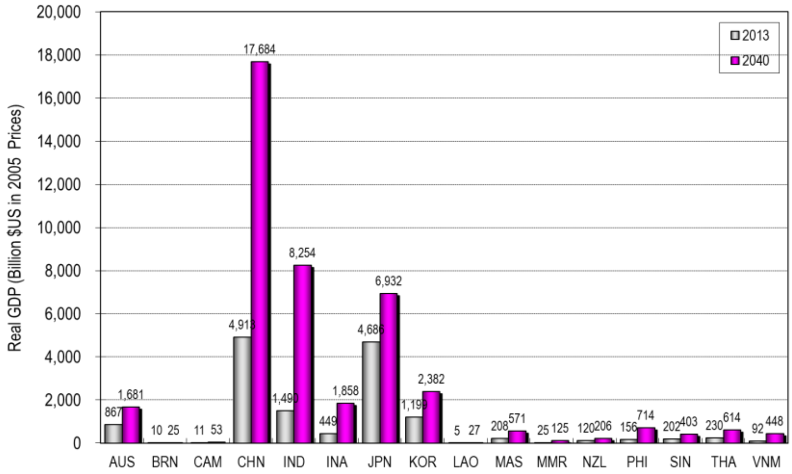
In the models used for this study, assumed changes in economic output to 2040 are set exogenously. GDP data (in 2005 US$) were obtained from the World Bank (2014). Assumed GDP growth rates to 2040 were submitted by all EAS countries. In general, these assumptions took into account actual GDP growth rates from 2005 to 2013, 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.

In 2013, total GDP in the EAS region was about 14.7 trillion in 2005 US$ and it accounted for about 26 percent of global GDP. The GDP of the EAS region is assumed to grow at an average annual rate of about 4 percent from 2013 to 2040. This implies that by 2040, total GDP of the EAS region will reach about 42 trillion in 2005 US$.

China is projected to be the largest economy in terms of real GDP of about 17.6 trillion by 2040. India and Japan are projected to be the next largest economies with projected GDPs of about 8.2 trillion 2005 US$ and 6.9 trillion 2005 US$, respectively in 2040 (Figure 1-3).

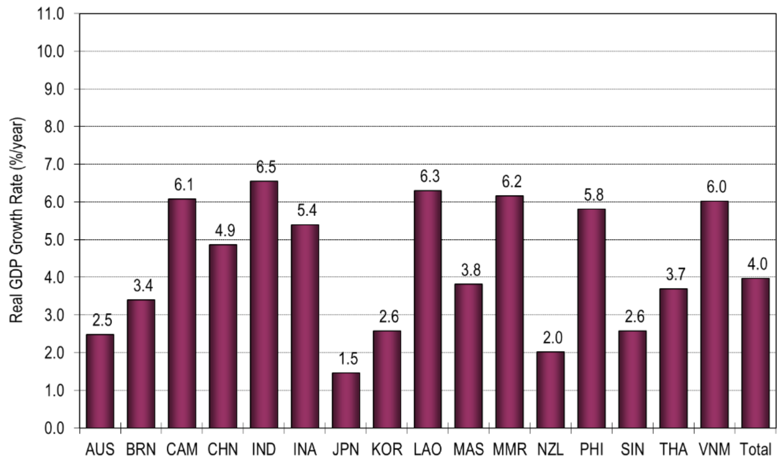
As shown in Figure 1-4, long-term economic growth rates are assumed to be quite high in the developing countries, with the highest growth rates in India, Lao PDR, Myanmar, Cambodia, Viet Nam, and the Philippines. Economic growth in other developing countries is also assumed to be relatively rapid. Due 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, Singapore, Brunei, Japan, Korea, and New Zealand – are assumed to experience slower, but still significant, economic growth.

**Figure 1-3. Assumed Economic Activity in the EAS Region, 2013 and 2040**




EAS = East Asia Summit (AUS = Australia; BRN = Brunei Darussalam; KHM = Cambodia; CHN = China; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam); GDP = gross domestic product.
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases.
https://unstats.un.org/unsd/databases.htm (accessed June 2016).

**Figure 1-4. Assumed Average Annual Growth in GDP, 2013–2040**



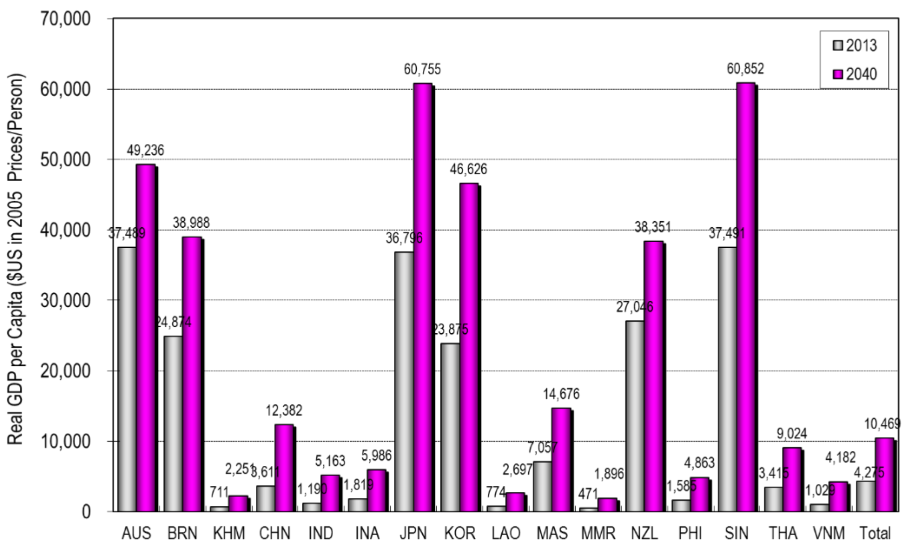

AUS = Australia; BRN = Brunei; KHM = Cambodia; CHN = China; GDP = gross domestic product; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL= New Zealand; PHI= Philippine; SIN = Singapore; THA = Thailand; VNM = Viet Nam).
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases.
https://unstats.un.org/unsd/databases.htm (accessed June 2016).

Average real GDP per capita in the EAS region is assumed to increase from about US$4,270 in 2013 to about US$10,500 in 2040. However, as shown in Figure 1-5, there are, and will continue to be, significant differences in GDP per capita. In 2013, per capita GDP ranged from about US$471 in Myanmar to over US$36,000 in Australia, Japan, and Singapore. In 2040, per capita GDP is assumed to range from about US$1,896 in Myanmar to over US$60,000 in Japan and Singapore.

## 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, except for Lao PDR and Viet Nam. There is assumed to be no difference in road vehicle ownership between the BAU and APS.

**Figure 1-5. Real GDP per Capita, 2013 and 2040**




AUS = Australia; BRN = Brunei Darussalam; KHM= Cambodia; CHN = China; IND = India; GDP = gross domestic product; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam.
Source: United Nations Statistics Division (2014), United Nations Statistics Division (UNSD) Statistical Databases. https://unstats.un.org/unsd/databases.htm (accessed November 2014).

Strong population and economic growth is projected to drive significant increases in demand for transport services in the EAS region. By 2040, the number of road vehicles in EAS is projected to increase to about 808.9 million, increasing almost threefold from 2013. However, rail is expected to meet an increasing share of total transport demand due to repaid acceleration of rail transportation connectivity in the ASEAN region.

Average per capita vehicle ownership in the EAS region is projected to increase from 0.081 to 0.202 from 2013 to 2040. However, vehicle ownership on a per capita basis is projected to vary significantly among countries.

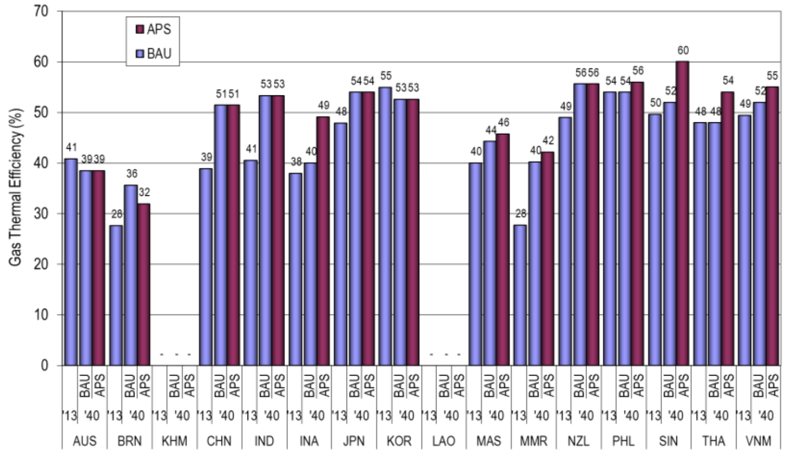
## 3.4. Electricity Generation

### 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 2013 thermal efficiencies by fuel type (coal, gas, and oil) were derived from International Energy Agency data (IEA, 2011). 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's *Asia/World Energy Outlook 2014.*

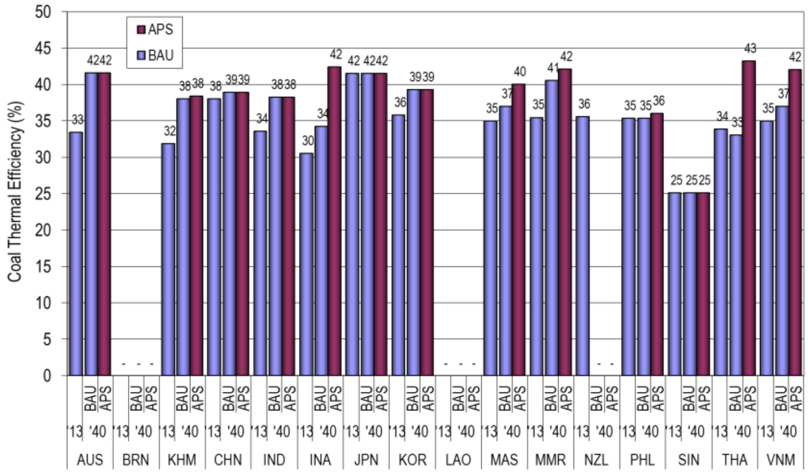
Thermal efficiencies may differ significantly between countries due to differences in technological availability, age, cost of technology, temperatures, and the cost and availability of fuel inputs. Thermal efficiency in the EAS countries is expected to improve considerably over time in the BAU as more 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 (see Figures 1-6 and 1-7).

**Figure 1-6. Thermal Efficiencies of Gas Electricity Generation**




APS = Alternative Policy Scenario; AUS = Australia; BAU = Business-as-Usual scenario; BRN = Brunei Darussalam; KHM= Cambodia; CHN = China; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam.
Source: Long-range Energy Alternatives Planning System (LEAP)'s database.

**Figure 1-7. Thermal Efficiencies of Coal Electricity Generation**

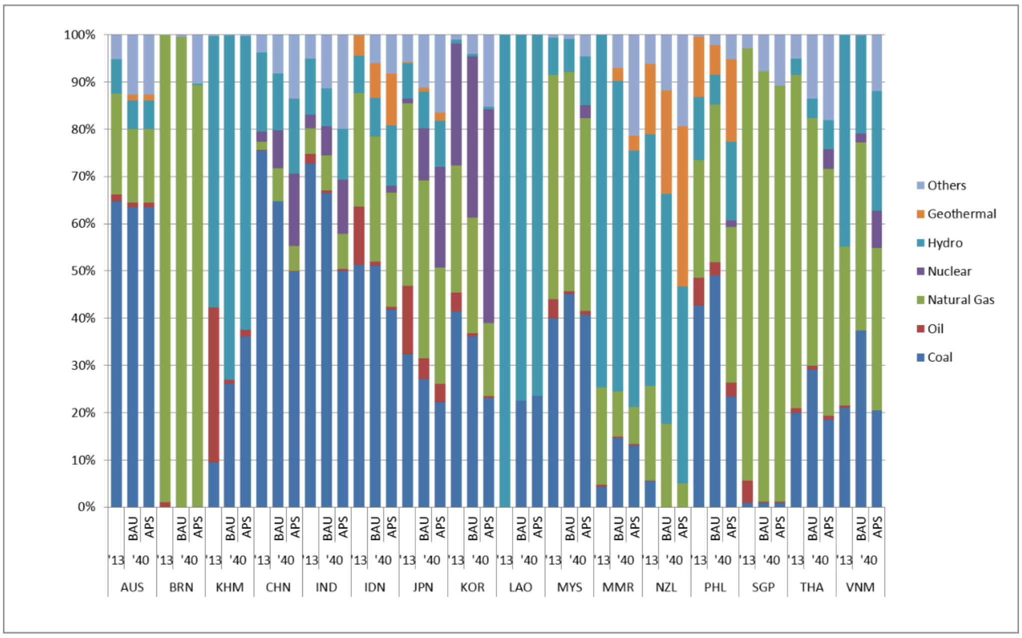



APS = Alternative Policy Scenario; AUS = Australia; BAU = Business-as-Usual scenario; BRN = Brunei Darussalam; KHM= Cambodia; CHN = China; IND = India; INA = Indonesia; JPN = Japan; KOR = South Korea; LAO = Lao PDR; MAS = Malaysia; MMR = Myanmar; NZL = New Zealand; PHI = Philippines; SIN = Singapore; THA = Thailand; VNM = Viet Nam.
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 among countries, reflecting both historical and current conditions, including access to and cost of resources and technology. It was, therefore, an exogenous input to the model. It is an important input, not only because it is a key driver of demand for primary fuels, but also because the fuel mix used can have important implications for GhG emissions. 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 Asia Summit; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario(s).
(AUS=Australia; BRN=Brunei; KHM= Cambodia; CHN= China; IND= India; INA= Indonesia; JPN= Japan; KOR= South Korea; LAO= Lao PDR; MAS= Malaysia; MMR= Myanmar; NZL= New Zealand; PHI= Philippine; SIN= Singapore; THA= Thailand; VNM= Viet Nam).
Source: Country Energy Saving Potential Report – sub-report of this main report, 2016.

Coal is projected to remain the dominant source of electricity generation in the 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 58.4 percent in the BAU to about 44.6 percent in the APS by 2040, as countries are assumed to implement policies designed to reduce the emissions intensity of electricity generation. In the APS, the share of lower emission fuels such as hydro, nuclear, and non-hydro renewable energy are expected to be higher than in the

BAU 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 resolving this problem 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 2040. 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.

Table 1-3 shows electricity access in ASEAN and the East Asia region. It also informed the progress of access to electricity in urban versus rural area from 1990 to 2012. Whereas tremendous progress of almost 100 percent of energy access has been observed in Malaysia, Singapore, Thailand, Viet Nam, China, Korea, Japan, Australia, and New Zealand, some countries in the Southeast Asia have struggled to improve energy access for their population.

## 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 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 1-4 summarises the assumptions regarding use of biofuels.

**Table 1-3. Access to Electricity**

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

* The number was taken from the presentation of Khin Seint Wint (2014), Renewable Energy Association of Myanmar.

** The number was taken from ASEAN Guideline on Off-grid Rural Electrification Approaches, ASEAN Center for Energy (ACE, 2013).

Source: World Development Indicators, 2014.

**Table 1-4. Assumptions on Biofuels – Summary by Country**

| Country | Period | Assumptions |
|---|---|---|
| Australia | | No targets on biofuels |
| Brunei Darussalam | | No targets on biofuels |
| Cambodia | | No targets on biofuels |
| China | 2030 | BAU: 20 billion litres ; APS: 60 billion litres |
| India | 2017 | 20 percent blending of biofuels, both for bio-diesel and bio-ethanol |
| Indonesia | 2025 | Bioethanol: 15 percent blend from 3–7 percent in 2010<br>Bio-diesel: 20 percent blend from 1–5 percent in 2010 |
| Japan | 2005–2030 | No biofuel targets submitted |
| Republic of Korea | 2012<br>2020<br>2030 | Replace 1.4 percent of diesel with biodiesel<br>Replace 6.7 percent of diesel with biodiesel<br>Replace 11.4 percent of diesel with biodiesel |
| Lao PDR | 2030 | Utilise biofuels equivalent to 10 percent of road transport fuels |
| Malaysia | 2030 | Replace 5 percent of diesel in road transport with biodiesel |
| Myanmar | 2020 | Replace 8 percent of transport diesel with biodiesel |
| New Zealand | 2012–2030 | Mandatory biofuels sales obligation of 3.4 percent by 2012 |
| Philippines | 2025–2035 | BAU: The Biofuels Law requires 10 percent bio-ethanol/gasoline blend and 2 percent biodiesel/diesel blend 2 years from enactment of the law (roughly 2009)<br>APS: Displace 20 percent of diesel and gasoline with biofuels by 2025 |
| Thailand | | Biofuels to displace 12.2 percent of transport energy demand |
| Viet Nam | 2020 | 10 percent ethanol blend in gasoline for road transport |

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Country Energy Saving Potential Report – sub-report of this main report, 2016.

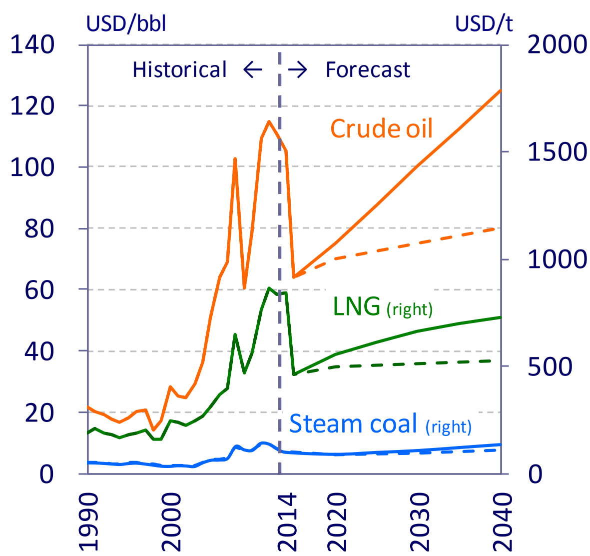
The largest increases in consumption of biofuels in the APS are expected in India and China. In all countries, biofuels are expected to meet only a small portion of the transport fuel demand by 2040.

## 3.6. Crude Oil Price

Figure 1-9 depicts the oil price assumptions used in the modelling. In the Reference Scenario, the crude oil price is US$100/billion barrels (bbl) in 2013, then drops to US$75/bbl in early 2014, then rises gradually to US$100/bbl by 2030, and to US$125/bbl in 2040. The rises of the oil price in 2030 and 2040 are due to combined factors such as robust demand growth in non-OECD countries, new emerging geopolitical risks and financial factors, oil supply constraints reflecting rising depletion rates for oil fields, etc. Prices of liquefied natural gas (LNG) will rise accordingly, with the existing price disparity shrinking due to expanding interregional trade.

In the Lower Price Scenario, energy prices remain lower due to dull growth in demand in accordance with the diffusion of energy saving technologies, as well as further promotion of unconventional resources development.

**Figure 1-9. Real Oil, LNG, and Coal Price Assumptions (Real prices are in 2014 US$)**



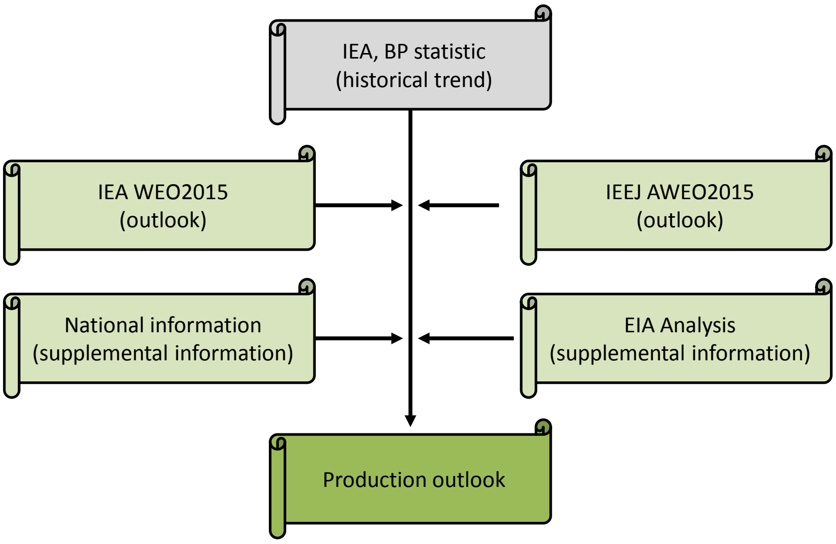

LNG = liquefied natural gas; bbl = billion barrels; t = ton.
Note: Solid line = Reference; Dashed line = Lower Price.
Source: IEEJ's oil price assumptions, 2016.

## 3.7. Assumption of Fossil Fuel Production Outlook

### 3.7.1. Analytical method

The fossil fuel production outlook is generated through the Delphi process' 'expert's judgment.' First, a historical data set of production volume is collected from British Petroleum and IEA statistics. The data is utilised to understand the transition of production volume in each country. Second, a reference was made to the IEA *World Energy Outlook 2015* and the IEEJ *Asia-World Energy Outlook 2015* in order to understand the future direction of changes in production volume. The estimated fossil fuel outlook also utilises supplementary information such as the national plans and targets provided by each Working Group member and the country analyses issued by the EIA (see Figure 1-10 and Table 1-5).

**Figure 1-10. Approach of Estimation**




IEA = International Energy Agency; BP = British Petroleum; IEEJ = Institute of Energy Economics, Japan; AWEO = ASIA Energy Outlook; EIA = [US] Energy Information Administration; WEO = World Economic Outlook.
Source: Working Group of this study, 2016.

**Table 1-5. Reference Materials and their Estimation**

| | IEA WEO 2015 | IEEJ AWEO 2015 |
|---|---|---|
| Oil | • Employ the New Policies Scenario, among the Current Policies Scenario, New Policies Scenario, 450 Scenario, Low Oil Price Scenario.<br>• Production increase until 2020 and decline after that time. | • Employ the Advanced Technologies Case, among the Reference Case, Advanced Technologies Case, Low Oil Price Case.<br>• Production is estimated to decrease in many Asian countries. |
| Natural gas | • Employ the New Policies Scenario.<br>• Production steadily increases towards 2040. | • Employ the Advanced Technologies Case.<br>• Production is estimated to increase in line with IEA WEO 2015. |
| Coal | • Employ the New Policies Scenario.<br>• Production increase in major producing countries, except China where demand for power generation and industry sectors are estimated to decrease. | • Employ the Advanced Technologies Case.<br>• Production is estimated to decrease as demand declines. |

IEA = International Energy Agency; WEO = World Energy Outlook; IEEJ = Institute of Energy Economics, Japan.
Source: Working Group of the study, 2016.

### 3.7.2. Results of the fossil fuel production outlook

Tables 1-6 and 1-7 present the assumptions of the fossil fuel production outlook. The results indicate that:

- For crude oil, many countries will not be able to maintain recent production levels except in some cases such as Australia and Philippines where the oil production amount surpasses that of 2014. In most countries, oil reserves are estimated to be depleted in the future, an estimate based on the size of a country's oil reservoir (ERIA, 2015). Although some countries have untapped oil resources, their size seems too small to maintain current production amounts. In addition, insufficient investment in exploring new fields will hamper increasing production amounts. Furthermore, some fields may be too costly to exploit due to their geographical condition, such as deep sea and mountainous areas.

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

- Coal (thermal + coking) production is estimated to decrease in China, the major coal-producing country, whereas India, the second largest coal consumer, will increase production. Their energy policies are different. China has changed its policy to pursue cleaner energy use, so it intends to curb coal consumption, whereas India's priority is to ensure energy supply at an affordable price, so it plans to increase domestically available cheap energy sources such as coal. Australia, a major coal exporter, is estimated to decrease production as global coal demand declines due to its gradual shift to a low-carbon society. Another major exporter, Indonesia, will increase production to meet its own consumption.

**Table 1-6. Production Outlook of Oil and Gas**

| | Oil Production (1000b/d) | | | | | | Gas Production (Bcm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2020 | 2025 | 2030 | 2035 | 2040 | 2014 | 2020 | 2025 | 2030 | 2035 | 2040 |
| Australia | 448 | 600 | 650 | 650 | 600 | 600 | 58.8 | 133.0 | 144.5 | 165.5 | 175.5 | 174.0 |
| Brunei | 138 | 140 | 130 | 130 | 120 | 120 | 11.9 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 |
| China | 4,341 | 4,300 | 4,250 | 4,200 | 4,100 | 4,000 | 134.5 | 172.0 | 212.0 | 255.0 | 299.0 | 342.0 |
| India | 895 | 740 | 680 | 680 | 700 | 720 | 31.7 | 38.0 | 45.0 | 55.0 | 69.0 | 89.0 |
| Indonesia | 852 | 830 | 820 | 800 | 780 | 770 | 73.4 | 80.0 | 82.0 | 83.0 | 84.0 | 85.0 |
| Japan | 17 | 15 | 15 | 15 | 15 | 15 | 3.9 | 3.5 | 3.0 | 3.0 | 3.0 | 2.5 |
| Korea | 20 | 15 | 15 | 15 | 15 | 15 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Malaysia | 666 | 650 | 620 | 600 | 600 | 600 | 66.4 | 68.0 | 70.0 | 67.0 | 65.0 | 65.0 |
| Myanmar | 20 | 20 | 20 | 20 | 20 | 20 | 16.8 | 17.5 | 18.5 | 18.5 | 18.5 | 18.5 |
| Philippines | 24 | 39 | 35 | 30 | 30 | 30 | 3.4 | 3.0 | 4.0 | 7.0 | 7.0 | 8.0 |
| New Zealand | 47 | 27 | 10 | 3 | 1 | 1 | 5.4 | 4.0 | 3.0 | 2.0 | 1.0 | 1.0 |
| Thailand | 453 | 480 | 470 | 460 | 450 | 440 | 42.1 | 42.0 | 41.0 | 40.0 | 40.0 | 40.0 |
| Vietnam | 365 | 360 | 350 | 330 | 320 | 320 | 11.1 | 11.0 | 15.0 | 18.0 | 22.0 | 25.0 |
| Other Asia Pacific | 144 | 150 | 140 | 130 | 130 | 130 | 73.7 | 77.0 | 76.0 | 75.0 | 74.0 | 74.0 |
| **Total Asia Pacific** | **8,430** | **8,366** | **8,205** | **8,063** | **7,881** | **7,781** | **533.6** | **662.0** | **727.0** | **802.0** | **871.0** | **937.0** |

b/d = barrel/day; Bcm = billion cubic metre.
Source: Working Group of the study, 2016.

**Table 1-7. Production Outlook of Coal**

| | Coal Production (Mton) | | | | | |
|---|---|---|---|---|---|---|
| | 2012 | 2020 | 2025 | 2030 | 2035 | 2040 |
| Australia | 431 | 437 | 421 | 412 | 411 | 405 |
| China | 3,532 | 3,548 | 3,383 | 3,286 | 3,132 | 2,944 |
| India | 604 | 627 | 650 | 624 | 652 | 683 |
| Indonesia | 444 | 471 | 476 | 478 | 478 | 480 |
| Korea | 2.09 | 1.76 | 1.20 | 0.63 | 0.07 | 0 |
| Lao PDR | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Malaysia | 3.0 | 3.2 | 3.6 | 4.0 | 4.0 | 4.0 |
| Myanmar | 0.8 | 0.6 | 0.8 | 0.9 | 1.0 | 1.0 |
| Philippines | 7.3 | 7.1 | 7.9 | 9 | 9 | 9 |
| New Zealand | 4.9 | 4.1 | 4.0 | 3.9 | 3.8 | 3.7 |
| Thailand | 18 | 19 | 18 | 14 | 10 | 7 |
| Viet Nam | 42 | 42 | 41 | 42 | 49 | 53 |
| **Total** | **5,090** | **5,161** | **5,007** | **4,875** | **4,752** | **4,591** |

Mton = million tons.
Source: Working Group of the study, 2016.

## 3.8. 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, and which were proposed policies, and should apply only to the APS. Quantitative energy savings were estimated based on the countries' own assumptions and modelling results. Table 1-8 shows the summary of energy saving goals, action plans, and policies collected from each EAS Working Group member in 2014.

**Table 1-8. Summary of Energy Saving Goals, Action Plans, and Policies Collected from Each EAS Working Group Member**

| | Indicator | Goals |
|---|---|---|
| Australia | Carbon pollution | 5 percent reduction below 2000 level by 2020 |
| Brunei Darussalam | Energy intensity | 45 percent improvement by 2035 from 2005 level |
| Cambodia | Final energy consumption | 10 percent reduction of BAU by 2030 |
| China | Energy intensity | 16 percent improvement during the 12th 5-year plan (2011–2015) |
| India | Not submitted | |
| Indonesia | Energy intensity | Reduce by 1 percent/year until 2025 |
| Japan | Energy intensity | 30 percent improvement in energy intensity in 2030 from 2003 level |
| Korea, Rep. of | Energy intensity | 46.7 percent reduction by 2030 from 2006 level |
| Lao PDR | Final energy consumption | 10 percent reduction from BAU by 2030<br>5 percent energy intensity reduction by 2030, from 2015. |
| Malaysia | Final energy consumption | 8.6 percent reduction from BAU by 2020 |
| Myanmar | TPES | • 5 percent reduction from BAU by 2020<br>• 10 percent reduction from BAU by 2030<br>(Final energy consumption: 5 percent by 2020 and 8 percent by 2030). |
| New Zealand | Energy intensity | 1.3 percent per year improvement from 2011 to 2016 |
| Philippines | Final energy consumption | 10 percent savings from BAU by 2030 |
| Singapore | Energy intensity | • 20 percent reduction by 2020 from 2005 level<br>• 35 percent reduction by 2030 from 2005 level |
| Thailand | Energy intensity | • 15 percent reduction by 2020 from 2005 level<br>• 25 percent reduction by 2030 from 2005 level |
| Viet Nam | Final energy consumption | • 3–5 percent saving from BAU until 2015<br>• 5–8 percent saving from BAU after 2015 |

EAS = East Asia Summit; TPES = Total Primary Energy Supply; BAU = Business-as-Usual scenario.
Source: Tomoyuki (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 from 2013 to 2040. This relatively strong economic growth and rising per capita incomes in the EAS countries could mean significant reductions in poverty and significant increases in living standards for hundreds of millions of people.

With economic growth will come increasing access to, and demand for, electricity and rising levels of vehicle ownership. The continued reliance on fossil fuels to meet the increases in energy demand may be associated with increased GhG emissions and climate change challenges unless low emission technologies are used. Even if fossil fuel resources are 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 GhG 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 GhG will be very challenging given such strong growth. However, as will be discussed in Section 4.3, sharp reductions in GhG are being called for by scientists. This huge 'headwind' working against EEC and emission reductions poses a challenge to the EAS region that needs to be addressed.

# 4. Energy and Environmental Outlook for the EAS Region

## 4.1. Business-as-Usual Scenario

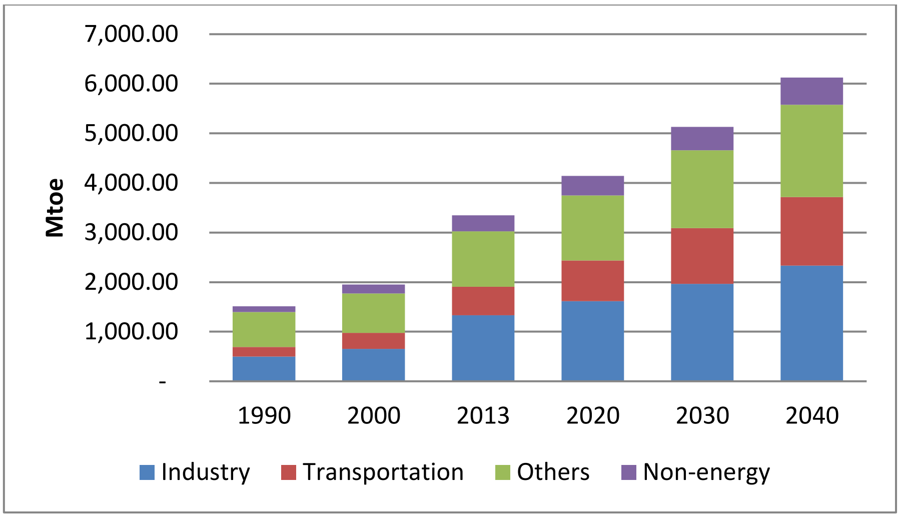
### 4.1.1. Final energy consumption

Between 2013 and 2040, total final energy consumption[3] 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 consumption is projected to increase from 3,347 million tons of oil equivalent (Mtoe) in 2013 to 6,129 Mtoe in 2040. By sector, transport energy demand is projected to grow most rapidly, increasing by 3.3 percent per year, as a result of motorisation driven by increasing disposable income as EAS economies grow. Demand in the commercial and residential ('Others') sectors 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 1-11 shows final energy consumption by sector under BAU in EAS, from 1990 to 2040.

The shares of final energy consumption by sector in 2013–2040 indicate that the transport sector is projected to have an increasing share, growing from 17.2 percent to 22.6 percent in 2013–2040. The industrial and other (largely residential and commercial) sectors are projected to have decreasing shares – 39.8 percent to 38.0 percent for industry, and 33.4 percent to 30.3 percent for 'Others' – from 2013 to 2040. The share of non-energy demand is also projected to have a decreasing share, from 19.6 percent to 9.1 percent, during 2013–2040. Details of sectoral shares in final energy consumption are shown in Figure 1-12.

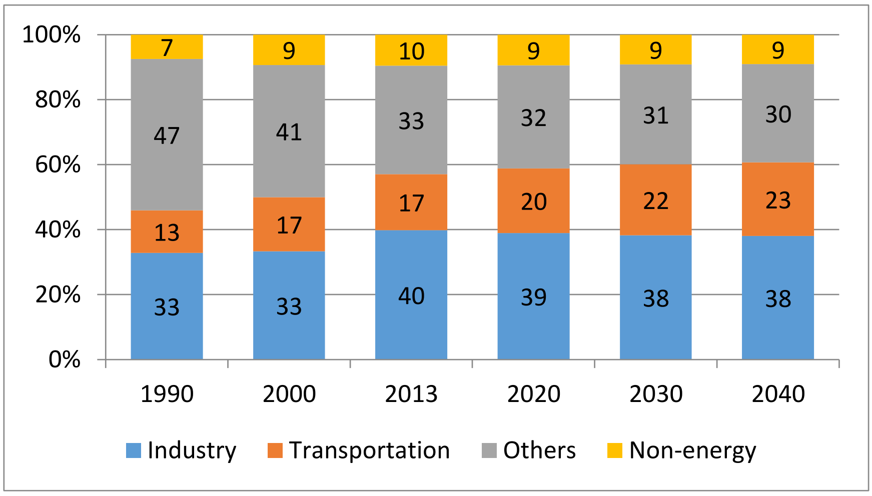
[3] Refers to energy in the form in which it is actually consumed, i.e. including electricity, but not including the fuels and/or energy sources used to generate electricity.

**Figure 1-11. Final Energy Consumption by Sector (1990–2040), BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

**Figure 1-12. Final Energy Consumption Share by Sector (1990–2040)**

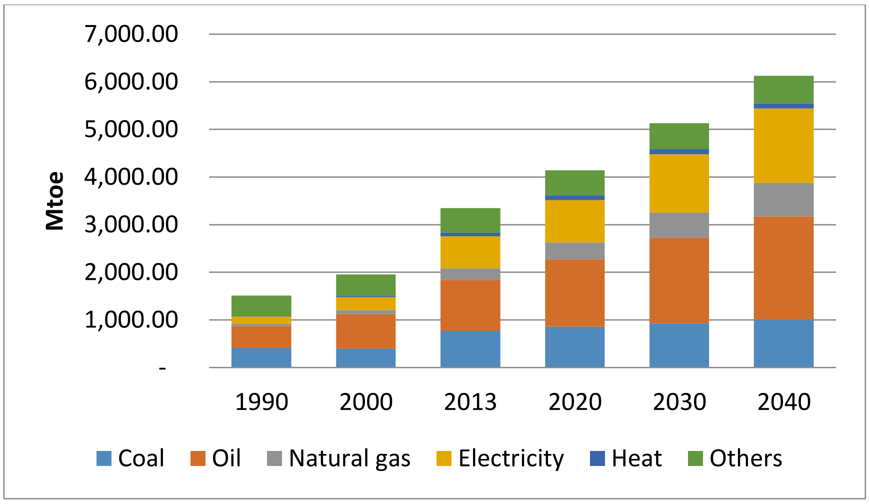



Source: Authors' calculation.

Figures 1-13 and 1-14 show final energy consumption and shares by fuel type in the EAS under the BAU from 1990 to 2040. By energy source, natural gas demand in the BAU is projected to show the fastest growth, increasing by 4 percent per year, from 243 Mtoe in 2013 to 704 Mtoe in 2040.

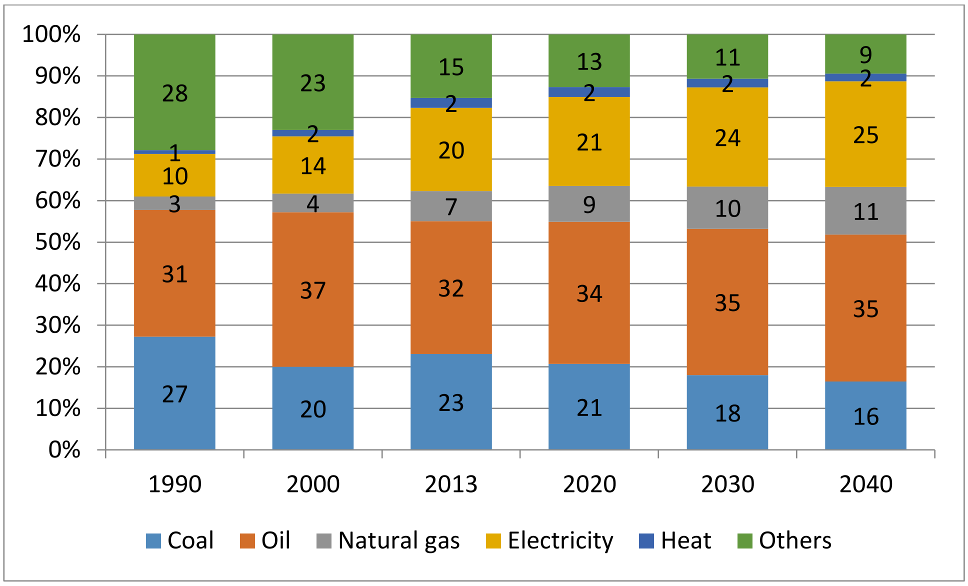
Although oil will retain the largest share of total final energy consumption, it is projected to grow at a lower rate of 2.6 percent per year in 2013–2040, reaching 2,164 Mtoe in 2040, compared with the average annual growth of 3.8 percent over the last 2 decades. However, its share will still increase from 32 percent in 2013 to 35.3 percent in 2040. Demand for electricity will grow at a relatively fast rate of 3.2 percent per year. Its share will increase from 20 percent in 2012 to 25.4 percent in 2040, surpassing the share of coal. Coal demand will grow at a slower rate of 1 percent per year on average, reaching 1,010 Mtoe in 2040. Other fuels, which are mostly solid and liquid biofuels, will have a slow annual growth rate of 0.5 percent on average, but consumption of liquid biofuels will grow rapidly, reaching 579 Mtoe in 2040. Consequently, the share of other fuels will decline from 15.3 percent in 2013 to 9.4 percent in 2035. This slow growth is due to the gradual shift from non-commercial biomass to conventional fuels such as liquefied petroleum gas (LPG) and electricity in the residential sector.

**Figure 1-13. Final Energy Consumption by Fuel (1990–2040)**




Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

**Figure 1-14. Final Energy Consumption Share by Fuel (1990–2040)**




Source: Authors' calculation.

### 4.1.2. Primary energy supply

Figure 1-15 shows primary energy supply from 1990 to 2040. Primary energy supply[4] in the EAS region is projected to grow at a slightly slower pace, of 2.2 percent per year, as final energy consumption grows at 2.3 percent per year.

EAS primary energy supply is projected to increase from 5,257 Mtoe in 2013 to 9,517 Mtoe in 2040. Coal will remain as the largest share of primary energy supply, but its growth is expected to be slower, increasing at 1.7 percent per year. Consequently, the share of coal in total primary energy supply (TPES) is forecast to decline from 52 percent in 2013 to 44.8 percent in 2040.

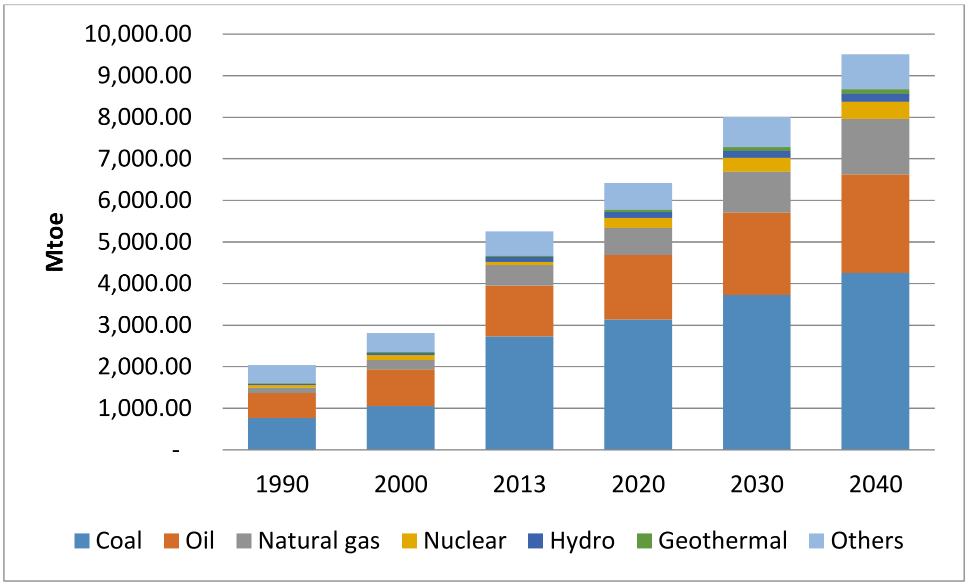
Among fossil sources of energy, natural gas is projected to see the fastest growth from 2013–2040, increasing at an annual average rate of 3.7 percent. Its share in the total will consequently increase from 9.1 percent (equivalent to 499 Mtoe) in 2013 to 12.7 percent (equivalent to 1339 Mtoe) in 2040.

Nuclear energy is also projected to increase at a rapid rate of 6.4 percent per year on average and its share will grow from 1.5 percent in 2013 to 4.3 percent in

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

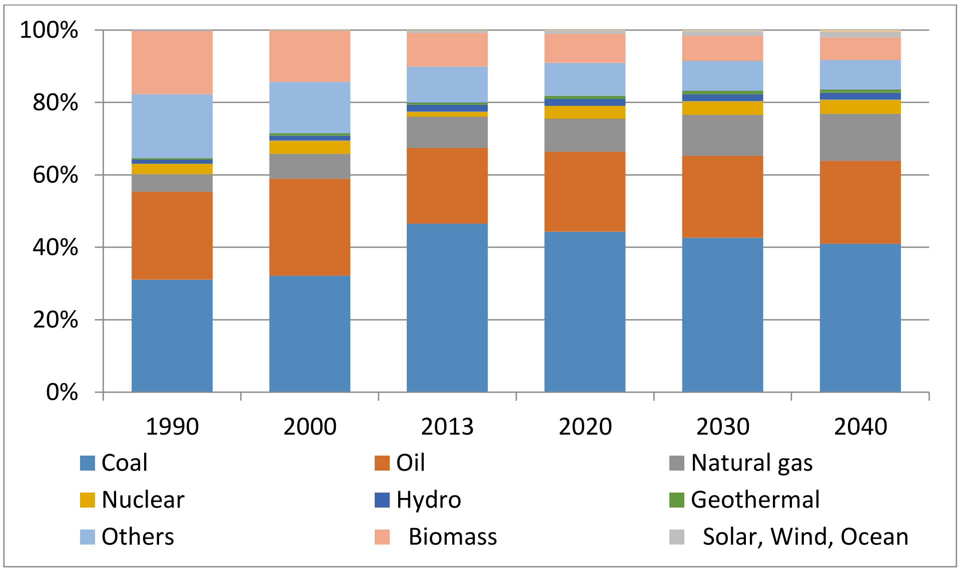
2040. This is due to the assumed resumption of nuclear power generation in Japan, the expansion of nuclear power generation capacity in China and India, and the introduction of this energy source in Viet Nam.

**Figure 1-15. Primary Energy Supply in EAS (1990–2040)**




Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

**Figure 1-16. Share of Primary Energy Mix by Sources in EAS (1990–2040)**



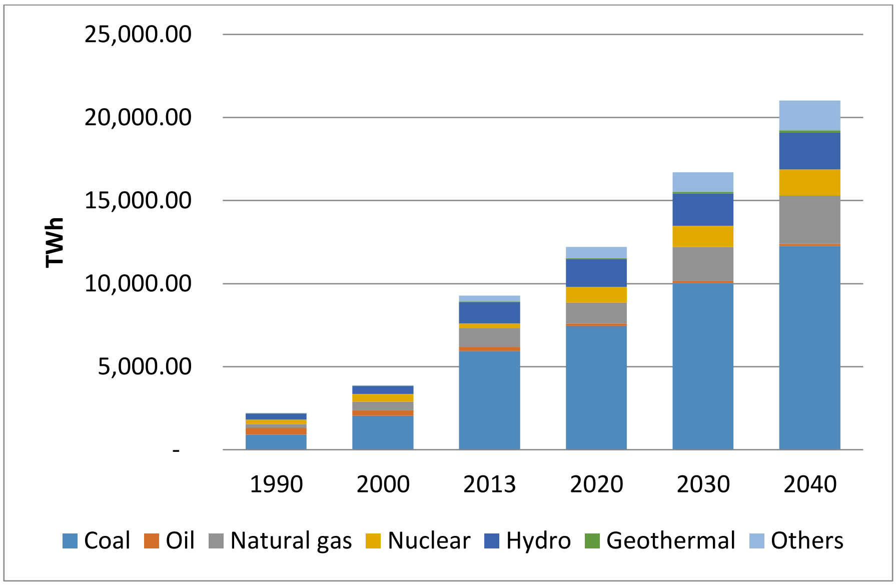

EAS = East Asia Summit.
Source: Authors' calculation.

Among the energy sources, 'Others' – which is made up of solar, wind, and solid and liquid biofuels – will see the slowest growth rate of 1.4 percent. Consequently, the share of these other sources of energy will decrease from 11.1 percent in 2013 to 8.9 percent in 2040. Geothermal energy will increase at a rapid pace of 4.1 percent per year, but its share will remain low and will reach only 1.1 percent in 2040, a slight increase from 0.7 percent in 2013. The growth of hydro will be 2.0 percent per year and its share will remain low, at around 2.0 percent from 2013 to 2040. Figure 1-16 shows the shares of each energy source in the total primary energy mix from 1990 to 2040.

### 4.1.3. Power generation in EAS

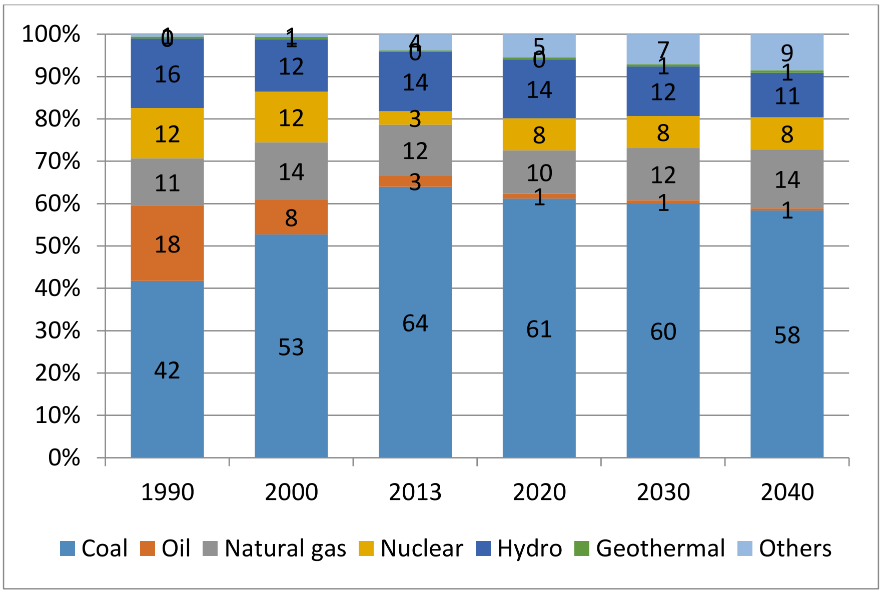
Figure 1-17 shows the power generation output in the EAS region. Total EAS power generation is projected to grow at 3.1 percent per year on average, from 2013 (equivalent to 9,282 TWh) to 2040 (equivalent to 21,015 TWh). However, the growth rate from 1990 to 2013 was 6.5 percent, more than twice as high as the projected growth rate from 2013 to 2040.

**Figure 1-17. Power Generation in EAS (1990–2040)**




EAS = East Asia Summit; TWh = terawatt-hour.
Source: Authors' calculation.

**Figure 1-18. Share of Power Generation Mix in EAS (1990–2040)**



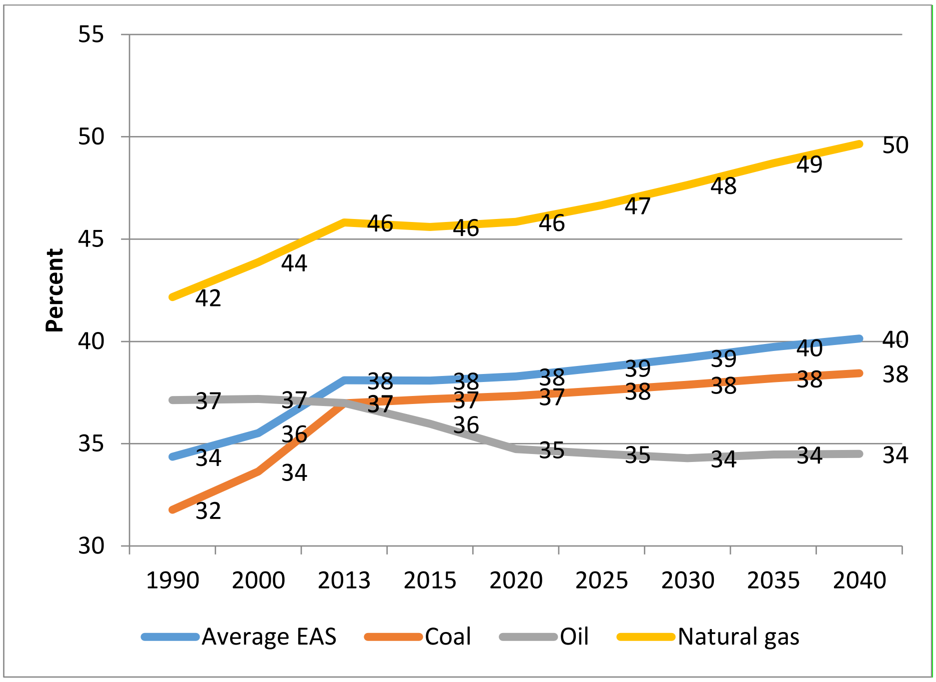

Source: Authors' calculation.

Figure 1-18 shows the shares of each energy source in electricity generation in 1990–2040. The share of coal-fired generation is projected to continue to be the largest and will be about 58.4 percent in 2040, a little drop from the 64 percent share in 2013. The share of natural gas is projected to increase from 12 percent in 2013 to 14 percent in 2040. The nuclear share (3.2 percent in 2013) is forecast to increase to 7.6 percent in 2040. Geothermal (0.3 percent in 2013) and other (wind, solar, biomass, etc., at 3.9 percent) shares will also increase to 0.6 percent and 8.5 percent in 2040, respectively. The shares of oil and hydro are projected to decrease, from 2.7 percent to 0.5 percent, and from 14.0 percent to 10.6 percent, respectively, over the same period.

Figure 1-19 shows the thermal efficiency of coal-, oil-, and natural gas-fired power plants from 1990 to 2040. Thermal efficiency is projected to grow in EAS from 2013–2040 due to improvement in electricity generation technologies such as combined-cycle gas turbines and advanced coal power plant technologies. The efficiency of coal thermal power plants, which is a mix of old and new power plants, will increase slightly, from 37 percent in 2013 to 38.4 percent in 2040. The efficiency of natural gas power plants will also increase, from 45.8 percent in 2013 to 49.6 percent in 2040. Oil power plants, which will not be used very much in future, will see a deterioration in efficiency, dropping from 37.0 percent in 2013 to

34.5 percent in 2040. The drop in thermal efficiency of oil power plants is understandable as facilities are ageing.

**Figure 1-19. Thermal Efficiency by Fuel, BAU (1990–2040)**



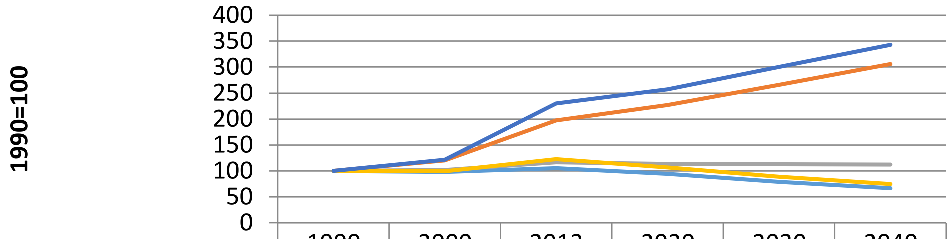

BAU = Business-as-Usual scenario; EAS = East Asia Summit.
Source: Authors' calculation.

### 4.1.4. Primary energy intensity and per capita energy demand

Figure 1-20 shows the energy intensity and energy per capita from 1990 to 2040. For BAU, energy intensity in EAS is projected to decline by 23 percent, from 359 toe/million US$ (constant 2005) in 2013 to 227 toe/million US$ in 2040. The improvement in energy intensity is also reflected in the improvement in $CO_2$ intensity at a similar pace.

In contrast to energy intensity, energy demand per capita is projected to increase by 206 percent, from 1.5 toe per person in 2013 to 2.4 toe per person in 2040. This could be attributed to the projected continuing economic growth in the region, which will bring about a more energy-intensive lifestyle as people are able to purchase vehicles, household appliances, and other energy-consuming devices due to rise in disposable income. As energy demand per capita increases, $CO_2$ per capita is projected to increase at a similar rate.

**Figure 1-20. Energy Indicators in EAS**




| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|---|
| Energy Intensity | 100 | 98 | 105 | 94 | 79 | 67 |
| Energy per Capita | 100 | 120 | 197 | 227 | 266 | 306 |
| CO2 per Energy | 100 | 101 | 116 | 113 | 113 | 112 |
| CO2 Intensity | 100 | 99 | 123 | 107 | 89 | 75 |
| CO2 per Capita | 100 | 122 | 230 | 257 | 300 | 343 |

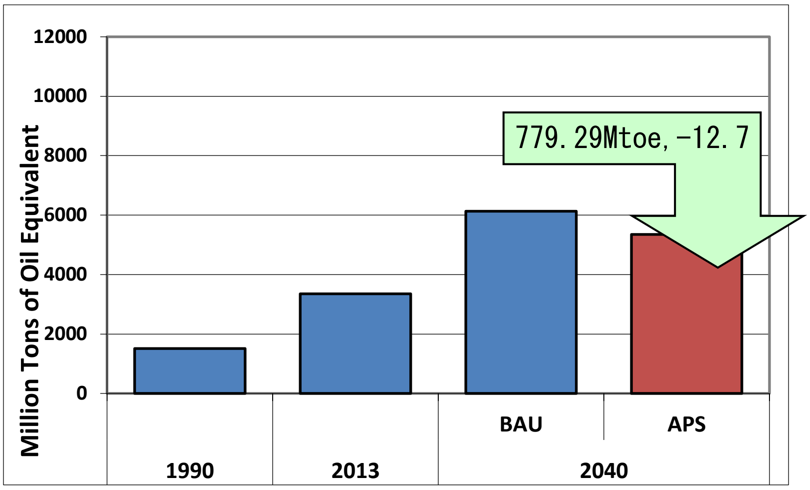
EAS = East Asia Summit; $CO_2$ = carbon dioxide.
Source: Authors' calculation.

## 4.2. Comparison of BAU and APS

### 4.2.1. Total final energy consumption – BAU vs APS

In the APS case, final energy consumption is projected to rise to 5,349 Mtoe, 779 Mtoe or 12.7 percent lower than in the BAU case in 2040. This is due to the various energy efficiency plans and programmes, presented in Section 3 above, on both the supply and demand sides that are to be implemented by EAS countries. Figure 1-21 shows the evolution of final energy consumption in 1990–2040 in both BAU and APS.

**Figure 1-21. Total Final Energy Consumption, BAU and APS**

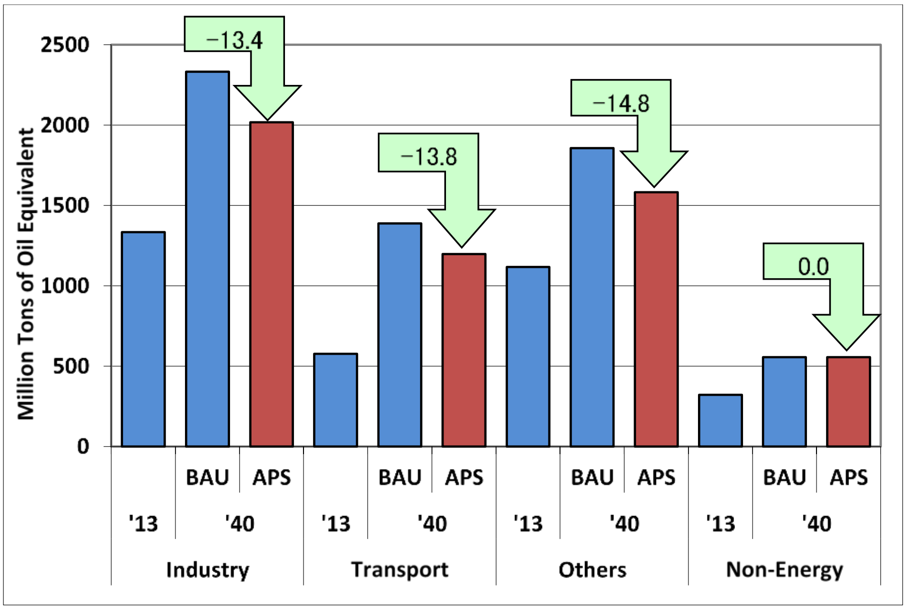



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

### 4.2.2. Final energy consumption by sector – BAU vs APS

Figure 1-22 shows the composition of final energy consumption by sector in both the BAU and APS. Final energy consumption 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 (13.4 percent), followed by the 'others' sector (14.8 percent), the transport sector (13.8 percent); non-energy demand will not be significantly different from the BAU.

**Figure 1-22. Final Energy Consumption by Sector, BAU vs APS**

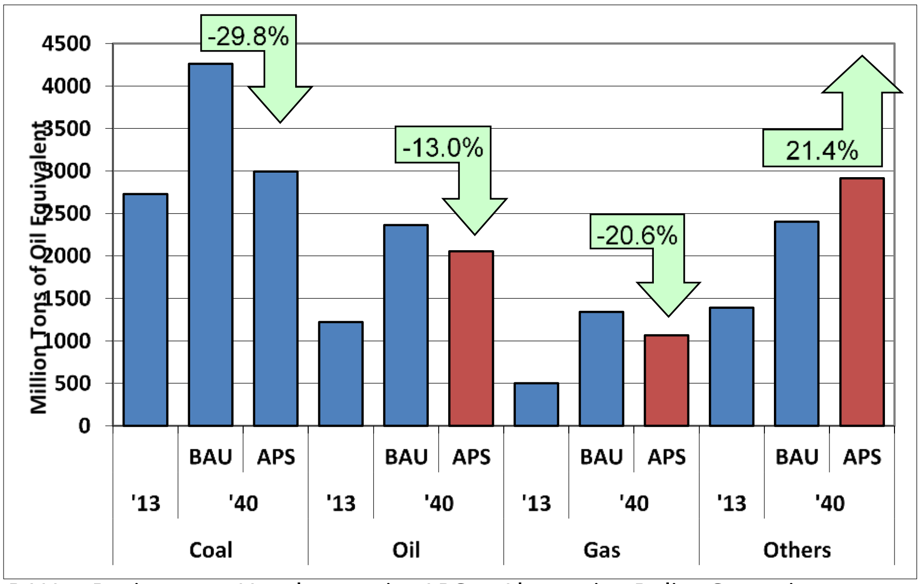



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Authors' calculation.

### 4.2.3. Primary energy supply by sources – BAU vs APS

Figure 1-23 shows primary energy supply by fuel sources. In the APS case, growth in final energy consumption for all fuels is lower compared with the BAU case. The growth rate in final energy consumption of APS is projected to be 1.6 percent per year on average from 2013 to 2040. This rate is lower than the BAU case in which the growth rate is projected to be 2.2 percent. In absolute terms, the largest reduction will be in coal demand, by 1,268 Mtoe or 29.8 percent, from the BAU's 4,261 Mtoe to 2,993 Mtoe in the APS. The saving potentials for other fuels are projected to be 306 Mtoe for oil (equivalent to a 13 percent reduction from BAU), and 275 Mtoe for gas (equivalent to a 20.6 percent reduction from the BAU).

**Figure 1-23. Primary Energy Supply by Sources, BAU and APS**



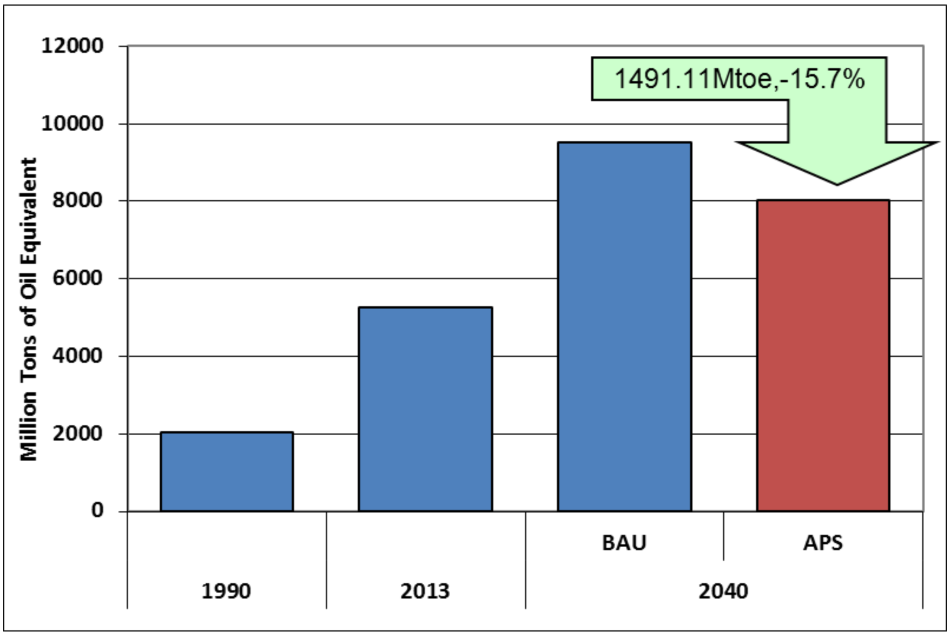

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Authors' calculation.

### 4.2.4. Total primary energy supply – BAU vs APS

Figure 1-24 shows TPES in both BAU and APS. The total saving potential in the TPES is expected to be 1,491 Mtoe, a consumption reduction from 9,518 Mtoe in BAU to 8,026 Mtoe in APS. This saving potential represents a 15.7 percent reduction from BAU to APS.

The energy saving potential is brought about by improvements in both the transformation sector, particularly power generation, and the final energy consumption sector where efficiencies of household appliances and more efficient building designs are expected. For the 'others' sector, there is an expected increase of renewable energy in the energy supply, which is projected to be a 21.4 percent increase from the BAU to APS.

**Figure 1-24. Total Primary Energy Supply – BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

## 4.3. $CO_2$ Emissions from Energy Consumption

### 4.3.1. $CO_2$ emissions

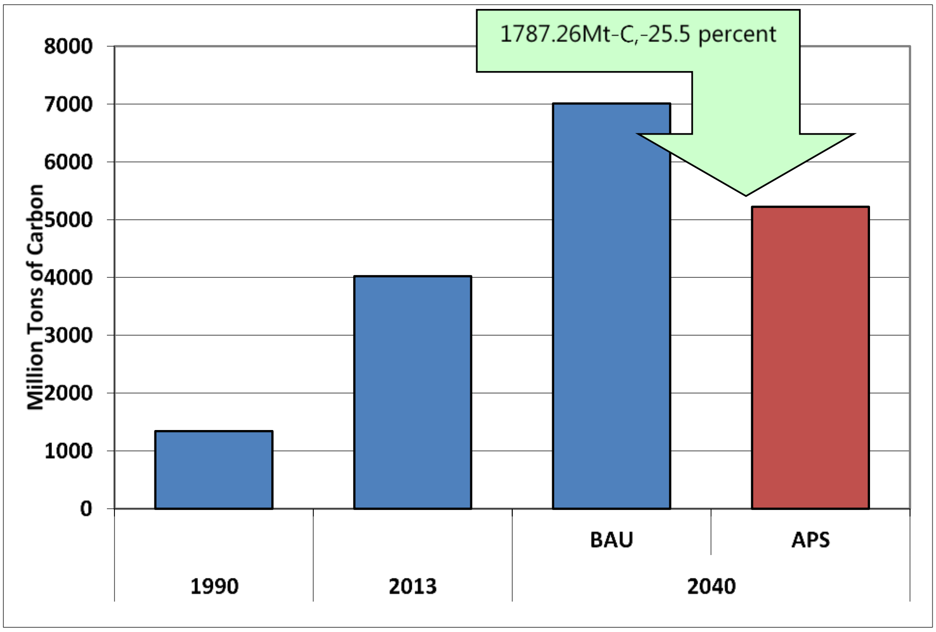
As shown in Figure 1-25, $CO_2$ emissions from energy consumption in the BAU case are projected to increase from 4,023 million tons of Carbon (Mt–C) in 2013 to 7,010 Mt–C in 2040, implying an average annual growth rate of 2.1 percent. This is slightly lower than growth in TPES of 2.2 percent per year. In the APS case, $CO_2$ emissions are projected to be 5,223 Mt–C in 2040, 25.5 percent lower than under the BAU.

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2 degrees Celsius (°C). The Paris Agreement is a bridge between today's policies and climate neutrality before the end of the century.

Although the emission reductions under the APS are significant, $CO_2$ emissions from energy demand in the APS case in 2040 will still be above 2013 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 much more than 2°C compared with pre-industrial levels, global $CO_2$ emissions would need to peak between 2000 and 2015.

In the adopted version of the Paris Agreement, the parties will also 'pursue efforts' to limit the temperature increase to 1.5°C, which will require zero emissions sometime between 2030 and 2050, according to the scientists. However, this study shows that even in the APS, the emission will be about 4,870 Mt-C. It is supposed to be at zero emission for the efforts to limit the temperature increase to 1.5°C to be successful.

**Figure 1-25. Total $CO_2$ Emissions – BAU and APS**



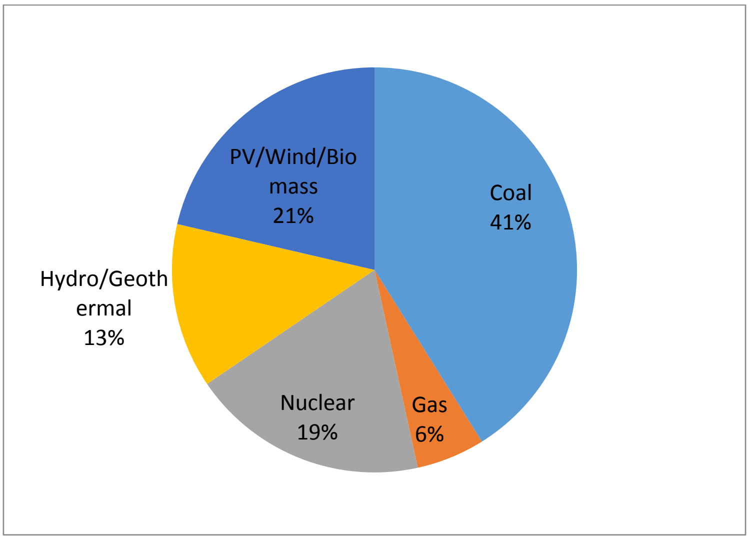

$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

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. Therefore, it is very important that the COP21 through the Intended Nationally Determined Contributions (INDCs) will need to seriously implement the GhG abatement and traces the way to achieving the targets set in INDCs.

## 4.4. Necessary Investment Cost for Power Sector

Based on the energy outlook results, BAU and APS, the Working Group estimated the necessary investment in the power sector, especially power generation facilities, which comprise of coal, gas, nuclear, hydro, geothermal, solar photovoltaic (PV), wind, and biomass power generation plants. It drew on several sources of information to obtain the current capital cost of each power plant, but it did not forecast future capital cost due to its uncertainty. For all EAS countries taken together, approximately US$4 trillion would be needed due to the rapid increase in electricity demand in the region. Figures 1-26 and 1-27 show the investment shares by power generation type for the BAU and the APS. It is clear that investment in power generation under the APS could shift to low-carbon power generation sources such as nuclear and PV/wind/biomass.

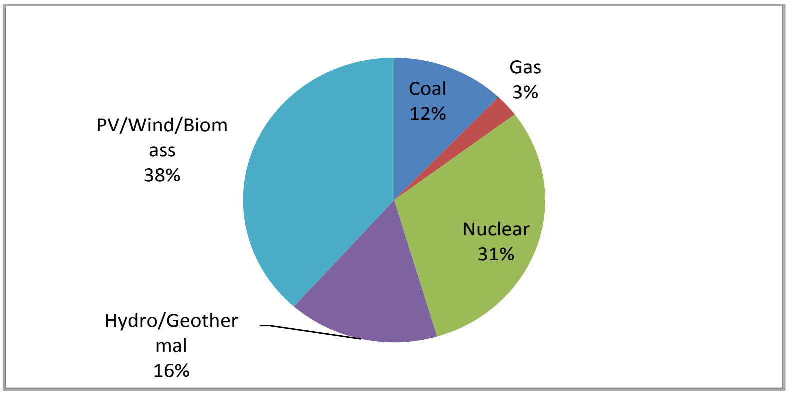
**Figure 1-26. Investment Share by Power Sources (EAS–BAU)**




EAS = East Asia Summit; BAU = Business-as-Usual scenario; PV = photovoltaic.
Source: Authors' calculation.

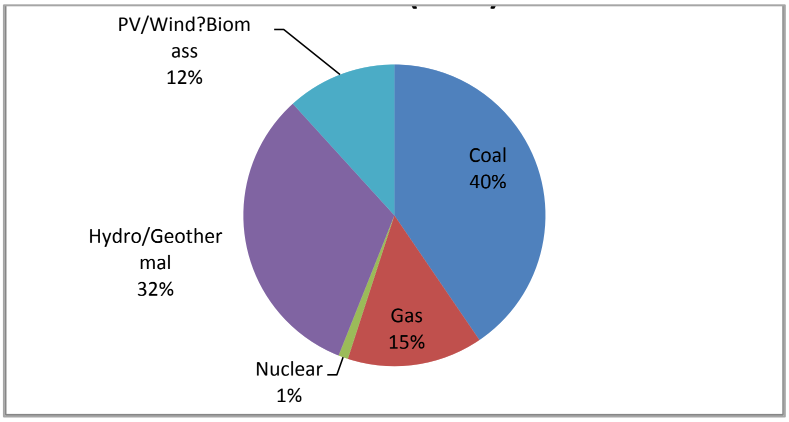
Figures 1-28 and 1-29 show the investment need for the 10 ASEAN Member States and the '+6' countries – Australia, China, India, Japan, Korea, and New Zealand. ASEAN would account around US$600 billion and the +6 countries for around US$3.4 trillion due to the huge investment in power generation needed by China and India. The investment shares by power sources are quite different. In case of the BAU, investment in coal and hydro/geothermal power are the dominant shares in the ASEAN–BAU case, whereas for the +6 countries the greatest investment needs are in coal, nuclear, and PV/wind/biomass power plants.

**Figure 1-27. Investment Share by Power Sources (EAS–APS)**



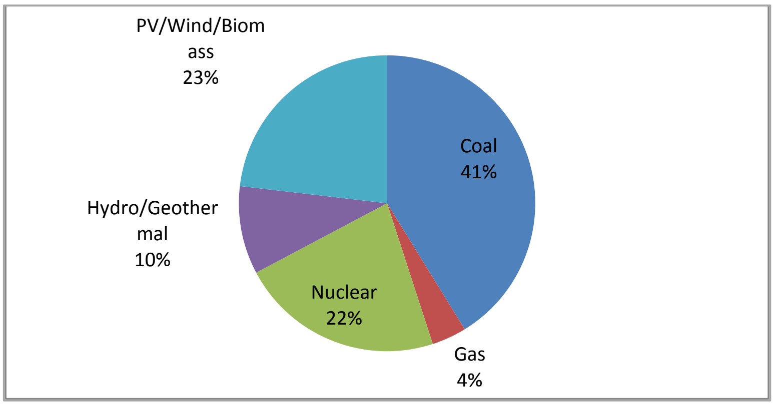

EAS = East Asia Summit; EAS = Alternative Policy Scenario; PV = photovoltaic.
Source: Authors' calculation.

**Figure 1-28. Investment Share by Power Sources (ASEAN–BAU)**




ASEAN = Association of Southeast Asian Nations; BAU = Business-as-Usual scenario; PV = photovoltaic.
Source: Authors' calculation.

**Figure 1-29. Investment Share by Power Sources (+6 – BAU)**

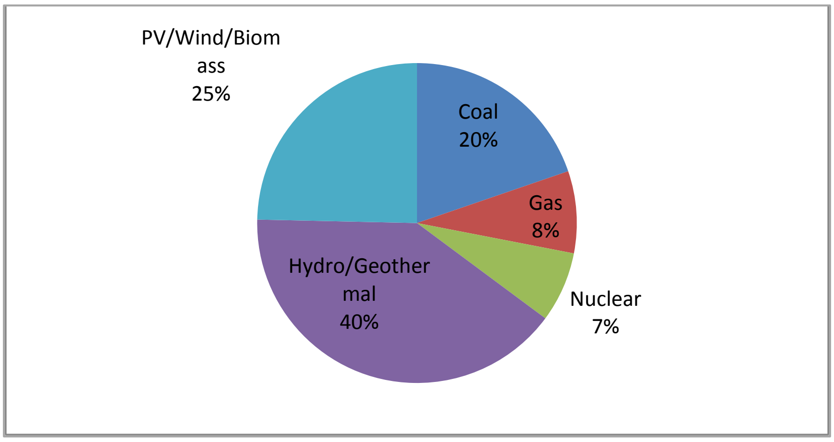



BAU = Business-as-Usual scenario: PV = photovoltaic.
Source: Authors' calculation.

In the APS case, ASEAN will shift from coal to hydro/geothermal and PV/wind/biomass, whereas the +6 countries will shift from coal to nuclear and PV/wind/biomass.

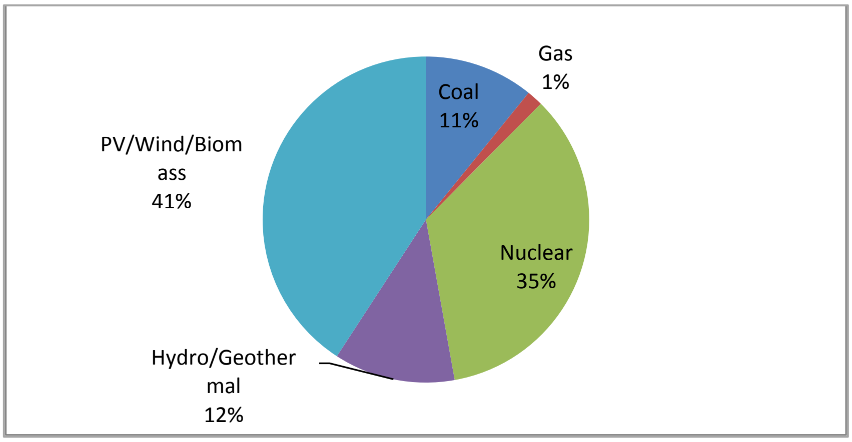
Figures 1-30 and 1-31 show the investment share by power sources under the APS for ASEAN and the +6 countries. The increase of the renewable share in power generation could be expected as the operation rate of renewable energy such as solar PV and wind power plants is quite low. If the policy to promote solar PV and wind is implemented, a large capacity of solar PV and wind will be needed; this means initial capital (investment) costs could be higher.

**Figure 1-30. Investment Share by Power Sources (ASEAN–APS)**




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

**Figure 1-31. Investment Share by Power Sources (+6–APS)**




APS = Alternative Policy Scenario.
Source: Authors' calculation.

## 5. Conclusions and Recommendations

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

### 5.1. Key Findings

Based on projected changes in socio-economic factors, energy consumption, and $C0_2$ emissions in the BAU and the APS, the Working Group members identified several key findings:

- Sustained population and economic growth in the EAS region will lead to significant increases in energy demand. Total final energy consumption in 2040 will increase 1.8 times from 2013, with natural gas increasing 2.9 times during this period. Oil will increase 2.0 times, but will retain its highest fuel share in final consumption at 2,164 Mtoe. Transportation sector demand – which is dominated by road transport – will increase 2.4 times to 1,388 Mtoe in 2040.
- Electricity generation from 2013 to 2040 will increase 2.3 times, to 21015.3 GWh from 2013, and coal is projected to increase 2.1 times. Although

nuclear will increase 5.4 times and NRE 2.5 times during this period, coal will still have the largest share, at 58.4 percent, in 2040. Electricity generation will be the source of 64.4 percent of the 4,261 Mtoe of primary consumption of coal in the EAS region in 2040.

- TPES will increase 1.8 times in 2013–2040. But even in the BAU, the EAS region's energy elasticity, which is defined as the growth rate of primary energy supply divided by the growth rate of GDP from 2013 to 2040, is projected to improve to 0.56 (2.2/4.0), compared with 1.06 (4.2/4.0) from 1990 to 2013.
- 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, defined as the growth rate of $CO_2$ emissions divided by the growth rate of GDP in 2013–2040, will be 26 percent lower than energy elasticity. There are two reasons for this. The first is diversification among fossil energy from coal to gas. Coal's share of the total primary energy mix is forecast to decline from around 52 percent in 2013 to 45 percent in 2040. On the other hand, the share of gas is projected to increase to 14.0 percent from 9.5 percent over the same period. The second reason is the increased use of carbon-neutral energy, such as nuclear power, hydro power, geothermal power, and NRE. The share of carbon-neutral energy in 2013 was 15.4 percent, but is forecast to increase to 16.3 percent in 2040.
- Overall, the EAS energy mix in the BAU will change in 2013–2040. The share of coal and oil will fall from 75 percent to 70 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.
- Industry remains a major consumer of energy, but the transport sector's consumption continues to increase rapidly. These two sectors are challenging sectors in terms of improving energy efficiency and reducing $CO_2$ emissions. Hence, appropriate EEC programmes and low-emission technologies are needed in these sectors.
- 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 supply;
- 13.2 percent in energy intensity; and
- 23.8 percent in energy derived $CO_2$ emissions.

Based on the key findings, this study also quantifies the power generation investment needed for the EAS region for both BAU and APS. It shows that the investment requirement for power generation for the total EAS countries will be around US$3.8 trillion under the BAU to increase the generation capacity to meet the demand over the 2013–2040 period. Most of the investment (41 percent) under the BAU will be for additional coal power plants, assumed to be mainly supercritical plants. Investment for additional nuclear power plants will be around 19 percent and 34 percent for NRE plants.

In the APS, although electricity demand is lower due to the implementation of efficiency measures, the estimated investment will be larger (US$4 trillion), mainly because of the increased share of renewable imposed under the APS in addition to the EEC measures. The largest share of total investment will be for additional capacity of NRE plants such as hydro, geothermal, solar PV, wind, and biomass, projected to account for about 54 percent. The investment share for additional capacity of nuclear power plants will also be high, at 31 percent. Investment for additional coal power plants will account for only 12 percent and the remaining 3 percent will be that of gas combined cycle plants.

## 5.2. 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.

1) ***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 2040. There are several EEC action plans to be implemented, which include building design and replacement of existing facilities and equipment with more efficient ones. Those policies are listed by areas/sectors:
   - The building sector would need both passive and active design policies such as:
     - Building codes and rewards for green building will need to be set up and enforced by law.
     - Governments need to provide financial support to implement building energy efficiency measures for both new buildings and existing buildings (retrofit).
     - Governments need to establish funds such as the Energy Service Company. There are ways to raise funds such as levies on petroleum.
     - A good and practical green building business model will need to be explored and established meet to the context and situation.
     - Energy building codes will need to be implemented, and designated large consumers for energy audit and applied green building need to be chosen. For example, some public buildings in Indonesia have targets of 10 percent electricity saving, and the government established energy building awards to promote the energy efficiency activity in public and commercial building sector.

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

- The road transport sector will need to consider measures to reduce energy consumption per unit of transport activities such as:
  - Improve fuel economy;
  - Shift from personal to mass transportation mode;

  - Shift to more efficient technologies such as hybrid vehicles and clean alternative fuels;
- Other sectors will need to consider measures to improve energy efficiency such as:
  - 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.

2) ***Renewable energy policies:*** There is a need to shift from fossil to non-fossil fuels. This could be attained by increasing the share of NRE as well as nuclear energy in the energy mix of each country. Several policies and actions will need to be considered:

- Renewable technologies are not as competitive as thermal power generation technologies using fossil fuel. Supportive renewable energy 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.
- The intermittent nature of renewable energy sources poses significant challenges in integrating renewable energy generation with existing electricity grids. Thus, government investment in electricity storage technologies, especially for solar and wind power, will be very important.

3) ***Technology development policies:*** To curb the increasing $CO_2$ emissions, environmental technologies will need to be considered:

- The development of carbon capture and storage (CCS) technology will be very important in controlling the release of greenhouse gases into the atmosphere. Continued research and development (R&D) will be important to ensure the future economic viability of deploying CCS technology.

- Hydrogen fuel could be extracted during the process of fossil fuel combustion, and thus make thermal efficiency very high (for the power plant, it is IGFC – Integrated Gasification Fuel-cell). Hydrogen fuel development is very promising and could be commercialised in the future. Continued R&D in fuel cells will be important for future clean fuel utilisation.
- There needs to be a carbon market to speed up environmental technology development. Hence, development of clean coal technology (CCT) will need to be accelerated in the ASEAN region with the help of attractive financial frameworks, lowering the borrowing costs of long-term loans.
- Technological cooperation and technology diffusion will be need to be accelerated in the ASEAN region.

4) ***Energy supply security policies:*** The region is largely depending on imported oil and gas. Thus, measures to secure the supply of energy will be very important for the region. Several measures are identified:

- Promote regional energy cooperation such as the trans-ASEAN gas pipeline and the ASEAN Power Grid;
- Diversify sources of import;
- Strengthen energy infrastructure including the construction of receiving LNG terminals and re-gasification plants;
- To have an optimal energy mix (the share of energy supply from various sources), especially increasing the share of renewable energy;
- For the oil and gas producing countries, the management of and policies for up-stream activity such as oil and gas exploration and down-stream activity such as oil and gas end-use regulation will be essential;
- ASEAN may need to look into the strategic reserve or stock piling requirement in the near future under the ASEAN Petroleum Security Agreement to support the ASEAN countries in case of events such as oil supply shocks or disruptions.

## 5.3. Recommendations

According to this energy outlook study, energy consumption in the EAS region will increase rapidly due to stable economic and population growth, and will continue to depend largely on fossil fuel energy, such as coal, oil, and gas up until 2040 (BAU). But if EAS countries dedicate themselves to implementing their EEC policies and increase low-carbon energy technologies such as nuclear power generation and solar PV/wind (APS), the EAS region could achieve remarkable energy savings in the APS, especially through fossil fuel savings compared with BAU, and significantly reduce carbon dioxide emissions. It is essential, therefore, that EAS countries implement their EEC and renewable energy policies (energy saving targets and action plans) in accordance with their respective timetables.

This energy outlook study also shows that a lot of energy savings, especially on oil and electricity consumption by final users, will come from energy efficiency activities. So the EEC policies (specified by energy saving targets and action plans) of EAS countries, which will be applied across sectors – industry, transport, residential, and commercial – should be appropriate and feasible. Government support for the activities of energy efficiency and conservation service companies is also essential.

Increasing the share of renewable energy such as hydro, geothermal, solar PV, wind, and biomass will contribute to a reduction in fossil fuel consumption and mitigate carbon dioxide emissions. It will require appropriate government policies such as renewable targets, legal approaches such as FIT/RPS, and revised FIT to include bidding and tendering processes.

Energy supply security in the EAS region is a top priority energy issue. EEC and renewable energy contribute to maintain regional energy security through reducing fossil fuel consumption and increasing the use of domestic energy. Moreover, energy supply sources can be diversified through regional energy networks such as the Trans-ASEAN Gas Pipeline and the ASEAN Power Grid, LNG receiving terminals, and oil stockpiling through the ASEAN Petroleum Security

Agreement. And nuclear power generation is another option to maintain energy supply security in the region.

According to the Energy Outlook's results, as coal power generation will be still dominant in the EAS region in 2040, greater use of clean coal technology (CCT) and development of carbon capture storage (CCS) technology is critical because as it will make coal power plants in the region carbon free. Hydrogen technology also has a key role as an alternative to use of fossil fuels, as it can be applied across sectors such as the power generation, industrial, and residential sectors.

This Energy Outlook study has started to estimate the necessary investment cost for the power generation sector. The indication is that the EAS region will need around US$4 trillion for the construction of power plants. ASEAN will need US$600 billion, the '+6' countries US$3.4 trillion for power generation facilities. But the share of investment cost by type of power plant is quite different between the BAU and the APS. In the BAU, a lot of money will be allocated to coal power plants (CCT), whereas under the APS more money will be allocated to renewable energy electricity, such as hydro and solar PV/wind in ASEAN and renewable energy electricity and nuclear power plants in the +6 countries. If EAS countries could achieve their existing renewable energy policies (APS), they would be able to allocate significant funds for developing nuclear, hydro, and solar PV/wind power plants.

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# Chapter 3

## Brunei Darussalam Country Report

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Chapter 3

# Brunei Darussalam Country Report

ENERGY AND INDUSTRY DEPARTMENT, PRIME MINISTER'S OFFICE,
BRUNEI DARUSSALAM

## 1. Background

Brunei Darussalam is located on the north-west coast of Borneo Island in Southeast Asia. The country's proximity to the South China Sea provides it with access to one of the important trade corridors in the world.

The total area of Brunei is 5,765 square kilometres and the country is divided into four administrative districts, namely Brunei–Muara, Belait, Tutong, and Temburong. Its capital city is Bandar Seri Begawan, located in the Brunei–Muara District.

Brunei is an economy with great economic potential. Its gross domestic product (GDP) in 2013 was around US$10 billion at 2005 constant prices. With a population of 406,200, Brunei's GDP per capita was almost US$25,000 at 2005 constant prices. About 60 percent of Brunei's GDP is generated by the energy sector, reflecting the huge contribution of this sector to the country's economy. The energy sector also dominates the country's export values, with crude oil, liquefied natural gas (LNG), and methanol exports accounting for over 90 percent of its total exports. The main export destinations for these commodities are India (crude oil), Japan (LNG), and China (methanol).

To lead Brunei's economy into a sustainable future, Brunei's Energy White Paper (EWP), launched in March 2014, set-out three strategic goals. Strategic Goal 1 is to strengthen and to grow oil and gas upstream and downstream activities; Strategic Goal 2 is to ensure safe, secure, reliable, and efficient supply and use of energy; and Strategic Goal 3 is to maximise economic spin-off from the energy industry.

## 2. Energy Supply and Consumption in 2013

Oil and natural gas remain the main primary sources of energy for Brunei. In 2013, total primary energy supply (TPES) for both energy sources was 2.87 Mtoe, with 2.17 Mtoe or 75.7 percent for domestic gas consumption. The 2013 TPES was 3.39 Mtoe lower than in 2012, mainly due to a drop in oil and natural gas production in 2013. As an oil and LNG exporter, Brunei exported 85.4 percent of its oil and natural gas (as LNG) produced in 2013.

Public utilities in Brunei have an installed power generation capacity of 806.2 MW including solar photovoltaic at 1.2 MW. Electricity production by the public utilities was 3.9 TWh in 2013. In the same year, installed capacity of auto producers was 110.4 MW; they produced 0.40 TWh of electricity, an increase of 0.05 TWh from 2012, which is related to an increase of electricity demand from the oil and gas industry.

Brunei's total final energy consumption (TFEC) in 2013 amounted to 0.92 Mtoe, a decrease of 0.97 Mtoe from 2012, mainly due to a decline in final energy consumption in the industrial sector from 0.22 Mtoe in 2012 to 0.17 Mtoe in 2013. The transport sector was the highest energy user in 2013, at 0.45 Mtoe or 48.4 percent of the TFEC. This was followed by the 'others' sector (Commercial and Residential) at 0.29 Mtoe (31.8 percent), the Industrial Sector at 0.17 Mtoe (18.3 percent), and Non-Energy use at 0.01 Mtoe (1.5 percent). In terms of energy sources, oil products consumption consisted mainly of gasoline, diesel, kerosene, and LPG at 0.63 Mtoe, which accounted for 68.3 percent of final energy consumption. This was followed by electricity at 0.27 Mtoe (29.4 percent) and town gas at 0.02 Mtoe (2.3 percent).

**Table 3-1. Energy Supply and Consumption 2013 (Mtoe)**

| Supply and Consumption | Oil | Gas | Electricity | Total |
|---|---|---|---|---|
| **Primary Energy Supplies** | | | | |
| Indigenous Production | 8.01 | 10.45 | - | 18.46 |
| Net Import and Others | -7.31 | -8.28 | - | -15.59 |
| **Total Primary Energy Supply** | **0.70** | **2.17** | **-** | **2.87** |
| | | | | |
| **Final Energy Consumption** | | | | |
| Industrial Sector | 0.15 | - | 0.02 | 0.17 |
| Transport Sector | 0.45 | - | - | 0.45 |
| Others Sector[1] | 0.02 | 0.02 | 0.25 | 0.29 |
| Non-Energy | 0.01 | - | - | 0.01 |
| **Total Final Energy Consumption** | **0.63** | **0.02** | **0.27** | **0.92** |

Mtoe = million tons of oil equivalent.
Note: Heating Values conversion factor of for natural gas: 1 TJ = 0.02388 Ktoe is based on IEA conversion factors.
Source: IEA and IEEJ, 2016.

## 3. Energy Policies

### 3.1. Supply

Brunei has an aspiration to boost upstream production by maximising the potential of its matured fields and venturing into further exploration and development activities. On the exploration side, in order to ensure the sustainability of crude oil and natural gas production in the country, an increase in the seismic data acquisition activities in Brunei over the last few years has contributed to a high number of exploration successes. In addition, other upstream projects such as secondary and tertiary recovery from existing fields

[1] Others sector includes Residential and Commercial.

have been implemented to increase the recovery from these matured fields and increase in the country's reserve as well as improve the productivity of Brunei's production. However, the country's crude oil and natural gas production in 2013 declined to 372 KBOE per day from 403 KBOE per day in 2012 due to continuous efforts in maintenance activities to address asset integrity issues. The positive impact from asset maintenance activities should become apparent in the coming years

In line with the national vision set out in Wawasan Brunei 2035, Brunei is working further in downstream by maximising the added value creation potential from upstream production and assets. In addition to the Methanol plant, which has been in operation since 2010, preparation for several downstream projects such as export oriented refinery and gas petrochemical projects has progressed. These are expected to be commercially on-stream by 2019.

As for renewable energy, Brunei targets to increase its share of the power generation mix from renewable energy to at least 10 percent by 2035. Brunei has started to develop renewable energy resources, particularly solar photovoltaic (PV) and waste-to-energy which are deemed feasible at this stage. To support the development of renewable energy sources, the government plans to introduce renewable energy policy and regulatory frameworks that will stimulate investment both by the government and the private sector in developing and deploying renewable energy.

### 3.2. Consumption

Brunei has made much progress in terms of improving energy efficiency and conservation (EEC) with its aims of a 45 percent energy intensity reduction by 2035. In achieving the energy intensity target, relevant government agencies and industry have been collaborating to draw up the appropriate legislation and to introduce financial and fiscal policy measures that promote energy efficiency and low-energy intensive industries.

One initiative was electricity tariff reform, which was implemented on 1 January 2012. The main objective of this reform is to move from a regressive to a progressive tariff structure. Its implementation has shown a positive result, particularly in the residential sector where electricity consumption in 2013 increased by only 0.2 percent, compared with its natural growth of 4 percent per year.

On the power generation side, the government's aspiration is to improve power generation efficiency to over 45 percent by 2020. The simple cycle power plant will be replaced with a more efficient combined-cycle or co-generation plant (CHP plant) and a structured maintenance programme will be put in place.

## 4. Outlook Result

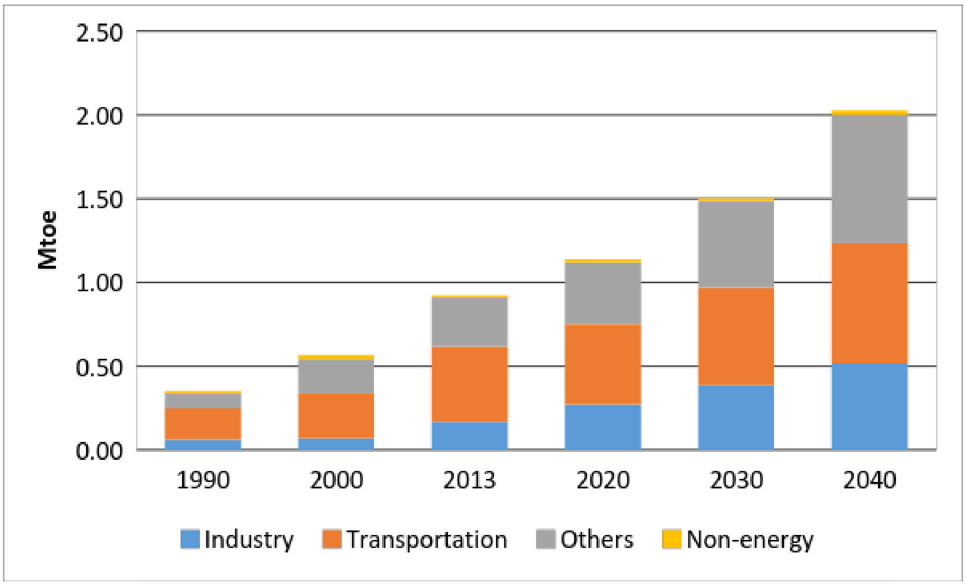
### 4.1. Final Energy Consumption

#### *Business-as-Usual scenario (BAU)*

Brunei's TFEC has increased over the years due to the country's continued overall economic growth – it rose from 0.35 million tons of oil equivalent (Mtoe) in 1990 to 0.92 Mtoe in 2013. Under the Business-as-Usual scenario (BAU), the projected average annual increase in TFEC from 2013 to 2040 is 3.0 percent, from 0.92 Mtoe to 2.02 Mtoe in 2040. This projected increase in TFEC is linked to a projected constant annual GDP growth rate of 3.4 percent over the projection period. The projected GDP growth rate is supported by the country's aspiration to strengthen its economic structure by developing its commercial and services sectors and industrial sector. But the highest rate of increase in energy consumption by sector from the model will come from the industrial sector, which is expected to grow at 4.2 percent per year. Energy consumption of the 'others' sector, covering mainly the residential and commercial sectors, is estimated to increase by 3.6 percent per year. This is driven by annual projected population growth of 1.7 percent from 2013 to 2040 and an increase in the economic activities of the commercial sector. Energy consumption of the transport sector and the non-energy sector is estimated to grow by 1.8 percent each.

In 2040, the share of oil in the country's total energy demand is forecast to be 59.7 percent, mainly to be consumed as transportation fuel. TFEC of oil in 2013 accounted for the largest share in total demand at 68.3 percent. In 2013, TFEC of oil was 0.63 Mtoe and it is projected to increase to 1.21 Mtoe in 2040. The model also predicted that demand for electricity will increase at an average annual rate of 4.0 percent, from 0.29 Mtoe in 2013 to 0.77 Mtoe in 2040.

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



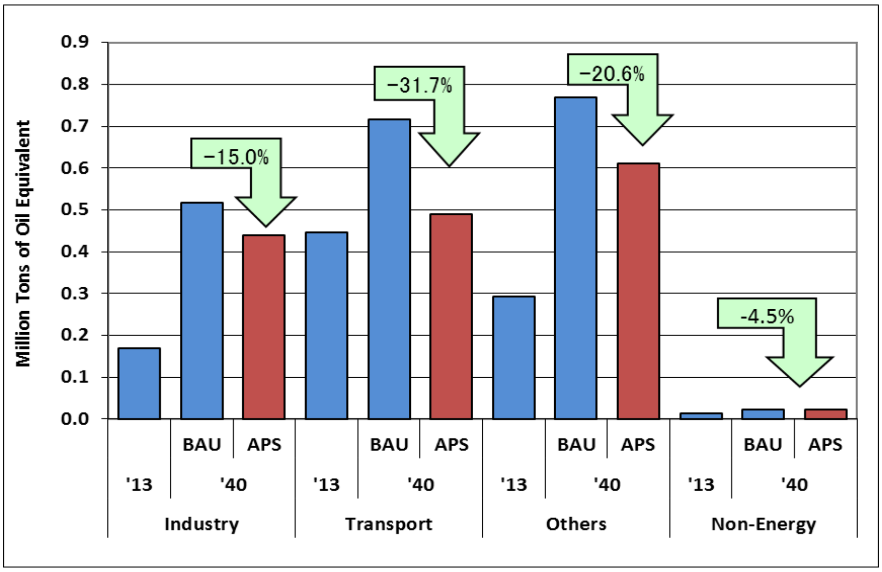

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### *Alternative Policy Scenario (APS)*

An Alternative Policy Scenario (APS) was developed with the aim of achieving the energy intensity reduction targets through the deployment of advanced technologies for energy saving and the enforcement of relevant initiatives. It is used as a basis to estimate the energy saving potential for Brunei. Under the APS, the overall TFEC in 2040 will be 1.56 Mtoe. In 2040, about 39.1 percent of total energy demand will be from the 'others' sector, followed by the transportation sector at 31.4 percent and the industry sector at 28.1 percent. Non-energy sector demand will make up 1.4 percent.

The expected improvement in vehicle fuel efficiency as a result of the proposed fuel economy regulations would be the main factor for the declining demand growth rate in the transportation sector. TFEC is projected to grow at an annual average rate of 2 percent from 2013 to 2040. Based on the result of the Long-range Energy Alternatives Planning (LEAP) model for energy outlook, the TFEC under the APS will be 23 percent lower than that of the BAU. The transportation sector will contribute a large part of the reduction in 2040 by 31.7 percent, followed by the 'others' sector, the industrial sector, and the non-energy sector at 20.6 percent, 15.0 percent, and 4.5 percent, respectively.

**Figure 3-2. Final Energy Consumption by Sector, BAU and APS**




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

## 4.2. Primary Energy Supply

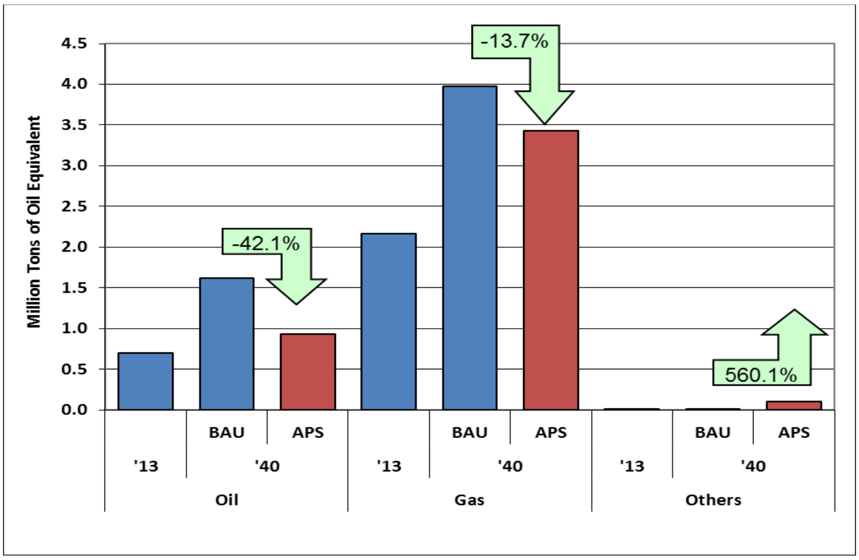
### *Business-As-Usual Scenario*

Under the BAU, TPES of Brunei is projected to reach 5.61 Mtoe in 2040, which represents an annual average increase of 2.5 percent from 2.87 Mtoe in 2013. TPES of Brunei in 2013 was dominated by natural gas, at 75.7 percent, with oil accounting for 24.3 percent.

TPES for oil is expected to grow at an annual average rate of 3.2 percent, from 0.70 Mtoe in 2013 to 1.62 Mtoe in 2040, while natural gas is expected to increase at 2.3 percent per year from 2.17 Mtoe to 3.98 Mtoe during the projection period.

Supply from renewable energy from solar and municipal waste-to-energy plants, will reach 0.02 Mtoe or 0.03 percent of TPES in 2040.

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




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

***Alternative Policy Scenario***

A significant decrease in TPES for oil and natural gas is projected between the BAU and the APS in 2040. In 2040, the oil supply under APS will be 0.94 Mtoe against 1.62 Mtoe for the BAU, or 42.1 percent lower. The natural gas supply under the APS is also predicted to be 13.7 percent lower than under the BAU. But there is a significant increase in supply from renewable energy, particularly from solar and waste-to-energy sources, as shown in Figure 3.

## 4.3. Power Generation

In Brunei, power generation capacity from public utilities is dominated by natural gas. From 806.2 MW of installed capacity (including 1.2 MW Solar PV), only 12 MW is contributed by diesel. In addition to the public utilities capacity, the auto producers’ capacity in 2013 was 110.4 MW. Based on the model projection under the BAU, about 10.47 TWh of electricity will be generated in 2040 from both public utilities and auto producers, including from renewable energy of 0.05 TWh.

This represents an average annual increase of 3.7 percent. Under the APS, electricity generation is projected to increase by 2.9 percent per year, reaching 8.46 TWh in 2040, which includes renewable energy, at 0.9 TWh. Total power generation under the APS will be 2.01 TWh or 19.2 percent lower compared with the BAU.

## 4.4. Projected Energy Saving[2]

The energy saving potential that could be achieved through the implementation of legislative measures on EEC, as well as the development of renewable energy in Brunei, is about 1.14 Mtoe of TPES or equivalent to a reduction of 20.3 percent from the BAU in 2040.

## 4.5. Carbon Dioxide ($CO_2$) Emission

***Business-As-Usual***

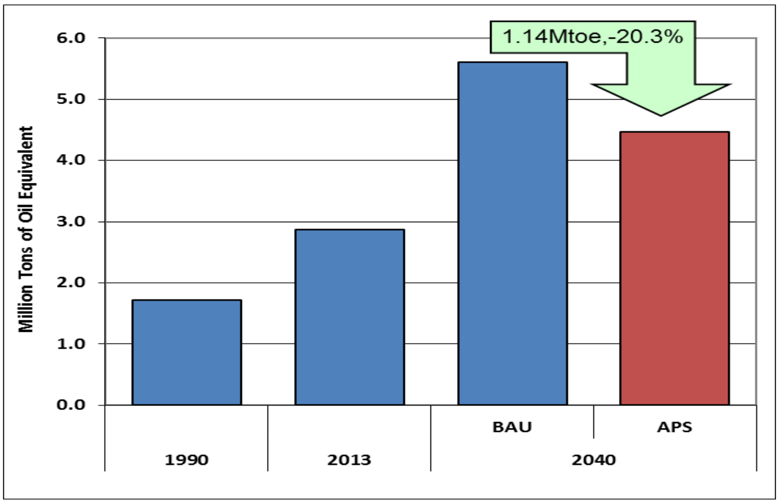
The percentage increase in the $CO_2$ emission correlates to the increase in TPES. This is expected because the energy mix for Brunei is 99 percent dependent on fossil fuels. The $CO_2$ emission in 2013 was 1.9 Mt-C. An increase of 2.5 percent per year is expected with an eventual value of 3.7 Mt-C in 2040.

***Alternative Policy Scenario***

In the APS, $CO_2$ emission could decrease by 20.5 percent in 2040 compared with the BAU. The result of the model shows that a total of 2.9 Mt-C will be emitted by 2040. The decrease in $CO_2$ emission is attributed to the lower oil consumption, particularly in power generation plants.

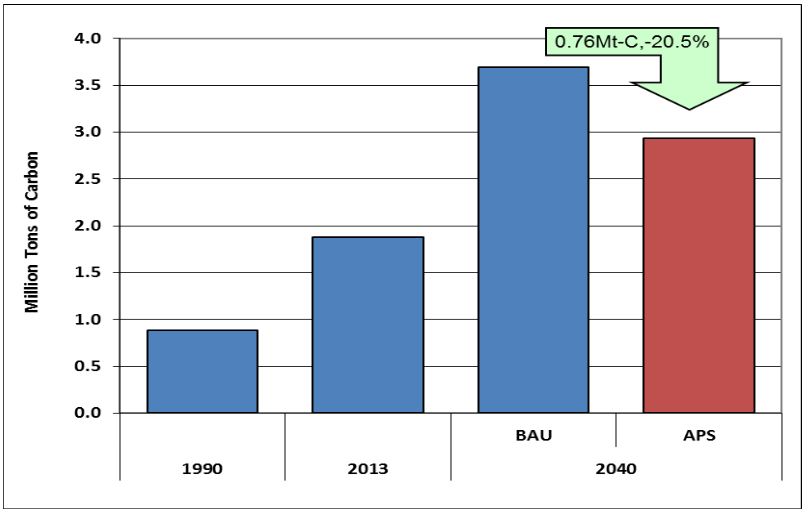
[2] The difference between primary energy supply in the BAU and the APS.

**Figure 3-4. Reduction of Primary Energy Supply, BAU and APS**




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

**Figure 3-5. $CO_2$ Emission from Energy Consumption, BAU and APS**




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

## 5. Findings and Policy Implications

### 5.1. Findings

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

The result of the model used by this study shows the improvement in energy efficiency, when coupled with the implementation of appropriate legislative measures and development of renewable energy, contributing to a reduction in both TPES and TFEC at 20.3 percent and 22.7 percent, respectively. The model also shows that the improvement in energy efficiency will help to reduce $CO_2$ emission by 20.5 percent.

### 5.2. Policy Implications

The projected increase in TPES and TFEC requires Brunei to undertake concerted efforts and close coordination among relevant stakeholders such as those of the government agencies, industries, and also individuals, to continuously promote EEC as well as achieve renewable energy development. Despite its aspiration to increase oil and natural gas production by 2035, Brunei acknowledges the importance of the national aspiration to reduce TPES by 63 percent by 2035 from the BAU. The primary energy supply reduction is focused on fossil fuel supplies for inland use, such as fossil fuel for power generation.

These aspirations generate the following policy implications for Brunei:

1. Energy Efficiency and Conservation

   - Brunei should continue to strengthen its efforts to promote standards and labelling for products and appliances, raising awareness of EEC, as well as implementing EEC Building Guidelines for Non-residential buildings. At the same time, Brunei also needs to continue its efforts to ensure the implementation of fuel economy regulation and the development of relevant financial incentives to promote EEC.

2. Renewable Energy

   - Brunei's government is planning to utilise a waste-to-energy facility. This facility is expected to have an installed capacity of up to 10 MW. Whether other alternative energy sources such as wind power, hydro power, and ocean are economically and technically feasible in the medium term and the long term is still being researched. These initiatives are supporting the government's aspiration of generating at least 10 percent of the total power generation mix from renewable resources by 2035.

- In this regard, the country should prioritise its efforts to introduce renewable energy policy and regulatory frameworks and market deployment of solar PV and waste-to-energy technology by means of exploring policy incentives such as Feed-in Tariff and Net-Energy metering.

3. Energy Security

- For domestic consumption of petroleum products, the current refinery has a capacity of 12,000 barrels per day for its crude distillation unit and 6,000 barrels per day for its reformer unit. Based on the current domestic demand, it can only meet about 60 percent of total demand. The balance is met by imported products. Domestic supply of natural gas for power plants has been stable at around 3.3 million $m^3$ per day in the last several years. With regard to power efficiency improvement, Brunei should continue with its efforts to improve power efficiency with the aim of all power generation reaching an efficiency of at least 45 percent by 2020.

- To support future energy security, Brunei should continue to strengthen upstream in order to meet the country's production target.

4. Technology Development to support EEC and Renewable Energy

- Brunei should continue to support research, development, and demonstration activities as well as promote technology transfer on EEC and renewable energy. This includes continuing to work with the Brunei National Energy Research Institute (BNERI) on sustainable energy policies and research, increase collaboration with local institutions such as Universiti Brunei Darussalam and Universiti Teknologi Brunei, and enhance the international partnership on promoting sustainable energy.

# Chapter 4

## Cambodia Country Report

September 2016

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Chapter 4

# Cambodia Country Report

**CHIPHONG SARASY**, DEPARTMENT OF NEW AND RENEWABLE ENERGY
MINISTRY OF MINES AND ENERGY, CAMBODIA

## 1. Background

The Kingdom of Cambodia is located in the Lower Mekong region of Southeast Asia. It has an area of 181,035 km$^2$, an 800 km border with Thailand in the west, 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. There are about 2.5 million hectares of arable land and over 0.5 million hectares of pastureland.

Real gross domestic product (GDP) in 2013 was US$10.7 million, comprising agriculture (24.2 percent); manufacturing (22.4 percent); electricity, gas, and water (0.6 percent); commerce including hotels and restaurants (14.2 percent); transport and telecommunications (6.4 percent); construction industry (5.8 percent); financial operations (8.1 percent); and 'others' (18.3 percent). The Cambodian economy maintained high economic growth exceeding an annual average 10 percent from 2004 to 2007. Although the economic growth rate in 2009 fell to 0.1 percent due to the impact of the global economic crisis, it recovered to 6.0 percent in 2010. The economic growth rates in 2011, 2012, and 2013 were 7.1 percent, 7.3 percent, and 7.2 percent, respectively. In short, steady GDP growth rates were maintained except in 2009. Growth is forecast by the Ministry of Economy and Finance to be maintained at around 7 percent per year.

Based on the 2008 Population Census of Cambodia, the population was 13,388,910 in 2008, 56 percent of which was under 24 years old. Cambodia's population in 2013 was 15.1 million. The continuing inflow of population into urban areas could make up more than 15 percent of the national population in future. Population density is about 75 people per square kilometre and 85–90 percent still lives in rural areas. Phnom Penh Capital City has a population of about 2 million, and Siem Reap Province has about 100,000 people.

Cambodia’s power generation facility by fuels is shown in Table 4.1. Installed capacity of hydropower accounted for about 60 percent of the total. Energy generated from hydropower in 2013 was around two times as much as in 2012. Cambodia’s hydropower energy potential was estimated at 10,000 MW, 50 percent of which is in the Mekong mainstream, 40 percent in its tributaries, and 10 percent in the south-western coastal area outside the Mekong River Basin. Hydropower capacity of up to 4,931 MW will be developed by 2020. Coal-fired power generation will have a capacity of 380 MW by 2015.

**Table 4.1. Power Generation Facility, by Fuel**

| No. | Type of Generation | Installed Capacity [MW] | | Proportion in Percent for 2013 |
|---|---|---|---|---|
| | | 2012 | 2013 | |
| 1 | Hydro | 225 | 683 | 59.06 |
| 2 | Diesel/Heavy Fuel Oil | 321 | 325 | 28.17 |
| 3 | Biomass | 22.5 | 14.5 | 1.26 |
| 4 | Coal | 13.0 | 133 | 11.52 |
| **Total** | | 581.5 | 1,155.5 | 100 |

MW = megawatt.
Source: EAC report 2013.

Cambodia’s total primary energy supply (TPES) in 2013 stood at 6.82 million tons of oil equivalent (Mtoe), with renewable energy (mostly biomass) accounting for the largest share at approximately 60 percent, followed by oil at 36.6 percent, and coal at 0.7 percent.

Final energy consumption had increased to 6 Mtoe by 2013. It is dependent on imports of petroleum products as Cambodia has no crude oil production or oil refining facilities. Its electricity supply is dominated by hydro at 57.4 percent, with oil, coal, and biomass accounting for the rest.

## 2. Modelling Assumptions

### 2.1. GDP and Population

In forecasting energy demand to 2040, the GDP of Cambodia is assumed to grow at an annual average rate of 6.1 percent. With its population projected to grow by 1.6 percent per year, the forecast is for GDP per capita growth of 4.4 percent per year up to 2040.

### 2.2. Electricity Generation

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

### 2.3. Energy Efficiency and Conservation Policies

Cambodia's energy efficiency and conservation (EEC) 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 to competent organisations for testing and certification of energy-efficient products, and establishment of 'Green Learning Rooms' in selected schools to impart life-long education on the relevance of EEC.
- Improving energy efficiency in buildings and public facilities.
- Improving energy efficiency in industries in cooperation with the United Nations Industrial Development Organisation (UNIDO) and the Ministry of Industry, Mines and Energy (MIME) (now changed to Ministry of Mines and Energy, MME) to be implemented in the four sectors of rice milling, brick kilns, rubber refinery, and garment.

Cambodia is also preparing an action plan for EEC in cooperation with the Energy Efficiency Design sub-working group. Specific actions plans are being drafted for the industry, 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 scenario (BAU). These initial estimates were used in forecasting the energy demand in the Alternative Policy Scenario (APS).

In a close consultation process between the previous MIME and EUEI–PDF that started in July 2011, it was decided to launch a project to support the Royal Government of Cambodia 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 have been 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
5. Efficient use of biomass resources for residential and industrial purposes

## 3. Outlook Results

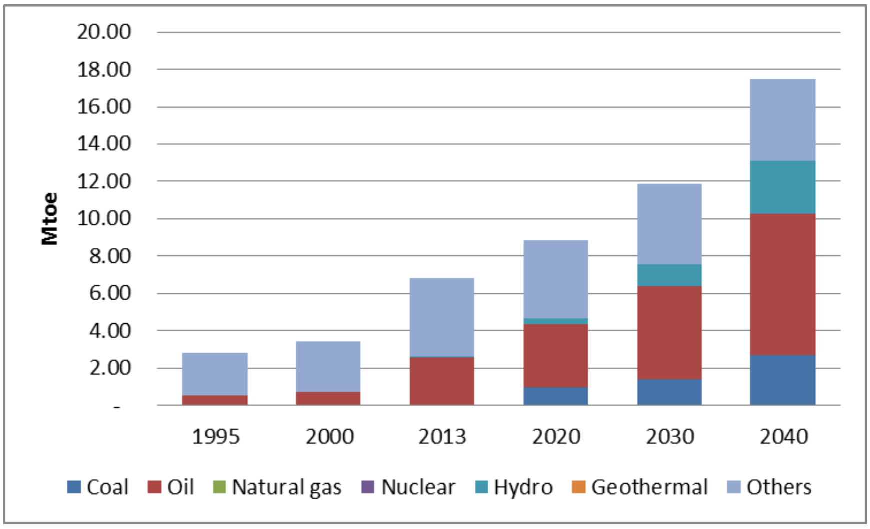
### 3.1. Business-as-Usual (BAU) Scenario

#### 3.1.1. Primary energy supply

Primary energy supply in Cambodia grew at 5 percent per year, which is a slightly faster rate than final energy consumption from 2.84 Mtoe in 1995 to 6.82 Mtoe in 2013. Among the major energy sources, the fastest growing was oil. Oil consumption grew at an average annual rate of 9.2 percent between 1995 and 2013 (see Figure 4-1).

In the BAU, Cambodia's primary energy supply/consumption is projected to increase at an annual average rate of 3.5 percent or by 2.56 times from 6.82 Mtoe in 2013 to 17.46 Mtoe in 2040. The fastest growth is expected in coal, increasing at an annual average rate 16.3 percent between 2013 and 2040, followed by hydro, oil, and others (including biomass) at 13.8 percent, 4.2 percent, and 0.2 percent, respectively. The share of hydro is projected to increase from 1.3 percent in 2013 to 16.3 percent in 2040. This growth in its share is due to the huge potential for water reservoirs in Cambodia. The share of oil is projected to increase from 36.6 percent in 2013 to 43.4 percent in 2040 due to the projected growth in the numbers of cars and motorbikes in the transportation sector.

**Figure 4-1. Primary Energy Supply by Source, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

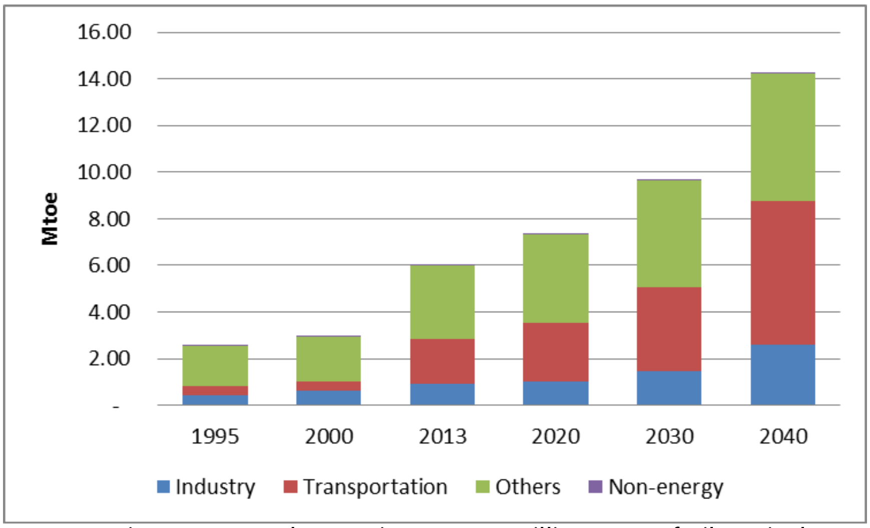
### 3.1.2. Final energy consumption

**By sector**

Cambodia's final energy consumption grew at an average annual rate of 4.9 percent, from 2.54 Mtoe in 1995 to 6.00 Mtoe in 2013.

In the BAU, driven by assumed strong economic growth and an increasing population, final energy consumption is projected to increase at an annual average rate of 3.3 percent or by almost 2.4 times, from 6.00 Mtoe in 2013 to 14.29 Mtoe in 2040 (Figure 4-2). The strongest growth in consumption is projected to occur in the transportation sector, which will increase at an annual average rate of 4.3 percent or by 3.15 times, from 1.95 Mtoe in 2013 to 6.15 Mtoe in 2040. The industry sector is projected to grow at an annual rate of 4.0 percent or by 2.87 times, from 0.9 Mtoe in 2013 to 2.59 Mtoe in 2040, followed by the non-energy sector and the 'others' sector at 3.3 percent (from 0.02 Mtoe in 2013 to 0.05 Mtoe in 2040) and 2.1 percent (from 3.13 Mtoe in 2013 to 5.51 Mtoe in 2040), respectively.

**Figure 4-2. Final Energy Consumption by Sector, BAU**

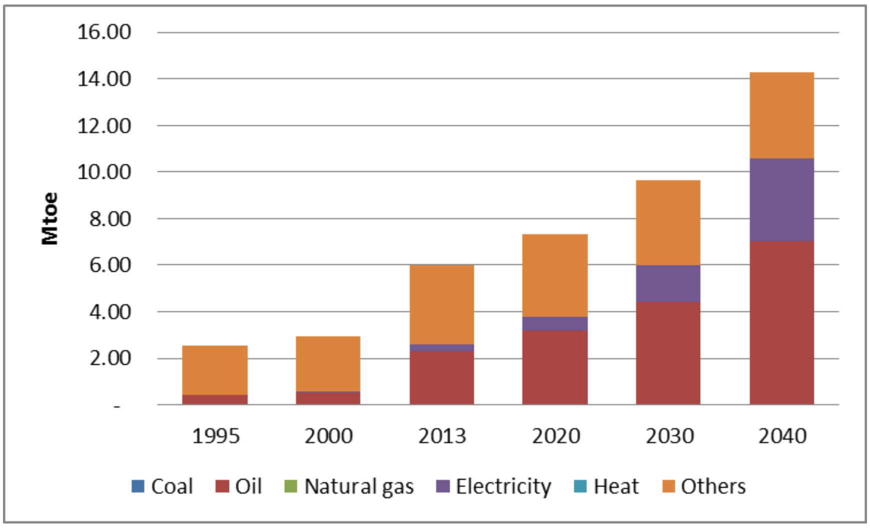



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

## By fuel

Electricity is projected to see the fastest growth in final energy consumption, increasing by 9.8 percent per year or by 12.61 times from 0.28 Mtoe in 2013 to 3.58 Mtoe in 2040. Oil is projected to show the second highest growth rate of 4.2 percent per year or by 3.06 times, from 2.29 Mtoe in 2013 to 7.02 Mtoe in 2040. Others, mainly solid and liquid biofuels, will increase at 0.3 percent per year from 3.42 Mtoe in 2013 to 3.69 Mtoe in 2040 (Figure 4-3).

**Figure 4-3. Final Energy Consumption by Fuel, BAU**



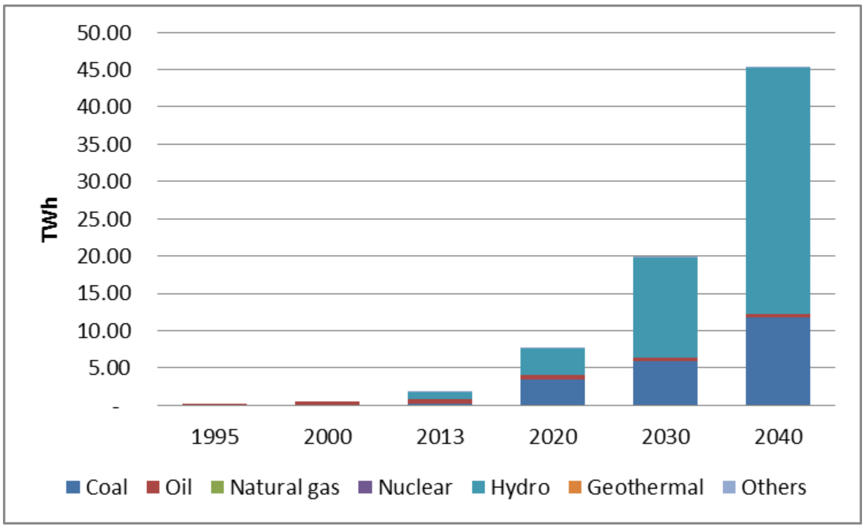

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.1.3. Electricity generation

Electricity generation increased at 12.9 percent per year from 0.20 TWh in 1995 to 1.77 TWh in 2013. From 1995 to 2001, 100 percent of electricity generated came from oil-fired power plants. In 2002, a hydro power plant started operation in Cambodia and by 2013 its share in the power generation mix had increased to 57.4 percent. Coal power generation was also introduced to Cambodia rather late in 2009. By 2013, the share of coal in the power generation mix had risen to 9.5 percent.

In the BAU, to meet the demand for electricity, power generation is projected to increase at an average annual rate of 12.8 percent between 2013 and 2040. The fastest growth in electricity generation will be in coal (17.0 percent per year), followed by hydro (13.8 percent per year), and 'others' (8.3 percent per year) (Figure 4-4). Generation from oil-fired power plants will decrease considerably due to high fuel cost.

**Figure 4-4. Power Generation by Fuel, BAU**



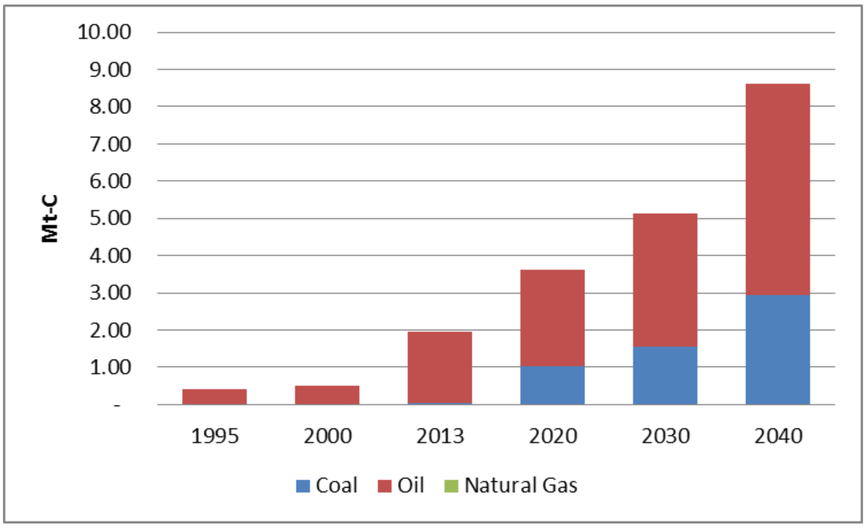

BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

### 3.1.4. Carbon Dioxide ($CO_2$) emissions

$CO_2$ emissions from energy consumption are projected to increase by 5.6 percent per year from 1.96 Mt-C in 2013 to 8.62 Mt-C in 2040 under the BAU.

Oil is the largest source of carbon emissions; it will increase from 1.91 Mt-C in 2013 to 5.69 Mt-C in 2040. Emission from coal is expected to have the fastest growth rate at 16.3 percent per year from 0.05 Mt-C in 2013 to 2.93 Mt-C in 2040 (Figure 4-5).

**Figure 4-5. $CO_2$ Emission from Energy Consumption, BAU**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; Mt-C = metric tons of carbon.
Source: Author's calculation.

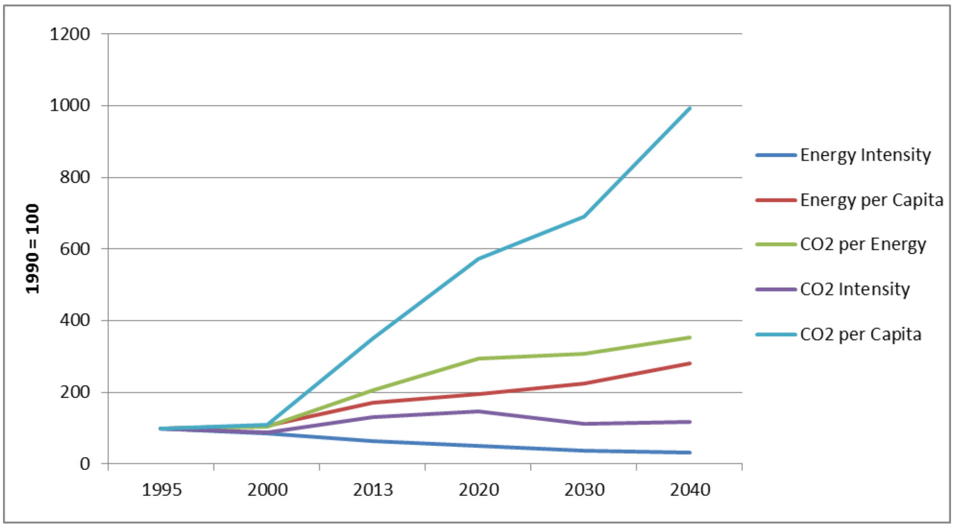
### 3.1.5. Energy indicators

Energy intensity had a decreasing trend from 1,002 toe/million US$ in 1995 to 636 toe/million US$ in 2013. In the BAU, energy intensity will further decrease to 331 toe/million US$ in 2040. This indicates that energy will be used more efficiently in economic development. This is mainly due to 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 0.27 toe/person in 1995 to 0.45 toe/person in 2013. In the BAU, energy per capita will further increase to 0.75

toe/person in 2040. This indicates that living standards of people are improving, resulting in increasing energy demand per capita. Figure 4-6 shows various indicators of energy consumption.

**Figure 4-6. Energy and $CO_2$ Indicators**




$CO_2$ = carbon dioxide.
Source: Author's calculation.

$CO_2$ per energy in the BAU case is projected to increase from 0.29 metric tons of carbon per toe (t-C/toe) in 2013 to 0.49 t-C/toe in 2040, implying faster growth of fossil fuels in total energy consumption.

But $CO_2$ intensity had been increasing from 140 t-C/million US$ in 1995 to 183 t-C/million US$ in 2013. It will drop further to 164 t-C/million US$ in 2040.

## 4. Scenario Analysis

### 4.1. Alternative Policy Scenario (APS)

The APS consists of scenarios such as the 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 of each scenario:

- APS1: focus on EEC on the demand side, such as:
  - Energy demand in all sectors to be reduced by 10 percent in 2015 and 20 percent by 2040 relative to the BAU.
  - Using efficient motorbikes and hybrid cars in road transport.
  - Replacing inefficient devices with efficient ones in commercial and residential sectors, for example for 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 percent until 2040, in the BAU. In the APS, it is assumed that new coal power plants will have thermal efficiencies of 38.8 percent.
- APS3: Additional 5,000 MW of hydro power plants by 2040 is assumed in this scenario.
- APS5 or APS: Combination of APS1 to APS3.

