ENERGY OUTLOOK AND ANALYSIS OF ENERGY SAVING POTENTIAL IN EAST ASIA

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Edited by

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Cover Art by Artmosphere.

Book design by Chrestella Budyanto.

ERIA Research Project Report 2013, No. 19

Published September 2014

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National Library of Indonesia Cataloguing in Publication Data

ISBN 978-602-8660-76-1

9 786028 660761

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Foreword

Energy security and climate change are very important issues in the world. At the 2nd East Asia Summit (EAS) held in Cebu, Philippines in January 2007, the leaders of the region declared that East Asia could mitigate these problems by strong leadership on several countermeasures. These include: a) promotion of energy conservation, b) utilisation of bio-fuels, and c) 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 in implementing these countermeasures. ERIA is responsible for studying the potential impacts of the countermeasures. ERIA is focusing on energy studies in two areas: first, promotion of energy conservation, and second, utilisation of bio-fuels.

This report was prepared by the Working Group for the 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 2013 to May 2014, including methodology, estimated impacts of current energy saving goals, and policy recommendations to the ECTF. This report extends and enhances the analysis of the working group undertaken annually from 2007 to 2012.

The structure of this report is still similar to the previous versions in view of the application of similar methodology but it should be noted that one of the important accomplishments of this research 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 taking 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 through 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.

Prof. Hidetoshi Nishimura
Executive Director
ERIA
September 2014

Acknowledgements

This analysis has been implemented by a working group under ERIA. It was a joint effort of Working Group members from the EAS countries and The Institute of Energy Economics, Japan (IEEJ). We would like to acknowledge the support provided by everyone involved. We would especially like to take the opportunity to express our gratitude to the members of the Working Group, ERIA, International Affairs Division of Agency for Natural Resources and Energy (ANRE) / Ministry of Economy, Trade and Industry (METI) of Japan, and IEEJ's Energy Outlook Modelling Team.

Special acknowledgement is also given to Ms. Cecilya L. Malik of Indonesia and Dr. Yanfei Li of ERIA for their contributions in the editing of this report.

Mr. Shigeru Kimura
Leader of the Working Group
2014

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Energy Outlook and Analysis of Energy Saving Potential in EAS

1. Introduction

Responding to the Cebu Declaration on East Asia Energy Security announced by the leaders of the 16 countries of the East Asia Summit (EAS) on 15 January 2007, the EAS Energy Cooperation Task Force (ECTF) was established and one of the agreed areas for cooperation was energy efficiency and conservation. Taking the initiative, Japan proposed to undertake a study on the energy savings and CO_2 emission reduction potential in the EAS region. The study would quantify the total potential savings under the individual energy efficiency goals, action plans and policies of each country above and beyond Business As Usual[1]. The study would provide insights to national energy ministers for establishing goals, action plans and policies to improve energy efficiency in their respective countries.

1.1. The East Asia Summit

The East Asia Summit (EAS) is a collection of diverse countries. There are wide variations among them in terms of per capita income, standard of living, population density, energy resource endowments, climate, and energy consumption per capita. It is composed of the 10 member countries of the Association of Southeast Asian Nations (ASEAN), namely: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam, and six other countries, namely: Australia, China, India, Japan, Republic of Korea and New Zealand.[2]

While some EAS countries have what might be called mature economies, the majority have developing economies. Several countries have a per capita GDP of less than 1000 US$ (in 2005 prices[3]). Countries with mature economies have higher energy consumption per capita, while developing countries generally have lower energy consumption per capita. A large percentage of the

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

[2] The Ministry of Foreign Affairs of Japan (2005) *Kuala Lumpur Declaration on the East Asia Summit, 2005*. Tokyo: http://www.mofa.go.jp/region/asia-paci/eas/joint0512.html (accessed February 27, 2008).

[3] All US$ (US Dollar) in this document are stated at constant year 2005 values unless specified.

people in the latter countries still meet their energy needs mainly with traditional biomass fuels.

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

Despite the differences among the 16 countries, the EAS leaders agree 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[4].

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

Table 1: Geographic, Demographic, and Economic Profiles, 2011

	Land Area (thousand sq.km.)[1]	Population (million)	Population Density (persons/ sq.km.)	GDP (Billion 2005US$)	GDP per Capita (2005US$/ person)
Australia	7,682	22.3	2.9	818.3	36,628
Brunei Darussalam	5.3	0.4	77.1	10.1	24,765
Cambodia	181	14.6	82.7	9.3	637
China	9,327	1,344.1	144.1	4,194.9	3,121
India	2,973	1,221.2	410.7	1,326.2	1,086
Indonesia	1,911	243.8	134.6	402.4	1,651
Japan	378	127.8	350.7	4,622.0	36,161
Korea, Rep.	97	49.8	512.7	1,056.6	21,226
Lao PDR	231	6.5	28.3	4.3	666
Malaysia	329	28.8	87.5	187.8	6,531
Myanmar	653	48.3	74.0	21.5	444
New Zealand	263	4.4	16.7	122.2	27,749
Philippines	298	95.1	318.8	135.9	1,430
Singapore	0.7	5.2	7,405.3	178.2	34,379
Thailand	511	66.6	130.3	210.3	3,158
Vietnam	310	87.8	283.3	83.2	947

Note: [1] Information on the land area of Cambodia, Indonesia and Japan were provided by the WG members from these countries.
Source: World Bank (2014) World Databank: http://databank.worldbank.org/ddp/home.do. Washington DC (accessed: 16 April 2014); United Nations Statistics Division (2013) UNSD Statistical Databases: https://unstats.un.org/unsd/databases.htm. New York (accessed: November 2013) and Government of Cambodia.

[4] The Ministry of Foreign Affairs of Japan (2005) *Prime Minister Junichiro Koizumi Attends the EAS, ASEAN+3, and Japan-ASEAN Summit Meetings, (Overview and Preliminary Evaluation)*, 2005. Tokyo: http://www.mofa.go.jp/region/asia-paci/eas/summary0512.html (accessed February 28,2008)

Table 2: Economic Structure and Energy Consumption, 2011

	GDP (Billion 2005US$)	Share of Industry In GDP, %[1]	Share of Services in GDP, %[1]	Share of Agriculture in GDP, %[1]	Primary Energy Consumption (Mtoe)	Energy Consumption per Capita (toe/person)
Australia	818.3	28.5	69.0	2.5	135.8	6.1
Brunei Darussalam	10.1	71.7	27.7	0.6	3.4	8.3
Cambodia	9.3	23.5	39.8	36.7	5.3	0.4
China	4,194.9	46.6	43.4	10.0	2,727.7	2.0
India	1,326.2	27.2	54.9	17.9	749.5	0.6
Indonesia	402.4	47.1	38.2	14.7	227.5	0.9
Japan	4,622.0	26.2	72.7	1.2	461.5	3.6
Korea, Rep.	1,056.6	39.3	58.0	2.7	260.4	5.2
Lao PDR	4.3	34.8	35.7	29.5	2.4	0.4
Malaysia	187.8	40.4	47.8	11.8	64.3	2.2
Myanmar	21.5	40.1	37.5	39.8	14.1	0.3
New Zealand	122.2	24.1	69.3	6.6	18.2	4.1
Philippines	135.9	31.3	55.9	12.7	40.5	0.4
Singapore	178.2	26.7	73.3	0.0	29.8	5.7
Thailand	210.3	43.0	43.7	13.3	115.9	1.7
Vietnam	83.2	37.9	42.0	20.1	53.5	0.6

Note: [1] Sectoral shares to GDP New Zealand are 2009 values.
Source: World Bank (2014) World Databank: http://databank.worldbank.org/ddp/home.do. Washington DC (accessed: 16 April 2014); International Energy Agency (IEA) (2013) Energy Balances of OECD Countries 2011 and Energy Balances of Non-OECD Countries 2011, Paris; and United Nations Statistics Division (2013) UNSD Statistical Databases: https://unstats.un.org/unsd/databases.htm (accessed: November 2013).

1.2. Rationale

The rationale of this study is derived from the Cebu Declaration[5], which highlighted a number of goals including the following:

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

To be able to design an action plan or policy measures to reduce energy consumption, projections of energy consumption by sector are required. Hence, Japan suggested the preparation of an energy outlook for the EAS region, including an estimate of the energy savings and CO_2 emission reduction

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

potential if current and proposed national energy efficiency and conservation goals, action plans and policies could be implemented as planned by the EAS countries.

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

1.3. Objective

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

Specifically, a business-as-usual BAU scenario was developed for each country outlining future sectoral and economy-wide energy consumption assuming no significant changes to government policies. An alternative policy scenario (APS) was also designed to examine the potential impacts if additional energy efficiency goals, action plans or policies that are currently, or likely to be, under consideration were developed. Increased uptake of renewable energy sources - including liquid biofuels - and nuclear energy as well as utilisation of more efficient thermal power plant technologies were also considered in the APS. The difference between the BAU and APS in both the final and primary energy consumption represents potential energy savings. The difference in CO_2 emissions in the two scenarios represents the greenhouse gas emission reduction potential.

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

2. Data and Methodology

2.1. Scenarios Examined

The study continued to examine two scenarios, as in the studies conducted annually from 2007 to 2012, a BAU scenario reflecting each country's current goals, action plans and policies, and an APS. The APS included additional goals, action plans and policies reported at the EAS-EMM7 held in September 2013 in Bali, Indonesia or those that are currently, or likely to be, under consideration.

One might be tempted to call the APS a 'maximum effort' case, however, 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 2013, the APS assumptions were grouped into four, namely: a) more efficient final energy demand (APS1), b) more efficient thermal power generation (APS2), c) higher consumption of NRE and bio-fuels (APS3) and d) introduction or higher utilisation of nuclear energy (APS4). The energy models are able to estimate the individual impacts of these assumptions in both primary energy demand and CO_2 emissions. The combination of these assumptions constitutes the assumptions of the APS.

The assumptions in APS1 are the reduction targets in sectoral final energy demand assuming that more efficient technologies are utilised and energy saving practices are implemented in the industrial, transport, residential, commercial and even the agricultural sectors for some countries. This scenario resulted in less primary energy and CO_2 emission in proportion with the reduction in final energy demand.

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

In APS3, higher contribution of new and renewable energy (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, the primary energy consumption may not decrease as NRE technologies using biomass and geothermal energy are assumed to have lower efficiencies compared to fossil fuels-fired generation when converting electricity generated from these NRE sources to primary energy equivalent.

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

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

In every country, there is still a great deal to be learned from experience about what works and does not work. It is worthwhile to update this study periodically, as the quality and scope of the national goals, action plans and policies are likely to improve considerably over time allowing for valuable collaboration across countries.

2.2. The Definition of Energy Saving Potential and Its Limitations

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

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

2.3. Data

For consistency, the historical energy data used in this analysis came from the International Energy Agency's (IEA) energy balances for OECD and non-OECD countries except for Australia and Lao PDR. Australian national energy data were converted from Gross Calorific Value (GCV) to Net Calorific Value (NCV) to be consistent with IEA energy balances. Estimations of national energy data from Lao PDR were made using the same methodology as 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) while 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 WG members from each EAS country where these data are available. Where official data were not available, estimates were obtained from other sources or developed by IEEJ.

2.4. Methodology

In 2007, the primary model used was the IEEJ World Energy Outlook Model which is used by IEEJ in the preparation of their *Asia/World Energy Outlook*[6]. In 2013, eight of the 10 ASEAN member countries utilised their own energy models. Australia used its own national model as well. IEEJ also assisted Brunei Darussalam and Cambodia in making their projections using the assumptions provided by their respective WG members during the first meeting. The remaining countries provided key assumptions to IEEJ on population and GDP growth, electric generation fuel mixes and EEC goals, action plans and policies. The IEEJ models were then used to develop energy projections for these countries.

In the next section, brief descriptions of the energy models in this study are provided.

> *Australia:* Australian projections were developed using the country's E_4cast model[7], 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

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[6] Ito, K., Morita, Y., Koyama, K., Shen, Z., Yanagisawa, A., and Suehiro, S. 2007 "*Asia/World Energy Outlook 2007*," October 2007, Tokyo.

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

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.

ASEAN countries: The energy models of ASEAN countries were developed using the 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 forecasted using energy demand equations by energy and sector and future macroeconomic assumptions. For this study, all the ten member countries used the LEAP model, of which two were assisted by IEEJ in their model development.

Other countries: Other countries used the IEEJ model which has a macro-economic module that calculates coefficients for various explanatory variables based on exogenously specified GDP growth rates. The macro-economic module also projects prices for natural gas and coal based on exogenously specified oil price assumptions. Demand equations are econometrically calculated in another module using the historical data while future parameters are projected using the explanatory variables from the macro-economic module. An econometric approach means that future demand and supply will be heavily influenced by historical trends. However, the supply of energy and new technologies is treated exogenously. For electricity generation, the WG 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. Socio-economic Indicators and Energy Policies: Assumptions

Growth in energy consumption and greenhouse gas (GHG) emissions is driven by a variety of socio-economic factors. In the EAS region, these factors, including increasing population, sustained economic growth, increasing vehicle ownership, and increasing access to electricity, will tend to increase energy demand. Together, they create what might be called a huge growth 'headwind' that works against efforts to limit energy consumption. Understanding the nature and size of this 'headwind' is critical to any analysis of energy demand in the EAS region. However, an increase in consumption of energy services is fundamental for achieving a range of socioeconomic development goals.

