I. Introduction

Background of the Study

The 48 regional members of the Asian Development Bank (ADB) in Asia and the Pacific are a diverse group, with differing levels of economic development and energy resource endowment. Collectively, in 2005, this group covered 25% of the total land area of the world and had 56% of the world's population, but only 34.7% of the world's gross domestic product (GDP).

The economic disparities, however, are so wide that 31 members have very low per capita GDP, ranging from $800–$5,000 (purchasing power parity or PPP, in current US dollars), while seven have per capita GDP of $5,000–$15,000, and the remaining 10 have high per capita GDP of $20,000–$50,000.

As most of these members aim to achieve economic development and improvement in living conditions while the affluent few strive to maintain their standard of living, it can be expected that the already high level of collective energy consumption of these economies will continue to grow, and that this will translate into a substantial energy investment requirement and contribute to the potential for further global warming.

This study, which was prepared by a team of consultants from the Asia Pacific Energy Research Centre (APERC) of the Institute of Energy Economics, Japan (IEEJ) under an ADB regional technical assistance project aims to estimate the future demand for energy of all members, the investment requirements to meet this demand, and the resulting carbon dioxide (CO_2) emissions potential associated with the increasing energy demand. The study also attempts to identify policy and technological issues that need to be considered to mitigate the adverse impacts of increasing energy demand.

Scope of the Study and Report Structure

This outlook attempts to project the balance between energy demand and supply for the 48 regional members of ADB. However, due to the unavailability of energy data, the Marshall Islands, the Federated States of Micronesia, and Tuvalu are not included in the study. The outlook results are presented by member, by subregion, and by region. Based on the projected energy demand and supply, CO_2 emissions and investment requirements are derived. These will offer a basis for policy making and development planning geared toward sustainable economic development in the regional members in Asia and the Pacific.

The outlook report comprises the following:

- an overview of the energy demand and supply outlook, electricity outlook, CO_2 emissions outlook, and energy investment outlook;
- discussions on the energy outlook by subregion for Central and West Asia, East Asia, the Pacific, South Asia, and Southeast Asia;

- analysis of the major issues that are likely to affect the balance between energy demand and supply, with focus on energy access, energy security, energy efficiency, and urbanization;
- analysis of the energy demand and supply outlook for each of the 45 ADB members in Asia and the Pacific; and
- the energy outlook in table format.

Macroeconomic Assumptions

Gross Domestic Product

GDP assumptions were derived from both APERC and ADB.

APERC provided the GDP assumptions for the following 15 APEC members:

- East Asia: the People's Republic of China; Hong Kong, China; the Republic of Korea; and Taipei,China.
- Southeast Asia: Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam.
- The Pacific: Papua New Guinea.
- Developed Group: Australia, Japan, and New Zealand.

For the other members, the GDP assumptions were obtained from ADB:

- Central and West Asia: Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan.
- East Asia: Mongolia.
- The Pacific: Fiji Islands, Timor-Leste, and other Pacific islands.
- South Asia: Bangladesh, Bhutan, India, the Maldives, Nepal, and Sri Lanka.
- Southeast Asia: Cambodia, the Lao People's Democratic Republic, and Myanmar.

For historical GDP data, the World Bank's *World Development Indicators* (2008) was used for all members except Turkmenistan, which uses ADB estimates. GDP values in this report are expressed in US dollars at 2000 constant prices, while the GDP values in the investment chapter are expressed in dollars at 2006 constant prices.

Population Data

The United Nations' *World Urbanization Prospects* (2007) was used for both historical data and projections for all the regional members. The urban and rural population data were obtained from the same source. Taipei,China's population projection was obtained from the Council for Economic Planning and Development, Taipei,China (2007).

Crude Oil Price

The crude oil price assumption was obtained from the International Energy Agency (IEA) *World Energy Outlook 2008*. With this assumption, the average IEA crude oil import price is assumed to reach $100 per barrel (constant 2007 prices) by 2015 and then rise to $122 per barrel in 2030 (Table 1.1).

Table 1.1: Crude Oil Price Assumption

	Unit: $/barrel			
	2000	2007	2015	2030
Real Price (2007 prices)	33.3	69.3	100	122
Nominal Price	28.0	69.3	120	206

Source: International Energy Agency (2008).

Energy Data

In trying to maintain the internal consistency of data, IEA *Energy Balances of OECD and Non-OECD Countries* (2008) was utilized as the data source for the historical trend analysis of 31 regional members. These members represent more than 99.9% of the total primary energy demand of Asia and the Pacific. For the economies that belong to the Asia–Pacific Economic Cooperation (APEC), energy data is available from the APEC energy database; however, it was not utilized to maintain internal consistency—excluding Papua New Guinea, for which energy data is not available from IEA.

