Chapter 1

Main Report

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CHAPTER 1

Main Report

1. Introduction

Responding to the Cebu Declaration on East Asia Energy Security on 15 January 2007 by the leaders of the 16 countries of the East Asia Summit (EAS), the EAS Energy Cooperation Task Force (ECTF) was established and one of the agreed areas for cooperation was the Energy Efficiency and Conservation. Japan proposed to undertake a study of 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. The first study was undertaken in 2007 and was updated annually to incorporate more recent information and on member countries' energy saving potentials and energy efficiency goals, action plans and policies. The 2012 study was again updated to undertake the following:

- Reflect the energy efficiency goals and actions plans submitted by the energy ministers during the 6th EAS Energy Minister's Meeting (EMM) held in Phnom Penh, Cambodia on 12 September 2012 in the latest energy outlook until 2035; and
- Revise the questionnaires collected during the phase 2 of the pilot end-use energy consumption survey in the residential sector in view of the apparent overestimation of electricity consumption of variable-load household appliances.

[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.

This is the report of that study.

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

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

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 Vietnam, and 6 other countries, namely: Australia, China, India, Japan, Republic of Korea and New Zealand.[3]

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 2000 prices[4]). 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 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,

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

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

[4] All US$ (US Dollar) in this document are stated at constant year 2000 values unless specified.

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[5].

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

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

Table 1: Geographic, Demographic, and Economic Profiles, 2010

	Land Area (thousand sq.km.)[1]	Population (million)	Population Density (persons/ sq.km.)	GDP (Billion 2000US$)[2]	GDP per Capita (2000US$/ person)
Australia	7,682	22.18	2.89	561.8	25,324
Brunei Darussalam	5.3	0.40	75.70	6.9	17,221
Cambodia	181	14.14	78.11	7.9	558
China	9,327	1,337.83	143.43	3,246.0	2,426
India	2,973	1,170.94	393.83	995.5	850
Indonesia	1,812	237.64	131.18	274.7	1,156
Japan	365	127.23	349.05	5,029.3	39,530
Korea, Rep.	97	49.41	508.86	801.3	16,216
Lao PDR	231	6.20	26.86	3.4	556
Malaysia	329	28.40	86.44	147.3	5,185
Myanmar	653	47.96	73.42	20.3	423
New Zealand	263	4.37	16.59	68.3	15,634
Philippines	298	93.26	312.77	129.0	1,383
Singapore	0.7	5.08	7,251.43	165.7	32,645
Thailand	511	69.12	135.30	145.0	2,098
Vietnam	310	86.90	280.26	62.8	723

Note: [1] Information on the land area data of Cambodia was provided by the Cambodian government.

[2] GDP data of Myanmar at constant 2000 US$ values are calculated by IEEJ.

Source: World Bank (2012) World Databank: http://databank.worldbank.org/ddp/home.do. Washington DC (accessed: November, 2012) and Government of Cambodia.

Table 2: Economic Structure and Energy Consumption, 2010

	GDP (Billion 2000US$)	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	561.8	19.8	77.9	2.3	124.7	5.6
Brunei Darussalam	6.9	74.1	25.3	0.6	3.1	7.9
Cambodia	7.9	23.3	40.7	36.0	1.4	0.1
China	3,246.0	46.7	43.2	10.1	2,212.5	1.7
India	995.5	27.6	54.4	18.0	523.9	0.4
Indonesia	274.7	47.0	37.7	15.3	158.6	0.7
Japan	5,029.3	27.4	71.5	1.2	494.0	3.9
Korea, Rep.	801.3	38.8	58.5	2.6	247.3	5.0
Lao PDR	3.4	31.8	35.5	32.7	0.9	0.1
Malaysia	147.3	41.1	48.5	10.4	69.2	2.4
Myanmar	20.3	48.4	16.2	35.4	6.0	0.1
New Zealand	68.3	24.8	69.5	5.6	18.2	4.2
Philippines	129.0	32.6	55.1	12.3	34.9	0.4
Singapore	165.7	27.9	72.1	0.0	33.1	6.5
Thailand	145.0	44.7	43.0	12.4	112.2	1.6
Vietnam	62.8	41.1	38.3	20.6	40.9	0.5

Note: [1] Sectoral shares to GDP of Myanmar are 2004 values while those of New Zealand are 2006 values.

Sources: World Bank (2012) World Databank: http://databank.worldbank.org/ddp/home.do. Washington DC (accessed November, 2012); International Energy Agency (IEA) (2011) Energy Balances of OECD Countries 2010 and Energy Balances of Non-OECD Countries 2011, Paris.

1.2. Rationale

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

- improving the efficiency and environmental performance of fossil fuel use;
- reducing the dependence on conventional fuels through intensified energy efficiency and conservation programmes, 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.

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

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

The Economic Research Institute for ASEAN and East Asia (ERIA) approved the proposal of the Japanese government to conduct a study on energy saving and CO_2 emission reduction potentials in the East Asia Region. As a result, the Working Group (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 this study is to analyse the potential impacts of proposed additional energy saving goals, action plans and policies in the East Asia Summit region on energy consumption by fuel and sector and greenhouse gas emissions.

Specifically a BAU scenario was developed for each country outlining future sectoral and economy-wide energy consumption assuming no significant changes to government policies. An APS was also designed to examine the potential impacts if additional energy efficiency goals, action plans or policies were developed that are currently, or likely to be, under consideration. Increased uptake of renewable energy sources and nuclear energy was also considered in the APS. The difference between the BAU and APS represent potential energy savings.

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

1.4. Working Group Activities in 2012

In 2012, the WG continued to assess energy saving potentials in the EAS region using the goals, action plans and policies reported at the 6th EAS Energy Ministers

Meeting (EAS-EMM6). The WG in 2012 enhanced and extended the analysis that was undertaken from 2007 to 2011. The WG conducted three meetings, one in Cambodia in August 2012, another in Indonesia in November 2012 (for Southeast Asian member states only) and another meeting in Kuala Lumpur in April 2013.

During the first meeting, the WG discussed and developed the 2012 research plan and provided updates on revised energy saving goals, action plans and policies that each EAS country reported in 2012 as well as each of the countries' economic development plans. The research plan included the revision of the questionnaires obtained during phase 2 pilot survey in the residential sector. The revision was necessary due to the overestimation of the consumption of variable-load household appliances. It was learned that variable-load appliances do not always operate at its maximum power rating due to temperature controls and variable speed of the motors in these appliances. The updated report on the pilot end-use energy consumption survey in the residential sector is presented in Section 5 of this main report.

During the second meeting, which was a special meeting for the ASEAN countries, the WG provided capacity building on energy modelling as there were several new members in the WG from Brunei Darussalam, Lao PDR, Myanmar, and Singapore. For the more seasoned members, the agenda covered discussions on more reliable energy outlook and review of energy outlook models of their respective countries.

During the third meeting, the WG discussed the preliminary energy outlook of each country and the policy implications that could be derived from the outlook results. The contents of the research report were also discussed and decided during the third meeting along with the responsibilities of each WG members and IEEJ in the writing of the report. The WG also discussed the preliminary report of additional research projects carried out by ERIA in 2012.

1.5. Additional Research Studies

In 2012, research studies related to energy efficiency and emission reduction were commissioned by Japan. These are the following:

- Best Energy Mix in the Transport Sector
- Green Growth in Asia Phase 2
- Asian Potential on Biofuels Market

The report on Best Energy Mix in the Transport Sector in Indonesia is included as part of the Annexes of this report.

Other studies on energy were conducted by ERIA during the year 2012-2013. These are the following:

- Energy Market Integration Study
- Energy Security Indices
- Energy Efficiency Improvement in Urban Transport
- Effective Investment in Power Infrastructure
- Nuclear Safety Management

2. Data and Methodology

2.1. Scenarios Examined

The study continued to examine two scenarios, as in the studies conducted annually from 2007 to 2011, a Business As Usual (BAU) scenario reflecting each country's current goals, action plans and policies, and an Alternative Policy Scenario (APS). The APS included additional goals, action plans and policies reported at the EAS-EMM6 held in September 2012 in Phnom Penh, Cambodia 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.

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 Savings 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 was converted from Gross Calorific Value (GCV) to Net Calorific Value (NCV) to be consistent with IEA energy balances. Estimations of national energy data from Lao PDR were made using the same methodology as IEA. The socio-economic data were obtained from the World Bank's online World Databank - World Development Indicators (WDI) and Global Development Finance (GDF). 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*[7]. Following capacity building exercises in ASEAN, 8 of the 10 member countries utilised their own energy models with IEEJ support. In addition, Australia and Korea also used their own national models. However, in 2011, the WG decided to use IEEJ's energy outlook on Korea in view of the non-participation of the country to the study in the past 3 years. In 2012, the IEEJ energy outlook on Korea was again used but with the strong involvement of the new member from Korea who started to join the WG just during the third meeting. 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 and the LEAP 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, 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 sector 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.

[7] Ito, *et al.* (2007).

ASEAN countries: The LEAP model is 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.

2.5. Enhancing the 2011 Study

From 2007 to 2011, a study was undertaken annually to assess the potential energy savings in the EAS region that could be achieved through the implementation of energy saving goals, action plans and policies. Subsequently this study was revised and extended in 2012 to incorporate more recent information and estimation procedures and incorporate further information about energy saving potentials and energy efficiency goals, action plans and policies submitted during the EAS-EMM6 in Phnom Penh, Cambodia. Specifically, the following new information is incorporated in this study:

- revised recent energy saving goals, action plans and policies in each country;
- more conservative GDP growth projections

- projected future oil prices; and
- results of the revision of the questionnaires collected during phase 2 of the pilot end-use energy consumption survey in the residential sector;

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.

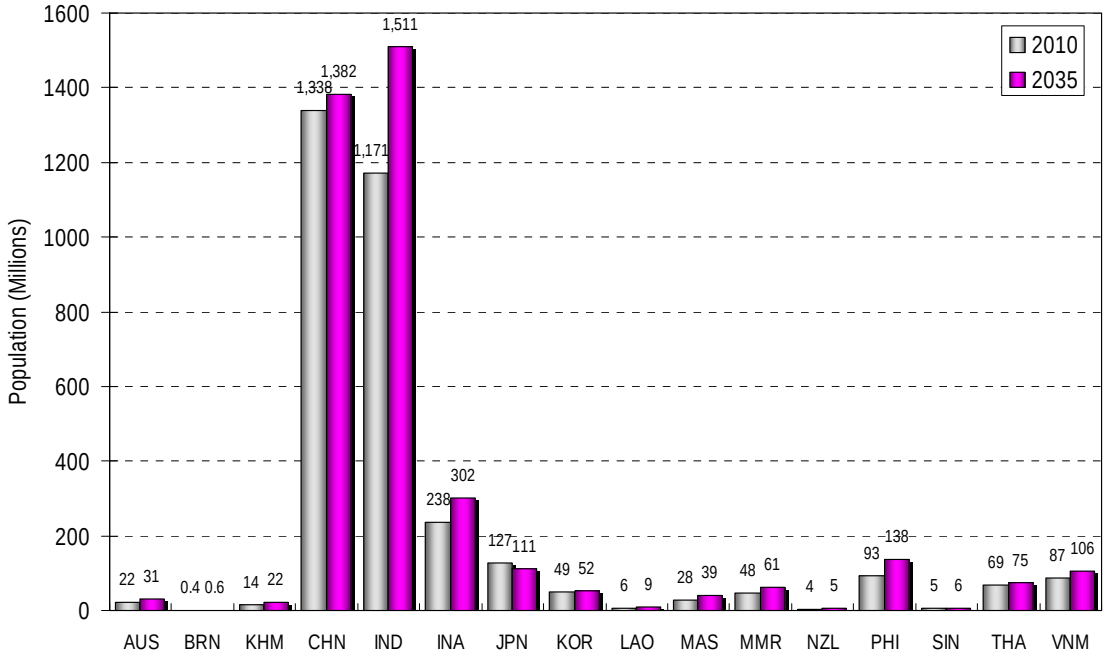
In this section assumptions regarding key socioeconomic indicators and energy policies until 2035 are discussed for the EAS countries.

3.1. Population

In the models used for this study, changes in population to 2035 are set exogenously. It is assumed to 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 2010, the total population in the EAS region was about 3.3 billion – around 48 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 per cent reaching about 3.85 billion in 2035. Figure 1 shows the 2010 and projected 2035 population by country.

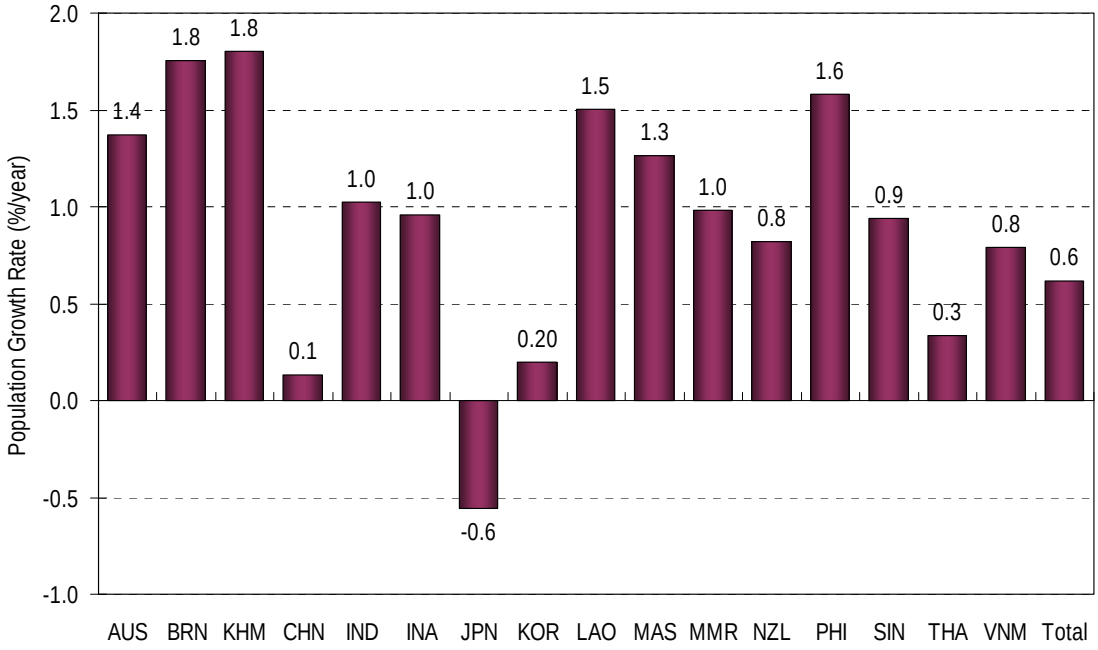
Figure 1: Assumed Population in the EAS Region, 2010 and 2035



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 about 76 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, 2010 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 2000 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.