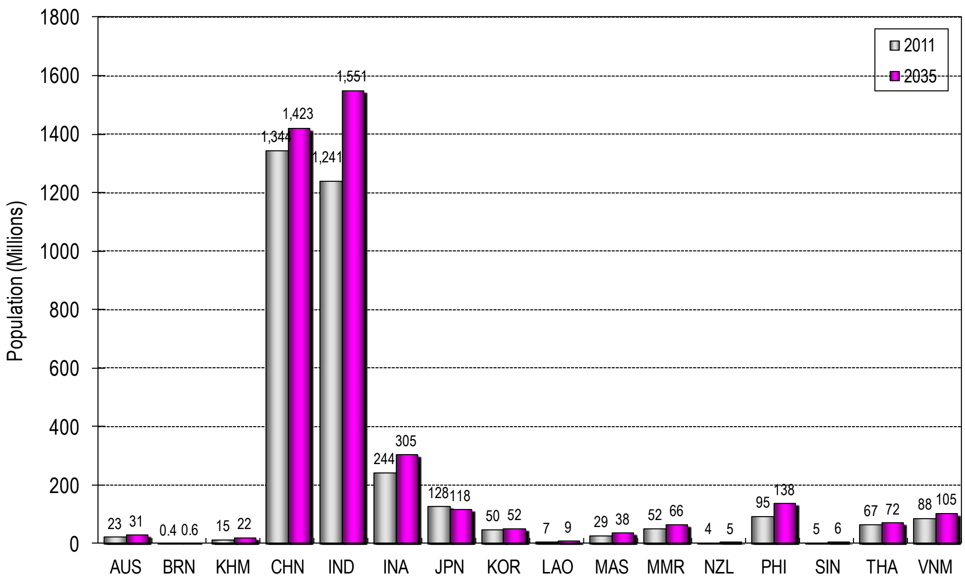
In this section, assumptions regarding key socioeconomic indicators and energy policies until 2035 are discussed for the EAS countries.

3.1.Population

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

In 2011, the total population in the EAS region was about 3.4 billion – around 49 per cent of total world population. Based on the forecasts, population in the EAS region is projected to increase at an average annual rate of about 0.6 percent reaching about 3.94 billion in 2035. Figure 1 shows the 2011 and projected 2035 population by country.

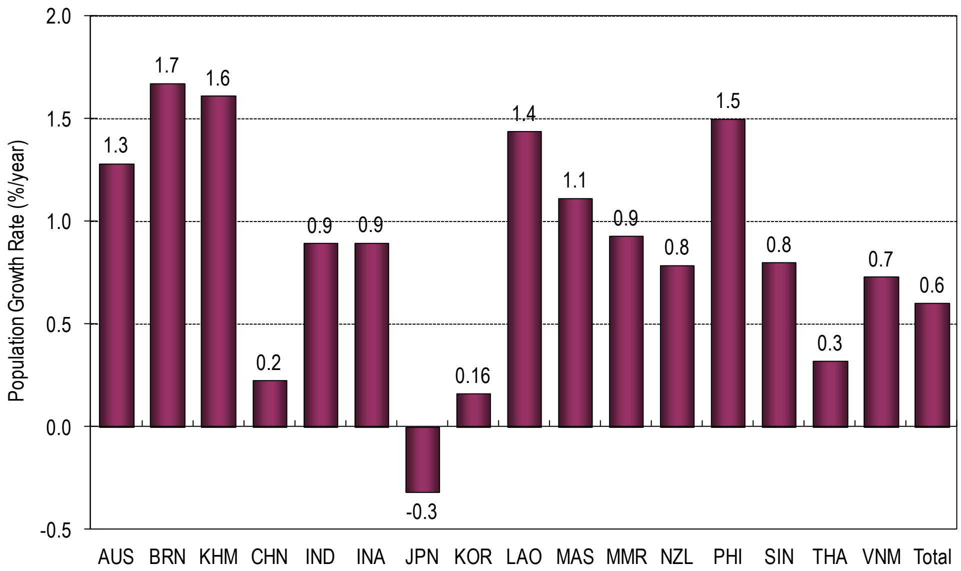
Figure 1: Assumed Population in the EAS Region, 2011 and 2035



As shown in Figure 2, growth in population is generally assumed to be fastest in developing countries. China and Thailand are notable and significant exceptions, as they are expected to have relatively modest population growth. Nevertheless, by 2035, India and China are assumed to account for over 75 percent of the total population in the EAS region with populations of around 1.5 billion each.

Countries with more mature economies tend to have slower population growth. Australia, New Zealand, and Singapore are assumed to have low, but still significant, population growth. The Republic of 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 2: Assumed Average Annual Growth in Population, 2011 to 2035



3.2.Economic Activity

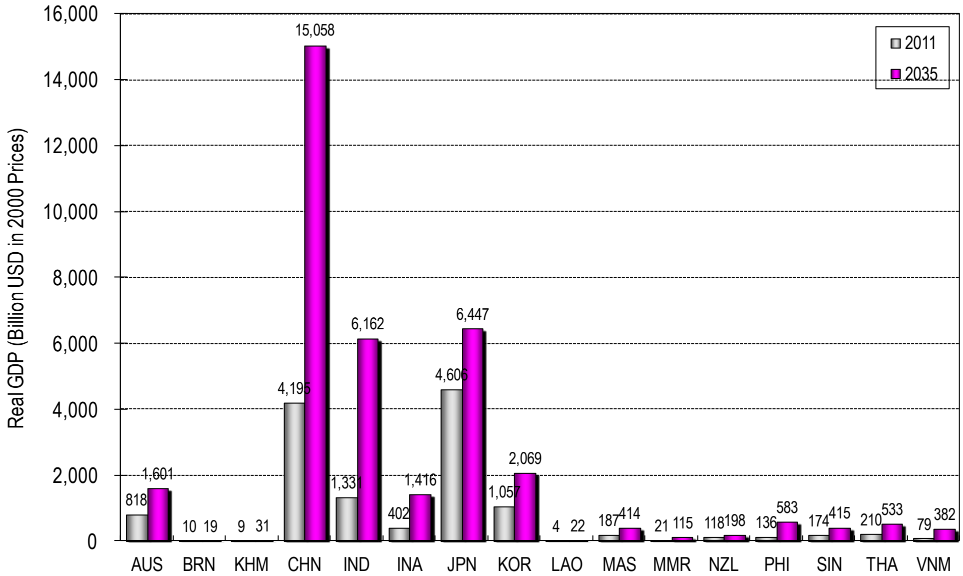
In the models used for this study, assumed changes in economic output to 2035 are set exogenously. GDP data (in 2005 US$) were obtained from the World Bank.[8] Assumed GDP growth rates to 2035 were submitted by all the EAS countries. In general, these assumptions took into account the actual GDP growth rates from 2005 to 2011 which are already reflective of the economic recession and recovery in the United States and other countries in the world. No difference in growth rates was assumed between the BAU and APS scenarios.

In 2011, total GDP in the EAS region was about 13.4 trillion in 2005 US$ and it accounted for about 25 percent of global GDP. The GDP of the EAS region is assumed to grow at an average annual rate of about 4.2 percent from 2011 to 2035. This implies that by 2035, total GDP in the EAS region will reach about 35.5 trillion in 2005 US$.

[8] World Bank 2012. *World Databank - World Development Indicators (WDI) and Global Development Finance (GDF)*. http://databank.worldbank.org/ddp/home.do (accessed: November 2012).

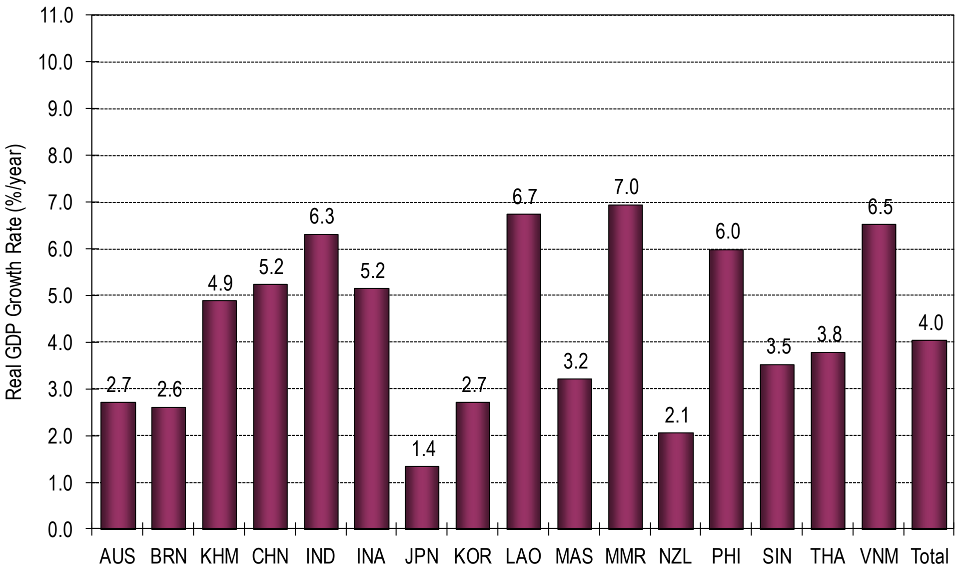
In 2011, Japan was the largest economy by far in terms of total economic output: about 4.6 trillion 2005 US$. However, by 2035, China is projected to be the largest economy with an estimated GDP of about 15.1 trillion 2005 US$. Japan and India are projected to be the next largest economies with projected GDPs of about 6.4 trillion 2005 US$ and 6.2 trillion 2005 US$ respectively in 2035 (see Figure 3).

Figure 3: Assumed Economic Activity in the EAS Region, 2011 and 2035



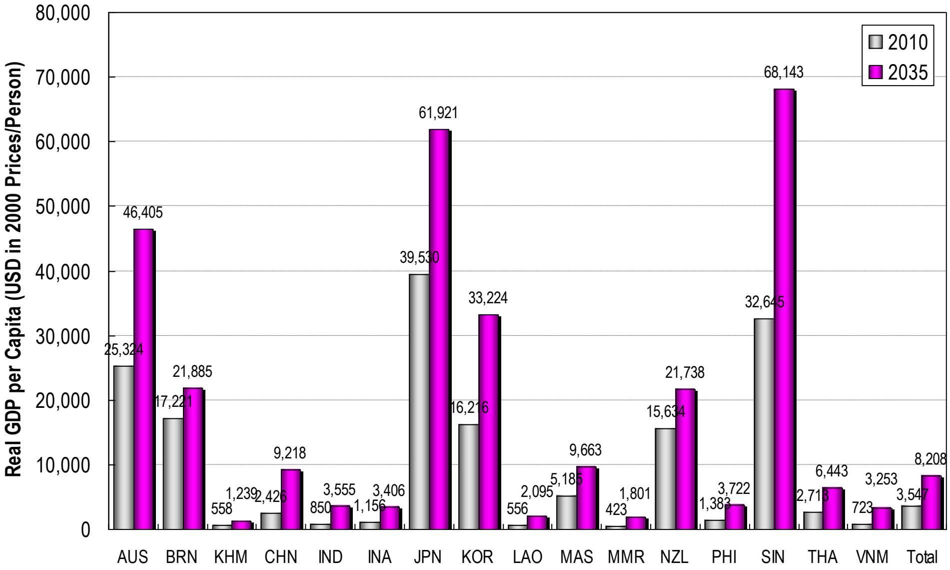
As shown in Figure 4, long term economic growth rates are assumed to be quite high in the developing countries, with the highest growth rates in India, Lao PDR, Myanmar and Viet Nam. Economic growth in other developing countries is also assumed to be relatively rapid. Due to the large size of their economies,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

Figure 4: Assumed Average Annual Growth in GDP, 2011 to 2035



Average GDP per capita in the EAS region is assumed to increase from about US$3,900 in 2011 to about US$9,000 in 2035. However, as shown in Figure 5, there is, and will continue to be, significant differences in GDP per capita. In 2011, per capita GDP ranged from about US$450 in Myanmar to over US$36,000 in Australia and Japan. In 2035, per capita GDP is assumed to range from just over US$1,200 in Cambodia to about US$68,000 in Singapore.

Figure 5: Real GDP per Capita, 2011 and 2035



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 Australia, Brunei Darussalam, China, India, Japan, Korea, Lao PDR, Myanmar, New Zealand, the Philippines and Singapore. There is assumed to be no difference in road vehicle ownership between the BAU scenario and APS.

Strong population and economic growth is projected to drive significant increases in demand for transport services in India and China. By 2035, the number of road vehicles in China and India is projected to increase to about 290 million and 148 million, respectively. However, in both countries, despite the huge growth in road vehicles, rail is expected to meet an increasing share of total transport demand.

