PART I. MAIN REPORT

Chapter 1

Main Report

June 2011

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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 in 2008 and 2009 to incorporate more recent information and estimation procedures and incorporate further information about energy saving potentials and energy efficiency goals, action plans and policies. The study was again updated in 2010 to undertake the following:

- Reflect the energy efficiency goals and actions plans submitted by the energy ministers during the 4th EAS Energy Minister's Meeting (EMM) held in Da Lat, Viet Nam on 22 July 2010 in the latest energy outlook until 2030 ;
- Conduct a pilot end-use energy consumption survey in the residential sector in recognition of the need for more detailed energy statistics in the estimation of the energy saving potential in the sector; and
- Conduct a bottom-up analysis of energy saving potential in the cement, residential, transportation and building sectors in selected EAS countries.

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].

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

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

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 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, 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. It should be noted that developing countries generally have less energy consumption per capita compared to developed countries. However, as the economies of these countries grow, it should be expected that energy consumption per capita will grow as well. Table 1 shows the geographic, demographic and economic profiles of the 16 EAS countries. Table 2 shows their economic structure and energy consumption profile.

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[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.

Table 1. Geographic, Demographic, and Economic Profiles, 2008

	Land Area (thousand sq.km.)[1]	Population (thousands)	Population Density (persons/ sq.km.)	GDP (Billion 2000US$)[2]	GDP per Capita (2000US$/ person)
Australia	7,682	21,432	2.79	521.54	24,335
Brunei Darussalam	5.3	392	74.4	7.26	18,507
Cambodia	181	14,562	80.4	7.44	511
China	9,327	1,324,655	142.0	2,602.57	1,965
India	2,973	1,139,965	383.4	817.94	718
Indonesia	1,812	227,345	125.5	247.23	1,087
Japan	365	127,704	350.4	5,166.28	40,455
Korea, Rep.	97	48,607	501.5	750.81	15,447
Lao PDR	231	6,205	26.9	2.95	475
Malaysia	329	27,014	82.2	139.16	5,151
Myanmar	654	49,563	75.8	18.84	380
New Zealand	268	4,269	15.9	64.01	14,995
Philippines	298	90,348	303.01	110.71	1,225
Singapore	0.697	4,839	6,943	135.46	27,991
Thailand	511	67,386	131.9	177.92	2,640
Vietnam	310	86,211	278.0	55.80	647

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

[2] GDP data of Brunei Darussalam and Myanmar are estimated based on real GDP growth rate in 2008 obtained from Asian Development Bank

Source: World Bank 2010. *World Development Indicator CD-ROM 2010.* Washington DC, Government of Cambodia and Asian Development Bank.

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].

[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 2. Economic Structure and Energy Consumption, 2008

	GDP (Billion 2000US$)	Share of Industry In GDP, %[1]	Share of Services in GDP, %[1]	Share of Agriculture in GDP, %[1]	Energy Consumption (Mtoe)	Energy Consumption per Capita (toe/person)
Australia	503.0	29.1	68.4	2.5	129.0	6.0
Brunei Darussalam	7.0	71.0	28.3	0.7	3.6	9.3
Cambodia	7.1	23.9	41.5	34.6	1.7	0.12
China	2,387.7	48.6	40.1	11.3	1,915.8	1.4
India	771.1	28.8	53.7	17.5	486.9	0.4
Indonesia	233.1	48.1	37.5	14.4	153.6	0.7
Japan	5,206.0	29.3	69.3	1.4	491.1	3.8
Korea, Rep.	734.5	37.1	60.3	2.5	227.2	4.7
Lao PDR	2.7	28.2	37.1	34.7	0.9	0.15
Malaysia	133.0	47.7	42.0	10.2	71.1	2.6
Myanmar	16.9	16.2	35.4	48.4	5.9	0.12
New Zealand	64.2	25.5	68.0	6.4	17.2	4.0
Philippines	106.6	31.6	53.5	14.9	36.9	0.4
Singapore	133.9	27.8	72.2	0.1	18.5	3.8
Thailand	173.8	44.2	44.2	11.6	101.0	1.5
Vietnam	52.6	39.7	38.2	22.1	35.4	0.4

Note: [1] Sectoral shares to GDP of Brunei Darussalam, Japan and Malaysia are 2007 values while those of Myanmar and New Zealand are the values in 2004 due to absence of more up-to-date data.

Sources: World Bank (2010) *World Development Indicators CD-ROM 2010*. Washington DC and International Energy Agency (IEA) (2010) *Energy Balances of OECD Countries 2010 and Energy Balances of Non-OECD Countries 2010*, 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.

To be able to design an action plan or policy measures to reduce energy consumption,

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

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 2010

In 2010, the WG continued to assess energy saving potentials in the EAS region using the goals, action plans and policies reported at the 4th EAS Energy Ministers Meeting (EAS-EMM4). The WG in 2010 enhanced and extended the analysis that was undertaken from 2007 to 2009. The WG conducted two meetings in Jakarta and one meeting in Singapore from September 2010 to April 2011.

During the first meeting, the WG discussed and developed the 2010 research plan and provided updates on revised energy saving goals, action plans and policies of each EAS country reported in 2010. The research plan included the conduct of a small survey in the residential sector using a questionnaire and estimation of end-use energy consumption using the results of the small survey. During the meeting the WG designed the questionnaire to be used in the small survey and the WG members were asked to ask their colleagues in their respective countries to respond to the survey. The Sub-Working Group on Energy Efficiency Design was also asked to conduct a bottom-up analysis of energy efficiency in selected sectors in selected countries.

During the second meeting, the WG members presented the preliminary results of the energy saving potential analysis and submitted the accomplished questionnaires from their respective countries. The questionnaires were processed using a computer program developed by IEEJ and the WG discussed the results. It was noted that the questionnaire is not simple and respondents would need the assistance of experts to be able to respond to it. There were also some formulas in the questionnaire that need to be refined. The WG members were also asked to revise the questionnaires to reflect the correct power ratings of certain appliances. The SWG members also presented the preliminary results of their bottom-up analysis in energy saving potential in the cement industry in Vietnam and the Philippines, the building sector in Thailand and Indonesia as well as the residential sector in Lao PDR and Cambodia.

The third meeting was devoted to refining and finalizing the outlook results and extracting policy implications and recommendations from the results. The WG also re-examined the revised responses to the questionnaires. The SWG also presented the final result of their bottom-up analysis in the cement industry in Vietnam, transport sector in Singapore, building sector in Thailand and residential sector in Lao PDR.

1.5. Additional Research Studies

In 2010, two additional research studies were conducted by the WG and its SWG on Energy Efficiency Design. These are the pilot residential end-use energy consumption survey and the analysis of energy saving potential using the bottom-up approach. The methodologies and results of these studies will be discussed in the latter part of this report.

In addition, other related research studies were commissioned by Japan. Brief descriptions of these studies are also presented in the latter part of this report.

1.5.1. Pilot Residential End-Use Energy Consumption Survey

Recognizing the need to collect more detailed data in the assessment of energy saving potential, the WG decided to conduct a study on appropriate questionnaire for energy consumption surveys in industry, residential and commercial sectors. For the 2010 research study, it was decided to concentrate first on the residential sector by conducting a pilot survey on end-use energy consumption to determine the energy consumption profile of the sector. The results could be used to determine the residential end-use which has the largest energy saving potential. This exercise is considered to give an idea to countries that have not yet charted their energy efficiency plans on how to collect data for the analysis.

1.5.2. Analysis of Energy Saving Potential Using Bottom-up Approach

The WG also considered the need for a bottom-up analysis of energy saving potential in specific sectors in selected countries. The objective of the bottom-up analysis is to determine the energy saving potential if the existing technologies are replaced with more efficient ones in selected sectors. This analysis was carried out by the SWG on Energy Efficiency Design.

1.5.3. Additional Research Activities

The WG also took note of the related independent research studies commissioned by METI of Japan. The WG believes that these studies would complement the analysis that the WG is carrying out and it is important for the WG to keep track of the developments on these projects. These projects are as follows: i) study on the use of low rank coal and utilization of clean coal technology; ii) research on identifying barriers to technology transfer for CO_2 mitigation in East Asia; iii) study on utilization of iron and steel-making slag products for energy saving, CO_2 emission reduction and environment conservation in East Asia; iv) survey analysis of the road transport sector for reducing CO_2 emission; and v) survey on diffusion of smart grid in East Asia.

2. DATA AND METHODOLOGY

2.1. Scenarios Examined

The study continued to examine two scenarios, as in the studies conducted annually from 2007 to 2009, 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 EAS-EMM4 held in July 2010 in Da Lat, Viet Nam 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 are currently unable 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 repeat 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 is not really focused 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 Korea and Lao PDR. Korean 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 Development Indicator CD-ROM 2010 published by the World Bank. 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, 9 of the 10 member countries utilised their own energy models with IEEJ support. In addition, Australia and Korea also used their own national models. 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 Global Trade and Environment Model (GTEM) at the Australian Bureau of Agricultural and Resource Economics (ABARE). GTEM is a computable general equilibrium model of the world economy with detailed sectoral and regional representation. In the electricity, transport and iron and steel sectors, detailed technological and fuel representation is incorporated.

Korea: Korean projections were developed using the KEEI-LEDS (KEEI Long-term Energy Demand System) Model. The Korean KEEI-LEDS model is an energy-economy modelling system of Korean energy markets to 2050. The model projects primary and final energy consumption using assumptions on macroeconomic and demographic factors, world energy prices, behavioural and technological choice criteria and performance characteristics of energy technologies. GDP is endogenously determined and thus differs between the APS and BAU scenario.

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

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, nine member countries used the LEAP model, of which one was developed by IEEJ.

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 2009 Study

In 2009, a study[8] was undertaken 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 2010 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-EMM4 in Da Lat, Viet Nam. Specifically, the following new information is incorporated in this study:

- revised recent energy saving goals, action plans and policies in each country;
- projected future oil prices;
- results of the pilot end-use energy consumption survey in the residential sector; and
- bottom-up analysis of energy saving potential in selected sectors in selected countries.

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[8] ERIA Research Project Report 2009, No. 11, Analysis on Energy Saving Potential in East Asia. www.eria.org.

2.6. Pilot Survey on Residential End-Use Energy Consumption

The conduct of the pilot survey started with the designing of the questionnaire, actual conduct of survey, processing of the returned questionnaire and analysis of the results. It was agreed that WG members would ask at least 10 of their colleagues in their respective countries to participate in the pilot survey.

2.6.1. Designing the Questionnaire

The designing of the questionnaire was carried out during the first WG meeting in 2010. IEEJ prepared a draft questionnaire which was discussed and revised following the suggestions of all WG members. The questionnaire requires for the number of electricity consuming devices in each household including the power rating and hours of operation. From the information, the electricity consumption per end-use can be estimated as follows:

$$End-use_i = \sum_j D_j * PR_j * HPD_j * DPM_j$$

Where i is the type of end use such as lighting, cooking, refrigeration, water heating, etc; while Dj is the type of device, PR is the power rating, HPD is the average number of hours of operation per day and DPM is average number of days of operation per month.

For devices that consume other sources of energy such as oil, gas, coal and biomass, etc., the required data for the number of other devices, average consumption per day and days of usage per month. The energy consumption per end-use is estimated as follows:

$$End-use_i = D_j * ACPD_j * DUPM_j$$

In this formula, *ACP*D is the average energy consumption per day and *DUPM* is the average days of operation per month.

The end-uses are classified as follows:

- Lighting;
- Cooking;
- Water heating;
- Refrigeration;
- Ventilation and Air Conditioning;

- Other appliances; and
- Other uses including stand-by power

2.6.2. Pilot Survey

After the designing of the questionnaire during the first meeting, the IEEJ finalized the questionnaire. The WG leader asked the WG members from ASEAN member states and China to proceed with the pilot survey of their colleagues using the finalized questionnaire.

2.6.3. Processing the Returned Questionnaires

The IEEJ prepared a computer program to process the returned questionnaires. The objective was to get the average consumption of all the respondents per country and determine the most energy consuming end-use. The relationship between household and dwelling size to energy consumption was also analyzed.

2.7. Analysis of Energy Saving Potential in Specific Sectors Using Bottom-up Approach

Four analyses were carried out by the sub-working group on energy efficiency design. These are in the cement industry by Viet Nam, residential sector by Lao PDR, transport sector by Singapore and building sector by Thailand. The reports on these analyses are presented in the annexes.

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.

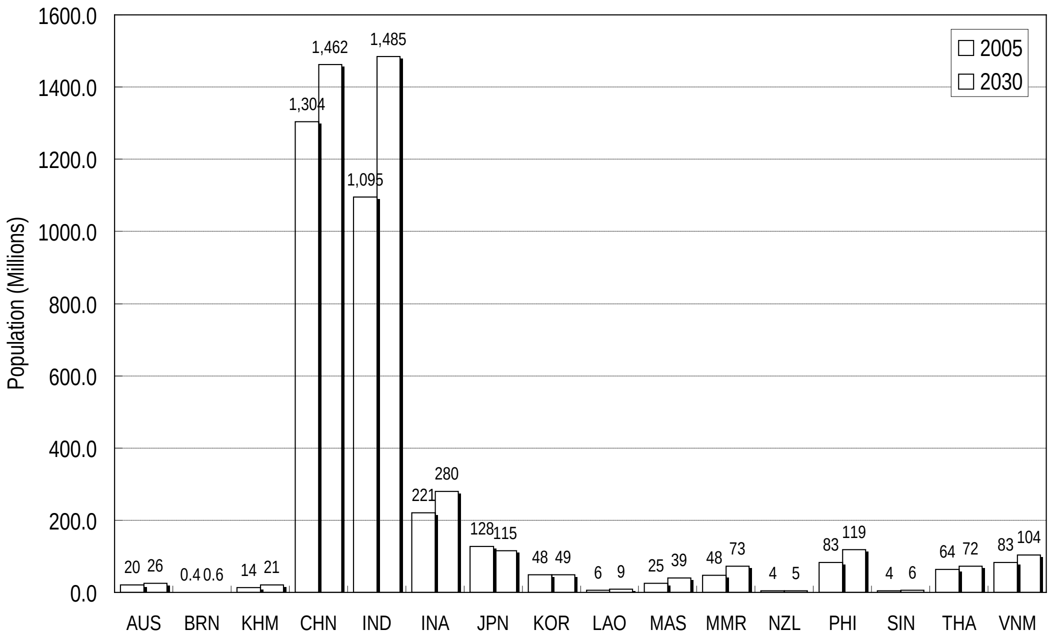
In this section assumptions regarding key socioeconomic indicators and energy policies until 2030 are discussed for the EAS countries.