For those members for which data is not included in IEA (2008), the *United Nations' Statistics Database* was the source of energy data for the following members: Afghanistan, Bhutan, the Cook Islands, Fiji Islands, Kiribati, the Maldives, Nauru, Palau, Samoa, Solomon Islands, Timor-Leste, Tonga, and Vanuatu.

The outlook exercise was not conducted for the Marshall Islands, the Federated States of Micronesia, and Tuvalu due to unavailability of energy data.

Outlook Time Periods

The base year is 2005, although the historical trend analysis was made up to 2006. In Asia and the Pacific, 2005 is often utilized as the base year for the energy intensity improvement target; therefore, for the purpose of calculating the likely pathways toward meeting the energy intensity improvement target, 2005 was chosen as the base year.[2] In the summary table, both 2005 and 2006 values are presented. The outlook period is 2015 to 2030.

[2] A notable example is the APEC, where leaders agreed to set a target for a 25% energy intensity improvement by 2030 (2005 as the base year).

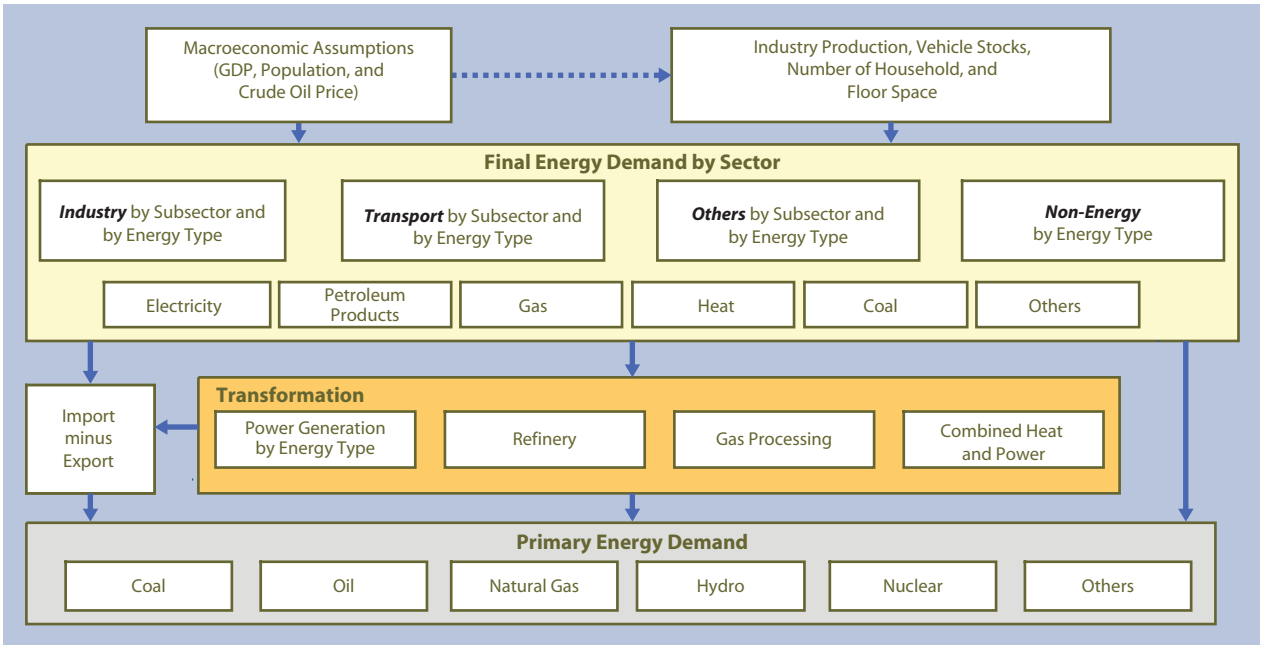
Energy Outlook Methodologies

To forecast energy demand, an econometric approach was applied. The IEEJ model is utilized in the majority of the countries' analyses. Demand equations are econometrically estimated using the historical data, while future values are projected using the explanatory variables. The IEEJ model allows historical trend analysis of socioeconomic variables and its correlation with energy trends.

The steps taken to forecast energy demand and supply are explained in Figure 1.1.

- For those countries that have socioeconomic data such as industrial production, vehicle stocks, household numbers, and floor space, the future assumptions are derived by using the key macroeconomic assumptions—including GDP, population, and crude oil price. These socioeconomic variables offer the basis for analyzing final energy demand. For those countries where socioeconomic data are not available, the key macroeconomic indicators are used as the underlying driver for final energy demand.
- Once the final energy demand projections by type of energy are ready, the transformation analysis—including electricity generation, oil refining, gas processing, and coal transformation—follows. In addition, the international electricity trade is analyzed as a source of electricity supply.
- Using the outcomes from the analyses of final energy demand, energy requirements, and transformation, the primary energy demand outlook by energy type is produced.
- Given the projected primary energy demand, energy imports and exports are analyzed by type of energy based on domestic energy reserves information and assessment of energy supply infrastructure development for pipelines, tankers, and receiving terminals.