Per capita vehicle ownership is projected to increase in the EAS region. However, vehicle ownership on a per capita basis is projected to continue 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 2011 thermal efficiencies by fuel type (coal, gas, and oil) were derived from International Energy Agency data[9]. Thermal efficiencies by fuel (coal, gas, and oil) were projected by the following countries: Australia, Brunei Darussalam, Indonesia, Japan, Malaysia, the Philippines, Singapore, Thailand and Viet Nam, and growth rates in thermal efficiency were derived from these projections. For the remaining countries, assumptions about the potential changes in thermal efficiency were based on IEEJ *Asia/World Energy Outlook 2011.*

Thermal efficiencies may differ significantly between countries due to differences in technological availability, age and cost of technology, temperatures and the cost and availability of fuel inputs. Thermal efficiency in the EAS countries is expected to improve considerably over time in the BAU scenario as more advanced generation technologies such as natural gas combined cycle and supercritical coal plants become available. In many countries, there are also assumed to be additional improvements in the APS. See Figure 6 and Figure 7.

[9] IEA (2011) *Energy Balances of OECD Countries 2011 and Energy Balances of Non-OECD Countries 2010*. Paris.

Figure 6: Thermal Efficiencies of Gas Electricity Generation

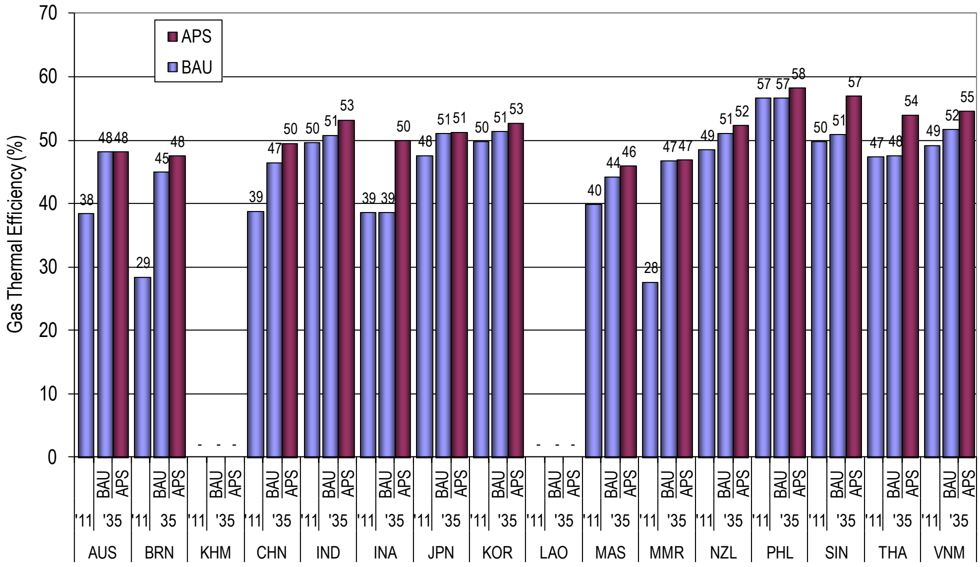
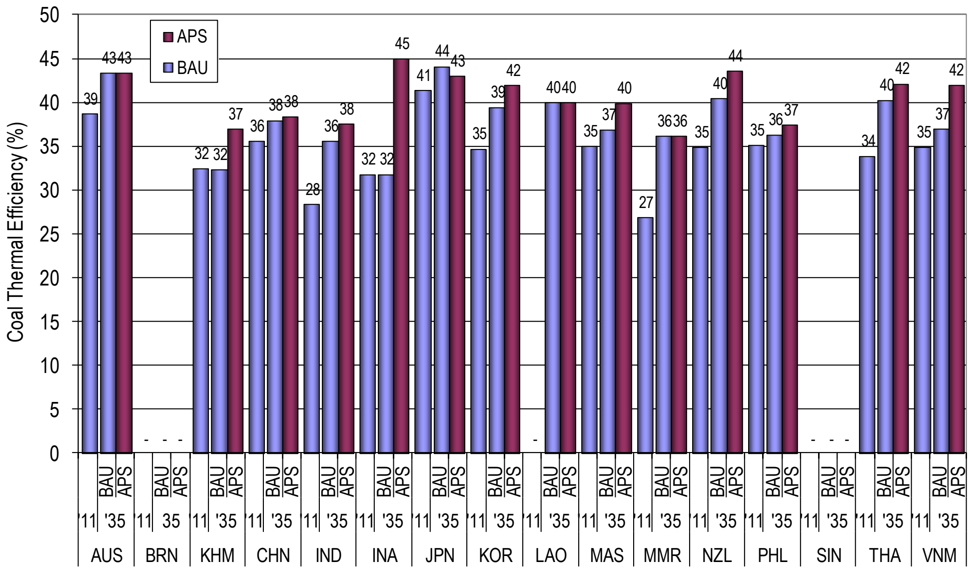


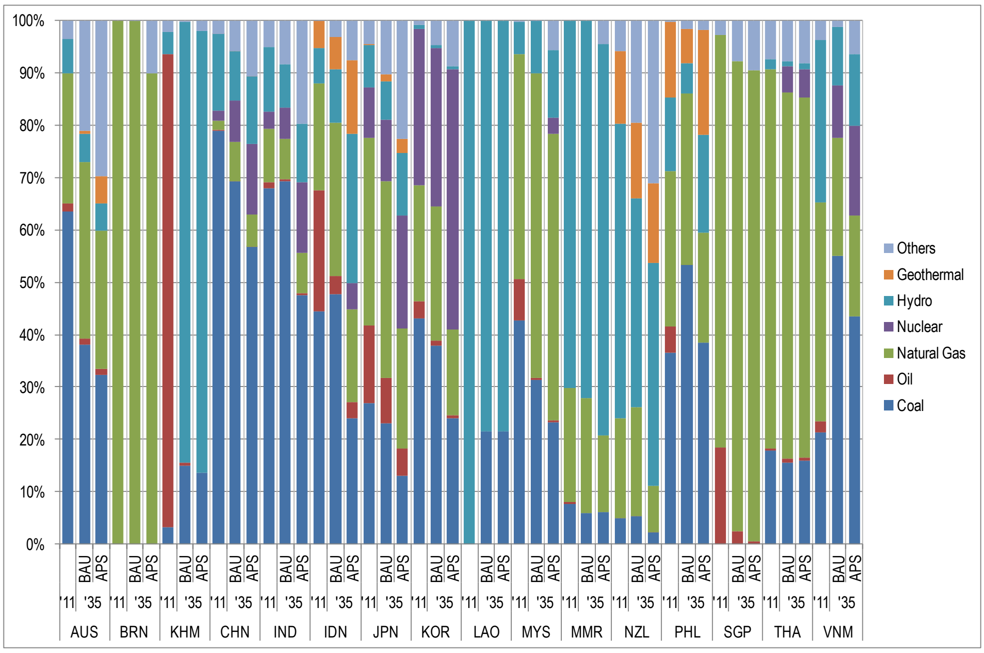
Figure 7: Thermal Efficiencies of Coal Electricity Generation



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

Figure 8: Share of Fuel Type in the Electricity Generation Mix in the EAS Region



Coal is projected to remain the dominant source of electricity generation in the EAS region as a whole in both the BAU scenario and APS. However, the share of coal in electricity generation in the EAS region is projected to decline from about 60.0 percent in the BAU scenario to about 45.9 percent in the APS by 2035 as countries are assumed to implement policies designed to reduce the emissions intensity of electricity generation. In the APS, the shares of lower emission fuels such as hydro, nuclear, and non-hydro renewable energy are expected to be higher than in the BAU scenario on average in the EAS region. The use of oil in electricity generation is assumed to decline to almost negligible levels across the EAS region as a whole.

3.4.3 Access to Electricity

Currently, many households in developing countries lack access to electricity, and eliminating this situation is a major development goal. At the WG meetings, a number of the developing countries reported on initiatives to significantly expand access to electricity in their countries by 2035. Although this increasing access to electricity is another one of the drivers of increasing energy demand in the EAS region, it was not explicitly represented in the model used for this study. Nevertheless, the impact of increasing access to electricity on electricity demand should be largely reflected through the increased demand for electricity as a result of the relatively rapid GDP growth that is assumed to be experienced in these same countries.

3.5. Use of Biofuels

The WG members from each country were asked to include information regarding the potential use of biofuels in the BAU scenario and APS. Some, but not all, countries in the EAS region have plans to increase the contribution of biofuels in the transport fuel mix to enhance energy security or meet other policy objectives. For China and Japan, the assumptions on the use of biofuels were based on the IEEJ *Asia/World Energy Outlook 2011*. Table 3 summarizes the assumptions regarding use of biofuels.

Table 3: Assumptions on Biofuels – Summary by Country

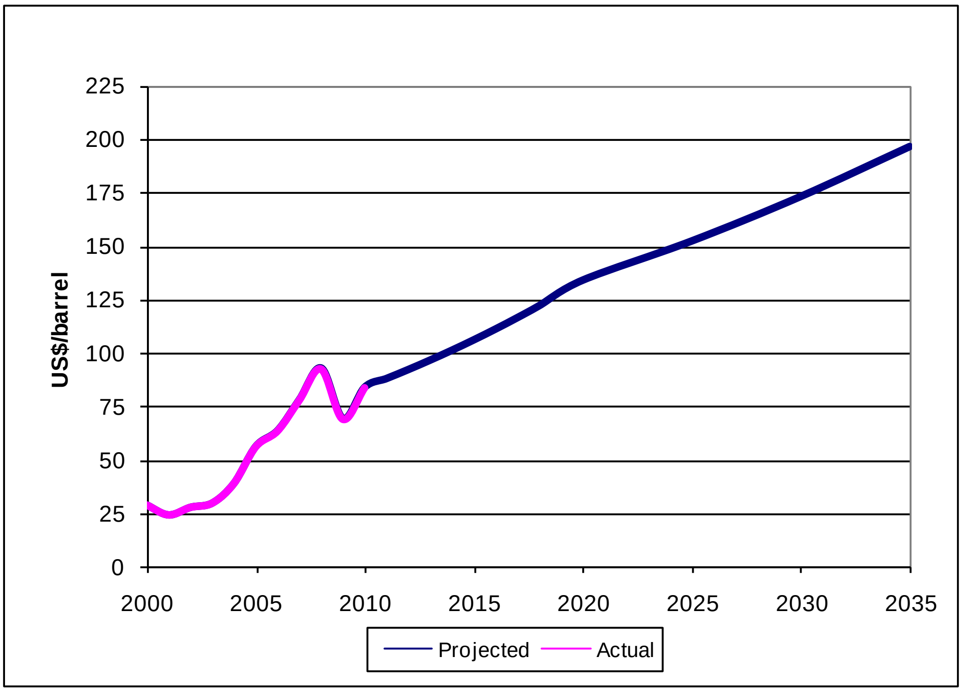
Country	Period	Assumptions
Australia		No targets on biofuels.
Brunei Darussalam		No targets on biofuels.
Cambodia		No targets on biofuels.
China	2030	BAU: 20 billion litres, APS 60 billion litres
India	2017	20% blending of biofuels, both for bio-diesel and bio-ethanol.
Indonesia	2025	Bioethanol: 15%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

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

3.6. Crude Oil Price

Future changes in crude oil prices remain highly uncertain. In this modelling exercise, the crude oil price, as measured by Japan's average import price (current USD), is assumed to increase from about US$88 a barrel in 2011 to US$197 a barrel in 2035 (Figure 9). This projection is similar to the trend of the oil price assumption in Asia/World Energy Outlook 2013 of the Institute of Energy Economics, Japan.

Figure 9: Nominal Oil Price Assumptions to 2035



3.7. Energy Saving Goals

Information about the potential energy savings achievable under specific policy initiatives to increase energy efficiency and reduce energy consumption was collected from each of the WG members from the 16 EAS countries. Each WG member specified which policy initiatives were existing policy, and should be applied to the BAU scenario, and which were proposed policies, and should apply only to the APS. Quantitative energy savings were estimated based on the country's own assumptions and modelling results. Table 4 shows the summary of energy saving goals, action plans and policies collected from each EAS WG member in 2013.

Table 4: Summary of Energy Saving Goals, Action Plans and Policies Collected from each EAS WG Member

	BAU scenario	APS
Australia[10]	• End use energy efficiency improvement is assumed to be 0.5% per year over the projection period for most fuels in non energy-intensive end-use sectors • For energy-intensive industries, improvement is assumed to be 0.2% per year • Some individual sectors such as transport are assigned a higher efficiency assumption than 0.5 per cent per year	
Brunei Darussalam[11]		Reduce energy intensity by 45% by 2035 in line with the country's commitment to APEC through supply and demand side measures such as: • Reduce the projected energy consumption in the BAU by 36%, 41%, 10% and 13% in the residential, commercial, industrial and transport sectors, respectively • Increase efficiency in power generation from 23% to more than 45%
Cambodia		10% reduction of BAU energy consumption by 2015 to increase further to 15% by 2035
China		• 16% energy intensity reduction from 2011 to 2015 • 40-~45% carbon intensity reduction from 2006 to 2020
India		• 20 to 25% improvement in CO_2 Intensity by 2020 relative to 2005 level
Japan		• 30% improvement in energy intensity in 2030 from 2005 level
Republic of Korea		• Reduce final energy intensity by 46% in 2030 from 2009 level

Table 4 continued

[10] Syed, Arif. (2012). *Australian Energy Projections*. Canberra. Page 31.
[11] Energy Department, Prime Minister's Office (2013). *Brunei Darussalam Energy White Paper*. Bandar Seri Begawan. Page 26.

