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ELECTRICITY IN THE DEVELOPING COUNTRIES: TRENDS IN SUPPLY AND OSE SINCE 1970

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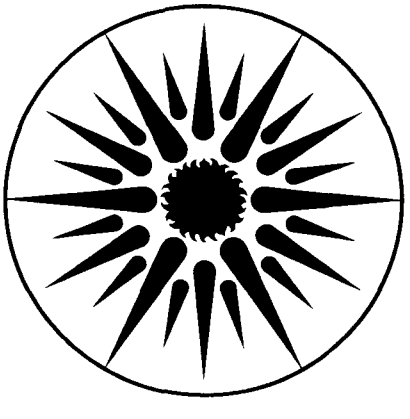
Electricity in the Developing Countries: Trends in Supply and Use since 1970

S. Meyers and J. Sathaye

December 1988



APPLIED SCIENCE DIVISION

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ELECTRICITY IN THE DEVELOPING COUNTRIES: TRENDS IN SUPPLY AND USE SINCE 1970

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December 1988

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EXECUTIVE SUMMARY

The share of world electricity production accounted for by the developing countries (LDCs) grew from 11% in 1970 to 20% in 1986. The average annual growth rate for LDC electricity production in this period — 8.4% — was over twice the rate of 3.8% in the industrialized countries. Growth in the 1980s — 6.7%/year through 1986 — has been less than the rate of 9.4%/year in the 1970s, mainly due to slower economic growth in Latin America and Africa. Per capita electricity production in the LDCs increased from 0.2 to 0.5 MWh between 1970 and 1986, but this is still well below the average of 6.8 MWh in the industrialized countries. The total installed capacity of electricity generating plants in the LDCs is now close to 500 GW. (The U.S. has 720 GW.)

Electricity production has grown fastest in Asia (9.5%/year between 1970 and 1986), followed by China (8.8%/year), Latin America (7.7%/year), and Africa (6.4%/year). There has been considerable decline in growth in the 1980s in Latin America and Africa, but not in Asia. Among the 13 countries in our study, growth ranged from 5.2%/year in Argentina to 13.2%/year in South Korea. Indonesia, Malaysia, and Thailand averaged growth in excess of 10%/year, and Pakistan, Taiwan, and Brazil were close to this.

Electricity generation is much higher in China (450 TWh in 1986) than in any other LDC. Brazil (212 TWh) and India (202 TWh) are also major producers of electricity. The next largest — Mexico, South Korea, and Taiwan — are well below Brazil and India.

The share of total LDC electricity production derived from fossil fuels has remained at about 65% since 1970. In contrast, the fossil fuel dependency of electricity production in the industrialized countries has declined from 76% to 64%. The share of fossil fuels in 1986 was 77% in China and Africa (56% if South Africa is excluded), and 70% in Asia. In Latin America the hydropower share increased from 51% to 61% between 1970 and 1986. Hydro's role has increased in China since 1970, but has declined in Asia and Africa.

The LDCs have experienced a shift in power generation away from oil to coal, natural gas, and nuclear power (mainly in Asia). Coal dominates power generation in China and India, and is also prominent in South Korea and Taiwan. Natural gas plays an important role in Pakistan, Thailand and Venezuela. Nuclear power accounts for over 40% of generation in South Korea and Taiwan, but is a minor source elsewhere. For 12 major LDCs, the combined share of oil in total public generation declined from 27% in 1970 to 17% in 1986. The share of hydro fell from 48% to 44%, coal grew from 15% to 22%, while nuclear went from 2% to 9%.

The extent to which electricity consumption grows faster than the economy depends in part on the stage of economic development in which a country finds itself. The ratios between average growth in electricity consumption and growth in real GDP in the 1970-86 period in the 13 study LDCs were mostly between 1.6 and 1.9. Electricity consumption has grown much faster than GDP in times of strong economic growth. In many cases, it has also continued to increase during periods of little or no growth or even decline in GDP.

The electricity-GDP ratio was lower in Taiwan and Malaysia (1.2 and 1.4, respectively), reflecting these countries having achieved a more mature phase of economic development. In South Korea and Taiwan, the ratio was lower in the 1980-86 period than in the 1970s as a result of change in their economic structure and the introduction of new and more efficient processes.