## 4.2. Energy Saving Potential and $CO_2$ Emissions Reduction

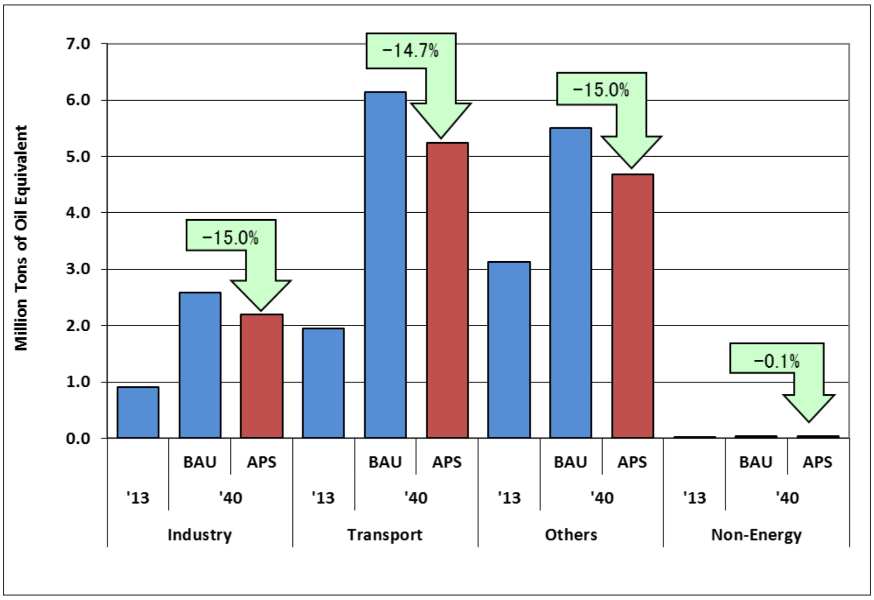
### 4.2.1. Final energy consumption

In the APS, final energy consumption is projected to increase at a slower rate of 2.7 percent (compared with 3.3 percent in the BAU), from 6.00 Mtoe in 2013 to 12.18 Mtoe in 2040 because of EEC measures (APS1) in industrial, transportation, residential, and commercial ('others') sectors.

Final energy consumption is expected to make savings amounting to 2.1 Mtoe. The bulk of the savings are expected to occur in the transportation sector (0.9 Mtoe), followed by the 'others' sector (0.8 Mtoe), and the industry sector (0.4 Mtoe).

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

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




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

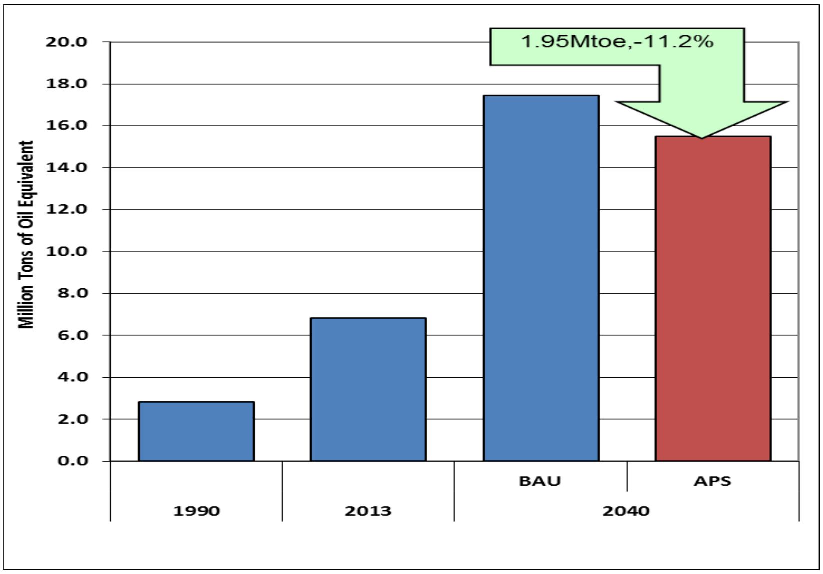
### 4.2.2. Primary energy supply

In the APS, primary energy supply/consumption is projected to increase at a slower rate of 3.1 percent per year from 6.82 Mtoe in 2013 to 15.51 Mtoe in 2040. The saving 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 of 17.0 percent compared with 16.3 percent in the BAU, followed by hydro with 12.4 percent, compared with 13.8 percent in the BAU, respectively, over the same period.

The total saving will be equal to 1.95 Mtoe, which is equivalent to 11.2 percent of Cambodia's primary energy supply in 2040 (Figure 4-8).

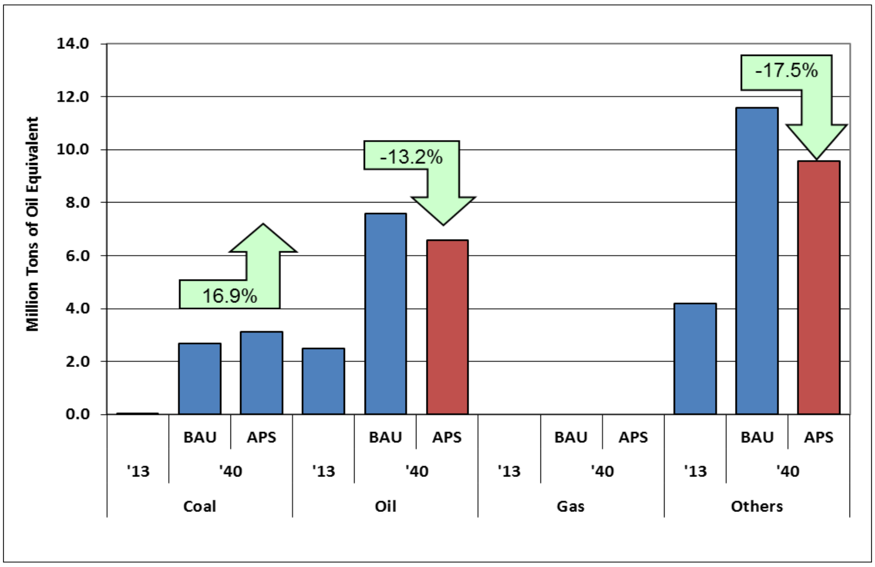
**Figure 4-8. Primary Energy Supply by Fuel, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

The reduction in consumption, relative to the BAU, comes from EEC measures on the demand side (APS1), more aggressive uptake of energy efficiency in thermal power plants (APS2), and adoption of renewable energy (APS3) on the supply side. Accordingly, the energy saving potential from other energy sources would be 17.5 percent, followed by oil at 13.2 percent. Coal is projected to increase by 16.9 percent (Figure 4-9).

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



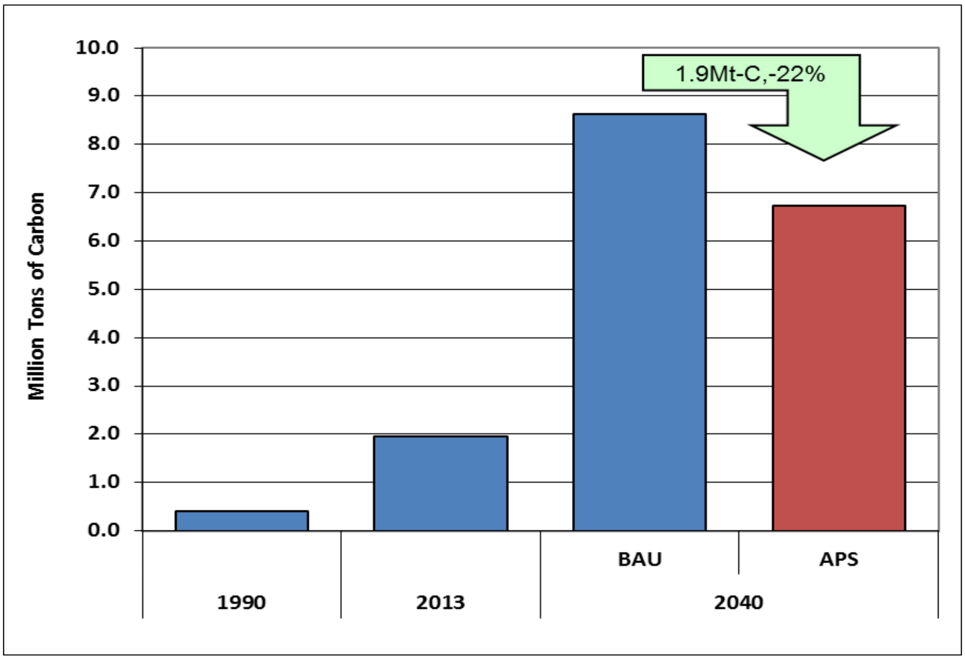

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

### 4.2.3. $CO_2$ Emissions

$CO_2$ emissions from energy consumption under the BAU are projected to increase by 5.6 percent per year from 1.96 million metric tons of carbon (Mt-C) in 2013 to 8.62 Mt-C in 2040. Under the APS, the annual increase in $CO_2$ emissions is projected to be 4.7 percent per year between 2013 and 2040, which represents a 22 percent reduction from 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 4-10. $CO_2$ Emission by Fuel, BAU and APS**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = metric tons of carbon.
Source: Author's calculation.

## 5. Key Findings and Policy Implications

The above analysis on energy saving potential produces the following 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 are estimated to have significant potential to help meet future demand in a sustainable manner.
- Cambodia's energy intensity will be further reduced due to efficient use of energy.
- The annual growth of energy demand in the transportation sector is projected to be the highest at 4.3 percent in the BAU and its share will increase continuously from 32.5 percent in 2013 to 43.0 percent in 2040. This shows that the transportation sector has large energy saving potential.
- Electricity demand is increasing at the highest annual growth rate of 9.3 percent in the BAU and growth is projected to be slightly lower at 9.2 percent in the APS.
- Coal thermal power plants will be the major power generation source in Cambodia in the coming years. Its share in total power generation output is projected to increase continuously from 9.5 percent in 2013 to 26.0 percent in 2040. This is also the area with the largest expected energy savings and greenhouse gas (GhG) mitigation potential in Cambodia.
- Hydropower plants will be the second major source of power generation in Cambodia in the coming years. Its share in total power generation output is projected to increase continuously from 57.4 percent in 2013 to 72.9 percent in 2040.

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

- Promotion of the establishment of targets and a road map for EEC implementation: The targets for EEC in Cambodia should be set for the short-, medium-, and long-term periods and focus on the buildings and industrial sectors. The long-term plan should be based on an assessment of the energy saving potential for all energy sectors, including the residential and commercial sectors, which have large energy saving potential up to 2040. Moreover, some activities could promote EEC in Cambodia, such as (i) support for the development of professionals in the energy conservation field to be responsible persons for energy management and operation, verification and monitoring, consultancy and engineering services provision, and the planning, supervision, and promotion of the implementation of energy conservation measures; (ii) support for the development of institutional capability of agencies/organisations in both the public and private sectors, responsible for the planning, supervision, and promotion of the implementation of energy conservation measures; (iii) support for the operation of energy savings companies to alleviate technical and financial risks of entrepreneurs wishing to implement energy conservation measures; and (iv) public relations and provision of knowledge about energy conservation to the general public, via the teaching/learning process in educational institutions, fostering youth awareness.

- Compulsory energy labelling for electrical appliances: Annual growth of electricity demand in residential and commercial ('other') sectors is projected to be substantial compared with other sectors. Compulsory energy labelling for electrical appliances could be an effective management measure to generate energy savings.
  - Priority for development of advanced hydro and coal thermal power technology: Hydro and coal thermal power plants will be the major power generators in Cambodia up to 2040. 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. It is necessary to draw up a strategy and construct mechanisms to support renewable energy development.

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# Chapter 5

## China Country Report

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Chapter 5

# 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 is studded with more than 5,000 islands. Due to its huge size, China's climate is obviously very diverse, ranging from an unbearable 48 °C in the northwest during summer to an equally unbearable -40 °C in the far north in winter.

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

### 1.1. Economy and Population

China's gross domestic product (GDP) in 2013 was around US$4,913 billion (in 2005 US$ terms), which translates into a per capita GDP of around US$3,610 (in 2005 US$ terms). China is currently the world's most populous country, with a population of about 1.37 billion in 2015.[1] To mitigate population growth, China

[1] China National Bureau of Statistics.

has implemented a family planning policy since the 1970s. However, in 2015, the 'one child' policy was discontinued and couples who satisfy certain conditions are now allowed to have two children. China has been experiencing a fast urbanisation process at an annual growth rate of approximately 1 percent since 1978 when China's reform and opening up started. At the end of 2015, around 56.1 percent of the population was living in urban areas.

## 1.2. Energy Situation

In terms of energy resources, China is endowed with coal, oil, and gas reserves and tremendous hydropower potential. China is the world's largest coal producer and has the third largest coal reserves, with recoverable reserves of 114.5 billion tons. In 2015, China produced 3.75 billion tons of raw coal. China is still a major crude oil producer, with output of 214.6 million tons of crude oil in 2015. However, driven by very fast increases in China's oil demand, China became an oil importer in the 1990s. In 2014, the amount of net imported oil reached 328 million tons with a growth rate of 6.4 percent and a dependence level of more than 60 percent. China is also a large producer and exporter of energy-intensive items. In 2015, it produced 1.12 billion tons of finished steel and 2.36 billion tons of cement, and exported 112 million tons 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, while the per capita average of both oil and natural gas reserves is only about one-fifteenth of the world average. The per-capita average of arable land is less than 30 percent of the world average, which hinders the development of biomass energy.

Since 1990, coal has dominated the primary energy supply, with 60.6 percent, while oil, natural gas, and hydro consumption accounted for 13.6 percent, 1.5 percent, and 1.3 percent, respectively. However, biomass consumption represented 23.0 percent, which is lower only than coal consumption. In 2013, coal was still a major fuel, with a higher share of about 67.7 percent. The share of other energy sources increased from 1990 levels to 15.8 percent for oil, 4.6 percent for gas, and 2.6 percent for hydro, but the share of biomass decreased to

7.1 percent. Primary energy supply in China increased at an average annual rate of around 5.6 percent from 870.7 Mtoe in 1990 to 3021.9 Mtoe in 2013. Energy intensity (primary energy supply per unit of GDP declined from 1,641 tons of oil equivalent per million US$ in 1990 to 615 tons of oil equivalent per million 2005 US$ in 2013.

Final energy consumption in China increased at a lower annual average rate of 4.5 percent from 664.2 Mtoe in 1990 to 1814.06 Mtoe in 2013. Coal accounted for 47.9 percent of final energy consumption in 1990 and 33.3 percent in 2013. In 1990, oil consumption accounted for 12.7 percent of final energy consumption and increased at a rapid annual average rate of 7.4 percent from 1990 to 2013, resulting in a significant increase in its share of final energy consumption, which reached 24.0 percent in 2013. Both electricity and natural gas consumption grew sharply at 10.5 percent per year and 10.8 percent per year, respectively, from 1990 to 2013, which resulted in increases in the shares of electricity and natural gas consumption from 5.9 percent and 1.3 percent in 1990 to 21.3 percent and 5.2 percent in 2013, respectively. In 2013, the share of electricity consumption had become nearly equal to that of oil consumption in final energy consumption.

Among the sectors, industry is the major energy consumer in China, followed by the residential and commercial ('others') sectors. The share of industry consumption increased from 36.7 percent in 1990 to 48.4 percent in 2013. Conversely, the share of energy consumption in 'others' declined from 51.8 percent in 1990 to 30.2 percent in 2013, because of relatively faster growth in the industry and transport sectors.

Power generation in China is mainly from coal-fired plants, with their electricity generation accounting for around 71.0 percent of the total amount in 1990. By 2013, this share had increased to 75.4 percent. The share of hydro was 20.4 percent in 1990, but had declined to 16.8 percent in 2013. Gas and oil, collectively, accounted for about 2.0 percent of total generation in 2013. The share of nuclear power increased to about 2.1 percent in 2013.

The government is pushing the development of a modern energy industry. It has adopted resource conservation and environmental protection as two basic state policies, giving prominence to building a resource-conserving and environment-friendly society as a key part 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 (IEEJ) and were taken from modelling of the Business-as-Usual scenario (BAU) and the Alternative Policy Scenario (APS).

China's population increased from 1.143 billion in 1990 to 1.361 billion in 2013 and it is projected to grow at an annual average rate of 0.2 percent from 2013 to 2040. The population will peak at 1.450 billion around 2030 and reach 1.428 billion people by 2040.

China's economy grew at an average annual rate of 10.2 percent from US$530.6 billion in 1990 to about US$4,913.0 billion in 2013 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.2 percent per year from 2013 to 2020 because of the 'new normal' stage of China's economy, by 5.1 percent per year from 2020 to 2030, and by 3.7 percent per year from 2030 to 2040. The average annual GDP growth rate from 2013 to 2040 is 4.9 percent. It is estimated to reach US$17,683.8 billion by 2040. Given the GDP and population assumptions, GDP per capita in China is assumed to increase from around US$3.61 thousand per capita (in 2005 US$ terms) in 2013 to US$12.4 thousand per capita (in 2005 US$ terms) in 2040.

### 2.2. Energy and Climate Change Policies and Their Performance

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

China's Outline of the 12th Five-Year Plan (2012–2015) for National Economic and Social Development stipulated that by 2015 energy consumption per unit of GDP would drop by 16 percent from 2010. To achieve this goal, the government implemented administrative measures, market-based measures, and legal measures to promote energy conservation. Energy intensity reduction goals were assigned to provincial governments and progress made was announced publicly every year. During the past five years (2011–2015), energy consumption grew at a rate of 3.6 percent and GDP increased at a rate of 7.8 percent. It resulted in a reduction of energy intensity of by 18.2 percent during the 5-year period, which achieves the target of 16 percent. Specifically, energy consumption per unit of GDP in 2015 decreased by 5.6 percent compared with 2014.

In addition to energy intensity targets, controlling the total amount of energy consumption is proposed. According to the Energy Development Strategic Action Plan (2014–2020), China's coal consumption (primary energy supply) would be controlled at an upper limit of 2,940 million tons of oil equivalent (Mtoe) in 2020 and the primary energy supply will be capped at 3,362 Mtoe in 2020. According to the 13th Five-Year Plan of Energy Development, which has not been issued officially, by 2020, the ratio of coal consumption to total energy consumption should be lowered to at most 60 percent and natural gas consumption should account for 10 percent of the total amount. In addition, the amount of new energy vehicles will reach 2 million.

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

China has also made great efforts to develop non-fossil fuel and the development of renewable energy has 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 a target of increasing the share of non-fossil energy to about 15 percent by 2020 (measured in coal-equivalent) and to about 20 percent in 2030. Subsidisation policies have also been developed to encourage development of wind power, solar photovoltaic, and biomass. In 2015, China invested US$102.9 billion in renewable energy, accounting for 36 percent of the world total. By the end of 2015, power generation capacity had reached 1,508 GW. Within this, the capacity of hydropower, which ranked first globally, reached 319 GW, increasing at a growth rate of 4.9 percent; the capacity of nuclear power plants was 26.08 GW; the on-grid wind power capacity, which was the largest in the world, amounted to 129.34 GW, increasing 33.5 percent year-on-year; on-grid solar power reached 43.18 GW, growing 73.7 percent from a year earlier. The installed electricity capacity of non-fossil fuel, including, hydro, nuclear, wind, and solar energies, in 2015 made up 34.3 percent of the total, 1.5 percent higher than in 2014. The electricity generated from non-fossil fuel accounted for 25.1 percent of total on-grid electricity in 2015. China's current installed capacity, under-construction capacity, and power generation of hydropower, the accumulative installed capacity of PV solar power, and the capacity of under-construction nuclear power all rank the first in the world, which has made a positive contribution to addressing the problem of global climate change.

After the evaluation in 2015, China phased out backward production capacity in the following industries: small thermal power units, 4.23 GW; cement, 50 million tons; and steel, 30 million tons. To reduce the surplus production capacity, from 2016, no new coal mine projects are to be approved for 3 years, and crude steel production capacity will be reduced by 100–150 million tons in 5 years.

In our 2015 scenario analyses, we have established five APS scenarios, APS1–5, and they are as follows: APS1 – energy efficiency and conservation (EEC) in final consumption sectors; APS2 – EEC in thermal efficiency in coal, oil, and gas fired power generations; APS3 – increase of hydro, geothermal, and non-renewable energy (NRE); APS4 – increase of nuclear; and APS5 – implement all of these scenarios, i.e. APS1 to APS4. If not specified otherwise, all results we present in this chapter under APS refer to APS5.

## 3. Outlook Results

### 3.1. Final Energy Consumption

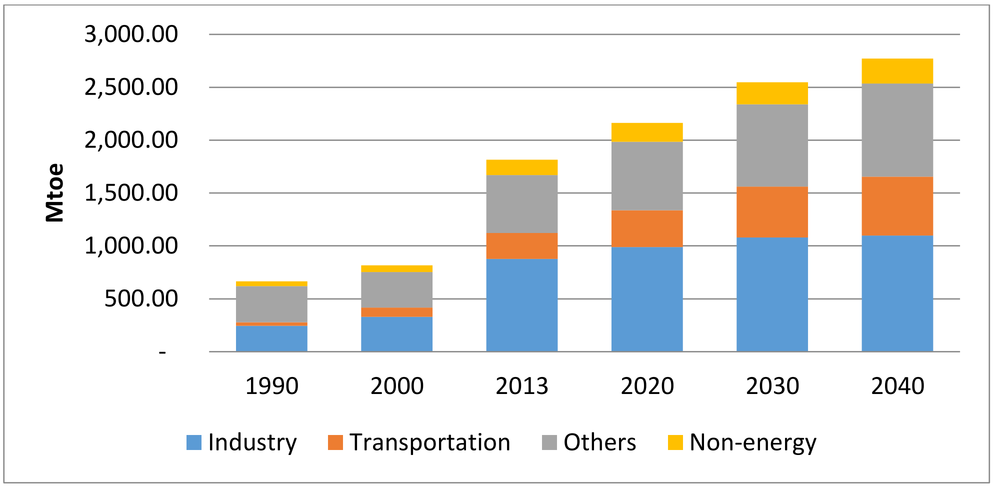
Between 2013 and 2040, growth in China's final energy consumption is projected to be slow, reflecting lower economic and population growth assumptions.

***Business-as-Usual (BAU) Scenario***

Final energy consumption is projected to increase at an average annual rate of 1.6 percent between 2013 and 2040. Transportation sector consumption is projected to grow the fastest, increasing by 3.1 percent a year, followed by the non-energy sector with 1.9 percent. Energy consumption in the industry sector is projected to grow at an average annual rate of 0.8 percent. Figure 5-1 shows China's final energy consumption by sector under the BAU.

Among energy sources, natural gas consumption in the BAU, which is projected to show the fastest growth, increases by 4.7 percent per year, from 93.79 Mtoe in 2013 to 325.73 Mtoe in 2040. Though coal will continue to account for a major portion of final energy consumption, it is projected to decrease by 0.5 percent per year, arriving at 528.24 Mtoe in 2040, compared with the increase of 2.8 percent per year over the last 2 decades.

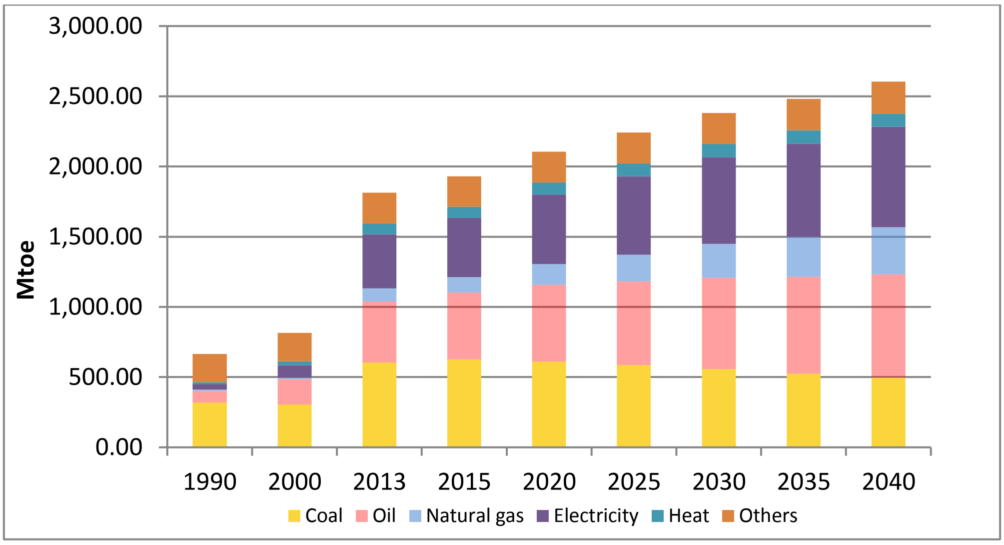
**Figure 5-1. Final Energy Consumption by Sector, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

Consumption of electricity and heat are projected to increase at an average annual rate of 2.6 percent and 1.1 percent, respectively, over the same period, achieving 774.48 Mtoe and 101.24 Mtoe in 2040. Oil is projected to grow by 2.4 percent annually to around 815.86 Mtoe in 2040. Figure 5-2 shows China's final energy consumption by fuel under the BAU.

**Figure 5-2. Final Energy Consumption by Fuel, BAU**

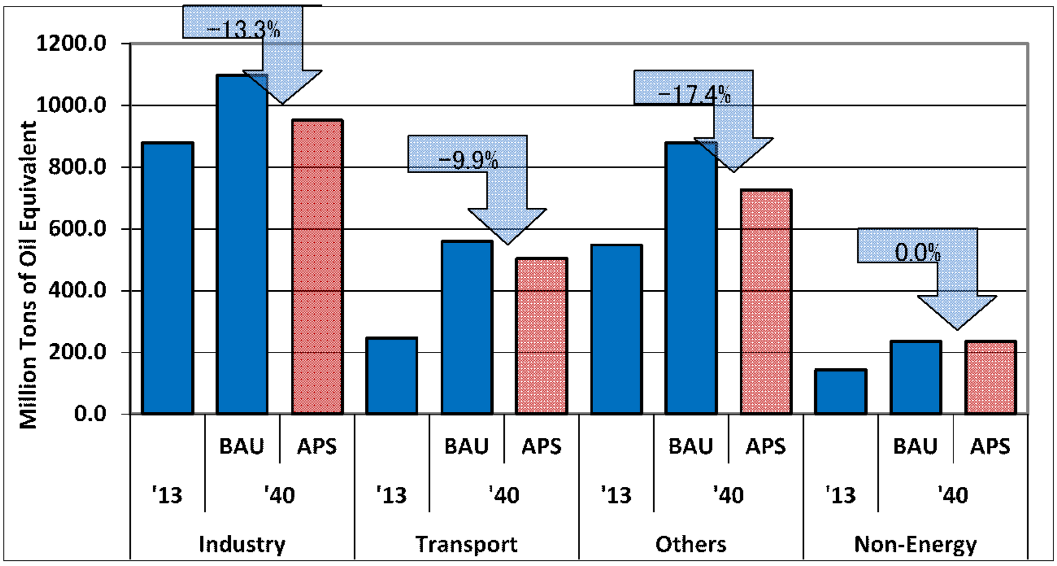



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

***Alternative Policy Scenario (APS)***

In the APS scenario, final energy consumption is projected to increase by 1.1 percent per year, from 1814.06 Mtoe in 2013 to 2416.64 Mtoe in 2040, as a result of EEC programmes. 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 5-3 shows the final energy consumption in China in 2013 and 2040 in both the BAU and the APS.

**Figure 5-3. Final Energy Consumption, BAU and APS**




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

## 3.2. Primary Energy Supply Consumption

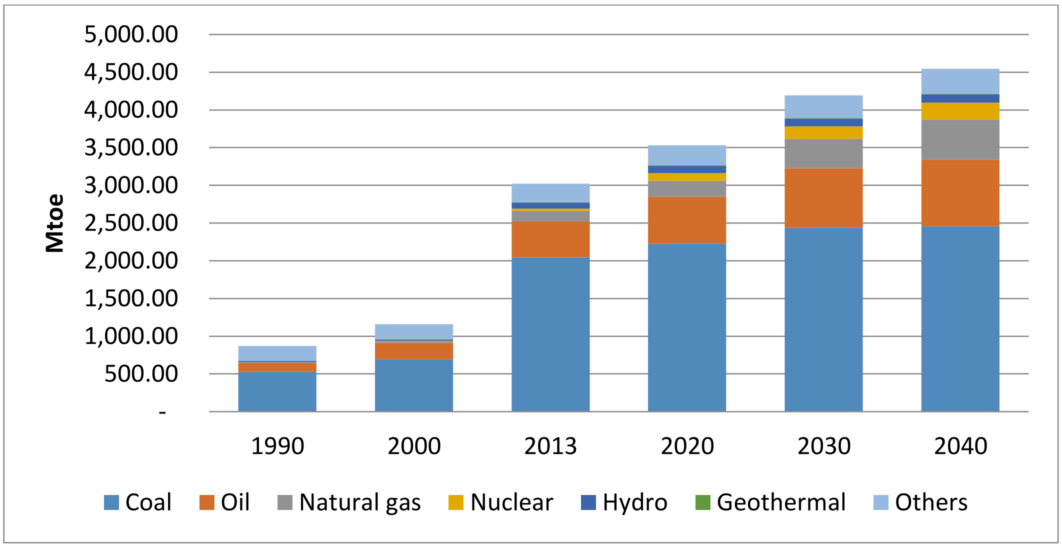
Primary energy supply in China is projected to grow at a slower pace than in the past years. Growth in primary energy supply/consumption is expected to be slightly slower than final energy consumption because of improved efficiency in the energy transformation sector.

***Business-as-Usual Scenario***

In the BAU, China's primary energy supply is projected to increase at an annual average rate of 1.5 percent per year to 4,544.85 Mtoe in 2040. Coal will still constitute the largest share in total primary energy, but its growth is expected to be slower, increasing by 0.7 percent a year. Consequently, the share of coal in total primary energy is projected to decline from 67.7 percent in 2013 to 54.1 percent in 2040.

Nuclear energy is projected to exhibit the fastest growth between 2013 and 2040, increasing at an annual average rate of 7.8 percent, followed by natural gas at 5.1 percent. Oil and hydro are projected to grow at lower rates of 2.3 and 1.2 percent per year, respectively. The share of natural gas is projected to increase from 4.6 percent in 2013 to 11.8 percent in 2040, whereas the share of nuclear will increase from 1.0 percent to 4.9 percent. The share of oil is projected to increase from 15.8 percent in 2013 to 19.4 percent in 2040 and hydro is projected to slightly decrease from 2.6 percent in 2013 to 2.4 percent in 2040. Figure 5-4 shows China's primary energy supply by energy under BAU.

**Figure 5-4. Primary Energy Supply by Energy, BAU**

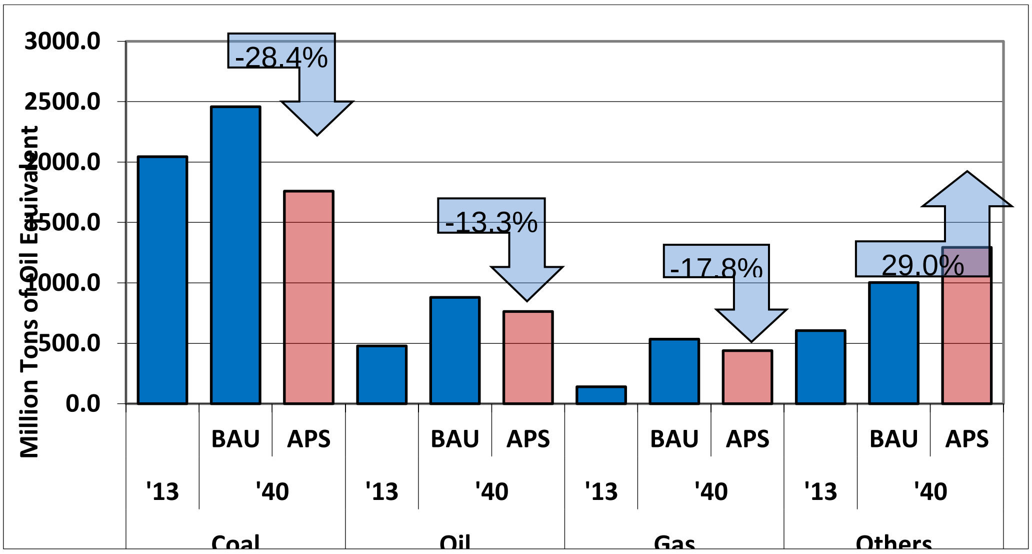



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

### *Alternative Policy Scenario*

In the APS, primary energy supply is projected to increase by 0.9 percent per year between 2013 and 2040. By 2040, primary energy supply is projected to have reached 3,810.28 Mtoe. The growth in primary energy supply is projected to be slower under the APS than the BAU (Figure 5-5). Coal is projected to decrease by 0.6 percent a year, oil will increase by 1.7 percent a year, and natural gas will grow by 4.3 percent a year. For nuclear, the annual average growth rate will be higher than the BAU, increasing by 9.7 percent a year between 2013 and 2040. The growth rate of hydro in the APS is expected to be higher than the BAU, increasing by 1.7 percent per year. The consumption mitigation in the APS is achieved through EEC measures on the demand side.

**Figure 5-5. Primary Energy Supply by Source, BAU and APS**



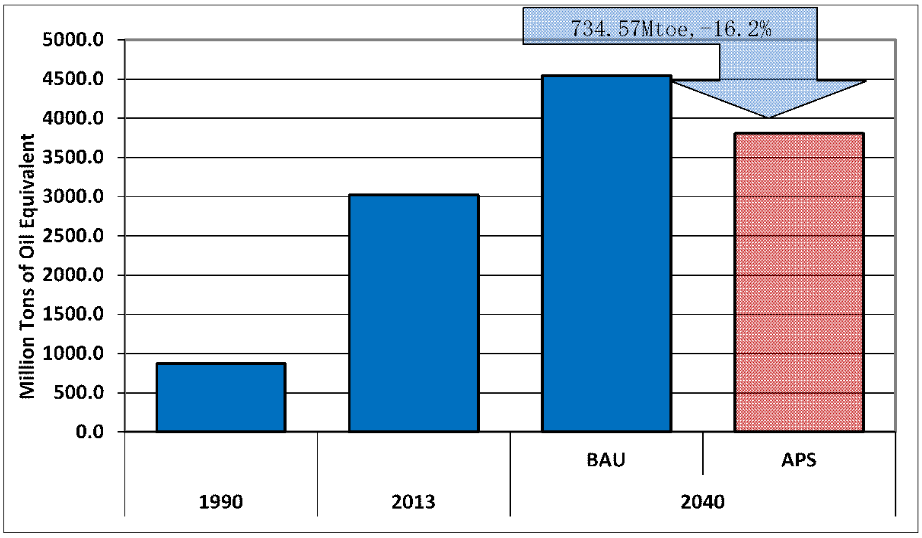

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Authors' calculation.

## 3.3. Projected Energy Savings

It is estimated that the implementation of EEC goals and action plans in China could reduce primary energy supply/consumption in 2040 by about 734.6 Mtoe under the APS, relative to the BAU. In the APS, China's primary energy supply/consumption is around 16.2 percent lower than in the BAU (Figure 5-6).

In terms of final energy consumption, there is an estimated saving of 146.2 Mtoe in the industry sector, 55.2 Mtoe in the transportation sector, and 152.8 Mtoe in the 'others' sector in 2040 under the APS, relative to the BAU.

**Figure 5-6. Primary Energy Supply, BAU and APS**



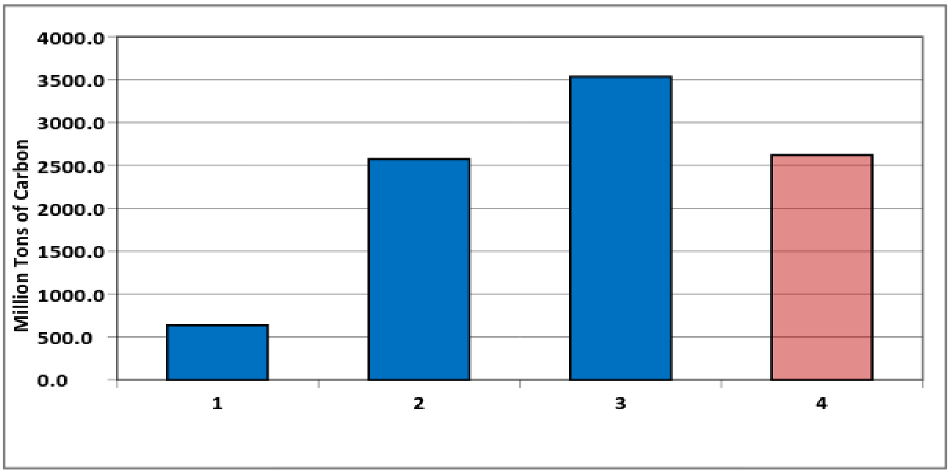

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

### 3.4. $CO_2$ Emissions from Energy Consumption

$CO_2$ emissions from energy consumption are projected to increase by 1.2 percent per year from 2573.7 Mt-C in 2013 to 3533.5 Mt-C in 2040 under the BAU. This percentage increase is lower than that in primary energy supply (1.5 percent) over the same period, indicating an improvement in the emissions intensity of the China's economy.

In the APS, the annual increase in $CO_2$ emissions between 2013 and 2040 is projected to be 0.1 percent. This rate is also lower than the average annual growth rate in primary energy supply over the same period. The difference between the APS and the BAU $CO_2$ emissions growth rates indicates that the energy saving goals and action plans of China are effective in reducing $CO_2$ emissions (Figure 5-7).

**Figure 5-7. $CO_2$ Emission from Energy Consumption, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Authors' calculation.

## 3.5. Power Generation

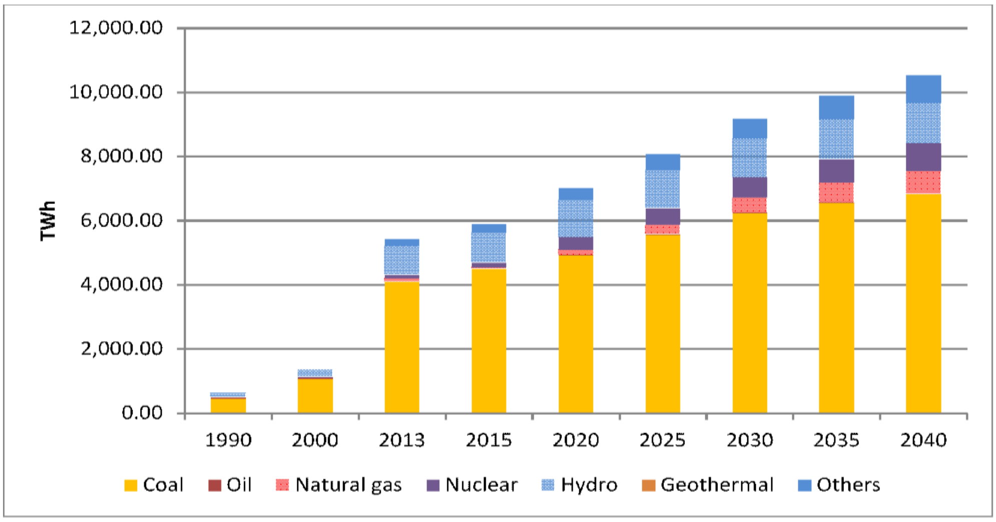
Power generation in China is projected to grow more slowly between 2013 and 2040 than in the last 2 decades.

### *Business-as-Usual Scenario (BAU)*

In this scenario, power generation in China is projected to grow at a slower pace, by 2.5 percent per year from 5,422.16 TWh in 2013 to 10,535.51 TWh in 2040 (Figure 5-8).

The share of coal power under BAU is projected to see a decreasing trend from 75.4 percent in 2013 to 64.7 percent in 2040. Conversely, the share of natural gas and nuclear are both projected to grow, because of their cleanness compared with coal in particular, from 1.8 percent and 2.1 percent in 2013 to 6.9 percent and 8.1 percent in 2040, respectively. The share of oil is projected to decrease slightly. Other methods of power generation are projected to see their shares increasing. The fast development of photovoltaic power generation in China is a typical example reflecting China's clean power generation tendency. China's thermal efficiency by fuel under BAU is projected to increase between 2013 and 2040, as can be seen in Figure 5-9.

**Figure 5-8. Power Generation, BAU**

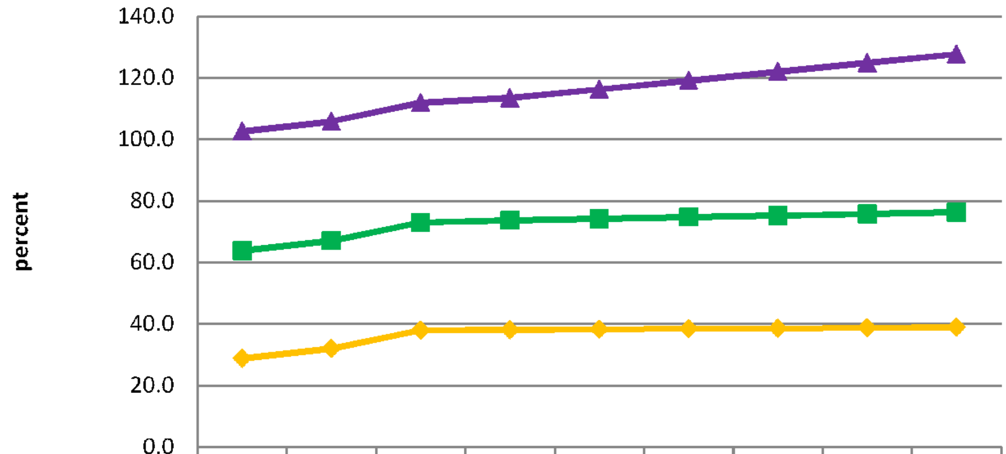



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; TWh = terawatt-hour.
Source: Authors' calculation.

### *Alternative Policy Scenario (APS)*

In APS, total power generation increases by 1.9 percent per year between 2013 and 2040. By 2040, total power generation output is projected to reach 8,895.01 TWh. Except for coal-fired power, oil power, and natural gas power, the annual growth rate per year between 2013 and 2040 of all other fuel power under APS are projected to grow faster than in BAU. In 2040, nuclear power, hydropower, geothermal power, and 'others' are projected to increase under APS by 9.7 percent, 1.7 percent, 6.1 percent, and 6.8 percent between 2013 and 2040, respectively.

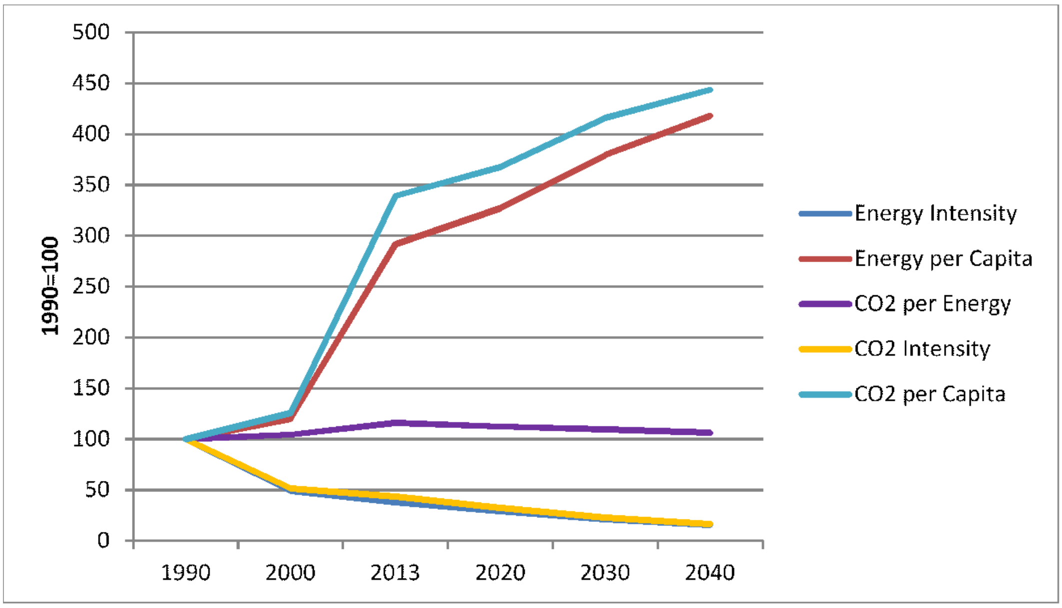
**Figure 5-9. Thermal Efficiency by Fuel, BAU**




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

BAU = Business-as-Usual scenario.
Source: Authors' calculation.

**Figure 5-10. Energy Indicators, BAU**




BAU = Business-as-Usual scenario; $CO_2$ = carbon dioxide.
Source: Authors' calculation.

### 3.6. Energy Intensity

According to the assumed economic and population data along with the projected energy information of China, energy intensity (defined as primary energy supply over GDP) and energy per capita are presented in Figure 5-10 along with other vital energy indicators under the BAU. From 1990 to 2013, it shows that China's energy intensity saw a remarkable drop as a result of efforts on energy efficiency. In 2040, energy intensity in China is projected to drop to around 257 toe per million US dollars (in 2005 US$ terms). With the improvement of living standards in China, energy per capita under the BAU is projected to reach 3.18 toe per person in 2040. Compared with energy intensity in the BAU, energy intensity in the APS is projected to show a more rapidly decreasing rate of 3.8 percent from 2013 to 2040.

## 4. Implications and Policy Recommendations

Since China is the world's largest developing country, eliminating poverty and improving the quality of life have always been of paramount importance. In recent years, China has witnessed fast growth in its economy, but the urbanisation rate is still low, reaching 56.1 percent in 2015. On the other hand, China is the world's biggest energy consumer and $CO_2$ emitter, so it is also faced with great pressure on energy saving and $CO_2$ reductions. In the past 3 decades, China has made great efforts and set ambitious targets on energy conservation and climate change mitigation. During the 2014 Asia–Pacific Economic Cooperation (APEC) summit, China and the United States made a Joint Announcement on Climate Change, according to which China vowed to achieve a peak of $CO_2$ emission and increase the share of non-fossil fuels in primary energy supply to around 20 percent by 2030. In April 2016, China signed the Paris Agreement, in which the above commitments are included along with a commitment by China to cut carbon emissions per unit of GDP by 60–65 percent by 2030 from 2005 levels.

As China's GDP will keep growing fast, albeit at a slower pace compared with the last 20 years, its energy demand and $CO_2$ emissions will increase accordingly in the foreseeable future. But energy intensity (energy demand per unit of GDP) and emission intensity ($CO_2$ emission per unit of GDP) are required to decrease for China to be able to meet its targets. According to the model results, if sound EEC policies could be implemented, China could reduce its total primary energy supply by around 16.2 percent and $CO_2$ emissions by about 25.9 percent by 2040.

Coal consumption has decreased since 2014 and it decreased by 3.7 percent in 2015. It is projected that coal consumption can be cut by 28.4 percent in the APS compared with the BAU. To improve urban air quality, Chinese metropolises, such as Beijing and Shanghai, have shown great ambition in controlling the use of coal, so the relatively low growth rate of coal consumption may persist in the coming years. Therefore, development of clean and low-carbon energies will be encouraged, especially renewable energy and nuclear energy in the power generation sector. To realise the optimisation of the energy structure, policies such as energy taxes and carbon taxes that will limit the energy-intensive and pollution-intensive industries should be carried out. And more market-based measures, for instance, electricity market reform, energy pricing reform, and the green certificate trade, are needed to make energy more market-oriented and motivate more enterprises to take actions.

Energy efficiency improvement in the final consumption sectors (APS1) has the largest potential to reduce $CO_2$ emissions. Of the final consumption sectors, the industry sector has the potential to reduce energy consumption by 13.3 percent based on the results. Measures such as the closure of small and inefficient power plants, coalmines, and small energy-intensive plants in industries like cement and steel, and stricter approval requirements for energy-intensive industries need to be implemented. And a change in industrial structure – from heavy to light industries and from industry to services – is also needed. Moreover, considering the fact that China has entered the ‘new normal,’ in which its economic growth rate will be only moderately high, and the GDP of the tertiary sector accounts for half of the total amount, in the long run it will be more important to enhance energy efficiency in the residential, commercial, and transportation sectors for energy saving and $CO_2$ reduction.

# Chapter 6

## India Country Report

September 2016

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Chapter 6

# India Country Report[1]

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## 1. Background

India is located in South Asia and has a land area of 2,973 thousand square kilometres. It has the second largest population in the world. In 1990 it had around 869 million people, and this rose to 1,252 million in 2013, at an average annual growth rate of 1.6 percent. India's gross domestic product (GDP) increased at an average annual rate of 6.5 percent from US$350 billion in 1990 to US$1,490 billion (2005 constant prices) in 2013, ranking it as the third largest economy in the Asia region. The services and the industry sectors are the largest contributors to India's GDP.

### 1.1. Energy Situation

India's primary energy supply increased by 4.1 percent per year, from around 307 Mtoe in 1990 to 775 Mtoe in 2013. In 2013, coal represented the largest share of primary energy at 44.0 percent. Coal is mainly consumed for power generation and by industry. 'Others,'[2] most of which is the non-commercial biomass used by the residential sector, had the second largest share at 24.8 percent, followed by oil at 22.7 percent in 2013. The remaining shares were natural gas (5.7 percent), hydro (1.6 percent), and nuclear (1.2 percent). Compared with 1990, the share of

[1] Based on Model run and broad assumptions by IEEJ.
[2] Others constitute non-commercial biomass, wind, solar, solid, and liquid biomass and other renewable energy sources as well as electricity imports or exports.

non-commercial biomass energy decreased, whereas the share of fossil energy including coal, oil, and natural gas increased. Among the major energy sources, the fastest growing were natural gas and nuclear energy. Natural gas grew at an average annual rate of 6.4 percent and nuclear grew by 7.8 percent per year. Coal, oil, and hydro consumption increased, but at slower annual average rates of 5.8 percent, 4.7 percent, and 3.0 percent, respectively.

India generated 1,193 TWh of electricity in 2013. The average annual growth in electricity generation between 1990 and 2013 was 6.3 percent, almost as high as the growth in GDP. The shares of generation by fuel in 2013 were: coal 72.8 percent, hydro 11.9 percent, natural gas 5.5 percent, nuclear 2.9 percent, oil 1.9 percent, and 'others' (wind, solar PV, and other renewable energy sources) 5.0 percent.

India's final energy consumption grew by 3.4 percent per year from 243 Mtoe in 1990 to 528 Mtoe in 2013. Between 1990 and 2013, the industry sector grew by 4.4 percent per year, the transport sector by 5.7 percent per year, and the residential and commercial ('others') sectors by 2.3 percent per year. Non-energy use[3] saw fast growth, increasing by 4.5 percent a year.

Among commercial fossil energy, oil was the most consumed product with a share of 20.6 percent of total final energy consumption in 1990, and 28.4 percent in 2013. The share of coal increased from 16.0 percent in 1990 to 19.6 percent in 2013. The share of electricity increased from 7.6 percent in 1990 to 14.5 percent in 2013. Similarly, the share of natural gas increased from 2.3 percent in 1990 to 5.0 percent in 2013. The share of other energy, most of which is non-commercial biomass, fell from 53.5 percent in 1990 to 32.5 percent in 2013.

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

## 2. Modelling Assumptions

India's GDP is assumed to grow at an average annual rate of 6.5 percent from 2013 to 2040, and the population is forecast to increase by 0.9 percent a year.

Concerning future electricity supply, the share of coal in electricity generation will continue to be the largest one. Nuclear power plants and 'others,' especially wind and solar, are projected to increase to 2040, but 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 measures to ensure 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

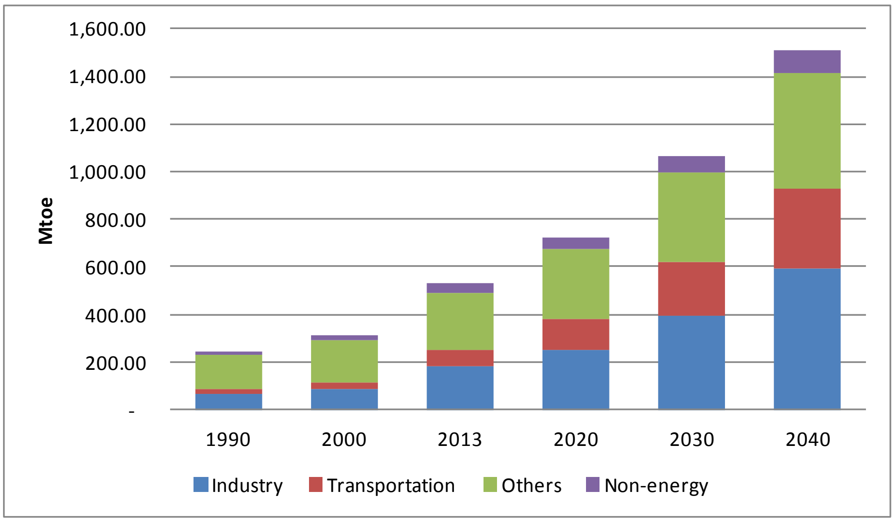
### 3.1. Business-as-Usual (BAU) Scenario

#### 3.1.1. Final energy consumption

Under BAU, with assumed strong economic growth and a growing population, India's final energy consumption is projected to increase at an average rate of 4.0 percent per year from 528 Mtoe in 2013 to 1,508 Mtoe in 2040 (Figure 6-1). The strongest growth is projected to occur in the transport sector, increasing by 5.7 percent a year between 2013 and 2040. Strong growth is also expected in the industry sector (4.5 percent a year) and non-energy consumption (3.7 percent a year). Due to the large share of non-commercial energy in the final energy consumption, the growth rate of the 'others' sector that includes the residential and commercial sectors, is projected to be modest at 2.7 percent per year. However, in the residential and commercial sectors, the consumption of commercial energy, especially electricity, will increase rapidly.

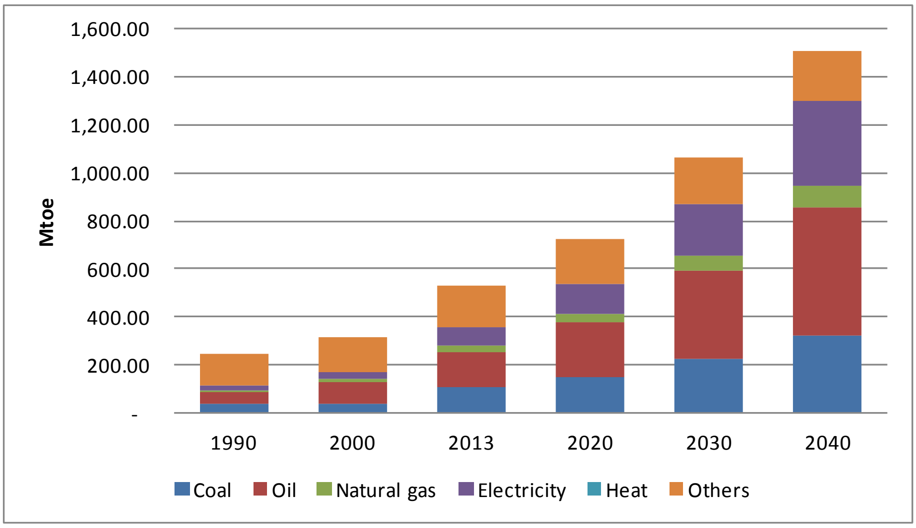
The share of 'others,' which is the largest at 45.1 percent in 2013, will drop to 32.2 percent in 2040. The share of industry will increase to 39.3 percent in 2040 from 33.9 percent in 2013 and the share of transport will be 22.1 percent in 2040, up from 14.2 percent in 2013.

**Figure 6-1. Final Energy Consumption by Sector**




Mtoe = million tons of oil equivalent.
Source: Author's calculations.

**Figure 6-2. Final Energy Consumption by Energy**




Mtoe = million tons of oil equivalent.
Source: Author's calculations.

In the final energy consumption by source, electricity will see the fastest growth, increasing by 5.8 percent per year over the period 2013–2040 (Figure 6-2). Oil demand will increase at the second highest rate of 4.8 percent per year, followed by natural gas (4.7 percent a year), and coal (4.3 percent a year).

### 3.1.2. Primary energy supply

Under BAU, India's primary energy supply will increase at an average annual rate of 4.1 percent to 2,281 Mtoe in 2040 from 775 Mtoe in 2013. Coal consumption, driven by the demand of power generation, will grow by 4.5 percent per year and reach 1,129 Mtoe in 2040, from 341 Mtoe in 2013, maintaining the largest share at 49.5 percent in 2040 (44.0 percent in 2013). Due to rapid motorisation, oil will increase to 567 Mtoe and is forecast to have the second largest share at 24.8 percent in 2040. The average annual growth rate for oil demand during 2013–2040 is estimated at 4.4 percent. Natural gas consumption is expected to increase by 5.1 percent per year between 2013 and 2040. Its share will be 7.5 percent in 2040, 1.8 percentage points up from 5.7 percent in 2013. Figure 6-3 shows the projected primary energy supply in India from 1990 to 2040 under the BAU.

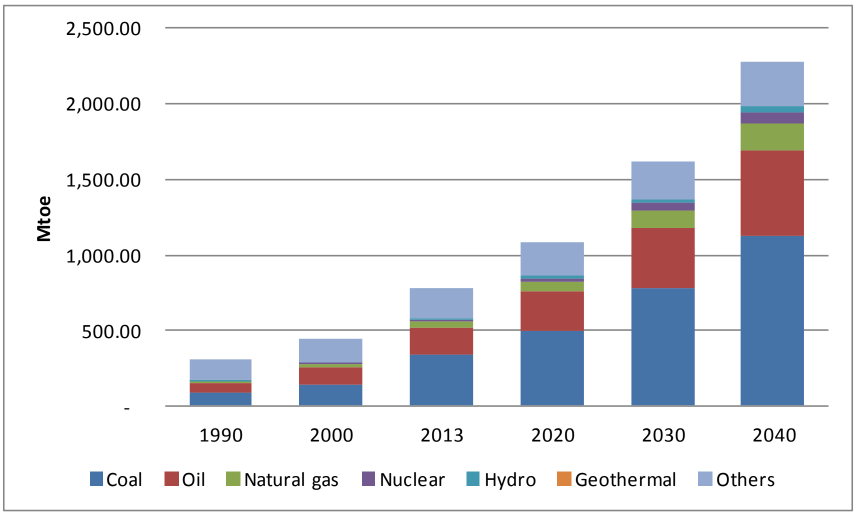
Nuclear energy is expected to grow the fastest at an average annual rate of 8.5 percent, with its share increasing from 1.2 percent in 2013 to 3.5 percent in 2040. Within 'others,' solar and wind will increase significantly, but due to the slow growth of non-commercial biomass, which has the largest portion overall, 'others' is projected to increase by an average 1.7 percent a year through to 2040. Its share will drop to 13.2 percent from 24.8 percent in 2013.

### 3.1.3. Power generation

In 2013, power generation in India was 1,193 TWh. Under BAU, India's power generation will increase at an annual average rate of 5.5 percent per year to 5,077 TWh in 2040. Coal will continue to dominate India's power generation mix, but its share will drop from 72.8 percent in 2013 to 66.5 percent in 2040.

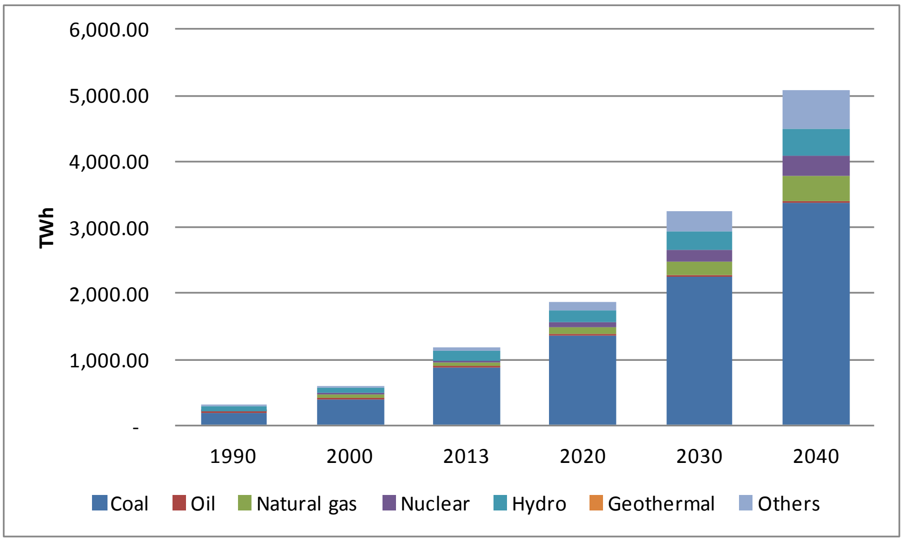
Hydro's share in India's power generation mix will decline from 11.9 percent in 2013 to 8.0 percent in 2040, and oil's share will decline from 1.9 percent in 2013 to 0.5 percent in 2040. In contrast, the share of nuclear power will increase from 2.9 percent to 6.1 percent, and new energy including wind and solar power will increase from 5.0 percent to 11.4 percent.

**Figure 6-3. Primary Energy Supply by Source**




Mtoe = million tons of oil equivalent.
Source: Author's calculations.

**Figure 6-4. Power Generation, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculations.

The share of natural gas will be 7.5 percent in 2040, and the annual average growth rate during 2013–2040 will be 6.8 percent. Figure 6-4 shows the projected power generation in India from 1990 to 2040 under the BAU.

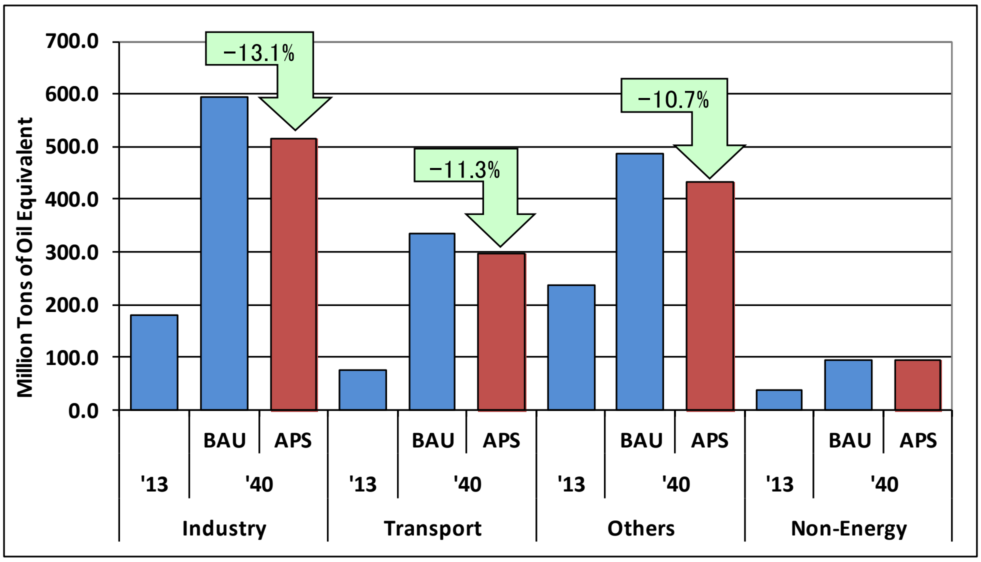
## 3.2. Energy Saving and Carbon Dioxide ($CO_2$) Reduction Potential

### 3.2.1. Final energy consumption

Under the Alternative Policy Scenario (APS), final energy consumption is projected to increase at a slower rate of 3.5 percent per year from 528 Mtoe in 2013 to 1,341 Mtoe in 2040. This is 167 Mtoe or 11.1 percent lower than under BAU. 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 2040, under APS relative to BAU, there is an estimated saving of 78 Mtoe (13.1 percent) in the industry sector, 38 Mtoe (11.3 percent) in the transport sector, and 52 Mtoe (10.7 percent) in the 'others' sector.

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

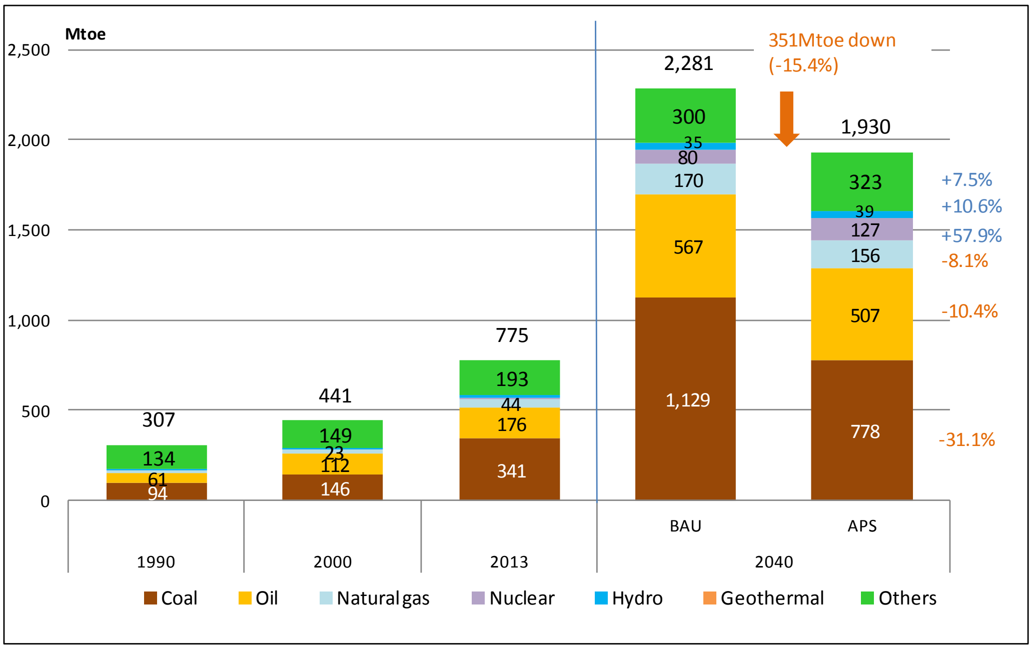



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculations.

### 3.2.2. Primary Energy Supply

Under APS, relative to BAU, India's primary energy supply is projected to increase at a slower rate of 3.4 percent per year to 1,930 Mtoe in 2040. The difference between primary energy supply under the BAU versus the APS in 2040 is 351 Mtoe or 15.4 percent (Figure 6-6).

**Figure 6-6. Total Primary Energy Supply, BAU and APS**




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

In the APS, nuclear will be the fastest growing energy source, increasing at 10.3 percent per year, to reach 127 Mtoe in 2040, 57.9 percent higher than the BAU. Hydro and 'others' will grow at 4.4 percent and 1.9 percent per year, increasing to 39 Mtoe and 323 Mtoe, respectively, which represents an increase of 10.6 percent and 7.5 percent, respectively.

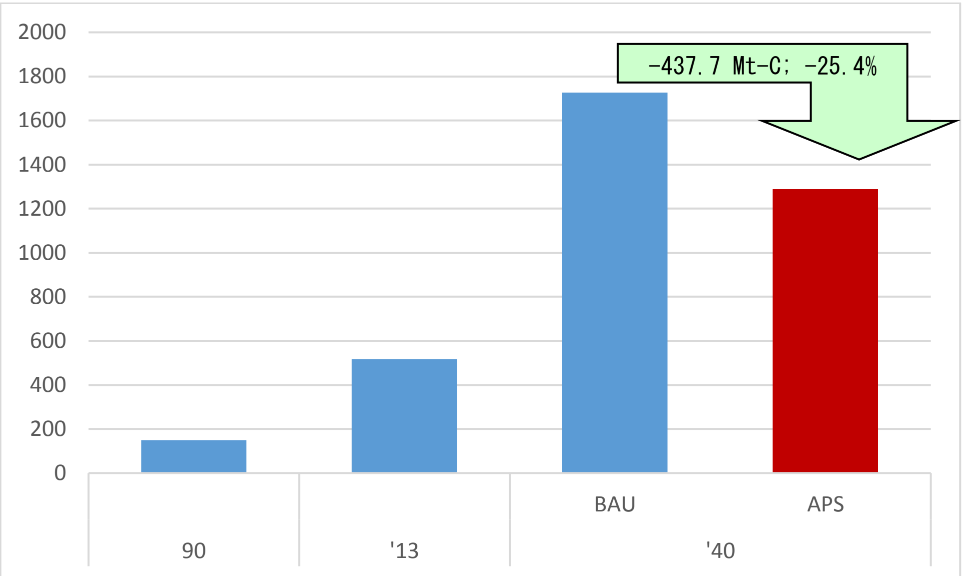
Natural gas, oil, and coal will grow at slower annual rates of 4.8 percent, 4.0 percent, and 3.1 percent, respectively, increasing to 156 Mtoe, 507 Mtoe, and 778 Mtoe in 2040, respectively. These are 8.1 percent, 10.4 percent, and 31.1 percent lower, respectively, than in BAU.

### 3.2.3. $CO_2$ Emissions

Under BAU, $CO_2$ emissions from energy consumption will increase by 4.6 percent per year from 517 Mt-C in 2013 to 1,727 Mt-C in 2040.

In the APS, the annual increase in $CO_2$ emissions from 2013 to 2040 will be slower than in the BAU at 3.4 percent. $CO_2$ emissions in 2040 will be 1,289 Mt-C, 25.3 percent lower than in the BAU. Reduced demand for coal in final demand and in power generation and oil in the transport sector contribute most to the expected reduction in $CO_2$ emissions. Figure 6-7 shows the $CO_2$ emission in 2040 under the BAU versus the APS in this energy outlook.

**Figure 6-7. $CO_2$ Emissions from Energy Consumption, BAU and APS**




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

## 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 and the APS. Use of domestic coal for supply security, as well as more efficient coal technologies such as integrated gasification combined cycle, ultra-supercritical, etc., would be necessary. In the long and medium terms, research and development (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 capitalise on the increasing global natural gas production, it is necessary to enhance the infrastructure for importation, domestic transportation, and utilisation.
- India's government announced ambitious targets for renewable energy, but the cost and infrastructure will be the bottleneck. Developing the domestic manufacturing capacity can play an important role.
- Energy efficiency and demand side management are important. New power plants, new factories, new buildings, new appliances, and new cars, should be more efficient. The Minimum Energy Performance Standard and mandatory energy labels should be expanded to more equipment.
- There are huge potential savings in the power sector. Advanced technologies for power generation should be used as much as possible.
- Industry will account for 42 percent of the incremental energy use to 2040; energy efficiency programmes should be focused on this sector. Broadening the scope of the Perform, Achieve, Trade scheme will be important in achieving this.
- Growth of energy consumption in the transport sector should be curtailed.
- Losses in electricity distribution should be minimised by using better technologies.
- Rationalising energy prices across fuels and sectors is necessary.

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 1,910,931 square kilometres and is the world's 16th largest country in terms of land area. The 2010 population census showed that Indonesia's population had reached 238 million people with an average population density of 124 people per square kilometre. The population increased to 247 million people in 2013.

Indonesia's real gross domestic product (GDP) increased by 6.0 percent in 2012 and 5.6 percent in 2013, reaching US$449 billion (constant 2005 US$). From 1990 to 2013, GDP grew at an annual average rate of 4.9 percent. GDP per capita rose from only US$840 (constant 2005 US$) in 1990 to around US$1,820 (constant 2005 US$) in 1990.

Indonesia is richly endowed with natural resources. Its proven crude oil reserves were 11.6 billion barrels in 1980, 5.4 billion barrels in 1990, and at the end of 2013 were estimated at 3.7 billion barrels.

Indonesia is the world's largest liquefied natural gas (LNG) exporter. Its proven reserves were 2.9 trillion cubic meters (TCM) in 1990, 2.5 TCM in 2005, and 2.9 TCM (around 101.5 trillion cubic feet) in 2013. Indonesia is also a coal exporter with proven coal reserves of around 32.3 billion tons at the end of 2013.

In addition to fossil energy resources, Indonesia's non-fossil energy resources include hydro, geothermal, biomass, and other renewable energy such as solar and wind. For hydro, the estimated potential is 75 gigawatt (GW) and that of geothermal more than 28 GW.

Indonesia's total primary energy supply (TPES) was around 224 million tons of oil equivalent (Mtoe) in 2013. Oil represented the largest share of primary energy supply in 2013 at around 34 percent, followed by 'others' (mainly biomass) at 24 percent, natural gas at 18 percent, and coal at 16 percent. The remaining share of 8 percent represents hydro and geothermal.

Indonesia has around 51 GW of installed electricity generating capacity and generated around 216 TWh of electricity in 2013. The state electricity company of Indonesia, PT PLN PERSERO, owned and operated generation plants with a combined capacity of about 36 GW in 2013, composed of: 25 percent oil, 36 percent coal, 27 percent gas, 10 percent hydro, and 2 percent 'others' (geothermal, solar, and wind).

## 2. Modelling Assumptions

As mentioned above, Indonesia's real GDP growth was 5.6 percent in 2013. This is lower than the targeted growth of 6.3 percent in the revised state budget (APBN–P) 2013. The state budget (APBN) 2016 targeted real GDP growth of 5.5 percent for 2016 and between 6.0 and 7.2 percent for 2017. For 2018 and 2019, the growth rate is forecast at 6.2–7.8 percent and 6.5–8.2 percent, respectively.

The National Energy Council (DEN) assumed 8 percent GDP growth from 2015 to 2025 and slowed to 7.25 percent in 2035 and 6.5 percent in 2050. The assumed GDP growth rates were used in the formulation of the National Energy Policy (KEN) issued through Government Regulation no. 79 of 2014. On average, Indonesia's assumed annual GDP growth from 2013 to 2040 for the KEN is around 7.6 percent.

Although the prediction of GDP growth for Indonesia is around 7 to 7.6 percent per year, for the purpose of this study it was assumed that real GDP would grow more slowly, at an average annual rate of 5.4 percent from 2013 to 2040. This is based on the economic projections of the International Monetary Fund (IMF) and The World Bank. Population growth of 0.9 percent per year is assumed over the same period, based on the revised population projection of the Central Bureau of Statistic (BPS).

The scenarios are similar to last year's report, i.e. the Business-as-Usual scenario (BAU) and the five Alternative Policy Scenarios (APS). These APS reflect the additional policy interventions that are likely to be implemented, such as energy efficiency and conservation (EEC) targets and action plans; efficiency improvement in power generation plants; more aggressive adoption of renewable energy; and introduction of nuclear energy. In the case of Indonesia, the five APS considered are as follows:

1) More efficient final energy consumption (APS1), with specific energy saving targets by sector (Table 7-1), were considered as the basis for the analysis. In addition, Article 9 of the 2014 National Energy Policy (KEN) stated that energy elasticity achievement shall be less than 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.

**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

BOE = barrel of oil equivalent; EC = Energy Conservation.
Source: Harris (2014), Energy Efficiency Implementation to Reduce GhG Emission, Directorate of Energy Conservation, Directorate General of New, Renewable Energy, and Energy Conservation (DGNREEC), Ministry of Energy Mineral Resources Republic of Indonesia (MEMR).

2) More efficient thermal power generation (APS2), where higher improvement of existing coal power plant and the introduction of cleaner coal technologies have been considered in the analysis. In addition, the most efficient natural gas combined-cycle technologies were also considered for this scenario.

3) Higher contribution of NRE and bio-fuels (APS3) – In this case higher penetration of new and renewable energy (NRE) for electricity generation and utilisation of liquid biofuels in the transport sector are assumed as compared with the BAU.

4) Introduction or higher utilisation of nuclear energy (APS4), where the assumption was it will be in operation after 2020, similar to the assumption in the previous study. This is in line with current plans of two units to be constructed after 2020, each with a capacity of 1,000 MW.

5) The combination of APS1 and APS4 constitutes the assumptions of the APS (APS5).

# 3. Outlook Results

## 3.1. Business-as-Usual Scenario (BAU)

### 3.1.1. Final energy consumption

Indonesia's final energy consumption increased at an average annual rate of 3.1 percent between 1990 and 2013, 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 4.3 percent per year between 2013 and 2040 in the BAU.

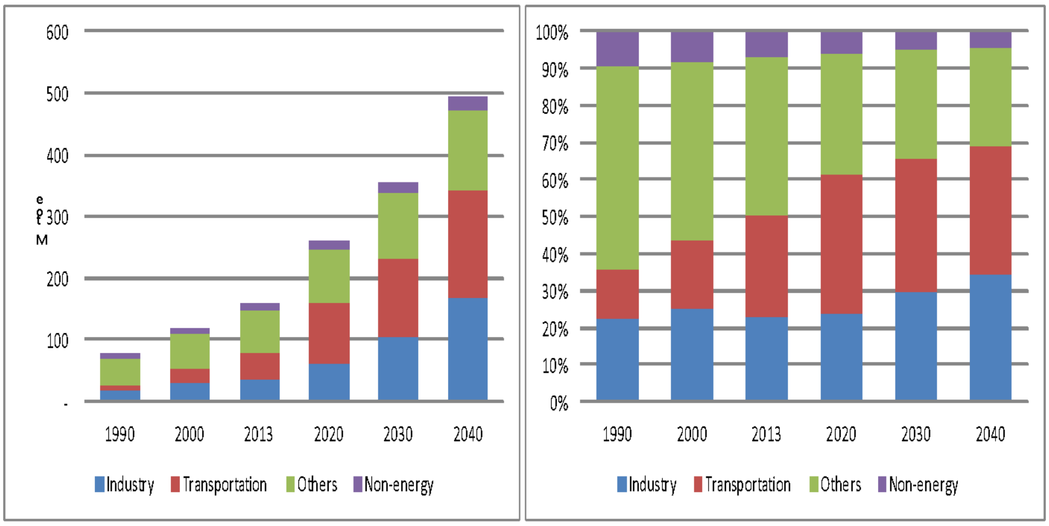
This growth stems from the rapid increase in energy consumed in the transportation and industrial sectors. The transportation sector is still heavily dependent on oil. In the past, the final energy consumption of the transport sector grew at an average rate of 6.3 percent per year over the 1990–2013 period. This growth is expected to continue up to 2040 for the BAU, but at a slightly lower rate of 5.2 percent per year.

Final energy consumption in the industrial sector grew at a slower rate than the transportation sector over the 1990–2013 period (3.1 percent per year). It will see the highest growth as compared with the other sectors from 2013–2040, at an average rate of 5.8 percent per year.

The 'other' sector's (mainly consisting of the residential and commercial) final energy consumption grew at an average rate of 1.9 percent per year over the 1990–2013 period. The final energy consumption of this sector for the period 2013–2040 is projected to increase more rapidly under the BAU, at an average annual growth rate of 2.4 percent.

The 'others' sector had the highest share in total final energy consumption from 1990 to 2013 because of the high consumption of biomass mainly in the residential sector. But the share decreased from around 55 percent in 1990 to 43 percent in 2013. It is expected that the share will continue to decline in the future as household appliances become more efficient and more alternatives such as natural gas and liquefied petroleum gas (LPG) are used. The sector's share in total final energy consumption will fall to 26 percent in 2040.

**Figure 7-1. Final Energy Consumption by Sector**




Mtoe = million tons of oil equivalent.
Source: Author's calculations.

The transportation sector's share in total final energy consumption increased from around 13 percent in 1990 to 27 percent in 2013. This share will continue to increase, reaching 35 percent in 2040. The combined share of oil and alternative fuels for transport will contribute more to the increase of the transportation sector's share in total final energy consumption.

The industrial sector's share in total final energy consumption was 23 percent over the 1990 to 2013 period and it is expected to increase to 34 percent by 2040 in line with the expected growth in industrial activities.

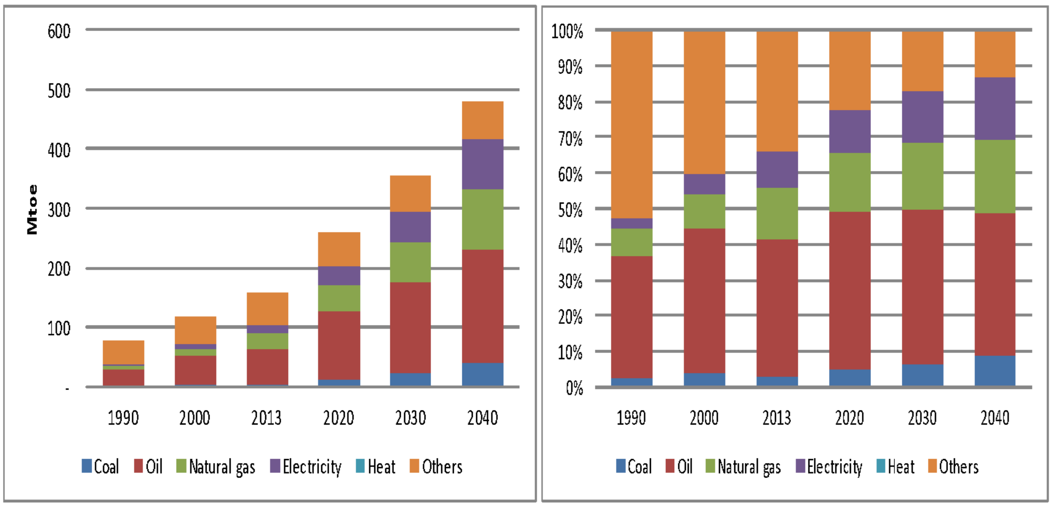
By fuel type, electricity experienced the fastest growth over the 1990–2013 period, at an average rate of 8.6 percent per year. This rapid growth of electricity demand was due to the significant increase in industrial and residential sector consumption, from 2.4 Mtoe in 1990 to 16.1 Mtoe in 2013. Coal will also increasing significantly over the same period as industry expands, particularly the cement industries. Total coal demand increased from 2 Mtoe in 1990 to almost 5 Mtoe in 2013, growing at an average rate of 3.4 percent per year.

As for natural gas and oil, average annual growth of these fuels over the 1990–2013 period was 6.1 percent and 3.6 percent, respectively. Demand for other fuels (mostly biomass for households) increased by around 12 Mtoe, at an average rate of 1.1 percent per year.

In future, demand for all fuels will continue to increase. For coal, demand will increase the fastest at an average rate of 8.5 percent per year, to 41 Mtoe in 2040. Electricity is also expected to grow, but at a slower rate than in the past. The average annual growth rate for electricity demand is forecast at 6.2 percent per year over the 2013–2040 period.

Natural gas and oil demand will grow at average rates of 5.5 percent per year and 4.3 percent per year, respectively, between 2013 and 2040. Demand for 'Other' fuels will increase the slowest over the same period, at an average growth rate of 0.6 percent per year. This is mainly due to an expected fall in the growth rate of biomass consumption of the residential sector.

**Figure 7-2. Final Energy Consumption by Energy, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

Oil will continue to play a major role in the country's final energy consumption, although more alternative fuels will be consumed by the end-use sectors. It is expected that the share of oil will be around 40 percent in 2040, increasing from 38 percent in 2013. The remaining shares will be those of coal (9 percent), natural gas (21 percent), electricity (17 percent), and ‘others’ (13 percent).

### 3.1.2. Primary energy supply

Primary energy supply in Indonesia grew faster than final energy consumption, at about 3.6 percent per year from 99 Mtoe in 1990 to 224 Mtoe in 2013. Among the major energy sources, the fastest growing fuels between 1990 and 2013 were coal and geothermal energy. Coal consumption grew at an average annual rate of around 11 percent while geothermal energy grew at 10 percent per year. Gas consumption increased at a slower rate of 4 percent per year while oil consumption grew slightly more slowly at 3.7 percent per year.

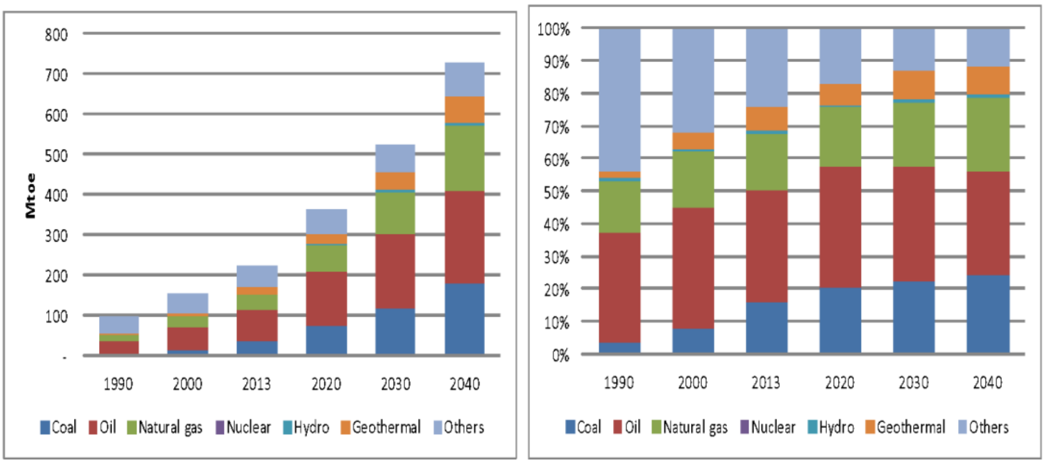
In the BAU, Indonesia’s primary energy supply is projected to increase at an average annual rate of 4.5 percent, reaching 729 Mtoe in 2040. Coal is projected to continue growing but at a slower rate of 6.1 percent per year over the projection period. Geothermal energy is also expected to increase over the projection period, but growth will be slower than that witnessed over the past two decades because of the difficulties of expanding exploration in protected forest areas. Moreover, 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 2040 is 5.3 percent per year.

Hydro, on the other hand, will increase at a faster rate of 6.3 percent per year between 2013 and 2040 compared with the 1990–2013 period. This is because more hydro plants will be built in future, such as in East Kalimantan. Consideration is being given to building more run-of-river type hydro rather than the reservoir type.

Oil consumption is projected to increase at an average annual rate of 4.2 percent over the projection period from 2013 to 2040. At the same time, natural gas consumption is expected to increase slightly faster than oil at an average rate of 5.4 percent per year.

It is assumed that there will be no uptake of nuclear energy in the BAU. 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 Supply, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

Oil constituted the largest share of TPES and had increased slightly from 33.8 percent in 1990 to 34 percent in 2013. The share of natural gas in the total mix also increased slightly, from 16 percent in 1990 to 18 percent in 2013.

Since both coal and geothermal experienced rapid growth over the 1990–2013 period, the shares or these energy sources in the total fuel mix increased significantly. Coal's share in the total primary energy mix increased from around 4 percent to 16 percent and that of geothermal from 2 percent to 7 percent. Hydro's share increased slightly, from 0.5 percent to 0.7 percent. As the 'others,' which include biomass, solar, wind, ocean, biofuels, and electricity, grew slower than the other fuels, its share declined from 44 percent in 1990 to 24 percent in 2013.

In the BAU, oil's share will still be dominant throughout the 2013–2040 period and the share of oil in the total primary energy mix will continue to decline, reaching 32 percent in 2040. The share of natural gas will increase to 22 percent by the end of the projection period and that of coal will increase to 24 percent.

Hydro's share in the total primary energy mix will increase slightly, to 1 percent even though hydro grows faster than geothermal.

### 3.1.3. Power generation

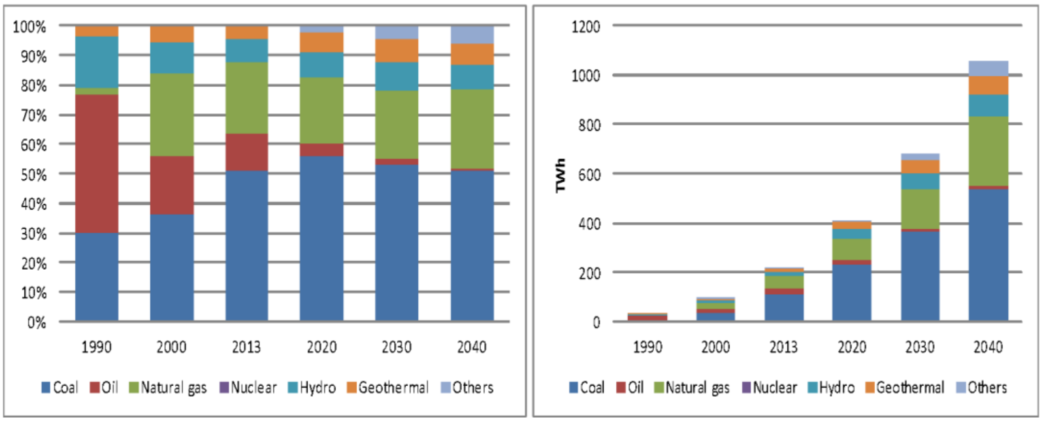
Power generation output increased at an average rate of 8.6 percent per year over the past two decades, from around 33 TWh in 1990 to almost 216 TWh in 2013. The fastest growth occurred in the production of electricity from natural gas plants at 20 percent per year. This is due to the increase in gas turbine and combined cycle capacities as natural gas became increasingly available.

In the BAU, to meet the demand for electricity, power generation is projected to increase at a slower rate of 6.1 percent per year reaching 1,061 TWh in 2040. By type of fuel, generation from 'others' will see the fastest growth at an average rate of 22.4 percent per year. The main reason for this very rapid growth is that generation from these other sources was very small in 2013, but is expected to increase significantly as a result of the government's policy to increase the use of NRE sources including solar PV, wind, biomass, etc., which are classified as 'others.'

Generation from geothermal and hydro are also growing fast, but much slower than 'others,' at 8.1 percent per year and 6.3 percent per year, respectively.

Power generation from natural gas will continue to increase, but at a much slower rate of 6.5 percent per year while coal based power generation will grow at an average annual rate of 6.1 percent. No nuclear plant is considered under the BAU.

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




TWh = terawatt-hour.
Source: Author's calculations.

The share of coal will remain dominant in the total power generation of the country. The share of coal in total power generation was lower than oil in 1990 (30 percent). The share increased over time as more coal power plants were constructed. In 2013, the share increased to 51 percent, higher than that of oil. It is expected that this share will not change significantly in the future. In 2040, the share of coal in total power generation will still be around 51 percent.

Oil had the largest share in power generation in 1990 (47 percent). By 2013, the share of oil declined to around 12 percent as production from coal and natural gas plants increased rapidly. The share of natural gas in 2013 reached 24 percent and will continue to increase, to 26.5 percent by 2040 under the BAU.

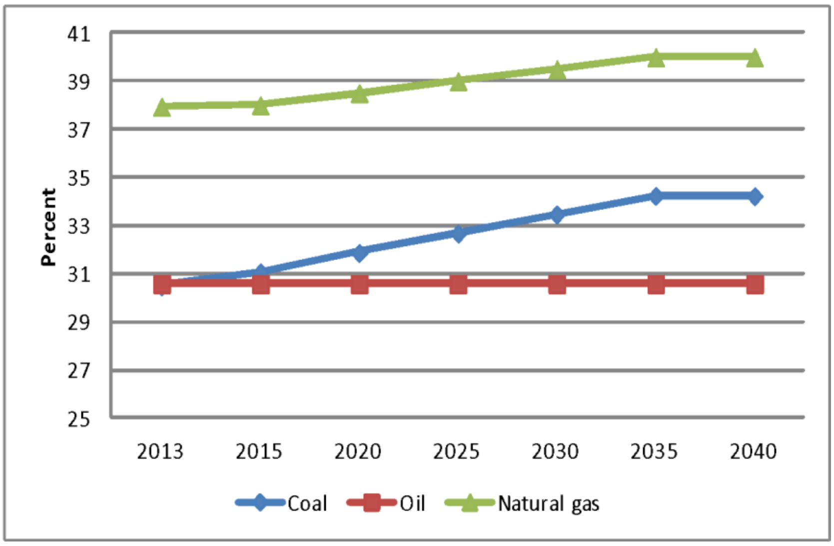
Hydro also had an important role in the total electricity production of the country. Its share in 1990 reached 17.5 percent. But in 2013 the share had declined to 7.9 percent. It is expected that under the BAU, hydro's share will increase slightly to 8.3 percent in 2040.

Geothermal and other renewables' share made up about 4.5 percent of total power generation in 2013. The role of these renewables is expected to increase significantly in the future and the share is projected to increase to 13.3 percent by 2040.

The average thermal efficiency of fossil fuel-based power plants was around 32 percent in 2013. In the BAU, it was assumed that there will be a slight improvement in the efficiency of the coal and natural gas power plants causing the thermal efficiency of fossil fuel plants to increase to almost 36 percent in 2040.

By fuel, coal fired power plants' thermal efficiency will increase from 30.5 percent in 2013 to 34.2 percent in 2040 while natural gas is assumed to increase from 38 percent to 40 percent. Oil will remain below 31 percent over the 2013–2040 period.

**Figure 7-5. Thermal Efficiency, BAU**




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

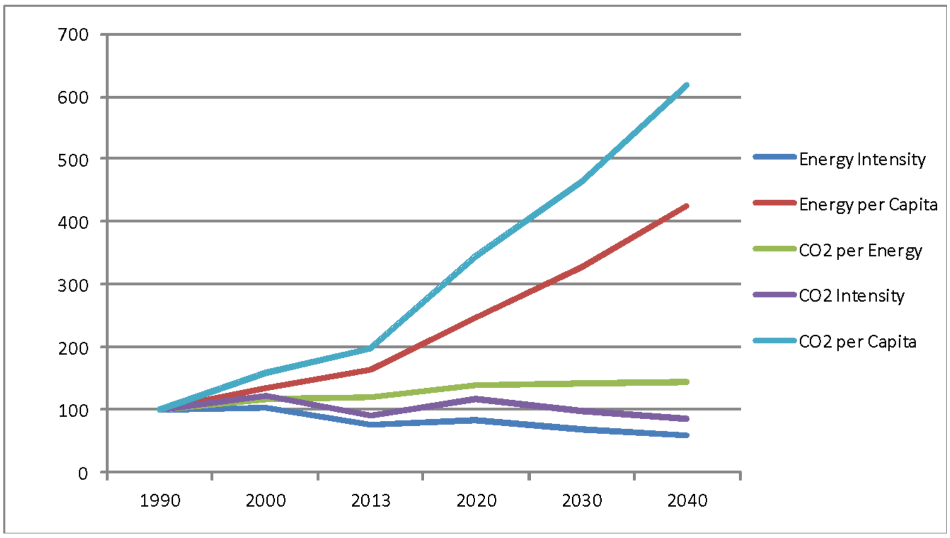
### 3.1.4. Energy indicators

Indonesia's primary energy intensity (TPES/GDP) had been increasing up until 2000. Since then, the intensity declined and reached a level of 499 toe/million 2005 US$ in 2013. Final energy intensity had been declining and reached a level of 355 toe/million 2005 US$ in 2013. These are indications 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, primary and final energy intensity is projected to decline at an average annual rate of 0.9 and 1.1 percent, respectively, over the 2013 to 2040 period. Primary energy intensity in 2040 will be around 392 toe/million 2005 US$ and final energy intensity is projected to be 267 toe/million 2005 US$. Thus, the energy intensity ratio is expected to improve by almost 21 percent (primary) and 25 percent (final) in 2040 as compared with 2013.

Per capita energy consumption, measured as the ratio of TPES to the total population, increased from 0.55 in 1990 to 0.91 in 2013. This level of energy consumption per capita is an indication that people's energy access is improving, which is reflected by the electrification ratio. In 2013, the electrification ratio was around 80.5 percent and it reached 88.5 percent in 2015. The government expects that all households will have access to electricity by 2020.

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




$CO_2$ = carbon dioxide.
Source: Authors' calculations.

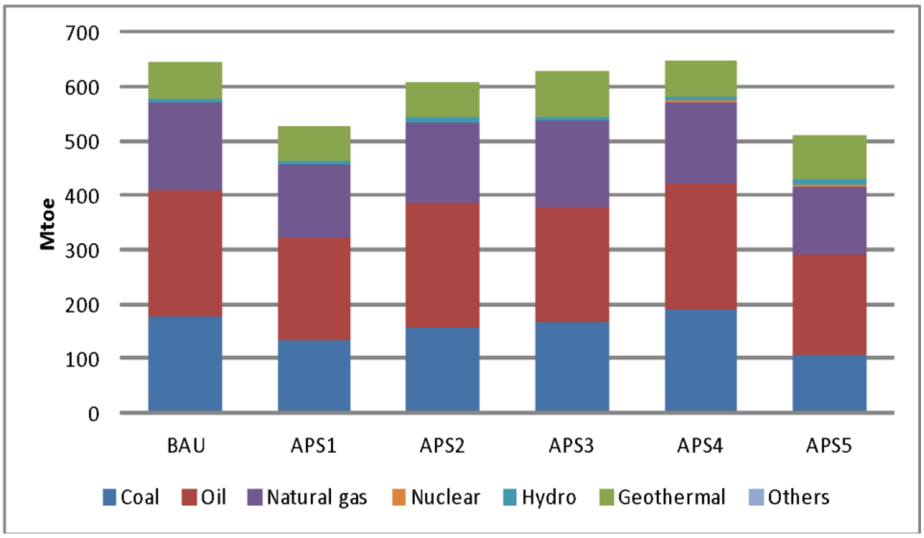
Under the BAU, energy consumption per capita will continue to increase and will reach 2.3 toe per person in 2040. This result is in accordance with the existing national energy policy (2014), which targeted a level of 1.4 toe in 2025 and 3.2 to in 2050.

In the BAU, the elasticity of final energy consumption is expected to continue to decline and reach 0.79 in 2040. Elasticity below 1.0 indicates that growth in final energy consumption will be slower than growth in GDP from 2013 to 2040.

### 3.2. Energy Saving and $CO_2$ Reduction Potential

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 primary energy supply in all the scenarios.

**Figure 7-7. Comparison of Scenarios to Total Primary Energy Supply in 2040**




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

In Figure 7-7 above, APS1 and APS5 have the largest reduction in primary energy supply in 2040 due to the energy efficiency assumptions on the demand-side. Energy efficiency assumptions in APS1 could reduce primary energy supply in BAU by as much as 121 Mtoe or 16.6 percent. For APS5, the reduction will be higher, amounting to 141 Mtoe or 19.4 percent

APS2, which assumes higher efficiency in thermal electricity generation, will also reduce the TPES in 2040, by 37 Mtoe or 5.1 percent as compared with the BAU. Under APS2, no efficiency measures were assumed for the final sector, thus it will have a lower impact than APS1. Therefore, the projected reduction is due mainly to the use of more efficient power generation and some of the conventional plants will cease operation after reaching the end of their technical life.

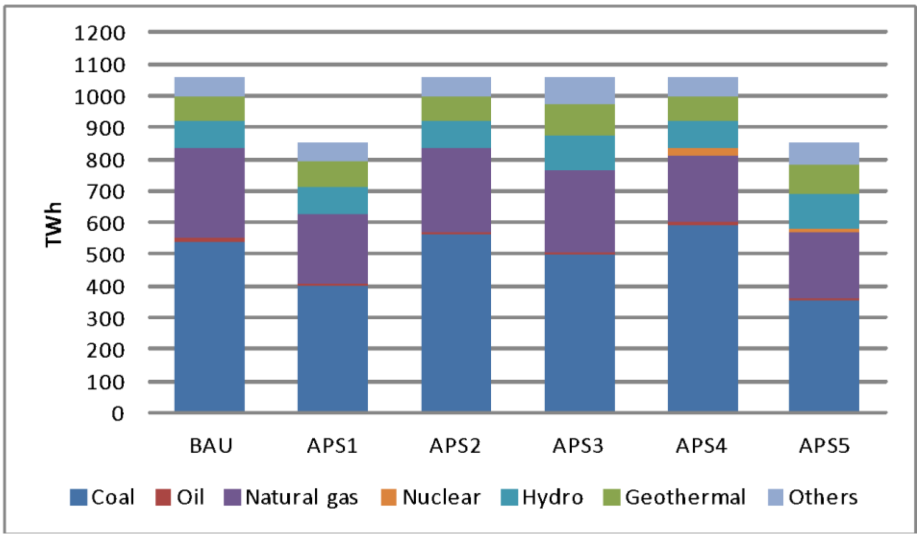
For APS3, the TPES increases slightly as more renewable energy for power generation comes into operation and more biofuels are expected to be consumed in the transportation sector. The difference between APS3 and BAU for 2040 is only around 7 Mtoe or 0.9 percent.

The planned introduction of nuclear power generation after 2020 (APS4) will increase the total primary energy mix of 2040 by only 2.8 Mtoe or 0.4 percent as compared with BAU. The result indicate that the introduction of nuclear plants will reduce the consumption of fossil fuels (coal, oil, gas) in generating power. However, considering that the efficiency of nuclear plants is slightly lower than the average thermal efficiency of fossil fuel plants, no savings compared with the BAU are expected.

Figure 7-8 shows the total electricity generation in 2040 in all scenarios. In APS1, due to the lower electricity demand, the shares of fossil-fired electricity generation will be lower than in the BAU – 73 percent as compared with 79 percent. In APS2, the share is the same as that of the BAU. In APS3, due to the assumption of more renewable energy, the shares of fossil fuel-fired generation could be reduced by 6.2 percent, while in APS4, nuclear energy could reduce fossil fuel's share by almost 2 percent. In APS5, where all scenarios are combined, the reduction in the share of fossil energy-based generation will be significant, i.e. almost 12 percent lower than the BAU.

In terms of $CO_2$ emission reduction, the energy efficiency assumption in APS1 could reduce emissions by 23 percent in 2040 as compared with the BAU.

**Figure 7-8. Comparison of Scenarios to Electricity Generation in 2040**



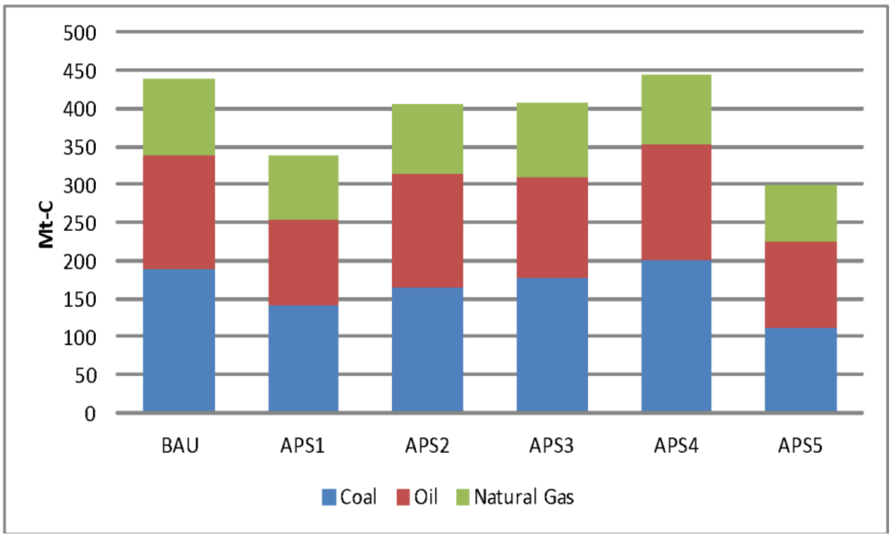

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; TWh = terawatt-hour.
Source: Author's calculations.

In APS2, the installation of more efficient new power plants is projected to reduce emissions by 7.4 percent. Higher contributions from renewable energy could reduce emissions by 7.0 percent. All these assumptions combined (APS5) could reduce BAU $CO_2$ emissions by 31.5 percent in 2040.

### 3.2.1. Final energy consumption

In the combined APS (APS5), final energy consumption is projected to increase at a slower rate than in the BAU, increasing at an average rate of 3.4 percent per year from 159 Mtoe in 2013 to 393 Mtoe in 2040. Slower growth under the APS, relative to the BAU, is projected across all sectors as a result of the government programme for EEC, particularly in the transport sector. Energy demand in the transport sector is projected to increase at a rate of 3.5 percent per year compared with 5.2 percent per year in the BAU. Figure 7-10 shows the final energy consumption by sector in 2013 and 2040 for both the BAU and the APS.

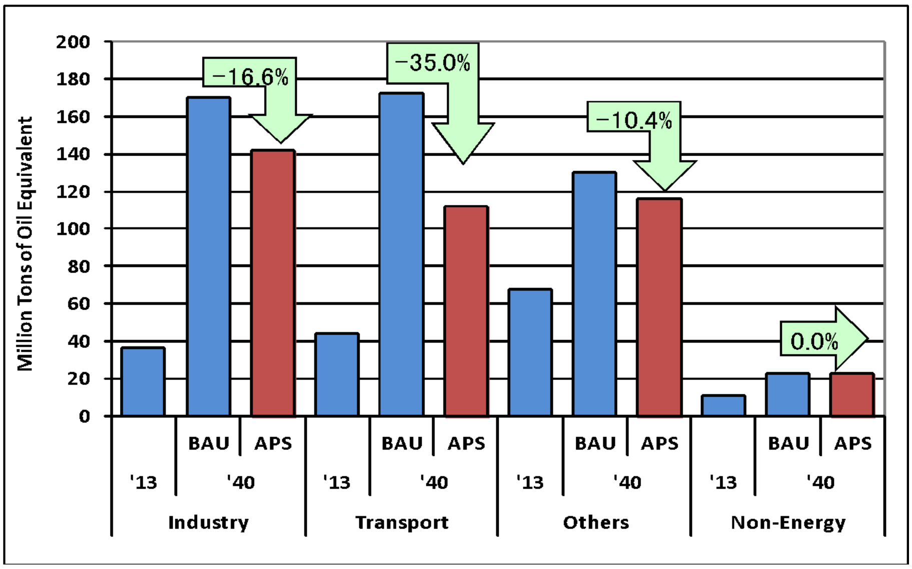
**Figure 7-9. Comparison of Scenarios to $CO_2$ Emission in 2040**




$CO_2$ = carbon dioxide; Mt-C = million tons of carbon; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculations.

In terms of final energy consumption savings, there is estimated to be a saving of 31 Mtoe in the industry sector, 42 Mtoe in the transport sector, and 13 Mtoe in the residential/commercial (other) sector by 2040 under the APS, relative to the BAU.

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



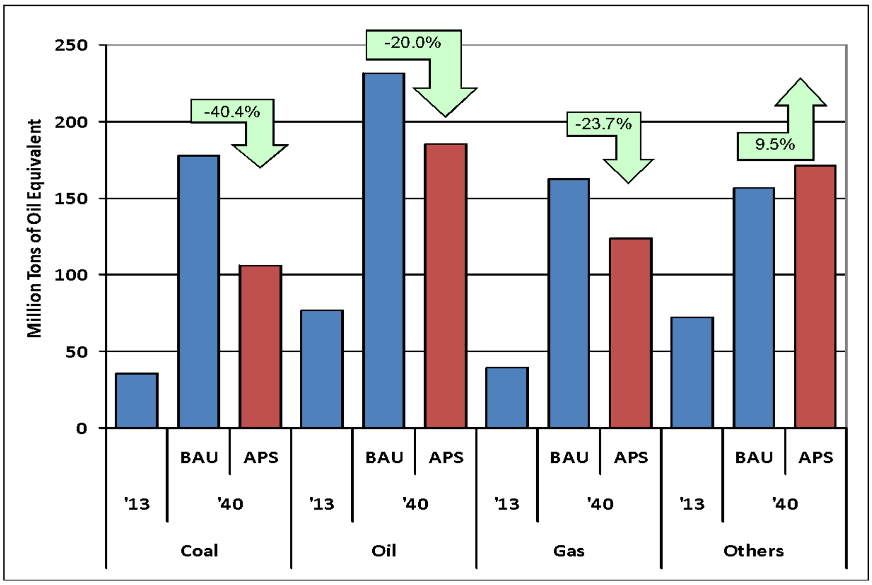

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculations.

### 3.2.2. Primary energy supply

In the combined APS (APS5), primary energy supply is projected to increase at a slower rate, relative to the BAU, at 3.6 percent per year to 587 Mtoe in 2040. All energy sources are projected to see positive average annual growth rates. However, some of these will be slower than in the BAU. The lower projected consumption relative to the BAU reflects EEC measures on the demand side and increased supply due to the use of more efficient technology for power generation.

In terms of the fuel type, there is estimated to be a saving of almost 72 Mtoe for coal, around 46 Mtoe for oil, and almost 39 Mtoe for natural gas by 2040 under the APS, relative to the BAU. In case of other resources (new and renewable resources, nuclear, and 'others') consumption in the APS in 2040 is expected to be 15 Mtoe higher than in the BAU.

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

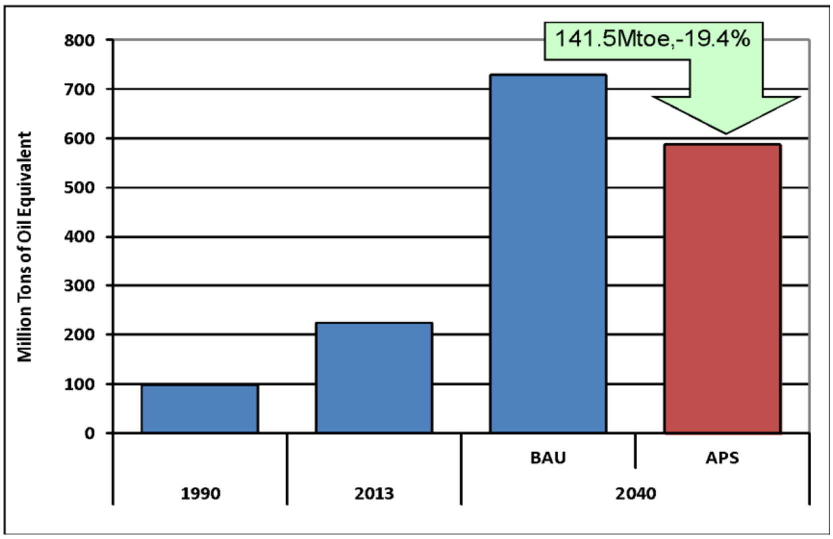



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculations.

### 3.2.3. Projected energy savings

The total energy savings (the difference between primary energy supply in the BAU and the APS) that could be achieved through the implementation of EEC and Indonesia's renewable energy targets and action plans, improved power plant efficiency, and the introduction of nuclear are projected to amount to 141.5 Mtoe in 2040. This is more than a half of Indonesia's primary energy supply in 2013, which was about 224 Mtoe.

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

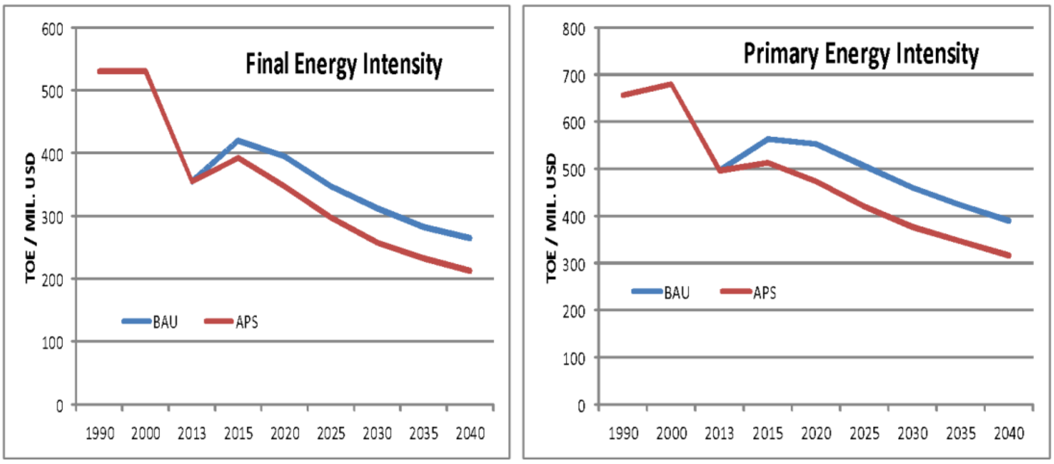



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

### 3.2.4. Energy intensities

The 2014 national energy policy emphasised the target of a 1 percent per year reduction in final energy intensity up to 2025. Under the BAU, the final energy intensity already declines at an average rate of 1.1 per year over the 2013–2040 period. Implementation of the sectoral EEC targets under the APS will result in a higher rate of decline rate for final energy intensity – 1.9 percent per year over the projection period. In terms of primary energy intensity, the annual reduction will be 0.9 percent under the BAU. In the APS, the annual reduction in primary energy intensity will be 1.7 percent due to comprehensive implementation of the sectoral EEC targets.

**Figure 7-13. Energy Intensity, BAU and APS**



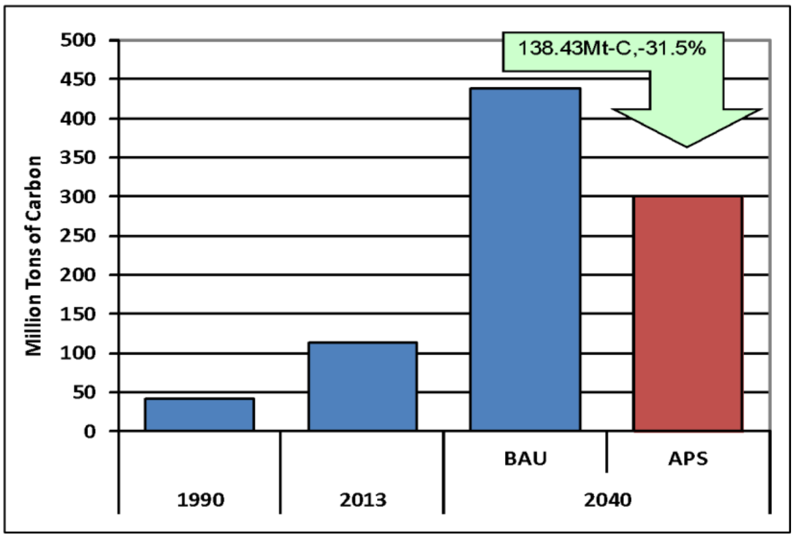

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; TOE = tons of oil equivalent; MIL = million; USD = United States dollars.
Source: Author's calculations.

### 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 5.2 percent, from around 113 Mt-C in 2013 to 439 Mt-C in 2040 in the BAU. This is driven by the increasing use of carbon intensive fuels, particularly the use of coal for power generation and industry, as well as oil in the transport sector.

In the combined APS (APS5), $CO_2$ emissions from 2013 to 2040 are expected to be 31.5 percent lower than in the BAU. This projected reduction will be due in great part to the inclusion of more energy conservation, higher efficiency, and elevated renewable targets assumed in the APS, and the inclusion of nuclear energy after 2020. The Indonesian government has committed to reducing $CO_2$ emissions by 29 percent in 2030 without international assistance and by 41 percent with international assistance.

**Figure 7-14. $CO_2$ Emissions from Energy Consumption, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's calculations.

This study's result is above the committed target of 29 percent. But to achieve the $CO_2$ reduction target of 41 percent, the combined target and action plan specified under APS5 would not be sufficient and should therefore be more aggressive.

## 4. Implications and Policy Recommendations

Indonesia's primary energy intensity (TPES/GDP) and final energy intensity (TFEC/GDP) have been declining as a result of greater utilisation of efficient energy technologies both by energy producers and consumers. Under the BAU, the primary energy intensity declines by 0.9 percent per year over the projection period. This nearly achieves the 1 percent goal stated in the 2014 National Energy Policy. Adapting the sectoral target under the APS1 combined with the renewable portfolio, efficient power plant technology, and introduction of nuclear, will allow the country's energy intensity to decline even more strongly, by 1.7 percent per year. The elasticity of primary energy supply is also projected to fall to below 1.0 under the BAU (0.8), and further to 0.7 under the assumption that the sectoral saving targets and the other policy interventions under APS2, APS3, and APS4 are fully implemented, as in the combined APS (APS5) scenario.

The primary energy supply per capita is in the range of 1.9 to 2.3 toe/person for all scenarios by 2040. This is still lower than for neighbouring countries like Thailand and Malaysia. Thus, there are still people without access to energy, as indicated by the electrification ratio of 88.5 percent in 2015. Further 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 still have the largest share in the total primary energy mix over the projection period. The 2014 National Energy Policy sets the target at less than 25 percent in 2025 and less than 20 percent in 2050. The transport sector, which is the main consumer of oil in the country, will be crucial for achieving these energy saving targets. Government should further encourage the transport sector programme through:

- Improving the public transport system
- Promoting the use of alternative fuels and more efficient vehicles

The current analysis, which assumed increased use of alternative fuels and more efficient vehicles in the transport sector and efficient boilers in the industries, resulted in oil consumption savings between the BAU and the APS as high as 23 percent in 2040. Developed countries in the region such as Japan and Australia should increase their efforts to introduce newly improved technologies to developing countries as early as possible.

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

- Expand the EEC programme to achieve a 10 percent electricity saving in government buildings and commercial buildings;
- Encourage revitalisation programmes of industries to improve the performance of boilers, burners, etc.;
- Expand labelling and performance standards for appliances in the residential sector;
- Developing regulatory framework to increase participation of the private sector and energy service companies in EEC;
- Formulating funding mechanism to develop efficient technologies and equipment.

Pursuing EEC programmes is one of the measures to reduce $CO_2$ emission to achieve the target of 29 percent committed to (without international support) and the target of 41 percent (with international support). Increasing the share of renewable energy sources in the supply mix, increasing the thermal efficiency of fossil fuel plants, and the introduction of nuclear, would result in further $CO_2$ emission reductions.

Both the BAU and the combined APS (APS5) project that renewable energy will play a major role in the country's energy mix. The government has made efforts to enhance renewable energy, such as increase the NRE shares in the 35 GW power development programme, put in place a domestic obligation for biofuels, provision of a 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. Nonetheless, further measures need to be taken to increase private sector involvement, such as improving transparency and awareness of government support mechanisms, encouraging financial institutions to participate in renewable energy projects, improving the mechanism for providing incentives to promote NRE sources, and increase collaboration with developed countries to promote low-carbon technologies.

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# Chapter 8

## Japan Country Report

September 2016

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Chapter 8

# Japan Country Report

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## 1. Background

Japan is a small island nation in Eastern Asia. It consists of several thousand islands spanning a land area of approximately 377,960 square kilometres 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 China surpassed Japan as the world's second-largest economy. Japan's real gross domestic product (GDP) in 2013 was about US$4,686 billion (constant 2005 prices), and the population is currently about 127 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 2013, Japan's net primary energy supply was 454.7 million tons of oil equivalent (Mtoe). By energy type, oil represented the largest share at 44.5 percent; coal was second at 26.7 percent; followed by natural gas (23.4 percent). Nuclear energy accounted for 0.5 percent. Others, such as hydro, geothermal, wind, and solar, made up the remaining 4.9 percent. In 2013, 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 98 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). Electricity generation mostly uses natural gas, followed by reticulated city gas, and industrial fuels. In 2013, primary natural gas consumption was 106.3 Mtoe.

Japan's final energy consumption recorded low growth of 0.2 percent per year from 297.8 Mtoe in 1990 to 311.4 Mtoe in 2013. 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 0.1 percent. Consumption in the industry sector decreased at a rate of 0.9 percent per year on average from 1990 to 2013. Oil was the most consumed product with a share of 61.2 percent in 1990, and it fell slightly, to 53.2 percent in 2013. Electricity was the second most consumed product.

Japan's primary energy supply grew at a rate of 0.1 percent per year from 439.3 Mtoe in 1990 to 454.6 Mtoe in 2013. Among the major energy sources, the fastest growing fuels were natural gas and coal. Natural gas and coal consumption grew at an average annual rate of 3.9 percent and 2.0 percent, respectively, whereas nuclear energy declined by 12.5 percent from 1990 to 2013 due to the Great East Japan Earthquake in March 2011. Oil consumption declined by 0.9 percent per year over the same period.

Japan had 289 GW of installed electricity generating capacity and generated about 1,038 TWh of electricity in 2013. The generation by energy type is broken down as follows: thermal (coal, natural gas, and oil) at 85.5 percent; nuclear (0.9 percent); hydro (7.5 percent); and geothermal, solar, and wind (6.0 percent).

## 2. Modelling Assumptions

In this outlook, Japan's real GDP is assumed to grow at an annual average rate of 1.5 percent from 2013 to 2040, projecting recovery from economic recession. In

2014, Abenomics[1] is estimated to have increased GDP strongly through the impact of economic reform to address Japan's two decades of stagnation. The approach has been known as the 'three arrows'. The first arrow would kick-start the economy out of its deflationary difficulties. Abe attempted to do this by increasing the money supply and making the country more competitive through encouraging private investment. The second arrow would address employment, and the third, which has been the most important and the most difficult arrow, announced in June 2014, composed of a number of new policies such as corporate tax rate cuts and liberalisation of the healthcare and agriculture sectors. Other measures that have been taken include changes to the investment strategy of the Government Pension Investment Fund and getting rid of a spousal tax exemption to encourage women to find work and improve their career opportunities.

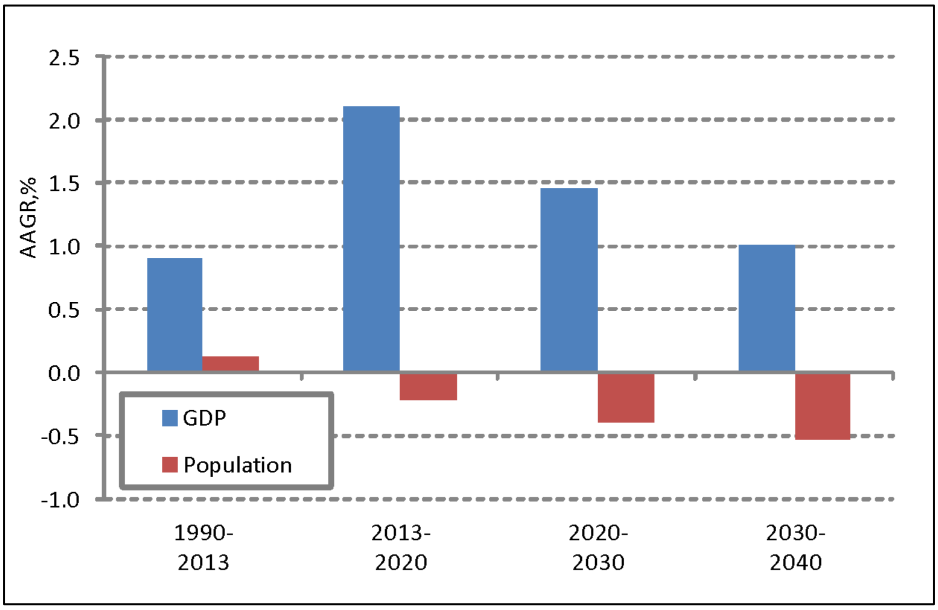
The industry structure, with the maturing of Japanese society and economy, will become increasingly oriented towards the services industry. Japan's population is projected to decline by about 0.4 percent per year from 2013 to 2040 due to the falling birth rate. This means Japan's population is expected to decrease from 127 million in 2013 to 114 million in 2040. Figure 8-1 shows the assumptions for GDP and population growth in this study.

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

The New Strategic Energy Plan was approved by the cabinet in April 2014, and based on this plan, the Long-term Energy Supply and Demand Outlook was approved by the Ministry of Economy, Trade and Industry in July 2015. It foresees that the share of nuclear power will fall sharply, from approximately 30 percent of total electricity generation before the Great East Japan Earthquake, to approximately 20 to 22 percent by 2030.

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

**Figure 8-1. Growth Rate of GDP and Population**



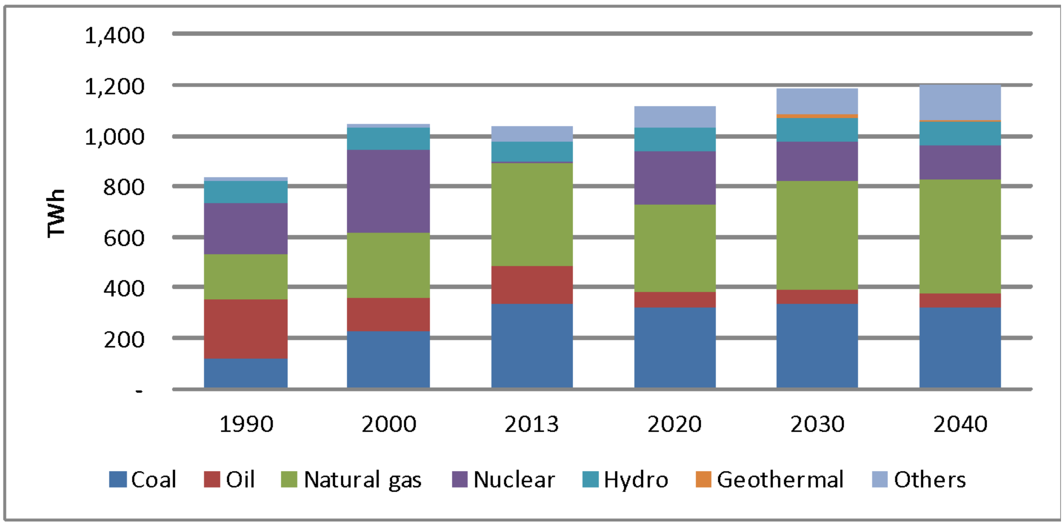

GDP = gross domestic product; AAGR = average annual growth rate.
Source: Author's calculation.

The share of renewable energy will be about 22–24 percent of total electricity generation in 2030, compared with 11 percent before the Great East Japan Earthquake. And the base load rate consisting of hydropower, coal-fired thermal power, nuclear power, etc., will be approximately 56 percent.

Figure 8-2 shows the projected power generation mix in Japan to 2040 under the Business-as-Usual scenario (BAU), and Figure 8-3 shows the assumed thermal efficiencies of thermal power plants in the BAU.

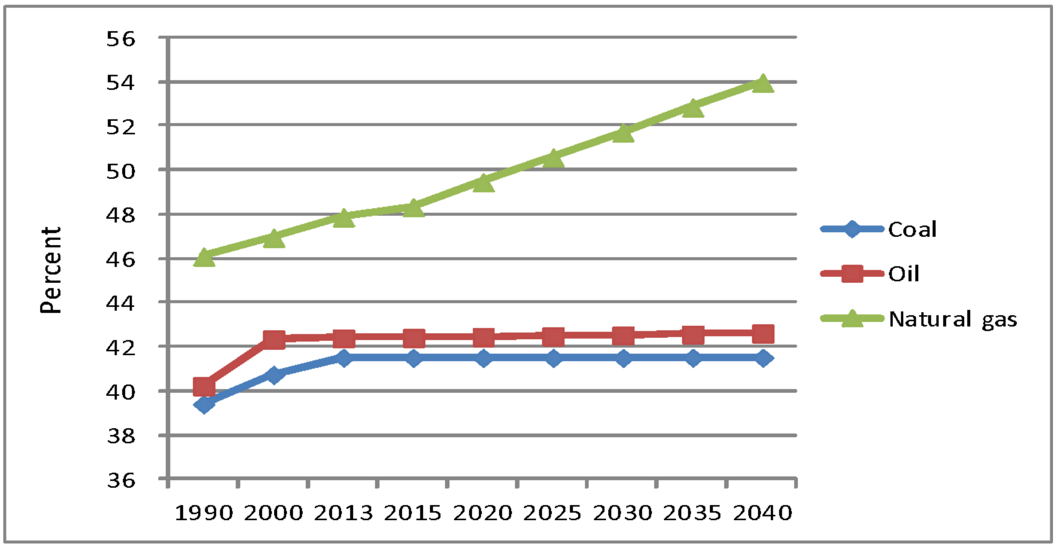
Japan's energy savings goal will be attained through the implementation of national energy efficiency programmes in all energy-consuming sectors. For the industry sector, energy savings are expected from improvements in manufacturing technologies. In the residential and commercial sectors, the 'Top Runner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

**Figure 8-2. Power Generation, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

**Figure 8-3. Thermal Efficiency, BAU**




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

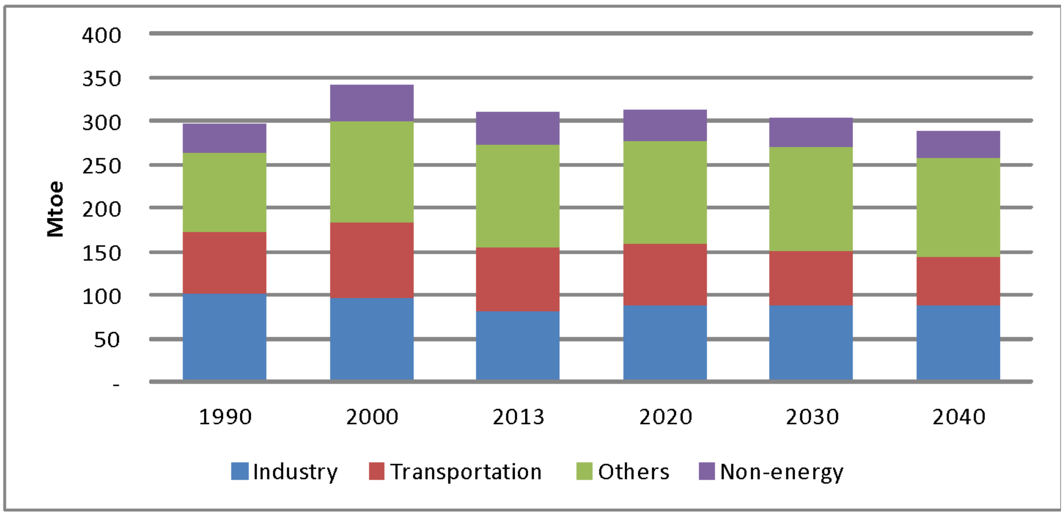
## 3. Outlook Results

### 3.1. Business-as-Usual Scenario (BAU)

#### 3.1.1. Final energy demand

With the projected relatively low economic growth and the declining population, Japan's final energy consumption from 2013 to 2040 is projected to decline at an average rate of 0.3 percent per year in the BAU scenario. This is also driven by the projected decline in the energy consumption of the transportation sector brought about by improving energy efficiency. The final energy consumption of the industrial sector is projected to increase at an annual average rate of 0.2 percent between 2013 and 2040. Figure 8-4 shows the projected final energy consumption by sector from 1990 to 2040 under BAU.

**Figure 8-4. Final Energy Consumption by Sector, BAU**



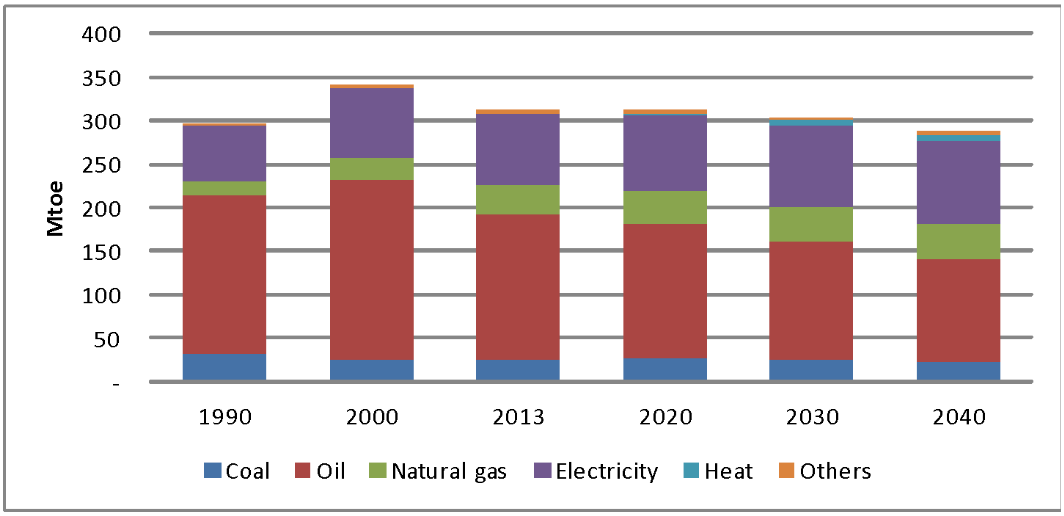

BAU = Business-as-Usual scenario; Mtoe = millions tons of oil equivalent.
Source: Author's calculation.