Figure 1.1: Model Framework



GDP = gross domestic product.

Source: Asia Pacific Energy Research Centre (2009).

The level of disaggregation in the analysis by sector and by energy type depends on the data availability. Of course, an extensive literature survey was conducted to reflect policy shifts in the outlook results. For example, in a case where the historical trends do not necessarily offer an accurate assessment of future energy demand due to a change in policy, the analysis is conducted outside of the model, and the results are reflected in the model as exogenous variables.

For the countries with relatively short data periods, the Long-Range Energy Alternatives Planning System (LEAP) software was utilized to project future energy demand and supply using the intensity approach. Intensity approach is based on historical trend analysis in combination with a literature survey to determine the level of energy intensities (energy requirement per unit of GDP or per unit of population). Cross-sectional comparison was carried out to appropriately assess future energy intensity levels.

Calculations of CO_2 Emissions

CO_2 emissions in this energy outlook were calculated following the 1996 Revised Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC). As such, only emissions from fossil fuels were calculated. However, fugitive emissions were not taken into account—only the emissions from fuel combustion of both stationary and mobile sources.

Emissions from the following sectors are included:

- transformation;
- own use; and
- final demand sectors, which include industry, transport, commercial, residential, agriculture, and other sectors.

Fuel combustion occurs in the transformation, own use, and final demand sectors. In the transformation sector, fuel is combusted in heat and electricity generation, as well as in the operation of machineries in other transformation processes. It should be noted that crude oil that is refined into petroleum products is not combusted. Hence, there are no emissions calculated for refinery throughputs, but the refinery gas and other fuels combusted to operate the crude oil distillation units are included in the calculation of CO_2 emissions. The fuels combusted for heating, pumping, traction, and lighting purposes in energy extraction and other energy transformation processes are also included.

In final energy demand, the estimated demand for fossil fuels—which excludes non-energy demand in the industrial, transport, residential, commercial, agriculture, and other sectors—is also included for the calculation of CO_2 emissions.

Energy data are in net calorific values (NCV) which are lower than the gross calorific values (GCV) by the following factors:

Coal and coal products:	95% of GCV
Oil and oil products:	95% of GCV
Natural gas:	90% of GCV

The conversion factors used in the calculation are the average conversion factors from the 1996 revised guidelines of the IPCC as shown in Table 1.2. Members may have different

Table 1.2: 1996 IPCC Average Carbon Emission Factors

Oil and Oil Products	t-C/TJ	Coal and Coal Products	t-C/TJ
Crude Oil	20.0	Anthracite	26.8
Orimulsion	22.0	Coking Coal	25.8
Natural Gas Liquids	17.2	Other Bituminous Coal	25.8
Gasoline	18.9	Subbituminous Coal	26.2
Jet Kerosene	19.5	Lignite	27.6
Other Kerosene	19.6	Oil Shale	29.1
Shale Oil	20.0	Peat	28.9
Gas/Diesel Oil	20.2	Coal Briquettes	25.8
Residual Fuel Oil	21.1	Coke Oven/ Gas Coke	29.5
LPG	17.2	Coke Oven Gas	13.0
Ethane	16.8	Blast Furnace Gas	66.0
Naphtha	20.0	Natural Gas (Dry)	15.3
Bitumen	22.0		
Lubricants	20.0		
Petroleum Coke	27.5		
Refinery Feedstocks	20.0		
Refinery Gas	18.2		
Other Oil Products	20.0		

IPCC = Intergovernmental Panel on Climate Change, LPG = liquefied petroleum gas, t-C/TJ = tons of carbon per terajoule.

Source: IEA (2007).

emission factors for each of the products, but in this outlook, average values shown in the table are used for comparability and consistency.

Corrections for unoxidized carbon are also applied, using the following multipliers:

Coal:	0.98
Peat:	0.99
Oil:	0.99
Gas:	0.995

Afterwards, the results are multiplied by 44/12 the molecular ratio of CO_2 to carbon, to convert the numbers from tons of carbon to tons of CO_2 equivalent.

Special Notes

The readers of this *Energy Outlook* should take note of the following:

- The Marshall Islands, the Federated States of Micronesia, and Tuvalu were not included in this study due to unavailability of data.
- Energy demand in the other sectors includes those for residential, commercial, and other non-specified sectors, such as agriculture.