POLICY RESEARCH WORKING PAPER 1557

Electricity Demand in Asia and the Effects on Energy Supply and the Investment Environment

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Takamasa Akiyama

Electricity demand in seven Asian economies is expected to increase sharply in the coming years. To meet this demand, these countries must develop stronger domestic bond and stock markets to meet capital requirements for projected power development projects and pollution control.

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Summary findings

Demand for energy (including electricity) has been increasing more rapidly in developing Asian economies than anywhere else in the world and is expected to continue growing. To meet rising demand, these countries must address such issues as how to meet the resulting enormous capital requirements and how to prevent environmental deterioration.

To calculate what those capital requirements may be, and to estimate potential environmental damage, Ishiguro and Akiyama built econometric energy demand models for seven economies: China, Indonesia, Malaysia, the Philippines, Republic of Korea, Taiwan (China), and Thailand.

They estimate that electricity demand will increase an average 8.1 percent a year between 1993 and 2010 (the same rate as in 1980–92) — increasing 4.9-fold for the period. Growth rates for power demand are expend to decline in Indonesia, Korea, and Taiwan (China), but increase in Malaysia and the Philippines. China's growth rate is expected to remain about 7.6 percent a year. Demand growth is expected to shift from the industrial sector to the residential and commercial sector, whose share in electricity demand is expected to increase from 24 percent (1990) to 44 percent (2010).

Total electricity generated is expect to increase 3.8-fold, from 1.26 trillion kwh in 1993 to 4.8 trillion kwh in 2010, with coal accounting for 68 percent of the increase, oil 4 percent, natural gas 7 percent, nuclear power 8 percent, and hydro 12 percent.

Investment costs range from an estimated US$579 billion to US$772 billion (1992 dollars) for 1994–2005 and an estimated US$428 billion to US$485 billion for 2005–10.

To finance power development projects, many governments are encouraging "build, operate, and own" or "build, operate, transfer" schemes, but there is a limit to the use of these schemes, which require foreign capital and thus reimbursements in hard currency. Because the seven governments must mobilize substantial domestic resources to finance capital requirements, it is essential that these countries develop or strengthen development of domestic bond and stock markets.

To control emissions of pollutants will cost an estimated US$165 billion (in 1992 dollars) in 1994–2010.

This paper — a joint product of the Commodity Policy and Analysis Unit, International Economics Department, and Japan's Nomura Research Institute — is part of a larger effort to analyze commodity markets and their impact on developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Grace Ilogon, room N5-032, telephone 202-473-3732, fax 202-522-3564, Internet address gilogon@worldbank.org. December 1995. (61 pages)

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ABSTRACT

Demand for electricity as well as for total energy has been increasing more rapidly in the developing economies of East and Southeast Asia than in any other region of the world, and future growth is expected to continue to be high. To meet rising demand successfully, these economies must now address a number of issues. These issues include enormous capital requirements and prevention of environmental deterioration.

This paper attempts to project future electricity demand; estimate the amount of capital needed to meet this demand; and determine the extent of the environmental burden that will accompany a much-enlarged power sector in seven economies of the region, i.e., China, Indonesia, Korea, Malaysia, the Philippines, Taiwan, China and Thailand.

Econometric energy demand models were built for the seven economies. The models were then used to analyze and project power demand in the industrial and residential/commercial sectors, and in industrial subsectors where data were available. Income elasticities of demand in the industrial sector were found to be lower in the more industrialized economies, suggesting that energy conservation measures have been undertaken and reflecting that industrial products of these economies have been shifting from low value-added, energy-intensive ones, to high value-added, less energy-intensive outputs. Income elasticities in the residential/commercial sectors were found to be much higher than unity for all seven economies. This reflects the growing number of office buildings, shops, and electric appliances in use in these economies.

For the seven economies as a whole, electricity demand is projected to increase at an average rate of 8.1 percent p.a. for the period 1993-2010, which, coincidentally, is the same rate as that for the period 1980-1992. Final electricity use of the seven economies is projected to increase from 805 billion kWh in 1990 to 3,925 billion kWh in 2010, which is a 4.9-fold increase. The growth rates for power demand in Indonesia, Korea and Taiwan, China are expected to decline, while those in the Philippines and Malaysia are expected to increase. China's growth rate is expected to be about the same as for the preceding period --7.6 percent p.a. The growth in electricity demand in the seven economies as a whole is projected to shift from the industrial sector to the residential/commercial sector. As a result, the latter's share in total electricity demand is expected to increase from 24 percent in 1990 to 44 percent in 2010.

Based on these demand projections, final electricity supply in terms of kW and kWh was projected. For this purpose, total system losses and capacity factors were forecast based on recent historical data. Fuel mixes to produce power were also projected based on utilities' plans and recent trends. Total electricity generated by the seven economies is projected to increase from 1.26 trillion kWh in 1993 to 4.8 trillion kWh in 2010, which would be a 3.8-fold increase. The shares of coal, oil, natural gas, nuclear, and hydro in 2010 are expected to be 68 percent, 4 percent, 7 percent, 8 percent, and 12 percent, respectively. The increment in installed capacity of the seven economies is projected at 448 million kW during the period 1994-2005 and 315 million kW during the period 2006-2010.

The amount of capital that will be required to build additional power generation facilities was estimated on the basis of recent construction costs. Investment costs are estimated to be between US$579 billion and US$772 billion (in 1992 dollars) for the period 1994-2005, and between US$ 428 billion and US$ 585 billion for the period 2005-2010. To finance power development projects, many governments are encouraging the use of BOO/BOT schemes. Given that most of these schemes will involve foreign capital and thus require reimbursements in hard currency, there will be a limit to which these schemes can be used. As a result, governments in these seven economies will need to mobilize domestic resources to finance a substantial part of the capital requirements. The development of domestic bond and stock markets will be urgently needed in countries where these markets do not exist or are underdeveloped.

The growth in power generation in the seven economies is likely to cause serious environmental problems. Total CO_2 emissions are projected to increase from about 270 million tons of carbon equivalent in 1993 to about 925 million tons in 2010. Emissions of NO_x , SO_x , and particulate matter (PM) are expected to multiply by 2.5, 3.1, and 1.7, respectively, by 2010. Assuming that all newly constructed coal- and oil-fired power plants will be equipped with SO_x , NO_x , and PM reduction facilities to protect air quality, the cost for these facilities is projected to be US$165 billion (in 1992 dollars) for the period 1994-2010.

Weights and Measures

bpd	barrel per day (1 barrel = 159 liters)
GJ	Giga-Joule (239,000 kcal)
PJ	Peta Joule
kg	kilogram (2.205 pounds)
km	kilometer (0.62 miles)
kW	kilowatt
kWh	kilowatt-hour (860 kilocalories)
MW	megawatt (1,000 kW)
toe	ton oil equivalent (10^7 kilocalories)
ton	metric ton(1,000 kilograms)

Acronyms

ADB	Asian Development Bank
BOO	Build, Operate, and Own
BOT	Build, Operate, and Transfer
DSM	Demand Side Management
EP	Electric Precipitator
ERI	Energy Research Institute (of China)
EGAT	Electricity Generating Authority of Thailand
EPRI	Electric Power Research Institute (of China)
FGD	Flue Gas Desulfurization
FY	Fiscal Year
GDP	Gross Domestic Product
GOC	Government of China
GOK	Government of Korea
IEA	International Energy Agency
IEC	International Economics Department (of the World Bank)
IECCP	Commodity Policy and Analysis Unit (of the World Bank)
IPP	Independent Power Project
KEPCO	Korea Electric Power Corporation
LNG	Liquefied Natural Gas
MEA	Metropolitan Electricity Authority (of Thailand)
MOEP	Ministry of Electric Power (of China)
NPC	National Power Corporation (of the Philippines)
NRI	Nomura Research Institute, Ltd.
OECD	Overseas Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
PDP	Power Development Plan (or Program)
PEA	Provincial Electricity Authority (of Thailand)
PLN	Perusahaan Umum Listrik Nagara (of Indonesia)
PM	Particulate Matter
SCR	Selective Catalytic Reduction
SEB	Sabah Electricity Board (of Malaysia)
SESCO	Sarawak Electricity Supply Corporation (of Malaysia)
SPC	State Planning Commission (of China)
TNB	Tenaga Nasional Berhad (of Indonesia)

INTRODUCTION

The electricity demand of Asian developing countries has been increasing rapidly. Seven economies examined in this study--China, Indonesia, Korea, Malaysia, the Philippines, Taiwan, China and Thailand--consumed a combined total of 898 billion kWh in 1991. Many of these economies posted double-digit percentage annual growth in electricity consumption. This high growth is expected to continue into the 21st century.

In order to meet the rapidly increasing power demand in these economies, power supply has to be increased also at a rapid pace. An immediate concern is whether these economies can find capital to finance the enormous costs required to expand their power generation capacities and to enlarge the accompanying transmission and distribution systems. In order to cope with the situation, the structure of the power sector of the region has been changing recently. Many existing monopolistic utilities are expected to be incorporated or privatized in the near future. A number of independent power projects (IPPs) have been in progress since the late 1980s because governments and existing public utilities have had difficulty in financing the power development projects to meet the rapidly increasing demand. Another reason is that the government-owned public utilities have become too inefficient to adapt to rapidly changing business circumstances and to keep up with advancing modern technologies.

Because of the sheer size of incremental generation and because a large portion of it is expected to come from coal-fired power, environmental problems are likely to exacerbate greatly in many countries. Even today the environmental deterioration caused by power generation is a serious issue in many areas including around Bangkok and various parts in China. Environmental damage is likely to spread and would become an important regional issue. Pollution caused by power generation can be alleviated to a significant degree by the installation of anti-pollution devices. However, such devices would add considerable costs to the already high costs of building generating facilities.

The first section of this paper projects electricity demand in the seven economies, using econometric energy models. Model projections are compared with forecasts made by the governments or utilities of the economies concerned. The second section examines the prospects for electricity supply, based on utilities' plans and projects' energy mixes. The third section projects capital requirements for power development. The fourth

section evaluates the environmental burden arising from fossil fuel consumption, and the fifth section provides the conclusions.

1
PROJECTIONS OF ELECTRICITY DEMAND

Econometric models were constructed to make projections of electricity demand through 2010 in the seven economies covered by the study. The projected values were then evaluated and compared with projections made by the seven economies or by their electric power agencies.

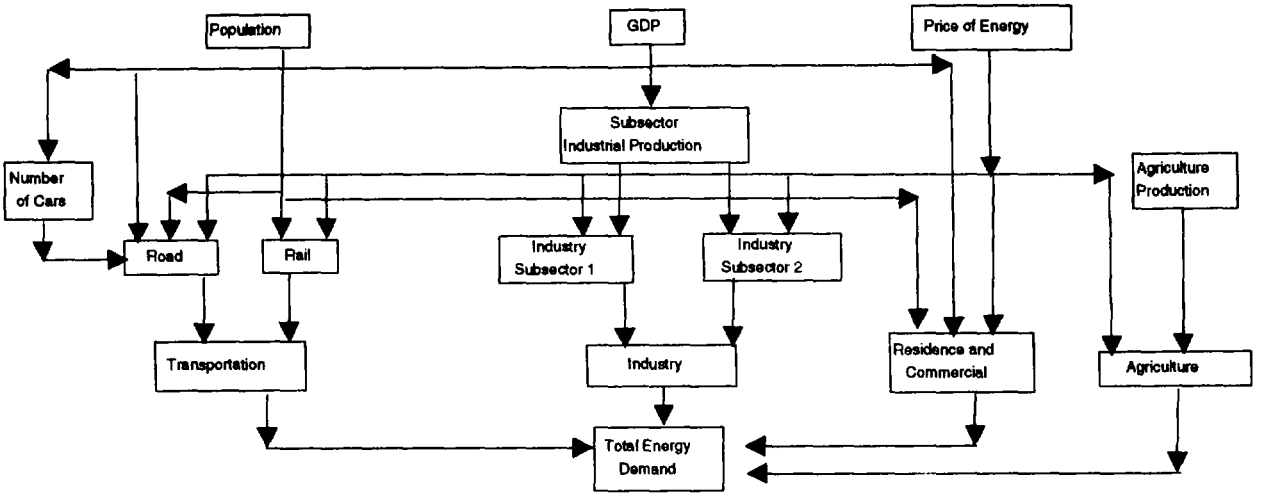
MODEL USED FOR PROJECTING ELECTRICITY DEMAND

Econometric models to analyze and project energy demand in five Asian developing countries (China, India, Indonesia, Korea, and Thailand) were constructed and used in the Bank's Energy Demand in Five Major Asian Developing Countries (Ishiguro and Akiyama 1995). For the present study, similar models were constructed for Malaysia, Taiwan, China and the Philippines.

Structure of the Model

Differences in the models from one country to another were mainly the result of differences in the availability of data and information. The structure of a typical model is shown in Figure 1.1 as a flow chart. As shown in Figure 1.1, total energy demand is the sum of energy demand in four sectors--transportation, industry, household, and agriculture. Depending on data availability, the industrial sector was disaggregated into subsectors. Where possible, demand in all sectors and subsectors was disaggregated to show demand for electricity and for fossil fuels. The main exogenous variables used in the model included population, GDP, prices of energy, and time trend. Time trend was used mainly to capture changes in efficiency in energy use. These past trends were not automatically extrapolated in the projection exercises. Information on recent policies, technologies, and the extent of energy conservation efforts was taken into account in extrapolating time trends.

Figure 1.1: Structure of Energy Demand Model



Source: IEC, World Bank.

The data used in the models were mainly from the IEA. Data on GDP, value-added by sector, and population came from the Bank, while data on value-added at subsector levels and data on other variables came from each individual economy sources.

Assumptions

The main exogenous variables used were projections of GDP and population through 2010. These are given in Table 1.1. Because the Bank's GDP projections extend only to 2005, it was assumed that growth rates for the period 2005-2010 would be the same as for the period 2001-2005.

To determine the distribution of GDP among industry, services, and agriculture, it was assumed that each sector's share of incremental GDP between 1985 and 1991 would be the same during the projection period,[1] except for China. For China, projections in

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[1] Mathematically this can be expressed as:

$$\Delta VA_t^i = \Delta GDP_t * \frac{\Delta VA^i_{85-91}}{\Delta GDP_{85-91}}$$

where ΔVA_t^i = change in value-added in sector i from year t-1 to year t

ΔGDP_t = change in GDP from year t-1 to year t

"China: Issues and Options of Greenhouse Gas Emission and Control," undertaken jointly by the government of China, UNDP and the Energy and Industry Department of the World Bank (1994) were used.