By fuel type, consumption of coal and oil are projected to decrease at an average annual rate of 0.5 and 1.2 percent, respectively, between 2013 and 2040. Consumption of natural gas and electricity are projected to increase, however, at a rate of 0.5 and 0.7 percent per year, respectively, over the period. Figure 8-5 shows the projected final energy consumption by source from 1990 to 2040 under the BAU.

### 3.1.2. Primary energy supply

Under BAU, Japan's total primary energy supply is projected to decrease at an average annual rate of 0.2 percent per year from 454.6 Mtoe in 2013 to 436.1 Mtoe in 2040 (Figure 8-6). This decrease is due mainly to the decreasing use of oil at an annual average growth rate of 1.5 percent over the period 2013–2040. On the other hand, nuclear and hydro will have increasing annual average growth rates of 10.3 percent and 0.7 percent, respectively.

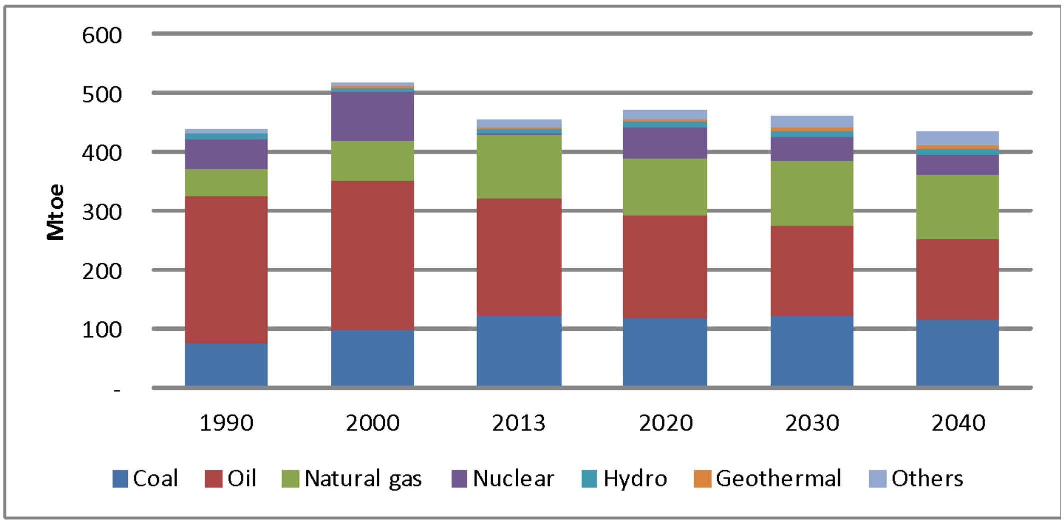
**Figure 8-5. Final Energy Consumption by Source, BAU**




BAU = Business-as-Usual scenario; Mtoe = millions tons of oil equivalent.
Source: Author's calculation.

Geothermal energy will grow at an average rate of 5.0 percent per year while other energies (such as biomass, solar, and wind) will increase at an annual rate of 2.0 percent in the same period. The share of nuclear in 2013 and 2040 is projected to increase from 0.5 percent to 7.9 percent. The Long-term Energy Supply and Demand Outlook by the Ministry of Economy, Trade and Industry highlights that the self-sufficiency rates of primary energy supply including renewable energy will increase to 24.3 percent in 2030.

**Figure 8-6. Total Primary Energy Supply, BAU**



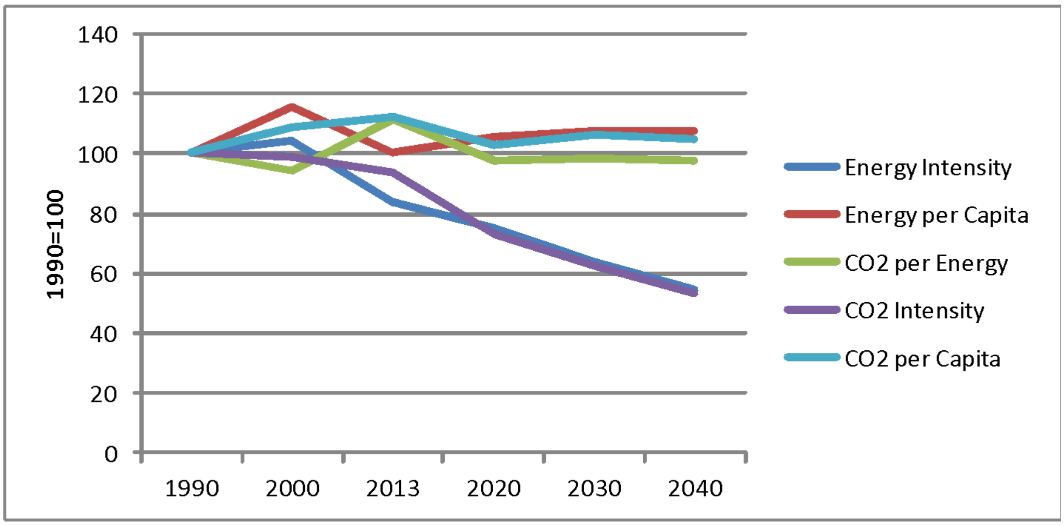

BAU = Business-as-Usual scenario; Mtoe = millions tons of oil equivalent.
Source: Author's calculation.

### 3.1.3. Energy indicators

Energy consumption per capita towards 2040 will increase at a faster rate than in the last decades. Income elasticity between 2013 and 2040 is expected to be negative, because the growth rate of energy consumption is expected to be negative and the GDP growth rate is forecast to be positive.

Except for energy consumption per capita, all other energy indicators will see decreases from 2013 levels by 2040. The carbon dioxide ($CO_2$) intensity carbonisation rate – $CO_2$ emission per unit of energy consumption – will be about 45 percent lower than 1990 levels and about 40 percent lower than in 2013. Figure 8-7 shows the evolution of various indicators of energy consumption in Japan from 1990 to 2040 under BAU.

**Figure 8-7. Indices of Energy and $CO_2$ Intensities, Energy per Capita and Carbonisation Rate, BAU (1990 level = 100)**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario.
Source: Author's calculation.

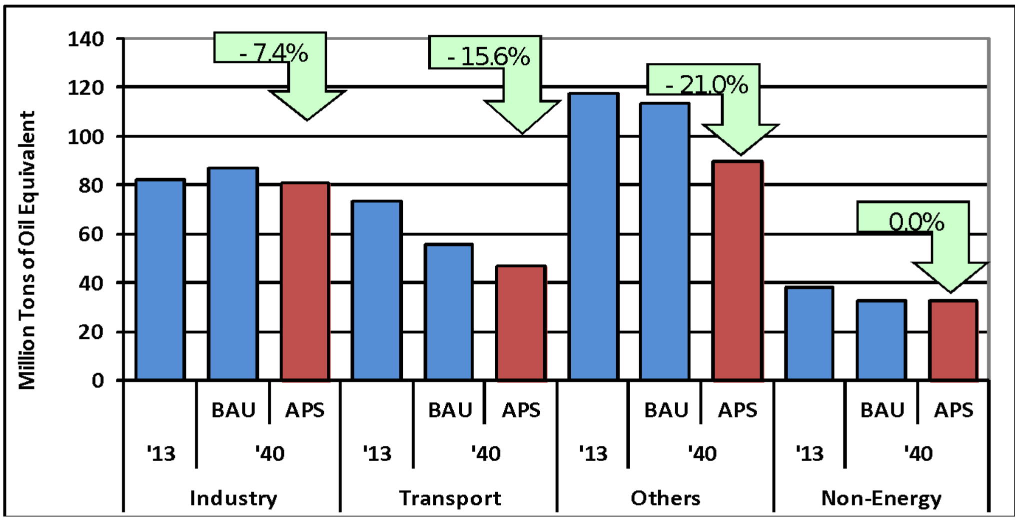
## 3.2. Energy Saving and $CO_2$ Reduction Potential

### 3.2.1. Final energy demand

In the Alternative Policy Scenario (APS), final energy consumption is projected to decline at a faster rate of 0.8 percent per year from 311.4 Mtoe in 2013 to 250.4 Mtoe in 2040. A rapid decline of 1.7 percent per year will be experienced in the transport sector due to the Top Runner Program and more aggressive energy management systems. Japan will make continuous efforts to improve energy efficiency, especially with regard to introducing energy efficient automobiles such as hybrid vehicles, electric vehicles, and plug-in hybrid electric vehicles.

The industry sector and services 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 consumption by sector in BAU and APS are shown in Figure 8-8.

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

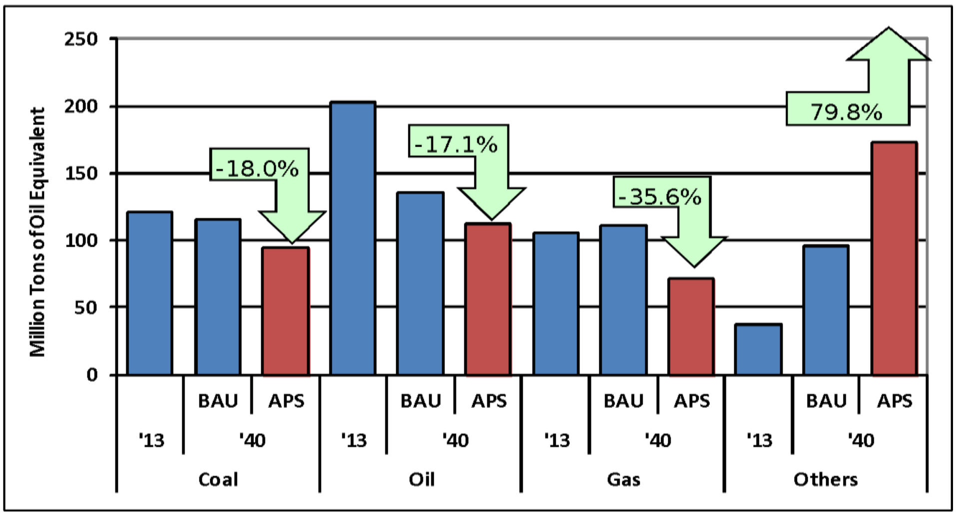



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

### 3.2.2. Primary energy supply

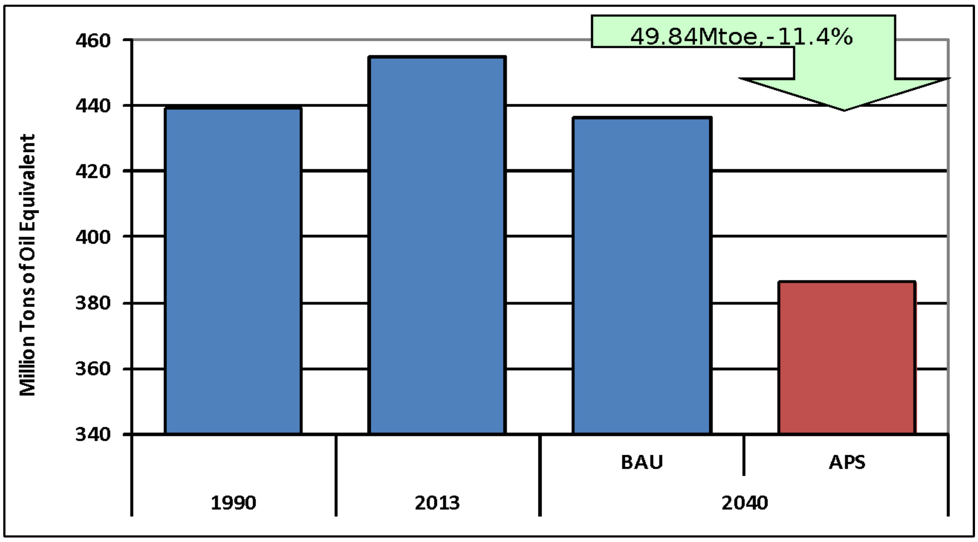
In the APS, the projected primary energy supply of Japan will decline at a rate of 0.6 percent per year to 386.3 Mtoe in 2040, 68.4 Mtoe lower than primary demand in 2013. Coal, oil, and natural gas will see decreasing annual average growth rates of 0.9 percent, 2.2 percent, and 1.4 percent, respectively. These decreases are due mainly to the increase of nuclear. Nuclear will have an increasing annual average growth rate of 12.4 percent. Figure 8-9 shows the primary energy supply by source under BAU and APS.

**Figure 8-9. Primary Energy Supply by Source, BAU and APS**




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

**Figure 8-10. Total Primary Energy Supply, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.2.3. Projected energy saving

The energy savings that could be derived from Japan's action plans amount to 49.8 Mtoe, the difference between the primary energy supply of the BAU and the APS (Figure 8-10). This is equivalent to an 11.4 percent reduction in Japan's BAU consumption in 2040.

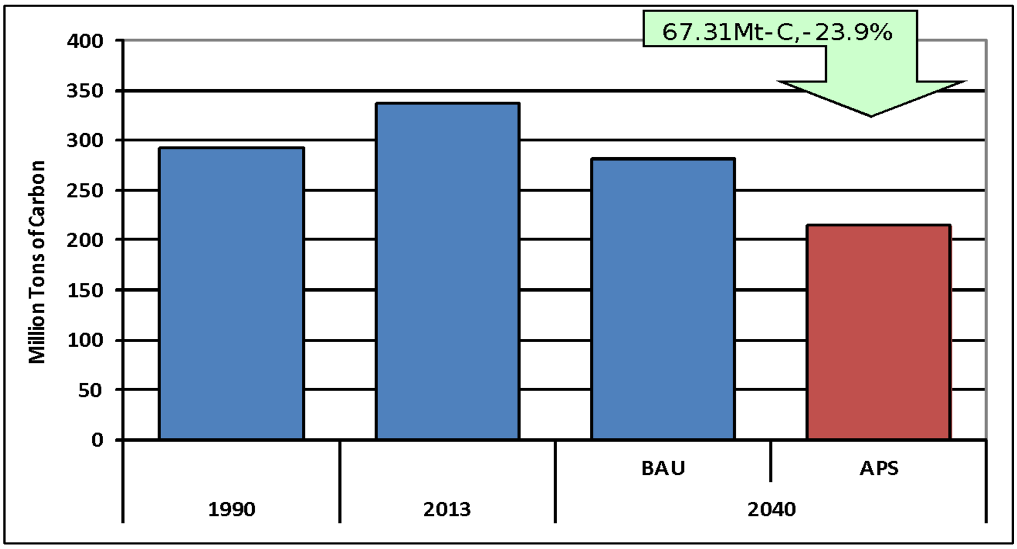
In terms of savings in final energy demand, there is an estimated saving of 23.9 Mtoe in the residential/commercial sector, and 8.7 Mtoe in the transportation sector in 2040 in the APS, relative to the BAU. The projected decreases in the consumption of the transportation sector from 2013 to 2040 are 17.8 Mtoe in the BAU and 26.7 Mtoe in the APS. This is attributable to the increase in more efficient vehicles.

### 3.2.4. $CO_2$ emissions from energy consumption

Under BAU, $CO_2$ emissions from energy consumption are projected to decrease at an average annual rate of 0.7 percent from 336.6 metric tons of carbon (Mt-C) in 2013 to 282.0 Mt-C in 2040 (Figure 8-11).

Under APS, the annual decrease in $CO_2$ emissions from 2013 to 2040 is projected to decline at an average annual rate of 1.7 percent. This rate of decrease is higher than that of primary energy supply of 0.6 percent. This indicates that the energy savings goals and action plans of Japan are very effective in reducing $CO_2$ emissions.

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




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = metric tons of carbon.
Source: Author's calculation.

## 4. Implications and Policy Recommendations

Japan's primary energy intensity has been declining since 1980 and it is the lowest 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.

The New Strategic Energy Plan was approved by the cabinet in April 2014. Based on the plan, the Long-term Energy Supply and Demand Outlook was approved by the Ministry of Economy, Trade and Industry in July 2015; it presents the ideal structure of energy supply and demand. This can be realised if appropriate measures are taken based on the fundamental direction of energy policies. Japan's envisioned policy objectives are safety, energy security, economic efficiency, and environment, which are the basic ideals of its energy policies.

In APS, which is estimated based on the Outlook, and even in BAU, $CO_2$ emissions in 2040 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 26 percent in 2030 compared with the 2013 level. However, to achieve the target, Japan should effectively implement its policies on low-carbon technology, including both energy efficiency and zero emission energy. Regarding energy efficiency, the APS (higher aim of renewable share and energy saving technology) needs the promotional policies such as the required 1 percent improvement per year for large energy-consuming companies and the target of a 50 percent share in total sales of vehicles for hybrid vehicles. Regarding zero emission energy, renewable energy in Japan is concentrated in photovoltaics (PV). However, it needs to promote stable power sources such as geothermal and small hydro as well. To achieve the APS, it is necessary to restart nuclear plants under the improved nuclear safety system and based on intensive and effective communication with local residents.

In addition, as the world leader in energy efficiency, Japan should introduce such successful policies to other countries as early as possible. By doing so, Japan will be able to more effectively contribute to reducing world energy consumption, which would mean more available energy for the future years to come. This would benefit Japan economically as well. Therefore, Japan should look not only at its own market but also at the world market as a whole when developing policies regarding energy efficiency and low-carbon energy.

# Chapter 9

## Republic of Korea Country Report

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Chapter 9

# Republic of Korea Country Report

**KYUNG-JIN BOO**, TECHNOLOGY, MANAGEMENT, ECONOMICS, POLICY PROGRAM, COLLEGE OF ENGINEERING, SEOUL NATIONAL UNIVERSITY

## 1. Background

The Republic of Korea (henceforth, Korea) is located in the southern half of the Korean Peninsula and shares a 238 km border with North Korea. It occupies 100,188 square kilometres and includes about 3,000, mostly small, uninhabited islands. Korea is a mountainous country with lowlands accounting for only 30 percent of the total land area. The climate is temperate, with heavy rainfall in summer. As of 2015, Korea has a population of 50.62 million, over 90 percent of which live in urban areas. Korea has recorded tremendous economic growth over the past half century. Its 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 Korea from continuing economic growth. However, due to the recent deterioration in the global economy, growth slowed, recording 2.3 percent in 2012, before recovering to 2.9 percent in 2013 and 3.3 percent in 2014.[1] The Korean economy is dominated by manufacturing, particularly electronic products, passenger vehicles, and petrochemicals. Agriculture, forestry, and fishing made up only 2.1 percent of total GDP in 2014.

Korea has no domestic oil resources and has produced only a small amount of anthracite coal. It imports most of its coal, which is bituminous coal. In 2013,

[1] Bank of Korea, 2015.

Korea had to import 95.7 percent of its energy needs. It is the fifth-largest oil importer and the second largest importer of liquefied natural gas (LNG) in the world.

Total primary consumption in 2013 was 263.83 Mtoe, increasing by 4.6 percent per year from 1990. Although primary energy supply is dominated by oil and coal, nuclear power and LNG also supply a significant share of the country's primary energy. The strongest growth from 1990 to 2013 occurred in natural gas (13.2 percent per year) and coal (5.0 percent per year). Oil and nuclear uses increased at the relatively slower rates of 2.9 and 4.3 percent per year, respectively.

Final energy consumption in 2013 was 167.84 Mtoe, increasing at an average annual rate of 4.2 percent from 1990. The industry sector accounted for 28.4 percent of final energy consumption in 2013, followed by 'others' (26.8 percent) and transportation (18.7 percent). Consumption of natural gas in the industry sector has grown two and half times in the last decade and oil accounts for nearly half of the industry sector's energy consumption.

In 2013, electric power generators in Korea produced 537.89 terawatt-hour (TWh) of electricity, with coal and nuclear combined providing more than two thirds of Korea's electricity. Natural gas accounted for 26.9 percent of generation in 2013. Total electricity consumption grew at an average annual rate of 7.3 percent from 1990 to 2013. When broken down by fuel, coal, natural gas, and nuclear grew at an average annual rate of 11.7 percent, 12.5 percent, and 4.3 percent, respectively, from 1990 to 2013. But over the same period oil recorded much lower growth, at an annual average rate of 0.6 percent. Other energy sources such as new and renewable energies showed rapid growth, at an annual rate of 45.7 percent.

Since the 1990s, the Korean government has produced five Basic Plans for Rational Energy Use. They are revised every 5 years and contain a variety of policy tools and programmes developed and implemented under the auspices 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 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 Use has a variety of key policy tools and programmes to attain the energy savings target. Among them are voluntary agreements, energy audits, energy service companies, appliance labelling and Standards, Fuel Economy, and Public Transit and Mode Shifting. These policy tools have been and will continue to play important roles in energy savings.

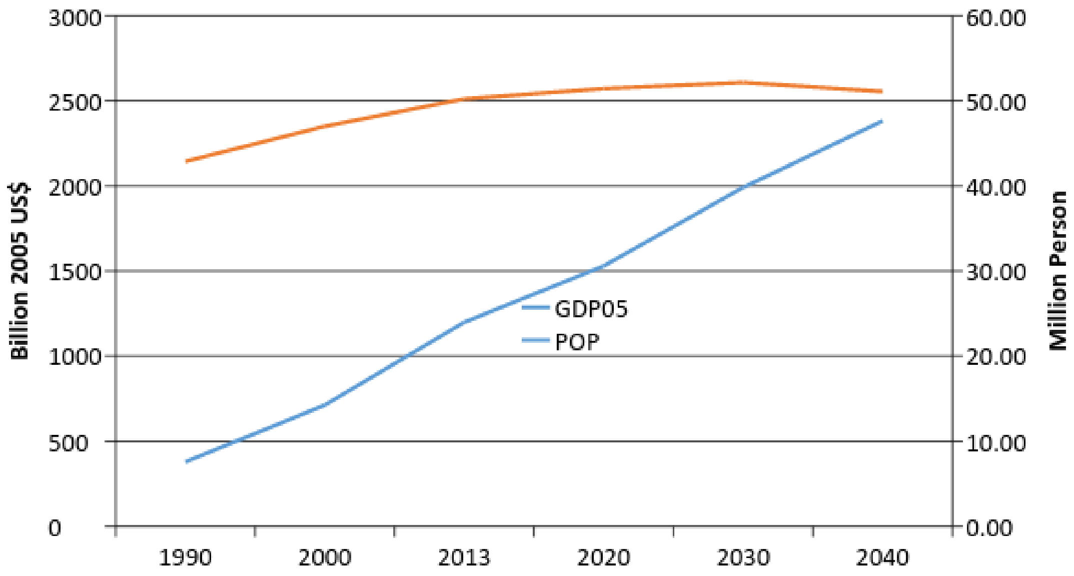
## 2. Modelling Assumptions

Korea's GDP expanded at an average annual rate of 5.1 percent between 1990 and 2013. In this report, Korea's GDP is assumed to grow at an average annual rate of 2.6 percent from 2013 to 2040. Following the global recession in 2009, the Korean economy has been a little bit shaken, but it is still in good shape and growth is expected to recover to an annual average 3.5 percent from 2013 to 2020, before slowing to an annual average 2.7 percent from 2020 to 2030, and to 1.8 percent from 2030 to 2040.

Korea is expected to continue to rely heavily on coal and nuclear energy for power generation to meet the base load. Gas-fired power generation is projected to increase between 2013 and 2040, whereas oil-fired generation is projected to decline. Generation from hydro sources is projected to remain relatively stable. There is projected to be strong growth in electricity generation from wind power and solar photovoltaic (PV), driven by the renewable portfolio standards (RPS), launched in January 2012.

Korea's energy saving goal can be attained through implementing energy efficiency improvement programmes in all energy sectors.

**Figure 9-1. Assumptions for GDP and Population**




GDP = gross domestic product; GDP05 = GDP at constant 2005 prices; POP = population.
Source: Author's calculation.

In the industrial sector, energy saving is expected from the expansion of Voluntary Agreements, 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 ('others') sector, a minimum efficiency standards programme is projected to induce huge savings in addition to 'e-Standby Korea 2010.'

## 3. Outlook Results

### 3.1. Final Energy Consumption

Korea's final energy consumption registered annual average growth of 4.2 percent from 64.9 Mtoe in 1990 to 167.84 Mtoe in 2013.[2] The non-energy sector had the highest growth rate during this period, at 8.5 percent per year, followed by the industry sector with 4.0 percent. Energy consumption in the

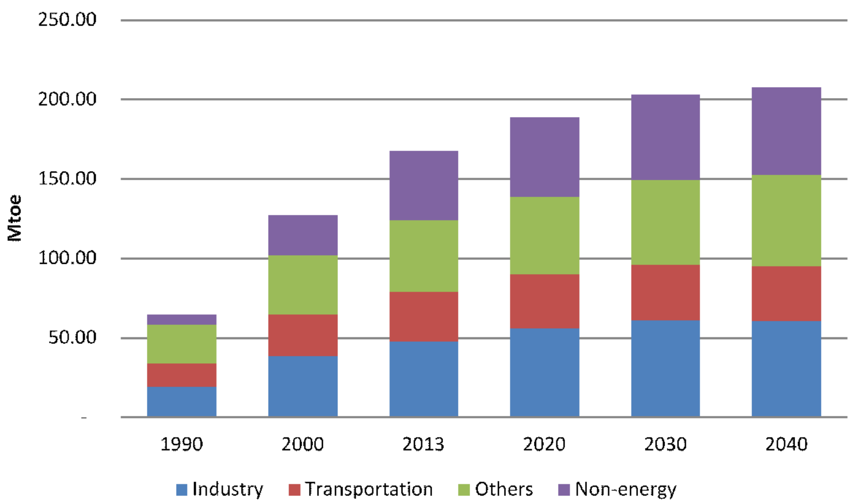
[2] Energy consumption is calculated based on net calorific values, as converted by IEEJ from original data submitted by the Republic of Korea.

residential/commercial/public (other) sector grew at a relatively slow pace of 2.7 percent per year. Oil was the most consumed product, with its 1990 share of 67.3 percent declining to 50.4 percent in 2013. The share of coal in final energy consumption fell by 12.3 percentage points between 1990 and 2013, whereas the share of electricity doubled to become the second most consumed product.

### 3.2. Business-as-Usual Scenario (BAU)

With an assumption of low economic and population growth, final energy consumption in Korea is projected to increase at a low average rate of 0.8 percent per year between 2013 and 2040 under the Business-as-Usual scenario (BAU). This is largely due to low projected growth of energy consumption in transportation, where it is expected to slow to an annual average rate of 0.3 percent between 2013 and 2040. Growth in final energy consumption is expected to be led by the industrial and the non-energy sector up to 2020, at 2.3 percent and 1.8 percent, respectively, per year, before being overtaken by the other sectors, such as the residential, commercial, and public sectors, and grow at only 0.9 percent up to 2030. After 2030, all sectors are expected to slow to a rate of less than 0.5 percent or see negative annual average growth of -0.1 percent except for the 'others' sector.

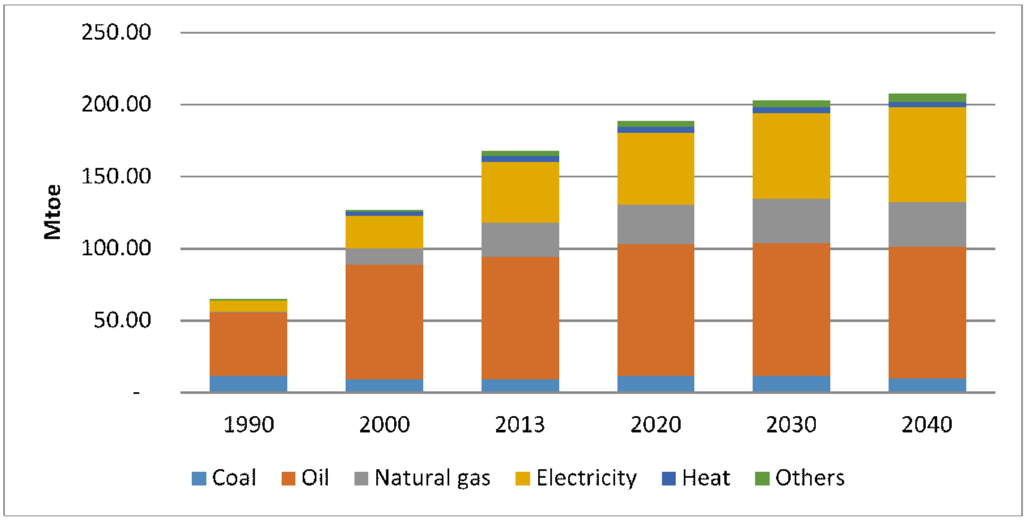
**Figure 9-2. Final Energy Consumption by Sector, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Final energy consumption by energy types is expected to see a pattern similar to that of energy consumption by sector. The average annual growth rate for 2013 to 2040 is projected at 0.1 percent for coal, 0.3 percent for oil, 0.9 percent for natural gas, 1.7 percent for electricity, and -0.3 percent for heat. Heat energy consumption is anticipated to peak between 2013 and 2015, and slowly decrease thereafter, showing a negative growth rate. This is because of the projected decrease in population and changing life styles that use more electricity for heating. Other energy types, including renewable energies, are expected to grow at 1.8 percent per year, faster than other energies. Increasing use of renewable energies, in addition to natural gas, as clean and green energy, will make a significant contribution to the projected reduction in carbon dioxide ($CO_2$) emissions.

**Figure 9-3. Final Energy Consumption by Energy, BAU**



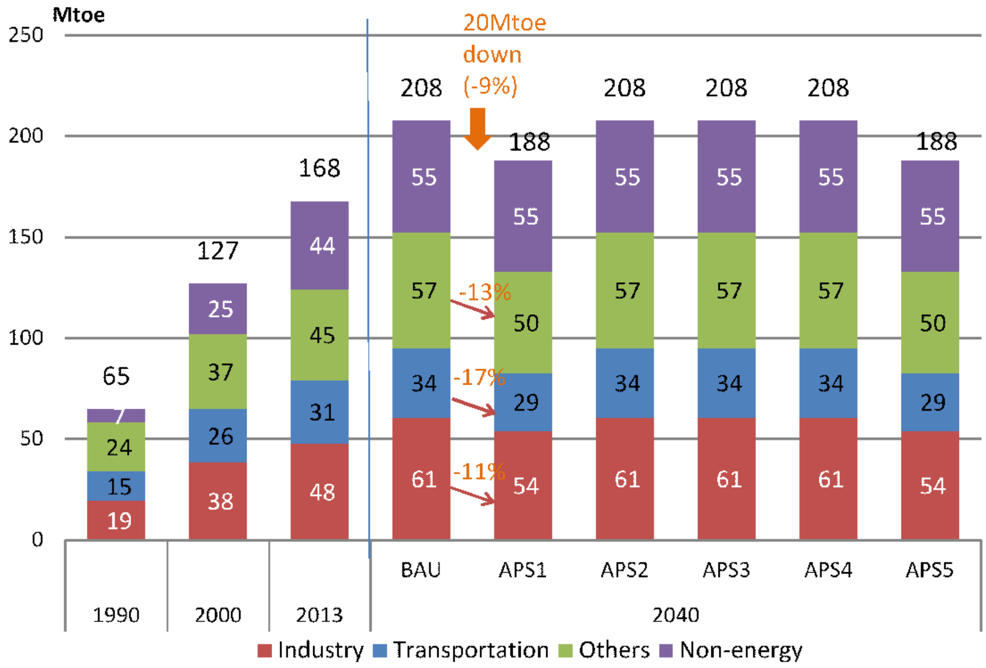

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.3. Alternative Policy Scenarios (APS)

In this section, five alternative scenarios are developed based on the focus of policy options: first, improved efficiency of final energy consumption (APS1); second, more efficient thermal power generation (APS2); third, higher contribution of renewable energy to total supply (APS3); fourth, contribution of nuclear energy to total supply (APS4); and finally, the combined effects of APS 1–4 (APS5).

Final energy consumption by sector in each APS is shown in Figure 9-5. Total final energy consumption is to be reduced only in the case of APS1 (improved efficiency), showing 188.0 Mtoe, which is 19.7 Mtoe (9.5 percent) lower than that in the BAU. Other APS are the same, with 207.7 ktoe for APS2–APS4. The total amount and share of final energy consumption by sector is the same as in the case of BAU. Accordingly, APS5, which combines all APS, gives 188.0 Mtoe, 19.7 Mtoe (9.5 percent) lower than in the BAU, and the same as in APS1.

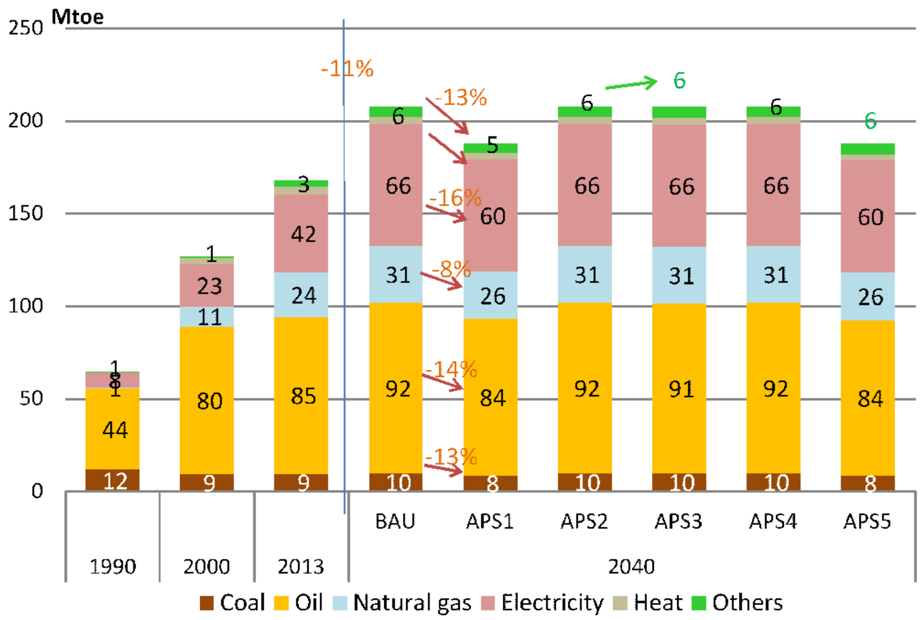
**Figure 9-4. Final Energy Consumption by Sector, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Final energy consumption by energy in all scenarios is shown in Figure 9-5. In APS1 (improved efficiency), electricity accounts for the largest share of energy saving, followed by oil and natural gas. Unlike in the case of final energy consumption by sector, energy demand by energy source shows only a little change depending on the specific policy approach of each scenario. In APS3 (higher contribution of renewable energy to total supply), the category of 'others,' including renewable energy, is to be increased by 0.5 Mtoe more than in 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.

**Figure 9-5. Final Energy Consumption by Energy, BAU and APS**



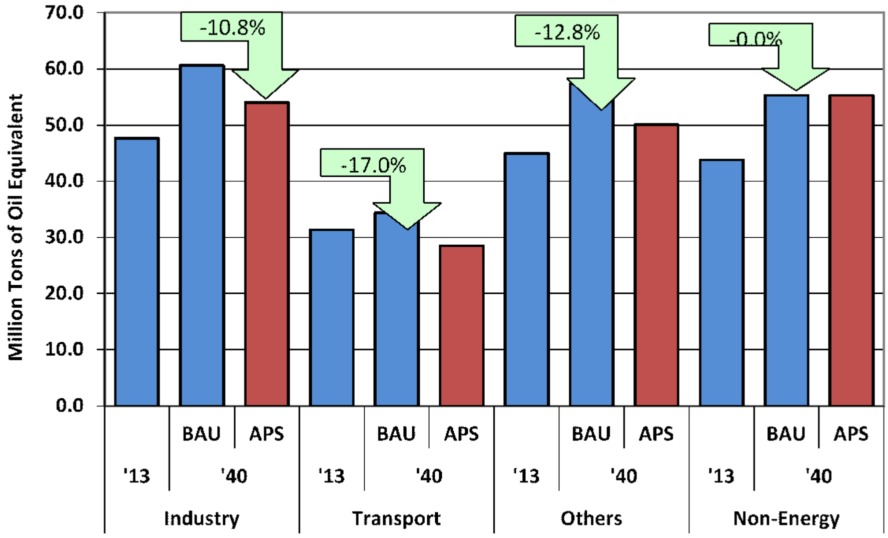

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

In APS5, which combines APS1, APS2, APS3, and APS4, final energy consumption is projected to increase at an average annual rate of 0.4 percent from 167.8Mtoe in 2013 to 188.0 Mtoe in 2040. Energy demand in the transportation sector is projected to decrease at an annual average rate of -0.4 percent over the same period. The rate of growth is much slower across all sectors as compared with the BAU (Figure 9-6).

### 3.4. Primary Energy Supply

Primary energy supply in Korea grew at an average rate of 4.6 percent from 92.9 Mtoe in 1990 to 263.8 Mtoe in 2013. Among the major energy sources, natural gas was the fastest growing at an average annual rate of 13.2 percent. In contrast, coal grew at a rate of 5.0 percent a year, followed by nuclear and oil at 4.3 percent and 2.9 percent, respectively, over the same period.

**Figure 9-6. Final Energy Consumption by Sector, BAU and APS**




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

Other energy sources, mainly renewable energies such as solar, wind, biomass, and ocean energy, grew rapidly at a rate of 8.8 percent over the same period, which indicates that the Korean government has been successfully implementing its Low Carbon Green Growth policy.

### *Business-as-Usual Scenario (BAU)*

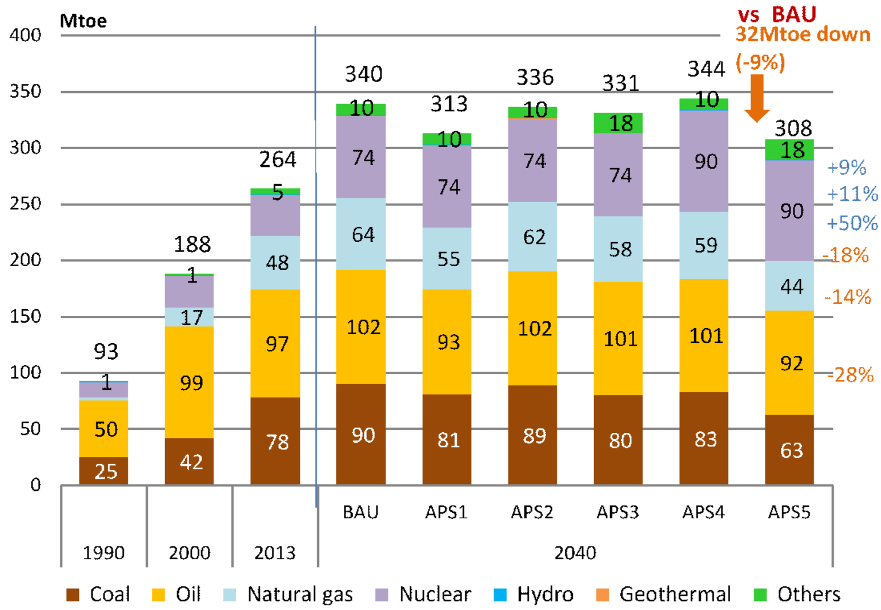
In BAU, primary energy supply in Korea is projected to increase at an annual average rate of 0.9 percent from 263.8 Mtoe in 2013 to 339.6 Mtoe in 2040. Growth for all the energy sources is projected to slow. Consumption of nuclear shows the fastest growth with a rate of 2.7 percent per year, and natural gas and coal show much slower average annual growth rates of 1.1 percent and 0.5 percent, respectively, from 2013 to 2040. The projected growth in nuclear will largely be at the expense of oil, with the share of oil expected to decline from 36.6 percent in 2013 to 29.9 percent in 2040.

### *Alternative Policy Scenario*

Based on the projection and analysis of final energy consumption by sector and by energy source, primary energy supply is projected for all five scenarios.

Unlike in final energy consumption, each APS has different amounts and shares by energy source depending on their specific policy focus. Except for APS4 (contribution of nuclear energy to total supply), APS1, APS2, and APS3 have a primary energy supply lower than BAU. Among those APS, APS1 (improved efficiency of final energy consumption) has the lowest consumption, at 313.0 Mtoe, which is 7.8 percent lower than that in the BAU, followed by APS3 (higher contribution of renewable energy to total supply), at 331.4 Mtoe, and APS2 (more efficient thermal power generation), at 336.5 Mtoe. In APS1, the largest reduction is in the consumption of natural gas, 14.0 percent, followed by coal, 10.1 percent, and oil, 8.1 percent. Nuclear and others (renewable energies) are the same as in the BAU.

**Figure 9-7. Primary Energy Supply by Energy, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

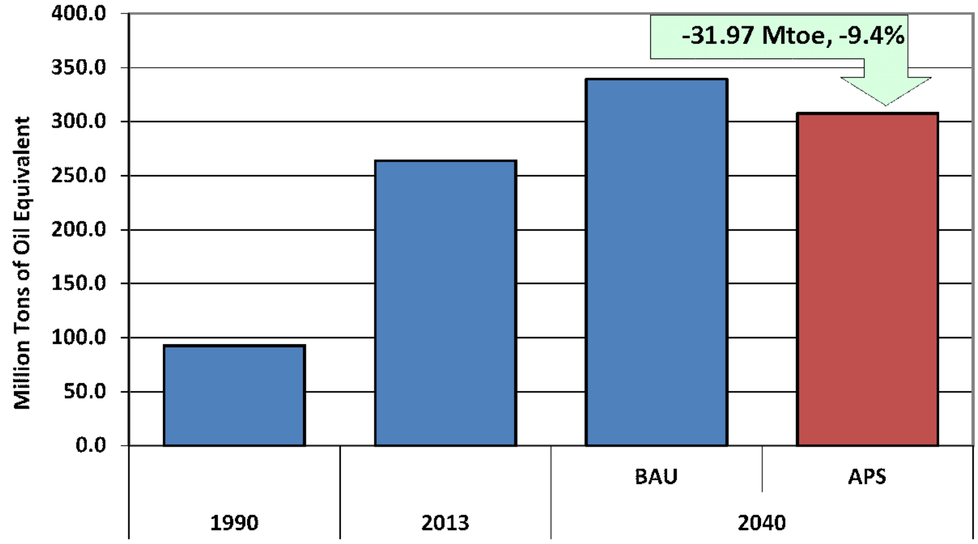
In APS5, which combines all other APS, primary energy supply is projected to increase at a lower rate of 0.6 percent per year from 263.8 Mtoe in 2013 to 307.57 Mtoe in 2040. Fossil fuels such as coal, oil, and natural gas will gradually decrease their consumption from 2013 to 2040, whereas nuclear and renewable energies will increase their consumption by 3.4 percent and 4.7 percent per year, respectively (Figure 9-7). Energy efficiency and conservation (EEC) measures on the demand side will be the main contributors to the projected reduction in consumption growth.

### *Projected Energy Saving*

Major energy policy approaches to reducing energy demand in Korea are as follows: First, energy policy should be shifted from a supply-oriented approach to a demand-oriented one. Reform of energy pricing and energy taxation is the most pressing issue. In this context, market mechanisms should be introduced in energy pricing so that rational energy use is induced through the sharing of full information on the 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 industries and green industries, which consume less, and cleaner energies. Third, energy efficiency standards and codes should be applied in product design and production processes as well as in the design and construction of systems such as factories, buildings, and plants. Under these policy directions, the Korean government should develop and implement an action plan that contains milestones and strategies with specific and cost-effective policy tools.

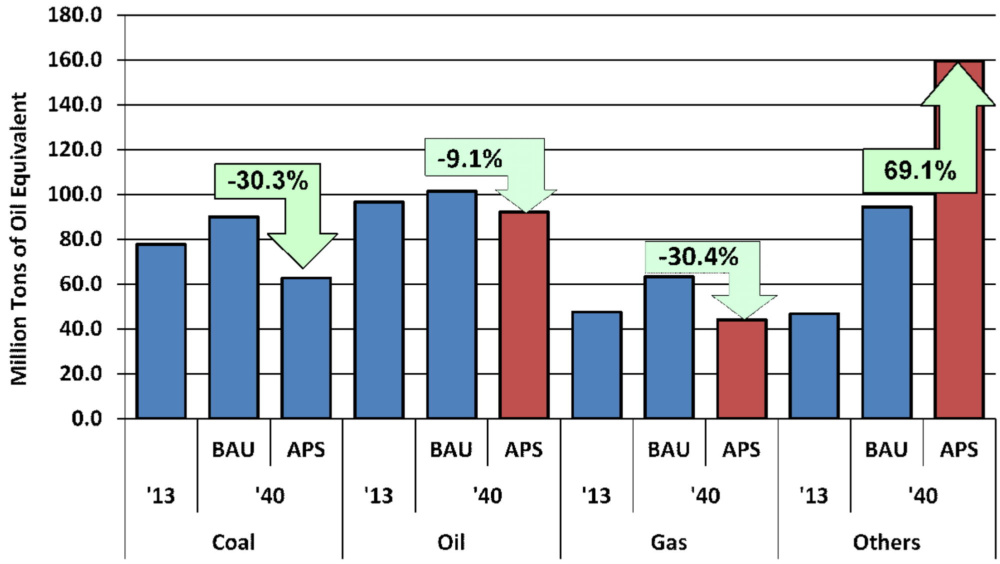
The energy savings that could be derived from the energy saving targets, action plans, and policy tools in Korea, as briefly mentioned in the previous paragraph, is 31.97 Mtoe, the difference between primary energy supply in the BAU and the APS in 2040 (Figure 9-8). This is equivalent to 12.1 percent of Korea’s consumption in 2013. Figure 9-9 shows the energy savings potential by energy source. Among the energy sources, gas and coal have the largest projected reduction in energy demand at rates of -30.4 percent and -30.3 percent, respectively, followed by oil at -9.1 percent. In contrast, other energy sources such as nuclear and renewable energies increase by 69.1 percent compared with the BAU.

**Figure 9-8. Total Primary Energy Supply, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

**Figure 9-9. Primary Energy Supply by Source, BAU and APS**



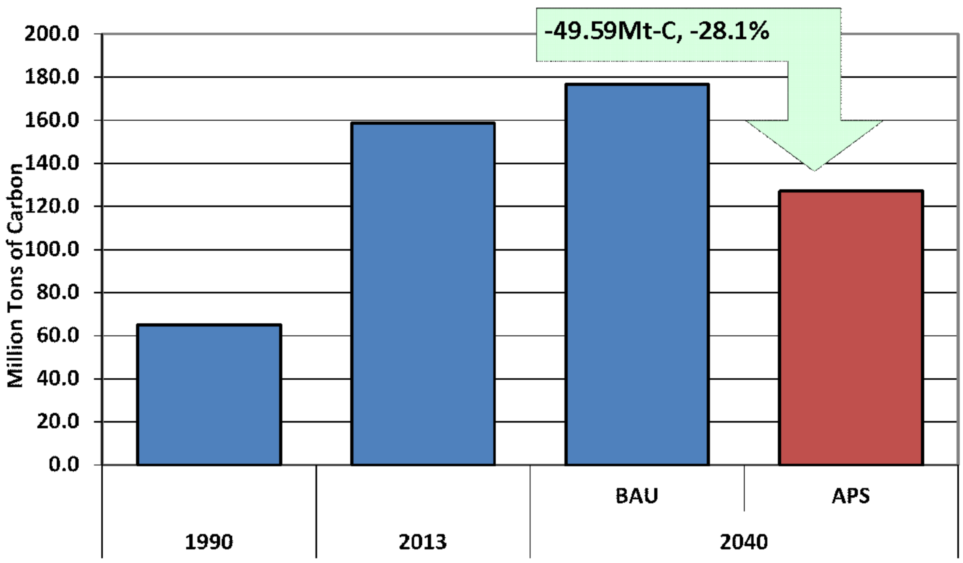

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

### 3.5. Carbon Dioxide ($CO_2$) Emissions from Energy Consumption

$CO_2$ emissions from energy consumption are projected to increase at an annual average rate of 0.4 percent from 158.7 Mt C in 2013 to 176.7Mt C in 2040, based on the BAU. This growth rate is slower than that for primary energy supply, indicating that 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 -0.8 percent between 2013 and 2040. The difference in $CO_2$ emissions between the BAU and APS is 49.59 Mt C, a -28.1 percent decrease (Figure 9-10). To attain such an ambitious target, the Korean government will have to develop and implement cost-effective and consensus-based action plans for energy saving and $CO_2$ emissions reduction.

**Figure 9-10. $CO_2$ Emission from Energy Consumption, BAU and APS**

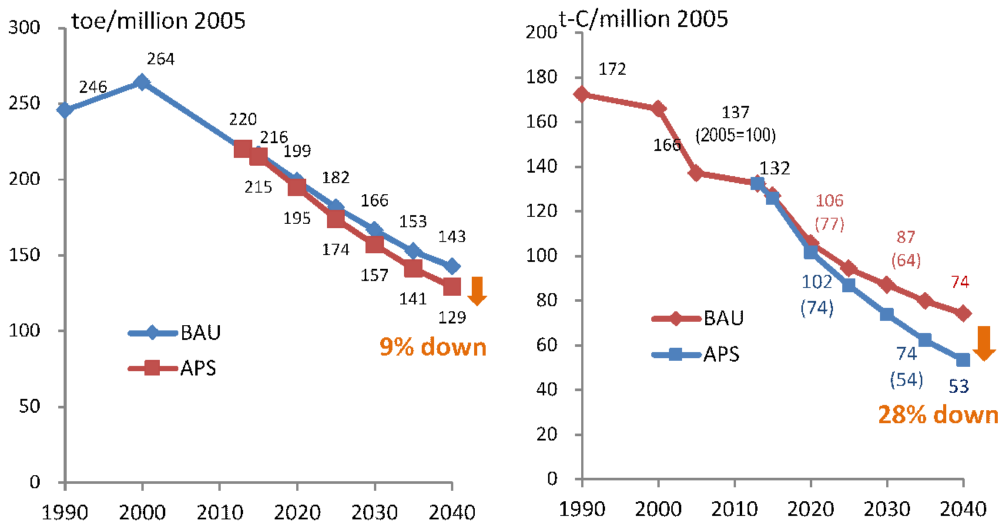



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.6. Energy and Carbon Intensity

As a result of energy savings, the energy intensity of GDP is projected to improve, as shown in Figure 9-11. In the BAU, energy consumption per unit of GDP (toe/million 2005 US$) is projected to fall from 220 to 143, which is a 35.2 percent improvement. In the APS it is expected to improve by 41.4 percent. The energy intensity in the APS is 10 percent below that in the BAU. Carbon intensity is also projected to improve for both the BAU and the APS, mainly due to the forecast reduction in the primary energy supply in terms of energy intensity. The improvement in carbon intensity, $CO_2$ emissions per unit of GDP (t-C/million 2005 US$), is more salient than the improvement in energy intensity. It is projected to decrease from 132 to 74 and 53 for BAU and APS, by 44 percent and 60 percent, respectively.

**Figure 9-11. Energy and Carbon Intensities**




toe = tons of oil equivalent; t-C = tons of carbon; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

## 4. Implications and Policy Recommendations

Korea, even without any domestic energy resources economically available, has been making great strides in economic growth, unprecedented in any other countries. Such huge 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 entering the 21st century, the Korean government shifted its energy policy to a sustainable, efficient, and energy saving approach, which was to some extent reflected in the 1st (2008) and 2nd (2013) National Energy Basic Plans.

Korea's total primary and final energy consumption in the 1990s had 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 Korea's GDP has gradually declined, resulting in reduced energy intensity. However, the shift to a less energy-intensive industrial structure takes time, which means that energy-intensive industry will prevail for the short- to mid-term future. But in the longer term, Korea will and has to transform its industrial structure into a less energy-intensive one.

As mentioned above, the government recently released the 2nd National Energy Basic Plan,[3] with a complete shift from a supply-oriented to a demand-oriented approach. Its basic policy direction consists of six major agendas, with demand-oriented energy policy as a first priority. The other five are (i) building a distributed generation, (ii) harmonisation of the environment and safety, (iii) strengthened energy security, (iv) stable energy supply, and (v) implementation of energy policy with people's support.

As the first priority, energy policy will shift to a demand-oriented approach. The target is to save 13 percent of the total primary energy supply along with 15 percent of electric power consumption. Under this agenda, four policy tasks are proposed: (i) reform of energy-related taxation, (ii) reform of energy pricing, (iii) information and communications technology (ICT)–based demand management, and (iv) strengthening programmes by sector. Reform of energy-related taxation as well as energy pricing is intended to induce a rational use of electricity by coordinating relative prices between electricity and non-electricity energy.

[3] The Korean government worked on the 2nd National Energy Basic Plan in 2013, releasing its report in early 2014.

Additionally, it was proposed that social costs such as nuclear safety, reinforcement of transmission lines, and reduction in greenhouse gas (GhG) emissions, should be duly reflected.

Over the past 3 decades, the major concerns of successive Korean governments have been energy security, energy efficiency, and environmental preservation. The energy security issue has been dealt with by promoting foreign resource development-import and renewable energy development. The issue of energy efficiency improvement has been addressed through programmes supported by the series of Five Year Basic Plans of Rational Energy Use. The environmental issue caused by consumption of fossil and nuclear energy has been dealt with by the relevant offices of the Ministry of Environment. Now is the time for Korea to synergise those efforts exerted so far by selection and concentration of policy tools and programmes through coordination among relevant ministries, as clearly specified in the Second Energy Basic Plan.

It is highly recommended that Korea keep up with the current policy goals of transforming into a less energy-intensive, greener economic structure and implementing policies to decouple the long-cherished nexus of economic growth and energy consumption by implementing the major policy agendas and their corresponding policy tools and programmes. Such nationwide efforts and campaigns should eventually transform the Korean economy into a less energy-intensive and greener one in terms of energy savings as well as reduced $CO_2$ emissions. Such an achievement would position Korea as one of the leading nations globally in terms of low-carbon green growth.

Chapter 10

# Lao PDR Country Report

**Khamso Kouphokam**, Department of Energy Policy and Planning Ministry of Energy and Mines, Lao PDR

## 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 6,644,009 people in 2013 and the average population density is 28 persons per square kilometre. Lao PDR consists of 18 provinces and its capital city is Vientiane, with a population of 810,846 people.

Since Lao PDR changed its economic policy to an 'open door' policy in 1986, the economy has been developing and expanding rapidly. Its gross domestic product (GDP) in 2013 increased by 8.02[1] percent from 2012, to 39,647 billion kip (at 2002 constant prices). This is equivalent to US$140,814 million, which means per capita income was US$1,628 in 2013. The economy has been gradually changing in focus from agriculture-oriented activities to a wider range of activities, such as services and industry. In 2013, the share of the services sector was 37.9 percent of total GDP, that of the agriculture sector 23.5 percent, and that of the industry sector 33.2 percent. The share of the industrial sector is expected to rise in the

[1] Statistics Yearbook 2013 of Lao PDR.

coming years due to expected investments in the mineral and hydropower sectors.

### 1.2. Energy Supply–Demand Situation

Lao PDR's Total Primary Energy Supply (TPEC) in 2013 was 2.47 Mtoe. The country's primary energy mix consists of four types of energy – oil, hydro, coal, and biomass. In 2013, electricity exports reached 0.98 Mtoe and accounted for more than half of total power consumed and 73.2 percent of total hydropower generation in the country. Consumption of biomass continued to be the highest because it is abundant in Lao PDR; it has been used for many generations and mostly does not need to be purchased as a commercial commodity. It remains an important energy source for cooking, and for small industries; in 2013 its consumption amounted to 1.27 Mtoe, representing 51.3 percent of TPEC. Consumption of oil products was the second highest after biomass. Lao PDR does not have any refineries and all consumption of oil products has been met by imports from Thailand and Viet Nam. In 2013, oil product imports to supply the demand of the transport and other sectors amounted to 0.84 Mtoe. In the same year, only 0.004 Mtoe of coal was consumed, mainly in industrial sector. But coal demand is expected to increase sharply in the near future as the first large coal power plant has been in operation since 2015.

Due to its geographic position, Lao PDR is richly endowed with hydropower resources, as it has many rivers. According to the Mekong River Commission Study in 1995, Lao PDR has a potential hydropower resource of 26,000 megawatt (MW). However, until 2013, only 3,230 MW[2] of installed capacity or 12.4 percent of total potential had been realised. In 2013, Lao PDR produced around 15,512 GWh[3] of electricity, 81 percent of which (equivalent to 12,494 GWh) had been exported to Thailand and Cambodia and 19 percent consumed domestically. Power exports are projected to increase sharply, because the government has reached agreements with its neighbouring countries to export 7,000 MW to Thailand and 5,000 MW to Viet Nam by 2020. The power source for exports is

[2] Electricity Statistics Yearbook 2013, Department of Energy Policy and Planning.
[3] Electricity Statistics Yearbook 2013, Department of Energy Policy and Planning.

mainly hydropower. Lao PDR is constructing a thermal power plant for export purposes, however. It is the Hongsa Lignite Power Project, which has 1,878 MW of installed capacity. And another four hydropower projects are under construction for energy export as well. All export projects are being developed by foreign private investors through the Build–Operate–Transfer (BOT) scheme.

The power sector plays a major role in the energy sector and in the country's economy. Electricity has been becoming an important source of revenue from abroad and at the same time a source of energy for economic activities. Even though in the short term not much revenue will be generated for the state from power exports as most exporting power plants are owned by private parties, income from the sector will increase sharply in the longer term when the concession agreements end and their ownership is transferred to the government. This revenue is considered as more sustainable.

The electrification ratio in Lao PDR was 87 percent in 2013.[4] According to the government's plan, it will strive to increase the electrification ratio to 90 percent by 2020. This plan is one of the government's priorities to help eradicate the country's poverty. Considering the projected increase of electricity demand in Lao PDR and the planned power production for export, optimisation of the power sector will be necessary to secure the future supply of electricity.

## 1.3. Energy Policies

Since establishment of the Ministry of Energy and Mines in 2006, the government's energy policy has received much public attention and support. It evolved gradually from covering just power sector policy to include energy policies more broadly with a view to the development of a sustainable and environmentally friendly energy sector. The improvement of energy policy could be credited to the Association of Southeast Asian Nations (ASEAN), for the close cooperation amongst its members.

[4] Electricity Statistics Yearbook 2013, Department of Energy Policy and Planning.

Even though Lao PDR is a land locked country, it is fortunate to be located in the middle of the Mekong Sub-region, surrounded by three big economies – China, Thailand, and Viet Nam – and two medium-sized economies – Myanmar and Cambodia. Lao PDR has been promoting itself as a land-linked country, well placed to take advantage of its central location. Based on the energy policies exchanged in the ASEAN+3 (China, Japan, Korea) energy cooperation platform, it is clear that these countries have high energy demand and therefore supporting the energy trade and power integration in this region should result in energy security and sustainable development. Lao PDR has been trading electricity with Thailand for many decades and this is now being expanded to Lao PDR's other neighbouring countries, which will support regional energy cooperation. Lao PDR will increase power exports to 15,000 MW by 2030 – by 10,000 MW to Thailand, and by 5,000 MW to Viet Nam, Cambodia, and Myanmar collectively.

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

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

## 2. Modelling Assumptions

This study aims to forecast the energy growth and demand of Lao PDR from a base year of 2013 to 2040, and to evaluate its energy saving and carbon dioxide ($CO_2$) emission reduction potential if it were to adopt certain Alternative Policy

Scenarios (APS). In this study four scenarios – the Business-as-Usual (BAU), Alternative Policy Scenario (APS)1, APS3, and APS5 – are used, as described below:

- BAU is a scenario based on the assumed growth of GDP, population, and oil price;
- APS1 is a scenario in which Lao PDR implements energy saving and conservation programmes that reduce energy consumption by 10 percent during the study period (2013–2040);
- APS3 is a scenario in which Lao PDR implements a biofuel programme, blending 10 percent of biofuel with all oil to be consumed in the country during the study period (2013–2040);
- APS5 is a scenario that combines APS1 and APS3 into one scenario.

**Table 10-1. GDP and Population Growth Assumptions (Annual Averages)**

| Projection Period | GDP Growth, % | Population Growth, % |
|---|---|---|
| 2013–2020 | 7.1 | 1.5 |
| 2020–2030 | 6.4 | 1.5 |
| 2030–2040 | 5.7 | 1.5 |
| 2013–2040 | 6.3 | 1.5 |

GDP = gross domestic product (GDP).
Source: Author's calculations.

## 3. Outlook Results

### 3.1 Business-as-Usual Scenario (BAU)

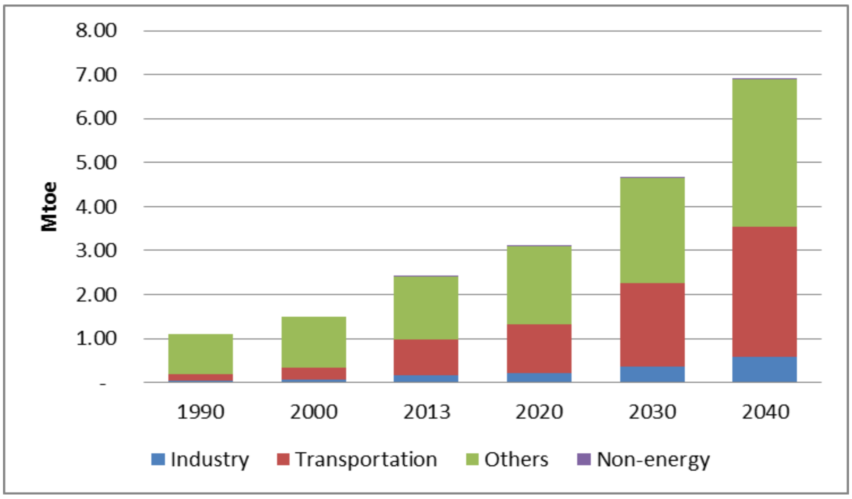
#### 3.1.1. Final energy consumption

In Lao PDR, final energy consists of coal, oil, electricity, and others. The country's Total Final Energy Consumption (TFEC) increased at an average annual rate of 3.5 percent from 1.09 Mtoe in 1990 to 2.41 Mtoe in 2013. The growth is forecast to continue at faster average annual rates of 3.7 percent from 2013 to 2020 and 4.2

percent from 2020 to 2030. From 2030 to 2040 it is expected to grow at a slower rate of 4.0 percent per year.

Like other Southeast Asian countries, Lao PDR has four sectors that use energy – industry, transportation, 'others,' and non-energy. 'Others' cover sub-sectors such as residential, agriculture, services, and commerce. During the 1990–2013 period, the transportation sector increased at the highest rate of 7.3 percent per year followed by the industry sector at 6.4 percent per year, whereas the 'others' sector grew at the lowest rate of 2.1 percent per year. The transportation sector is forecast to continue growing fastest until 2030, from which time it is expected to be the industry sector. However, for the 2013 to 2040 study period as a whole, of all sectors the transportation sector is still expected to register the highest growth at 4.9 percent per year. This is followed by the industry sector at an average annual rate of 4.8 percent, others at 3.2 percent, and non-energy at 2.2 percent.

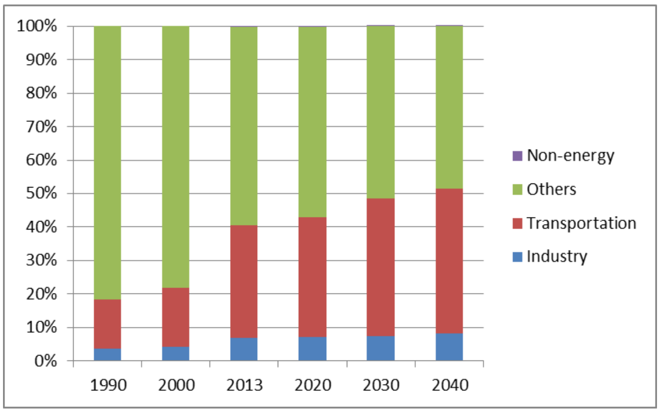
**Figure 10-1. Final Energy Consumption by Sector**




Mtoe = million tons of oil equivalent.
Source: Author's calculation.

In terms of energy types, 'others,' which is mainly biomass, was the most consumed energy in 2013, at 1.27 Mtoe, and it made up 52.7 percent of TFEC. It is expected that 'others' will continue to have more than half the share until 2015, from which time its share will be less than half, but it will remain the dominant share until 2020, compared with other energy types.

**Figure 10-2. Sectors' Share in Final Energy Consumption**



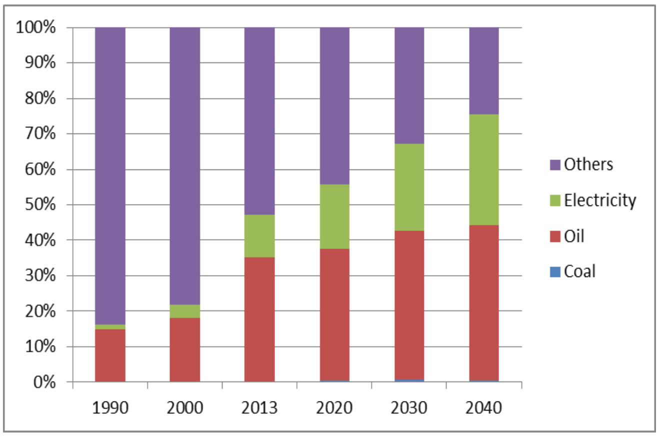

Source: Author's calculation.

In 2020, its share is estimated to be 44.2 percent and that of oil 37.0 percent of TFEC. Biomass from fuel wood and charcoal is the most prevalent in Lao PDR because a majority of Lao people still live in rural areas and rely on fuel wood as their main cooking fuel. Although use of fuel wood is inconvenient compared with other energy types like electricity and liquefied petroleum gas (LPG), mostly used for cooking purposes in urban areas, it costs less or nothing for the consumers. Another important factor in this study concerns the average annual growth rate of 'others' or biomass: even though it has a higher share in final energy consumption, it grew at a lower rate of 1.1 percent per year during the 2013–2040 period. 'Others' accounted for consumption of 1.27 Mtoe in 2013 and this is expected to increase to 1.69 Mtoe in 2040.

Oil is one of the important energy sources for Lao PDR because the transportation sector relies totally on this fuel. The oil price directly affects the country's socio-economic development, i.e. in part it determines the cost of living and doing business in the country. But unlike electricity and coal, oil is the only energy that is not produced domestically and for which Lao PDR is still dependent on other countries; it is imported from Thailand and Viet Nam.

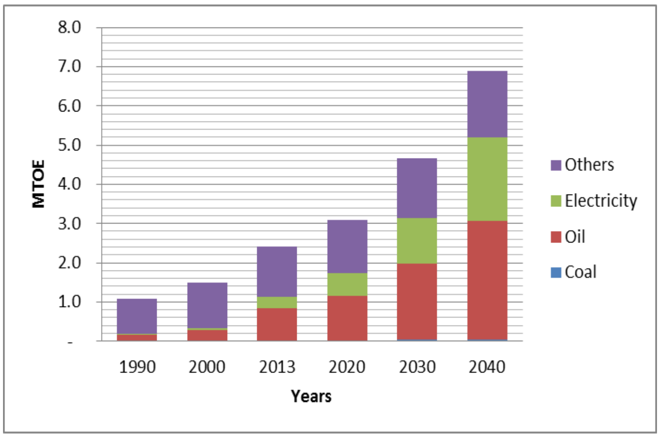
Its trend should be closely examined in this study, therefore. In 2013, 0.84 Mtoe of oil was consumed and consumption is projected to grow at an average annual rate of 4.8 percent during the 2013–2040 period.

**Figure 10-3. Final Energy Consumption by Fuel**




Source: Author's calculation.

**Figure 10-4. Fuels' Share in Final Energy Consumption**




Mtoe = million tons of oil equivalent.
Source: Author's calculation.

It is also forecast to take up a bigger share of TFEC from 2024 onwards, even though it ranks second after biomass from 1990 to 2020. Oil demand is expected to rise from 0.88 Mtoe in 2015 to 1.53 Mtoe in 2025, to 2.44 Mtoe in 2035, and to 3.02 Mtoe in 2040. Oil is projected to increase at an average annual growth rate of 4.5 percent from 2013 to 2020, by 5.5 percent from 2020 to 2030 period, by 4.5 percent from 2030 to 2040, and by 4.8 percent during the 2013–2040 period. This is the third highest growth rate compared with coal, electricity, and biomass in the 2013–2040 period.

### 3.1.2. Primary energy supply

Lao PDR's primary energy consists of coal, oil, hydro, and 'others,' the latter covering biomass, biofuels, and electricity for export. Lao PDR's Total Primary Energy Supply (TPEC) increased at an average annual rate of 3.2 percent from 1.20 Mtoe in 1990 to 2.47 Mtoe in 2013. Growth is expected to continue at a faster rate of 11.4 percent per year from 2013 to 2020 as a lot of coal will need to be used from 2015 for a new thermal power plant. From 2020 to 2030, TPEC's annual growth rate is projected to continue at a slower rate of 3.2 percent per year and at 2.8 percent from 2030 to 2040. Lao PDR's primary energy supply, however, is forecast to grow at an average annual rate of 5.1 percent over the whole period of this study, i.e. in 2013–2040.

In 2013, hydro was the most used energy, at 1.33 Mtoe, followed by biomass (1.27 Mtoe) and oil (0.84 Mtoe). Coal was little used in 1990–2015, but is estimated to have increased sharply from 2015 as the Hongsa Lignite Coal Power Plant started operation then. This causes coal to increase at a very high rate of 155.4 percent on average per year in the 2013–2020 period and its share in TPEC is forecast to increase from 0.3 percent in 2015 to 59.3 percent in 2020. Coal's share is projected to remain high and above 50 percent continuously until 2030, but to fall to 44.2 percent in 2035 and 38.4 percent in 2040. Demand for coal is forecast to grow slowly at an average annual rate of 1.6 percent from 2020 to 2030 and will see no increase at all from 2030 to 2040, although over the entire period of study from 2013 to 2040 it is expected to increase by 28.3 percent, which is higher than any of the other primary energy sources.

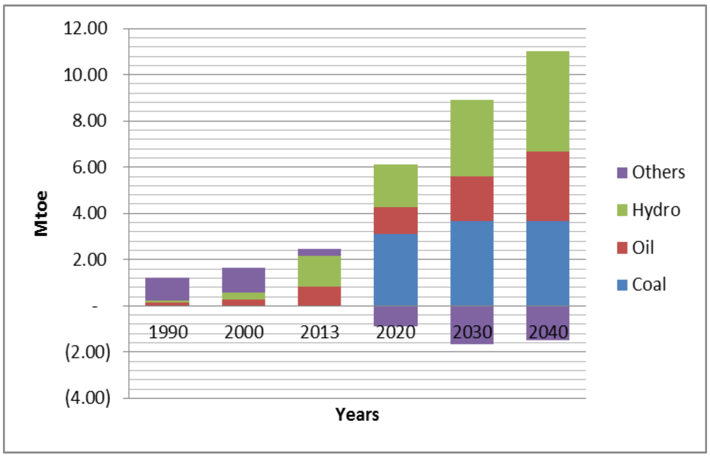
Hydro use is estimated to amount to 1.33 Mtoe in 2013 and is estimated to have a share of 67.6 percent of TPEC in 2015. It is forecast to grow at an average annual rate of 4.5 percent during the 2013–2040 period, so hydro demand will increase to 4.35 Mtoe by 2040. The increase in hydro is due to Lao PDR's intensive efforts to develop hydropower projects to be able to meet increasing domestic demand and increase exports to its neighbouring countries. Lao PDR has agreements to export 7,000 MW to Thailand and 5,000 MW to Viet Nam by 2020.

Biomass has also been much used in Lao PDR as it is a cheaper fuel for cooking and the main fuel used by most rural people. Consumption of biomass increased from 1.01 Mtoe in 1990 to 1.27 Mtoe in 2013, and is projected to increase to 1.30 Mtoe in 2015, 1.37 Mtoe in 2020, 1.44 Mtoe in 2025, 1.52 Mtoe in 2030, 1.61 Mtoe in 2035, and 1.69 Mtoe in 2040. In terms of its growth rate, similar to the projection for biomass in final energy, biomass in primary energy is estimated to grow at 1.1 percent from 2013 to 2040.

Oil has also been growing strongly in Lao PDR because many people can increasingly afford to buy private cars for their commutes, so the number of vehicles has been growing steadily. So far, Lao PDR has not had any refineries, so all oil products are imported. More than 20 oil companies are doing business in Lao PDR; they are authorised to import and sell oil within the country. In 1990, oil use amounted to a mere 0.16 Mtoe, and it increased at an average annual rate of 7.4 percent during the 1990–2013 period. In 1990, its share of TPEC amounted to 13.6 percent. Oil use increased to 0.28 Mtoe in 2000 and 0.84 Mtoe in 2013, with its share of TPEC rising accordingly, from 17.2 percent in 2000 to 34.1 percent in 2013, but it is estimated to be down to 33.3 percent in 2015, and projected to fall to 21.8 percent in 2020, before increasing again to 23.9 percent in 2025, 27.0 percent in 2030, 29.6 percent in 2035, and 31.7 percent in 2040. The average annual growth rate of oil is expected to be the second highest at 4.8 percent, after that of coal, during the 2013–2040 period.

Apart from the primary energies described above that are produced domestically and imported from its neighbours, Lao PDR still exports a significant amount of electricity to Viet Nam, Cambodia, and above all to Thailand. Therefore, in Figure 10-5, 'others' from 2020 onwards shows negative growth because exported electricity is greater than biomass. Lao PDR has been exporting power to Thailand since the Nam Ngum dam was built and started operation in 1971, and many other power plants followed suit after that. Exports increased from 0.05 Mtoe in 1990 to 0.98 Mtoe in 2013, are estimated at 1.33 Mtoe in 2015, and are projected to increase to 2.24 Mtoe in 2020, 3.16 Mtoe in 2025, and 3.19 Mtoe in 2030, 2035, and 2040. Electricity for export is expected to have a high average annual growth rate of 13–14 percent from 1990 to 2020, but over the longer term, for the 2013–2040 period, it is forecast to grow at a rate of 4.5 percent only.

**Figure 10-5. Primary Energy Supply by Source**




Mtoe = million tons of oil equivalent.
Source: Author's calculation.

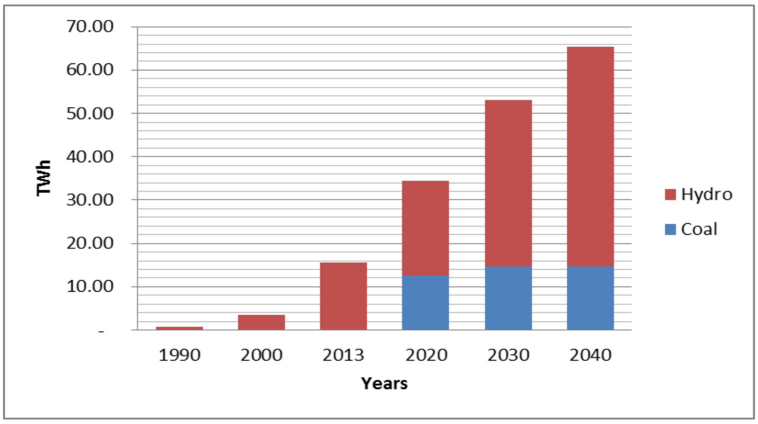
**Figure 10-6. Fuel Shares in Primary Energy Supply**


Source: Author's calculation.

### 3.1.3. Power generation

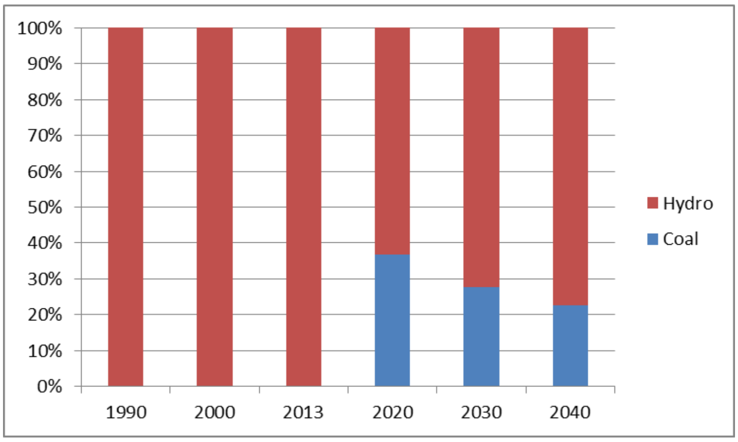
The history of power generation in Lao PDR can be divided into several periods. During the first period, from 1970 to 2015, all power was generated from one source, i.e. hydropower. The second period is from 2015, when Lao PDR has both hydropower and thermal power plants, as the Hongsa Lignite Power plant started operating in 2015. In 1990, Lao PDR produced only 0.82 TWh of electricity; it increased to 3.44 TWh in 2000 and 15.51 TWh in 2013 and is estimated at 20.79 TWh in 2015. Power generation output is forecast to increase sharply from 2015 to 2040, to 34.40 TWh in 2020, 48.79 TWh in 2025, 53.12 TWh in 2030, 58.35 TWh in 2035, and 65.30 TWh in 2040. All power generated before 2015 was from hydropower sources. From 1990 to 2013, power generation grew at an average annual rate of 13.6 percent. It is expected to grow by 12.1 from 2013 to 2020, by 4.4 percent from 2020 to 2030, and by 2.1 percent from 2030 to 2040. As a result of the first thermal power plant coming into operation in 2015, the power generation mix in Lao PDR will change – which can be seen in Figures 10-7 and 10-8 – from 2020 onwards. For example, in 2020 hydropower plants are forecast to account for 63.3 percent of total power generation output and thermal power plants will account for 36.7 percent of total generation. The share of hydropower plants is forecast to remain higher than that of thermal power plants throughout the study period.

**Figure 10-7. Electricity Generation in 2040**




TWh = terawatt-hour.
Source: Author's calculation.

**Figure 10-8. Technologies' Share in Electricity Generation in 2040**

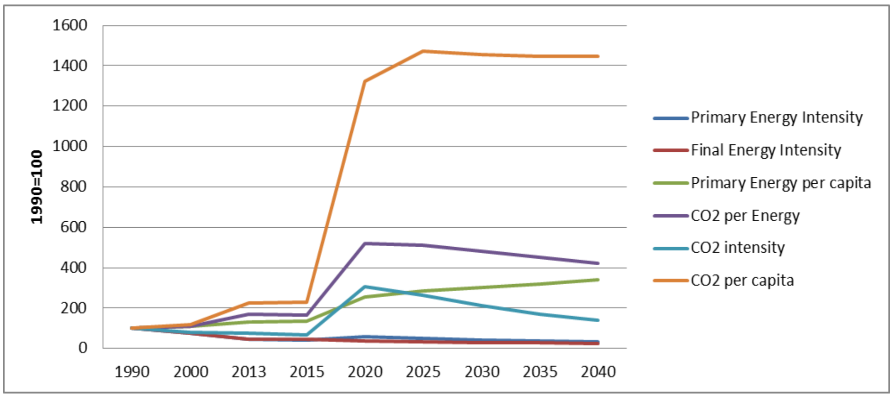



Source: Author's calculation.

### 3.1.4. Energy indicators

Lao PDR's primary energy intensity (TPES/GDP) peaked in 1990, reaching its highest level of 1,080 toe/million 2005 US$. It is expected to decline very strongly to its lowest level of 359 toe/million 2005 US$ in 2040. Similarly, final energy intensity was at a very low 984 toe/million 2005 US$ in 1990 and fell to 473 toe/million 2005 US$ in 2013. It is estimated at 437 toe/million 2005 US$ in 2015, and forecast to fall further, to 377 toe/million 2005 US$ in 2020, 335 toe/million 2005 US$ in 2025, 305 toe/million 2005 US$ in 2030, 280 toe/million 2005 US$ in 2035, and 260 toe/million 2005 US$ in 2040. These figures are a good indication that energy consumers are implementing energy efficiency and conservation programmes.

**Figure 10-9. Energy Intensity and Other Energy Indicators (1990=100)**



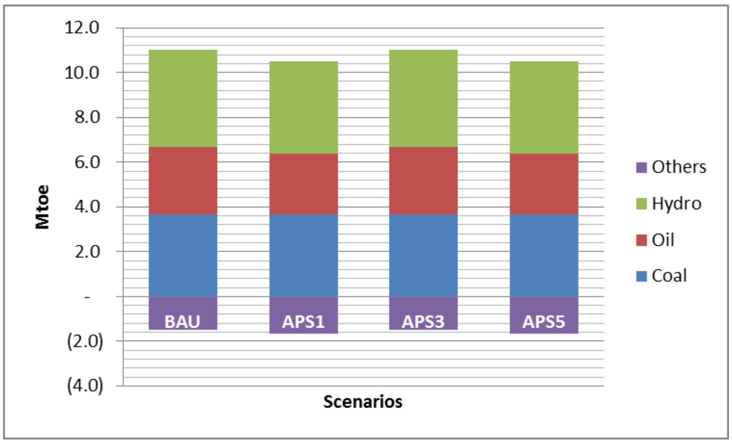

$CO_2$ = carbon dioxide.
Source: Author's calculation.

## 3.2. Energy Saving and $CO_2$ Reduction Potential

As mentioned above, for this study Lao PDR uses three APS for its energy saving and $CO_2$ reduction potential: Energy Efficiency and Conservation (EEC) scenario (APS1); development of renewable energy (APS3); and APS5, which combines APS1, APS2, and APS3. Implementation of these three APS result in some changes. Firstly, the primary energy supply of APS1 is reduced by 0.520 Mtoe compared with the BAU, i.e. it declined from 7.830 Mtoe in the BAU to 7.309 Mtoe in APS1. Secondly, there is no change in primary energy supply under APS3.

Thirdly, the primary energy supply of APS5 is reduced by the same amount as in APS1. The reduction in primary energy supply mainly comes from the implementation of energy efficiency and conservation programmes, i.e. a reduction of 10 percent in energy consumption. In particular, all existing primary energies such as coal, oil, hydro, and others are reduced (Figure 10-10).

**Figure 10-10. Comparison of Scenarios to Primary Energy Supply in 2040**

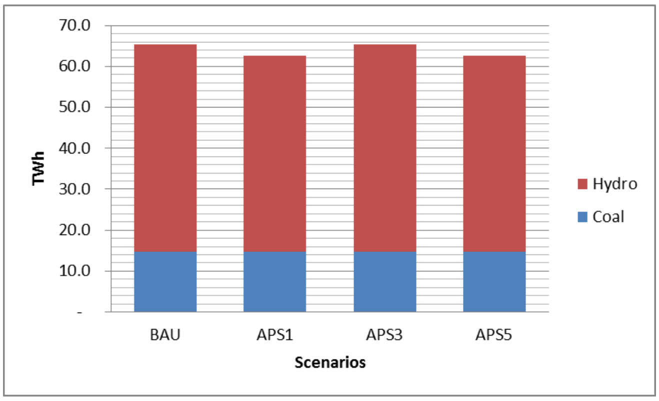



Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Figure 10-11 shows that power generation falls from 65.296 TWh in BAU to 62.671 TWh in APS1, i.e. there is a difference of 2.625 TWh. As APS5 is the combination of APS1 and APS3, and there is no energy saving under APS3, the amount of power generation reduced in APS5 is the same as in APS1. Similar to those for the primary energy supply, that reduction was mainly from the implementation of energy efficiency and conservation programmes, which reduced energy consumption by 10 percent.

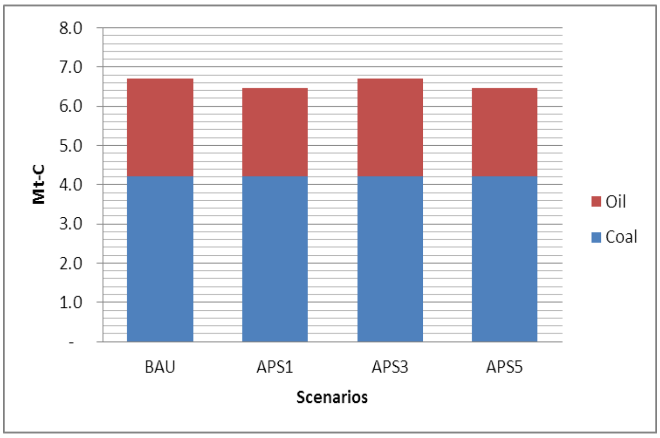
Figure 10-12 illustrates that by comparing levels of $CO_2$ emission across the four scenarios, $CO_2$ emission was reduced by 0.224 Mt-C in APS1 as well as in APS5. The $CO_2$ emission declined from 6.704 Mt-C in the BAU to 6.460 Mt-C in APS1 and to 6.460 Mt-C in APS5. This reduction is mainly due to energy efficiency and conservation programmes.

**Figure 10-11. Comparison of Scenarios to Electricity Generation in 2040**




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

**Figure 10-12. Comparison of Scenarios to Carbon Emissions in 2040**




Mt-C = million tons of carbon; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

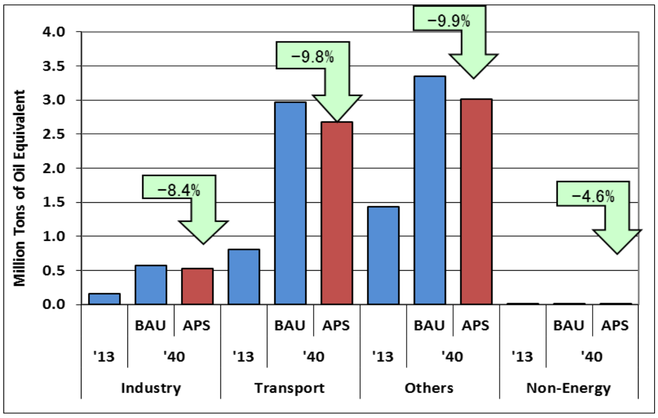
### 3.1.5. Final energy consumption

When comparing the trends of final energy consumption of the BAU and the APS in each sector, the model gives the following results: In APS1, final energy consumption is expected to increase from 2.41 Mtoe in 2013 to 6.22 Mtoe in 2040. The 'others' sector in APS1 has had the majority share in total final energy consumption since the beginning of the study period (in 2013 its share was 59.5 percent), it is forecast to decline gradually and in 2040 its share is expected to be

48.5 percent. The transportation sector is projected to have the second highest energy demand over the forecast period. In 2013, its final energy consumption was 0.81 Mtoe, it is estimated to have decreased to 0.71 Mtoe in 2015, and is expected to increase to 1.00 Mtoe in 2020, 1.34 Mtoe in 2025, 1.72 Mtoe in 2030, 2.16 Mtoe in 2035, and 2.68 Mtoe in 2040. Average annual final energy consumption during the 2013–2040 period in APS1 is expected to grow less fast than under the BAU; it is forecast to grow by 4.0 percent per year in the BAU and by 3.6 percent in APS1.

As shown in Figure 10-13, final energy consumption in the industry sector is projected to be 8.4 percent lower in the APS than in the BAU in 2040.

**Figure 10-13. Final Energy Consumption by Sector, BAU and APS**



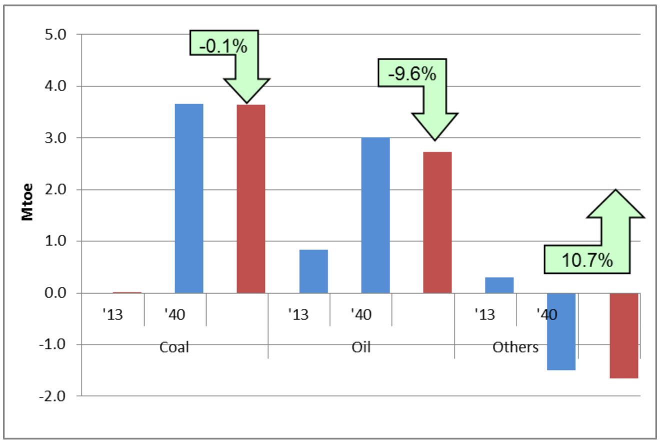

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author’s calculation.

### 3.1.6. Primary energy supply

In APS1, 2.47 Mtoe of primary energy was consumed in 2013 and consumption is expected to increase to 4.96 Mtoe in 2020, 6.78 Mtoe in 2030, and 8.84 Mtoe in 2040. Primary energy grew at an average annual growth rate of 3.2 percent from 1990 to 2013. It is expected to grow by 10.4 percent per year from 2013 to 2020, by 3.2 percent per year in the 2020–2030 period, and by 2.7 percent per year in the 2030–2040 period. From 2013 to 2040, primary energy is expected to increase at an annual average rate of 4.8 percent.

Figure 10-14 shows that when comparing BAU and APS in 2040, 0.1 percent less coal is expected to be consumed in the APS, and 9.6 percent less oil, but 10.7 percent more 'other' due to a forecast increase of power exports to Lao PDR's neighbours.

**Figure 10-14. Primary Energy Supply by Source, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario;
Mtoe = million tons of oil equivalent.
Source: Author's calculation.

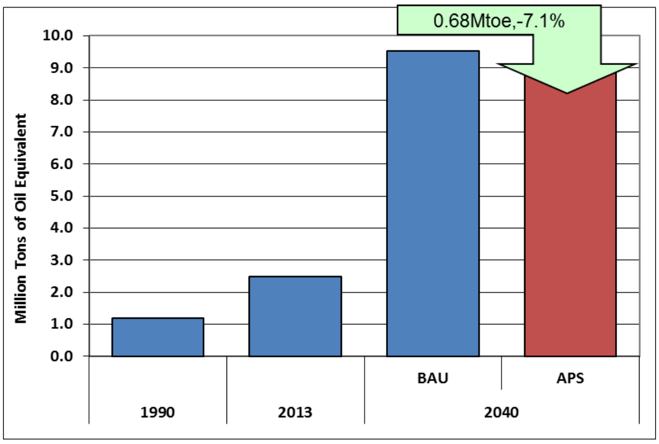
### 3.1.7. Projected energy savings

Figure 10-5 shows that in 2040 primary energy is expected to decrease from the BAU level to the APS level by 0.68 Mtoe or 7.1 percent. This decrease in total primary energy supply is due to implementation of the planned 10 percent reduction in energy consumption from 2013 to 2030.

### 3.1.8. Energy intensities

As Lao PDR endeavours to improve itself towards an efficient and competitive economy and promote sustainable development, energy intensity both for final energy and primary energy will be reduced significantly.

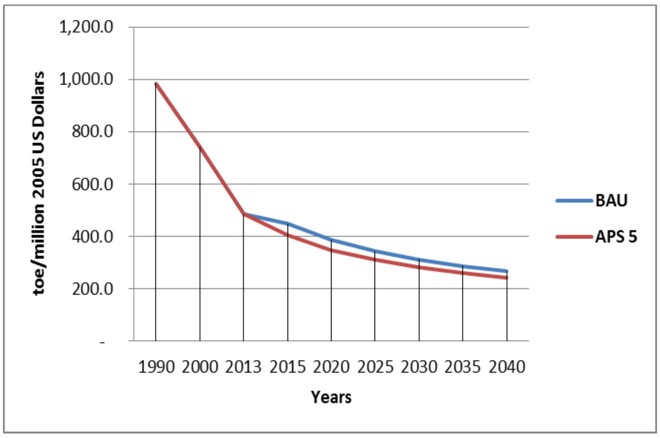
**Figure 10-15. Total Primary Energy Supply, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario;
Mtoe = million tons of oil equivalent.
Source: Author's calculation.

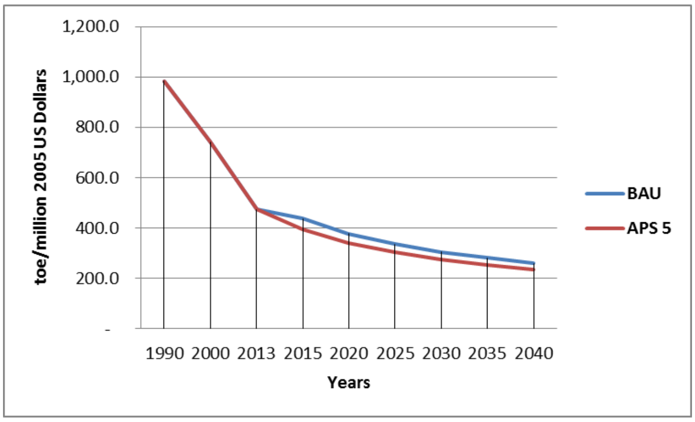
Final energy intensity is projected to decrease from 473 toe/million 2005 US$ in 2013 to 260 toe/million 2005 US$ in 2040. Primary energy intensity is expected to decline from 486 toe/million 2005 US$ in 2013 to 359 toe/million 2005 US$ in 2040. As the graphs in Figure 10-16 and Figure 10-17 show, energy intensity in APS5 is less than in the BAU. This is due to the implementation of the planned 10 percent energy saving from 2013 to 2030. However, Figure 10-17 shows an increase in energy intensity during 2015 to 2020 because of the coming into operation of the Hongsa Lignite thermal power plant in the North.

**Figure 10-16. Final Energy Intensity, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario;
toe = tons of oil equivalent.
Source: Author's calculation.

**Figure 10-17. Primary Energy Intensity, BAU and APS**

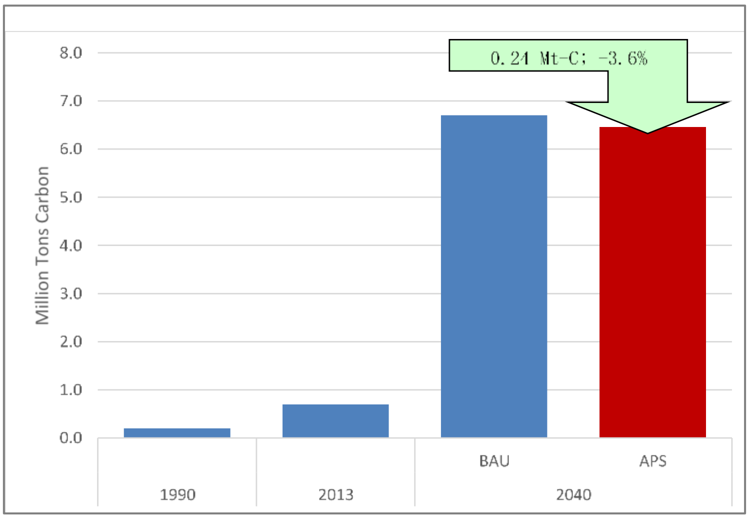



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; toe = tons of oil equivalent.
Source: Author's calculation.

### 3.1.9. $CO_2$ Emissions

By implementing a 10 percent reduction in energy consumption, Lao PDR can reduce $CO_2$ emission by 0.24 Mt-C or by 3.6 percent compared with the BAU in 2040 (Figure 10-18).

**Figure 10-18. $CO_2$ Emission from Energy Consumption, BAU vs APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

## 4. Implications and Policy Recommendations

According to this study, Lao PDR is expected to achieve its projected 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, a 10 percent decrease of biofuels in oil supply for the transportation sector, and a reduction of 10 percent in energy consumption of all sectors.

To achieve energy reduction both in TPEC and TFEC, as well as the desired reduction in $CO_2$ emissions, Lao PDR should extend the implementation of its renewable energy and energy conservation programmes until 2040. As the energy conservation programmes are the most important in achieving the planned energy reduction, it should be adopted as a national policy. The industry sector should implement the energy management system, develop and implement its own energy saving or reduction plans, cooperate with the government on energy security, and regularly conduct seminars on energy saving measures. The transport sector should increase public transport in the big cities and conduct campaigns to promote the use of thereof. And the 'other' sector should raise public awareness on energy conservation and implement energy management in the building sector. Moreover, a study on the correlation between GDP and energy consumption should be carried out and energy statistics should be improved accordingly. In addition, the government should consider the following measures:

- Implement EEC programmes in all sectors;
- Establish an EEC fund (similar to that of Thailand) to support EEC programmes and ESCOs;
- Increase public transport and switch to the use of electric vehicles (including public buses and tuk-tuk), which would reduce not only oil imports and $CO_2$ emissions, but also traffic congestion, which has been getting worse and worse;
- Reform electricity tariffs to encourage more EEC activities, e.g. time of use pricing;

- Increase the share of coal thermal power generation in the power generation mix by using local coals and clean coal technology (CCT) to secure a stable supply of electricity;
- Promote power trade within ASEAN.

# Chapter 11

## Malaysia Country Report

September 2016

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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°C. Malaysia's gross domestic product (GDP) grew steadily over the last 24 years, at an annual average rate of 5.8 percent from 1990 to 2013, except for sluggish growth in 1998 due to the Asian Financial Crisis and in 2001 due to slow growth of export demand for electronic products. Malaysia also experienced a downturn as a result of the global financial 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 2013, reserves included 5.85 billion barrels of crude oil and condensates, 98.32 trillion cubic feet of natural gas, and 1,483.1 million tons of coal. In terms of energy equivalent, Malaysia has gas reserves four times the size of its crude oil reserves. Natural gas reserves off the east coast of Peninsular Malaysia are dedicated for domestic consumption, whereas those in Sarawak are allocated as revenue earner in the form of liquefied natural gas (LNG) exports. Malaysia is a net energy exporter. Mineral fuels, lubricants, etc., contributed 22.3 percent of the economy's export earnings in 2013 or RM[1] 160,348 million.

[1] Malaysian ringgit.

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 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 give renewable energy the necessary lift to greater heights in the next 5 years. Efforts to promote energy efficiency need to be intensified. In addition, climate change, which is inextricably linked with energy use, has become increasingly important, as people begin to appreciate the implications of an increased risk of unpredictable, severe weather and rapid changes to the ecosystem. Thus, the need to work towards a truly sustainable energy future becomes more compelling. A sustainable energy system is central to meeting the economic goals of Malaysia. Malaysia's levels of energy use per unit of production (intensity) are high compared 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 only with supply, but also the management of demand for energy services, by increasing energy efficiency and the use of renewable energy sources to meet any remaining demand.

Over the years, the Government of Malaysia has formulated various 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:

- Petroleum Development Act (1974)
- National Petroleum Policy (1975)
- National Energy Policy (1979)
- National Depletion Policy (1980)
- Four-Fuel Diversification Policy (1981)
- Fifth Fuel Policy (2000)
- Biofuel Policy (2006)

- National Green Technology Policy (2009)
- National Renewable Energy Policy and Action Plan (2010)
- New Energy Policy and 10th Malaysia Plan (2010)
- 11th Malaysia Plan (2015)

## 2. Modelling Assumptions

In determining the forecast of final energy consumption, an econometrics approach was applied by using the historical correlation between energy demands as well as macroeconomic and activity indicators. Final energy consumption equations were derived by 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 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) and population, were the best variables to use to establish 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 there was failure to derive a statistically sound equation, other methods, such as share or percentage approach, 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 Tenaga Nasional Berhad (TNB) assumptions. Most of all the energy demand equations for Malaysia were using GDP as the key factor to determine future projections. This was due to high correlation between energy demand and GDP. The assumptions for GDP growth rates are as follows:

**Table 11-1. GDP Growth Assumptions to 2040, in Percent per Year**

| | GDP Growth Rate (%) |
|---|---|
| 2013–2020 | 4.60 |
| 2021–2030 | 3.80 |
| 2030–2040 | 3.20 |

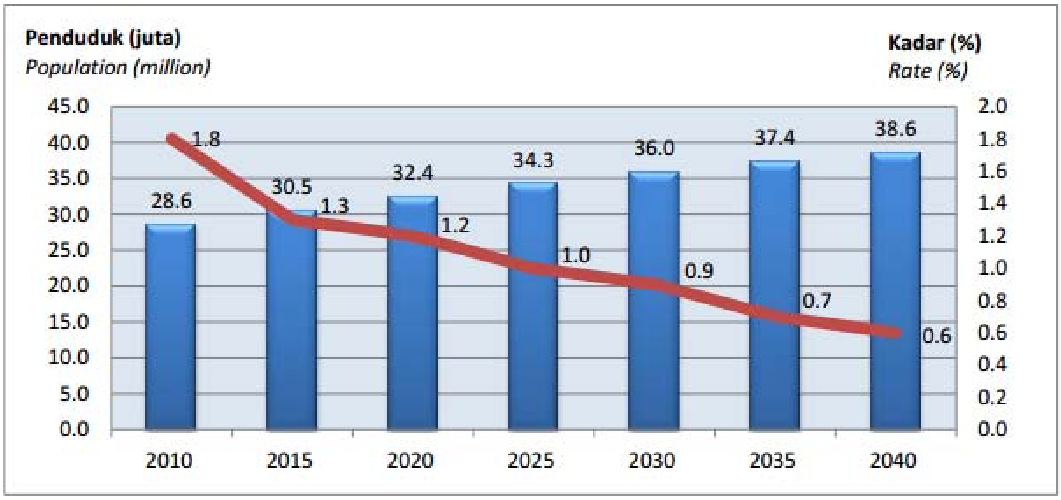
Source: ERIA.

Another important parameter in projecting future energy demand is population growth rates. Apart from future GDP growth rates, annual average population growth was considered as one of the key drivers for future energy growth. In 2013, Malaysia's population was 29.5 million and it is projected to increase by 9.4 million (31.9 percent) to 38.9 million in 2040. However, the annual population growth rate is expected to decrease from 1.4 per cent between 2013 and 2020, to 1.1 percent between 2020 and 2030, and 0.8 percent from 2030 to 2040. This situation is in tandem with the targeted decline in the fertility rate and expected international migration. The assumptions for future population growth rates, obtained from the Department of Statistics Malaysia, can be seen in Figure 11-1.

In the process of accelerating its economic and social development, supported by its current position as a net energy exporter, Malaysia provides subsidies on energy use for various users. The amount of energy subsidies offered to various energy users in the country has been growing from year to year, corresponding with the volatility of global energy prices and growing demand for energy.

The amount of subsidies has reached a worrisome level, stretching government expenditure capacity beyond its limits and eating into the share of other developmental budget allocations.

**Figure 11-1. Population Growth Assumption to 2040**




Source: Department of Statistics Malaysia.

This situation has prompted the Malaysian Government to review its policies related to energy subsidies and to take action to manage energy subsidies with proper mitigation measures. In this regard, energy efficiency offers a sound solution to mitigating the effects of the gradual removal of energy subsidies.

In promoting energy efficiency, the Ministry of Energy, Green Technology and Water (MEGTW) had 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 of the Act, to promote efficient use of electricity in the country. Based on the Act, MEGTW issued the Efficient Management of Electrical Energy Regulation 2008. Under that regulation, all installations that consume or generate 3 million kWh or more of electricity over a period of 6 months will be required to engage an electrical energy manager who shall, among others, be responsible for analysing total consumption of electrical energy, advise on the development and implementation of measures to ensure efficient management of electrical energy, and monitor the effectiveness of the measures taken. The Energy Commission is empowered to enforce the Energy Efficiency Regulations.

The latest regulatory instrument to promote energy efficiency improvement is the Electricity Regulations (Amendment) 2013. The regulation has been amended to allow the implementation of Minimum Energy Performance Standards (MEPS) on 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, quota mechanisms, a Renewable Energy Master Plan, and an implementing agency – the Sustainable Energy Development Authority (SEDA). Malaysia has opted for FiT to drive the development of renewable capacity. FiT is guaranteed by the Renewable Energy Act 2011 and the levels are set by SEDA. The scheme is intended to provide a reasonable level of return for investors over a fixed period to give a level of certainty. FiTs are available for biogas, biomass, solar PV, and small hydro, and support duration is 16 years for biomass and biogas and 21 years for small hydropower and solar PV.

There is a capacity quota system 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. FiT levels adjust to the cost of the technology. With the exception of small hydro, FiTs have been revised every year according to different digression rates since 2013. 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 worked well only in relatively experienced markets, with a more of a track record and greater 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 to 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 also 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 tons of freight annually.

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

In setting up the scenarios for this project, several assumptions and scenarios have been identified. They are as follows:

- APS1 – Improved efficiency of final energy consumption
- APS2 – Higher efficiency of thermal electricity generation
- APS3 – Higher contribution of NRE (here NRE for electricity generation and biofuels for the transport sector are assumed)
- APS4 – Introduction of nuclear energy

- APS5 – Combined impact of scenarios APS1 to APS4

The details of the assumptions in their respective scenarios are mentioned in the following tables:

**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 2015 to 2040 by 1.35 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 1.0 percent per year from 2015 to 2040 |
| | 3. Total Energy Demand in Commercial Sector |
| | Potential reduction of total energy demand in commercial sector by 1.0 percent per year from 2015 until 2040. |

APS = Alternative Policy Scenario.
Source: Author.

**Table 11-3. Higher Efficiency of Thermal Electricity Generation**

| Scenarios | Assumptions |
|---|---|
| APS2 | 1.Higher efficiency of coal power plant by 40.0 percent in 2040 |
| | 2. Higher efficiency of natural gas power plant by 46.3 percent in 2040. |

Source: Author.

**Table 11-4. Renewable Energy Assumptions**

<table>
<tr><th>Scenarios</th><th colspan="7">Assumptions</th></tr>
<tr><td rowspan="8">APS2</td><td colspan="7">1. By 2030, Malaysia is expected to have the following renewable energy capacities in power generation:</td></tr>
<tr><td colspan="7">Cumulative Capacity (MW)</td></tr>
<tr><td>Year</td><td>Biomass</td><td>Biogas</td><td>Mini-Hydro</td><td>Solar PV</td><td>Solid Waste</td><td>Total</td></tr>
<tr><td>2015</td><td>330</td><td>100</td><td>290</td><td>55</td><td>200</td><td>975</td></tr>
<tr><td>2020</td><td>800</td><td>240</td><td>490</td><td>175</td><td>360</td><td>2,065</td></tr>
<tr><td>2025</td><td>1,190</td><td>350</td><td>490</td><td>399</td><td>380</td><td>2,809</td></tr>
<tr><td>2030</td><td>1,340</td><td>410</td><td>490</td><td>854</td><td>390</td><td>3,484</td></tr>
<tr><td colspan="7">2. In 2020, 7 percent of Malaysia’s share of diesel consumption in the transport sector will come from biodiesel.</td></tr>
</table>

MW = megawatt; APS = Alternative Policy Scenario; PV = photovoltaic.
Source: Author.

**Table 11-5. Nuclear Energy Assumption**

| Scenarios | Assumption |
|---|---|
| APS4 | 1. By 2027, a 2000 MW nuclear plant is expected to be commissioned. |

APS = Alternative Policy Scenario.
Source: Author.

**Table 11-6. APS Assumption**

| Scenarios | Assumption |
|---|---|
| APS5 | APS1 + APS2 + APS3 + APS4 |

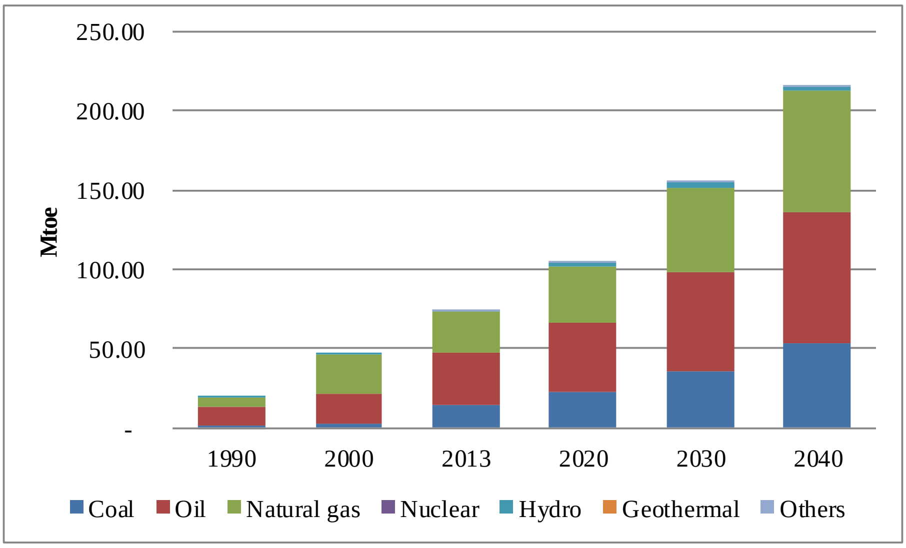
APS = Alternative Policy Scenario.
Source: Author.

# 3. Outlook Results

## 3.1. Business-as-Usual (BAU) Scenario

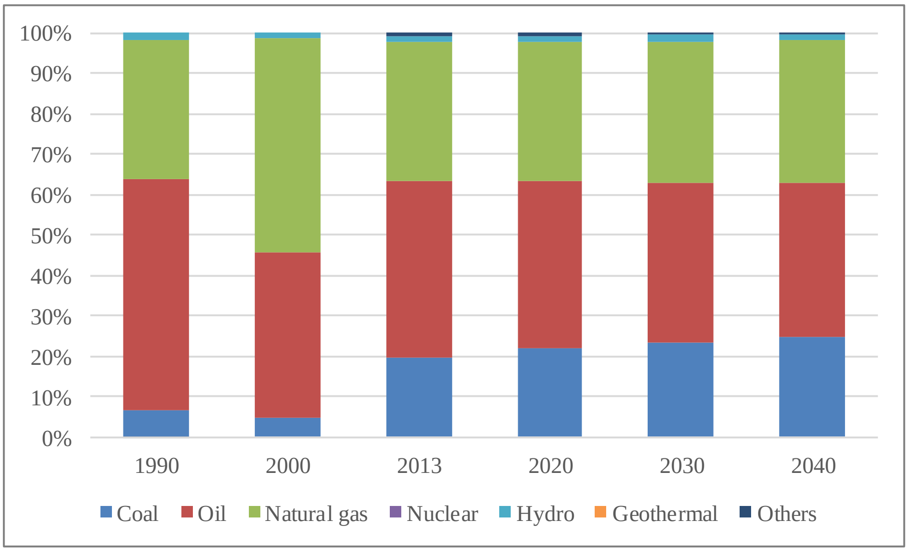
Primary energy supply in the Business-as-Usual (BAU) scenario registered average annual growth of 5.9 percent from 1990 to 2013 and is projected to increase by 4.0 percent per year from 2013 to 2040. Hydro is expected to increase from 0.91 Mtoe in 2013 to 2.75 Mtoe in 2040, at an average annual growth rate of 4.2 percent. Oil supply will increase at 3.5 percent per year from 2013 to 2040; coal supply, consumed mainly by the power sector, is forecast to increase by 4.9 percent per year from 2013 to 2040. Natural gas is projected to increase from 25.62 Mtoe in 2013 to 76.55 Mtoe in 2040, or at an average annual growth rate of 4.1 percent. Biomass for power generation will increase at an average annual rate of 7.3 percent from 2013 to 2040 and biofuel use for land transportation at 1.0 percent per year.

**Figure 11-2. Primary Energy Supply by Source, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's own calculation.

**Figure 11-3. Share of Primary Energy Supply by Source, BAU**



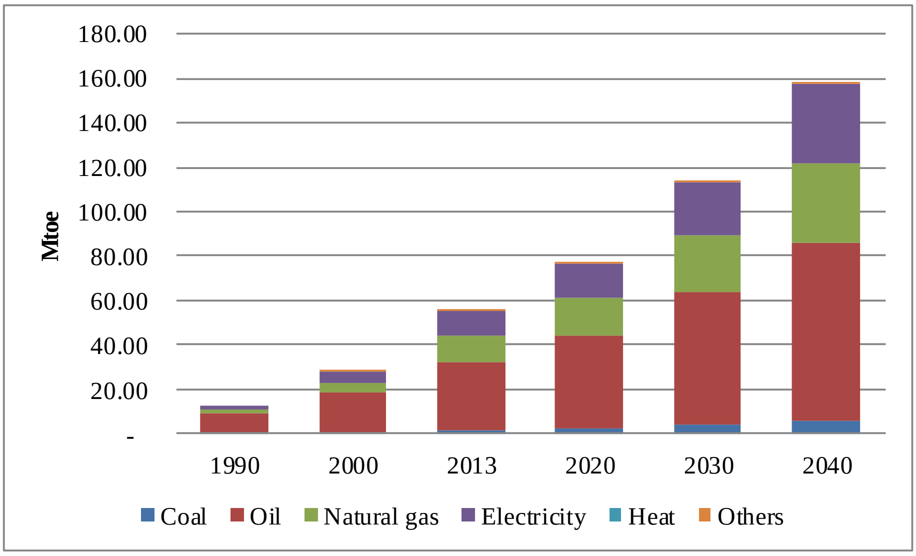

BAU = Business-as-Usual scenario.
Source: Author's own calculation.

In terms of share by source, oil's share will fall from 43.7 percent in 2013 to 38.3 percent in 2040, the share of natural gas will increase from 34.4 percent to 35.4 percent, coal's share will increase from 19.7 percent to 24.7 percent, and the share of hydro will increase from 1.2 percent to 1.3 percent over the projection period.

Final energy consumption in the BAU will increase from 55.29 Mtoe in 2013 to 157.37 Mtoe in 2040, or at an average annual growth rate of 4.0 percent. Final demand for coal and electricity will see the highest average annual growth rates of 4.8 percent and 4.4 percent from 2013 to 2040, respectively. Oil demand will grow from 30.60 Mtoe in 2013 to 80.83 Mtoe in 2040, or by 3.7 percent per year. Electricity demand will increase by 4.4 percent per year from 2013 until 2040 and other fuels will grow from 0.19 Mtoe in 2013 to 0.25 Mtoe in 2040, or by 1.0 percent per year.

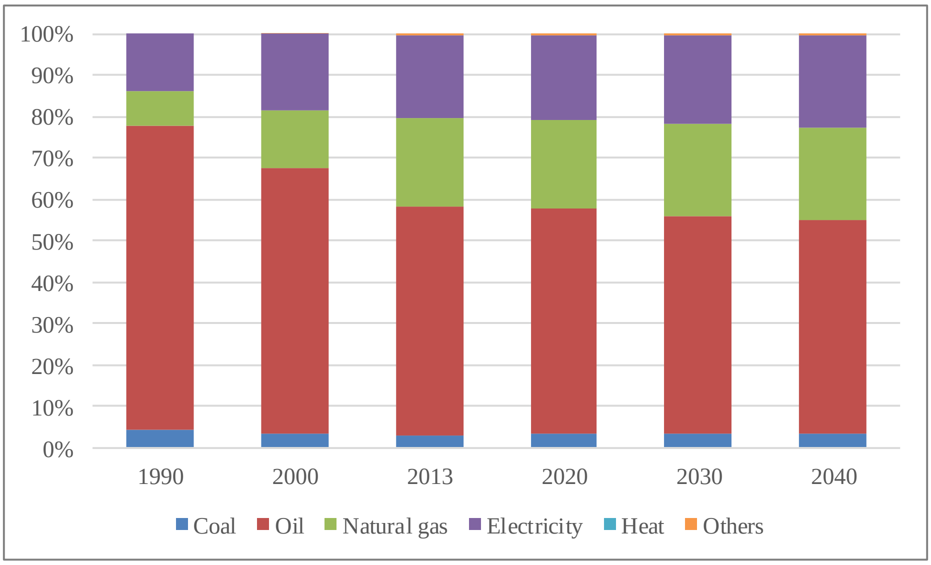
Analysis by share shows that oil will still dominate with 51.4 percent in 2040, slightly lower than its share in 2013 (55.3 percent), followed by natural gas and electricity, both 22.5 percent, in 2040. The share of coal will increase from 2.8 percent in 2013 to 3.5 percent in 2040.

**Figure 11-4. Final Energy Consumption by Energy Sources, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's own calculation.

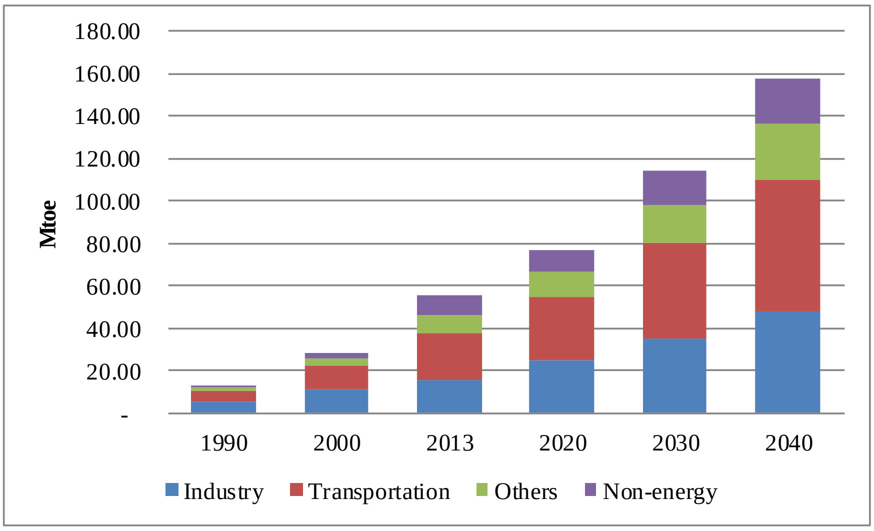
**Figure 11-5. Share of Final Energy Consumption by Energy Sources, BAU**




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

Final energy consumption by sector showed that industry and the 'others' sector will lead growth with 4.3 percent per year from 2013 to 2040, followed by the transport sector, projected to grow from 22.36 Mtoe in 2013 to 62.26 Mtoe in 2040, or by 3.9 percent per year. Non-energy use is expected to increase from 9.22 Mtoe in 2013 to 21.02 Mtoe in 2040, or at a rate of 3.1 percent per year.

**Figure 11-6. Final Energy Consumption by Sector, BAU**

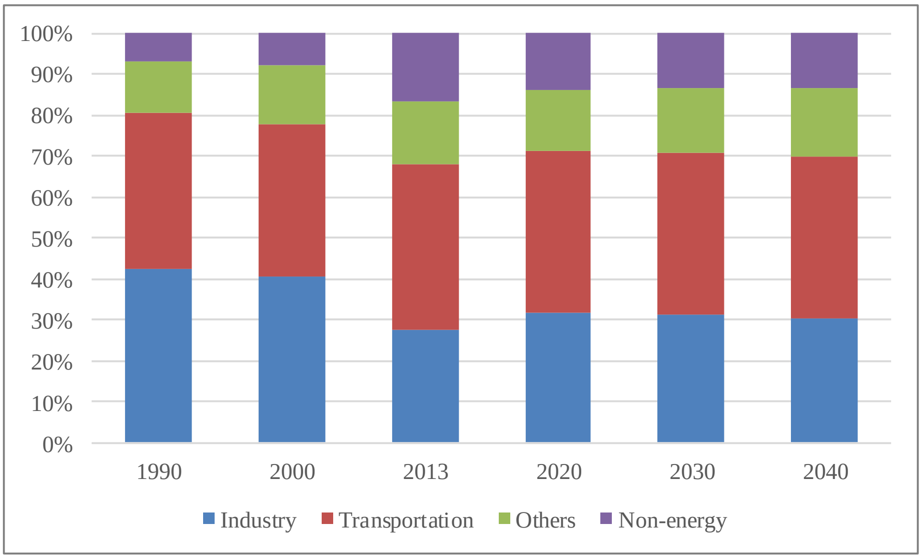



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's own calculation.

Analysis by share shows that the transport sector will still dominate energy usage in 2040 with 39.6 percent compared with 40.4 percent in 2013. This will be followed by the industry sector with a 30.4 percent share in 2040 as compared with 27.6 percent in 2013. The non-energy use share will be 13.4 percent of total final energy consumption (TFEC) in 2040, decreasing from its 2013 share of 16.7 percent. The share of the others sector is expected to be at 16.6 percent in 2040.

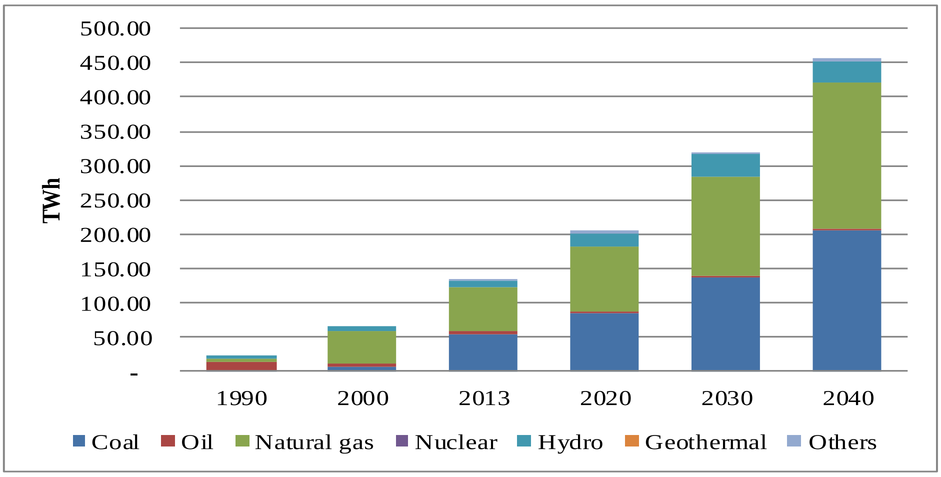
In the BAU, total power generation is expected to grow by around 4.7 percent per year from 2013 to 2040, reaching 456.89 TWh. Power generation from others will see the fastest growth at 6.6 percent per year from 2013 until 2040, followed by power generation from coal, projected to increase to almost 206.14 TWh in 2040 compared with 53.37 TWh in 2013.

**Figure 11-7. Share of Final Energy Consumption by Sector, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

**Figure 11-8. Power Generation by Fuel, BAU**

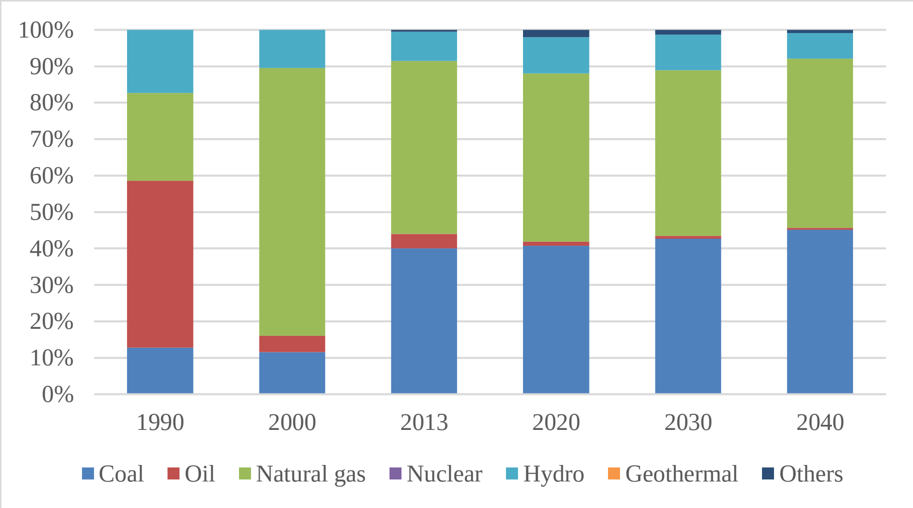



BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

Power generation from natural gas is expected to see annual average growth of 4.6 percent, or from 63.32 TWh in 2013 to 211.93 TWh in 2040. Power generation from oil is expected to decline by 2.6 percent per year to 2.61 TWh in 2040 compared with 5.26 TWh in 2013.

In terms of shares, the power generation mix will be dominated by natural gas and coal in 2040 with shares of 46.4 percent and 45.1 percent, respectively. Hydro follows with a share of 7.0 percent in 2040 from 7.9 percent in 2013. The share of others will be 0.9 percent of total power generation in 2040 and oil's share will be at 0.6 percent in 2040 compared with 3.9 percent in 2013.

**Figure 11-9. Share of Power Generation by Fuel, BAU**

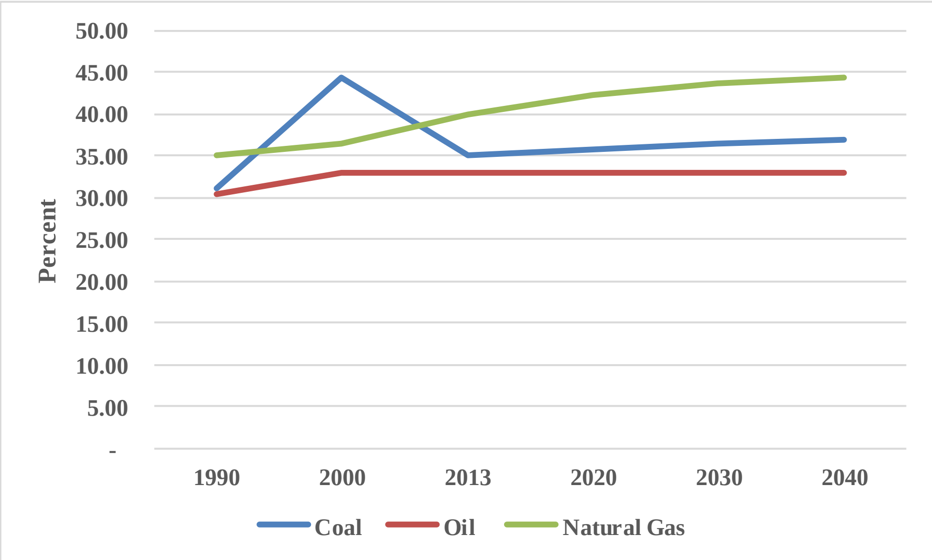



BAU = Business-as-Usual scenario.
Source: Author's own calculation.

In the BAU, the thermal efficiency of coal power plants is expected to improve to 37.0 percent in 2040 from 35.0 percent in 2013. Oil power plants are projected to remain more or less at the same level over the projection period, at around 33.0 percent. Natural gas power plants will further improve to almost 44.3 percent by 2040 from their 2013 level of 40.0 percent.

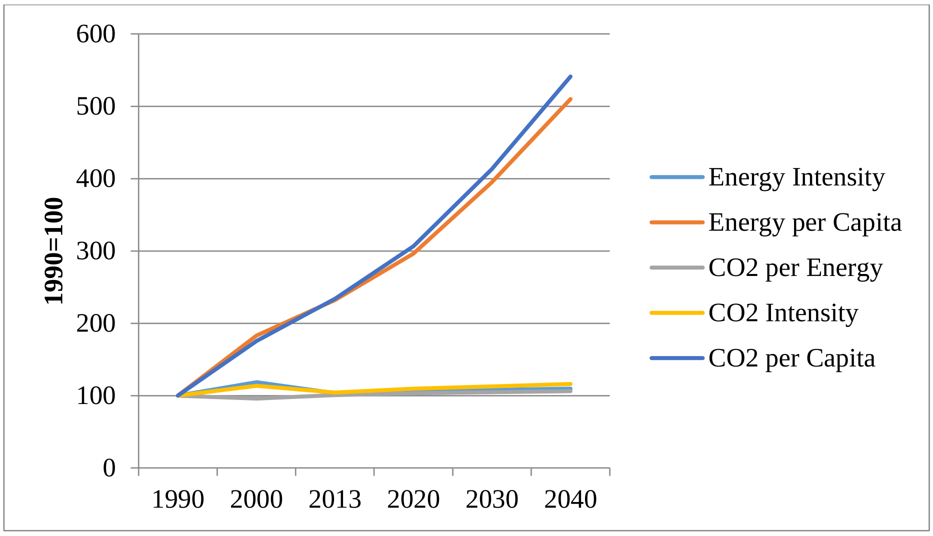
Malaysia's primary energy intensity is expected to increase to 379 toe/million 2005 US$ in 2040 from 358 toe/million 2005 US$ in 2013. Final energy intensity is projected to increase to 276 toe/million 2005 US$ in 2040 from 266 toe/million 2005 US$ in 2013. Primary energy per capita is projected to increase to 5.56 toe/person in 2040 from 2.53 toe/person in 2013. $CO_2$ intensity is expected to increase to 275 t-C/million 2005 US$ in 2040 from 266 t-C/million 2005 US$ in 2013. $CO_2$ per primary energy will increase slightly by 2040 to 0.73 t-C/toe from 0.69 t-C/toe in 2013.

**Figure 11-10. Thermal Efficiency by Fuel, BAU**




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

**Figure 11-11. Energy Indicators, BAU**



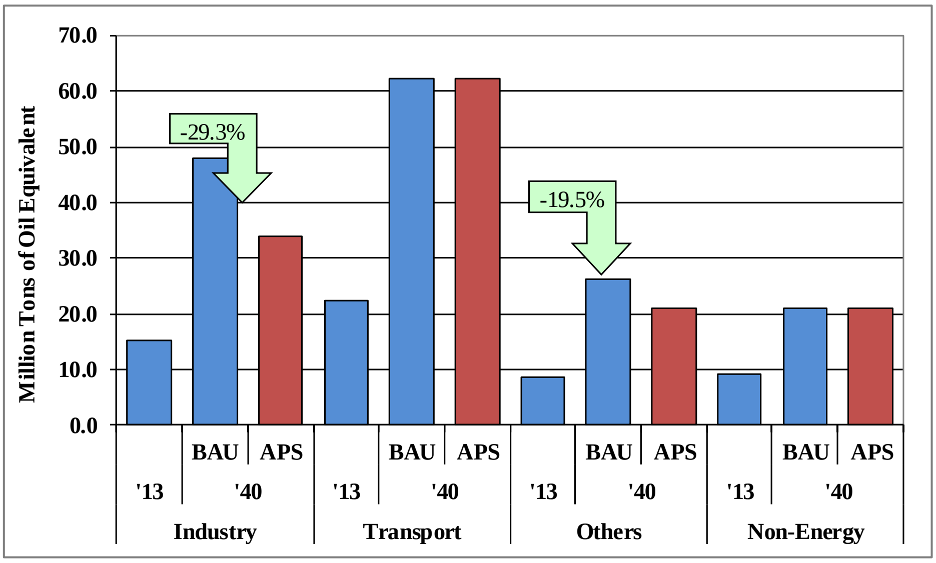

BAU = Business-as-Usual scenario; $CO_2$ = carbon dioxide.
Source: Author's own calculation.

## 3.2. Alternative Policy Scenario (APS)

In the Alternative Policy Scenario (APS), average annual growth in final energy consumption will be 3.5 percent from 2013 until 2040, slightly lower than in the BAU. The slower rate of increase in the APS will be the result of projected improvements in manufacturing technologies as well as efforts to improve energy efficiency, particularly in the industrial and commercial sectors. As a result, savings of 29.3 percent by 2040 are expected in the industry sector. In the others sector, the growth rate of energy consumption is projected to be slower than in the BAU, increasing at an average rate of 3.4 percent per year as compared with 4.3 percent per year in the BAU. The potential saving of 19.5 percent in 2040 can be achieved through implementing energy efficiency measures (Figure 11-12).