Indonesia		• Reduce energy intensity by 1% per year until 2025
		• Demand reduction relative to BAU by 2050
		  • Industry: 15-20%
		  • Transport: 15%
		• Residential/commercial: 5-10%

Lao PDR		• Reduce final energy consumption from BAU level by 10% from 2011-2015

Malaysia	Implementation of current policies by the government to promote energy efficiency in the industry, buildings and domestic sectors.	**1.** Residential Sector
		  • Relamping of incandescent bulbs with CFL
		  • Replacing of inefficient refrigerators with 5-star refrigerators
		2. Commercial Sector
		  • Raise air-conditioned space temperature
		  • Relamping of T8 with T5 fluorescent tubes in government buildings
		  • Building of energy audit
		3. Industrial
		  • Factory energy audit

New Zealand	The historical energy efficiency improvement of 0.5-1.0% per year is expected to continue in the BAU	By 2030, energy intensity will fall to just over half of that of 1990 level
Philippines		To attain energy savings equivalent to 15% of annual final demand relative to BAU through various energy efficiency programs in all sectors of the economy by 2020.
Singapore		• Reduce energy intensity by 20% by 2020 and by 35% by 2030 from the 2005 level. • Cap CO_2 emissions by 16% from BAU by 2020.
Thailand		• Reduce total final energy consumption by 20% relative to BAU by 2030
Viet Nam		• Reduce energy consumption between 5%-8% by 2015 relative to BAU

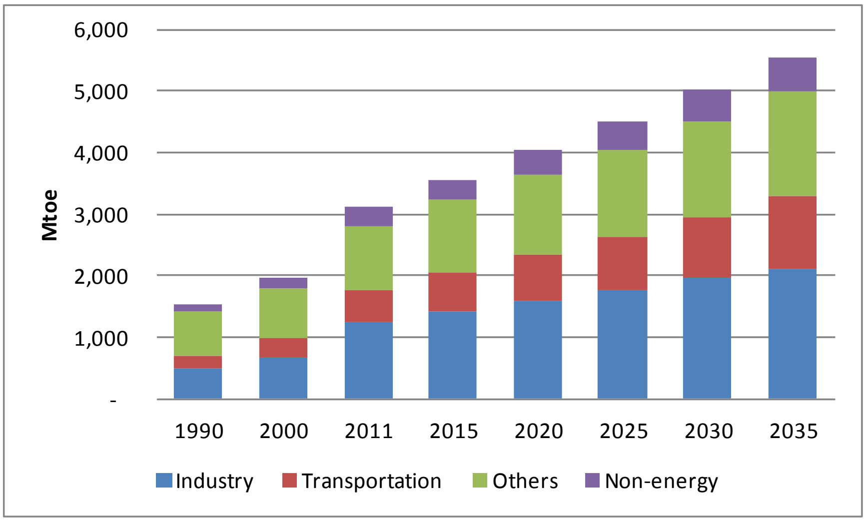
4. Energy And Environmental Outlook for the EAS Region

4.1. Business-as-Usual (BAU) Scenario

4.1.1. Final Energy Demand

Between 2011 and 2035, the total final energy demand[12] in the 16 EAS countries is projected to grow at an average annual rate of 2.4 percent, reflecting the assumed 4.2 percent annual GDP growth and 0.6 percent population growth. Final energy demand is projected to increase from 3112 Mtoe in 2011 to 5545 Mtoe in 2035. The transport sector demand is projected to grow most rapidly, increasing by 3.4 percent per year, as a result of motorization that is to be driven by increasing disposable income as EAS economies grow. The commercial and residential (Others) sectors' demand will grow at 2.0 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 2.3 percent. Figure 10 shows final energy demand by sector under BAU in EAS, from 1990 to 2035.

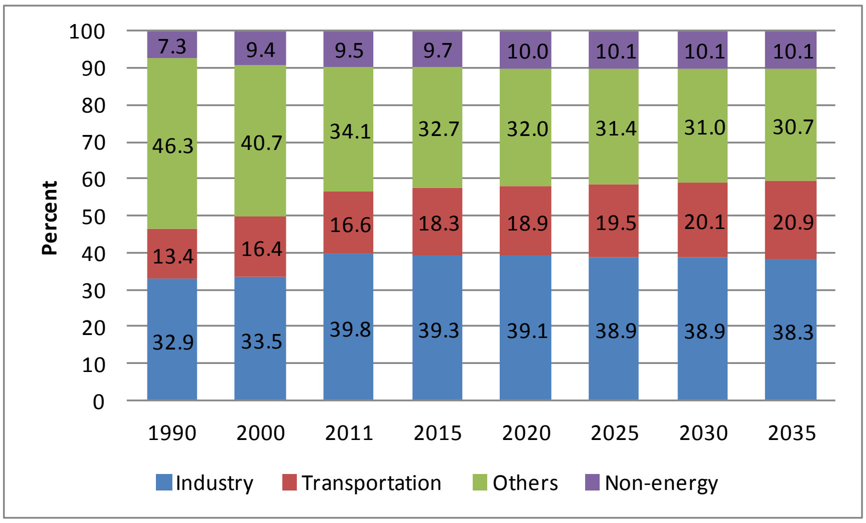
Figure 10: Final Energy Demand by Sector (1990 to 2035), BAU



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

There will be a slight change in the shares of the sectors in final energy demand from 2011 to 2035 with the transport sector having an increasing share while the industrial and other (largely residential and commercial) sectors will have decreasing shares. The industrial sector's share will slightly decrease from 39.8 percent in 2011 to 38.3 percent in 2035. The other sectors' share will significantly decrease from 34.1 percent to 30.7 percent during the same period. The share of transport sector, on the other hand, will increase from 16.6 percent to 20.9 percent from 2011 to 2035. Non-energy demand will also increase from 9.5 percent to 10.1 percent during the same period. The sectoral shares to final energy demand are shown in Figure 11.

Figure 11: Final Energy Demand Share by Sector (1990 to 2035)



For the energy sources, natural gas demand in the BAU scenario is projected to exhibit the fastest growth, increasing by 4.7 percent per year, from 212 Mtoe in 2011 to 636 Mtoe in 2035. Although oil will retain the largest share of total final energy demand, it is projected to grow at a much lower rate of 2.6 percent per year, reaching 1897 Mtoe in 2035. This is compared with its 3.8 percent per year growth over the last two decades. However, its share will still increase from 33.0 percent in 2011 to 34.2 percent in 2035. Demand for electricity will grow at a relatively fast rate of 3.6 percent per year. Its share will increase from 19.1 percent in 2011 to 25.1 percent in 2035 surpassing the share of coal. The growth in coal demand will grow at a slower rate of 1.1 percent per year on average. Other fuels, which are mostly solid and liquid biofuels, will have a slow annual growth rate of 0.5 percent on average although there will be a rapid growth rate on the consumption of the liquid biofuels. Consequently the share of other fuels will decline from 16.0 percent in 2010 to 10.2 percent in 2035. This slow growth is due to the gradual shift from non-commercial biomass to conventional fuels like LPG and electricity in the residential sector.

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

Figure 12: Final Energy Demand by Energy (1990 to 2035)

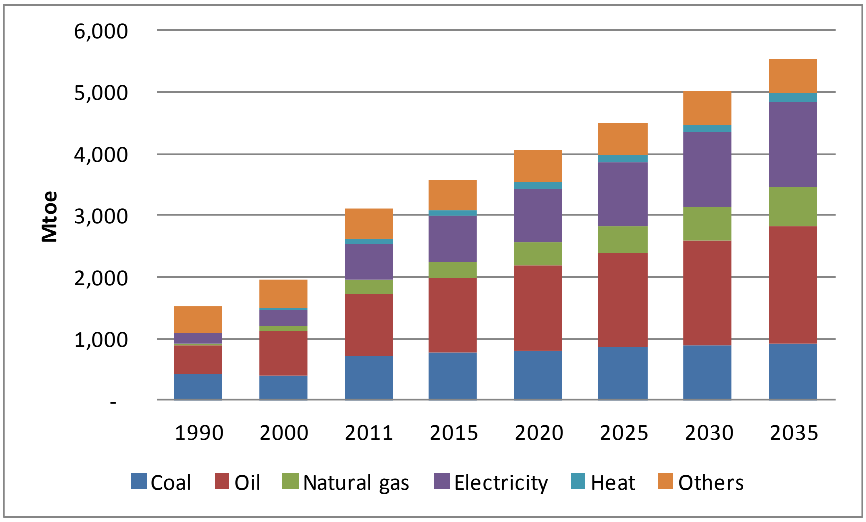
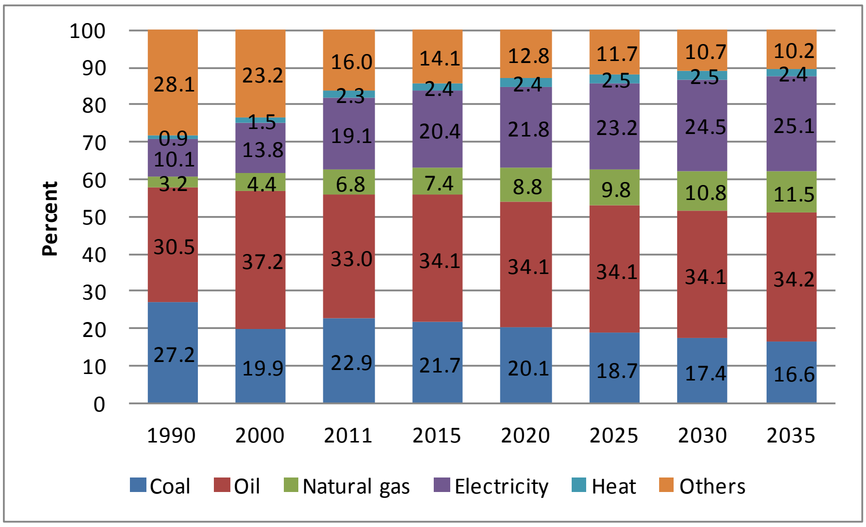


Figure 13: Final Energy Demand Share by Energy (1990 to 2035)



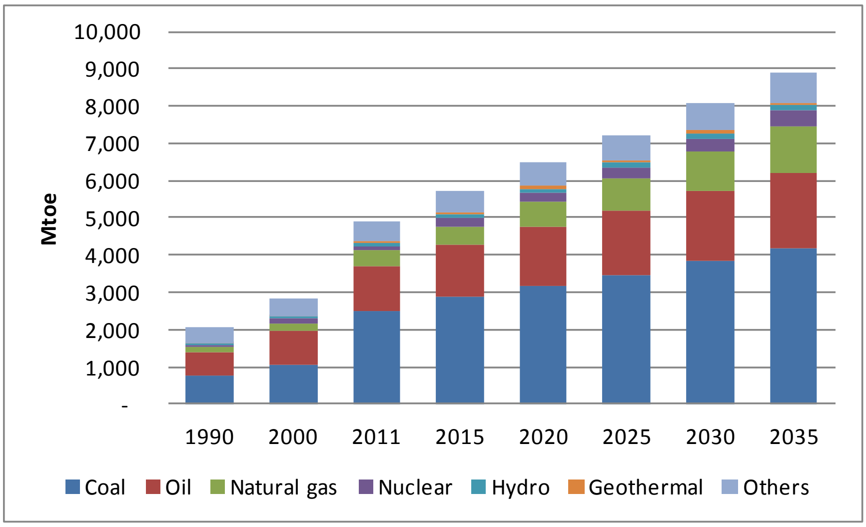
4.1.2. Primary Energy Demand

Primary energy demand[13] in EAS is projected to grow at a faster pace of 2.5 percent per year on average than the final energy demand of 2.4 percent. The EAS primary energy demand is projected to increase from 4910 Mtoe in

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

2011 to 8912 Mtoe in 2035. Coal will still constitute the largest share of primary demand, but its growth is expected to be slower, increasing at 2.1 percent per year. Consequently, the share of coal in total primary energy demand will decline from 51.1 percent in 2011 to 46.6 percent in 2035. Figure 14 shows the primary energy demand from 1990 to 2035.