Table 1.1: GDP and Population Growth, 1993-2010

(percent per annum)

	GDP			*Population*	
	1981-1990	*1994-2000*	*2000-2010a/*	*1994-2000*	*2000-2010*
	(Actual)	*(Forecast)*		*(Forecast)*	
China	8.8	8.6	8.4	1.2	1.2
Indonesia	5.6	6.4	6.4	1.5	1.5
Malaysia	5.3	8.1	7.8	2.2	2.1
Philippines	1.0	5.1	5.2	1.8	1.7
Korea	9.3	7.7	7.4	0.8	0.8
Taiwan, China	8.5	7.6	7.6	1.0	1.0
Thailand	8.0	8.9	8.6	1.3	1.3

a/ Projections only available up to 2003.
Projected rates for 2003 were assumed to continue through 2005.
Source: IEC, World Bank.

Key Elasticities

Income and price elasticities of demand for electricity were estimated econometrically for the seven economies for the industrial and residential/commercial sectors. The results are given in Table 1.2.

Care should be taken in interpreting these elasticities. Because of supply constraints, energy consumption in some years in some economies might have been smaller than demand.

ΔVA^{i}_{85-91} = change in value-added in sector i between 1985 and 1991.

ΔGDP_{85-91} = change in GDP between 1985 and 1991.

Table 1.2: Income and Price Elasticity of Demand for Electricity Residential/Commercial and Industrial Sectors

	Residential/Commercial		*Industrial Sector*	
	Income	*Price*	*Income*	*Price*
China	1.66	N.E.	0.68	N.E.
Indonesia	2.37	-0.03	3.16	N.S.
Malaysia	1.52	-0.14	0.86	-0.48
Philippines	1.97	-0.33	1.09	N.S.
Korea	1.58	N.S.	0.90	-0.39
Taiwan, China	1.10	-0.33	0.58	-0.37
Thailand	1.83	N.S.	1.18	N.S.

N.E. = Not estimated.
N.S. = Not statistically significant.
Source: IECCP, World Bank.

Energy demand in the industrial sector was disaggregated for those economies for which data were available. For Korea, Thailand, and Taiwan, China, data were available for the nine two-digit ISIC numbers (i.e., 31 to 39) for manufacturing, construction, and mining, for the period 1981 to 1990. It was also possible to disaggregate energy demand for each subsector. For China, data were available only for the period 1985-1990, so only the trend analysis on the energy intensities of electricity and fossil fuel for eleven subsectors were undertaken. The analysis showed a significant decline of 2.5 - 4 percent p.a., depending on the subsector. For Indonesia, the Philippines, and Malaysia, consistent data were available only for industry as a whole.

As shown in Table 1.2, income elasticities in the residential/commercial sector were found to be much higher than unity for all seven economies analyzed. The construction of office buildings and shops and the purchase of electric appliances were probably the major causes for the rapid increase in electricity demand in recent years. Price elasticities were low in this sector for all the seven economies, except the Philippines and Taiwan, China. In the Philippines, people appear to be price-conscious in their use of electricity. Taiwan, China's high price elasticity is probably the result of efforts in energy conservation in the 1980s.

Income elasticities of demand in the industrial sector were lower in the more industrialized of these economies (China, Korea, Malaysia and Taiwan, China) than in the less industrialized economies (Indonesia, Thailand, and the Philippines). This suggests

that energy conservation efforts in the more industrialized economies, and a shift from low value-added, energy-intensive products to high value-added, less energy-intensive ones were under way in the more industrialized countries. Also, price elasticities were higher in the more industrialized economies, again suggesting that prices had a greater impact on energy conservation and on shifts in production in these economies than in others.

RESULTS OF ELECTRICITY DEMAND PROJECTIONS

Although projected growth rates of final electricity demand between 1993 and 2010 varied from country to country, those of the seven economies as a whole were estimated at 8.1 percent p.a., the same as the figure for the period 1980-1992 (see Table 1.3). The final electricity demand of the seven economies was projected to increase from 805 billion kWh in 1990 to 1,803 billion kWh in 2005 (2.2 times as much as in 1990) and to 3,925 billion kWh in 2010 (4.9 times as much as in 1990).

The growth rates of electricity demand in Indonesia, Korea, and Taiwan, China are expected to decline, while those in the Philippines and Malaysia, where high economic growth is projected to continue, are expected to increase. In China, the recent level of growth in electricity demand is expected to continue. China's share of electricity demand in the region--about two-thirds--was projected to be stable up to 2010.

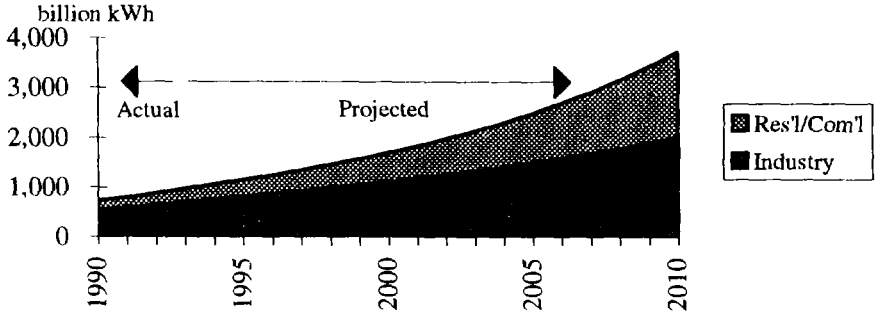
The electricity demand of the region as a whole was projected to shift from the industrial sector to the residential/commercial sector, as shown in Figure 1.2. Growth in electricity demand from the industrial sector was estimated at 6.3 percent p.a. between 1993 and 2010, which is one percentage point less than 7.3 percent p.a. in 1980-1990. Conversely, growth in the demand from the residential/commercial sector was projected to be 11.6 percent p.a. in 1993-2010, which is about twice the rate of that in the industrial sector. As a result, the residential/commercial sector's share of electricity demand is forecast to increase steadily, from 24 percent in 1990 to 32 percent in 2000 and to 44 percent in 2010.

Table 1.3: Final Electricity Demand in the Seven Economies (billion kWh)

Country	*Sector*	*1990*	*1995*	*2000*	*2005*	*2010*	*Annual Growth Rate*	
							1980-1992	*1993-2010*
China	Industrial	402.3	595.4	808.7	1,058.2	1,387.3	7.1%	5.7%
	Res'l/Com'l	76.0	153.4	289.2	542.8	1,018.8	14.2%	12.8%
	All	531.6	814.6	1,181.7	1,717.5	2,568.7	7.7%	7.6%
Indonesia	Industrial	14.2	23.3	40.6	68.0	110.5	19.3%	10.5%
	Res'l/Com'l	11.7	21.3	40.3	75.8	141.3	10.7%	12.6%
	All	27.7	47.3	84.7	149.0	258.9	13.8%	11.4%
Malaysia	Industrial	9.8	18.0	29.7	48.1	78.0	8.7%	9.8%
	Res'l/Com'l	10.3	16.8	26.7	40.8	61.7	8.5%	8.8%
	All	20.7	35.5	57.3	90.4	141.8	8.8%	9.3%
Philippines	Industrial	9.9	12.2	18.3	27.1	39.8	2.1%	7.9%
	Res'l/Com'l	10.4	13.0	19.0	27.0	37.4	5.2%	7.1%
	All	21.2	26.5	39.0	56.2	79.9	3.0%	7.4%
Korea	Industrial	56.8	83.4	113.3	148.1	195.9	9.9%	5.4%
	Res'l/Com'l	34.1	53.5	83.9	127.8	193.3	12.7%	8.5%
	All	93.4	140.3	200.8	280.1	394.2	11.0%	6.9%
Taiwan, China	Industrial	39.8	51.5	65.1	82.9	106.4	6.1%	4.8%
	Res'l/Com'l	27.0	42.6	61.9	88.8	126.4	10.2%	7.3%
	All	72.1	101.6	137.1	185.8	252.6	7.7%	6.1%
Thailand	Industrial	17.7	26.9	41.3	61.3	90.4	10.4%	8.2%
	Res'l/Com'l	20.1	37.9	60.0	91.3	136.1	12.0%	8.6%
	All	38.1	65.6	102.4	154.1	228.8	11.3%	8.4%
Total	Industrial	550.5	810.6	1,116.9	1,493.9	2,008.4	7.3%	6.3%
Seven	Res'l/Com'l	189.5	338.6	581.0	994.3	1,715.0	12.1%	11.6%
Economies	All	804.9	1,231.3	1,803.0	2,633.1	3,924.9	8.1%	8.1%

Source: IEA; IEC, World Bank.

Figure 1.2: Comparison of Final Electricity Demands in the Industrial and Residential/Commercial Sectors



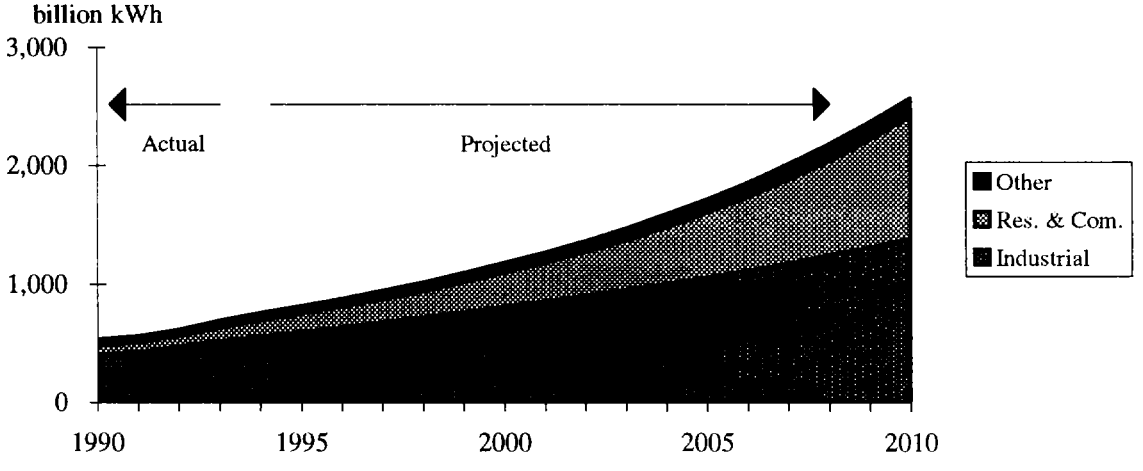
Source: IEC, World Bank.

China

Although growth in China's final electricity demand was projected to be one of the lowest among the seven economies; growth in demand in the residential/commercial sector is expected to be the highest. On the other hand, growth in demand in the industrial sector will be low: 5.7 percent p.a. vis-à-vis 12.8 percent p.a. in the residential/commercial sector between 1993 and 2010.

Growth in final electricity demand was projected to decline slightly, from 7.7 percent p.a. in 1980-1990 to 7.6 percent p.a. in 1993-2010. As shown in Figure 1.3, total final electricity demand is expected to increase to 1,182 billion kWh in 2000 (2.2 times as much as in 1990) and 2,569 billion kWh in 2010 (4.8 times as much as in 1990).

Figure 1.3: Final Electricity Demand: China



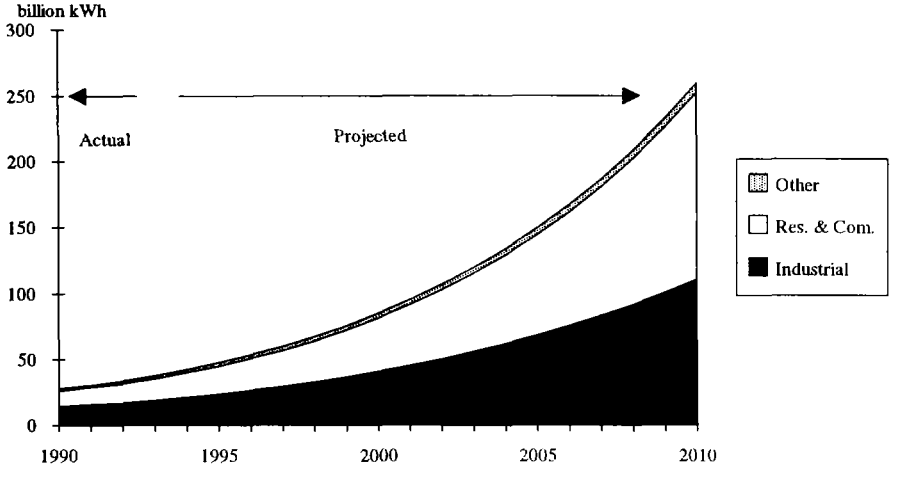
Source: IEC, World Bank.

Indonesia

During the 1980s, Indonesia posted the highest growth--13.8 percent p.a.--in total final electricity consumption among the seven economies. Although the rate is expected to decline to 11.4 percent p.a. between 1993 and 2010, that is still high compared to other countries. High growth in electricity demand is projected not only in the residential/commercial sector but also in the industrial sector. Indonesia's annual average growth rate in industrial sector demand is expected to be in double digits, unlike Korea's and Taiwan, China's which are expected to decline to about 5 percent p.a. As a result,

total final electricity demand of 27.7 billion kWh in 1990 is projected to increase three-fold, to 84.7 billion kWh in 2000, and more than nine fold, to 258.9 billion kWh, in 2010 (see Figure 1.4).

Figure 1.4: Final Electricity Demand: Indonesia

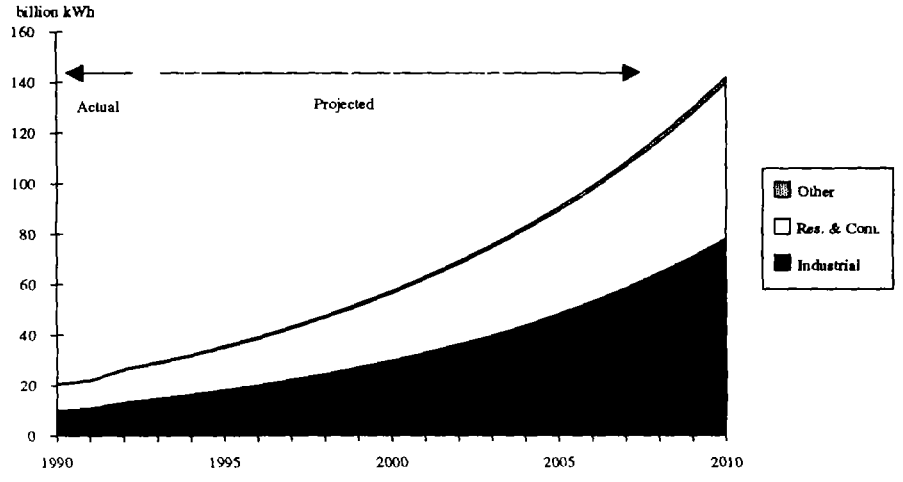


Source: IEC, World Bank.