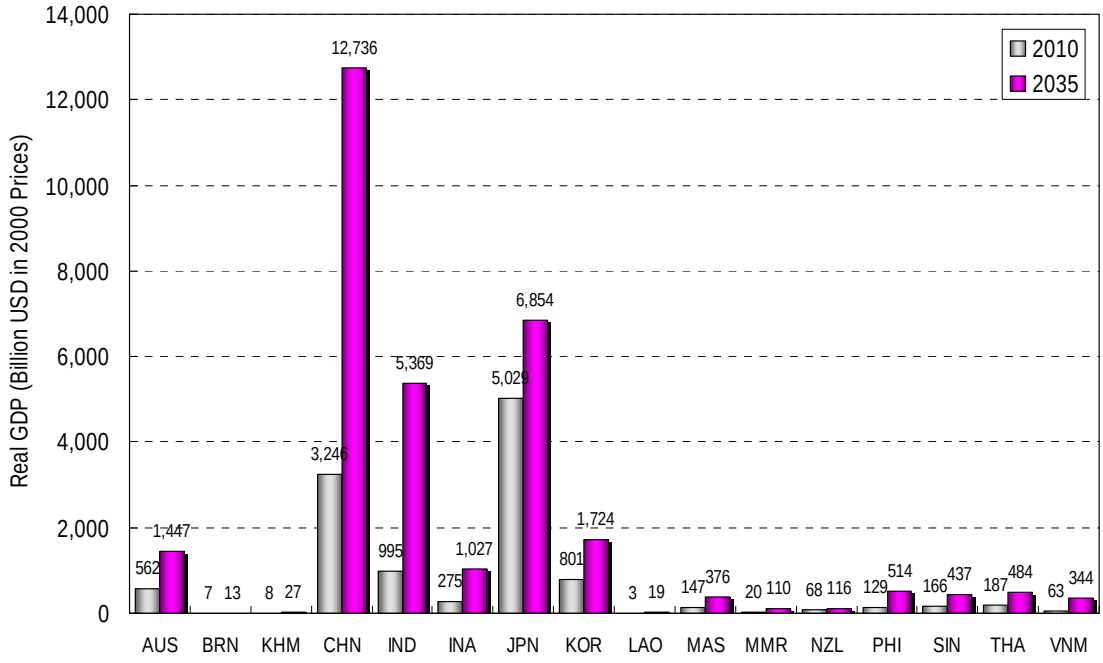
In 2010 total GDP in the EAS region was about 11.7 trillion in 2000 US$ and it accounted for about 28 percent of global GDP. The GDP of the EAS region is assumed to grow at an average annual rate of about 4.1 percent from 2010 to 2035. This implies that by 2035 total GDP in the EAS region will reach about 31.6 trillion in 2000 US$.

In 2010, Japan was the largest economy by far in terms of total economic output: about 5.0 trillion 2000 US$. However, by 2035, China is projected to be the largest economy with an estimated GDP of about 12.7 trillion 2000 US$. Japan and India

[8] World Bank (2012).

are projected to be the next largest economies with projected GDPs of about 6.9 trillion 2000 US$ and 5.4 trillion 2000 US$ respectively in 2035. See Figure 3.

Figure 3: Assumed Economic Activity in the EAS Region, 2010 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, 2010 to 2035

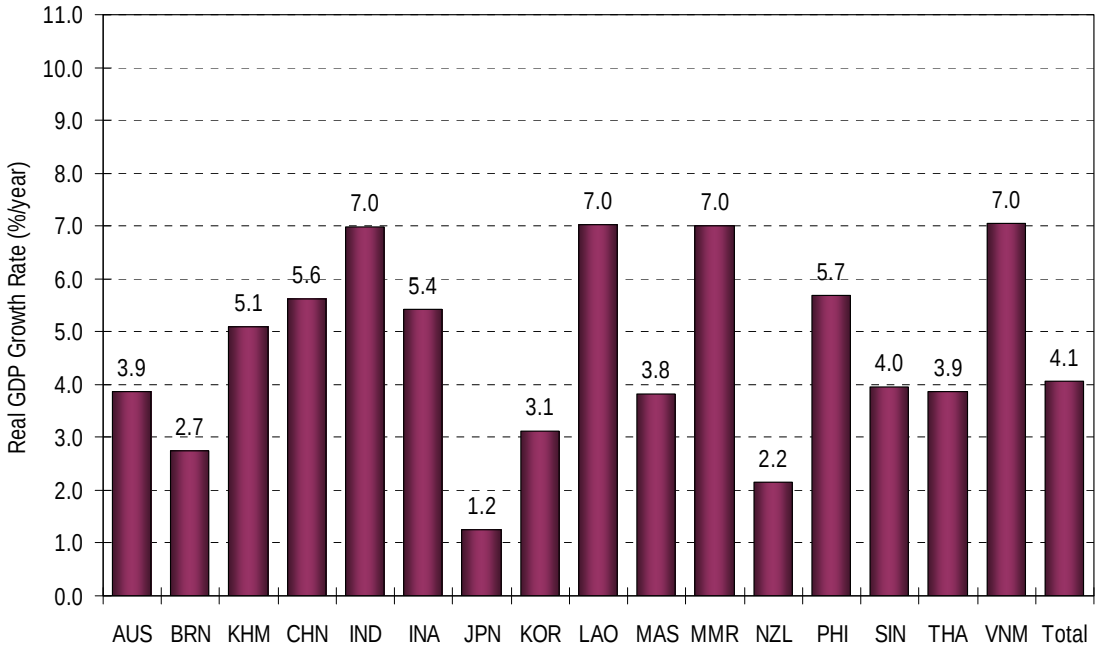
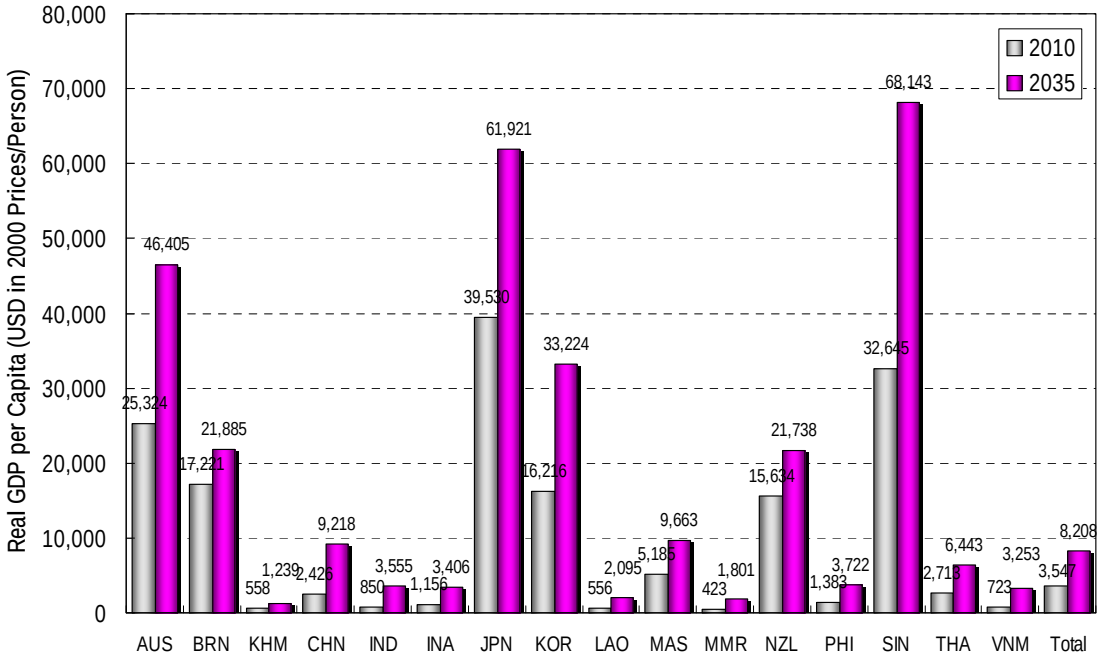


Figure 5: Real GDP per Capita, 2010 and 2035



Average GDP per capita in the EAS region is assumed to increase from about US$3500 in 2010 to about US$8200 in 2035. However, as shown in Figure 5, there

is, and will continue to be, significant differences in GDP per capita. In 2010, per capita GDP ranged from just over US$400 in Myanmar to about US$40,000 in Japan. In 2035, per capita GDP is assumed to range from just over US$1200 in Cambodia to about US$68,000 in 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 Australia, Brunei Darussalam, China, India, Japan, Korea, Lao PDR, Myanmar, New Zealand, 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 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 2010 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, Philippines, Singapore,

[9] IEA (2011).

Thailand and Vietnam, 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.

Figure 6: Thermal Efficiencies of Gas Electricity Generation

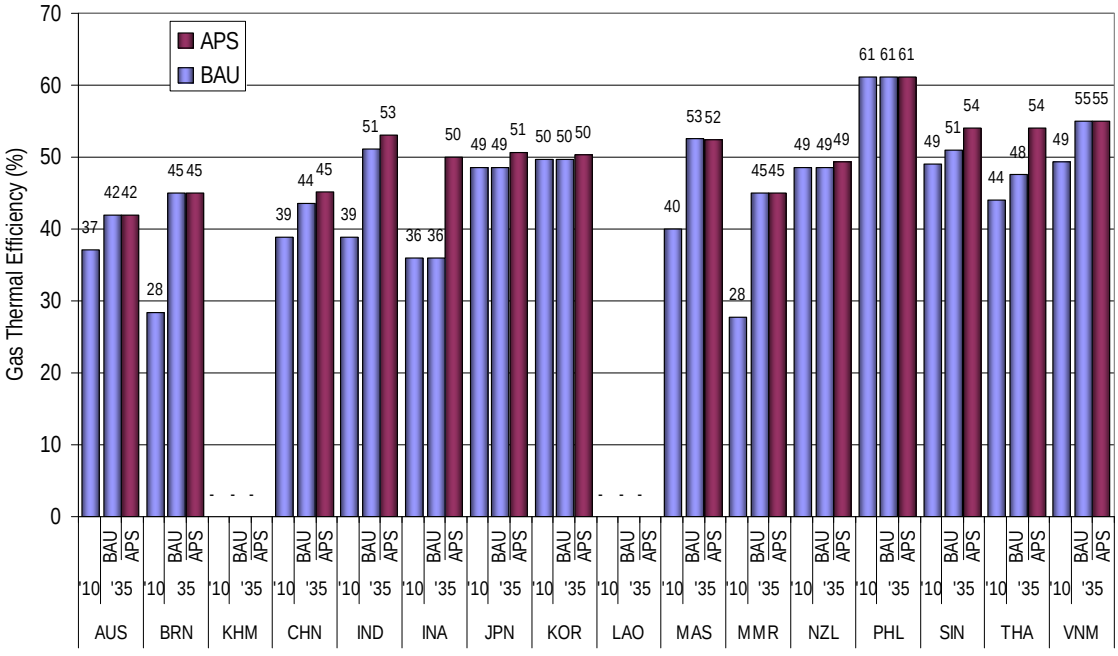
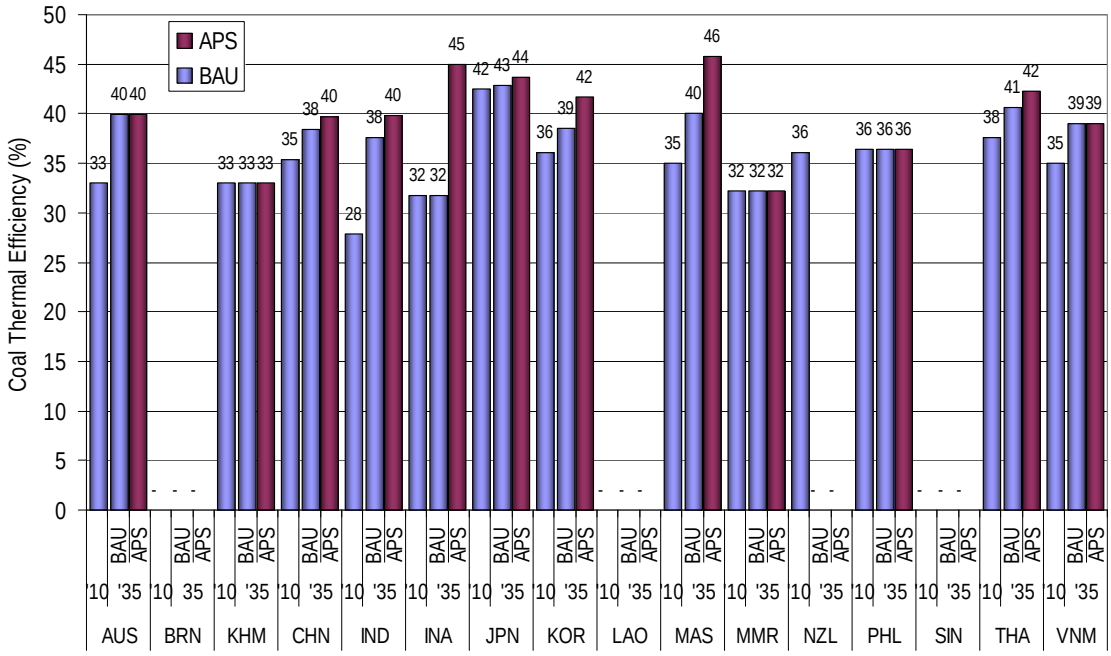


Figure 7: Thermal Efficiencies of Coal Electricity Generation

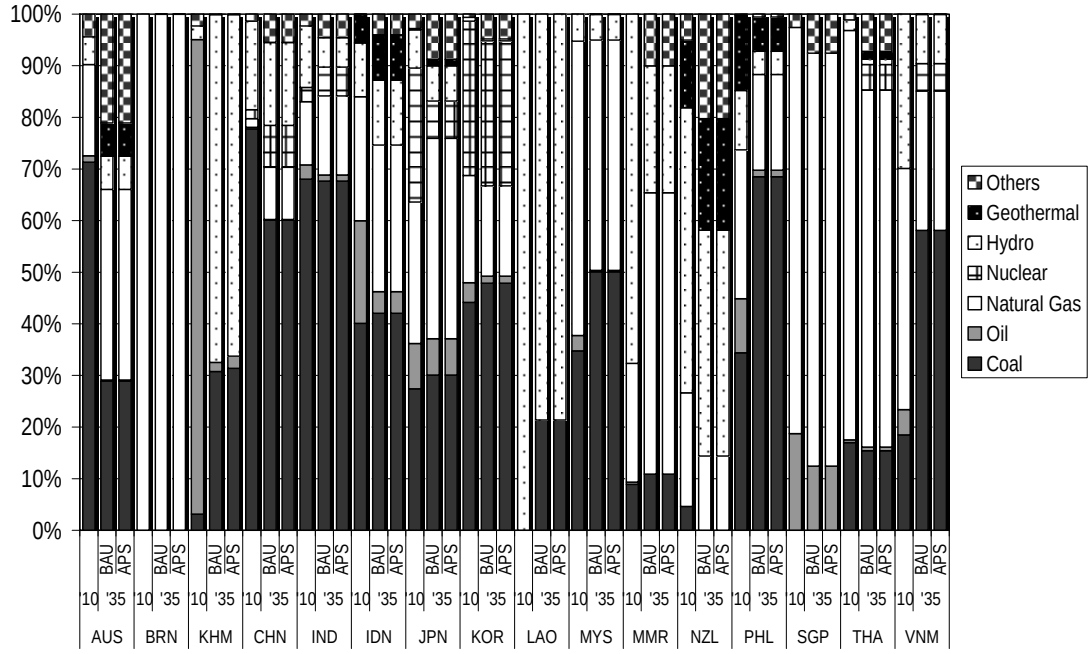


3.4.1 Electricity Generation Fuel Mix

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. Only China did not provide electricity generation fuel mix assumptions for the BAU scenario. IEEJ developed their own estimates based on other sources for this country.