3.1. Population

In the models used for this study, changes in population to 2030 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 2005, the total population in the EAS region was assumed to be about 3.15 billion – around 50 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 0.8 per cent reaching about 3.86 billion in 2030. Figure 1 shows the 2005 and projected 2030 population by country.

Figure 1. Assumed Population in the EAS Region, 2005 and 2030

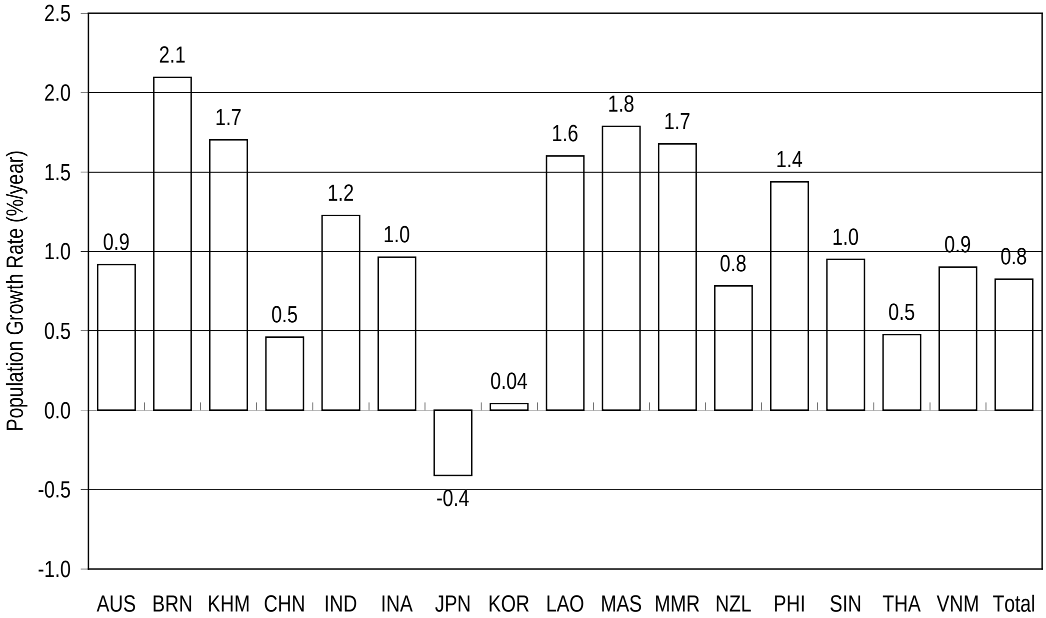


As shown in Figure 2, growth in population is generally assumed to be fastest in developing countries. China and Thailand are notable and significant exceptions, as they are expected to have relatively modest population growth. Nevertheless, by 2030, India and China are assumed to account for about 76 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, 2005 to 2030



3.2. Economic Activity

In the models used for this study, assumed changes in economic output to 2030 are set exogenously. GDP data (in 2000 US$) were obtained from the World Bank.[9] Assumed GDP growth rates to 2030 were submitted by all the EAS countries. In general these assumptions took into account the actual GDP growth rates from 2005 to 2010 which are already reflective of the economic recession in the United States and other countries in the world and the recovery experienced in 2010. No difference in growth rates was assumed between the BAU and APS scenarios.

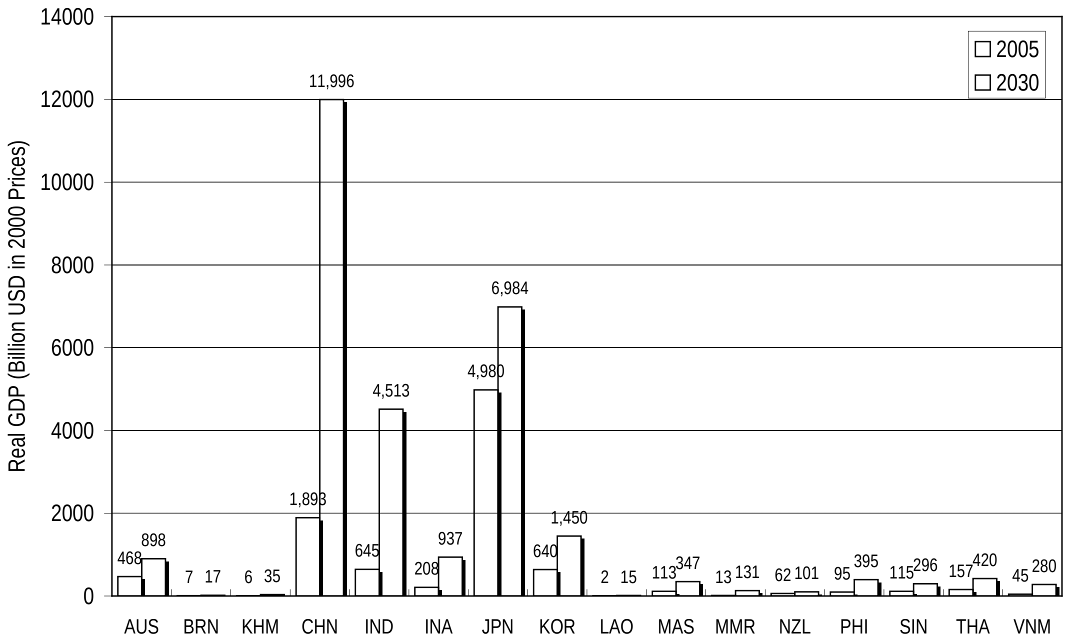
In 2005 total GDP in the EAS region was about 9.4 trillion in 2000 US$ and it accounted for about 22 percent of global GDP. The GDP of the EAS region is assumed to grow at an average annual rate of about 4.6 percent from 2005 to 2030. This implies that by 2030 total GDP in the EAS region will reach about 28.8 trillion in 2000 US$.

In 2005, Japan was the largest economy by far in terms of total economic output: about 5.0 trillion 2000 US$. However, by 2030 China is projected to be the largest economy with an

[9] World Bank (2010) *World Development Indicator CD-ROM 2010.* Washington DC

estimated GDP of about 12.0 trillion 2000 US$. Japan and India are projected to be the next largest economies with projected GDPs of about 7.0 trillion 2000 US$ and 4.5 trillion 2000 US$ respectively in 2030. See Figure 3.

Figure 3. Assumed Economic Activity in the EAS Region



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 China, Myanmar, India, Viet Nam, Cambodia and Lao PDR. 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, New Zealand, and Singapore — are assumed to experience slower, but still significant, economic growth.

Average GDP per capita in the EAS region is assumed to increase from about US$3,000 in 2005 to about US$7,500 in 2030. However, as shown in Figure 5, there is, and will continue to be, significant differences in GDP per capita. In 2005, per capita GDP ranged from about US$280 in Myanmar to about US$39,000 in Japan. In 2030, per capita GDP is assumed to range from about US$1,600 in Cambodia to about US$60,600 in Japan.

Figure 4. Assumed Average Annual Growth in GDP, 2005 to 2030

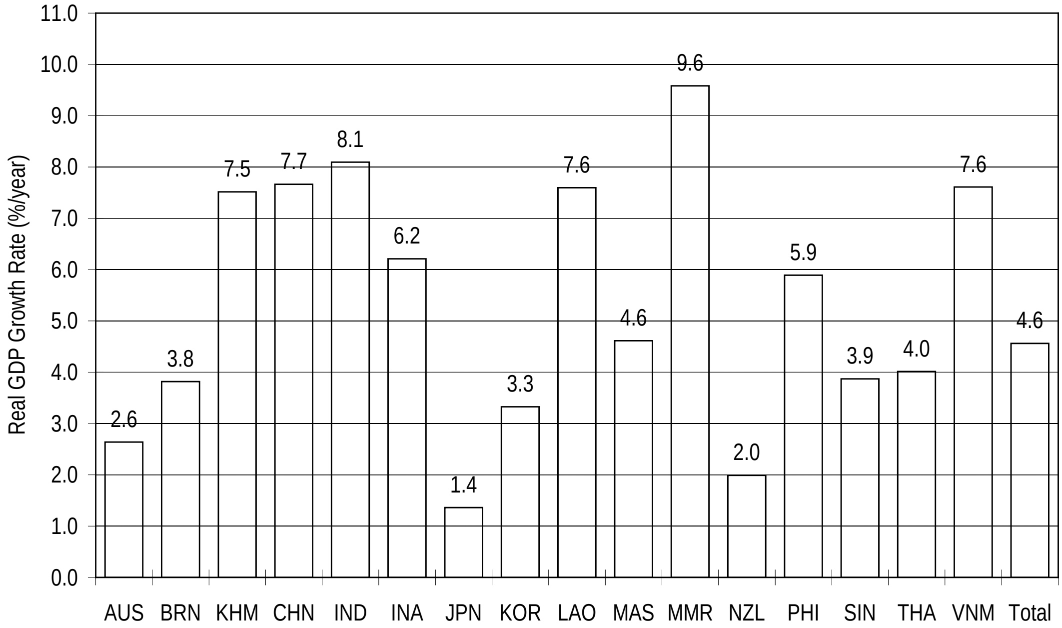
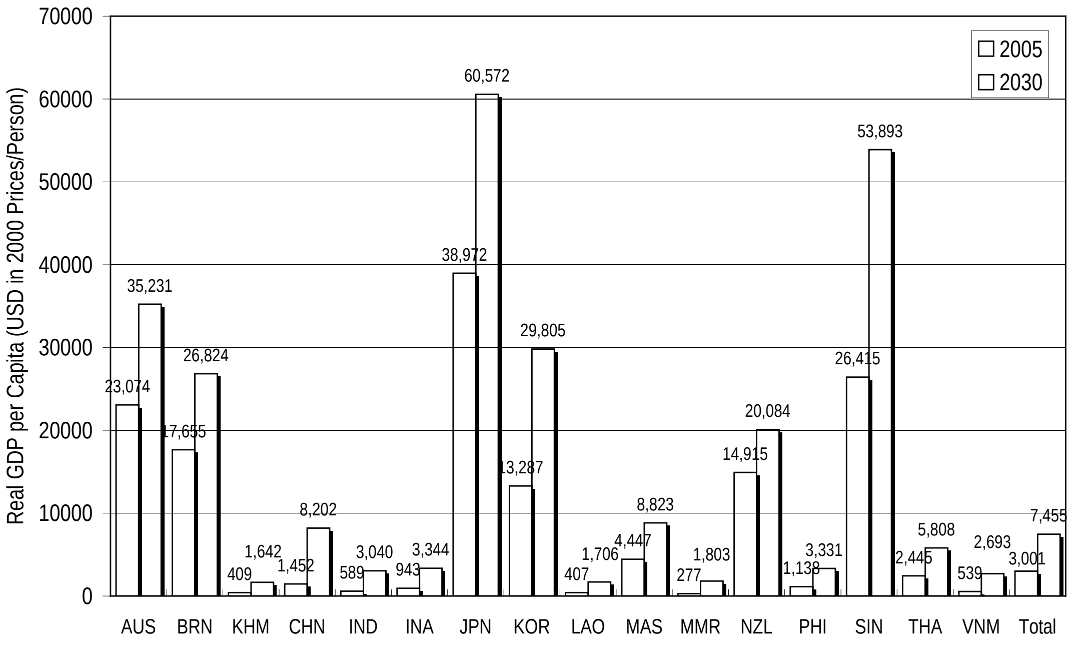


Figure 5. Real GDP per Capita, 2005 to 2030



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 China, India, Japan, Republic of Korea. 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 2030 the number of road vehicles in China and India is projected to increase to about 206 million and 113 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 2005 thermal efficiencies by fuel type (coal, gas, and oil) were derived from International Energy Agency data[10]. Thermal efficiency projections by fuel (coal, gas, and oil) were submitted by the following countries: Australia, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, 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 2010.*

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

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

considerably over time in the BAU scenario as more advanced generation technologies such as natural gas combined cycle and supercritical coal plant 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