Malaysia

In Malaysia, growth in total electricity demand towards the year 2010 is expected to be higher than in the 1980s and early 1990s because growth in demand in the industrial sector is projected to stay at a high level. Higher demand growth in the industrial sector is a salient feature of Malaysia. While electricity demand in the other countries was projected to shift from industrial use to household and commercial uses, growth in demand in the industrial sector is expected to be higher than in the residential/commercial sector. In Malaysia, the growth rate of total final electricity demand was projected to be 9.3 percent p.a. As a result, total final electricity demand of 20.7 billion kWh in 1990 will increase almost three fold, to 57.3 billion kWh in 2000, and seven fold, to 141.8 billion kWh in 2010, as shown in Figure 1.5.

Figure 1.5: Final Electricity Demand: Malaysia



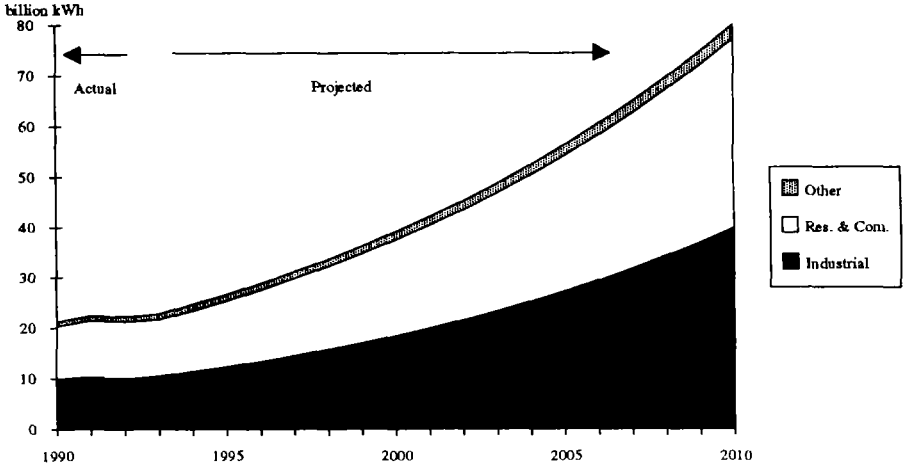
Source: IEC, World Bank.

The Philippines

Like Malaysia, the Philippines is expected to post higher growth in final electricity demand in the future than in the recent past. One difference between the Philippines and Malaysia is that the Philippines' low growth in demand during the 1980s was mainly caused by supply problems. The growth rate in electricity consumption in the industrial sector between 1980 and 1992 was only 2.1 percent p.a. This low growth rate does not mean that growth in actual demand stayed at such a low level, but that the increase in supply was limited to this level. In other words, the demand was constrained and unsatisfied because of supply problems. Higher growth in electricity demand than in the recent past in the industrial sector is expected because economic growth is expected to be higher during the projection period than it was in the 1980s, and electricity supply is likely to increase more than it did in the past because of efforts to streamline the power sector.

As shown in Figure 1.6, electricity demand of 21.2 billion kWh in 1990 was projected to increase about two fold, to 39 billion kWh in 2000, and about four fold, to 141.8 billion kWh, in 2010.

Figure 1.6: Final Electricity Demand: the Philippines



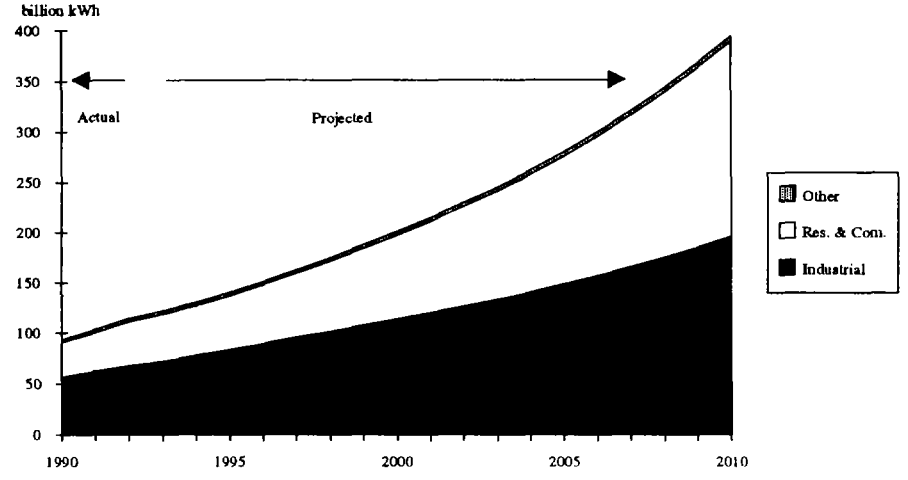
Source: IEC, World Bank.

Korea

The growth rate of electricity demand in Korea is expected to decline in the future due to three reasons: first, Korea's economic growth is expected to be lower than in the recent past; second, the structure of the industrial sector is expected to shift toward the manufacture of high-value-added and low-energy-intensive products; and third, energy saving in the manufacturing sector should continue to rise. In other words, Korea's pattern of energy consumption is expected to become more like that of the industrialized countries, such as Japan, in the near future. The growth rate of final electricity demand was projected to decline from 11 percent p.a. in 1980-1992 to 6.9 percent p.a. in 1993-2010. Total final electricity demand will increase from 93.4 billion kWh in 1990 to 200.8 billion kWh in 2000 (2.1 times as much as in 1990) and 394.2 billion kWh in 2010 (4.2 times as much as in 1990), as shown in Figure 1.7.

In addition to Korea's declining growth in demand, another feature is that the residential/commercial sector's share of electricity demand will sharply increase, from 36 percent in 1990 to 42 percent in 2000 and 49 percent in 2010, because of increasing living standards.

Figure 1.7: Final Electricity Demand: Korea



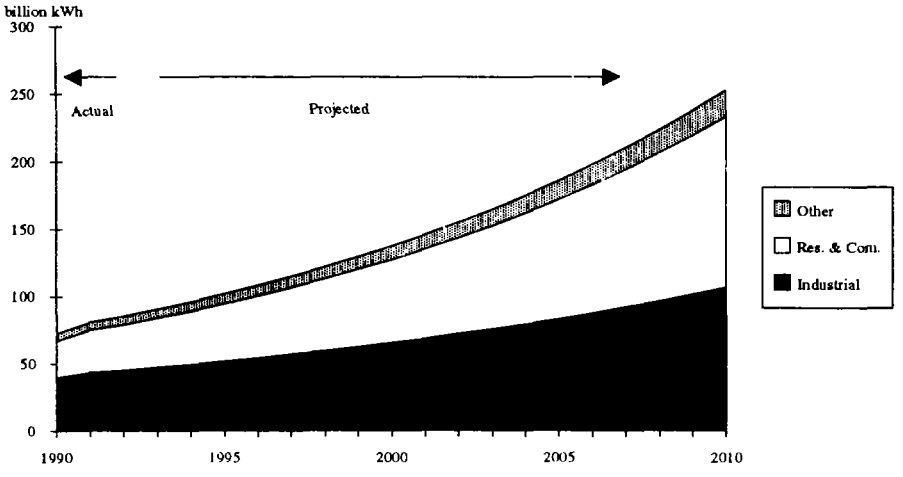
Source: IEC, World Bank.

Taiwan, China

In Taiwan, China as well as in Korea, growth in final electricity demand is expected to decline to a rate of 6.1 percent p.a. in 1993-2010. This growth will be the lowest among the seven economies. The growth rate of demand from the industrial sector will drop from 6.1 percent p.a. in 1980-1992 to 4.8 percent p.a. in 1993-2010. As shown in Figure 1.8, total final electricity demand will increase from 72.1 billion kWh in 1990 to 137.1 billion kWh in 2000 (1.9 times as much as in 1990) and 252.6 billion kWh in 2010 (3.5 times as much as in 1990).

Although growth in demand in the residential/commercial sector will also decline, it is still expected to stay at a higher level (7.3 percent p.a.) than the rate in the industrial sector. Due to this difference in growth rates, the residential/commercial sector's share will increase sharply--from 37 percent in 1990 to 50 percent in 2010.

Figure 1.8: Final Electricity Demand: Taiwan, China



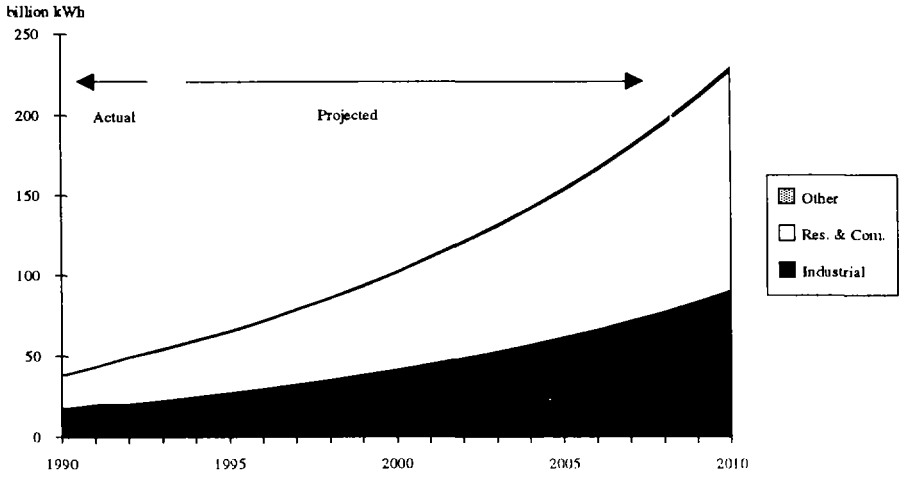
Source: IEC, World Bank.

Thailand

In Thailand, electricity demand during the 1980s grew at the rate of 11 percent p.a., the same rate as in Korea. While the growth rate of demand in Korea in 1993-2010 is expected to decline to 6.9 percent p.a., the growth rate in Thailand is projected to stay at a higher level of 8.4 percent p.a. because growth in demand from the industrial sector is projected to be high. The final electricity demand of 38.1 billion kWh in 1990 is projected to increase to 102.4 billion kWh in 2000 (2.7 times as much as in 1990) and 228.8 billion kWh in 2010 (6 times as much as in 1990), as shown in Figure 1.9.

Demand structure is expected to change. The industrial sector's share should decline from 46 percent to 40 percent between 1990 and 2010. On the other hand, the residential/commercial sector's share should increase from 53 percent to 59 percent during the same period.

Figure 1.9: Final Electricity Demand: Thailand



Source: IEC, World Bank.

Comparison Between the Current Plans of the Governments or Utilities and the IECCP Model Projections

Table 1.4 shows the difference between the projections of the governments or utilities of each economy and those of the model up to the year 2005. The figures for China, the Philippines, Taiwan, China and Thailand show significant differences. The difference in Korea's, Taiwan, China's and Thailand's figures are probably due to an assumption by the governments or utilities that they will achieve substantial energy conservation through demand side management (DSM). Large differences in the figures for China and the Philippines can be explained as follows:

China. Although the figures quoted here may not be the ones authorized by the Government of China (GOC), these are projections announced by governmental organizations. The lower number is the figure found in the base scenario of future power demand projection made by the Electric Power Research Institute (EPRI) of the Ministry of Electric Power (MOEP). The higher number is the figure received directly from MOEP. In Table 1.4, final electricity demand was calculated under an assumption that total electricity losses will be 20 percent in 2005 because the original figures were defined as electricity generation. The IECCP model projection is 8-14 percent higher than GOC's projection. This difference is attributed to the fact that GDP elasticities in the IECCP model are higher than those of GOC's.

The Philippines. The large difference is attributed to differences in GDP projections. The National Power Corporation (NPC) used the highest GDP figure--a 10 percent p.a. growth rate--among the economic growth scenarios drawn by the Government of the Philippines. Conversely, the GDP growth rates used in the model were 5.1 percent or 5.2 percent p.a. NPC has already revised its projection internally and has reduced expected power demand by about 10 percent in a draft of the new 1995 Power Development Program.

Table 1.4: Comparison Between Current Plans and Model Projections for 2005[1/]

(billion kWh)

Country	*Current Plan*		*Model*	*Difference*
China	1,470	2/	1,717	14.4%
	1,580	3/		8.0%
Indonesia	153	4/	149	-2.5%
Malaysia	86	5/	90	5.4%
Philippines	91	6/	56	-62.4%
Korea	264	7/	280	5.8%
Taiwan, China	170	8/	186	8.5%
Thailand	140	9/	154	9.1%

Source: IEC Estimates

1/ Assumed total system losses are as follows:

China	20%
Indonesia	20%
Malaysia	15%
Philippines	18%
Korea	10%
Taiwan, China	10%
Thailand	11%

2/ Base scenario of EPRI's projection

3/ Ministry of Electric Power

4/ PLN

5/ Ministry of Trade, Industry and Energy

6/ Department of Electricity Supply

7/ Power Development Program of NPC

8/ Program 8201 of Taipower

9/ 1911LFWG's projection in Revised PDP92-01

2
PROSPECTS FOR ELECTRICITY SUPPLY

OVERVIEW

As discussed in Section 1, substantial electric power development will be needed to meet the rapidly increasing electricity demand in the seven economies examined. Results of the final electricity demand projection using the model show that electricity supply is expected to increase more than twofold by 2005 and almost fourfold by 2010, compared to 1993. Two chief sources of additional energy for the production of electric power are likely to be: (i) a substantial increase in coal's share as a source of power supply; and (ii) accelerated nuclear power development, especially in China, Korea, and Taiwan, China.

This section analyzes current government and utility plans for electric power development, and projects future power supplies and energy mixes. It also discusses potential problems arising from future power development in the region.

CURRENT POWER DEVELOPMENT PLANS OF GOVERNMENTS AND UTILITIES

Current power development plans of the region's governments and utilities will focus on the next ten to fifteen years. This section briefly reviews the likely course of power source development in the seven economies during that period.