The industrial sector dominates electricity consumption in nearly all LDCs, but its share of total consumption has generally declined in the face of faster growth in the residential and commercial sectors. Electricity use in these sectors — particularly residential — grew faster than consumption by industry in all of the 12 countries except Argentina and Brazil. The share of the buildings sector has also increased in China in the 1980s.

Overall electricity intensity in industry rose significantly in Latin America in the 1970-86 period, but did not increase greatly in the Asian countries except Thailand. There was a modest decline in Malaysia and Taiwan. The main factor is change in the composition of the industrial sector, though introduction of more modern and efficient factories also plays a role.

Residential electricity use per capita has grown at more than 10%/year in most of the countries. The growth has been caused by rising ownership of appliances and increase in the number of homes that have electricity. Growth has been especially rapid in South Korea, Thailand, and Pakistan. Home air-conditioning has not spread very far yet except in Taiwan, but this could be a major area of growth in the future.

As electricity demand grows, many LDCs face increasing difficulty as they seek to expand supply and maintain existing systems. Power shortages are critical in many countries, and environmental issues are becoming more important. Measures that are receiving closer attention include reform of tariffs to better reflect costs, reducing demand through end-use efficiency improvement, encouraging private power generation, and improving technical and managerial aspects of electric utilties.

1. INTRODUCTION

The purpose of this report is to provide an overview of historic trends and the current situation concerning electricity supply and consumption in the developing countries (LDCs). While these countries still account for a relatively modest share of world electricity production, their demand for electricity is growing at a much faster rate than that of the industrialized countries. Thus, the power sector in the LDCs will become increasingly important as a consumer of energy and a producer of carbon dioxide.

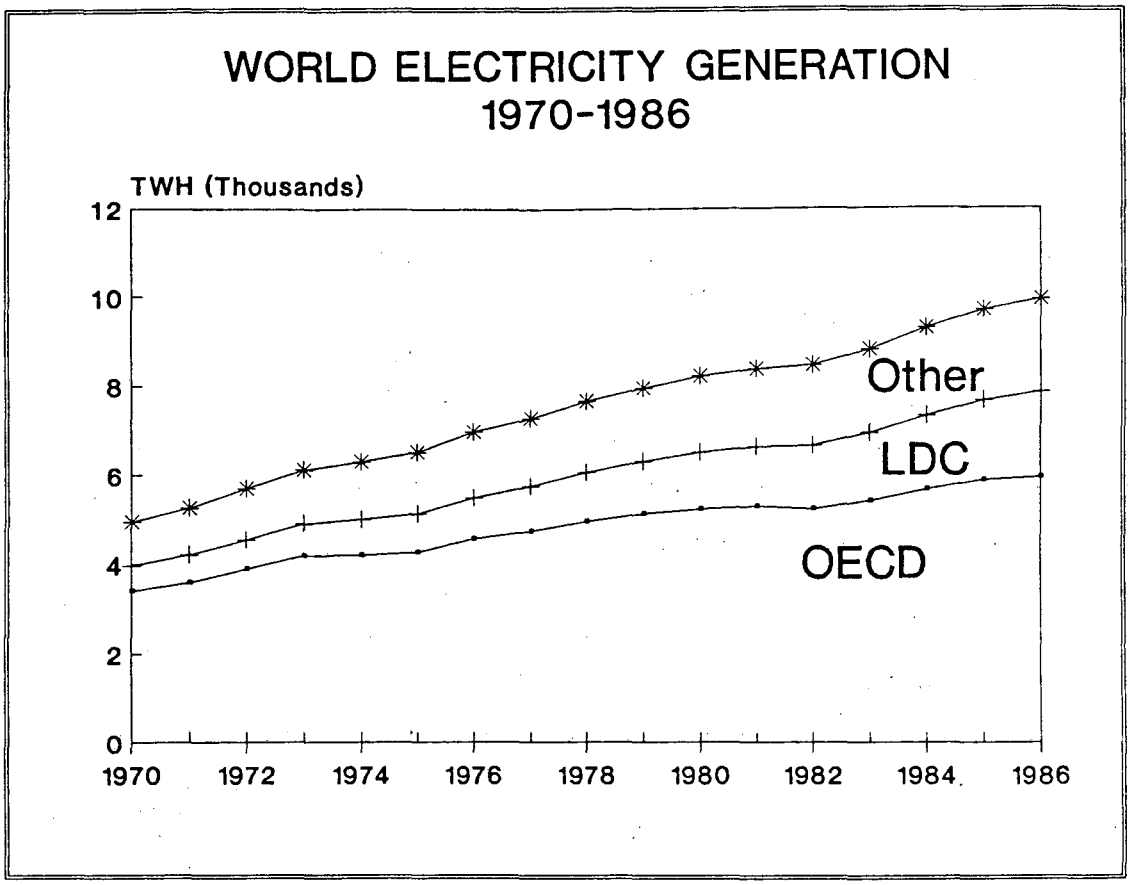
The share of world electricity production accounted for by the developing countries grew from 11% in 1970 to 20% in 1986 (See Figure 1.1). The average annual growth rate for LDC electricity production in this period — 8.4% — was over twice the rate of 3.8% recorded in the "developed" countries (OECD and others).