Across the EAS countries in the APS, it was initially assumed that hydro and nuclear output would remain the same as in the BAU scenario, and any reduction in electricity demand would be distributed among the other fuels in proportion to their BAU share. These initial APS results were then reviewed by the WG members from each country, who in some cases suggested additional changes. 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 and APS. However, the share of coal in electricity generation in the EAS region is projected to decline from about 56.3 percent in the BAU scenario to about 40.8 percent in the APS by 2035 as countries are assumed to implement policies designed to reduce the emissions intensity of electricity generation. In the APS, the share of lower emission fuels such as hydro, nuclear, and non-hydro renewable energy are expected to be higher than in the BAU scenario on average in the EAS region. The use of oil in electricity generation is assumed to decline to almost negligible levels across the EAS region as a whole.

3.4.2 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

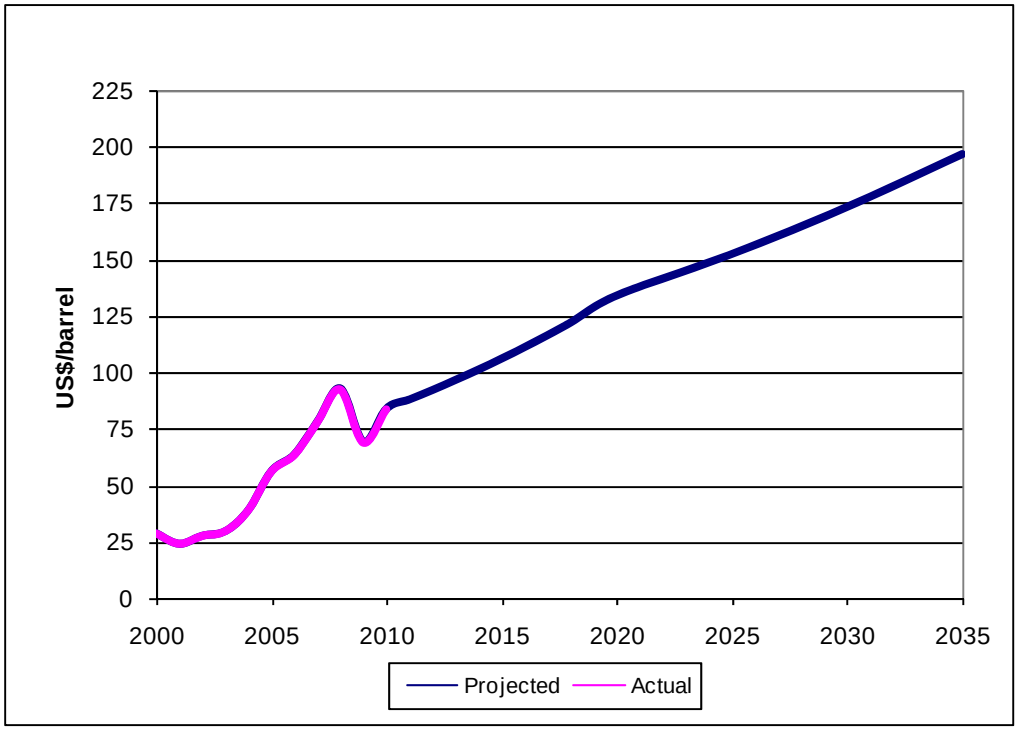
Country	Period	Assumptions
Australia	2010	No targets on biofuels.
Brunei Darussalam		No targets on biofuels.
Cambodia	2030	10% of road transport diesel and 20% of road transport motor gasoline will be displaced by biodiesel and bioethanol, respectively
China	2030	BAU: 20 billion litres, APS 60 billion 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	Utilize 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
Vietnam	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$79 a barrel in 2010 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 2012 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: Summary of Energy Saving Goals, Action Plans and Policies Collected from each EAS WG Member

	BAU scenario	APS
Australia	• 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.	
Brunei Darussalam	Brunei Darussalam aims to contribute to the 25% improvement in regional energy efficiency by 2030 (with 2005 as baseline), as declared by APEC leaders in the Sydney Declaration on Climate Change and Energy.	Reduce energy intensity by 45% by 2030 in line with the country's commitment to APEC through supply and demand side measures such as: • Reduce energy consumption of the top 5 government offices by 10% • Reduce energy consumption in the residential sector by 10% • Conversion of existing simple-cycle power plants to combined-cycle units • Expansion of cogeneration plants with heat recovery and steam generator
Cambodia		10% reduction of BAU energy consumption by 2015
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

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%

Table 4 continued

	BAU scenario	APS
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
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 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 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 10% of annual final demand relative to BAU through various energy efficiency programs in all sectors of the economy.
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
Vietnam		• Reduce energy consumption between 5%-8% by 2015 relative to BAU

3.8. Economic Growth and Climate Change Mitigation

Economic growth in the EAS countries is needed to provide for the region's growing population and improving living standards. Economic growth is assumed to exceed population growth in the 2010 to 2035 time period. This relatively strong economic growth and rising per capita incomes in the EAS countries could mean significant declines in poverty and significant increases in living standards for hundreds of millions of people.

With economic growth will come increasing access to, and demand for, electricity and rising levels of vehicle ownership. The continued reliance on fossil

fuels to meet the increases in energy demand may be associated with increased greenhouse gas emissions and climate change challenges unless low emission technologies are used. Even if fossil fuel resources are sufficient, much of the fuel is likely to be imported from other regions, and no assurance can be given that they will be secure or affordable. Fossil fuel consumption using today's technologies will lead to considerable increases in greenhouse gas emissions, potentially creating new longer-term threats to the region's living standards and economic vitality. Growing adverse health impacts throughout the region are also likely as a result of particulate emissions.

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

4. Energy And Environmental Outlook for the EAS Region

4.1. Business-as-Usual (BAU) Scenario

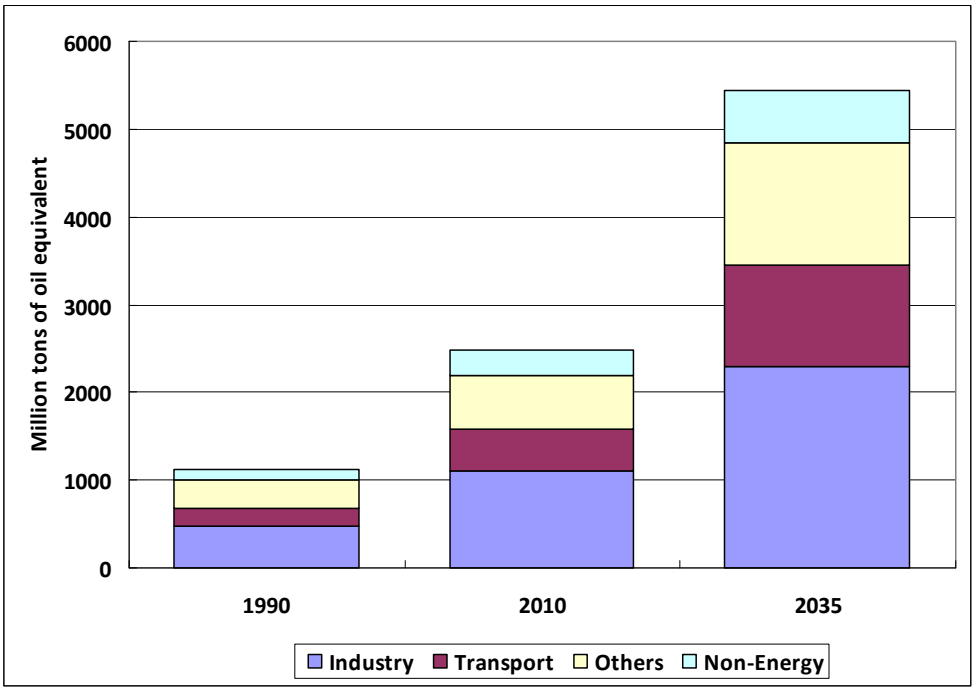
4.1.1.Final Energy Demand

Between 2010 and 2035, the total final energy demand[10] in the 16 EAS countries is projected to grow at an average annual rate of 3.2 percent, reflecting the assumed 4.1 percent annual GDP growth and 0.6 percent population growth. Final energy demand is projected to increase from 2489 Mtoe in 2010 to 5439 Mtoe in 2035. The transport sector demand is projected to grow most rapidly, increasing by 3.6 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'

[10] 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.

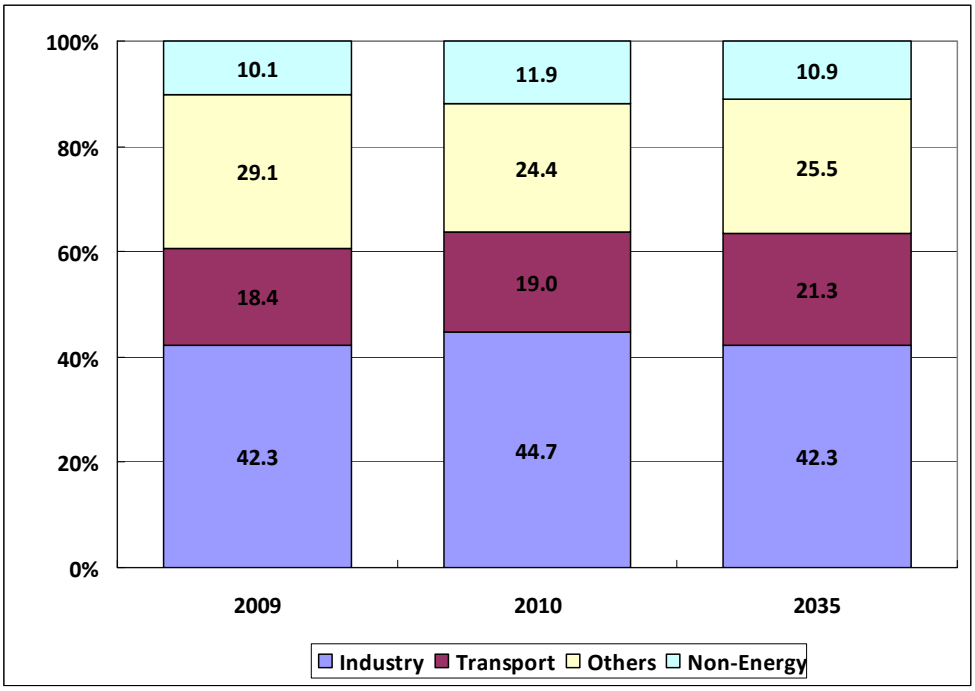
demand will grow at 3.4 percent per year faster than that of the industry sector reflective of EAS countries preference to change the structure of their economies to less energy intensive activities. Energy demand in the industry sector is projected to grow at an average annual rate of 2.9 percent. Figure 10 shows final energy demand by sector under in EAS, in 1990, 2010, and 2035.

Figure 10: Final Energy Demand by Sector (1990, 2010 and 2035)



There will be a slight change in the shares of the sectors in final energy demand from 2010 to 2035 with both the transport and other (largely residential and commercial) sectors having increasing shares while the industry sector will have a decreasing share. The transport sector's share will increase from 19.0 percent in 2010 to 21.3 percent in 2035. The other sectors' share will also increase from 24.4 percent to 25.5 percent during the same period. The share of industry sector, on the other hand, will decrease from 44.7 percent to 42.3 percent from 2010 to 2035. Non-energy demand will also decrease like the industry sector from 11.9 percent to 10.9 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, 2010 and 2035)



For the energy sources, natural gas demand in the BAU scenario is projected to exhibit the fastest growth, increasing by 5.3 percent per year, from 180 Mtoe in 2010 to 657 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 2.9 percent per year, reaching 1999 Mtoe in 2035. This is compared with its 3.7 percent per year growth over the last two decades. Its share will decline from 39.0 percent in 2010 to 36.7 percent in 2035. Demand for electricity will grow at a relatively fast rate of 3.8 percent per year. Its share will increase from 22.3 percent in 2010 to 25.9 percent in 2035 surpassing the share of coal. The growth in coal demand will grow at a slower rate of 2.1 percent per year on average. Other fuels, which are mostly solid and liquid biofuels, will have a rapid annual growth rate of 4.1 percent on average. The share will however remain low but will increase from 1.9 percent in 2010 to 2.4 percent in 2035.

Figure 12 and 13 show the final energy demand and shares by energy in the EAS under the BAU, in 1990, 2010, and 2035.

Figure 12: Final Energy Demand by Energy (1990, 2010 and 2035)

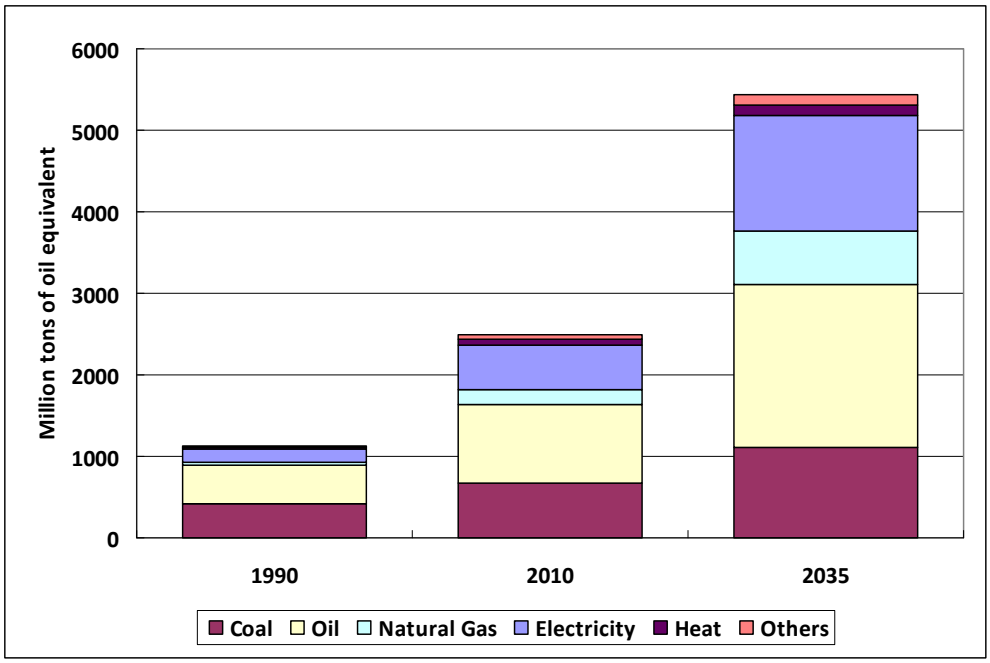
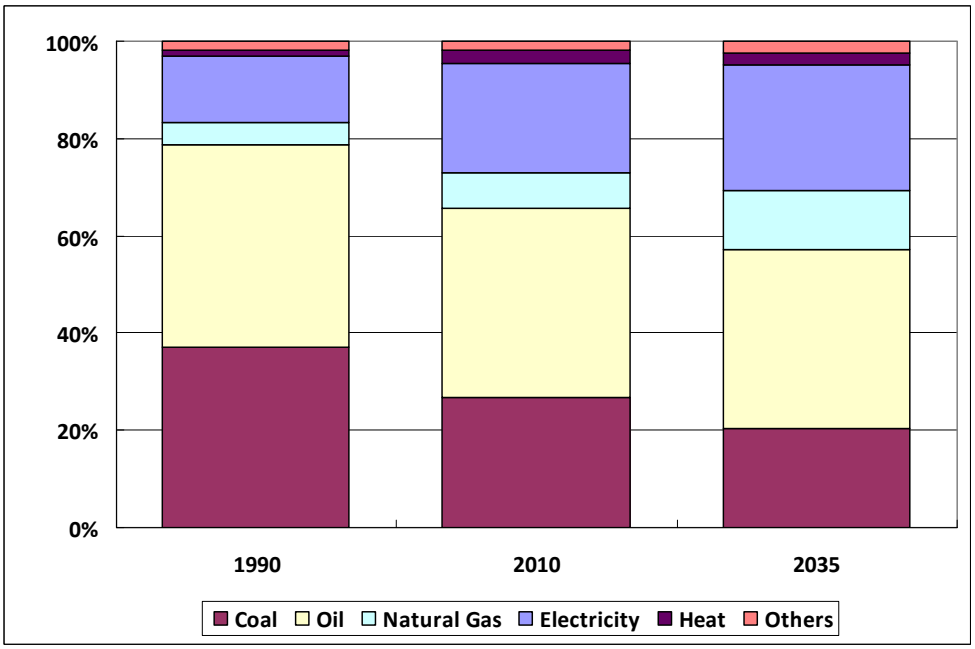