China's Power Development Plan

Since China has an abundant domestic supply of coal, its high dependency on coal for electric power generation is expected to continue. More than 80 percent of the increase in power supply during the period is expected to come from coal-fired power plants. However, the coastal region, where growth in electric power demand is much higher than in other regions, is so far away from domestic coal mines that high-voltage lines to transmit electric power to the region are not a practical solution. Although several large hydro-power projects on the Huanghe (Yellow) and Yangtze Rivers and a number of small diesel power projects are under way, they will not provide enough new capacity to

meet the increase in demand. The government plans to accelerate nuclear power development and has announced that nuclear plants are expected to account for 3 percent of total power capacity (kW) and 4 percent of electricity output (kWh) by the year 2010.

Indonesia's Power Development Plan

Although Indonesia still depends heavily on oil-fired plants to generate electricity, the country's power sector is shifting from oil to other energy sources because oil production capacity is expected to decline after the mid-1990s.[1] With regard to natural gas, exports take precedence over domestic uses. Consequently, domestic coal is likely to become a major substitute for oil as a source of power production.[2] The government is also keen to develop nuclear power, although it does not have any concrete plans to do so yet.

Malaysia's Power Development Plan

There has been a shift from oil to natural gas as a source of electric power in Malaysia since the mid-1980s because of the abundance of natural gas reserves. As a result, natural gas provided 62 percent of the energy used for power generation in 1993. The government believes that imported coal may be needed in the future to avoid heavy dependence on natural gas. The government is reluctant to develop nuclear power because of its high cost.

The Philippines' Power Development Plan

Since domestic fuel supplies are limited, any increase in power generation in the Philippines will have to depend on foreign energy sources. Under the Power Development Program (PDP) of 1993 of the National Power Corporation (NPC), the energy mix after 1999 is incomplete because of lack of domestic sources. The unidentified energy source's share of total supply will gradually increase to 50 percent in 2006. Although the

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[1] See Sastrohartono (1993).

[2] Sub-bituminous coal produced in Indonesia has low sulfur and is a preferable fuel for power generation. Present proven reserve of coal in the Central and South Sumatra has an equivalent volume supplying 5 million tons a year for 30 years.

development of natural gas in Palawan is expected in the future, the supply is limited.[3] The use of imported coal will therefore be the most probable option in the next century.

Korea's Power Development Plan

Under its current power development program, Korea will depend for its future power supply mainly on nuclear power. Nuclear power's share of total electricity generation in 2006 is expectded to rise to almost 50 percent. Korea actively developed nuclear power plants during the 1970s and 1980s, and substituted nuclear energy for oil. Coal will be another major power source and is expected to account for 34 percent of Korea's electric power production in 2006.

Korea's current nuclear development program calls for building an additional fourteen reactors by 2006. Whether these plans will materialize in light of increasing criticism of nuclear power is uncertain. If the nuclear plan is not realized, Korea will depend more on coal or LNG, or both, as sources of energy.

Taiwan, China's Power Development Plan

Taiwan, China's energy mix is quite diversified. Coal, LNG, and nuclear energy are proportionally allocated in the government's plan. In 2006, nuclear and coal-fired power plants will each account for one-third of Taiwan, China's power generation, and oil-fired, LNG-fired, and hydro the remaining one-third.

Thailand's Power Development Plan

Dependency on imported energy is expected to increase substantially in the next century. Although Thailand has domestic reserves of natural gas and lignite, production is believed to have peaked. EGAT plans to increase coal imports and to purchase electricity from the Lao People's Democratic Republic after 2000.

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[3] It is estimated that Palawan has enough natural gas to provide a maximum 3 million kW of power generation.

METHODOLOGY AND ASSUMPTIONS USED IN PROJECTING ELECTRICITY SUPPLY

The Methodology

Based on the projections of final electricity demand given in Section 1, electric power supply in terms of both kWh and kW was projected up to the year 2010. Gross electricity output (kWh) was defined as final electricity demand plus total system losses. Installed capacities were also calculated, based on projected gross output and estimation of the capacity factor of each power source.

Total system losses. Based on historical data from the 1980s (see Figure 2.1), total system losses betweem 2005 or 2010 are projected at 20 percent in China, 20 percent in Indonesia, 15 percent in Malaysia, 18 percent in the Philippines, 10 percent in Korea, 10 percent in Taiwan, China and 11 percent in Thailand.

Although in China and Malaysia there have been some improvements in total system losses since the late 1980s, these improvements might not continue significantly. In Malaysia, for example, total system losses declined between FY1987 and FY1989 but began to increase again in FY1990. With regard to China, estimating total system losses is much more difficult due to insufficient data. In Figure 2.1, losses in China are less than 15 percent, but these figures do not include distribution losses. Transmission and distribution losses in China are estimated at 16 to 20 percent in the early 1990s. Moreover, auxiliary consumption of thermal power plants, which account for roughly 90 percent of the total electricity generation, is estimated at 8 percent in 1990.[4]

As regards Korea and Taiwan, China, losses might not improve significantly because the total system losses of 10 percent are technically near the best on record. Japan's total system losses, for example, are at present from 9 to 10 percent, one of the lowest such figures among the industrialized countries.

Capacity factor. Capacity factors change with power source diversification. The capacity factor of hydro-power plants is generally lower than that of coal-fired and nuclear power plants. This is because hydro-power is strongly affected by seasonal weather

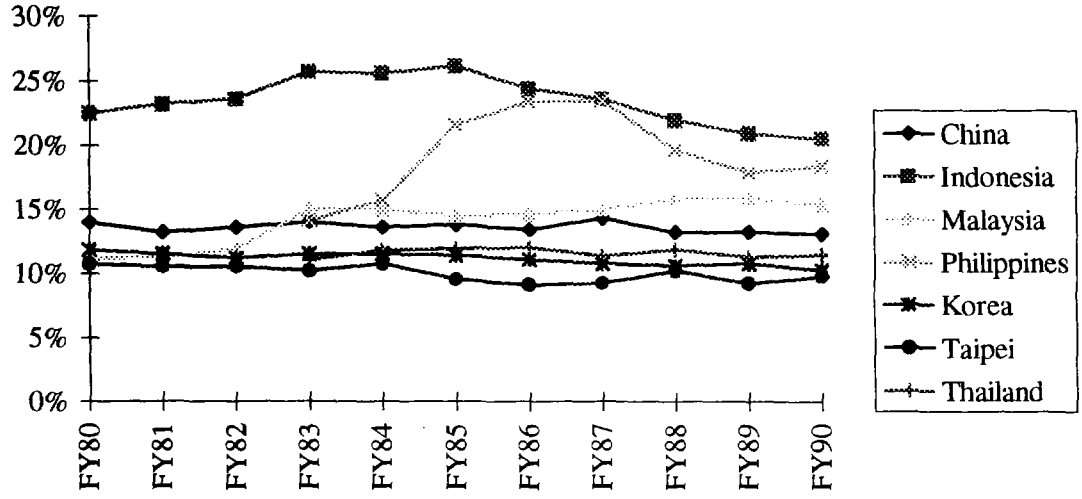
[4] Ishiguro and Akiyama, 1995.

conditions and its availability is not high in many cases, while the role of coal-fired and nuclear power is base load power supply with a high capacity factor. Diesel and gas turbine power plants are in general used for peak or middle-peak power supply. However, the situation in many developing countries is not so simple. In China, for example, it is expected that potential power demand will be more than 20 percent higher than the actual power supply over the decade and that all power sources are to be operated as a base load power supply.

In addition, there is another element that changes capacity factors of power plants: load curve. In the Asian developing economies discussed here, power demand from the residential/commercial sector has been increasing rapidly and is expected to continue increasing. The increase in power demand from the residential/commercial sector might worsen the shape of the load curve because incremental power demand from this sector will come from electric appliances, including air conditioners, which are mainly used in daytime. As a result, increasing daytime power demand and relatively low nighttime demand may decrease the load and capacity factors of power plants.

Such country-specific conditions, which will strongly affect the future capacity factor, were not discussed in this study because of lack of information and data. Therefore, the average capacity factors of power plants in each economy were quoted and estimated from figures in current power development plans, and are given in Table 2.1.

Figure 2.1: Total System Losses



Source: ADB

Table 2.1: Estimated Capacity Factors

(percent)

	2005	2010
China	50	53
Indonesia	39	42
Malaysia	49	48
Philippines	51	49
Korea	63	63
Taiwan, China	54	48
Thailand	62	67

Source: IECCP estimates

The Assumptions

The assumptions here are based on the current plans of governments and utilities for allocating primary energy, which, in turn, are based on energy or electric power development policies. The assumptions were used to forecast the most likely course of power development in the medium to long term.

China's Primary Energy Source Allocation

Energy Mix (kWh). Electricity generated by oil- and natural gas-fired power plants is assumed to stay at the same level in 2010 as in 1990. Hydro's share is to stay at 15 percent; while nuclear power is to account for 4 percent of total electricity generation in 2010 (the government's target). Coal-fired power is assumed to account for the remainder.

Installed Capacity (kW). The growth rate of installed capacity of oil-fired power will be half the growth rate of total installed capacity. Hydro's share is assumed to stay at the same level as in 1993, while nuclear power is to account for 3 percent of total installed capacity in 2010 (the government's target). Coal-fired power is to account for the remainder.

Indonesia's Primary Energy Source Allocation

Energy Mix (kWh). Based on PLN's plans, growth rates of oil, natural gas, and other energy sources are each assumed to be 5 percent p.a. Hydro's share is to remain at the 1993 level, and coal is to account for the remainder.

Installed Capacity (kW). The installed capacities of oil-, natural gas-fired, and other power sources are all expected to grow by 5 percent p.a. Coal is assumed to account for the remainder.

Malaysia's Primary Energy Source Allocation

Energy Mix (kWh). Hydro is assumed to provide 5 billion kWh and oil, 10 billion kWh. These together with natural gas are assumed to supply 75 percent of total electricity output. Coal is to account for the rest.

Installed Capacity (kW). Hydro capacity is assumed to stay at 1.5 million kW, oil at 2.6 million kW, and together with natural gas are assumed to provide 75 percent of total capacity. Coal is to account for the rest.

The Philippines' Primary Energy Source Allocation

Energy Mix (kWh). Except for coal, the share of energy mix in NPC's present program is assumed to materialize in 2005, and coal-fired power is to account for the remaining energy output. During the period 2006-2010, incremental electric output is assumed to come from coal.

Installed Capacity (kW). Except for coal-fired power plants, installed capacity is assumed to remain the same up to 2005. In 2006-2010, incremental capacity is assumed to depend on coal-fired power plants.

Korea's Primary Energy Source Allocation

Energy Mix (kWh). After 2005, electricity output over the projected amount given in the present plan is assumed to come from coal. Incremental electricity output during the period 2006-2010 is to be generated in equal amounts by coal, LNG, and nuclear.

Installed Capacity (kW). Except for coal-fired power plants, installed capacity up to the year 2005 is assumed to be the same as KEPCO's plan. Coal-fired power is to account for the remaining energy output. Incremental capacity during the period 2006-2010 will come equally from coal-fired, LNG-fired, and nuclear power plants.

Taiwan, China's Primary Energy Source Allocation

Energy Mix (kWh). The difference in electricity outputs between the utliities' plan and that of the IECCP model is to be generated equally by coal, LNG, and nuclear power plants.

Installed Capacity (kW). Installed capacity over the projected amount given in the present program is assumed to be shared equally by coal, LNG, and nuclear power plants.

Energy Mix (kWh). The difference in electricity outputs between EGAT's plan and that of the IECCP model is assumed to come from coal.

Installed Capacity (kW). The installed capacities of hydro, oil, natural gas, and other types of power plants will be the same as those of the present EGAT program. Coal will account for the remaining capacity, and incremental capacity during the period 2006-2010 will come from coal-fired power plants.

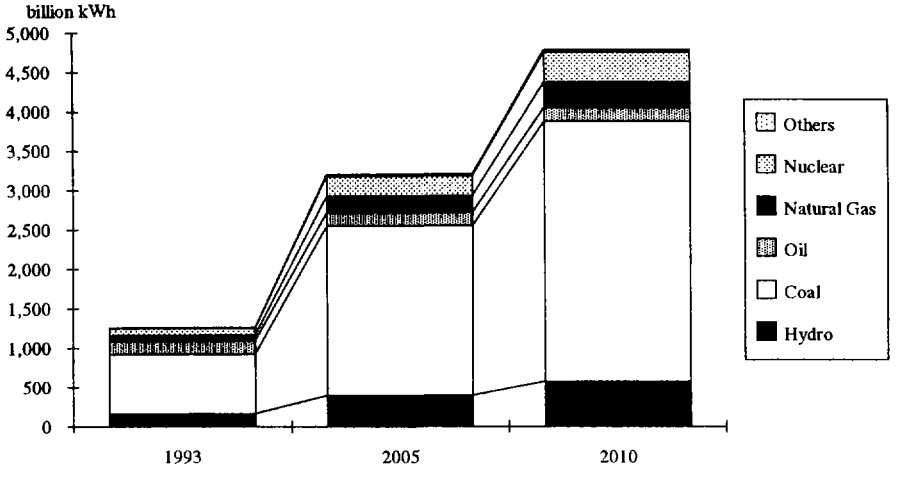
THE RESULTS OF ELECTRICITY SUPPLY PROJECTION

Gross Electricity Generation and Energy Mix

Total electricity generation of the seven economies is projected to increase from 1.26 trillion kWh in 1993 to 3.2 trillion kWh (2.5 times as much as in 1993) in 2005 and 4.8 trillion kWh (3.8 times as much as in 1993) in 2010, as shown in Figure 2.2 and Table 2.2.

A substantial increase in coal dependency is projected. In 2010, coal is forecast to account for 68 percent (an eight percentage point increase from 1990) of electricity production; oil, 4 percent (a ten percentage point decrease); natural gas, 7 percent (a two percentage point increase); nuclear, 8 percent (a one percentage point increase); and hydro, 12 percent (a one percentage point decrease).