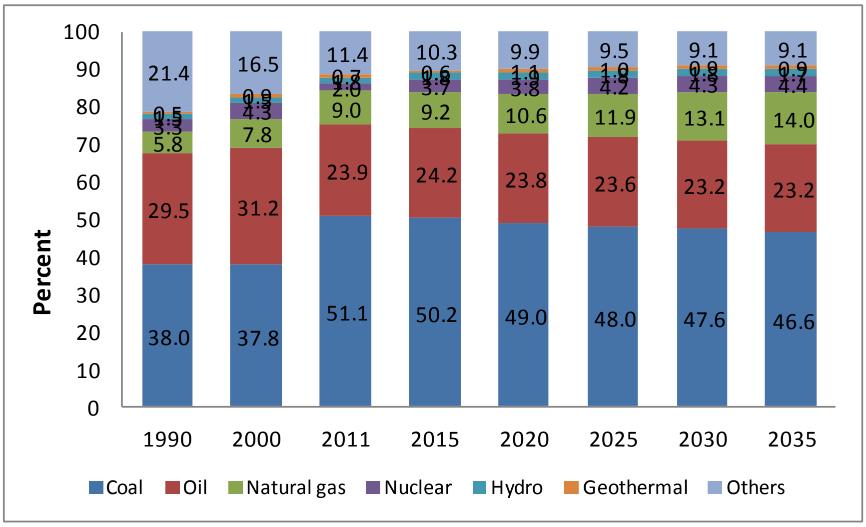
Figure 14: Primary Energy Demand in EAS (1990 to 2035)



Among fossil sources of energy, natural gas is projected to exhibit the fastest growth between 2011 and 2035, increasing at an annual average rate of 4.4 percent. Its share to the total will subsequently increase from 9.0 percent in 2011 to 14.0 percent in 2035. Nuclear energy is also projected to increase at a rapid rate of 6.0 percent per year on average and its share will improve from 2.0 percent in 2011 to 4.4 percent in 2035. This is due to the expansion of power generation capacity in China and India and the introduction of this energy source in Viet Nam.

Among the energy sources, “Others” - which constitute solar, wind as well as solid and liquid biofuels - will have the slowest growth rate of 1.6 percent. Consequently, the share of these other sources of energy will decrease from 11.4 percent in 2011 to 9.1 percent in 2035. Geothermal energy will increase at a rapid pace of 3.7 percent per year but its share will remain low at 0.9 percent in 2035, slightly increasing from 0.7 percent in 2011. The growth of hydro will be 2.3 percent per year and its share will remain low at below 2.0 percent from 2010 to 2035. Figure 15 shows the shares of each energy source to the total primary energy mix from 1990 to 2035.

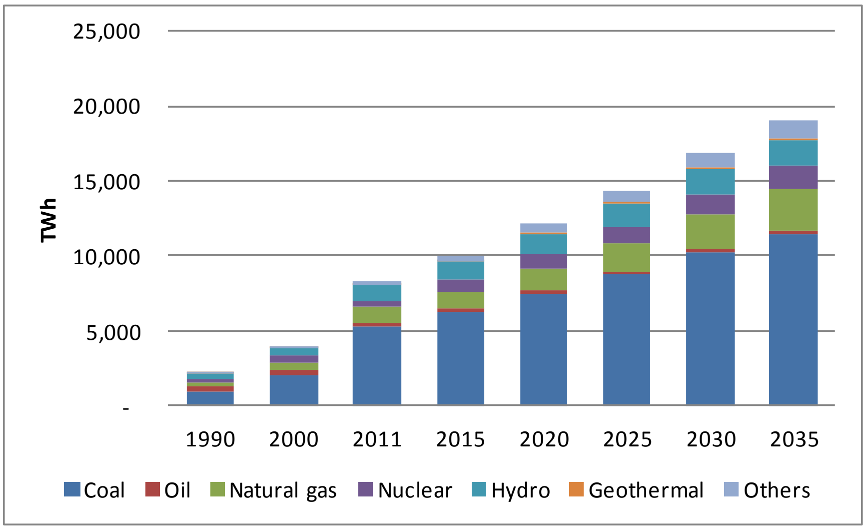
Figure 15: Primary Energy Mix in EAS (1990 to 2035)



4.1.3. Power Generation

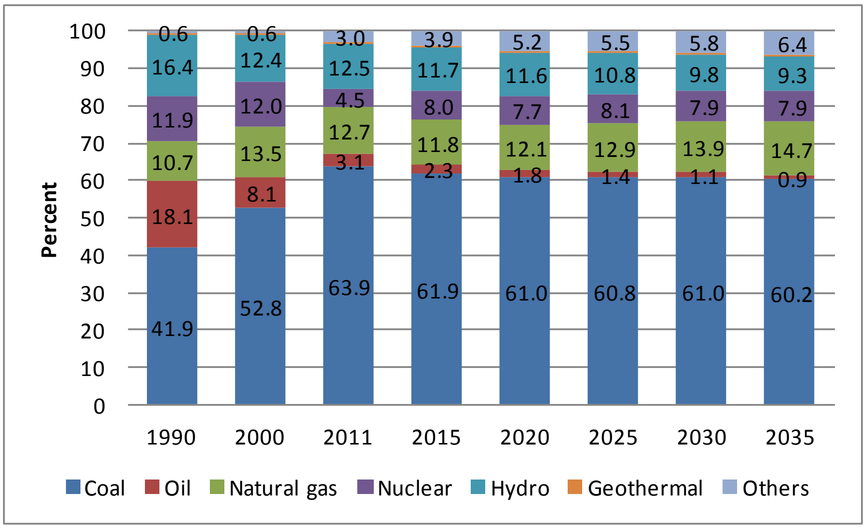
Power generation in EAS is projected to grow at 3.5 percent per year on average from 2011 (8308 TWh) to 2035 (19,050 TWh), slower than the 6.5 percent annual rate of growth from 1990 to 2011 (Figure 16).

Figure 16: Power Generation in EAS (1990 to 2035)



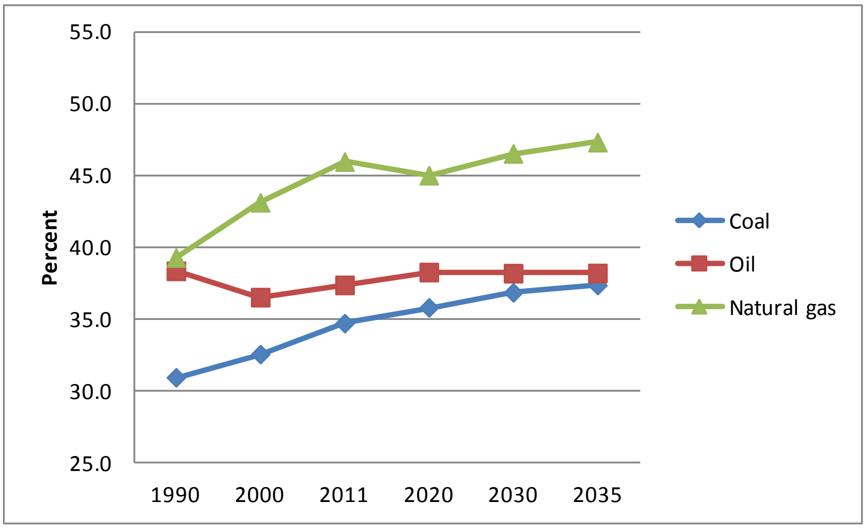
The share of coal–fired generation is projected to continue to be the largest and will remain above 60 percent of the total until 2035. Natural gas share is projected to increase from 12.7 percent in 2011 to 14.7 percent in 2035 along with those of nuclear (4.5 percent in 2011 to 7.9 percent in 2035), geothermal (0.3 percent to 0.5 percent) and others (wind, solar, biomass, etc at 3.0 percent to 6.4 percent). The shares of oil and hydro are projected to decrease from 3.1 percent to 0.9 percent and 12.5 percent to 9.3 percent, respectively, during the same period. Figure 17 shows the shares of each energy source in electricity generation from 1990 to 2035.

Figure 17: Power Generation Mix in EAS (1990 to 2035)



Thermal efficiency is projected to grow in EAS from 2011 to 2035 due to improvement in electricity generation technologies like combined-cycle gas turbines and advanced coal power plant technologies. From 34.7 percent in 2011, the efficiency of coal thermal power plants, which is a mix of old and new power plants, will increase to 37.3 percent in 2035. Efficiency of natural gas power plants will also increase from 45.9 percent in 2011 to 47.3 percent in 2035. Even oil power plants, which will not be used significantly in the future, will have improved efficiency from 37.3 percent in 2011 to 38.2 percent in 2035. Figure 18 shows the thermal efficiency of coal-, oil- and natural gas-fired power plants from 1990 to 2035.

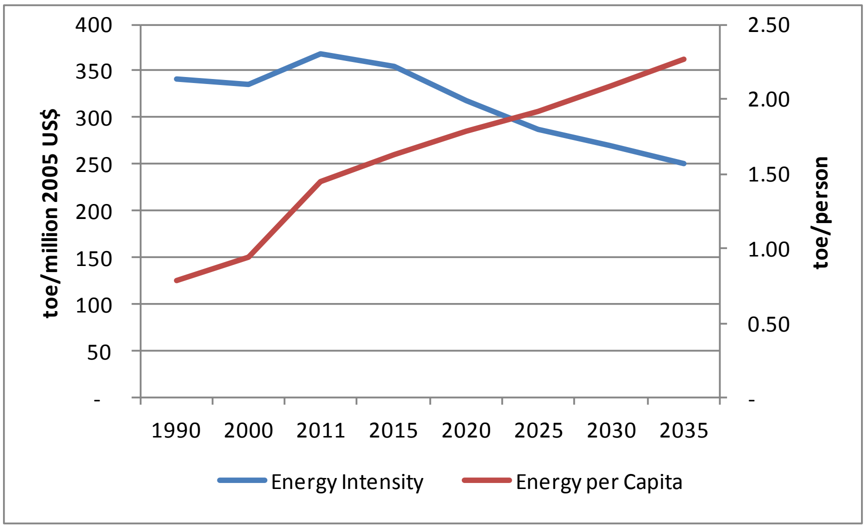
Figure 18: Thermal Efficiency by Fuel, BAU (1990 to 2035)



4.1.4. Energy Intensity and per Capita Energy Demand

Even in the BAU, energy intensity in EAS is projected to decline from 368 toe/million US$ (constant 2005) in 2011 to 250 toe/million US$ in 2035. In contrast, energy demand per capita is projected to continue to increase from 1.45 toe per person in 2011 to 2.26 toe per person in 2035. This could be attributed to the projected continuing economic growth in the region, which will bring about a more energy intensive lifestyle as people are able to purchase vehicles, household appliances and other energy consuming devices as disposable income increases. Figure 19 shows the energy intensity and energy per capita from 1990 to 2035.

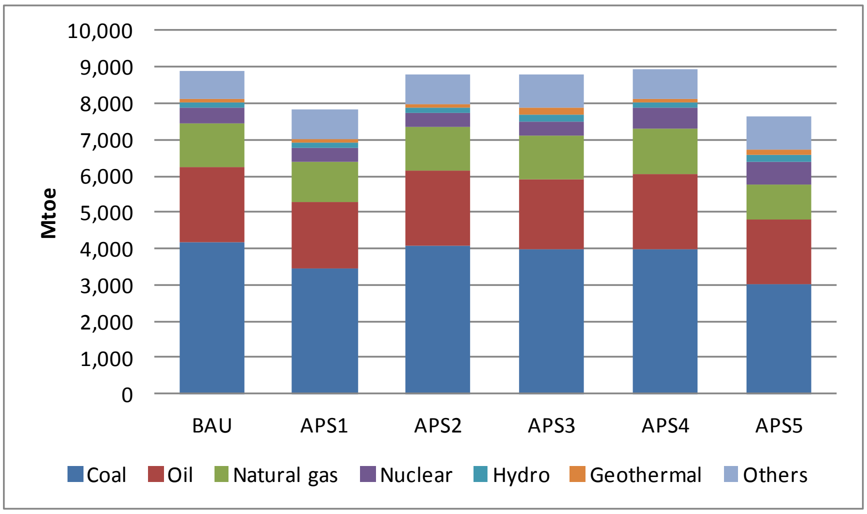
Figure 19: Energy Intensity and per Capita Energy Demand in EAS



4.2. Alternative Policy Scenario (APS)

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

Figure 20: Total Primary Energy Supply in EAS in 2035 (All Scenarios)



APS1 and APS5 have the largest reduction in total primary energy supply due to the energy efficiency assumptions in the demand-side. Energy efficiency assumptions in APS1 could reduce total primary energy supply in BAU by as much as 1104 Mtoe or 12.4 percent.

APS2 which assumes higher efficiency in thermal electricity generation has lower impact than APS1. This is due to the assumptions that only the newly constructed power plants will have higher efficiency. It is expected that existing power plants will continue to operate until the end of their lifetimes. This is why, only 129 Mtoe or 1.4 percent of the total primary energy supply in the BAU is saved in this scenario. This energy saving is almost equal to the total primary energy consumption of Australia in 2011.

APS3 assumes higher penetration of renewable energy in electricity generation and higher consumption of biofuels in the transportation sector. Like APS2, there is only a small reduction in the BAU value of 96 Mtoe or 1.1 percent reduction. Although hydro, solar and wind energy are assumed to have 100 percent thermal efficiency when converted to primary energy, the contributions of these energy sources were dwarfed by the contribution of biomass and geothermal energy, which have lower thermal efficiencies than the fossil-fired electricity generation that were replaced in this scenario. However, this 1.1 percent reduction in primary energy consumption can result in a 5.0 percent reduction in BAU CO_2 emission.

APS4 assumes higher contribution of nuclear energy in power generation. In this, the total primary energy supply is higher by 27 Mtoe or 0.3 percent than the total primary energy supply in the BAU. This is due to the relatively lower thermal efficiency of nuclear power generation (33%) compared to new coal and natural gas-fired power plants. However, due to the reduction in fossil fuels that would be replaced by nuclear energy, there could be a 3.0 percent reduction in the BAU CO2 emission in this scenario.