The share of LDC electricity production derived from fossil fuels has remained at about 65% since 1970 (See Figure 1.2). In contrast, the fossil fuel dependency of electricity production in the industrialized countries has declined from 76% to 64% as a result of growing use of nuclear power. In the LDCs as in the industrialized countries, there has been a shift away from oil to coal, natural gas, and to a lesser extent, nuclear power.

Because economic growth is advancing at a rapid rate in many developing countries, and the current level of electricity use is relatively low, continued high growth in LDC electricity demand is likely. Per capita electricity production in the LDCs increased from 0.2 MWh to 0.5 MWh between 1970 and 1986, but this is still well below the average of 6.8 MWh in the industrialized countries. As growth in industrial production and urbanization continue in the LDCs, demand for electricity is likely to increase at a high rate. This may vary considerably among regions, and among countries within regions.

Many factors will affect the actual growth in electricity generation. On the supply side, the high level of debt that has accumulated in many LDCs has led to concern about their ability to finance the expected investment for new electricity production. Given this problem, along with the difficulty in maintaining the existing system and the need to improve service, in some countries supply may not be able to keep pace with the underlying demand. Furthermore, growing environmental concerns at regional, national, and international levels may place constraints on development of particular power sources (hydro, coal, nuclear power). In this context, government policy may be increasingly important as a force to influence electricity demand and the mix of supply options.

FIGURE 1.1


WORLD ELECTRICITY GENERATION
1970-1986
TWH (Thousands)
12
10
8
6
4
2
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
Other
LDC
OECD