Figure 2.2: Projections of Gross Electricity Generation and Energy Mix in the Seven Asian Economies



Source: IEC

Table 2.2: Projections of Gross Electricity Generation and Energy Mix in the Seven Asian Economies

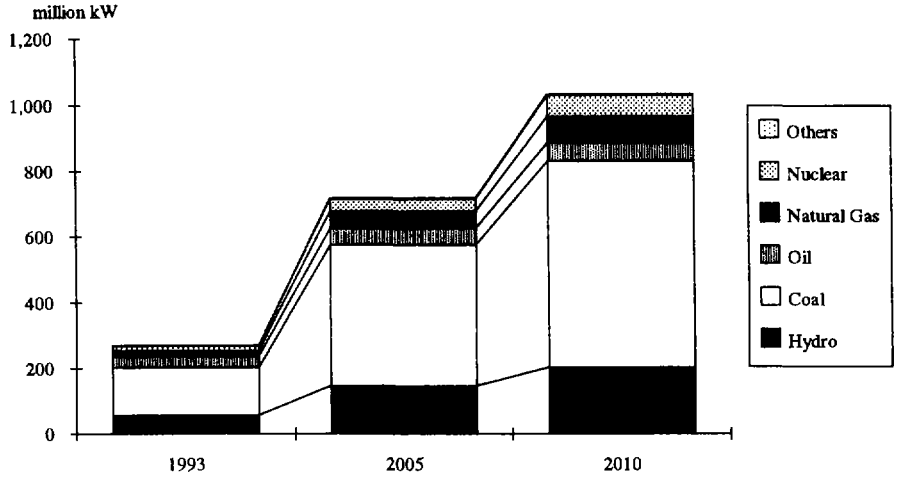
	Hydro	Coal	Oil	Natural Gas	Nuclear	Others	Total
1993	164	758	172	69	89	10	1,263
2005	394	2,149	170	206	253	26	3,198
2010	577	3,286	181	319	384	27	4,774

Source: IEC

Installed Capacity and Power Sources

The increment in installed capacity in the seven economies is projected to be 448 million kW during the period 1994-2005 and 315 million kW during the period 2006-2010 (Figure 2.3 and Table 2.3). Coal-fired power plants will account for 63 percent of the total increment in capacity; hydro, about 19 percent; natural gas, 8 percent; and nuclear, 7 percent, between 1994 and 2010.

Figure 2.3: Projections of Installed Capacity in the Seven Asian Economies



Source: IEC

Table 2.3: Projections of Installed Capacity in the Seven Asian Economies
(million KW)

	Hydro	Coal	Oil	Natural Gas	Nuclear	Others	Total
1993	56	145	35	18	13	1	269
2005	145	428	51	52	38	3	717
2010	202	628	55	81	63	3	1,032

Source: IEC

3
CAPITAL REQUIREMENT FOR FUTURE POWER DEVELOPMENT

OVERVIEW

A major concern of the countries examined is the enormous amount of investment that will be needed to meet the expected rise in demand for electricity. Raising such a large amount of capital will not be easy for these developing economies and for the multilateral and bilateral financing institutions, including the World Bank. This section analyzes the investment requirement for further electric power development and discusses the availability of capital for the electric power sector.

CAPITAL REQUIREMENT

Methodology for Estimating Capital Requirement

The capital requirement for future electric power development was estimated on the basis of projections of installed capacity up to 2010. First, the capital requirement for power plant construction by plant type was estimated. Then the costs of constructing transmission and distribution systems were also estimated, using recent ratios of transmission and distribution costs to power plant construction costs.

Power Plant Construction Costs

Power plant construction costs were estimated based mainly on the basis of data available in the Bank's project appraisal reports and information provided by the utilities. The cost data were then converted into 1992 U.S. dollars. The estimated plant construction costs are given in Table 3.1.

Table 3.1: Estimated Plant Construction Costs
(1992 US$/kW)

	Hydro		*Coal*		*Oil*		*Natural Gas*		*Nuclear*		*Others*	
	(low)	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*	*(low)*	*(high*	*(low)*	*(high)*	*(low)*	*(high)*
China	400	600	600	800	600	800	600	800	1,200	1,500		
Indonesia	1,200	1,500	700	900	600	700	600	700			2,100	2,400
Malaysia	1,200	1,500	1,800	2,200	800	1,200	800	1,200				
Philippines	3,000	3,500	1,200	1,500	800	1,200	800	1,200			2,100	2,400
Korea	3,000	3,500	2,200	2,600	1,200	1,500	2,000	4,000	2,500	3,000		
Taiwan, China	3,000	3,500	2,200	2,600	1,200	1,500	2,000	4,000	2,500	3,000		
Thailand	1,000	1,200	1,000	1,300	800	1,200	700	900				

Source: IECCP estimates

Costs for Constructing Transmission and Distribution Systems and Others

The cost of constructing transmission and distribution systems and other costs (such as overhead) were estimated by using data collected by the Bank. In Table 3.2, these costs are given as percentages of the total investment in power development.

Table 3.2: Generation, Transmission and Distribution System and Other Costs as a Percentage of Total Investment

	Generation	*Transmission*	*Distribution*	*Others*
China	66	7	18	9
Indonesia	54	14	30	2
Malaysia	61	8	22	9
Philippines	62	10	19	9
Korea	70	6	15	9
Taiwan, China	70	6	15	9
Thailand	64	8	21	7

Source: World Bank 1990

Projection of Capital Requirements

The estimated total capital requirements (in terms of 1992 U.S. dollars) are US$579-772 billion between 1994 and 2005, and US$428-585 billion between 2006 and 2010 (see Table 3.3). This shows that the region as a whole will have to raise US$48-64 billion a year during the period 1994-2005 and US$86-117 billion a year during the period 2006-2010.

Table 3.3: Capital Requirements for Future Electric Power Development
(1992 US$ billion)

(between 1994 and 2005)

	Generation		*Transmission*		*Distribution*		*Others*		*Total*	
	(low)	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*
China	176.4	239.1	18.7	25.4	48.1	65.2	24.1	32.6	267.3	362.2
Indonesia	32.0	40.3	8.3	10.4	17.8	22.4	1.2	1.5	59.3	74.6
Malaysia	15.7	22.8	2.1	3.0	5.7	8.2	2.3	3.4	25.8	37.4
Philippines	13.1	15.8	2.1	2.6	4.0	4.8	1.9	2.3	21.1	25.5
Korea	72.7	90.8	6.2	7.8	15.6	19.5	9.3	11.7	103.8	129.7
Taiwan,China	50.3	73.0	4.3	6.3	10.8	15.6	6.5	9.4	71.9	104.3
Thailand	18.8	24.2	2.4	3.0	6.2	7.9	2.1	2.6	29.4	37.8
Total	379.1	506.0	44.1	58.4	108.1	143.7	47.3	63.5	578.6	771.5

(between 2006 and 2010)

	Generation		*Transmission*		*Distribution*		*Others*		*Total*	
	(low)	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*	*(low)*	*(high)*
China	117.5	158.8	12.5	16.8	32.0	43.3	16.0	21.7	178.0	240.6
Indonesia	26.0	32.8	6.7	8.5	14.4	18.2	1.0	1.2	48.1	60.7
Malaysia	13.5	19.1	1.8	2.5	4.9	6.9	2.0	2.8	22.2	31.4
Philippines	8.8	11.0	1.4	1.8	2.7	3.4	1.3	1.6	14.2	17.7
Korea	51.3	73.6	4.4	6.3	11.0	15.8	6.6	9.5	73.3	105.1
Taiwan,China	51.6	73.9	4.4	6.3	11.1	15.8	6.6	9.5	73.7	105.6
Thailand	11.9	15.5	1.5	1.9	3.9	5.1	1.3	1.7	18.6	24.2
Total	280.6	384.7	32.7	44.2	80.0	108.5	34.8	47.9	428.1	585.3

Source: IECCP estimates

Given that the total GDP of the seven economies as a whole is estimated at US$2,196 billion (in 1992 U.S. dollars) in 2000, [1] an average investment requirement of US$48-64 billion a year during the period 1994-2005 will represent between 2.2 percent and 2.9 percent of the GDP of these economies.

AVAILABILITY OF CAPITAL FOR INVESTMENT IN THE POWER SECTOR

Bilateral and multilateral loans and export credits have been the major financial sources for the power sector in the developing countries. These sources, however, cannot be expected to increase in the future.

[1] Based on the IECCP model simulation.

Extensions of bilateral credit loans have been generally decreasing. Overseas Development Assistance (ODA) from the Development Assistance Committee (DAC) fell to US$6 billion in 1993 because donor countries cut their aid budgets. The share of ODA from DAC fell to 0.29 percent of GDP, its lowest level since 1973.[2] The flow of bilateral loans to the power sector in East and Southeast Asia was US$7.12 billion during the period 1980-1991.[3]

The World Bank has estimated that future lending to the power sector in the developing countries will remain at the 1992 level of about US$3 billion.[4] The Asian Development Bank is also expected to keep its lending program for the power sector at the current level. As a result, multilateral funding to the power sector will remain on the level of the recent past. Given that the gross flow of multilateral funds for the sector was US$6.5 billion during the period 1980-91, a similar level of US$600 million per year can be expected. That would account for 1 - 2 percent of the total investment requirement of the region for electric power facilities.

Export credits have substantially contributed to fund raising for the power projects, accounting for around 15 percent of foreign financing. The shares of export credits in the external debt of the power sector vary from one country to another, and it is difficult to project how these shares will change in the future. The shares in 1991 were: 2 percent in China, 14 percent in the Philippines, 18 percent in Thailand, and 49 percent in Korea. The share of export credits in the external debt for the region is not likely to exceed 20 percent.

The discussion above suggests that the combination of bilateral and multilateral funds and export credits will be able to support only a limited portion of the capital requirement for future power development. To facilitate the financing of power development in the region, it will be necessary to stimulate investment by the private sector. BOO/BOT schemes have become a popular method of financing power projects since the late 1980s. However, BOO/BOT schemes are not likely to solve the problem. This is partly because foreign capital, including Hong Kong capital, already accounts for a major share of BOO/BOT projects in the region. Hence, most of the reimbursement for

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2 World Bank 1994.

3 Ibid.

4 World Bank 1993.

foreign capital will be in foreign exchange. Repayment may conceivably be restricted by the debt-to-service coverage ratio of each country, since the revenue from power projects will be in domestic currences.

Although BOO/BOT schemes will play an important role in the future, mobilizing domestic savings for the power sector will become an important measure because it cannot be assumed that foreign capital will fill the future investment requirement. Domestic savings in some of these seven economies are high. In China, for example, these savings are estimated at some tens of billions of US dollars. To accelerate financing of the power sector, it will be imperative to mobilize these domestic savings through domestic bond and stock markets.

Besides mobilizing domestic savings, increasing funds by generating profit through business is important and may be the most important means of raising funds. The electricity tariff structure in the region, however, is often distorted by government policy, as a result, the revenue of a power utility cannot cover the costs of electricity supply. This situation weakens the financial position of a power utility and jeopardizes its investment for future power development. Hence, along with creating new fundraising programs, electricity tariff restrictions and government subsidies for power supply must be corrected.

4
THE IMPACT OF INCREASED POWER DEMAND ON THE ENVIRONMENT

OVERVIEW

The rapid pace of power development in the seven economies in the future will make the environmental burden of fossil fuel consumption a matter of great concern. This section evaluates the magnitude of the additional carbon dioxide (CO_2), nitrogen oxide (NOx), sulfur dioxide (SOx), and particulate matter (PM) that will be emitted by electric power plants that burn fossil fuels.

Except in Korea and Taiwan, China, the installation of such environmental protection devices as flue gas desulfurization (FGD) and selective catalytic reduction (SCR) processes is not common. The installation of electric precipitators (EP) is also limited to only a few countries. Given that a number of coal-fired power plants are expected to be constructed in the future, the environmental burden will increase substantially. In some regions in China, the Philippines, and Thailand, environmental problems caused by coal-fired power plants are already being reported.

MAGNITUDE OF INCREASING ENVIRONMENTAL BURDEN

Fossil Fuel Consumption in the Power Sector

To project fossil fuel consumption in the electric power sector, the following summations were used:

Heat value of fossil fuels. The heat values of steam coal used for coal-fired power plants were assumed to be: imported coal, 26.37 GJ/kg; China's domestic coal, 20.9 GJ/kg; Indonesia's domestic coal, 20.93 GJ/kg; and Thailand's lignite, 10.46 GJ/kg. The heat value of heavy fuel oil was assumed to be 62.65 GJ/kg.

Thermal efficiency of power plants. Based on actual data on fuel consumption and electricity output since 1980, the average thermal efficiency by type of fuel was projected for 1993, 2005, and 2010. The results are summarized in Table 4.1

Table 4.1: Average Projected Thermal Efficiency of Thermal Power Plants
(in percent)

	Coal			*Fuel oil*			*Natural gas*		
	1993	2005	2010	1993	2005	2010	1993	2005	2010
China	30	32	34	33	33	33	35	35	35
Indonesia	35	35	35	30	35	35	25	25	25
Malaysia	35	35	35	30	35	35	40	45	45
Philippines	34	35	35	32	32	32	25	45	45
Korea	35	35	35	35	35	35	45	45	45
Taiwan, China	35	35	35	35	35	35	40	45	45
Thailand	33	35	35	34	34	34	38	45	45

Source: IEC estimates

Fossil fuel consumption. Based on the projected electricity supply and energy mixes in Section 2, fossil fuel consumption was also calculated. The results are summarized in Table 4.2.

Table 4.2: Projected Fossil Fuel Consumption
(Peta Joule)

	Coal			Fuel oil			Natural gas		
	1993	2005	2010	1993	2005	2010	1993	2005	2010
China	7,853	19,207	26,972	545	545	545	31	31	31
Indonesia	172	1,146	2,195	253	390	498	22	37	49
Malaysia	42	119	275	48	103	103	184	638	1,001
Philippines	24	335	632	160	79	79	-	-	-
Korea	305	1,178	1,613	427	236	236	113	277	615
Taiwan, China	385	683	937	256	404	404	22	225	422
Thailand	151	1,079	1,942	174	34	34	261	462	462

Source: IEC estimates

CO_2 Emissions

CO_2 emissions caused by thermal power production were estimated at 260-270 million tons of carbon equivalent (tons-C) in 1993, three-fourths of which came from China. Given that the world total of CO_2 emissions in 1991, caused by fossil fuel consumption, was 5.9 billion tons-C, the seven economies accounted for only about 4 percent of these global emissions in the early 1990s. CO_2 emissions from the region are

expected to increase 2.4-fold by 2005 and 3.3-fold by 2010, compared to 1993 (see Table 4.3).

To project CO_2 emissions from thermal power plants in the region, the emission factors shown in Table 4.4 were used in this study.