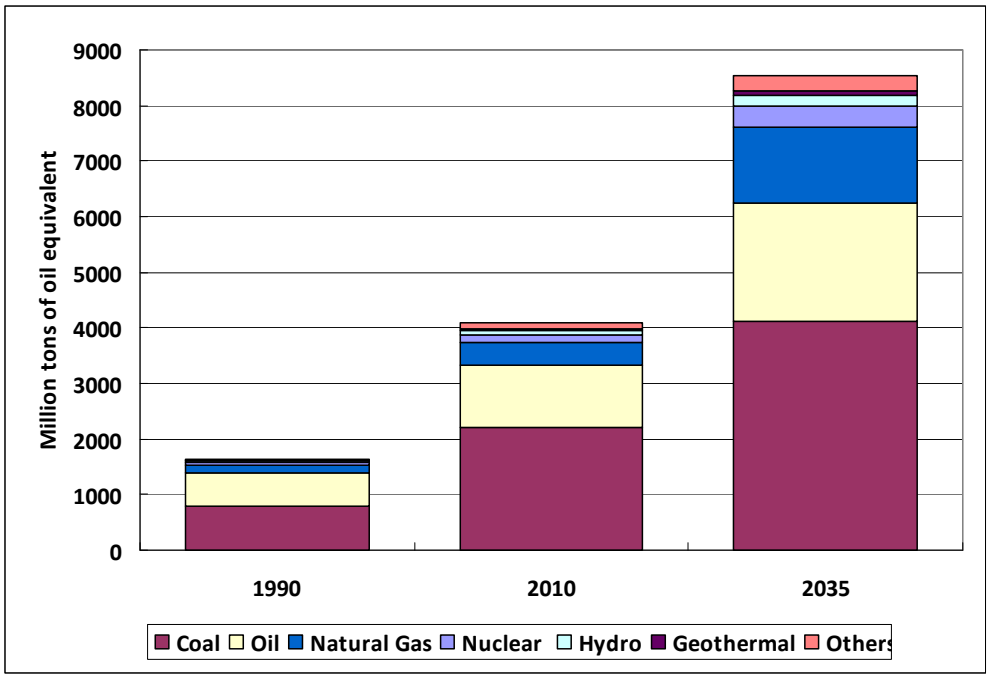
Figure 13: Final Energy Demand Share by Energy (1990, 2010 and 2035)



4.1.2.Primary Energy Demand

Primary energy demand[11] in EAS is projected to grow at a slower pace of 3.0 percent per year on average than the final energy demand of 3.2 percent. It is expected that growth in primary energy demand will be slightly slower than final energy demand because of improved efficiency in the energy transformation sector. The EAS primary energy demand is projected to increase from 4079 Mtoe in 2010 to 8536 Mtoe in 2035. Coal will still constitute the largest share of primary demand, but its growth is expected to be slower, increasing at 2.5 percent per year. Consequently, the share of coal in total primary energy demand will decline from 54.1 percent in 2010 to 48.3 percent in 2035. Figure 14 shows the primary energy demand in 1990, 2010 and 2035.

Figure 14: Primary Energy Demand in EAS (1990, 2010 and 2035)



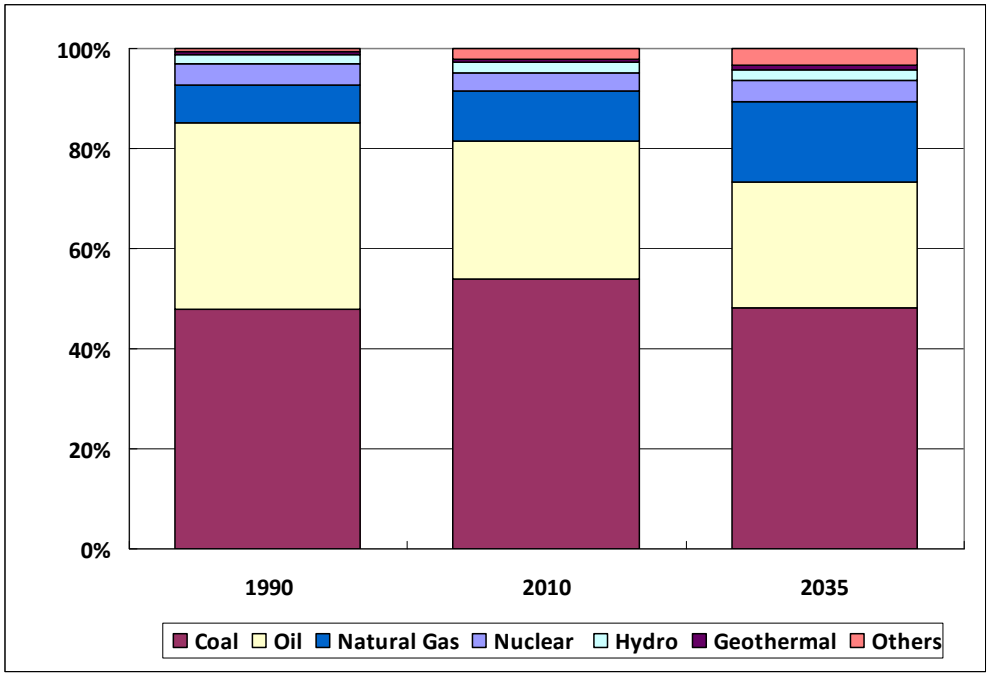
Among conventional sources of energy, natural gas is projected to exhibit the fastest growth between 2010 and 2035, increasing at an annual average rate of 4.9 percent. Its share to the total will subsequently increase from 10.2 percent in 2010 to

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

16.0 percent in 2035. Nuclear energy is also projected to increase at a rapid rate of 4.0 percent per year on average and its share will improve from 3.4 percent in 2010 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 Vietnam.

Among the energy sources, "Others" - which constitute solar, wind as well as solid and liquid biofuels - will have the fastest growth rate of 4.7 percent. Consequently, the share of these other sources of energy will increase from 2.1 percent in 2010 to 3.2 percent in 2035. Geothermal energy will also increase at a rapid pace of 4.3 percent per year but its share will remain low at 0.9 percent in 2035, slightly increasing from 0.6 percent in 2010. The growth of hydro will be 3.1 percent per year and its share will remain at 2.2 percent from 2010 to 2035. Figure 15 shows the shares of each energy source to the total primary energy mix in 1990, 2010 and 2035.

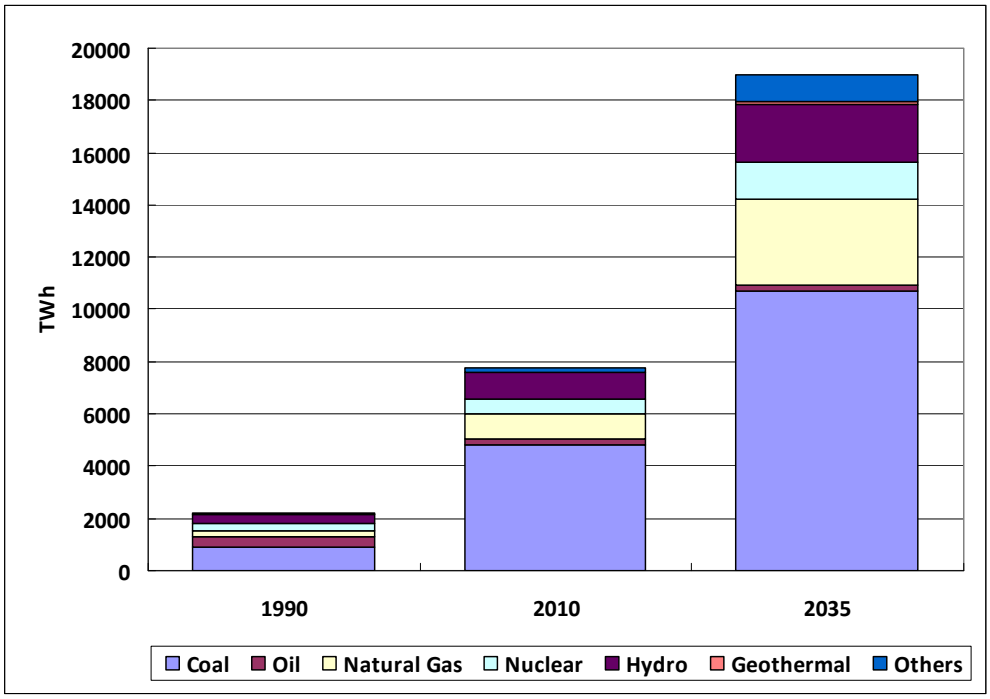
Figure 15: Primary Energy Mix in EAS (1990, 2010 and 2035)



4.1.3.Power Generation

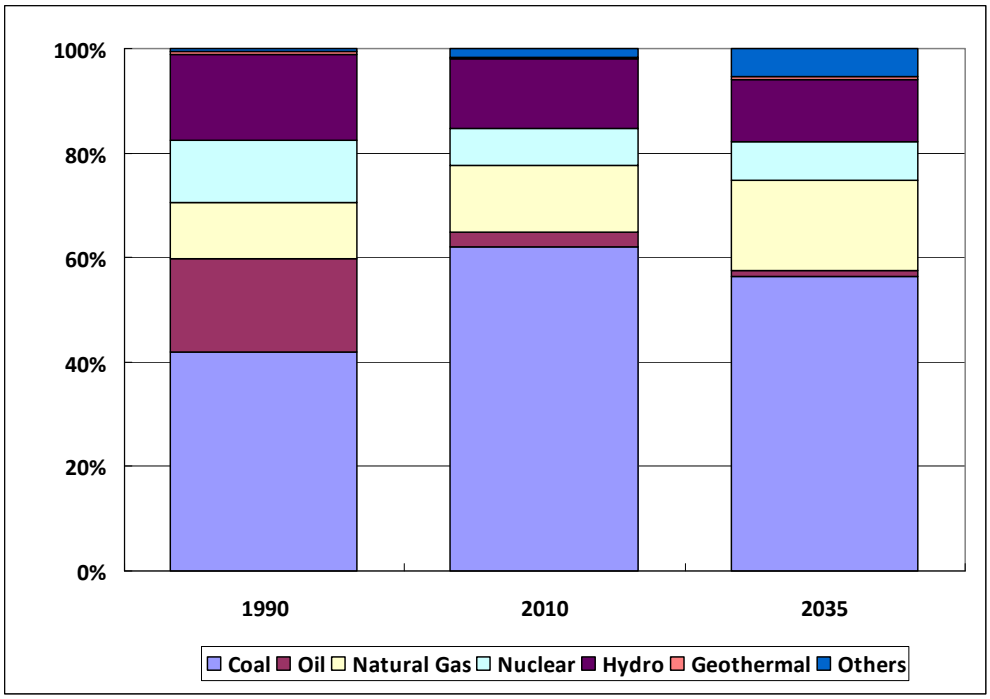
Power generation in EAS is projected to grow at 3.7 percent per year on average from 2010 (7740 TWh) to 2035 (19,012 TWh), slower than the 6.5 percent annual rate of growth from 1990 to 2010 (Figure 16).

Figure 16: Power Generation in EAS (1990, 2010 and 2035)



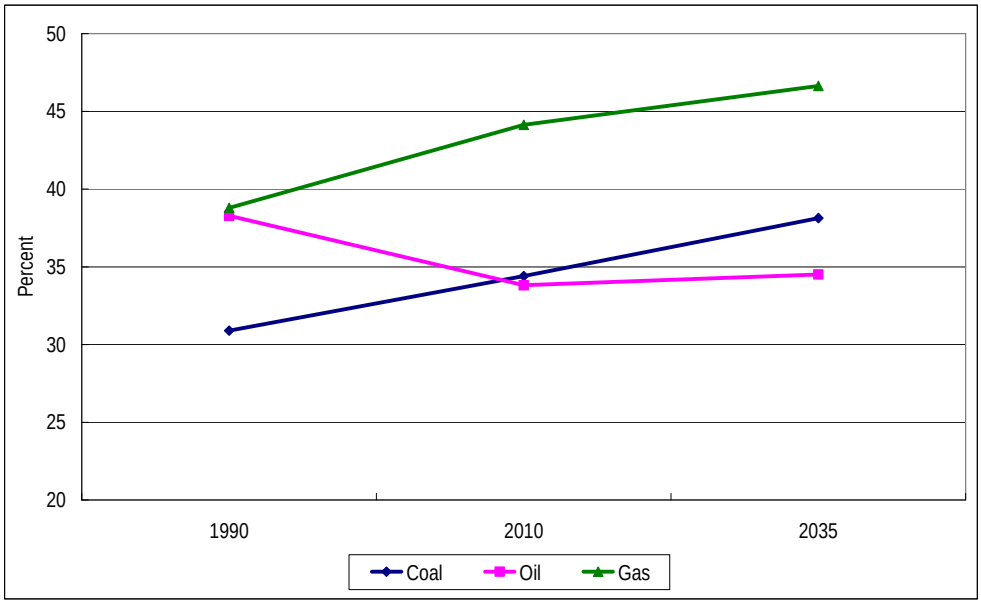
The share of coal–fired generation is projected to continue to be the largest and will remain above 56 percent of the total until 2035. Natural gas share is projected to increase from 12.7 percent in 2010 to 17.3 percent in 2035 along with those of nuclear (6.9 percent in 2010 to 7.5 percent in 2035), geothermal (0.4 percent to 0.7 percent) and others (wind, solar, biomass, etc at 1.7 percent to 5.4 percent). The shares of oil and hydro are projected to decrease slightly from 2.8 percent to 1.1 percent and 13.4 percent to 11.7 percent, respectively, during the same period. Figure 17 shows the shares of each energy source in electricity generation in 1990, 2010 and 2035.

Figure 17: Power Generation Mix in EAS (1990, 2010 and 2035)



Thermal efficiency is projected to grow in EAS from 2010 to 2035 due to improvement in electricity generation technologies like combined-cycle gas turbines and advanced coal power plant technologies. From 34.4 percent in 2010, the efficiency of coal thermal power plants, which is a mix of old and new power plants, will increase to 38.1 percent in 2035. Efficiency of natural gas power plants will also increase from 44.1 percent in 2010 to 46.6 percent in 2035. Even oil power plants, which will not be used significantly in the future, will have improved efficiency from 33.8 percent in 2010 to 34.5 percent in 2035. Figure 18 shows the thermal efficiency of coal-, oil- and natural gas-fired power generation.