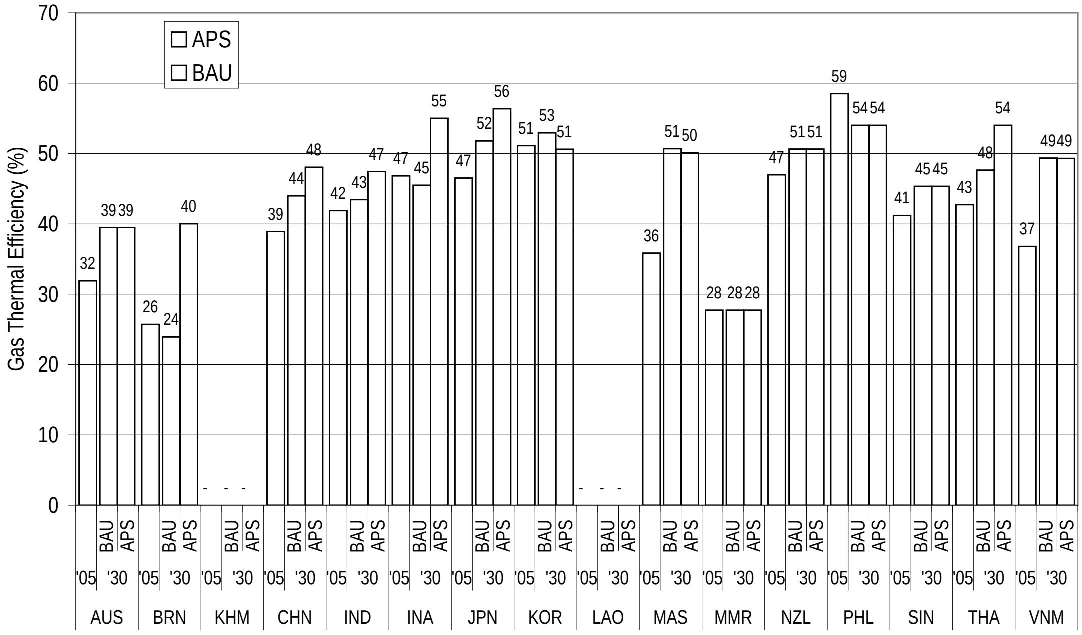
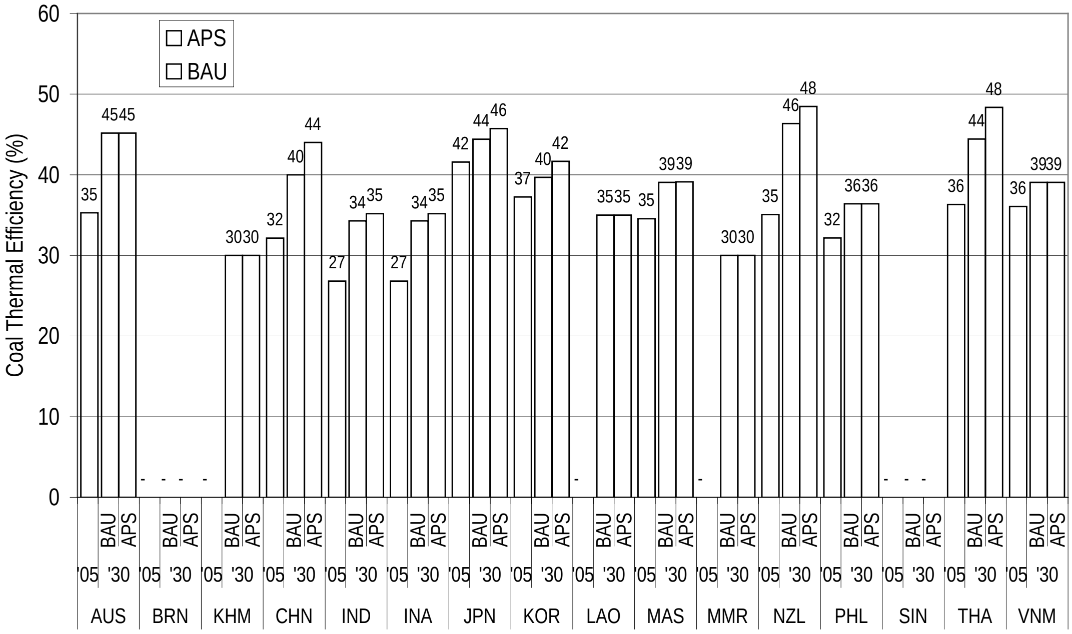


Figure 7. Thermal Efficiencies of Coal Electricity Generation

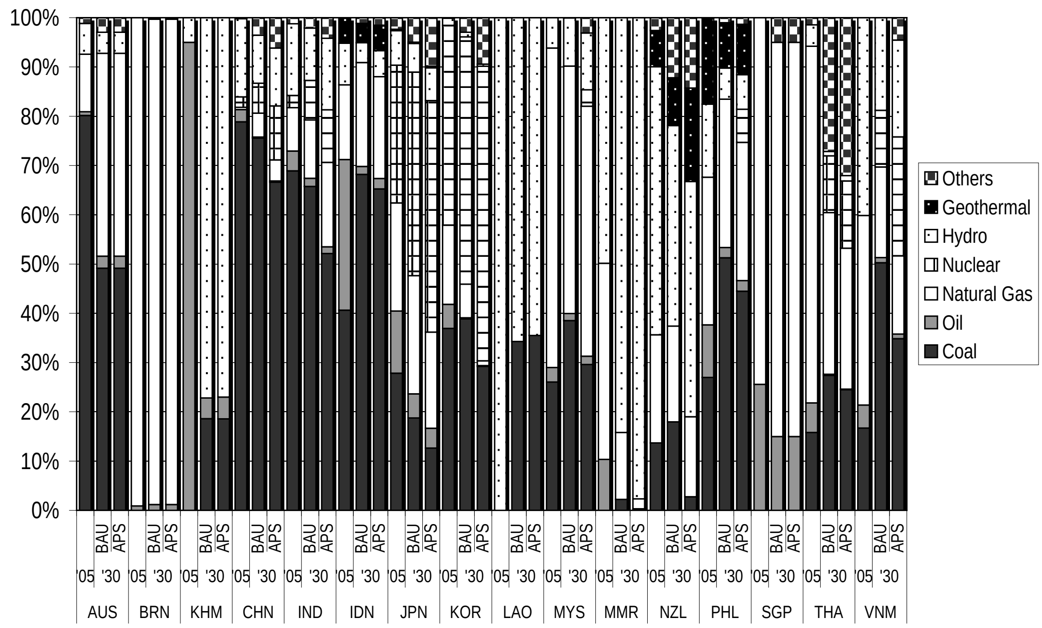


3.4.1 Electricity Generation Fuel Mix

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 64.3 percent in the BAU scenario to about 54.1

percent in the APS by 2030 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 natural gas, 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 2030. 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 submit 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 2010.* Table 3 summarises the assumptions regarding use of biofuels.

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 2030.

Table 3. Assumptions on Biofuels – Summary by Country

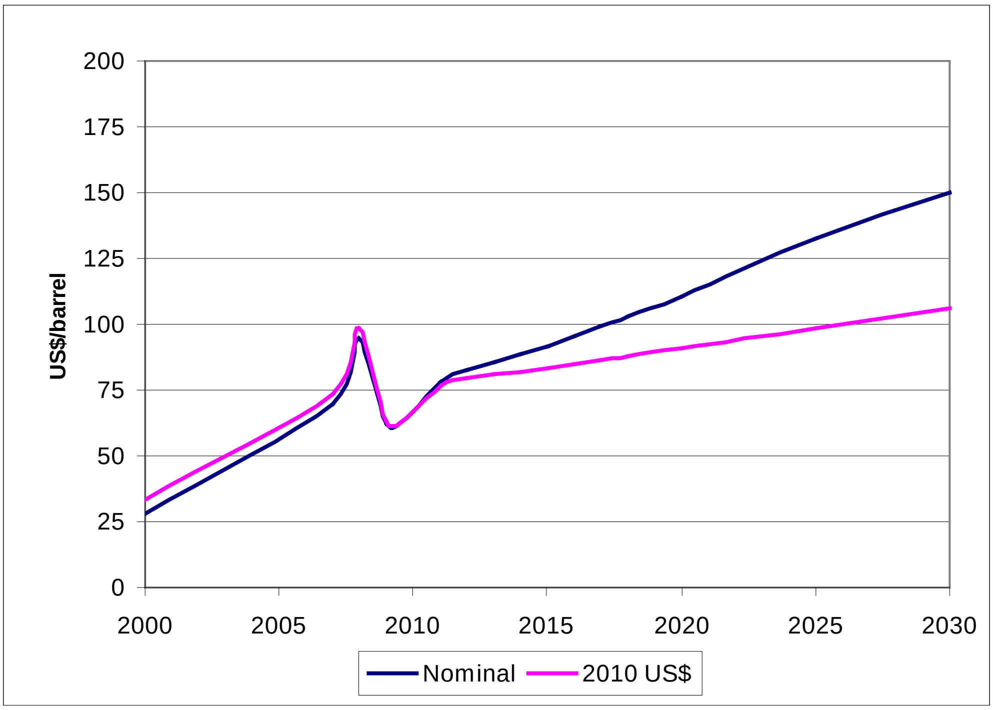
Country	Period	Assumptions
Australia	2010	Minimum: 1.1-1.4% of transport fuel; maximum 5% of transport fuel.
Brunei Darussalam		No targets on biofuels.
China	2030	21.7 Mtoe of biofuels will be used by 2030
Cambodia	2030	10% of road transport diesel and 20% of road transport motor gasoline will be displaced by biodiesel and bioethanol, respectively
India	2011-12	Aims to produce enough biodiesel to achieve 20% blend for high speed diesel.
Indonesia	2005-2010 2011-2015 2016-2025	Biofuel utilization of 2% of energy mix or 5.29 million KL. Biofuel utilization of 3% of energy mix or 9.84 million KL. Biofuel utilization of 5% of energy mix or 22.26 million KL.
Japan	2005-2030	No biofuel targets submitted.
Republic of Korea	2012 2020 2030	Replace 1.4% of diesel with biodiesel. Replace 6.7% of diesel with biodiesel. Replace 11.4% of diesel with biodiesel.
Lao PDR	2006-2030	No targets on biofuels.
Malaysia	2030	Replace 5% of diesel in road transport with biodiesel
Myanmar	2020	Aims to replace 8% of transport diesel with biodiesel.
New Zealand	2012-2030	Mandatory biofuels sales obligation of 3.4% by 2012.
Philippines	2006-2030	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 15% of diesel and 20% of gasoline with biofuels
Thailand		Biofuels to displace 12.2% of transport energy demand
Vietnam		250 thousand tons of bioethanol and biodiesel in 2015 to increase to 1.8 million tons by 2025

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 (constant 2010 prices), is assumed to increase from about US$66.59 a barrel in 2010 to US$105.79 a barrel in 2030 (Figure 9). This projection, which took into consideration the oil futures prices in New York

Mercantile Exchange, is similar to the trend of the oil price assumption in Annual Energy Outlook 2010 of the Energy Information Agency (EIA) of the United States of America. The EIA's projection however is for the oil price in the US Market in 2008 US$.

Figure 9. Oil Price Assumptions to 2030



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	No official energy saving goals but is committed to reduce GHG emission by between 5% (unconditional) and 25% (conditional depending on the actions of other countries) below 2000 levels by 2020 on which improvements in energy efficiency improvement is a major contributor	
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.	
Cambodia		10% reduction of BAU energy consumption by 2015
China		20% reduction in energy intensity by 2010 with declines of 4.4% per year between 2005 and 2010 and additionally, 2-3% per year for the period 2010-2020.
India		20 to 25% improvement in CO2 Intensity by 2020
Indonesia		Reduce energy to GDP elasticity to less than 1 by 2025. Reduce energy intensity by 1% per year until 2025
Japan		30% improvement in energy intensity from 2003 by 2030
Republic of Korea	Reduce primary energy intensity from 0.358 toe/thousands US$ from 2005 to 0.237 Mtoe/thousand US$ by 2030 from various sectoral energy efficiency and conservation programmes	Reduce TPES by 46% in 2030 from 544 MTOE in the BAU to 300 MTOE through various sectoral action plans
Lao PDR		Policy proposal: Reduce final energy consumption by 10% from BAU
Malaysia	Implementation of current policies by the government to promote energy efficiency in the industry, buildings and domestic sectors.	• Reduction of final energy consumption in the industrial, commercial and residential sectors by 10% from 2011 to 2030 • Reduce the final energy consumption of the transportation sector by 1.39 ktoe in 2030
Myanmar		• Increase energy savings by 5% in APS relative to BAU in 2020 and 8% by 2030 • In industry, improve energy efficiency by 10% in APS relative to BAU by 2020
New Zealand	The historical energy efficiency improvement of 0.5-1.0% per year is expected to continue in the BAU	• 30 PJ of savings in non-transport energy per year by 2025 • 20 PJ of energy savings in the transport sector by 2015
Philippines		To attain energy savings equivalent to 10% of annual final demand through various energy efficiency programmes in all sectors of the economy.
Singapore		• Reduce energy intensity by 20% by 2020 and by 35% by 2030 from the 2005 level. • Cap CO2 emissions by 16% from BAU by 2020.

Table 4. continued

	BAU scenario	APS
Thailand		Reduce total final energy consumption by 20%by 2011 relative to BAU through :
Vietnam		Reduce energy consumption by 3%-5% by 2010 and between 5%-8% by 2010-2015

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 2005 to 2030 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 4.2, 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.

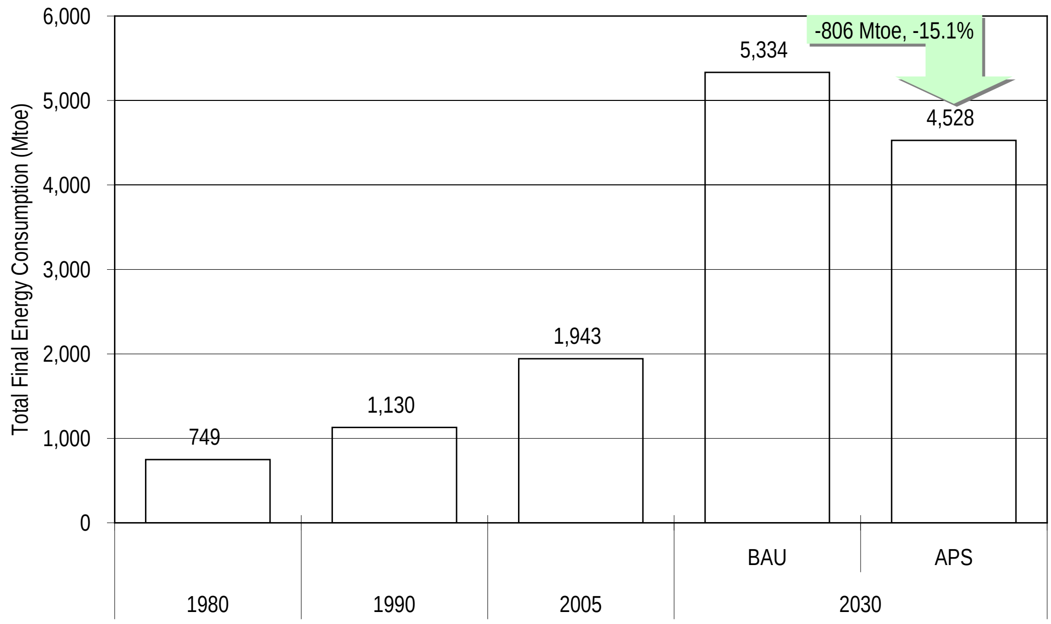
4. ENERGY AND ENVIRONMENTAL OUTLOOK FOR THE EAS REGION

4.1. Energy Consumption

4.1.1. Total Final Energy Consumption

The previous chapter discussed the social and economic drivers that are expected to lead to a sustained increase in energy consumption in the EAS region to 2030. These drivers include rising population, rapid economic growth, increasing automobile ownership, and increasing access to electricity. The net result of these trends is illustrated in Figure 10 below. It shows that under the BAU case, final energy consumption is projected to increase from 1,943 Mtoe in 2005 to 5,334 Mtoe in 2030, an increase of 4.1 percent per year on average. In the APS case, final energy consumption is projected to rise to 4,528 Mtoe, 15.1 percent less than in the BAU case by 2030. 'Final energy consumption' refers to energy in the form in which it is actually consumed, that is, including electricity, but not including the fuels used to generate electricity.