Table 4.3: Projection of CO_2 Emissions from Thermal Power Plants
(million tons of carbon equivalent)

	1993			2005			2010		
China	200.4	-	208.3	472.9	-	492.1	659.2	-	686.3
Indonesia	9.7	-	10.0	36.2	-	37.4	63.8	-	66.1
Malaysia	4.6	-	5.0	13.9	-	15.3	22.8	-	25.0
Philippines	3.9	-	4.0	9.7	-	10.0	16.8	-	17.4
Korea	17.9	-	18.4	37.1	-	38.8	52.3	-	55.1
Taiwan, China	14.9	-	15.3	28.0	-	29.2	36.9	-	38.7
Thailand	10.9	-	11.6	33.1	-	35.1	53.8	-	56.6
Total	262.3	-	272.5	630.9	-	658.0	905.6	-	945.3

Source: IEC estimates

Table 4.4: Emission Factors of CO_2
(carbon equivalent)

	g-carbon/MJ			t-carbon/toe		
Coal	24	-	25	1.00	-	1.05
Fuel oil	-	21	-	-	0.88	-
Natural gas	14	-	16	0.59	-	0.67

Source: OECD 1991

NO_x, SO_x, and PM Emissions

To calculate NO_x, SO_x, and PM emissions, the emission factors shown in Table 4.5 were used. These factors, however, show the theoretical volume of emissions at the outlet of a boiler. Net emissions entrained in flue gas were estimated on the basis of two assumptions:

(i) FGD and SRC devices are not installed; and
(ii) dust collectors with efficiency of 92-98 percent are installed.

Table 4.5: Emission Factors of NO_x, SO_x, and PM

China

	Coal	Natural Gas	Fuel oil
SOx	1	-	860
NOx	280 - 630	50 - 140	150 - 245
PM	12,200	14	76

Indonesia

	Coal	Natural Gas	Fuel oil
SOx	430	-	860
NOx	280 - 630	50 - 140	150 - 245
PM	4,060	-	76

Malaysia

	Coal	Natural Gas	Fuel oil
SOx	340	-	860
NOx	280 - 630	50 - 140	150 - 245
PM	4,550	-	76

Philippines

	Coal	Natural Gas	Fuel oil
SOx	340	-	860
NOx	280 - 630	50 - 140	150 - 245
PM	4,550	-	76

Korea

	Coal	Natural Gas	Fuel oil
SOx	340	-	860
NOx	280 - 630	50 - 140	150 - 245
PM	4,550	-	76

Thailand

	Coal	Lignite	Natural Gas	Fuel Oil
SOx	360	2,541	-	1433
NO·	379	955	78	166
	4,550	21,900	-	76

Taiwan, China

	Coal	Natural Gas	Fuel oil
SOx	340	-	150 245
NOx	280 - 630	50 - 140	76
PM	4,550	-	

Note 1. Characteristics of coal are as follows:

	Heat value (GJ/t)	Sulfur (%)	Ash (%)
Chinese coal	20.93	1.2	30
Indonesian coal	20.92	0.5	10
Thai lign ie	10.46	2.9	27
Imported coal	26.37	0.5	10

Note 2. 90% of the sulfur and 85% of the ash contained in coal are entrained in flue gas.
Note 3. Heat value of fuel oil is 41.82 GJ/ton, and sulfur content 1.8%.

Source: World Bank, 1993; Sloss 1993.

Projections of NO_x, SO_x, and PM emissions are summarized in Table 4.6. NO_x emissions, estimated to be 4.46 million tons in 1993, are projected to increase 2.5 times by 2005 and 3.6 times by 2010. SO_x emissions, estimated to be 10.42 million tons in 1993, were projected to increase 2.2 times by 2005 and 3.1 times by 2010. PM emissions, estimated at 8.14 million tons in 1993, are projected to increase 1.5 times by 2005 and 1.7 times by 2010.

Table 4.6: NO_x, SO_x, and PM Emissions
(million tons)

	NOx			SO2			PM		
	1993	2005	2010	1993	2005	2010	1993	2005	2010
China	3.65	8.76	12.25	8.57	20.29	28.30	7.70	11.74	13.18
Indonesia	0.13	0.60	1.09	0.29	0.83	1.37	0.05	0.17	0.22
Malaysia	0.05	0.14	0.24	0.06	0.13	0.18	0.01	0.02	0.03
Philippines	0.04	0.17	0.30	0.15	0.18	0.28	0.02	0.05	0.06
Korea	0.23	0.60	0.83	0.47	0.60	0.75	0.09	0.13	0.16
Taiwan, China	0.23	0.41	0.54	0.35	0.58	0.67	0.09	0.09	0.12
Thailand	0.13	0.54	0.93	0.53	0.81	1.14	0.18	0.24	0.25
Total	4.46	11.21	16.19	10.42	23.42	32.69	8.14	12.44	14.01

Source: IEC estimates

COSTS FOR ENVIRONMENTAL PROTECTION

Under the assumption that, after 1994, a newly constructed coal-fired power plant will be equipped with FGD, SCR and EP, and a newly constructed oil-fired power plant, with FGD and SCR, investment costs required for these plants were estimated. To evaluate the cost, the following assumption were used:

SO_x reduction rate of FGD:	95 percent
NO_x reduction rate of SCR:	80 percent
PM reduction rate of EP:	100 percent

Plant construction cost:[1]	FGD	US$240/kW
	SCR	US$50/kW
	EP	US$40/kW

The projected investment requirement is summarized in Table 4.7. The costs required for eleven years between 1994 and 2005, in the seven economies, are estimated at US$98 billion in terms of 1992 constant U.S. dollars. For the following five years, between 2006 and 2010, an estimated US$67 billion will be needed. The costs for flue gas treatment are equivalent to about 15 percent of capital requirement for future power development during the same period.

[1] Based on the plant construction costs in Japan. [Solos, Leslie L et al 1992].

Table 4.7: Costs for Flue Gas Treatment

(1992 US$ billion)

	NOx		SO2		PM		Total	
	1994-2005	2006-10	1994-2005	2006-10	1994-2005	2006-10	1994-2005	2006-10
China	11.26	7.19	54.02	34.49	8.67	5.66	73.95	47.34
Indonesia	1.54	1.28	7.39	6.12	1.10	0.94	10.03	8.33
Malaysia	0.08	0.01	0.36	0.05	0.07	0.00	0.50	0.06
Philippines	0.20	0.37	0.96	1.75	0.11	0.29	1.27	2.41
Korea	0.69	0.39	3.31	1.85	0.55	0.31	4.55	2.54
Taiwan, China	0.54	0.39	2.59	1.85	0.26	0.31	3.39	2.54
Thailand	0.71	0.60	3.38	2.86	0.56	0.48	4.65	3.93
Total	15.01	10.20	72.02	48.96	11.32	7.98	98.35	67.14

Source: IEC estimates

5
CONCLUDING REMARKS

The present paper analyzed and projected electricity demand and its implications for seven economies in East and Southeast Asia, a region where demand has been increasing at a very rapid rate. The paper found that the high growth rate of demand in the region is likely to continue- slightly over 8 percent p.a. through 2010. This rate would increase the final electricity demand of the seven economies from 805 billion kWh in 1990 to 1,803 billion kWh in 2005 and 3,925 billion kWh in 2010. The reasons for the continued high demand growth include expected high economic growth, further industrialization, and increasing demand for electric appliances.

To meet this high demand growth, the supply of electricity must be increased at a rapid rate. The analysis in this paper suggests that expansion of the power sector in these economies is likely to encounter several difficulties, the main ones being the raising of sufficient capital and reducing the environmental deterioration caused by the burning of fossil fuels to produce electric power.

The capital required to increase power supply, estimated between US$579 billion and US$772 billion (in 1992 dollars) for the period 1994-2005 and between US$428 billion and US$585 billion for the period 2001-2010, is extremely large. Perhaps one-half of the requirement can be financed by BOO/BOT schemes, bilateral and multilateral loans and export credits. However, the bulk of the financing would need to be raised domestically. For this purpose, many of these economies need to develop or enlarage bond and stock markets so that domestic savings can be channelled efficiently to finance the power sector.

In some of the economies analyzed, environmental issues are already becoming critical. Projections made in the paper indicate that coal is likely to be used more than any other primary energy source to generate additional electricity because of its availability and cost. The major problem with coal is that its combustion releases more polluting gases and particulate matter than other energy sources. A solution would be to install pollution-reduction facilities. However, these facilities would add about 15 percent to the capital required to increase needed power supply. Nuclear energy is another possibility, but given its high costs and the enormous risks involved in the event of misoperation, it is

doubtful that nuclear energy will contribute much to the expansion of generation in the next 15 years in these economies.

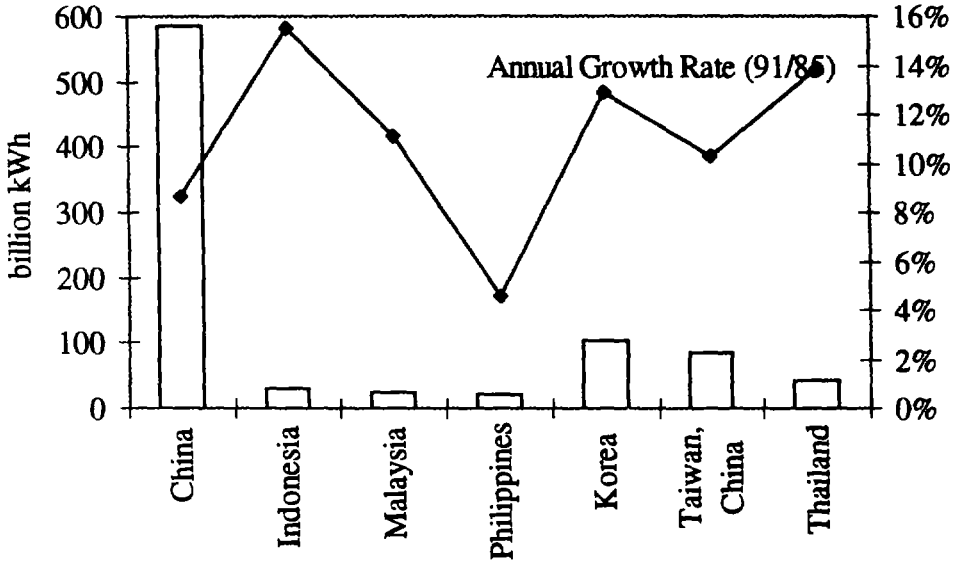
Given that the problems of CO_2, NO_x, SO_x and particulate matter in these economies are likely to be regional or even global ones, international cooperation will be indispensable in coping with them. Another area where international cooperation could help is in energy conservation. The industrialized countries have developed know-how and technology in energy conservation, including demand-side management (DSM). As discussed in a number of papers on the subject, there is substantial scope for improving efficiency in electricity use in these economies.

ANNEX
SALIENT FEATURES OF THE POWER SECTOR IN ASIA

OVERVIEW

The electricity demand of Asian developing countries has been increasing rapidly. Seven economies examined in this study--China, Indonesia, Korea, Malaysia, the Philippines, Taiwan, China, and Thailand--consumed 892 billion kWh in 1991, as a whole. Many of these economies posted double-digit percentage annual growth in electricity consumption. This high growth is expected to continue towards the twenty-first century. Several salient features in the power sector include: (i) China's share of electricity demand in this region is overwhelmingly high--two-thirds; and (ii) dependency on coal is high compared to other primary energy sources (coal's share in 1993 accounted for about 60 percent of total electricity generation). This is because China, the largest electricity consuming country, depends for two-thirds of its power supply on coal-fired power.

Figure A1: Final Electricity Consumption, 1991



Source: IEA

The structure of the power sector of the region has been changing recently. Many existing monopolistic public utilities are expected to be corporatized or privatized in the near future. A number of independent power projects (IPPs) have been in progress since

the late 1980s, in the main, because governments and existing public utilities have had difficulty in financing the power development projects needed to meet rapidly increasing demand. Another reason is that many of the government-owned public utilities are considered to be too inflexible to adapt to rapidly changing business circumstances and to keep up with advancing modern technologies.

This Annex reviews and discusses the current status of electricity supply and demand, and current power development plans or programs of governments and utilities by country or economy.

CHINA

Structure of Electricity Consumption

The growth of electricity consumption has been accelerating since the mid-1980s (e.g., 8.6 percent p.a. during the period 1986-1991 vis-à-vis 6.6 percent p.a. during the period 1980-1985) because of high economic growth in recent years (see Table A1). The growth in electricity consumption in the residential/commercial sector was especially high--about 15 percent p.a during the 1980s. The transportation sector also posted a double-digit percentage growth rate of electricity consumption because of rapid electrification of the rail system. Although electricity consumption in the industrial sector increased at a lower rate than that in other sectors, its share in total electricity consumption has been overwhelmingly high (e.g., three-fourths in 1991).

Table A1: Final Electricity Consumption in China

(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									85/80	91/85
Total	259.210	100%	356.010	100%	542.890	100%	584.630	100%	6.6%	8.6%
Industry	210.480	81%	279.710	79%	413.680	76%	437.670	75%	5.9%	7.7%
Transportation	2.650	1%	6.340	2%	10.590	2%	11.720	2%	19.1%	10.8%
Res'l/Com'l	19.080	7%	38.220	11%	75.940	14%	87.260	15%	14.9%	14.8%
Agriculture	27.000	10%	31.740	9%	42.680	8%	47.980	8%	3.3%	7.1%

Source: China Statistical Yearbook

Current Status of Power Supply

China suffers from severe power shortages. The power supply at present is estimated to be 20 percent less than potential demand.

Power sector. Although there are thirteen power grid networks with power capacity of over one million kW, an integrated power grid system throughout the country does not exist. Major networks comprise the following five: the Northeast; North China; East China; Central China; and Northwest Power Network.[1]

Installed capacity. Installed capacity has increased rapidly at a growth rate of 9.7 percent p.a. since 1985 and was 182 kW in 1993, as shown in Table A2.[2] Hydro's share continued to decline to about one-fourth in 1990. Thermal power, consisting mainly of coal-fired power, accounted for 67 percent of total installed capacity in 1990. Three nuclear reactors are in operation.

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1 In addition, there are eight major provincial grids and two autonomous regional grids.

2 Apparently, this figure includes auto producers.

Table A2: Installed Capacity in China

(million kW)

	1980		*1985*		*1990*		*1993*		*Annual Growth Rate*		
									85/80	*90/85*	*93/90*
Total	65.869	100%	87.053	100%	137.890	100%	182.000	100%	5.7%	9.6%	9.7%
Hydro	20.318	31%	26.415	30%	36.046	26%	na	na	5.4%	6.4%	-
Coal	na	na	na	na	92.132	67%	na	na	-	-	-
Oil	na	na	na	na	9.752	7%	na	na	-	-	-
Natural Gas	na	na	na	na	na	na	na	na	-	-	-
Nuclear	-	-	-	-	0.300	0%	0.300	0%	-	-	-

Note: na=not available

Source: ADB, Ministry of Energy, Ministry of Electric Power, State Statistical Bureau.