In the APS, primary energy supply is projected to increase at a slower rate than in the BAU, by 3.3 percent per year, from 74.48 Mtoe in 2013 to 176.87 Mtoe in 2040. Solar and biomass will be growing fastest, at average rates of 18.0 percent per year and 10.3 percent per year, respectively. This is due to the implementation of Feed-in-Tariff (FiT) in power generation, which is expected to have a big impact on the primary energy supply in 2040 as more renewable energy for power generation is expected to be commissioned.

**Figure 11-12. Final Energy Consumption by Sector, BAU and APS**




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

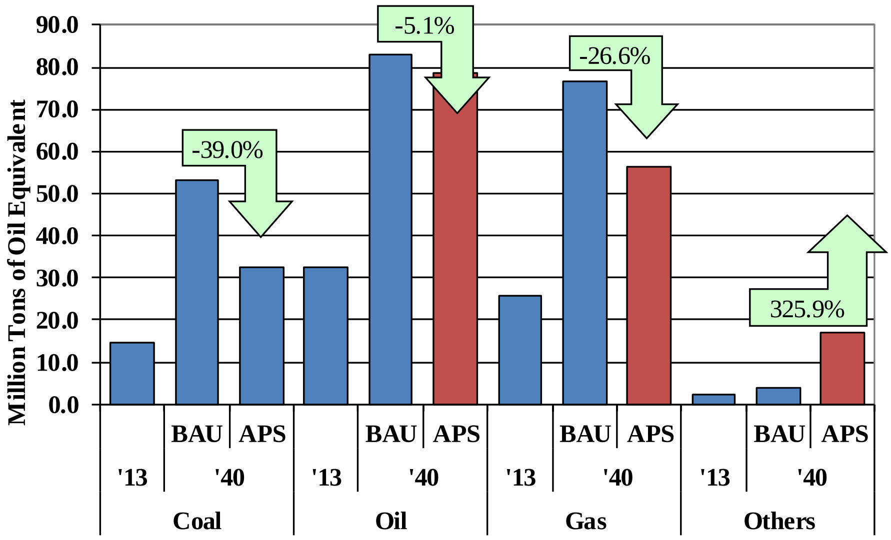
Hydro will also increase fast, but at a slower rate of 4.4 percent per year from 2013 to 2040. Oil will have a slower growth rate of 3.3 percent per year from 2013 until 2040 than in the BAU. Natural gas is projected to increase at 3.0 percent per year over the projection period and coal is projected to increase at the same rate

(Figure 11-13). Nuclear power will be introduced as a new energy source after 2025.

### 3.3. Projected Energy Saving

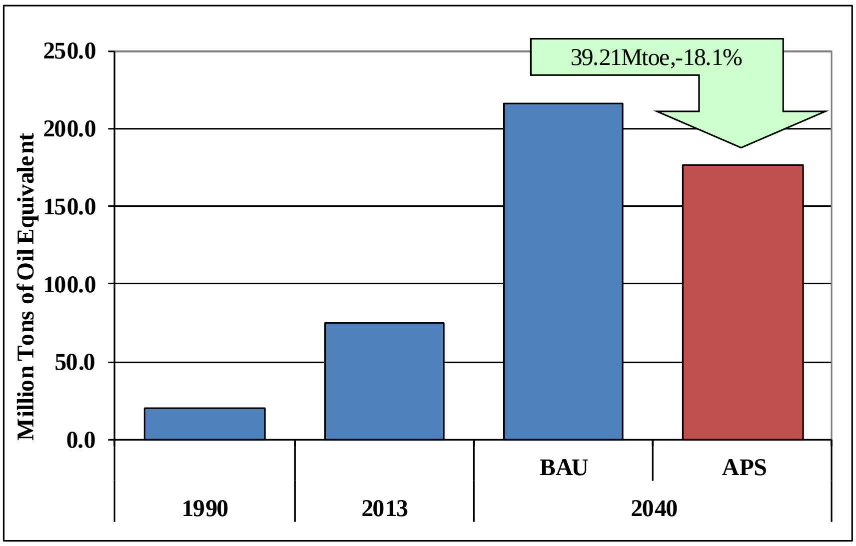
The energy savings that can be achieved under the APS, relative to the BAU, as a result of efforts to improve energy efficiency in the industrial and commercial sectors, more efficient thermal power supply, and a higher contribution from renewable energy, are estimated at 39.21 Mtoe in 2040 (Figure 11-14). The major saving that can be achieved from that total primary energy supply is by switching from coal or natural gas to renewable energy and nuclear power. For final energy consumption, the saving of 19.1 Mtoe that can be achieved in 2040 will be made up of savings of 14.0 Mtoe in the industrial sector and 5.1 Mtoe in the 'others' sector.

**Figure 11-13. Primary Energy Supply by Source, BAU and APS5**




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

**Figure 11-14. Total Primary Energy Supply, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.

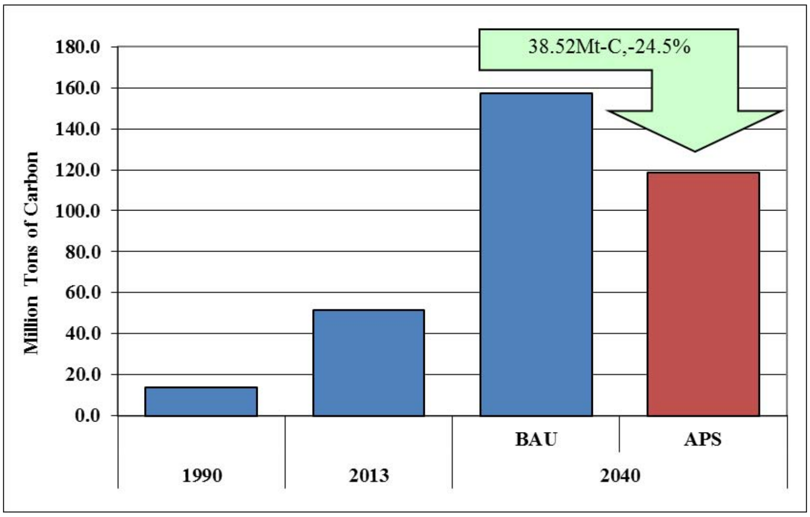
Source: Author's own calculation.

### 3.4. $CO_2$ Emissions

In the BAU, total carbon dioxide ($CO_2$) emissions from energy consumption are projected to increase by 4.2 percent per year from their 2013 level to 2040. In 2013, the $CO_2$ emissions level was 51.4 million tons of carbon (Mt-C) and it is expected to increase to 157.1 Mt-C in 2040 under the BAU.

In the APS, the projected annual increase in $CO_2$ emissions from 2013 to 2040 will be 3.1 percent per year lower than in the BAU, which is fairly consistent with the expected growth in primary energy supply. The reduction in $CO_2$ emissions in the APS of 38.5 Mt-C or 24.5 percent relative to the BAU is due to a significant decrease in coal consumption for power generation in the APS, relative to the BAU, as coal consumption is being replaced by natural gas and other clean energy sources such as nuclear and renewable energy. Furthermore, the projected lower energy usage in the industrial and commercial sectors, and fuel switching in the transport sector will also contribute to the expected 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 Consumption, BAU and APS**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's own calculation.

## 4. Conclusions

Malaysia's primary energy intensity in the APS is expected to be 18.2 percent lower in 2040 than in the BAU. The reduction of primary energy intensity will be due to Malaysia's energy saving measures, promoting energy efficiency and renewable energy. A contribution will also be made by the programmes and activities under the Eleventh Malaysia Plan, as the main strategies for the energy sector will be focused on improving infrastructure and service deliveries. Specific strategies for tackling governance and public communication issues will be undertaken. The oil and gas subsector will be strengthened by improving security and reliability of supply, instituting a regulatory framework for the gas market, enhancing downstream business, and eliminating market distortions. The strategies for the electricity subsector will focus on creating a sustainable tariff framework, better management of resources, and enhancing rural electrification. Demand Side Management (DSM) also marks an important paradigm shift for Malaysia towards efficient management of energy sources.

Malaysia faces several energy issues and challenges that can be addressed in a holistic manner. Reformulation of the sustainable energy plan can help to achieve future economic targets. One major challenge is managing public perception about the development of coal-fired and nuclear power plants, which is crucial for overcoming negative perceptions. The public must be kept informed about the availability of new clean coal and emission control technologies to protect the environment. This includes communication and public awareness programmes to build buy-in for the development of coal and nuclear power plants required to secure the electricity supply. As the country is preparing to embark on the use of nuclear power, a communication plan needs to be rolled out immediately. The government will spearhead a coordinated communication plan for this purpose. This initiative will include public communication, stakeholder management strategies, and action plans. Specific strategies will be designed to target civil society, non-governmental organisations (NGOs), mass media, teachers, community leaders, and other relevant groups.

Sustained efforts to institute market-based energy pricing will be made to reduce energy subsidies. Initiatives to review the pricing structure of gas supply will be continued to gradually align current piped gas prices towards market parity. In addition, Incentive Based Regulation (IBR) for gas will be introduced to ensure efficient resource allocation, usage, and sustainable financial performance. Fuel cost is the largest input in the electricity tariff and the generation fuel mix needs to be optimised to ensure low cost of supply and affordable tariffs. In line with the policy to gradually remove energy subsidies, the tariff requires periodical adjustments. Therefore, the electricity tariff will be reviewed to achieve market parity. Based on the current tariff structure, the first 300 kilowatt hours (kWh) of electricity consumption, which is the lifeline band, will not be affected by the tariff increase. The price for RON95 petrol, RON97 petrol, and diesel will continue to be regulated using a managed-float system to stem leakages. The Compressed Natural Gas (CNG) prices will also be reviewed accordingly, to gradually remove subsidies and encourage expansion of CNG retail infrastructure.

Studies will be conducted to identify new renewable energy sources to diversify the generation mix. New renewable energy sources such as wind, geothermal, and ocean energy will be explored. Currently, a national wind mapping exercise expected to be completed by 2016 is underway and will enable a study on the feasibility of wind energy to be carried out. Geothermal potential will also be further explored following the discovery of a 12 square kilometre geothermal field in Apas Kiri, Sabah. The viability of ocean energy will be explored to take advantage of Malaysia's geographical position of being surrounded by sea.

As for energy efficiency initiatives, Minimum Energy Performance Standards (MEPS) and energy labelling will help to improve the energy efficiency of appliances enabling consumers to choose products that use less energy. An additional four domestic appliances – vacuum cleaners, instant water heaters, irons, and electric ovens – will be included in the MEPS and labelling programme. There will be 14 appliances under this programme and the scope of MEPS for air-conditioners and refrigerators will be expanded.

# Chapter 12

## Myanmar Country Report

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Chapter 12

# Myanmar Country Report

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## 1. Background

### 1.1. Country Profile

Myanmar is the largest country in the mainland of Southeast Asia. Its territorial area covers 676,577 square kilometres and 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 the total land area is covered with forest, and most of the land area is utilised for agriculture. Myanmar had a population of 53 million in 2013, with an average annual growth rate of 1.0 percent per year from 1990 to 2013.

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 resources 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 km coastal strip along the southern part is also a good area for the development of marine ecosystems and an abundant source of marine products and mineral resources.

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, bio-diesel, and biogas are Myanmar's potential energy sources.

Myanmar's proven energy reserves comprise of 141.98 million barrels of oil, 10.66 trillion cubic feet of gas, and 540.31 million metric tons of coal. The country is a net exporter of energy, exporting substantial amounts of natural gas and coal to neighbouring countries. However, it imports around 70 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 2013, to 53 million in 2013. Myanmar's gross domestic product (GDP) was US$[1]24.9 billion (constant 2005) in 2013 and its GDP per capita grew from around US$100 in 1990 to US$470 in 2013. With the objectives of enhancing economic development in Myanmar, 5-year short-term plans were formulated and implemented from 1992 to 2013. The first (1992–1995), second (1996–2000), third (2001–2005), and fourth plan (2006–2010) achieved average annual GDP growth rates of 7.5 percent, 8.5 percent, 12.8 percent, and 12.0 percent, respectively. The last 5-year plan (2011–2016) was formulated to achieve an average annual GDP growth rate of 7.6 percent.

## 1.3. Energy Consumption in the Base Year

Myanmar's total primary energy supply (TPES) was 16.46 million tons of oil equivalent (Mtoe) in 2013. Natural gas is mainly used for electricity generation and in industry. Myanmar has 4,145 megawatts (MW) of installed generation capacity and produced about 11.89 terawatt-hours (TWh) of electricity in 2013. In

[1] All US$ in this report are in constant 2005 values unless otherwise specified.

the same year, thermal (coal, natural gas, and oil) and hydro accounted for 25.3 percent and 74.7 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 6.2 percent from 2013 to 2040, slowing from 1990–2013's growth of 9.2 percent. The population is assumed to increase by about 0.8 percent per year from 2013 to 2040.

### 2.2. Energy Consumption and Electricity Generation

Hydro and natural gas have dominated electricity generation in Myanmar. Other fuels such as oil and coal also contributed in the country's generation mix, but in total only less than 13 percent in 1990. It is assumed that the share of coal in the generation mix will be more than 14.7 percent in 2040. The government's plan is to increase further the shares of natural gas, coal, hydro, and other renewables in the total generation mix and decrease oil's share. Myanmar also has 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 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, especially solar and wind, which are abundant under Myanmar's climatic condition, is encouraged. It 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 scenario (BAU) levels are expected from improvement 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 improvements will be achieved by improved vehicle fuel economy and more effective traffic management.

Myanmar still lacks a national strategy and action plan for mitigating and adapting to climate change, but several ministries have been implementing sector-specific initiatives relevant to climate change. The government is encouraging the use of biofuel in the transport and agriculture sectors to reduce oil dependency and curb carbon dioxide ($CO_2$) emissions. These efforts are already in place, although the amount of biofuel used in the country 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 Natural Resources and Environmental Conservation (MONREC), 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 MONREC, 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 for approval.

Myanmar's primary energy saving goal is to reduce energy consumption by 5 percent in 2020 and by 10 percent in 2030, relative to the BAU. Specifically, the goals could be achieved by 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 Association of Southeast Asian Nations (ASEAN) Energy Manager Accreditation Scheme (AEMAS) Program by 2010–2015.

On a sectoral basis, the EEC measures in Myanmar are listed below:

- In industry, gradual replacement of low efficiency equipment with higher efficiency alternatives will be encouraged.
- In the transport 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 transport with greater volume capacity for freight and passenger. Improvement in 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 improvement in 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 bio-diesel (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, EEC, 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 achieve the 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, electric appliances, etc.
- Encourage the private sector to implement the 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.
- To consider EEC on both the demand and supply sides of electricity.
- There should be proper policy measures and action plans to achieve energy savings targets.

## 2.5. Action Plan

The energy efficiency initiatives of Myanmar covered buildings, households, and the industrial and transport sectors. They are as follows:

**Table 12-1. Energy Efficiency Initiatives**

| Sectors | EEC Initiatives |
|---|---|
| Industrial | - Promote the introduction of equipment and facilities with high-energy conservation capacity.<br>- Develop energy statistics<br>- Develop goals for voluntary action plans<br>- Develop R&D and AEMAS programme |
| Transportation | - Raise the fuel efficiency in terms of passenger-km, and km/litre<br>- Fuel substitution with biofuels |
| Electricity | - Develop technology transfer and renewable energy, knowledge in rural areas<br>- Assist sustainable, renewable energy application in electricity generation |
| Household | - Labelling systems for buildings and appliances<br>- Develop demand side management programmes<br>- Thorough management of energy and other resources |

EEC = energy efficiency and conservation; R&D = research and development; AEMAS = ASEAN Energy Manager Accreditation Scheme.
Source: Author's compilation from various sources of the Ministry of Electricity and Energy, The Union of Myanmar, 2015.

### 2.6. Alternative Policy Scenarios (APS)

In the previous studies, two scenarios were formulated to analyse the impact of policy interventions to the energy sector. The Business-as-Usual scenario (BAU), which serves as the reference case to project energy demand and carbon dioxide ($CO_2$) 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 EEC targets, expedite penetration of new and renewable energy, and introduce cleaner technology including opting for a nuclear power plant. To understand further the impact of individual policy interventions, this year's study formulated five alternative policy scenarios as follows:

1) APS1: Improved energy efficiency of final energy consumption
2) APS2: Higher efficiency of thermal electricity generation
3) APS3: Higher contribution of new and renewable energy (NRE) (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, the APS4 has not been considered in the analysis. Thus, APS5 would only consist of APS1, APS2, and APS3.

## 3. Outlook Results

### 3.1. Business-as-Usual (BAU) Scenario

#### *Final energy consumption*

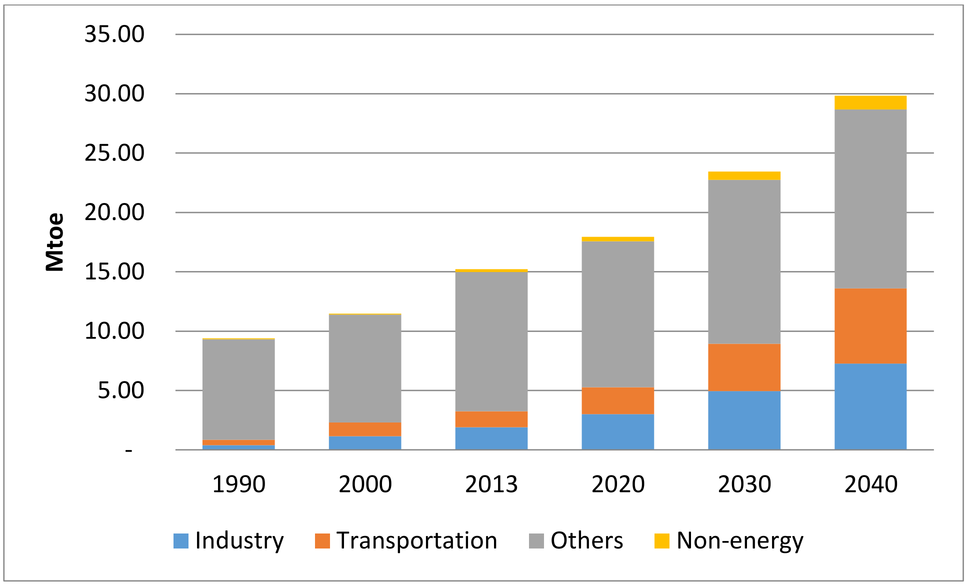
Total final energy consumption (TFEC) in Myanmar increased by about 2.1 percent per year from 9.4 Mtoe in 1990 to 15.23 Mtoe in 2013. The industrial sector was the fastest growing sector with an average annual growth of 7.1 percent between 1990 and 2013. Consequently, the share of this sector in TFEC increased from around 4.2 percent in 1990 to 12.4 percent in 2013. The transport sector was the second fastest growing sector with an average annual growth rate of 5.0 percent over the same period and the share of this sector in TFEC increased from 4.7 percent in 1990 to 9.0 percent in 2013.

The ‘others’ sector, which comprises the commercial, residential, and agricultural sectors, was the major contributor to TFEC. The shares of this sector, however, declined from 90.1 percent in 1990 to 77.0 percent in 2013. This indicates that annual growth of demand for this sector was slower than the industry and transport sector. The average annual growth rate of the demand of the ‘others’ sector was 1.4 percent between 1990 and 2013. Non-energy consumption grew gradually at an average annual rate of 4.2 percent over the same period from almost 0.1 Mtoe in 1990 to 0.24 Mtoe in 2013. Although the share of this sector in demand was only 1 percent in 1990, it increased slighly to 1.6 percent in 2013.

Using the socio-economic assumptions stated above, final energy consumption in Myanmar is projected to grow at an annual rate of 2.5 percent under the BAU, reaching 29.84 Mtoe in 2040. The industrial sector, which experienced the fastest growth in final energy consumption during the 1990–2013 period, is expected to slow in the future. Final energy consumption of the industrial sector will increase at an average rate of 5.1 percent per year while tranport sector demand will grow faster at 5.8 percent per year. Final energy consumption of the other sectors (mainly the residential and commercial sectors) is projected to grow at an annual average rate of 0.9 percent, slower than in the past. This is mainly because of the fall in biomass demand, which represents the bulk of fuel consumed by the sector. Figure 12-1 shows the final energy consumption by sector to 2040 under the BAU.

The respective growth of the sectors under the BAU will result in a continuous increase of the transport, industrial, and non-energy sector shares in TFEC and a decline in the ‘others’ sector’s share. The transport, industrial, and non-energy sector share is projected to increase to 21.3 percent, 24.4 percent, and 3.9 percent, respectively, in 2040. The ‘others’ sector’s share will decline to 50.5 percent from 77.0 percent in 2013.

**Figure 12-1: Final Energy Consumption by Sector, BAU**



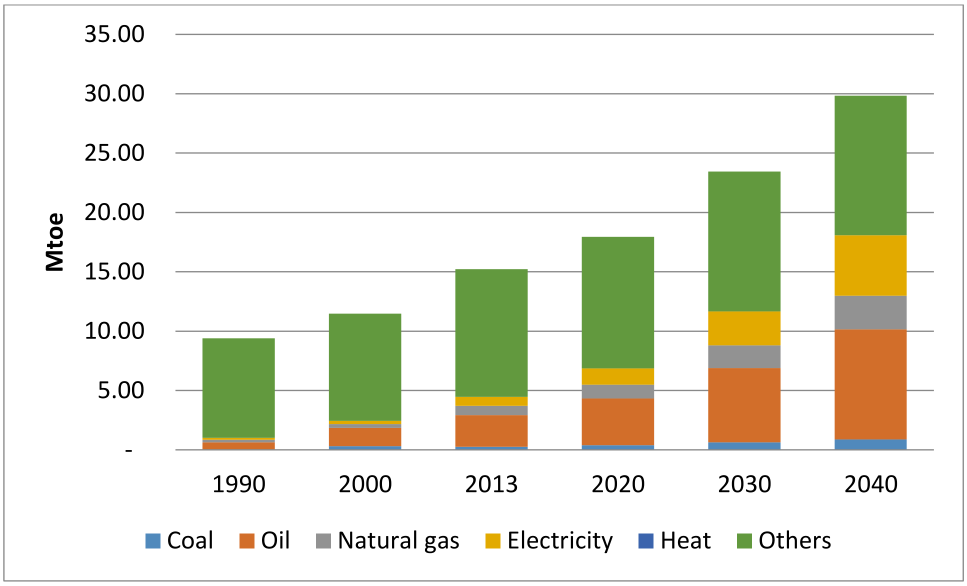

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

By fuel type, 'others,' which is mostly biomass, were the most consumed fuel in 1990 with a share of 89.2 percent in Myanmar's TFEC. Its share decreased to 70.8 percent in 2013 due to the higher growth of the other fuels. The demand for natural gas increased from 0.23 Mtoe in 1990 to 0.77 Mtoe in 2013 while for oil it increased from 0.59 Mtoe to 2.69 Mtoe over the same period. Electricity demand increased fastest at an average growth rate of 7.3 percent per year over the 1990 to 2013 period.

Under the BAU, the share of other fuels will decline to 39.4 percent in 2040, indicating that its future use will grow slower than for the other fuels. In contrast, the share of oil will continue to increase and reach 31.1 percent in 2040 from 17.7 percent in 2013, with an average growth of 4.7 percent per year. This is due to the rapid increase of transport sector activities over the 2013 to 2040 period. Figure 12-2 shows the final energy consumption by fuel type to 2040 under the BAU.

Coal is projected to grow at an average annual rate of 4.8 percent from 2013 to 2040, still slower than natural gas (5.0 percent).

**Figure 12-2. Final Energy Consumption by Fuel, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

Electricity demand will still grow fastest, at an average annual rate of 7.4 percent over the same period, its share increasing from 4.9 percent in 2013 to 17.1 percent in 2040.

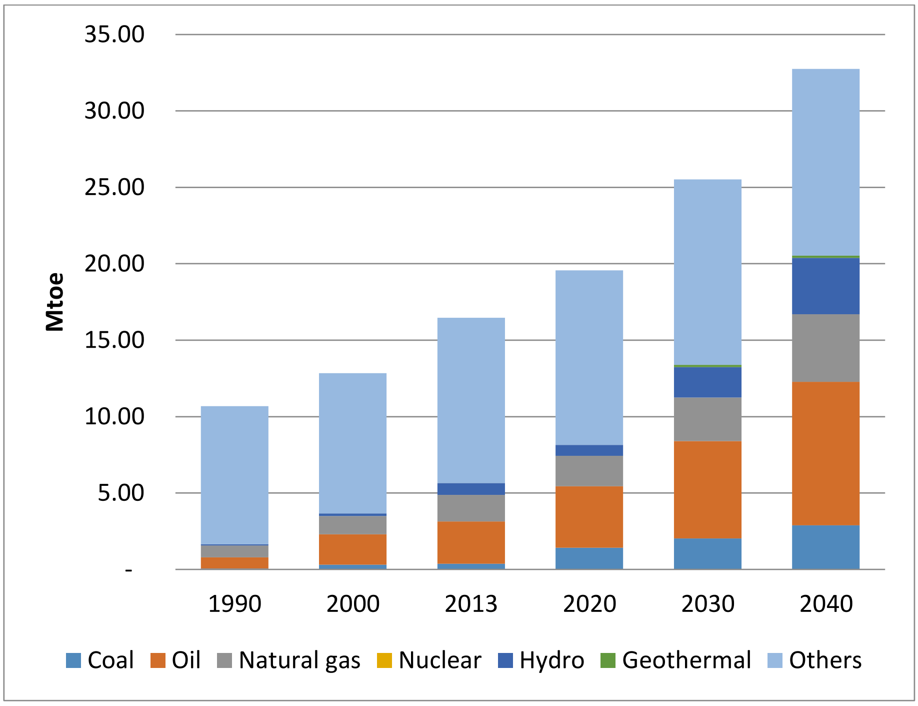
### *Primary energy supply*

Primary energy supply in Myanmar grew at an average annual rate of 1.9 percent from 10.7 Mtoe in 1990 to 16.5 Mtoe in 2013. Among the major energy sources, the fastest growing were hydro and coal with average annual growth rates of 9.1 percent and 7.7 percent, respectively. Natural gas consumption grew at an average annual rate of 3.7 percent over the same period. Oil consumption increased at 6.0 percent per year on average over the same period. Others, such as biomass, dominated the primary energy supply mix in 2013 with a share of 65.7 percent. Oil and natural gas, with respective shares of 16.8 percent and 10.6 percent, had the next largest shares among the major fuels over the same period.

In the BAU, Myanmar's primary energy supply is projected to increase at an annual average rate of 2.6 percent per year to 32.7 Mtoe in 2040. Hydro and natural gas are expected to grow at average annual rates of 6.0 percent and 3.5 percent, respectively. Coal will grow faster at 7.9 percent from 2013 to 2040 and oil will grow at 4.6 percent per year.

The share of oil and hydro in the total primary energy mix of Myanmar will increase to 28.7 percent and 11.2 percent, respectively, in 2040. Coal's share will also increase, from 2.3 percent in 2013 to 8.8 percent in 2040. Natural gas' share will remain more or less the same at around 13.5 percent over the projection period. Notably, the share of biomass will decrease due to its slow growth that is driven only by the growth of the rural population. From 65.7 percent in 2013, its share will decline to 36.1 percent in 2040.

**Figure 12-3. Primary Energy Supply by Source, BAU**



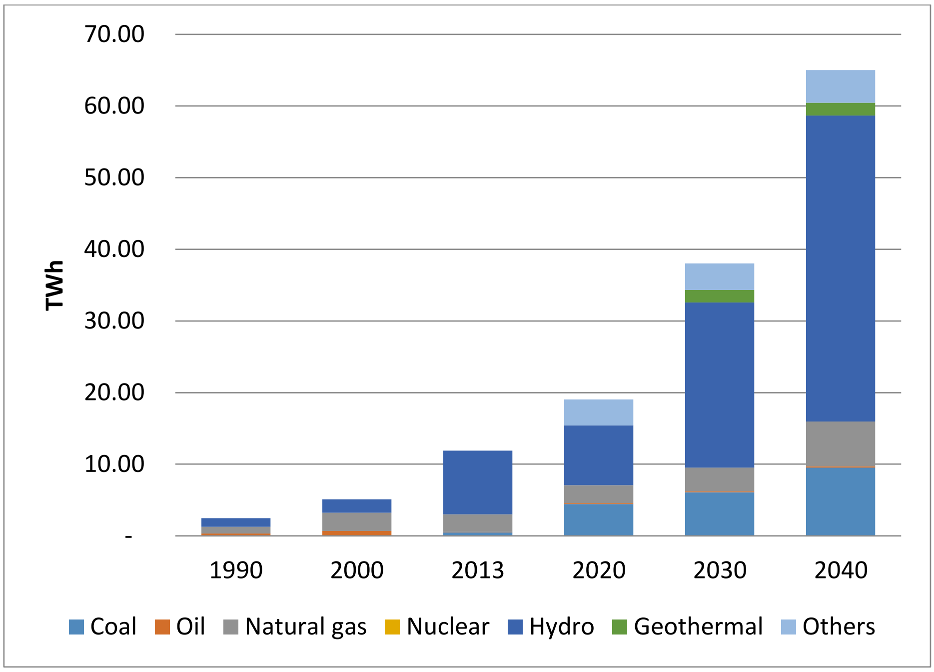

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

***Power generation***

Hydro and natural gas dominated the power sector fuel mix in Myanmar. In 2013, the share of hydro in the power generation mix reached 74.7 percent, while the natural gas share was 20.5 percent. The remaining fuels (coal and oil) accounted for only 4.8 percent of the total generation mix.

Under the BAU, oil-based power plants will cease operation after 2040 and natural gas-based power plants' share will decrease to around 10 percent in 2040. Consequently, coal-based power plants will have increasing roles.

**Figure 12-4. Power Generation Mix, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculations.

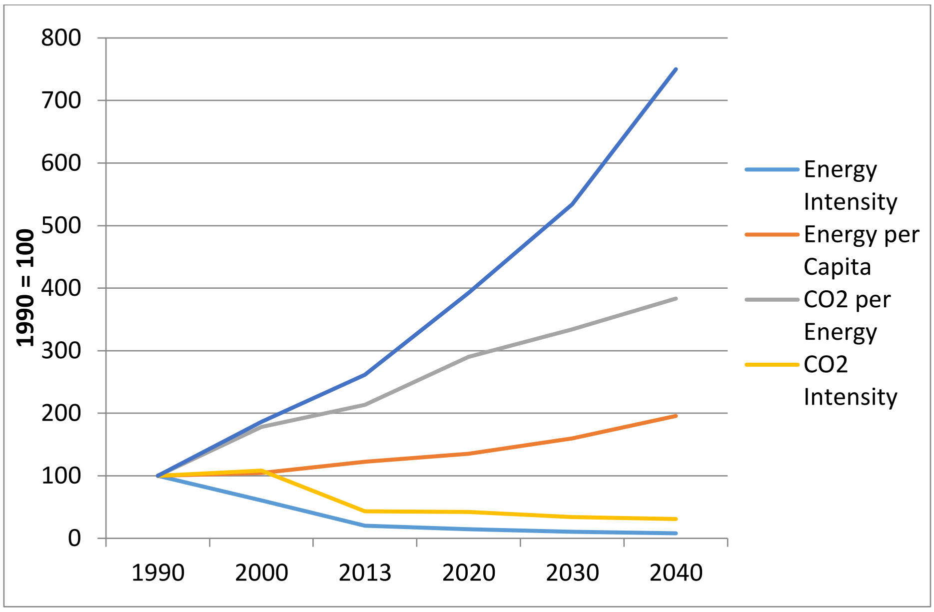
The share of electricity generated from coal-based power plants will increase to 14.7 percent in 2040. Hydro will continue to dominate the power sector fuel mix, but with its share decreasing to 65.7 percent in 2040 from 74.7 percent in 2013.

Total electricity generation from the different plants will grow at an average annual rate of 6.5 percent and coal-based power plants will grow at an average annual rate of 11.4 percent. Hydro-power generation will also increase, at an average annual rate of 6.0 percent from 2013 to 2040, and natural gas based power plants are forecast to grow by 3.5 percent.

### *Energy intensity, energy per capita, and energy elasticity*

Myanmar's primary energy intensity (TPES/GDP) has been declining since 1990. In 2013, the primary energy intensity was 660 toe/million 2005 US$, lower than in 1990 when it was 3,243 toe/million 2005 US$. It is projected that the intensity will continue to decrease, to 262 toe/million 2005 US$ by 2040, at an average rate of 3.4 percent per year. Energy consumption per capita rose from 0.25 toe in 1990 to 0.31 toe in 2013 and will increase to 0.50 by 2040, at an average annual growth rate of 1.7 percent. The $CO_2$ intensity was 340 t-C/million 2005 US$ in 1990 and decreased to 148 t-C/million 2005 US$ in 2013. It is projected to increase to 105 t-C/million 2005 US$ in 2040 at an average annual growth rate of 1.3 percent. Figure 12-5 shows the evolution of these energy indicators from 1990 to 2040.

**Figure 12-5. Energy Intensity, $CO_2$ Intensity, and Energy per Capita**



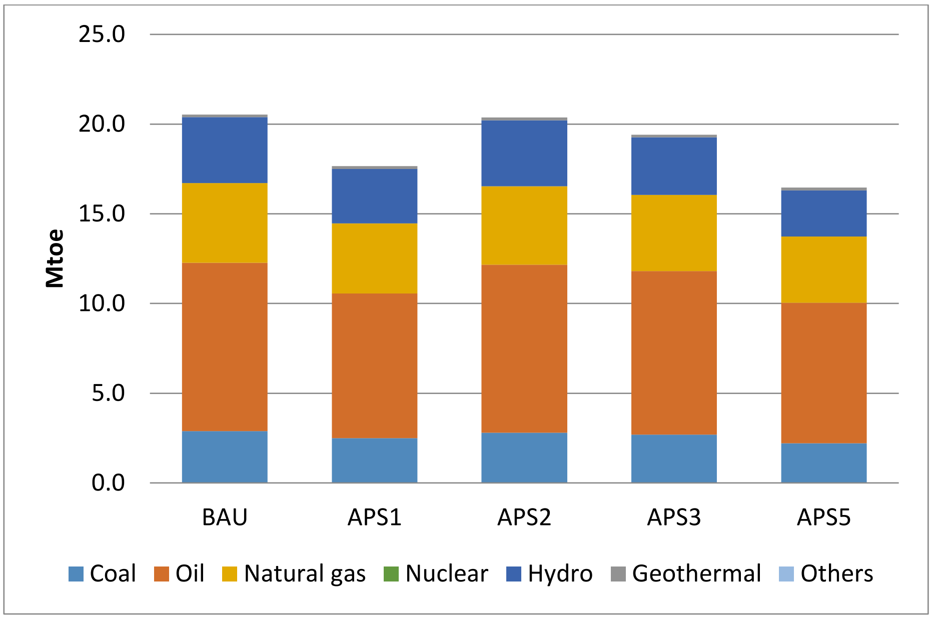

$CO_2$ = carbon dioxide.
Source: Author's calculations.

### 3.2. Energy Saving Potential (APS)

The Alternative Policy Scenario (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 TPES in all the scenarios.

APS5 has the largest reduction in TPES due to the implementation of EEC action plans, improvement of thermal efficiency of fossil-fueled power plants, and higher penetration of new and renewable energy in the country's supply mix. The average annual growth rate of TPES under APS5 will be around 2.1 percent over the projection period. In 2040, the reduction of primary energy supply in APS5 as compared with the BAU will be 3.8 Mtoe, or 11.6 percent.

**Figure 12-6. Comparison of Scenarios to Total Primary Energy Supply in 2040**




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

Individually, implementation of only energy efficiency targets and masterplan, as defined in APS1, will reduce the TPES of Myanmar by 3.5 Mtoe or 10.5 percent in 2040 as compared with the BAU. The average annual growth rate of primary energy supply in APS1 will be 2.2 percent, slightly faster than APS5. APS2, which assumes higher efficiency in thermal electricity generation, will reduce the TPES by 0.16 Mtoe or 0.8 percent compared with the BAU. The country's TPES under APS2 will grow at an annual average rate of 2.6 percent, similar to the BAU. Since no final energy consumption efficiency measures were assumed for APS2, the impact on the primary enegy supply will be lower than for APS1 or APS5. Of all the fossil fuels considered, implementation of this higher efficiency of thermal power generation policy intervention will reduce the use of coal and natural gas for power generation. As the result of high efficient thermal power generation, it could achieve a higher reduction in coal use of almost 3.6 percent in 2040.

If policy for higher penetration of new and renewable energy (NRE) is implemented, there will also be a reduction in TPES compared with the BAU by 0.2 Mtoe or 0.7 percent. By fuel type, there is a reduction in coal and natural gas consumption, but the use of renewable energy is increasing, mainly hydro by 13 percent (0.5 Mtoe).

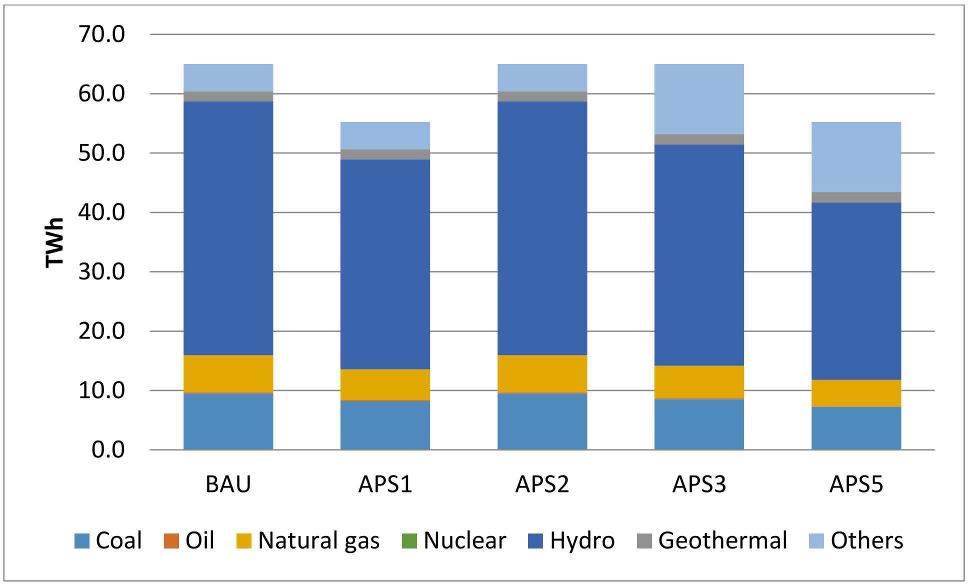
The impacts of implementing policy interventions will also be reflected in the country's power generation. Figure 12-7 shows total electricity generation in 2040 in all scenarios. In both APS1 and APS5, due to the lower electricity demand, power generation will be reduced by 9.75 Mtoe or 15.0 percent as compared with the BAU. The reduction in power generation will be from natural gas, coal, and hydro plants, with the highest reduction in hydro-power plants (7.3 Mtoe in APS1 and 12.8 Mtoe in APS5).

Under APS2 and APS3, the total amount of electricity generated will be similar to the BAU because no efficiency measures were imposed on the final end-use sector. The differences, however, lie in the fuel mix for power generation under APS3. More 'others' renewable power plants such as solar, wind, biomass, etc., will be in operation over the planning period, replacing some of the fossil-fueled power plants, (natural gas fueled plants), which are supposed to be in operation up to 2040.

In terms of CO2 emission reduction, the energy efficiency assumption in APS5 is expected to reduce emissions by at most around 2.48 million metric tons of carbon (Mt-C), which is 18.8 percent lower than the BAU. The decrease in CO2 indicates that the energy saving goals, action plans and policies in the promotion of programmes, and switching to less carbon-intensive technologies such as renewable sources in the supply mix will be effective in reducing CO2 emissions. Figure 12-8 shows the projected CO2 emissions in 2040 in all scenarios.

In APS1 and APS5, TFEC will be lower so that $CO_2$ emissions from energy consumption will also be lower, reaching only around 11.3 Mt-C. This is a reduction of $CO_2$ emission by around 1.9 Mt-C, which is around 14 percent lower than the BAU. In APS3, higher contributions from renewable energy could reduce emissions by 4.2 percent as compared with the BAU. Total $CO_2$ emissions under APS3 will be around 12.6 Mt-C, which is around 0.6 Mt-C lower than the 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.

**Figure 12-7. Comparison of Scenarios of Electricity Generation in 2040**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; TWh = terawatt-hour.
Source: Author's calculations.

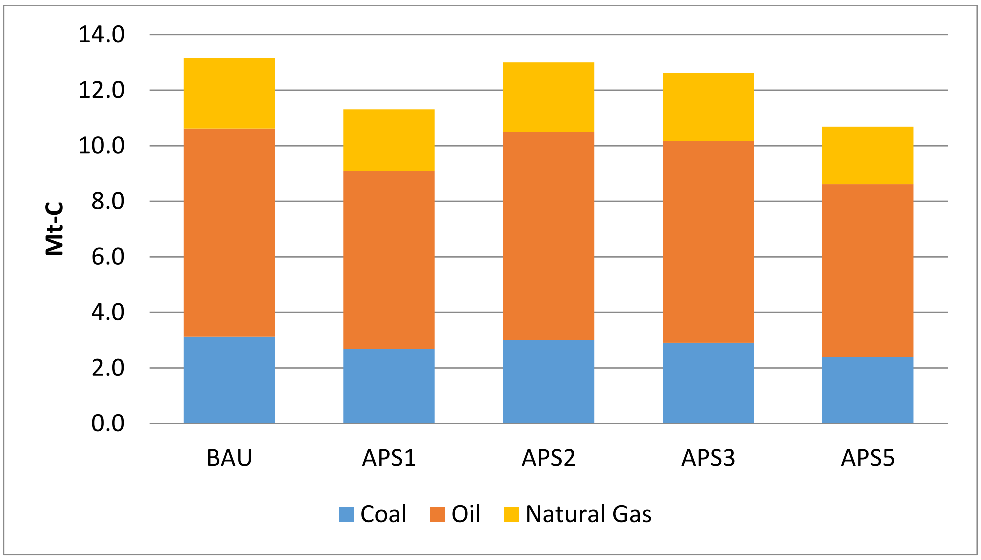
### 3.2.1. Final energy consumption

In the APS, which is the combined APS (APS5), final energy consumption is projected to grow at a lower average annual rate of 2.1 percent as compared with the 2.5 percent annual growth in the BAU. The reason for the slower growth rate is technological improvements in manufacturing processes and the reduction of final energy consumption of electricity and oil in the residential and commercial ('other') sector. Figure 12-9 shows the differences in final energy consumption in 2040 by sector in the BAU and the APS.

***Primary energy supply***

In the APS, Myanmar's primary energy supply is projected to increase at a slightly lower rate than in the BAU, at 2.1 percent per year from 16.46 Mtoe in 2013 to 28.93 Mtoe in 2040. Coal will be the fastest growing at 6.8 percent per year followed by oil at 3.9 percent per year between 2013 and 2040.

**Figure 12-8. Comparison of $CO_2$ Emission in all Scenarios in 2040**




$CO_2$ = carbon dioxide; Mt-C = million tons of carbon; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

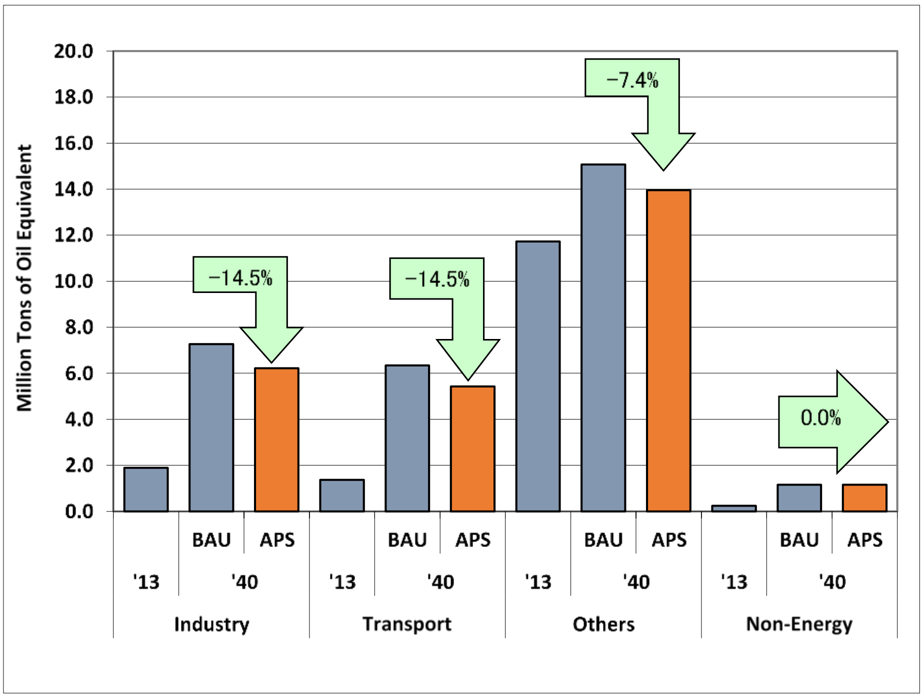
Natural gas is expected to grow at average annual rate of 2.8 percent over the same period, lower than hydro, which is expected to grow at 4.6 percent per year. Figure 12-10 shows the primary energy supply by source in 2040 under the BAU and the APS.

***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).

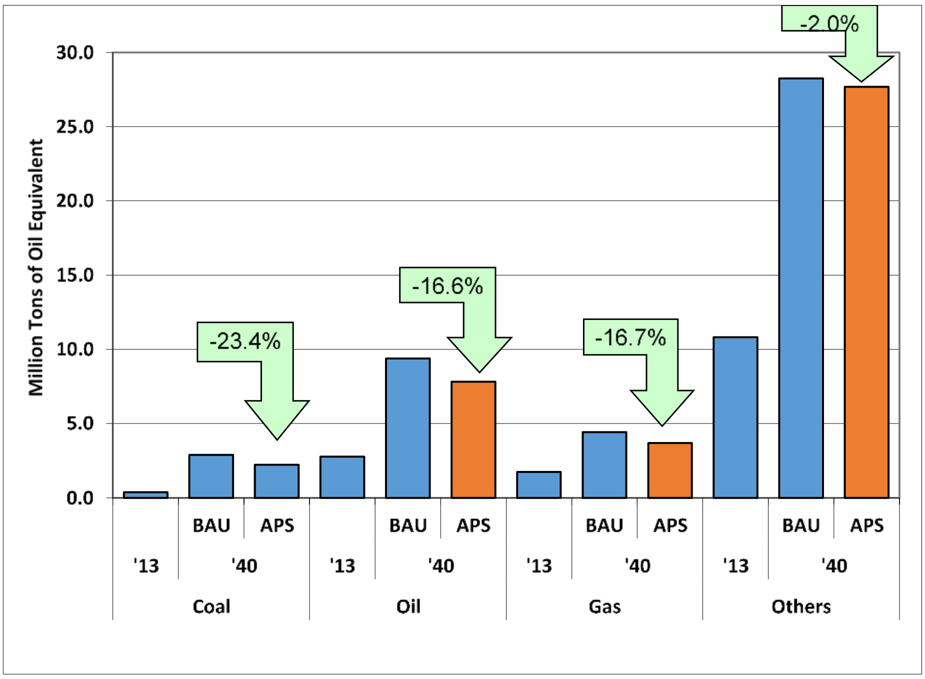
The choice of fuel type is determined by available supply, since energy demand has to be met mainly by domestic sources. Obviously, there is a gap between demand and supply, but demand is much higher than the actual requirement. Due to these constraints, coefficients, derived by time series regression, have been applied to allocate energy. These allocations are made based on the priorities of the state organisations and enterprises. For the private sector, allocations are made based on the registered licensed capacity of the firms.

**Figure 12-9. Final Energy Consumption by Sector, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario
Source: Study outcome.

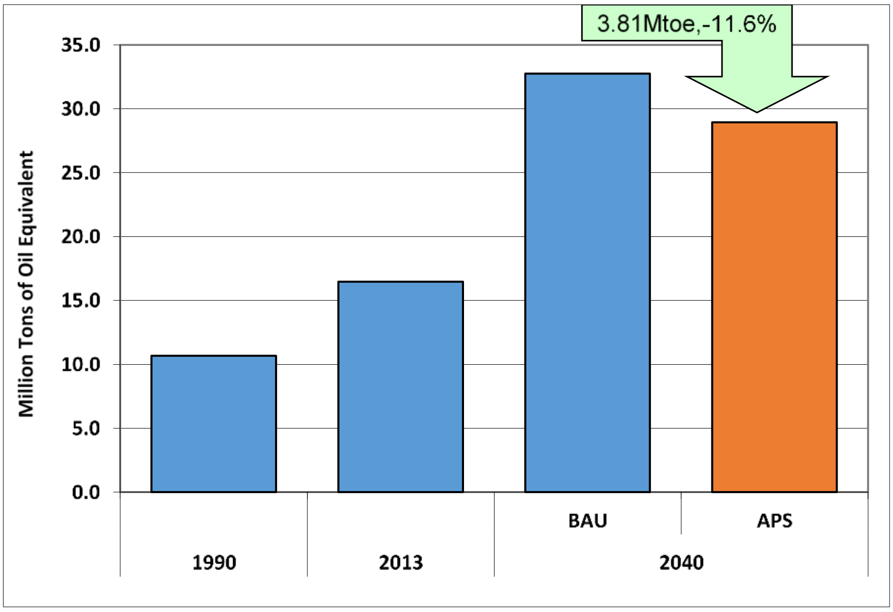
**Figure 12-10. Primary Energy Supply by Source, BAU and APS**




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

Future savings in energy could be made through savings in primary energy supply in the residential, commercial, transportation, and industrial sectors. In view of this, Myanmar has implemented a range of EEC goals and action plans, which target energy savings in all sectors of the economy and in cooperation with both the private and public sectors. There is an estimated saving of 3.81 Mtoe in 2040 in the APS, relative to the BAU. This is equivalent to a 11.6 percent saving of the primary energy supply in 2040 of the BAU (Figure 12-11). Myanmar has plans to decrease the growth in primary energy supply by implementing a range of EEC measures on the demand side.

**Figure 12-11. Evolution of Primary Energy Supply, BAU and APS**

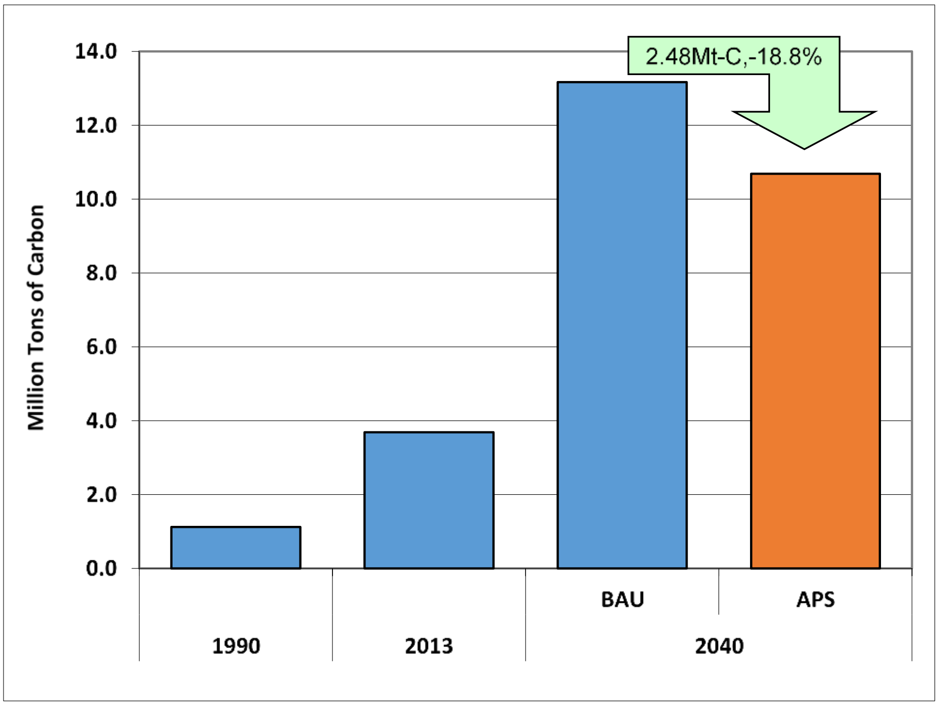



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe =
Source: Author’s calculations.

### *$CO_2$ reduction potential*

In the APS, the energy efficiency policy of Myanmar is projected to reduce growth in $CO_2$ emissions from energy consumption. In 2040, in the APS, $CO_2$ emissions from energy consumption are projected to reach about 2.48 million tons of carbon (Mt-C), which is about 18.8 percent below the BAU level (Figure 12-12).

**Figure 12-12. $CO_2$ Emission from Energy Consumption, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C =million tons of carbon.
Source: Author's calculations.

## 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 can be taken into consideration:

- An integrated national energy policy including energy efficiency will be formulated by the National Energy Management Committee (NEMC).
- Coordination mechanism and institutional arrangement and 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 for energy consumption, which can be done by combining this survey with existing surveys.
- Due to the continuous 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 been calculated for the industrial, commercial, and household sectors.
- There is a need for a detailed policy mechanism for the renewable energy sector to implement the potential programmes and projects. This mechanism should be developed and planned in conjunction with external stakeholders, who offer experience, advanced technologies, new markets, and investment.
- There is a need to improve energy management practices for industrial and commercial sectors.
- A dedicated energy efficiency body needs to be established to oversee the energy efficiency programme of Myanmar.
- Refinement of the current energy efficiency target will be necessary 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.
- In view of the low electrification rate, the government needs to formulate schemes to enhance private participation, including by foreign companies, to accelerate power sector development including a transmission and distribution system to ensure reliable electricity supply to consumers.
- 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 implement policies and programmes 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 exploration of new domestic natural gas resources is still being undertaken.

- Consider civilian nuclear energy policy and exploration of geothermal energy potential for electricity generation.
- Biomass consumption is increasing continuously; the government should remove taxes on LPG and kerosene to reduce the cost of LPG use in the residential sector.
- Encourage private companies to invest in new refinery capacities to meet domestic petroleum products demand.

# Chapter 13

## New Zealand Country Report

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Tsunoda. M (2016), 'Republic of Korea Country Report' in Kimura. S and Han. Pan (eds.) in *Energy Outlook and Energy Saving Potential in East Asia 2016.* ERIA Research Project Report 2015-5, Jakarta: ERIA, pp.261-272.

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 kilometres (km) east of Australia. It consists of three main islands (the North Island, the South Island, and Stewart Island), and a number of other 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$173.0 billion, or about US$38,600 per capita. Although 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. New Zealand has locally produced crude oil, which is generally exported because of its high quality and, therefore, high value on the international market. To meet its oil demand, over half of all imported oil to New Zealand in 2013 was produced in the Middle East. Remaining energy 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 tons of coal, 80 percent of which are South Island lignites.

In 2013, New Zealand's total primary energy supply (TPES) was around 19.5 million tons 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 20 percent and 22 percent, respectively. The remainder of the primary energy supply were hydro at 10 percent, coal at 8 percent, biomass with 6 percent, and a smaller percentage of other renewables such as wind and solar photovoltaic (PV).

Final energy consumption was about 13.2 Mtoe in 2013. By sector, the transport sector accounted for 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 31 percent, whereas the total of agricultural, residential, and commercial sectors were 25 percent. The balance of 9 percent was consumed by the non-energy sector.

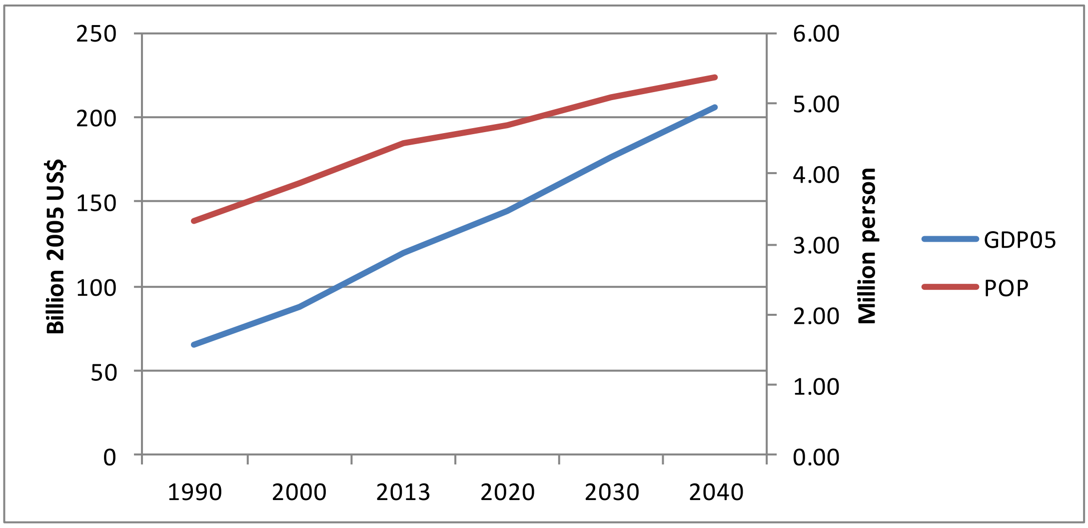
The total gross power generation output in 2013 was about 43.3 TWh. Hydro accounted for about 53 percent as the most utilised source, whereas natural gas represented the second most utilised source at over 20 percent, followed by geothermal power at about 15 percent, coal at 6 percent, and other renewables at 6 percent. Oil is used in electricity generation only as a minor source for peaking and emergency supply.

## 2. Modelling Assumptions

In this outlook, New Zealand's GDP is assumed to grow at an average annual rate of 2.0 percent between 2013 and 2040. Its population will increase by about 20 percent to 5.4 million by 2040, from 4.4 million currently. See Figure 13-1.

In the Business-as-Usual scenario (BAU), hydro use in power generation will remain constant, as most hydro sites have already been developed. Generation from natural gas based plants is projected to increase slightly, at an annual average rate of 0.5 percent. Geothermal power generation will increase at an annual average growth rate of 2.4 percent and wind generation will continue to grow, but it will still contribute only a small share of New Zealand's electricity by 2040. In contrast, coal power generation will disappear (Figure 13-2). Thermal efficiency of gas- and oil-fired power plants may not increase so much in the future, because new large fossil fuel based plants are not planned. Moreover, Genesis Energy (New Zealand's largest energy company) has decided to decommission its coal-fired power plants by 2023.

**Figure 13-1. GDP and Population**

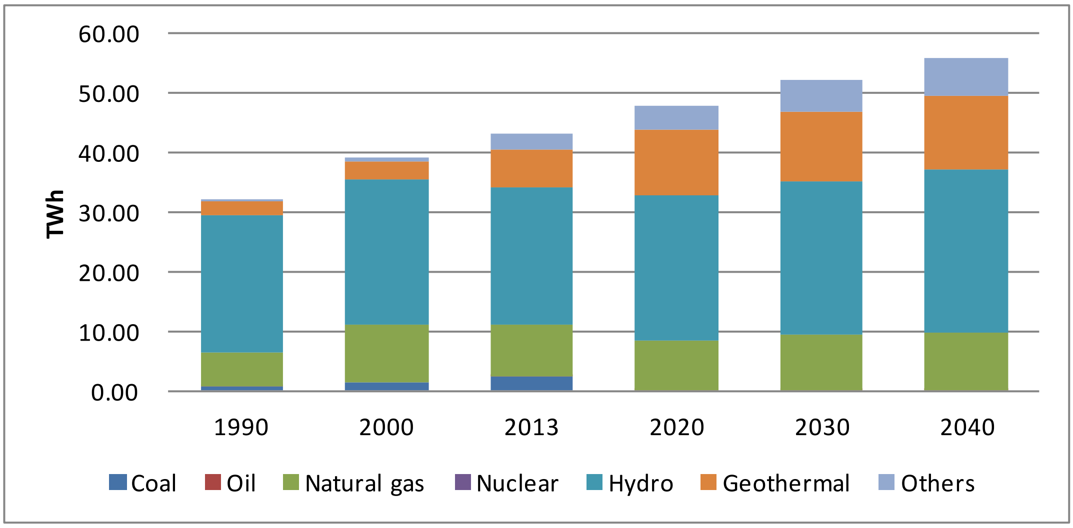



GDP = gross domestic product; GDP05 = GDP at 2005 constant prices; POP = Population.
Source: Author's calculations.

In terms of energy demand, the overall energy intensity of the economy improved in real terms at an annual average rate of 0.8 percent from 1990 to 2013.

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 2014.

**Figure 13-2. Power Generation by Fuel, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculations.

The New Zealand government implemented an emissions trading scheme in 2010 and is currently (May 2016) undertaking a review of that scheme to determine how it can best support New Zealand in both meeting its climate change targets and transitioning to a low emissions economy. New Zealand has also, through its Energy and Energy Efficiency and Conservation Strategies, set a target for 90 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, work, and in transport, as well as the development and deployment of sustainable energy technologies.

## 3. Outlook Results

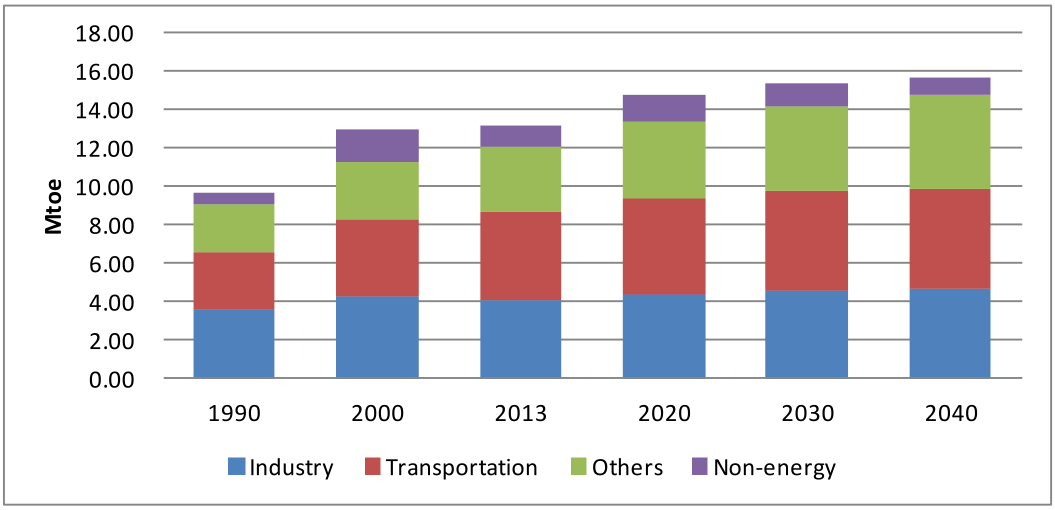
### 3.1. Final Energy Consumption

New Zealand's final energy consumption grew by 1.4 percent per year from 9.7 Mtoe in 1990 to 13.2 Mtoe in 2013. Oil increased from 4.03 Mtoe to 5.93 Mtoe, electricity also rose from 2.43 Mtoe to 3.26 Mtoe, and natural gas also rose from 1.80 Mtoe to 2.16 Mtoe for the same period. On the other hand, coal was in decline, falling from 0.67 Mtoe to 0.62 Mtoe.

### 3.1.1. Business-as-Usual Scenario (BAU)

In the Business-as-Usual scenario (BAU), final energy consumption from 2013 to 2040 is projected to grow by 2.4 Mtoe at an average rate of 0.6 percent per year. The 'others' sector (agricultural, residential, and commercial) will have the largest rise of 1.5 Mtoe between 2013 and 2040, growing at an average annual rate of 1.4 percent. Transport sector consumption is projected to increase by 0.6 Mtoe at an annual rate of 0.5 percent and the industry sector is projected to increase by 0.6 Mtoe in 2040. Non-energy sector consumption will decline by 0.3 Mtoe at an annual rate of 1.0 percent (Figure 13-3).

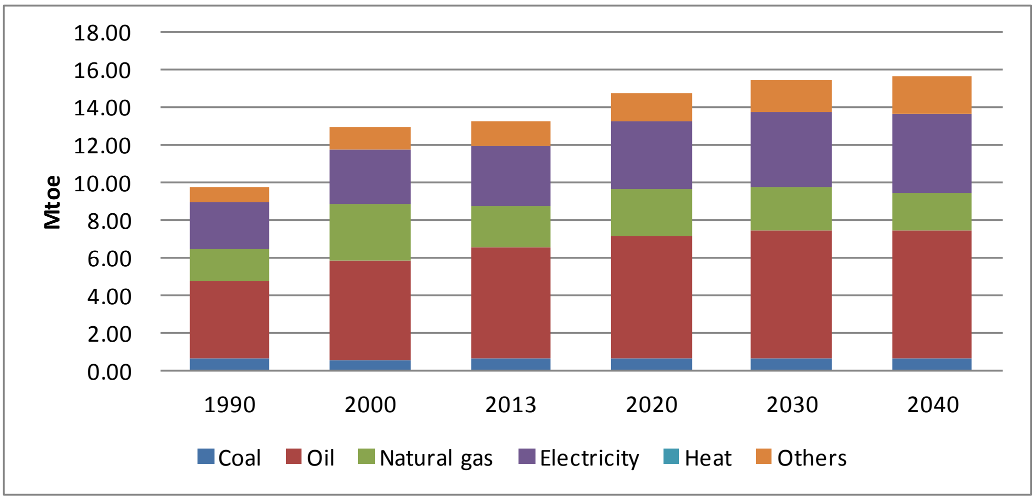
**Figure 13-3. Final Energy Consumption by Sector, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Note: The 'others' sector includes the agricultural, residential, and commercial sectors.
Source: Author's calculations.

By source, final demand of electricity will steadily increase by 1.0 Mtoe between 2013 and 2040 at an average rate of 1.0 percent per year. Final demand of other renewable energy – which includes geothermal, solar, biogas, and woody biomass used for direct-use heat applications – will increase by 0.7 Mtoe at an average rate of 1.6 percent per year. Final demand of oil will also rise, by 0.9 Mtoe at an average rate of 0.5 percent, whereas coal demand in 2040 will remain at the same level as in 2013. Natural gas will decrease slightly, by 0.2 Mtoe at 0.3 percent per year (Figure 13-4).

**Figure 13-4. Final Energy Consumption by Energy, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Note: The 'Others' sector includes geothermal, solar, biogas, and woody biomass.
Source: Author's calculations.

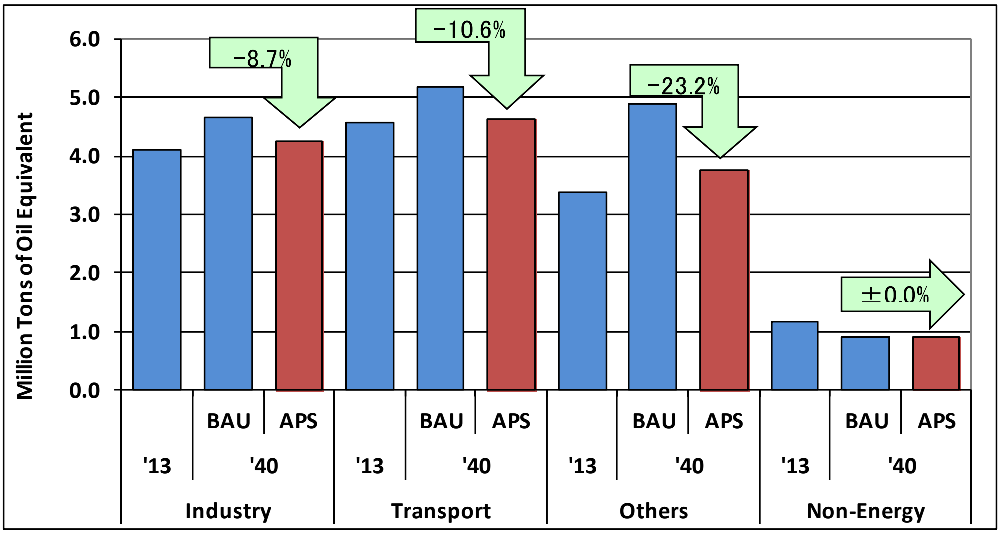
### 3.1.2. Alternative Policy Scenario (APS)

In the Alternative Policy Scenario (APS), final energy consumption will be slightly higher in 2040. The increase in final energy consumption will be 0.3 Mtoe between 2013 and 2040. Energy use in the 'Others' sector will increase at an average rate of 0.4 percent per year, reflecting increasing use of efficient appliances in the residential and commercial sectors. Energy use in the industrial sector is projected to increase at an annual average rate of 0.2 percent. Energy use in the transport sector will rise slightly, reflecting a shift to more energy efficient vehicles, particularly electric vehicles. The sectoral final energy consumption in 2013 and 2040 in the BAU and the APS is shown in Figure 13-5.

## 3.2. Primary Energy Supply

Primary energy supply in New Zealand grew at a rate of 1.8 percent per year from 12.8 Mtoe in 1990 to 19.5 Mtoe in 2013. The fastest growing primary fuel in absolute terms was oil, rising from 3.5 Mtoe in 1990 to 6.4 Mtoe in 2013. The increase in oil consumption is due to the rapid growth in transport energy demand.

**Figure 13-5. Final Energy Consumption by Sector, BAU and APS**



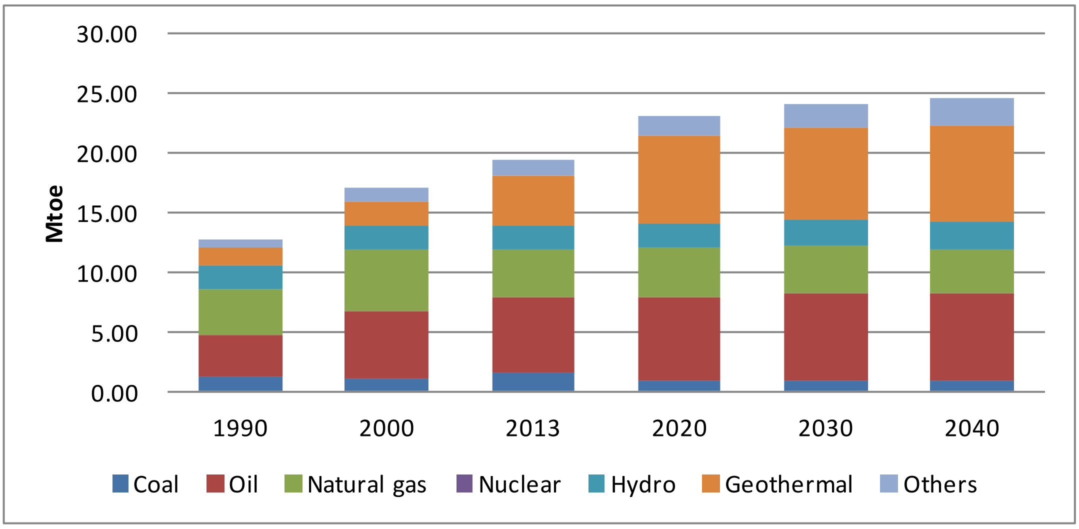

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculations.

Coal consumption also increased, at an annual average growth rate of 1.2 percent, whereas natural gas demand remained nearly unchanged from 1990 to 2013, reflecting a decrease in gas production from the Maui gas field. Geothermal energy use grew from 1.5 Mtoe in 1990 to 4.2 Mtoe in 2013 at an annual rate of 4.7 percent for electricity generation, while hydro demand for electricity production was unchanged. 'Other' energy sources, which include biomass, solar, wind, liquid biofuels, and biogas, increased by 2.3 percent per year.

### 3.2.1. Business-as-Usual (BAU) Scenario

In the BAU, New Zealand's primary energy supply will grow at an average annual rate of 0.9 percent to 24.7 Mtoe in 2040 from 19.5 Mtoe in 2013. Geothermal energy is projected to contribute most to the incremental growth of primary energy supply between 2013 and 2040 and will account for 32.2 percent of the total primary energy supply in 2040. 'Others' primary energy will grow by 2.1 percent per year, reflecting mainly the expected growth in wind power, and the share of 'Others' will account for 9.8 percent of the total primary energy supply in 2040. In contrast, primary fossil fuel will slightly increase, at an average rate of 0.01 percent and its share of the total will account for 48.5 percent in 2040, down from 61.1 percent in 2013. The remaining 9.5 percent of the total share in 2040 will be hydro for electricity generation, increasing at an annual average growth rate of 0.6 percent (Figure 13-6).

**Figure 13-6. Primary Energy Supply by Source, BAU**



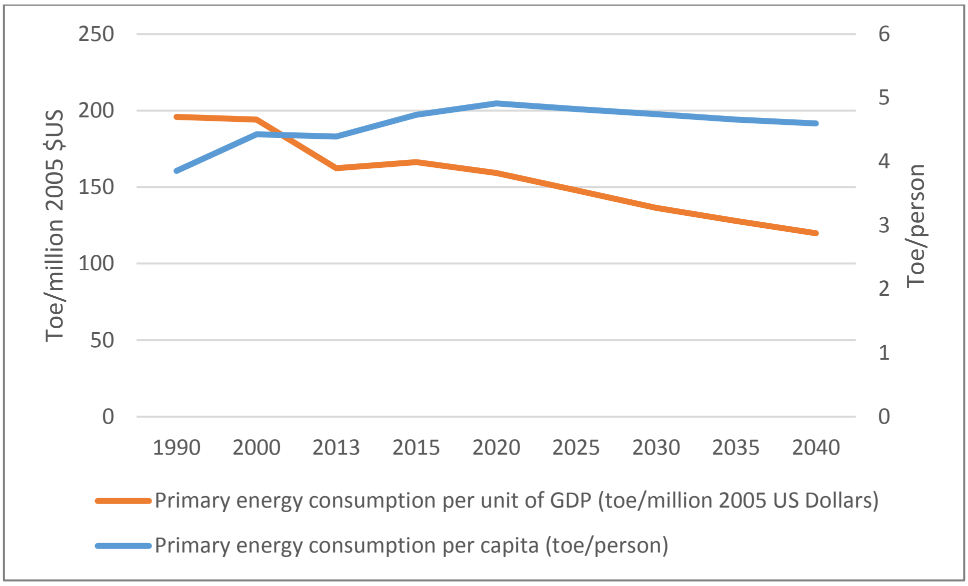

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

The lower growth of primary energy supply relative to GDP growth will result in lower energy intensity in the future. From 162 toe/million US$ in 2013, energy intensity will improve to 120 toe/million US$ in 2040. Primary energy supply per capita will increase, however, from 4.39 toe per person in 2013 to 4.60 toe per person in 2040. Figure 13-7 shows the primary energy intensity and the energy per capita as indicators.

### 3.2.2. Alternative Policy Scenario (APS)

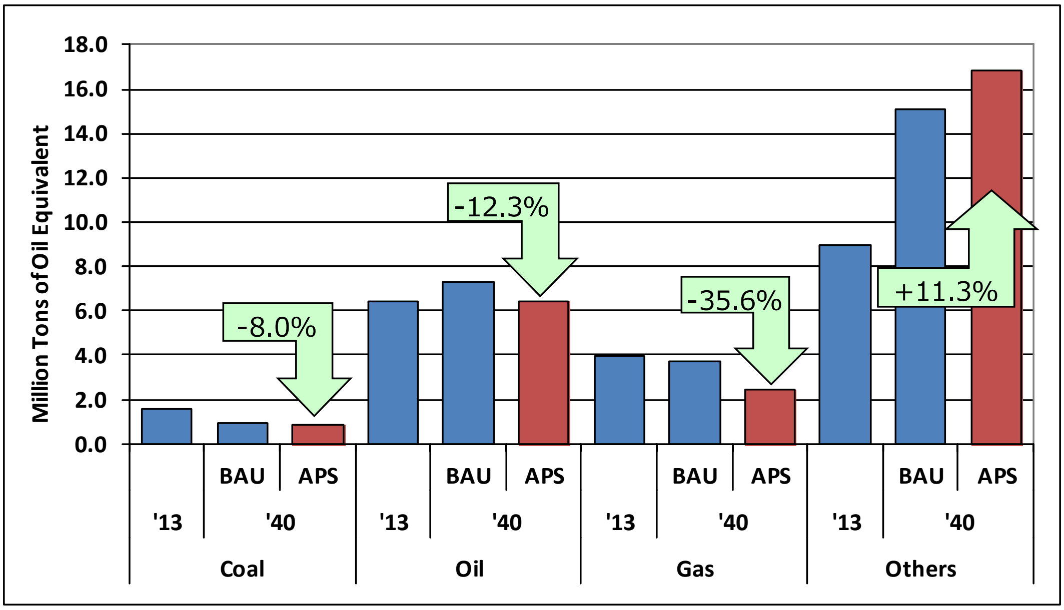
In the APS, primary energy supply is projected to grow at a lower rate of 0.8 percent per year to 24.0 Mtoe in 2040. Coal and gas are expected to show significant declines of 2.3 percent and 1.8 percent per year, respectively. Oil demand remained almost unchanged from 2013 to 2040, whereas geothermal primary energy is expected to grow by 3.3 percent per year (like in the BAU). 'Others' primary energy, which includes biomass, solar, wind, liquid biofuels, and biogas, is expected to grow by 2.3 percent per year (Figure 13-8).

**Figure 13-7. Primary Energy Intensity and Energy per Capita Indicator, BAU**




BAU = Business-as-Usual scenario; GDP = gross domestic product; toe = tons of oil equivalent.
Source: Author's calculations.

**Figure 13-8. Primary Energy Supply by Source, BAU and APS**

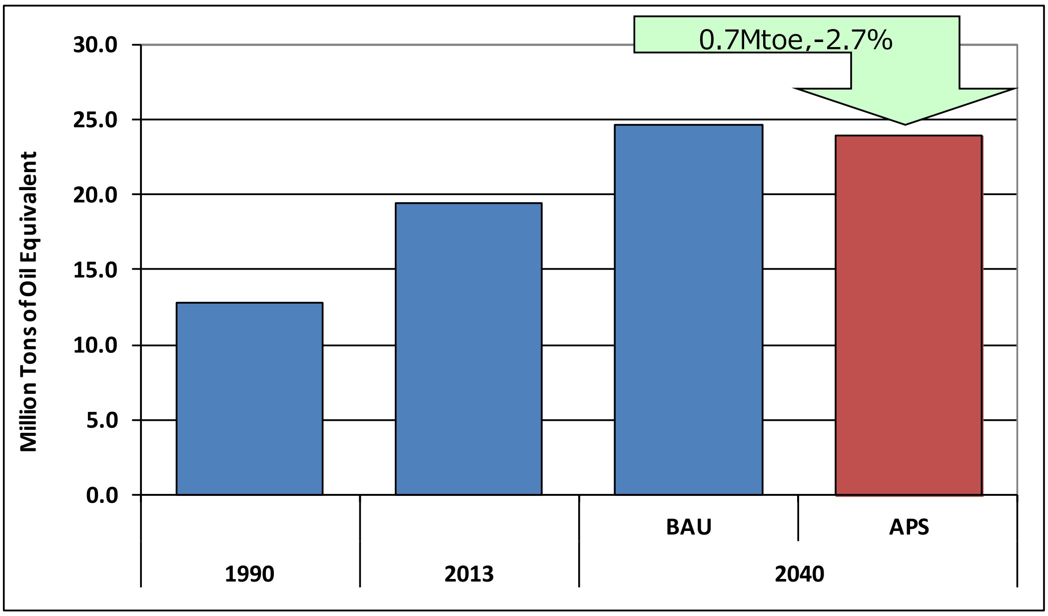



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Note: The 'others' sector includes biomass, solar, wind, liquid biofuels, biogas, hydro, and geothermal.
Source: Author's calculations.

### 3.3. Projected Energy Savings

Under the APS, energy savings could amount to 0.7 Mtoe in 2040, the difference between the primary energy supply in the BAU and the APS – 2.7 percent less than under the BAU in 2040 (Figure 13-9).

**Figure 13-9. Total Primary Energy Supply, BAU and APS**



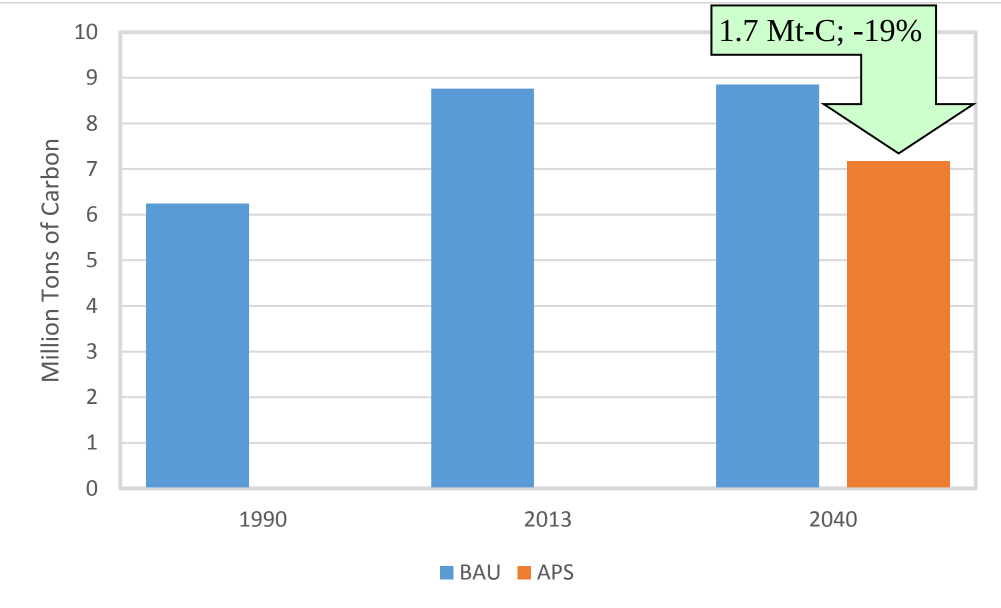

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculations.

The above savings in primary energy are mainly due to a switch of 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.

### 3.4. $CO_2$ Emissions

Carbon dioxide ($CO_2$) emissions in the BAU will increase slightly, from 8.8 million tons of carbon (Mt-C) in 2013 to 8.9 Mt-C in 2040. In the APS, $CO_2$ emissions will decrease from 2013 to 2040 by 0.7 percent per year. Since primary energy supply, excluding geothermal, is more or less stable over this period, the decrease reflects the switch to renewable energy in electricity generation, and the switch of automobiles to electric vehicles in the transport sector. Figure 13-10 shows the difference of $CO_2$ emissions from energy consumption between the BAU and the APS in 2040 compared with 1990 and 2013 in New Zealand.

**Figure 13-10. $CO_2$ Emissions from Energy Consumption, BAU and APS**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's calculations.

## 4. Implications and Policy Recommendations

Although New Zealand's primary energy intensity (energy per dollar of GDP) has been declining since 1990, energy use has continued to grow steadily, reflecting economic growth, population growth, and increasing numbers of private road vehicles.

New Zealand generates a high proportion of its electricity from renewable sources, particularly hydro, although $CO_2$ emissions from this sector have grown with large investment in fossil fuel based generation in the 1990s and 2000s. Trading of carbon credits will incentivise investment into new renewable generation technologies, with geothermal and wind as prospective options, provided $CO_2$ trading prices rise above the current levels. As the Acting Minister of Energy and Resources announced on 30 August 2011, New Zealand's ambitious goal is for 90 percent of electricity generation to be from renewable sources by 2025. New Zealand's large base of renewable generation, however, limits the room for $CO_2$ emissions reduction in the electricity generation sector. In March 2016, the minister announced that the targets will be developed and the New Zealand Energy Efficiency and Conservation Strategy (NZEECS) 2011–2016 will be replaced by mid-2017. The NZEECS's successor will have a carbon reduction focus.

New Zealand has some other opportunities to improve energy efficiency, for example through improving the efficiency of vehicles, improving the insulation of buildings, and improving the efficiency of heat production in industry, or switching to lower-carbon fuels.

The largest potential energy and carbon savings are in the transport sector. Growth in energy consumption in the transport sector has been slowing in recent years, mainly because of high fuel prices and a shift to smaller vehicles. Furthermore, reduction in emissions from the transport sector is possible through a switch to electric vehicles and increased use of biofuels. Electric vehicles are a good match for New Zealand given the high proportion of electricity generated from renewables, and the relatively short distances of average trips. Also, charging infrastructure already exists in most residential dwellings. The government recently announced a package of measures designed to encourage the use of electric vehicles. The target is to double the number of electric vehicles every year through to 2021 and to do so by removing barriers that have until now prevented households and businesses from choosing electric cars. Current barriers include the limited selection of models available; a lack of widespread public charging infrastructure; and lack of awareness about electric vehicles.

In the building sector, stronger regulation to enhance the energy efficiency of new and existing buildings in the residential and commercial sectors should be considered. In addition, New Zealand should give consideration to a package of measures (including regulatory instruments) to improve the energy efficiency of industrial heat plants.

# Chapter 14

## Philippines Country Report

September 2016

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Chapter 14

# Philippines Country Report

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## 1. Background

### 1.1. Socio-economic Situation

The Philippines, officially known as The Republic of the Philippines, with Manila as its capital city is an archipelago comprising of more than 7,000 islands that are categorised broadly under three main geographical divisions from north to south: Luzon, Visayas, and Mindanao. It is a sovereign island country in Southeast Asia situated in the western Pacific Ocean. The country is located in the midst of Southeast Asia's main water bodies – the South China Sea, Philippine Sea, Sulu Sea, and Celebes Sea.

In 2013, the Philippine economy posted a 7.2 percent growth rate, slightly higher than in 2012 when it was 6.8 percent. The growth of the economy was largely due to the vigorous economic activities in the industrial and services sectors in 2012 and 2013, when annual growth rates of 9.2 percent and 7.0 percent, respectively, were posted. The increase in the industrial sector was driven by growth in the manufacturing sector, which expanded by 10.3 percent during the period. Growth in the services sector is attributed to robust domestic trade and services and a boom in real estate business. Agriculture, hunting, forestry, and fishing posted a 1.1 percent increase during the period, a 1.7 percentage point decline from the 2012 level. Gross domestic product (GDP, valued at constant 2005 US$) per capita of the country was US$1,584.5 in 2013.

## 1.2. Policy Initiatives

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 the 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 ensuring it will not cause damage to the people and environment. The target of a 60 percent self-sufficiency level as part of the energy security goal of the country 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 meet the country's future energy requirements.

Another key component in the country's energy security strategy is the need to seize the opportunities presented by 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 continuously work 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 percent energy savings from the total annual energy demand. The DOE has been making efforts to reduce demand for energy while ensuring energy requirements are met to support economic growth. It has taken the lead in trying to increase 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 and downstream oil industries 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***

The passage of Republic Act No. 9513 or Renewable Energy Act of 2008 legally supports the policy and programme framework to promote the utilisation of renewable energy resources and technologies. On 14 June 2011, the government unveiled the National Renewable Energy Program (NREP) or the 'Green Energy Roadmap' of the Philippines. The NREP is anchored on the DOE's Energy Reform Agenda, which aims to ensure greater energy supply security for the country. It has established the policy and programme framework for the promotion of renewable energy and a road map to guide efforts in realising the market penetration targets of each renewable energy resource in the country. The roadmap is targeting 15,304 MW installed renewable energy capacity by 2030. The NREP also provides for policy mechanisms to support the implementation of the Renewable Energy Act. These policy mechanisms include: Renewable Portfolio Standards (RPS), Feed-in Tariff (FiT), Green Energy Option Program, and Net-Metering for Renewable Energy.

The RPS sets the minimum percentage of generation from eligible renewable energy resources, provided by the generators, distribution utilities, and electric suppliers. Initially, an installation target of 760 megawatts (MW) from renewable energy is set for the first 3 years from 2013 to 2015, broken down as follows: biomass (250 MW), run-of-river hydro (250 MW), solar (50 MW), wind (200 MW), and ocean (10 MW).

On the other hand, the FiT provides guaranteed payments on a fixed rate per kWh for renewable energy 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 sources, particularly, run-of-river hydro, biomass, wind, and solar. Approved FiT rates for biomass, hydropower, solar, and wind are 6.63 PhP[1], 5.90 PhP, 9.68PhP, and 8.53 PhP per kilowatt-hour (kWh), respectively. Currently, there is no FiT rate for ocean energy since the technology is still being studied and not yet available in the country.

[1] Philippine peso.

### *Alternative Fuels*

*Biofuels*

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.

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. On the other hand, the country now enjoys an accelerated use of E10 (10%) bioethanol blend as supplied by most gasoline retailers in the Philippines.

To serve the technical requirements for the biofuels programme and ensure its continuous research and development, the DOE provided counterpart funding of P50 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 form 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. Similarly, the 'B5 Testing on Public Utility Jeepneys' project between the Philippine Coconut Authority (PCA) and UP–National Center for Transportation Studies (UP–NCTS) was also launched in July 2013.

*Compressed Natural Gas (CNG)*

Currently, there are 61 compressed natural gas (CNG) buses in the Philippines, of which 41 are commercially run. The CNG buses are servicing the Manila–Batangas–Laguna routes. In addition, 20 CNG buses that had completed technical evaluation and testing. As of June 2012, seven bus operators had been accredited for CNG bus operation. The CNG Mother-refuelling 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 Auto–LPG programme of the government, 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 by 2 years. These schemes promote 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 Auto–LPG-fuelled Jeepney and Electric-Powered Jeepney that were completed in October 2013 (Department of Energy, 2013).

*E-Vehicle*

To date, 623 of various types of electric vehicles have been demonstrated in various cities and municipalities (Makati, Taguig, Mandaluyong, Quezon, Puerto Princesa, Davao, and Surigao del Norte) of the country. The E-vehicle programme is one of the government's initiatives towards a 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 thrusts. The goal is to achieve total barangay[2] electrification by the end of 2010. In August 2012, the country's total electrification level had reached 99.98 percent, with 41,965 barangays already with access to electricity out of the 41,974 (formerly 41,980) barangays. Given the importance of electricity in the economic development of the country, the electrification programme of the government is being extended to the household level. The government is targeting to achieve 90.0 percent household electrification by 2017.

On 30 December 2013, the household electrification level stood at 79.5 percent. This means that out of the 21.4 million households, 17.0 million are connected to electricity.[3]

## 1.3. Energy

The country's total primary energy supply (TPES) in 2013 reached 44.5 million tons of oil equivalent (Mtoe). Oil accounted for the biggest share of 31.6 percent in the total energy supply, followed by coal and geothermal with shares of 22.5 percent and 18.6 percent, respectively, in the mix. Total production reached 24.3 Mtoe, bringing the energy self-sufficiency level of the country to 54.6 percent in 2013.

Total electricity generation in the Philippines in 2013 reached 75.3 terawatt-hours (TWh). Coal-fired power plants remained the major source of power generation with total installed capacity of 5568 megawatt (MW) in 2013. Coal contributed 42.6 percent or 32.1 TWh in the total power generation mix of the country and

[2] Filipino term for a village, district, or ward, which is the smallest administrative division in the Philippines.

[3] Status of Household Electrification as of 31 December 2013.

natural gas-fired power plants accounted for 25.0 percent or 18.8 TWh in the power mix. Currently, the country has three natural gas power plants with a combined installed capacity of 2,861 MW. On the other hand, the combined share of renewable energy in the total power generation mix was 26.5 percent in 2013.

## 2. Modelling Assumptions

Five scenarios were developed to assess the energy savings potential of the country aside from the Business-as-Usual scenario (BAU). The BAU serves as the reference case in the projection of energy demand and carbon dioxide ($CO_2$) emission of the energy sector. The BAU incorporates the energy sector's existing energy policies, plans, and programmes that are being implemented and will be pursued within the forecast period.

The Alternative Policy Scenario (APS)1 assessed the impact of possible policy interventions in terms of utilisation of efficient and environment-friendly technologies for future energy use together with its corresponding $CO_2$ emission reduction. This is an assumption that the energy saving goals of 10 percent in 2025 and 20 percent in 2035 from annual final energy consumption of the country will 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[4] Program' also contribute to the energy saving goals of the country. In the residential and commercial sectors, the utilisation of more efficient electrical appliances is projected to induce savings. Energy labelling and ratings on major electrical appliances will help consumers to choose more efficient electrical products.

[4] Filipino term for 'change lamps' wherein the DOE distributes CFL lamps for free to consumers in exchange for their incandescent bulbs.

The APS2 assessed the effect of a more efficient thermal power generation, particularly due to future coal and natural gas power plant technology.

The APS3 measured 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 to test its impact on the TPES. The NREP provides the foundation for developing the country's renewable energy resources, stimulating investments in the renewable energy 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. Also covered by APS3 were the intensified development and utilisation of alternative fuels for transport such as compressed natural gas (CNG) and electric vehicle as a continuing strategy to reduce the country's dependence on imported oil.

Although the Philippines currently has no clear policy direction on the use of nuclear energy in its power generation, APS4 considered additional capacity from nuclear power to determine the impact of a possible long-term nuclear option. And lastly, the APS5 combined the effects of the four scenarios (APS1, APS2, APS3, and APS4).

In the model, GDP is assumed to grow at an average annual rate of around 6.0 percent (IMF, 2015) from 2016 to 2020 and the population is forecast to grow at a rate of 1.5 percent. Population growth is based on the adjusted 2000 census-based medium population projections using the results of the 2007 population census including the population level of 93.3 million for 2010.

# 3. Outlook Results

## 3.1. Business-as-Usual Scenario (BAU)

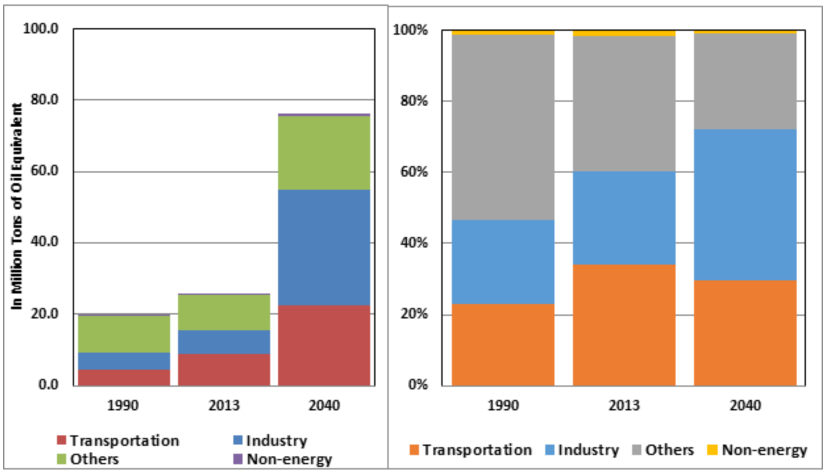
### 3.1.1. Final energy consumption

***Final energy consumption by sector***

The Philippines' final energy consumption grew from 19.7 Mtoe in 1990 to 25.9 Mtoe in 2013 at an average annual growth rate of about 1.2 percent. From 1990 to 2013, energy demand in the transport sector grew fastest, at an average annual rate of 2.9 percent, followed by the industrial sector with 1.7 percent growth.

Final energy consumption is expected to grow at an annual average rate of 4.1 percent in the BAU from 2013 to 2040. The transport sector is forecast to grow at an average annual rate of 3.5 percent and the industrial and other sectors are expected to grow at average annual rates of 6.0 percent and 2.8 percent, respectively (Figure 14-1).

**Figure 14-1. Final Energy Consumption by Sector, BAU**



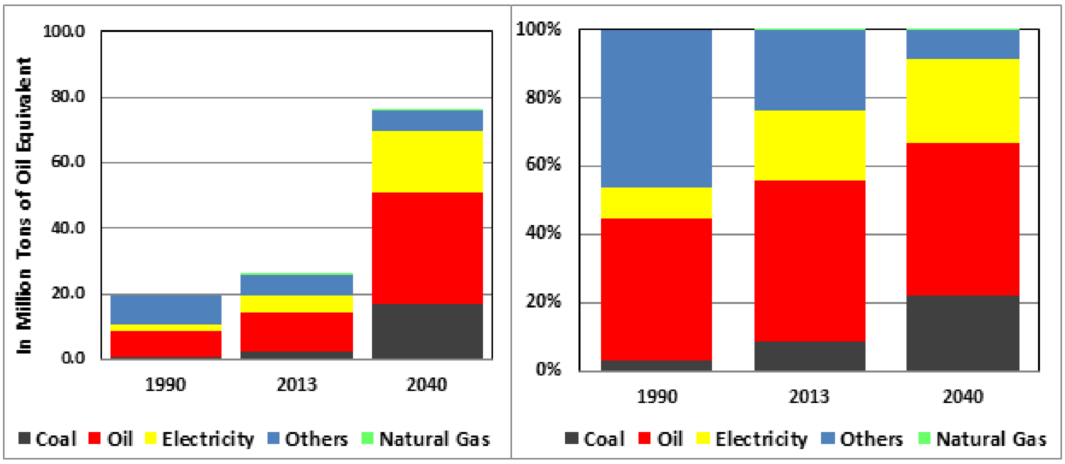

BAU = Business-as-Usual scenario.
Source: Author's calculation.

The aggregate energy demand of other sectors such as residential, commercial, and agriculture comprised the biggest share in the total demand mix from 1990 to 2013, although their share fell from 52.2 percent to 38.0 percent. Over the same period, the shares of the industry and transport sectors in the demand mix rose from 23.7 percent to 26.4 percent and from 23.0 percent to 33.9 percent, respectively. From 2015 to 2025, the share of the transport sector is expected to dominate the demand mix. The share of industry sector demand in the mix will overtake that of the transport sector as the most energy intensive sector from 2025 to 2040. At the end of the projection period, the industry sector will account for a 42.7 percent share in the demand mix and the transport sector will account for 29.5 percent. The share of 'other' sectors in the demand mix will continue to decline over the forecast period to reach 26.9 percent in 2040.

### *Final energy consumption by fuel*

By fuel, demand for natural gas is projected to grow at an average annual rate of 3.8 percent over the forecast period and oil demand is expected to grow by 3.9 percent, to be used mainly for the transport sector. The fastest growth is expected to be demand for coal for non-power application, which will increase at an annual average rate of 7.8 percent over the planning period, with the bulk of its end-use demand expected to come from the cement industry. Electricity is expected to see the second-fastest growth of 4.8 percent (Figure 14-2).

**Figure 14-2. Final Energy Consumption by Fuel, BAU**




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

Oil will remain the most consumed fuel throughout the planning period, with a projected share of 44.8 percent in the demand mix by 2040, which is lower than its 47.3 percent share in 2013.

Electricity will contribute a share of 24.4 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 RE, although projected to be on a downward trend, will account for 8.7 percent of the demand mix in 2040. The continuing importance of coal in the industry sector is evident from its projected share of 21.9 percent of energy demand in 2040.

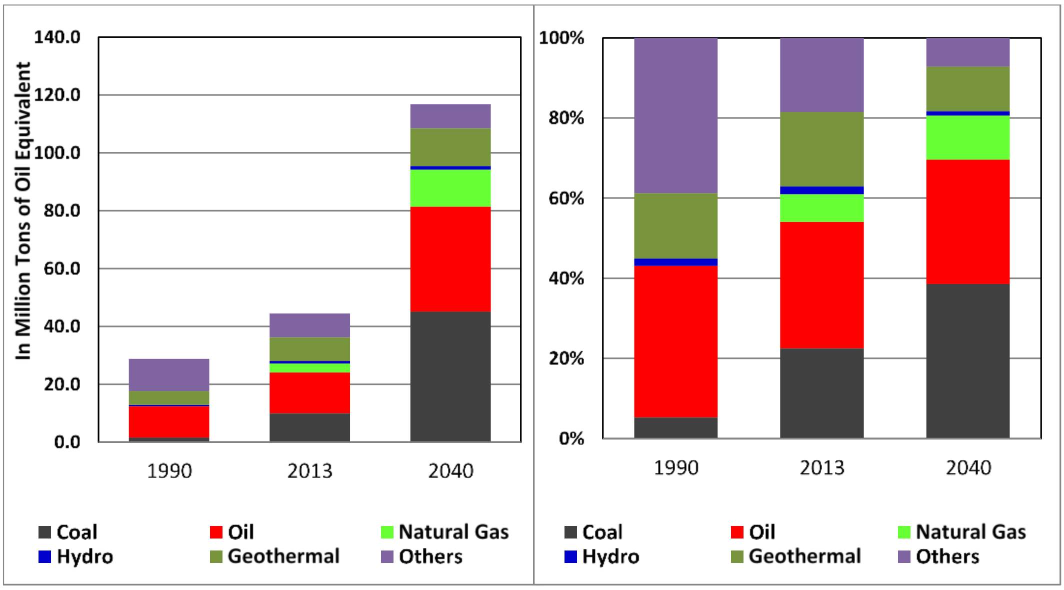
***Primary energy supply by fuel***

Primary energy supply in the Philippines grew at an annual average rate of 1.9 percent, from 28.7 Mtoe in 1990 to 44.5 Mtoe in 2013. Among the major energy sources, consumption of coal grew the fastest at 8.5 percent per year followed by geothermal and hydro, with 2.5 percent and 2.2 percent, respectively. Oil grew at a very low rate of 1.1 percent per year from 1990 to 2013 and primary energy supply of other fuels declined by an annual average 1.3 percent.

From 2013 to 2040, the country's primary energy supply is expected to increase by 3.6 percent per year from its 2013 level of 44.5 Mtoe to 116.8 Mtoe in 2040. Consumption for all major energy sources is projected to increase during this period, with coal growing the fastest at 5.7 percent per year. Natural gas is expected to expand at a similar rate of 5.4 percent and oil is projected to grow by 3.6 percent. Major renewable energy consumption from geothermal and hydro is expected to see average annual growth of 1.7 percent and 1.5 percent, respectively, and other fuels' aggregated consumption is forecast to grow at just 0.1 percent per year on average over the forecast period.

Coal will account for the largest share in the total energy supply of the Philippines from 2030 up until the end of the planning period, reaching a 38.6 percent share in 2040. Oil and natural gas, part of the country's major energy sources, are projected to account for 31.1 percent and 11.0 percent, respectively, at the end of the planning period. Geothermal and hydro, which are mainly used for power generation, will have shares of 11.1 percent and 1.1 percent, respectively, and 'other' fuels will account for 7.2 percent in the supply mix in 2040 (Figure 14-3).

**Figure 14-3. Primary Energy Supply by Sector, BAU**

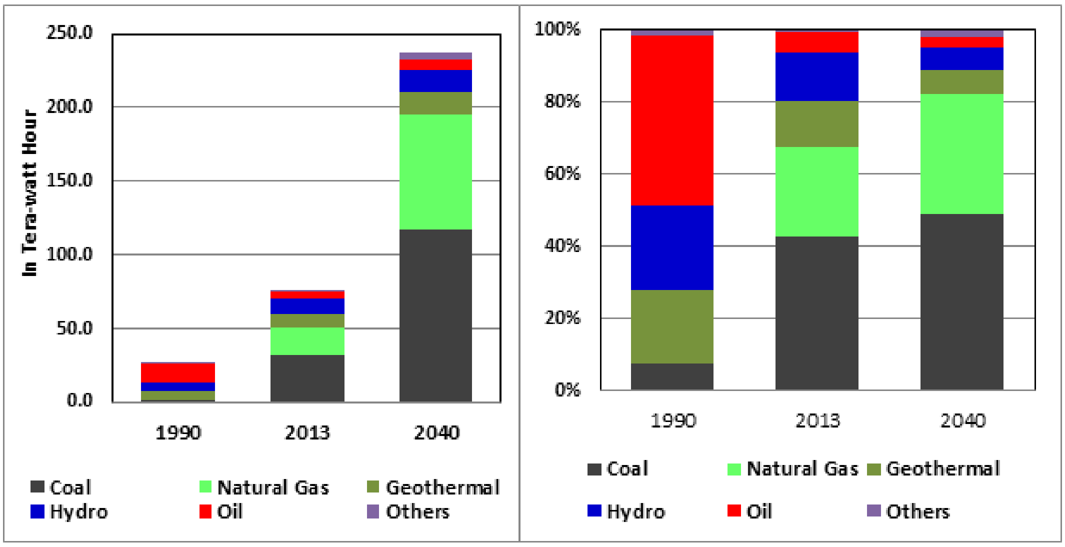



BAU = Business-as-Usual scenario.
Source: Author's calculation.

### *Power generation*

Total power generation in the Philippines in 2013 reached 75.3 terawatt-hours (TWh), almost triple the country's level in 1990. Power generation is expected to increase by an annual average 4.3 percent over the planning period. Coal remained the major source in power generation, accounting for a share of 42.6 percent in 2013. At the end of the planning period, the share of coal is expected to be 49.1 percent, as it is expected to increase at an annual average rate of 4.9 percent – from 32.1 TWh in 2013 to 116.5 TWh in 2040. Natural gas follows, with growth in output from 18.8 TWh in 2013 to 79.3 TWh in 2040, increasing at an average rate of 5.5 percent per year. Oil's share in the generation mix, by contrast, will continue to decline, reaching a share of just 2.8 percent in 2040. Power generation from hydro and geothermal are expected to grow at steady rates of 1.4 percent and 1.7 percent per year, respectively. Other sources of power generation, aggregate output from solar, wind, and biomass, is expected to increase at an annual average rate of 11.1 percent (Figure 14-4).

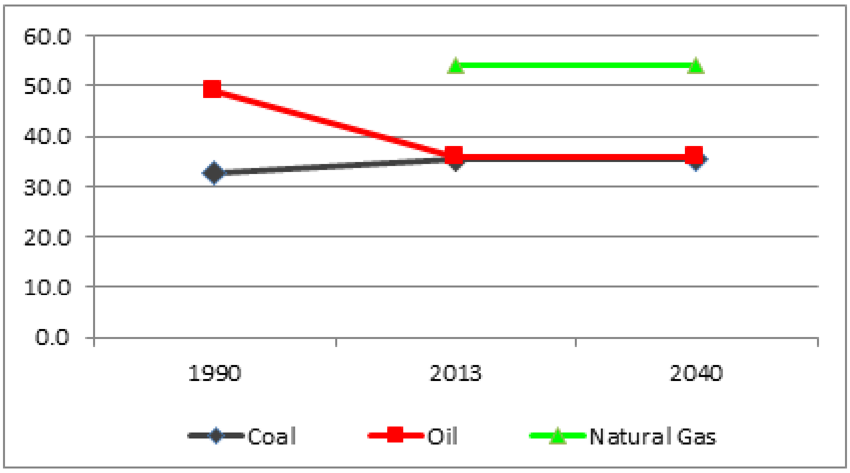
**Figure 14-4. Power Generation by Fuel, BAU**




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

The thermal efficiencies of coal, oil, and natural gas under the BAU are projected to remain constant for the entire planning period. Coal thermal efficiency is set at 35.3 percent, and oil and natural gas power plant efficiencies are set at 35.9 percent and 54.0 percent, respectively.

**Figure 14-5. Thermal Efficiency by Fuel, BAU**



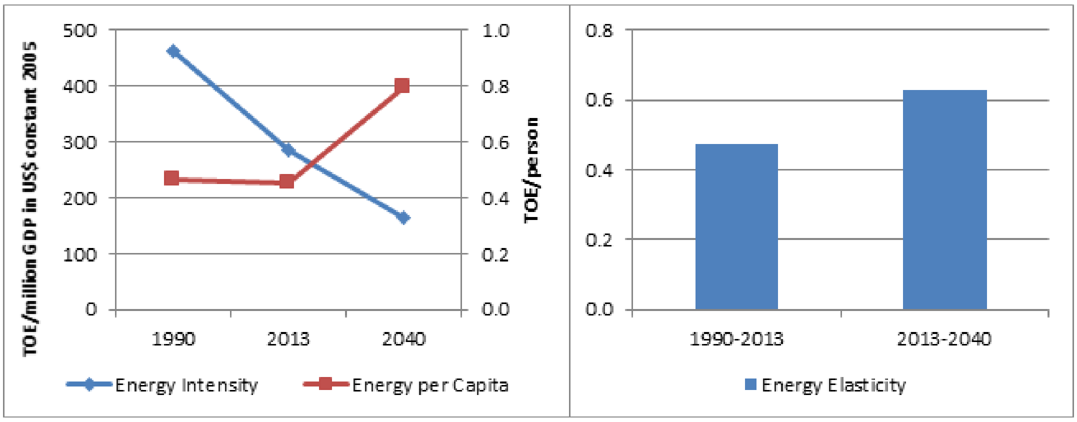

BAU = Business-as-Usual scenario.
Source: Author's calculation.

### Energy indicators

Under the BAU, energy intensity of the Philippines is projected to decrease at an average annual rate of 2.0 percent from 2013 to 2040. Energy intensity is the ratio of total primary energy over GDP. The significant reduction of energy intensity is attributable to the government's efforts in promoting energy conservation and efficiency in the different sectors of the economy. The level of energy per capita is projected to increase from 0.45 toe/person in 2013 to 0.80 toe/person in 2040, indicating the steady improvement in energy accessibility and services in the country.

Energy elasticity is the relationship between changes in the primary energy supply and the changes in GDP. It is expected to be approximately 0.6 from 2013 to 2040, an indication that energy demand will rise less than proportionately in relation to income.

**Figure 14-6. Energy Intensity, Energy Per Capita, and Energy Elasticity**

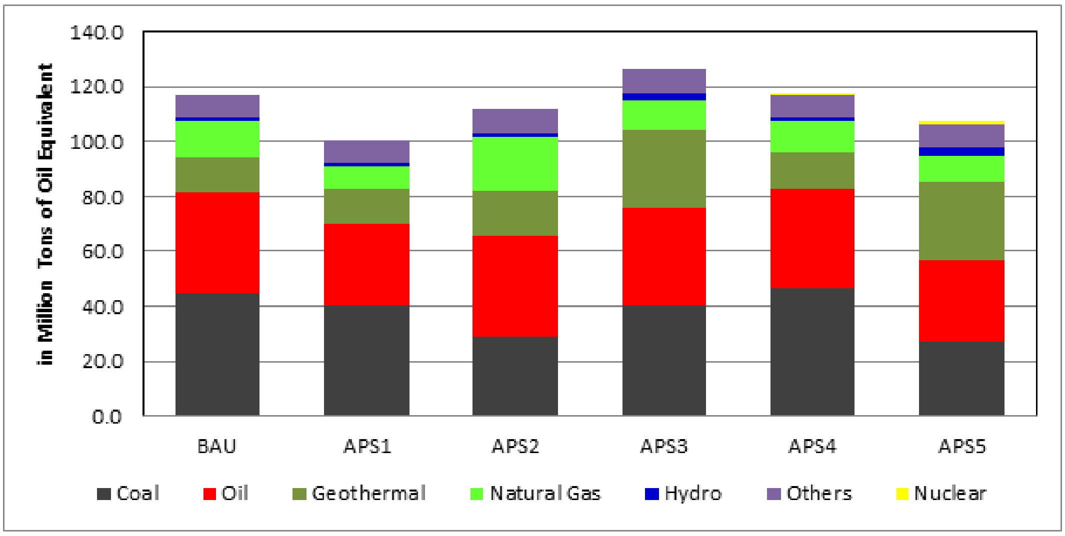



TOE = tons of oil equivalent; GDP = gross domestic product.
Source: Author's calculation.

## 3.2. Alternative Policy Scenario (APS)

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. Comparison of Scenarios to Primary Energy Supply in 2040**




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

Figure 14-7 shows that APS1 has the lowest level of total primary energy supply due to the energy efficiency assumptions on the demand side. Under this scenario, the country's total primary energy supply (TPES) will grow at an annual average rate of 3.1 percent to reach 100.5 Mtoe in 2040, which is 14.0 percent lower than for the BAU. This is attributable to the effectiveness of energy efficiency measures implemented in the various sectors of the economy under APS1.

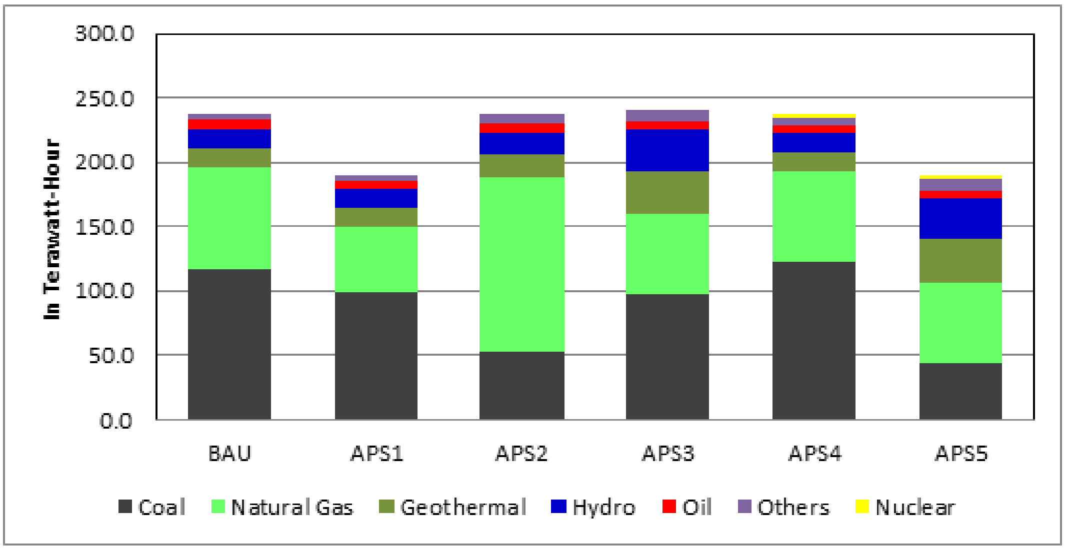
APS2, which assumes higher efficiency in thermal electricity generation, will have a total primary energy supply of 111.9 Mtoe in 2040, or 4.2 percent lower than the BAU. Under APS2, the country's TPES is expected to increase by 3.5 percent per year over the planning period. The bulk of the reduction in TPES in this scenario vis-à-vis the BAU would be from coal and natural gas as more efficient power plants are assumed to be used to generate power in this scenario.

TPES under APS3 is 8.2 percent higher at 126.4 Mtoe in 2040 than in the BAU. This is mainly due to the projeced increase in the use of geothermal energy in power generation. The efficiency of geothermal plants is usually lower than that of fossil-fueled power plants. Hence, more fuel input will be required to generate the same amount of electricity.

In APS4, TPES in 2040 will be just 0.7 percent higher than in the BAU, reaching 117.6 Mtoe at the end of the forecast period. 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 35.3 percent and 54.0 percent, respectively.

Lastly, APS5 (representing the combined effects and/or assumptions of APS1, APS2, APS3, and APS4) will result in a TPES of 107.2 Mtoe in 2040, which is 8.3 percent lower than the BAU level.

**Figure 14-8. Comparison of Scenarios to Electricity Generation in 2040**

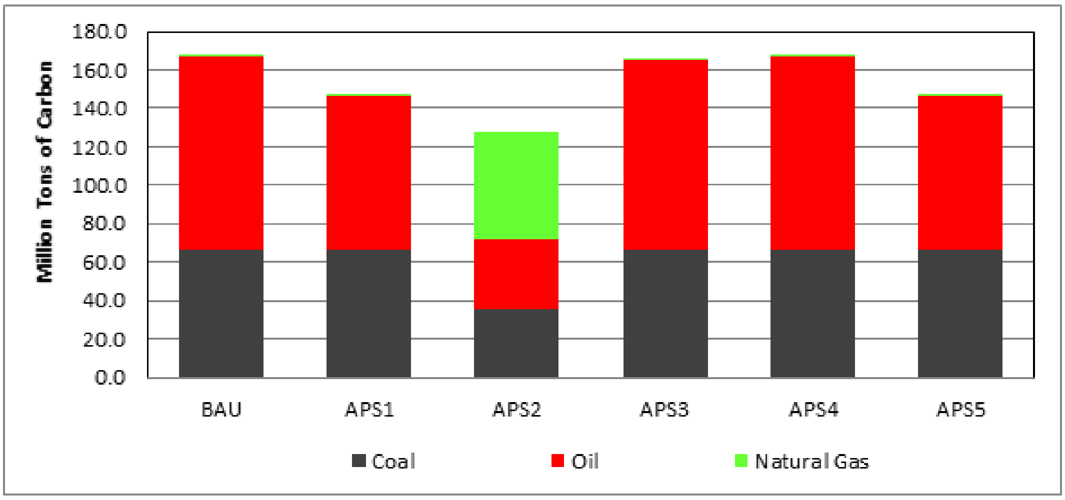



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author’s calculation.

Figure 14-8 shows the total electricity generation in 2040 for all scenarios. In APS1, the total generation output is 20.0 percent less than the BAU due to its lower electricity demand. The share of fossil fuels under APS1 will be 82.3 percent, versus 85.2 percent in the BAU, while the share of renewable energy will be 17.7 percent higher vis-à-vis 14.8 percent in the BAU.

The shares of fossil and renewable energy fuels under APS2 are similar to those of APS1, and total generation output is equal to the BAU level at 237.6 TWh. In APS3, due to the assumption of more renewable energy, the share of fossil fuel-fired power generation will only be 69.1 percent, which is significantly lower than under the BAU with an 85.2 percent share. In APS4, fossil fuel-fired power generation will account for 83.9 percent of the total power generation mix, indicating that nuclear power displaced 1.3 percent of fossil fuel power output. In APS5, the share of fossil fuel-fired power generation will be further reduced, to 59.3 percent, as renewable energy will contribute its maximum possible share in the generation mix at 39.3 percent, while nuclear accounts for 1.4 percent in the mix.

**Figure 14-9. Comparison of Scenarios to $CO_2$ Emission in 2040**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

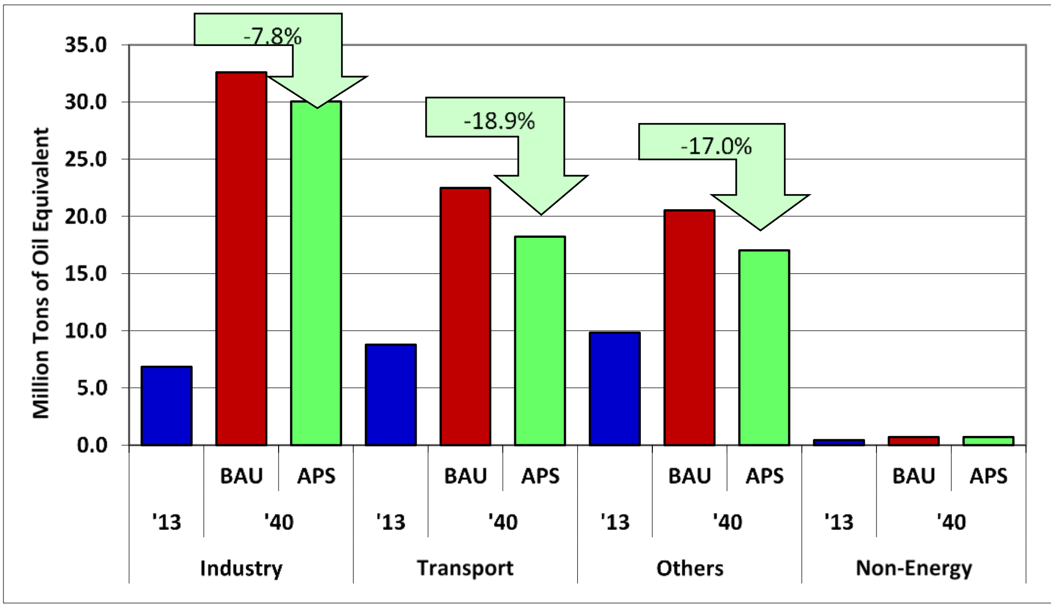
In terms of $CO_2$ emission reduction, the energy efficiency assumption in APS1 is expected to reduce emissions by around 20.2 million metric ton of carbon (Mt-C), which is 12.1 percent lower than the BAU. The decrease in $CO_2$ indicates that the energy saving goals, action plans, and policies to promote energy efficiency and conservation programmes will be effective in reducing $CO_2$ emissions.

$CO_2$ emission under APS2 and APS4 will be the same as that of the BAU at 167.4 Mt-C. In APS3, the reduction could be 1.4 Mt-C, which is 0.9 percent lower than the BAU. Combining all the assumptions in APS1, APS2, APS3, and APS4 into APS5 can reduce BAU $CO_2$ emissions by 19.6 Mt-C or 11.7 percent.

## Final energy consumption

In the APS (APS5), final energy consumption is projected to increase at a slower rate of 3.5 percent per year compared with the BAU, from 25.9 Mtoe in 2013 to 66.0 Mtoe in 2040. Slower growth under the APS, relative to the BAU, is projected across all sectors as a result of the government programme of promoting energy efficiency and conservation. The industry sector will experience the fastest growth, at 5.6 percent per year, followed by the transport sector at 2.7 percent per year. Figure 14-10 shows the final energy consumption by sector in 2013 and 2040 in both the BAU and the APS. The total reduction in final energy consumption will be 13.5 percent in 2040, as all sectors are expected to see lower demand levels in APS5, with the exception of the non-energy sector.

**Figure 14-10. Final Energy Consumption by Sector, BAU and APS**



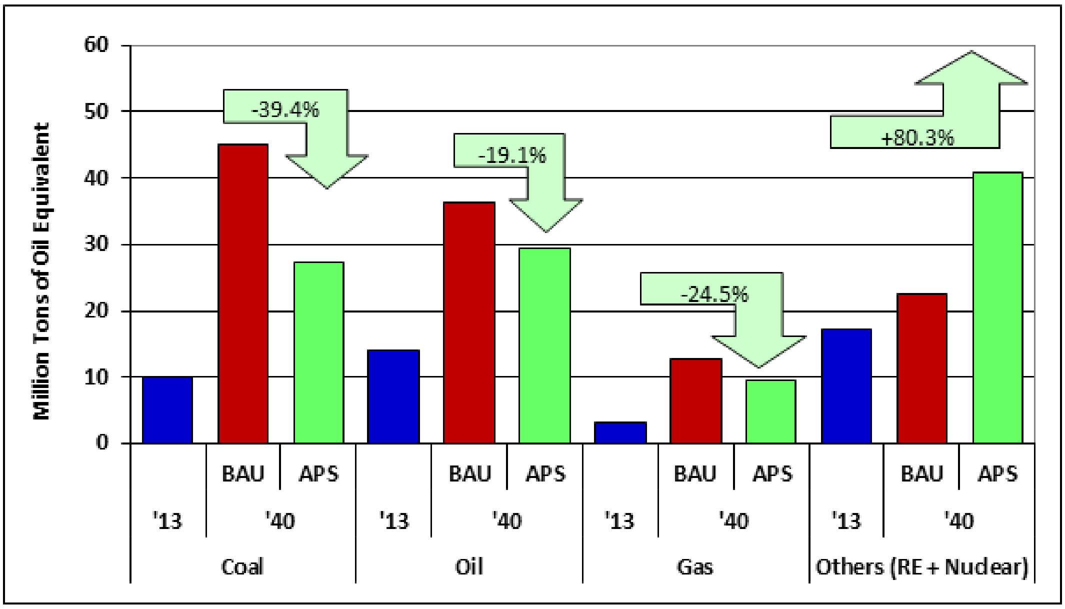

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

## Primary energy consumption

Over the projection period, the relative share of each form of energy is expected to change significantly in response to a different economic structure and policy environment. The country's primary energy supply under the APS will grow at an average annual rate of 3.3 percent, increasing from 44.5 Mtoe in 2013 to 107.2 Mtoe in 2040. In comparison with the BAU, the APS will register a level of energy that is 8.3 percent lower in 2040 due to the projected reduction in fossil fuel supply (Figure 14-11).

RE sources are expected to feature significantly in the TPES under the APS. Geothermal and hydro are projected to see the fastest growth rates over the projection period, increasing by 4.7 percent and 4.3 percent per year, respectively. Other RE, such as solar, wind, and biofuels, are also expected to contribute considerably to TPES under the APS. Energy supply from fossil fuels such as coal, oil, and natural gas, is projected to increase by 3.8 percent, 2.8 percent, and 4.3 percent per year, respectively, for this scenario.

**Figure 14-11. Total Primary Energy Supply by Fuel, BAU and APS**

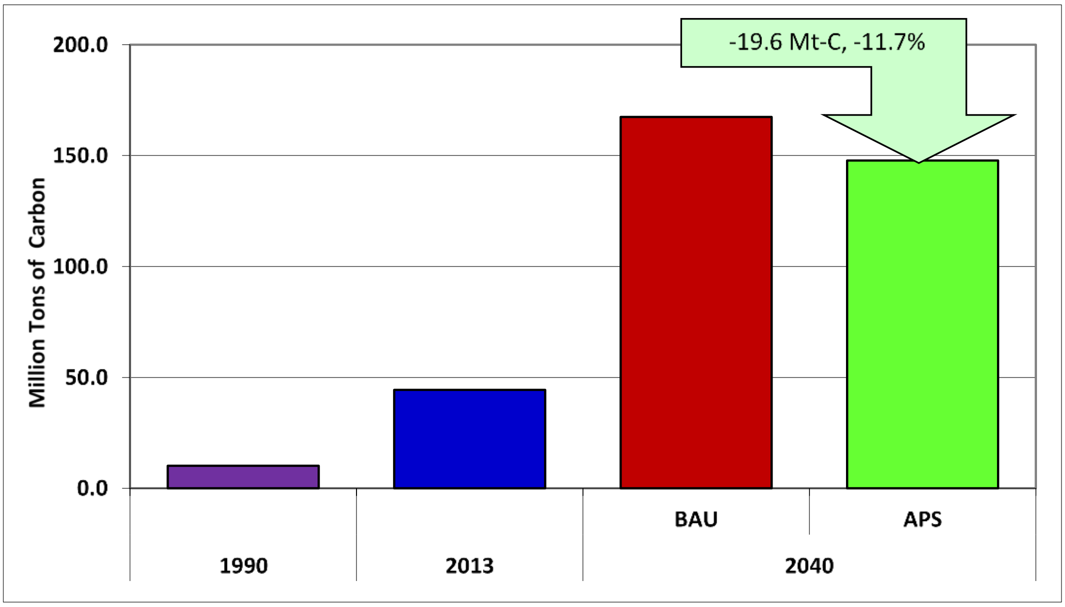



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; RE = renewable energy.
Source: Author's calculation.

### $CO_2$ reduction potential

The total $CO_2$ emissions from energy consumption will reach a level of 147.8 Mt-C under the APS, indicating a 19.6 Mt-C reduction, which is 11.7 percent lower than the BAU level. The decrease in $CO_2$ indicates that applying all the assumptions for energy saving goals to increase renewable energy and alternative fuels in the total supply and improve thermal efficiency in power generation will meet the target of reducing the $CO_2$ emissions from related energy sectors' activities (Figure 14-12).

**Figure 14-12. $CO_2$ Savings Potential, BAU and APS5**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's calculation.

## 4. Implications and Policy Recommendations

The Philippine energy sector's Energy Reform has comprised three pillars – ensure energy security, achieve optimal energy pricing, and develop a sustainable energy system. Key to successful implementation of the three pillars is good governance, particularly transparency, which is comprised of initiatives, implementation, and information regarding the development of the three pillars. In the BAU model, self-sufficiency decreased by 15 percent from 2013 to 2040, i.e. from 55.0 percent to 40.0 percent. In the APS, however, the level of self-sufficiency will be maintained at around 60 percent up to 2040. This indicates that the government needs to strictly implement the identified targets for the different energy sub-sectors. It should also find a way to encourage the stakeholders to invest in and support the government's thrusts on good governance and initiatives to further enhance operational efficiency and data transparency and exchanges among stakeholders.

Under the BAU for the supply side, the primary energy supply of coal will see the fastest growth rate at 5.7 percent throughout the planning period. This is due to the significant contribution of this fuel in power generation, which corresponds to the increasing demand for electricity at a 4.8 percent annual average rate. It was projected that towards the end of the planning period, coal supply levels will even surpass the country's requirement for oil resources, which is mainly utilised in the transport sector. The aggregated share of renewable energy at 19.4 percent is less than half of 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 energy security policy in adopting the use of clean, green, and sustainable sources of energy, particularly in the power sector. However, there is an issue in implementing the policy considering the current condition of the power sector as a deregulated industry.

The government under these circumstances has only limited control over what type of power plants to put up since the power industry has already been established as private driven investment. To some extent this issue can be addressed by formulating fuel mix policy for power generation to guide and inform investors and other key players of the industry on the preferred power mix for the Philippines for the benefit of the long-term sustainability of the country's power sector. The proposed fuel mix policy for power generation directed the power generation capacity shares of cleaner sources of power generation such as renewable energy and natural gas in the country's total power generation capacity for at least 30 percent by 2030. The recently issued department circular to maintain renewable energy capacity for at least 30 percent of the total power capacity is achievable based on the APS scenario; however, the 30 percent share of natural gas may not be possible based on the APS scenario, which only accounted for 18 percent of the total power generation capacity by 2030.

On the demand side, oil will register the biggest share in the final energy consumption by around 45.0 percent towards the end of the planning period for BAU and 42 percent for APS. 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 the biggest across different scenarios. This is because oil is the major fuel of the transport sector, which has an annual average share of 95.0 percent in the demand mix of the sector across the planning period. As indicated by the outlook model results, transport sector will be the biggest user of energy until 2023, while industry sector will be the most energy intensive sector after the specified period. Coal as the most dominant fuel of industry sector with an average share of 40 percent across the planning period will become one of the major fuels for non-power application energy consumption. In this regard, the government should have to push the programme on sustainable fuels and expand the use of natural gas not only for transport sector but also for industry sector as well. It would be appropriate for the government to focus on the promotion of alternative fuels in the transport and industry sectors to substitute partly and directly the use of oil and coal in the sectors with the extended implementation of alternative fuels promotional 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 and industry sectors will help not only in reducing energy requirement but also lessen GHG emission coming from the energy intensive sectors.

On the other hand, under the APS, energy intensity and $CO_2$ intensity will continue to decline from 2013 to 2040, 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 45 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 most likely more than the increasing trend of the transport sector and could have high potential energy savings.

Currently, the Philippines have 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 10 percent in the cost of the consumption of fuel and electricity among 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.

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 through energy programmes and projects will be strictly implemented.