Figure 21 shows the total electricity generation mix in EAS in 2035 in all scenarios. In APS1, due to the lower electricity demand, the shares of fossil-fired electricity generation were lower than in the BAU scenario. In APS2, the shares are the same as those of the BAU. In APS3, due to the assumption of more renewable energy, fossil fuel-fired generation could be reduced by 9.5 percent while in APS4, nuclear energy could reduce fossil fuel share by 5.7 percent. In APS5, reduction in fossil energy-based generation could be reduced by as much as 33.5 percent.

Figure 21: Electricity Generation in 2035 in EAS in all Scenarios

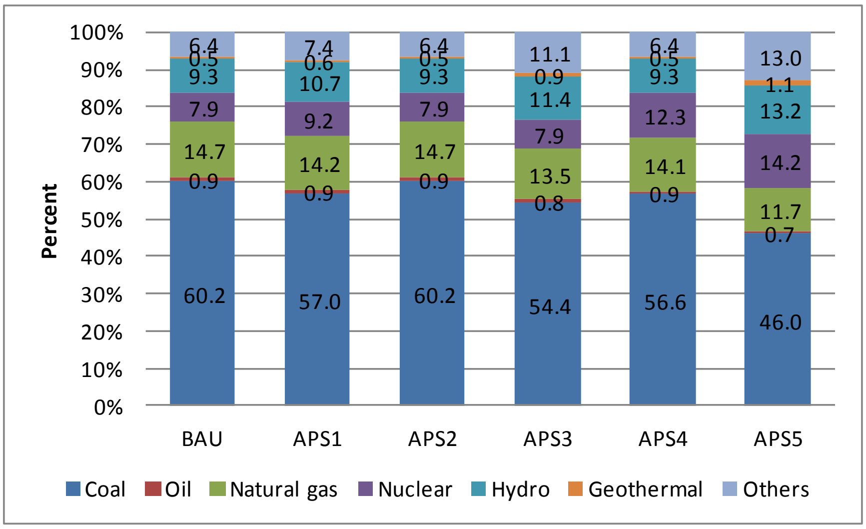
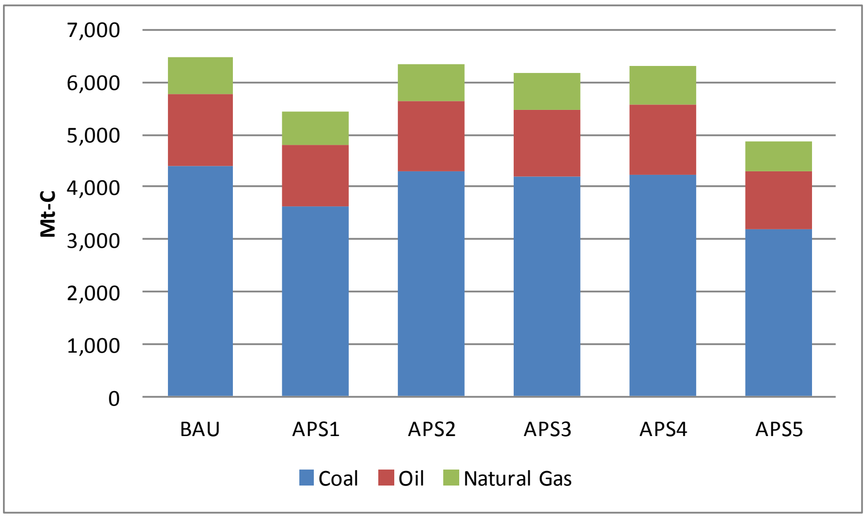


Figure 22: Total EAS CO_2 Emissions in 2035 in all Scenarios



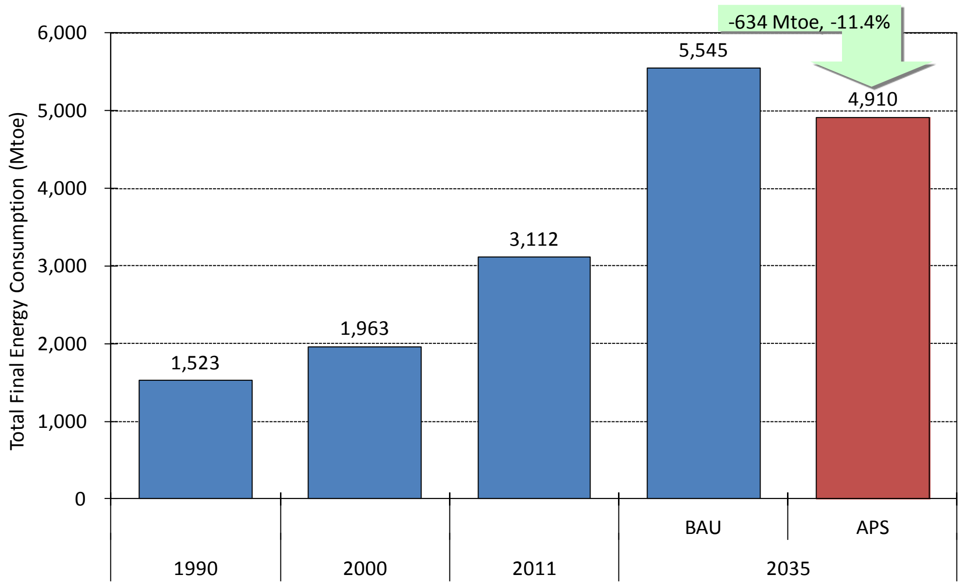
In terms of CO_2 emission reduction, energy efficiency assumption in APS1 could reduce emissions in the BAU by 16.1 percent in 2035. In APS2, the installation of more efficient new power plants is able to reduce emissions by 2.2 percent. Higher contributions from renewable energy could reduce emissions by 5.0 percent while higher contribution from nuclear energy could result in emission reduction of 2.9 percent. All these assumptions combined could reduce BAU CO_2 emissions by 25.2 percent in 2035. Figure 22 shows the estimated CO_2 emissions in all the analysed scenarios.

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

4.2.1. Total Final Energy Demand

In the APS case, final energy demand is projected to rise to 4,910 Mtoe, 634 Mtoe or 11.4 percent lower than in the BAU case in 2035. This is due to the various energy efficiency plans and programs presented in Section 3 above in both the supply and demand sides that are to be implemented by EAS countries. Figure 23 shows the evolution of final energy demand from 1990 to 2035 in both the BAU and APS scenarios.

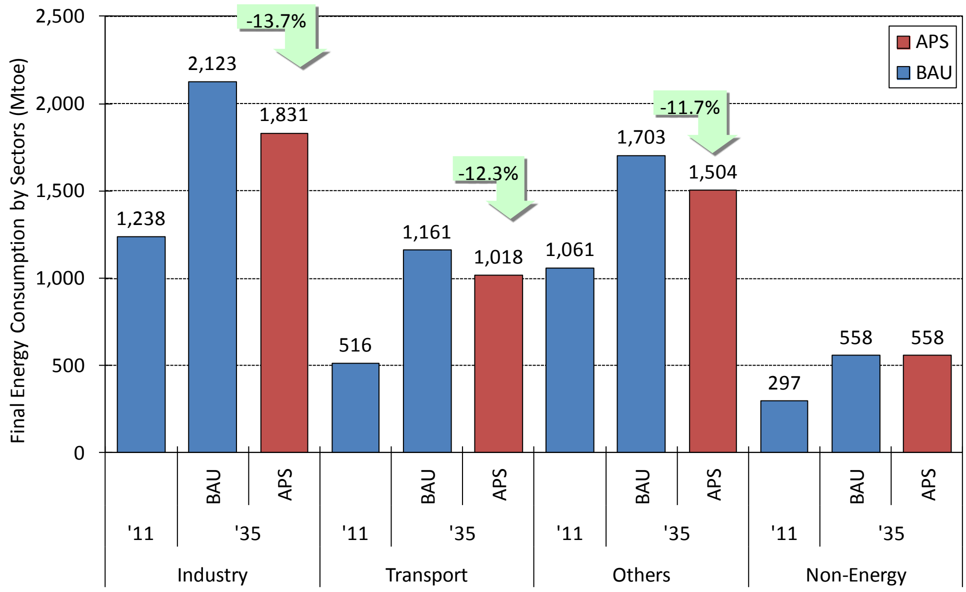
Figure 23: Total Final Energy Demand, BAU and APS



4.2.2. Final Energy Demand by Sector

Figure 24 shows the composition of final energy demand by sector in both the BAU and APS. Final energy demand in most sectors is significantly reduced in the APS case compared with the BAU case. In percentage terms, the reduction is largest in the industry sector at 13.7 percent, followed by the transport sector at 12.3 percent and the 'others' sector at 11.7 percent. Non-energy demand will not be different from the BAU.

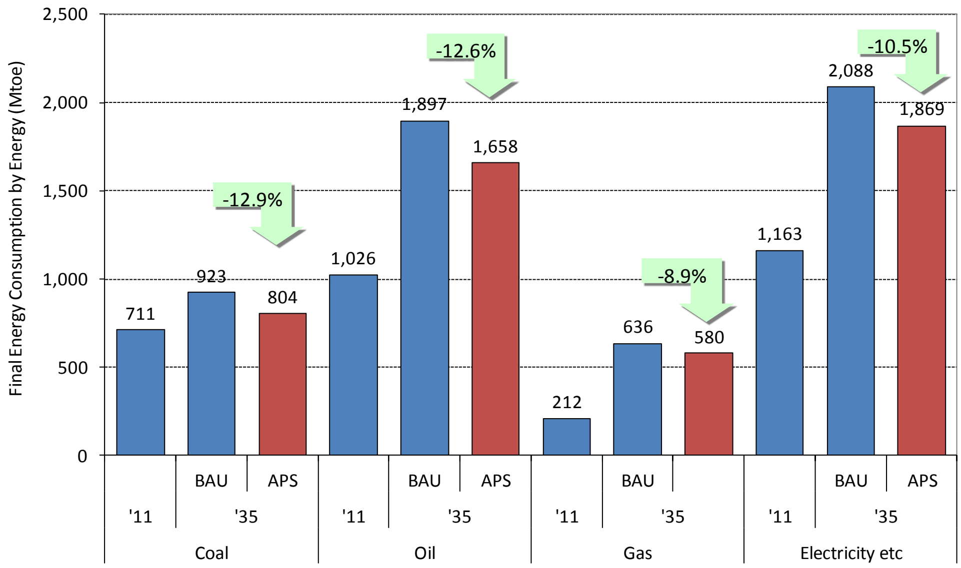
Figure 24: Final Energy Demand by Sector, BAU and APS



4.2.3. Final Energy Demand by Fuel

Figure 25 shows final energy demand by type of fuel. In the APS case, growth in final demand for all fuels is lower compared with the BAU case. The growth rate of 1.9 percent per year on average is lower than the BAU's 2.4 percent. The largest reduction will be in oil demand at 239 Mtoe or 12.6 percent from the BAU's 1,897 Mtoe to 1,658 Mtoe in the APS. This potential saving in oil is equivalent to 59 percent of China's final oil demand in 2011. The saving potential in other fuels which includes electricity and heat is second largest at 220 Mtoe, equivalent to a reduction of 10.5 percent from BAU. This is to be brought about by improvement in the efficiencies of household appliances and more efficient building designs. The saving potential for coal is 119 Mtoe and this will come mostly from energy efficiency in the industrial sector. The saving potential for natural gas is around 57 Mtoe or 8.9 percent from the BAU demand.

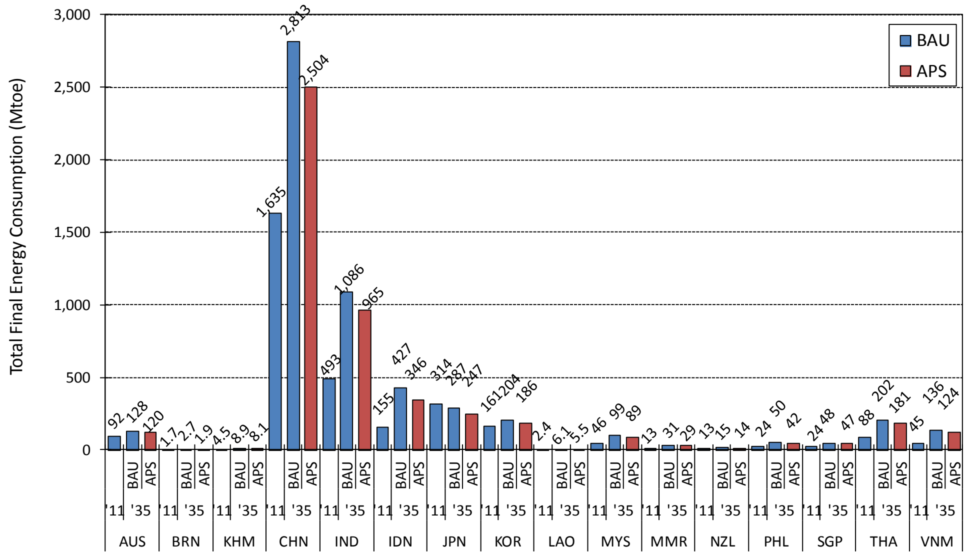
Figure 25: Final Energy Demand by Fuel, BAU and APS



4.2.4. Final Energy Demand by Country

Figure 26 shows final energy demand by country. The most striking result is that China is projected to continue to dominate EAS region's final energy demand until 2035. China is projected to account for about 50.7 percent of the EAS region's final energy demand in 2035, down from about 52.5 percent in 2011. Just five countries—China, India, Indonesia, Japan, and Republic of Korea—are projected to account for 86.9 percent of the EAS region's final energy demand in 2035, with the growth in final energy demand concentrated in just three countries: China, India, and Indonesia. In fact, these "big three" countries are projected to account for 84.0 percent of the growth in energy demand for the entire EAS region between 2011 and 2035. In the APS case, growth in most countries, including the "big three", is significantly lower relative to the BAU scenario. However, the "big three" are still projected to account for 85.2 percent of the growth in energy demand in the EAS region between 2011 and 2035.