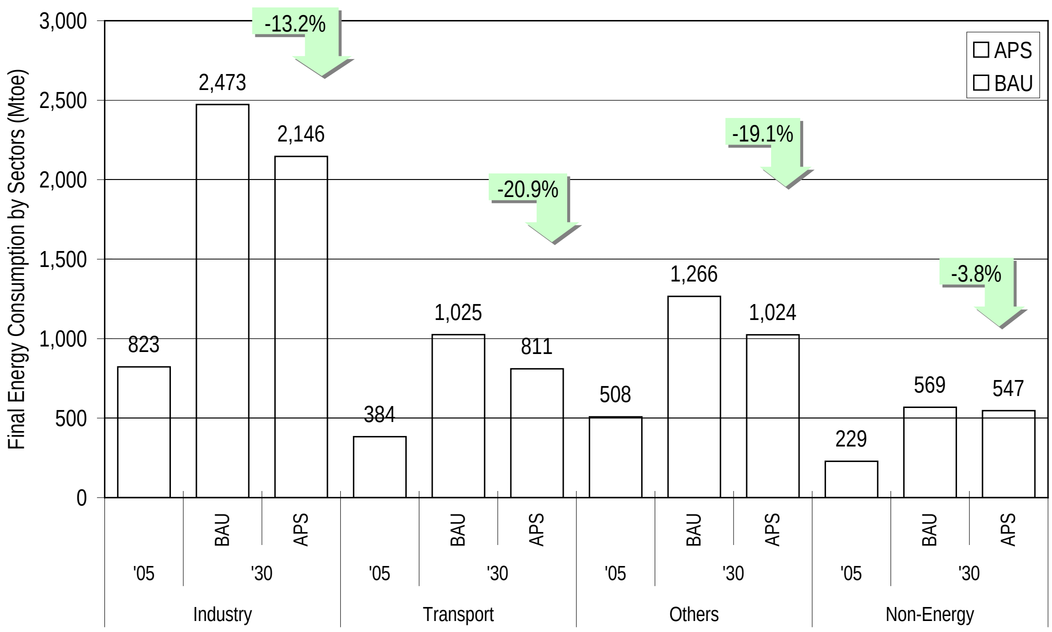
Figure 10. Total Final Energy Consumption



4.1.2. Final Energy Consumption by Sector

Figure 11 shows final energy consumption by sector. Final energy consumption in all sectors is projected to increase dramatically between 2005 and 2030. While in 2005, 42.3 percent of final energy consumption was for industry, by 2030, it is projected to increase further to 46.4 percent at the expense of the transport and 'other' (primarily residential and commercial) sectors. This trend reflects the expectation of further industrial expansion in China although there will be rising levels of automobile ownership, increased access to and demand of electricity, and rising living standards made possible by economic growth. Final energy consumption in most sectors is significantly reduced in the APS case compared to the BAU case. In percentage terms, the reduction is larger in the transport sector than in industry.

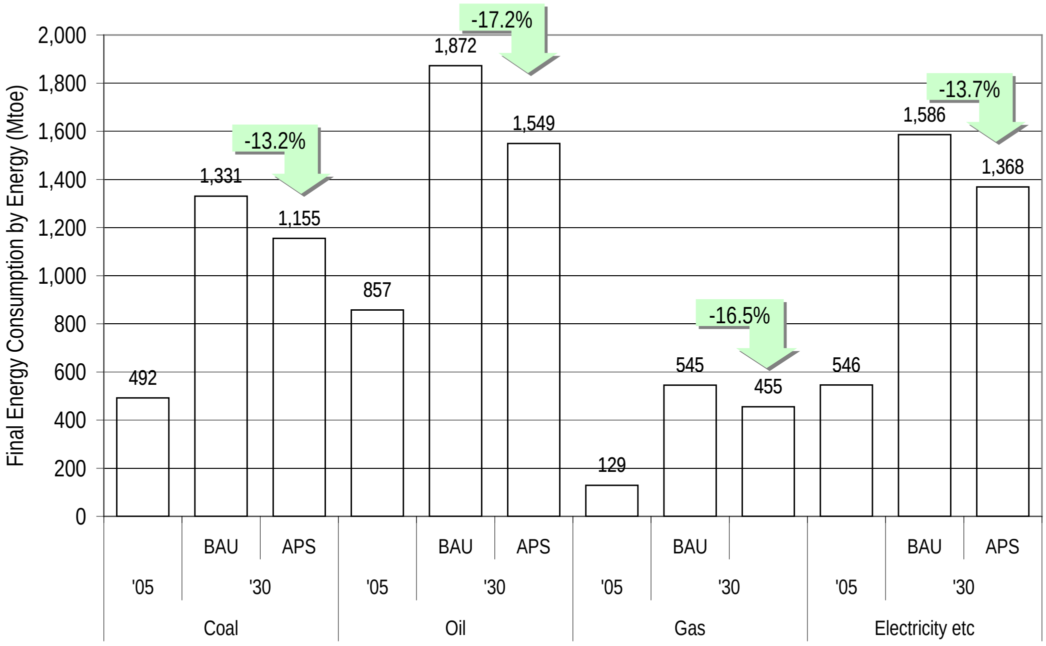
Figure 11. Final Energy Consumption by Sector



4.1.3. Final Energy Consumption by Fuel

Figure 12 shows final energy consumption by type of fuel. Oil was the largest final energy source in 2005, with over 44 percent market share. This share is projected to decrease to around 35 percent in 2030. Oil consumption is projected to increase by 3.2 percent per year on average between 2005 and 2030. Electricity consumption increases even more in percentage terms, with demand growing on average by 5.0 percent per year between 2005 and 2030. However, in level terms, electricity consumption will be lower than oil consumption in 2030 in the BAU case. Natural gas is one of the fastest growing final energy sources increasing on average by 5.9 percent per year between 2005 and 2030. However, by 2030, it still achieves only about a 10 percent market share. Final energy use of coal is projected to grow on average by 4.1 percent per year. In the APS case, growth in final demand for all fuels is reduced compared with the BAU case.

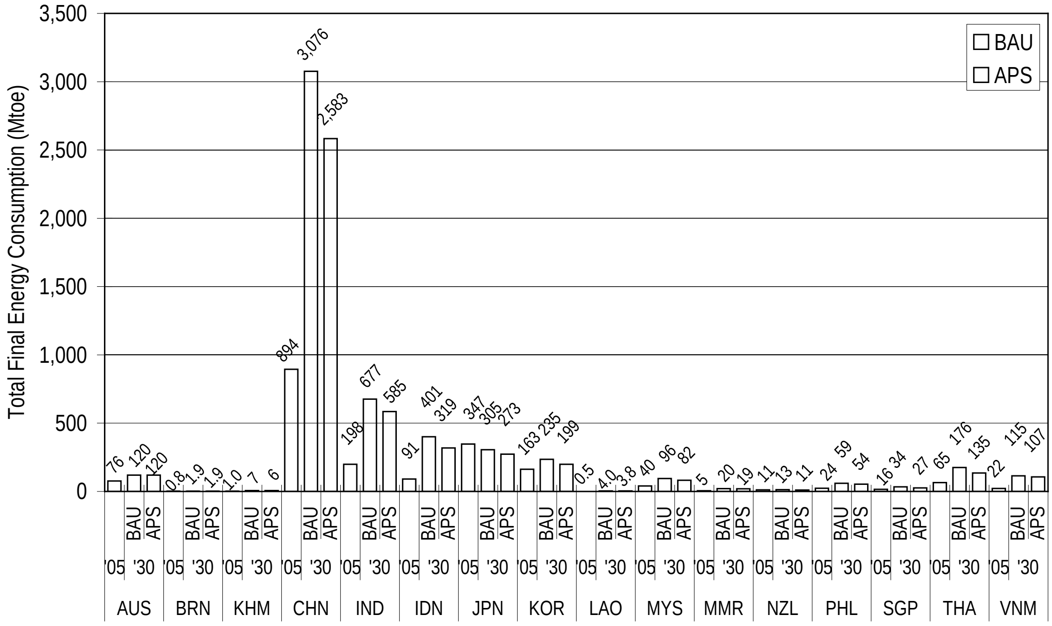
Figure 12. Final Energy Consumption by Fuel



4.1.4. Final Energy Consumption by Country

Figure 13 shows final energy consumption by country. The most striking result in this graph is that China is projected to dominate EAS region final energy demand by 2030. China is projected to account for about 57.6 percent of EAS region final energy consumption by 2030, up from about 46.0 percent in 2005. Just five countries—China, India, Indonesia, Japan, and Republic of Korea—are projected to account for 88.0 percent of EAS region final energy demand in 2030, 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 87.6 percent of the growth in energy demand of the entire EAS region between 2005 and 2030. In the APS case, growth in most countries, including the ‘big three’, is significantly reduced relative to the BAU scenario. However, the big three are still projected to account for 89.1 percent of the growth in energy demand in the EAS region between 2005 and 2030.

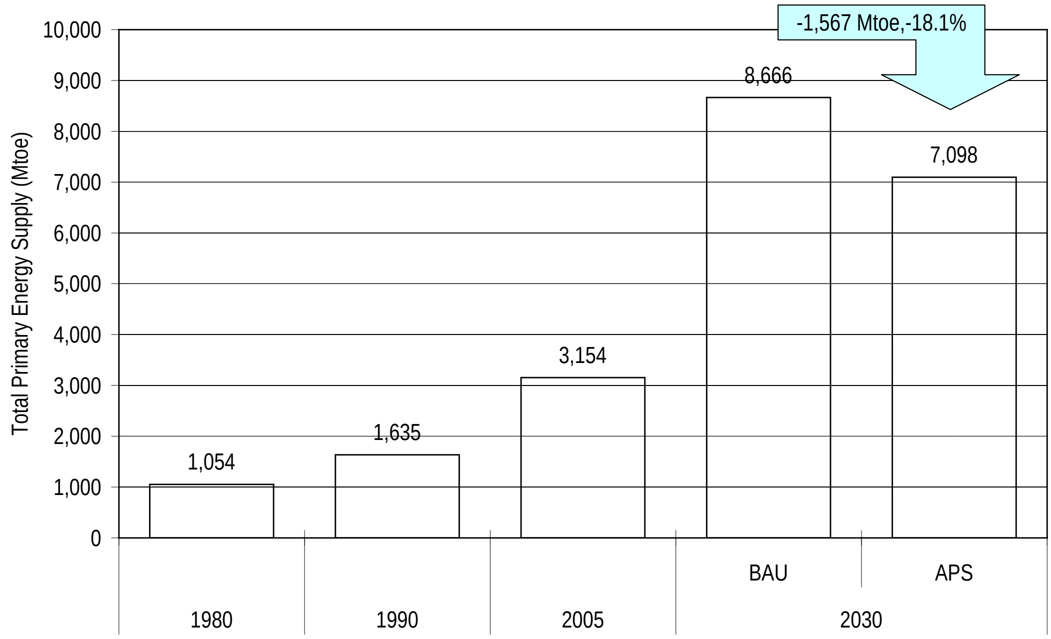
Figure 13. Total Final Energy Consumption by Country



4.1.5. Total Primary Energy Demand

The pattern followed by primary energy demand is, as one would expect, similar to final energy consumption. "Primary energy demand" refers to energy in its raw form, before any transformations, most significantly the generation of electricity. Figure 14 shows that total primary energy demand is projected to increase from 3,154 Mtoe in 2005 to 8,666 Mtoe in 2030 in the BAU case, an increase on average of 4.1 percent per year. In the APS case, demand is projected to grow to 7,098 Mtoe by 2030, 18.1 percent less than in the BAU case. The reduction in 2030 primary energy demand in the APS case compared to the BAU case of 1,567 Mtoe is roughly equivalent to China's 2005 consumption.

Figure 14. Total Primary Energy Demand

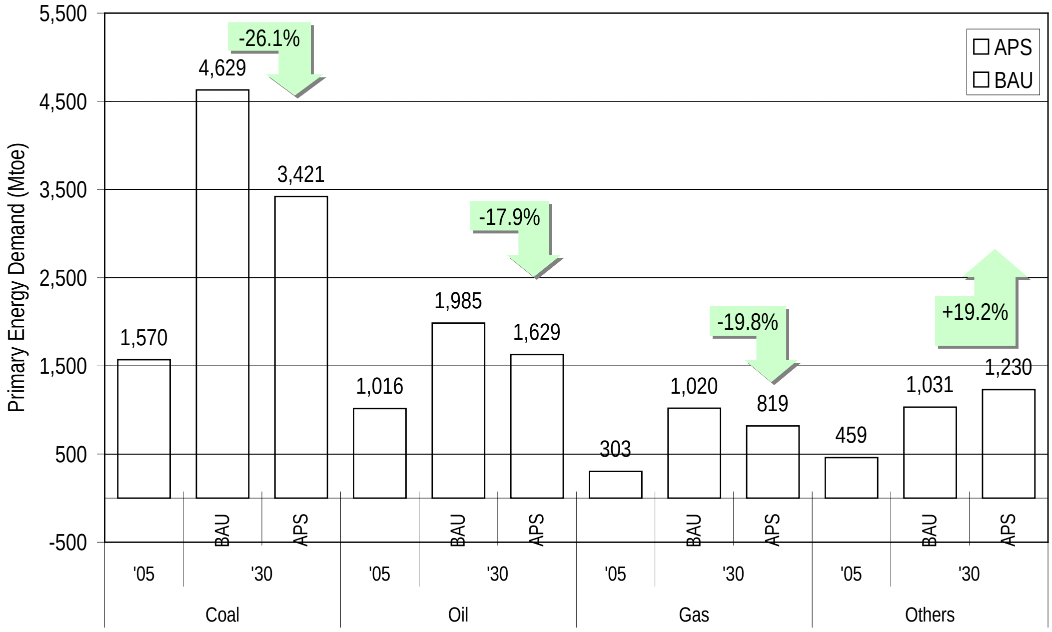


4.1.6. Primary Energy Demand by Source

Figure 15 shows primary energy demand by energy source. Coal is currently the largest source of primary energy in the EAS region, and is projected to remain the largest to 2030. Coal is also projected to have the largest growth over this period in the BAU scenario as measured in Mtoe (3,052 Mtoe), but not in terms of growth rate (up 4.4 percent per year on average). This growth is mainly due to increased use of coal for electricity generation. Oil has the next largest growth as measured in Mtoe (969 Mtoe), but a slower growth rate (up 2.7 per cent per year on average). This growth is mainly due to rising automobile ownership and transport demand. Natural gas is projected to grow by 5.0 percent per year on average, reflecting the growing use of gas in both electricity generation and as a consumer fuel. Nuclear is also projected to grow quickly (up 5.1 percent per year on average), but still projected to account for only about 5.4 percent of EAS region primary energy in the year 2030. Geothermal energy will also have a fast growth rate of 4.2 percent per annum although its share to the total EAS primary energy will remain below 1.0 percent in 2030.