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# Chapter 15

## Singapore Country Report

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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 a per capita gross domestic product (GDP) of US$37,491 (in constant 2005 terms) in 2013. Singapore submitted its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat on 3 July 2015[1] and has signed off to the Paris Agreement as of 22 April 2016.[2] Singapore's INDC highlights its intentions to reduce its emission intensity by 36 percent from 2005 levels by 2030. In addition to emissions intensity targets, Singapore also intends to stabilise emissions with the aim of peaking around 2030. Under the Copenhagen Accord, Singapore also has a voluntary target of reducing carbon dioxide ($CO_2$) emissions by 7 to 11 percent

[1] National Climate Change Secretariat (NCCS) (2015), 'Singapore's Submission to the United Nations Framework Convention on Climate Change (UNFCCC)', https://www.nccs.gov.sg/news/singapore %E2 %80 %99s-submission-united-nations-framework-convention-climate-change-unfccc

[2] Ministry of Foreign Affairs, Singapore (2016), 'MFA Press Release: National Statement of Singapore delivered by Minister for Foreign Affairs Dr Vivian Balakrishnan at the Signature Ceremony of the Paris Agreement in New York, 22 April 2016', https://www.mfa.gov.sg/content/mfa/media_centre/press_room/pr/2016/201604/press_20160423.html

below business-as-usual levels in 2020,[3] which will be increased to 16 percent if there is a global agreement on climate change.

## 2. Singapore's Policy Initiatives

The Inter-Ministerial Committee on Climate Change (IMCC) was created in 2007 to facilitate a Whole-of-Government approach to addressing climate change related issues. Chaired by Mr Teo Chee Hean, the Deputy Prime Minister and Co-ordinating Minister for National Security and Minister of Home Affairs, the committee is attended by the Ministers for the Environment and Water Resources, Finance, Foreign Affairs, National Development, Trade and Industry, as well as Transport, to provide overarching strategic planning for Singapore's mitigation efforts.

With a national policy framework to maintain a balance among the policy objectives of economic competitiveness, energy security, and environmental sustainability,[4] the switch to cleaner fuels, energy efficiency improvements, and the promotion of alternative sources of energy, in particular solar energy, were highlighted as the main tenets of Singapore's mitigation policies.

**Fuel switch**

Recognising the value of sustainability and the environment, Singapore switched from fuel oil to the cleaner natural gas in its power generation in the early days, despite the higher costs. Today, natural gas remains a key component of Singapore's power generation mix. In 2015, natural gas represented 95.5 percent of the total licensed generation capacity in Singapore.[5] Petroleum products and 'others' accounted for the remaining 0.7 percent and 3 percent,[6] respectively. In a

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[3] 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', http://app.nccs.gov.sg/news_details.aspx?nid=642&pageid=97.
[4] Ministry of Trade and Industry of Singapore (2007), 'National Energy Policy Report – Energy for Growth', http://app.mti.gov.sg/data/pages/2546/doc/NEPR.pdf.
[5] Energy Market Authority (2016), 'Singapore Energy Statistics 2015', https://www.ema.gov.sg/cmsmedia/Publications_and_Statistics/Publications/SES2015_Final_website_2mb.pdf
[6] ibid.

consultation paper released by the Energy Market Authority (EMA) in 2015,[7] natural gas is expected to remain a dominant energy source in Singapore's power sector into the future.

To expand the country's import capability and sourcing options for liquefied natural gas (LNG), Singapore commenced commercial operations with its newly constructed LNG terminal in May 2013. It currently has a throughput capacity of 6 million tons per year,[8] and 9 million metric tons per annum (Mtpa) from 2017 with a fourth storage tank to be constructed.[9] The current aim is to increase the targeted annual capacity to 11 Mtpa by 2018.[10]

**Alternative energy promotion**

Despite being renewable-energy disadvantaged due to its dense and urban landscape, Singapore has voiced its intention to capitalise on the only viable renewable option: solar energy. Although there are no subsidies for solar technology, there is policy support for the deployment of solar resources in the form of removal of non-market barriers, system support in terms of facilitating system integration of the intermittency of solar energy without compromising grid stability and continued support for research, development, and demonstration (RD&D) efforts aimed at cost reduction and efficiency improvement of solar modules. In addition to policy support for RD&D, the public sector is also seen to be active in test-bedding projects for innovative solar deployment. As part of the policy objective of accelerating the scale of solar deployment in Singapore, the Housing and Development Board (HDB) recently awarded a public tender for the installation and management of 76MWp of solar photovoltaic (PV) panels under the SolarNova programme.[11] The SolarNova

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[7] Energy Market Authority (2015), 'Preparing for Future Power Generation Investments in Singapore', https://www.ema.gov.sg/cmsmedia/Consultations/Electricity/Consultation 20Paper 20-%20Preparing_for_Future_Power_Generation_Investments_in_Singapore.pdf
[8] Boon, R. (2013), 'Singapore's LNG Terminal Straits Commercial Operations', The Straits Times, 7 May.
[9] ChannelNewsAsia (2014), Singapore Opens First LNG Terminal, Plans for Second Terminal, 25 February.
[10] Otavio Veras (2016), Singapore Aims High as Asia's LNG Trading Hub. The Business Times, 24 February 2016.
[11] Housing and Development Board (2015), 'Singapore's Largest Solar Panel Installation Awarded To Sunseap Leasing Under SolarNova's First Tender', http://www.hdb.gov.sg/cs/infoweb/press-release/singapore-largest-solar-panel-installation-awarded-to-sunseap

programme, which is led by the Economic Development Board (EBD), is a government-led programme to promote solar deployment through aggregating solar demand across the public sector.[12] The EDB and the Public Utilities Board (PUB) have also partnered up to install floating PV platforms in reservoirs.[13]

Beyond these forms of support, Singapore also has a national target to deploy 350 MWp of solar PV by 2020, and extend the share of solar PV to 8 percent of Singapore's peak electricity demand by 2030.[14]

In 2010, Singapore explored the nuclear option with a nuclear energy pre-feasibility study. The results of the study, which were confirmed in a 2012 statement from the Ministry of Trade and Industry, was that nuclear energy was not suitable for deployment given that the high risks associated with the dense urban population of Singapore outweigh the benefits.[15] However, Singapore will continue to monitor technological development and may revisit the option in the future. In the meantime, Singapore will cooperate with international and regional players to actively tackle issues regarding nuclear safety and emergency planning.

**Energy efficiency improvements**

Energy efficiency is another integral part of Singapore's mitigation efforts. An inter-agency Energy Efficiency Programme Office (EEPO) led by the National Environment Agency and the Energy Market Authority (EMA), was established in May 2007 to help promote and facilitate the adoption of energy efficiency across a variety of sectors in Singapore.[16] Across the nation, energy efficiency improvements are promoted through a mix of standards and regulation, public awareness, and messaging, as well as promotion of technological advancements

[12] Ministry of Trade and Industry (2014), 'SolarNova Factsheet', https://www.mti.gov.sg/MTIInsights/SiteAssets/Pages/Budget-2014/SolarNova.pdf
[13] Channel News Asia (2015), 'PUB Embarks on Study to Tap into Solar Energy via Reservoirs', http://www.channelnewsasia.com/news/singapore/pub-embarks-on-study-to/2285544.html
[14] National Climate Change Secretariat (NCCS) (2016), 'Singapore's Approach to Alternative Energy', https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapores-approach-alternative-energy
[15] Ministry of Trade and Industry (2012), 'Factsheet Nuclear Energy Pre-feasibility Study', https://www.mti.gov.sg/NewsRoom/Documents/Pre-FS %20factsheet.pdf
[16] Energy Efficiency Programme Office (2013), 'About E2PO', http://app.e2singapore.gov.sg/About_Esup2/supPO/Objective_and_Members.aspx

***Households***

Households account for about one-sixth of the electricity consumed in Singapore[17] and thus is a key sector for energy efficiency policies. The Mandatory Energy Labelling Scheme (MELS) and Minimum Energy Performance Standards (MEPS) are two pillars of residential energy efficiency policies. The MELS, introduced in 2008, imposes compulsory display of energy labels on relevant household appliances. Initially only levied on all registrable air-conditioners and refrigerators, the requirement has progressively expanded through the years to include television sets, clothes dryers, and lighting. The MELS serves to inform consumers and help them identify, and thereby purchase, more energy efficient appliances. The MEPS is a supply-side policy that complements the MELS by prohibiting sale of appliance models that do not meet the minimum specified energy efficiency levels. 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.

In addition to the MELS and MEPS, various public messaging campaigns that aim to target behavioural change in households were also introduced. These initiatives target both the initial purchasing decision and behaviour at the consumption stage. For example, the Life Cycle Calculator improves consumer awareness at the purchasing stage, while the Home Energy Auditor motivates energy efficiency behavioural change when consuming electricity at home. Recent public messaging campaigns have also begun targeting residential interior design with the *Resource Efficiency Guide for New Home Owners.*

The relevant ministries are currently studying the feasibility and cost–benefit of utilising smart home technologies, such as the Home Energy Management Systems (HEMS), to reduce residential energy consumption. Residents living in the Yuhua estate in the west of Singapore will be the first as a pilot estate to

[17] National Climate Change Secretariat (NCCS) (2016). 'Households', https://www.nccs.gov.sg/climate-change-and-singapore/domestic-actions/reducing-emissions/households

experience such technologies, with progressive implementation of 'Smart Living' features until 2018.[18]

***Transport***

Energy efficiency in the transport sector is governed by three complementary policy objectives: (i) reducing private transport, (ii) promoting public transport ridership, and (iii) promoting non-motorised transport.

A 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.[19] In view of the land constraints on road expansion, the annual vehicle population growth rate was 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 has been 0.25 percent since 2015.[20] The Fuel Economy Labelling Scheme has mandated fuel economy labels to be affixed to vehicles at the point of sale since 2012.[21] This is complemented by the Carbon Emissions-based Vehicle Scheme (CEVS), which was introduced in 2013. The CEVS was due to expire in June 2015, but was extended from July 2015. 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 of less than or equal to 135g 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, of more than 185g $CO_2$/km, will incur a corresponding registration surcharge of between S$5,000 and S$20,000. Cars with carbon emissions between 136 and 185g $CO_2$/km receive neither rebate nor surcharge. To encourage taxi companies

[18] Housing & Development Board (2015), 'Yuhua the First Existing HDB Estate to Go Smart', http://www.hdb.gov.sg/cs/infoweb/press-release/yuhua-the-first-existing-hdb-estate-to-go-smart
[19] 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
[20] 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
[21] Land Transport Authority (n.d.), 'Fuel Economy Labelling Scheme (FELS)', http://www.onemotoring.com.sg/publish/onemotoring/en/lta_information_guidelines/buy_a_new_vehicle/fuel_economy_.html

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.[22] The treatment of electric vehicles under the CEVS will take into account the power consumption of the vehicle for every kilometre driven and factor in the embedded emissions from the grid emissions factor.[23]

Public transport is the most energy efficient mode of travel. Under the Land Transport Masterplan, Singapore targets to achieve a 75 percent public transport modal share during peak hours by 2030, up from 66 percent in 2014. In a nutshell, the promotion of public transport ridership is achieved by ensuring the efficiency and reliability of public transport services. In addition to constantly upgrading and expanding the current fleet of public transport vehicles, actions were also taken to expand the existing metro lines and outreach. Mandatory give-way operations also ensure bus priority on the roads. Moreover, a Park & Ride scheme was initiated to ensure a seamless switch between private and public transport.

The government will create more connections through the construction of two new rail lines and three new extensions. By 2030, the rail network will have doubled from the existing 178 kilometres (km) in 2013 to about 360 km, and eight in 10 homes will be located within a 10-minute walk from a train station. Public buses will connect commuters to even more places, with new bus routes added to the bus network. Singapore is adding about 80 new bus services under the Bus Service Enhancement Programme.

To improve the overall experience of commuters, especially in the first and last mile of their journeys, the government will also be building more than 200 km of sheltered walkways. More integrated transport hubs will also be built to enable commuters to switch between different types of transport easily, with convenient access to retail, dining, and other lifestyle services. Cycling and walking are also

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[22] Land Transport Authority (2015), 'Revised Carbon Emissions-based Vehicle Scheme (CEVS) from 1 July 2015', *Press Release*, http://www.lta.gov.sg/apps/news/page.aspx?c=2&id=8aa03b88-409f-4852-b2df-09077e101468

[23] Straits Times (2016), 'LTA Relooking Case of Tesla Electric Car Slapped with $15,000 Carbon Surcharge', http://www.straitstimes.com/singapore/transport/lta-relooking-case-of-tesla-electric-car-slapped-with-15000-carbon-surcharge.

encouraged through public messaging campaigns. Specifically, the Intra-town Cycling programme launched by the Land Transport Authority promotes cycling through the designation of specialised road cycling paths. The island-wide cycling path network will eventually be well over 700 km in length. Moreover, an electric vehicle pilot car-sharing programme is currently in progress, which will see the introduction of 1,000 EVs and charging infrastructure to promote their use.[24]

***Buildings***

At the design stage, energy efficiency in building is governed by the Building and Construction Authority (BCA) of Singapore's Green Mark Scheme. Launched in January 2005 to promote environment sustainability in the construction and real estate sectors, the Green Mark Scheme targets environmentally friendly design in buildings, with a focus on energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green features focusing on landlords' contributions to 'going green.'25 Since April 2008, all new buildings and existing buildings undergoing major retrofitting works with a gross floor area above 2,000 square meters must meet Green Mark Certified standards. The BCA Green Mark Scheme promotes the adoption of green building technologies and reduces the use of electricity in the commercial sector via efficiency improvements and conservation. Buildings exceeding the minimum requirements are also awarded higher accreditations, such as the Platinum Green Mark, which serves to promote exceptional performance. Technical and financial support mechanisms are also provided to motivate continued energy efficiency upgrades. The Building Energy Efficiency Roadmap, published jointly by the National Climate Change Secretariat and the National Research Foundation in 2014, evaluates existing energy efficiency technologies for building providing technical expertise in the area. A variety of financial support mechanisms, such as Green Mark Incentive Scheme for Existing Buildings and Premises and the Building Retrofit Energy Efficiency Financing scheme are available to provide co-financing for retrofitting and energy efficiency upgrades. The target is for at least 80

[24] Land Transport Authority (2014), 'Joint News Release by the Land transport Authority & EDB on EV Phase 2 – Share an Electric Car', http://www.lta.gov.sg/apps/news/page.aspx?c=2&id=b1f98bcd-e4fc-4902-9f9d-08bc2309c3df

[25] E2 Singapore (2016), 'Buildings', http://www.e2singapore.gov.sg/Buildings.aspx

percent of the buildings in Singapore to achieve BCA Green Mark Certified rating by 2030.26

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 that posits that there is an energy efficiency potential of 20 percent. IDA also launched a new Green Data Centre Innovation Programme aimed at promoting innovative technological approaches to improving data centre energy efficiency.

Since 2006, the Public Sector Taking the Lead in Environmental Sustainability (PSTLES) initiative has placed the public sector at the forefront of building energy efficiency. Under the PSTLES, all existing public sector buildings have to meet a minimum Gold Mark rating, as determined by the type of building. Moreover, a Guaranteed Energy Savings Performance (GESP) Contracts initiative was introduced to ensure reaping the expected energy savings. Under the GESP Contract structure, the public sector agency is expected to engage an accredited energy services company who is to carry out an energy audit, implement the relevant energy efficiency measures, and guarantee annual energy savings over a 3 to 5 year contract period.[27] The efficacy of this initiative could be proved by average electricity savings of 15 percent across 14 projects by March 2015[28], contributing to annual monetary savings of S$6 million.

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[26] Building Construction Authority (2013), 'R&D Framework', Build Green Magazine, Issue 02/13, https://www.bca.gov.sg/greenmark/others/BGreen2013.pdf

[27] E2 Singapore (n.d.), 'Guaranteed Energy Savings Performance (GESP) Contracting Model in the Public Sector', http://www.e2singapore.gov.sg/DATA/0/docs/GESP%20Contract/e2singapore%20-GESP%20contract%20overview%20(revised).pdf

[28] E2 Singapore (2015), 'Public Sector Taking the Lead in Environmental Sustainability (PSTLES)', http://www.e2singapore.gov.sg/Buildings/BCA_Green_Mark_Scheme/Public_Sector_Taking_the_Lead_in_Environmental_Sustainability.aspx

***Industry***

The industry-focused Energy Efficiency National Partnership 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. Energy-intensive companies consuming more than 15 GWh (electricity) or 54 TJ (fuel or steam) per year are required to appoint an energy manager, monitor and report energy use and greenhouse gas emissions, and submit energy efficiency improvement plans.[29] Besides legislation enforcing mandatory energy management practices, policies were also introduced to incentivise energy efficiency investments. The energy services company Accreditation Scheme supports the Energy Conservation Act by ensuring professionalism in energy related services. To date, there are a total of 29 Qualified Energy Services Specialists from 19 Accredited ECSOs.

Incentives and grants, such as the Design for Efficiency Scheme, Energy Efficiency Improvement Assistance Scheme, and the Grant for Energy Efficiency Technologies (GREET), were also put in place as co-financing schemes to reduce the initial costs of energy efficiency upgrades. The One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology is another example of a tax incentive to encourage energy efficiency upgrades in industries.[30] Knowledge sharing is also promoted through industry-focused seminars and provision of energy management training and resources.

[29] National Environment Agency, (2014), ' Energy Efficiency National Partnership', http://app.e2singapore.gov.sg/Programmes/Energy_Efficiency_National_Partnership.aspx

[30]E2 Singapore (2015), One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology (ADAS), http://www.e2singapore.gov.sg/Industry/Designing_a_New_Facility/OneYear_Accelerated_Depreciation_Allowance_for_Energy_Efficient_Equipment_and_Technology.aspx

## 3. Modelling Assumptions

### 3.1. Power Generation Sector

In the Business-as-Usual scenario (BAU), the generation efficiency of combined-cycle gas turbine plants is assumed to improve from 49.6 percent in 2013 to 52 percent in 2040, registering an increase of 4.84 percent due to progression towards a competitive electricity market. For single-cycle thermal (ST) plants, efficiency is expected to improve marginally, from 40.14 percent to 42 percent in 2040. With respect to the use of solar generation capacity, it is assumed to grow from less than 0.1 percent to around 5 percent of aggregate demand for electricity in 2040, as part of public efforts towards promoting renewable energies.

With respect to Alternative Policy Scenario (APS)2, which takes into account greater potential for efficiency in the power generation sector, combined-cycle gas turbine plants will achieve 60 percent efficiency by 2040, while ST plants could reach 45 percent. APS3 allows for the share of solar to reach 8 percent of Singapore's total electricity needs in 2040.

### 3.2. Transport Sector

The demand for petrol, natural gas, and diesel for Singapore's road vehicles are assumed to be dependent primarily on vehicle growth. Consistent with vehicle quota targets set by the Land Transportation Authority, vehicle growth will remain at 0.5 percent from 2012 to 2014, and 0.25 percent from 2015 onwards under the BAU. Electricity demand for the Mass Rapid Transit (MRT) system is mainly driven by the expected expansion of railway length, which will increase from 153.2 km to 328.3 km by 2030, an annual average growth rate (AAGR) of 1.02 percent per year.

For APS1, it is assumed that vehicle growth drops further, to 0.2 percent in 2017 and beyond. No carbon mitigation efforts are imposed for electricity use in the MRT system, hence APS1 remains similar to BAU here.

### 3.3. Residential Sector

In the BAU, the MEPS, MELS, and continued community outreach efforts to promote energy conservation among households is expected to slow electricity demand growth to an AAGR of 1.5 percent from 2013 to 2040. Electricity demand growth can be further reduced to an AAGR of 1.4 percent in APS1. Demand for natural gas and oil products remain similar to BAU.

### 3.4. Commercial Sector

In the BAU, electricity demand is assumed to increase at an AAGR of 1.5 percent from 2013 to 2040, which will eventually end up 17 percent below baseline econometric forecasts in 2040. APS1 will lead to a further reduction in AAGR for electricity demand, to 1.36 percent. No reduction is expected from natural gas and oil consumption.

### 3.5. Industry/Petrochemicals Sector

For industry, The BAU assumes that natural gas, electricity, diesel, kerosene, residual fuel oil, as well as refinery gas demand will grow to reach 5 percent below econometric estimates. This relates to an AAGR of 3.6 percent across all fuels from 2013 to 2040. Demand growth will slow further to 3.4 percent in APS1, which is also 10 percent below econometric estimates in 2040. The BAU and APS1 remain similar for the other fuels in the industry sector.

Production of ethylene is assumed to grow linearly to reach 6 million tons per year by 2020, which translates to 22.2 Mtoe of naphtha produced[31] in the BAU, in line with policy targets. Naphtha is used as an intermediary fuel to produce petrochemicals mainly stockpiled for exports from Singapore to other countries. Hence, statistics for energy and carbon reduction potential, as well as energy intensity, are also reported for the BAU and APS5 with the exclusion of naphtha demand so as not to skew the result of energy intensity and emissions.

[31] Economic Development Board (EDB), (2012).
http://www.sedb.com/content/edb/sg/en_uk/index/news/articles/exxonmobil_s_second.print.html

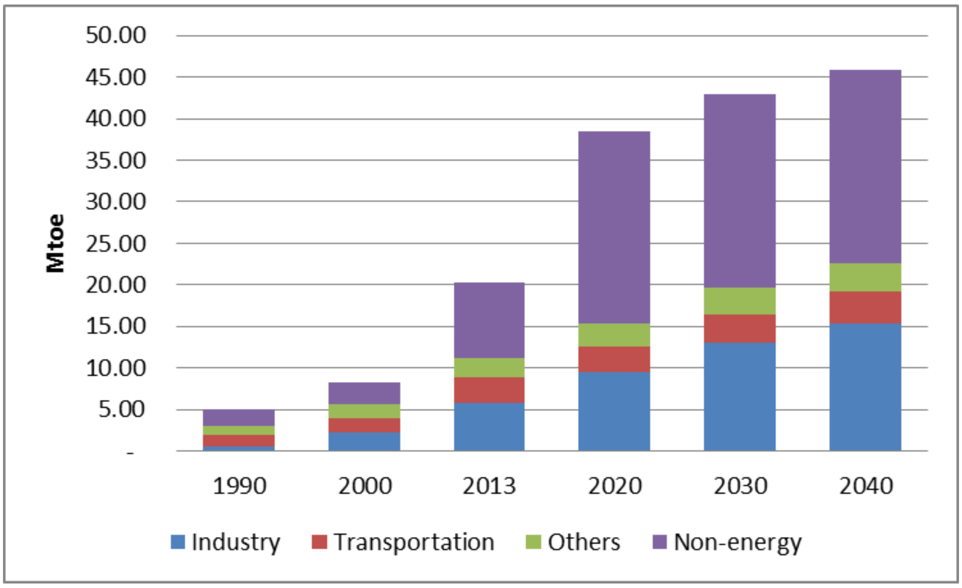
## 4. Outlook Results

### 4.1. Business-as-Usual Scenario (BAU)

#### 4.1.1. Final energy consumption

Singapore's final energy consumption grew at an annual average rate of 6.3 percent from 5.01 Mtoe in 1990 to 20.24 Mtoe in 2013. During the same period, oil was the dominant energy source, with 3.8 Mtoe and 14.9 Mtoe consumed in 1990 and 2013, respectively. Approximately 45.0 percent of the country's final energy was consumed for non-energy uses in 2013, particularly as feedstock for petrochemical production. In 1990, 27.1 percent of the final energy consumption was used in the transport sector, although its share of total final energy consumption declined by more than 45 percent, reaching around 14.6 percent only in 2013.

**Figure 15-1. Final Energy Consumption by Sector, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Under the BAU, final energy consumption is projected to grow by 3.1 percent a year between 2013 and 2040. The fastest growth is expected to occur in both the petrochemical and industry sector, increasing by 3.6 percent a year (Figure 15-1 above). The transport sector is projected to grow by 1.0 percent per year while the ‘others’ (residential and commercial) sector is projected to grow by 1.4 percent per year. The exclusion of naphtha demand for Singapore will reduce the AAGR for final energy consumption to only 2.5 percent.

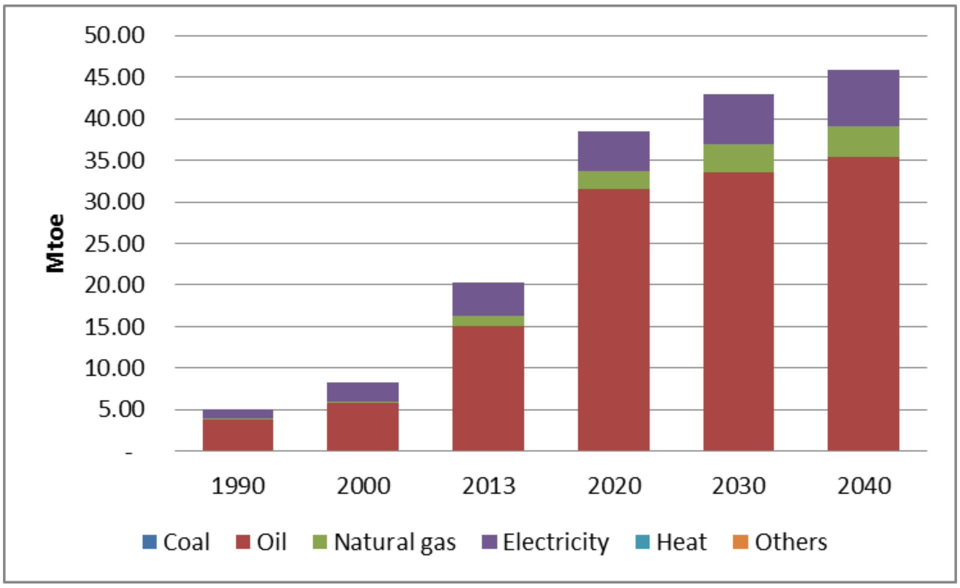
Under the BAU, non-energy consumption will still comprise the highest share in the total final energy consumption followed by the industrial sector. By the end of 2020, non-energy use will exceed 60.0 percent of Singapore’s final energy consumption, before declining slightly to 50.7 percent in 2040, assuming that there is no further expansion in petrochemical facilities in Singapore. Excluding naphtha leads to negligible demand in petrochemicals, where they only take up 4.3 percent of the total share of energy use. The industrial sector’s share will increase marginally, from a 28.9 percent share in 2013 to around 33.3 percent in 2040.

The transport sector’s share in final energy consumption from 2013 to 2040 is expected to decrease to 8.5 percent from its 27.1 percent share in 1990. This decrease stems from the country’s national policies advocating more efficient automobile technology and the promotion of public transport as the main means of transportation. In addition, the Certificate of Entitlement quotas are also expected to remain effective in curbing vehicle growth.

By fuel type, natural gas saw the fastest growth from 1990 to 2013, increasing at an average rate of 14.1 percent per year. The growth of natural gas was due to the increasing demand in its use, mainly in the rapidly expanding industry sector. Demand for electricity grew at an average annual rate of 5.6 percent from 1990 to 2013.

Under the BAU, demand for natural gas is expected to continue expanding, but at a slower average growth rate of 4.0 percent per year until 2040, and electricity demand will grow at an average rate of only 2.0 percent per year.

**Figure 15-2. Final Energy Consumption by Fuel, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Oil is still expected to play a major role in the country's final energy consumption. From 1990 to 2013, the share of oil fell from 76.1 percent to around 73.5 percent. Under the BAU, oil's share in final energy consumption is projected to rise to 81.4 percent in 2020, before falling to 76.9 percent in 2040. This decline is mainly due to high growth in natural gas usage, which will increase from its share of 6.4 percent in 2013 to 8.1 percent in 2040. The share of electricity in final energy consumption will decrease to around 12.5 percent in 2020 and rise to 14.8 percent in 2040. Figure 15-2 shows the final energy consumption by fuel.

If naphtha is not included, the share of oil will reach 13 Mtoe in 2040, only 55.2 percent of total final energy consumption.

### 4.1.2. Primary energy supply

Primary energy supply grew by 4.1 percent per year, from 11.53 Mtoe in 1990 to 28.73 Mtoe in 2013. Singapore's dominant source of energy in 1990 was oil, consumption of which increased by 2.3 percent per year from 11.44 Mtoe in 1990 to 19.22 Mtoe in 2013. 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 8.9 Mtoe in 2013.

Primary energy supply in the BAU is projected to grow by 2.5 percent per year between 2013 and 2040 (Figure 15-3). Among the energy sources, solar energy is expected to grow the fastest at 22.8 percent a year, followed by oil at 2.7 percent per year. Natural gas demand is expected to grow in line with the expansion of gas-fired power plants.

Singapore’s net generation capacity has already increased by more than 2,000 MW or about 20.0 percent of current installed capacity with more efficient combined cycle gas turbines.[32]

Nevertheless, oil is expected to remain the primary energy source, accounting for 69.2 percent of primary energy supply in 2040, followed by natural gas at 28.5 percent.

The exclusion of naphtha from the energy balance will still see oil as the primary energy source at 48.8 percent. In this case, oil demand will grow with an AAGR of 1.6 percent, and total primary energy grows by only 2.0 percent.

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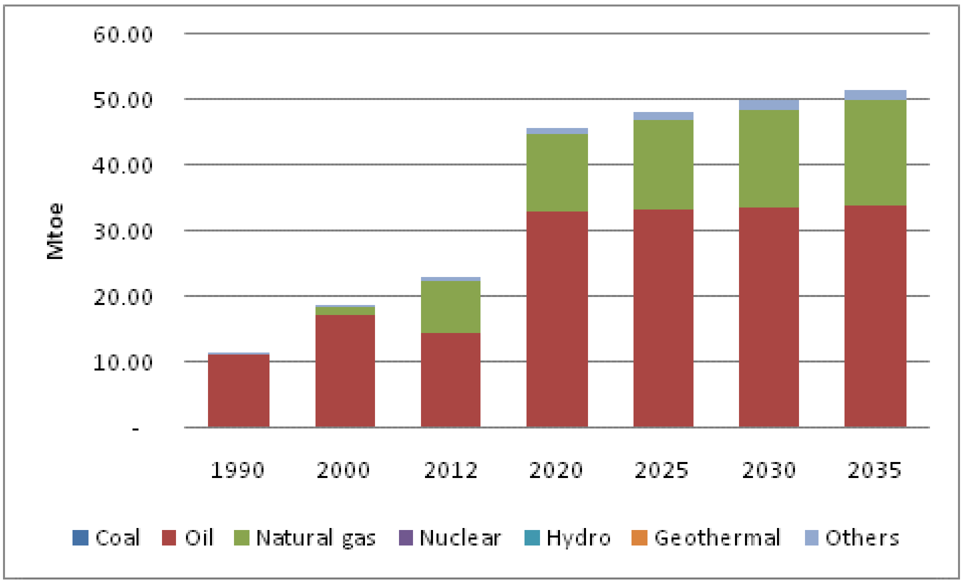
[32] Ministry of Trade and Industry (2013). ‘Speech by Mr S. Iswaran’ at the *Committee of Supply Debate under Head V,* 11 March. https://www.mti.gov.sg/NewsRoom/Pages/Mr-S-Iswaran,-Second-Minister-For-Trade-and-Industry,-During-The-Committee-Of-Supply-Debate-Under-Head.aspx

**Figure 15-3. Total Primary Energy Supply, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 4.1.3. Power generation

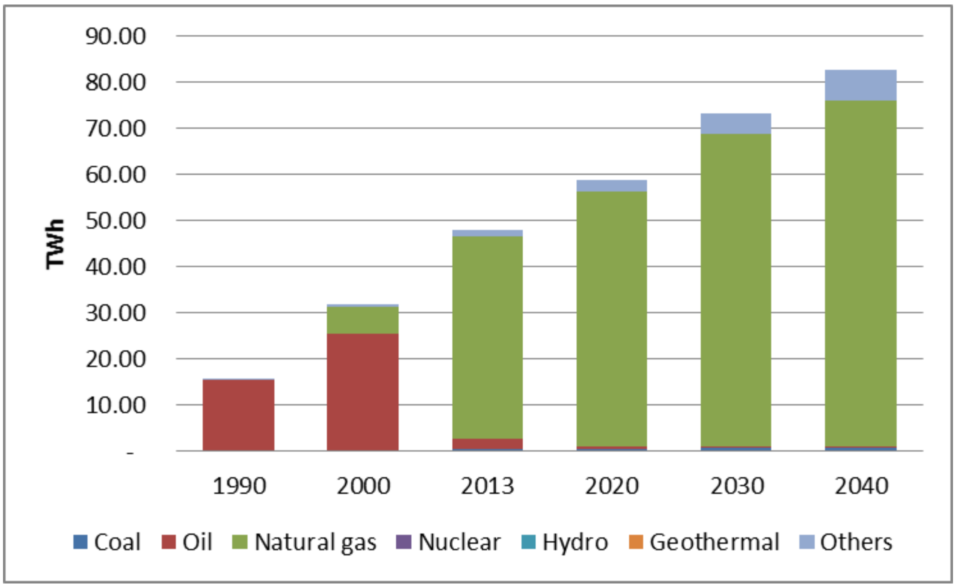
Electricity generation grew by 5.0 percent per year from 15.7 TWh to 48.0 TWh from 1990 to 2013. The electricity generation mix has changed significantly over the past decade. Natural gas, which accounted for 28.0 percent of electricity generation in Singapore in 2001, grew rapidly to supply 91.5 percent of Singapore's electricity in 2013. Fuel oil use for thermal power generation was around 2.33 TWh in 2013. Biomass and solar took up a small proportion of the mix, totalling to around 2.9 percent in 2013. Coal started to be utilised in 2013 as a substitute for the supply of hydrogen and carbon monoxide as feedstock for the energy and petrochemical sector. It is projected to grow only marginally, at 2.0 percent per year.

In the BAU, power generation is projected to increase at a slower rate of 2.0 percent per year, reaching 82.48 TWh in 2040. By type of fuel, generation from 'Others', which comprises of biomass and solar power, will see the fastest growth at an average rate of almost 5.9 percent per year. Others power generation is expected to increase its share from a minimal share of 2.9 percent in 2013 to 7.8 percent in 2040.

From the end of 2013 and in the years thereafter, at least 90.0 percent of the country's power generation mix is estimated to come from natural gas under the BAU. Its share of the generation mix gradually declines from 94.8 percent in 2015 to 91.0 percent in 2040 as more solar power is utilised. The share of oil will decline to 0.4 percent over the same period.

The average thermal efficiency of Singapore's fossil-fuelled power plants was around 30.3 percent in 1990 and improved to 48.6 percent in 2013 as more natural gas-fired power plants came into operation. In the BAU, thermal efficiency of fossil plants is expected to improve further, to around 51.5 percent in 2040. By fuel, natural gas plants' thermal efficiency will be 52.0 percent in 2040, and oil will be at 41.5 percent.

**Figure 15-4. Electricity Generation, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

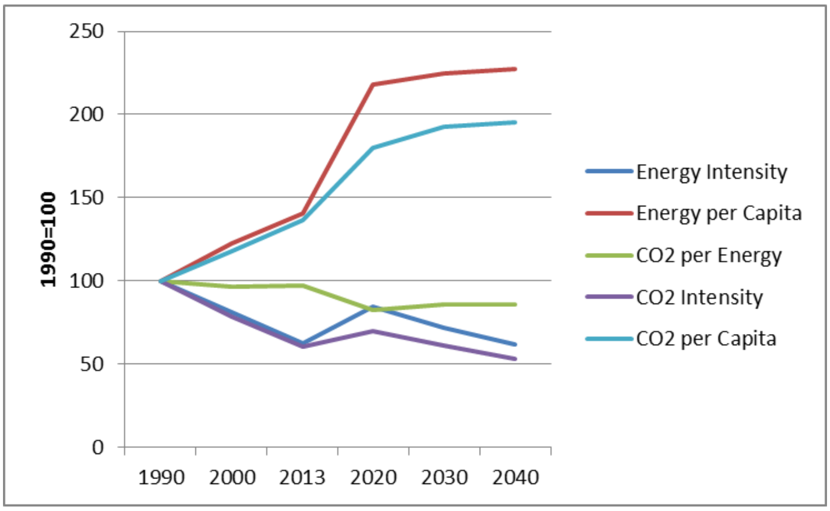
#### 4.1.4. Energy indicators

Primary energy intensity, which is computed as the ratio of primary energy supply over GDP, is expected to increase. Energy intensity continues to increase as Singapore's population will experience slower growth in the future. Energy and

$CO_2$ per capita increases as population growth is expected to remain lower than fossil fuel demand growth.

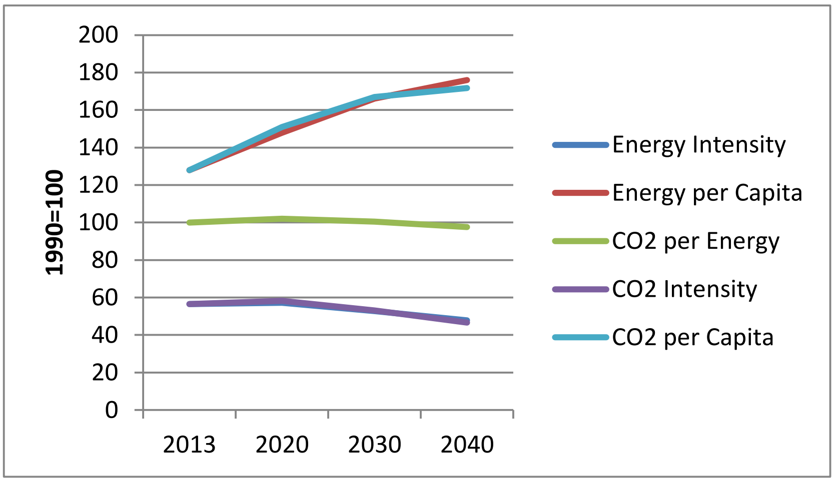
The exclusion of naphtha leads to a slower growth for energy per capita and $CO_2$ per capita. Energy intensity and $CO_2$ intensity both decrease as well, compared with forecasts containing naphtha.

**Figure 15-5a. Energy Indicators, BAU**




BAU = Business-as-Usual scenario; $CO_2$ = carbon dioxide.
Source: Author's calculation.

**Figure 15-5b. Future Energy Indicators, BAU excluding Naphtha**




BAU = Business-as-Usual scenario; $CO_2$ = carbon dioxide.
Source: Author's calculation.

## 4.2. Energy Saving and $CO_2$ Reduction Potential

### 4.2.1. Final energy consumption

Final energy consumption under APS1 is projected to increase by 3.0 percent, from 2013 to 2040. Similar to the BAU case, the non-energy sector leads the growth numbers at 3.6 percent per year, followed by the industry sector at 3.4 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. APS5, a combination of all APS, will have the same final energy consumption as that of APS1.

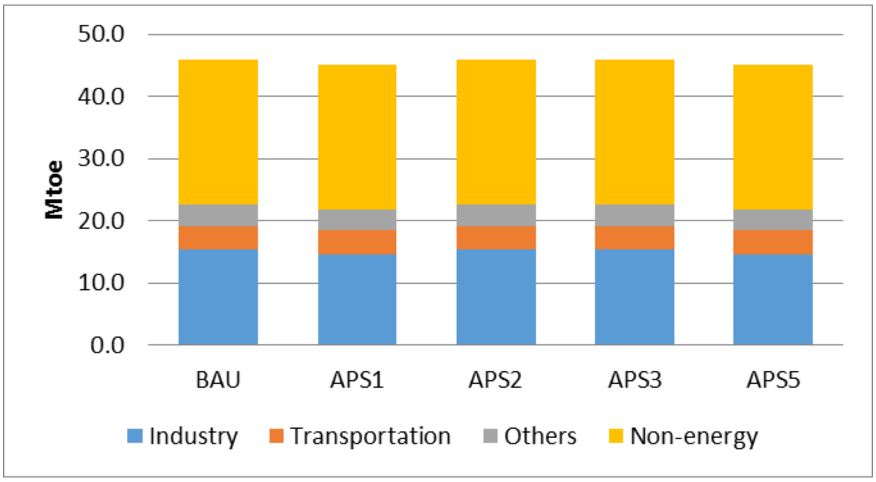
### 4.2.2. Primary energy supply

Results from APS2 show that primary energy supply from 2013 to 2040 will increase at an average annual rate of 2.5 percent, a 1.65 Mtoe decrease from the BAU (Figure 15-7) in 2040.

This translates to a reduction of 2.9 percent from the BAU in 2040. APS1 and APS3 will help to lower primary energy supply by 1.19 Mtoe and 190 ktoe, respectively, in 2040. This illustrates that policies targeting end-user energy efficiency and renewables currently still play only a secondary role to power generation efficiency policies in reducing primary energy supply.

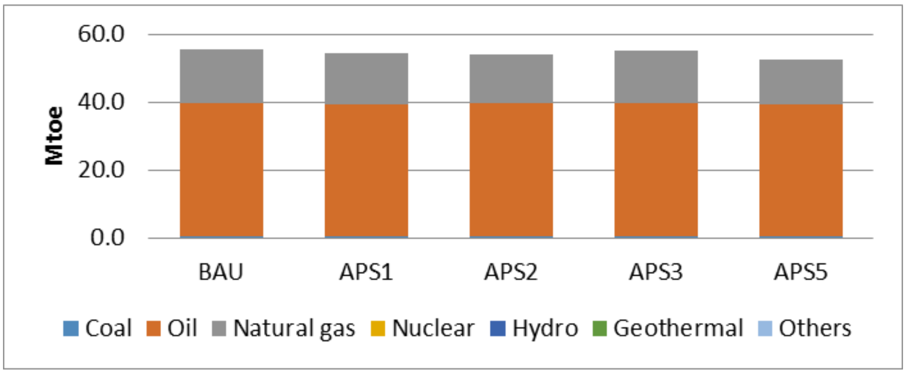
Most of the reduction in primary energy supply will come from natural gas at 2.6 Mtoe, which is a drop of 16.4 percent from the BAU (Figure 15-8A). Oil only falls by 1.1 percent as it is limited by the already declining BAU consumption for power generation, as well as the large consumption in the petrochemical non-energy use.

**Figure 15-6. Total Final Energy Consumption by Sector, BAU and APS1–5**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

**Figure 15-7. Total Primary Energy Supply by Fuel, BAU and APS1–5**



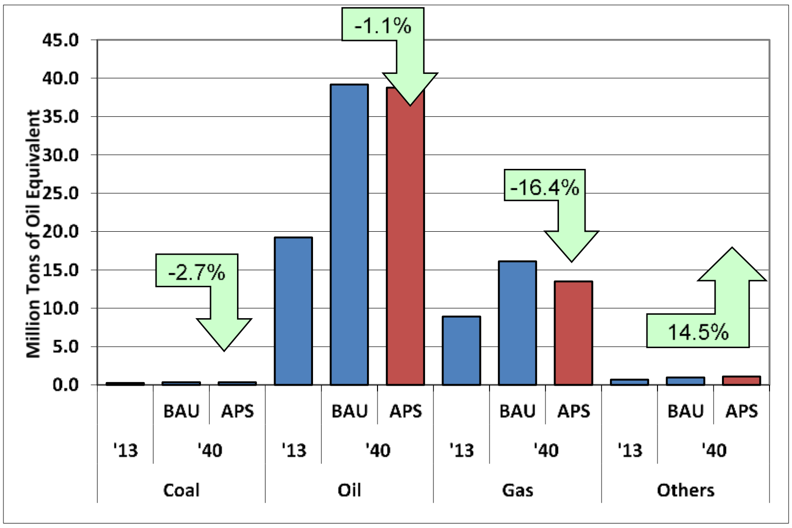

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

The exclusion of naphtha will lead to a reduction of 2.4 percent from the BAU for oil consumption (Figure 15-8b). Biomass' consumption will remain relatively constant, whereas solar power progresses significantly but remains small in magnitude. Hence, this leads to an increase in consumption of 'others' by 14.5 percent.

### 4.2.3. Power generation

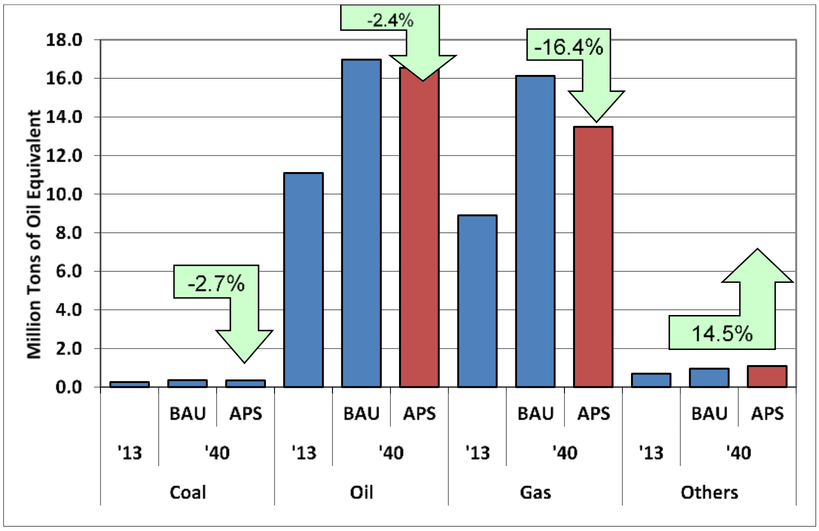
Results from APS1 and APS5 show a decrease in electricity generation, registering a drop of 3.53 TWh or 4.29 percent from the BAU. APS2 and APS3 assume the same generation as the BAU since final energy consumption does not fall under these two scenarios.

**Figure 15-8a: Primary Energy Supply by Fuel, BAU and APS5**



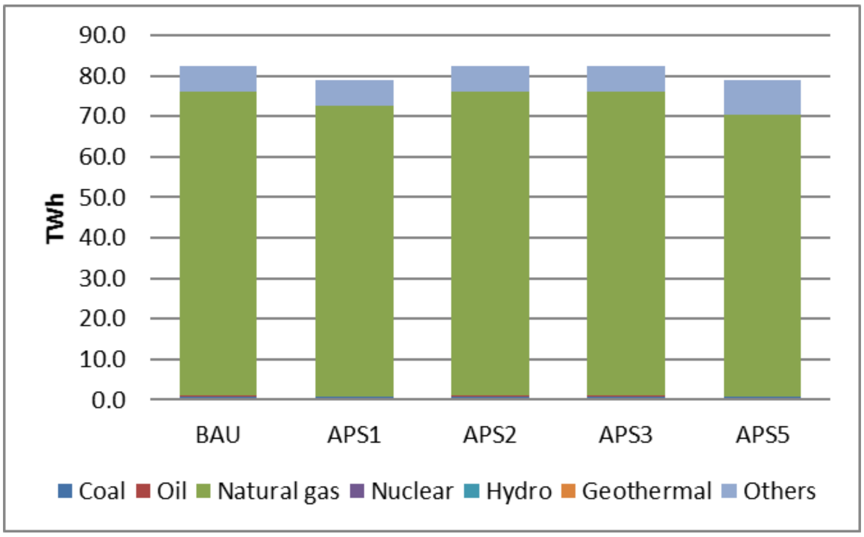

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario.
Source: Author's calculation.

**Figure 15-8b: Primary Energy supply by Fuel, BAU and APS5, excluding Naphtha**




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

**Figure 15-9: Electricity Generation, TWh**




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

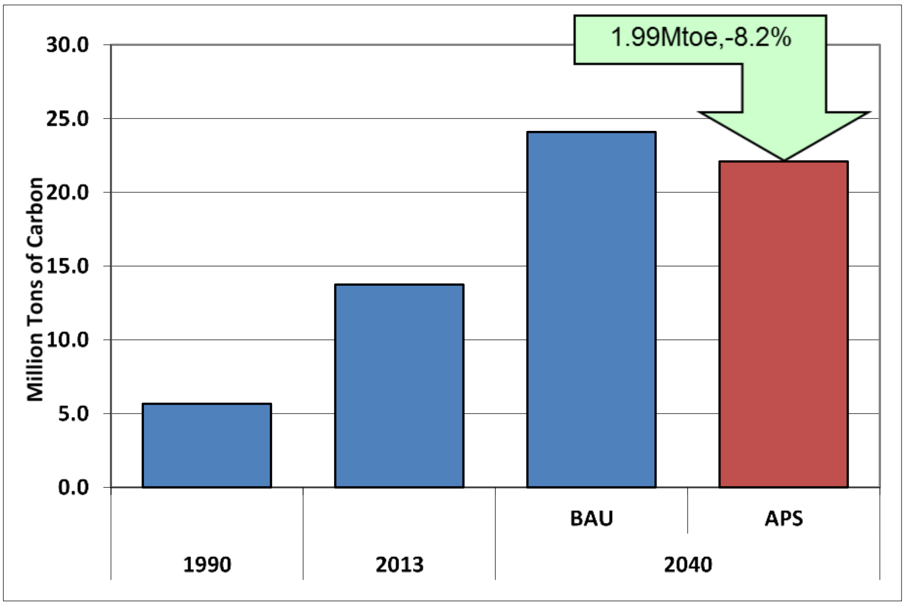
### 4.2.4. $CO_2$ reduction potential

Under the BAU, $CO_2$ emissions from energy demand are projected to increase at an average annual rate of 2.1 percent, from 13.7 Mt-C in 2013 to around 24.1 Mt-C in 2040 (Figure 15-10A).

$CO_2$ emissions reduction potential comes mainly from improvements in thermal efficiency for power generation (APS2), with savings of 1.1 Mt-C in 2040, equivalent to a 4.6 percent decrease from the BAU. Educational policies and incentives that target behavioural changes in end-consumers of energy are also very beneficial, with APS1 registering emissions reduction of 0.8 Mt-C in the same time period (a 3.3 percent reduction from the BAU). Increased utilisation of solar power results in emissions reduction of 0.26 Mt-C (a 1.1 percent reduction from the BAU). Overall, APS5 will contribute to emissions reduction of 2.71 Mt-C, which is a 4.8 percent reduction from the BAU. Under this scenario, carbon emissions will increase at an annual average rate of 1.8 percent from 2013 to 2040, compared with 2.1 percent under the BAU.

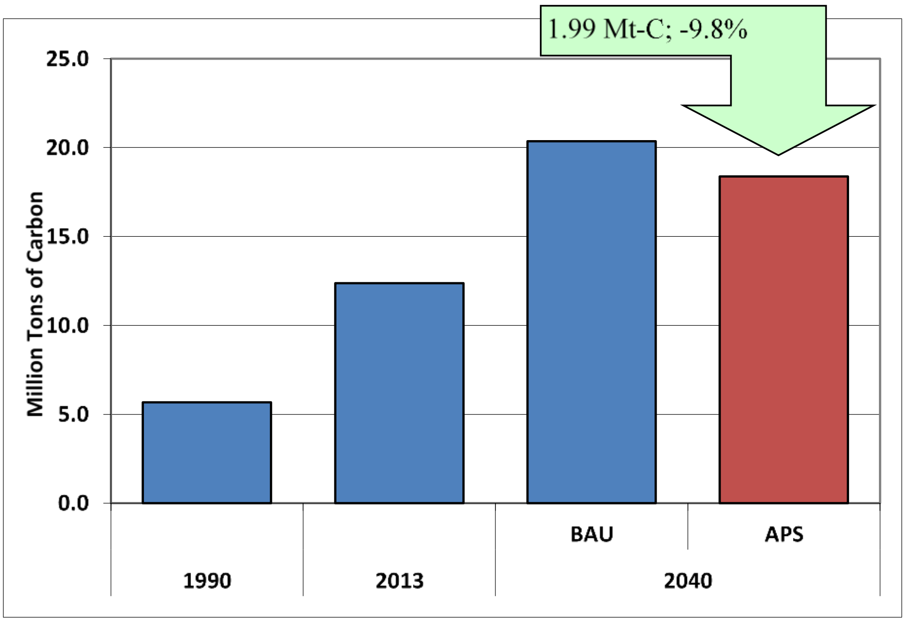
If naphtha is not included, the total reduction in $CO_2$ emissions remains at 1.99 Mt-C from the BAU to APS5 (Figure 15-10B). The percentage reduction is now 9.8 percent instead of 8.2 percent.

**Figure 15-10a. $CO_2$ Emissions from Energy Consumption, BAU and APS5**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

**Figure 15-10b. $CO_2$ Emissions from Energy Consumption excluding Naphtha, BAU and APS5**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's calculation.

## 5. Implications and Policy Recommendations

The Singapore government has been progressively implementing new strategies to help incentivise and advocate the adoption of clean energy technologies and conservation behaviour amongst both industries and households. These programmes include a number of funding schemes, such as 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 services companies to help conserve energy.

Solar adoption, an electric vehicle car-sharing programme, as well as SMART technologies pave the way for further carbon reduction for both industries and households in the future. There is also an initiative to improve the petrochemical industry's energy efficiency and competitiveness by way of a 'heat-integration' plan.[34]

Singapore has also taken measures to ensure that its energy needs are diversified across more countries for energy imports, rather than depending on gas pipeline flows from Malaysia and Indonesia as it transits towards using more natural gas to power its electricity needs. Currently, Singapore has plans to increase LNG import storage facilities, and it is appointing another one or two companies to import LNG for Singapore in the short term. Coal use for co-generation, as well as the greater adoption of solar are an indication of efforts made towards fuel mix diversification.

As shown in the forecast results for the BAU with 2013 as the base year, Singapore is already on track to meet its projected 2020 targets of hitting 77.2

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[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.

million tons of $CO_2$,[35] with estimations showing the potential to go as low as 18.9 Mt-C or about 70 million tons of $CO_2$ if greater efforts are made to reduce emissions.

Despite the limitations posed by its small size and the paucity of renewable energy sources, Singapore's long-term commitment to building a sustainable city will ensure that the efforts of using energy efficiently and in an environmentally viable manner will continue to receive broad support.

[35] NCCS (2016), 'Singapore's Emissions Profile'. https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapores-emissions-profile

# Chapter 16

## Thailand Country Report

September 2016

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Chapter 16

# Thailand Country Report

SUPIT PADPREM, ENERGY INFORMATION SYSTEM DEVELOPMENT DIVISION, ENERGY POLICY AND PLANNING OFFICE, MINISTRY OF ENERGY, THAILAND

## 1. Background

Thailand is in the middle of the South East Asian mainland, with the Pacific Ocean on the south-east coast and the Indian Ocean on the south-west coast. Its land area is approximately 513,115 square kilometres, with great plains at the centre, mountainous areas up north, and highlands in the north-east. Its gross domestic product (GDP) in 2013 was around US$230.4 billion (in constant 2005 US$ terms). In 2013, the population was 67.5 million and income per capita was around US$3,420.

Thailand is an energy importer, especially crude oil, because of very limited domestic resources. Thailand's indigenous energy resources include natural gas, coal (only lignite), and biomass. In 2013, 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 tons of lignite.

Thailand's total primary energy supply (TPES) reached 132.3Mtoe in 2013. Oil accounted for the largest share at around 38.5 percent, followed by natural gas (28.6 percent), and coal (12.9 percent). 'Others' accounted for the remaining 20 percent. In 2013, net imports of energy accounted for 56.5 percent of TPES. Due to very limited indigenous oil resources, Thailand imported around 75 percent of its oil and most of its bituminous coal. Although Thailand produces large quantities of natural gas, about 20 percent of its use was imported from Myanmar and other countries. In Thailand, natural gas is used as a major energy source for power generation. In 2013, primary natural gas supply registered at 37.84 Mtoe, around 80.0 percent of which was sourced from domestic supply and the rest imported from neighbouring countries. Coal was mainly consumed in power generation and industry, but it was also heavily used in cement and paper production.

Thailand has 33.7 GW of installed electricity generation capacity and power generation was about 165.7 TWh in 2013. The majority of Thailand's power generation was using thermal sources (coal, natural gas, and oil), accounting for 91.5 percent of generation, followed by hydro at 3.5 percent, with geothermal, solar, small hydro, and biomass making up the remainder.

## 2. Modelling Assumptions

GDP growth from 1990 to 2013 was a moderate 4.2 percent per year. Thailand's GDP is assumed to grow at an average rate of 3.7 percent per year between 2013 and 2040. Population growth is also projected to be quite slow at around 0.03 percent per year between 2013 and 2040, compared with average growth of about 0.8 percent per year between 1990 and 2013.

Natural gas and coal are projected to be the largest energy sources for power generation. Conversely, the shares of fuel-oil and diesel power plants are projected to remain constant. Nuclear power and renewable energy are projected to increase their shares in the power generation mix under the Alternative Policy Scenario (APS).

Thailand's energy saving goals is 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 in the Bangkok metro area railway network will contribute to energy savings. Significant improvements in energy efficiency in passenger vehicles are also expected to be achieved in line with new developments in car technologies and the introduction of the next phase of the Eco car programme II.

Government policies will continue to encourage the increased use of alternative fuels, especially biofuels. Reductions in the growth of carbon dioxide ($CO_2$) 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

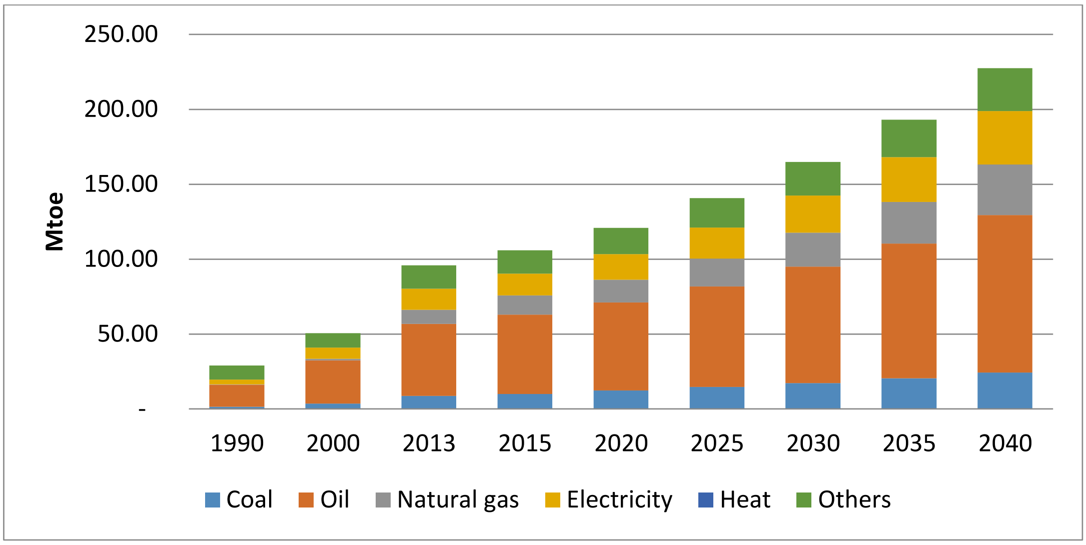
### 3.1. Business-as-Usual Scenario (BAU)

Between 1990 and 2013, Thailand's final energy consumption grew at an average rate of 5.4 percent per year from 28.9 Mtoe in 1990 to 95.8 Mtoe in 2013 (see Figure 16-1). Given moderate economic growth and a low population growth rate, final energy consumption is projected to grow at a slower rate of 3.3 percent per year between 2013 and 2040.

Oil has been the dominant fuel in Thailand's final energy consumption, accounting for 48.0 Mtoe or a 50.1 percent share in 2013. Electricity was the second largest energy fuel, accounting for 14.1 Mtoe or a 14.8 percent share in 2013.

Oil is expected to remain the largest final energy source throughout the projection period. Its share, however, is projected to decline from the 2013 level to 46.2 percent in 2040. In 2040, the shares of electricity, natural gas, and coal in final energy consumption are projected to increase to 15.7 percent, 14.9 percent, and 10.7 percent, respectively.

**Figure 16-1. Final Energy Consumption by Fuel, BAU**

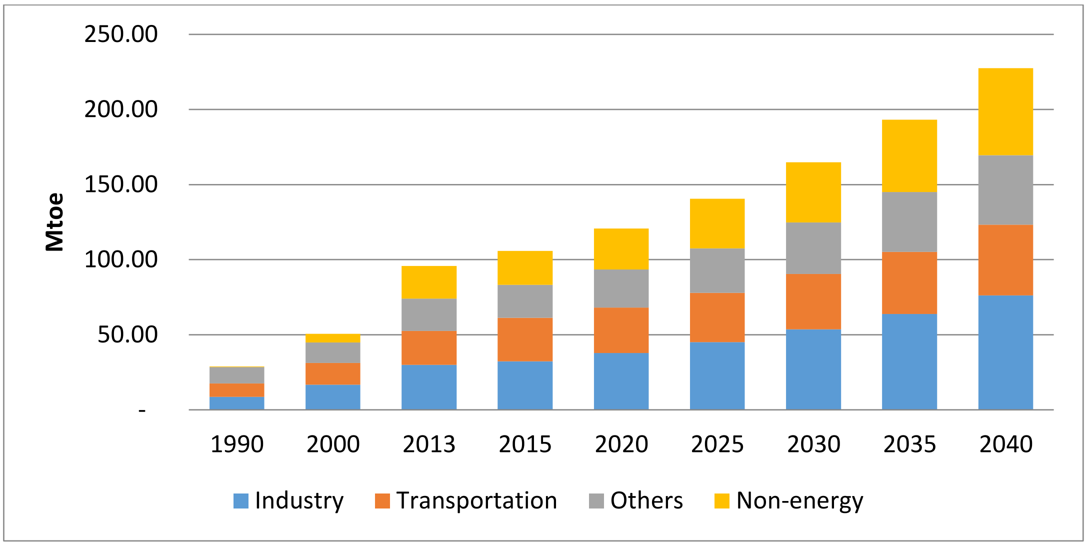



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

The industry sector had a 30 percent share in the total final energy consumption (TFEC) of Thailand in 1990 at a level of 8.7 Mtoe (see Figure 16-2). The demand of the sector grew at an average rate of 5.5 percent a year between 1990 and 2013, and its share increased to 31.2 percent (equivalent to 29.9 Mtoe) in 2013, which made it the largest consuming sector. The industry sector is projected to remain the largest consumer, accounting for 33.5 percent (equivalent to 76.3 Mtoe) in 2040. In contrast, the sector called 'others' (manly residential and commercial sector) will account for the smallest proportion of final energy consumption in 2040 at 20.3 percent, while previously it was 37.3 percent in 1990.

Primary energy supply grew at an average annual rate of 5.0 percent from 42.6 Mtoe in 1990 to 132.3 Mtoe in 2013, driven largely by fast economic development between 1990 and 1996. This growth in primary energy supply was achieved despite the severe economic crisis in 1997–1998 and the world economic crisis in 2008. In 2013, the major sources of primary energy were oil, natural gas, and coal with shares of 38.5 percent (50.9 Mtoe), 28.6 percent (37.8 Mtoe), and 12.9 percent (17.1 Mtoe), respectively.

**Figure 16-2. Final Energy Consumption by Sector, BAU**



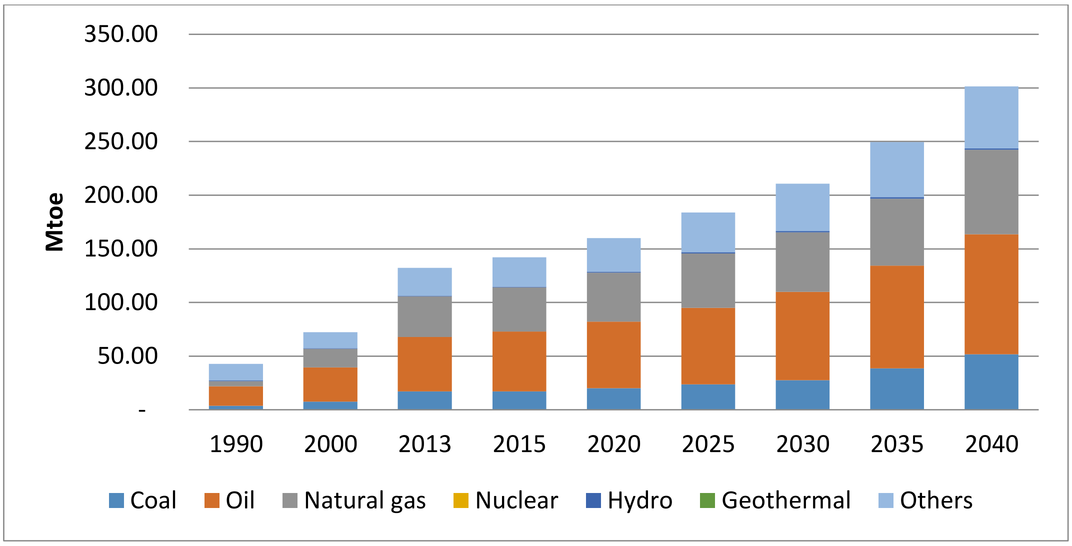

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

Although oil remained the largest source between 1990 and 2013, its share in primary energy supply decreased slightly from 42.8 percent in 1990 to 38.5 percent in 2013. Natural gas, which is mainly consumed in the power generation sector, became an important source of energy with its share in primary energy supply increasing significantly from 11.9 percent in 1990 to 28.6 percent in 2013. The share of hydropower declined from 1.0 percent in 1990 to only 0.4 percent in 2013.

In the Business-as-Usual scenario (BAU), primary energy supply is projected to grow on average by 3.6 percent per year from 2013 to 2040, reaching 301.5 Mtoe in 2040 (see Figure 16-3). The highest average annual growth rate is expected in coal (6.5 percent), with consumption projected to reach 51.6 Mtoe in 2040. Natural gas will follow at an annual average growth rate of 3.6 percent, reaching 112.1 Mtoe in 2040. Oil growth in the same period will be slower than from 1990 to 2013; it is projected to increase at an average rate of 3.1 percent per year. Although coal and natural gas increased faster than oil, the latter will retain its highest share in the total primary energy supply. The share of oil will decline to 37.2 percent in 2040 while the shares of coal and natural gas will be around 17.1 percent and 26.1 percent, respectively.  Biomass is expected to grow at an average rate of 2.8 percent per year between 2013 and 2040.

This rate is slower than the annual average growth rate of total primary energy supply (3.6 percent), and as a result the share of biomass in the total primary energy mix will decline from 17.6 percent in 2013 to 15.4 percent in 2040.

**Figure 16-3. Primary Energy Supply by Fuel, BAU**

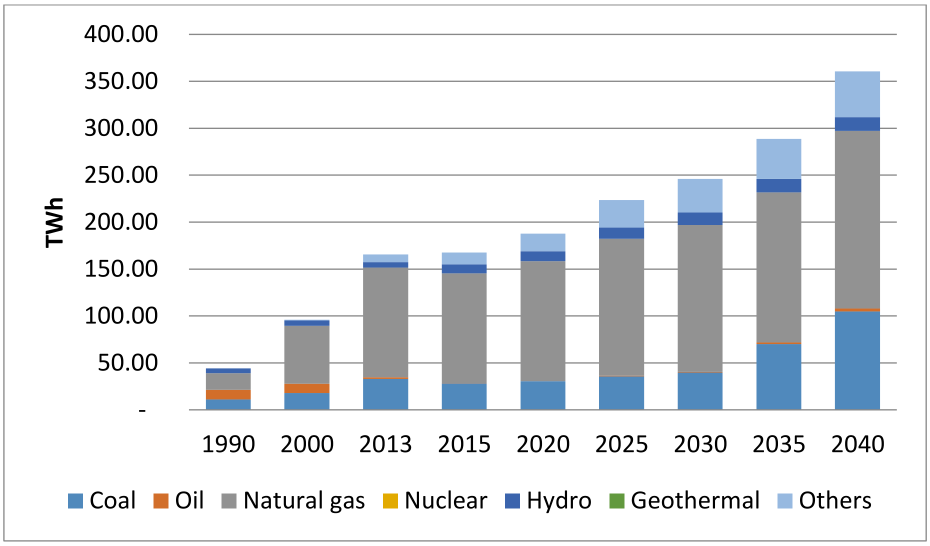



BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

In 1990, the total power generation was 44.2 TWh and it reached 165.7 TWh in 2013, with an average growth rate of 5.9 percent per year. As shown in Figure 16-4, natural gas has been a major fuel for power generation since 1990. Natural gas in power generation grew at a robust rate of 8.5 percent per year from 17.8 TWh (40.2 percent share) in 1990 to 117.0 TWh (70.6 percent share) in 2013. Coal had the second largest share at 25.0 percent in 1990, but it fell to 19.9 percent in 2013. Oil was the least used fuel in power generation, with only 1.7 TWh in 2013.

In the BAU, power generation is expected to grow at around 2.9 percent per year from 2013 to 2040 and will reach 360.8 TWh in 2040. In 2040, natural gas will remain the dominant fuel used in power generation with the highest share of 52.5 percent or 189.3 TWh. Coal will still be the second largest source of power generation with a 29.1 percent share or a level of 105.0 TWh expected in 2040. Power generation from hydro will increase by 3.6 percent per year from 5.8 TWh in 2013 to 14.8 TWh in 2040.

**Figure 16-4. Power Generation by Fuel, BAU**



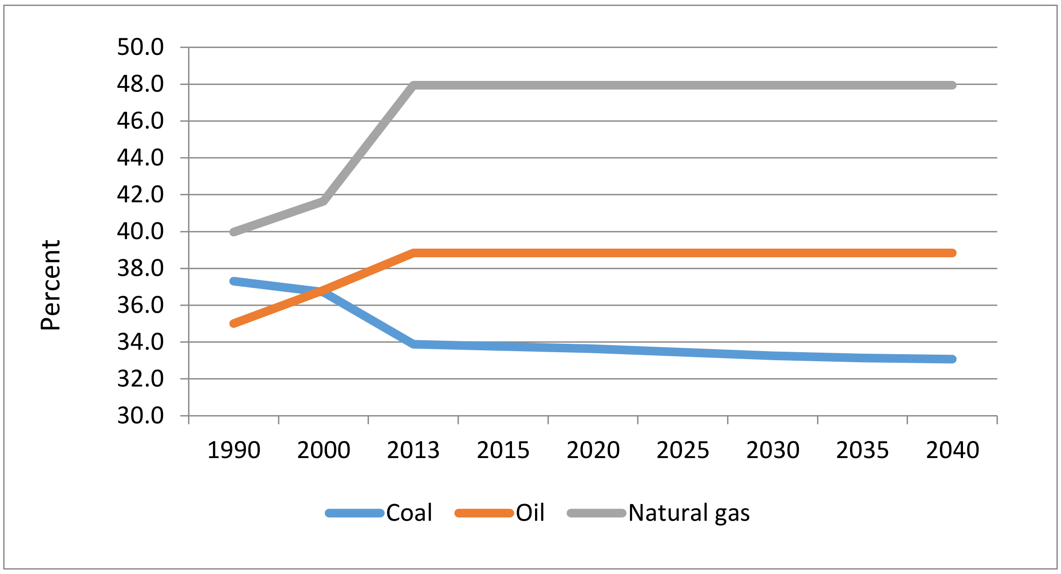

BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

Natural gas has the highest thermal efficiency improvement. A 40 percent efficiency of natural gas in 1990 improved to almost 48 percent in 2013 and is expected to remain unchanged until 2040. Coal thermal efficiency declined by almost 0.4 percent from 1990 to 2013, and is not expected to improve over the study period (Figure 16-5).

Figure 16-6 shows the energy indicators. Energy intensity reached 574 toe/million at 2005 US$ in 2013. In the BAU, energy intensity is projected to decline by 0.6 percent per year to reach 491 toe/million 2005 US$ in 2040. Energy per capita will increase from almost 2.0 toe per person in 2013 to 4.4 toe per person in 2040.

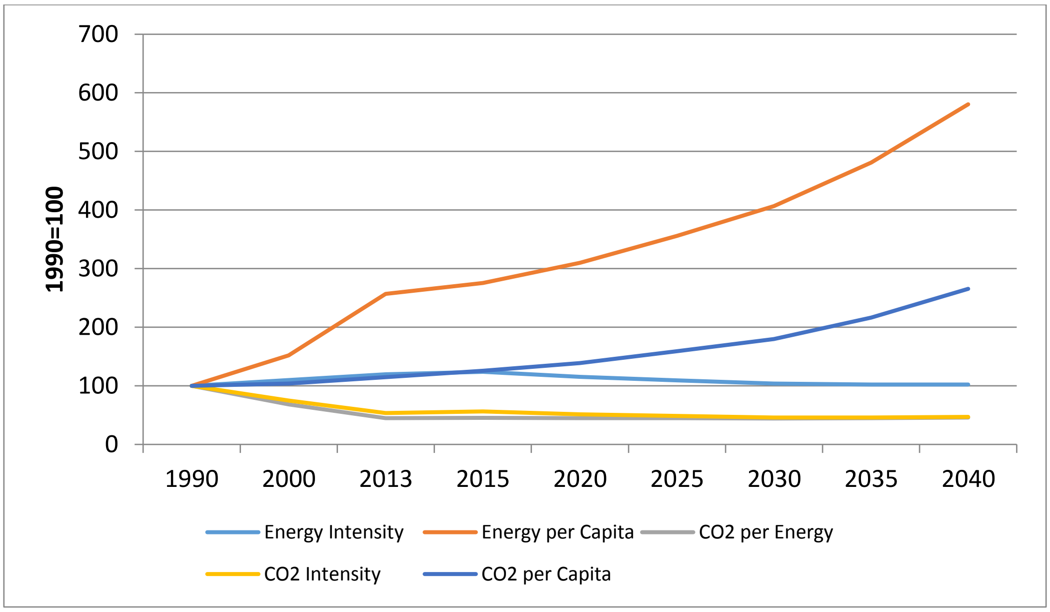
Energy elasticity between 1990 and 2013 was 1.2, which indicates that energy demand rose at a faster rate than economic output. In the BAU, energy elasticity is projected at 0.8 between 2013 and 2040, which means that energy demand will grow at a slower rate than economic output.

**Figure 16-5. Thermal Efficiency by Fuel, BAU**




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

**Figure 16-6. Energy Indicators**



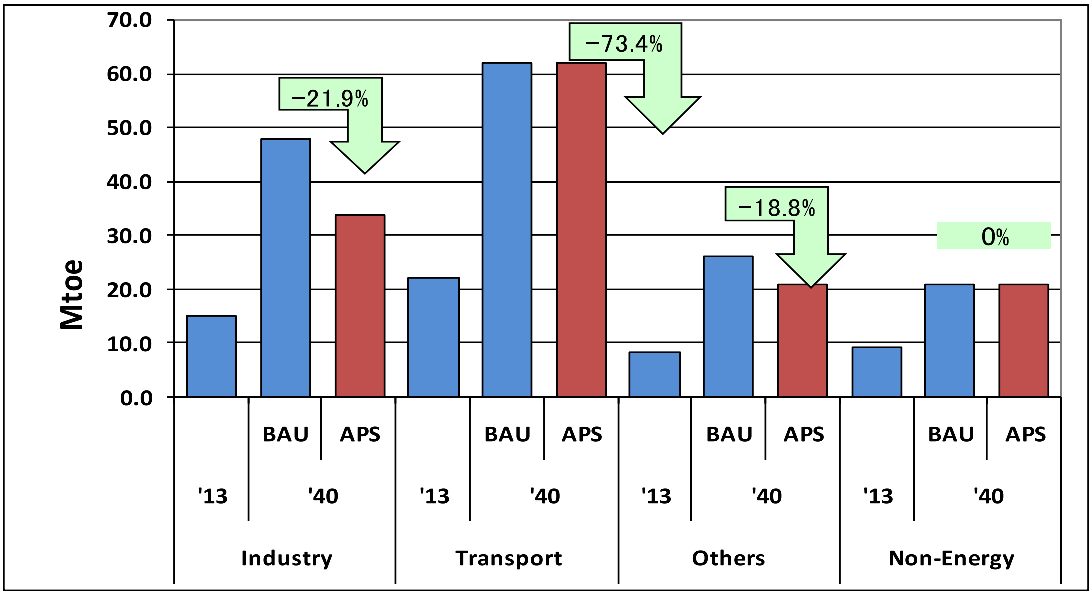

$CO_2$ = carbon monoxide.
Source: Author's calculation.

## 3.2. Energy Saving and $CO_2$ Reduction Potential

### 3.2.1. Final energy consumption

In the APS, final energy consumption is projected to grow by 2.1 percent per year, from 95.8 Mtoe in 2013 to 167.6 Mtoe in 2040. This is 26.4 percent lower than in the BAU, in which it will grow at an average annual rate of 3.3 percent over the projection period. The majority of energy savings will be achieved through energy efficiency improvement programmes implemented in the industry (21.9 percent) and transportation (73.4 percent) sectors. Improvements will also be achieved in 'other' sectors (18.8 percent), as shown in Figure 16-7.

**Figure 16-7. Final Energy Consumption by Sector, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

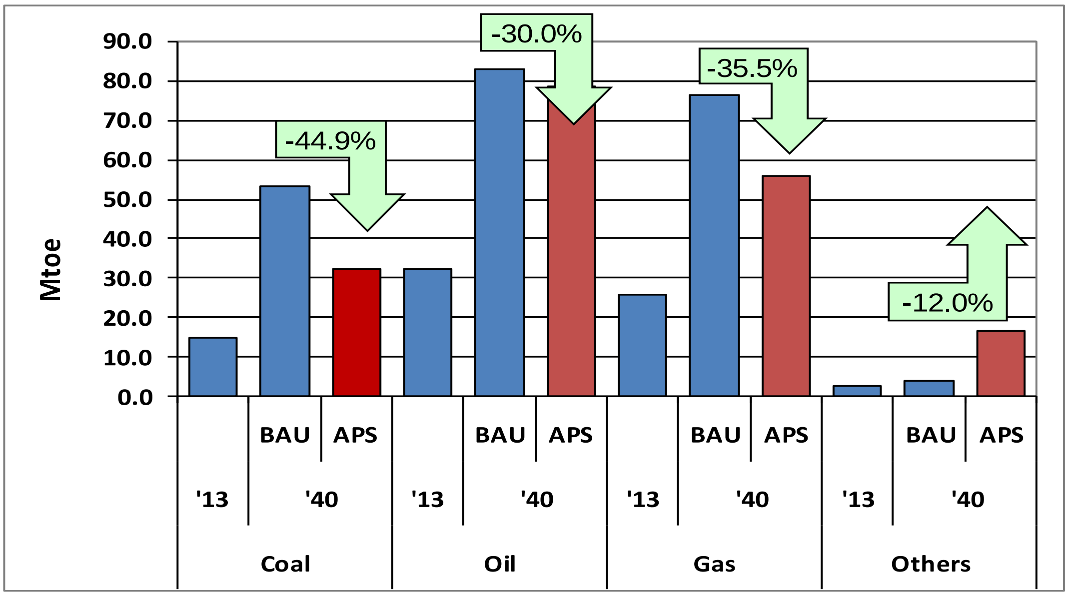
### 3.2.2. Primary energy supply

In the APS, growth in primary energy supply is projected to be much slower than in the BAU, increasing at 1.7 percent per year (compared with 3.1 percent in the BAU) to reach 209.7 Mtoe in 2040. Primary energy supply is expected to be about

30.4 percent lower in the APS than in the BAU in 2040 – an energy saving of about 91.8 Mtoe.

Coal and oil are projected to increase at slower annual average rates of 1.9 percent and 1.6 percent, respectively (4.2 percent and 3.0 percent in the BAU). Natural gas use is projected to increase at an annual average rate of 1.1 percent (2.8 percent in the BAU) from 37.8 Mtoe in 2013 to 50.8 Mtoe in 2040. The lower growth rates compared with the BAU are mainly achieved through energy efficiency and conservation measures on the demand side. The differences in the projections between the two scenarios are shown in Figure 16-8.

**Figure 16-8. Primary Energy Supply by Source, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

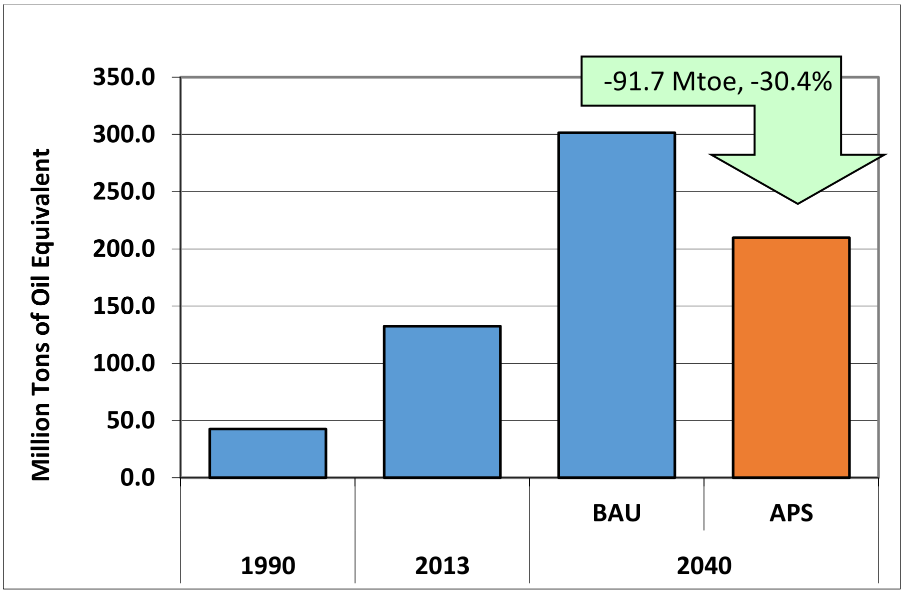
### 3.2.3. Projected energy savings

The difference between primary energy supply in the BAU and the APS in 2040 is 91.7 Mtoe (Figure 16-9). This represents the potential energy savings that could be achieved if energy efficiency and conservation goals and action plans were implemented. Oil and natural gas will contribute the largest energy savings at

33.6 Mtoe and 27.9 Mtoe, respectively. Energy saving from coal will reach 23.2 Mtoe in 2040, but the contribution of non-fossil energy sources will also be 7.1 Mtoe lower than in the BAU.

In final energy consumption, the savings in the APS compared with the BAU in 2040 will reach 59.9 Mtoe. The largest savings are expected to be achieved in the transport sector, at 34.6 Mtoe. The industry and 'other' sectors are expected to achieve energy savings of 16.7 Mtoe and 8.6 Mtoe, respectively.

**Figure 16-9. Total Primary Energy Supply, BAU and APS**



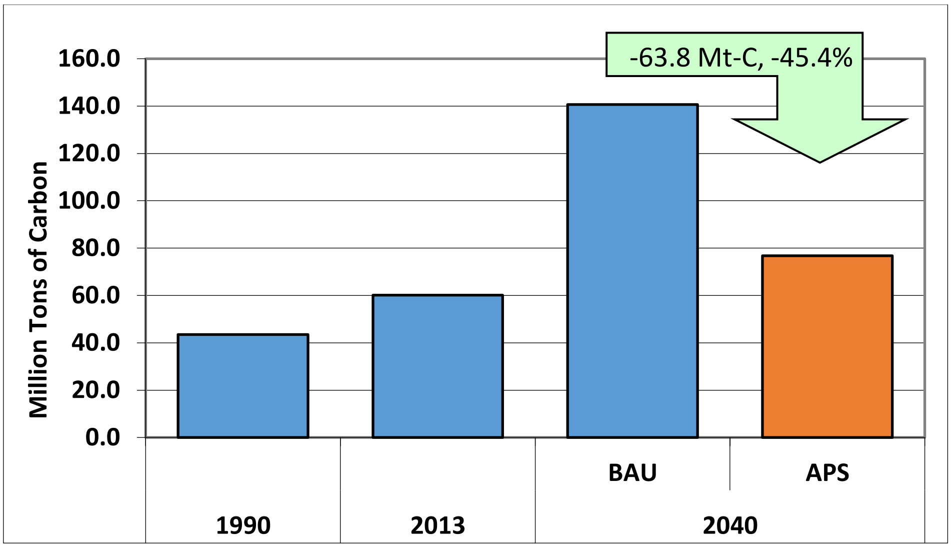

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.3. $CO_2$ Emissions

$CO_2$ emissions from energy consumption are projected to increase by 3.2 percent per year on average from 60.2 Mt-C in 2013 to 140.6 Mt-C in 2040 under the BAU. Under the APS, the average annual growth in $CO_2$ emissions from 2013 to 2040 is projected to be 0.9 percent, with an emission level of 76.8 Mt-C in 2040. The difference in $CO_2$ emissions between the BAU and the APS is 63.8Mt-C or 45.4 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 16-10).

**Figure 16-10. $CO_2$ Emissions from Energy Consumption, BAU and APS**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
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. However, the energy intensity of the economy has declined since it recovered from the crisis. Furthermore, with Thailand's energy efficiency programmes in a wide range of areas (including industry, transportation, and residential sectors), and high oil prices in the world market, a further decline in the energy intensity of the Thai economy is to be expected.

Improving energy efficiency will also help Thailand (which is an oil importer) to address the challenges posed by high world oil prices. Thailand is committed to reducing the intensity of energy consumption, particularly oil consumption, and to looking for more sustainable energy sources and environment-friendly fuels. It was recognised that the more Thailand saves energy, the less sensitive it will be to fluctuations in world energy prices and supply. Furthermore, Thailand has realised that energy saving is important and that it should put greater efforts into it.

Although Thailand has an alternative policy for the next 23 years, oil will remain a major energy source for its economy. Oil is one of the most sensitive energies in terms of price and security. Thailand should focus more on oil savings in future to become less dependent on this fuel. Furthermore, energy use in the transportation sector in future will be lower than in the other sectors. The sector is also less productive than the others, meaning it consumes more energy but produces less value added. The greater the energy savings that can be achieved in the transport sector, the greater the benefits for the economy as a whole.

Chapter 17

# Viet Nam Country Report

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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 2013, Viet Nam had a population of 89.7 million and a gross domestic product (GDP) of US$92.3 billion in 2005 US$ terms. The commercial sector contributed most to Viet Nam's GDP (43.8 percent), followed by the industry sector (38.6 percent), and agriculture (17.6 percent). GDP per capita was US$1,029 in 2005 US$ terms in 2013.

Viet Nam possesses considerable indigenous energy resources. It has 3,390 million tons of proven recoverable reserves of coal, 460 million cubic meters of crude oil reserves, and 610 billion cubic meters of gas reserves.

Viet Nam's primary energy supply was 60.1 Mtoe in 2013. Oil represented the largest share of Viet Nam's primary energy supply at 27.3 percent; coal was second at 26.9 percent, followed by natural gas (14.9 percent), hydro (8.2 percent), and 'others'[1] (22.7 percent). Viet Nam is a net exporter of crude oil and coal but is an importer of petroleum products because of capacity limitations at the Dung Quat oil refinery (6.5 million tons a year), which is able to meet around 45 percent of domestic demand.

[1] 'Others' consists of biomass, solar, wind, ocean resources, biofuels, as well as electricity.

Coal is mainly used in the industry sector, with consumption of 16.2 million tons of oil equivalent (Mtoe) in 2013, whereas natural gas is largely used for electricity generation.

Viet Nam had around 30.6 GW of installed generating capacity and generated 127.3 TWh of electricity in 2013. Most of Viet Nam's electricity generation comes from thermal sources (coal, natural gas, and oil), accounting for 55.2 percent of total generation, with hydro accounting for 44.7 percent and others for 0.1 percent.

## 2. Modelling Assumptions

In this outlook, Viet Nam's GDP is assumed to grow at an average annual rate of 6.0 percent from 2013 to 2040. Growth is projected to be faster in the first part of the outlook period, increasing by 6.8 percent per year between 2013 and 2020. For the remaining periods of 2020–2030 and 2030–2040, the country's economic growth will be slightly reduced at annual rates of 6.2 percent per year and 5.2 percent per year, respectively. Population growth is projected to increase at the much slower rate of 0.7 percent per year between 2013 and 2040.

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 2028, in line with Viet Nam's revised nuclear power development plan. In the Business-as-Usual scenario (BAU), it is assumed that the first unit of nuclear power with a capacity of 1,200 MW will be installed in 2028 and will be followed by a second unit and a third unit of nuclear power with total capacity of 2,300 MW and 3,500 MW in 2029 and 2030, respectively.

Viet Nam's energy saving goals are estimated at 3–5 percent of total energy consumption, equivalent to 5 Mtoe, between 2006 and 2010, and 5–8 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 since 2014, in line with the master plan on renewable energy development.

From the above analysis, the Alternative Policy Scenarios (APS) proposed are as follows: the EEC scenario (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 5–8 percent of energy reduction from 2013 to 2015 and 12 percent by 2040.
    - EEC2: Switching from diesel oil 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 improved coal cooking stoves, compact fluorescent lamp in lighting, and efficient refrigerators and air conditioners in residential cooling.
    - EEC4: Using EEC measures in the commercial sector to reduce electricity consumption by 12 percent by 2040.

- 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 2040, compared with 37 percent, 40 percent, and 32 percent, respectively, in the BAU, while natural gas with combined cycle gas turbine technologies will increase to 55 percent by 2040 compared with 52 percent in the BAU.

- APS3: Development of renewable energy technologies:
  Installed electricity generating capacity from renewable energy is assumed to reach 35,800 MW in 2040, with solar PV contributing 16,000 MW, wind 10,000 MW, small hydro 5,600 MW, biomass 4,000 MW, and biogas 200 MW. Moreover, Viet Nam has considered the use of biofuels to reduce dependency on oil and curb carbon dioxide ($CO_2$) 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 1.8 million tons and 2.0 million tons of biofuels in 2035 and in 2040, respectively.

- APS4: Maximum nuclear power development:
  The installed capacity of nuclear power plants is expected to reach a further 9,500 MW and 15,500 MW under the APS scenario by 2035 and 2040, respectively, compared with only 3,500 by 2030 in the BAU.

- APS5: Combining all APSs from APS1 to APS4.

## 3. Outlook Results

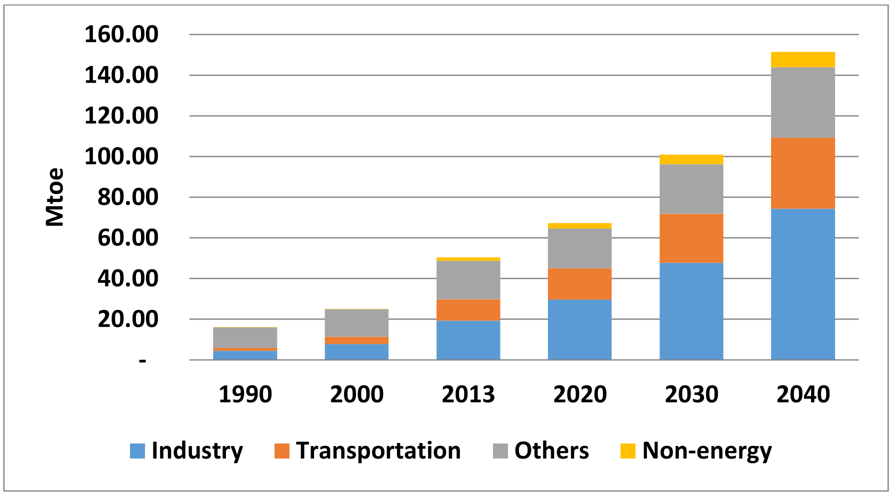
### 3.1. Business-as-Usual (BAU) Scenario

#### 3.1.1. Final energy consumption

Viet Nam's final energy consumption increased at an average annual rate of 5.1 percent from 1990 to 2013, from 16.1 Mtoe to 50.5 Mtoe. The fastest growth occurred in the transport sector (9.2 percent per year), followed by the industrial sector (6.5 percent), and the residential/commercial ('others') sector (2.8 percent). Non-energy use increased at an average rate of 19.6 percent per year.

From 2013 to 2040, final energy consumption is projected to increase at an average rate of 4.2 percent per year under the BAU, driven by strong economic growth, assumed to average 6.0 percent per year, and population growth of 0.7 percent per year. The strongest growth in consumption is projected to occur in the industry sector, increasing by 5.1 percent per year, followed by the transportation sector (4.6 percent), and the residential/commercial ('others') sector (2.3 percent). Non-energy use is expected to increase by 5.7 percent per year (Figure 17-1).

**Figure 17-1. Final Energy Consumption by Sector, BAU**



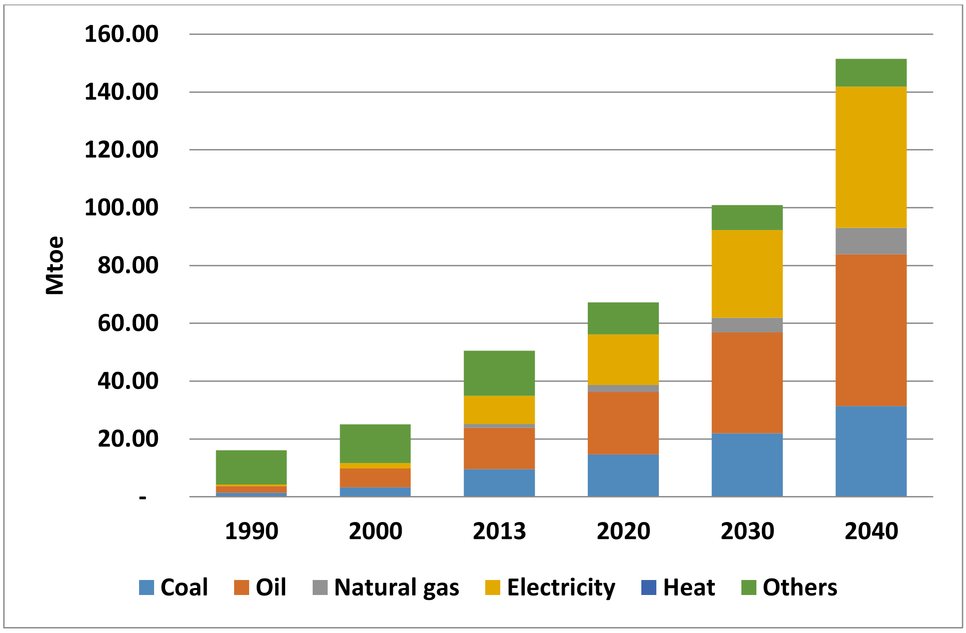

BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

The bulk of the country's energy consumption, or about 63.0 percent in 1990, comes from the residential/commercial ('others') sector, where biomass fuel used for residential cooking takes the dominant share of the sector. This share is on a strongly decreasing trend, to 37.5 percent by 2013 and 22.8 percent by 2040 due to the substitution of biomass fuels by commercial fuels with higher efficiency. The decreasing share of the sector is also due in part to the growing economy. The impact of economic growth will translate to an improvement in standards of living, thus promoting the transition from biomass fuels to the commercial fuels.

From 2013 to 2040, the industrial sector tends to be the largest consuming sector in Viet Nam. The share of energy consumption in the industrial sector will increase from 38.4 percent in 2013 to 49.1 percent in 2040. The second biggest consumer is the transport sector, although its share will increase slowly from 20.7 percent in 2013 to 23.1 percent in 2040.

Meanwhile, other fuels (mostly biomass) are the most consumed products, accounting for 73.9 percent of final energy consumption in 1990, but this declined to 30.8 percent in 2013. Oil is the second most consumed product, accounting for 14.5 percent of final energy consumption in 1990, increasing to 28.2 percent in 2013. The share of coal consumed from 1990 to 2013 increased from 8.3 percent to 18.9 percent. Electricity took a small share of 3.3 percent in 1990, but there was a significant increase to 19.4 percent in 2013.

**Figure 17-2. Final Energy Consumption by Fuel, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

On a per fuel basis under the BAU, natural gas is projected to see the fastest growth in final energy consumption, increasing by 7.4 percent per year between 2013 and 2040. Electricity is projected to have the second highest growth rate of 6.1 percent per year, followed by oil at 4.9 percent and coal at 4.5 percent. Other fuels (mostly biomass) are projected to decrease at an annual rate of 1.7 percent due to the expected transition from biomass fuels to commercial fuels (Figure 17-2). Other fuels (dominated by biomass) take the largest share of 30.8 percent in 2013, but this will fall to as low as 6.4 percent by 2040. Oil products take the second largest share of 28.2 percent in 2013 and this share is projected to increase to 34.6 percent in 2040. The third largest share of demand is electricity, which is projected to increase from 19.4 percent in 2013 to 32.2 percent in 2040. Coal and natural gas are used primarily in the industry sector with shares of 18.9 percent and 2.7 percent, respectively, in 2013; and their shares are expected to increase to 20.7 percent and 6.1 percent, respectively, in 2040.

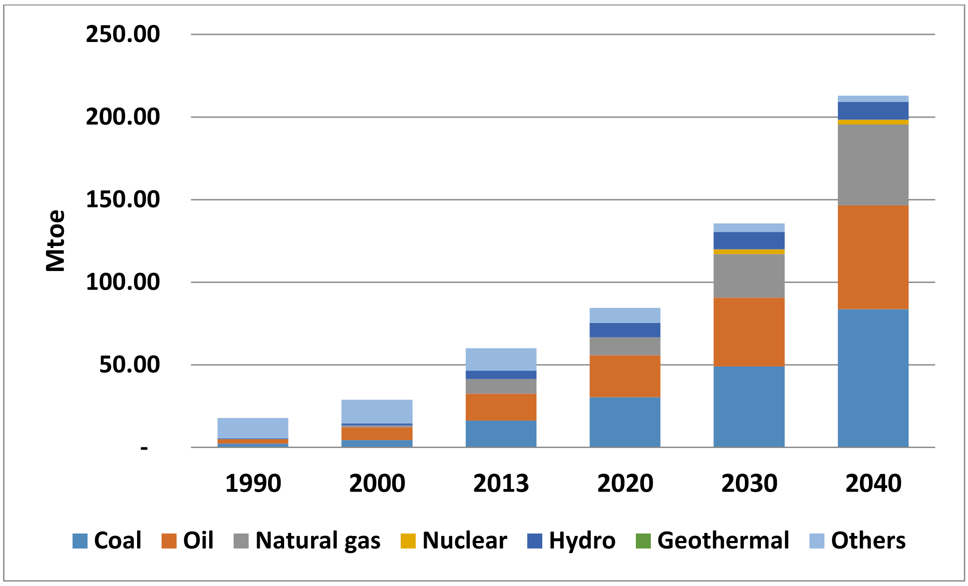
### 3.1.2. Primary energy supply

Primary energy supply in Viet Nam grew at a faster rate than final energy consumption, increasing by 5.4 percent per year or by 3.4 times from 17.9 Mtoe in 1990 to 60.1 Mtoe in 2013. Among the major energy sources, the fastest growing were natural gas, hydro, coal, and oil. Natural gas consumption grew at an average annual rate of 41.6 percent from 1990 to 2013, whereas hydro, coal, and oil grew at 10.8 percent, 9.0 percent, and 8.1 percent per year, respectively.

In the BAU, Viet Nam's primary energy supply is projected to increase at an average annual rate of 4.8 percent or by 3.5 times from 60.1 Mtoe in 2013 to 212.9 Mtoe in 2040. The fastest growth is expected in natural gas, increasing at an annual average rate of 6.5 percent between 2013 and 2040, followed by coal, oil, and hydro at 6.3 percent, 5.1 percent, and 2.9 percent, respectively, whereas other fuels (mostly biomass) will decrease strongly, by 4.7 percent per year (Figure 17-3). Oil accounted for the largest share 27.3 percent, of the primary energy supply in 2013 and this is projected to increase slightly to 29.5 percent in 2040.

The share of coal was 26.9 percent in 2013 and will increase to 39.3 percent in 2040. Natural gas accounted for a share of 14.9 percent in 2013 and is projected to increase to 23.1 percent in 2040. These growth rates are due to the projected decline of hydro and 'others,' the shares of which are projected to decline from 8.2 percent to 5.0 percent and from 22.7 percent to 1.8 percent, respectively.

**Figure 17-3. Primary Energy Supply, BAU**




BAU = Business-as-Usual scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

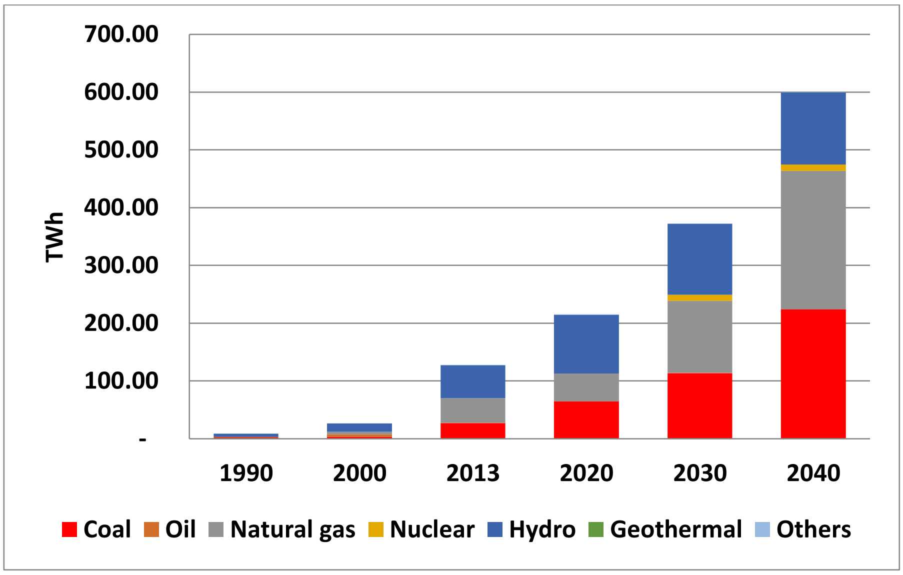
### 3.1.3. Power generation

Power generation output increased by 12.4 percent per year or by 14.7 times, from 8.7 TWh in 1990 to 127.3 TWh in 2013. The fastest growth occurred in natural gas power generation (47.1 percent per year), followed by coal (12.0 per cent), and hydropower (10.8 percent). These high growth rates are due to the decrease of oil by 3.8 percent per year. (Figure 17-4)

To meet electricity demand under the BAU, power generation is projected to increase at an average rate of 5.9 percent per year, or by 4.7 times, from 2013 to 2040. The fastest growth will be in coal power generation (8.2 percent per year), followed by 'others' (mostly small hydropower generation) (6.9 percent), natural gas (6.6 per cent), and hydro-power generation (2.9 percent).

By the end of 2013, most of the country's power requirement was met by hydropower, which comprised about 44.7 percent of the total power generation mix. The share of natural gas power generation was around 33.7 percent, and the rest was from coal and oil power generation.

**Figure 17-4. Power Generation by Type of Fuel, BAU**




BAU = Business-as-Usual scenario; TWh = terawatt-hour.
Source: Author's calculation.

In the BAU, natural gas will be the major fuel for power generation from 2030 to 2040, with its share projected to increase from 33.3 percent in 2030 to 39.8 percent in 2040, whereas the share of hydro in total power generation will decline from 32.9 percent to around 20.8 percent.

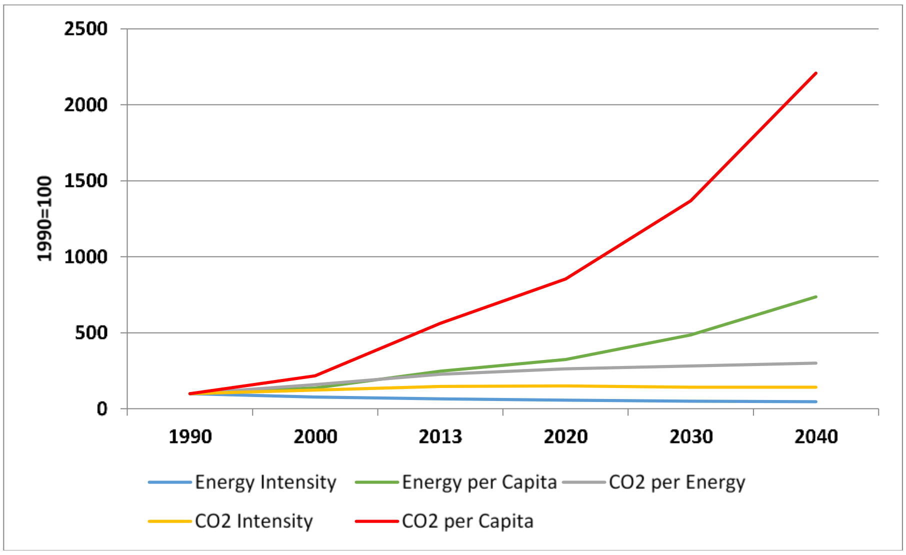
### 3.1.4. Energy indicators

Viet Nam's energy intensity was on a decreasing trend from 1990 to 2013. Both primary and final energy intensities fell from 1,006 and 905 toe/million 2005 US$ in 1990 to 651 and 547 toe/million 2005 US$ in 2013, respectively. This was mainly due to high economic growth, which resulted in significant reductions in biomass fuels used for cooking in the residential sector, although the energy requirement in the industrial sector and transport sector increased strongly during that period. The final energy intensity under the BAU is estimated to continue its decreasing trend, falling from 547 to 338 toe/million 2005 US$ by 2040, which provides a good indication that energy for economic development will be used efficiently in the forecast period.

Primary energy per capita increased from 0.27 toe/person in 1990 to 0.67 toe/person in 2013 and is forecast to increase to 1.99 toe/person in 2040. This indicates that people's living standards and incomes will increase, resulting in an increase in primary energy supply per capita.

Regarding greenhouse gas (GhG) emissions, $CO_2$ intensity and $CO_2$ per unit of energy increased from 1990 to 2013, from 265 t-C/million 2005 US$ and 0.26 t-C/toe in 1990 to 389 t-C/million 2005 US$ and 0.6 t-C/toe in 2013, respectively. In the BAU, $CO_2$ intensity and $CO_2$ per unit of energy are also forecast to increase up to 2020, to 400 t-C/million 2005 US$ and 0.69 t-C/toe, respectively. Beyond 2020, $CO_2$ intensity will decline to 376 t-C/million 2005 US$ in 2040, whereas $CO_2$ per energy will maintain its slight increase reaching around 0.79 t-C/toe. $CO_2$ per capita remains on an increasing trend due to energy demand increasing faster than the population (Figure 17-5).

**Figure 17-5. Energy Indicators**



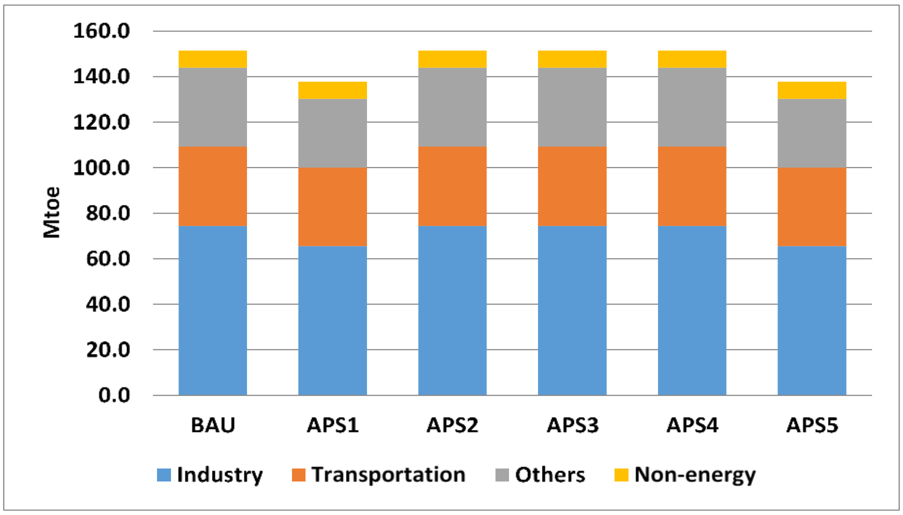

$CO_2$ = carbon dioxide.
Source: Author's calculation.

## 3.2. Energy Saving and $CO_2$ Emissions Reduction Potential

### 3.2.1. Final energy consumption

In the APS (or APS5), final energy consumption is projected to increase at a slower rate of 3.8 percent per year (compared with 4.2 percent in the BAU), from 50.5 Mtoe in 2013 to 137.8 Mtoe in 2040 because of EEC measures (APS1) in the industrial, transport, and residential and commercial ('other') sectors (Figure 17-6).

**Figure 17-6. Final Energy Consumption by Sector, BAU and APSs**

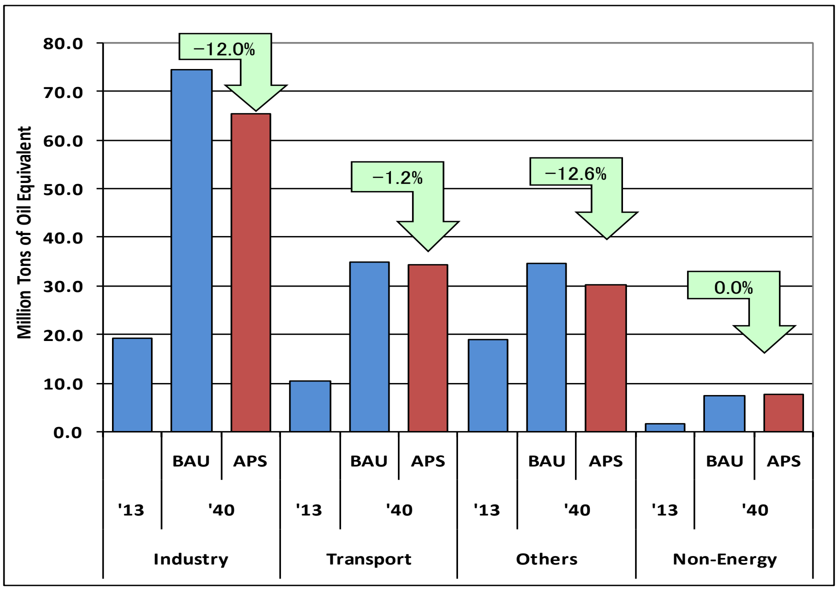



BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

The bulk of the savings are expected in the residential/commercial ('others') sector, at 4.4 Mtoe, equivalent to a 12.6 percent reduction, followed by the industry sector with 8.9 Mtoe, equivalent to a 12.0 percent reduction, and the transportation sector with 0.4 Mtoe, equivalent to a 1.2 percent reduction (Figure 17-7).

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

**Figure 17-7. Final Energy Consumption, BAU vs APS**




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

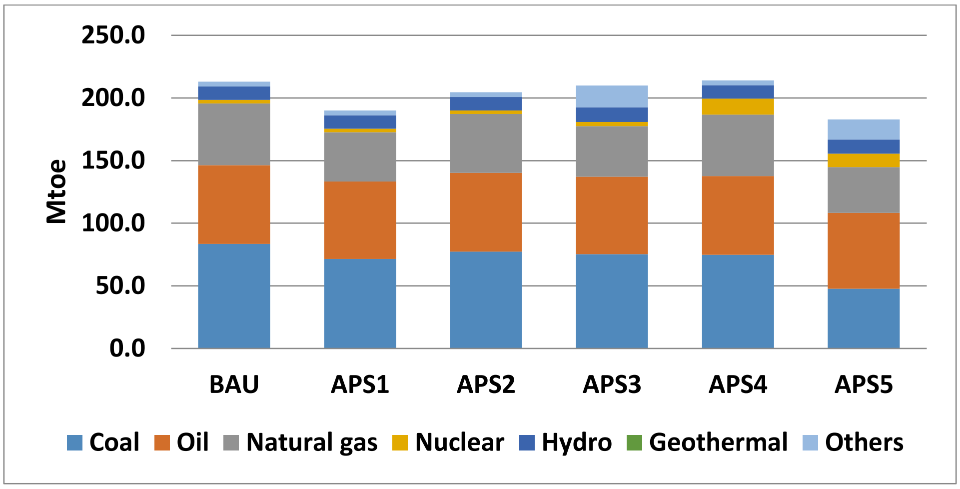
### 3.2.2. Primary energy supply

In APS5, the primary energy supply is projected to increase at a slower rate of 4.2 percent per year from 60.1 Mtoe in 2013 to 182.8 Mtoe in 2040. Natural gas is projected to grow at the highest average annual rate of 5.3 percent compared with 6.5 percent in the BAU, followed by oil and coal with 5.0 percent and 4.1 percent (compared with 5.1 percent and 6.3 percent in BAU), respectively, over the same period. (Figure 17-8)

The expected slower growth in consumption, relative to the BAU, is due to EEC measures on the demand side (APS1), and the more aggressive uptake of energy efficiency measures in thermal power plants (APS2), renewable energy (APS3), and nuclear energy (APS4) on the supply side. Coal has the highest energy saving potential at 42.8 percent, followed by natural gas (25.7 percent), and oil (3.5 percent) (Figure 17-9).

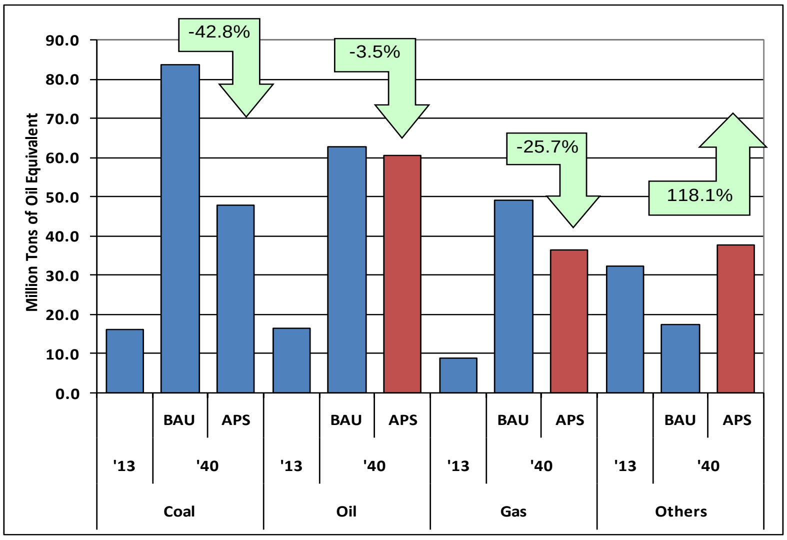
The total savings are expected to amount to 30.1 Mtoe, equivalent to 14.2 percent of Viet Nam's total primary energy supply in 2040 (Figure 17-10).

**Figure 17-8. Primary Energy Supply by Fuel, BAU and APSs**



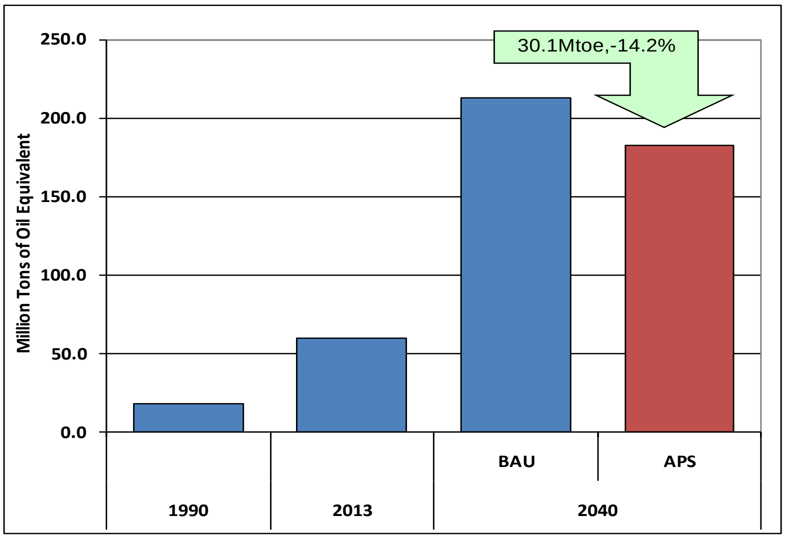

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

**Figure 17-9. Primary Energy Saving Potential by Fuel, BAU vs APS**




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

**Figure 17-10. Evolution of Primary Energy Supply, BAU and APS**



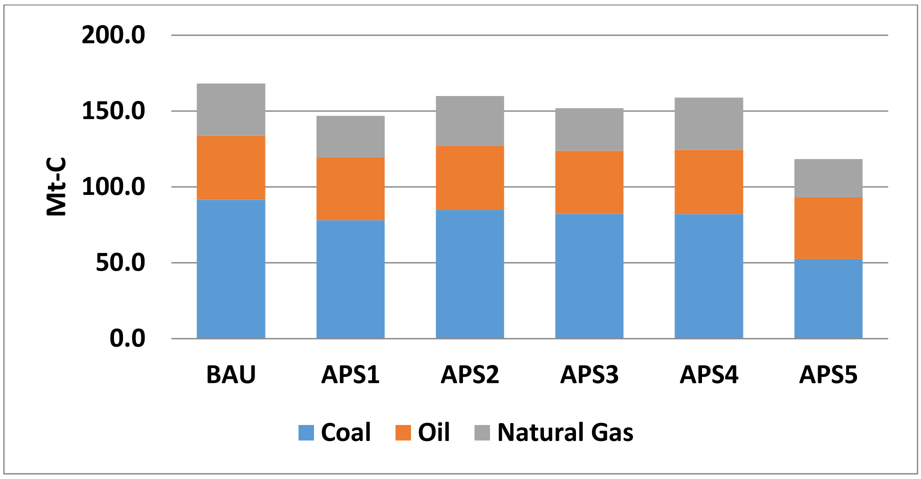

BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent.
Source: Author's calculation.

### 3.2.3. $CO_2$ reduction potential

$CO_2$ emissions from energy consumption under the BAU are projected to increase by 5.9 percent per year from 35.9 million metric ton of carbon (Mt-C) in 2013 to 168.2 Mt-C in 2040. In APS5, the annual increase in $CO_2$ emissions between 2013 and 2040 is projected to be 4.5 percent a year, which is 1.4 percentage points lower than in the BAU.

The expected $CO_2$ emission reduction is derived mostly 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 the projected $CO_2$ reduction (Figure 17-11).

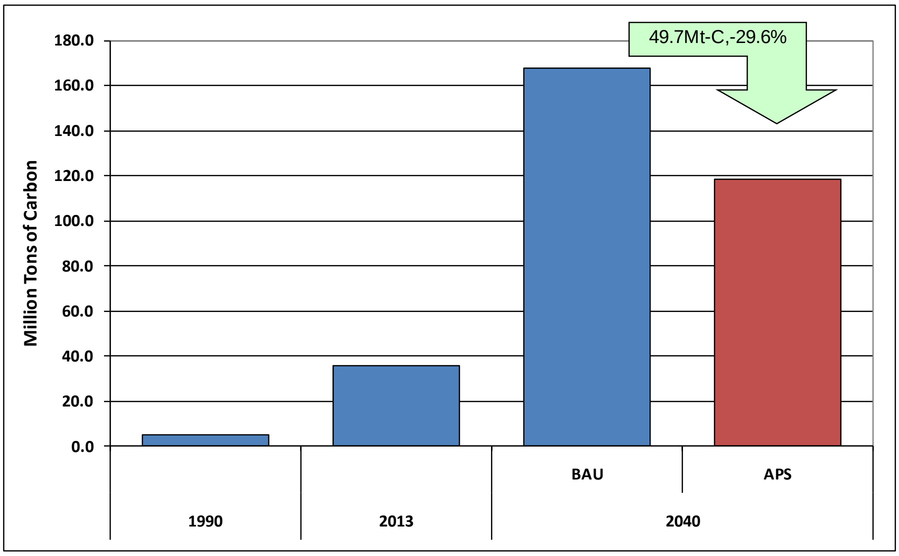
**Figure 17-11. $CO_2$ Emissions by Fuel, BAU and APSs**




$CO_2$ = carbon dioxide; BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mtoe = million tons of oil equivalent; Mt-C = million tons of carbon.
Source: Author's calculation.

$CO_2$ emissions under the APS will be around 49.7 Mt-C lower, equal to a 29.6 percent reduction, in 2040, indicating that Viet Nam's energy saving goals and action plans are very effective in reducing $CO_2$ emissions (Figure 17-12).

**Figure 17-12. Evolution of $CO_2$ Emissions, BAU and APS**




BAU = Business-as-Usual scenario; APS = Alternative Policy Scenario; Mt-C = million tons of carbon.
Source: Author's calculation.

## 4. Key Findings and Policy Implications

The above analysis of Viet Nam's energy saving potential generates the following key findings:

- 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. EEC measures have the potential to contribute to meeting expected higher demand in a sustainable manner.
- Viet Nam's energy intensity, which is among the highest in the world, indicates a high saving potential. However, the energy saving potential derived from Viet Nam's EEC goals (30.1 Mtoe) seems to be modest compared with its potential.
- Electricity demand will increase with the highest annual growth rate of 6.1 percent in the BAU, whereas it is projected to decline by 5.6 percent in the APS. This decline is an indication that the planned EEC measures will be effective in reducing 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. Their share of total of power generation output is expected to increase continuously from 21.1 percent in 2013 to 37.4 percent in 2040 in the BAU. 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 is GhG emissions reduction.

Based on the above findings, the following actions are recommended for effective implementation of EEC measures in Viet Nam:

- **Establishment of new targets and a road map for EEC implementation**: Energy demand in Viet Nam in the BAU is expected to continue to grow at a significant rate in the coming years and EEC scenarios on the demand side are most effective compared with other proposed scenarios on energy saving as well as GhG emissions reduction. Therefore, EEC activities need to be strengthened through updating and setting new overall targets for individual sectors for 2016–2025 for the national EEC programme, as well as preparation of specific road maps to achieve these targets.

- **Compulsory energy labelling for electrical appliances:** Annual growth of electricity demand is projected at the second highest rate of 6.1 percent in the BAU, especially demand for electricity in the residential and commercial (others) 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 be the major power generators in Viet Nam up to 2040. Therefore, the existing thermal power plants needs to be retrofitted to improve the efficiency of power generation and energy-efficient technologies should be prioritised for new coal thermal power plants development.
- **Priority for renewable energy development:** Coal power generation is projected to have the dominant share in the coming years, which will make Viet Nam reliant on coal imports for power generation. Renewable energy technology-based power generation is an important factor in achieving energy independence, energy security, and GhG abatement. Therefore, it is necessary to put in place support policies and mechanisms to promote renewable energy development.

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Annex 1

# Energy Saving Potential Study on Thailand's Road Sector:

## Applying Thailand's Transport Model

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### 1. Purpose and Scope of the Study

In this study, a transport model for Thailand was developed to estimate oil demand of road transportation. This study captures only road transport, i.e. it excludes other modes of transport such as rail, water, and air. The model will calculate the demand for vehicle use on roads first, and then derive the amount of oil and other fuel required to run the vehicles.

Vehicles in Thailand are of several types, with the major types of vehicles in terms of energy consumption being private passenger cars (less than 7 passengers), light trucks (pick-up trucks), motorcycles, and heavy trucks. This model includes every type of vehicle on Thailand's roads, also taxis and buses, for example.

Different types of vehicles use different types of fuel. For example, fuel used in private passenger cars is probably gasoline, diesel, liquefied petroleum gas (LPG), compressed natural gas (CNG), hybrid, and others. Pick-up trucks also use several fuel types, i.e. gasoline, diesel, LPG, CNG, and others. Unlike private passenger cars and pick-up trucks, motorcycles mostly use gasoline.

## 2. Methodology

As mentioned above, this model is an end-user model. Fuel consumption is calculated as
the derived demand of vehicle use. The structure of the method shown below will give an idea how it works.

- CS = f(GDP per capita, vehicle price/CPI)

A change in vehicle stock (CS) depends on gross domestic product (GDP) per capita and the real price of the vehicle. The equation calculates the size of the vehicle fleet in the future. In other words, it estimates the numbers of each type of vehicle as a function of people's income and how affordable the vehicle is. Here price functions were applied only to private passenger cars, pick-up truck, and motorcycles.

- FC = Number of vehicles $_t$ * Mileage $_t$ / Fuel Economy $_t$ (n: vehicle, m: fuel)

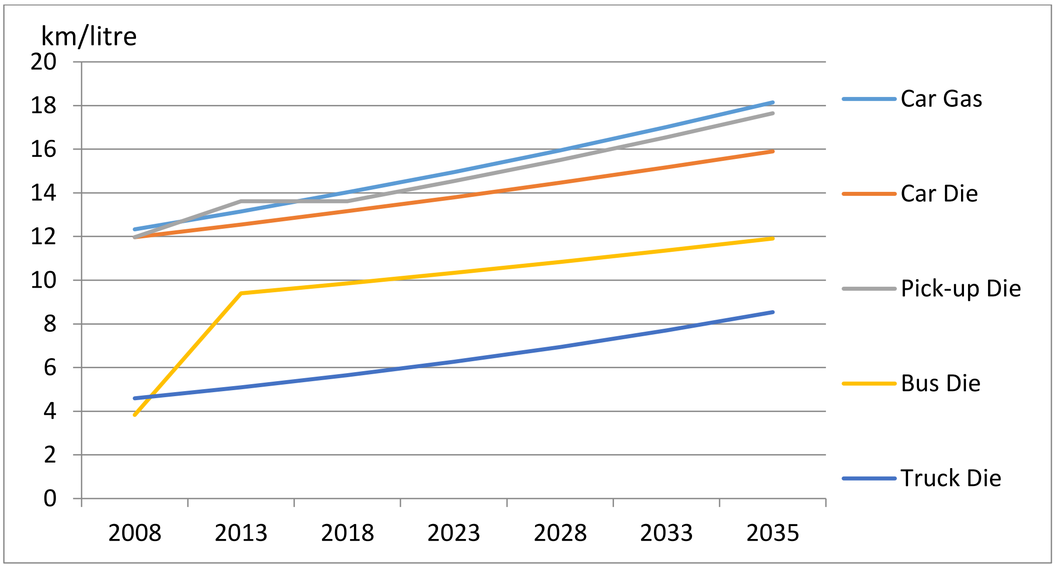
The above equation shows the fuel consumption (FC) of a vehicle. In year t, the total number of type n vehicles, which use fuel m, is multiplied by the average mileage of the vehicles. This is divided by average fuel economy (km/litre) of type n vehicles in year t. It estimates the consumption of fuel m by vehicle n. For example, the total consumption of gasoline by private passenger cars equals the number of private passenger cars times its average mileage per year divided by its average km per litre in the same year. This model relies heavily on survey information, especially regarding average mileage and fuel economy of each vehicle type and each fuel. The survey should be conducted as the priority sector.

In general, the average vehicle mileage of a country should decline when the vehicle stock increases. For example, in the case of Japan from 1970 to 2013, we found that the average mileage declined at a rate of between -0.68 percent to -0.80 percent a year approximately. However, in the case of Thailand, the surveys have been conducted periodically every 3 or 5 years. A clear trend of mileage change has not yet been detected. If such a clear trend is observed in future surveys, it will benefit the model assumptions and the quality of results. Mileage information, according to surveys carried out in 2008, is presented in Table 1.

**Table 1. Average Mileage by Vehicle Type in 2008**

| Type | Km per Year (Country Average) |
|---|---|
| Passenger Cars | 19,787 |
| Light Truck (Pick-up) | 25,669 |
| Motorcycles | 7,114 |

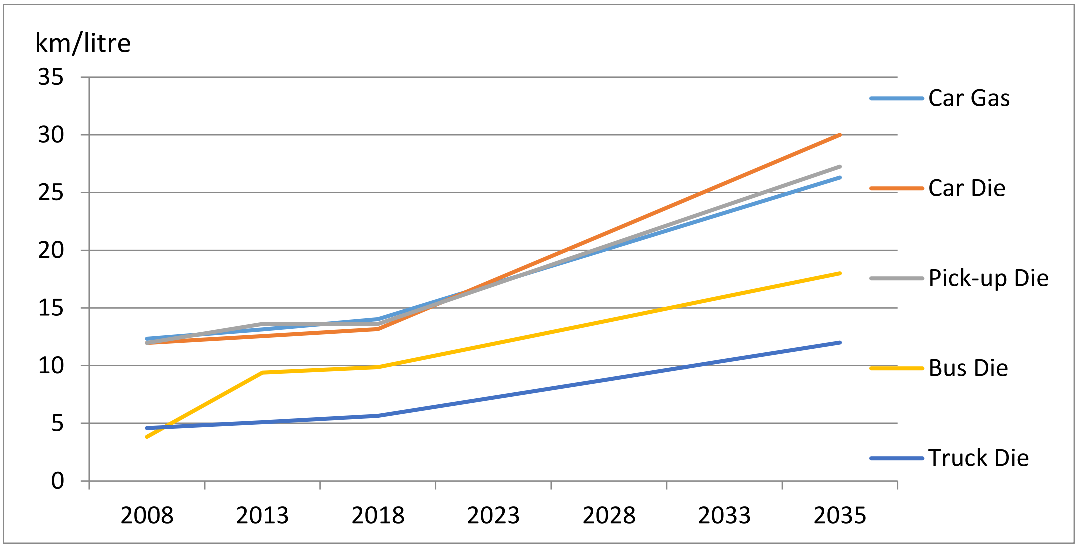
**Figure 1. Fuel Economy (km per litre) 2035 BAU**




BAU = Business-as-Usual scenario; km = kilometre; die = diesel.

Fuel economy improvement is easier to deduce from the 2008 and 2013 surveys. The improvement varies by vehicle type. The improvement rate between surveys becomes an assumption for the Business-as-Usual scenario (BAU) (See Figure 1). In case of the Alternative Policy Scenario (APS), the government will put in a strong effort to achieve the Energy Efficiency (EE) plan (See Figure 2). Fuel economy consumption improvement will be focused on and will be assumed to apply state-of-the-art technology, which will be assumed to have a positive impact into the next 2 decades, at the end of which it will be country average assumption finally.

**Figure 2. Fuel Economy (km per litre) 2035 APS**



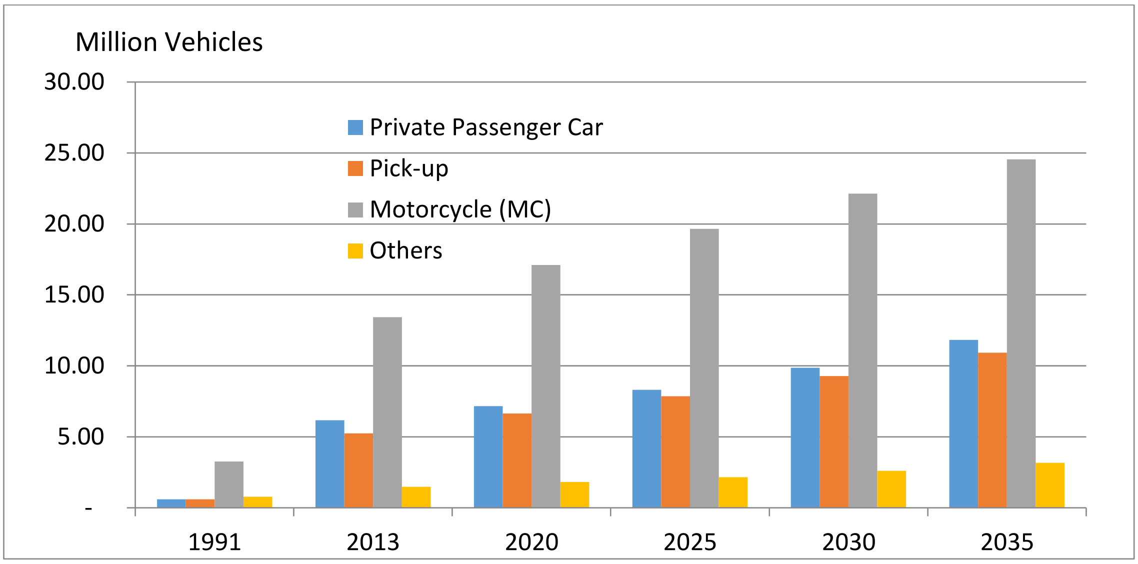

APS = Alternative Policy Scenario; km = kilometre; die = diesel.