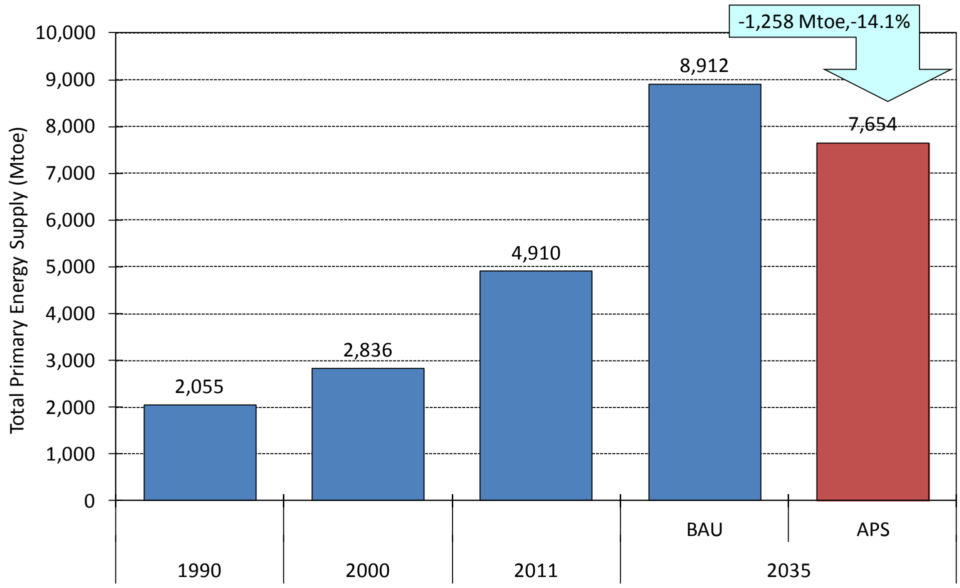
Figure 26: Total Final Energy Demand by Country, BAU and APS



4.2.5. Total Primary Energy Demand

The pattern followed by primary energy demand is, as one would expect, similar to final energy demand. Figure 27 shows that total primary energy demand is projected to increase from 4,910 Mtoe in 2011 to 8,912 Mtoe in 2035 in the BAU case, an increase on average of 2.5 percent per year. In the APS case, demand is projected to grow to 7,654 Mtoe by 2035, 14.1 percent lower than in the BAU case. The reduction in 2035 primary energy demand in the APS case, compared with the BAU case of 1,258 Mtoe, is roughly equivalent to 46 percent of China's demand in 2011.

Figure 27: Total Primary Energy Demand, BAU and APS

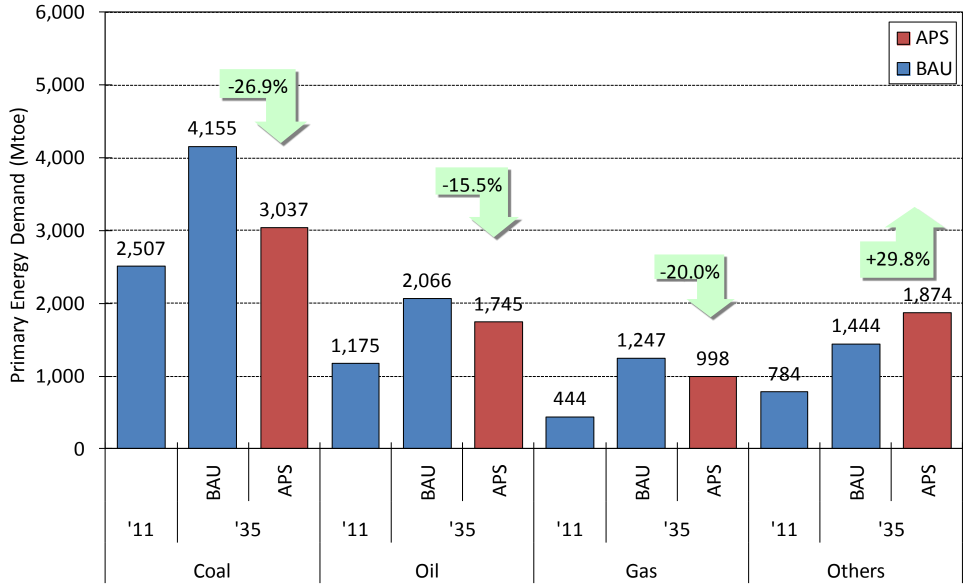


4.2.6. Primary Energy Demand by Source

In the APS scenario, growth in coal, oil and natural gas primary demand is projected to be considerably lower than the BAU. Coal demand for example, will be 26.9 percent lower in the APS or equivalent to 1,118 Mtoe, 44.6 percent of EAS coal demand of 2,507 Mtoe in 2011. This reflects a shift from coal-fired electricity generation to nuclear and renewable energy in the APS case. Demand for oil will also be lower in the APS, by 321 Mtoe or 15.5 percent. This is due to the combined effect or more efficient vehicles and the utilisation of alternative fuels in the transport sector such as natural gas, electricity and biofuels. The demand of natural gas will also be lower in the APS at 20.0 percent of the BAU, equivalent to 249 Mtoe. This is mainly due to reduced electricity demand in the APS and the introduction of more efficient power generation technologies and alternative fuels such as nuclear, solar and wind energy. Other fuels, which include these alternative energy sources, on the other hand, will be higher by 29.8 percent in the APS as compared to BAU.

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

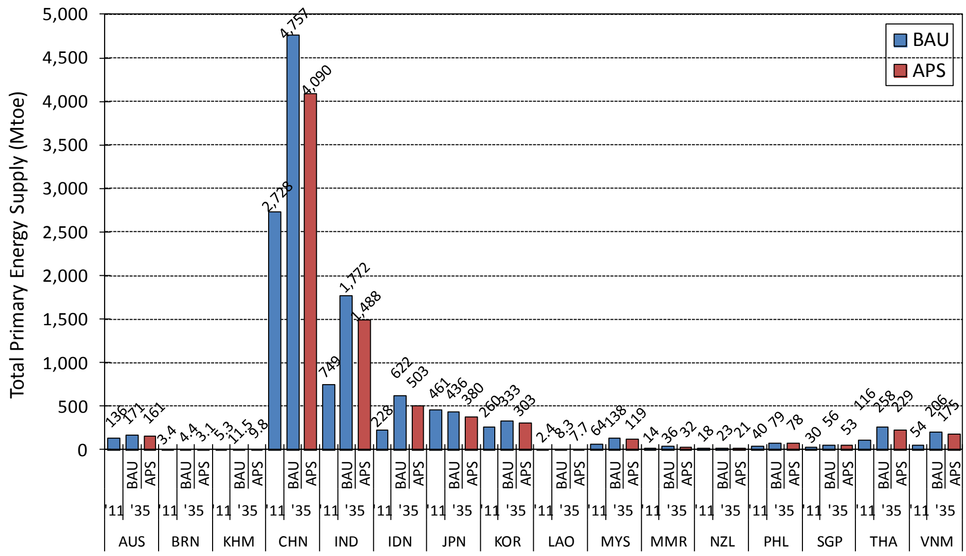
Figure 28: Primary Energy Demand by Source, BAU and APS



4.2.7. Primary Energy Demand by Country

Figure 29 shows primary energy demand by country, which is similar to the pattern for final energy demand by country shown in Figure 26. Five countries - China, India, Indonesia, Japan, and Republic of Korea - are projected to account for 88.8 percent of EAS region's primary energy in 2035. The 'big three' - China, India, and Indonesia - will dominate the growth in EAS region's primary energy, accounting for 86.1 percent of the growth between 2011 and 2035. In the APS case, growth in primary energy demand in most countries is significantly lower, but the dominance of demand by five countries and the relative importance of the growth in three countries remain unchanged.

Figure 29: Primary Energy Demand by Country, BAU and APS



4.2.8. Primary Energy Intensity by Country

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

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

	2011	2035		Variance		
		BAU	APS	APS/BAU	2011/2035 BAU	2011/2035 APS
	(toe/million 2005 US$)	(toe/million 2005 US$)	(toe/million 2005 US$)	%	%	%
Australia	166	107	100	-6.1	-35.6	-39.5
Brunei Darussalam	336	228	161	-29.3	-32.1	-52.0
Cambodia	573	373	318	-14.6	-34.9	-44.4
China	650	312	268	-14.0	-52.1	-58.8
India	563	288	241	-16.0	-48.9	-57.1
Indonesia	565	439	355	-19.1	-22.3	-37.2
Japan	100	68	59	-12.8	-32.5	-41.1
Korea	246	161	146	-8.9	-34.8	-40.6
Lao PDR	553	373	346	-7.3	-32.5	-37.4
Malaysia	343	334	288	-13.6	-2.8	-16.0
Myanmar	655	311	282	-9.5	-52.5	-57.0
New Zealand	153	117	105	-10.1	-23.9	-31.6
Philippines	298	136	135	-1.0	-54.3	-54.8
Singapore	171	135	129	-4.7	-21.3	-24.9
Thailand	551	483	429	-11.3	-12.3	-22.3
Viet Nam	680	540	458	-15.1	-20.6	-32.6
Total	368	250	215	-14.1	-32.0	-41.6

4.3. Carbon Dioxide (CO_2) Emissions from Energy Consumption

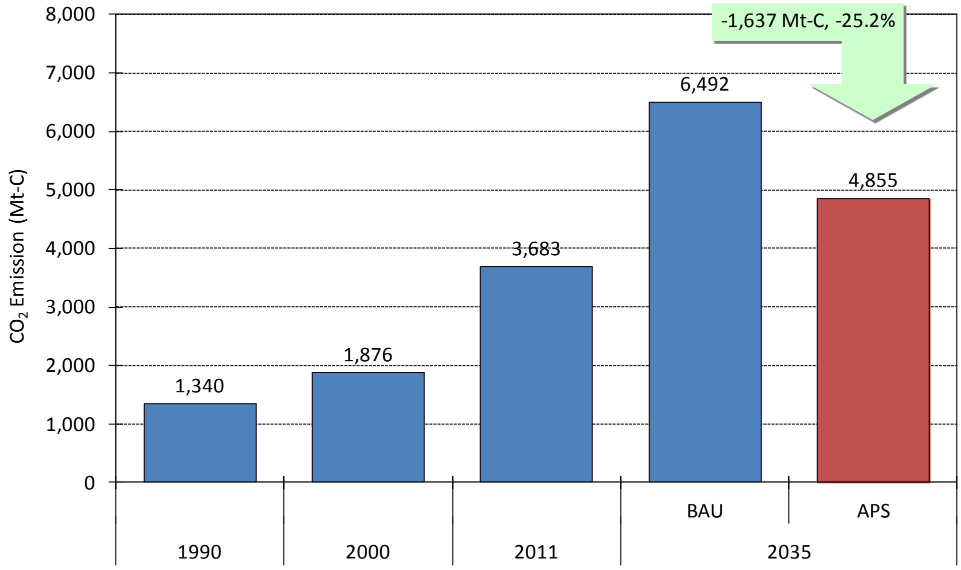
4.3.1. CO_2 Emissions

As shown in Figure 30, CO_2 emissions from energy consumption in the BAU case are projected to increase from 3,683 million tonnes of Carbon (Mt-C) in 2011 to 6,492 Mt-C in 2035, implying an average annual growth rate of 2.4 percent. This is slightly lower than the growth in total primary energy demand of 2.5 percent per year. In the APS case, CO_2 emissions are projected to be 4,855 Mt-C in 2035, 25.2 percent lower than under the BAU case.