In the APS scenario, growth in coal and oil primary consumption is projected to be sharply reduced. However, the reduction in average natural gas growth is much lower. These results reflect a shift from coal-fired electricity generation to natural gas and nuclear in the APS case, along with measures to reduce the demand for transport fuels.

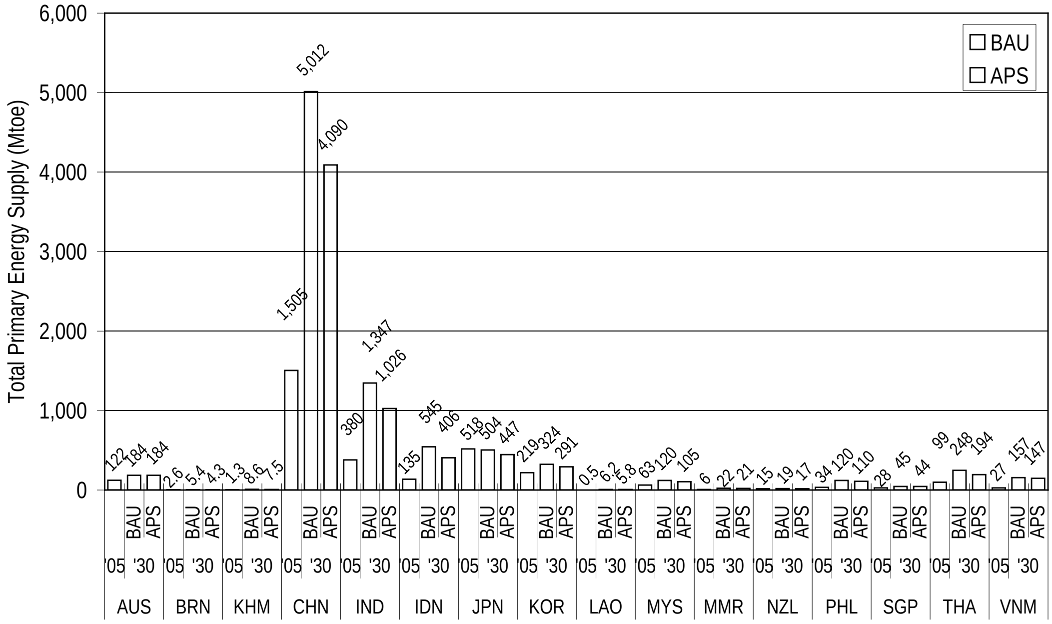
Figure 15. Primary Energy Demand by Source



4.1.7. Primary Energy Demand by Country

Figure 16 shows primary energy demand by country, which is similar to the pattern for final energy consumption by country shown in Figure 13. Five countries - China, India, Indonesia, Japan, and Republic of Korea - are projected to account for 89.2 percent of EAS region primary energy in 2030. The 'big three' - China, India, and Indonesia - will dominate the growth in EAS region primary energy, accounting for 88.6 percent of the growth over the period from 2005 to 2030. In the APS case, growth in primary energy demand in most countries is significantly reduced, but the dominance of demand by five countries and the relative importance of the growth in three countries remain unchanged.

Figure 16. Primary Energy Demand by Country, 2005 and 2030



4.1.8. 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 summarised. It should be noted that these results are illustrative of the potential energy savings that can be achieved and should not be interpreted as official country projections.

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

	2005	2030		Variance		
		BAU	APS	APS/BAU	2005/2030 BAU	2005/2030 APS
	(toe/million US$)	(toe/million US$)	(toe/million US$)	%	%	%
Australia	260	205	205	0.0	-21.2	-21.2
Brunei Darussalam	397	321	255	-20.7	-19.2	-35.9
Cambodia	228	245	215	-12.2	7.5	-5.6
China	795	418	341	-18.4	-47.4	-57.1
India	589	298	227	-23.8	-49.4	-61.4
Indonesia	650	581	433	-25.5	-10.6	-33.4
Japan	104	72	64	-11.3	-30.7	-38.5
Korea	342	223	179	-19.6	-34.6	-47.5
Lao PDR	193	412	388	-5.9	113.8	101.2
Malaysia	558	346	301	-13.0	-38.0	-46.0
Myanmar	439	171	159	-7.0	-61.0	-63.8
New Zealand	247	183	164	-10.5	-25.8	-33.6
Philippines	358	304	278	-8.6	-15.0	-22.3
Singapore	241	152	148	-2.6	-37.0	-38.7
Thailand	630	590	463	-21.5	-6.3	-26.5
Viet Nam	609	560	523	-6.5	-8.1	-14.1
Total	334	301	245	-18.6	-9.9	-26.7

4.2. Carbon Dioxide (CO_2) Emissions from Energy Consumption

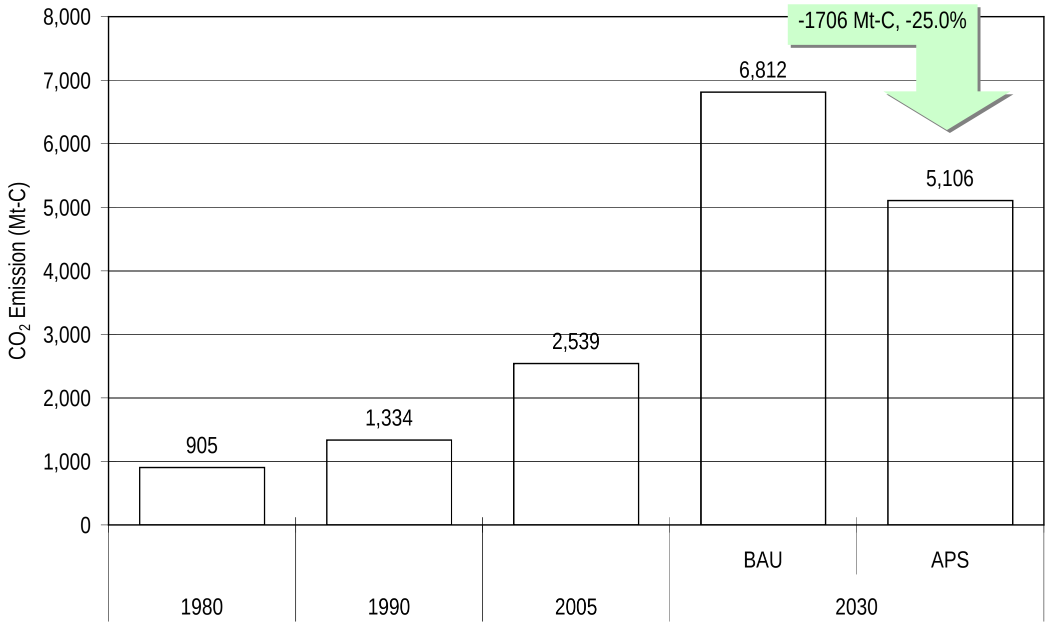
4.2.1. CO_2 Emission Results

As shown in Figure 17, CO_2 emissions from energy consumption in the BAU case are projected to increase from 2,539 metric tons of carbon (Mt C) in 2005 to 6,812 Mt C in 2030, implying an average annual growth rate of 4.0 percent. This is slightly lower than the growth in total primary energy demand of 4.1 percent per year. In the APS case, CO_2 emissions are projected to be 5,106 Mt C in 2030, 25.0 percent lower than under the BAU case.

While the emission reductions under the APS are significant, CO_2 emissions from energy consumption in the APS case in 2030 will still be above 2005 levels and far above 1990 levels. Scientific evidence suggests that these reductions will not be adequate to prevent severe climate change impacts. The analysis of the Intergovernmental Panel on Climate Change (IPCC) (reference) suggests that to keep the global mean temperature rise at not much more than 2^oC compared to 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^oC range, CO_2 emissions would need to peak between 2010 and 2030 and be 70 to 105 percent of year 2000 levels by 2050.[11]

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

Figure 17. Total CO_2 Emissions



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^{o}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^{o}C, millions of people could experience coastal flooding each year.[12]

As shown in Figure 18, 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 2,900 Mt C and 760 Mt C respectively of the projected 4,273 Mt C increase in EAS region emissions from 2005 to 2030 under the BAU case, or 85.7 percent of the total growth in the EAS region. Adding in Indonesia's growth of 313 Mt C, these three countries account for 3,973 Mt C or 93.0 percent of the total growth in EAS region. No other country will account for a growth of more than 108 Mt C. Japan is the only country in the EAS Region whose emissions are expected to decline under the BAU case probably as a result of a decrease in population, improvement in energy efficiency and increased share of lower emission fuels.

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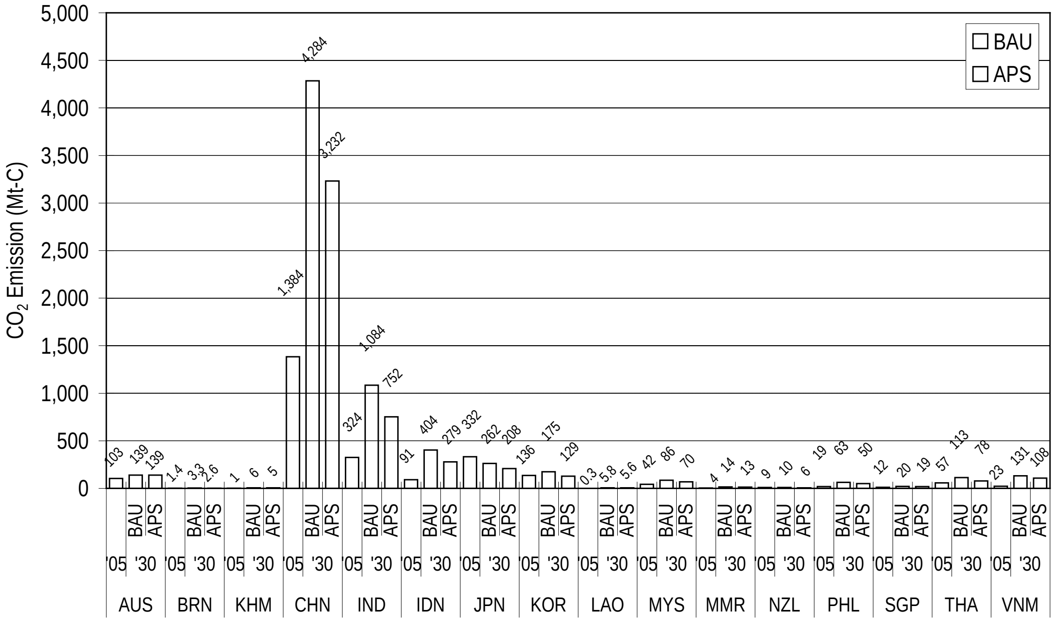
[12] These examples are taken from "Summary for Policymakers" in *Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Figure SPM.7. The examples assume that 1^{o} C of temperature increase has already occurred, as per this same report, Figure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

Figure 18. CO_2 Emissions by Country



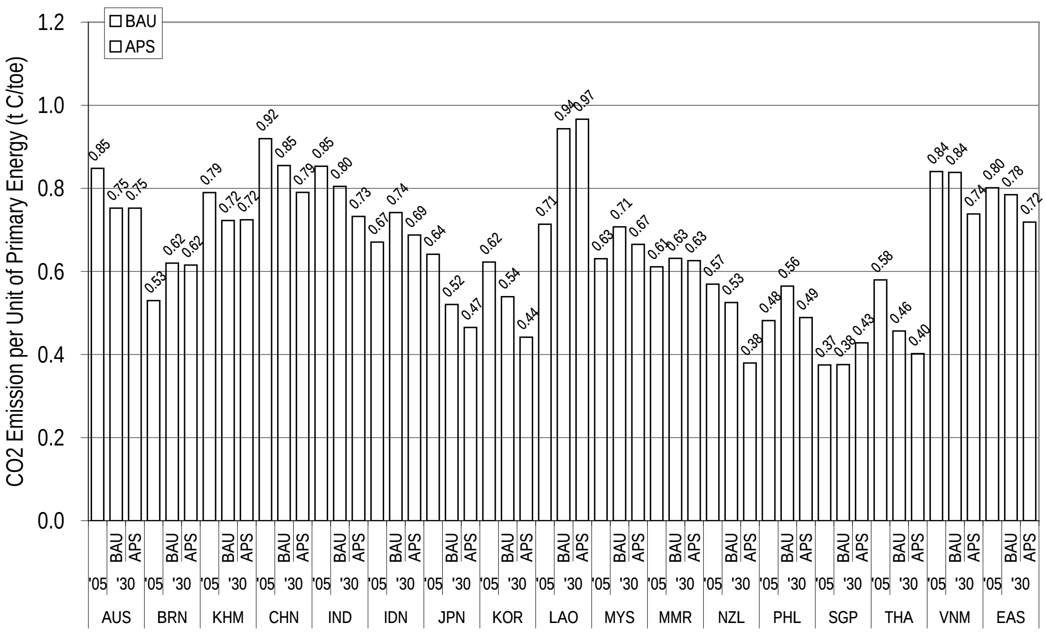
Under the APS case, China and India are still dominant, accounting for 1,848 and 427 Mt C respectively of the projected 2,464 Mt C growth in EAS region emissions from 2005 to 2030, or 88.6 percent. Adding in 188 Mt C from Indonesia accounts for 2,463 Mt C or 96.0 percent of the EAS region total. No other country will account for a growth of more than 85 Mt C. Emissions from Japan, Republic of Korea, and New Zealand are expected to decline under the APS case relative to 2005 levels due to effective mitigation policies.