## 3. Outlook Results

### 3.1. Vehicle Fleet Stocks in Thailand

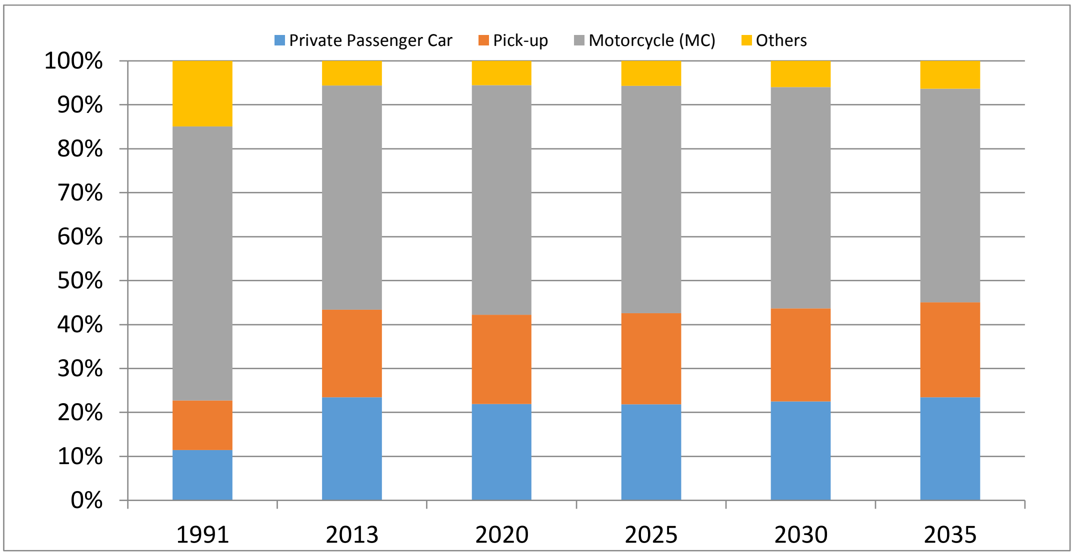
In 2013, private passenger cars, pick-up trucks, and motorcycles were the three largest fleets in Thailand, together making up more than 94 percent of the total vehicle population in 2013, and this will remain the case until 2035. Of all types of vehicles, the motorcycle population is the largest, with 13.4 million vehicles in 2013, followed by private passenger cars (6.2 million), pick-up trucks (5.3 million), and the others (1.5 million). From 1991 to 2013, vehicles in Thailand showed robust growth, especially private passenger cars and pick-up trucks, which had the highest growth of 11.2 percent and 10.4 percent, respectively. In 2035, total vehicles are forecast to grow at around 3.0 percent on average, a compound growth of private passenger cars, pick-up trucks, and motorcycles (of 3.0 percent, 3.4 percent, and 2.8 percent, respectively) and reach 11.8 million, 10.9 million, and 24.6 million vehicles, respectively (Figures 3 and 4).

**Figure 3. Vehicle Stock by Type**




Source: National Statistical Office (NSO), 2016.

**Figure 4. Share of Vehicle by Type**

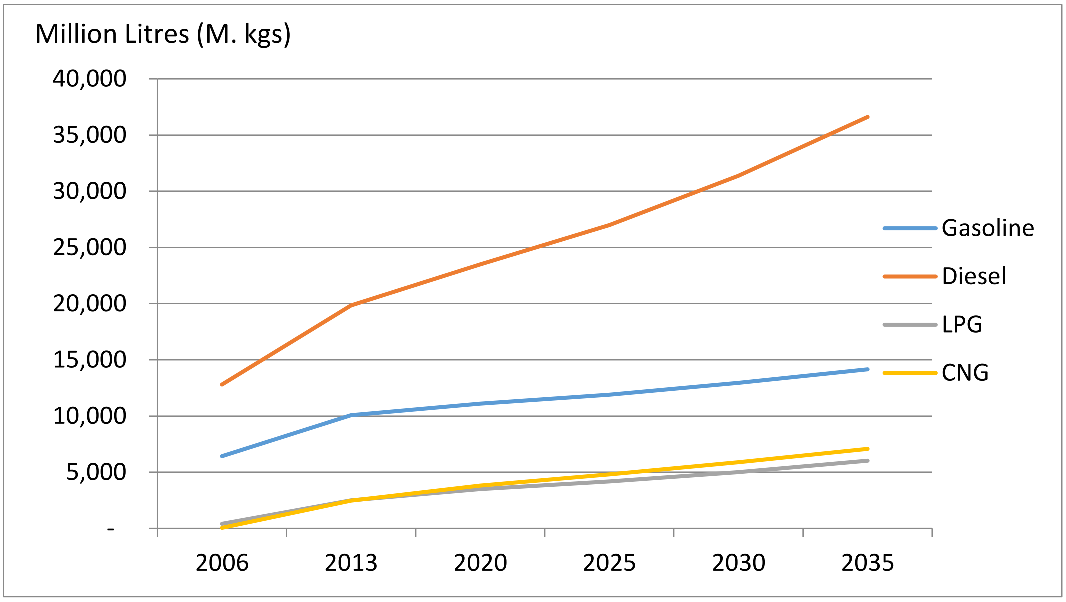



Source: National Statistical Office (NSO), 2016.

## 3.2. Business-as-Usual Scenario (BAU) – Oil Consumption

Road transport in Thailand consumed a lot of oil, natural gas, diesel, gasoline, and LPG from oil. Diesel was the largest fuel in this sector in 2013, reaching 19.8 billion litres, and is forecast at 36.6 billion litres in 2035 with an average growth rate of around 2.8 percent. For gasoline, LPG, and CNG, the average growth rate up until 2035 will be 1.6 percent, 4.1 percent, and 4.9 percent, respectively. Consumption is expected to increase from 10.1 billion litres, 2.5 billion litres, and 2.5 billion kg in 2013 to 14.2 billion litres, 6.0 billion litres, and 7.1 billion kg, respectively, in 2035. (See Figure 5.)

**Figure 5. Oil and Natural Gas Consumption by Road Transport, BAU**



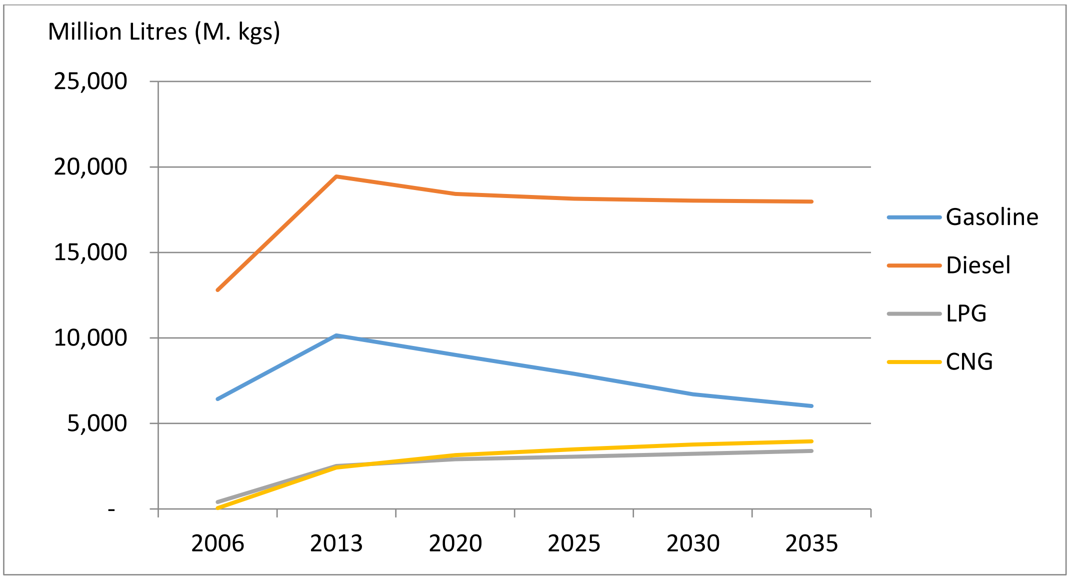

BAU = Business-as-Usual scenario; M. kgs = million kilogrammes; LPG = liquefied petroleum gas; CNG = Compressed Natural Gas.
Source: National Statistical Office (NSO), 2016.

### 3.3. Energy Saving Potential, Alternative Policy Scenario (APS)

The APS targets to reduce diesel and gasoline consumption in road transport. If, under the APS, diesel and gasoline are to meet the targets of 18.9 and 6.8 billion litres, respectively, in 2035, these must be achieved through efficiency improvements and use of alternative fuels. The transport model would recommend that today the best efficiency vehicles could be applied to reach the 2035 average fuel economy. Meeting these targets cannot be achieved by efficiency improvements alone; it would also require use of alternative fuel vehicles such as electric vehicles (EV) and fuel cell vehicles (FCV) to replace gasoline-fuelled private passenger cars. It will substantially reduce gasoline consumption in private passenger cars as they are the top gasoline consumers in road transport, along with motorcycles.

As a result, consumption of diesel and gasoline are projected to decline to 18.0 and 6.0 billion litres in 2035, compared with their targets of 18.9 and 6.8 billion litres, respectively. However, consumption of LPG and CNG will be 3.4 billion litres and 4.0 billion kg with average growth of 1.4 percent and 2.2 percent, respectively, due to the impact of efficiency improvements of all vehicles.

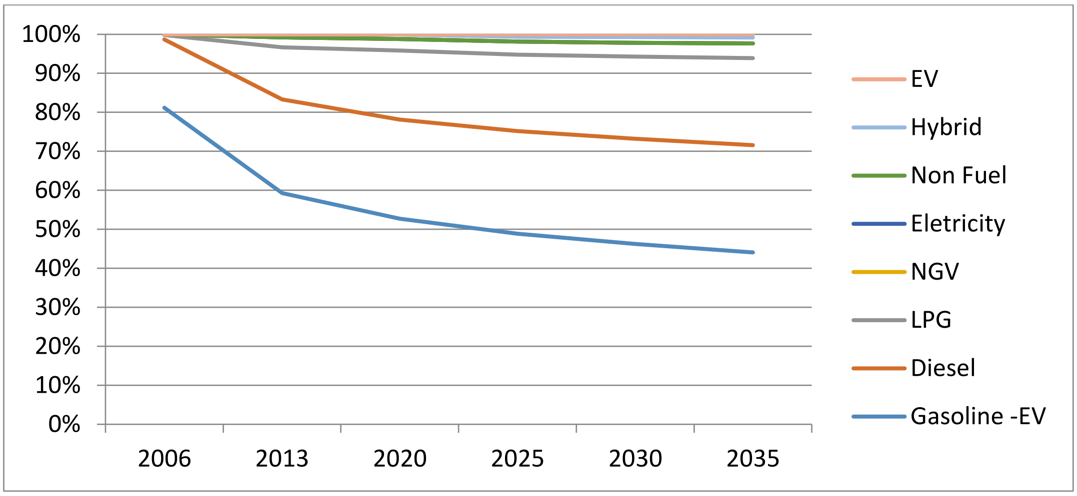
**Figure 6. Oil and Natural Gas Consumption by Road Transport, APS**




APS = Alternative Policy Scenario; M. kgs = million kilogrammes; LPG = liquefied petroleum gas; CNG = Compressed Natural Gas.
Source: National Statistical Office (NSO), 2016.

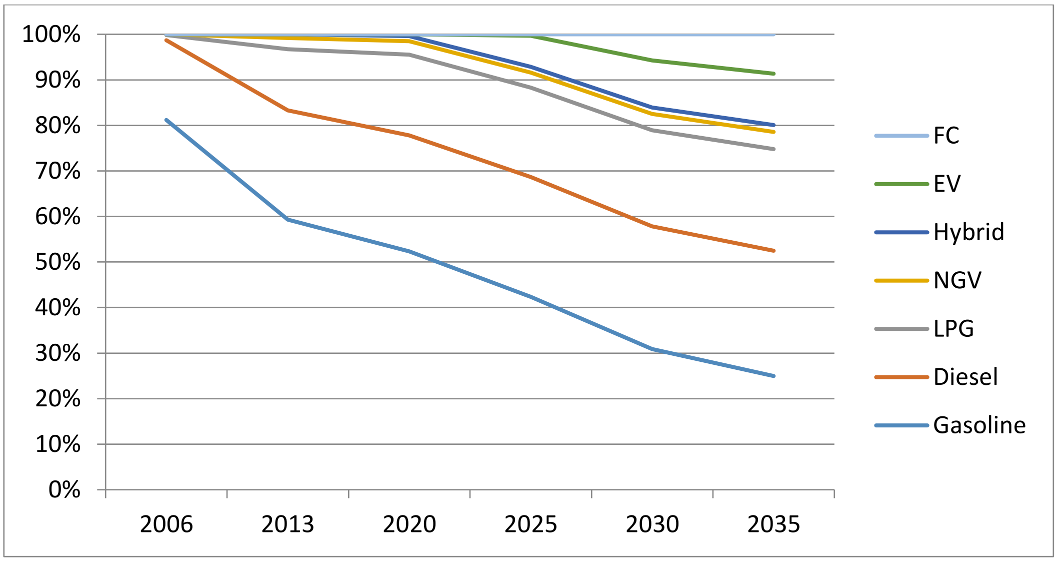
There will be a change in the number of gasoline vehicles when an efficiency policy to reduce the consumption of gasoline by substituting gasoline vehicles with EV and FCV is implemented under the APS. Due to greater diversification in vehicle powertrain technologies, the APS implies that oil can be replaced to a greater extent by other fuels – Electric Vehicles (EV), Fuel Cell Vehicles (FCV), Natural Gas Vehicles (NGV), and Liquefied Petroleum Gas (LPG, only from natural gas). (See Figures 7 and 8.)

**Figure 7. Private Passenger Cars by Fuel Type, BAU**




BAU = Business-as-Usual scenario; EV = electric vehicles; NGV = natural gas vehicles; LPG = liquefied petroleum gas; CNG = Compressed Natural Gas.
Source: National Statistical Office (NSO), 2016.

**Figure 8. Private Passenger Cars by Fuel Type, APS**




APS = Alternative Policy Scenario; FC = fuel consumption; EV = electric vehicles; NGV = natural gas vehicles; LPG = liquefied petroleum gas; CNG = Compressed Natural Gas**.**
Source: National Statistical Office (NSO), 2016.

## 4. Findings and Recommendations

The transport model we developed for Thailand shows that efficiency improvements alone are unlikely to achieve the goals of the APS. However, the goals could possibly be achieved when policy is combined with efficiency improvements and alternative fuel technologies such as EV and FCV. Furthermore, electric powertrain technologies can be applied to motorcycles as well, which would further reduce gasoline consumption significantly.

When comparing fuel economy improvements in gasoline and diesel in passenger cars, diesel has a higher figure, at nearly 30 km/litre, than gasoline, somewhere around 26 km/litre. Policy should place greater emphasis on promoting fuel efficiency in diesel vehicles than in gasoline vehicles.

Finally, for Thailand to achieve its ultimate goal of reducing total oil consumption, it should set ambitious policy targets for energy efficiency in transportation. Firstly, to improve vehicle efficiency to at least today's state-of-the-art technology, so as to reduce fuel consumption per kilometre, is one of the most effective ways to reduce oil consumption for the country as a whole. Secondly, to promote diesel vehicle use in private passenger cars, the efficiency improvement of diesel is expected to occur sooner than that of gasoline. Lastly, to diversify vehicle types, compared between the BAU and the APS, without promoting EV, FCV, Hybrid, and CNG, the oil consumption reduction goal for 2035 cannot be achieved through efficiency improvements alone.

Annex 2

# Policies to Promote EEC Buildings in Korea

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## 1. Overview

Since 1993, the Republic of Korea (henceforth, Korea) has developed a Rational Energy Utilization Basic Plan for every 5-year period, with revisions to the plan at the end of each 5-year period. The latest plan, the 5th Basic Plan, was announced in 2014, and it set a target of reducing final energy consumption by 4.1 percent and improving energy intensity by 3.6 percent in 2017 compared with the Business-as-Usual scenario (BAU). The government introduced various measures to achieve this target, which focuses on more innovative energy management policy tools rather than a simple and top-down energy conservation approach.[1] In view of this, the government has been implementing the following policy agenda: 1) energy demand management by energy users in the industrial, transport, buildings, and public sectors; 2) reforming the current energy pricing and market mechanisms; 3) reforming the energy information system; and 4) improvement in energy efficiency.

Key policy agendas include: a) when a business entity builds a new facility and/or expands the existing facilities, it has to prepare an energy demand management facility or energy saving plan; 2) target of fuel economy to be set so that the average fuel economy reaches the level of industrialised countries by 2020 (for example, Japan: 20.3km/L; European Union [EU]: 26.5km/L); 3) in the buildings

[1] The target of the 4th Basic Plan of 2008 was an 11.3 percent improvement in energy intensity compared with the 2012 level.

sector, investment in energy efficient windows can be subsidised with low-interest rates (Green Remodeling Program). The Ministry of Trade, Industry, and Energy (MOTIE) anticipates that, if the 5th Energy Rational Use Basic Plan is successfully implemented, the nation's energy consumption would fall by 4.1 percent, which would translate into a market creation of about 2.8 trillion Korean won for energy efficiency and conservation technologies and a reduction of 88 million tons in carbon dioxide ($CO_2$) emissions.

In the buildings sector, a couple of new policy tools are introduced. As for the existing buildings, two new programmes are initiated as follows.

- First, a building energy management system (BEMS) is developed and applicable to energy-intensive buildings and commercial/business structures. Its demonstration project is to be implemented for a selected 100 buildings for 5 years, starting from 2015. Fifty percent of the investment is to be subsidised up to 20 million won.
- Second, the Green Remodeling Program is reinforced in connection with the Green Card programme by the Ministry of Environment (MOE).

For newly built buildings, the Zero Energy Buildings 2025 programme will be implemented through a step-by-step reinforcement of 'Designing Criteria for Buildings Energy Savings,' resulting in a 90 percent reduction in heating/cooling energy use by 2020. Another new programme is to mandate the certification of energy efficiency labelling to identify the energy performance of buildings. Currently, this programme is voluntary but will be mandatory for apartment complexes with over 500 households and business facilities with a floor area exceeding 3,000 $m^2$.

## 2. Policy Tools

### 2.1. Energy Audits

This programme provides energy consumers with technical consulting services by energy auditing agencies that have technical equipment and know-how. By measuring and analysing the actual use of energy in large companies or buildings that consume significant amounts of energy, loss factors are determined and improvement measures can be proposed. The government offers free energy audits for small and medium-sized companies, and larger companies can purchase the audit service. As a result of the 6,200 audits the government performed between 1980 and 2004, the government estimates that a 10 percent average energy savings rate has been achieved, equivalent to savings of 3.5 Mtoe over the period.

### 2.2. Energy Service Companies

Energy Service Companies (ESCOs) are companies equipped with required facilities, capital, and technology and registered to the Ministry of Trade, Industry and Energy pursuant to Article 25 of the Energy Use Rationalization Act and Article 30 of the Enforcement Decree of the same Act. The Korean government provides two types of support for ESCOs. It provides money directly to ESCOs to support preliminary work for still unproven efficiency technologies and provides funding directly to industrial companies to pay for ESCO services. The government pays the initial investment cost and then collects repayment based on subsequent energy savings. Once the government's initial investment has been repaid, the remaining benefits flow directly to the customer.

### 2.3. Building Codes and Efficiency Audits

To improve Korea's building energy codes, which are currently at a relatively low level compared with other International Energy Agency (IEA) countries, the Korea Institute of Construction Technology was tasked with investigating building energy efficiency assessment standards and strengthening current codes and policies in July 2005. On the basis of its results, the government prepared action plans and implemented them in 2007. Moreover, the existing programme, which requires a building energy savings plan for new buildings over a certain size, was strengthened and expanded to other building types. In addition, a performance-based energy code, which limits total energy use per unit area, has been implemented in these buildings.

The government is currently working on more stringent building insulation standards that will become tighter over time. Insulation standards, which are currently mandatory for all new buildings, will also be expanded to apply to significant renovations of existing buildings. To improve energy efficiency for windows, the Korean government plans to introduce more stringent standards. Korea is also studying whether to mandate that all real estate transactions for large buildings include an energy efficiency certification, with the associated document attached to all sale and purchase transactions. In 2007, the government mandated that energy audits be conducted every 5 years for buildings with energy consumption of more than 2,000 toe/year. Buildings that achieve outstanding energy performance can be exempted from this requirement.

### 2.4. Appliance Labelling and Standards

In 2004, Korea set a goal that the standby power of all electronic products be reduced to 1 watt by 2010, a goal that was later codified into e-Standby Korea 2010. The e-Standby programme aims to promote the widespread use of energy saving products that reduce standby power consumption. Standby power is electricity consumed by appliances that are plugged in but not in use. The products that meet the 1-Watt (W) standard are entitled to bear the 'Energy Saving Label.' When they fail to meet the standard, the 'Standby Warning Label' is displayed on the front of the product.

The programme was implemented in three stages according to the 'Standby Korea 2010' roadmap. The programme's ultimate goal is to reduce standby power of each electrical device below one watt by 2010. The first stage is the 'Voluntary 1 W Policy' that ran from 2005 to 2007. The second stage is the 'Preparation for Transition to a Mandatory 1 W Policy' from 2008 to 2009. From 2010, the 'Mandatory 1W Policy,' which is the ultimate goal of the roadmap, will be implemented as the final stage. At this stage, appliances sold in Korea will be subject to compliance with a 1-watt usage of power or less when in standby mode.

Korea is actively working to promote energy efficiency standards and labelling for appliances. The energy efficiency standards and labelling programme, launched in 1992 and subsequently reviewed in 2004, requires companies to label the energy efficiency of products in 18 categories, including refrigerators, air-conditioners, and cars. The comparative energy labels range from 5 (least efficient) to 1 (most efficient or 'target' level) and no product with a rating less than 5 may be sold after the effective date. The programme currently covers 21 products.

The government also has a programme to certify and label high-efficiency products, which was introduced in 1996. The programme covers 34 items including inductor motors, boilers, pumps, and lighting equipment. In 1999, the government started the standby power saving programme, a voluntary system that initially labelled products in 14 categories, including computers, printers, copying machines, televisions, and video-cassette recorders (VCRs).

## 3. Buildings

### 3.1. Buildings Energy & GHG Target Management Scheme (BGHG)

The Buildings Energy & GHG Target Management Scheme (BGHG) was implemented as a core measure to meet the mid-term reduction target in GHG (by 2020) prescribed in Article 42 of the Basic Law of Low-Carbon and Green Growth and Articles 26–32 of the Enforcement Decree of the same law. Companies with a high level of GHG emissions and energy consumption are designated as companies under surveillance. Targets of GHG emissions and fossil fuel energy are imposed on them and they are required to evaluate their performance. The targets are set following a discussion between the government and the respective companies. Incentives (support for implementation) and penalties (improvement order and penalty) are given based on the fulfilment of the target. Targeted subjects of the programme are categorised as corporates and business premises. The scope of the target is slated to be expanded pursuant to Article 29 of the Enforcement Decree of the Basic Law of Low-Carbon and Green Growth.

The Ministry of Environment oversees the programme implementation and runs the Greenhouse Gas Inventory & Research Center of Korea, which was established to develop a comprehensive GHG information management system. Supervising institutes in each section serves as a single window to oversee tasks of target setting, implementation, and giving support to those targeted companies.

**Table 1. Criteria for Eligible Management Companies**

| Category | **Before 31 December 2011** | | **From 1 January 2012** | | **From 1 January 2014** | |
|---|---|---|---|---|---|---|
| | **Corporate** | **Business Premise** | **Corporate** | **Business Premise** | **Corporate** | **Business Premise** |
| GHG (tCO2) | 125,000 | 25,000 | 87,500 | 20,000 | 50,000 | 15,000 |
| Energy (TJ) | 500 | 100 | 350 | 90 | 200 | 80 |

* Relevant law: The article 29 of the Enforcement Decree of the Basic Law of Low-carbon and Green Growth.
* 1TJ = 23.88 toe
Source: Ministry of Education, Science and Technology, 2016.

## 3.2. Buildings Energy Efficiency Certification

The Korean government assesses and certifies energy efficiency of buildings in terms of energy consumption and GHG emissions to improve energy efficiency. Starting with a certification programme for apartment buildings in 2001, it was mandated that new apartments in the public sector should obtain certification higher than level 2 pursuant to the Prime Minister Guideline (June 2008), which was again strengthened up to level 1 in 2011. The scope of this regulation was expanded to include non-residential buildings (The Green Building Promotion Act, 2013). The government estimates $CO_2$ emissions and energy consumption for heating, cooling, and hot water supply of buildings based on their design specifications and issues certificates ranging from level 7 to level 1 +++ (total 10 levels).

### 3.3. Building Energy Code Compliance

This programme sets obligatory requirements on energy saving design including preventing heat loss and installing energy saving facilities and develops energy efficiency indexes for effective management of building energy. This regulatory history is as follows:

- In 2003, the Korea Energy Agency (KEA) reviewed energy-saving worksheets pursuant to the local government ordinance.
- In 2008, the KEA was designated as a review and advisory institution by law (Article 22 of the Rule on Construction Standards of Buildings, order of the Ministry of Land, Transportation and Maritime Affairs).
- In 2010, the Insulation Standard was raised to 20 percent.
- In 2011, the Total Annual Energy Consumption programme was implemented for office buildings with areas greater than 10,000$m^2$.
- In 2013, the Green Building Promotion Act was implemented. The heat transmission coefficient standard was raised to 30 percent and the scope of applicable buildings was broadened.

Proprietors of buildings should submit a Building Energy Code Compliance application for construction permits of new buildings with a gross area greater than 500 $m^2$ pursuant to the Building Design Standards for Energy Saving (the Notification of the Ministry of Land, Infrastructure and Transportation) and the Green Building Promotion Act. The KEA reviews the worksheet to check if the property satisfies all of the standards and gets at least 65 points on the Energy Performance Index (EPI) (minimum 75 points for public buildings) and decides on the issuance of the building permit. The main content of the Building Energy Code Compliance is as follows:

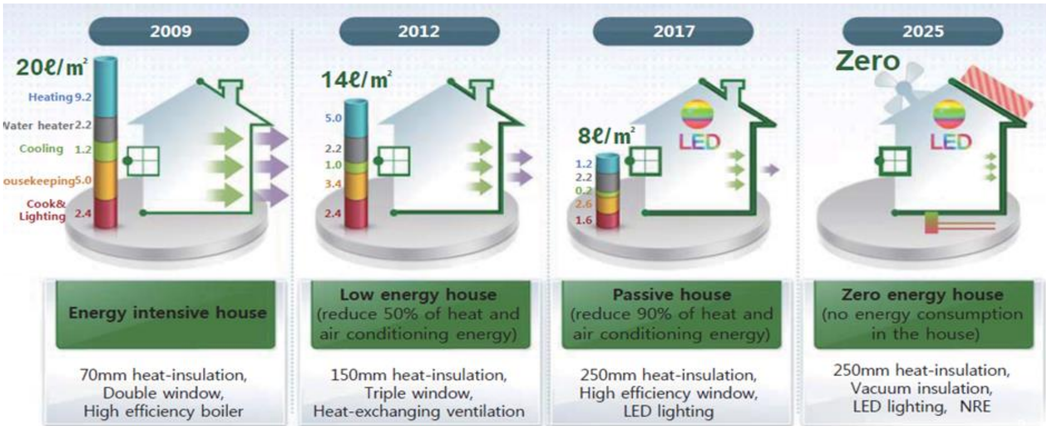
Construction: 1) energy-saving design criteria including average heat transmission coefficient, air-tightness of window, and rooftop landscape; 2) machinery and electric facilities: installing high-efficiency-certified products and adopting energy-saving control techniques; 3) new and renewable energy:

utilising new and renewable energy for the electric load and capacity for cooling, heating, and supplying hot water.

The targets of the programme are buildings with gross areas greater than 500 $m^2$ that apply for a building permit, as prescribed in Article 10 of Enforcement Decree of the Green Building Promotion Act (Buildings required to submit Building Energy Code Compliance).

Through this programme, the heat-insulation standard for windows and walls, starting with a 15 percent reduction in 2012 to a 30 percent reduction in 2017, a 60 percent reduction in 2020, and a 100 percent reduction (obligatory zero energy) in 2025, as shown in Figure 1.

**Figure 1. Heat-insulation Standard for Windows and Walls to Be Strengthened**




Source: Ministry of Education, Science and Technology, 2016.

### 3.4. Performance Evaluation of Eco-friendly House

This programme was designed to develop standards for the construction of energy-saving and eco-friendly housing and construct 2 million of such buildings by 2020 to meet the challenges of climate change and achieve low-carbon green growth. A landlord of an apartment complex with more than 30 households should submit a green home performance evaluation statement and related materials to the local autonomies when applying for business operation approval. The local governments decide on the approval based on the review of energy agencies including the KEA.

The programme consists mainly of two items: performance standards and construction standards. As for performance standards, total energy consumption ($CO_2$ emission) should be lowered by over 30 percent for households with living areas greater than 60 $m^2$ and by over 25 percent for households with living areas of less than 60 $m^2$ in terms of heating, hot water supply, heat source, and electricity energy.[2] Construction standards strengthen the heat insulation standard prescribed in the Regulation on the Designing Energy Saving Buildings.[3] It also specifies installation of high-efficiency condensing.[4] In addition, it mandates installation of high-efficiency appliances (highly air-tight windows, high-efficiency equipment and materials, standby power cut-off devices, network switches, high-efficiency lighting, automatic switching systems for public restrooms, and individual temperature controlling systems).

The buildings must satisfy standards in one of three categories: performance evaluation of eco-friendly homes, design standards of eco-friendly homes, and building energy efficiency certification.

### 3.5. Rational Energy Use in the Public Sector

This programme aims to raise awareness of energy efficiency improvement and conservation in response to the United Nations Framework Convention on Climate Change (UNFCC) by encouraging the public sector to reduce energy consumption, to improve energy efficiency, and to increase the use of new and renewable energy. In this context, this programme is designed to implement energy consumption rationalisation measures of the central and local governments pursuant to Article 8 of the Energy Use Rationalisation Act.

[2] There are a total of 14 evaluation criteria: exterior walls, side-walls, windows, exterior doors, floors, roofs, boilers, integrated energy use, new and renewable energy use (solar PV, solar thermal, geothermal, wind).
[3] The standard is more than 43 percent higher for windows and more than 31 percent for walls.
[4] Boilers (houses using district heating systems or integrated heating systems are not applicable).

**Table 2. Criteria of Construction & Performance Evaluation of Eco-friendly House**

| Category | Performance Evaluation | | Design Standards | | Energy Efficiency | |
|---|---|---|---|---|---|---|
| **Evaluation** | • Compliance of mandatory features·<br>• Reduction rate of total energy consumption or $CO_2$ emission per household | | • Compliance of design standards for windows, walls, exterior gates, etc. | | • Primary energy supply per unit area per year | |
| Criteria | Exclusive living area | | Exclusive living area | | Exclusive living area | |
| | Over $60m^2$ | Below $60m^2$ | Over $60m^2$ | Below $60m^2$ | Over $60m^2$ | Below $60m^2$ |
| | Reduction by more than 30 percent | Reduction by more than 25 percent | Meet the standards for windows, walls, energy source systems, etc. | | ***Level 1*** Compliance of standards for windows, walls, etc. | ***Level 2*** Compliance of standards for windows and walls etc. |

Source: Ministry of Education, Science and Technology, 2016.

The government develops obligatory requirements for energy use rationalisation in public buildings and supervises the compliance pursuant to the Regulations on Energy Use Rationalization of Public Buildings. The programme is targeted at: 1) Central administrative agencies and local government agencies, 2) Agencies prescribed in Article 4 of the Act on the Management of the Public Institutions, 3) Local public corporations prescribed in Article 49 and Article 76 of the Local Public Enterprises act, 4) National and public schools and universities, 5) Municipal and provincial offices of education, 6) National University Hospitals, and 7) Seoul National University.

### 3.6. Buildings Energy Auditor

This programme is a national qualification system to train building energy auditors. The assessors would be engaged in building energy management efforts such as the building energy efficiency certification programme. The KEA trains building energy assessors in anticipation of the expansion of the scope of buildings subject to efficiency certification and mandatory implementation of the certification system.

- Building energy efficiency certification: The scope of the certification was limited to apartments and office buildings. But in future individual housings and buildings for all purposes with gross areas greater than 500 $m^2$ will also be subject to the certification.
- Energy saving worksheet: The scope of the certification was limited to buildings with limited purpose and size such as office buildings with gross areas greater than 3,000 $m^2$ and accommodation buildings with gross areas greater than 2,000 $m^2$. All types of buildings with gross areas greater than 500 $m^2$ will also be subject to the certification.

## 4. Way Forward

Up until now, the Korean government has made great efforts to improve the energy efficiency of buildings. Under the Basic Plan for Rational Energy Use, which has been renewed five times since 1992, many programmes and regulations on energy-efficient buildings have been developed and implemented. As a result, policy outcomes are seen to be successful in terms of institutional arrangements and performance of the building energy management system (BEMS). However, there remains much to be done on the path to a successful implementation of BEMS. Let us take a look at a couple of issues and the policy options to address them.

First, energy demand management in Korea is being implemented in the form of cooperative governance between relevant ministries. Under these circumstances, structural reform of energy policy is required to conduct an integrated demand management, including 1) a collaborative administration manual under the Government 3.0;[5] 2) establishing a channel between the central government and the local autonomies in which a roadmap developed by the central government

[5] Government 3.0 is a new paradigm for government operation to deliver customised public services and generate new jobs in a creative manner by opening and sharing government-owned data with the public and encouraging communication and collaboration between government departments.

guides the development of specific and detailed programmes by local autonomies; and 3) creation of local communities to collectively and voluntarily participate in BEMS.

Second, a database for a building energy management system (BEMS) should be established. As relevant ministries have arrived at a consensus on the necessity of a database, it is high time that relevant ministries get together and develop an integrated portal for building energy management, which would send the right signal to the government and the public. The government could then use this portal to develop feasible and attainable mid- and long-term targets and policies for building an energy management system, and the public might respond with valuable feedback and voluntary participation in the government programmes.

Third, guideline development and incentive provision are necessary to promote the development and adoption of building technologies. The 2nd Energy Basic Plan states that energy consumption is to be reduced by 15 percent by 2020 through a variety of regulations and incentives for building energy management programmes. However, a limited government budget and civil society’s poor awareness of building energy management make it difficult for policies to take effect. In an effort to overcome these barriers, the Korean government should design a phased incentive system and raise the existing subsidies for building energy management along with providing construction and design guidelines for re-modelling, renovation of existing buildings, and construction of new buildings.

Last but not least, buildings are designed by architects according to requirements of owners so they have diverse structures and functions. Building energy management has to be approached from different perspectives, therefore. It is recommended that the contents of BEMS have different elements. In this regard, design of BEMS calls for participation of experts with a lot of experience in this field: ‘BEMS Coordinators.’ Since there are only few BEMS coordinators domestically available, the Korean government has to establish a training and education system to cultivate an appropriate number of BEMS coordinators to promote BEMS activities.

# Chapter 2

## Australia Country Report

September 2016

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Chapter 2

# Australia Country Report

**ARIF SYED**, RESEARCH AND ANALYSIS PROGRAM, OFFICE OF THE CHIEF ECONOMIST, DEPARTMENT OF INDUSTRY AND SCIENCE, AUSTRALIA

## 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 (TWh) 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 from renewable sources by 2049–2050.

Primary energy supply is projected to grow by 42 percent, at an annual average rate of growth of 1 percent. This compares with average annual growth in primary energy supply 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 (RET) 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 2-1). 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.

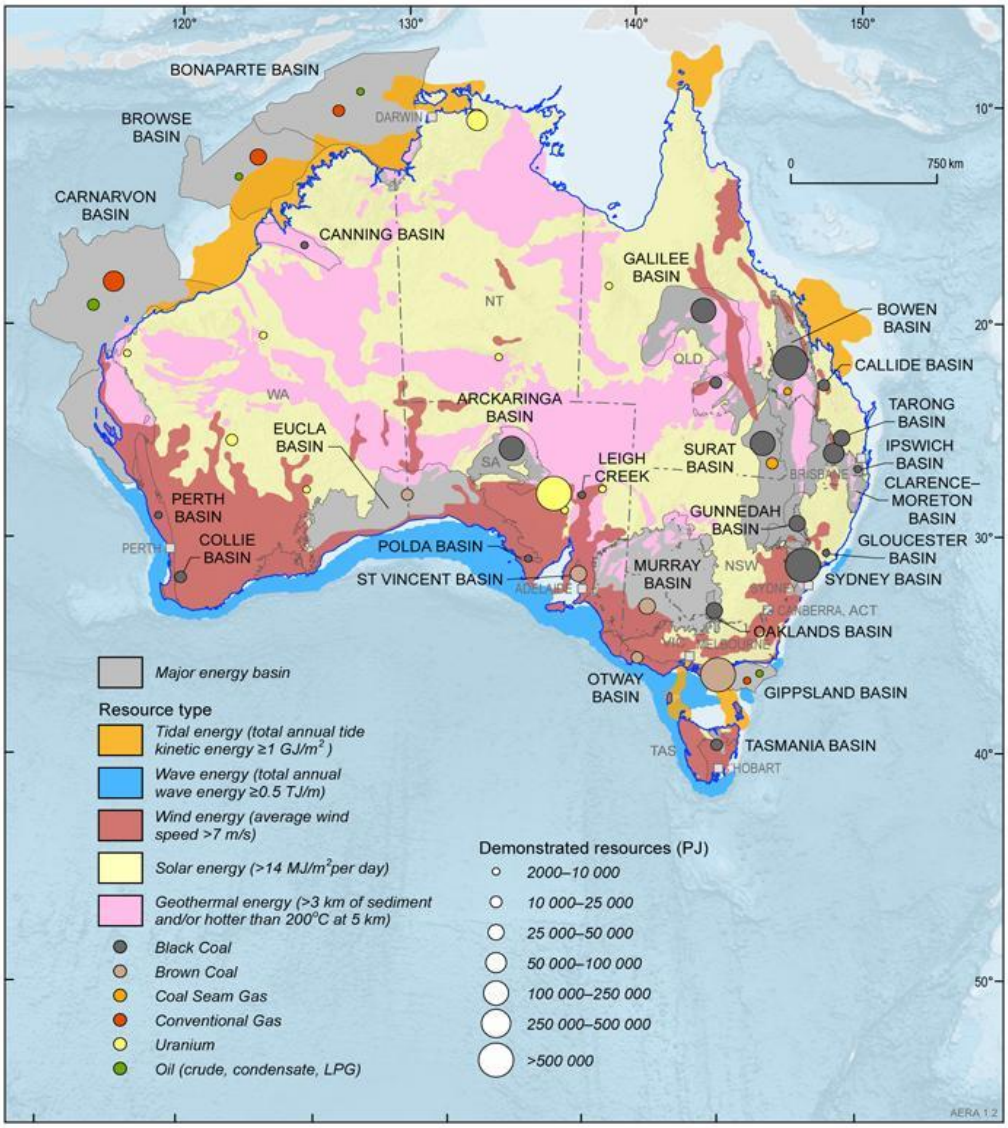
Geoscience Australia and the Bureau of Resources and Energy Economics (BREE) published the *Australian Energy Resource Assessment* (AERA) in June 2014 (Geoscience Australia and BREE, 2014), which has informed the present section of this report. Australia's energy resources are a key contributor to Australia's economic prosperity. It is estimated that total demonstrated non-renewable energy resources, except 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**

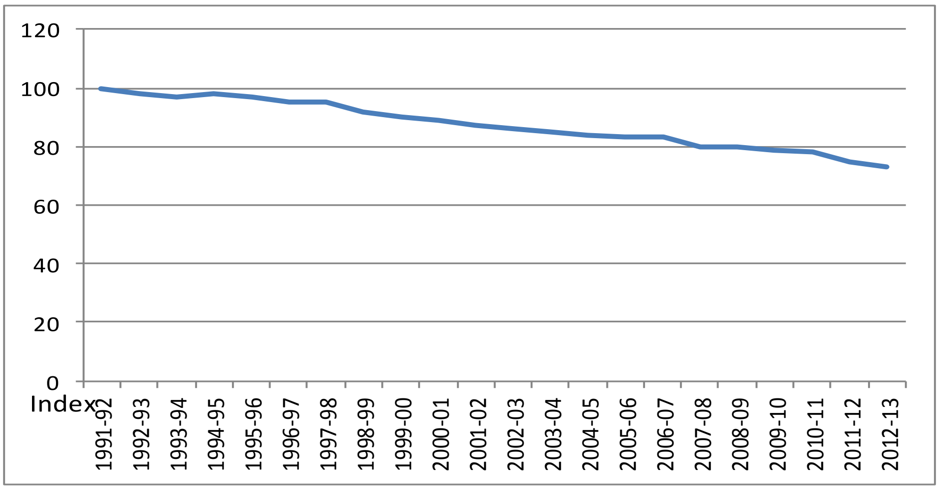



Source: Geoscience Australia and BREE (2014).

## 1.1.2. Energy consumption

Primary energy supply 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 3 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.

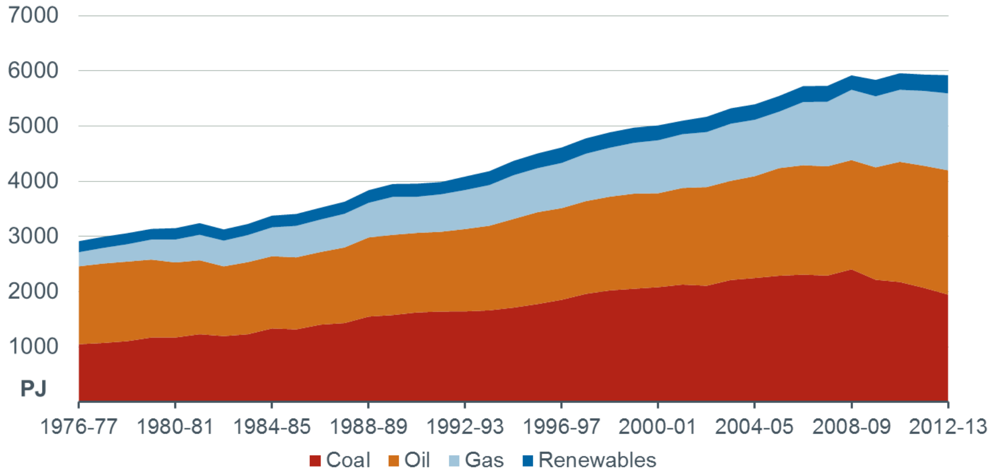
**Figure 2-1. Australian Energy Intensity**




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**




PJ = petajoules.
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 supply.

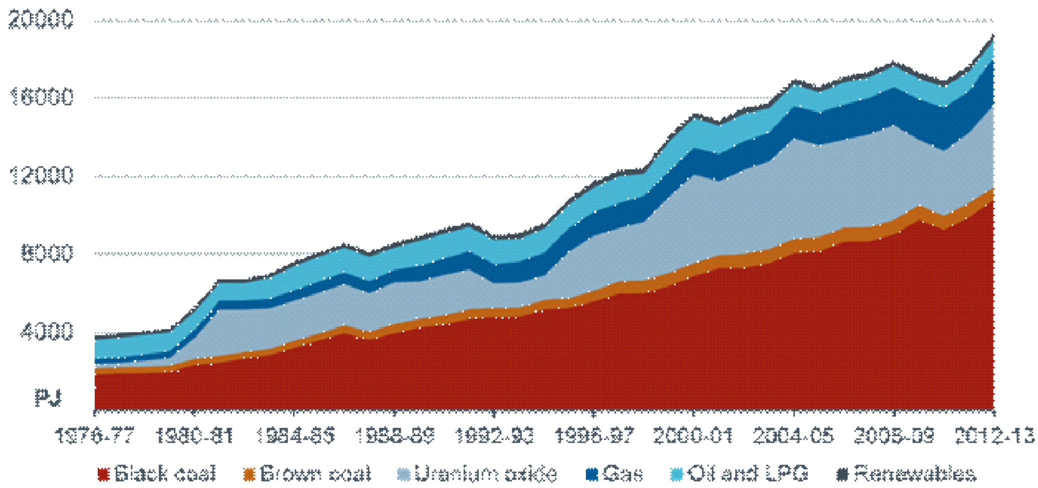
### 1.1.3. Energy production

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, 2012). 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**



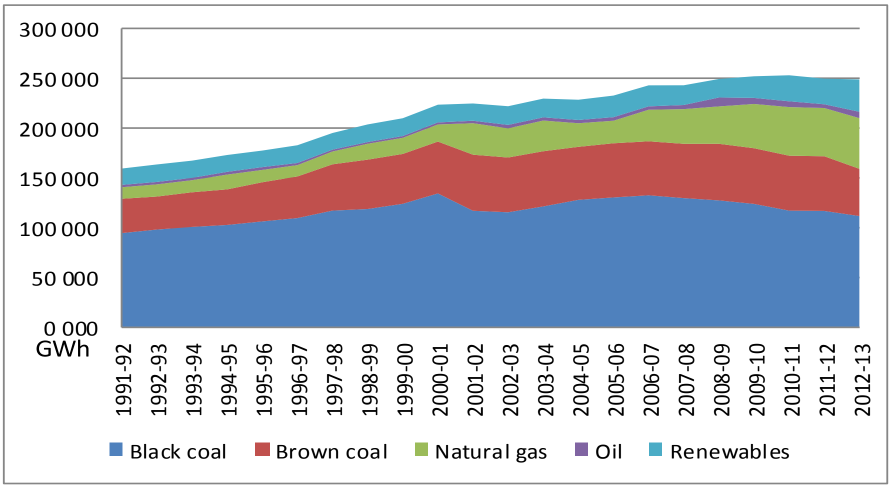

PJ = petajoules; LPG = liquefied petroleum gas.
Source: BREE (2014a), Table J.

### 1.1.4. Electricity generation

Electricity generation grew 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 2-4). It decreased from 253 TWh (around 911 petajoules) in 2010–2011 to 249 TWh (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**




GWh = gigawatt-hour.
Source: BREE (2014a), Table O.

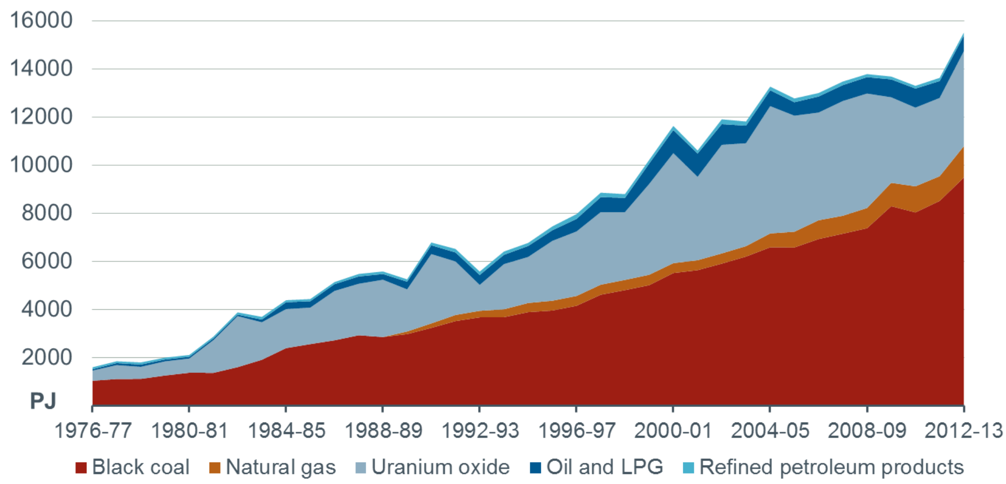
The share of renewables in Australian electricity generation rose from approximately 8 percent in 2003–2004 to about 13 percent in 2012–2013.

### 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).

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.

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




PJ = petajoules; LPG = liquefied petroleum gas.
Source: BREE (2014a), Table J.

In 2013–2014, LNG exports reached 1,303 petajoules (around 23.9 million tons). 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 RET aims 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 RET legislation requires that the scheme is reviewed every 2 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).

In *E4cast*, the RET is modelled as a constraint on electricity generation – renewable energy must be greater than or equal to the interim target in any given year.

**Table 2-1. LRET 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 |

TWh = terawatt-hour.
Source: CER (2014).

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 2 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 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 2 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 2-2.

### 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.

**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).

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 RET 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) for 2015–2050 on energy consumption, electricity generation, and production are provided in Tables 2-4 to 2-8 below.

## 3.1. Energy Consumption

Total primary energy supply is projected to grow by nearly 42 percent (or 1 percent per year) over the projection period (Table 4). This compares with average annual growth in primary energy supply 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 supply 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.

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.

**Table 2-4. Primary Energy Supply, 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.

At the sectoral level, the main drivers of primary energy supply 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 supply from 2014–2015 to 2049–2050 (Table 2-8).

The electricity generation sector accounted for the largest share (34 percent) of primary energy supply in 2014–2015. Total primary energy supply 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 Supply, 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 supply 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 supply 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 supply 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 supply 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 supply. In 2049–2050, the sector is projected to account for 14 percent of Australian primary energy supply.

## 3.2. Electricity Generation

- Gross electricity generation is projected to grow by nearly 30 percent (or 0.8 percent per year) from 255 TWh in 2014–2015 to 332 TWh 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 2014–15 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.

## 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 2.8) 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 supply to energy production (excluding uranium) is estimated to be 35 percent. By 2049–2050, this ratio is projected to have fallen to 31 percent.

**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 | 2,312 | 3,169 | 3,734 | 53 | 57 | 1.4 |
| Gas | 999 | 1,159 | 1,346 | 23 | 20 | 0.9 |
| Renewables | 186 | 220 | 240 | 4 | 4 | 0.7 |
| Electricity | 784 | 1,037 | 1,111 | 18 | 17 | 1.0 |
| **Total** a) | **4,399** | **5,725** | **6,582** | **100** | **100** | **1.2** |

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

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 to the western market have the potential to reach 44 million tons (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 tons. 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.

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 2-8). Gas production is projected to increase from 3,109 petajoules (57 million tons) in 2014–2015 to 7,398 petajoules (136 million tons) 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.

**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** | **17,009** | **26,492** | **27,104** | **98** | **98** | **1.3** |
| Coal | 13,021 | 19,299 | 19,441 | 75 | 71 | 1.2 |
| black coal | 12,557 | 18,834 | 18,932 | 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 | 6,748 | 7,398 | 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** | **17,350** | **26,933** | **27,567** | **100** | **100** | **1.3** |

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

## 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 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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Annex 3

# Technical and Economical Study on Solar Thermal Cooling

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## 1. Introduction

Most of the Association of Southeast Asian Nations (ASEAN) have hot and humid climates. Due to the climatic conditions and the demand for thermal comfort, energy consumption for air conditioning in buildings takes up the largest share in the energy requirements of buildings. As the region's economic activities and population increase, the demand for energy consumption for buildings in ASEAN countries will increase. ASEAN countries like most other countries in the world are diversifying and decarbonising energy supply. Such a trend and a reduction on the reliance on fossil fuels stems from the region's quest for improvement in energy security, an increase in renewable energy for greater sustainability, and a reduction in greenhouse gas emissions while meeting the demand for improvement in standards of living and hence, thermal comfort. Therefore, using solar thermal cooling, one of the renewable energy options, will improve the stability of electricity grids by reducing electrical energy consumption and peak power demand.[1]

This study explores the indicative viability of harnessing solar energy to supplement the generation of chilled water through solar thermal hybrid chiller systems and solar photovoltaic (PV) hybrid chiller systems.

## 2. Solar Energy

There is an abundance of solar energy in varying degrees in a typical hot and humid climate. The International Energy Agency (IEA) reported in 2015 that the estimated total capacity of solar thermal collectors in operation worldwide by the end of 2014 was 406 $GW_{th}$ or 580 million square metres of collector area. This corresponds to an annual collector yield of 341 TWh, which is equivalent to savings of 36.7 million tons of oil and 118.6 million tons of $CO_2$.[2] Compared with other forms of renewable energy, solar heating's contribution in meeting global energy demand is, besides the traditional renewable energies like biomass and hydropower, second only to wind power (at 735 TWh).[2] In terms of installed capacity, solar thermal leads, wind power is second at 370 $GW_{el}$, and photovoltaic is third at 177 $GW_{el}$.[2]

Solar energy is harnessed in essentially two ways for useful applications – 1) capturing light rays of solar energy through solar PV panels for electricity generation; 2) harnessing solar thermal energy through solar collectors for the production of hot water for heating purposes and, alternatively, for the generation of chilled water through absorption chillers for air-conditioning purposes.

Solar PV electricity generation has been promoted and implemented in the region. Production of hot water through solar collectors for process heating and shower purposes is also fairly well established in the region. However, production of hot water for the purpose of generating chilled water for the air-conditioning systems in buildings has yet to be nurtured into market acceptance.

By comparison, solar PV electricity generation is more straightforward, but only less than 35 percent of the available solar energy is harnessed for conversion to electricity, whereas the remaining 65 percent is converted to the non-useful heating of solar PV panels.[3] On the other hand, a solar thermal cooling system is capable of absorbing more than 95 percent of incident solar radiation[3], depending on the medium used in the system. Therefore, it may be worthwhile to consider harnessing solar thermal energy for the generation of chilled water.

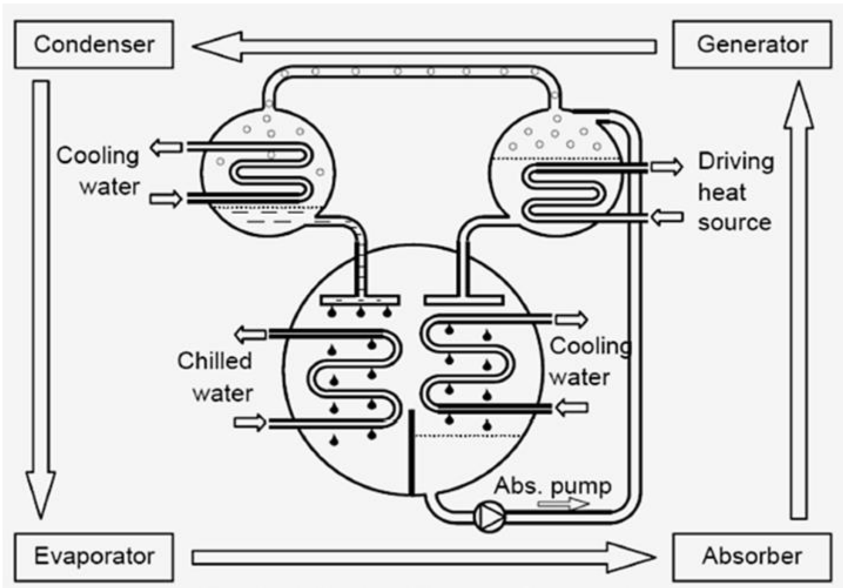
However, in terms of real-world application, solar thermal cooling system is unable to cope with daily cooling load requirements because of the limitations of solar cooling systems. The following sections will outline the basic working principles of solar thermal cooling and will discuss the merits and limitations of solar thermal cooling systems.

## 3. Solar Thermal Cooling

Solar thermal cooling is based on the application of the absorption cycle instead of the conventional compression cycle in refrigeration. The conventional refrigeration system has four basic functions – evaporation, compression, condensing, and throttling-expansion cycles, whereas the basic solar thermal cooling system or solar thermal absorption refrigeration technology[2] is based on single-effect absorption cycle, which has the following four basic functions:

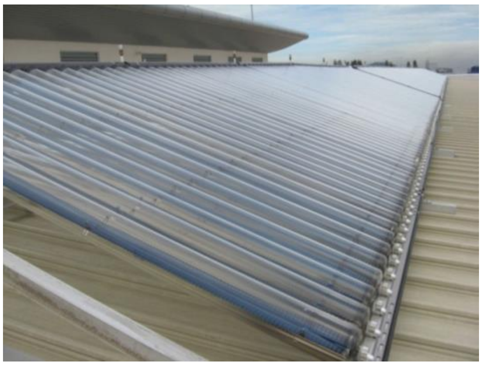
- Evaporation
- Absorption
- Generation
- Condensing

**Figure 1. Flow Diagram of Solar Assisted Single-effect LiBr-$H_2$0 Absorption Cycle**




Source: Edison Kong, SDC District Cooling Sdn. Bhd.

**Figure 2. Absorption Chiller and High-efficiency Evacuated Tube Solar Collectors**



Source: Edison Kong, SDC District Cooling Sdn. Bhd.

The main components of a solar thermal cooling system are the absorption chiller and high-efficiency evacuated tube solar collectors, as illustrated in Figure 2. Solar thermal cooling systems have the potential to be used in commercial and office buildings, where the timing of demand for air-conditioning coincides with the greatest availability of solar radiation in hot and humid climates and most cooling is required during the day. In hot and humid climates, air-conditioning takes up the largest share of energy use in buildings. Solar air-conditioning facilities can reduce the peak load demand for electricity and this certainly considerably reduces infrastructure costs; otherwise the transmission and distribution assets need to be sized up to cater for the greater peak electricity demand. This will also result in significant reductions in greenhouse gas (GHG) emissions.

The generation of chilled water from solar thermal cooling systems is subject to weather conditions and sunshine hours, but the latter should have minimal impact in most ASEAN countries where the daylight hours are relatively long. And unlike solar PV, evacuated solar collectors are able to harness solar thermal energy with reasonable efficiency, even in overcast or diffuse sunlight conditions. Nevertheless, solar thermal cooling systems will not be able to function like conventional electric chillers, which can provide relatively quick start-up in the generation of chilled water as required in the morning and in fluctuating cooling load demand scenarios, and of course as required for the cooling load demand at night.

Therefore, despite the advantages of providing thermal cooling by harnessing the free solar energy source, it is necessary to consider the solar thermal hybrid chiller system, which is a solar thermal cooling system combined with a conventional electric chiller, to address the limitations of using only a solar thermal cooling system. A solar thermal hybrid chiller system captures the best of both solar thermal and electric usage by installing an absorption chiller as the main equipment in the solar air-conditioning system in parallel with an electric vapour compression system. This system is hereafter referred to as Option 1. The second option (Option 2) is to install a solar PV hybrid chiller system, which comprises of a solar PV system and conventional electric chiller.

## 4. Economic Comparisons

Having identified two possible options of harnessing solar energy for air conditioning in buildings, two case studies in economic comparisons of the additional investments that would be incurred in various configurations of solar thermal hybrid chiller systems and solar PV hybrid chiller systems were conducted. These two case studies were based on hypothetical installation and operational costs in Malaysia, and simulation of various configurations and refrigeration capacities. The objective of these case studies was to obtain an indication of economic viability of the two possible options discussed above for the harnessing of solar energy in generating chilled water for air conditioning in buildings. To make an economic comparison of these two options, the refrigeration capacity of the respective chillers were made identical. The capacities of the electric chiller, solar thermal chiller system, and solar PV system in various configurations were arbitrarily selected.

### 4.1. Option 1 – Solar Thermal Hybrid Chiller System

Table 1 summarises an economic comparison of additional investments in various configurations of a solar thermal hybrid chiller system, based on estimated equipment costs, operational costs, and electricity tariff C2 (medium voltage peak/off-peak commercial tariff) in Malaysia.

**Table 1. Economic Comparison of Additional Investments in Various Configurations of a Solar Thermal Hybrid Chiller System**

| Electric Chiller | 90 RT | 235 RT | 175 RT | 350 RT | 250 RT |
|---|---|---|---|---|---|
| Solar Thermal Chiller System | 50 RT | 75 RT | 135 RT | 150 RT | 250 RT |
| Additional Investment (RM) | 630,000 | 982,500 | 1,690,100 | 1,788,000 | 2,587,500 |
| Additional Annual O&M Costs (RM) | 14,700 | 22,050 | 37,989 | 39,195 | 60,938 |
| Energy Saving (kWh) | 113,278 | 172,288 | 311,360 | 340,502 | 578,336 |
| Net Energy Cost Saving (RM) | 39,251 | 53,772 | 99,066 | 116,192 | 202,143 |
| % Energy Saving | 16.7 | 13.9 | 25.1 | 16.0 | 27.1 |
| Simple Payback Period (years) | 16.1 | 18.3 | 17.1 | 15.4 | 12.8 |
| IRR | 2% | 1% | 2% | 3% | 5% |

RT = refrigeration ton; RM = ringgit; kWh = kilowatt-hour.
Source: Analysed by Ir. Leong Siew Meng under the guidance of Shigeru Kimura, based on inputs from Solar District Cooling Sdn. Bhd.

Table 1 shows some interesting findings. The higher share of a solar thermal chiller system in refrigeration capacity provides greater energy saving potentials (>27 percent for large refrigeration capacity), which seems to be more economically viable than the lower capacity of a solar thermal chiller system. However, the overall viability of installing a solar thermal hybrid chiller system is still low with a relatively low internal rate of return (IRR) and a relatively long payback period. It should be noted that the estimated net energy cost savings were based on the Malaysian electricity tariff, which contains energy subsidies from the Malaysian government. Therefore, the IRR and payback period will improve in countries with high energy costs and no energy subsidies.

### 4.2. Option 2 – Solar PV Hybrid Chiller System

Table 2 summarises an economic comparison of additional investments in various configurations of a solar PV hybrid chiller system.

It shows some interesting findings. The energy saving potentials of a solar PV hybrid chiller system do not appear to be as high as that of Option 1. The energy savings in the solar PV hybrid chiller system are due to the electricity generation by the solar PV system to supplement the electricity needed to operate the electric chiller. The energy savings estimated in Option 2 did not take account of the degradation factor, which is prevalent in solar PV panels. Therefore, the energy saving potential of Option 1 is more promising.

However, the economic viability of the solar PV hybrid chiller system seems to be better than Option 1. This is the case because the present market scenario favours the solar PV system due to its growing market acceptance and relatively lower costs compared with the solar thermal chiller system.

**Table 2. Economic Comparison of Additional Investments in Various Configurations of a Solar PV Hybrid Chiller System**

| Electric Chiller | 90 RT | 235 RT | 17511.2RT | 350 RT | 250 RT |
|---|---|---|---|---|---|
| Solar PV System | 50 RT (36kW) | 75 RT (54kW) | 135 RT (97kW) | 150 RT (107kW) | 250 RT (179kW) |
| Additional Investment (RM) | 292,250 | 412,875 | 708,718 | 883,575 | 1,276,125 |
| Energy Saving (kWh) | 39,325 | 58,988 | 106,178 | 117,975 | 196,625 |
| % Energy Saving | 5.8 | 4.7 | 8.5 | 5.5 | 9.2 |
| Energy Cost Saving (RM) | 27,052 | 40,578 | 73,040 | 81,156 | 135,260 |
| Simple Payback Period (years) | 10.8 | 10.2 | 9.7 | 10.9 | 9.4 |
| IRR | 7% | 8% | 8% | 7% | 9% |

RT = refrigeration ton; kW = kilowatt; RM = ringgit; kWh = kilowatt-hour.
Source: Analysed by Ir. Leong Siew Meng under the guidance of Shigeru Kimura, based on inputs from Solar District Cooling Sdn. Bhd.

## 5. Potential Market Outlook

Solar thermal cooling is still a niche technology and its presence is relatively insignificant in ASEAN countries, although the region has excellent solar resources and huge air-conditioning requirements due to climatic conditions, population growth, economic, and urbanisation developments. Based on the current market scenario, multiple market barriers, mostly economic, prevent the technology from achieving market penetration.[5] The following summarises the market barriers:

- Low electricity prices, especially in Malaysia, Indonesia, and Brunei Darussalam
- High capital costs in solar cooling systems
- Low costs in conventional air conditioning for low capacities such as split-unit air conditioners
- High maintenance costs due to lack of trained serviced personnel experienced with solar cooling
- Low number of installed solar cooling systems
- Solar cooling system complexity

However, market potentials and opportunities may be developed under the following scenarios:

- The barriers mentioned in the above are addressed, especially with improvement in the economics of solar cooling systems (lower capital costs, etc.)
- Advancement in the technology, especially with improvement in Coefficient of Performance (COP) of the small to medium capacity of solar cooling systems
- Greater support from governments and vigorous promotion of the technology
- Incentives for peak power savings
- Recognition and incentives for harnessing of solar thermal energy as RE (renewable energy)

- Financing mechanism for solar thermal cooling systems
- Encouragement to building owners to adopt green building certification programmes that give recognition to solar thermal cooling

## 6. Conclusion

The solar thermal absorption refrigeration technology is not new, but unlike other solar energy systems such as the solar hot water system and solar PV system, it has yet to make major inroads into market acceptance. This study suggests it is technically feasible for the solar thermal hybrid chiller system, comprising of the solar chiller system and the conventional electric chiller, to cater for both the base-load and fluctuating cooling load requirements of a building. However, it is economically unattractive under the present capital and operational cost scenarios in Malaysia, as the IRR is relatively low compared with the alternative option in solar PV hybrid chiller systems. The commercialisation of solar thermal hybrid chiller systems is still in its early stages.

It should be noted that the extent of energy savings achievable by the solar thermal hybrid chiller systems (Option 1) is substantially higher than that of the solar PV hybrid chiller system (Option 2), which is expected as a solar thermal cooling system is capable of absorbing more than 95 percent of incident solar radiation compared with only up to 35 percent of the available solar energy[3] being harnessed for the conversion to electricity in the Option 2 technology.

Based on this study, it is concluded that the solar thermal cooling system is currently not competitive in terms of economic cost compared with the solar PV hybrid system due to its high capital and operation and maintenance costs. However, a solar thermal cooling system can provide greater electricity savings than a solar PV hybrid system. It is apparent from Table 1 that larger commercial installations of solar thermal chiller systems are more viable than smaller units. Market barriers, market potentials, and opportunities are discussed. The main barriers to implementation of solar thermal cooling are essentially economic and concerted efforts by all parties are required to tap into the benefits of solar thermal cooling for the population in hot and humid climates such as those of the ASEAN region.

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Annex 4

# Summary Result Tables

# EAS [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **2,040.8** | **5,257.0** | **6,420.0** | **8,008.0** | **9,517.5** | **100** | **100** | **100** | **100** | **100** | **4.2** | **2.9** | **2.2** | **1.7** | **2.2** |
| Coal | 772.1 | 2,727.0 | 3,134.5 | 3,732.9 | 4,261.1 | 37.8 | 51.9 | 48.8 | 46.6 | 44.8 | 5.6 | 2.0 | 1.8 | 1.3 | 1.7 |
| Oil | 603.3 | 1,222.2 | 1,559.5 | 1,980.1 | 2,361.4 | 29.6 | 23.2 | 24.3 | 24.7 | 24.8 | 3.1 | 3.5 | 2.4 | 1.8 | 2.5 |
| Natural gas | 118.9 | 499.8 | 646.4 | 986.0 | 1,339.0 | 5.8 | 9.5 | 10.1 | 12.3 | 14.1 | 6.4 | 3.7 | 4.3 | 3.1 | 3.7 |
| Nuclear | 68.1 | 76.6 | 241.5 | 328.8 | 413.5 | 3.3 | 1.5 | 3.8 | 4.1 | 4.3 | 0.5 | 17.8 | 3.1 | 2.3 | 6.4 |
| Hydro | 30.9 | 111.8 | 145.7 | 168.0 | 190.8 | 1.5 | 2.1 | 2.3 | 2.1 | 2.0 | 5.7 | 3.9 | 1.4 | 1.3 | 2.0 |
| Geothermal | 9.7 | 35.7 | 53.1 | 81.6 | 106.5 | 0.5 | 0.7 | 0.8 | 1.0 | 1.1 | 5.8 | 5.8 | 4.4 | 2.7 | 4.1 |
| Others | 437.7 | 584.0 | 639.3 | 730.6 | 845.4 | 21.4 | 11.1 | 10.0 | 9.1 | 8.9 | 1.3 | 1.3 | 1.3 | 1.5 | 1.4 |
| Biomass | 436.1 | 539.2 | 561.0 | 597.5 | 640.7 | 21.4 | 10.3 | 8.7 | 7.5 | 6.7 | 0.9 | 0.6 | 0.6 | 0.7 | 0.6 |
| Solar, Wind, Ocean | 1.3 | 39.7 | 64.9 | 111.0 | 171.0 | 0.1 | 0.8 | 1.0 | 1.4 | 1.8 | 15.8 | 7.3 | 5.5 | 4.4 | 5.6 |
| Biofuels | 0.0 | 4.7 | 13.4 | 19.3 | 28.3 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | - | 16.2 | 3.7 | 3.9 | 6.9 |
| Electricit | 0.3 | 0.4 | 0.1 | 2.8 | 5.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 2.1 | -23.9 | 45.5 | 6.6 | 9.6 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1,509.5** | **3,347.4** | **4,141.1** | **5,132.9** | **6,128.6** | **100** | **100** | **100** | **100** | **100** | **3.5** | **3.1** | **2.2** | **1.8** | **2.3** |
| Industry | 495.8 | 1,333.2 | 1,614.5 | 1,961.9 | 2,330.7 | 32.8 | 39.8 | 39.0 | 38.2 | 38.0 | 4.4 | 2.8 | 2.0 | 1.7 | 2.1 |
| Transportation | 197.2 | 576.4 | 822.5 | 1,124.7 | 1,387.9 | 13.1 | 17.2 | 19.9 | 21.9 | 22.6 | 4.8 | 5.2 | 3.2 | 2.1 | 3.3 |
| Others | 703.7 | 1,117.2 | 1,312.6 | 1,575.4 | 1,855.2 | 46.6 | 33.4 | 31.7 | 30.7 | 30.3 | 2.0 | 2.3 | 1.8 | 1.6 | 1.9 |
| Non-energy | 112.7 | 320.6 | 391.6 | 470.9 | 554.7 | 7.5 | 9.6 | 9.5 | 9.2 | 9.1 | 4.6 | 2.9 | 1.9 | 1.7 | 2.1 |
| **Total** | **1,509.5** | **3,347.4** | **4,141.1** | **5,132.9** | **6,128.6** | **100** | **100** | **100** | **100** | **100** | **3.5** | **3.1** | **2.2** | **1.8** | **2.3** |
| Coal | 411.5 | 773.0 | 858.0 | 925.0 | 1,010.0 | 27.3 | 23.1 | 20.7 | 18.0 | 16.5 | 2.8 | 1.5 | 0.8 | 0.9 | 1.0 |
| Oil | 460.4 | 1,070.1 | 1,415.5 | 1,805.2 | 2,164.3 | 30.5 | 32.0 | 34.2 | 35.2 | 35.3 | 3.7 | 4.1 | 2.5 | 1.8 | 2.6 |
| Natural gas | 48.4 | 242.7 | 356.7 | 522.0 | 704.0 | 3.2 | 7.2 | 8.6 | 10.2 | 11.5 | 7.3 | 5.7 | 3.9 | 3.0 | 4.0 |
| Electricity | 154.8 | 669.3 | 888.3 | 1,226.8 | 1,559.7 | 10.3 | 20.0 | 21.5 | 23.9 | 25.4 | 6.6 | 4.1 | 3.3 | 2.4 | 3.2 |
| Heat | 13.4 | 81.0 | 96.4 | 107.9 | 111.6 | 0.9 | 2.4 | 2.3 | 2.1 | 1.8 | 8.1 | 2.5 | 1.1 | 0.3 | 1.2 |
| Others | 420.9 | 511.3 | 526.2 | 545.9 | 579.0 | 27.9 | 15.3 | 12.7 | 10.6 | 9.4 | 0.8 | 0.4 | 0.4 | 0.6 | 0.5 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **2,196.5** | **9,282.5** | **12,212.6** | **16,699.4** | **21,015.3** | **100** | **100** | **100** | **100** | **100** | **6.5** | **4.0** | **3.2** | **2.3** | **3.1** |
| Coal | 916.9 | 5,939.6 | 7,472.3 | 10,028.4 | 12,262.8 | 41.7 | 64.0 | 61.2 | 60.1 | 58.4 | 8.5 | 3.3 | 3.0 | 2.0 | 2.7 |
| Oil | 388.5 | 246.2 | 137.6 | 124.7 | 115.3 | 17.7 | 2.7 | 1.1 | 0.7 | 0.5 | -2.0 | -8.0 | -1.0 | -0.8 | -2.8 |
| Natural gas | 247.1 | 1,116.7 | 1,253.4 | 2,059.9 | 2,918.4 | 11.2 | 12.0 | 10.3 | 12.3 | 13.9 | 6.8 | 1.7 | 5.1 | 3.5 | 3.6 |
| Nuclear | 261.3 | 293.9 | 926.6 | 1,261.9 | 1,586.8 | 11.9 | 3.2 | 7.6 | 7.6 | 7.6 | 0.5 | 17.8 | 3.1 | 2.3 | 6.4 |
| Hydro | 359.5 | 1,300.1 | 1,694.2 | 1,954.1 | 2,219.5 | 16.4 | 14.0 | 13.9 | 11.7 | 10.6 | 5.7 | 3.9 | 1.4 | 1.3 | 2.0 |
| Geothermal | 10.5 | 28.1 | 58.0 | 92.0 | 120.5 | 0.5 | 0.3 | 0.5 | 0.6 | 0.6 | 4.4 | 10.9 | 4.7 | 2.7 | 5.5 |
| Others | 12.7 | 357.9 | 670.5 | 1,178.4 | 1,792.0 | 0.6 | 3.9 | 5.5 | 7.1 | 8.5 | 15.6 | 9.4 | 5.8 | 4.3 | 6.1 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **388.58** | **1,648.16** | **1,990.72** | **2,679.39** | **3,277.53** | **100** | **100** | **100** | **100** | **100** | **6.5** | **2.7** | **3.0** | **2.0** | **2.6** |
| Coal | 248.21 | 1,381.32 | 1,721.50 | 2,276.32 | 2,743.27 | 63.9 | 83.8 | 86.5 | 85.0 | 83.7 | 7.7 | 3.2 | 2.8 | 1.9 | 2.6 |
| Oil | 89.98 | 57.23 | 34.06 | 31.28 | 28.74 | 23.2 | 3.5 | 1.7 | 1.2 | 0.9 | -1.9 | -7.1 | -0.8 | -0.8 | -2.5 |
| Natural gas | 50.40 | 209.61 | 235.16 | 371.79 | 505.51 | 13.0 | 12.7 | 11.8 | 13.9 | 15.4 | 6.4 | 1.7 | 4.7 | 3.1 | 3.3 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **34** | **38** | **38** | **39** | **40** | **0.5** | **0.1** | **0.2** | **0.2** | **0.2** |
| Coal | 32 | 37 | 37 | 38 | 38 | 0.7 | 0.1 | 0.1 | 0.1 | 0.1 |
| Oil | 37 | 37 | 35 | 34 | 34 | 0.0 | -0.9 | -0.1 | 0.1 | -0.3 |
| Natural gas | 42 | 46 | 46 | 48 | 50 | 0.4 | 0.0 | 0.4 | 0.4 | 0.3 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1,340.8** | **4,023.8** | **4,785.5** | **5,941.7** | **7,010.4** | **100** | **100** | **100** | **100** | **100** | **4.9** | **2.5** | **2.2** | **1.7** | **2.1** |
| Coal | 825.5 | 2,902.2 | 3,336.8 | 3,981.1 | 4,560.4 | 61.6 | 72.1 | 69.7 | 67.0 | 65.1 | 5.6 | 2.0 | 1.8 | 1.4 | 1.7 |
| Oil | 444.7 | 836.3 | 1,078.8 | 1,386.1 | 1,673.7 | 33.2 | 20.8 | 22.5 | 23.3 | 23.9 | 2.8 | 3.7 | 2.5 | 1.9 | 2.6 |
| Natural Gas | 70.6 | 285.2 | 369.9 | 574.4 | 776.2 | 5.3 | 7.1 | 7.7 | 9.7 | 11.1 | 6.3 | 3.8 | 4.5 | 3.1 | 3.8 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 5,990 | 14,663 | 20,016 | 29,900 | 41,975 | 4.0 | 4.5 | 4.1 | 3.5 | 4.0 |
| Population (millions of people) | 2,629 | 3,430 | 3,649 | 3,878 | 4,009 | 1.2 | 0.9 | 0.6 | 0.3 | 0.6 |
| GDP per capita (thousands of 2005 USD/person) | 2.28 | 4.27 | 5.5 | 7.7 | 10.5 | 2.8 | 3.6 | 3.5 | 3.1 | 3.4 |
| Primary energy consumption per capita (toe/person) | 0.78 | 1.53 | 1.76 | 2.06 | 2.37 | 3.0 | 2.0 | 1.6 | 1.4 | 1.6 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 341 | 359 | 321 | 268 | 227 | 0.2 | -1.6 | -1.8 | -1.7 | -1.7 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 252 | 228 | 207 | 172 | 146 | -0.4 | -1.4 | -1.8 | -1.6 | -1.6 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 224 | 274 | 239 | 199 | 167 | 0.9 | -1.9 | -1.8 | -1.7 | -1.8 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.66 | 0.77 | 0.75 | 0.74 | 0.74 | 0.7 | -0.4 | 0.0 | -0.1 | -0.1 |
| Automobile ownership volume (millions of vehicles) | 83.5 | 279.0 | 439.1 | 631.6 | 808.9 | 5.4 | 6.7 | 3.7 | 2.5 | 4.0 |
| Automobile ownership volume per capita (vehicles per person) | 0.032 | 0.081 | 0.120 | 0.163 | 0.202 | 4.2 | 5.8 | 3.1 | 2.2 | 3.4 |

# EAS [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **2,040.8** | **5,257.0** | **6,077.1** | **7,108.7** | **8,026.4** | **100** | **100** | **100** | **100** | **100** | **4.2** | **2.1** | **1.6** | **1.2** | **1.6** |
| Coal | 772.1 | 2,727.0 | 2,851.6 | 2,966.0 | 2,993.0 | 37.8 | 51.9 | 46.9 | 41.7 | 37.3 | 5.6 | 0.6 | 0.4 | 0.1 | 0.3 |
| Oil | 603.3 | 1,222.2 | 1,486.8 | 1,793.1 | 2,055.2 | 29.6 | 23.2 | 24.5 | 25.2 | 25.6 | 3.1 | 2.8 | 1.9 | 1.4 | 1.9 |
| Natural gas | 118.9 | 499.8 | 597.3 | 833.4 | 1,063.5 | 5.8 | 9.5 | 9.8 | 11.7 | 13.3 | 6.4 | 2.6 | 3.4 | 2.5 | 2.8 |
| Nuclear | 68.1 | 76.6 | 277.1 | 457.4 | 647.3 | 3.3 | 1.5 | 4.6 | 6.4 | 8.1 | 0.5 | 20.2 | 5.1 | 3.5 | 8.2 |
| Hydro | 30.9 | 111.8 | 155.3 | 182.4 | 209.3 | 1.5 | 2.1 | 2.6 | 2.6 | 2.6 | 5.7 | 4.8 | 1.6 | 1.4 | 2.4 |
| Geothermal | 9.7 | 35.7 | 54.8 | 105.9 | 146.5 | 0.5 | 0.7 | 0.9 | 1.5 | 1.8 | 5.8 | 6.3 | 6.8 | 3.3 | 5.4 |
| Others | 437.7 | 584.0 | 654.3 | 770.4 | 911.5 | 21.4 | 11.1 | 10.8 | 10.8 | 11.4 | 1.3 | 1.6 | 1.6 | 1.7 | 1.7 |
| Biomass | 436.1 | 539.1 | 561.4 | 586.7 | 621.4 | 21.4 | 10.3 | 9.2 | 8.3 | 7.7 | 0.9 | 0.6 | 0.4 | 0.6 | 0.5 |
| Solar, Wind, Ocean | 1.3 | 39.7 | 78.3 | 154.8 | 237.4 | 0.1 | 0.8 | 1.3 | 2.2 | 3.0 | 15.8 | 10.2 | 7.1 | 4.4 | 6.8 |
| Biofuels | 0.0 | 4.8 | 14.6 | 28.3 | 49.1 | 0.0 | 0.1 | 0.2 | 0.4 | 0.6 | - | 17.3 | 6.8 | 5.7 | 9.0 |
| Electricit | 0.3 | 0.4 | 0.0 | 0.6 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | -172.2 | - | 19.8 | 8.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **1,509.5** | **3,347.4** | **3,962.6** | **4,661.5** | **5,349.3** | **100** | **100** | **100** | **100** | **100** | **3.5** | **2.4** | **1.6** | **1.4** | **1.8** |
| Industry | 495.8 | 1,333.2 | 1,533.5 | 1,754.6 | 2,017.5 | 32.8 | 39.8 | 38.7 | 37.6 | 37.7 | 4.4 | 2.0 | 1.4 | 1.4 | 1.5 |
| Transportation | 197.2 | 576.4 | 775.2 | 1,007.7 | 1,196.5 | 13.1 | 17.2 | 19.6 | 21.6 | 22.4 | 4.8 | 4.3 | 2.7 | 1.7 | 2.7 |
| Others | 703.7 | 1,117.2 | 1,262.3 | 1,428.2 | 1,580.6 | 46.6 | 33.4 | 31.9 | 30.6 | 29.5 | 2.0 | 1.8 | 1.2 | 1.0 | 1.3 |
| Non-energy | 112.7 | 320.6 | 391.6 | 470.9 | 554.7 | 7.5 | 9.6 | 9.9 | 10.1 | 10.4 | 4.6 | 2.9 | 1.9 | 1.7 | 2.1 |
| **Total** | **1,509.5** | **3,347.4** | **3,962.6** | **4,661.4** | **5,349.3** | **100** | **100** | **100** | **100** | **100** | **3.5** | **2.4** | **1.6** | **1.4** | **1.8** |
| Coal | 411.5 | 773.0 | 817.6 | 824.6 | 856.5 | 27.3 | 23.1 | 20.6 | 17.7 | 16.0 | 2.8 | 0.8 | 0.1 | 0.4 | 0.4 |
| Oil | 460.4 | 1,070.1 | 1,348.8 | 1,632.0 | 1,877.5 | 30.5 | 32.0 | 34.0 | 35.0 | 35.1 | 3.7 | 3.4 | 1.9 | 1.4 | 2.1 |
| Natural gas | 48.4 | 242.7 | 342.8 | 483.5 | 639.6 | 3.2 | 7.2 | 8.7 | 10.4 | 12.0 | 7.3 | 5.1 | 3.5 | 2.8 | 3.7 |
| Electricity | 154.8 | 669.3 | 845.8 | 1,094.7 | 1,314.3 | 10.3 | 20.0 | 21.3 | 23.5 | 24.6 | 6.6 | 3.4 | 2.6 | 1.8 | 2.5 |
| Heat | 13.4 | 81.0 | 92.4 | 98.2 | 98.4 | 0.9 | 2.4 | 2.3 | 2.1 | 1.8 | 8.1 | 1.9 | 0.6 | 0.0 | 0.7 |
| Others | 420.9 | 511.3 | 515.1 | 528.5 | 562.9 | 27.9 | 15.3 | 13.0 | 11.3 | 10.5 | 0.8 | 0.1 | 0.3 | 0.6 | 0.4 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **2,196.5** | **9,282.5** | **11,624.6** | **14,899.3** | **17,677.5** | **100** | **100** | **100** | **100** | **100** | **6.5** | **3.3** | **2.5** | **1.7** | **2.4** |
| Coal | 916.9 | 5,939.6 | 6,598.7 | 7,493.5 | 7,890.2 | 41.7 | 64.0 | 56.8 | 50.3 | 44.6 | 8.5 | 1.5 | 1.3 | 0.5 | 1.1 |
| Oil | 388.5 | 246.2 | 126.0 | 101.5 | 89.6 | 17.7 | 2.7 | 1.1 | 0.7 | 0.5 | -2.0 | -9.1 | -2.1 | -1.2 | -3.7 |
| Natural gas | 247.1 | 1,116.7 | 1,112.8 | 1,587.5 | 2,006.9 | 11.2 | 12.0 | 9.6 | 10.7 | 11.4 | 6.8 | -0.1 | 3.6 | 2.4 | 2.2 |
| Nuclear | 261.3 | 293.9 | 1,063.1 | 1,755.3 | 2,484.0 | 11.9 | 3.2 | 9.1 | 11.8 | 14.1 | 0.5 | 20.2 | 5.1 | 3.5 | 8.2 |
| Hydro | 359.5 | 1,300.1 | 1,806.6 | 2,121.2 | 2,435.6 | 16.4 | 14.0 | 15.5 | 14.2 | 13.8 | 5.7 | 4.8 | 1.6 | 1.4 | 2.4 |
| Geothermal | 10.5 | 28.1 | 60.2 | 121.1 | 168.2 | 0.5 | 0.3 | 0.5 | 0.8 | 1.0 | 4.4 | 11.5 | 7.2 | 3.3 | 6.8 |
| Others | 12.7 | 357.9 | 857.2 | 1,719.2 | 2,603.0 | 0.6 | 3.9 | 7.4 | 11.5 | 14.7 | 15.6 | 13.3 | 7.2 | 4.2 | 7.6 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **388.6** | **1,648.2** | **1,739.7** | **1,968.2** | **2,066.3** | **100** | **100** | **100** | **100** | **100** | **6.5** | **0.8** | **1.2** | **0.5** | **0.8** |
| Coal | 248.2 | 1,381.3 | 1,504.6 | 1,668.6 | 1,716.6 | 63.9 | 83.8 | 86.5 | 84.8 | 83.1 | 7.7 | 1.2 | 1.0 | 0.3 | 0.8 |
| Oil | 90.0 | 57.2 | 30.9 | 24.9 | 21.6 | 23.2 | 3.5 | 1.8 | 1.3 | 1.0 | -1.9 | -8.4 | -2.2 | -1.4 | -3.5 |
| Natural gas | 50.4 | 209.6 | 204.2 | 274.7 | 328.2 | 13.0 | 12.7 | 11.7 | 14.0 | 15.9 | 6.4 | -0.4 | 3.0 | 1.8 | 1.7 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **34** | **38** | **39** | **40** | **42** | **0.5** | **0.2** | **0.4** | **0.4** | **0.3** |
| Coal | 32 | 37 | 38 | 39 | 40 | 0.7 | 0.3 | 0.2 | 0.2 | 0.2 |
| Oil | 37 | 37 | 35 | 35 | 36 | 0.0 | -0.8 | 0.0 | 0.2 | -0.1 |
| Natural gas | 42 | 46 | 47 | 50 | 53 | 0.4 | 0.3 | 0.6 | 0.6 | 0.5 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **1,340.8** | **4,023.8** | **4,393.7** | **4,869.6** | **5,223.1** | **100** | **100** | **100** | **100** | **100** | **4.9** | **1.3** | **1.0** | **0.7** | **1.0** |
| Coal | 825.5 | 2,902.2 | 3,036.0 | 3,164.1 | 3,210.9 | 61.6 | 72.1 | 69.1 | 65.0 | 61.5 | 5.6 | 0.6 | 0.4 | 0.1 | 0.4 |
| Oil | 444.7 | 836.3 | 1,017.1 | 1,224.4 | 1,405.1 | 33.2 | 20.8 | 23.1 | 25.1 | 26.9 | 2.8 | 2.8 | 1.9 | 1.4 | 1.9 |
| Natural Gas | 70.6 | 285.2 | 340.6 | 481.1 | 607.1 | 5.3 | 7.1 | 7.8 | 9.9 | 11.6 | 6.3 | 2.6 | 3.5 | 2.4 | 2.8 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 5,990 | 14,663 | 20,016 | 29,900 | 41,975 | 4.0 | 4.5 | 4.1 | 3.5 | 4.0 |
| Population (millions of people) | 2,629 | 3,430 | 3,649 | 3,878 | 4,009 | 1.2 | 0.9 | 0.6 | 0.3 | 0.6 |
| GDP per capita (thousands of 2005 USD/person) | 2.28 | 4.27 | 5.5 | 7.7 | 10.5 | 2.8 | 3.6 | 3.5 | 3.1 | 3.4 |
| Primary energy consumption per capita (toe/person) | 0.78 | 1.53 | 1.67 | 1.83 | 2.00 | 3.0 | 1.2 | 1.0 | 0.9 | 1.0 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 341 | 359 | 304 | 238 | 191 | 0.2 | -2.3 | -2.4 | -2.2 | -2.3 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 252 | 228 | 198 | 156 | 127 | -0.4 | -2.0 | -2.4 | -2.0 | -2.1 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 224 | 274 | 220 | 163 | 124 | 0.9 | -3.1 | -2.9 | -2.7 | -2.9 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.66 | 0.77 | 0.72 | 0.69 | 0.65 | 0.7 | -0.8 | -0.5 | -0.5 | -0.6 |
| Automobile ownership volume (millions of vehicles) | 83.5 | 278.2 | 438.3 | 630.8 | 808.0 | 5.4 | 6.7 | 3.7 | 2.5 | 4.0 |
| Automobile ownership volume per capita (vehicles per person) | 0.032 | 0.081 | 0.120 | 0.163 | 0.202 | 4.2 | 5.8 | 3.1 | 2.2 | 3.4 |

# Australia [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **86.38** | **129.14** | **153.50** | **173.13** | **193.38** | **100** | **100** | **100** | **100** | **100** | **1.8** | **2.5** | **1.2** | **1.1** | **1.5** |
| Coal | 35.13 | 45.65 | 40.45 | 43.27 | 46.13 | 40.7 | 35.4 | 26.4 | 25.0 | 23.9 | 1.1 | -1.7 | 0.7 | 0.6 | 0.0 |
| Oil | 31.20 | 45.89 | 63.26 | 73.69 | 84.48 | 36.1 | 35.5 | 41.2 | 42.6 | 43.7 | 1.7 | 4.7 | 1.5 | 1.4 | 2.3 |
| Natural gas | 14.79 | 29.72 | 41.04 | 46.24 | 51.58 | 17.1 | 23.0 | 26.7 | 26.7 | 26.7 | 3.1 | 4.7 | 1.2 | 1.1 | 2.1 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.22 | 1.56 | 1.62 | 1.62 | 1.62 | 1.4 | 1.2 | 1.1 | 0.9 | 0.8 | 1.1 | 0.5 | 0.0 | 0.0 | 0.1 |
| Geothermal | - | 0.00 | 0.08 | 0.25 | 0.45 | - | 0.0 | 0.1 | 0.1 | 0.2 | - | 112.3 | 11.6 | 5.9 | 29.3 |
| Others | 4.04 | 6.32 | 7.03 | 8.06 | 9.12 | 4.7 | 4.9 | 4.6 | 4.7 | 4.7 | 2.0 | 1.5 | 1.4 | 1.2 | 1.4 |
| Biomass | 3.96 | 4.84 | 0.00 | 0.00 | 0.00 | 4.6 | 3.7 | 0.0 | 0.0 | 0.0 | 0.9 | -100.0 | - | - | -100.0 |
| Solar, Wind, Ocean | 0.08 | 1.27 | 2.23 | 2.96 | 3.73 | 0.1 | 1.0 | 1.5 | 1.7 | 1.9 | 12.7 | 8.4 | 2.9 | 2.4 | 4.1 |
| Biofuels | - | 0.22 | 4.81 | 5.10 | 5.41 | - | 0.2 | 3.1 | 2.9 | 2.8 | - | 55.7 | 0.6 | 0.6 | 12.7 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **56.65** | **80.79** | **112.97** | **128.81** | **145.15** | **100** | **100** | **100** | **100** | **100** | **1.6** | **4.9** | **1.3** | **1.2** | **2.2** |
| Industry | 19.32 | 25.23 | 44.97 | 51.00 | 57.21 | 34.1 | 31.2 | 39.8 | 39.6 | 39.4 | 1.2 | 8.6 | 1.3 | 1.2 | 3.1 |
| Transportation | 21.11 | 31.14 | 45.48 | 52.33 | 59.41 | 37.3 | 38.5 | 40.3 | 40.6 | 40.9 | 1.7 | 5.6 | 1.4 | 1.3 | 2.4 |
| Others | 12.27 | 19.69 | 22.52 | 25.48 | 28.53 | 21.7 | 24.4 | 19.9 | 19.8 | 19.7 | 2.1 | 1.9 | 1.2 | 1.1 | 1.4 |
| Non-energy | 3.95 | 4.74 | 0.00 | 0.00 | 0.00 | 7.0 | 5.9 | 0.0 | 0.0 | 0.0 | 0.8 | -100.0 | - | - | -100.0 |
| **Total** | **56.65** | **80.79** | **112.98** | **128.78** | **145.15** | **100** | **100** | **100** | **100** | **100** | **1.6** | **4.9** | **1.3** | **1.2** | **2.2** |
| Coal | 4.56 | 3.30 | 2.96 | 3.20 | 3.52 | 8.0 | 4.1 | 2.6 | 2.5 | 2.4 | -1.4 | -1.6 | 0.8 | 1.0 | 0.2 |
| Oil | 29.00 | 41.49 | 60.33 | 70.56 | 80.36 | 51.2 | 51.4 | 53.4 | 54.8 | 55.4 | 1.6 | 5.5 | 1.6 | 1.3 | 2.5 |
| Natural gas | 8.65 | 13.48 | 24.81 | 26.72 | 29.39 | 15.3 | 16.7 | 22.0 | 20.7 | 20.2 | 1.9 | 9.1 | 0.7 | 1.0 | 2.9 |
| Electricity | 11.11 | 17.72 | 20.23 | 23.25 | 26.30 | 19.6 | 21.9 | 17.9 | 18.1 | 18.1 | 2.0 | 1.9 | 1.4 | 1.2 | 1.5 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 3.33 | 4.81 | 4.64 | 5.05 | 5.58 | 5.9 | 5.9 | 4.1 | 3.9 | 3.8 | 1.6 | -0.5 | 0.8 | 1.0 | 0.6 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **154.29** | **248.96** | **270.00** | **300.00** | **334.49** | **100** | **100** | **100** | **100** | **100** | **2.1** | **1.2** | **1.1** | **1.1** | **1.1** |
| Coal | 121.48 | 161.20 | 172.25 | 190.75 | 212.38 | 78.7 | 64.7 | 63.8 | 63.6 | 63.5 | 1.2 | 1.0 | 1.0 | 1.1 | 1.0 |
| Oil | 3.55 | 3.41 | 3.00 | 3.00 | 3.19 | 2.3 | 1.4 | 1.1 | 1.0 | 1.0 | -0.2 | -1.8 | 0.0 | 0.6 | -0.3 |
| Natural gas | 14.36 | 53.09 | 49.75 | 49.25 | 52.03 | 9.3 | 21.3 | 18.4 | 16.4 | 15.6 | 5.9 | -0.9 | -0.1 | 0.6 | -0.1 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 14.15 | 18.17 | 19.00 | 19.00 | 20.18 | 9.2 | 7.3 | 7.0 | 6.3 | 6.0 | 1.1 | 0.6 | 0.0 | 0.6 | 0.4 |
| Geothermal | - | 0.00 | 1.00 | 3.00 | 4.25 | 0.0 | 0.0 | 0.4 | 1.0 | 1.3 | - | 168.3 | 11.6 | 3.5 | 36.3 |
| Others | 0.75 | 13.09 | 25.00 | 35.00 | 42.48 | 0.5 | 5.3 | 9.3 | 11.7 | 12.7 | 13.2 | 9.7 | 3.4 | 2.0 | 4.5 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **33.30** | **53.56** | **49.40** | **51.87** | **56.37** | **100** | **100** | **100** | **100** | **100** | **2.1** | **-1.1** | **0.5** | **0.8** | **0.2** |
| Coal | 28.88 | 41.49 | 37.49 | 40.07 | 43.92 | 86.7 | 77.5 | 75.9 | 77.3 | 77.9 | 1.6 | -1.4 | 0.7 | 0.9 | 0.2 |
| Oil | 0.95 | 0.90 | 0.80 | 0.80 | 0.83 | 2.8 | 1.7 | 1.6 | 1.5 | 1.5 | -0.2 | -1.8 | 0.0 | 0.4 | -0.3 |
| Natural gas | 3.47 | 11.17 | 11.11 | 11.00 | 11.62 | 10.4 | 20.9 | 22.5 | 21.2 | 20.6 | 5.2 | -0.1 | -0.1 | 0.6 | 0.1 |

**Thermal Efficiency**

| | % | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **36** | **35** | **39** | **40** | **41** | | | | | | **-0.1** | **1.6** | **0.3** | **0.1** | **0.6** |
| Coal | 36 | 33 | 40 | 41 | 42 | | | | | | -0.3 | 2.4 | 0.4 | 0.2 | 0.8 |
| Oil | 32 | 32 | 32 | 32 | 33 | | | | | | 0.0 | -0.1 | 0.0 | 0.2 | 0.1 |
| Natural gas | 36 | 41 | 39 | 39 | 39 | | | | | | 0.6 | -0.9 | 0.0 | 0.0 | -0.2 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **70.3** | **102.9** | **123.3** | **138.4** | **154.0** | **100** | **100** | **100** | **100** | **100** | **1.7** | **2.6** | **1.2** | **1.1** | **1.5** |
| Coal | 37.9 | 49.3 | 44.04 | 47.10 | 50.22 | 54.0 | 47.9 | 35.7 | 34.0 | 32.6 | 1.1 | -1.6 | 0.7 | 0.6 | 0.1 |
| Oil | 23.2 | 35.1 | 52.97 | 61.70 | 70.74 | 33.0 | 34.1 | 43.0 | 44.6 | 45.9 | 1.8 | 6.1 | 1.5 | 1.4 | 2.6 |
| Natural Gas | 9.2 | 18.6 | 26.29 | 29.62 | 33.04 | 13.1 | 18.0 | 21.3 | 21.4 | 21.5 | 3.1 | 5.1 | 1.2 | 1.1 | 2.2 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 427 | 867 | 1,026 | 1,313 | 1,681 | 3.1 | 2.4 | 2.5 | 2.5 | 2.5 |
| Population (millions of people) | 17 | 23 | 26 | 30 | 34 | 1.3 | 1.7 | 1.5 | 1.3 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 25.03 | 37.49 | 39.5 | 43.8 | 49.2 | 1.8 | 0.8 | 1.0 | 1.2 | 1.0 |
| Primary energy consumption per capita (toe/person) | 5.06 | 5.58 | 5.92 | 5.77 | 5.67 | 0.4 | 0.8 | -0.2 | -0.2 | 0.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 202 | 149 | 150 | 132 | 115 | -1.3 | 0.1 | -1.3 | -1.4 | -1.0 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 133 | 93 | 110 | 98 | 86 | -1.5 | 2.4 | -1.2 | -1.3 | -0.3 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 165 | 119 | 120 | 105 | 92 | -1.4 | 0.2 | -1.3 | -1.4 | -1.0 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.81 | 0.80 | 0.80 | 0.80 | 0.80 | -0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Automobile ownership volume (millions of vehicles) | 9.8 | 16.4 | 18.6 | 21.7 | 25.3 | 2.3 | 1.8 | 1.6 | 1.6 | 1.6 |
| Automobile ownership volume per capita (vehicles per person) | 0.57 | 0.71 | 0.72 | 0.72 | 0.74 | 0.9 | 0.2 | 0.1 | 0.3 | 0.2 |

# Australia [APS=BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **86.38** | **129.14** | **153.50** | **173.13** | **193.38** | **100** | **100** | **100** | **100** | **100** | **1.8** | **2.5** | **1.2** | **1.1** | **1.5** |
| Coal | 35.13 | 45.65 | 40.45 | 43.27 | 46.13 | 40.7 | 35.4 | 26.4 | 25.0 | 23.9 | 1.1 | -1.7 | 0.7 | 0.6 | 0.0 |
| Oil | 31.20 | 45.89 | 63.26 | 73.69 | 84.48 | 36.1 | 35.5 | 41.2 | 42.6 | 43.7 | 1.7 | 4.7 | 1.5 | 1.4 | 2.3 |
| Natural gas | 14.79 | 29.72 | 41.04 | 46.24 | 51.58 | 17.1 | 23.0 | 26.7 | 26.7 | 26.7 | 3.1 | 4.7 | 1.2 | 1.1 | 2.1 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.22 | 1.56 | 1.62 | 1.62 | 1.62 | 1.4 | 1.2 | 1.1 | 0.9 | 0.8 | 1.1 | 0.5 | 0.0 | 0.0 | 0.1 |
| Geothermal | - | 0.00 | 0.08 | 0.25 | 0.45 | - | 0.0 | 0.1 | 0.1 | 0.2 | - | 112.3 | 11.6 | 5.9 | 29.3 |
| Others | 4.04 | 6.32 | 7.03 | 8.06 | 9.12 | 4.7 | 4.9 | 4.6 | 4.7 | 4.7 | 2.0 | 1.5 | 1.4 | 1.2 | 1.4 |
| Biomass | 3.96 | 4.84 | 0.00 | 0.00 | 0.00 | 4.6 | 3.7 | 0.0 | 0.0 | 0.0 | 0.9 | -100.0 | - | - | -100.0 |
| Solar, Wind, Ocean | 0.08 | 1.27 | 2.23 | 2.96 | 3.73 | 0.1 | 1.0 | 1.5 | 1.7 | 1.9 | 12.7 | 8.4 | 2.9 | 2.4 | 4.1 |
| Biofuels | - | 0.22 | 4.81 | 5.10 | 5.41 | - | 0.2 | 3.1 | 2.9 | 2.8 | - | 55.7 | 0.6 | 0.6 | 12.7 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **56.65** | **80.79** | **112.97** | **128.81** | **145.15** | **100** | **100** | **100** | **100** | **100** | **1.6** | **4.9** | **1.3** | **1.2** | **2.2** |
| Industry | 19.32 | 25.23 | 44.97 | 51.00 | 57.21 | 34.1 | 31.2 | 39.8 | 39.6 | 39.4 | 1.2 | 8.6 | 1.3 | 1.2 | 3.1 |
| Transportation | 21.11 | 31.14 | 45.48 | 52.33 | 59.41 | 37.3 | 38.5 | 40.3 | 40.6 | 40.9 | 1.7 | 5.6 | 1.4 | 1.3 | 2.4 |
| Others | 12.27 | 19.69 | 22.52 | 25.48 | 28.53 | 21.7 | 24.4 | 19.9 | 19.8 | 19.7 | 2.1 | 1.9 | 1.2 | 1.1 | 1.4 |
| Non-energy | 3.95 | 4.74 | 0.00 | 0.00 | 0.00 | 7.0 | 5.9 | 0.0 | 0.0 | 0.0 | 0.8 | -100.0 | - | - | -100.0 |
| **Total** | **56.65** | **80.79** | **112.98** | **128.78** | **145.15** | **100** | **100** | **100** | **100** | **100** | **1.6** | **4.9** | **1.3** | **1.2** | **2.2** |
| Coal | 4.56 | 3.30 | 2.96 | 3.20 | 3.52 | 8.0 | 4.1 | 2.6 | 2.5 | 2.4 | -1.4 | -1.6 | 0.8 | 1.0 | 0.2 |
| Oil | 29.00 | 41.49 | 60.33 | 70.56 | 80.36 | 51.2 | 51.4 | 53.4 | 54.8 | 55.4 | 1.6 | 5.5 | 1.6 | 1.3 | 2.5 |
| Natural gas | 8.65 | 13.48 | 24.81 | 26.72 | 29.39 | 15.3 | 16.7 | 22.0 | 20.7 | 20.2 | 1.9 | 9.1 | 0.7 | 1.0 | 2.9 |
| Electricity | 11.11 | 17.72 | 20.23 | 23.25 | 26.30 | 19.6 | 21.9 | 17.9 | 18.1 | 18.1 | 2.0 | 1.9 | 1.4 | 1.2 | 1.5 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 3.33 | 4.81 | 4.64 | 5.05 | 5.58 | 5.9 | 5.9 | 4.1 | 3.9 | 3.8 | 1.6 | -0.5 | 0.8 | 1.0 | 0.6 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **154.29** | **248.96** | **270.00** | **300.00** | **334.49** | **100** | **100** | **100** | **100** | **100** | **2.1** | **1.2** | **1.1** | **1.1** | **1.1** |
| Coal | 121.48 | 161.20 | 172.25 | 190.75 | 212.38 | 78.7 | 64.7 | 63.8 | 63.6 | 63.5 | 1.2 | 1.0 | 1.0 | 1.1 | 1.0 |
| Oil | 3.55 | 3.41 | 3.00 | 3.00 | 3.19 | 2.3 | 1.4 | 1.1 | 1.0 | 1.0 | -0.2 | -1.8 | 0.0 | 0.6 | -0.3 |
| Natural gas | 14.36 | 53.09 | 49.75 | 49.25 | 52.03 | 9.3 | 21.3 | 18.4 | 16.4 | 15.6 | 5.9 | -0.9 | -0.1 | 0.6 | -0.1 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 14.15 | 18.17 | 19.00 | 19.00 | 20.18 | 9.2 | 7.3 | 7.0 | 6.3 | 6.0 | 1.1 | 0.6 | 0.0 | 0.6 | 0.4 |
| Geothermal | - | 0.00 | 1.00 | 3.00 | 4.25 | 0.0 | 0.0 | 0.4 | 1.0 | 1.3 | - | 168.3 | 11.6 | 3.5 | 36.3 |
| Others | 0.75 | 13.09 | 25.00 | 35.00 | 42.48 | 0.5 | 5.3 | 9.3 | 11.7 | 12.7 | 13.2 | 9.7 | 3.4 | 2.0 | 4.5 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **33.30** | **53.56** | **49.40** | **51.87** | **56.37** | **100** | **100** | **100** | **100** | **100** | **2.1** | **-1.1** | **0.5** | **0.8** | **0.2** |
| Coal | 28.88 | 41.49 | 37.49 | 40.07 | 43.92 | 86.7 | 77.5 | 75.9 | 77.3 | 77.9 | 1.6 | -1.4 | 0.7 | 0.9 | 0.2 |
| Oil | 0.95 | 0.90 | 0.80 | 0.80 | 0.83 | 2.8 | 1.7 | 1.6 | 1.5 | 1.5 | -0.2 | -1.8 | 0.0 | 0.4 | -0.3 |
| Natural gas | 3.47 | 11.17 | 11.11 | 11.00 | 11.62 | 10.4 | 20.9 | 22.5 | 21.2 | 20.6 | 5.2 | -0.1 | -0.1 | 0.6 | 0.1 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **36** | **35** | **39** | **40** | **41** | **-0.1** | **1.6** | **0.3** | **0.1** | **0.6** |
| Coal | 36 | 33 | 40 | 41 | 42 | -0.3 | 2.4 | 0.4 | 0.2 | 0.8 |
| Oil | 32 | 32 | 32 | 32 | 33 | 0.0 | -0.1 | 0.0 | 0.2 | 0.1 |
| Natural gas | 36 | 41 | 39 | 39 | 39 | 0.6 | -0.9 | 0.0 | 0.0 | -0.2 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **70.3** | **102.9** | **123.3** | **138.4** | **154.0** | **100** | **100** | **100** | **100** | **100** | **1.7** | **2.6** | **1.2** | **1.1** | **1.5** |
| Coal | 37.9 | 49.3 | 44.04 | 47.10 | 50.22 | 54.0 | 47.9 | 35.7 | 34.0 | 32.6 | 1.1 | -1.6 | 0.7 | 0.6 | 0.1 |
| Oil | 23.2 | 35.1 | 52.97 | 61.70 | 70.74 | 33.0 | 34.1 | 43.0 | 44.6 | 45.9 | 1.8 | 6.1 | 1.5 | 1.4 | 2.6 |
| Natural Gas | 9.2 | 18.6 | 26.29 | 29.62 | 33.04 | 13.1 | 18.0 | 21.3 | 21.4 | 21.5 | 3.1 | 5.1 | 1.2 | 1.1 | 2.2 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 427 | 867 | 1,026 | 1,313 | 1,681 | 3.1 | 2.4 | 2.5 | 2.5 | 2.5 |
| Population (millions of people) | 17 | 23 | 26 | 30 | 34 | 1.3 | 1.7 | 1.5 | 1.3 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 25.03 | 37.49 | 39.5 | 43.8 | 49.2 | 1.8 | 0.8 | 1.0 | 1.2 | 1.0 |
| Primary energy consumption per capita (toe/person) | 5.06 | 5.58 | 5.92 | 5.77 | 5.67 | 0.4 | 0.8 | -0.2 | -0.2 | 0.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 202 | 149 | 150 | 132 | 115 | -1.3 | 0.1 | -1.3 | -1.4 | -1.0 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 133 | 93 | 110 | 98 | 86 | -1.5 | 2.4 | -1.2 | -1.3 | -0.3 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 165 | 119 | 120 | 105 | 92 | -1.4 | 0.2 | -1.3 | -1.4 | -1.0 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.81 | 0.80 | 0.80 | 0.80 | 0.80 | -0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Automobile ownership volume (millions of vehicles) | 9.8 | 16.4 | 18.6 | 21.7 | 25.3 | 2.3 | 1.8 | 1.6 | 1.6 | 1.6 |
| Automobile ownership volume per capita (vehicles per person) | 0.57 | 0.71 | 0.72 | 0.72 | 0.74 | 0.9 | 0.2 | 0.1 | 0.3 | 0.2 |

# Brunei Darussalam [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.72** | **2.87** | **4.05** | **4.76** | **5.61** | **100** | **100** | **100** | **100** | **100** | **2.2** | **5.1** | **1.6** | **1.7** | **2.5** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.05 | 0.70 | 1.17 | 1.37 | 1.62 | 2.7 | 24.3 | 28.8 | 28.9 | 28.8 | 12.4 | 7.6 | 1.6 | 1.6 | 3.2 |
| Natural gas | 1.68 | 2.17 | 2.87 | 3.37 | 3.98 | 97.3 | 75.7 | 70.8 | 70.8 | 70.9 | 1.1 | 4.1 | 1.6 | 1.7 | 2.3 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.0 | 0.0 | 0.4 | 0.3 | 0.3 | - | 94.7 | 0.0 | 0.0 | 18.9 |
| Biomass | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.0 | 0.0 | 0.4 | 0.3 | 0.3 | - | - | 0.0 | 0.0 | - |
| Solar, Wind, Ocean | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.35** | **0.92** | **1.14** | **1.50** | **2.02** | **100** | **100** | **100** | **100** | **100** | **4.3** | **3.0** | **2.8** | **3.0** | **3.0** |
| Industry | 0.06 | 0.17 | 0.27 | 0.38 | 0.52 | 17.4 | 18.3 | 23.8 | 25.6 | 25.5 | 4.5 | 6.9 | 3.6 | 3.0 | 4.2 |
| Transportation | 0.19 | 0.45 | 0.48 | 0.59 | 0.72 | 53.6 | 48.4 | 42.4 | 39.0 | 35.4 | 3.8 | 1.1 | 2.0 | 2.0 | 1.8 |
| Others | 0.09 | 0.29 | 0.37 | 0.51 | 0.77 | 24.2 | 31.8 | 32.3 | 34.1 | 38.0 | 5.5 | 3.3 | 3.4 | 4.1 | 3.6 |
| Non-energy | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 4.8 | 1.5 | 1.6 | 1.3 | 1.1 | -0.8 | 3.5 | 1.2 | 1.1 | 1.8 |
| **Total** | **0.35** | **0.92** | **1.14** | **1.50** | **2.02** | **100** | **100** | **100** | **100** | **100** | **4.3** | **3.0** | **2.8** | **3.0** | **3.0** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.26 | 0.63 | 0.76 | 0.96 | 1.21 | 74.6 | 68.3 | 66.5 | 64.1 | 59.7 | 3.9 | 2.7 | 2.4 | 2.3 | 2.4 |
| Natural gas | 0.00 | 0.02 | 0.03 | 0.04 | 0.04 | 0.0 | 2.3 | 2.8 | 2.4 | 2.1 | - | 6.3 | 1.3 | 1.3 | 2.5 |
| Electricity | 0.09 | 0.27 | 0.35 | 0.50 | 0.77 | 24.9 | 29.4 | 30.7 | 33.5 | 38.3 | 5.1 | 3.7 | 3.7 | 4.4 | 4.0 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | -100.0 | - | - | - | - |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.17** | **3.93** | **5.09** | **7.04** | **10.47** | **100** | **100** | **100** | **100** | **100** | **5.4** | **3.8** | **3.3** | **4.1** | **3.7** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 | 0.9 | 1.0 | 0.0 | 0.0 | 0.0 | 5.5 | -100.0 | - | - | -100.0 |
| Natural gas | 1.16 | 3.89 | 5.04 | 7.00 | 10.43 | 99.1 | 99.0 | 99.1 | 99.4 | 99.6 | 5.4 | 3.8 | 3.3 | 4.1 | 3.7 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.05 | 0.05 | 0.05 | 0.0 | 0.0 | 0.9 | 0.6 | 0.4 | - | 60.4 | 0.0 | 0.0 | 13.0 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.46** | **1.22** | **1.44** | **1.93** | **2.52** | **100** | **100** | **100** | **100** | **100** | **4.3** | **2.3** | **3.0** | **2.7** | **2.7** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.6 | 0.9 | 0.0 | 0.0 | 0.0 | 5.7 | -100.0 | - | - | -100.0 |
| Natural gas | 0.46 | 1.21 | 1.44 | 1.93 | 2.52 | 99.4 | 99.1 | 100.0 | 100.0 | 100.0 | 4.3 | 2.5 | 3.0 | 2.7 | 2.8 |