Electricity Generation. Electricity generation has increased substantially in the mid-1980s to 837 billion kWh (gross) in 1993, and posted a 10.5 percent p.a. growth rate during the period 1990-1993. The energy mix in 1990 was hydro 20 percent, coal 72 percent, and oil 8 percent. Hydro's share stayed at a level of about 20 percent during the 1980s (see Table A3).

Table A3: Electricity Generation (Gross) in China

(billion kWh)

	1980		*1985*		*1990*		*1993*		*Annual Growth Rate*		
									85/80	*90/85*	*93/90*
Total	300.628	100%	410.689	100%	621.320	100%	837.400	100%	6.4%	8.6%	10.5%
Hydro	58.211	19%	92.374	22%	126.350	20%	na	na	9.7%	6.5%	-
Coal	177.118	59%	262.836	64%	444.875	72%	na	na	-	-	-
Oil	63.998	21%	53.095	13%	47.044	8%	na	na	-	-	-
Natural Gas	1.301	0%	2.384	1%	3.051	0%	na	na	-	-	-
Nuclear	-	-	-	-	-	-	na	na	-	-	-

Note: na=not available.

Plants with capacity less than 500kW are excluded. Auto producers might be included.

Source: ADB, Ministry of Energy, Ministry of Electric Power, State Statistical Bureau.

INDONESIA

Structure of Electricity Consumption

Electricity consumption increased at a rate of over 15 percent p.a. during the 1980s and the early 1990s. This growth is much higher than that of other Asian developing countries. The industrial sector posted high growth of more than 20 percent p.a. due to rapid industrialization in the 1980s. The residential/commercial sector was the largest electricity consuming sector in the early 1980s, but the consumption of the industrial sector rapidly increased and its share surpassed that of the residential/commercial sector in the late 1980s. In 1991, the industrial sector accounted for 52 percent of final electricity consumption, while the residential/commercial sector accounted for 43 percent (see Table A4).

Table A4: Final Electricity Consumption in Indonesia
(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									90/80	*91/85*
Total	6.472	100%	12.706	100%	27.741	100%	30.166	100%	15.7%	15.5%
Industry	1.714	26%	4.874	38%	14.166	51%	15.820	52%	23.5%	21.7%
Transport	-	-	-	-	-	-	-	-	-	-
Res'l/Com'l	4.004	62%	6.398	50%	11.657	42%	12.984	43%	11.3%	12.5%
Others	0.754	12%	1.434	11%	1.917	7%	1.362	5%	9.8%	-0.8%

Source: IEA

Current Status of Power Supply

Power sector. Indonesia's power sector is composed of:

(a) the government-owned power corporation, PLN (Perusahaan Umum Listrik Negara);

(b) a large number of auto producers in the industrial sector (self-generation or captive use);

(c) a small number of electric cooperatives in the rural area; and

(d) a large number of unregistered enterprises operated by small communities (village level).

Although PLN, in principle, has been the only utility fully responsible for power generation, transmission and distribution, the government has allowed private enterprises to generate and sell electricity for ordinary consumers since the mid-1980s [PLN 1992].[3] The government announced that it would encourage private enterprises to enter the power business under the condition of free competition in order to reinforce the power supply and improve the technology of the power sector. The government also planned to restructure and corporatize PLN, to amend related laws,[4] and to establish a strategy for enhancing investment in the power sector.

Installed capacity. Since PLN's power capacity has been insufficient, a large number of auto producers in the industrial sector have supplied substantial electricity. The estimated present ratio of PLN's installed capacity to auto producers' is 4:6. Currently, forty percent of households in the city areas and seventy percent in the rural areas do not have electricity. The industrial sector at present depends, for half of the supply of electricity, on self-generation.

PLN's installed capacity in FY1991/92 was 9,189 MW composed of fuel oil-fired 24 percent, diesel 20 percent, coal-fired 19 percent, gas turbine 14 percent, and geothermal 2 percent (see Table A5). Coal-fired power, introduced in FY1984/85, has become one of the major base load power.

Table A5: Installed Capacity of PLN

(million kW)

	80/81		*85/86*		*90/91*		*Annual Growth Rate*	
							80/81-85/86	*85/86-90/91*
Total	2.555	100%	5.635	100%	9.108	100%	17.1%	10.1%
Hydro	0.379	15%	1.066	19%	1.973	22%	23.0%	13.1%
Coal-fired	-	-	0.800	14%	1.731	19%	-	16.7%
Oil-fired	0.756	30%	1.686	30%	2.216	24%	17.4%	5.6%
Diesel	0.524	21%	0.936	17%	1.814	20%	12.3%	14.1%
Gas Turbine	0.896	35%	1.117	20%	1.234	14%	4.5%	2.0%
Geothermal	-	-	0.030	1%	0.140	2%	-	36.1%

Source: ADB, PLN.

[3] 1985 Law No. 15 and 1992 President Decree No. 37.

[4] Promulgation is scheduled in June 1996 [PLN 1992].

In FY1990/91, gross electricity generation was 34 billion kWh, 4.5 times that in FY1980/81. Incremental demand has been met mainly by expanding the capacity of coal-fired power and partly by expanding hydros. In FY1990/91, the energy mix was oil 43 percent, coal 34 percent, hydro 17 percent, and natural gas and geothermal 3 percent each (see Table A6).

Table A6: Electricity Generation (Gross) of PLN

(billion kWh)

	80/81		*85/86*		*90/91*		*Annual Growth Rate*	
							80/81-85/86	*85/86-90/91*
Total	7.502	100%	15.338	100%	34.011	100%	15.4%	17.3%
Hydro	1.345	18%	2.990	19%	5.675	17%	17.3%	13.7%
Thermal	6.157	82%	12.348	81%	28.336	83%	14.9%	18.1%
Coal	-	-	2.353	15%	11.603	34%	-	37.6%
Oil	6.157	82%	9.497	62%	14.639	43%	9.1%	9.0%
Natural Gas	-	-	0.274	2%	0.969	3%	-	28.7%
Geothermal	-	-	0.224	1%	1.125	3%	-	38.1%

Source: ADB, PLN.

MALAYSIA

Structure of Electricity Consumption

The industrial sector accounts for about half of the final electricity consumption, and the residential/commercial sector accounts for most of the balance. This make-up has not changed substantially. Malaysia's final electricity consumption in 1991 was 23.2 billion kWh, which is half that of Thailand and comparable to that of the Philippines. The growth rate between 1985 and 1991 was relatively high--11.1 percent p.a. compared to 7.4 percnet p.a. in the first half of the 1980s--because electricity consumption of the industrial sector substantially increased in the second half of the 1980s (e.g., 15.4 percent p.a. between 1985 and 1991). On the other hand, the growth rate in the residential/commercial sector declined from 10.0 percent p.a. during the first half of the 1980s to 7.6 percent p.a. during the second half (see Table A7).

Table A7: Final Electricity Consumption in Malaysia

(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									85/80	91/85
Total	8.672	100%	12.376	100%	20.658	100%	23.246	100%	7.4%	11.1%
Industry	4.458	51%	5.159	42%	9.838	48%	12.170	52%	3.0%	15.4%
Transport	-	-	-	-	-	-	-	-	-	-
Res'l/Com'l	4.214	49%	6.779	55%	10.290	50%	10.546	45%	10.0%	7.6%
Others	-	-	0.438	4%	0.530	3%	0.530	2%	-	3.2%

Source: IEA

Current Status of Power Supply

Power sector. Three regional utilities--Tenaga Nasional Berhad (TNB) in the peninsula, Sabah Electricity Board (SEB) in the State of Sabah, and Sarawak Electricity Supply Corporation in the State of Sarawak (SESCO)--are responsible for power supply. TNB is a dominant utility among the three, accounting for 91 percent of total electricity generation in FY1993, whereas, SEC accounted for 5 percent and SESCO, 4 percent. In 1990, auto producers generated electricity equivalent to 4.5 percent of the electricity generated by utilities.

Installed capacity. TNB's installed capacity tripled from 2.04 million kW in FY1980 to 6.10 million kW in FY1990. Since the mid-1980s, incremental capacity has depended mainly on natural gas, coal, and hydro sources. The make-up of power capacity in FY1990 was heavy fuel oil 38 percent, hydro 24 percent, combined cycle 18 percent, gas turbine 5 percent, and diesel 3 percent (see Table A8).

The installed capacities of SEB and SESCO in FY1993 were 454 MW and 524 MW, respectively. They depend for their power source mainly on diesel generators (e.g., SEC, 71 percent and SESCO, 49 percent in FY1990), due to their small size.

Table A8: Installed Capacity of TNB

(million kW)

	FY80		*FY85*		*FY90*		*FY93*		*Annual Growth Rate*		
									80/85	*85/90*	*93/90*
Total	2.041	100%	3.787	100%	5.120	100%	6.100	100%	13.2%	6.2%	6.0%
Hydro	0.613	30%	1.147	30%	1.250	24%	na	na	13.3%	1.7%	na
Coal	-	-	-	-	0.600	12%	na	na	-	-	na
Heavy Fuel Oil	1.210	59%	1.576	42%	1.930	38%	na	na	5.4%	4.1%	na
Gas Turbine	0.100	5%	0.260	7%	0.280	5%	na	na	21.1%	1.5%	na
Diesel	0.118	6%	0.205	5%	0.160	3%	na	na	11.7%	-4.8%	na
Combined Cycle	0.000	0%	0.600	16%	0.900	18%	na	na	-	8.4%	na

Note: na=not available

Source: ADB, Department of Electricity Supply.

Electricity generation. Electricity generation of TNB in FY1993 was 30 billion kWh. Electricity generation has increased rapidly (e.g., 10.4 percent p.a. in FY1985-90 and 13.3 percent p.a. in FY1990-93), as shown in Table A9. TNB has substituted oil mainly with natural gas. It also introduced coal-fired in FY1989. Energy mix in FY1993 was natural gas 64 percent, oil 27 percent, and coal and hydro 5 percent each.

Table A9: Electricity Generation (Gross) of TNB

(billion kWh)

	FY80		*FY85*		*FY90*		*FY93*		*Annual Growth Rate*		
									80/85	*85/90*	*93/90*
Total	8.165	100%	12.624	100%	20.668	100%	30.059	100%	9.1%	10.4%	13.3%
Hydro	1.126	14%	3.004	24%	3.275	16%	1.540	5%	21.7%	1.7%	-22.2%
Coal					3.146	15%	1.456	5%			-22.6%
Heavy Fuel Oil	6.431	79%	7.433	59%	8.580	42%	4.501	15%	2.9%	2.9%	-19.4%
Diesel	0.608	7%	1.090	9%	0.355	2%	3.681	12%	12.4%	-20.1%	118.1%
Natural Gas		0%	1.097	9%	5.312	26%	19.230	64%		37.1%	53.5%

Source: ADB, Department of Electricity Supply.

THE PHILIPPINES

Structure of Electricity Consumption

In 1991, the residential/commercial sector accounted for half of the final electricity consumption; the industry sector about 40 percent, and the other sector

including agriculture, the remaining 10 percent. While the growth rate of electricity consumption during the period 1985-91 was 4.6 percent p.a., as a whole, the residential/commercial sector posted a higher growth rate of 6.3 percent p.a. Conversely, the industrial sector posted a lower growth rate of 2.8 percent p.a. (see Table A10). This difference is mainly due to the fact that the industrial sector shifted from buying electricity from utilities to generating its own due to power shortages and brown-outs.[5]

Table A10: Final Electricity Consumption in the Philippines
(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									90/80	91/85
Total	17.037	100%	17.088	100%	21.242	100%	22.377	100%	2.2%	4.6%
Industry	8.210	48%	7.895	46%	9.943	47%	9.339	42%	1.9%	2.8%
Transportation	-	-	-	-	0.029	0%	0.021	0%	-	-
Res'l/Com'l	5.867	34%	7.713	45%	10.363	49%	11.097	50%	5.9%	6.3%
Others	2.960	17%	1.480	9%	0.907	4%	1.920	9%	-11.2%	4.4%

Source: IEA

Current Status of Power Supply

Power sector. The Philippines' power sector comprises: (i) the National Power Corporation (NPC), responsible for power generation and transmission; (ii) 17 regional distribution utilities; and (iii) 120 rural electric cooperatives. During the oil crises in the 1970s, the government restructured the Philippines' power sector and assigned NPC the leading role in the development of power generation and transmission facilities. The government, however, revised this monopolistic role and promulgated a new law allowing IPPs in 1987. As a result, many private enterprises have entered into the power generation business since the late 1980s.

Installed capacity. NPC's capacity increased from 5,549 MW in 1985 to 6,663 MW in 1992,[6] as shown in Table A11. In the early to mid-1980s, incremental capacity came from hydro, geothermal and coal-fired power plants. Since the late 1980s, however, power generation has been reinforced by expanding oil-fired power (mainly

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[5] The growth rate of fuel consumption in the industrial sector during the same period was 5.9 percent p.a., twice that of electricity consumption.

[6] This capacity seems to include IPPs' capacity.

diesel generators) to meet rapidly increasing electricity demand. As a result, oil's share in 1992 accounted for 48 percent of total capacity, hydro 33 percent, geothermal 13 percent, and coal 6 percent.

Table A11: Installed Capacity of NPC

(million kW)

	1980		1985		1990		1992		Annual Growth Rate	
									90/80	92/85
Total	3.821	100%	5.549	100%	6.037	100%	6.663	100%	4.7%	2.6%
Hydro	0.940	25%	1.944	35%	2.132	35%	2.190	33%	8.5%	1.7%
Coal	-	-	0.350	6%	0.405	7%	0.405	6%	-	2.1%
Oil	2.435	64%	2.362	43%	2.612	43%	3.145	47%	0.7%	4.2%
Geothermal	0.446	12%	0.894	16%	0.888	15%	0.888	13%	7.1%	-0.1%

Source: IEA

Electricity generation. After the mid-1980s, incremental electricity generation came mainly from oil-fired diesel power with increasing capacity factor. In 1992, total electricity sales was 25.6 billion kWh, and the energy mix was oil 53 percent, geothermal 22 percent, hydro 17 percent, and coal 8 percent (see Table A12).