4.2.2. Fundamental Drivers of CO_2 Emissions from Energy Consumption

The CO_2 emission results 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.

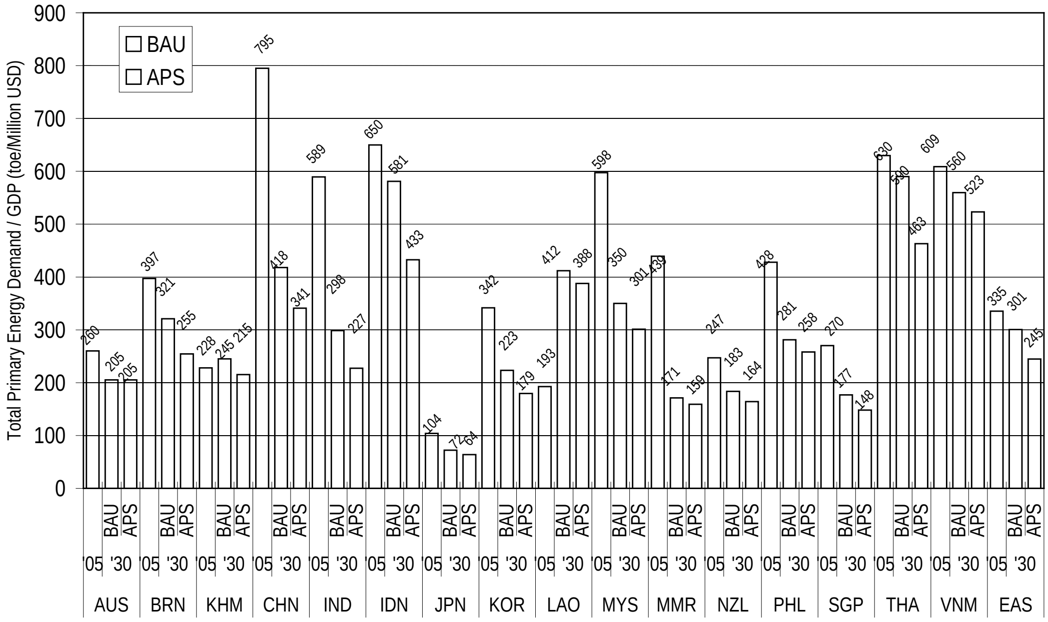
i) Emissions per unit of primary energy are projected to decline to 0.79 t C/toe in 2030 from 0.80 t C/toe in 2005 under the BAU case. Under the APS case, this will decline to 0.72 t C/toe in 2030, or by 10.6 percent from 2005 (Figure 19). The reduction under the APS case reflects a shift away from coal and oil, the two most emission-intensive fuels.

Figure 19. Emissions per Unit of Primary Energy



ii) Primary energy per unit of GDP is projected to decrease from 333 toe/million US$ in 2005 to 301 toe/million US$ in 2030 under the BAU case, or by 9.9 percent (Figure 20). Under the APS case, this will decline to 245 toe/million US$ in 2030, or by 26.7 percent. The reduction 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 269 t C/million US$ in 2005 to 236 t C/million US$ in 2030 under the BAU case, or by 12.1 percent. Under the APS, this will decline to 176 t C/million US$ in 2030, 34.5 percent lower than 2005.

Figure 20. Primary Energy Demand per Unit of GDP



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 3,000 US$/person in 2005 to 7,500 US$/person in 2030, an increase of 150 percent. Looking at (i), (ii), and (iii) in combination, emissions per person are projected to increase from 0.81 t C/person in 2005 to 1.76 t C/person in 2030 under the BAU case, or by 118.5 percent. Under the APS, emissions rise to only 1.32 t C/person in 2030, or 63.7 percent higher than 2005. However, the rising emission per capita is associated with increase in GDP/person and improvement in living standards.

iv) Finally, population in the EAS Region is expected to grow from 3,147 million in 2005 to 3,865 million in 2030, or by 22.8 percent. Combined, all these drivers lead to growth in emissions from 2,539 Mt C in 2005 to 6,812 Mt C in 2030 under the BAU case, or 168.3 percent. Under the APS, emissions grow to 5,106 Mt C in 2030, or 101.1 percent.

5. THE PILOT SURVEY ON RESIDENTIAL END-USE ENERGY CONSUMPTION

5.1. Research Objective

With a 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 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 such energy saving programs. Trial surveys were carried out by each WG member in ASEAN and China involving few respondents. The trial survey produced some results and most importantly the conduct of the survey gave an idea on how to improve the survey to figure out the real structure of household energy consumption.

The questionnaire was designed by the WG members and consists of five parts; the electricity, petroleum, natural gas, biomass and coal briquettes.

5.2. Data Collection

The respondents to the trial survey were selected by the WG members and are mostly their colleagues. From December 2010 to March 2011, there were 68 respondents from Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore and Thailand During the 2nd WG meeting, the returned questionnaires were processed using a computer program prepared by the IEEJ. However, due to strange results such as very high consumption in refrigeration, the WG leader asked the members to reflect the actual power ratings of refrigerators accordingly. China, Myanmar and Thailand were not able to revise the questionnaire. In this regard, only the questionnaires from 6 ASEAN countries were processed and are included in this report.

The profile of the respondents is shown in Table 6.

Table 6. Profile of Pilot Survey Respondents

	Number of Respondents	Persons per household	Floor area(m^2)
Cambodia	12	6.42	132.17
Indonesia	9	4.33	111.78
Laos	10	4.50	128.40
Malaysia	9	4.78	167.39
Philippines	18	4.06	67.06
Singapore	10	4.60	188.60
TOTAL	68	4.75	124.64

5.3. Main Electrical Appliances and Equipment in Households

This section shows the number of electrical appliances used in households. The number of electric fans and air conditioners are 2.91 units and 0.96 units per household, respectively. Respondents in Cambodia and Malaysia reported more than 4 units of electric fans per household. The number of microwave oven was 0.41 units. The number of refrigerator is almost 1 unit per household. The number of CRT TV is 1 unit per household and 0.56 unit for LCD TV. The number of lighting fixtures is about 10 units per household. CFL accounts for more than 4 units per household. This is quite high compared to Japan which has 2-3 units. This is due to a sampling bias which is concentrated on respondents with stable income, large floor space and living in urban area.

Table 7. Main Appliances in Households

(unit per household)

	Cambodia	Indonesia	Laos	Malaysia	Philippines	Singapore	Total
AC	1.33	1.00	1.00	0.56	0.28	2.00	0.96
Fan	4.08	1.56	2.60	4.00	2.72	2.40	2.91
Exhaust Fan	0.17	0.89	3.10	0.00	0.11	0.00	0.63
Electric Range/Stove	0.00	0.00	0.90	0.11	0.33	0.30	0.28
Rice Cooker	0.58	0.89	1.00	0.89	0.61	0.90	0.78
Microwave	0.00	0.33	0.50	0.78	0.33	0.70	0.41
Refrigerator	0.67	1.00	1.00	1.00	0.94	1.00	0.93
Water heating(electric)	0.08	0.44	1.00	0.44	0.06	0.90	0.43
CRT TV	1.25	1.00	1.60	0.78	1.17	0.00	1.00
LCD TV	0.33	1.00	0.20	0.89	0.28	1.00	0.56
Desktop	0.42	0.44	0.20	0.11	0.33	0.80	0.38
Laptop	1.08	1.00	0.40	1.56	0.67	0.70	0.87
Washing Machine	0.42	0.89	0.70	1.00	0.67	1.00	0.75
Iron	0.92	1.00	0.70	1.00	0.94	0.00	0.78
Video Players (VHS, DVD, etc)	0.67	0.44	1.00	0.56	0.67	0.00	0.57
Incandescent bulb	1.17	0.67	0.50	0.56	0.61	0.00	0.60
Fluorescent lamp (old type)	0.75	0.11	3.20	1.22	0.83	0.00	1.00
Fluorescent lamp (thin tubes)	5.00	2.00	5.40	4.78	0.61	11.80	4.47
CFL	4.33	6.89	5.30	5.33	5.17	0.00	4.53

5.4. Hours of Usage of Cooling and Ventilation

The ASEAN region, which is covered by this analysis, has a moderate climate with its average temperature of 29^{o}C which can reach as high as 40^{o}C.[13] Therefore, use of air-conditioning is quite higher than in cooler countries. As shown Table 8, the number of days per month that cooling and ventilation is used account for over 25 days. The number of hours of use per day for air conditioner accounts for 4.24 hours, fans; 6.64 hours and other ventilation; 3.81 hours.

One exception is the Philippines where there is low presence of air conditioner and operation of only 2 hours per day. This is because of high electricity cost in the country which is about 23 US cents per kWh, the second highest in the ERIA region, following Japan's 28 US cents per kWh. The hours used per day of air conditioners and electricity fans were only 2 to 3 hours per day in Lao PDR. This is due to the cooler climate in the country.

Table 8. Hours Used per Day and Days of Usage per Month for Cooling and Ventilation

	AC		Fan		Exhaust Fan	
	hours per day	days per month	hours per day	days per month	hours per day	days per month
Cambodia	4.28	24.44	7.50	28.75	5.00	18.00
Indonesia	6.00	30.00	5.86	23.57	2.25	22.50
Laos	2.20	17.40	3.25	23.50	4.49	30.00
Malaysia	4.20	20.00	9.67	28.89	0.01	30.00
Philippines	2.00	26.00	7.18	27.94	5.50	25.00
Singapore	5.56	17.25	4.88	17.50	-	-
TOTAL	4.24	22.50	6.64	25.79	3.81	26.94

5.5. Residential Energy Consumption

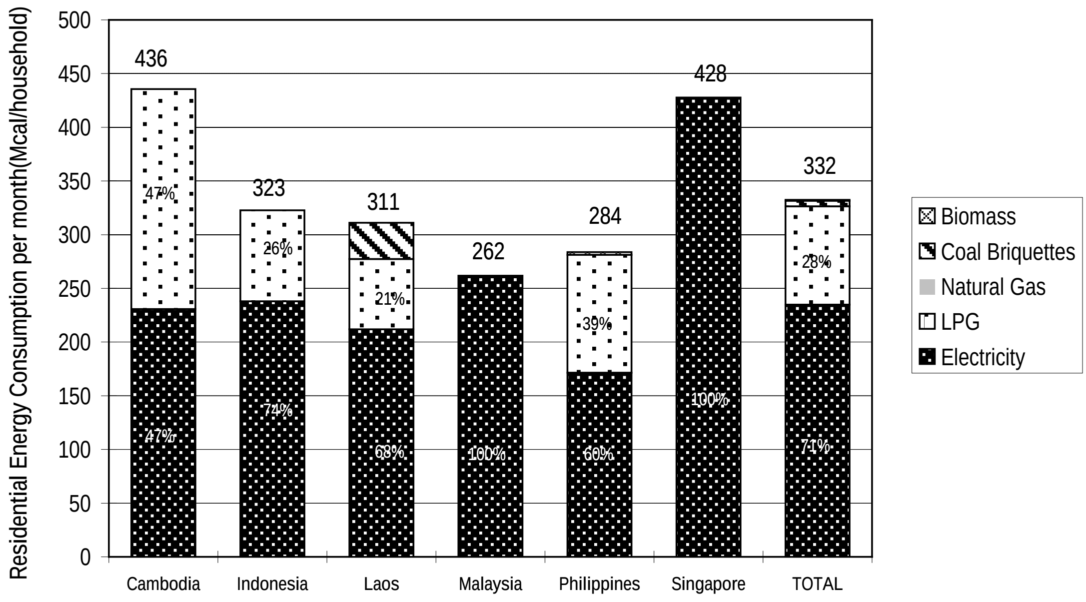
5.5.1. Monthly Energy Consumption by Energy Use

The average of monthly energy consumption in the six countries was 332 Mcal per household. Cambodia had the highest consumption levels, followed by Singapore and Indonesia. This is due to a large floor space of the respondents. In contrast, Malaysia had the lowest energy consumption as the survey respondents did not report consumption of petroleum products and natural gas. The Philippines had the second lowest energy consumption due to smaller floor space in dwellings of the respondents. Consumption of Lao PDR is the third lowest among the six countries due to a cooler climate as compared to other countries. On the average, electricity accounted for 71 percent of the total energy consumption, 28 percent for LPG and

[13] Retireasia.com (undated) *Geography, Climate, Weather in Southeast Asia.* Accessed 03 June 2011. http://www.retire-asia.com/asia-weather.shtml

2 percent for coal briquettes that is reported only in Lao PDR.