**Thermal Efficiency**

| | % | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | | | | | | |
| **Total** | **22** | **28** | **30** | **31** | **36** | | | | | | **1.0** | **1.3** | **0.3** | **1.3** | **0.9** |
| Coal | - | - | - | - | - | | | | | | - | - | - | - | - |
| Oil | 32 | 30 | - | - | - | | | | | | -0.2 | - | - | - | - |
| Natural gas | 22 | 28 | 30 | 31 | 36 | | | | | | 1.0 | 1.3 | 0.3 | 1.3 | 0.9 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.88** | **1.88** | **2.61** | **3.10** | **3.69** | **100** | **100** | **100** | **100** | **100** | **3.3** | **4.8** | **1.7** | **1.8** | **2.5** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.20 | 0.52 | 0.79 | 0.96 | 1.16 | 22.4 | 27.8 | 30.2 | 30.9 | 31.5 | 4.3 | 6.1 | 2.0 | 1.9 | 3.0 |
| Natural Gas | 0.68 | 1.36 | 1.82 | 2.14 | 2.53 | 77.6 | 72.2 | 69.8 | 69.1 | 68.5 | 3.0 | 4.3 | 1.6 | 1.7 | 2.3 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 6.9 | 10.1 | 13.4 | 18.9 | 24.9 | 1.7 | 4.1 | 3.5 | 2.8 | 3.4 |
| Population (millions of people) | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 2.0 | 1.7 | 1.7 | 1.7 | 1.7 |
| GDP per capita (thousands of 2005 USD/person) | 26.8 | 24.9 | 29.4 | 35.0 | 39.0 | -0.3 | 2.4 | 1.7 | 1.1 | 1.7 |
| Primary energy consumption per capita (toe/person) | 6.7 | 7.1 | 8.9 | 8.8 | 8.8 | 0.2 | 3.4 | -0.1 | 0.0 | 0.8 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 250 | 284 | 302 | 252 | 225 | 0.6 | 0.9 | -1.8 | -1.1 | -0.8 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 51 | 91 | 85 | 80 | 81 | 2.6 | -1.0 | -0.6 | 0.2 | -0.4 |
| CO2 emissions per unit of GDP (t-C/million 2005 US Dollars) | 128 | 186 | 195 | 164 | 148 | 1.6 | 0.6 | -1.7 | -1.0 | -0.8 |
| CO2 emissions per unit of primary energy consumption (t-C/toe) | 0.5 | 0.7 | 0.6 | 0.7 | 0.7 | 1.1 | -0.3 | 0.1 | 0.1 | 0.0 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Brunei Darussalam [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1.72** | **2.87** | **3.11** | **3.65** | **4.47** | **100** | **100** | **100** | **100** | **100** | **2.2** | **1.2** | **1.6** | **2.0** | **1.7** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.05 | 0.70 | 0.53 | 0.71 | 0.94 | 2.7 | 24.3 | 17.1 | 19.6 | 21.0 | 12.4 | -3.8 | 3.0 | 2.8 | 1.1 |
| Natural gas | 1.68 | 2.17 | 2.53 | 2.86 | 3.43 | 97.3 | 75.7 | 81.3 | 78.5 | 76.8 | 1.1 | 2.2 | 1.3 | 1.8 | 1.7 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | - | - | - | 1.0 | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.05 | 0.07 | 0.10 | 0.0 | 0.0 | 1.5 | 1.9 | 2.2 | - | 129.0 | 3.8 | 3.6 | 27.3 |
| Biomass | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.0 | 0.0 | 1.0 | 0.8 | 0.7 | - | - | 0.0 | 0.0 | - |
| Solar, Wind, Ocean | 0.00 | 0.00 | 0.02 | 0.04 | 0.07 | 0.0 | 0.0 | 0.6 | 1.1 | 1.5 | - | 98.1 | 8.5 | 5.8 | 25.6 |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.35** | **0.92** | **0.84** | **1.12** | **1.56** | **100** | **100** | **100** | **100** | **100** | **4.3** | **-1.4** | **3.0** | **3.3** | **2.0** |
| Industry | 0.06 | 0.17 | 0.23 | 0.32 | 0.44 | 17.4 | 18.3 | 27.2 | 28.4 | 28.1 | 4.5 | 4.4 | 3.4 | 3.2 | 3.6 |
| Transportation | 0.19 | 0.45 | 0.29 | 0.38 | 0.49 | 53.6 | 48.4 | 35.0 | 34.0 | 31.4 | 3.8 | -5.8 | 2.7 | 2.5 | 0.3 |
| Others | 0.09 | 0.29 | 0.30 | 0.40 | 0.61 | 24.2 | 31.8 | 35.7 | 35.8 | 39.1 | 5.5 | 0.3 | 3.0 | 4.2 | 2.8 |
| Non-energy | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 4.8 | 1.5 | 2.0 | 1.7 | 1.4 | -0.8 | 2.8 | 1.2 | 1.1 | 1.6 |
| **Total** | **0.35** | **0.92** | **0.84** | **1.12** | **1.56** | **100** | **100** | **100** | **100** | **100** | **4.3** | **-1.4** | **3.0** | **3.3** | **2.0** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.26 | 0.63 | 0.52 | 0.69 | 0.90 | 74.6 | 68.3 | 62.6 | 61.7 | 57.8 | 3.9 | -2.6 | 2.8 | 2.7 | 1.3 |
| Natural gas | - | 0.02 | 0.03 | 0.04 | 0.04 | - | 2.3 | 3.9 | 3.3 | 2.7 | - | 6.3 | 1.3 | 1.3 | 2.5 |
| Electricity | 0.09 | 0.27 | 0.28 | 0.39 | 0.62 | 24.9 | 29.4 | 33.6 | 35.0 | 39.5 | 5.1 | 0.5 | 3.4 | 4.6 | 3.1 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | -100.0 | - | - | - | - |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1.17** | **3.93** | **4.22** | **5.64** | **8.46** | **100** | **100** | **100** | **100** | **100** | **5.4** | **1.0** | **3.0** | **4.1** | **2.9** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 | 0.9 | 1.0 | 0.0 | 0.0 | 0.0 | 5.5 | -100.0 | - | - | -100.0 |
| Natural gas | 1.16 | 3.89 | 3.93 | 5.07 | 7.56 | 99.1 | 99.0 | 93.2 | 90.0 | 89.3 | 5.4 | 0.1 | 2.6 | 4.1 | 2.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.0 | 0.0 | 0.0 | 0.03 | 0.03 | 0.0 | 0.0 | 0.0 | 0.5 | 0.3 | - | - | - | 1.0 | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.29 | 0.54 | 0.88 | 0.0 | 0.0 | 6.8 | 9.5 | 10.3 | - | 108.7 | 6.5 | 5.0 | 26.1 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.46** | **1.22** | **1.16** | **1.48** | **2.03** | **100** | **100** | **100** | **100** | **100** | **4.3** | **-0.8** | **2.5** | **3.2** | **1.9** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.6 | 0.9 | 0.0 | 0.0 | 0.0 | 5.7 | -100.0 | - | - | -100.0 |
| Natural gas | 0.46 | 1.21 | 1.16 | 1.48 | 2.03 | 99.4 | 99.1 | 100.0 | 100.0 | 100.0 | 4.3 | -0.7 | 2.5 | 3.2 | 1.9 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **21.8** | **27.7** | **29.2** | **29.5** | **32.0** | **1.0** | **0.8** | **0.1** | **0.8** | **0.5** |
| Coal | - | - | - | - | - | - | - | - | - | - |
| Oil | 32 | 30 | - | - | - | -0.2 | - | - | - | - |
| Natural gas | 22 | 28 | 29 | 29 | 32 | 1.0 | 0.8 | 0.1 | 0.8 | 0.5 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.9** | **1.9** | **2.0** | **2.4** | **2.9** | **100** | **100** | **100** | **100** | **100** | **3.3** | **1.1** | **1.6** | **2.1** | **1.7** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.2 | 0.5 | 0.4 | 0.6 | 0.8 | 22.4 | 27.8 | 21.2 | 24.1 | 25.7 | 4.3 | -2.7 | 2.9 | 2.7 | 1.4 |
| Natural Gas | 0.7 | 1.4 | 1.6 | 1.8 | 2.2 | 77.6 | 72.2 | 78.8 | 75.9 | 74.3 | 3.0 | 2.4 | 1.3 | 1.8 | 1.8 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 6.9 | 10.1 | 13.4 | 18.9 | 24.9 | 1.7 | 4.1 | 3.5 | 2.8 | 3.4 |
| Population (millions of people) | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 2.0 | 1.7 | 1.7 | 1.7 | 1.7 |
| GDP per capita (thousands of 2005 USD/person) | 26.8 | 24.9 | 29.4 | 35.0 | 39.0 | -0.3 | 2.4 | 1.7 | 1.1 | 1.7 |
| Primary energy consumption per capita (toe/person) | 6.7 | 7.1 | 6.8 | 6.8 | 7.0 | 0.2 | -0.5 | -0.1 | 0.3 | 0.0 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 250 | 284 | 232 | 193 | 180 | 0.6 | -2.8 | -1.8 | -0.7 | -1.7 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 51 | 91 | 63 | 60 | 63 | 2.6 | -5.3 | -0.5 | 0.5 | -1.4 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 128 | 186 | 152 | 127 | 118 | 1.6 | -2.9 | -1.8 | -0.7 | -1.7 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.5 | 0.7 | 0.7 | 0.7 | 0.7 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Cambodia [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **2.84** | **6.82** | **8.82** | **11.86** | **17.46** | **100** | **100** | **100** | **100** | **100** | **5.0** | **3.8** | **3.0** | **3.9** | **3.5** |
| Coal | - | 0.05 | 0.94 | 1.42 | 2.67 | - | 0.7 | 10.6 | 11.9 | 15.3 | - | 54.1 | 4.2 | 6.5 | 16.3 |
| Oil | 0.51 | 2.49 | 3.41 | 4.96 | 7.57 | 18.0 | 36.6 | 38.6 | 41.8 | 43.4 | 9.2 | 4.6 | 3.8 | 4.3 | 4.2 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.00 | 0.09 | 0.31 | 1.15 | 2.84 | 0.0 | 1.3 | 3.5 | 9.7 | 16.3 | - | 19.9 | 14.0 | 9.4 | 13.8 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 2.33 | 4.19 | 4.17 | 4.33 | 4.37 | 82.0 | 61.5 | 47.2 | 36.5 | 25.1 | 3.3 | -0.1 | 0.4 | 0.1 | 0.2 |
| Biomass | 2.33 | 4.00 | 4.17 | 4.33 | 4.37 | 82.0 | 58.6 | 47.2 | 36.5 | 25.1 | 3.1 | 0.6 | 0.4 | 0.1 | 0.3 |
| Solar, Wind, Ocean | - | 0.00 | 0.00 | 0.00 | 0.00 | - | 0.0 | 0.0 | 0.0 | 0.0 | - | - | 0.0 | 0.0 | - |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | 0.20 | 0.00 | 0.00 | 0.00 | - | 2.9 | 0.0 | 0.0 | 0.0 | - | -100.0 | - | - | -100.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **2.54** | **6.00** | **7.34** | **9.67** | **14.29** | **100** | **100** | **100** | **100** | **100** | **4.9** | **2.9** | **2.8** | **4.0** | **3.3** |
| Industry | 0.44 | 0.90 | 1.04 | 1.49 | 2.59 | 17.2 | 15.0 | 14.2 | 15.4 | 18.1 | 4.1 | 2.1 | 3.6 | 5.7 | 4.0 |
| Transportation | 0.38 | 1.95 | 2.48 | 3.58 | 6.15 | 15.0 | 32.5 | 33.8 | 37.0 | 43.0 | 9.5 | 3.5 | 3.7 | 5.6 | 4.3 |
| Others | 1.72 | 3.13 | 3.80 | 4.57 | 5.51 | 67.5 | 52.2 | 51.7 | 47.3 | 38.5 | 3.4 | 2.8 | 1.9 | 1.9 | 2.1 |
| Non-energy | 0.01 | 0.02 | 0.02 | 0.03 | 0.05 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 5.6 | 3.1 | 3.0 | 3.9 | 3.3 |
| **Total** | **2.54** | **6.00** | **7.34** | **9.67** | **14.29** | **100** | **100** | **100** | **100** | **100** | **4.9** | **2.9** | **2.8** | **4.0** | **3.3** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.44 | 2.29 | 3.19 | 4.43 | 7.02 | 17.3 | 38.2 | 43.4 | 45.8 | 49.1 | 9.6 | 4.8 | 3.3 | 4.7 | 4.2 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricity | 0.01 | 0.28 | 0.61 | 1.57 | 3.58 | 0.4 | 4.7 | 8.3 | 16.3 | 25.1 | 20.4 | 11.5 | 9.9 | 8.6 | 9.8 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 2.09 | 3.42 | 3.54 | 3.67 | 3.69 | 82.3 | 57.1 | 48.3 | 37.9 | 25.8 | 2.8 | 0.5 | 0.3 | 0.1 | 0.3 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.20** | **1.77** | **7.70** | **19.87** | **45.31** | **100** | **100** | **100** | **100** | **100** | **12.9** | **23.4** | **9.9** | **8.6** | **12.8** |
| Coal | - | 0.17 | 3.50 | 5.93 | 11.80 | - | 9.5 | 45.4 | 29.9 | 26.0 | - | 54.2 | 5.4 | 7.1 | 17.0 |
| Oil | 0.20 | 0.58 | 0.53 | 0.47 | 0.44 | 100.0 | 32.7 | 6.8 | 2.4 | 1.0 | 6.1 | -1.4 | -1.1 | -0.8 | -1.0 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.00 | 1.02 | 3.62 | 13.41 | 33.01 | 0.0 | 57.4 | 47.0 | 67.5 | 72.9 | - | 19.9 | 14.0 | 9.4 | 13.8 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.01 | 0.06 | 0.06 | 0.06 | 0.0 | 0.4 | 0.8 | 0.3 | 0.1 | - | 36.1 | 0.0 | 0.0 | 8.3 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.10** | **0.20** | **1.08** | **1.54** | **2.79** | **100** | **100** | **100** | **100** | **100** | **3.9** | **27.3** | **3.6** | **6.1** | **10.3** |
| Coal | - | 0.05 | 0.94 | 1.42 | 2.67 | - | 22.9 | 87.1 | 91.9 | 95.9 | - | 54.1 | 4.2 | 6.5 | 16.3 |
| Oil | 0.10 | 0.15 | 0.14 | 0.13 | 0.12 | 100.0 | 77.1 | 12.9 | 8.1 | 4.1 | 2.5 | -1.4 | -1.1 | -0.8 | -1.0 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **17** | **32** | **32** | **36** | **38** | **3.6** | **-0.1** | **1.1** | **0.6** | **0.6** |
| Coal | - | 32 | 32 | 36 | 38 | - | 0.1 | 1.2 | 0.5 | 0.7 |
| Oil | 17 | 33 | 33 | 33 | 33 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | - | - | - | - | - | - | - | - | - | - |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.40** | **1.96** | **3.62** | **5.13** | **8.62** | **100** | **100** | **100** | **100** | **100** | **9.3** | **9.1** | **3.5** | **5.3** | **5.6** |
| Coal | - | 0.05 | 1.03 | 1.56 | 2.93 | - | 2.5 | 28.5 | 30.4 | 34.0 | - | 54.1 | 4.2 | 6.5 | 16.3 |
| Oil | 0.40 | 1.91 | 2.59 | 3.57 | 5.69 | 100.0 | 97.5 | 71.5 | 69.6 | 66.0 | 9.1 | 4.4 | 3.3 | 4.8 | 4.1 |
| Natural Gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 2.8 | 10.7 | 17.6 | 32.4 | 52.7 | 7.7 | 7.3 | 6.3 | 5.0 | 6.1 |
| Population (millions of people) | 10.7 | 15.1 | 17.1 | 20.0 | 23.4 | 1.9 | 1.8 | 1.6 | 1.6 | 1.6 |
| GDP per capita (thousands of 2005 USD/person) | 0.26 | 0.71 | 1.0 | 1.6 | 2.3 | 5.6 | 5.4 | 4.6 | 3.3 | 4.4 |
| Primary energy consumption per capita (toe/person) | 0.27 | 0.45 | 0.52 | 0.59 | 0.75 | 3.0 | 1.9 | 1.4 | 2.3 | 1.9 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,002 | 636 | 502 | 366 | 331 | -2.5 | -3.3 | -3.1 | -1.0 | -2.4 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 899 | 560 | 418 | 299 | 271 | -2.6 | -4.1 | -3.3 | -1.0 | -2.6 |
| CO2 emissions per unit of GDP (t-C/million 2005 US Dollars) | 140 | 183 | 206 | 158 | 164 | 1.5 | 1.7 | -2.6 | 0.3 | -0.4 |
| CO2 emissions per unit of primary energy consumption (t-C/toe) | 0.14 | 0.29 | 0.41 | 0.43 | 0.49 | 4.1 | 5.2 | 0.5 | 1.3 | 2.0 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Cambodia [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **2.84** | **6.82** | **8.43** | **11.05** | **15.51** | **100** | **100** | **100** | **100** | **100** | **5.0** | **3.1** | **2.7** | **3.4** | **3.1** |
| Coal | - | 0.05 | 0.89 | 2.04 | 3.12 | 0.0 | 0.7 | 10.5 | 18.5 | 20.1 | - | 52.8 | 8.7 | 4.3 | 17.0 |
| Oil | 0.51 | 2.49 | 3.26 | 4.44 | 6.58 | 18.0 | 36.6 | 38.6 | 40.2 | 42.4 | 9.2 | 3.9 | 3.2 | 4.0 | 3.7 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | 0.09 | 0.29 | 0.71 | 2.06 | 0.0 | 1.3 | 3.5 | 6.4 | 13.3 | - | 18.9 | 9.2 | 11.3 | 12.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 2.33 | 4.19 | 4.00 | 3.86 | 3.75 | 82.0 | 61.5 | 47.4 | 34.9 | 24.2 | 3.3 | -0.7 | -0.4 | -0.3 | -0.4 |
| Biomass | 2.33 | 4.00 | 4.00 | 3.86 | 3.75 | 82.0 | 58.6 | 47.4 | 34.9 | 24.2 | 3.1 | 0.0 | -0.4 | -0.3 | -0.2 |
| Solar, Wind, Ocean | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | 0.0 | 0.0 | - |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | 0.20 | 0.00 | 0.00 | 0.00 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | - | -100.0 | - | - | -100.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **2.54** | **6.00** | **7.00** | **8.57** | **12.18** | **100** | **100** | **100** | **100** | **100** | **4.9** | **2.2** | **2.0** | **3.6** | **2.7** |
| Industry | 0.44 | 0.90 | 0.99 | 1.31 | 2.20 | 17.2 | 15.0 | 14.2 | 15.3 | 18.1 | 4.1 | 1.4 | 2.9 | 5.3 | 3.4 |
| Transportation | 0.38 | 1.95 | 2.37 | 3.18 | 5.25 | 15.0 | 32.5 | 33.9 | 37.1 | 43.1 | 9.5 | 2.8 | 3.0 | 5.1 | 3.7 |
| Others | 1.72 | 3.13 | 3.61 | 4.04 | 4.68 | 67.5 | 52.2 | 51.7 | 47.2 | 38.5 | 3.4 | 2.1 | 1.1 | 1.5 | 1.5 |
| Non-energy | 0.01 | 0.02 | 0.02 | 0.03 | 0.05 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 5.6 | 3.1 | 3.0 | 3.8 | 3.3 |
| **Total** | **2.54** | **6.00** | **7.00** | **8.57** | **12.18** | **100** | **100** | **100** | **100** | **100** | **4.9** | **2.2** | **2.0** | **3.6** | **2.7** |
| Coal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Oil | 0.44 | 2.29 | 3.04 | 3.94 | 5.99 | 17.3 | 38.2 | 43.5 | 46.0 | 49.2 | 9.6 | 4.1 | 2.6 | 4.3 | 3.6 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricity | 0.01 | 0.28 | 0.58 | 1.39 | 3.05 | 0.4 | 4.7 | 8.3 | 16.2 | 25.0 | 20.4 | 10.7 | 9.1 | 8.2 | 9.2 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 2.09 | 3.42 | 3.37 | 3.24 | 3.14 | 82.3 | 57.1 | 48.2 | 37.8 | 25.8 | 2.8 | -0.2 | -0.4 | -0.3 | -0.3 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.20** | **1.77** | **7.33** | **17.57** | **38.51** | **100** | **100** | **100** | **100** | **100** | **12.9** | **22.5** | **9.1** | **8.2** | **12.1** |
| Coal | - | 0.17 | 3.30 | 8.88 | 13.93 | 0.0 | 9.5 | 45.0 | 50.5 | 36.2 | - | 52.9 | 10.4 | 4.6 | 17.8 |
| Oil | 0.20 | 0.58 | 0.50 | 0.35 | 0.52 | 100.0 | 32.7 | 6.8 | 2.0 | 1.3 | 6.1 | -2.2 | -3.4 | 3.9 | -0.4 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | 1.02 | 3.41 | 8.21 | 23.94 | 0.0 | 57.4 | 46.5 | 46.7 | 62.2 | - | 18.9 | 9.2 | 11.3 | 12.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | - | 0.01 | 0.13 | 0.13 | 0.13 | 0.0 | 0.4 | 1.7 | 0.7 | 0.3 | - | 52.5 | 0.0 | 0.0 | 11.6 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.10** | **0.20** | **1.02** | **2.14** | **3.26** | **100** | **100** | **100** | **100** | **100** | **3.9** | **26.3** | **7.7** | **4.3** | **10.9** |
| Coal | - | 0.046 | 0.886 | 2.044 | 3.121 | 0.0 | 22.9 | 87.1 | 95.6 | 95.8 | - | 52.8 | 8.7 | 4.3 | 17.0 |
| Oil | 0.10 | 0.153 | 0.131 | 0.093 | 0.136 | 100.0 | 77.1 | 12.9 | 4.4 | 4.2 | 2.5 | -2.2 | -3.4 | 3.9 | -0.4 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **17.2** | **32.4** | **32.1** | **37.1** | **38.1** | **3.6** | **-0.1** | **1.5** | **0.3** | **0.6** |
| Coal | - | 32 | 32 | 37 | 38 | - | 0.1 | 1.6 | 0.3 | 0.7 |
| Oil | 17 | 33 | 33 | 33 | 33 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | - | - | - | - | - | - | - | - | - | - |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.40** | **1.96** | **3.44** | **4.31** | **6.73** | **100** | **100** | **100** | **100** | **100** | **9.3** | **8.4** | **2.3** | **4.5** | **4.7** |
| Coal | - | 0.05 | 0.97 | 1.16 | 1.84 | 0.0 | 2.5 | 28.3 | 26.9 | 27.3 | - | 52.8 | 1.8 | 4.7 | 14.3 |
| Oil | 0.40 | 1.91 | 2.47 | 3.16 | 4.89 | 100.0 | 97.5 | 71.7 | 73.1 | 72.7 | 9.1 | 3.7 | 2.5 | 4.5 | 3.5 |
| Natural Gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1995 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 2.8 | 10.7 | 17.6 | 32.4 | 52.7 | 7.7 | 7.3 | 6.3 | 5.0 | 6.1 |
| Population (millions of people) | 10.7 | 15.1 | 17.1 | 20.0 | 23.4 | 1.9 | 1.8 | 1.6 | 1.6 | 1.6 |
| GDP per capita (thousands of 2005 USD/person) | 0.26 | 0.71 | 1.0 | 1.6 | 2.3 | 5.6 | 5.4 | 4.6 | 3.3 | 4.4 |
| Primary energy consumption per capita (toe/person) | 0.27 | 0.45 | 0.49 | 0.55 | 0.66 | 3.0 | 1.3 | 1.1 | 1.8 | 1.4 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,002 | 636 | 480 | 341 | 294 | -2.5 | -3.9 | -3.3 | -1.5 | -2.8 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 899 | 560 | 398 | 265 | 231 | -2.6 | -4.7 | -4.0 | -1.4 | -3.2 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 140 | 183 | 196 | 133 | 128 | 1.5 | 1.0 | -3.8 | -0.4 | -1.3 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.14 | 0.29 | 0.41 | 0.39 | 0.43 | 4.1 | 5.1 | -0.4 | 1.1 | 1.5 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# China [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **870.7** | **3,021.9** | **3,532.8** | **4,191.5** | **4,544.8** | **100** | **100** | **100** | **100** | **100** | **5.6** | **2.3** | **1.7** | **0.8** | **1.5** |
| Coal | 527.6 | 2,044.9 | 2,225.2 | 2,436.3 | 2,458.5 | 60.6 | 67.7 | 63.0 | 58.1 | 54.1 | 6.1 | 1.2 | 0.9 | 0.1 | 0.7 |
| Oil | 118.8 | 478.3 | 624.6 | 791.2 | 880.1 | 13.6 | 15.8 | 17.7 | 18.9 | 19.4 | 6.2 | 3.9 | 2.4 | 1.1 | 2.3 |
| Natural gas | 12.8 | 140.2 | 209.7 | 389.9 | 534.2 | 1.5 | 4.6 | 5.9 | 9.3 | 11.8 | 11.0 | 5.9 | 6.4 | 3.2 | 5.1 |
| Nuclear | 0.0 | 29.1 | 102.4 | 162.3 | 222.3 | 0.0 | 1.0 | 2.9 | 3.9 | 4.9 | - | 19.7 | 4.7 | 3.2 | 7.8 |
| Hydro | 10.9 | 78.2 | 99.0 | 104.3 | 108.8 | 1.3 | 2.6 | 2.8 | 2.5 | 2.4 | 8.9 | 3.4 | 0.5 | 0.4 | 1.2 |
| Geothermal | 0.0 | 4.5 | 6.4 | 8.6 | 10.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.2 | - | 5.1 | 3.1 | 1.5 | 3.0 |
| Others | 200.6 | 246.7 | 265.6 | 298.9 | 331.0 | 23.0 | 8.2 | 7.5 | 7.1 | 7.3 | 0.9 | 1.1 | 1.2 | 1.0 | 1.1 |
| Biomass | 200.4 | 214.0 | 215.5 | 219.4 | 216.2 | 23.0 | 7.1 | 6.1 | 5.2 | 4.8 | 0.3 | 0.1 | 0.2 | -0.1 | 0.0 |
| Solar, Wind, Ocean | 0.0 | 32.0 | 48.3 | 76.2 | 109.5 | 0.0 | 1.1 | 1.4 | 1.8 | 2.4 | 34.9 | 6.0 | 4.7 | 3.7 | 4.7 |
| Biofuels | 0.0 | 1.7 | 2.8 | 4.3 | 6.3 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | - | 7.2 | 4.5 | 4.1 | 5.0 |
| Electricit | 0.2 | -1.0 | -1.0 | -1.0 | -1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -208.4 | 0.0 | 0.0 | 0.0 | 0.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **664.2** | **1,814.1** | **2,162.3** | **2,548.0** | **2,770.9** | **100** | **100** | **100** | **100** | **100** | **4.5** | **2.5** | **1.7** | **0.8** | **1.6** |
| Industry | 243.7 | 878.0 | 990.1 | 1,079.3 | 1,097.2 | 36.7 | 48.4 | 45.8 | 42.4 | 39.6 | 5.7 | 1.7 | 0.9 | 0.2 | 0.8 |
| Transportation | 33.5 | 245.5 | 347.4 | 482.9 | 558.9 | 5.0 | 13.5 | 16.1 | 19.0 | 20.2 | 9.1 | 5.1 | 3.3 | 1.5 | 3.1 |
| Others | 344.1 | 547.8 | 648.7 | 777.9 | 879.5 | 51.8 | 30.2 | 30.0 | 30.5 | 31.7 | 2.0 | 2.4 | 1.8 | 1.2 | 1.8 |
| Non-energy | 42.9 | 142.8 | 176.1 | 208.0 | 235.2 | 6.5 | 7.9 | 8.1 | 8.2 | 8.5 | 5.4 | 3.0 | 1.7 | 1.2 | 1.9 |
| **Total** | **664.2** | **1,814.1** | **2,162.3** | **2,548.0** | **2,770.9** | **100** | **100** | **100** | **100** | **100** | **4.5** | **2.5** | **1.7** | **0.8** | **1.6** |
| Coal | 318.1 | 603.2 | 624.8 | 587.0 | 528.2 | 47.9 | 33.3 | 28.9 | 23.0 | 19.1 | 2.8 | 0.5 | -0.6 | -1.0 | -0.5 |
| Oil | 84.6 | 434.5 | 575.7 | 731.9 | 815.9 | 12.7 | 24.0 | 26.6 | 28.7 | 29.4 | 7.4 | 4.1 | 2.4 | 1.1 | 2.4 |
| Natural gas | 8.9 | 93.8 | 147.0 | 237.9 | 325.7 | 1.3 | 5.2 | 6.8 | 9.3 | 11.8 | 10.8 | 6.6 | 4.9 | 3.2 | 4.7 |
| Electricity | 39.0 | 386.3 | 507.0 | 670.4 | 774.5 | 5.9 | 21.3 | 23.4 | 26.3 | 28.0 | 10.5 | 4.0 | 2.8 | 1.5 | 2.6 |
| Heat | 13.2 | 76.2 | 89.6 | 99.2 | 101.2 | 2.0 | 4.2 | 4.1 | 3.9 | 3.7 | 7.9 | 2.3 | 1.0 | 0.2 | 1.1 |
| Others | 200.4 | 220.0 | 218.2 | 221.5 | 225.4 | 30.2 | 12.1 | 10.1 | 8.7 | 8.1 | 0.4 | -0.1 | 0.2 | 0.2 | 0.1 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **621.3** | **5,422.2** | **7,017.0** | **9,184.9** | **10,535.5** | **100** | **100** | **100** | **100** | **100** | **9.9** | **3.8** | **2.7** | **1.4** | **2.5** |
| Coal | 441.4 | 4,090.5 | 4,925.2 | 6,237.4 | 6,819.4 | 71.0 | 75.4 | 70.2 | 67.9 | 64.7 | 10.2 | 2.7 | 2.4 | 0.9 | 1.9 |
| Oil | 50.4 | 6.6 | 6.5 | 6.3 | 6.2 | 8.1 | 0.1 | 0.1 | 0.1 | 0.1 | -8.5 | -0.3 | -0.2 | -0.2 | -0.2 |
| Natural gas | 2.8 | 99.3 | 160.4 | 480.8 | 729.0 | 0.4 | 1.8 | 2.3 | 5.2 | 6.9 | 16.9 | 7.1 | 11.6 | 4.3 | 7.7 |
| Nuclear | 0.0 | 111.6 | 392.8 | 622.9 | 853.0 | 0.0 | 2.1 | 5.6 | 6.8 | 8.1 | - | 19.7 | 4.7 | 3.2 | 7.8 |
| Hydro | 126.7 | 909.2 | 1,151.1 | 1,212.8 | 1,264.7 | 20.4 | 16.8 | 16.4 | 13.2 | 12.0 | 8.9 | 3.4 | 0.5 | 0.4 | 1.2 |
| Geothermal | 0.1 | 0.1 | 0.3 | 0.3 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 14.6 | 1.5 | 1.4 | 4.7 |
| Others | 0.0 | 204.8 | 380.8 | 624.2 | 862.8 | 0.0 | 3.8 | 5.4 | 6.8 | 8.2 | 53.3 | 9.3 | 5.1 | 3.3 | 5.5 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **144.7** | **949.3** | **1,141.9** | **1,480.0** | **1,629.7** | **100** | **100** | **100** | **100** | **100** | **8.5** | **2.7** | **2.6** | **1.0** | **2.0** |
| Coal | 131.8 | 925.8 | 1,107.6 | 1,390.2 | 1,506.4 | 91.0 | 97.5 | 97.0 | 93.9 | 92.4 | 8.8 | 2.6 | 2.3 | 0.8 | 1.8 |
| Oil | 12.4 | 1.6 | 1.5 | 1.5 | 1.4 | 8.5 | 0.2 | 0.1 | 0.1 | 0.1 | -8.5 | -0.7 | -0.4 | -0.3 | -0.4 |
| Natural gas | 0.6 | 22.0 | 32.7 | 88.3 | 121.9 | 0.4 | 2.3 | 2.9 | 6.0 | 7.5 | 16.9 | 5.9 | 10.4 | 3.3 | 6.6 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **29** | **38** | **38** | **39** | **40** | **1.1** | **0.1** | **0.2** | **0.2** | **0.2** |
| Coal | 29 | 38 | 38 | 39 | 39 | 1.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Oil | 35 | 35 | 36 | 37 | 37 | 0.0 | 0.4 | 0.2 | 0.2 | 0.2 |
| Natural gas | 39 | 39 | 42 | 47 | 51 | 0.0 | 1.2 | 1.1 | 1.0 | 1.0 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **637.8** | **2,573.7** | **2,907.1** | **3,364.0** | **3,533.5** | **100** | **100** | **100** | **100** | **100** | **6.3** | **1.8** | **1.5** | **0.5** | **1.2** |
| Coal | 549.0 | 2,170.2 | 2,358.8 | 2,581.5 | 2,601.3 | 86.1 | 84.3 | 81.1 | 76.7 | 73.6 | 6.2 | 1.2 | 0.9 | 0.1 | 0.7 |
| Oil | 83.5 | 323.9 | 427.3 | 552.2 | 617.0 | 13.1 | 12.6 | 14.7 | 16.4 | 17.5 | 6.1 | 4.0 | 2.6 | 1.1 | 2.4 |
| Natural Gas | 5.3 | 79.6 | 121.0 | 230.3 | 315.2 | 0.8 | 3.1 | 4.2 | 6.8 | 8.9 | 12.5 | 6.2 | 6.6 | 3.2 | 5.2 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 531 | 4,913 | 7,471 | 12,297 | 17,684 | 10.2 | 6.2 | 5.1 | 3.7 | 4.9 |
| Population (millions of people) | 1,143 | 1,361 | 1,418 | 1,450 | 1,428 | 0.8 | 0.6 | 0.2 | -0.1 | 0.2 |
| GDP per capita (thousands of 2005 USD/person) | 0.46 | 3.61 | 5.3 | 8.5 | 12.4 | 9.3 | 5.5 | 4.9 | 3.9 | 4.7 |
| Primary energy consumption per capita (toe/person) | 0.76 | 2.22 | 2.49 | 2.89 | 3.18 | 4.8 | 1.7 | 1.5 | 1.0 | 1.3 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,641 | 615 | 473 | 341 | 257 | -4.2 | -3.7 | -3.2 | -2.8 | -3.2 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,252 | 369 | 289 | 207 | 157 | -5.2 | -3.4 | -3.3 | -2.8 | -3.1 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 1,202 | 524 | 389 | 274 | 200 | -3.5 | -4.2 | -3.5 | -3.1 | -3.5 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.73 | 0.85 | 0.82 | 0.80 | 0.78 | 0.7 | -0.5 | -0.2 | -0.3 | -0.3 |
| Automobile ownership volume (millions of vehicles) | 5.3 | 126.7 | 247.7 | 354.7 | 420.9 | 14.8 | 10.1 | 3.7 | 1.7 | 4.5 |
| Automobile ownership volume per capita (vehicles per person) | 0.00 | 0.09 | 0.17 | 0.24 | 0.29 | 13.9 | 9.4 | 3.4 | 1.9 | 4.4 |

# China [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **870.7** | **3,021.9** | **3,348.6** | **3,720.6** | **3,810.3** | **100** | **100** | **100** | **100** | **100** | **5.6** | **1.5** | **1.1** | **0.2** | **0.9** |
| Coal | 527.6 | 2,044.9 | 2,045.2 | 1,982.7 | 1,759.6 | 60.6 | 67.7 | 61.1 | 53.3 | 46.2 | 6.1 | 0.0 | -0.3 | -1.2 | -0.6 |
| Oil | 118.8 | 478.3 | 599.9 | 722.2 | 763.3 | 13.6 | 15.8 | 17.9 | 19.4 | 20.0 | 6.2 | 3.3 | 1.9 | 0.6 | 1.7 |
| Natural gas | 12.8 | 140.2 | 199.1 | 340.4 | 439.2 | 1.5 | 4.6 | 5.9 | 9.1 | 11.5 | 11.0 | 5.1 | 5.5 | 2.6 | 4.3 |
| Nuclear | 0.0 | 29.1 | 117.4 | 236.2 | 354.9 | 0.0 | 1.0 | 3.5 | 6.3 | 9.3 | - | 22.1 | 7.2 | 4.2 | 9.7 |
| Hydro | 10.9 | 78.2 | 107.2 | 115.0 | 122.0 | 1.3 | 2.6 | 3.2 | 3.1 | 3.2 | 8.9 | 4.6 | 0.7 | 0.6 | 1.7 |
| Geothermal | 0.0 | 4.5 | 6.4 | 8.7 | 10.2 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | - | 5.1 | 3.2 | 1.5 | 3.1 |
| Others | 200.6 | 246.7 | 273.3 | 315.4 | 361.2 | 23.0 | 8.2 | 8.2 | 8.5 | 9.5 | 0.9 | 1.5 | 1.4 | 1.4 | 1.4 |
| Biomass | 200.4 | 214.0 | 215.4 | 211.5 | 200.9 | 23.0 | 7.1 | 6.4 | 5.7 | 5.3 | 0.3 | 0.1 | -0.2 | -0.5 | -0.2 |
| Solar, Wind, Ocean | 0.0 | 32.0 | 55.7 | 92.8 | 136.3 | 0.0 | 1.1 | 1.7 | 2.5 | 3.6 | 34.9 | 8.2 | 5.2 | 3.9 | 5.5 |
| Biofuels | 0.0 | 1.7 | 3.2 | 12.2 | 25.1 | 0.0 | 0.1 | 0.1 | 0.3 | 0.7 | - | 9.6 | 14.2 | 7.5 | 10.5 |
| Electricit | 0.2 | -1.0 | -1.0 | -1.0 | -1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -208.4 | 0.0 | 0.0 | 0.0 | 0.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **664.2** | **1,814.1** | **2,073.1** | **2,316.3** | **2,416.6** | **100** | **100** | **100** | **100** | **100** | **4.5** | **1.9** | **1.1** | **0.4** | **1.1** |
| Industry | 243.7 | 878.0 | 938.8 | 956.7 | 951.0 | 36.7 | 48.4 | 45.3 | 41.3 | 39.4 | 5.7 | 1.0 | 0.2 | -0.1 | 0.3 |
| Transportation | 33.5 | 245.5 | 335.1 | 451.6 | 503.7 | 5.0 | 13.5 | 16.2 | 19.5 | 20.8 | 9.1 | 4.5 | 3.0 | 1.1 | 2.7 |
| Others | 344.1 | 547.8 | 623.1 | 700.0 | 726.7 | 51.8 | 30.2 | 30.1 | 30.2 | 30.1 | 2.0 | 1.9 | 1.2 | 0.4 | 1.1 |
| Non-energy | 42.9 | 142.8 | 176.1 | 208.0 | 235.2 | 6.5 | 7.9 | 8.5 | 9.0 | 9.7 | 5.4 | 3.0 | 1.7 | 1.2 | 1.9 |
| **Total** | **664.2** | **1,814.1** | **2,073.1** | **2,316.3** | **2,416.6** | **100** | **100** | **100** | **100** | **100** | **4.5** | **1.9** | **1.1** | **0.4** | **1.1** |
| Coal | 318.1 | 603.2 | 595.3 | 521.1 | 445.3 | 47.9 | 33.3 | 28.7 | 22.5 | 18.4 | 2.8 | -0.2 | -1.3 | -1.6 | -1.1 |
| Oil | 84.6 | 434.5 | 553.2 | 668.8 | 708.9 | 12.7 | 24.0 | 26.7 | 28.9 | 29.3 | 7.4 | 3.5 | 1.9 | 0.6 | 1.8 |
| Natural gas | 8.9 | 93.8 | 142.5 | 222.5 | 299.9 | 1.3 | 5.2 | 6.9 | 9.6 | 12.4 | 10.8 | 6.2 | 4.6 | 3.0 | 4.4 |
| Electricity | 39.0 | 386.3 | 484.8 | 601.4 | 653.9 | 5.9 | 21.3 | 23.4 | 26.0 | 27.1 | 10.5 | 3.3 | 2.2 | 0.8 | 2.0 |
| Heat | 13.2 | 76.2 | 85.4 | 89.3 | 87.7 | 2.0 | 4.2 | 4.1 | 3.9 | 3.6 | 7.9 | 1.6 | 0.5 | -0.2 | 0.5 |
| Others | 200.4 | 220.0 | 211.9 | 213.2 | 220.9 | 30.2 | 12.1 | 10.2 | 9.2 | 9.1 | 0.4 | -0.5 | 0.1 | 0.4 | 0.0 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **621.3** | **5,422.2** | **6,709.9** | **8,239.2** | **8,895.0** | **100** | **100** | **100** | **100** | **100** | **9.9** | **3.1** | **2.1** | **0.8** | **1.9** |
| Coal | 441.4 | 4,090.5 | 4,376.8 | 4,779.1 | 4,436.1 | 71.0 | 75.4 | 65.2 | 58.0 | 49.9 | 10.2 | 1.0 | 0.9 | -0.7 | 0.3 |
| Oil | 50.4 | 6.6 | 6.5 | 6.3 | 6.2 | 8.1 | 0.1 | 0.1 | 0.1 | 0.1 | -8.5 | -0.3 | -0.2 | -0.2 | -0.2 |
| Natural gas | 2.8 | 99.3 | 142.6 | 368.5 | 474.5 | 0.4 | 1.8 | 2.1 | 4.5 | 5.3 | 16.9 | 5.3 | 10.0 | 2.6 | 6.0 |
| Nuclear | 0.0 | 111.6 | 450.7 | 906.2 | 1,361.7 | 0.0 | 2.1 | 6.7 | 11.0 | 15.3 | - | 22.1 | 7.2 | 4.2 | 9.7 |
| Hydro | 126.7 | 909.2 | 1,247.0 | 1,337.2 | 1,418.0 | 20.4 | 16.8 | 18.6 | 16.2 | 15.9 | 8.9 | 4.6 | 0.7 | 0.6 | 1.7 |
| Geothermal | 0.1 | 0.1 | 0.3 | 0.4 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.9 | 15.0 | 3.7 | 2.6 | 6.1 |
| Others | 0.0 | 204.8 | 486.2 | 841.4 | 1,197.9 | 0.0 | 3.8 | 7.2 | 10.2 | 13.5 | 53.3 | 13.1 | 5.6 | 3.6 | 6.8 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **144.7** | **949.3** | **1,012.2** | **1,125.6** | **1,047.3** | **100** | **100** | **100** | **100** | **100** | **8.5** | **0.9** | **1.1** | **-0.7** | **0.4** |
| Coal | 131.8 | 925.8 | 981.9 | 1,058.4 | 969.9 | 91.0 | 97.5 | 97.0 | 94.0 | 92.6 | 8.8 | 0.8 | 0.8 | -0.9 | 0.2 |
| Oil | 12.4 | 1.6 | 1.5 | 1.4 | 1.3 | 8.5 | 0.2 | 0.1 | 0.1 | 0.1 | -8.5 | -0.9 | -0.6 | -0.6 | -0.7 |
| Natural gas | 0.6 | 22.0 | 28.7 | 65.8 | 76.0 | 0.4 | 2.3 | 2.8 | 5.8 | 7.3 | 16.9 | 3.9 | 8.6 | 1.5 | 4.7 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **29** | **38** | **38** | **39** | **40** | **1.1** | **0.2** | **0.2** | **0.3** | **0.2** |
| Coal | 29 | 38 | 38 | 39 | 39 | 1.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Oil | 35 | 35 | 37 | 38 | 40 | 0.0 | 0.7 | 0.4 | 0.4 | 0.5 |
| Natural gas | 39 | 39 | 43 | 48 | 54 | 0.0 | 1.3 | 1.2 | 1.1 | 1.2 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **637.8** | **2,573.7** | **2,685.3** | **2,784.8** | **2,620.1** | **100** | **100** | **100** | **100** | **100** | **6.3** | **0.6** | **0.4** | **-0.6** | **0.1** |
| Coal | 549.0 | 2,170.2 | 2,164.3 | 2,091.7 | 1,846.5 | 86.1 | 84.3 | 80.6 | 75.1 | 70.5 | 6.2 | 0.0 | -0.3 | -1.2 | -0.6 |
| Oil | 83.5 | 323.9 | 406.7 | 494.5 | 519.2 | 13.1 | 12.6 | 15.1 | 17.8 | 19.8 | 6.1 | 3.3 | 2.0 | 0.5 | 1.8 |
| Natural Gas | 5.3 | 79.6 | 114.2 | 198.6 | 254.3 | 0.8 | 3.1 | 4.3 | 7.1 | 9.7 | 12.5 | 5.3 | 5.7 | 2.5 | 4.4 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 531 | 4,913 | 7,471 | 12,297 | 17,684 | 10.2 | 6.2 | 5.1 | 3.7 | 4.9 |
| Population (millions of people) | 1,143 | 1,361 | 1,418 | 1,450 | 1,428 | 0.8 | 0.6 | 0.2 | -0.1 | 0.2 |
| GDP per capita (thousands of 2005 USD/person) | 0.46 | 3.61 | 5.3 | 8.5 | 12.4 | 9.3 | 5.5 | 4.9 | 3.9 | 4.7 |
| Primary energy consumption per capita (toe/person) | 0.76 | 2.22 | 2.36 | 2.57 | 2.67 | 4.8 | 0.9 | 0.8 | 0.4 | 0.7 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,641 | 615 | 448 | 303 | 215 | -4.2 | -4.4 | -3.9 | -3.3 | -3.8 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,252 | 369 | 278 | 188 | 137 | -5.2 | -4.0 | -3.8 | -3.2 | -3.6 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 1,202 | 524 | 359 | 226 | 148 | -3.5 | -5.2 | -4.5 | -4.2 | -4.6 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.73 | 0.85 | 0.80 | 0.75 | 0.69 | 0.7 | -0.9 | -0.7 | -0.8 | -0.8 |
| Automobile ownership volume (millions of vehicles) | 5.3 | 126.7 | 247.7 | 354.7 | 420.9 | 14.8 | 10.1 | 3.7 | 1.7 | 4.5 |
| Automobile ownership volume per capita (vehicles per person) | 0.00 | 0.09 | 0.17 | 0.24 | 0.29 | 13.9 | 9.4 | 3.4 | 1.9 | 4.4 |

# India [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **306.6** | **775.4** | **1,080.7** | **1,617.6** | **2,281.1** | **100** | **100** | **100** | **100** | **100** | **4.1** | **4.9** | **4.1** | **3.5** | **4.1** |
| Coal | 93.6 | 341.4 | 502.2 | 780.9 | 1,128.9 | 30.5 | 44.0 | 46.5 | 48.3 | 49.5 | 5.8 | 5.7 | 4.5 | 3.8 | 4.5 |
| Oil | 61.1 | 175.9 | 259.2 | 401.8 | 566.5 | 19.9 | 22.7 | 24.0 | 24.8 | 24.8 | 4.7 | 5.7 | 4.5 | 3.5 | 4.4 |
| Natural gas | 10.6 | 44.5 | 65.9 | 108.9 | 170.0 | 3.4 | 5.7 | 6.1 | 6.7 | 7.5 | 6.4 | 5.8 | 5.1 | 4.6 | 5.1 |
| Nuclear | 1.6 | 8.9 | 18.9 | 49.3 | 80.3 | 0.5 | 1.2 | 1.7 | 3.0 | 3.5 | 7.8 | 11.3 | 10.1 | 5.0 | 8.5 |
| Hydro | 6.2 | 12.2 | 16.0 | 23.7 | 35.1 | 2.0 | 1.6 | 1.5 | 1.5 | 1.5 | 3.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 133.6 | 192.6 | 218.5 | 253.0 | 300.3 | 43.6 | 24.8 | 20.2 | 15.6 | 13.2 | 1.6 | 1.8 | 1.5 | 1.7 | 1.7 |
| Biomass | 133.5 | 188.3 | 209.5 | 230.0 | 254.7 | 43.5 | 24.3 | 19.4 | 14.2 | 11.2 | 1.5 | 1.5 | 0.9 | 1.0 | 1.1 |
| Solar, Wind, Ocean | 0.0 | 3.6 | 8.3 | 21.9 | 43.6 | 0.0 | 0.5 | 0.8 | 1.4 | 1.9 | 29.0 | 12.6 | 10.1 | 7.1 | 9.6 |
| Biofuels | 0.0 | 0.2 | 0.2 | 0.7 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | - | 6.2 | 11.6 | 8.2 | 8.9 |
| Electricit | 0.1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **243.5** | **528.3** | **722.9** | **1,065.4** | **1,508.4** | **100** | **100** | **100** | **100** | **100** | **3.4** | **4.6** | **4.0** | **3.5** | **4.0** |
| Industry | 66.9 | 179.1 | 251.3 | 396.3 | 592.8 | 27.5 | 33.9 | 34.8 | 37.2 | 39.3 | 4.4 | 5.0 | 4.7 | 4.1 | 4.5 |
| Transportation | 20.8 | 74.8 | 126.1 | 224.3 | 333.8 | 8.6 | 14.2 | 17.4 | 21.1 | 22.1 | 5.7 | 7.7 | 5.9 | 4.1 | 5.7 |
| Others | 142.5 | 238.0 | 296.8 | 374.4 | 485.7 | 58.5 | 45.1 | 41.1 | 35.1 | 32.2 | 2.3 | 3.2 | 2.4 | 2.6 | 2.7 |
| Non-energy | 13.3 | 36.4 | 48.8 | 70.3 | 96.0 | 5.5 | 6.9 | 6.7 | 6.6 | 6.4 | 4.5 | 4.3 | 3.7 | 3.2 | 3.7 |
| **Total** | **243.5** | **528.3** | **722.9** | **1,065.4** | **1,508.4** | **100** | **100** | **100** | **100** | **100** | **3.4** | **4.6** | **4.0** | **3.5** | **4.0** |
| Coal | 38.9 | 103.5 | 145.6 | 221.9 | 324.7 | 16.0 | 19.6 | 20.1 | 20.8 | 21.5 | 4.3 | 5.0 | 4.3 | 3.9 | 4.3 |
| Oil | 50.2 | 150.0 | 230.8 | 369.6 | 530.9 | 20.6 | 28.4 | 31.9 | 34.7 | 35.2 | 4.9 | 6.3 | 4.8 | 3.7 | 4.8 |
| Natural gas | 5.6 | 26.6 | 38.3 | 60.9 | 91.7 | 2.3 | 5.0 | 5.3 | 5.7 | 6.1 | 7.0 | 5.3 | 4.7 | 4.2 | 4.7 |
| Electricity | 18.5 | 76.5 | 122.6 | 218.7 | 352.1 | 7.6 | 14.5 | 17.0 | 20.5 | 23.3 | 6.4 | 7.0 | 6.0 | 4.9 | 5.8 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 130.3 | 171.7 | 185.6 | 194.3 | 209.0 | 53.5 | 32.5 | 25.7 | 18.2 | 13.9 | 1.2 | 1.1 | 0.5 | 0.7 | 0.7 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **292.7** | **1,193.5** | **1,881.0** | **3,254.3** | **5,076.6** | **100** | **100** | **100** | **100** | **100** | **6.3** | **6.7** | **5.6** | **4.5** | **5.5** |
| Coal | 191.6 | 869.2 | 1,360.2 | 2,244.8 | 3,376.7 | 65.5 | 72.8 | 72.3 | 69.0 | 66.5 | 6.8 | 6.6 | 5.1 | 4.2 | 5.2 |
| Oil | 13.3 | 23.2 | 25.5 | 26.5 | 24.8 | 4.5 | 1.9 | 1.4 | 0.8 | 0.5 | 2.4 | 1.4 | 0.4 | -0.7 | 0.2 |
| Natural gas | 10.0 | 65.1 | 109.1 | 211.4 | 380.6 | 3.4 | 5.5 | 5.8 | 6.5 | 7.5 | 8.5 | 7.7 | 6.8 | 6.1 | 6.8 |
| Nuclear | 6.1 | 34.2 | 72.3 | 189.1 | 308.0 | 2.1 | 2.9 | 3.8 | 5.8 | 6.1 | 7.8 | 11.3 | 10.1 | 5.0 | 8.5 |
| Hydro | 71.7 | 141.6 | 186.4 | 275.9 | 408.4 | 24.5 | 11.9 | 9.9 | 8.5 | 8.0 | 3.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.0 | 60.2 | 127.5 | 306.6 | 578.0 | 0.0 | 5.0 | 6.8 | 9.4 | 11.4 | 38.8 | 11.3 | 9.2 | 6.5 | 8.7 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **57.4** | **244.7** | **366.8** | **575.7** | **829.8** | **100** | **100** | **100** | **100** | **100** | **6.5** | **6.0** | **4.6** | **3.7** | **4.6** |
| Coal | 48.9 | 222.9 | 336.6 | 529.1 | 759.8 | 85.2 | 91.1 | 91.8 | 91.9 | 91.6 | 6.8 | 6.1 | 4.6 | 3.7 | 4.6 |
| Oil | 5.0 | 8.0 | 8.9 | 9.2 | 8.6 | 8.7 | 3.3 | 2.4 | 1.6 | 1.0 | 2.1 | 1.4 | 0.4 | -0.7 | 0.3 |
| Natural gas | 3.5 | 13.8 | 21.4 | 37.4 | 61.4 | 6.0 | 5.6 | 5.8 | 6.5 | 7.4 | 6.2 | 6.5 | 5.7 | 5.1 | 5.7 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **32** | **34** | **35** | **37** | **39** | **0.2** | **0.6** | **0.6** | **0.6** | **0.6** |
| Coal | 34 | 34 | 35 | 36 | 38 | 0.0 | 0.5 | 0.5 | 0.5 | 0.5 |
| Oil | 23 | 25 | 25 | 25 | 25 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 25 | 41 | 44 | 49 | 53 | 2.2 | 1.1 | 1.0 | 0.9 | 1.0 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **148.9** | **516.7** | **763.9** | **1,194.4** | **1,726.6** | **100** | **100** | **100** | **100** | **100** | **5.6** | **5.7** | **4.6** | **3.8** | **4.6** |
| Coal | 101.1 | 368.7 | 542.4 | 843.3 | 1,219.3 | 67.9 | 71.4 | 71.0 | 70.6 | 70.6 | 5.8 | 5.7 | 4.5 | 3.8 | 4.5 |
| Oil | 44.2 | 128.3 | 189.6 | 293.8 | 413.3 | 29.7 | 24.8 | 24.8 | 24.6 | 23.9 | 4.7 | 5.7 | 4.5 | 3.5 | 4.4 |
| Natural Gas | 3.6 | 19.6 | 32.0 | 57.3 | 94.1 | 2.4 | 3.8 | 4.2 | 4.8 | 5.4 | 7.7 | 7.2 | 6.0 | 5.1 | 6.0 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 350 | 1,490 | 2,477 | 4,721 | 8,254 | 6.5 | 7.5 | 6.7 | 5.7 | 6.5 |
| Population (millions of people) | 869 | 1,252 | 1,359 | 1,495 | 1,599 | 1.6 | 1.2 | 1.0 | 0.7 | 0.9 |
| GDP per capita (thousands of 2005 USD/person) | 0.40 | 1.19 | 1.8 | 3.2 | 5.2 | 4.8 | 6.3 | 5.6 | 5.0 | 5.6 |
| Primary energy consumption per capita (toe/person) | 0.35 | 0.62 | 0.80 | 1.08 | 1.43 | 2.5 | 3.6 | 3.1 | 2.8 | 3.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 875 | 521 | 436 | 343 | 276 | -2.2 | -2.5 | -2.4 | -2.1 | -2.3 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 695 | 355 | 292 | 226 | 183 | -2.9 | -2.7 | -2.5 | -2.1 | -2.4 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 425 | 347 | 308 | 253 | 209 | -0.9 | -1.7 | -2.0 | -1.9 | -1.9 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.49 | 0.67 | 0.71 | 0.74 | 0.76 | 1.4 | 0.8 | 0.4 | 0.2 | 0.5 |
| Automobile ownership volume (millions of vehicles) | 4.3 | 32.5 | 64.6 | 142.7 | 245.1 | 9.2 | 10.3 | 8.3 | 5.6 | 7.8 |
| Automobile ownership volume per capita (vehicles per person) | 0.00 | 0.03 | 0.05 | 0.10 | 0.15 | 7.4 | 9.0 | 7.2 | 4.8 | 6.8 |

# India [APS]

## Primary energy consumption

| | MTOE | | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **306.6** | **441.3** | **775.4** | **1,030.4** | **1,441.1** | **1,929.8** | **100** | **100** | **100** | **100** | **100** | **4.1** | **4.1** | **3.4** | **3.0** | **3.4** |
| Coal | 93.6 | 146.4 | 341.4 | 451.8 | 591.5 | 777.6 | 30.5 | 44.0 | 43.9 | 41.0 | 40.3 | 5.8 | 4.1 | 2.7 | 2.8 | 3.1 |
| Oil | 61.1 | 112.0 | 175.9 | 252.4 | 375.7 | 507.4 | 19.9 | 22.7 | 24.5 | 26.1 | 26.3 | 4.7 | 5.3 | 4.1 | 3.1 | 4.0 |
| Natural gas | 10.6 | 23.1 | 44.5 | 64.1 | 102.9 | 156.2 | 3.4 | 5.7 | 6.2 | 7.1 | 8.1 | 6.4 | 5.4 | 4.8 | 4.3 | 4.8 |
| Nuclear | 1.6 | 4.4 | 8.9 | 21.2 | 74.5 | 126.7 | 0.5 | 1.2 | 2.1 | 5.2 | 6.6 | 7.8 | 13.1 | 13.4 | 5.5 | 10.3 |
| Hydro | 6.2 | 6.4 | 12.2 | 16.6 | 25.7 | 38.8 | 2.0 | 1.6 | 1.6 | 1.8 | 2.0 | 3.0 | 4.5 | 4.5 | 4.2 | 4.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 133.6 | 149.1 | 192.6 | 224.3 | 270.8 | 322.9 | 43.6 | 24.8 | 21.8 | 18.8 | 16.7 | 1.6 | 2.2 | 1.9 | 1.8 | 1.9 |
| Biomass | 133.5 | 148.8 | 188.3 | 211.0 | 229.7 | 252.0 | 43.5 | 24.3 | 20.5 | 15.9 | 13.1 | 1.5 | 1.6 | 0.9 | 0.9 | 1.1 |
| Solar, Wind, Ocean | 0.0 | 0.2 | 3.6 | 12.3 | 38.8 | 66.0 | 0.0 | 0.5 | 1.2 | 2.7 | 3.4 | 29.0 | 19.0 | 12.2 | 5.4 | 11.3 |
| Biofuels | 0.0 | 0.1 | 0.2 | 0.5 | 1.8 | 4.4 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | - | 19.4 | 13.0 | 9.5 | 13.3 |
| Electricit | 0.1 | 0.1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 |

## Final energy demand

| | MTOE | | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **243.5** | **315.4** | **528.3** | **701.3** | **989.6** | **1,341.0** | **100** | **100** | **100** | **100** | **100** | **3.4** | **4.1** | **3.5** | **3.1** | **3.5** |
| Industry | 66.9 | 83.5 | 179.1 | 241.8 | 362.2 | 515.0 | 27.5 | 33.9 | 34.5 | 36.6 | 38.4 | 4.4 | 4.4 | 4.1 | 3.6 | 4.0 |
| Transportation | 20.8 | 31.9 | 74.8 | 122.7 | 208.7 | 296.0 | 8.6 | 14.2 | 17.5 | 21.1 | 22.1 | 5.7 | 7.3 | 5.4 | 3.6 | 5.2 |
| Others | 142.5 | 173.2 | 238.0 | 288.0 | 348.3 | 434.0 | 58.5 | 45.1 | 41.1 | 35.2 | 32.4 | 2.3 | 2.8 | 1.9 | 2.2 | 2.2 |
| Non-energy | 13.3 | 26.8 | 36.4 | 48.8 | 70.3 | 96.0 | 5.5 | 6.9 | 7.0 | 7.1 | 7.2 | 4.5 | 4.3 | 3.7 | 3.2 | 3.7 |
| **Total** | **243.5** | **315.4** | **528.3** | **701.3** | **989.6** | **1,341.0** | **100** | **100** | **100** | **100** | **100** | **3.4** | **4.1** | **3.5** | **3.1** | **3.5** |
| Coal | 38.9 | 34.6 | 103.5 | 139.7 | 200.2 | 276.0 | 16.0 | 19.6 | 19.9 | 20.2 | 20.6 | 4.3 | 4.4 | 3.7 | 3.3 | 3.7 |
| Oil | 50.2 | 94.4 | 150.0 | 225.0 | 345.7 | 475.4 | 20.6 | 28.4 | 32.1 | 34.9 | 35.5 | 4.9 | 6.0 | 4.4 | 3.2 | 4.4 |
| Natural gas | 5.6 | 9.7 | 26.6 | 38.2 | 60.5 | 91.0 | 2.3 | 5.0 | 5.4 | 6.1 | 6.8 | 7.0 | 5.3 | 4.7 | 4.2 | 4.7 |
| Electricity | 18.5 | 32.4 | 76.5 | 115.5 | 193.4 | 294.1 | 7.6 | 14.5 | 16.5 | 19.5 | 21.9 | 6.4 | 6.1 | 5.3 | 4.3 | 5.1 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 130.3 | 144.4 | 171.7 | 183.0 | 189.7 | 204.5 | 53.5 | 32.5 | 26.1 | 19.2 | 15.2 | 1.2 | 0.9 | 0.4 | 0.8 | 0.6 |

## Power generation Output

| | TWh | | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **292.7** | **569.7** | **1,193.5** | **1,772.9** | **2,878.7** | **4,240.3** | **100** | **100** | **100** | **100** | **100** | **6.3** | **5.8** | **5.0** | **3.9** | **4.8** |
| Coal | 191.6 | 390.2 | 869.2 | 1,191.2 | 1,570.3 | 2,117.3 | 65.5 | 72.8 | 67.2 | 54.5 | 49.9 | 6.8 | 4.6 | 2.8 | 3.0 | 3.4 |
| Oil | 13.3 | 29.2 | 23.2 | 23.9 | 23.3 | 20.6 | 4.5 | 1.9 | 1.3 | 0.8 | 0.5 | 2.4 | 0.4 | -0.3 | -1.2 | -0.4 |
| Natural gas | 10.0 | 56.0 | 65.1 | 102.2 | 185.9 | 316.3 | 3.4 | 5.5 | 5.8 | 6.5 | 7.5 | 8.5 | 6.7 | 6.2 | 5.5 | 6.0 |
| Nuclear | 6.1 | 16.9 | 34.2 | 81.2 | 285.8 | 486.4 | 2.1 | 2.9 | 4.6 | 9.9 | 11.5 | 7.8 | 13.1 | 13.4 | 5.5 | 10.3 |
| Hydro | 71.7 | 74.5 | 141.6 | 192.7 | 299.3 | 451.7 | 24.5 | 11.9 | 10.9 | 10.4 | 10.7 | 3.0 | 4.5 | 4.5 | 4.2 | 4.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.0 | 3.0 | 60.2 | 181.6 | 514.1 | 848.1 | 0.0 | 5.0 | 10.2 | 17.9 | 20.0 | 38.8 | 17.1 | 11.0 | 5.1 | 10.3 |

## Power generation Input

| | MTOE | | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **57.4** | **121.7** | **244.7** | **321.1** | **405.5** | **523.8** | **100** | **100** | **100** | **100** | **100** | **6.5** | **4.0** | **2.4** | **2.6** | **2.9** |
| Coal | 48.9 | 103.5 | 222.9 | 293.2 | 365.6 | 467.6 | 85.2 | 91.1 | 91.3 | 90.2 | 89.3 | 6.8 | 4.0 | 2.2 | 2.5 | 2.8 |
| Oil | 5.0 | 9.0 | 8.0 | 8.1 | 7.6 | 6.4 | 8.7 | 3.3 | 2.5 | 1.9 | 1.2 | 2.1 | 0.0 | -0.7 | -1.6 | -0.8 |
| Natural gas | 3.5 | 9.3 | 13.8 | 19.9 | 32.3 | 49.8 | 6.0 | 5.6 | 6.2 | 8.0 | 9.5 | 6.2 | 5.4 | 5.0 | 4.4 | 4.9 |

## Thermal Efficiency

| | % | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **32** | **34** | **34** | **35** | **38** | **40** | **0.2** | **0.7** | **0.7** | **0.7** | **0.7** |
| Coal | 34 | 32 | 34 | 35 | 37 | 39 | 0.0 | 0.6 | 0.6 | 0.5 | 0.6 |
| Oil | 23 | 28 | 25 | 25 | 26 | 27 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Natural gas | 25 | 52 | 41 | 44 | 49 | 55 | 2.2 | 1.2 | 1.1 | 1.0 | 1.1 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2000 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **148.9** | **245.7** | **516.7** | **702.7** | **964.1** | **1,288.9** | **100** | **100** | **100** | **100** | **100** | **5.6** | **4.5** | **3.2** | **2.9** | **3.4** |
| Coal | 101.1 | 158.1 | 368.7 | 488.0 | 638.8 | 839.8 | 67.9 | 71.4 | 69.4 | 66.3 | 65.2 | 5.8 | 4.1 | 2.7 | 2.8 | 3.1 |
| Oil | 44.2 | 77.7 | 128.3 | 183.9 | 271.9 | 363.8 | 29.7 | 24.8 | 26.2 | 28.2 | 28.2 | 4.7 | 5.3 | 4.0 | 3.0 | 3.9 |
| Natural Gas | 3.6 | 9.9 | 19.6 | 30.8 | 53.4 | 85.3 | 2.4 | 3.8 | 4.4 | 5.5 | 6.6 | 7.7 | 6.7 | 5.7 | 4.8 | 5.6 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 350 | 1,490 | 2,477 | 4,721 | 8,254 | 6.5 | 7.5 | 6.7 | 5.7 | 6.5 |
| Population (millions of people) | 869 | 1,252 | 1,359 | 1,495 | 1,599 | 1.6 | 1.2 | 1.0 | 0.7 | 0.9 |
| GDP per capita (thousands of 2005 USD/person) | 0.40 | 1.19 | 1.8 | 3.2 | 5.2 | 4.8 | 6.3 | 5.6 | 5.0 | 5.6 |
| Primary energy consumption per capita (toe/person) | 0.35 | 0.62 | 0.76 | 0.96 | 1.21 | 2.5 | 2.9 | 2.4 | 2.3 | 2.5 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 875 | 521 | 416 | 305 | 234 | -2.2 | -3.2 | -3.0 | -2.6 | -2.9 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 695 | 355 | 283 | 210 | 162 | -2.9 | -3.2 | -3.0 | -2.5 | -2.8 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 425 | 347 | 284 | 204 | 156 | -0.9 | -2.8 | -3.2 | -2.6 | -2.9 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.49 | 0.67 | 0.68 | 0.67 | 0.67 | 1.4 | 0.3 | -0.2 | 0.0 | 0.0 |
| Automobile ownership volume (millions of vehicles) | 4.3 | 32.5 | 64.6 | 142.7 | 245.1 | 9.2 | 10.3 | 8.3 | 5.6 | 7.8 |
| Automobile ownership volume per capita (vehicles per person) | 0.00 | 0.03 | 0.05 | 0.10 | 0.15 | 7.4 | 9.0 | 7.2 | 4.8 | 6.8 |

# INDONESIA [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **98.6** | **223.9** | **365.1** | **527.3** | **728.6** | **100** | **100** | **100** | **100** | **100** | **3.6** | **7.2** | **3.7** | **3.3** | **4.5** |
| Coal | 3.5 | 35.8 | 74.9 | 117.5 | 177.6 | 3.6 | 16.0 | 20.5 | 22.3 | 24.4 | 10.6 | 11.1 | 4.6 | 4.2 | 6.1 |
| Oil | 33.3 | 76.8 | 134.8 | 185.5 | 231.6 | 33.8 | 34.3 | 36.9 | 35.2 | 31.8 | 3.7 | 8.4 | 3.2 | 2.2 | 4.2 |
| Natural gas | 15.8 | 39.3 | 66.4 | 103.7 | 162.6 | 16.0 | 17.5 | 18.2 | 19.7 | 22.3 | 4.0 | 7.8 | 4.6 | 4.6 | 5.4 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.5 | 1.5 | 3.1 | 5.7 | 7.5 | 0.5 | 0.7 | 0.9 | 1.1 | 1.0 | 4.8 | 11.5 | 6.1 | 2.9 | 6.3 |
| Geothermal | 1.9 | 16.2 | 24.8 | 45.8 | 65.8 | 2.0 | 7.2 | 6.8 | 8.7 | 9.0 | 9.7 | 6.3 | 6.4 | 3.7 | 5.3 |
| Others | 43.5 | 54.4 | 61.1 | 69.1 | 83.5 | 44.1 | 24.3 | 16.7 | 13.1 | 11.5 | 1.0 | 1.7 | 1.2 | 1.9 | 1.6 |
| Biomass | 43.5 | 53.8 | 58.0 | 63.0 | 72.6 | 44.1 | 24.0 | 15.9 | 12.0 | 10.0 | 0.9 | 1.1 | 0.8 | 1.4 | 1.1 |
| Solar, Wind, Ocean | | 0.0 | 0.2 | 0.6 | 1.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | - | 132.6 | 11.4 | 5.4 | 32.1 |
| Biofuels | | 0.5 | 2.9 | 5.4 | 9.8 | 0.0 | 0.2 | 0.8 | 1.0 | 1.4 | - | 27.8 | 6.4 | 6.1 | 11.5 |
| Electricity | | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | -100.0 | - | - | -100.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **79.8** | **159.5** | **261.2** | **356.9** | **479.8** | **100** | **100** | **100** | **100** | **100** | **3.1** | **7.3** | **3.2** | **3.0** | **4.2** |
| Industry | 18.1 | 36.8 | 62.7 | 106.1 | 173.4 | 22.7 | 23.1 | 24.0 | 29.7 | 36.1 | 3.1 | 7.9 | 5.4 | 5.0 | 5.9 |
| Transportation | 10.7 | 43.8 | 97.8 | 128.0 | 153.9 | 13.4 | 27.5 | 37.4 | 35.9 | 32.1 | 6.3 | 12.2 | 2.7 | 1.9 | 4.8 |
| Others | 43.7 | 67.9 | 85.6 | 104.7 | 129.8 | 54.7 | 42.6 | 32.8 | 29.3 | 27.1 | 1.9 | 3.4 | 2.0 | 2.2 | 2.4 |
| Non-energy | 7.4 | 11.0 | 15.1 | 18.1 | 22.6 | 9.2 | 6.9 | 5.8 | 5.1 | 4.7 | 1.8 | 4.6 | 1.8 | 2.2 | 2.7 |
| **Total** | **79.8** | **159.5** | **261.2** | **356.9** | **479.8** | **100** | **100** | **100** | **100** | **100** | **3.1** | **7.3** | **3.2** | **3.0** | **4.2** |
| Coal | 2.1 | 4.6 | 12.4 | 23.7 | 41.4 | 2.7 | 2.9 | 4.8 | 6.6 | 8.6 | 3.4 | 15.2 | 6.7 | 5.7 | 8.5 |
| Oil | 27.2 | 61.4 | 116.6 | 154.2 | 192.2 | 34.1 | 38.5 | 44.6 | 43.2 | 40.1 | 3.6 | 9.6 | 2.8 | 2.2 | 4.3 |
| Natural gas | 6.0 | 23.6 | 42.7 | 66.1 | 99.9 | 7.5 | 14.8 | 16.3 | 18.5 | 20.8 | 6.1 | 8.8 | 4.5 | 4.2 | 5.5 |
| Electricity | 2.4 | 16.1 | 30.9 | 52.5 | 82.5 | 3.0 | 10.1 | 11.8 | 14.7 | 17.2 | 8.6 | 9.8 | 5.4 | 4.6 | 6.2 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 42.0 | 53.8 | 58.6 | 60.4 | 63.8 | 52.6 | 33.7 | 22.4 | 16.9 | 13.3 | 1.1 | 1.2 | 0.3 | 0.5 | 0.6 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **32.7** | **215.6** | **411.7** | **686.2** | **1,061.0** | **100** | **100** | **100** | **100** | **100** | **8.6** | **9.7** | **5.2** | **4.5** | **6.1** |
| Coal | 9.8 | 110.5 | 231.6 | 365.2 | 542.2 | 29.9 | 51.2 | 56.3 | 53.2 | 51.1 | 11.1 | 11.2 | 4.7 | 4.0 | 6.1 |
| Oil | 15.3 | 26.8 | 16.3 | 12.8 | 8.8 | 46.9 | 12.4 | 4.0 | 1.9 | 0.8 | 2.4 | -6.8 | -2.4 | -3.7 | -4.0 |
| Natural gas | 0.7 | 51.8 | 91.0 | 160.4 | 281.4 | 2.2 | 24.0 | 22.1 | 23.4 | 26.5 | 20.3 | 8.4 | 5.8 | 5.8 | 6.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 5.7 | 16.9 | 36.2 | 65.7 | 87.6 | 17.5 | 7.9 | 8.8 | 9.6 | 8.3 | 4.8 | 11.5 | 6.1 | 2.9 | 6.3 |
| Geothermal | 1.1 | 9.4 | 28.8 | 53.3 | 76.5 | 3.4 | 4.4 | 7.0 | 7.8 | 7.2 | 9.7 | 17.3 | 6.4 | 3.7 | 8.1 |
| Others | 0.0 | 0.3 | 7.8 | 28.8 | 64.5 | 0.0 | 0.1 | 1.9 | 4.2 | 6.1 | - | 61.3 | 14.0 | 8.4 | 22.4 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **6.5** | **50.4** | **87.4** | **132.3** | **199.2** | **100** | **100** | **100** | **100** | **100** | **9.3** | **8.2** | **4.2** | **4.2** | **5.2** |
| Coal | 2.3 | 31.2 | 62.5 | 93.8 | 136.2 | 35.7 | 61.8 | 71.5 | 70.9 | 68.4 | 11.9 | 10.5 | 4.1 | 3.8 | 5.6 |
| Oil | 4.0 | 7.5 | 4.6 | 3.6 | 2.5 | 61.0 | 14.9 | 5.3 | 2.7 | 1.2 | 2.8 | -6.8 | -2.4 | -3.7 | -4.0 |
| Natural gas | 0.2 | 11.7 | 20.3 | 34.9 | 60.5 | 3.2 | 23.3 | 23.2 | 26.4 | 30.4 | 19.1 | 8.2 | 5.6 | 5.7 | 6.3 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **34** | **32** | **33** | **35** | **36** | **-0.3** | **0.5** | **0.5** | **0.3** | **0.4** |
| Coal | 36 | 30 | 32 | 33 | 34 | -0.7 | 0.6 | 0.5 | 0.2 | 0.4 |
| Oil | 33 | 31 | 31 | 31 | 31 | -0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 30 | 38 | 39 | 40 | 40 | 1.0 | 0.2 | 0.3 | 0.1 | 0.2 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **40.9** | **112.6** | **211.4** | **309.4** | **439.1** | **100** | **100** | **100** | **100** | **100** | **4.5** | **9.4** | **3.9** | **3.6** | **5.2** |
| Coal | 8.4 | 37.8 | 79.3 | 124.4 | 188.0 | 20.5 | 33.6 | 37.5 | 40.2 | 42.8 | 6.8 | 11.1 | 4.6 | 4.2 | 6.1 |
| Oil | 27.2 | 50.6 | 91.6 | 120.7 | 150.1 | 66.6 | 44.9 | 43.3 | 39.0 | 34.2 | 2.7 | 8.9 | 2.8 | 2.2 | 4.1 |
| Natural Gas | 5.3 | 24.2 | 40.5 | 64.3 | 101.1 | 12.9 | 21.5 | 19.2 | 20.8 | 23.0 | 6.8 | 7.6 | 4.7 | 4.6 | 5.4 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 150 | 449 | 658 | 1,140 | 1,858 | 4.9 | 5.6 | 5.6 | 5.0 | 5.4 |
| Population (millions of people) | 179 | 247 | 268 | 292 | 310 | 1.4 | 1.2 | 0.9 | 0.6 | 0.9 |
| GDP per capita (thousands of 2005 USD/person) | 0.84 | 1.82 | 2.5 | 3.9 | 6.0 | 3.4 | 4.4 | 4.7 | 4.4 | 4.5 |
| Primary energy consumption per capita (toe/person) | 0.55 | 0.91 | 1.36 | 1.81 | 2.35 | 2.2 | 6.0 | 2.9 | 2.6 | 3.6 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 657 | 499 | 555 | 462 | 392 | -1.2 | 1.5 | -1.8 | -1.6 | -0.9 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 532 | 355 | 397 | 313 | 258 | -1.7 | 1.6 | -2.3 | -1.9 | -1.2 |
| CO2 emissions per unit of GDP (t-C/million 2005 US Dollars) | 272 | 251 | 321 | 271 | 236 | -0.4 | 3.6 | -1.7 | -1.4 | -0.2 |
| CO2 emissions per unit of primary energy consumption (t-C/toe) | 0.41 | 0.50 | 0.58 | 0.59 | 0.60 | 0.8 | 2.0 | 0.1 | 0.3 | 0.7 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# INDONESIA [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **98.6** | **223.9** | **311.2** | **429.6** | **587.1** | **100** | **100** | **100** | **100** | **100** | **3.6** | **4.8** | **3.3** | **3.2** | **3.6** |
| Coal | 3.5 | 35.8 | 50.2 | 66.8 | 105.9 | 3.6 | 16.0 | 16.1 | 15.6 | 18.0 | 10.6 | 5.0 | 2.9 | 4.7 | 4.1 |
| Oil | 33.3 | 76.8 | 114.3 | 146.1 | 185.4 | 33.8 | 34.3 | 36.7 | 34.0 | 31.6 | 3.7 | 5.8 | 2.5 | 2.4 | 3.3 |
| Natural gas | 15.8 | 39.3 | 59.5 | 83.4 | 124.1 | 16.0 | 17.5 | 19.1 | 19.4 | 21.1 | 4.0 | 6.1 | 3.4 | 4.1 | 4.4 |
| Nuclear | - | - | - | 1.3 | 3.2 | - | - | - | 0.3 | 0.5 | - | - | - | 9.4 | - |
| Hydro | 0.5 | 1.5 | 3.1 | 6.8 | 9.4 | 0.5 | 0.7 | 1.0 | 1.6 | 1.6 | 4.8 | 11.5 | 8.1 | 3.3 | 7.2 |
| Geothermal | 1.9 | 16.2 | 24.8 | 61.7 | 81.4 | 2.0 | 7.2 | 8.0 | 14.4 | 13.9 | 9.7 | 6.3 | 9.6 | 2.8 | 6.2 |
| Others | 43.5 | 54.4 | 59.3 | 63.4 | 77.7 | 44.1 | 24.3 | 19.0 | 14.8 | 13.2 | 1.0 | 1.2 | 0.7 | 2.1 | 1.3 |
| Biomass | 43.5 | 53.8 | 56.7 | 58.5 | 68.6 | 44.1 | 24.0 | 18.2 | 13.6 | 11.7 | 0.9 | 0.8 | 0.3 | 1.6 | 0.9 |
| Solar, Wind, Ocean | - | 0.0 | 0.2 | 1.1 | 2.2 | - | 0.0 | 0.1 | 0.3 | 0.4 | - | 132.6 | 18.7 | 7.0 | 36.0 |
| Biofuels | - | 0.5 | 2.3 | 3.8 | 6.9 | - | 0.2 | 0.8 | 0.9 | 1.2 | - | 23.8 | 5.0 | 6.1 | 10.0 |
| Electricity | - | 0.1 | 0.0 | 0.0 | 0.0 | - | 0.0 | 0.0 | 0.0 | 0.0 | - | -100.0 | - | - | -100.0 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **79.8** | **159.5** | **229.8** | **292.9** | **393.3** | **100** | **100** | **100** | **100** | **100** | **3.1** | **5.4** | **2.5** | **3.0** | **3.4** |
| Industry | 18.1 | 36.8 | 54.3 | 87.0 | 142.1 | 22.7 | 23.1 | 23.6 | 29.7 | 36.1 | 3.1 | 5.7 | 4.8 | 5.0 | 5.1 |
| Transportation | 10.7 | 43.8 | 79.3 | 92.4 | 112.3 | 13.4 | 27.5 | 34.5 | 31.6 | 28.5 | 6.3 | 8.8 | 1.5 | 2.0 | 3.5 |
| Others | 43.7 | 67.9 | 81.1 | 95.3 | 116.4 | 54.7 | 42.6 | 35.3 | 32.6 | 29.6 | 1.9 | 2.6 | 1.6 | 2.0 | 2.0 |
| Non-energy | 7.4 | 11.0 | 15.1 | 18.1 | 22.6 | 9.2 | 6.9 | 6.6 | 6.2 | 5.7 | 1.8 | 4.6 | 1.8 | 2.2 | 2.7 |
| **Total** | **79.8** | **159.5** | **229.8** | **292.9** | **393.3** | **100** | **100** | **100** | **100** | **100** | **3.1** | **5.4** | **2.5** | **3.0** | **3.4** |
| Coal | 2.1 | 4.6 | 10.6 | 19.1 | 33.3 | 2.7 | 2.9 | 4.6 | 6.5 | 8.5 | 3.4 | 12.7 | 6.1 | 5.7 | 7.6 |
| Oil | 27.2 | 61.4 | 97.0 | 116.5 | 147.2 | 34.1 | 38.5 | 42.2 | 39.8 | 37.4 | 3.6 | 6.7 | 1.9 | 2.4 | 3.3 |
| Natural gas | 6.0 | 23.6 | 38.4 | 56.9 | 85.7 | 7.5 | 14.8 | 16.7 | 19.4 | 21.8 | 6.1 | 7.2 | 4.0 | 4.2 | 4.9 |
| Electricity | 2.4 | 16.1 | 26.8 | 42.7 | 67.2 | 3.0 | 10.1 | 11.7 | 14.6 | 17.1 | 8.6 | 7.6 | 4.8 | 4.6 | 5.4 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 42.0 | 53.8 | 57.1 | 57.7 | 59.9 | 52.6 | 33.7 | 24.8 | 19.7 | 15.2 | 1.1 | 0.9 | 0.1 | 0.4 | 0.4 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **32.7** | **215.6** | **354.5** | **552.0** | **855.0** | **100** | **100** | **100** | **100** | **100** | **8.6** | **7.4** | **4.5** | **4.5** | **5.2** |
| Coal | 9.8 | 110.5 | 174.8 | 229.9 | 357.6 | 29.9 | 51.2 | 49.3 | 41.6 | 41.8 | 11.1 | 6.8 | 2.8 | 4.5 | 4.4 |
| Oil | 15.3 | 26.8 | 13.4 | 7.0 | 4.4 | 46.9 | 12.4 | 3.8 | 1.3 | 0.5 | 2.4 | -9.5 | -6.2 | -4.6 | -6.5 |
| Natural gas | 0.7 | 51.8 | 94.5 | 134.5 | 207.0 | 2.2 | 24.0 | 26.7 | 24.4 | 24.2 | 20.3 | 9.0 | 3.6 | 4.4 | 5.3 |
| Nuclear | - | - | - | 5.0 | 12.3 | - | - | - | 0.9 | 1.4 | - | - | - | 9.4 | - |
| Hydro | 5.7 | 16.9 | 36.2 | 78.8 | 109.5 | 17.5 | 7.9 | 10.2 | 14.3 | 12.8 | 4.8 | 11.5 | 8.1 | 3.3 | 7.2 |
| Geothermal | 1.1 | 9.4 | 28.8 | 71.8 | 94.6 | 3.4 | 4.4 | 8.1 | 13.0 | 11.1 | 9.7 | 17.3 | 9.6 | 2.8 | 8.9 |
| Others | 0.0 | 0.3 | 6.8 | 25.0 | 69.5 | 0.0 | 0.1 | 1.9 | 4.5 | 8.1 | - | 58.2 | 13.9 | 10.8 | 22.8 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **6.5** | **50.4** | **61.0** | **73.6** | **110.0** | **100** | **100** | **100** | **100** | **100** | **9.3** | **2.8** | **1.9** | **4.1** | **2.9** |
| Coal | 2.3 | 31.2 | 39.6 | 47.7 | 72.6 | 35.7 | 61.8 | 64.9 | 64.9 | 65.9 | 11.9 | 3.5 | 1.9 | 4.3 | 3.2 |
| Oil | 4.0 | 7.5 | 3.8 | 2.0 | 1.2 | 61.0 | 14.9 | 6.2 | 2.7 | 1.1 | 2.8 | -9.5 | -6.2 | -4.6 | -6.5 |
| Natural gas | 0.2 | 11.7 | 17.7 | 23.9 | 36.2 | 3.2 | 23.3 | 29.0 | 32.4 | 32.9 | 19.1 | 6.0 | 3.0 | 4.3 | 4.3 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **34** | **32** | **40** | **43** | **44** | **-0.3** | **3.1** | **0.9** | **0.2** | **1.2** |
| Coal | 36 | 30 | 38 | 41 | 42 | -0.7 | 3.2 | 0.9 | 0.2 | 1.2 |
| Oil | 33 | 31 | 31 | 31 | 31 | -0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 30 | 38 | 46 | 48 | 49 | 1.0 | 2.8 | 0.5 | 0.1 | 1.0 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **40.9** | **112.6** | **164.1** | **210.6** | **300.7** | **100** | **100** | **100** | **100** | **100** | **4.5** | **5.5** | **2.5** | **3.6** | **3.7** |
| Coal | 8.4 | 37.8 | 53.1 | 70.7 | 112.1 | 20.5 | 33.6 | 32.4 | 33.6 | 37.3 | 6.8 | 5.0 | 2.9 | 4.7 | 4.1 |
| Oil | 27.2 | 50.6 | 75.2 | 89.0 | 112.7 | 66.6 | 44.9 | 45.8 | 42.3 | 37.5 | 2.7 | 5.8 | 1.7 | 2.4 | 3.0 |
| Natural Gas | 5.3 | 24.2 | 35.8 | 50.9 | 75.9 | 12.9 | 21.5 | 21.8 | 24.2 | 25.3 | 6.8 | 5.8 | 3.6 | 4.1 | 4.3 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 150.1 | 449.1 | 658.3 | 1140.5 | 1857.7 | 4.9 | 5.6 | 5.6 | 5.0 | 5.4 |
| Population (millions of people) | 178.6 | 246.9 | 267.6 | 291.7 | 310.3 | 1.4 | 1.2 | 0.9 | 0.6 | 0.9 |
| GDP per capita (thousands of 2005 USD/person) | 0.84 | 1.82 | 2.5 | 3.9 | 6.0 | 3.4 | 4.4 | 4.7 | 4.4 | 4.5 |
| Primary energy consumption per capita (toe/person) | 0.55 | 0.91 | 1.16 | 1.47 | 1.89 | 2.2 | 3.6 | 2.4 | 2.5 | 2.8 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 657 | 499 | 473 | 377 | 316 | -1.2 | -0.8 | -2.2 | -1.7 | -1.7 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 532 | 355 | 349 | 257 | 212 | -1.7 | -0.2 | -3.0 | -1.9 | -1.9 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 272 | 251 | 249 | 185 | 162 | -0.4 | -0.1 | -3.0 | -1.3 | -1.6 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.41 | 0.50 | 0.53 | 0.49 | 0.51 | 0.8 | 0.7 | -0.7 | 0.4 | 0.1 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Japan [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **439.3** | **454.7** | **471.2** | **461.0** | **436.1** | **100** | **100** | **100** | **100** | **100** | **0.1** | **0.5** | **-0.2** | **-0.6** | **-0.2** |
| Coal | 76.6 | 121.3 | 117.9 | 120.7 | 115.6 | 17.4 | 26.7 | 25.0 | 26.2 | 26.5 | 2.0 | -0.4 | 0.2 | -0.4 | -0.2 |
| Oil | 250.4 | 202.4 | 174.6 | 154.8 | 135.1 | 57.0 | 44.5 | 37.1 | 33.6 | 31.0 | -0.9 | -2.1 | -1.2 | -1.3 | -1.5 |
| Natural gas | 44.2 | 106.3 | 96.6 | 110.4 | 111.6 | 10.1 | 23.4 | 20.5 | 23.9 | 25.6 | 3.9 | -1.4 | 1.3 | 0.1 | 0.2 |
| Nuclear | 52.7 | 2.4 | 54.4 | 40.8 | 34.5 | 12.0 | 0.5 | 11.6 | 8.8 | 7.9 | -12.5 | 56.0 | -2.8 | -1.7 | 10.3 |
| Hydro | 7.7 | 6.7 | 8.1 | 8.1 | 8.1 | 1.7 | 1.5 | 1.7 | 1.8 | 1.9 | -0.6 | 2.7 | 0.0 | 0.0 | 0.7 |
| Geothermal | 1.6 | 2.4 | 3.8 | 7.7 | 9.0 | 0.4 | 0.5 | 0.8 | 1.7 | 2.1 | 1.9 | 6.9 | 7.1 | 1.6 | 5.0 |
| Others | 6.1 | 13.1 | 15.7 | 18.7 | 22.2 | 1.4 | 2.9 | 3.3 | 4.0 | 5.1 | 3.4 | 2.6 | 1.7 | 1.8 | 2.0 |
| Biomass | 4.9 | 11.1 | 12.1 | 12.8 | 13.8 | 1.1 | 2.5 | 2.6 | 2.8 | 3.2 | 3.6 | 1.2 | 0.6 | 0.7 | 0.8 |
| Solar, Wind, Ocean | 1.2 | 2.0 | 3.1 | 4.7 | 6.6 | 0.3 | 0.4 | 0.7 | 1.0 | 1.5 | 2.3 | 6.5 | 4.2 | 3.4 | 4.5 |
| Biofuels | - | 0.0 | 0.5 | 1.1 | 1.8 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 | - | 2,343.4 | 8.0 | 5.0 | 140.0 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **297.8** | **311.4** | **312.5** | **304.9** | **289.4** | **100** | **100** | **100** | **100** | **100** | **0.2** | **0.1** | **-0.2** | **-0.5** | **-0.3** |
| Industry | 100.7 | 82.0 | 88.8 | 88.6 | 87.3 | 33.8 | 26.3 | 28.4 | 29.1 | 30.2 | -0.9 | 1.1 | 0.0 | -0.1 | 0.2 |
| Transportation | 71.8 | 73.4 | 69.6 | 62.2 | 55.5 | 24.1 | 23.6 | 22.3 | 20.4 | 19.2 | 0.1 | -0.8 | -1.1 | -1.1 | -1.0 |
| Others | 90.9 | 117.8 | 118.3 | 119.1 | 113.7 | 30.5 | 37.8 | 37.9 | 39.1 | 39.3 | 1.1 | 0.1 | 0.1 | -0.5 | -0.1 |
| Non-energy | 34.4 | 38.1 | 35.7 | 35.0 | 32.9 | 11.6 | 12.2 | 11.4 | 11.5 | 11.4 | 0.4 | -0.9 | -0.2 | -0.6 | -0.5 |
| **Total** | **297.8** | **311.4** | **312.5** | **304.9** | **289.4** | **100** | **100** | **100** | **100** | **100** | **0.2** | **0.1** | **-0.2** | **-0.5** | **-0.3** |
| Coal | 31.7 | 25.9 | 26.5 | 25.2 | 22.8 | 10.6 | 8.3 | 8.5 | 8.3 | 7.9 | -0.9 | 0.3 | -0.5 | -1.0 | -0.5 |
| Oil | 182.3 | 165.7 | 154.7 | 136.9 | 118.0 | 61.2 | 53.2 | 49.5 | 44.9 | 40.8 | -0.4 | -1.0 | -1.2 | -1.5 | -1.2 |
| Natural gas | 15.2 | 33.9 | 36.7 | 38.7 | 39.3 | 5.1 | 10.9 | 11.8 | 12.7 | 13.6 | 3.5 | 1.1 | 0.5 | 0.1 | 0.5 |
| Electricity | 64.5 | 81.7 | 88.2 | 94.9 | 97.4 | 21.6 | 26.2 | 28.2 | 31.1 | 33.7 | 1.0 | 1.1 | 0.7 | 0.3 | 0.7 |
| Heat | 0.2 | 0.5 | 2.6 | 4.7 | 6.5 | 0.1 | 0.2 | 0.8 | 1.5 | 2.3 | 4.5 | 25.1 | 6.0 | 3.4 | 9.6 |
| Others | 3.9 | 3.6 | 3.7 | 4.4 | 5.3 | 1.3 | 1.1 | 1.2 | 1.4 | 1.8 | -0.4 | 0.6 | 1.7 | 1.9 | 1.5 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **835.5** | **1,038.5** | **1,115.6** | **1,188.4** | **1,200.3** | **100** | **100** | **100** | **100** | **100** | **0.9** | **1.0** | **0.6** | **0.1** | **0.5** |
| Coal | 116.3 | 336.7 | 318.0 | 337.3 | 324.7 | 13.9 | 32.4 | 28.5 | 28.4 | 27.1 | 4.7 | -0.8 | 0.6 | -0.4 | -0.1 |
| Oil | 236.6 | 149.9 | 66.7 | 57.0 | 53.0 | 28.3 | 14.4 | 6.0 | 4.8 | 4.4 | -2.0 | -10.9 | -1.6 | -0.7 | -3.8 |
| Natural gas | 178.5 | 401.7 | 343.1 | 429.6 | 451.9 | 21.4 | 38.7 | 30.8 | 36.2 | 37.7 | 3.6 | -2.2 | 2.3 | 0.5 | 0.4 |
| Nuclear | 202.3 | 9.3 | 208.9 | 156.5 | 132.2 | 24.2 | 0.9 | 18.7 | 13.2 | 11.0 | -12.5 | 56.0 | -2.8 | -1.7 | 10.3 |
| Hydro | 89.3 | 78.1 | 94.1 | 94.3 | 94.4 | 10.7 | 7.5 | 8.4 | 7.9 | 7.9 | -0.6 | 2.7 | 0.0 | 0.0 | 0.7 |
| Geothermal | 1.7 | 2.6 | 4.3 | 8.7 | 10.3 | 0.2 | 0.2 | 0.4 | 0.7 | 0.9 | 1.8 | 7.4 | 7.4 | 1.7 | 5.2 |
| Others | 10.7 | 60.2 | 80.6 | 105.1 | 133.7 | 1.3 | 5.8 | 7.2 | 8.8 | 11.1 | 7.8 | 4.3 | 2.7 | 2.4 | 3.0 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **109.3** | **172.3** | **139.0** | **152.8** | **149.9** | **100** | **100** | **100** | **100** | **100** | **2.0** | **-3.0** | **0.9** | **-0.2** | **-0.5** |
| Coal | 25.4 | 69.7 | 65.9 | 69.8 | 67.2 | 23.2 | 40.5 | 47.4 | 45.7 | 44.9 | 4.5 | -0.8 | 0.6 | -0.4 | -0.1 |
| Oil | 50.6 | 30.4 | 13.5 | 11.5 | 10.7 | 46.3 | 17.6 | 9.7 | 7.5 | 7.1 | -2.2 | -10.9 | -1.6 | -0.7 | -3.8 |
| Natural gas | 33.3 | 72.1 | 59.6 | 71.4 | 72.0 | 30.5 | 41.9 | 42.9 | 46.7 | 48.0 | 3.4 | -2.7 | 1.8 | 0.1 | 0.0 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **42** | **44** | **45** | **46** | **48** | **0.3** | **0.2** | **0.3** | **0.3** | **0.3** |
| Coal | 39 | 42 | 42 | 42 | 42 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | 40 | 42 | 42 | 43 | 43 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 46 | 48 | 49 | 52 | 54 | 0.2 | 0.5 | 0.4 | 0.4 | 0.4 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **291.8** | **336.6** | **305.5** | **301.3** | **282.0** | **100** | **100** | **100** | **100** | **100** | **0.6** | **-1.4** | **-0.1** | **-0.7** | **-0.7** |
| Coal | 82.3 | 130.6 | 127.0 | 130.0 | 124.5 | 28.2 | 38.8 | 41.6 | 43.1 | 44.1 | 2.0 | -0.4 | 0.2 | -0.4 | -0.2 |
| Oil | 181.4 | 138.1 | 116.8 | 100.8 | 86.2 | 62.2 | 41.0 | 38.2 | 33.5 | 30.6 | -1.2 | -2.4 | -1.5 | -1.6 | -1.7 |
| Natural Gas | 28.1 | 67.9 | 61.7 | 70.5 | 71.3 | 9.6 | 20.2 | 20.2 | 23.4 | 25.3 | 3.9 | -1.4 | 1.4 | 0.1 | 0.2 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 3,801 | 4,686 | 5,423 | 6,267 | 6,932 | 0.9 | 2.1 | 1.5 | 1.0 | 1.5 |
| Population (millions of people) | 124 | 127 | 125 | 120 | 114 | 0.1 | -0.2 | -0.4 | -0.5 | -0.4 |
| GDP per capita (thousands of 2005 USD/person) | 30.8 | 36.8 | 43.3 | 52.0 | 60.8 | 0.8 | 2.3 | 1.9 | 1.6 | 1.9 |
| Primary energy consumption per capita (toe/person) | 3.6 | 3.6 | 3.8 | 3.8 | 3.8 | 0.0 | 0.7 | 0.2 | 0.0 | 0.3 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 116 | 97 | 87 | 74 | 63 | -0.8 | -1.6 | -1.7 | -1.6 | -1.6 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 78 | 66 | 58 | 49 | 42 | -0.7 | -2.0 | -1.7 | -1.5 | -1.7 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 77 | 72 | 56 | 48 | 41 | -0.3 | -3.4 | -1.6 | -1.7 | -2.1 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.7 | 0.7 | 0.6 | 0.7 | 0.6 | 0.5 | -1.9 | 0.1 | -0.1 | -0.5 |
| Automobile ownership volume (millions of vehicles) | 57.7 | 76.5 | 76.6 | 73.9 | 71.1 | 1.2 | 0.0 | -0.4 | -0.4 | -0.3 |
| Automobile ownership volume per capita (vehicles per person) | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 1.1 | 0.2 | 0.0 | 0.2 | 0.1 |

# Japan [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **439.3** | **454.7** | **460.9** | **425.7** | **386.3** | **100** | **100** | **100** | **100** | **100** | **0.1** | **0.2** | **-0.8** | **-1.0** | **-0.6** |
| Coal | 76.6 | 121.3 | 109.3 | 104.7 | 94.7 | 17.4 | 26.7 | 23.7 | 24.6 | 24.5 | 2.0 | -1.5 | -0.4 | -1.0 | -0.9 |
| Oil | 250.4 | 202.4 | 166.7 | 138.3 | 112.0 | 57.0 | 44.5 | 36.2 | 32.5 | 29.0 | -0.9 | -2.7 | -1.9 | -2.1 | -2.2 |
| Natural gas | 44.2 | 106.3 | 82.1 | 80.1 | 71.9 | 10.1 | 23.4 | 17.8 | 18.8 | 18.6 | 3.9 | -3.6 | -0.3 | -1.1 | -1.4 |
| Nuclear | 52.7 | 2.4 | 72.6 | 60.7 | 56.3 | 12.0 | 0.5 | 15.8 | 14.3 | 14.6 | -12.5 | 62.5 | -1.8 | -0.7 | 12.4 |
| Hydro | 7.7 | 6.7 | 7.8 | 8.4 | 8.4 | 1.7 | 1.5 | 1.7 | 2.0 | 2.2 | -0.6 | 2.2 | 0.8 | 0.0 | 0.9 |
| Geothermal | 1.6 | 2.4 | 3.9 | 10.3 | 15.4 | 0.4 | 0.5 | 0.8 | 2.4 | 4.0 | 1.9 | 7.0 | 10.3 | 4.2 | 7.1 |
| Others | 6.1 | 13.1 | 18.4 | 23.2 | 27.4 | 1.4 | 2.9 | 4.0 | 5.4 | 7.1 | 3.4 | 4.9 | 2.3 | 1.7 | 2.8 |
| Biomass | 4.9 | 11.0 | 13.7 | 15.3 | 16.5 | 1.1 | 2.4 | 3.0 | 3.6 | 4.3 | 3.6 | 3.2 | 1.1 | 0.7 | 1.5 |
| Solar, Wind, Ocean | 1.2 | 2.0 | 3.9 | 6.6 | 9.0 | 0.3 | 0.4 | 0.8 | 1.6 | 2.3 | 2.3 | 10.0 | 5.5 | 3.2 | 5.8 |
| Biofuels | - | 0.1 | 0.8 | 1.2 | 1.9 | 0.0 | 0.0 | 0.2 | 0.3 | 0.5 | - | 33.6 | 4.7 | 4.7 | 11.5 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **297.8** | **311.4** | **302.1** | **277.7** | **250.4** | **100** | **100** | **100** | **100** | **100** | **0.2** | **-0.4** | **-0.8** | **-1.0** | **-0.8** |
| Industry | 100.7 | 82.0 | 87.1 | 84.8 | 80.9 | 33.8 | 26.3 | 28.8 | 30.5 | 32.3 | -0.9 | 0.9 | -0.3 | -0.5 | -0.1 |
| Transportation | 71.8 | 73.4 | 66.3 | 55.2 | 46.8 | 24.1 | 23.6 | 22.0 | 19.9 | 18.7 | 0.1 | -1.4 | -1.8 | -1.6 | -1.7 |
| Others | 90.9 | 117.8 | 112.9 | 102.7 | 89.8 | 30.5 | 37.8 | 37.4 | 37.0 | 35.9 | 1.1 | -0.6 | -0.9 | -1.3 | -1.0 |
| Non-energy | 34.4 | 38.1 | 35.7 | 35.0 | 32.9 | 11.6 | 12.2 | 11.8 | 12.6 | 13.1 | 0.4 | -0.9 | -0.2 | -0.6 | -0.5 |
| **Total** | **297.8** | **311.4** | **302.1** | **277.7** | **250.4** | **100** | **100** | **100** | **100** | **100** | **0.2** | **-0.4** | **-0.8** | **-1.0** | **-0.8** |
| Coal | 31.7 | 25.9 | 26.6 | 25.2 | 22.7 | 10.6 | 8.3 | 8.8 | 9.1 | 9.1 | -0.9 | 0.3 | -0.5 | -1.0 | -0.5 |
| Oil | 182.3 | 165.7 | 148.0 | 122.2 | 97.6 | 61.2 | 53.2 | 49.0 | 44.0 | 39.0 | -0.4 | -1.6 | -1.9 | -2.2 | -1.9 |
| Natural gas | 15.2 | 33.9 | 35.2 | 34.2 | 31.8 | 5.1 | 10.9 | 11.7 | 12.3 | 12.7 | 3.5 | 0.5 | -0.3 | -0.7 | -0.2 |
| Electricity | 64.5 | 81.7 | 85.1 | 85.6 | 84.3 | 21.6 | 26.2 | 28.2 | 30.8 | 33.7 | 1.0 | 0.6 | 0.1 | -0.2 | 0.1 |
| Heat | 0.2 | 0.5 | 3.0 | 5.1 | 7.2 | 0.1 | 0.2 | 1.0 | 1.8 | 2.9 | 4.5 | 27.3 | 5.6 | 3.5 | 10.0 |
| Others | 3.9 | 3.6 | 4.3 | 5.4 | 6.8 | 1.3 | 1.1 | 1.4 | 1.9 | 2.7 | -0.4 | 2.6 | 2.4 | 2.3 | 2.4 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **835.5** | **1,038.5** | **1,074.6** | **1,058.3** | **1,011.0** | **100** | **100** | **100** | **100** | **100** | **0.9** | **0.5** | **-0.2** | **-0.5** | **-0.1** |
| Coal | 116.3 | 336.7 | 276.2 | 260.5 | 224.3 | 13.9 | 32.4 | 25.7 | 24.6 | 22.2 | 4.7 | -2.8 | -0.6 | -1.5 | -1.5 |
| Oil | 236.6 | 149.9 | 61.3 | 48.1 | 39.8 | 28.3 | 14.4 | 5.7 | 4.5 | 3.9 | -2.0 | -12.0 | -2.4 | -1.9 | -4.8 |
| Natural gas | 178.5 | 401.7 | 268.6 | 273.7 | 248.5 | 21.4 | 38.7 | 25.0 | 25.9 | 24.6 | 3.6 | -5.6 | 0.2 | -1.0 | -1.8 |
| Nuclear | 202.3 | 9.3 | 278.7 | 232.9 | 216.2 | 24.2 | 0.9 | 25.9 | 22.0 | 21.4 | -12.5 | 62.5 | -1.8 | -0.7 | 12.4 |
| Hydro | 89.3 | 78.1 | 90.7 | 98.1 | 98.2 | 10.7 | 7.5 | 8.4 | 9.3 | 9.7 | -0.6 | 2.2 | 0.8 | 0.0 | 0.9 |
| Geothermal | 1.7 | 2.6 | 4.3 | 11.7 | 17.7 | 0.2 | 0.2 | 0.4 | 1.1 | 1.8 | 1.8 | 7.4 | 10.6 | 4.2 | 7.4 |
| Others | 10.7 | 60.2 | 95.0 | 133.2 | 166.3 | 1.3 | 5.8 | 8.8 | 12.6 | 16.5 | 7.8 | 6.7 | 3.4 | 2.2 | 3.8 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **109.3** | **172.3** | **116.3** | **109.2** | **94.0** | **100** | **100** | **100** | **100** | **100** | **2.0** | **-5.5** | **-0.6** | **-1.5** | **-2.2** |
| Coal | 25.4 | 69.7 | 57.2 | 53.9 | 46.4 | 23.2 | 40.5 | 49.2 | 49.4 | 49.4 | 4.5 | -2.8 | -0.6 | -1.5 | -1.5 |
| Oil | 50.6 | 30.4 | 12.4 | 9.7 | 8.0 | 46.3 | 17.6 | 10.7 | 8.9 | 8.5 | -2.2 | -12.0 | -2.4 | -1.9 | -4.8 |
| Natural gas | 33.3 | 72.1 | 46.7 | 45.5 | 39.6 | 30.5 | 41.9 | 40.1 | 41.7 | 42.1 | 3.4 | -6.0 | -0.3 | -1.4 | -2.2 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **42** | **44** | **45** | **46** | **47** | **0.3** | **0.2** | **0.2** | **0.2** | **0.2** |
| Coal | 39 | 42 | 42 | 42 | 42 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | 40 | 42 | 42 | 43 | 43 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 46 | 48 | 49 | 52 | 54 | 0.2 | 0.5 | 0.4 | 0.4 | 0.4 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **291.8** | **336.6** | **280.4** | **250.9** | **214.7** | **100** | **100** | **100** | **100** | **100** | **0.6** | **-2.6** | **-1.1** | **-1.5** | **-1.7** |
| Coal | 82.3 | 130.6 | 117.7 | 112.7 | 102.0 | 28.2 | 38.8 | 42.0 | 44.9 | 47.5 | 2.0 | -1.5 | -0.4 | -1.0 | -0.9 |
| Oil | 181.4 | 138.1 | 110.2 | 87.0 | 66.8 | 62.2 | 41.0 | 39.3 | 34.7 | 31.1 | -1.2 | -3.2 | -2.3 | -2.6 | -2.7 |
| Natural Gas | 28.1 | 67.9 | 52.4 | 51.1 | 45.9 | 9.6 | 20.2 | 18.7 | 20.4 | 21.4 | 3.9 | -3.6 | -0.3 | -1.1 | -1.4 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 3,801 | 4,686 | 5,423 | 6,267 | 6,932 | 0.9 | 2.1 | 1.5 | 1.0 | 1.5 |
| Population (millions of people) | 124 | 127 | 125 | 120 | 114 | 0.1 | -0.2 | -0.4 | -0.5 | -0.4 |
| GDP per capita (thousands of 2005 USD/person) | 30.8 | 36.8 | 43.3 | 52.0 | 60.8 | 0.8 | 2.3 | 1.9 | 1.6 | 1.9 |
| Primary energy consumption per capita (toe/person) | 3.6 | 3.6 | 3.7 | 3.5 | 3.4 | 0.0 | 0.4 | -0.4 | -0.4 | -0.2 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 116 | 97 | 85 | 68 | 56 | -0.8 | -1.9 | -2.2 | -2.0 | -2.0 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 78 | 66 | 56 | 44 | 36 | -0.7 | -2.5 | -2.3 | -2.0 | -2.2 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 77 | 72 | 52 | 40 | 31 | -0.3 | -4.6 | -2.5 | -2.5 | -3.1 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 | -2.8 | -0.3 | -0.6 | -1.1 |
| Automobile ownership volume (millions of vehicles) | 57.7 | 76.5 | 76.6 | 73.9 | 71.1 | 1.2 | 0.0 | -0.4 | -0.4 | -0.3 |
| Automobile ownership volume per capita (vehicles per person) | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 1.1 | 0.2 | 0.0 | 0.2 | 0.1 |

# Korea [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **92.9** | **263.8** | **304.3** | **331.5** | **339.5** | **100** | **100** | **100** | **100** | **100** | **4.6** | **2.1** | **0.9** | **0.2** | **0.9** |
| Coal | 25.4 | 77.9 | 79.3 | 87.5 | 90.2 | 27.3 | 29.5 | 26.1 | 26.4 | 26.6 | 5.0 | 0.3 | 1.0 | 0.3 | 0.5 |
| Oil | 49.7 | 96.6 | 102.5 | 102.6 | 101.5 | 53.5 | 36.6 | 33.7 | 30.9 | 29.9 | 2.9 | 0.9 | 0.0 | -0.1 | 0.2 |
| Natural gas | 2.7 | 47.6 | 49.8 | 59.3 | 63.5 | 2.9 | 18.0 | 16.4 | 17.9 | 18.7 | 13.2 | 0.6 | 1.8 | 0.7 | 1.1 |
| Nuclear | 13.8 | 36.2 | 65.8 | 73.6 | 73.6 | 14.8 | 13.7 | 21.6 | 22.2 | 21.7 | 4.3 | 8.9 | 1.1 | 0.0 | 2.7 |
| Hydro | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | -1.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Geothermal | - | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | -2.8 | 1.9 | 1.6 | 0.6 |
| Others | 0.7 | 5.2 | 6.4 | 8.1 | 10.2 | 0.8 | 2.0 | 2.1 | 2.4 | 3.0 | 8.8 | 3.2 | 2.3 | 2.4 | 2.6 |
| Biomass | 0.7 | 4.3 | 4.9 | 5.7 | 6.5 | 0.8 | 1.6 | 1.6 | 1.7 | 1.9 | 8.1 | 1.8 | 1.5 | 1.2 | 1.5 |
| Solar, Wind, Ocean | 0.0 | 0.4 | 0.8 | 1.7 | 3.0 | 0.0 | 0.1 | 0.3 | 0.5 | 0.9 | 16.8 | 13.2 | 6.9 | 6.1 | 8.2 |
| Biofuels | - | 0.4 | 0.4 | 0.4 | 0.5 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | - | 1.4 | 1.2 | 1.1 | 1.2 |
| Electricit | - | 0.1 | 0.3 | 0.3 | 0.3 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | - | 16.1 | 0.0 | 0.0 | 3.9 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **64.9** | **167.8** | **188.6** | **202.9** | **207.7** | **100** | **100** | **100** | **100** | **100** | **4.2** | **1.7** | **0.7** | **0.2** | **0.8** |
| Industry | 19.3 | 47.7 | 55.8 | 61.1 | 60.6 | 29.7 | 28.4 | 29.6 | 30.1 | 29.2 | 4.0 | 2.3 | 0.9 | -0.1 | 0.9 |
| Transportation | 14.6 | 31.4 | 34.4 | 34.7 | 34.4 | 22.5 | 18.7 | 18.3 | 17.1 | 16.6 | 3.4 | 1.3 | 0.1 | -0.1 | 0.3 |
| Others | 24.3 | 45.0 | 48.6 | 53.4 | 57.4 | 37.5 | 26.8 | 25.8 | 26.3 | 27.6 | 2.7 | 1.1 | 0.9 | 0.7 | 0.9 |
| Non-energy | 6.7 | 43.8 | 49.7 | 53.7 | 55.3 | 10.4 | 26.1 | 26.4 | 26.5 | 26.6 | 8.5 | 1.8 | 0.8 | 0.3 | 0.9 |
| **Total** | **64.9** | **167.8** | **188.6** | **202.9** | **207.7** | **100** | **100** | **100** | **100** | **100** | **4.2** | **1.7** | **0.7** | **0.2** | **0.8** |
| Coal | 11.7 | 9.5 | 11.4 | 11.4 | 9.8 | 18.1 | 5.6 | 6.0 | 5.6 | 4.7 | -0.9 | 2.7 | 0.0 | -1.5 | 0.1 |
| Oil | 43.7 | 84.6 | 92.0 | 92.6 | 91.9 | 67.3 | 50.4 | 48.8 | 45.6 | 44.2 | 2.9 | 1.2 | 0.1 | -0.1 | 0.3 |
| Natural gas | 0.7 | 24.1 | 26.9 | 30.8 | 30.8 | 1.0 | 14.4 | 14.3 | 15.2 | 14.8 | 16.8 | 1.6 | 1.4 | 0.0 | 0.9 |
| Electricity | 8.1 | 41.9 | 50.2 | 59.4 | 65.7 | 12.5 | 25.0 | 26.6 | 29.3 | 31.6 | 7.4 | 2.6 | 1.7 | 1.0 | 1.7 |
| Heat | - | 4.3 | 4.2 | 4.0 | 3.9 | 0.0 | 2.5 | 2.2 | 2.0 | 1.9 | - | -0.3 | -0.3 | -0.4 | -0.3 |
| Others | 0.7 | 3.5 | 3.9 | 4.7 | 5.6 | 1.1 | 2.1 | 2.1 | 2.3 | 2.7 | 7.0 | 1.8 | 1.7 | 1.9 | 1.8 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **105.4** | **537.9** | **634.5** | **749.1** | **827.4** | **100** | **100** | **100** | **100** | **100** | **7.3** | **2.4** | **1.7** | **1.0** | **1.6** |
| Coal | 17.7 | 222.8 | 220.1 | 261.4 | 298.3 | 16.8 | 41.4 | 34.7 | 34.9 | 36.1 | 11.7 | -0.2 | 1.7 | 1.3 | 1.1 |
| Oil | 18.9 | 21.4 | 11.0 | 7.5 | 6.3 | 17.9 | 4.0 | 1.7 | 1.0 | 0.8 | 0.6 | -9.1 | -3.7 | -1.8 | -4.4 |
| Natural gas | 9.6 | 144.8 | 135.0 | 172.9 | 202.2 | 9.1 | 26.9 | 21.3 | 23.1 | 24.4 | 12.5 | -1.0 | 2.5 | 1.6 | 1.2 |
| Nuclear | 52.9 | 138.8 | 252.6 | 282.5 | 282.5 | 50.2 | 25.8 | 39.8 | 37.7 | 34.1 | 4.3 | 8.9 | 1.1 | 0.0 | 2.7 |
| Hydro | 6.4 | 4.3 | 4.3 | 4.3 | 4.3 | 6.0 | 0.8 | 0.7 | 0.6 | 0.5 | -1.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Geothermal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | 0.0 | 5.7 | 11.5 | 20.5 | 33.9 | 0.0 | 1.1 | 1.8 | 2.7 | 4.1 | 45.7 | 10.4 | 6.0 | 5.1 | 6.8 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **12.5** | **81.4** | **77.2** | **89.9** | **100.0** | **100** | **100** | **100** | **100** | **100** | **8.5** | **-0.7** | **1.5** | **1.1** | **0.8** |
| Coal | 6.0 | 53.6 | 51.6 | 59.2 | 65.3 | 47.7 | 65.9 | 66.8 | 65.9 | 65.4 | 10.0 | -0.5 | 1.4 | 1.0 | 0.7 |
| Oil | 4.5 | 5.1 | 2.7 | 1.9 | 1.6 | 36.0 | 6.3 | 3.4 | 2.1 | 1.6 | 0.5 | -8.9 | -3.5 | -1.6 | -4.3 |
| Natural gas | 2.0 | 22.7 | 23.0 | 28.8 | 33.1 | 16.3 | 27.9 | 29.7 | 32.1 | 33.1 | 11.0 | 0.2 | 2.3 | 1.4 | 1.4 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **32** | **41** | **41** | **42** | **44** | **1.1** | **-0.1** | **0.4** | **0.3** | **0.2** |
| Coal | 25 | 36 | 37 | 38 | 39 | 1.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| Oil | 36 | 36 | 36 | 35 | 34 | 0.0 | -0.2 | -0.2 | -0.2 | -0.2 |
| Natural gas | 41 | 55 | 51 | 52 | 53 | 1.3 | -1.2 | 0.2 | 0.2 | -0.2 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **65.2** | **158.7** | **161.6** | **173.3** | **176.7** | **100** | **100** | **100** | **100** | **100** | **3.9** | **0.3** | **0.7** | **0.2** | **0.4** |
| Coal | 27.4 | 83.6 | 85.1 | 94.0 | 96.9 | 42.1 | 52.7 | 52.7 | 54.2 | 54.8 | 5.0 | 0.3 | 1.0 | 0.3 | 0.5 |
| Oil | 36.0 | 44.6 | 44.6 | 41.3 | 39.1 | 55.2 | 28.1 | 27.6 | 23.8 | 22.1 | 0.9 | 0.0 | -0.8 | -0.6 | -0.5 |
| Natural Gas | 1.7 | 30.5 | 31.9 | 38.0 | 40.7 | 2.7 | 19.2 | 19.8 | 21.9 | 23.0 | 13.2 | 0.6 | 1.8 | 0.7 | 1.1 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 378 | 1,199 | 1,530 | 1,991 | 2,382 | 5.1 | 3.5 | 2.7 | 1.8 | 2.6 |
| Population (millions of people) | 43 | 50 | 51 | 52 | 51 | 0.7 | 0.3 | 0.1 | -0.2 | 0.1 |
| GDP per capita (thousands of 2005 USD/person) | 8.8 | 23.9 | 29.7 | 38.2 | 46.6 | 4.4 | 3.2 | 2.5 | 2.0 | 2.5 |
| Primary energy consumption per capita (toe/person) | 2.2 | 5.3 | 5.9 | 6.4 | 6.6 | 3.9 | 1.7 | 0.7 | 0.4 | 0.9 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 246 | 220 | 199 | 166 | 143 | -0.5 | -1.4 | -1.8 | -1.5 | -1.6 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 172 | 140 | 123 | 102 | 87 | -0.9 | -1.8 | -1.9 | -1.5 | -1.7 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 172 | 132 | 106 | 87 | 74 | -1.1 | -3.2 | -1.9 | -1.6 | -2.1 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.7 | 0.6 | 0.5 | 0.5 | 0.5 | -0.7 | -1.8 | -0.2 | 0.0 | -0.5 |
| Automobile ownership volume (millions of vehicles) | 3.4 | 19.4 | 22.3 | 26.1 | 28.8 | 7.9 | 2.0 | 1.6 | 1.0 | 1.5 |
| Automobile ownership volume per capita (vehicles per person) | 0.1 | 0.4 | 0.4 | 0.5 | 0.6 | 7.1 | 1.7 | 1.4 | 1.2 | 1.4 |

# Korea [APS]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **92.9** | **263.8** | **297.5** | **312.4** | **307.6** | **100** | **100** | **100** | **100** | **100** | **4.6** | **1.7** | **0.5** | **-0.2** | **0.6** |
| Coal | 25.4 | 77.9 | 76.3 | 73.5 | 62.8 | 27.3 | 29.5 | 25.6 | 23.5 | 20.4 | 5.0 | -0.3 | -0.4 | -1.6 | -0.8 |
| Oil | 49.7 | 96.6 | 101.2 | 97.1 | 92.3 | 53.5 | 36.6 | 34.0 | 31.1 | 30.0 | 2.9 | 0.7 | -0.4 | -0.5 | -0.2 |
| Natural gas | 2.7 | 47.6 | 46.7 | 48.9 | 44.2 | 2.9 | 18.0 | 15.7 | 15.6 | 14.4 | 13.2 | -0.3 | 0.5 | -1.0 | -0.3 |
| Nuclear | 13.8 | 36.2 | 65.8 | 80.1 | 89.8 | 14.8 | 13.7 | 22.1 | 25.6 | 29.2 | 4.3 | 8.9 | 2.0 | 1.2 | 3.4 |
| Hydro | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | -1.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Geothermal | - | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | -2.8 | 1.9 | 1.6 | 0.6 |
| Others | 0.7 | 5.2 | 7.1 | 12.4 | 17.8 | 0.8 | 2.0 | 2.4 | 4.0 | 5.8 | 8.8 | 4.6 | 5.8 | 3.7 | 4.7 |
| Biomass | 0.7 | 4.3 | 5.0 | 5.9 | 6.8 | 0.8 | 1.6 | 1.7 | 1.9 | 2.2 | 8.1 | 2.1 | 1.7 | 1.3 | 1.7 |
| Solar, Wind, Ocean | 0.0 | 0.4 | 1.4 | 5.3 | 9.9 | 0.0 | 0.1 | 0.5 | 1.7 | 3.2 | 16.8 | 21.3 | 14.5 | 6.3 | 13.1 |
| Biofuels | - | 0.4 | 0.4 | 0.8 | 1.0 | 0.0 | 0.1 | 0.1 | 0.3 | 0.3 | - | 1.6 | 7.4 | 1.7 | 3.8 |
| Electricit | - | 0.1 | 0.3 | 0.3 | 0.3 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | - | 16.1 | 0.0 | 0.0 | 3.9 |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **64.9** | **167.8** | **184.4** | **191.5** | **188.0** | **100** | **100** | **100** | **100** | **100** | **4.2** | **1.4** | **0.4** | **-0.2** | **0.4** |
| Industry | 19.3 | 47.7 | 54.1 | 57.1 | 54.1 | 29.7 | 28.4 | 29.4 | 29.8 | 28.8 | 4.0 | 1.8 | 0.5 | -0.5 | 0.5 |
| Transportation | 14.6 | 31.4 | 33.2 | 31.1 | 28.5 | 22.5 | 18.7 | 18.0 | 16.2 | 15.2 | 3.4 | 0.8 | -0.7 | -0.9 | -0.4 |
| Others | 24.3 | 45.0 | 47.3 | 49.6 | 50.1 | 37.5 | 26.8 | 25.6 | 25.9 | 26.6 | 2.7 | 0.7 | 0.5 | 0.1 | 0.4 |
| Non-energy | 6.7 | 43.8 | 49.7 | 53.7 | 55.3 | 10.4 | 26.1 | 27.0 | 28.0 | 29.4 | 8.5 | 1.8 | 0.8 | 0.3 | 0.9 |
| **Total** | **64.9** | **167.8** | **184.4** | **191.5** | **188.0** | **100** | **100** | **100** | **100** | **100** | **4.2** | **1.4** | **0.4** | **-0.2** | **0.4** |
| Coal | 11.7 | 9.5 | 11.1 | 10.6 | 8.4 | 18.1 | 5.6 | 6.0 | 5.5 | 4.5 | -0.9 | 2.3 | -0.4 | -2.3 | -0.4 |
| Oil | 43.7 | 84.6 | 91.1 | 88.0 | 84.0 | 67.3 | 50.4 | 49.4 | 45.9 | 44.7 | 2.9 | 1.1 | -0.3 | -0.5 | 0.0 |
| Natural gas | 0.7 | 24.1 | 25.1 | 27.4 | 25.8 | 1.0 | 14.4 | 13.6 | 14.3 | 13.7 | 16.8 | 0.5 | 0.9 | -0.6 | 0.2 |
| Electricity | 8.1 | 41.9 | 49.2 | 56.8 | 60.4 | 12.5 | 25.0 | 26.7 | 29.7 | 32.1 | 7.4 | 2.3 | 1.5 | 0.6 | 1.4 |
| Heat | - | 4.3 | 4.0 | 3.8 | 3.4 | 0.0 | 2.5 | 2.2 | 2.0 | 1.8 | - | -0.7 | -0.7 | -0.9 | -0.8 |
| Others | 0.7 | 3.5 | 3.9 | 4.9 | 5.9 | 1.1 | 2.1 | 2.1 | 2.6 | 3.1 | 7.0 | 1.6 | 2.4 | 1.8 | 2.0 |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **105.4** | **537.9** | **622.7** | **717.5** | **761.9** | **100** | **100** | **100** | **100** | **100** | **7.3** | **2.1** | **1.4** | **0.6** | **1.3** |
| Coal | 17.7 | 222.8 | 209.0 | 202.2 | 175.6 | 16.8 | 41.4 | 33.6 | 28.2 | 23.0 | 11.7 | -0.9 | -0.3 | -1.4 | -0.9 |
| Oil | 18.9 | 21.4 | 10.5 | 5.8 | 3.7 | 17.9 | 4.0 | 1.7 | 0.8 | 0.5 | 0.6 | -9.7 | -5.7 | -4.4 | -6.3 |
| Natural gas | 9.6 | 144.8 | 128.2 | 133.3 | 118.1 | 9.1 | 26.9 | 20.6 | 18.6 | 15.5 | 12.5 | -1.7 | 0.4 | -1.2 | -0.8 |
| Nuclear | 52.9 | 138.8 | 252.6 | 307.4 | 344.8 | 50.2 | 25.8 | 40.6 | 42.8 | 45.2 | 4.3 | 8.9 | 2.0 | 1.2 | 3.4 |
| Hydro | 6.4 | 4.3 | 4.3 | 4.3 | 4.3 | 6.0 | 0.8 | 0.7 | 0.6 | 0.6 | -1.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Geothermal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | 0.0 | 5.7 | 18.1 | 64.5 | 115.5 | 0.0 | 1.1 | 2.9 | 9.0 | 15.2 | 45.7 | 17.9 | 13.5 | 6.0 | 11.8 |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **12.5** | **81.4** | **72.7** | **68.0** | **56.8** | **100** | **100** | **100** | **100** | **100** | **8.5** | **-1.6** | **-0.7** | **-1.8** | **-1.3** |
| Coal | 6.0 | 53.6 | 48.7 | 45.0 | 37.5 | 47.7 | 65.9 | 66.9 | 66.2 | 66.0 | 10.0 | -1.4 | -0.8 | -1.8 | -1.3 |
| Oil | 4.5 | 5.1 | 2.5 | 1.4 | 0.9 | 36.0 | 6.3 | 3.5 | 2.1 | 1.6 | 0.5 | -9.6 | -5.5 | -4.2 | -6.1 |
| Natural gas | 2.0 | 22.7 | 21.5 | 21.6 | 18.4 | 16.3 | 27.9 | 29.6 | 31.7 | 32.4 | 11.0 | -0.7 | 0.0 | -1.6 | -0.8 |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **32** | **41** | **41** | **43** | **45** | **1.1** | **0.0** | **0.5** | **0.4** | **0.3** |
| Coal | 25 | 36 | 37 | 39 | 40 | 1.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| Oil | 36 | 36 | 36 | 35 | 34 | 0.0 | -0.2 | -0.2 | -0.2 | -0.2 |
| Natural gas | 41 | 55 | 51 | 53 | 55 | 1.3 | -1.0 | 0.4 | 0.4 | 0.0 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **65.2** | **158.7** | **155.3** | **146.9** | **127.1** | **100** | **100** | **100** | **100** | **100** | **3.9** | **-0.3** | **-0.6** | **-1.4** | **-0.8** |
| Coal | 27.4 | 83.6 | 81.9 | 78.9 | 67.4 | 42.1 | 52.7 | 52.7 | 53.7 | 53.0 | 5.0 | -0.3 | -0.4 | -1.6 | -0.8 |
| Oil | 36.0 | 44.6 | 43.5 | 36.7 | 31.4 | 55.2 | 28.1 | 28.0 | 25.0 | 24.7 | 0.9 | -0.3 | -1.7 | -1.6 | -1.3 |
| Natural Gas | 1.7 | 30.5 | 29.9 | 31.3 | 28.4 | 2.7 | 19.2 | 19.3 | 21.3 | 22.3 | 13.2 | -0.3 | 0.5 | -1.0 | -0.3 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 378 | 1,199 | 1,530 | 1,991 | 2,382 | 5.1 | 3.5 | 2.7 | 1.8 | 2.6 |
| Population (millions of people) | 43 | 50 | 51 | 52 | 51 | 0.7 | 0.3 | 0.1 | -0.2 | 0.1 |
| GDP per capita (thousands of 2005 USD/person) | 8.8 | 23.9 | 29.7 | 38.2 | 46.6 | 4.4 | 3.2 | 2.5 | 2.0 | 2.5 |
| Primary energy consumption per capita (toe/person) | 2.2 | 5.3 | 5.8 | 6.0 | 6.0 | 3.9 | 1.4 | 0.3 | 0.1 | 0.5 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 246 | 220 | 195 | 157 | 129 | -0.5 | -1.7 | -2.1 | -1.9 | -2.0 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 172 | 140 | 121 | 96 | 79 | -0.9 | -2.1 | -2.2 | -2.0 | -2.1 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 172 | 132 | 102 | 74 | 53 | -1.1 | -3.7 | -3.1 | -3.2 | -3.3 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | -0.7 | -2.0 | -1.0 | -1.3 | -1.4 |
| Automobile ownership volume (millions of vehicles) | 3.4 | 19.4 | 22.3 | 26.1 | 28.8 | 7.9 | 2.0 | 1.6 | 1.0 | 1.5 |
| Automobile ownership volume per capita (vehicles per person) | 0.1 | 0.4 | 0.4 | 0.5 | 0.6 | 7.1 | 1.7 | 1.4 | 1.2 | 1.4 |

# Lao PDR [BAU]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1.20** | **2.47** | **5.26** | **7.23** | **9.52** | **100** | **100** | **100** | **100** | **100** | **3.2** | **11.4** | **3.2** | **2.8** | **5.1** |
| Coal | 0.00 | 0.00 | 3.12 | 3.65 | 3.65 | 0.0 | 0.2 | 59.3 | 50.4 | 38.4 | - | 155.4 | 1.6 | 0.0 | 28.3 |
| Oil | 0.16 | 0.84 | 1.15 | 1.95 | 3.02 | 13.6 | 34.1 | 21.8 | 27.0 | 31.7 | 7.4 | 4.5 | 5.5 | 4.5 | 4.8 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.07 | 1.33 | 1.87 | 3.30 | 4.35 | 5.9 | 53.9 | 35.6 | 45.7 | 45.7 | 13.6 | 5.0 | 5.8 | 2.8 | 4.5 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.97 | 0.29 | -0.88 | -1.67 | -1.50 | 80.5 | 11.9 | -16.6 | -23.1 | -15.7 | -5.0 | -216.9 | 6.7 | -1.1 | -206.2 |
| Biomass | 1.01 | 1.27 | 1.37 | 1.52 | 1.69 | 84.6 | 51.3 | 26.0 | 21.0 | 17.8 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 |
| Solar, Wind, Ocean | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Biofuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Electricity | -0.05 | -0.98 | -2.24 | -3.19 | -3.19 | -4.1 | -39.5 | -42.6 | -44.1 | -33.5 | 13.9 | 12.6 | 3.6 | 0.0 | 4.5 |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1.09** | **2.41** | **3.10** | **4.65** | **6.89** | **100** | **100** | **100** | **100** | **100** | **3.5** | **3.7** | **4.2** | **4.0** | **4.0** |
| Industry | 0.04 | 0.16 | 0.22 | 0.35 | 0.57 | 3.6 | 6.8 | 7.0 | 7.5 | 8.3 | 6.4 | 4.2 | 4.9 | 5.0 | 4.8 |
| Transportation | 0.16 | 0.81 | 1.11 | 1.91 | 2.97 | 14.7 | 33.7 | 35.8 | 41.0 | 43.1 | 7.3 | 4.6 | 5.6 | 4.5 | 4.9 |
| Others | 0.89 | 1.43 | 1.77 | 2.39 | 3.35 | 81.7 | 59.5 | 57.1 | 51.4 | 48.6 | 2.1 | 3.1 | 3.1 | 3.4 | 3.2 |
| Non-energy | - | 0.00 | 0.00 | 0.00 | 0.01 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | - | 2.0 | 2.5 | 2.0 | 2.2 |
| **Total** | **1.09** | **2.41** | **3.10** | **4.65** | **6.89** | **100** | **100** | **100** | **100** | **100** | **3.5** | **3.7** | **4.2** | **4.0** | **4.0** |
| Coal | 0.00 | 0.00 | 0.02 | 0.03 | 0.04 | 0.0 | 0.2 | 0.6 | 0.7 | 0.5 | - | 22.7 | 5.3 | 1.8 | 8.2 |
| Oil | 0.16 | 0.84 | 1.15 | 1.95 | 3.02 | 14.9 | 35.0 | 37.0 | 41.9 | 43.8 | 7.4 | 4.5 | 5.5 | 4.5 | 4.8 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricity | 0.01 | 0.29 | 0.57 | 1.15 | 2.14 | 1.3 | 12.1 | 18.3 | 24.7 | 31.1 | 14.0 | 10.0 | 7.3 | 6.4 | 7.7 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.92 | 1.27 | 1.37 | 1.52 | 1.69 | 83.8 | 52.7 | 44.2 | 32.7 | 24.6 | 1.4 | 1.1 | 1.1 | 1.1 | 1.1 |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.82** | **15.51** | **34.40** | **53.12** | **65.30** | **100** | **100** | **100** | **100** | **100** | **13.6** | **12.1** | **4.4** | **2.1** | **5.5** |
| Coal | 0.00 | 0.00 | 12.61 | 14.72 | 14.72 | 0.0 | 0.0 | 36.7 | 27.7 | 22.5 | - | - | 1.6 | 0.0 | - |
| Oil | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.82 | 15.51 | 21.79 | 38.41 | 50.58 | 100.0 | 100.0 | 63.3 | 72.3 | 77.5 | 13.6 | 5.0 | 5.8 | 2.8 | 4.5 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.00** | **0.00** | **3.10** | **3.62** | **3.62** | **-** | **-** | **100** | **100** | **100** | **-** | **-** | **1.6** | **0.0** | **-** |
| Coal | 0.00 | 0.00 | 3.10 | 3.62 | 3.62 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | - | - | 1.6 | 0.0 | - |
| Oil | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **-** | **-** | **35** | **35** | **35** | **-** | **-** | **0.0** | **0.0** | **-** |
| Coal | - | - | 35 | 35 | 35 | - | - | 0.0 | 0.0 | - |
| Oil | - | - | - | - | - | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - |

## $CO_2$ emissions

| BAU | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.20** | **0.70** | **4.55** | **5.82** | **6.70** | **100** | **100** | **100** | **100** | **100** | **5.6** | **30.7** | **2.5** | **1.4** | **8.7** |
| Coal | 0.00 | 0.00 | 3.60 | 4.21 | 4.22 | 0.0 | 0.7 | 79.3 | 72.4 | 63.0 | - | 157.3 | 1.6 | 0.0 | 28.5 |
| Oil | 0.20 | 0.69 | 0.94 | 1.60 | 2.48 | 100.0 | 99.3 | 20.7 | 27.6 | 37.0 | 5.6 | 4.5 | 5.5 | 4.5 | 4.8 |
| Natural Gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 1.1 | 5.1 | 8.2 | 15.3 | 26.5 | 6.8 | 7.1 | 6.4 | 5.7 | 6.3 |
| Population (millions of people) | 4.2 | 6.6 | 7.3 | 8.5 | 9.8 | 1.9 | 1.5 | 1.5 | 1.5 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 0.26 | 0.77 | 1.1 | 1.8 | 2.7 | 4.8 | 5.5 | 4.8 | 4.1 | 4.7 |
| Primary energy consumption per capita (toe/person) | 0.3 | 0.4 | 0.7 | 0.9 | 1.0 | 1.2 | 9.7 | 1.7 | 1.3 | 3.6 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,080 | 486 | 640 | 474 | 359 | -3.4 | 4.0 | -3.0 | -2.7 | -1.1 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 984 | 473 | 377 | 305 | 260 | -3.1 | -3.2 | -2.1 | -1.6 | -2.2 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 180 | 137 | 553 | 381 | 253 | -1.2 | 22.1 | -3.6 | -4.0 | 2.3 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.2 | 0.3 | 0.9 | 0.8 | 0.7 | 2.3 | 17.3 | -0.7 | -1.3 | 3.4 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Lao PDR (APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.20** | **2.47** | **4.96** | **6.78** | **8.84** | **100** | **100** | **100** | **100** | **100** | **3.2** | **10.4** | **3.2** | **2.7** | **4.8** |
| Coal | - | 0.00 | 3.12 | 3.64 | 3.65 | 0.0 | 0.2 | 62.8 | 53.8 | 41.3 | - | 155.4 | 1.6 | 0.0 | 28.3 |
| Oil | 0.16 | 0.84 | 1.04 | 1.76 | 2.73 | 13.6 | 34.1 | 20.9 | 26.0 | 30.8 | 7.4 | 3.0 | 5.5 | 4.5 | 4.4 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.07 | 1.33 | 1.81 | 3.18 | 4.12 | 5.9 | 53.9 | 36.6 | 47.0 | 46.6 | 13.6 | 4.5 | 5.8 | 2.6 | 4.3 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.97 | 0.29 | -1.01 | -1.81 | -1.66 | 80.5 | 11.9 | -20.3 | -26.7 | -18.7 | -5.0 | -219.2 | 6.1 | -0.9 | -206.6 |
| Biomass | 1.01 | 1.27 | 1.24 | 1.38 | 1.53 | 84.6 | 51.3 | 25.0 | 20.3 | 17.3 | 1.0 | -0.4 | 1.1 | 1.1 | 0.7 |
| Solar, Wind, Ocean | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Biofuels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Electricity | -0.05 | -0.98 | -2.24 | -3.19 | -3.19 | -4.1 | -39.5 | -45.2 | -47.1 | -36.1 | 13.9 | 12.6 | 3.6 | 0.0 | 4.5 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.09** | **2.41** | **2.80** | **4.20** | **6.22** | **100** | **100** | **100** | **100** | **100** | **3.5** | **2.2** | **4.1** | **4.0** | **3.6** |
| Industry | 0.04 | 0.16 | 0.20 | 0.32 | 0.52 | 3.6 | 6.8 | 7.2 | 7.7 | 8.4 | 6.4 | 3.1 | 4.8 | 4.9 | 4.4 |
| Transportation | 0.16 | 0.81 | 1.00 | 1.72 | 2.68 | 14.7 | 33.7 | 35.7 | 41.0 | 43.0 | 7.3 | 3.1 | 5.6 | 4.5 | 4.5 |
| Others | 0.89 | 1.43 | 1.59 | 2.15 | 3.02 | 81.7 | 59.5 | 56.9 | 51.2 | 48.5 | 2.1 | 1.5 | 3.1 | 3.4 | 2.8 |
| Non-energy | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | - | 1.3 | 2.5 | 2.0 | 2.0 |
| **Total** | **1.09** | **2.41** | **2.80** | **4.20** | **6.22** | **100** | **100** | **100** | **100** | **100** | **3.5** | **2.2** | **4.1** | **4.0** | **3.6** |
| Coal | - | 0.00 | 0.02 | 0.03 | 0.03 | 0.0 | 0.2 | 0.6 | 0.7 | 0.5 | - | 20.8 | 5.3 | 1.8 | 7.8 |
| Oil | 0.16 | 0.84 | 1.04 | 1.76 | 2.73 | 14.9 | 35.0 | 37.0 | 41.9 | 43.8 | 7.4 | 3.0 | 5.5 | 4.5 | 4.4 |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricity | 0.01 | 0.29 | 0.51 | 1.04 | 1.93 | 1.3 | 12.1 | 18.2 | 24.6 | 31.0 | 14.0 | 8.4 | 7.3 | 6.4 | 7.3 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.92 | 1.27 | 1.24 | 1.38 | 1.53 | 83.8 | 52.7 | 44.2 | 32.8 | 24.6 | 1.4 | -0.4 | 1.1 | 1.1 | 0.7 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.82** | **15.51** | **33.71** | **51.72** | **62.67** | **100** | **100** | **100** | **100** | **100** | **13.6** | **11.7** | **4.4** | **1.9** | **5.3** |
| Coal | 0.00 | 0.00 | 12.61 | 14.72 | 14.72 | 0.0 | 0.0 | 37.4 | 28.5 | 23.5 | - | - | 1.6 | 0.0 | - |
| Oil | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.82 | 15.51 | 21.09 | 37.00 | 47.95 | 100.0 | 100.0 | 62.6 | 71.5 | 76.5 | 13.6 | 4.5 | 5.8 | 2.6 | 4.3 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.00** | **0.00** | **3.10** | **3.62** | **3.62** | **-** | **-** | **100** | **100** | **100** | **-** | **-** | **1.6** | **0.0** | **-** |
| Coal | 0.00 | 0.00 | 3.10 | 3.62 | 3.62 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | - | - | 1.6 | 0.0 | - |
| Oil | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **-** | **-** | **35** | **35** | **35** | **-** | **-** | **0.0** | **0.0** | **-** |
| Coal | - | - | 35 | 35 | 35 | - | - | 0.0 | 0.0 | - |
| Oil | - | - | - | - | - | - | - | - | - | - |
| Natural gas | - | - | - | - | - | - | - | - | - | - |