Table A12: Electricity Sales of NPC

(billion kWh)

	1980		*1985*		*1990*		*1992*		*Annual Growth Rate*	
									90/80	*92/85*
Total	15.086	100%	18.757	100%	24.799	100%	25.567	100%	5.1%	4.5%
Oil	9.507	63%	6.713	36%	11.541	47%	13.436	53%	2.0%	10.4%
Coal	-	-	1.585	8%	1.741	7%	2.169	8%	-	4.6%
Hydro	3.502	23%	5.514	29%	6.047	24%	4.270	17%	5.6%	-3.6%
Geothermal	2.077	14%	4.945	26%	5.470	22%	5.692	22%	10.2%	2.0%

Source: NPC

KOREA

Structure of Electricity Consumption

Although the industrial sector still holds the largest share of the final electricity consumption, its share continued to decline during the 1980s (from 69 percent in 1980 to 60 percent in 1990), as shown in Table A13. Conversely, the share of the

residential/commercial sector increased (from 29 percent in 1980 to 37 percent in 1991) at the expense of the industrial sector. Final electricity consumption has posted double-digit percentage annual growth since 1980. The growth rate from the mid-1980s to early 1990s was very high (12.9 percent p.a.) mainly because of the economic boom in the late-1980s which accelerated electricity consumption.

Table A13: Final Electricity Consumption in Korea

(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									90/80	91/85
Total	32.060	100%	49.824	100%	93.374	100%	103.369	100%	11.3%	12.9%
Industry	22.045	69%	31.188	63%	56.780	61%	62.400	60%	9.9%	12.3%
Transportation	-	-	-	-	1.012	1%	1.091	1%	-	-
Res'l/Com'l	9.423	29%	17.309	35%	34.123	37%	38.009	37%	13.7%	14.1%
Others	0.194	1%	0.603	1%	1.458	2%	1.779	2%	22.4%	19.8%

Source: IEA

Current Status of Power Supply

Power sector. The government-owned utility, Korean Electric Power Corporation (KEPCO), is responsible for generation, transmission, and distribution. In addition to KEPCO, two other entities are involved in power generation: the Kyongin Energy Company (KEC) and the Industrial Site and Water Development Corporation (ISWACO). The government is, however, considering to privatize KEPCO and to introduce IPPs. As a result, the structure of the power sector is expected to change drastically in the near future.

Installed capacity. In 1992, KEPCO's installed capacity was 24.12 million kW, of which nuclear power accounted for 7.61 million kW (32 percent of total installed capacity), LNG-fired 6.26 million kW (23 percent), oil-fired 4.05 million kW (20 percent), coal-fired 3.70 million kW (15 percent), and hydro 2.49 million kW (10 percent) (see Table A14). During the 1980s, nuclear power development was given high priority and coal and LNG (liquefied natural gas) substituted for oil.

Table A14: Installed Capacity of KEPCO

(million kW)

	1980		*1985*		*1990*		*1992*		*Annual Growth Rate*	
									85/80	*92/85*
Total	9.391	100%	16.137	100%	21.021	100%	24.120	100%	11.4%	5.9%
Hydro	1.157	12%	2.223	14%	2.340	11%	2.498	10%	14.0%	1.7%
Coal	0.888	9%	3.700	23%	3.700	18%	3.700	15%	33.0%	0.0%
Heavy Oil	5.525	59%	6.212	38%	3.662	17%	3.662	15%	2.4%	-7.3%
Internal Combustion	0.315	3%	0.216	1%	0.313	1%	0.388	2%	-7.3%	8.8%
LNG	-	-	-	-	2.550	12%	2.550	11%	-	-
Combined Cycle	0.920	10%	0.920	6%	0.840	4%	3.706	15%	0.0%	22.0%
Nuclear	0.587	6%	2.866	18%	7.616	36%	7.616	32%	37.3%	15.0%

Source: ADB; Ministry of Trade, Industry and Energy.

Electricity generation. In 1992, KEPCO generated 131 billion kWh. Nuclear power generated 56.5 billion kWh (43 percent of total gross generation), followed by oil with 35.3 kWh (27 percent), coal with 22.1 billion kWh (17 percent), LNG with 12.2 billion kWh (9 percent), and hydro with 4.9 billion kWh (4 percent).

Since the oil crises in the 1970s, KEPCO has substituted nuclear power for oil-fired. Oil's share continued to decline in the first half of the 1980s, but it has again increased to meet increasing electricity demand after the oil price collapse in the mid-1980s (see Table A15).

Table A15: Electricity Generation (gross) of KEPCO

(billion kWh)

	1980		*1985*		*1990*		*1992*		*Annual Growth Rate*	
									85/80	*92/85*
Gross Generation	37.239	100%	58.007	100%	107.670	100%	130.963	100%	9.3%	12.3%
Hydro	1.984	5%	3.659	6%	6.361	6%	4.863	4%	13.0%	4.1%
Thermal	31.778	85%	37.603	65%	48.422	45%	69.570	53%	3.4%	9.2%
Coal	2.481	7%	17.639	30%	19.961	19%	22.072	17%	48.0%	3.3%
Oil	29.297	79%	19.964	34%	18.856	18%	35.311	27%	-7.4%	8.5%
LNG	-	-	-	-	9.604	9%	12.187	9%	-	-
Nuclear	3.477	9%	16.745	29%	52.887	49%	56.530	43%	36.9%	19.0%
Net Generation	35.083		53.908		100.003		122.309		9.0%	12.4%

Source: Ministry of Trade, Industry and Energy.

TAIWAN, CHINA

Structure of Electricity Consumption

The industrial sector accounts for half of the final electricity consumption, and the residential/commercial sector, one-third. Because of high economic growth during the second half of the 1980s and the early 1990s, final electricity consumption increased rapidly at a rate of 8.7 percent p.a. between 1985 and 1992. The residential/commercial sector posted a double-digit percentage growth rate--11.9 percent p.a.--during the same period. Conversely, the growth of consumption in the industrial sector was relatively low--6.7 percent p.a. (see Table A16).

Table A16: Final Electricity Consumption in Taiwan, China
(billion kWh)

	1980		*1985*		*1990*		*1992*		*Annual Growth Rate*	
									90/80	92/85
Total	36.877	100%	47.316	100%	73.999	100%	85.090	100%	7.2%	8.7%
Industry	23.792	65%	28.180	60%	40.523	55%	44.485	52%	5.5%	6.7%
Transportation	0.306	1%	0.365	1%	0.434	1%	0.437	1%	3.6%	2.6%
Res'l/Com'l	9.131	25%	12.947	27%	23.219	31%	28.447	33%	9.8%	11.9%
Others	3.648	10%	5.824	12%	9.823	13%	11.720	14%	10.4%	10.5%

Source: Energy Commission

Current Status of Power Supply

Power sector. The state-owned enterprise, Taiwan Electric Power Corporation (Taipower), is fully responsible for power generation, transmission, and distribution.

Installed capacity. Installed capacity doubled from 9.06 million kW in 1980 to 19.36 million kW in 1993. Through intensive introduction of nuclear and coal-fired power during the 1980s, and of LNG-fired after 1990, Taipower expanded its generating capacity and substituted for oil-fired power. In 1993, the configuration of installed capacity was coal 30 percent, nuclear 27 percent, oil 25 percent, hydro 13 percent, and LNG 5 percent (see Table A17).

Table A17: Installed Capacity of Taipower

(million kW)

	1980		*1985*		*1990*		*1993*		*Annual Growth Rate*	
									85/80	*92/85*
Total	9.056	100%	15.970	100%	16.883	100%	19.355	100%	12.0%	2.4%
Hydro	1.386	15%	2.489	16%	2.562	15%	2.576	13%	12.4%	0.4%
Coal	0.980	11%	3.055	19%	3.675	22%	5.825	30%	25.5%	8.4%
Oil	5.418	60%	5.279	33%	4.751	28%	4.780	25%	-0.5%	-1.2%
LNG	-	-	0.003	-	0.751	4%	1.030	5%	-	-
Nuclear	1.272	14%	5.144	32%	5.144	30%	5.144	27%	32.2%	0.0%

Source: Taipower

Electricity generation. Incremental energy output, meeting increasing electricity demand, came from nuclear, coal, and LNG power sources. Although dependency on oil declined in the early 1980s, oil's share again increased after the oil price collapse in the mid-1980s. As a result, in 1993, electricity generated by oil-fired power increased to the same level as in 1980. In 1993, total electricity generation was 101.8 billion kWh. Coal accounted for 35 percent of total electricity generation, nuclear 32 percent, oil 23 percent, and LNG 3 percent (see Table A18).

Table A18: Electricity Generation (net) of Taipower

(billion kWh)

	1980		*1985*		*1990*		*1993*		*Annual Growth Rate*	
									85/80	*92/85*
Net Generation	40.813	100%	52.556	100%	82.350	100%	101.784	100%	5.2%	8.6%
Hydro	2.905	7%	6.900	13%	8.167	10%	6.696	7%	18.9%	-0.4%
Coal	5.688	14%	13.077	25%	20.467	25%	35.186	35%	18.1%	13.2%
Oil	24.408	60%	5.030	10%	20.873	25%	23.367	23%	-27.1%	21.2%
LNG	-	-	-	-	1.289	2%	3.549	3%	-	-
Nuclear	7.812	19%	27.546	52%	31.554	38%	32.986	32%	28.7%	2.3%

Note: LNG includes geothermal.

Source: Energy Commission, Taipower.

THAILAND

Structure of Electricity Consumption

Two sectors, industrial and residential/commercial, dominate almost all final electricity consumption. In 1991, consumption in these sectors was 43.1 billion kWh, 54 percent of which was consumed by the residential/commercial sector, and 45 percent by

the industrial sector. The growth in electricity consumption was markedly high in the second half of the 1980s compared to the first half (e.g., 13.8 percent p.a. during the period 1985-1991 vis-à-vis 8.8 percent p.a. during the period 1980-1985) because of the oil price collapse and an economic boom (see Table A19).

Table A19: Final Electricity Consumption in Thailand

(billion kWh)

	1980		*1985*		*1990*		*1991*		*Annual Growth Rate*	
									90/80	*91/85*
Total	13.026	100%	19.844	100%	38.102	100%	43.142	100%	11.3%	13.8%
Industry	6.332	49%	9.110	46%	17.687	46%	19.557	45%	10.8%	13.6%
Transportation	-	-	-	-	-	-	-	-	-	-
Res'l/Com'l	6.637	51%	10.637	54%	20.071	53%	23.128	54%	11.7%	13.8%
Others	0.057	0%	0.097	0%	0.345	1%	0.457	1%	19.7%	29.5%

Source: IEA

Current Status of Power Supply

Power sector. Thailand's power sector consists of three government-owned companies: the Electricity Generating Authority of Thailand (EGAT); the Metropolitan Electricity Authority (MEA); and the Provincial Electric Authority (PEA). Auto producers accounted for 4.3 percent of total electricity generation in 1990.

EGAT, established in 1968, is responsible for generation and transmission throughout the country, and also operates lignite mines to feed fuel for its lignite-fired power plants. EGAT sells electricity in bulk to MEA, PEA, and a few large-size, directly connected end-uses. In addition to its own generation, EGAT has electricity interchange arrangement with TNB of Malaysia and Electricité du Laos.

MEA, established in 1985 by a merger of utilities servicing the Bangkok area, is responsible for distributing power to Bangkok and suburbs. PEA, established in 1960, is responsible for distributing power to all areas of Thailand outside MEA's service territory.

Installed capacity. EGAT owns almost all power plants in Thailand. In FY1993, EGAT's installed capacity was 12.19 million kW. Of that, natural oil/gas-fired power accounted for 3.78 million kW (31 percent of total installed capacity), lignite-fired 2.06 million kW (17 percent), fuel oil-fired, diesel, and gas turbine the rest. During the

1980s, thermal power plants' share increased at the expense of hydro's share (see Table A20).

Table A20: Installed Capacity of EGAT

(million kW)

	FY1980		*FY1985*		*FY1990*		*FY1993*		*Annual Growth Rate*	
									85/80	*93/85*
Total	3.328	100%	6.460	100%	7.998	100%	12.189	100%	14.2%	8.3%
Hydro	1.270	38%	1.814	28%	2.249	28%	2.429	20%	7.4%	3.7%
Lignite-fired	0.210	6%	0.885	14%	1.459	18%	2.059	17%	33.3%	11.1%
Oil-fired	-	-	0.268	4%	0.268	3%	0.263	2%	-	-0.2%
Oil/Gas-fired	1.568	47%	2.475	38%	2.580	32%	3.780	31%	9.6%	5.4%
Diesel	0.115	3%	0.034	1%	0.028	0%	0.011	0%	-21.8%	-13.4%
Gas Turbine	0.165	5%	0.265	4%	0.238	3%	0.224	2%	9.9%	-2.1%
Combined Cycle	-	-	0.720	11%	1.177	15%	3.424	28%	-	21.5%

Source: ADB, EGAT.

Electricity generation. EGAT generates 99.8 percent of total electricity supply excluding self-generation. Responding to the high growth in electricity demand, the growth of EGAT's generation was high: 9.6 percent p.a. in FY1980-85 and 13 percent p.a. in FY1985-93. As a result, EGAT recorded 62.18 billion kWh of electricity generation in FY1993. During the 1980s, EGAT developed lignite and natural gas-fired power to meet rapidly increasing demand. The energy mix in FY1993 was natural gas, 44 percent; oil, 26 percent; lignite, 22 percent; and hydro 6 percent (see Table A21).

Table A21: Electricity Generation (gross) of EGAT

(billion kWh)

	FY1980		*FY1985*		*FY1990*		*FY1993*		*Annual Growth Rate*	
									85/80	*93/85*
Total	14.754	100%	23.357	100%	43.189	100%	62.180	100%	9.6%	13.0%
Hydro	1.653	11%	3.871	17%	4.858	11%	3.827	6%	18.6%	-0.1%
Thermal	12.348	84%	18.731	80%	37.614	87%	57.782	93%	8.7%	15.1%
Lignite	1.327	9%	4.451	19%	10.230	24%	13.831	22%	27.4%	15.2%
Oil	11.021	75%	4.231	18%	9.327	22%	16.367	26%	-17.4%	18.4%
Natural Gas	-	-	10.049	43%	18.057	42%	27.584	44%	-	13.5%
Purchase	0.753	5%	0.755	3%	0.717	2%	0.571	1%	0.1%	-3.4%

Source: EGAT

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