Figure 21. Energy Usage by Country

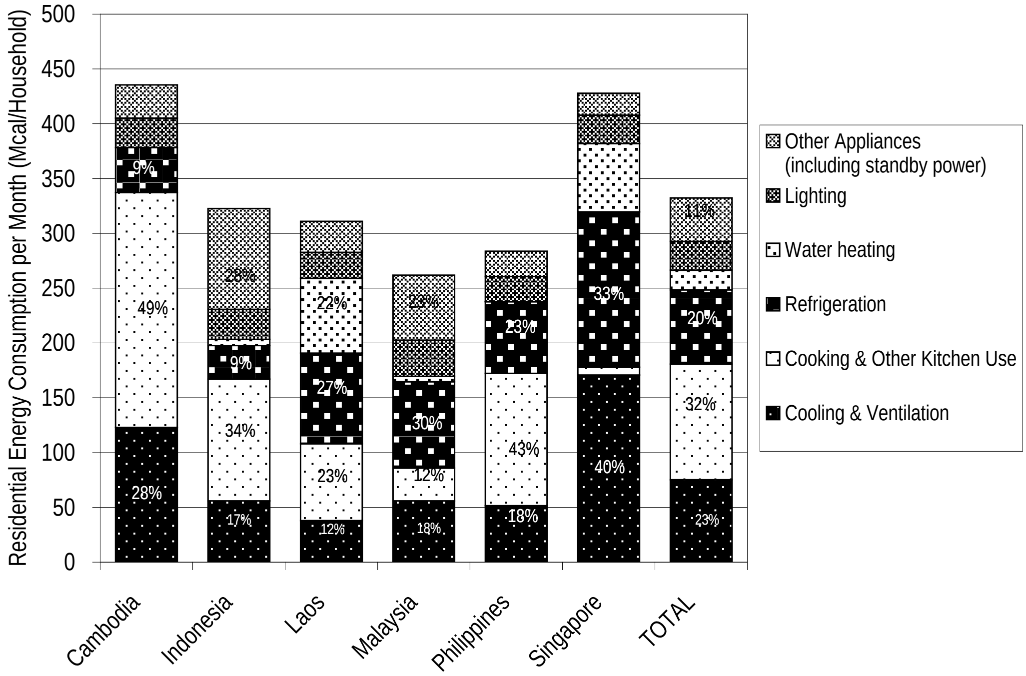


	Cambodia	Indonesia	Laos	Malaysia	Philippines	Singapore	TOTAL
Number of Respondents	12	9	10	9	18	10	68
Persons per household	6.4	4.3	4.5	4.8	4.1	4.6	4.8
Floor area(m^2)	132.2	111.8	128.4	167.4	67.1	188.6	124.6
Temperature	28.29	28.85	26.44	26.79	27.83	27.46	27.61

5.5.2. Monthly Energy Consumption by End Use

Figure 22 shows the average household residential energy consumption disaggregated by end use in the six countries. Of the total, 23 percent was used for cooling & ventilation, 32 percent for cooking & other kitchen use and 20 percent for refrigeration. The remaining energy use was attributed to water heating (5 percent), lighting (8 percent) and other appliances (12 percent).

Figure 22. Energy Usage by End-use by Country



5.5.3. Annual Household Energy Use per Capita

In this report, the annual energy consumption was estimated by multiplying the energy consumption per month by 12 months, assuming constant life style and climate. As shown in Figure 23, annual household energy use amounted to 73 kg oil equivalent per capita. Of this total, cooling, cooking and refrigeration attributed for 75 percent of the total energy consumption. This volume of energy use per capita in the 6 ASEAN countries was quite low compared to OECD countries. This is partly because there is virtually no space heating use in the ASEAN region.

Figure 23. Annual Household Energy Use per Capita in the EAS

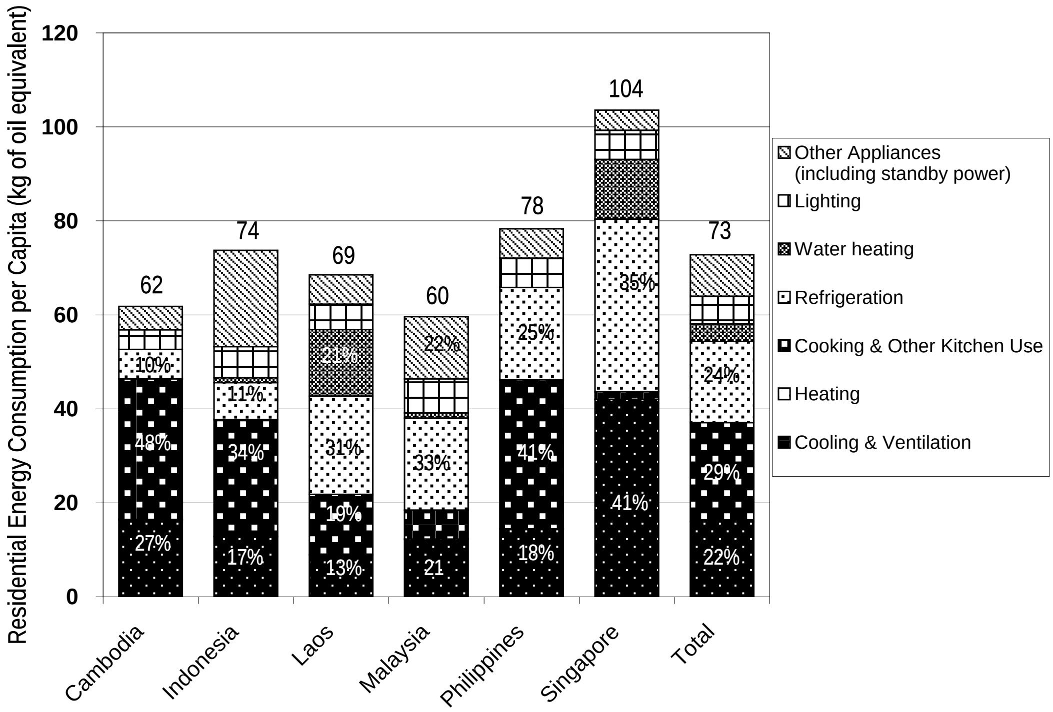
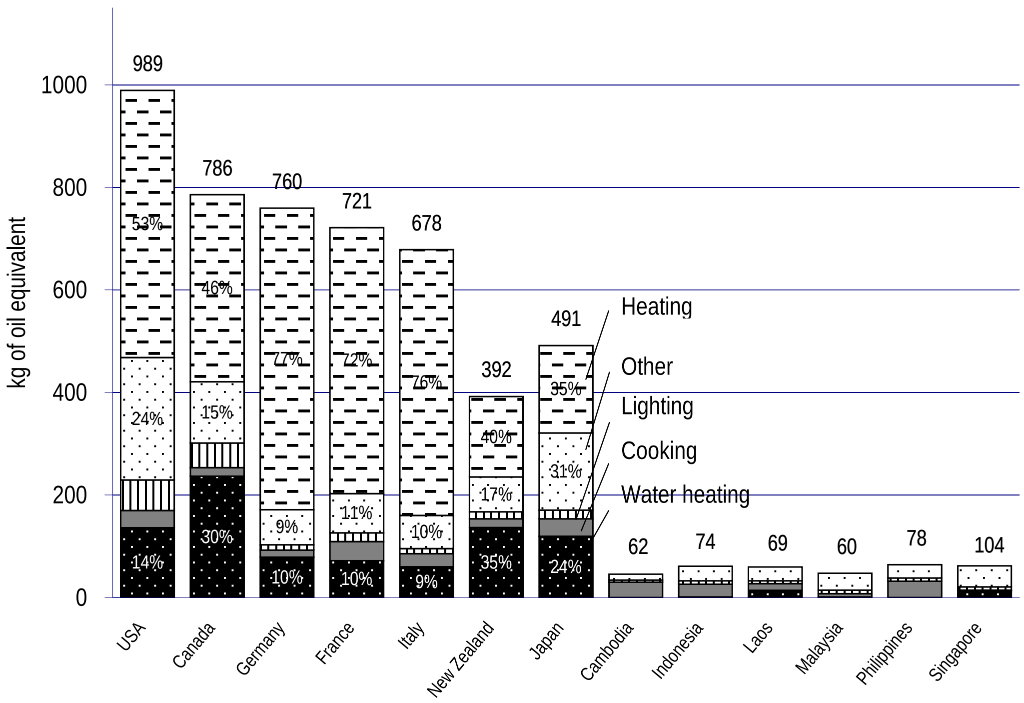


Figure 24. Annual Household Energy Use per Capita in the OECD and Selected ASEAN Countries

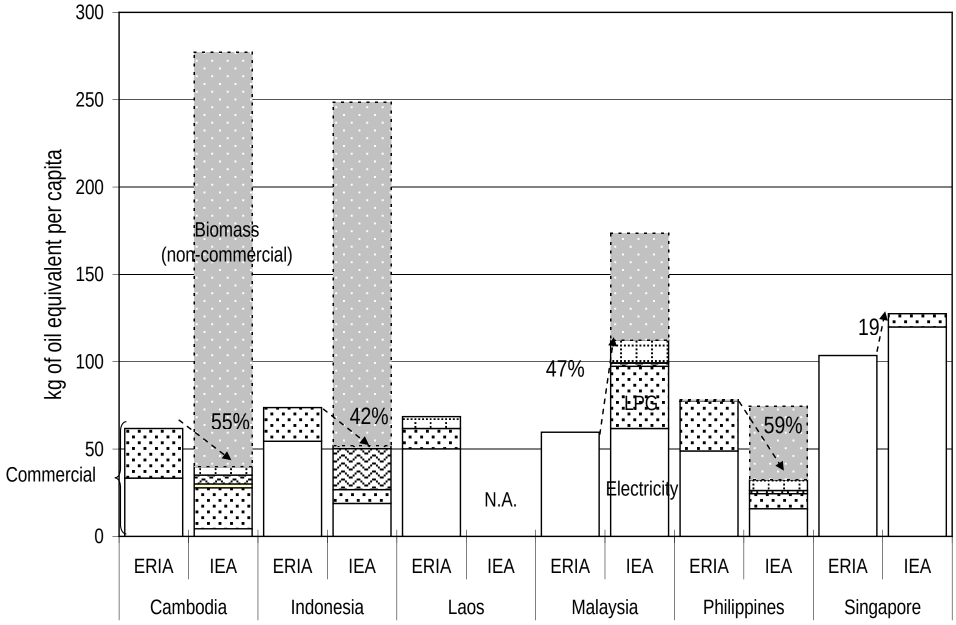


5.6. Statistical Issue- Gaps between the Sampling Survey and IEA statistics

This section shows the comparison between the sampling survey and the IEA statistics on annual household energy use per capita.

As shown in Figure 25, the gaps between the sampling survey and the IEA statistics are substantial. Also, the kinds of energy consumed are different from the IEA statistics, for instance, Cambodia, Indonesia, Malaysia and the Philippines did not consume biomass in the survey, however, there were biomass consumption in the IEA statistics. Instead, the IEA statistics show consumption of kerosene and diesel oil in Cambodia and Indonesia. This is due to sampling bias which covered respondents with stable income, large dwelling spaces and are living in urban areas. If biomass such as charcoal and other solid biomass are included, the gaps between the survey and the IEA statistics are larger.

Figure 25. Comparison between the Survey Results and IEA statistics



5.7. Conclusion

The trial survey showed that household energy consumption can be disaggregated by end-use. Likewise, the information that can be obtained from this kind of survey is very important in determining the highest energy consuming end-use on which energy efficiency improvement policies can be focused on. However, the following should be considered when conducting the survey:

- The survey should cover a wide spectrum of households to cover all kinds of households in the countries such as rural and urban, electrified and un-electrified, and all income levels, etc.
- Since weather has a substantial influence on energy consumption, the survey should also cover the seasonality of energy use. Thus, there might be a need to conduct four surveys in some countries to cover the four seasons.
- It was also experienced that it is difficult to determine the actual power ratings of refrigerators and air conditioners due to the operating nature of these appliances. It is therefore suggested that instead of asking for the power rating of the appliance, the model and maker of the equipment is reported instead. The surveyor or data processer can then obtain the power rating information from published sources.
- Some information asked in the questionnaire is also not easy to answer. Therefore, the survey should be carried out by interview method so that the surveyor can assist the respondent in answering the questions.
- As energy consumption pattern may change rapidly due to the introduction of new or improved appliances, the survey should be carried out every few years.

6. ADDITIONAL RESEARCH ACTIVITIES

In order to support and enhance capacity of the ERIA WG, the following research activities were implemented in 2010:

a. Application of a bottom-up approach to estimate energy saving potential in specific sectors assuming the use of more efficient technologies
b. Satellite projects - Five projects related with energy saving potential were implemented with the support of METI, Japan

Brief summaries of each research activity are shown below.

6.1. Bottom-up Approach

During the 1st ERIA WG meeting held in Jakarta in September 2010, the ERIA WG had a joint session with the EED SWG. During this joint session, the WG directed the SWG to conduct a test calculation on estimating energy saving potential in specific sectors applying a bottom-up approach. As an example, the ERIA WG presented a test calculation result of electricity saving potential for lighting use in the residential sector of Japan. After the presentation, the ERIA WG requested the SWG members to choose a target sector in their respective countries for this analysis. The selected sectors are below:

a. Industry sector
    - Cement sector in the Philippines and Viet Nam
    - Petro-chemical sector in Singapore (Due to lack of data, Singapore changed to Road Transport sector)
b. Residential sector
    Cambodia, Lao PDR and Myanmar
c. Commercial sector
    Building sector in Indonesia and Thailand

During the 2nd ERIA WG meeting in Jakarta in December 2010, the ERIA WG requested members of the SWG to present their test calculation results. Most of the results were estimation of savings from energy efficiency and conservation programs, but the ERIA WG wanted a report of energy saving potential in the future such as year 2030. In this regard, the WG requested the members to do further work focusing on potential energy savings in 2030. Finally the ERIA WG received four energy saving potential reports from the SWG. These are:

Lao PDR: Electricity saving in residential sector

The SWG member of Lao PDR listed all appliances used currently in households and forecasted the future penetration rates of appliances based on future number of household. For BAU, the member applied existing power ratings while for the APS, more efficient power rating were applied.

According to the assumed energy saving target of Lao PDR, energy saving potential of other sector consisting of mainly residential and commercial sectors is 54 ktoe in 2020. On the other hand, the calculated electricity saving potential in residential sector is 11 ktoe in 2030. The contribution ratio is about 20% and there is perhaps consistency between the assumed energy saving and the saving that could be realized from technology improvement.

Singapore: Energy saving potential in the transport sector

The SWG member of Singapore forecasted future car demand applying car ownership estimated by the Gompertz model (this is BAU) and assumed available technologies (hybrid, EV and CNG) to each type of vehicles (cars, taxis, trucks, buses and motorcycles) for APS. The target year was 2030 or 20 years from now which is considered too short to replace existing vehicles stock with highly efficient vehicles. In this regard, the estimated energy saving potential by 2030 was too small.