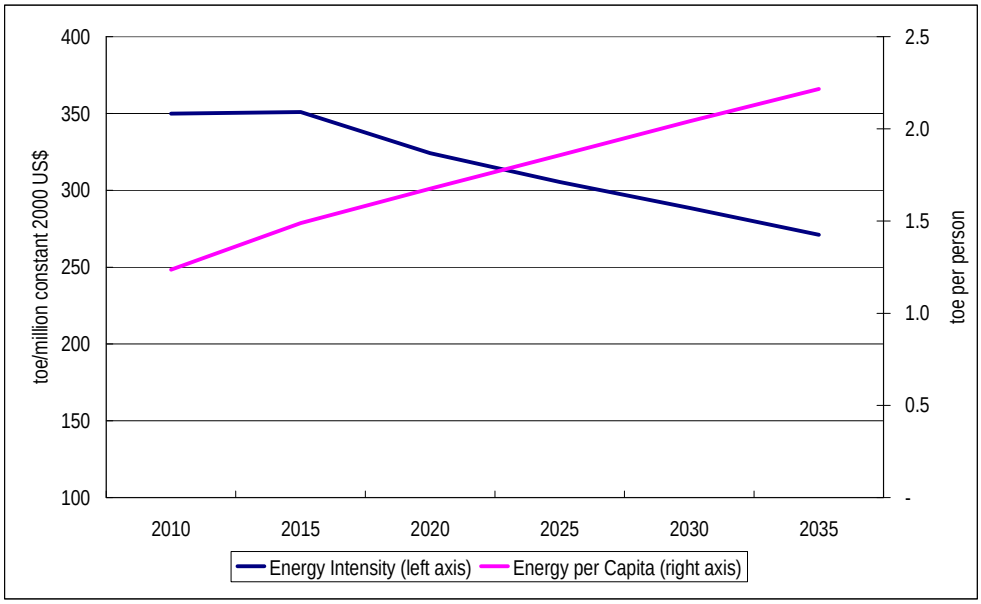
Figure 18: Thermal Efficiency by Fuel. BAU (1990, 2010 and 2035)



4.1.4.Energy Intensity and per Capita Energy Demand

Even in the BAU, energy intensity in EAS is projected to decline from 348 toe/million US$ (constant 2000) in 2010 to 270 toe/million US$ in 2035. In contrast, energy demand per capita is projected to continue to increase from 1.24 toe per person in 2010 to 2.22 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 in 1990, 2010 and 2035.

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

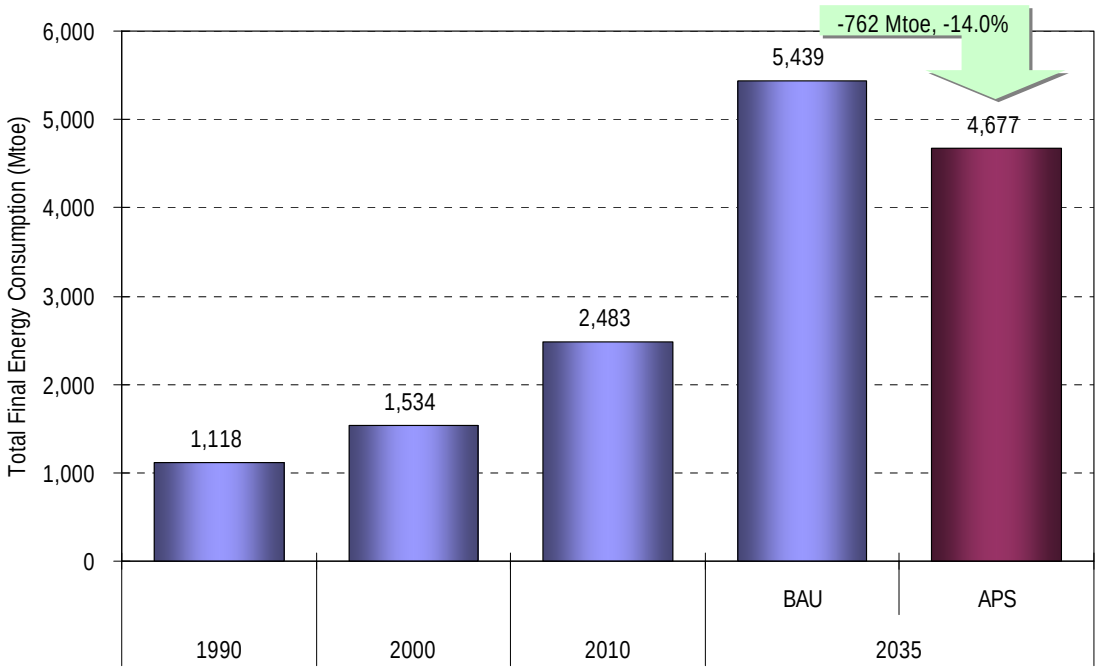


4.2. Alternative Policy Scenario (APS)

4.2.1.Total Final Energy Demand

In the APS case, final energy demand is projected to rise to 4677 Mtoe, 762 Mtoe or 14.0 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 21 shows the evolution of final energy demand from 1990 to 2035 in both the BAU and APS scenarios.

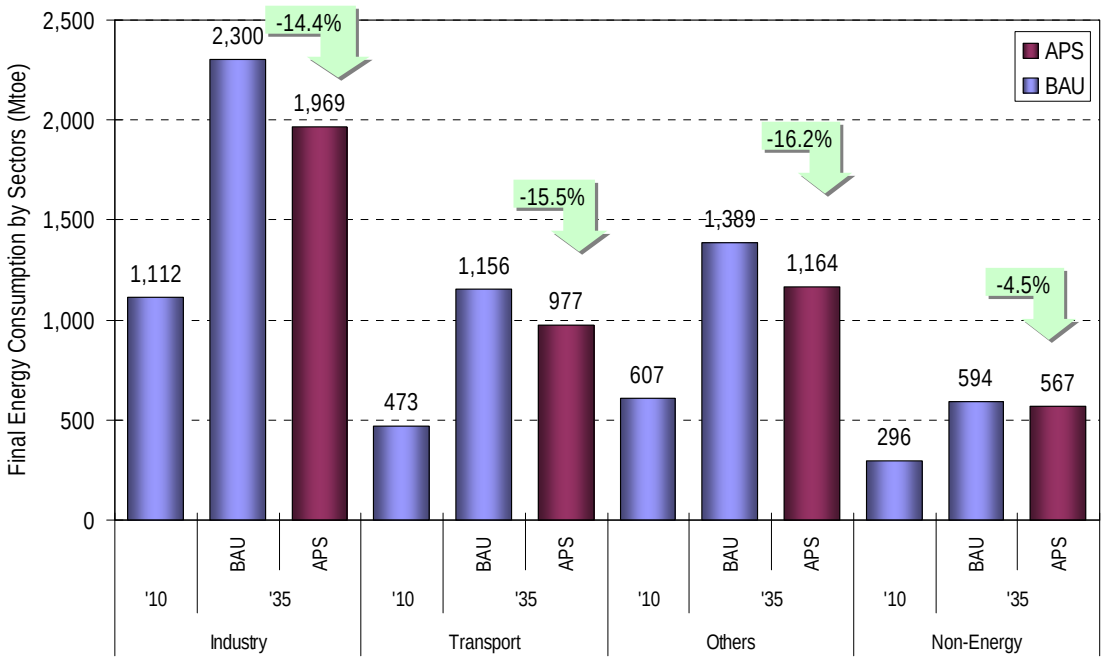
Figure 20: Total Final Energy Demand, BAU and APS



4.2.2. Final Energy Demand by Sector

Figure 21 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 other sectors at 16.2 percent, followed by the transport sector at 15.5 percent and the industry at 14.4 percent. Non-energy demand will also be lower in the APS by 4.5 percent as compared to the BAU.

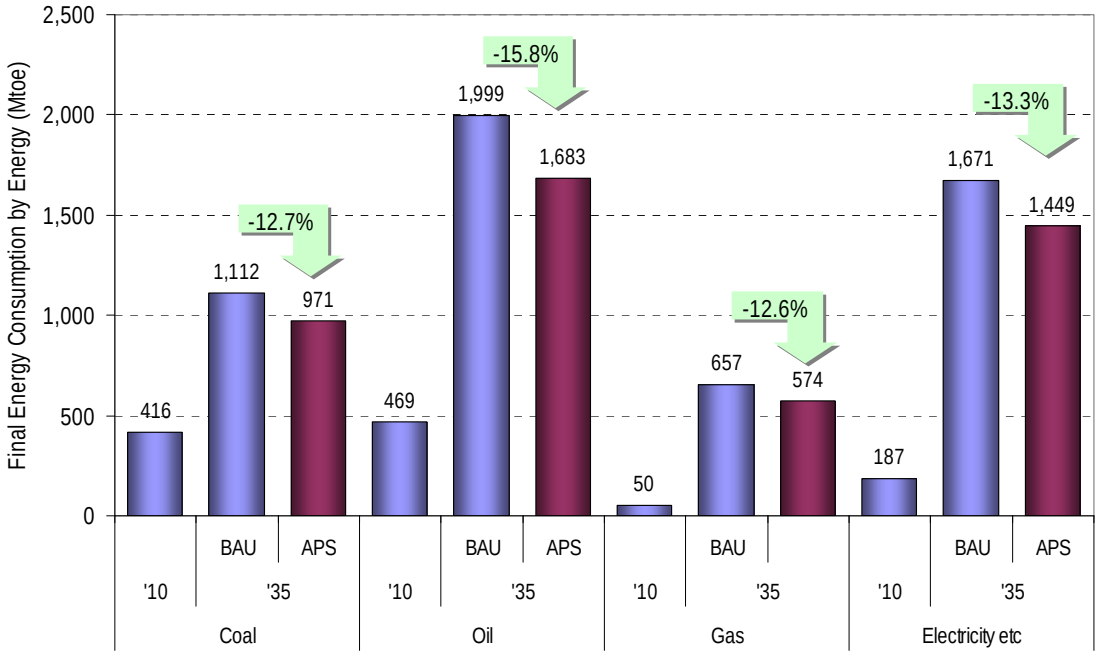
Figure 21: Final Energy Demand by Sector, BAU and APS



4.2.3.Final Energy Demand by Fuel

Figure 22 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 2.6 percent per year on average is lower than the BAU's 3.2 percent. The largest reduction will be in oil demand at 316 Mtoe or 15.8 percent from the BAU's 1999 Mtoe to 1683 Mtoe in the APS. This potential saving in oil is equivalent to 86 percent of China's final oil demand in 2010. The saving potential in other fuels which includes electricity and heat is second largest at 223 Mtoe, equivalent to a reduction of 13.3 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 141 Mtoe and this will come mostly from energy efficiency in the industrial sector. The saving potential for natural gas is around 83 Mtoe or 12.6 percent from the BAU demand.

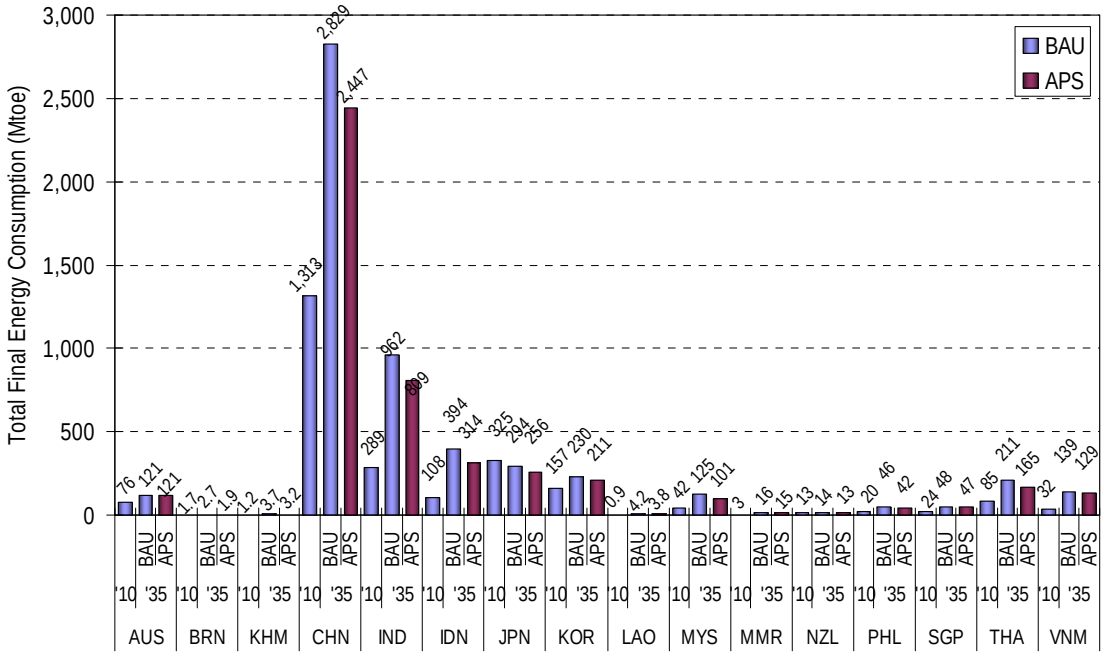
Figure 22: Final Energy Demand by Fuel, BAU and APS



4.2.4.Final Energy Demand by Country

Figure 23 shows final energy demand by country. The most striking result is that China is projected to continue to dominate EAS region final energy demand until 2035. China is projected to account for about 52.3 percent of EAS region final energy demand in 2035, down from about 52.8 percent in 2010. Just five countries—China, India, Indonesia, Japan, and Republic of Korea—are projected to account for 86.6 percent of EAS region 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 83.7 percent of the growth in energy demand for the entire EAS region between 2010 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 84.8 percent of the growth in energy demand in the EAS region between 2010 and 2035.

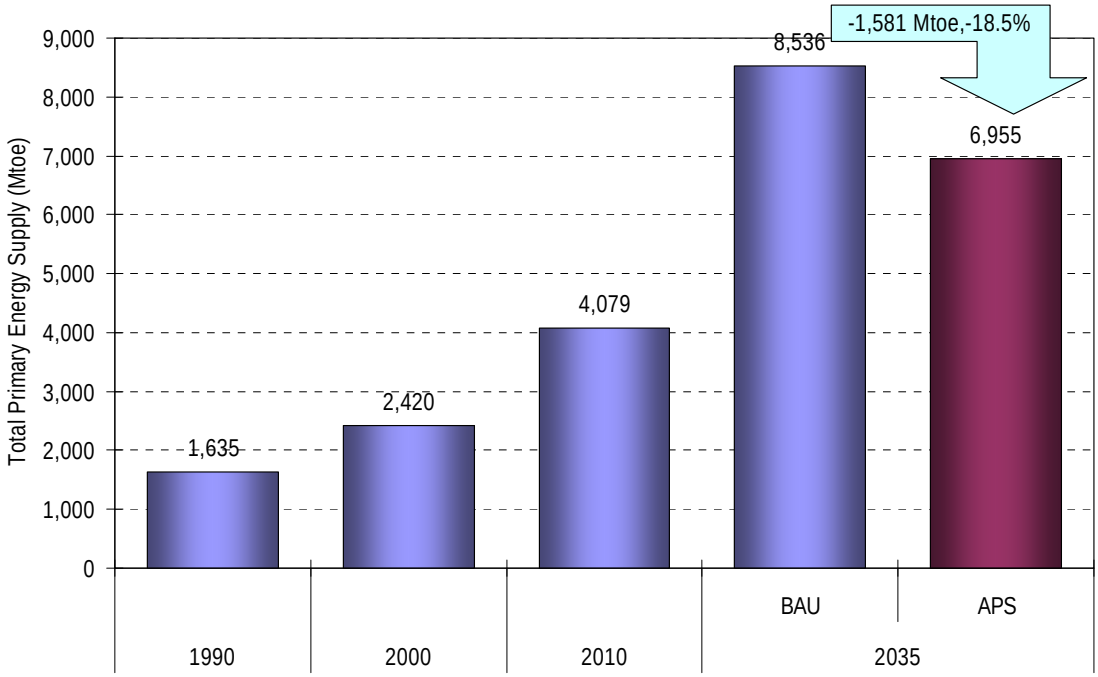
Figure 23: Total Final Energy Demand by Country, BAU and APS



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 24 shows that total primary energy demand is projected to increase from 4079 Mtoe in 2010 to 8536 Mtoe in 2035 in the BAU case, an increase on average of 3.0 percent per year. In the APS case, demand is projected to grow to 6955 Mtoe by 2035, 18.5 percent lower than in the BAU case. The reduction in 2035 primary energy demand in the APS case compared with the BAU case of 1,581 Mtoe is roughly equivalent to 71% of China's demand in 2010.