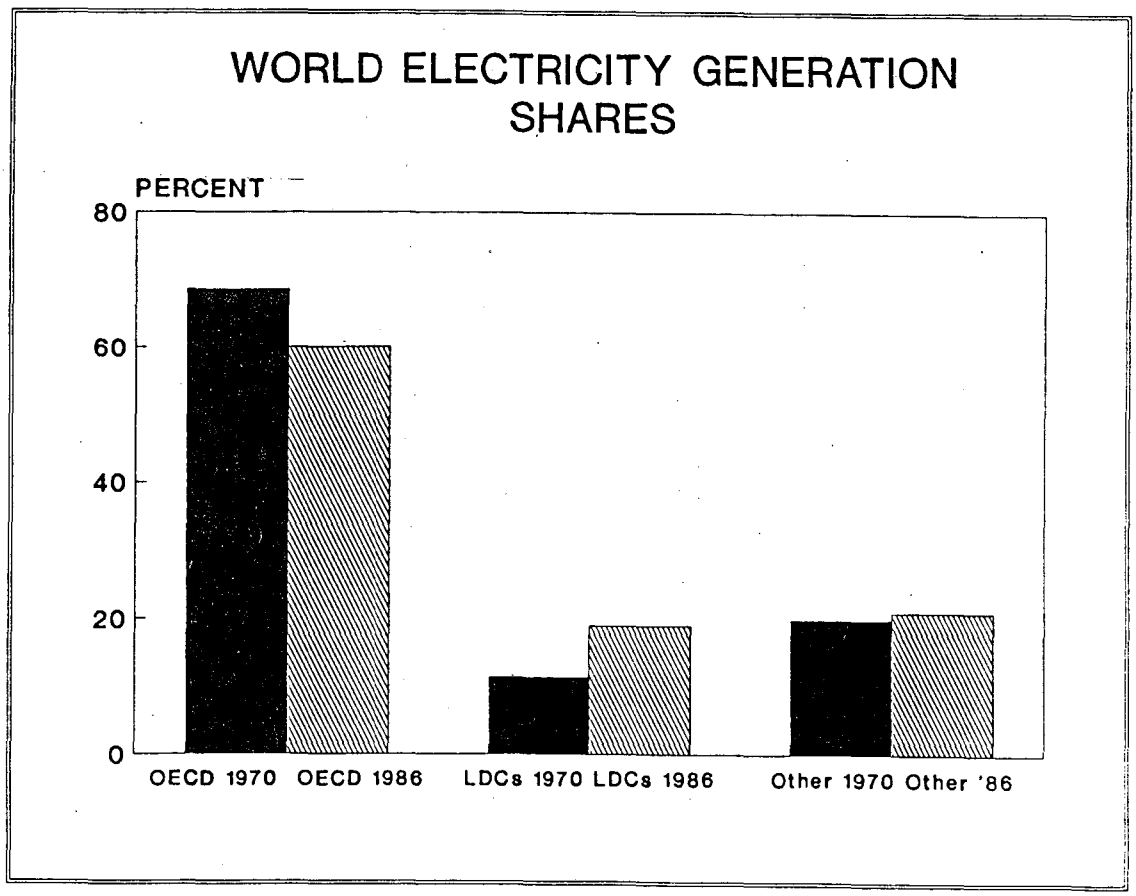
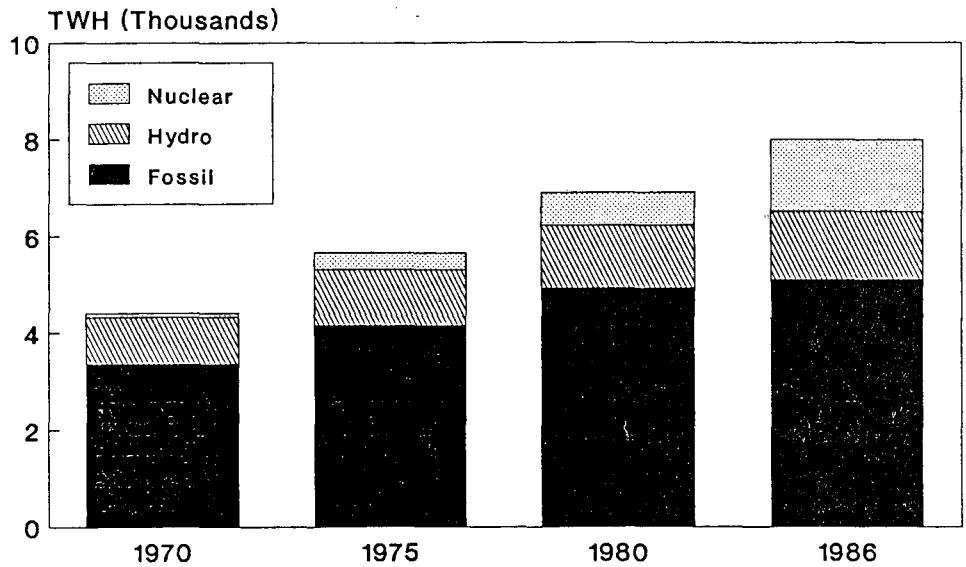