The energy saving potential in transport sector using the policy target is almost 0 ktoe in 2030 and the potential by the bottom-up approach is 2 ktoe in 2030. Long-term energy efficiency policy could be necessary for the transport sector especially in road sector.

Thailand: Energy saving potential in the building sector

The SWG member of Thailand broke down the building type into commercial and non-commercial as well as energy consumption to end-use such as lighting, cooling and others. The member forecasted future energy consumption in the two types of buildings based on GDP growth assumption (this is BAU) and applied future efficiency improvement ratio to the three end-use consumptions (APS).

The energy saving potential based on energy efficiency policy in the other sectors is 9 Mtoe in 2030. On the other hand, the technical energy saving potential in the building sector is 2 Mtoe in 2030. The contribution of the building sector to the total is equivalent to more than 20% which seems to be appropriate.

Vietnam: Energy saving potential in Cement sector

The SWG member of Vietnam estimated future cement production until 2030 and estimated the energy consumption if current available technologies (wet and dry kiln) are used for the BAU. For the APS, more energy efficient technologies (energy efficient dry kiln) were assumed to estimate energy consumption. The difference in energy consumption between BAU and APS will be energy saving potential.

The policy energy saving potential in the industry sector is estimated at 4.3 Mtoe. On the other hand, the technical energy saving potential in cement sector is 1.6 Mtoe. This is 37% of the industrial sector. This seems appropriate considering that the share of the cement sector to the total industry in terms of energy consumption which is about 34% in 2005. However, it is forecasted that the share would decline to 10-12 % in 2030. In this regard, there could be more energy saving potential in other industry sub-sectors such as chemical and machinery sub-sectors.

The detailed reports are attached as Annex-2.

Although the reports contained the preliminary and test calculation results, the reports provided useful information to the government energy saving targets.

The ERIA WG recognizes the effectiveness of the bottom-up approach and intends to extend to all sectors and all energy uses. More reliable future efficiency assumptions are needed and these assumptions should be developed based on more careful and exhaustive research.

6.2. Satellite Projects

In 2010 the SWG on Energy Efficiency Design conducted energy saving potential analysis using the bottom-up approach in the cement industry in Vietnam, residential sector in Lao PDR, transportation sector in Singapore and building sector in Thailand. In addition the government of Japan through METI commissioned other research studies such as:

a. Needs for Clean Coal Technologies (CCT) in East Asia
b. Identifying Institutional Barriers for Technology Transfer for CO_2 Mitigation in East Asia
c. Basic Study on Utilization of Iron and Steel-Making Slag Products for Energy Saving, CO_2 Emission Reduction and Environmental Conservation in East Asia
d. Survey Analysis of the Road Transport Sector for Reducing CO_2 Emission
e. Survey of Diffusion of Smart Grid in East Asia

Brief descriptions of these projects are given below.

6.2.1. Study on the Utilization of Low Rank Coal and Clean Coal Technology in East Asia

In view of the anticipated continuous increase of coal consumption in East Asia for power generation and the consequential adverse environmental impact, Japan commissioned a study to determine the diversity of coal demand, the needs for clean coal technology, and the barriers in the promotion of low rank coal utilization as well as high efficiency coal-fired power generation technologies in East Asia. In 2009, the project was able to collect and organize information on the status of the use of low rank coal and development level of each utilization technologies. Information on the status of coal-fired power generation and the needs for high-efficiency coal-fired generation were also collected from selected East Asian countries. In 2010, the project collected and organized information on policy targets and barriers related to utilization of low rank coal and demand for high efficiency coal-fired power generation.

The study will analyze measures to eliminate or deal with barriers in adopting and promoting low rank coal utilization technologies as well as high efficiency coal-fired power generation technologies in the third phase of the study next year.

6.2.2. Identifying Institutional Barriers for Technology Transfer for CO_2 Mitigation in East Asia

Following the implementation of its "bilateral offset mechanism", Japan has selected projects in several countries around the world that would qualify for the scheme. The mechanism is a post-2012 emission reduction credit mechanism proposed by Japan. The mechanism provides support/incentive to Japanese private sector to export emission reduction and low carbon technologies. Japan expects to benefit from emission reduction credits from the technology receiving countries. The mechanism gives the host or technology receiving country high end efficient technology at competitive terms while Japan gets the emission reduction credits.

Having selected projects in several countries as candidates for bilateral offset mechanism, Japan would like to identify barriers for technology transfers in host countries. In 2010, research on these barriers was conducted in India, Indonesia and Viet Nam. The barriers identified in the study are as follows:

- High cost of Japanese equipment compared to Korean and Chinese technologies;
- Slow decision-making process in host countries;
- Low awareness and acceptance of energy efficiency and conservation (EE&C);
- Lack of information on available technology;
- Lack of efficient funding mechanism for intellectual property rights for the most efficient technologies;
- Insufficient financial support for EE&C; and
- Lack of political stability and enabling business environment.

To promote technology transfer from Japan, the study proposed that the following:

- Technology transfer should be beneficial to both countries (Japan and host country);
- Clear setting of baseline and methodology;
- Clear setting of monitoring and verification processes;
- Clear crediting process;
- Clear bidding system in choosing Japanese technology;
- Capacity building;
- Financial support for purchasing credit at higher price than the carbon market price;

- Provision of loan at lower interest rate; and
- Establishment of Japan Clean Technology Fund.

6.2.3. Basic Study on Utilization of Iron and Steel-Making Slag Products for Energy Saving, CO_2 Emission Reduction and Environmental Conservation in East Asia

Recognizing the potential for CO_2 emission reduction of the use of steel-making slag in the cement sector and in the restoration of coral reefs that could absorb CO_2, Japan commissioned a study to provide bases for the promotion of the beneficial use of this industrial by-product in East Asia. The main activities carried out in this study were:

- Collection of information on the use, standards and scale of demand for iron and steel-making slag products in 16 EAS countries;
- Experimental study on coral reef restoration by using iron and steel-making slag in Indonesia; and
- Estimation of potential effect on reduction of CO_2 emission by utilizing iron and steel-making slag products.

Results of the study show that use of iron and steel-making slag as a material input for cement production could reduce CO_2 emission in two ways. The first is the reduction of CO_2 emission by the replacement of limestone with slag as feedstock for Portland cement production and the second is the reduction in fossil fuel energy requirement. Replacing limestone with slag would reduce CO_2 emission in decarbonising limestone by 43.3 percent while the fossil fuel energy reduction would result in 40.3 percent reduction. Overall, the total CO_2 emission reduction would amount to 42.1 percent from 768.6 kg- CO_2/t to 444.9 kg- CO_2/t.

In the use of iron and steel-making slag in restoration of coral reef, the assumption for estimation was the replacement of cement by slag in the production of marine block to which coral will be transplanted. The study show that production of cement produces 135 kg-CO_2/ t while production of marine block which is using the carbonic solid of iron and steel-making slag absorbs 55 kg-CO_2/t on the contrary. The study also claims that marine block made of slag has an equivalent growth effect of double that of a concrete block. From this information, the amount of CO_2 emission that could be avoided and absorbed could be calculated.

6.2.4. Survey Analysis of the Road Transport Sector for Reducing CO_2 Emission

This survey is a continuation of the survey carried out in 2009 in India. In the 2009 study report, it was concluded that there is a need to improve the city level automobile statistics through road traffic census and improvement in the vehicle registration system.

In the 2010 study, the objective was to improve and develop a database for the road transport sector for saving energy and reducing CO_2 emission in India. In addition, since the results in India would be applicable to other big cities in East Asia, the study was expanded to cover Jakarta, Indonesia which is heavily dependent on automobiles. Jakarta was considered as a model city for the examination of potential solution measures in building of a sustainable automotive society.

The 2010 study gave the following conclusions: For India, it is necessary to delete discarded vehicles in the vehicle registry to improve the database. The traffic count guideline produced by this project is a result of integrated method among three leading institutes on transport in India as well as the environmental sector and Japanese traffic volume census manual.

For Indonesia, future CO_2 emission in Jakarta was estimated based on transport characteristics of the metropolitan area, number of vehicles, and traffic volume. It is estimated that CO_2 emission will increase 1.6 times from the 2008 value in 2020. However, this result needs to be re-evaluated by including more accurate emission factors of new low emission vehicles that are expected to be disseminated in the future.

6.2.5. Survey on the Diffusion of Smart Grid in East Asia

The purpose of this study is to determine the present situation of smart grid development in China and India in terms of latest technological development, international standardization and other related issues. The study revealed that both China and India have plans of developing smart grids in view of the rapidly increasing demands for electricity which have to be met with both conventional and inevitably, renewable energy. The introduction of huge quantities of renewable energy in the electric grids would necessitate the introduction of smart grids.

7. CONCLUSIONS AND RECOMMENDATIONS

At the 3rd 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.

7.1. 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 as countries pursue their economic and development goals. The continued reliance on fossil fuels to meet this increased energy demand will also be associated with significant increases in greenhouse gas emissions.

2. Due to significant increase of electricity demand and use of road transport fuel, advanced energy efficient and low emission technologies (including clean coal technology and biofuels) need to be widely deployed throughout the region for the simultaneous achievement of socioeconomic and environmental development goals and improvement in energy security.

3. Throughout the region there exists potential to increase energy efficiency and reduce the growth in energy consumption and GHG emissions. The results of this analysis indicate that by 2030 the implementation of currently proposed energy efficiency goals, action plans and policies across the EAS region could lead to the following reductions:

    - 18.1 percent in primary energy demand;
    - 18.6 percent in energy intensity; and
    - 25.0 percent in energy derived CO_2 emissions

4. The share of carbon intensive energy such as oil and coal is reduced due to the 364 percent increase of the non-fossil energy such as biomass and nuclear in the APS in 2030. Therefore, the diversification of the regional energy mix will contribute to the improvements in the regional energy security as well as carbon intensity defined as emissions divided by energy consumption. But due to the recent incident in Japan, the national nuclear energy programs of some countries might be delayed.

5. It is recognized that the industry and transport sectors are major energy consuming sectors in the EAS region and are also 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 to

contribute to energy saving and CO_2 emission reduction.

7.2. Policy Implications

With the above key findings, the working group members also identified policy implications and aggregated them into three major categories. The identified policy recommendations are based on a shared desire to enhance promotion of energy efficiency and conservation policies, increase low carbon energy such as biomass, monitor energy saving goals and action plans, and prepare accurate energy consumption statistics. The recommendations of the working group are listed here. It should be noted, however, that appropriate policies will differ between countries based on differences in country circumstances, policy objectives, and market structures and that not all members necessarily agreed to all recommendations.

1. *Energy efficiency and conservation and renewable energy policies*

- Policymakers should set and continuously improve the energy saving goals and action plans for each sub-sector to have a basis in setting the target saving potential
- Policy mechanisms, which include incentives, to promote the use of renewable energy and implementation of energy efficiency and conservation programs are needed to be established.
- Policies to remove subsidies to fossil fuels and provision of incentives to encourage further development of energy efficiency and conservation programs and renewable energy need to be formulated.
- Increasing use of biofuels could result in competition for land between food and energy production. Therefore, other sources of biofuels need to be considered.

2. *Carbon emission mitigation*

- CCT along with CCS technology are key options for maintaining energy security and climate change mitigation through wiser use of coal.
- Rapid increase in oil demand in EAS will have to be increasingly met by imports. Continued efforts are necessary to improve vehicle fuel economy and to increase alternative fuel vehicles to slow oil demand growth.

- Measures to reduce CO_2 emissions would include restriction of carbon emissions such as carbon pricing, and provision of subsidies for the application of low emission technologies such as solar PV and low emission vehicles.

3. ***Enhancing reliable energy statistics for monitoring of energy saving goals, action plans and policies***

- There is a need for more analysis on the computation of energy saving potential/ Use of benchmarks and best practices are needed. Therefore, more reliable energy statistics, especially end-use data, is needed for a robust analysis of energy saving potential.

7.3. 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 carbon dioxide 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. A range of policy options are available which could drive improvements in energy efficiency or the enhanced uptake of low emissions technologies. These policies include: government leadership and funding, energy conservation regulations, CDM projects, energy management systems, energy efficiency standards and labelling, long term energy efficiency goals or plans, communication campaigns, performance and emission standards, renewable energy portfolio standards (RPS), enhanced research and development funding, and explicit emission pricing instruments such as carbon taxes and emissions trading. The choice of policies used in individual countries will depend on a range of country specific factors and other competing policy objectives.

A range of more energy efficient and lower emission technologies were identified for EAS countries. In particular, the use of more energy efficient vehicles and demand management strategies in the transportation, residential, and commercial sectors are key in achieving potential energy savings. Improvement in the efficiency of thermal electricity generation was also identified as essential in achieving energy savings. International collaboration on technology development and transfer was identified as an opportunity for achieving future gains.

Lack of reliable energy statistics of the energy consuming sectors will impose barriers in monitoring and evaluating the energy saving targets and action plans in the EAS countries. The pilot survey on end-use energy consumption in residential sector has contributed in increasing capacity on collecting the energy consumption statistics. It is recommended that a national energy consumption survey should be conducted in EAS countries where such data are insufficient.

The projected level of energy savings and reduction in CO_2 emission will be significant if all of the energy saving and lower emission fuel policies proposed at the 4th Energy Ministers Meeting in July 2010 were implemented in EAS countries. Although enhanced energy efficiency and an increase in the share of lower 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 CCS technologies, and enhanced uptake of lower emission fuels are recommended to further reduce the CO_2 emission.

In order to implement in depth analysis on energy saving potential, the bottom-up approach to estimate energy saving potential applying available technologies were conducted in specific sectors by EED SWG. The results are useful and have provided effective feedback to improve the energy saving targets. Likewise, the five satellite research projects have provided beneficial outcomes for the working group。 Therefore the continuation of these research projects is recommended.

Concrete action is required to facilitate inter-regional collaboration on technology development and transfer and policy implementation within the EAS countries and between the EAS countries and the rest of the world. It was also noted that additional upfront costs may be associated with implementing more energy efficient technologies and increasing the share of renewable energy sources. Therefore, financial and economic analyses should be included in the scope of this study.

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