Figure 24: Total Primary Energy Demand, BAU and APS

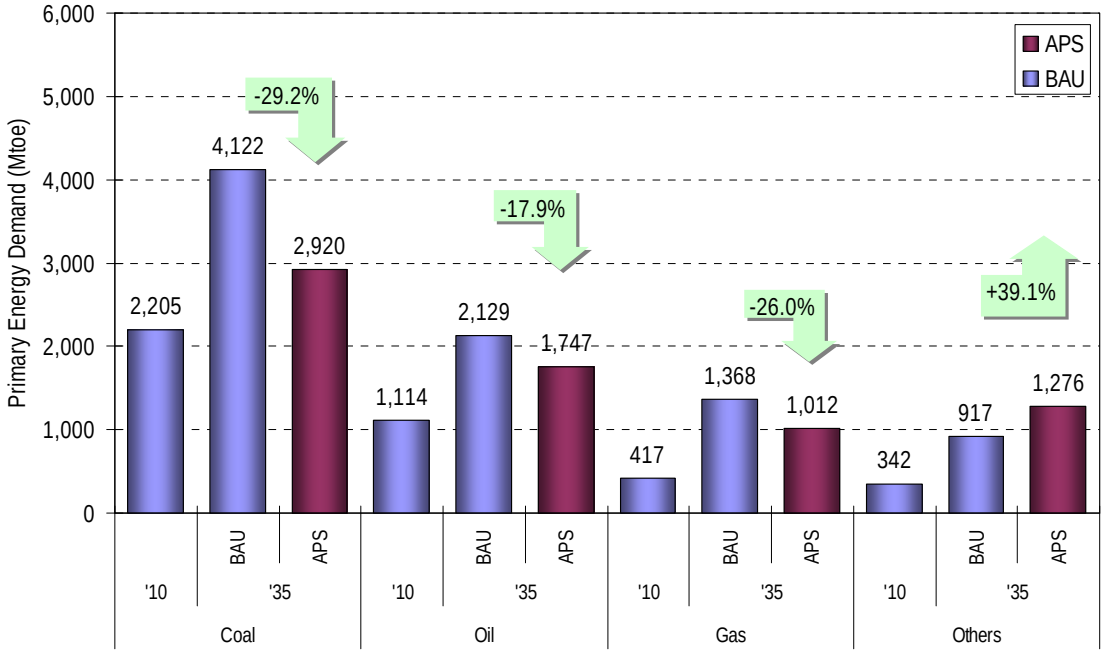


4.2.6.Primary Energy Demand by Source

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 29.2 percent lower in the APS or equivalent to 1202 Mtoe, more than half of EAS coal demand of 2206 Mtoe in 2010. 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 382 Mtoe or 17.9 percent. This is due to the combined effect or more efficient vehicles and the utilization 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 26.0 percent of the BAU, equivalent to 356 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 39.1 percent in the APS as compared to BAU.

Figure 25 shows primary energy demand by energy source in both scenarios.

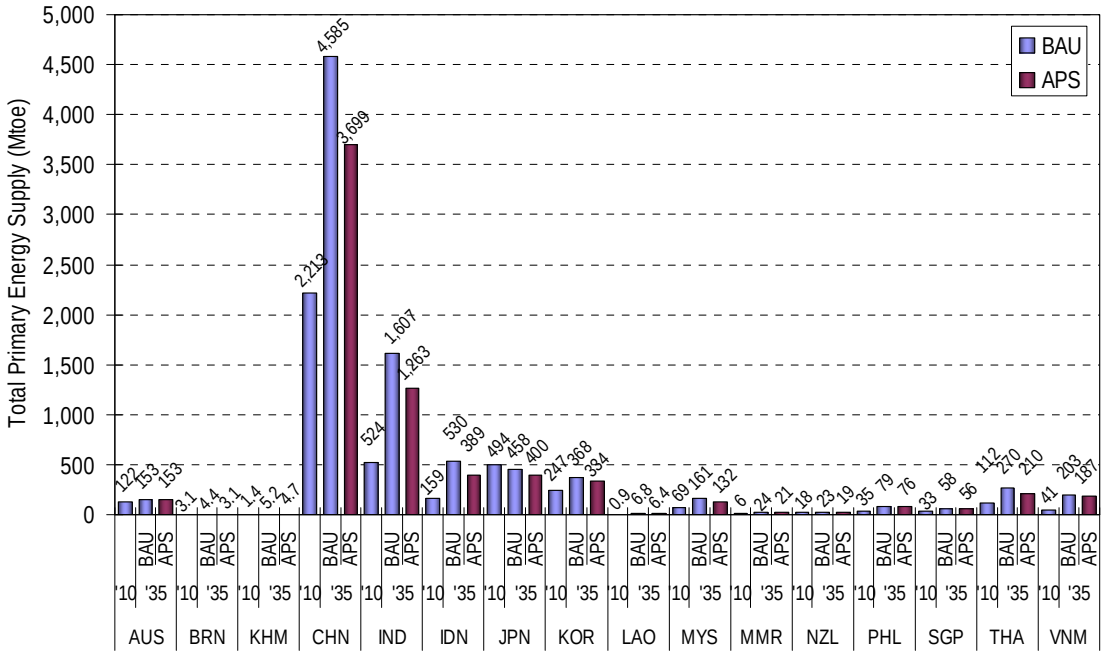
Figure 25: Primary Energy Demand by Source, BAU and APS



4.2.7.Primary Energy Demand by Country

Figure 26 shows primary energy demand by country, which is similar to the pattern for final energy demand by country shown in Figure 23. Five countries - China, India, Indonesia, Japan, and Republic of Korea - are projected to account for 88.5 percent of EAS region primary energy in 2035. The 'big three' - China, India, and Indonesia - will dominate the growth in EAS region primary energy, accounting for 86.0 percent of the growth between 2010 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 26: 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

	2010	2035		Variance		
		BAU	APS	APS/BAU	2010/2035 BAU	2010/2035 APS
	(toe/million US$)	(toe/million US$)	(toe/million US$)	%	%	%
Australia	218	106	106	0.0	-51.4	-51.4
Brunei Darussalam	456	324	233	-28.3	-28.9	-49.0
Cambodia	175	140	123	-12.1	-19.9	-29.6
China	682	360	290	-19.3	-47.2	-57.4
India	526	299	235	-21.4	-43.1	-55.3
Indonesia	577	516	379	-26.7	-10.6	-34.4
Japan	98	67	58	-12.7	-31.9	-40.6
Korea	309	213	194	-9.1	-30.9	-37.2
Lao PDR	260	362	339	-6.2	39.4	30.8
Malaysia	470	427	350	-18.0	-9.1	-25.5
Myanmar	297	217	193	-10.8	-27.1	-35.0
New Zealand	266	198	165	-16.5	-25.7	-38.0
Philippines	270	153	149	-2.8	-43.3	-44.9
Singapore	200	133	129	-3.1	-33.2	-35.3
Thailand	598	557	435	-22.0	-6.9	-27.4
Viet Nam	651	589	542	-8.0	-9.5	-16.7
Total	348	270	220	-18.5	-22.5	-36.8

4.3. Carbon Dioxide (CO_2) Emissions from Energy Consumption

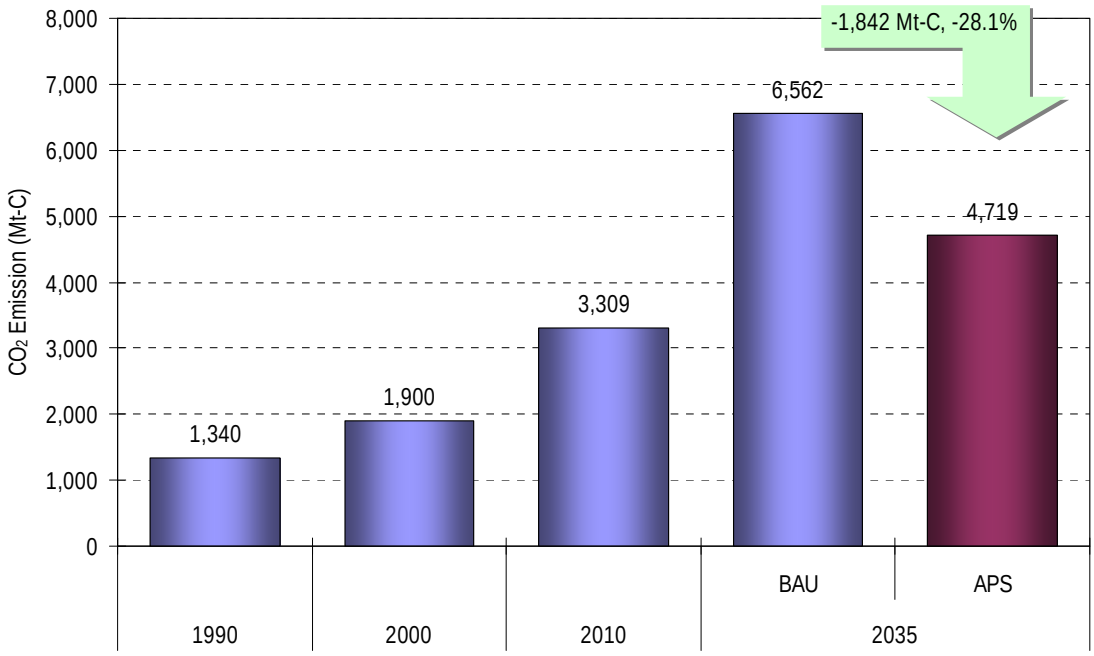
4.3.1.CO_2 Emissions

As shown in Figure 27, CO_2 emissions from energy consumption in the BAU case are projected to increase from 3309 million tonnes of Carbon (Mt-C) in 2010 to 6561 Mt-C in 2035, implying an average annual growth rate of 2.8 percent. This is slightly lower than the growth in total primary energy demand of 3.0 percent per year. In the APS case, CO_2 emissions are projected to be 4718 Mt-C in 2035, 28.1 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 2010 levels and far 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 much 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.[12]

Figure 27: Total CO_2 Emissions, BAU and APS



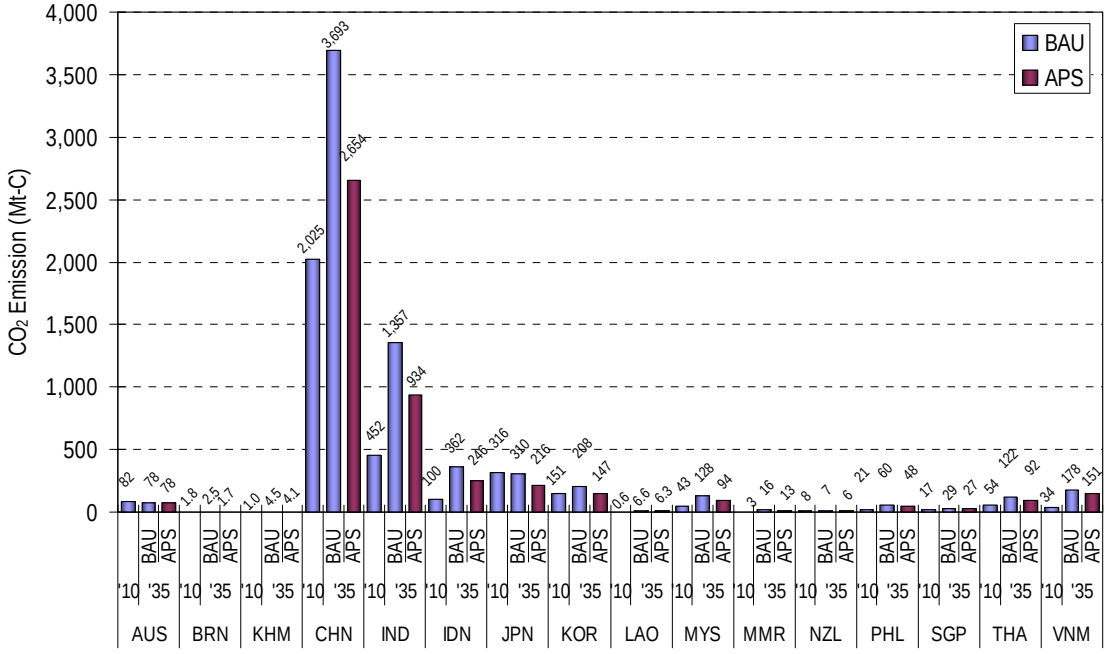
Although much depends on the mitigation achieved in other regions, it would appear unlikely that global emissions could meet either of these profiles given the contribution of the EAS region to global total emissions under the APS results. Yet the consequences of insufficient reductions in emissions 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

[12] 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.

could experience coastal flooding each year.[13]

As shown in Figure 28, 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 1668 Mt-C and 905 Mt-C, respectively, of the projected 3251 Mt-C increase in EAS region emissions from 2010 to 2035 under the BAU case, or 79.1 percent of the total growth in the EAS region. Adding Indonesia's growth of 263 Mt-C, these three countries account for 2835 Mt-C or 87.2 percent of the total growth in EAS region. No other country will account for growth of more than 150 Mt-C. Australia, Japan and New Zealand are the only countries in the EAS region whose emissions are projected to decline under the BAU case as a result of improved energy efficiency and increased utilisation of renewable energy.

Figure 28: CO_2 Emissions by Country, BAU and APS



Under the APS case, China and India are still dominant, accounting for 629 and 482 Mt-C, respectively, of the projected 1409 Mt-C growth in emissions in the EAS region between 2010 and 2035, or 79.6 percent. Adding 146 Mt-C from Indonesia,

[13] 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^{o} C of temperature increase has already occurred, as per this same report, Figure SPM.1.

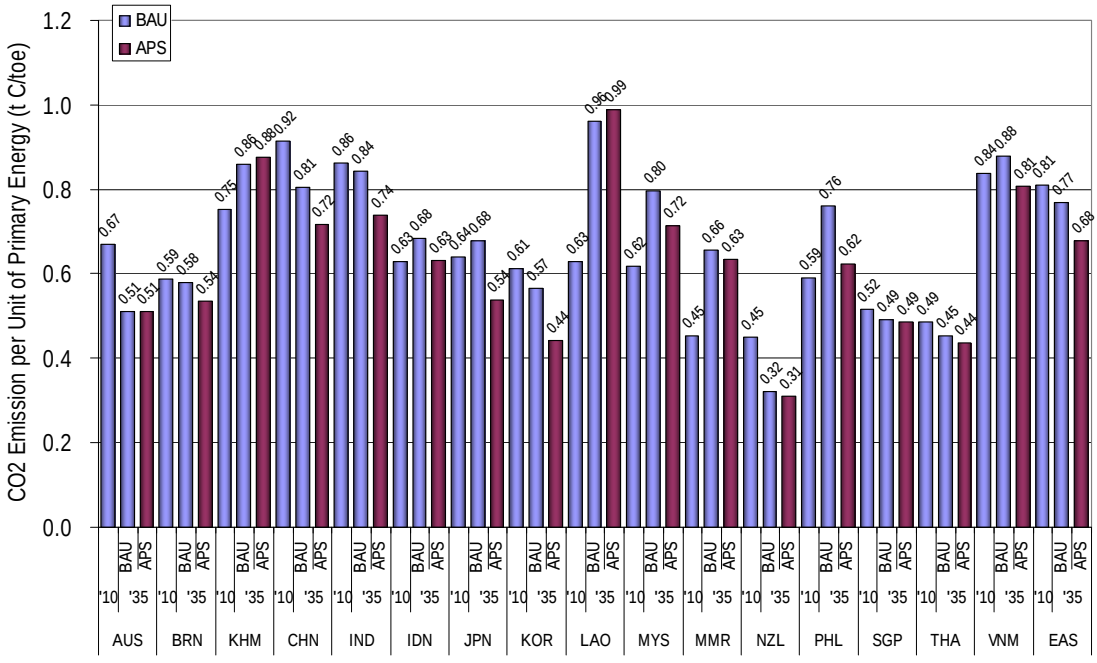
these three countries account for 1258 Mt-C or 89.3 percent of the EAS region total. No other country will account for a growth of more than 117 Mt-C. Emissions from Australia, Brunei Darussalam, Japan, the Republic of Korea and New Zealand are expected to decline under the APS case relative to 2010 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.