**$CO_2$ emissions**

| APS5 | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.20** | **0.70** | **4.45** | **5.66** | **6.46** | **100** | **100** | **100** | **100** | **100** | **5.6** | **30.3** | **2.4** | **1.3** | **8.6** |
| Coal | - | 0.00 | 3.60 | 4.21 | 4.22 | 0.0 | 0.7 | 80.9 | 74.4 | 65.3 | - | 157.3 | 1.6 | 0.0 | 28.5 |
| Oil | 0.20 | 0.69 | 0.85 | 1.45 | 2.24 | 100.0 | 99.3 | 19.1 | 25.6 | 34.7 | 5.6 | 3.0 | 5.5 | 4.5 | 4.4 |
| Natural Gas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 1.1 | 5.1 | 8.2 | 15.3 | 26.5 | 6.8 | 7.1 | 6.4 | 5.7 | 6.3 |
| Population (millions of people) | 4.2 | 6.6 | 7.3 | 8.5 | 9.8 | 1.9 | 1.5 | 1.5 | 1.5 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 0.3 | 0.8 | 1.1 | 1.8 | 2.7 | 4.8 | 5.5 | 4.8 | 4.1 | 4.7 |
| Primary energy consumption per capita (toe/person) | 0.3 | 0.4 | 0.7 | 0.8 | 0.9 | 1.2 | 8.8 | 1.6 | 1.2 | 3.3 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,080 | 486 | 603 | 444 | 333 | -3.4 | 3.1 | -3.0 | -2.8 | -1.4 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 984 | 473 | 340 | 275 | 235 | -3.1 | -4.6 | -2.1 | -1.6 | -2.6 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 180 | 137 | 541 | 371 | 244 | -1.2 | 21.7 | -3.7 | -4.1 | 2.2 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.2 | 0.3 | 0.9 | 0.8 | 0.7 | 2.3 | 18.0 | -0.7 | -1.3 | 3.6 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Malaysia [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **19.84** | **74.48** | **104.48** | **155.05** | **216.08** | 100 | 100 | 100 | 100 | 100 | **5.9** | **5.0** | **4.0** | **3.4** | **4.0** |
| Coal | 1.36 | 14.65 | 22.79 | 36.01 | 53.32 | 6.8 | 19.7 | 21.8 | 23.2 | 24.7 | 10.9 | 6.5 | 4.7 | 4.0 | 4.9 |
| Oil | 11.35 | 32.51 | 43.24 | 61.82 | 82.84 | 57.2 | 43.7 | 41.4 | 39.9 | 38.3 | 4.7 | 4.2 | 3.6 | 3.0 | 3.5 |
| Natural gas | 6.80 | 25.62 | 35.89 | 53.93 | 76.55 | 34.3 | 34.4 | 34.3 | 34.8 | 35.4 | 5.9 | 4.9 | 4.2 | 3.6 | 4.1 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.34 | 0.91 | 1.76 | 2.69 | 2.75 | 1.7 | 1.2 | 1.7 | 1.7 | 1.3 | 4.3 | 9.8 | 4.4 | 0.2 | 4.2 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | -0.01 | 0.78 | 0.81 | 0.60 | 0.61 | 0.0 | 1.0 | 0.8 | 0.4 | 0.3 | -224.5 | 0.6 | -3.0 | 0.1 | -0.9 |
| Biomass | 0.00 | 0.16 | 1.12 | 1.12 | 1.12 | 0.0 | 0.2 | 1.1 | 0.7 | 0.5 | - | 31.4 | 0.0 | 0.0 | 7.3 |
| Solar, Wind, Ocean | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | 4.6 | 0.0 | 0.0 | 1.2 |
| Biofuels | 0.00 | 0.19 | 0.20 | 0.22 | 0.25 | 0.0 | 0.3 | 0.2 | 0.1 | 0.1 | - | 1.0 | 1.0 | 1.0 | 1.0 |
| Electricity | -0.01 | 0.41 | -0.53 | -0.76 | -0.78 | 0.0 | 0.5 | -0.5 | -0.5 | -0.4 | -221.1 | -203.8 | 3.7 | 0.2 | -202.4 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **12.52** | **55.29** | **77.03** | **113.82** | **157.37** | 100 | 100 | 100 | 100 | 100 | **6.7** | **4.9** | **4.0** | **3.3** | **4.0** |
| Industry | 5.30 | 15.26 | 24.43 | 35.33 | 47.92 | 42.3 | 27.6 | 31.7 | 31.0 | 30.4 | 4.7 | 7.0 | 3.8 | 3.1 | 4.3 |
| Transportation | 4.76 | 22.36 | 30.42 | 45.01 | 62.26 | 38.0 | 40.4 | 39.5 | 39.5 | 39.6 | 7.0 | 4.5 | 4.0 | 3.3 | 3.9 |
| Others | 1.62 | 8.46 | 11.62 | 18.13 | 26.18 | 13.0 | 15.3 | 15.1 | 15.9 | 16.6 | 7.4 | 4.6 | 4.6 | 3.7 | 4.3 |
| Non-energy | 0.84 | 9.22 | 10.57 | 15.35 | 21.02 | 6.7 | 16.7 | 13.7 | 13.5 | 13.4 | 11.0 | 2.0 | 3.8 | 3.2 | 3.1 |
| **Total** | **12.52** | **55.29** | **77.03** | **113.82** | **157.37** | 100 | 100 | 100 | 100 | 100 | **6.7** | **4.9** | **4.0** | **3.3** | **4.0** |
| Coal | 0.51 | 1.54 | 2.65 | 3.93 | 5.47 | 4.1 | 2.8 | 3.4 | 3.5 | 3.5 | 4.9 | 8.1 | 4.0 | 3.4 | 4.8 |
| Oil | 9.19 | 30.60 | 41.74 | 59.79 | 80.83 | 73.5 | 55.3 | 54.2 | 52.5 | 51.4 | 5.4 | 4.5 | 3.7 | 3.1 | 3.7 |
| Natural gas | 1.09 | 12.01 | 16.68 | 25.26 | 35.41 | 8.7 | 21.7 | 21.7 | 22.2 | 22.5 | 11.0 | 4.8 | 4.2 | 3.4 | 4.1 |
| Electricity | 1.72 | 10.95 | 15.77 | 24.62 | 35.43 | 13.7 | 19.8 | 20.5 | 21.6 | 22.5 | 8.4 | 5.3 | 4.6 | 3.7 | 4.4 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.19 | 0.20 | 0.22 | 0.25 | 0.0 | 0.3 | 0.3 | 0.2 | 0.2 | - | 1.0 | 1.0 | 1.0 | 1.0 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **23.02** | **133.29** | **205.50** | **320.13** | **456.89** | 100 | 100 | 100 | 100 | 100 | **7.9** | **6.4** | **4.5** | **3.6** | **4.7** |
| Coal | 2.93 | 53.37 | 83.67 | 136.54 | 206.14 | 12.7 | 40.0 | 40.7 | 42.7 | 45.1 | 13.4 | 6.6 | 5.0 | 4.2 | 5.1 |
| Oil | 10.56 | 5.26 | 2.41 | 2.70 | 2.61 | 45.9 | 3.9 | 1.2 | 0.8 | 0.6 | -3.0 | -10.5 | 1.1 | -0.3 | -2.6 |
| Natural gas | 5.54 | 63.32 | 94.82 | 145.41 | 211.93 | 24.1 | 47.5 | 46.1 | 45.4 | 46.4 | 11.2 | 5.9 | 4.4 | 3.8 | 4.6 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 3.99 | 10.59 | 20.41 | 31.28 | 32.01 | 17.3 | 7.9 | 9.9 | 9.8 | 7.0 | 4.3 | 9.8 | 4.4 | 0.2 | 4.2 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.75 | 4.20 | 4.20 | 4.20 | 0.0 | 0.6 | 2.0 | 1.3 | 0.9 | - | 27.8 | 0.0 | 0.0 | 6.6 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **5.16** | **28.09** | **40.07** | **61.54** | **89.77** | 100 | 100 | 100 | 100 | 100 | **7.6** | **5.2** | **4.4** | **3.8** | **4.4** |
| Coal | 0.81 | 13.11 | 20.19 | 32.13 | 47.90 | 15.7 | 46.7 | 50.4 | 52.2 | 53.4 | 12.9 | 6.4 | 4.8 | 4.1 | 4.9 |
| Oil | 2.99 | 1.37 | 0.63 | 0.70 | 0.68 | 57.9 | 4.9 | 1.6 | 1.1 | 0.8 | -3.3 | -10.5 | 1.1 | -0.3 | -2.6 |
| Natural gas | 1.36 | 13.61 | 19.25 | 28.71 | 41.19 | 26.4 | 48.5 | 48.0 | 46.7 | 45.9 | 10.5 | 5.1 | 4.1 | 3.7 | 4.2 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **32** | **37** | **39** | **40** | **40** | **0.7** | **0.6** | **0.2** | **0.1** | **0.3** |
| Coal | 31 | 35 | 36 | 37 | 37 | 0.5 | 0.3 | 0.3 | 0.1 | 0.2 |
| Oil | 30 | 33 | 33 | 33 | 33 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 35 | 40 | 42 | 44 | 44 | 0.6 | 0.8 | 0.3 | 0.2 | 0.4 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **13.60** | **51.42** | **74.11** | **111.12** | **157.14** | 100 | 100 | 100 | 100 | 100 | **6.0** | **5.4** | **4.1** | **3.5** | **4.2** |
| Coal | 1.40 | 15.51 | 24.12 | 38.12 | 56.45 | 10.3 | 30.2 | 32.6 | 34.3 | 35.9 | 11.0 | 6.5 | 4.7 | 4.0 | 4.9 |
| Oil | 10.30 | 24.18 | 32.48 | 46.90 | 63.63 | 75.7 | 47.0 | 43.8 | 42.2 | 40.5 | 3.8 | 4.3 | 3.7 | 3.1 | 3.6 |
| Natural Gas | 1.90 | 11.73 | 17.50 | 26.10 | 37.06 | 14.0 | 22.8 | 23.6 | 23.5 | 23.6 | 8.2 | 5.9 | 4.1 | 3.6 | 4.4 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 57 | 208 | 285 | 415 | 571 | 5.8 | 4.6 | 3.8 | 3.2 | 3.8 |
| Population (millions of people) | 18 | 29 | 32 | 36 | 39 | 2.1 | 1.4 | 1.1 | 0.8 | 1.0 |
| GDP per capita (thousands of 2005 USD/person) | 3.1 | 7.1 | 8.8 | 11.5 | 14.7 | 3.6 | 3.2 | 2.7 | 2.4 | 2.7 |
| Primary energy consumption per capita (toe/person) | 1.09 | 2.53 | 3.23 | 4.30 | 5.56 | 3.7 | 3.5 | 2.9 | 2.6 | 3.0 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 346 | 358 | 366 | 374 | 379 | 0.1 | 0.3 | 0.2 | 0.1 | 0.2 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 218 | 266 | 270 | 274 | 276 | 0.9 | 0.2 | 0.2 | 0.1 | 0.1 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 237 | 247 | 260 | 268 | 275 | 0.2 | 0.7 | 0.3 | 0.3 | 0.4 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.69 | 0.69 | 0.71 | 0.72 | 0.73 | 0.0 | 0.4 | 0.1 | 0.1 | 0.2 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Malaysia [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **19.84** | **74.48** | **100.40** | **138.13** | **176.87** | **100** | **100** | **100** | **100** | **100** | **5.9** | **4.4** | **3.2** | **2.5** | **3.3** |
| Coal | 1.36 | 14.65 | 20.37 | 26.20 | 32.52 | 6.8 | 19.7 | 20.3 | 19.0 | 18.4 | 10.9 | 4.8 | 2.5 | 2.2 | 3.0 |
| Oil | 11.35 | 32.51 | 42.14 | 59.32 | 78.59 | 57.2 | 43.7 | 42.0 | 42.9 | 44.4 | 4.7 | 3.8 | 3.5 | 2.9 | 3.3 |
| Natural gas | 6.80 | 25.62 | 33.60 | 43.55 | 56.20 | 34.3 | 34.4 | 33.5 | 31.5 | 31.8 | 5.9 | 3.9 | 2.6 | 2.6 | 3.0 |
| Nuclear | - | - | - | 2.20 | 2.26 | - | - | - | 1.6 | 1.3 | - | - | - | 0.3 | - |
| Hydro | 0.34 | 0.91 | 1.82 | 2.85 | 2.92 | 1.7 | 1.2 | 1.8 | 2.1 | 1.6 | 4.3 | 10.4 | 4.6 | 0.2 | 4.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | -0.01 | 0.78 | 2.46 | 4.00 | 4.38 | 0.0 | 1.0 | 2.5 | 2.9 | 2.5 | -224.5 | 17.9 | 5.0 | 0.9 | 6.6 |
| Biomass | - | 0.16 | 1.62 | 2.33 | 2.33 | - | 0.2 | 1.6 | 1.7 | 1.3 | - | 38.6 | 3.7 | 0.0 | 10.3 |
| Solar, Wind, Ocean | - | 0.02 | 0.64 | 1.52 | 1.52 | - | 0.0 | 0.6 | 1.1 | 0.9 | - | 67.3 | 9.0 | 0.0 | 18.0 |
| Biofuels | - | 0.19 | 0.85 | 1.18 | 1.57 | - | 0.3 | 0.8 | 0.9 | 0.9 | - | 24.0 | 3.4 | 2.9 | 8.2 |
| Electricity | -0.01 | 0.41 | -0.64 | -1.03 | -1.05 | 0.0 | 0.5 | -0.6 | -0.7 | -0.6 | -221.1 | -206.6 | 4.9 | 0.2 | -203.6 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **12.52** | **55.29** | **75.10** | **105.45** | **138.25** | **100** | **100** | **100** | **100** | **100** | **6.7** | **4.5** | **3.5** | **2.7** | **3.5** |
| Industry | 5.30 | 15.26 | 22.93 | 29.04 | 33.89 | 42.3 | 27.6 | 30.5 | 27.5 | 24.5 | 4.7 | 6.0 | 2.4 | 1.6 | 3.0 |
| Transportation | 4.76 | 22.36 | 30.42 | 45.01 | 62.26 | 38.0 | 40.4 | 40.5 | 42.7 | 45.0 | 7.0 | 4.5 | 4.0 | 3.3 | 3.9 |
| Others | 1.62 | 8.46 | 11.18 | 16.04 | 21.08 | 13.0 | 15.3 | 14.9 | 15.2 | 15.2 | 7.4 | 4.1 | 3.7 | 2.8 | 3.4 |
| Non-energy | 0.84 | 9.22 | 10.57 | 15.35 | 21.02 | 6.7 | 16.7 | 14.1 | 14.6 | 15.2 | 11.0 | 2.0 | 3.8 | 3.2 | 3.1 |
| **Total** | **12.52** | **55.29** | **75.10** | **105.45** | **138.25** | **100** | **100** | **100** | **100** | **100** | **6.7** | **4.5** | **3.5** | **2.7** | **3.5** |
| Coal | 0.51 | 1.54 | 2.51 | 3.32 | 4.05 | 4.1 | 2.8 | 3.3 | 3.1 | 2.9 | 4.9 | 7.2 | 2.8 | 2.0 | 3.6 |
| Oil | 9.19 | 30.60 | 40.65 | 57.31 | 76.56 | 73.5 | 55.3 | 54.1 | 54.3 | 55.4 | 5.4 | 4.1 | 3.5 | 2.9 | 3.5 |
| Natural gas | 1.09 | 12.01 | 16.28 | 23.47 | 31.27 | 8.7 | 21.7 | 21.7 | 22.3 | 22.6 | 11.0 | 4.4 | 3.7 | 2.9 | 3.6 |
| Electricity | 1.72 | 10.95 | 14.82 | 20.18 | 24.80 | 13.7 | 19.8 | 19.7 | 19.1 | 17.9 | 8.4 | 4.4 | 3.1 | 2.1 | 3.1 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | - | 0.19 | 0.85 | 1.18 | 1.57 | 0.0 | 0.3 | 1.1 | 1.1 | 1.1 | - | 24.0 | 3.4 | 2.9 | 8.2 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **23.02** | **133.29** | **194.35** | **266.68** | **325.28** | **100** | **100** | **100** | **100** | **100** | **7.9** | **5.5** | **3.2** | **2.0** | **3.4** |
| Coal | 2.93 | 53.37 | 76.00 | 103.44 | 132.47 | 12.7 | 40.0 | 39.1 | 38.8 | 40.7 | 13.4 | 5.2 | 3.1 | 2.5 | 3.4 |
| Oil | 10.56 | 5.26 | 2.38 | 2.64 | 2.70 | 45.9 | 3.9 | 1.2 | 1.0 | 0.8 | -3.0 | -10.7 | 1.0 | 0.3 | -2.4 |
| Natural gas | 5.54 | 63.32 | 86.19 | 104.13 | 132.69 | 24.1 | 47.5 | 44.3 | 39.0 | 40.8 | 11.2 | 4.5 | 1.9 | 2.5 | 2.8 |
| Nuclear | - | - | - | 8.45 | 8.67 | 0.0 | 0.0 | 0.0 | 3.2 | 2.7 | - | - | - | 0.3 | - |
| Hydro | 3.99 | 10.59 | 21.19 | 33.18 | 33.91 | 17.3 | 7.9 | 10.9 | 12.4 | 10.4 | 4.3 | 10.4 | 4.6 | 0.2 | 4.4 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.00 | 0.75 | 8.58 | 14.84 | 14.84 | 0.0 | 0.6 | 4.4 | 5.6 | 4.6 | - | 41.6 | 5.6 | 0.0 | 11.7 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **5.16** | **28.09** | **35.81** | **43.65** | **54.11** | **100** | **100** | **100** | **100** | **100** | **7.6** | **3.5** | **2.0** | **2.2** | **2.5** |
| Coal | 0.81 | 13.11 | 17.86 | 22.89 | 28.48 | 15.7 | 46.7 | 49.9 | 52.4 | 52.6 | 12.9 | 4.5 | 2.5 | 2.2 | 2.9 |
| Oil | 2.99 | 1.37 | 0.62 | 0.69 | 0.70 | 57.9 | 4.9 | 1.7 | 1.6 | 1.3 | -3.3 | -10.7 | 1.0 | 0.3 | -2.4 |
| Natural gas | 1.36 | 13.61 | 17.33 | 20.08 | 24.93 | 26.4 | 48.5 | 48.4 | 46.0 | 46.1 | 10.5 | 3.5 | 1.5 | 2.2 | 2.3 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **32** | **37** | **40** | **41** | **43** | **0.7** | **0.8** | **0.5** | **0.3** | **0.5** |
| Coal | 31 | 35 | 37 | 39 | 40 | 0.5 | 0.6 | 0.6 | 0.3 | 0.5 |
| Oil | 30 | 33 | 33 | 33 | 33 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 35 | 40 | 43 | 45 | 46 | 0.6 | 1.0 | 0.4 | 0.3 | 0.5 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **13.60** | **51.42** | **69.17** | **92.05** | **118.62** | **100** | **100** | **100** | **100** | **100** | **6.0** | **4.3** | **2.9** | **2.6** | **3.1** |
| Coal | 1.40 | 15.51 | 21.56 | 27.74 | 34.43 | 10.3 | 30.2 | 31.2 | 30.1 | 29.0 | 11.0 | 4.8 | 2.6 | 2.2 | 3.0 |
| Oil | 10.30 | 24.18 | 31.56 | 44.83 | 60.10 | 75.7 | 47.0 | 45.6 | 48.7 | 50.7 | 3.8 | 3.9 | 3.6 | 3.0 | 3.4 |
| Natural Gas | 1.90 | 11.73 | 16.05 | 19.48 | 24.09 | 14.0 | 22.8 | 23.2 | 21.2 | 20.3 | 8.2 | 4.6 | 2.0 | 2.1 | 2.7 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 57 | 208 | 285 | 415 | 571 | 5.8 | 4.6 | 3.8 | 3.2 | 3.8 |
| Population (millions of people) | 18 | 29 | 32 | 36 | 39 | 2.1 | 1.4 | 1.1 | 0.8 | 1.0 |
| GDP per capita (thousands of 2005 USD/person) | 3.1 | 7.1 | 8.8 | 11.5 | 14.7 | 3.6 | 3.2 | 2.7 | 2.4 | 2.7 |
| Primary energy consumption per capita (toe/person) | 1.1 | 2.5 | 3.1 | 3.8 | 4.5 | 3.7 | 3.0 | 2.1 | 1.7 | 2.2 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 346 | 358 | 352 | 333 | 310 | 0.1 | -0.3 | -0.6 | -0.7 | -0.5 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 218 | 266 | 263 | 254 | 242 | 0.9 | -0.2 | -0.3 | -0.5 | -0.3 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 237 | 247 | 242 | 222 | 208 | 0.2 | -0.3 | -0.9 | -0.6 | -0.6 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.0 | 0.0 | -0.3 | 0.1 | -0.1 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# MYANMAR [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **10.68** | **16.46** | **19.58** | **25.53** | **32.74** | **100** | **100** | **100** | **100** | **100** | **1.9** | **2.5** | **2.7** | **2.5** | **2.6** |
| Coal | 0.07 | 0.37 | 1.43 | 2.03 | 2.89 | 0.6 | 2.3 | 7.3 | 7.9 | 8.8 | 7.7 | 21.2 | 3.6 | 3.6 | 7.9 |
| Oil | 0.73 | 2.77 | 4.02 | 6.38 | 9.38 | 6.8 | 16.8 | 20.6 | 25.0 | 28.7 | 6.0 | 5.5 | 4.7 | 3.9 | 4.6 |
| Natural gas | 0.76 | 1.74 | 1.99 | 2.86 | 4.43 | 7.1 | 10.6 | 10.1 | 11.2 | 13.5 | 3.7 | 1.9 | 3.7 | 4.5 | 3.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.10 | 0.76 | 0.72 | 1.98 | 3.68 | 1.0 | 4.6 | 3.7 | 7.8 | 11.2 | 9.1 | -0.8 | 10.7 | 6.4 | 6.0 |
| Geothermal | - | - | - | 0.15 | 0.15 | 0.0 | 0.0 | 0.0 | 0.6 | 0.5 | - | - | - | 0.0 | - |
| Others | 9.02 | 10.82 | 11.42 | 12.14 | 12.21 | 84.5 | 65.7 | 58.3 | 47.5 | 37.3 | 0.8 | 0.8 | 0.6 | 0.1 | 0.4 |
| Biomass | 9.02 | 10.82 | 11.11 | 11.82 | 11.82 | 84.5 | 65.7 | 56.8 | 46.3 | 36.1 | 0.8 | 0.4 | 0.6 | 0.0 | 0.3 |
| Solar, Wind, Ocean | - | 0.00 | 0.31 | 0.31 | 0.39 | 0.0 | 0.0 | 1.6 | 1.2 | 1.2 | - | - | 0.2 | 2.2 | - |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricity | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **9.40** | **15.23** | **17.94** | **23.45** | **29.84** | **100** | **100** | **100** | **100** | **100** | **2.1** | **2.4** | **2.7** | **2.4** | **2.5** |
| Industry | 0.39 | 1.89 | 3.02 | 4.94 | 7.27 | 4.2 | 12.4 | 16.8 | 21.1 | 24.4 | 7.1 | 6.9 | 5.1 | 3.9 | 5.1 |
| Transportation | 0.44 | 1.37 | 2.26 | 4.00 | 6.34 | 4.7 | 9.0 | 12.6 | 17.1 | 21.3 | 5.0 | 7.4 | 5.9 | 4.7 | 5.8 |
| Others | 8.47 | 11.73 | 12.28 | 13.81 | 15.07 | 90.1 | 77.0 | 68.5 | 58.9 | 50.5 | 1.4 | 0.7 | 1.2 | 0.9 | 0.9 |
| Non-energy | 0.09 | 0.24 | 0.37 | 0.69 | 1.16 | 1.0 | 1.6 | 2.1 | 2.9 | 3.9 | 4.2 | 6.3 | 6.4 | 5.3 | 6.0 |
| **Total** | **9.40** | **15.23** | **17.94** | **23.45** | **29.84** | **100** | **100** | **100** | **100** | **100** | **2.1** | **2.4** | **2.7** | **2.4** | **2.5** |
| Coal | 0.05 | 0.25 | 0.40 | 0.62 | 0.87 | 0.5 | 1.6 | 2.2 | 2.7 | 2.9 | 7.1 | 7.0 | 4.7 | 3.4 | 4.8 |
| Oil | 0.59 | 2.69 | 3.92 | 6.27 | 9.28 | 6.2 | 17.7 | 21.9 | 26.8 | 31.1 | 6.9 | 5.5 | 4.8 | 4.0 | 4.7 |
| Natural gas | 0.23 | 0.77 | 1.16 | 1.90 | 2.83 | 2.4 | 5.0 | 6.5 | 8.1 | 9.5 | 5.5 | 6.1 | 5.0 | 4.1 | 5.0 |
| Electricity | 0.15 | 0.75 | 1.39 | 2.88 | 5.09 | 1.6 | 4.9 | 7.8 | 12.3 | 17.1 | 7.3 | 9.2 | 7.5 | 5.9 | 7.4 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 8.39 | 10.78 | 11.07 | 11.78 | 11.77 | 89.2 | 70.8 | 61.7 | 50.2 | 39.4 | 1.1 | 0.4 | 0.6 | 0.0 | 0.3 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **2.48** | **11.89** | **19.04** | **38.02** | **65.03** | **100** | **100** | **100** | **100** | **100** | **7.1** | **7.0** | **7.2** | **5.5** | **6.5** |
| Coal | 0.04 | 0.51 | 4.42 | 6.07 | 9.54 | 1.6 | 4.3 | 23.2 | 16.0 | 14.7 | 11.7 | 36.0 | 3.2 | 4.6 | 11.4 |
| Oil | 0.27 | 0.06 | 0.15 | 0.15 | 0.15 | 10.9 | 0.5 | 0.8 | 0.4 | 0.2 | -6.7 | 15.7 | 0.0 | 0.0 | 3.8 |
| Natural gas | 0.97 | 2.44 | 2.48 | 3.28 | 6.25 | 39.3 | 20.5 | 13.0 | 8.6 | 9.6 | 4.1 | 0.2 | 2.8 | 6.7 | 3.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.19 | 8.88 | 8.37 | 23.08 | 42.75 | 48.1 | 74.7 | 43.9 | 60.7 | 65.7 | 9.1 | -0.8 | 10.7 | 6.4 | 6.0 |
| Geothermal | - | - | 0.00 | 1.75 | 1.75 | 0.0 | 0.0 | 0.0 | 4.6 | 2.7 | - | - | - | 0.0 | - |
| Others | - | - | 3.62 | 3.68 | 4.59 | 0.0 | 0.0 | 19.0 | 9.7 | 7.1 | - | - | 0.2 | 2.2 | - |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.51** | **0.90** | **1.67** | **2.16** | **3.40** | **100** | **100** | **100** | **100** | **100** | **2.5** | **9.3** | **2.6** | **4.6** | **5.1** |
| Coal | 0.01 | 0.12 | 1.03 | 1.40 | 2.02 | 2.4 | 13.9 | 61.5 | 64.9 | 59.5 | 10.7 | 35.2 | 3.1 | 3.7 | 10.9 |
| Oil | 0.06 | 0.01 | 0.04 | 0.04 | 0.04 | 12.5 | 1.6 | 2.3 | 1.8 | 1.1 | -6.4 | 15.7 | 0.0 | 0.0 | 3.8 |
| Natural gas | 0.43 | 0.76 | 0.60 | 0.72 | 1.34 | 85.1 | 84.5 | 36.1 | 33.4 | 39.3 | 2.5 | -3.2 | 1.8 | 6.4 | 2.1 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **22** | **29** | **36** | **38** | **40** | **1.3** | **3.3** | **0.4** | **0.7** | **1.2** |
| Coal | 29 | 35 | 37 | 37 | 41 | 0.9 | 0.6 | 0.1 | 0.9 | 0.5 |
| Oil | 36 | 34 | 34 | 34 | 34 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 19 | 28 | 35 | 39 | 40 | 1.6 | 3.5 | 1.0 | 0.3 | 1.4 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.1** | **3.7** | **6.0** | **9.0** | **13.2** | **100** | **100** | **100** | **100** | **100** | **5.3** | **7.1** | **4.2** | **3.9** | **4.8** |
| Coal | 0.1 | 0.4 | 1.5 | 2.2 | 3.1 | 8.9 | 10.9 | 25.9 | 24.5 | 23.8 | 6.2 | 21.2 | 3.6 | 3.6 | 7.9 |
| Oil | 0.6 | 2.2 | 3.2 | 5.1 | 7.5 | 50.0 | 60.0 | 54.0 | 56.9 | 56.9 | 6.2 | 5.5 | 4.7 | 3.9 | 4.6 |
| Natural Gas | 0.5 | 1.1 | 1.2 | 1.7 | 2.5 | 41.1 | 29.1 | 20.1 | 18.6 | 19.3 | 3.7 | 1.6 | 3.4 | 4.3 | 3.2 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 3.3 | 24.9 | 41.7 | 76.8 | 125.2 | 9.2 | 7.6 | 6.3 | 5.0 | 6.2 |
| Population (millions of people) | 42 | 53 | 57 | 63 | 66 | 1.0 | 1.1 | 1.0 | 0.5 | 0.8 |
| GDP per capita (thousands of 2005 USD/person) | 0.08 | 0.47 | 0.7 | 1.2 | 1.9 | 8.1 | 6.5 | 5.3 | 4.5 | 5.3 |
| Primary energy consumption per capita (toe/person) | 0.25 | 0.31 | 0.34 | 0.41 | 0.50 | 0.9 | 1.4 | 1.7 | 2.0 | 1.7 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 3,243 | 660 | 469 | 332 | 262 | -6.7 | -4.8 | -3.4 | -2.4 | -3.4 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 2,854 | 611 | 430 | 305 | 238 | -6.5 | -4.9 | -3.4 | -2.4 | -3.4 |
| CO2 emissions per unit of GDP (t-C/million 2005 US Dollars) | 340 | 148 | 143 | 116 | 105 | -3.6 | -0.5 | -2.0 | -1.0 | -1.3 |
| CO2 emissions per unit of primary energy consumption (t-C/toe) | 0.10 | 0.22 | 0.30 | 0.35 | 0.40 | 3.4 | 4.5 | 1.4 | 1.4 | 2.2 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# MYANMAR [APS]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **10.68** | **16.46** | **17.88** | **22.82** | **28.93** | **100** | **100** | **100** | **100** | **100** | **1.9** | **1.2** | **2.5** | **2.4** | **2.1** |
| Coal | 0.07 | 0.37 | 1.25 | 1.53 | 2.22 | 0.6 | 2.3 | 7.0 | 6.7 | 7.7 | 7.7 | 18.9 | 2.1 | 3.8 | 6.8 |
| Oil | 0.73 | 2.77 | 3.42 | 5.36 | 7.82 | 6.8 | 16.8 | 19.2 | 23.5 | 27.0 | 6.0 | 3.1 | 4.6 | 3.9 | 3.9 |
| Natural gas | 0.76 | 1.74 | 1.72 | 2.37 | 3.69 | 7.1 | 10.6 | 9.6 | 10.4 | 12.7 | 3.7 | -0.2 | 3.3 | 4.5 | 2.8 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.10 | 0.76 | 0.57 | 1.28 | 2.57 | 1.0 | 4.6 | 3.2 | 5.6 | 8.9 | 9.1 | -4.1 | 8.4 | 7.3 | 4.6 |
| Geothermal | - | - | - | 0.15 | 0.15 | 0.0 | 0.0 | 0.0 | 0.7 | 0.5 | - | - | - | 0.0 | - |
| Others | 9.02 | 10.82 | 10.92 | 12.13 | 12.48 | 84.5 | 65.7 | 61.1 | 53.2 | 43.1 | 0.8 | 0.1 | 1.1 | 0.3 | 0.5 |
| Biomass | 9.02 | 10.82 | 10.56 | 11.23 | 11.23 | 84.5 | 65.7 | 59.0 | 49.2 | 38.8 | 0.8 | -0.3 | 0.6 | 0.0 | 0.1 |
| Solar, Wind, Ocean | - | 0.00 | 0.30 | 0.76 | 1.01 | 0.0 | 0.0 | 1.7 | 3.3 | 3.5 | - | - | 9.7 | 2.9 | - |
| Biofuels | - | 0.00 | 0.06 | 0.14 | 0.24 | 0.0 | 0.0 | 0.3 | 0.6 | 0.8 | - | - | 8.5 | 5.5 | - |
| Electricity | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **9.40** | **15.23** | **16.44** | **21.24** | **26.75** | **100** | **100** | **100** | **100** | **100** | **2.1** | **1.1** | **2.6** | **2.3** | **2.1** |
| Industry | 0.39 | 1.89 | 2.60 | 4.24 | 6.22 | 4.2 | 12.4 | 15.8 | 20.0 | 23.2 | 7.1 | 4.6 | 5.0 | 3.9 | 4.5 |
| Transportation | 0.44 | 1.37 | 1.95 | 3.44 | 5.43 | 4.7 | 9.0 | 11.9 | 16.2 | 20.3 | 5.0 | 5.2 | 5.8 | 4.7 | 5.2 |
| Others | 8.47 | 11.73 | 11.51 | 12.88 | 13.95 | 90.1 | 77.0 | 70.0 | 60.6 | 52.2 | 1.4 | -0.3 | 1.1 | 0.8 | 0.6 |
| Non-energy | 0.09 | 0.24 | 0.37 | 0.69 | 1.16 | 1.0 | 1.6 | 2.3 | 3.2 | 4.3 | 4.2 | 6.3 | 6.4 | 5.3 | 6.0 |
| **Total** | **9.40** | **15.23** | **16.44** | **21.24** | **26.75** | **100** | **100** | **100** | **100** | **100** | **2.1** | **1.1** | **2.6** | **2.3** | **2.1** |
| Coal | 0.05 | 0.25 | 0.34 | 0.53 | 0.74 | 0.5 | 1.6 | 2.0 | 2.5 | 2.8 | 7.1 | 4.6 | 4.7 | 3.4 | 4.2 |
| Oil | 0.59 | 2.69 | 3.32 | 5.25 | 7.72 | 6.2 | 17.7 | 20.2 | 24.7 | 28.9 | 6.9 | 3.1 | 4.7 | 3.9 | 4.0 |
| Natural gas | 0.23 | 0.77 | 1.02 | 1.69 | 2.54 | 2.4 | 5.0 | 6.2 | 8.0 | 9.5 | 5.5 | 4.2 | 5.2 | 4.2 | 4.5 |
| Electricity | 0.15 | 0.75 | 1.18 | 2.45 | 4.33 | 1.6 | 4.9 | 7.2 | 11.5 | 16.2 | 7.3 | 6.7 | 7.5 | 5.9 | 6.7 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 8.39 | 10.78 | 10.57 | 11.32 | 11.42 | 89.2 | 70.8 | 64.3 | 53.3 | 42.7 | 1.1 | -0.3 | 0.7 | 0.1 | 0.2 |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **2.48** | **11.89** | **16.18** | **32.32** | **55.28** | **100** | **100** | **100** | **100** | **100** | **7.1** | **4.5** | **7.2** | **5.5** | **5.9** |
| Coal | 0.04 | 0.51 | 3.89 | 4.56 | 7.23 | 1.6 | 4.3 | 24.0 | 14.1 | 13.1 | 11.7 | 33.5 | 1.6 | 4.7 | 10.3 |
| Oil | 0.27 | 0.06 | 0.15 | 0.15 | 0.15 | 10.9 | 0.5 | 0.9 | 0.5 | 0.3 | -6.7 | 15.7 | 0.0 | 0.0 | 3.8 |
| Natural gas | 0.97 | 2.44 | 1.97 | 2.11 | 4.38 | 39.3 | 20.5 | 12.2 | 6.5 | 7.9 | 4.1 | -3.0 | 0.7 | 7.6 | 2.2 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.19 | 8.88 | 6.63 | 14.86 | 29.94 | 48.1 | 74.7 | 41.0 | 46.0 | 54.2 | 9.1 | -4.1 | 8.4 | 7.3 | 4.6 |
| Geothermal | - | - | 0.00 | 1.75 | 1.75 | 0.0 | 0.0 | 0.0 | 5.4 | 3.2 | - | - | - | 0.0 | - |
| Others | - | - | 3.54 | 8.87 | 11.82 | 0.0 | 0.0 | 21.9 | 27.5 | 21.4 | - | - | 9.6 | 2.9 | - |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **0.51** | **0.90** | **1.43** | **1.50** | **2.41** | **100** | **100** | **100** | **100** | **100** | **2.5** | **6.9** | **0.5** | **4.9** | **3.7** |
| Coal | 0.01 | 0.12 | 0.91 | 1.00 | 1.48 | 2.4 | 13.9 | 63.7 | 67.1 | 61.3 | 10.7 | 32.8 | 1.0 | 3.9 | 9.6 |
| Oil | 0.06 | 0.01 | 0.04 | 0.04 | 0.04 | 12.5 | 1.6 | 2.7 | 2.6 | 1.6 | -6.4 | 15.7 | 0.0 | 0.0 | 3.8 |
| Natural gas | 0.43 | 0.76 | 0.48 | 0.45 | 0.89 | 85.1 | 84.5 | 33.6 | 30.3 | 37.1 | 2.5 | -6.3 | -0.6 | 7.0 | 0.6 |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **22** | **29** | **36** | **39** | **42** | **1.3** | **3.3** | **0.8** | **0.7** | **1.4** |
| Coal | 29 | 35 | 37 | 39 | 42 | 0.9 | 0.5 | 0.6 | 0.7 | 0.6 |
| Oil | 36 | 34 | 34 | 34 | 34 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 19 | 28 | 35 | 40 | 42 | 1.6 | 3.5 | 1.3 | 0.5 | 1.6 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.12** | **3.68** | **5.10** | **7.27** | **10.68** | **100** | **100** | **100** | **100** | **100** | **5.3** | **4.7** | **3.6** | **3.9** | **4.0** |
| Coal | 0.10 | 0.40 | 1.35 | 1.66 | 2.40 | 8.9 | 10.9 | 26.4 | 22.8 | 22.4 | 6.2 | 18.9 | 2.1 | 3.8 | 6.8 |
| Oil | 0.56 | 2.21 | 2.72 | 4.26 | 6.22 | 50.0 | 60.0 | 53.5 | 58.5 | 58.2 | 6.2 | 3.0 | 4.6 | 3.9 | 3.9 |
| Natural Gas | 0.46 | 1.07 | 1.02 | 1.36 | 2.07 | 41.1 | 29.1 | 20.1 | 18.6 | 19.3 | 3.7 | -0.6 | 2.8 | 4.3 | 2.5 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 3.3 | 24.9 | 41.7 | 76.8 | 125.2 | 9.2 | 7.6 | 6.3 | 5.0 | 6.2 |
| Population (millions of people) | 42 | 53 | 57 | 63 | 66 | 1.0 | 1.1 | 1.0 | 0.5 | 0.8 |
| GDP per capita (thousands of 2005 USD/person) | 0.08 | 0.47 | 0.73 | 1.22 | 1.90 | 8.1 | 6.5 | 5.3 | 4.5 | 5.3 |
| Primary energy consumption per capita (toe/person) | 0.25 | 0.31 | 0.31 | 0.36 | 0.44 | 0.9 | 0.1 | 1.5 | 1.9 | 1.3 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 3,243 | 660 | 429 | 297 | 231 | -6.7 | -6.0 | -3.6 | -2.5 | -3.8 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 2,854 | 611 | 394 | 276 | 214 | -6.5 | -6.1 | -3.5 | -2.5 | -3.8 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 340 | 148 | 122 | 95 | 85 | -3.6 | -2.7 | -2.5 | -1.0 | -2.0 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.10 | 0.22 | 0.29 | 0.32 | 0.37 | 3.4 | 3.5 | 1.1 | 1.5 | 1.9 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# New Zealand [BAU]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **12.83** | **19.51** | **23.12** | **24.08** | **24.67** | **100** | **100** | **100** | **100** | **100** | **1.8** | **2.5** | **0.4** | **0.2** | **0.9** |
| Coal | 1.18 | 1.56 | 0.97 | 0.97 | 0.91 | 9.2 | 8.0 | 4.2 | 4.0 | 3.7 | 1.2 | -6.6 | 0.0 | -0.6 | -2.0 |
| Oil | 3.51 | 6.39 | 6.95 | 7.22 | 7.31 | 27.4 | 32.7 | 30.1 | 30.0 | 29.6 | 2.6 | 1.2 | 0.4 | 0.1 | 0.5 |
| Natural gas | 3.87 | 3.98 | 4.17 | 4.09 | 3.74 | 30.2 | 20.4 | 18.1 | 17.0 | 15.2 | 0.1 | 0.7 | -0.2 | -0.9 | -0.2 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.99 | 1.98 | 2.10 | 2.24 | 2.35 | 15.5 | 10.2 | 9.1 | 9.3 | 9.5 | 0.0 | 0.8 | 0.6 | 0.5 | 0.6 |
| Geothermal | 1.48 | 4.24 | 7.27 | 7.54 | 7.95 | 11.5 | 21.8 | 31.5 | 31.3 | 32.2 | 4.7 | 8.0 | 0.4 | 0.5 | 2.4 |
| Others | 0.80 | 1.36 | 1.66 | 2.04 | 2.41 | 6.2 | 7.0 | 7.2 | 8.5 | 9.8 | 2.3 | 2.9 | 2.1 | 1.7 | 2.1 |
| Biomass | 0.75 | 1.15 | 1.36 | 1.62 | 1.90 | 5.9 | 5.9 | 5.9 | 6.7 | 7.7 | 1.8 | 2.4 | 1.7 | 1.6 | 1.9 |
| Solar, Wind, Ocean | 0.04 | 0.21 | 0.28 | 0.40 | 0.49 | 0.3 | 1.1 | 1.2 | 1.7 | 2.0 | 6.9 | 4.3 | 3.7 | 2.2 | 3.3 |
| Biofuels | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | - | 29.0 | 0.5 | 0.2 | 7.1 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **9.72** | **13.23** | **14.75** | **15.43** | **15.65** | **100** | **100** | **100** | **100** | **100** | **1.4** | **1.6** | **0.5** | **0.1** | **0.6** |
| Industry | 3.60 | 4.09 | 4.402 | 4.60 | 4.67 | 37.0 | 31.0 | 29.8 | 29.8 | 29.9 | 0.6 | 1.0 | 0.4 | 0.2 | 0.5 |
| Transportation | 2.96 | 4.58 | 5.02 | 5.17 | 5.19 | 30.4 | 34.7 | 34.0 | 33.5 | 33.2 | 1.9 | 1.3 | 0.3 | 0.0 | 0.5 |
| Others | 2.54 | 3.37 | 3.94 | 4.46 | 4.89 | 26.2 | 25.5 | 26.7 | 28.9 | 31.2 | 1.2 | 2.2 | 1.3 | 0.9 | 1.4 |
| Non-energy | 0.62 | 1.17 | 1.40 | 1.20 | 0.89 | 6.4 | 8.9 | 9.5 | 7.8 | 5.7 | 2.8 | 2.5 | -1.5 | -2.9 | -1.0 |
| **Total** | **9.72** | **13.23** | **14.75** | **15.43** | **15.65** | **100** | **100** | **100** | **100** | **100** | **1.4** | **1.6** | **0.5** | **0.1** | **0.6** |
| Coal | 0.67 | 0.62 | 0.69 | 0.69 | 0.63 | 6.9 | 4.7 | 4.7 | 4.4 | 4.0 | -0.4 | 1.4 | 0.0 | -0.8 | 0.1 |
| Oil | 4.03 | 5.93 | 6.48 | 6.75 | 6.83 | 41.4 | 44.8 | 43.9 | 43.7 | 43.7 | 1.7 | 1.3 | 0.4 | 0.1 | 0.5 |
| Natural gas | 1.80 | 2.16 | 2.52 | 2.35 | 1.99 | 18.5 | 16.3 | 17.1 | 15.2 | 12.7 | 0.8 | 2.2 | -0.7 | -1.6 | -0.3 |
| Electricity | 2.43 | 3.26 | 3.61 | 3.96 | 4.25 | 25.0 | 24.6 | 24.5 | 25.7 | 27.2 | 1.3 | 1.5 | 0.9 | 0.7 | 1.0 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.79 | 1.26 | 1.46 | 1.69 | 1.94 | 8.1 | 9.5 | 9.9 | 11.0 | 12.4 | 2.1 | 2.1 | 1.5 | 1.4 | 1.6 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **32.27** | **43.26** | **47.75** | **52.27** | **56.03** | **100** | **100** | **100** | **100** | **100** | **1.3** | **1.4** | **0.9** | **0.7** | **1.0** |
| Coal | 0.66 | 2.40 | - | - | - | 2.1 | 5.5 | - | - | - | 5.7 | -100.0 | - | - | -100.0 |
| Oil | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -5.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 5.71 | 8.70 | 8.40 | 9.35 | 9.85 | 17.7 | 20.1 | 17.6 | 17.9 | 17.6 | 1.8 | -0.5 | 1.1 | 0.5 | 0.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 23.18 | 23.04 | 24.37 | 26.00 | 27.33 | 71.9 | 53.3 | 51.0 | 49.7 | 48.8 | 0.0 | 0.8 | 0.6 | 0.5 | 0.6 |
| Geothermal | 2.13 | 6.42 | 11.27 | 11.65 | 12.28 | 6.6 | 14.8 | 23.6 | 22.3 | 21.9 | 4.9 | 8.4 | 0.3 | 0.5 | 2.4 |
| Others | 0.57 | 2.70 | 3.71 | 5.27 | 6.58 | 1.8 | 6.2 | 7.8 | 10.1 | 11.7 | 7.0 | 4.7 | 3.6 | 2.2 | 3.4 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.41** | **2.11** | **1.43** | **1.51** | **1.52** | **100** | **100** | **100** | **100** | **100** | **1.8** | **-5.4** | **0.6** | **0.1** | **-1.2** |
| Coal | 0.17 | 0.58 | - | - | - | 11.9 | 27.5 | - | - | - | 5.5 | -100.0 | - | - | -100.0 |
| Oil | 0.01 | 0.00 | - | - | - | 0.4 | 0.0 | - | - | - | -7.5 | -100.0 | - | - | -100.0 |
| Natural gas | 1.24 | 1.53 | 1.43 | 1.51 | 1.52 | 87.7 | 72.5 | 100.0 | 100.0 | 100.0 | 0.9 | -1.0 | 0.6 | 0.1 | 0.0 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **39** | **45** | **51** | **53** | **56** | **0.7** | **1.6** | **0.5** | **0.5** | **0.8** |
| Coal | 34 | 36 | - | - | - | 0.2 | - | - | - | - |
| Oil | 14 | 25 | - | - | - | 2.6 | - | - | - | - |
| Natural gas | 40 | 49 | 51 | 53 | 56 | 0.9 | 0.5 | 0.5 | 0.5 | 0.5 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **6.24** | **8.76** | **8.57** | **8.87** | **8.86** | **100** | **100** | **100** | **100** | **100** | **1.5** | **-0.3** | **0.3** | **0.0** | **0.0** |
| Coal | 1.28 | 1.68 | 1.05 | 1.05 | 0.99 | 20.5 | 19.2 | 12.2 | 11.8 | 11.1 | 1.2 | -6.6 | 0.0 | -0.6 | -2.0 |
| Oil | 2.67 | 5.08 | 5.53 | 5.75 | 5.83 | 42.8 | 57.9 | 64.5 | 64.8 | 65.8 | 2.8 | 1.2 | 0.4 | 0.1 | 0.5 |
| Natural Gas | 2.29 | 2.00 | 2.00 | 2.07 | 2.04 | 36.7 | 22.9 | 23.3 | 23.4 | 23.1 | -0.6 | 0.0 | 0.4 | -0.1 | 0.1 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 65.5 | 120.1 | 145.2 | 176.5 | 205.8 | 2.7 | 2.7 | 2.0 | 1.5 | 2.0 |
| Population (millions of people) | 3.3 | 4.4 | 4.7 | 5.1 | 5.4 | 1.3 | 0.8 | 0.8 | 0.6 | 0.7 |
| GDP per capita (thousands of 2005 USD/person) | 19.7 | 27.0 | 30.9 | 34.8 | 38.4 | 1.4 | 1.9 | 1.2 | 1.0 | 1.3 |
| Primary energy consumption per capita (toe/person) | 3.9 | 4.4 | 4.9 | 4.7 | 4.6 | 0.6 | 1.6 | -0.4 | -0.3 | 0.2 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 196 | 162 | 159 | 136 | 120 | -0.8 | -0.3 | -1.5 | -1.3 | -1.1 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 148 | 110 | 102 | 87 | 76 | -1.3 | -1.1 | -1.5 | -1.4 | -1.4 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 95 | 73 | 59 | 50 | 43 | -1.2 | -3.0 | -1.6 | -1.5 | -1.9 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | -0.3 | -2.7 | -0.1 | -0.3 | -0.8 |
| Automobile ownership volume (millions of vehicles) | 1.8 | 3.2 | 3.7 | 4.0 | 4.3 | 2.6 | 1.8 | 1.0 | 0.6 | 1.0 |
| Automobile ownership volume per capita (vehicles per person) | 0.5 | 0.7 | 0.8 | 0.8 | 0.8 | 1.3 | 0.9 | 0.2 | 0.0 | 0.3 |

# New Zealand [APS]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **12.83** | **19.51** | **22.86** | **23.75** | **24.00** | **100** | **100** | **100** | **100** | **100** | **1.8** | **2.3** | **0.4** | **0.1** | **0.8** |
| Coal | 1.18 | 1.56 | 0.95 | 0.92 | 0.84 | 9.2 | 8.0 | 4.1 | 3.9 | 3.5 | 1.2 | -6.9 | -0.3 | -0.9 | -2.3 |
| Oil | 3.51 | 6.39 | 6.68 | 6.63 | 6.41 | 27.4 | 32.7 | 29.2 | 27.9 | 26.7 | 2.6 | 0.6 | -0.1 | -0.3 | 0.0 |
| Natural gas | 3.87 | 3.98 | 3.78 | 3.07 | 2.41 | 30.2 | 20.4 | 16.5 | 12.9 | 10.0 | 0.1 | -0.7 | -2.1 | -2.4 | -1.8 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 1.99 | 1.98 | 1.97 | 1.86 | 1.68 | 15.5 | 10.2 | 8.6 | 7.8 | 7.0 | 0.0 | -0.1 | -0.6 | -1.0 | -0.6 |
| Geothermal | 1.48 | 4.24 | 7.80 | 9.16 | 10.18 | 11.5 | 21.8 | 34.1 | 38.6 | 42.4 | 4.7 | 9.1 | 1.6 | 1.1 | 3.3 |
| Others | 0.80 | 1.36 | 1.69 | 2.11 | 2.49 | 6.2 | 7.0 | 7.4 | 8.9 | 10.4 | 2.3 | 3.2 | 2.2 | 1.7 | 2.3 |
| Biomass | 0.75 | 1.15 | 1.36 | 1.57 | 1.81 | 5.9 | 5.9 | 5.9 | 6.6 | 7.5 | 1.8 | 2.4 | 1.5 | 1.4 | 1.7 |
| Solar, Wind, Ocean | 0.04 | 0.21 | 0.31 | 0.52 | 0.66 | 0.3 | 1.1 | 1.4 | 2.2 | 2.7 | 6.9 | 6.2 | 5.1 | 2.5 | 4.4 |
| Biofuels | - | 0.00 | 0.02 | 0.02 | 0.02 | - | 0.0 | 0.1 | 0.1 | 0.1 | - | 26.1 | 0.6 | 0.2 | 6.5 |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **9.72** | **13.23** | **14.22** | **14.12** | **13.55** | **100** | **100** | **100** | **100** | **100** | **1.4** | **1.0** | **-0.1** | **-0.4** | **0.1** |
| Industry | 3.60 | 4.09 | 4.30 | 4.34 | 4.27 | 37.0 | 31.0 | 30.2 | 30.7 | 31.5 | 0.6 | 0.7 | 0.1 | -0.2 | 0.2 |
| Transportation | 2.96 | 4.58 | 4.88 | 4.83 | 4.64 | 30.4 | 34.7 | 34.3 | 34.2 | 34.2 | 1.9 | 0.9 | -0.1 | -0.4 | 0.0 |
| Others | 2.54 | 3.37 | 3.65 | 3.75 | 3.75 | 26.2 | 25.5 | 25.6 | 26.6 | 27.7 | 1.2 | 1.1 | 0.3 | 0.0 | 0.4 |
| Non-energy | 0.62 | 1.17 | 1.40 | 1.20 | 0.89 | 6.4 | 8.9 | 9.8 | 8.5 | 6.6 | 2.8 | 2.5 | -1.5 | -2.9 | -1.0 |
| **Total** | **9.72** | **13.23** | **14.22** | **14.12** | **13.55** | **100** | **100** | **100** | **100** | **100** | **1.4** | **1.0** | **-0.1** | **-0.4** | **0.1** |
| Coal | 0.67 | 0.62 | 0.67 | 0.64 | 0.56 | 6.9 | 4.7 | 4.7 | 4.5 | 4.1 | -0.4 | 1.0 | -0.4 | -1.3 | -0.4 |
| Oil | 4.03 | 5.93 | 6.21 | 6.17 | 5.94 | 41.4 | 44.8 | 43.7 | 43.7 | 43.8 | 1.7 | 0.7 | -0.1 | -0.4 | 0.0 |
| Natural gas | 1.80 | 2.16 | 2.51 | 2.26 | 1.82 | 18.5 | 16.3 | 17.6 | 16.0 | 13.4 | 0.8 | 2.2 | -1.1 | -2.1 | -0.6 |
| Electricity | 2.43 | 3.26 | 3.44 | 3.52 | 3.55 | 25.0 | 24.6 | 24.2 | 24.9 | 26.2 | 1.3 | 0.8 | 0.2 | 0.1 | 0.3 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.79 | 1.26 | 1.40 | 1.54 | 1.68 | 8.1 | 9.5 | 9.8 | 10.9 | 12.4 | 2.1 | 1.5 | 1.0 | 0.9 | 1.1 |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **32.27** | **43.26** | **45.48** | **46.57** | **46.91** | **100** | **100** | **100** | **100** | **100** | **1.3** | **0.7** | **0.2** | **0.1** | **0.3** |
| Coal | 0.66 | 2.40 | 0.00 | 0.00 | 0.00 | 2.1 | 5.5 | 0.0 | 0.0 | 0.0 | 5.7 | -100.0 | - | - | -100.0 |
| Oil | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -5.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural gas | 5.71 | 8.70 | 6.14 | 3.63 | 2.34 | 17.7 | 20.1 | 13.5 | 7.8 | 5.0 | 1.8 | -4.9 | -5.1 | -4.3 | -4.7 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 23.18 | 23.04 | 22.88 | 21.65 | 19.58 | 71.9 | 53.3 | 50.3 | 46.5 | 41.7 | 0.0 | -0.1 | -0.6 | -1.0 | -0.6 |
| Geothermal | 2.13 | 6.42 | 12.13 | 14.30 | 15.94 | 6.6 | 14.8 | 26.7 | 30.7 | 34.0 | 4.9 | 9.5 | 1.7 | 1.1 | 3.4 |
| Others | 0.57 | 2.70 | 4.32 | 6.98 | 9.05 | 1.8 | 6.2 | 9.5 | 15.0 | 19.3 | 7.0 | 7.0 | 4.9 | 2.6 | 4.6 |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **1.41** | **2.11** | **1.04** | **0.59** | **0.36** | **100** | **100** | **100** | **100** | **100** | **1.8** | **-9.6** | **-5.6** | **-4.7** | **-6.3** |
| Coal | 0.17 | 0.58 | - | - | - | 11.9 | 27.5 | - | - | - | 5.5 | -100.0 | - | - | -100.0 |
| Oil | 0.01 | 0.00 | - | - | - | 0.4 | 0.0 | - | - | - | -7.5 | -100.0 | - | - | -100.0 |
| Natural gas | 1.24 | 1.53 | 1.04 | 0.59 | 0.36 | 87.7 | 72.5 | 100.0 | 100.0 | 100.0 | 0.9 | -5.3 | -5.6 | -4.7 | -5.2 |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **39** | **45** | **51** | **53** | **56** | **0.7** | **1.6** | **0.5** | **0.5** | **0.8** |
| Coal | 34 | 36 | - | - | - | 0.2 | - | - | - | - |
| Oil | 14 | 25 | - | - | - | 2.6 | - | - | - | - |
| Natural gas | 40 | 49 | 51 | 53 | 56 | 0.9 | 0.5 | 0.5 | 0.5 | 0.5 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **6.24** | **8.76** | **8.08** | **7.67** | **7.17** | **100** | **100** | **100** | **100** | **100** | **1.5** | **-1.2** | **-0.5** | **-0.7** | **-0.7** |
| Coal | 1.28 | 1.68 | 1.02 | 0.99 | 0.91 | 20.5 | 19.2 | 12.7 | 12.9 | 12.7 | 1.2 | -6.9 | -0.3 | -0.9 | -2.3 |
| Oil | 2.67 | 5.08 | 5.31 | 5.26 | 5.07 | 42.8 | 57.9 | 65.7 | 68.6 | 70.7 | 2.8 | 0.6 | -0.1 | -0.4 | 0.0 |
| Natural Gas | 2.29 | 2.00 | 1.74 | 1.42 | 1.19 | 36.7 | 22.9 | 21.6 | 18.5 | 16.6 | -0.6 | -2.0 | -2.0 | -1.7 | -1.9 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 65.5 | 120.1 | 145.2 | 176.5 | 205.8 | 2.7 | 2.7 | 2.0 | 1.5 | 2.0 |
| Population (millions of people) | 3.3 | 4.4 | 4.7 | 5.1 | 5.4 | 1.3 | 0.8 | 0.8 | 0.6 | 0.7 |
| GDP per capita (thousands of 2005 USD/person) | 19.7 | 27.0 | 30.9 | 34.8 | 38.4 | 1.4 | 1.9 | 1.2 | 1.0 | 1.3 |
| Primary energy consumption per capita (toe/person) | 3.9 | 4.4 | 4.9 | 4.7 | 4.5 | 0.6 | 1.5 | -0.4 | -0.4 | 0.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 196 | 162 | 157 | 135 | 117 | -0.8 | -0.4 | -1.6 | -1.4 | -1.2 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 148 | 110 | 98 | 80 | 66 | -1.3 | -1.7 | -2.0 | -1.9 | -1.9 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 95 | 73 | 56 | 43 | 35 | -1.2 | -3.8 | -2.4 | -2.2 | -2.7 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.49 | 0.45 | 0.35 | 0.32 | 0.30 | -0.3 | -3.4 | -0.9 | -0.8 | -1.5 |
| Automobile ownership volume (millions of vehicles) | 1.8 | 3.2 | 3.7 | 4.0 | 4.3 | 2.6 | 1.8 | 1.0 | 0.6 | 1.0 |
| Automobile ownership volume per capita (vehicles per person) | 0.5 | 0.7 | 0.8 | 0.8 | 0.8 | 1.3 | 0.9 | 0.2 | 0.0 | 0.3 |

# Philippines [BAU]

| Primary Energy consumption Consumption | MTOE 1990 | 2013 | 2020 | 2030 | 2040 | % 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **28.71** | **44.46** | **54.80** | **77.99** | **116.82** | **100** | **100** | **100** | **100** | **100** | **1.9** | **3.0** | **3.9** | **3.6** |
| Coal | 1.53 | 10.00 | 14.60 | 25.93 | 45.07 | 5.3 | 22.5 | 26.6 | 33.2 | 38.6 | 8.5 | 5.6 | 5.8 | 5.7 |
| Oil | 10.84 | 14.05 | 17.93 | 25.40 | 36.28 | 37.8 | 31.6 | 32.7 | 32.6 | 31.1 | 1.1 | 3.5 | 3.6 | 3.6 |
| Natural gas | 0.00 | 3.06 | 3.76 | 6.80 | 12.80 | 0.0 | 6.9 | 6.9 | 8.7 | 11.0 | - | 3.0 | 6.3 | 5.4 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.52 | 0.86 | 1.09 | 1.21 | 1.27 | 1.8 | 1.9 | 2.0 | 1.6 | 1.1 | 2.2 | 3.4 | 0.8 | 1.5 |
| Geothermal | 4.70 | 8.26 | 10.67 | 11.40 | 13.02 | 16.4 | 18.6 | 19.5 | 14.6 | 11.1 | 2.5 | 3.7 | 1.0 | 1.7 |
| Others | 11.12 | 8.23 | 6.75 | 7.25 | 8.38 | 38.7 | 18.5 | 12.3 | 9.3 | 7.2 | -1.3 | -2.8 | 1.1 | 0.1 |
| Biomass | 11.12 | 7.87 | 5.95 | 6.16 | 6.82 | 38.7 | 17.7 | 10.9 | 7.9 | 5.8 | -1.5 | -3.9 | 0.7 | -0.5 |
| Solar, Wind, Ocean | 0.00 | 0.01 | 0.21 | 0.24 | 0.31 | 0.0 | 0.0 | 0.4 | 0.3 | 0.3 | - | 54.5 | 2.0 | 13.6 |
| Biofuels | 0.00 | 0.35 | 0.59 | 0.85 | 1.25 | 0.0 | 0.8 | 1.1 | 1.1 | 1.1 | - | 7.7 | 3.8 | 4.8 |
| Electricity | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

| Final Energy Demand | MTOE 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **19.65** | **25.87** | **32.83** | **48.81** | **76.28** | **100** | **100** | **100** | **100** | **100** | **1.2** | **3.5** | **4.3** | **4.1** |
| Industry | 4.66 | 6.84 | 10.35 | 17.88 | 32.58 | 23.7 | 26.4 | 31.5 | 36.6 | 42.7 | 1.7 | 6.1 | 5.9 | 6.0 |
| Transportation | 4.52 | 8.78 | 11.15 | 15.74 | 22.48 | 23.0 | 33.9 | 34.0 | 32.3 | 29.5 | 2.9 | 3.5 | 3.6 | 3.5 |
| Others | 10.25 | 9.83 | 10.85 | 14.62 | 20.52 | 52.2 | 38.0 | 33.0 | 29.9 | 26.9 | -0.2 | 1.4 | 3.2 | 2.8 |
| Non-energy | 0.23 | 0.43 | 0.48 | 0.57 | 0.70 | 1.2 | 1.7 | 1.5 | 1.2 | 0.9 | 2.8 | 1.6 | 1.9 | 1.8 |
| | **19.65** | **25.87** | **32.83** | **48.81** | **76.28** | **100** | **100** | **100** | **100** | **100** | **1.2** | **3.5** | **4.3** | **4.1** |
| Coal | 0.61 | 2.20 | 3.67 | 7.79 | 16.7 | 3.1 | 8.5 | 11.2 | 16.0 | 21.9 | 5.7 | 7.6 | 7.9 | 7.8 |
| Oil | 8.15 | 12.24 | 16.29 | 23.36 | 34.2 | 41.5 | 47.3 | 49.6 | 47.9 | 44.8 | 1.8 | 4.2 | 3.8 | 3.9 |
| Natural gas | 0.00 | 0.06 | 0.09 | 0.13 | 0.2 | 0.0 | 0.2 | 0.3 | 0.3 | 0.2 | - | 4.8 | 3.5 | 3.8 |
| Electricity | 1.82 | 5.29 | 7.49 | 11.83 | 18.6 | 9.3 | 20.5 | 22.8 | 24.2 | 24.4 | 4.7 | 5.1 | 4.6 | 4.8 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 9.07 | 6.08 | 5.29 | 5.70 | 6.6 | 46.1 | 23.5 | 16.1 | 11.7 | 8.7 | -1.7 | -2.0 | 1.1 | 0.3 |

| Power generation output | TWh 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **26.33** | **75.27** | **101.42** | **154.09** | **237.58** | **100** | **100** | **100** | **100** | **100** | **4.7** | **4.4** | **4.3** | **4.3** |
| Coal | 1.93 | 32.08 | 44.93 | 74.52 | 116.5 | 7.3 | 42.6 | 44.3 | 48.4 | 49.1 | 13.0 | 4.9 | 4.9 | 4.9 |
| Oil | 12.43 | 4.47 | 4.80 | 6.46 | 6.7 | 47.2 | 5.9 | 4.7 | 4.2 | 2.8 | -4.4 | 1.0 | 1.7 | 1.5 |
| Natural gas | 0.00 | 18.79 | 23.03 | 41.89 | 79.3 | 0.0 | 25.0 | 22.7 | 27.2 | 33.4 | - | 2.9 | 6.4 | 5.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 6.06 | 10.02 | 12.73 | 14.02 | 14.8 | 23.0 | 13.3 | 12.5 | 9.1 | 6.2 | 2.2 | 3.5 | 0.7 | 1.4 |
| Geothermal | 5.47 | 9.61 | 12.41 | 13.26 | 15.1 | 20.8 | 12.8 | 12.2 | 8.6 | 6.4 | 2.5 | 3.7 | 1.0 | 1.7 |
| Others | 0.43 | 0.30 | 3.52 | 3.94 | 5.2 | 1.6 | 0.4 | 3.5 | 2.6 | 2.2 | -1.6 | 42.2 | 1.9 | 11.1 |

| Power generation Input | MTOE 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2.69** | **11.87** | **15.75** | **26.35** | **42.58** | **100** | **100** | **100** | **100** | **100** | **6.7** | **4.1** | **5.1** | **4.8** |
| Coal | 0.51 | 7.81 | 10.93 | 18.13 | 28.4 | 18.9 | 65.8 | 69.4 | 68.8 | 66.6 | 12.6 | 4.9 | 4.9 | 4.9 |
| Oil | 2.18 | 1.07 | 1.15 | 1.55 | 1.6 | 81.1 | 9.0 | 7.3 | 5.9 | 3.8 | -3.0 | 1.0 | 1.7 | 1.5 |
| Natural gas | 0.00 | 2.99 | 3.67 | 6.67 | 12.6 | 0.0 | 25.2 | 23.3 | 25.3 | 29.6 | - | 2.9 | 6.4 | 5.5 |

| Thermal Efficiency | % 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|
| | **45.9** | **40.1** | **39.7** | **40.1** | **40.9** | **-0.6** | **-0.1** | **0.1** | **0.1** |
| Coal | 32.7 | 35.3 | 35.3 | 35.3 | 35.3 | 0.3 | 0.0 | 0.0 | 0.0 |
| Oil | 49.0 | 35.9 | 35.9 | 35.9 | 35.9 | -1.3 | 0.0 | 0.0 | 0.0 |
| Natural Gas | - | 54.0 | 54.0 | 54.0 | 54.0 | - | 0.0 | 0.0 | 0.0 |

| $CO_2$ Emission | Mt-C 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **10.2** | **44.3** | **62.3** | **99.7** | **167.4** | **100** | **100** | **100** | **100** | **100** | **6.6** | **5.0** | **5.1** | **5.0** |
| Coal | 1.4 | 8.3 | 14.2 | 30.8 | 66.4 | 13.4 | 18.8 | 22.9 | 30.8 | 39.7 | 8.2 | 8.0 | 8.0 | 8.0 |
| Oil | 8.8 | 35.9 | 47.9 | 68.6 | 100.6 | 86.6 | 80.9 | 76.8 | 68.8 | 60.1 | 6.3 | 4.2 | 3.8 | 3.9 |
| Natural Gas | 0.0 | 0.2 | 0.2 | 0.3 | 0.4 | 0.0 | 0.3 | 0.3 | 0.3 | 0.2 | - | 4.9 | 3.5 | 3.8 |

| | 1990 | 2013 | 2020 | 2030 | 2040 | AAGR(%) 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
|---|---|---|---|---|---|---|---|---|---|
| GDP (billions of 2005 US dollars) | 62.1 | 155.6 | 236.0 | 418.2 | 714.4 | 4.1 | 6.1 | 5.7 | 5.8 |
| Population (millions of people) | 61.9 | 98.2 | 112.3 | 129.1 | 146.9 | 2.0 | 1.9 | 1.3 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 1.00 | 1.58 | 2.1 | 3.2 | 4.9 | 2.0 | 4.1 | 4.3 | 4.2 |
| Primary energy consumption per capita (toe/person) | 0.46 | 0.45 | 0.49 | 0.60 | 0.80 | -0.1 | 1.1 | 2.5 | 2.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 462 | 286 | 232 | 186 | 164 | -2.1 | -2.9 | -1.7 | -2.0 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 316 | 166 | 139 | 117 | 107 | -2.8 | -2.5 | -1.3 | -1.6 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 164 | 285 | 264 | 238 | 234 | 2.4 | -1.1 | -0.6 | -0.7 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.35 | 1.00 | 1.14 | 1.28 | 1.43 | 4.6 | 1.9 | 1.2 | 1.4 |
| Automobile ownership volume (millions of vehicles) | 1.22 | 3.44 | 4.72 | 7.60 | 12.60 | 4.6 | 4.6 | 5.0 | 4.9 |
| Automobile ownership volume per capita (vehicles per person) | 0.02 | 0.04 | 0.04 | 0.06 | 0.09 | 2.5 | 2.6 | 3.6 | 3.4 |

# Philippines [APS]

| Primary energy consumption | MTOE | | | | | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **28.71** | **44.46** | **51.08** | **68.93** | **107.18** | **100** | **100** | **100** | **100** | **100** | **1.9** | **2.0** | **3.8** | **3.3** |
| Coal | 1.53 | 10.00 | 10.70 | 15.75 | 27.30 | 5.3 | 22.5 | 20.9 | 22.8 | 25.5 | 8.5 | 1.0 | 4.8 | 3.8 |
| Oil | 10.84 | 14.05 | 16.83 | 21.47 | 29.35 | 37.8 | 31.6 | 32.9 | 31.1 | 27.4 | 1.1 | 2.6 | 2.8 | 2.8 |
| Natural gas | - | 3.06 | 2.31 | 4.87 | 9.66 | - | 6.9 | 4.5 | 7.1 | 9.0 | - | -3.9 | 7.4 | 4.3 |
| Nuclear | - | - | - | 0.54 | 0.71 | - | - | - | 0.8 | 0.7 | - | - | - | - |
| Hydro | 0.52 | 0.86 | 2.56 | 2.89 | 2.71 | 1.8 | 1.9 | 5.0 | 4.2 | 2.5 | 2.2 | 16.9 | 0.3 | 4.3 |
| Geothermal | 4.70 | 8.26 | 11.82 | 15.63 | 28.67 | 16.4 | 18.6 | 23.1 | 22.7 | 26.7 | 2.5 | 5.3 | 4.5 | 4.7 |
| Others | 11.12 | 8.23 | 6.86 | 7.78 | 8.78 | 38.7 | 18.5 | 13.4 | 11.3 | 8.2 | -1.3 | -2.6 | 1.2 | 0.2 |
| Biomass | 11.12 | 7.87 | 5.94 | 6.39 | 7.10 | 38.7 | 17.7 | 11.6 | 9.3 | 6.6 | -1.5 | -3.9 | 0.9 | -0.4 |
| Solar, Wind, Ocean | - | 0.01 | 0.36 | 0.67 | 0.67 | - | 0.0 | 0.7 | 1.0 | 0.6 | - | 66.9 | 3.2 | 16.9 |
| Biofuels | - | 0.35 | 0.56 | 0.72 | 1.01 | - | 0.8 | 1.1 | 1.0 | 0.9 | - | 6.9 | 3.0 | 4.0 |
| Electricity | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

| Final energy demand | MTOE | | | | | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **19.65** | **25.87** | **31.59** | **43.82** | **66.00** | **100** | **100** | **100** | **100** | **100** | **1.2** | **2.9** | **3.8** | **3.5** |
| Industry | 4.66 | 6.84 | 10.06 | 16.71 | 30.05 | 23.7 | 26.4 | 31.8 | 38.1 | 45.5 | 1.7 | 5.7 | 5.6 | 5.6 |
| Transportation | 4.52 | 8.78 | 10.59 | 13.59 | 18.23 | 23.0 | 33.9 | 33.5 | 31.0 | 27.6 | 2.9 | 2.7 | 2.8 | 2.7 |
| Others | 10.25 | 9.83 | 10.46 | 12.95 | 17.03 | 52.2 | 38.0 | 33.1 | 29.6 | 25.8 | -0.2 | 0.9 | 2.5 | 2.1 |
| Non-energy | 0.23 | 0.43 | 0.48 | 0.57 | 0.70 | 1.2 | 1.7 | 1.5 | 1.3 | 1.1 | 2.8 | 1.6 | 1.9 | 1.8 |
| | **19.65** | **25.87** | **31.59** | **43.82** | **66.00** | **100** | **100** | **100** | **100** | **100** | **1.2** | **2.9** | **3.8** | **3.5** |
| Coal | 0.61 | 2.20 | 3.67 | 7.79 | 16.7 | 3.1 | 8.5 | 11.6 | 17.8 | 25.3 | 5.7 | 7.6 | 7.9 | 7.8 |
| Oil | 8.15 | 12.24 | 15.36 | 19.93 | 27.5 | 41.5 | 47.3 | 48.6 | 45.5 | 41.6 | 1.8 | 3.3 | 2.9 | 3.0 |
| Natural gas | 0.00 | 0.06 | 0.17 | 0.32 | 0.4 | 0.0 | 0.2 | 0.5 | 0.7 | 0.6 | - | 15.0 | 4.2 | 6.9 |
| Electricity | 1.82 | 5.29 | 7.06 | 10.06 | 14.9 | 9.3 | 20.5 | 22.3 | 23.0 | 22.5 | 4.7 | 4.2 | 3.8 | 3.9 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 9.07 | 6.08 | 5.33 | 5.73 | 6.6 | 46.1 | 23.5 | 16.9 | 13.1 | 9.9 | -1.7 | -1.9 | 1.0 | 0.3 |

| Power generation Output | TWh | | | | | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **26.33** | **75.27** | **95.50** | **130.98** | **190.07** | **100** | **100** | **100** | **100** | **100** | **4.7** | **3.5** | **3.5** | **3.5** |
| Coal | 1.93 | 32.08 | 29.44 | 33.30 | 44.36 | 7.3 | 42.6 | 30.8 | 25.4 | 23.3 | 13.0 | -1.2 | 2.1 | 1.2 |
| Oil | 12.43 | 4.47 | 3.98 | 4.37 | 5.83 | 47.2 | 5.9 | 4.2 | 3.3 | 3.1 | -4.4 | -1.6 | 1.9 | 1.0 |
| Natural gas | - | 18.79 | 13.47 | 30.12 | 62.53 | 0.0 | 25.0 | 14.1 | 23.0 | 32.9 | - | -4.6 | 8.0 | 4.6 |
| Nuclear | - | - | - | 2.05 | 2.74 | - | - | - | 1.6 | 1.4 | - | - | - | - |
| Hydro | 6.06 | 10.02 | 29.81 | 33.63 | 31.51 | 23.0 | 13.3 | 31.2 | 25.7 | 16.6 | 2.2 | 16.9 | 0.3 | 4.3 |
| Geothermal | 5.47 | 9.61 | 13.74 | 18.18 | 33.34 | 20.8 | 12.8 | 14.4 | 13.9 | 17.5 | 2.5 | 5.2 | 4.5 | 4.7 |
| Others | 0.43 | 0.30 | 5.06 | 9.32 | 9.76 | 1.6 | 0.4 | 5.3 | 7.1 | 5.1 | -1.6 | 49.8 | 3.3 | 13.8 |

| Power generation Input | MTOE | | | | | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **2.69** | **11.87** | **10.13** | **13.55** | **21.27** | **100** | **100** | **100** | **100** | **100** | **6.7** | **-2.2** | **3.8** | **2.2** |
| Coal | 0.51 | 7.81 | 7.03 | 7.95 | 10.60 | 18.9 | 65.8 | 69.4 | 58.7 | 49.8 | 12.6 | -1.5 | 2.1 | 1.1 |
| Oil | 2.18 | 1.07 | 0.95 | 1.05 | 1.40 | 81.1 | 9.0 | 9.4 | 7.7 | 6.6 | -3.0 | -1.6 | 1.9 | 1.0 |
| Natural gas | 0.00 | 2.99 | 2.14 | 4.55 | 9.27 | 0.0 | 25.2 | 21.2 | 33.6 | 43.6 | - | -4.6 | 7.6 | 4.3 |

| Thermal Efficiency | % | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **46** | **40** | **40** | **43** | **46** | **-0.6** | **-0.1** | **0.7** | **0.5** |
| Coal | 33 | 35 | 36 | 36 | 36 | 0.3 | 0.3 | 0.0 | 0.1 |
| Oil | 49 | 36 | 36 | 36 | 36 | -1.3 | 0.0 | 0.0 | 0.0 |
| Natural gas | - | 54 | 56 | 56 | 56 | - | 0.5 | 0.0 | 0.1 |

| $CO_2$ emissions | Mt-C | | | | | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| | **10.17** | **44.33** | **59.73** | **89.85** | **147.81** | **100** | **100** | **100** | **100** | **100** | **6.6** | **4.4** | **4.6** | **4.6** |
| Coal | 1.36 | 8.31 | 14.25 | 30.76 | 66.41 | 13.4 | 18.8 | 23.9 | 34.2 | 44.9 | 8.2 | 8.0 | 8.0 | 8.0 |
| Oil | 8.80 | 35.86 | 45.08 | 58.35 | 80.49 | 86.6 | 80.9 | 75.5 | 64.9 | 54.5 | 6.3 | 3.3 | 2.9 | 3.0 |
| Natural Gas | 0.00 | 0.15 | 0.40 | 0.74 | 0.91 | 0.0 | 0.3 | 0.7 | 0.8 | 0.6 | - | 15.0 | 4.2 | 6.9 |

| | | | | | | AAGR(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | |
| GDP (billions of 2005 US dollars) | 62.1 | 155.6 | 236.0 | 418.2 | 714.4 | 4.1 | 6.1 | 5.7 | 5.8 |
| Population (millions of people) | 61.9 | 98.2 | 112.3 | 129.1 | 146.9 | 2.0 | 1.9 | 1.3 | 1.5 |
| GDP per capita (thousands of 2005 USD/person) | 1.00 | 1.58 | 2.1 | 3.2 | 4.9 | 2.0 | 4.1 | 4.3 | 4.2 |
| Primary energy consumption per capita (toe/person) | 0.46 | 0.45 | 0.45 | 0.53 | 0.73 | -0.1 | 0.1 | 2.4 | 1.8 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 462 | 286 | 216 | 165 | 150 | -2.1 | -3.9 | -1.8 | -2.4 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 316 | 166 | 134 | 105 | 92 | -2.8 | -3.0 | -1.8 | -2.2 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 164 | 285 | 253 | 215 | 207 | 2.4 | -1.7 | -1.0 | -1.2 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.35 | 1.00 | 1.17 | 1.30 | 1.38 | 4.6 | 2.3 | 0.8 | 1.2 |
| Automobile ownership volume (millions of vehicles) | 1.22 | 3.44 | 4.72 | 7.60 | 12.60 | 4.6 | 4.6 | 5.0 | 4.9 |
| Automobile ownership volume per capita (vehicles per person) | 0.02 | 0.04 | 0.04 | 0.06 | 0.09 | 2.5 | 2.6 | 3.6 | 3.4 |

# Singapore [BAU]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **11.53** | **28.73** | **47.76** | **53.11** | **56.61** | **100** | **100** | **100** | **100** | **100** | **4.1** | **7.5** | **1.1** | **0.6** | **2.5** |
| Coal | 0.02 | 0.26 | 0.29 | 0.33 | 0.36 | 0.2 | 0.9 | 0.6 | 0.6 | 0.6 | 11.4 | 1.5 | 1.3 | 0.8 | 1.2 |
| Oil | 11.44 | 19.22 | 35.33 | 37.42 | 39.18 | 99.2 | 66.9 | 74.0 | 70.5 | 69.2 | 2.3 | 9.1 | 0.6 | 0.5 | 2.7 |
| Natural gas | 0.00 | 8.90 | 11.65 | 14.63 | 16.12 | 0.0 | 31.0 | 24.4 | 27.5 | 28.5 | - | 3.9 | 2.3 | 1.0 | 2.2 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.07 | 0.35 | 0.49 | 0.73 | 0.95 | 0.6 | 1.2 | 1.0 | 1.4 | 1.7 | 7.2 | 5.0 | 4.0 | 2.7 | 3.8 |
| Biomass | 0.07 | 0.35 | 0.43 | 0.53 | 0.60 | 0.6 | 1.2 | 0.9 | 1.0 | 1.1 | 7.2 | 2.9 | 2.2 | 1.2 | 2.0 |
| Solar, Wind, Ocean | 0.00 | 0.00 | 0.07 | 0.20 | 0.35 | 0.0 | 0.0 | 0.1 | 0.4 | 0.6 | - | 74.0 | 11.5 | 6.0 | 22.8 |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **5.01** | **20.24** | **38.54** | **42.93** | **45.88** | **100** | **100** | **100** | **100** | **100** | **6.3** | **9.6** | **1.1** | **0.7** | **3.1** |
| Industry | 0.61 | 5.86 | 9.48 | 13.03 | 15.29 | 12.1 | 28.9 | 24.6 | 30.4 | 33.3 | 10.4 | 7.1 | 3.2 | 1.6 | 3.6 |
| Transportation | 1.36 | 2.95 | 3.09 | 3.44 | 3.89 | 27.1 | 14.6 | 8.0 | 8.0 | 8.5 | 3.4 | 0.7 | 1.1 | 1.2 | 1.0 |
| Others | 1.13 | 2.37 | 2.79 | 3.24 | 3.46 | 22.6 | 11.7 | 7.2 | 7.6 | 7.5 | 3.3 | 2.3 | 1.5 | 0.6 | 1.4 |
| Non-energy | 1.91 | 9.06 | 23.18 | 23.22 | 23.24 | 38.2 | 44.8 | 60.1 | 54.1 | 50.7 | 7.0 | 14.4 | 0.0 | 0.0 | 3.6 |
| **Total** | **5.01** | **20.24** | **38.54** | **42.93** | **45.88** | **100** | **100** | **100** | **100** | **100** | **6.3** | **9.6** | **1.1** | **0.7** | **3.1** |
| Coal | 0.02 | 0.13 | 0.13 | 0.13 | 0.13 | 0.4 | 0.6 | 0.3 | 0.3 | 0.3 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | 3.81 | 14.87 | 31.37 | 33.48 | 35.27 | 76.1 | 73.5 | 81.4 | 78.0 | 76.9 | 6.1 | 11.3 | 0.7 | 0.5 | 3.3 |
| Natural gas | 0.06 | 1.30 | 2.23 | 3.32 | 3.71 | 1.2 | 6.4 | 5.8 | 7.7 | 8.1 | 14.1 | 8.0 | 4.1 | 1.1 | 4.0 |
| Electricity | 1.12 | 3.94 | 4.82 | 6.01 | 6.77 | 22.3 | 19.5 | 12.5 | 14.0 | 14.8 | 5.6 | 2.9 | 2.2 | 1.2 | 2.0 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **15.71** | **47.97** | **58.66** | **73.12** | **82.48** | **100** | **100** | **100** | **100** | **100** | **5.0** | **2.9** | **2.2** | **1.2** | **2.0** |
| Coal | - | 0.39 | 0.48 | 0.60 | 0.67 | 0.0 | 0.8 | 0.8 | 0.8 | 0.8 | - | 2.9 | 2.2 | 1.2 | 2.0 |
| Oil | 15.54 | 2.33 | 0.56 | 0.48 | 0.29 | 98.9 | 4.9 | 1.0 | 0.7 | 0.4 | -7.9 | -18.4 | -1.6 | -4.9 | -7.4 |
| Natural gas | - | 43.88 | 55.19 | 67.66 | 75.06 | 0.0 | 91.5 | 94.1 | 92.5 | 91.0 | - | 3.3 | 2.1 | 1.0 | 2.0 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.17 | 1.37 | 2.44 | 4.38 | 6.46 | 1.1 | 2.9 | 4.2 | 6.0 | 7.8 | 9.5 | 8.5 | 6.0 | 4.0 | 5.9 |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **4.42** | **8.24** | **9.70** | **11.61** | **12.70** | **100** | **100** | **100** | **100** | **100** | **2.7** | **2.4** | **1.8** | **0.9** | **1.6** |
| Coal | - | 0.13 | 0.16 | 0.20 | 0.23 | - | 1.6 | 1.7 | 1.8 | 1.8 | - | 2.9 | 2.2 | 1.2 | 2.0 |
| Oil | 4.42 | 0.50 | 0.12 | 0.10 | 0.06 | 100.0 | 6.1 | 1.2 | 0.9 | 0.5 | -9.0 | -18.6 | -1.7 | -4.9 | -7.5 |
| Natural gas | - | 7.61 | 9.42 | 11.31 | 12.41 | - | 92.3 | 97.1 | 97.4 | 97.7 | - | 3.1 | 1.8 | 0.9 | 1.8 |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **30.3** | **48.6** | **49.8** | **50.9** | **51.5** | **2.1** | **0.3** | **0.2** | **0.1** | **0.2** |
| Coal | - | 25.1 | 25.1 | 25.1 | 25.1 | - | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | 30.3 | 40.1 | 40.9 | 41.5 | 41.5 | 1.2 | 0.3 | 0.2 | 0.0 | 0.1 |
| Natural gas | - | 49.6 | 50.4 | 51.5 | 52.0 | - | 0.2 | 0.2 | 0.1 | 0.2 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **5.7** | **13.7** | **19.4** | **22.5** | **24.1** | **100** | **100** | **100** | **100** | **100** | **3.9** | **5.1** | **1.5** | **0.7** | **2.1** |
| Coal | 0.1 | - | - | - | - | 1.2 | - | - | - | - | -100.0 | - | - | - | - |
| Oil | 5.6 | 8.0 | 12.0 | 13.1 | 13.7 | 98.8 | 58.5 | 61.6 | 58.3 | 57.1 | 1.6 | 5.8 | 0.9 | 0.5 | 2.0 |
| Natural Gas | 0.0 | 5.7 | 7.5 | 9.4 | 10.3 | 0.0 | 41.5 | 38.4 | 41.7 | 42.9 | - | 3.9 | 2.3 | 1.0 | 2.2 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 50.4 | 202.4 | 248.7 | 326.7 | 402.5 | 6.23 | 2.99 | 2.76 | 2.11 | 2.58 |
| Population (millions of people) | 3.0 | 5.4 | 5.8 | 6.3 | 6.6 | 2.52 | 1.04 | 0.78 | 0.53 | 0.75 |
| GDP per capita (thousands of 2005 USD/person) | 16.55 | 37.49 | 42.8 | 52.1 | 60.9 | 3.62 | 1.92 | 1.97 | 1.57 | 1.81 |
| Primary energy consumption per capita (toe/person) | 3.78 | 5.32 | 8.23 | 8.47 | 8.56 | 1.49 | 6.42 | 0.29 | 0.11 | 1.78 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 229 | 142 | 192 | 163 | 141 | -2.05 | 4.41 | -1.65 | -1.44 | -0.03 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 99 | 100 | 155 | 131 | 114 | 0.03 | 6.46 | -1.63 | -1.41 | 0.49 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 112 | 68 | 78 | 69 | 60 | -2.17 | 2.02 | -1.25 | -1.40 | -0.47 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.49 | 0.48 | 0.41 | 0.42 | 0.43 | -0.12 | -2.29 | 0.41 | 0.04 | -0.43 |
| Automobile ownership volume (millions of vehicles) | - | 0.83 | 0.85 | 0.87 | 0.89 | - | 0.28 | 0.25 | 0.25 | 0.26 |
| Automobile ownership volume per capita (vehicles per person) | - | 0.154 | 0.146 | 0.138 | 0.134 | - | -0.75 | -0.52 | -0.28 | -0.49 |

# Singapore [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **11.53** | **28.73** | **47.03** | **51.03** | **53.68** | **100** | **100** | **100** | **100** | **100** | **4.1** | **7.3** | **0.8** | **0.5** | **2.3** |
| Coal | 0.02 | 0.26 | 0.29 | 0.33 | 0.35 | 0.2 | 0.9 | 0.6 | 0.6 | 0.7 | 11.4 | 1.4 | 1.2 | 0.7 | 1.1 |
| Oil | 11.44 | 19.22 | 35.23 | 37.13 | 38.76 | 99.2 | 66.9 | 74.9 | 72.8 | 72.2 | 2.3 | 9.0 | 0.5 | 0.4 | 2.6 |
| Natural gas | 0.00 | 8.90 | 10.98 | 12.76 | 13.48 | 0.0 | 31.0 | 23.3 | 25.0 | 25.1 | - | 3.0 | 1.5 | 0.5 | 1.5 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.07 | 0.35 | 0.52 | 0.81 | 1.09 | 0.6 | 1.2 | 1.1 | 1.6 | 2.0 | 7.2 | 6.0 | 4.5 | 3.0 | 4.3 |
| Biomass | 0.07 | 0.35 | 0.42 | 0.50 | 0.55 | 0.6 | 1.2 | 0.9 | 1.0 | 1.0 | 7.2 | 2.7 | 1.8 | 0.9 | 1.7 |
| Solar, Wind, Ocean | 0.00 | 0.00 | 0.10 | 0.31 | 0.54 | 0.0 | 0.0 | 0.2 | 0.6 | 1.0 | - | 85.5 | 11.4 | 5.9 | 24.8 |
| Biofuels | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Electricit | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **5.01** | **20.24** | **38.36** | **42.33** | **45.00** | **100** | **100** | **100** | **100** | **100** | **6.3** | **9.6** | **1.0** | **0.6** | **3.0** |
| Industry | 0.61 | 5.85 | 9.33 | 12.54 | 14.57 | 12.1 | 28.9 | 24.3 | 29.6 | 32.4 | 10.4 | 6.9 | 3.0 | 1.5 | 3.4 |
| Transportation | 1.36 | 2.95 | 3.09 | 3.42 | 3.86 | 27.1 | 14.6 | 8.0 | 8.1 | 8.6 | 3.4 | 0.6 | 1.0 | 1.2 | 1.0 |
| Others | 1.13 | 2.37 | 2.76 | 3.15 | 3.33 | 22.6 | 11.7 | 7.2 | 7.5 | 7.4 | 3.3 | 2.2 | 1.4 | 0.5 | 1.3 |
| Non-energy | 1.91 | 9.06 | 23.18 | 23.22 | 23.24 | 38.2 | 44.8 | 60.4 | 54.8 | 51.7 | 7.0 | 14.4 | 0.0 | 0.0 | 3.6 |
| **Total** | **5.01** | **20.24** | **38.36** | **42.33** | **45.00** | **100** | **100** | **100** | **100** | **100** | **6.3** | **9.6** | **1.0** | **0.6** | **3.0** |
| Coal | 0.02 | 0.13 | 0.13 | 0.13 | 0.13 | 0.4 | 0.6 | 0.3 | 0.3 | 0.3 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | 3.81 | 14.87 | 31.28 | 33.20 | 34.86 | 76.1 | 73.5 | 81.6 | 78.4 | 77.5 | 6.1 | 11.2 | 0.6 | 0.5 | 3.2 |
| Natural gas | 0.06 | 1.30 | 2.19 | 3.19 | 3.52 | 1.2 | 6.4 | 5.7 | 7.5 | 7.8 | 14.1 | 7.8 | 3.8 | 1.0 | 3.8 |
| Electricity | 1.12 | 3.94 | 4.75 | 5.81 | 6.48 | 22.3 | 19.5 | 12.4 | 13.7 | 14.4 | 5.6 | 2.7 | 2.0 | 1.1 | 1.9 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **15.71** | **47.97** | **57.90** | **70.70** | **78.95** | **100** | **100** | **100** | **100** | **100** | **5.0** | **2.7** | **2.0** | **1.1** | **1.9** |
| Coal | 0.00 | 0.39 | 0.47 | 0.58 | 0.64 | 0.0 | 0.8 | 0.8 | 0.8 | 0.8 | - | 2.7 | 2.0 | 1.1 | 1.9 |
| Oil | 15.54 | 2.33 | 0.50 | 0.43 | 0.28 | 98.9 | 4.9 | 0.9 | 0.6 | 0.4 | -7.9 | -19.7 | -1.5 | -4.3 | -7.6 |
| Natural gas | 0.00 | 43.88 | 54.07 | 64.13 | 69.47 | 0.0 | 91.5 | 93.4 | 90.7 | 88.0 | - | 3.0 | 1.7 | 0.8 | 1.7 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 0.17 | 1.37 | 2.86 | 5.56 | 8.55 | 1.1 | 2.9 | 4.9 | 7.9 | 10.8 | 9.5 | 11.0 | 6.9 | 4.4 | 7.0 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **0.00** | **8.24** | **9.05** | **9.85** | **10.23** | **-** | **100** | **100** | **100** | **100** | **-** | **1.4** | **0.8** | **0.4** | **0.8** |
| Coal | - | 0.13 | 0.16 | 0.20 | 0.22 | - | 1.6 | 1.8 | 2.0 | 2.2 | - | 2.7 | 2.0 | 1.1 | 1.9 |
| Oil | - | 0.50 | 0.10 | 0.08 | 0.05 | - | 6.1 | 1.1 | 0.9 | 0.5 | - | -20.1 | -2.0 | -4.6 | -8.0 |
| Natural gas | - | 7.61 | 8.79 | 9.57 | 9.96 | - | 92.3 | 97.1 | 97.1 | 97.3 | - | 2.1 | 0.9 | 0.4 | 1.0 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **-** | **48.6** | **52.3** | **56.9** | **59.2** | **-** | **1.0** | **0.8** | **0.4** | **0.7** |
| Coal | - | 25.1 | 25.1 | 25.1 | 25.1 | - | 0.0 | 0.0 | 0.0 | 0.0 |
| Oil | - | 40.1 | 41.7 | 43.9 | 45.0 | - | 0.5 | 0.5 | 0.2 | 0.4 |
| Natural gas | - | 49.6 | 52.9 | 57.6 | 60.0 | - | 0.9 | 0.9 | 0.4 | 0.7 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| **Total** | **5.7** | **13.7** | **18.9** | **21.1** | **22.1** | **100** | **100** | **100** | **100** | **100** | **3.9** | **4.7** | **1.1** | **0.5** | **1.8** |
| Coal | 0.1 | - | - | - | - | 1.2 | - | - | - | - | -100.0 | - | - | - | - |
| Oil | 5.6 | 8.0 | 11.9 | 12.9 | 13.5 | 98.8 | 58.5 | 62.8 | 61.2 | 60.9 | 1.6 | 5.7 | 0.8 | 0.4 | 1.9 |
| Natural Gas | 0.0 | 5.7 | 7.0 | 8.2 | 8.6 | 0.0 | 41.5 | 37.2 | 38.8 | 39.1 | - | 3.0 | 1.5 | 0.5 | 1.5 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 50.4 | 202.4 | 248.7 | 326.7 | 402.5 | 6.2 | 3.0 | 2.8 | 2.1 | 2.6 |
| Population (millions of people) | 3.0 | 5.4 | 5.8 | 6.3 | 6.6 | 2.5 | 1.0 | 0.8 | 0.5 | 0.8 |
| GDP per capita (thousands of 2005 USD/person) | 16.55 | 37.49 | 42.8 | 52.1 | 60.9 | 3.6 | 1.9 | 2.0 | 1.6 | 1.8 |
| Primary energy consumption per capita (toe/person) | 3.78 | 5.32 | 8.10 | 8.13 | 8.12 | 1.5 | 6.2 | 0.0 | 0.0 | 1.6 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 229 | 142 | 189 | 156 | 133 | -2.0 | 4.2 | -1.9 | -1.6 | -0.2 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 99 | 100 | 154 | 130 | 112 | 0.0 | 6.4 | -1.7 | -1.5 | 0.4 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 112 | 68 | 76 | 65 | 55 | -2.2 | 1.6 | -1.6 | -1.6 | -0.8 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.49 | 0.48 | 0.40 | 0.41 | 0.41 | -0.1 | -2.4 | 0.3 | 0.0 | -0.6 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Thailand [BAU]

| Primary energy consumption | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **42.63** | **132.30** | **160.07** | **210.67** | **301.48** | **100** | **100** | **100** | **100** | **100** | **5.0** | **2.8** | **2.8** | **3.6** | **3.1** |
| Coal | 3.82 | 17.09 | 20.02 | 27.52 | 51.59 | 9.0 | 12.9 | 12.5 | 13.1 | 17.1 | 6.7 | 2.3 | 3.2 | 6.5 | 4.2 |
| Oil | 17.96 | 50.89 | 62.00 | 82.28 | 112.10 | 42.1 | 38.5 | 38.7 | 39.1 | 37.2 | 4.6 | 2.9 | 2.9 | 3.1 | 3.0 |
| Natural gas | 4.99 | 37.84 | 45.78 | 55.52 | 78.72 | 11.7 | 28.6 | 28.6 | 26.4 | 26.1 | 9.2 | 2.8 | 1.9 | 3.6 | 2.8 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 0.43 | 0.49 | 0.89 | 1.14 | 1.27 | 1.0 | 0.4 | 0.6 | 0.5 | 0.4 | 0.6 | 8.7 | 2.5 | 1.1 | 3.6 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 15.43 | 25.99 | 31.39 | 44.21 | 57.79 | 36.2 | 19.6 | 19.6 | 21.0 | 19.2 | 2.3 | 2.7 | 3.5 | 2.7 | 3.0 |
| Biomass | 14.69 | 23.28 | 26.96 | 35.25 | 46.31 | 34.4 | 17.6 | 16.8 | 16.7 | 15.4 | 2.0 | 2.1 | 2.7 | 2.8 | 2.6 |
| Solar, Wind, Ocean | - | 0.16 | 0.91 | 1.86 | 2.04 | - | 0.1 | 0.6 | 0.9 | 0.7 | - | 28.1 | 7.3 | 0.9 | 9.8 |
| Biofuels | - | 1.20 | 0.95 | 1.10 | 1.36 | - | 0.9 | 0.6 | 0.5 | 0.5 | - | -3.3 | 1.5 | 2.1 | 0.5 |
| Electricity | 0.05 | 1.34 | 2.56 | 6.00 | 8.07 | 0.1 | 1.0 | 1.6 | 2.8 | 2.7 | 15.1 | 9.7 | 8.9 | 3.0 | 6.9 |

| Final energy demand | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **28.87** | **95.80** | **120.82** | **164.78** | **227.55** | **100** | **100** | **100** | **100** | **100** | **5.4** | **3.4** | **3.2** | **3.3** | **3.3** |
| Industry | 8.65 | 29.90 | 37.91 | 53.67 | 76.30 | 30.0 | 31.2 | 31.4 | 32.6 | 33.5 | 5.5 | 3.4 | 3.5 | 3.6 | 3.5 |
| Transportation | 9.01 | 22.63 | 30.24 | 36.78 | 47.08 | 31.2 | 23.6 | 25.0 | 22.3 | 20.7 | 4.1 | 4.2 | 2.0 | 2.5 | 2.8 |
| Others | 10.78 | 21.49 | 25.31 | 34.34 | 46.12 | 37.3 | 22.4 | 21.0 | 20.8 | 20.3 | 3.0 | 2.4 | 3.1 | 3.0 | 2.9 |
| Non-energy | 0.43 | 21.79 | 27.36 | 39.98 | 58.05 | 1.5 | 22.7 | 22.6 | 24.3 | 25.5 | 18.6 | 3.3 | 3.9 | 3.8 | 3.7 |
| | **28.87** | **95.80** | **120.82** | **164.78** | **227.55** | **100** | **100** | **100** | **100** | **100** | **5.4** | **3.4** | **3.2** | **3.3** | **3.3** |
| Coal | 1.31 | 8.73 | 12.24 | 17.27 | 24.28 | 4.5 | 9.1 | 10.1 | 10.5 | 10.7 | 8.6 | 4.9 | 3.5 | 3.5 | 3.9 |
| Oil | 14.93 | 48.01 | 58.90 | 77.67 | 105.11 | 51.7 | 50.1 | 48.8 | 47.1 | 46.2 | 5.2 | 3.0 | 2.8 | 3.1 | 2.9 |
| Natural gas | 0.14 | 9.44 | 15.11 | 22.74 | 33.82 | 0.5 | 9.9 | 12.5 | 13.8 | 14.9 | 20.2 | 7.0 | 4.2 | 4.0 | 4.8 |
| Electricity | 3.30 | 14.13 | 17.10 | 24.85 | 35.72 | 11.4 | 14.8 | 14.2 | 15.1 | 15.7 | 6.5 | 2.8 | 3.8 | 3.7 | 3.5 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 9.20 | 15.49 | 17.46 | 22.25 | 28.62 | 31.9 | 16.2 | 14.5 | 13.5 | 12.6 | 2.3 | 1.7 | 2.5 | 2.5 | 2.3 |

| Power generation Output | TWh | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **44.18** | **165.71** | **187.79** | **246.09** | **360.78** | **100** | **100** | **100** | **100** | **100** | **5.9** | **1.8** | **2.7** | **3.9** | **2.9** |
| Coal | 11.05 | 32.92 | 30.41 | 39.65 | 105.03 | 25.0 | 19.9 | 16.2 | 16.1 | 29.1 | 4.9 | -1.1 | 2.7 | 10.2 | 4.4 |
| Oil | 10.38 | 1.68 | - | 0.72 | 2.78 | 23.5 | 1.0 | - | 0.3 | 0.8 | -7.6 | -100.0 | - | 14.4 | 1.9 |
| Natural gas | 17.77 | 117.01 | 128.11 | 156.64 | 189.28 | 40.2 | 70.6 | 68.2 | 63.7 | 52.5 | 8.5 | 1.3 | 2.0 | 1.9 | 1.8 |
| Nuclear | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hydro | 4.98 | 5.75 | 10.30 | 13.24 | 14.82 | 11.3 | 3.5 | 5.5 | 5.4 | 4.1 | 0.6 | 8.7 | 2.5 | 1.1 | 3.6 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | - | 8.36 | 18.97 | 35.84 | 48.87 | - | 5.04 | 10.1 | 14.6 | 13.5 | - | 12.4 | 6.6 | 3.1 | 6.8 |

| Power generation Input | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **8.92** | **29.71** | **30.76** | **38.51** | **61.88** | **100** | **100** | **100** | **100** | **100** | **5.4** | **0.5** | **2.3** | **4.9** | **2.8** |
| Coal | 2.55 | 8.35 | 7.78 | 10.25 | 27.31 | 28.6 | 28.1 | 25.3 | 26.6 | 44.1 | 5.3 | -1.0 | 2.8 | 10.3 | 4.5 |
| Oil | 2.55 | 0.37 | - | 0.16 | 0.62 | 28.6 | 1.2 | - | 0.4 | 1.0 | -8.0 | -100.0 | - | 14.4 | 1.9 |
| Natural gas | 3.82 | 20.99 | 22.98 | 28.10 | 33.95 | 42.9 | 70.6 | 74.7 | 73.0 | 54.9 | 7.7 | 1.3 | 2.0 | 1.9 | 1.8 |

| Thermal Efficiency | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **38** | **44** | **44** | **44** | **41** | **0.7** | **0.1** | **-0.1** | **-0.6** | **-0.2** |
| Coal | 37 | 34 | 34 | 33 | 33 | -0.4 | -0.1 | -0.1 | -0.1 | -0.1 |
| Oil | 35 | 39 | - | 39 | 39 | 0.5 | - | - | | |
| Natural gas | 40 | 48 | 48 | 48 | 48 | 0.8 | | | | |

| $CO_2$ emissions | Mt-C | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **43.5** | **60.2** | **73.0** | **95.1** | **140.6** | **100** | **100** | **100** | **100** | **100** | **1.4** | **2.8** | **2.7** | **4.0** | **3.2** |
| Coal | 12.6 | 18.1 | 21.2 | 29.1 | 54.6 | 29.0 | 30.1 | 29.0 | 30.6 | 38.8 | 1.6 | 2.3 | 3.2 | 6.5 | 4.2 |
| Oil | 18.7 | 25.6 | 33.0 | 41.6 | 54.5 | 43.1 | 42.5 | 45.3 | 43.7 | 38.7 | 1.4 | 3.7 | 2.3 | 2.7 | 2.8 |
| Natural Gas | 12.1 | 16.5 | 18.8 | 24.4 | 31.5 | 27.9 | 27.4 | 25.7 | 25.6 | 22.4 | 1.3 | 1.9 | 2.6 | 2.6 | 2.4 |

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 88.9 | 230.4 | 289.3 | 422.7 | 613.8 | 4.2 | 3.3 | 3.9 | 3.8 | 3.7 |
| Population (millions of people) | 55.8 | 67.5 | 67.6 | 67.8 | 68.0 | 0.8 | 0.03 | 0.03 | 0.03 | 0.03 |
| GDP per capita (thousands of 2005 USD/person) | 1.59 | 3.42 | 4.3 | 6.2 | 9.0 | 3.4 | 3.3 | 3.8 | 3.8 | 3.7 |
| Primary energy consumption per capita (toe/person) | 0.76 | 1.96 | 2.37 | 3.11 | 4.43 | 4.2 | 2.7 | 2.8 | 3.6 | 3.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 479 | 574 | 553 | 498 | 491 | 0.8 | -0.5 | -1.0 | -0.1 | -0.6 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 325 | 416 | 418 | 390 | 371 | 1.1 | 0.1 | -0.7 | -0.5 | -0.4 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 489 | 261 | 252 | 225 | 229 | -2.7 | -0.5 | -1.1 | 0.2 | -0.5 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 1.02 | 0.45 | 0.46 | 0.45 | 0.47 | -3.4 | 0.0 | -0.1 | 0.3 | 0.1 |
| Automobile ownership volume (millions of vehicles) | - | - | - | - | - | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | | - | - | - | - | - |

# Thailand [APS]

| Primary energy consumption | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **42.63** | **132.30** | **141.28** | **161.35** | **209.74** | **100** | **100** | **100** | **100** | **100** | **5.0** | **0.9** | **1.3** | **2.7** | **1.7** |
| Coal | 3.82 | 17.09 | 17.06 | 20.65 | 28.44 | 9.0 | 12.9 | 12.1 | 12.8 | 13.6 | 6.7 | 0.0 | 1.9 | 3.3 | 1.9 |
| Oil | 17.96 | 50.89 | 54.98 | 62.94 | 78.52 | 42.1 | 38.5 | 38.9 | 39.0 | 37.4 | 4.6 | 1.1 | 1.4 | 2.2 | 1.6 |
| Natural gas | 4.99 | 37.84 | 39.39 | 39.86 | 50.81 | 11.7 | 28.6 | 27.9 | 24.7 | 24.2 | 9.2 | 0.6 | 0.1 | 2.5 | 1.1 |
| Nuclear | | | | | 2.84 | - | - | - | - | 1.4 | - | - | - | - | - |
| Hydro | 0.43 | 0.49 | 0.94 | 1.15 | 1.36 | 1.0 | 0.4 | 0.7 | 0.7 | 0.6 | 0.6 | 9.7 | 2.0 | 1.7 | 3.8 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 15.43 | 25.99 | 28.91 | 36.75 | 47.78 | 36.2 | 19.6 | 20.5 | 22.8 | 22.8 | 2.3 | 1.5 | 2.4 | 2.7 | 2.3 |
| Biomass | 14.69 | 23.28 | 25.02 | 30.79 | 38.55 | 34.4 | 17.6 | 17.7 | 19.1 | 18.4 | 2.0 | 1.0 | 2.1 | 2.3 | 1.9 |
| Solar, Wind, Ocean | | 0.16 | 0.61 | 1.41 | 2.33 | - | 0.1 | 0.4 | 0.9 | 1.1 | - | 20.8 | 8.8 | 5.1 | 10.4 |
| Biofuels | | 1.20 | 0.72 | 0.49 | 0.32 | - | 0.9 | 0.5 | 0.3 | 0.2 | - | -7.1 | -3.7 | -4.2 | -4.8 |
| Electricity | 0.05 | 1.34 | 2.56 | 4.06 | 6.57 | 0.1 | 1.0 | 1.8 | 2.5 | 3.1 | 15.1 | 9.7 | 4.7 | 4.9 | 6.1 |

| Final energy demand | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **28.87** | **95.80** | **108.60** | **130.55** | **167.63** | **100** | **100** | **100** | **100** | **100** | **5.4** | **1.8** | **1.9** | **2.5** | **2.1** |
| Industry | 8.65 | 29.90 | 34.15 | 43.89 | 59.59 | 30.0 | 31.2 | 31.4 | 33.6 | 35.5 | 5.5 | 1.9 | 2.5 | 3.1 | 2.6 |
| Transportation | 9.01 | 22.63 | 23.04 | 17.02 | 12.52 | 31.2 | 23.6 | 21.2 | 13.0 | 7.5 | 4.1 | 0.3 | -3.0 | -3.0 | -2.2 |
| Others | 10.78 | 21.49 | 24.06 | 29.67 | 37.47 | 37.3 | 22.4 | 22.1 | 22.7 | 22.4 | 3.0 | 1.6 | 2.1 | 2.4 | 2.1 |
| Non-energy | 0.43 | 21.79 | 27.36 | 39.98 | 58.05 | 1.5 | 22.7 | 25.2 | 30.6 | 34.6 | 18.6 | 3.3 | 3.9 | 3.8 | 3.7 |
| | **28.87** | **95.80** | **108.60** | **130.55** | **167.63** | **100** | **100** | **100** | **100** | **100** | **5.4** | **1.8** | **1.9** | **2.5** | **2.1** |
| Coal | 1.31 | 8.73 | 11.03 | 14.12 | 18.97 | 4.5 | 9.1 | 10.2 | 10.8 | 11.3 | 8.6 | 3.4 | 2.5 | 3.0 | 2.9 |
| Oil | 14.93 | 48.01 | 51.88 | 58.50 | 71.68 | 51.7 | 50.1 | 47.8 | 44.8 | 42.8 | 5.2 | 1.1 | 1.2 | 2.1 | 1.5 |
| Natural gas | 0.14 | 9.44 | 14.05 | 19.58 | 28.08 | 0.5 | 9.9 | 12.9 | 15.0 | 16.7 | 20.2 | 5.8 | 3.4 | 3.7 | 4.1 |
| Electricity | 3.30 | 14.13 | 15.56 | 19.82 | 26.34 | 11.4 | 14.8 | 14.3 | 15.2 | 15.7 | 6.5 | 1.4 | 2.4 | 2.9 | 2.3 |
| Heat | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 9.20 | 15.49 | 16.08 | 18.53 | 22.57 | 31.9 | 16.2 | 14.8 | 14.2 | 13.5 | 2.3 | 0.5 | 1.4 | 2.0 | 1.4 |

| Power generation Output | TWh | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **44.18** | **165.71** | **167.99** | **203.67** | **257.05** | **100** | **100** | **100** | **100** | **100** | **5.9** | **0.2** | **1.9** | **2.4** | **1.6** |
| Coal | 11.05 | 32.92 | 27.32 | 32.49 | 47.59 | 25.0 | 19.9 | 16.3 | 16.0 | 18.5 | 4.9 | -2.6 | 1.7 | 3.9 | 1.4 |
| Oil | 10.38 | 1.68 | | | 2.21 | 23.5 | 1.0 | - | - | 0.9 | -7.6 | -100.0 | - | - | 1.0 |
| Natural gas | 17.77 | 117.01 | 115.09 | 128.34 | 134.14 | 40.2 | 70.6 | 68.5 | 63.0 | 52.2 | 8.5 | -0.2 | 1.1 | 0.4 | 0.5 |
| Nuclear | | | | | 10.88 | - | - | - | - | 4.2 | - | - | - | - | - |
| Hydro | 4.98 | 5.75 | 10.96 | 13.38 | 15.84 | 11.3 | 3.5 | 6.5 | 6.6 | 6.2 | 0.6 | 9.7 | 2.0 | 1.7 | 3.8 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | | 8.36 | 14.63 | 29.47 | 46.39 | - | 5.0 | 8.7 | 14.5 | 18.0 | - | 8.3 | 7.3 | 4.6 | 6.6 |

| Power generation Input | MTOE | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **8.92** | **29.71** | **25.87** | **27.50** | **31.30** | **100** | **100** | **100** | **100** | **100** | **5.4** | **-2.0** | **0.6** | **1.3** | **0.2** |
| Coal | 2.55 | 8.35 | 6.03 | 6.53 | 9.47 | 28.6 | 28.1 | 23.3 | 23.7 | 30.2 | 5.3 | -4.6 | 0.8 | 3.8 | 0.5 |
| Oil | 2.55 | 0.37 | | | 0.47 | 28.6 | 1.2 | - | - | 1.5 | -8.0 | -100.0 | - | - | 0.9 |
| Natural gas | 3.82 | 20.99 | 19.85 | 20.97 | 21.36 | 42.9 | 70.6 | 76.7 | 76.3 | 68.2 | 7.7 | -0.8 | 0.6 | 0.2 | 0.1 |

| Thermal Efficiency | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **38** | **44** | **47** | **50** | **51** | **0.7** | **1.1** | **0.6** | **0.0** | **0.5** |
| Coal | 37 | 34 | 39 | 43 | 43 | -0.4 | 2.0 | 0.9 | 0.1 | 0.9 |
| Oil | 35 | 39 | - | - | 40 | 0.5 | - | - | - | 0.1 |
| Natural gas | 40 | 48 | 50 | 53 | 54 | 0.8 | 0.6 | 0.5 | 0.3 | 0.4 |

| $CO_2$ emissions | Mt-C | | | | | Share, % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | **43.47** | **60.17** | **61.45** | **65.37** | **76.78** | **100** | **100** | **100** | **100** | **100** | **1.4** | **0.3** | **0.6** | **1.6** | **0.9** |
| Coal | 12.62 | 18.09 | 18.06 | 21.86 | 30.10 | 29.0 | 30.1 | 29.4 | 33.4 | 39.2 | 1.6 | 0.0 | 1.9 | 3.3 | 1.9 |
| Oil | 18.71 | 25.59 | 27.29 | 25.70 | 26.83 | 43.1 | 42.5 | 44.4 | 39.3 | 34.9 | 1.4 | 0.9 | -0.6 | 0.4 | 0.2 |
| Natural Gas | 12.14 | 16.50 | 16.10 | 17.81 | 19.84 | 27.9 | 27.4 | 26.2 | 27.2 | 25.8 | 1.3 | -0.3 | 1.0 | 1.1 | 0.7 |

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| GDP (billions of 2005 US dollars) | 88.9 | 230.4 | 289.3 | 422.7 | 613.8 | 4.2 | 3.3 | 3.9 | 3.8 | 3.7 |
| Population (millions of people) | 55.8 | 67.5 | 67.6 | 67.8 | 68.0 | 0.8 | 0.03 | 0.03 | 0.03 | 0.03 |
| GDP per capita (thousands of 2005 USD/person) | 1.59 | 3.42 | 4.3 | 6.2 | 9.0 | 3.4 | 3.3 | 3.8 | 3.8 | 3.7 |
| Primary energy consumption per capita (toe/person) | 0.76 | 1.96 | 2.09 | 2.38 | 3.08 | 4.2 | 0.9 | 1.3 | 2.6 | 1.7 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 479 | 574 | 488 | 382 | 342 | 0.8 | -2.3 | -2.4 | -1.1 | -1.9 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 325 | 416 | 375 | 309 | 273 | 1.1 | -1.5 | -1.9 | -1.2 | -1.5 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 489 | 261 | 212 | 155 | 125 | -2.7 | -2.9 | -3.1 | -2.1 | -2.7 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 1.02 | 0.45 | 0.43 | 0.41 | 0.37 | -3.4 | -0.6 | -0.7 | -1.0 | -0.8 |
| Automobile ownership volume (millions of vehicles) | - | - | | | | - | - | - | - | |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | | - | - | - | - | |

# Viet Nam [BAU]

## Primary energy consumption

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **17.86** | **60.06** | **84.47** | **135.55** | **212.89** | **100** | **100** | **100** | **100** | **100** | **5.4** | **5.0** | **4.8** | **4.6** | **4.8** |
| Coal | 2.21 | 16.15 | 30.32 | 48.89 | 83.60 | 12.4 | 26.9 | 35.9 | 36.1 | 39.3 | 9.0 | 9.4 | 4.9 | 5.5 | 6.3 |
| Oil | 2.71 | 16.38 | 25.39 | 41.79 | 62.79 | 15.2 | 27.3 | 30.1 | 30.8 | 29.5 | 8.1 | 6.5 | 5.1 | 4.2 | 5.1 |
| Natural gas | 0.00 | 8.98 | 10.89 | 26.35 | 49.15 | 0.0 | 14.9 | 12.9 | 19.4 | 23.1 | 41.6 | 2.8 | 9.2 | 6.4 | 6.5 |
| Nuclear | - | - | - | 2.83 | 2.89 | 0.0 | 0.0 | 0.0 | 2.1 | 1.4 | - | - | - | 0.2 | - |
| Hydro | 0.46 | 4.90 | 8.74 | 10.55 | 10.72 | 2.6 | 8.2 | 10.4 | 7.8 | 5.0 | 10.8 | 8.6 | 1.9 | 0.2 | 2.9 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 12.47 | 13.66 | 9.12 | 5.14 | 3.74 | 69.8 | 22.7 | 10.8 | 3.8 | 1.8 | 0.4 | -5.6 | -5.6 | -3.1 | -4.7 |
| Biomass | 12.47 | 13.84 | 8.56 | 4.10 | 2.24 | 69.8 | 23.0 | 10.1 | 3.0 | 1.1 | 0.5 | -6.6 | -7.1 | -5.9 | -6.5 |
| Solar, Wind, Ocean | - | 0.01 | 0.02 | 0.02 | 0.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | 23.7 | 0.1 | 0.2 | 5.8 |
| Biofuels | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Electricit | - | -0.18 | 0.53 | 1.01 | 1.48 | 0.0 | -0.3 | 0.6 | 0.7 | 0.7 | - | -216.6 | 6.6 | 3.9 | -208.1 |

## Final energy demand

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **16.06** | **50.46** | **67.26** | **100.90** | **151.47** | **100** | **100** | **100** | **100** | **100** | **5.1** | **4.2** | **4.1** | **4.1** | **4.2** |
| Industry | 4.54 | 19.36 | 29.63 | 47.77 | 74.41 | 28.3 | 38.4 | 44.1 | 47.3 | 49.1 | 6.5 | 6.3 | 4.9 | 4.5 | 5.1 |
| Transportation | 1.38 | 10.46 | 15.51 | 24.09 | 34.91 | 8.6 | 20.7 | 23.1 | 23.9 | 23.1 | 9.2 | 5.8 | 4.5 | 3.8 | 4.6 |
| Others | 10.11 | 18.94 | 19.40 | 24.33 | 34.60 | 63.0 | 37.5 | 28.8 | 24.1 | 22.8 | 2.8 | 0.3 | 2.3 | 3.6 | 2.3 |
| Non-energy | 0.03 | 1.71 | 2.72 | 4.71 | 7.55 | 0.2 | 3.4 | 4.0 | 4.7 | 5.0 | 19.6 | 6.9 | 5.6 | 4.8 | 5.7 |
| | | | | | | | | | | | | | | | |
| **Total** | **16.06** | **50.46** | **67.26** | **100.90** | **151.47** | **100** | **100** | **100** | **100** | **100** | **5.1** | **4.2** | **4.1** | **4.1** | **4.2** |
| Coal | 1.33 | 9.55 | 14.61 | 21.96 | 31.40 | 8.3 | 18.9 | 21.7 | 21.8 | 20.7 | 9.0 | 6.3 | 4.2 | 3.6 | 4.5 |
| Oil | 2.33 | 14.22 | 21.61 | 34.82 | 52.40 | 14.5 | 28.2 | 32.1 | 34.5 | 34.6 | 8.2 | 6.2 | 4.9 | 4.2 | 4.9 |
| Natural gas | 0.00 | 1.35 | 2.46 | 5.11 | 9.19 | 0.0 | 2.7 | 3.7 | 5.1 | 6.1 | - | 9.0 | 7.6 | 6.1 | 7.4 |
| Electricity | 0.53 | 9.81 | 17.43 | 30.34 | 48.84 | 3.3 | 19.4 | 25.9 | 30.1 | 32.2 | 13.5 | 8.6 | 5.7 | 4.9 | 6.1 |
| Heat | - | - | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | 11.87 | 15.52 | 11.15 | 8.67 | 9.64 | 73.9 | 30.8 | 16.6 | 8.6 | 6.4 | 1.2 | -4.6 | -2.5 | 1.1 | -1.7 |

## Power generation Output

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **8.68** | **127.32** | **215.42** | **372.84** | **600.24** | **100** | **100** | **100** | **100** | **100** | **12.4** | **7.8** | **5.6** | **4.9** | **5.9** |
| Coal | 2.00 | 26.86 | 64.90 | 113.59 | 224.61 | 23.1 | 21.1 | 30.1 | 30.5 | 37.4 | 12.0 | 13.4 | 5.8 | 7.1 | 8.2 |
| Oil | 1.31 | 0.54 | 0.05 | 0.63 | 0.00 | 15.0 | 0.4 | 0.0 | 0.2 | 0.0 | -3.8 | -28.5 | 28.5 | -100.0 | -100.0 |
| Natural gas | 0.01 | 42.85 | 48.01 | 124.33 | 239.09 | 0.1 | 33.7 | 22.3 | 33.3 | 39.8 | 47.1 | 1.6 | 10.0 | 6.8 | 6.6 |
| Nuclear | 0.00 | 0.00 | 0.00 | 10.86 | 11.10 | 0.0 | 0.0 | 0.0 | 2.9 | 1.8 | - | - | - | 0.2 | - |
| Hydro | 5.37 | 56.94 | 101.68 | 122.64 | 124.63 | 61.8 | 44.7 | 47.2 | 32.9 | 20.8 | 10.8 | 8.6 | 1.9 | 0.2 | 2.9 |
| Geothermal | - | - | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | - | 0.13 | 0.78 | 0.79 | 0.80 | 0.0 | 0.1 | 0.4 | 0.2 | 0.1 | - | 28.9 | 0.1 | 0.2 | 6.9 |

## Power generation Input

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **1.27** | **14.20** | **23.97** | **48.04** | **91.75** | **100** | **100** | **100** | **100** | **100** | **11.1** | **7.8** | **7.2** | **6.7** | **7.2** |
| Coal | 0.89 | 6.60 | 15.71 | 26.94 | 52.20 | 69.8 | 46.5 | 65.5 | 56.1 | 56.9 | 9.1 | 13.2 | 5.5 | 6.8 | 8.0 |
| Oil | 0.38 | 0.14 | 0.01 | 0.16 | 0.00 | 30.0 | 1.0 | 0.1 | 0.3 | 0.0 | -4.1 | -28.7 | 27.6 | -100.0 | -100.0 |
| Natural gas | 0.00 | 7.45 | 8.25 | 20.95 | 39.55 | 0.2 | 52.5 | 34.4 | 43.6 | 43.1 | 40.5 | 1.5 | 9.8 | 6.6 | 6.4 |

## Thermal Efficiency

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **22** | **43** | **41** | **43** | **43** | **2.8** | **-0.7** | **0.5** | **0.2** | **0.1** |
| Coal | 19 | 35 | 36 | 36 | 37 | 2.6 | 0.2 | 0.2 | 0.2 | 0.2 |
| Oil | 29 | 32 | 33 | 35 | - | 0.4 | 0.3 | 0.7 | - | - |
| Natural gas | 17 | 49 | 50 | 51 | 52 | 4.7 | 0.2 | 0.2 | 0.2 | 0.2 |

## $CO_2$ emissions

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| **Total** | **4.70** | **35.91** | **58.51** | **100.46** | **168.17** | **100** | **100** | **100** | **100** | **100** | **9.2** | **7.2** | **5.6** | **5.3** | **5.9** |
| Coal | 2.50 | 17.96 | 33.44 | 53.79 | 91.51 | 53.2 | 50.0 | 57.2 | 53.5 | 54.4 | 9.0 | 9.3 | 4.9 | 5.5 | 6.2 |
| Oil | 2.20 | 11.71 | 17.55 | 28.30 | 42.27 | 46.8 | 32.6 | 30.0 | 28.2 | 25.1 | 7.5 | 5.9 | 4.9 | 4.1 | 4.9 |
| Natural Gas | 0.00 | 6.24 | 7.52 | 18.37 | 34.39 | 0.0 | 17.4 | 12.9 | 18.3 | 20.4 | - | 2.7 | 9.3 | 6.5 | 6.5 |

## Energy and economic indicators

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990- | 2013- | 2020- | 2030- | 2013- |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 2013 | 2020 | 2030 | 2040 | 2040 |
| GDP (billions of 2005 US dollars) | 17.8 | 92.3 | 146.3 | 268.3 | 447.5 | 7.4 | 6.8 | 6.2 | 5.2 | 6.0 |
| Population (millions of people) | 66.0 | 89.7 | 96.2 | 103.1 | 107.0 | 1.3 | 1.0 | 0.7 | 0.4 | 0.7 |
| GDP per capita (thousands of 2005 USD/person) | 0.27 | 1.029 | 1.5 | 2.6 | 4.2 | 6.0 | 5.8 | 5.5 | 4.9 | 5.3 |
| Primary energy consumption per capita (toe/person) | 0.27 | 0.67 | 0.88 | 1.31 | 1.99 | 4.0 | 4.0 | 4.1 | 4.2 | 4.1 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,006 | 651 | 577 | 505 | 476 | -1.9 | -1.7 | -1.3 | -0.6 | -1.2 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 905 | 547 | 460 | 376 | 338 | -2.2 | -2.5 | -2.0 | -1.0 | -1.8 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 265 | 389 | 400 | 374 | 376 | 1.7 | 0.4 | -0.7 | 0.0 | -0.1 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.26 | 0.60 | 0.69 | 0.74 | 0.79 | 3.6 | 2.1 | 0.7 | 0.6 | 1.0 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |

# Viet Nam [APS]

**Primary energy consumption**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **17.86** | **60.06** | **78.05** | **118.69** | **182.76** | **100** | **100** | **100** | **100** | **100** | **5.4** | **3.8** | **4.3** | **4.4** | **4.2** |
| Coal | 2.21 | 16.15 | 23.71 | 32.39 | 47.78 | 12.4 | 26.9 | 30.4 | 27.3 | 26.1 | 9.0 | 5.6 | 3.2 | 4.0 | 4.1 |
| Oil | 2.71 | 16.38 | 24.82 | 40.29 | 60.60 | 15.2 | 27.3 | 31.8 | 33.9 | 33.2 | 8.1 | 6.1 | 5.0 | 4.2 | 5.0 |
| Natural gas | 0.00 | 8.98 | 10.33 | 22.09 | 36.53 | 0.0 | 14.9 | 13.2 | 18.6 | 20.0 | 41.6 | 2.0 | 7.9 | 5.2 | 5.3 |
| Nuclear | 0.00 | 0.00 | 0.00 | 1.93 | 10.51 | 0.0 | 0.0 | 0.0 | 1.6 | 5.7 | - | - | - | 18.4 | - |
| Hydro | 0.46 | 4.90 | 8.65 | 10.53 | 11.26 | 2.6 | 8.2 | 11.1 | 8.9 | 6.2 | 10.8 | 8.5 | 2.0 | 0.7 | 3.1 |
| Geothermal | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Others | 12.47 | 13.66 | 10.54 | 11.46 | 16.08 | 69.8 | 22.7 | 13.5 | 9.7 | 8.8 | 0.4 | -3.6 | 0.8 | 3.4 | 0.6 |
| Biomass | 12.47 | 13.84 | 9.42 | 7.68 | 9.81 | 69.8 | 23.0 | 12.1 | 6.5 | 5.4 | 0.5 | -5.3 | -2.0 | 2.5 | -1.3 |
| Solar, Wind, Ocean | - | 0.01 | 0.22 | 1.89 | 3.52 | 0.0 | 0.0 | 0.3 | 1.6 | 1.9 | - | 70.5 | 23.8 | 6.4 | 27.2 |
| Biofuels | - | 0.00 | 0.37 | 0.89 | 1.28 | 0.0 | 0.0 | 0.5 | 0.7 | 0.7 | - | - | 9.3 | 3.7 | - |
| Electricit | - | -0.18 | 0.53 | 1.00 | 1.48 | 0.0 | -0.3 | 0.7 | 0.8 | 0.8 | - | -216.6 | 6.6 | 3.9 | -208.1 |

**Final energy demand**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **16.06** | **50.46** | **64.03** | **93.28** | **137.79** | **100** | **100** | **100** | **100** | **100** | **5.1** | **3.5** | **3.8** | **4.0** | **3.8** |
| Industry | 4.54 | 19.36 | 27.56 | 43.05 | 65.52 | 28.3 | 38.4 | 43.0 | 46.2 | 47.5 | 6.5 | 5.2 | 4.6 | 4.3 | 4.6 |
| Transportation | 1.38 | 10.46 | 15.41 | 23.83 | 34.50 | 8.6 | 20.7 | 24.1 | 25.5 | 25.0 | 9.2 | 5.7 | 4.5 | 3.8 | 4.5 |
| Others | 10.11 | 18.94 | 18.34 | 21.69 | 30.23 | 63.0 | 37.5 | 28.6 | 23.3 | 21.9 | 2.8 | -0.5 | 1.7 | 3.4 | 1.7 |
| Non-energy | 0.03 | 1.71 | 2.72 | 4.71 | 7.55 | 0.2 | 3.4 | 4.2 | 5.0 | 5.5 | 19.6 | 6.9 | 5.6 | 4.8 | 5.7 |
| **Total** | **16.06** | **50.46** | **64.03** | **93.28** | **137.79** | **100** | **100** | **100** | **100** | **100** | **5.1** | **3.5** | **3.8** | **4.0** | **3.8** |
| Coal | 1.33 | 9.55 | 13.11 | 18.70 | 26.07 | 8.3 | 18.9 | 20.5 | 20.1 | 18.9 | 9.0 | 4.6 | 3.6 | 3.4 | 3.8 |
| Oil | 2.33 | 14.22 | 21.05 | 33.47 | 50.21 | 14.5 | 28.2 | 32.9 | 35.9 | 36.4 | 8.2 | 5.8 | 4.7 | 4.1 | 4.8 |
| Natural gas | 0.00 | 1.35 | 2.35 | 4.77 | 8.37 | 0.0 | 2.7 | 3.7 | 5.1 | 6.1 | - | 8.3 | 7.3 | 5.8 | 7.0 |
| Electricity | 0.53 | 9.81 | 16.01 | 26.77 | 42.22 | 3.3 | 19.4 | 25.0 | 28.7 | 30.6 | 13.5 | 7.2 | 5.3 | 4.7 | 5.6 |
| Heat | - | - | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | 11.87 | 15.52 | 11.51 | 9.56 | 10.92 | 73.9 | 30.8 | 18.0 | 10.2 | 7.9 | 1.2 | -4.2 | -1.8 | 1.3 | -1.3 |

**Power generation Output**

| | TWh | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **8.68** | **127.32** | **197.29** | **327.65** | **516.54** | **100** | **100** | **100** | **100** | **100** | **12.4** | **6.5** | **5.2** | **4.7** | **5.3** |
| Coal | 2.00 | 26.86 | 45.39 | 62.74 | 106.04 | 23.1 | 21.1 | 23.0 | 19.1 | 20.5 | 12.0 | 7.8 | 3.3 | 5.4 | 5.2 |
| Oil | 1.31 | 0.54 | 0.00 | 0.00 | 0.00 | 15.0 | 0.4 | 0.0 | 0.0 | 0.0 | -3.8 | -100.0 | - | - | -100.0 |
| Natural gas | 0.01 | 42.85 | 46.09 | 104.74 | 177.42 | 0.1 | 33.7 | 23.4 | 32.0 | 34.3 | 47.1 | 1.0 | 8.6 | 5.4 | 5.4 |
| Nuclear | 0.00 | 0.00 | 0.00 | 7.42 | 40.32 | 0.0 | 0.0 | 0.0 | 2.3 | 7.8 | - | - | - | 18.4 | - |
| Hydro | 5.37 | 56.94 | 100.65 | 122.45 | 131.00 | 61.8 | 44.7 | 51.0 | 37.4 | 25.4 | 10.8 | 8.5 | 2.0 | 0.7 | 3.1 |
| Geothermal | - | - | - | - | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | - |
| Others | - | 0.13 | 5.15 | 30.30 | 61.77 | 0.0 | 0.1 | 2.6 | 9.2 | 12.0 | - | 68.8 | 19.4 | 7.4 | 25.6 |

**Power generation Input**

| | MTOE | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **1.27** | **14.20** | **18.39** | **30.70** | **49.45** | **100** | **100** | **100** | **100** | **100** | **11.1** | **3.8** | **5.3** | **4.9** | **4.7** |
| Coal | 0.89 | 6.60 | 10.60 | 13.69 | 21.71 | 69.8 | 46.5 | 57.6 | 44.6 | 43.9 | 9.1 | 7.0 | 2.6 | 4.7 | 4.5 |
| Oil | 0.38 | 0.14 | 0.00 | 0.00 | 0.00 | 30.0 | 1.0 | 0.0 | 0.0 | 0.0 | -4.1 | -100.0 | - | - | -100.0 |
| Natural gas | 0.00 | 7.45 | 7.79 | 17.01 | 27.75 | 0.2 | 52.5 | 42.4 | 55.4 | 56.1 | 40.5 | 0.6 | 8.1 | 5.0 | 5.0 |

**Thermal Efficiency**

| | % | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **22.4** | **42.5** | **42.8** | **46.9** | **49.3** | **2.8** | **0.1** | **0.9** | **0.5** | **0.5** |
| Coal | 19.4 | 35.0 | 36.8 | 39.4 | 42.0 | 2.6 | 0.7 | 0.7 | 0.6 | 0.7 |
| Oil | 29.4 | 31.9 | - | - | - | 0.4 | - | - | - | - |
| Natural gas | 17.2 | 49.4 | 50.9 | 52.9 | 55.0 | 4.7 | 0.4 | 0.4 | 0.4 | 0.4 |

**$CO_2$ emissions**

| | Mt-C | | | | | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| **Total** | **4.7** | **35.9** | **50.4** | **78.2** | **118.5** | **100** | **100** | **100** | **100** | **100** | **9.2** | **5.0** | **4.5** | **4.2** | **4.5** |
| Coal | 2.5 | 18.0 | 26.2 | 35.8 | 52.7 | 53.2 | 50.0 | 52.0 | 45.8 | 44.4 | 9.0 | 5.5 | 3.2 | 3.9 | 4.1 |
| Oil | 2.2 | 11.7 | 17.1 | 27.0 | 40.4 | 46.8 | 32.6 | 33.9 | 34.6 | 34.1 | 7.5 | 5.5 | 4.7 | 4.1 | 4.7 |
| Natural Gas | 0.0 | 6.2 | 7.1 | 15.3 | 25.4 | 0.0 | 17.4 | 14.1 | 19.6 | 21.4 | - | 1.9 | 8.0 | 5.2 | 5.3 |

**Energy and economic indicators**

| | | | | | | AAGR(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1990-2013 | 2013-2020 | 2020-2030 | 2030-2040 | 2013-2040 |
| | 1990 | 2013 | 2020 | 2030 | 2040 | | | | | |
| GDP (billions of 2005 US dollars) | 17.8 | 92.3 | 146.3 | 268.3 | 447.5 | 7.4 | 6.8 | 6.2 | 5.2 | 6.0 |
| Population (millions of people) | 66.0 | 89.7 | 96.2 | 103.1 | 107.0 | 1.3 | 1.0 | 0.7 | 0.4 | 0.7 |
| GDP per capita (thousands of 2005 USD/person) | 0.27 | 1.03 | 1.5 | 2.6 | 4.2 | 6.0 | 5.8 | 5.5 | 4.9 | 5.3 |
| Primary energy consumption per capita (toe/person) | 0.27 | 0.67 | 0.81 | 1.15 | 1.71 | 4.0 | 2.8 | 3.6 | 4.0 | 3.5 |
| Primary energy consumption per unit of GDP (toe/million 2005 US Dollars) | 1,006 | 651 | 533 | 442 | 408 | -1.9 | -2.8 | -1.9 | -0.8 | -1.7 |
| Final energy consumption per unit of GDP (toe/million 2005 US Dollars) | 905 | 547 | 438 | 348 | 308 | -2.2 | -3.1 | -2.3 | -1.2 | -2.1 |
| $CO_2$ emissions per unit of GDP (t-C/million 2005 US Dollars) | 265 | 389 | 344 | 291 | 265 | 1.7 | -1.7 | -1.7 | -1.0 | -1.4 |
| $CO_2$ emissions per unit of primary energy consumption (t-C/toe) | 0.26 | 0.60 | 0.65 | 0.66 | 0.65 | 3.6 | 1.1 | 0.2 | -0.2 | 0.3 |
| Automobile ownership volume (millions of vehicles) | | | | | | - | - | - | - | - |
| Automobile ownership volume per capita (vehicles per person) | - | - | - | - | - | - | - | - | - | - |