WORLD ELECTRICITY GENERATION
SHARES
PERCENT
80
60
40
20
0
OECD 1970
OECD 1986
LDCs 1970
LDCs 1986
Other 1970
Other '86

FIGURE 1.2

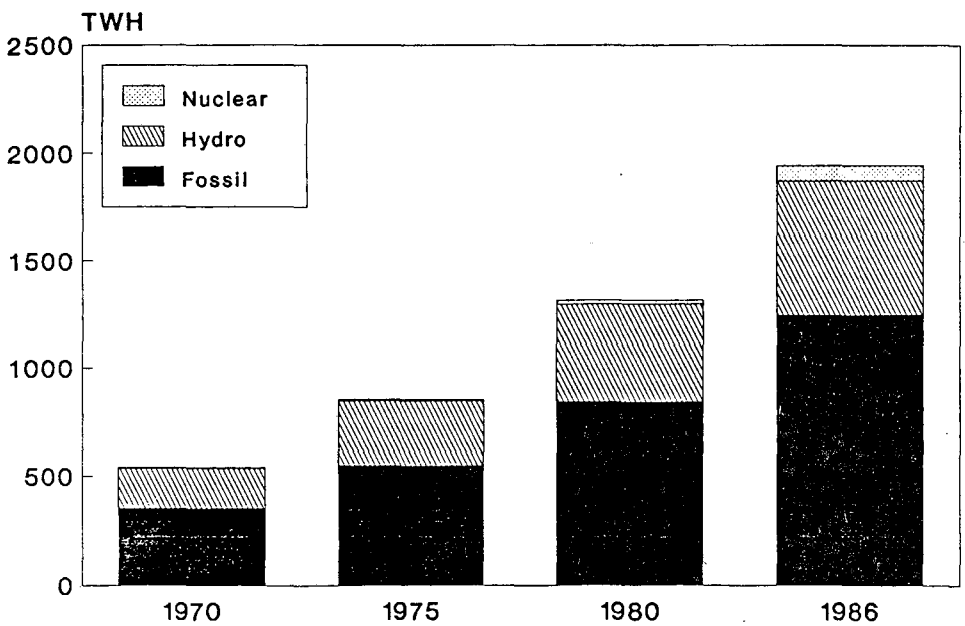
ELECTRICITY PRODUCTION BY SOURCE

INDUSTRIAL COUNTRIES



indsou

DEVELOPING COUNTRIES



ldcsou

Overview of This Report

This report provides basic information on trends concerning electricity supply and consumption in the developing countries between 1970 and 1986,* and discusses the main resource and policy issues affecting future development in these areas. Its main purpose is to describe what has happened, discuss some of the underlying causes, and identify areas that call for further analysis.

Chapter 2 describes the evolution since 1970 with respect to installed capacity and electricity generation for the LDCs as a whole and for the major regions (Asia, China, Latin America, and Africa). (We separate China from Asia because of its size.) The rest of the report provides more detailed information on electricity supply and demand, primarily focusing on 13 of the largest developing countries. These 13 countries account for about two-thirds of total LDC electricity generation. They are:

ASIA:	China, India, Indonesia, Malaysia, Pakistan, Philippines, South Korea, Taiwan, Thailand
LATIN AMERICA:	Argentina, Brazil, Mexico, Venezuela

Chapter 3 focuses on electricity supply. It describes changes in the mix of power sources for electricity generation that have occured since 1970, and discusses generating efficiency and the extent of the electricity supply network.

Chapter 4 describes the linkage between electricity demand and economic growth, the changing composition of electricity demand, and change in industrial and residential electricity intensity.

Chapter 5 discusses key policy issues concerning the development of electricity demand and supply in the developing countries.

Data Sources Used in This Report

The data presented in this chapter and in Chapter 2 have been assembled from various issues of the United Nations *Energy Statistics Yearbook*. The statistics compiled by the UN are sometimes inaccurate, but they are the only source that covers all countries. They serve as an approximation. The more detailed data presented in Chapters 3 and 4 have been compiled by LBL from statistical reports issued by the electric utilities or other entities of the respective countries. (In a few places we supplement these sources with UN statistics.)

* In the final draft, we will include data for 1987 for several countries.

As is generally the case with developing country statistics, the electric power statistics presented herein are subject to some uncertainty. In some cases, we have made estimates where data were unavailable or seemed to be in error. For some countries, for example, statistics were not available on electricity generation by fuel type, but rather by power plant type. In these cases we made estimates based on fuel consumption.

One point is worth noting here: it is common in discussions of national electricity generation and consumption to simply refer to public utilities. In some countries this seriously understates actual electricity generation. We have attempted to include data on so-called "self-generation," most of which is by industry. It is likely that this generation is understated.