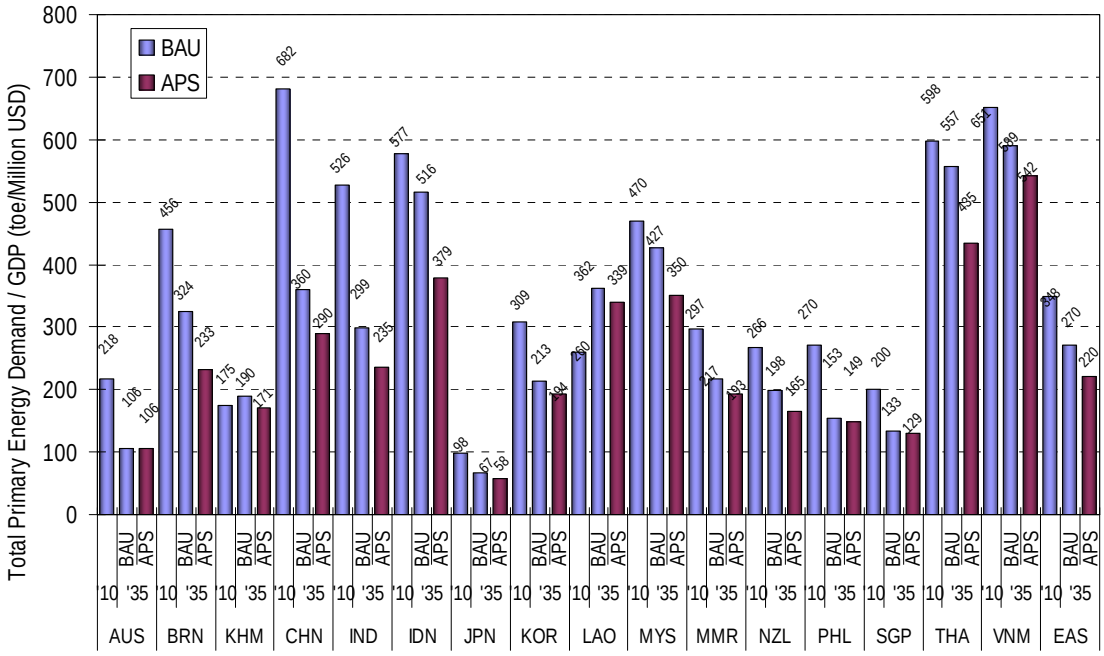
i) Emissions per unit of primary energy are projected to decline to 0.77 t-C/toe in 2035 from 0.81 t-C/toe in 2010 under the BAU case. Under the APS case, this will decline to 0.68 t-C/toe in 2035, equivalent to a decline of 16.3 percent from 2010 (Figure 29). The reduction under the APS case reflects a shift away from coal and oil, the two most emission-intensive fuels.

Figure 29: Emissions per Unit of Primary Energy, BAU and APS



ii) Primary energy per unit of GDP is projected to decline from 348 toe/million US$ in 2010 to 270 toe/million US$ in 2035 under the BAU case, or by 22.5 percent (Figure 30). Under the APS case, this will decline to 220 toe/million US$ in 2035, or by 36.8 percent. The lower emissions under the APS case reflects projected improvements in energy intensity. Looking at (i) and (ii) in combination, emissions per unit of GDP will decrease from 283 t-C/million US$ in 2010 to 208 t-C/million US$ in 2035 under the BAU case, or by 26.6 percent. Under the APS, this will decline to 149 t-C/million US$ in 2035, 47.2 percent lower than 2010.

Figure 30: 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 3500 US$/person in 2010 to 8200 US$/person in 2035, an increase of 131.5 percent. Looking at (i), (ii), and (iii) in combination, emissions per person are projected to increase from 1.0 t-C/person in 2010 to 1.7 t-C/person in 2035 under the BAU case, or by 70.0 percent. Under the APS, emissions rise to only 1.2 t-C/person in 2035, or

22.2 percent higher than 2010. 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 3301 million in 2010 to 3850 million in 2035, or by 16.6 percent. Combined, all these drivers lead to growth in emissions from 3309 Mt-C in 2010 to 6561 Mt C in 2035 under the BAU case, or 98.3 percent. Under the APS, emissions grow to 4718 Mt-C in 2035, or 42.6 percent.

5. The Pilot Survey on Residential End-use Energy Consumption

5.1. Research Objective

With the continuous high rate of economic growth and urbanization in the EAS region, household energy consumption has been increasing in recent years. Energy efficiency in the household sector has become a big concern in many countries. Energy saving programs in the sector are being implemented in many countries or are being planned in some countries. This research was carried out from 2010 to determine how energy is consumed in the residential sector in end-use level to serve as basis for formulation of energy saving goals and action plans in the sector and for monitoring performance of energy saving programs.

The survey was carried out again in 2011 to incorporate various lessons learned in the first trial survey. However, in view of the apparent mistake in estimating end-use consumption of appliances that are used at variable loads, an energy efficiency consultant was requested to study how the actual consumption of such kinds of household appliances should be calculated in 2012. The consultant carried out an experiment to determine how to correctly determine the actual consumption of such household appliances. The consultant's report is presented as Annex 1 of this report.

Working group members conducted the survey again to the same respondents using the same methodology from last year to collect more reliable data and reflect more realistic energy consumption structure. As a result, energy consumptions were revised by most respondents, as well as hours of usage and power ratings of electric

appliances. The revised samples and result are shown in the following section.

5.2. Data Collection

The respondents to the survey were selected by the working group members and consist mainly of colleagues and residents in their neighbourhood. A total of 112 respondents from Cambodia, Indonesia, Malaysia, Philippines, Lao PDR, Singapore, Thailand and Viet Nam participated in the survey. Seven of eight countries, except Singapore, asked the same respondents from last year to revise data such as number of appliances, hours of usage and power ratings. Singapore submitted new samples for this project. Respondents increased by 6 from last years' 106 respondents. The profile of the respondents is shown in Table 6.

Table 6: Profile of Pilot Survey Respondents

	n	%
Cambodia	20	18
Lao PDR	11	10
Viet Nam	10	9
Indonesia	17	15
Philippines	17	15
Thailand	12	11
Malaysia	15	13
Singapore	10	9
Total	112	100

The majority of the surveyed respondents live in urban areas, accounting for 66 percent of the participants, with the remainder in rural areas (34 percent) (Figure 31). The histogram in Figure 32 shows that the number of persons per respondent household is concentrated at around 4 to 5 persons. The majority of the respondents live in relatively large houses (Figures 33 and 34).

Figure 31: Share of Respondents in Urban and Rural Areas

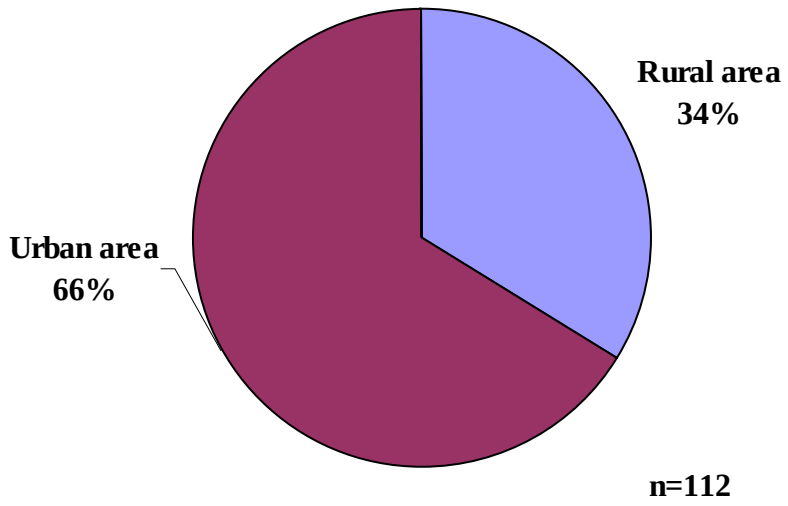


Figure 32: Histogram of Household Size

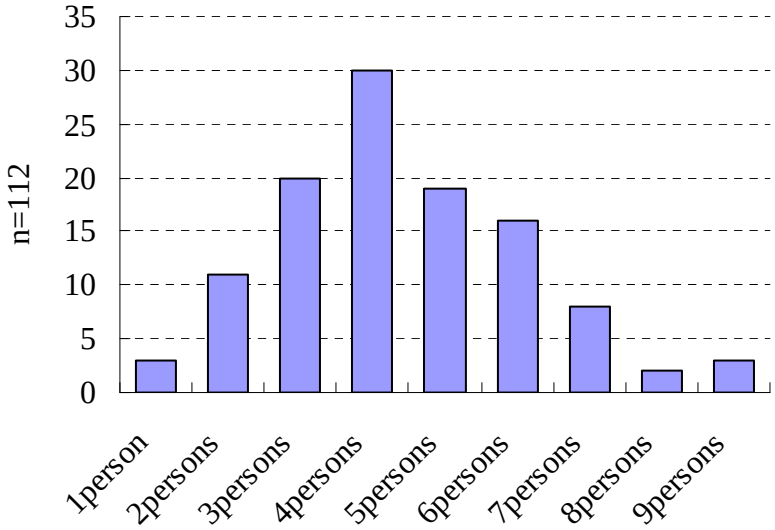


Figure 33: Share of Respondents by Type of Residence

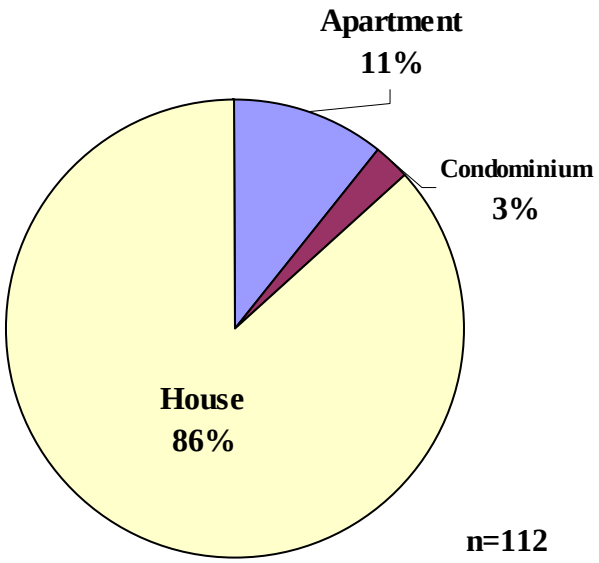
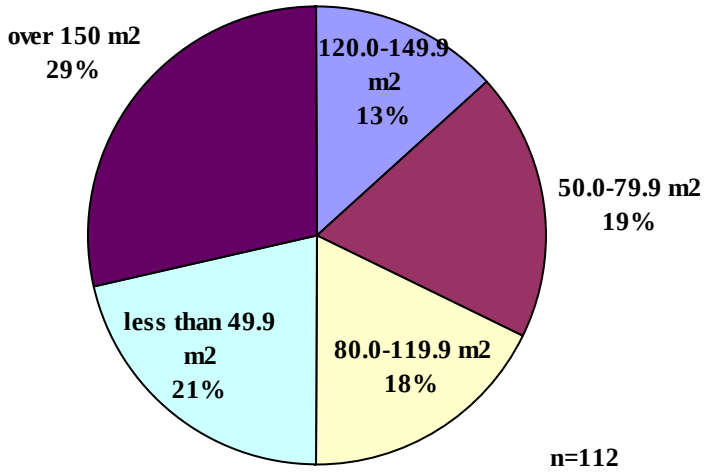


Figure 34: Share of Respondents by Floor Area



5.3. Main Electrical Appliances and Equipment in Households

The ownership of electrical appliances and equipment is much higher in urban areas, with large observed differences in the ownership of air conditioners,

refrigerators, rice cookers, personal computers and washing machines. In particular, there is a stark difference in the ownership of air conditioners - the number of air conditioners in urban and rural areas is 1.28 units and 0.32 units per household, respectively. The ownership of electrical appliances in urban areas is almost as high as in developed countries. The ownership of the three "must have" appliances in Japan such as a television, refrigerator and washing machine in participating countries is almost 1 unit per household in urban areas. Similarly, the number of televisions is almost 1 unit per household, in even rural areas.

Table 7: Main Appliances in Households

	Urban	Rural
A/C	1.28	0.32
Fan	2.64	1.66
Refrigerator	1.03	0.92
Electric stove	0.31	0.27
Microwave	0.79	0.36
Rice cooker	1.05	0.82
CRT	1.09	0.83
LCD	0.98	0.57
Desktop	0.79	0.25
Laptop	1.43	0.75
Washing machine	0.97	0.68

The number of electrical appliances in Singapore, Malaysia, which have the highest per capita incomes among the eight participating countries, is relatively higher. The number of air conditioners in the Philippines is relatively low compared with the other countries. This reflects the high electricity price in the Philippines which is about 23 US cents per kWh, the second highest in the ERIA region, following Japan at 28 US cents per kWh. As a result, awareness of energy savings in the Philippines is expected to be higher than other countries.

Table 8: Main Appliances in Households by country

	Cambodia *	Lao PDR*	Vietnam	Indonesia	Philippines	Thailand*	Malaysia	Singapore	Total
A/C	0.70	1.45	0.40	0.47	0.06	1.75	1.80	1.60	0.96
Fan	1.95	2.27	1.90	1.35	2.35	2.58	3.67	2.60	2.30
Refrigerator	1.00	0.91	1.00	0.71	1.00	1.33	1.07	1.10	1.00
Electric stove	-	0.00	-	0.00	-	0.67	1.20	0.71	0.30
Microwave	1.00	0.64	1.00	0.12	1.00	1.00	1.00	0.83	0.70
Rice cooker	1.00	1.00	1.00	0.71	1.00	1.18	1.13	1.00	0.99
CRT	1.10	0.64	1.00	0.82	1.07	1.00	1.22	1.17	0.99
LCD	1.00	0.64	1.00	0.47	1.00	1.56	1.00	1.17	0.88
Desktop	1.00	0.27	1.00	0.35	1.25	0.67	1.00	1.17	0.68
Laptop	1.13	0.82	-	0.53	1.20	1.83	2.00	2.63	1.31
Washing machine	1.00	0.82	1.00	0.47	1.00	1.08	1.07	1.00	0.90

(*) Most respondents of Lao PDR, Cambodia and Thailand live in urban areas.