While the emission reductions under the APS are significant, CO_2 emissions from energy demand under the APS case in 2035 will still be above 2011 levels and more than 3 times above 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) (reference) suggests that to keep the increase in global mean temperature to not more than 2°C compared with pre-industrial levels, global CO_2 emissions would need to peak between 2000 and 2015 and be reduced to between 15 and 50 percent of year 2000 levels (that is, a reduction of between 85 and 50 percent) by 2050. To keep temperature rises in the 3°C range, CO_2 emissions would need to peak between 2010 and 2030 and be 70 to 105 percent of year 2000 levels by 2050.[14]

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

Figure 30: Total CO_2 Emissions, BAU and APS

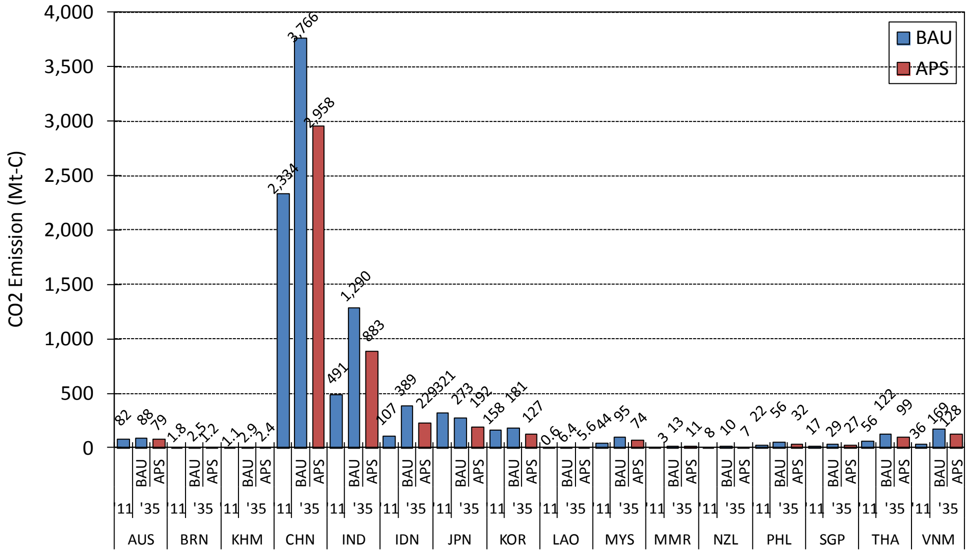


Although much depends on the mitigation achieved in other regions, it would appear unlikely that global emissions could meet either of these profiles given the contribution of the EAS region to global total emissions under the APS results. Yet, the consequences of insufficient reductions in emissions could be severe. For example, at 2°C above pre-industrial levels, up to 30 percent of species become at increasing risk of extinction, most corals become bleached, and droughts and water availability become an increasing problem worldwide. At 3°C, millions of people could experience coastal flooding each year.[15]

As shown in Figure 31, emissions and emission growth in the EAS region is projected to be dominated by China and India. In fact, China and India will account for 1,432 Mt-C and 799 Mt-C, respectively, of the projected 2,809 Mt-C increase in EAS region emissions from 2011 to 2035 under the BAU case, or 79.4 percent of the total growth in the EAS region. Adding Indonesia's growth of 281 Mt-C, these three countries account for 2,469 Mt-C or 89.4 percent of the total growth in EAS region. No other country will account for growth of more than 133 Mt-C. Japan is the only country in the EAS region whose emissions are projected to decline under the BAU case as a result of improved energy efficiency and increased utilisation of renewable energy.

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

Figure 31: CO_2 Emissions by Country, BAU and APS



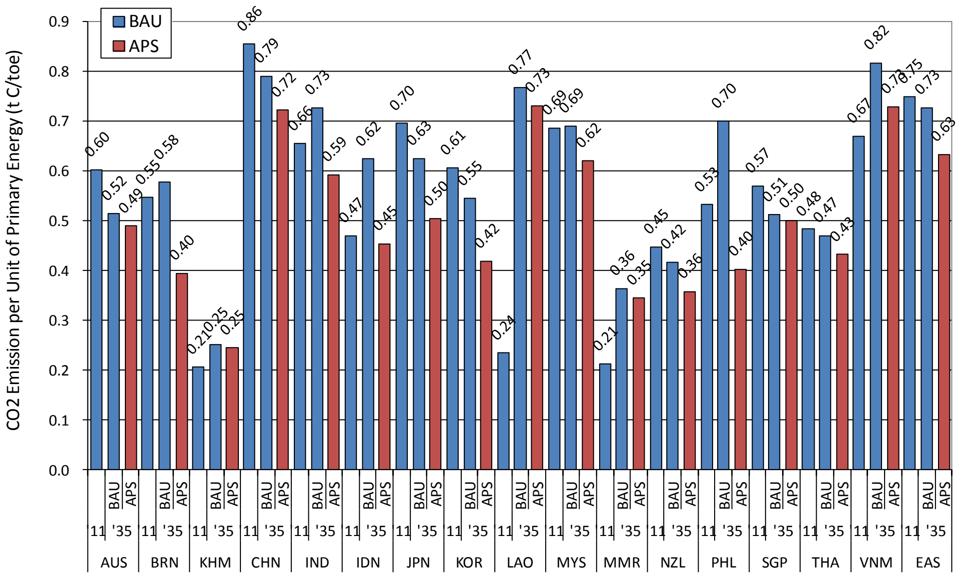
Under the APS case, China and India are still dominant, accounting for 624 and 392 Mt-C, respectively, of the projected 1,172 Mt-C growth in emissions in the EAS region between 2011 and 2035, or 86.7 percent. Adding 122 Mt-C from Indonesia, these three countries account for 1,138 Mt-C or 97.1 percent of the EAS region total. No other country will account for a growth of more than 92 Mt-C. Emissions from Australia, Brunei Darussalam, Japan, the Republic of Korea and New Zealand are expected to decline under the APS case relative to 2011 levels due to effective mitigation policies.

4.3.2. Fundamental Drivers of CO_2 Emissions from Energy Demand

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

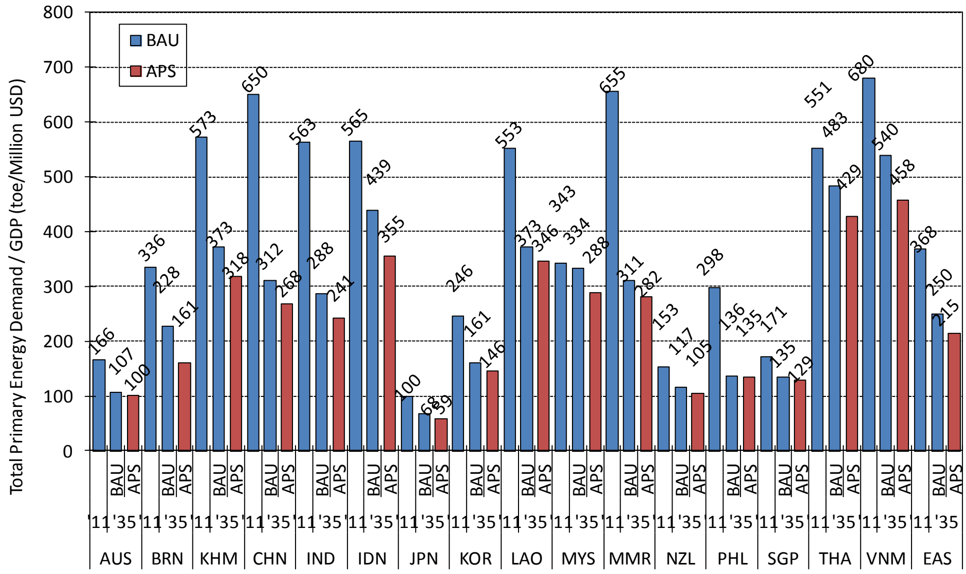
i) Emissions per unit of primary energy are projected to decline to 0.73 t-C/toe in 2035 from 0.75 t-C/toe in 2011 under the BAU case. Under the APS case, this will decline to 0.63 t-C/toe in 2035, equivalent to a decline of 15.4 percent from 2011 (Figure 32). The reduction under the APS case reflects a shift away from coal and oil, the two most emission-intensive fuels.

Figure 32: Emissions per Unit of Primary Energy, BAU and APS



ii) Primary energy per unit of GDP is projected to decline from 368 toe/million US$ in 2011 to 250 toe/million US$ in 2035 under the BAU case, or by 32.0 percent (Figure 33). Under the APS case, this will decline to 215 toe/million US$ in 2035, or by 41.6 percent. The lower emissions under the APS case reflect projected improvements in energy intensity. Looking at (i) and (ii) in combination, emissions per unit of GDP will decrease from 276 t-C/million US$ in 2011 to 182 t-C/million US$ in 2035 under the BAU case, or by 34.0 percent. Under the APS, this will decline to 136 t-C/million US$ in 2035, 50.6 percent lower than 2011.

Figure 33: Primary Energy Demand per Unit of GDP, BAU and APS



iii) Working against these declines in emissions per unit of primary energy and primary energy per unit of GDP is the projected significant increase in GDP per person in the EAS region, from around US$3,900/person in 2011 to US$9,000/person in 2035, an increase of 129.7 percent. Looking at (i), (ii), and (iii) in combination, emissions per person are projected to increase from 1.09 t-C/person in 2011 to 1.65 t-C/person in 2035 under the BAU case, or by 51.6 percent. Under the APS, emissions rise to only 1.23 t-C/person in 2035, or 13.4 percent higher than 2011. However, the rising emissions per capita are associated with increase in GDP/person and improvement in living standards.

iv) Finally, population in the EAS Region is expected to grow from 3,391 million in 2011 to 3,943 million in 2035, or by 16.3 percent. Combined, all these drivers lead to growth in emissions from 3,683 Mt-C in 2011 to 6,449 Mt C in 2035 under the BAU case, or 76.3 percent. Under the APS, emissions grow to 4,845 Mt-C in 2035, or 31.8 percent.

5. Conclusions and Recommendations

The working group 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 the projected changes in socio-economic factors, energy consumption, and carbon dioxide emissions in the BAU scenario and the APS, the working group members identified a number of key findings which are outlined below:

1. Sustained population and economic growth in the EAS region will lead to significant increases in energy demand. TPES in 2035 will increase 1.8 times from 2011. However, even in the BAU, the EAS region's energy elasticity, which is defined as the growth rate of primary energy demand divided by the growth rate of GDP from 2011 to 2030, is projected to improve to 0.60 (2.5/4.2) as compared to 1.10 (4.2/3.9) from 1990 to 2011.

2. The continued reliance on fossil fuels to meet increased energy demand will also be associated with significant increases in CO_2 emissions. However, even in the BAU, CO_2 elasticity, which is defined as the growth rate of CO_2 emissions divided by the growth rate of GDP from 2010 to 2035, will be 0.57 lower than the energy elasticity. There are two reasons for this. The first is diversification among fossil energy from coal to gas. Coal share of the total primary energy mix will decline from 51.1 percent in 2010 to 46.6 percent in 2035. On the other hand, gas share will increase to 14.0 percent from 9.0 percent during the same period. The second reason is the increased use of carbon neutral energy, such as nuclear power, hydro power, geothermal power and NRE. The share of carbon neutral energy in 2011 was 16.0 percent but it will increase to 16.2 percent in 2035.

3. The EAS energy mix in the BAU will change from 2011 to 2035. Coal and oil will decrease their share from 75.0 percent to 69.8 percent. The diversification of the regional energy mix, which increases the share of low and carbon neutral energy, will contribute to improvements in carbon intensity.

4. Industry remains as a major consumer of energy but the transport sector continues to increase rapidly. These two sectors are challenging sectors in terms of improving energy efficiency and reducing CO_2 emissions. In this regard, appropriate energy efficiency and conservation programs and low emission technologies are needed in these sectors.

5. 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:

- 14.1 percent in primary energy demand
- 14.1 percent in energy intensity
- 24.9 percent in energy derived CO_2 emissions.

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 address the 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 WG members necessarily agreed to all recommendations.

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

The industry sector would be a major source of energy savings because it will still remain the largest energy consuming sector by 2035. There are several EEC action plans to be implemented, which include replacement to more efficient facilities and equipment. In addition, the working group suggested the following points:

- Changing the industrial structure from heavy to light industries - Shifting of industries from energy intensive industry to less energy intensive industries would surely reduce energy consumption per unit of GDP output.

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

- Improvement of fuel economy
- Shift from personal to mass transportation mode
- Shift to more efficient and clean alternative fuels

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

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

b. *Need for Consistent EEC Policies*

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

- Demand side
  - Establishment of energy management system
  - Promotion of energy efficiency in small and medium enterprises (SMEs)
- Supply side
  - Strong support to energy technology development such as smart grids
  - Planning of best energy mix in both power generation and primary energy supply
  - Use of more efficient thermal power generation technologies
- Financial side
  - Provision of financial incentives on EEC such as soft loans, tax credits and other incentives that would support energy efficiency and conservation.

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

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

Various analyses show that the intermittent nature of renewable energy sources poses significant challenge in integrating renewable-energy generation to the electricity grids. Governments should therefore look into this integration problem as this would entail significant costs. Government investments in electricity storage technologies especially for solar and wind power might be needed.

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

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

d. *Rationalizing Energy Pricing Mechanism*

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

e. *End-use Energy Statistics*

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

5.3. Recommendations

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

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

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

The projected level of energy savings and reduction in CO_2 emissions will be significant if all of the energy saving and low emission fuel policies proposed at the 6th Energy Ministers Meeting in September 2013 were implemented in EAS countries. Although enhanced energy efficiency and an increase in the share of low emission and renewable fuels in the energy mix may also have other benefits such as increasing energy supply diversity and enhancing energy security, these measures are not enough to mitigate all of the challenges posed by climate change. Therefore, more aggressive saving goals, advanced technologies to reduce CO_2 emissions directly, such as clean coal technologies along with carbon capture and storage, and enhanced uptake of low emission fuels are recommended to further reduce CO_2 emissions.

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