5.4. Hours of Usage of Cooling and Ventilation

The ASEAN region has a moderate climate with an average temperature of 29^{o}C and a maximum temperature of around 40^{o}C.[14] Therefore, the use of air-conditioning is much higher than in countries with cooler climates. As shown in Table 9, each day, on average, air conditioners are used for 2.0 hours and fans for 4.6 hours.

One exception is the Philippines, where there is a low penetration of air conditioners and the average operation is close to 0 hours per day as a result of high electricity prices. In Lao PDR, air conditioners and electric fans were used for only 2 hours per day because of the relatively cooler climate. In Singapore, which has higher income level, the average operation is 7.8 hours per day.

[14] Retireasia.com (n.d.)

Table 9: Hours Used per Day for Cooling

	A/C		Fan	
	Days per month	Hours usage per day	Days per month	Hours usage per day
Cambodia*	9.6	3.0	14.2	9.1
Lao PDR*	5.5	2.2	11.3	2.7
Vietnam	0.0	0.0	6.5	5.2
Indonesia	10.2	2.5	17.4	2.6
Philippines	0.0	0.0	29.8	6.1
Thailand*	16.8	4.8	22.8	3.8
Malaysia	14.7	2.2	29.5	5.2
Singapore	24.0	7.8	29.6	8.4

5.5. Residential Energy Consumption

5.5.1. Monthly Energy Consumption by Energy Use

The average energy consumption between September 2011 and February 2012 including non-commercial energy or biomass in rural and urban areas was 2195 Megacalories (Mcal) and 2069 Mcal per household, respectively. In general, energy consumption per household in both urban and rural areas increases with higher incomes with the exception of the Philippines. Energy consumption in Malaysia, which has a high per capita income, is much higher than the lower income countries. In addition, it was observed that the electricity price also affected energy usage. For example, despite being in the middle income range of the surveyed countries, energy consumption in the Philippines is relatively low because of its high electricity price. The high electricity price has encouraged consumers in the Philippines to be more aware of their energy use as illustrated by the relatively lower use of air conditioners.

Table 10: Energy Usage by Country

(Mcal/household)

		Electricity	LPG	Kerosene	Biomass	Total	n	Number of household	Floor space
Rural area									
	Cambodia	122.0	43.0	3.1	1,741.7	1,909.7	10.0	6.2	45.0
	Vietnam	536.3	198.8	0.0	2,226.7	2,961.7	5.0	3.6	86.0
	Indonesia	159.6	0.0	1,189.8	1,141.7	2,491.1	4.0	4.4	59.3
	Philippines	548.5	610.3	0.0	728.9	1,887.7	5.0	4.6	125.7
	Thailand	1,099.5	728.2	0.0	0.0	1,827.7	7.0	3.8	116.3
	Malaysia	1,391.8	917.5	0.0	0.0	2,309.3	7.0	5.8	120.0
	Total	532.0	347.2	220.0	1,095.9	2,195.1	38.0	4.7	92.0
Urban area									
	Cambodia	1,151.3	502.4	0.0	186.3	1,840.0	10.0	6.4	90.0
	Lao PDR	1,602.0	347.5	0.0	786.4	2,736.0	10.0	4.9	131.4
	Vietnam	1,077.8	388.1	0.0	0.0	1,465.9	8.0	3.6	95.0
	Indonesia	1,604.3	910.2	0.0	0.0	2,514.5	5.0	3.8	106.0
	Philippines	535.5	253.4	0.0	16.0	804.9	10.0	3.5	53.5
	Thailand	1,339.8	21.2	0.0	0.0	1,361.1	10.0	2.8	109.4
	Malaysia	2,451.4	662.6	0.0	0.0	3,114.0	11.0	4.0	142.0
	Singapore	1,339.8	21.2	0.0	0.0	1,361.1	10.0	3.8	105.0
	Total	1,476.4	435.2	0.0	157.4	2,069.0	64.0	4.1	104.0
Share(%)									
Rural area									
	Cambodia	6.4	2.2	0.2	91.2	100.0			
	Vietnam	18.1	6.7	0.0	75.2	100.0			
	Indonesia	6.4	0.0	47.8	45.8	100.0			
	Philippines	29.1	32.3	0.0	38.6	100.0			
	Thailand	60.2	39.8	0.0	0.0	100.0			
	Malaysia	60.3	39.7	0.0	0.0	100.0			
	Total	24.2	15.8	10.0	49.9	100.0			
Urban area									
	Cambodia	62.6	27.3	0.0	10.1	100.0			
	Lao PDR	58.6	12.7	0.0	28.7	100.0			
	Vietnam	73.5	26.5	0.0	0.0	100.0			
	Indonesia	63.8	36.2	0.0	0.0	100.0			
	Philippines	66.5	31.5	0.0	2.0	100.0			
	Thailand	98.4	1.6	0.0	0.0	100.0			
	Malaysia	78.7	21.3	0.0	0.0	100.0			
	Singapore	98.4	1.6	0.0	0.0	100.0			
	Total	71.4	21.0	0.0	7.6	100.0			

5.5.2. Energy Consumption by End Use

Table 11 shows the average household residential energy consumption, disaggregated by end-use, between September 2011 and February 2012. In urban areas, 13 percent of energy consumption was used for cooling, 24 percent for cooking and other kitchen use and 17.6 percent for refrigeration. The remaining energy use was attributed to water heating (12 percent), lighting (13 percent) and other appliances (21 percent). In rural areas, 59 percent was used for cooking and 18 percent was used for water heating. The major energy source used for cooking and water heating is biomass such as wood, wood waste and rice husks. The remaining energy use in rural areas, which include refrigerators, lighting and other appliances, is less than 10 percent of total consumption. This is because the ownership of electrical appliances in rural areas is quite low in the eight countries.

Table 11: Energy Consumption by End Use

(Mcal/household)

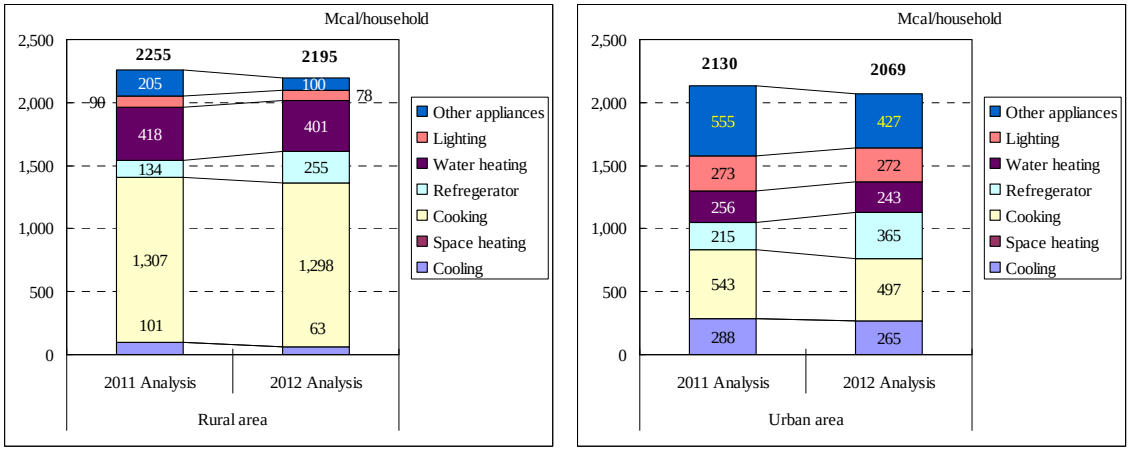
		Cooling	Space heating	Cooking	Refregerator	Water heating	Lighting	Other appliances	Total	n	Number of household	Floor space
Rural area												
	Cambodia	1.8	0.0	1,653.4	0.0	134.2	60.0	60.3	1,909.7	10.0	6.2	45.0
	Vietnam	11.1	0.0	1,923.2	225.3	530.7	41.0	230.4	2,961.7	5.0	3.6	86.0
	Indonesia	14.8	0.0	1,768.8	110.4	570.9	11.3	15.0	2,491.1	4.0	4.4	59.3
	Philippines	109.3	0.0	676.1	266.9	667.6	25.0	142.9	1,887.7	5.0	4.6	125.7
	Thailand	88.9	0.0	668.2	578.7	144.0	127.6	220.3	1,827.7	7.0	3.8	116.3
	Malaysia	222.6	0.0	678.1	721.1	396.2	279.0	12.2	2,309.3	7.0	5.8	120.0
	Total	63.4	0.0	1,298.1	254.9	400.6	78.0	100.1	2,195.1	38.0	4.7	92.0
Urban area												
	Cambodia	205.4	2.1	547.0	255.9	173.0	202.1	454.5	1,840.0	10.0	6.4	90.0
	Lao PDR	147.2	0.0	979.2	390.5	456.5	592.6	170.0	2,736.0	10.0	4.9	131.4
	Vietnam	14.2	0.0	376.3	332.8	52.1	52.3	638.2	1,465.9	8.0	3.6	95.0
	Indonesia	367.7	0.0	579.2	348.3	373.7	124.6	721.1	2,514.5	5.0	3.8	106.0
	Philippines	126.0	0.0	238.1	287.5	55.4	23.4	74.6	804.9	10.0	3.5	53.5
	Thailand	499.2	0.0	100.7	508.6	10.6	195.8	46.3	1,361.1	10.0	2.8	109.4
	Malaysia	358.0	0.0	555.3	497.7	382.9	599.4	720.6	3,114.0	11.0	4.0	142.0
	Singapore	335.9	2.1	410.7	308.8	273.7	229.3	645.1	2,205.6	10.0	3.8	105.0
	Total	265.0	0.6	496.8	365.0	242.6	272.1	426.9	2,069.0	74.0	4.1	104.0

Share(%)								
Rural area								
	Cambodia	0.1	0.0	86.6	0.0	7.0	3.1	3.2	100.0
	Vietnam	0.4	0.0	64.9	7.6	17.9	1.4	7.8	100.0
	Indonesia	0.6	0.0	71.0	4.4	22.9	0.5	0.6	100.0
	Philippines	5.8	0.0	35.8	14.1	35.4	1.3	7.6	100.0
	Thailand	4.9	0.0	36.6	31.7	7.9	7.0	12.1	100.0
	Malaysia	9.6	0.0	29.4	31.2	17.2	12.1	0.5	100.0
	Total	2.9	0.0	59.1	11.6	18.2	3.6	4.6	100.0
Urban area								
	Cambodia	11.2	0.1	29.7	13.9	9.4	11.0	24.7	100.0
	Lao PDR	5.4	0.0	35.8	14.3	16.7	21.7	6.2	100.0
	Vietnam	1.0	0.0	25.7	22.7	3.6	3.6	43.5	100.0
	Indonesia	14.6	0.0	23.0	13.9	14.9	5.0	28.7	100.0
	Philippines	15.7	0.0	29.6	35.7	6.9	2.9	9.3	100.0
	Thailand	36.7	0.0	7.4	37.4	0.8	14.4	3.4	100.0
	Malaysia	11.5	0.0	17.8	16.0	12.3	19.2	23.1	100.0
	Singapore	15.2	0.1	18.6	14.0	12.4	10.4	29.2	100.0
	Total	12.8	0.0	24.0	17.6	11.7	13.2	20.6	100.0

5.6. Comparison of result from previous project

In this project, power ratings for air conditioner, fan, lighting, electric stove and microwave oven were revised from rated power to operating power (Operating power = rated power*0.5-0.6). Working group members attempted to estimate end use energy consumption with reference to revised power rating information. As the result, energy consumptions for cooling, cooking and lighting were revised downward (Figure 35).

Figure 35: Comparison of End-use Energy Consumption between Estimates in 2011 and 2012



5.7. Lessons from the Survey

The survey was able to assist in disaggregating household energy consumption by end-use. The information contained in this survey was able to help determine the most energy consuming end-use applications, which can assist policy makers in the formulation of energy efficiency programs.

6. Conclusions and Recommendation

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

6.1. Key Findings

Based on 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. These 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 2.6 times from 2010. 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 2010 to 2030, is projected to improve to 0.73 (3.0/4.1) as compared to 1.34 (4.7/3.5) from 1990 to 2010.

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 0.68, 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 54.1 percent in 2010 to 48.3 percent in

2035. On the other hand, gas share will increase to 16.0 percent from 10.2 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 2010 was 8.1 percent but it will increase to 10.7 percent in 2035.

3. The EAS energy mix in the BAU will change from 2010 to 2035. Coal and oil will decrease their share from 81.6 percent to 73.2 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:

    - 18.5 percent in primary energy demand
    - 18.5 percent in energy intensity
    - 28.1 percent in energy derived CO_2 emissions.

6.2. Policy Implications

Based on the above key findings, the working group members identified a number of policy implications which were aggregated into five major categories. The

identified policy implications are based on a shared desire to enhance action plans in specific sectors, prepare appropriate energy efficiency policies, shift from fossil energy to non-fossil energy, rationalize energy pricing mechanisms, and 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 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 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:

- Lengthening the life span of manufacturing facilities and equipment - Lengthening the replacement cycle of industrial facilities will reduce the demand for energy intensive goods such as cement and steel. In addition, producing manufactured durable goods with longer life span will also reduce the need for frequent replacement of and consequently, the need for more energy.
- 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)
- Improving 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
- 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 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.

d. ***Rationalizing Energy Pricing Mechanism***

The WG group members recognized that distorted energy price is a barrier to the effective implementation of energy efficiency policies. It was therefore suggested that energy prices should be rationalized to reflect the real cost of energy while ensuring that the most vulnerable sectors of the society are still able to use energy. Rationalizing 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 recognized 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. In this regard, the WG conducted the pilot surveys in 2010 and 2011 to enhance the developing countries' capability in collecting end-use energy consumption data in the residential sector. However, it was observed that actual electricity consumption is quite different from estimated electricity consumption based on power ratings in the name plate or in the catalogues. The WG requested an expert to improve the estimation methodology and the expert suggested to apply a "diversity factor" for each appliance. The sample data collected by the pilot survey were revised using the "diversity factor". Through the analysis of the revised sample data, the WG noted the improvement on end-use energy consumption patterns. The WG hopes that end-use energy statistics become available in all energy consuming sectors in order to be able to conduct assessment of targets in each subsectors.

6.3. Recommendations

The analysis in this report indicates that there is significant potential for countries in the EAS region to reduce growth in energy consumption and CO_2 emissions by implementing policies across all sectors of the economy that encourage

improvements in energy efficiency and conservation and increase the use of lower emission technologies and fuels.

It is clear that many EAS countries already have a variety of policies aimed at achieving energy saving goals. However, it is recommended that detailed action plans which outline in a broad sense how these energy savings will be achieved should also be developed especially in industry and road transport sectors. Energy management is one of 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 road transport sector. Rationalizing 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, which covered both urban and rural areas, has contributed to improving the capability to collect energy consumption statistics. It is recommended that a national energy consumption survey be conducted in all sectors in EAS countries, applying the experience and know-how obtained through the pilot survey.

The projected level of energy savings and reduction in CO_2 emissions will be significant if all of the energy saving and low emission fuel policies proposed at the 6th Energy Ministers Meeting in September 2012 were implemented in EAS countries. Although enhanced energy efficiency and an increase in the share of low emission and renewable fuels in the energy mix may also have other benefits such as increasing energy supply diversity and enhancing energy security, these measures are not 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 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 scheme to support the inter-regional collaboration on technology transfer may be associated with implementing more energy efficient technologies and increasing the share of renewable energy sources.

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