A Note Regarding Diversity Among the LDCs

The LDCs, or Less Developed Countries, is a catch-all category that include countries that are quite different in terms of physical size, population, and stage of economic development. Although grouping all of these countries together facilitates a simple division of the world's countries, it does not allow for neat generalizations. Nor are all of the LDCs "less developed" than all non-LDCs. The high-income oil-exporters of the Persian Gulf region have higher average per capita GNP than many OECD countries. In most uses, the category "LDCs" does not include several European countries that the World Bank does include as "Developing countries": Greece, Portugal, Hungary, Poland, Yugoslavia, and Romania. In any case, the reader should be aware that some of the generalizations made in this report may not apply to the more advanced LDCs such as South Korea, Taiwan, and Venezuela.

2. OVERVIEW OF ELECTRICITY IN THE DEVELOPING COUNTRIES*

Growth in LDC electricity production has averaged 8% per year since 1970. Electricity production in the LDCs increased from 539 to 1954 TWh between 1970 and 1986. Growth in the 1980s — 6.7% per year through 1986 — has been less than the rate of 9.4% per year recorded in the 1970s, mainly due to slower economic growth in Latin America and Africa.

The total installed capacity of electricity generating plants in the LDCs is now close to 500 GW. This may be compared to the total in the U.S. of 720 GW.

Growth has varied among regions. Electricity production has grown fastest in Asia, followed by China, Latin America, and Africa (see Table 2.1).† There has been considerable decline in the growth rate of electricity production in the 1980s in Latin America and Africa, but not in Asia.

Table 2.1
Average Annual Growth in Electricity Production (%)

	1970-86	1970-80	1980-86
Asia	9.5	9.8	9.0
China	8.8	10.0	6.8
Latin America	7.7	9.3	5.1
Africa	6.4	7.9	3.9

As a result of the faster growth, the share of LDC electricity production accounted for by Asia increased from 33% in 1970 to 39% in 1986 (See Figure 2.1). Latin America accounts for 27%, China for 23%, and Africa for 12%. (Note: South Africa accounts for about half of total African electricity production.)

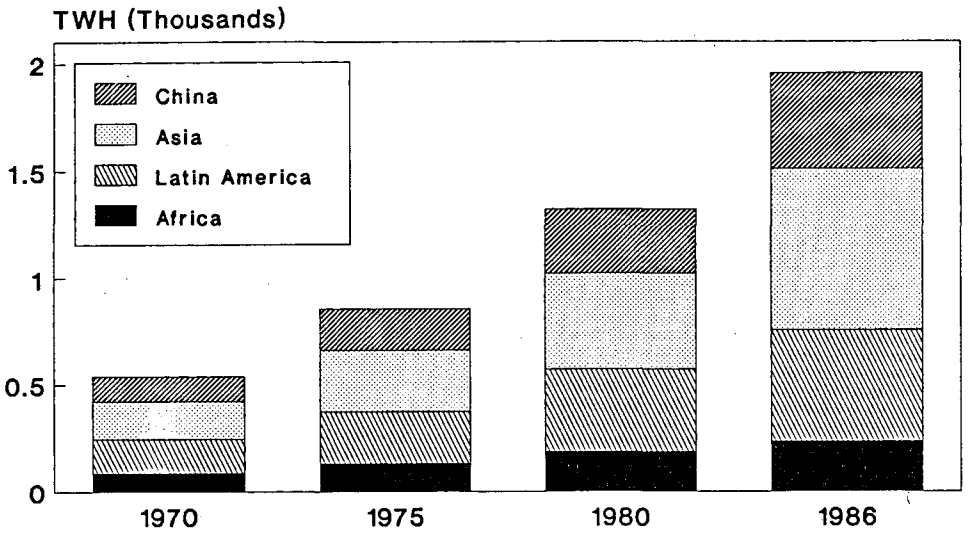
* The statistics reported in this chapter, which come from the United Nations, nominally include "self-generation" by industries. The accuracy of the UN statistics in this regard is questionable for many countries.

† Asia includes the Middle East and Pacific developing countries but excludes China, which because of its large size is reported separately. Latin America includes the Caribbean. Africa includes South Africa.

FIGURE 2.1

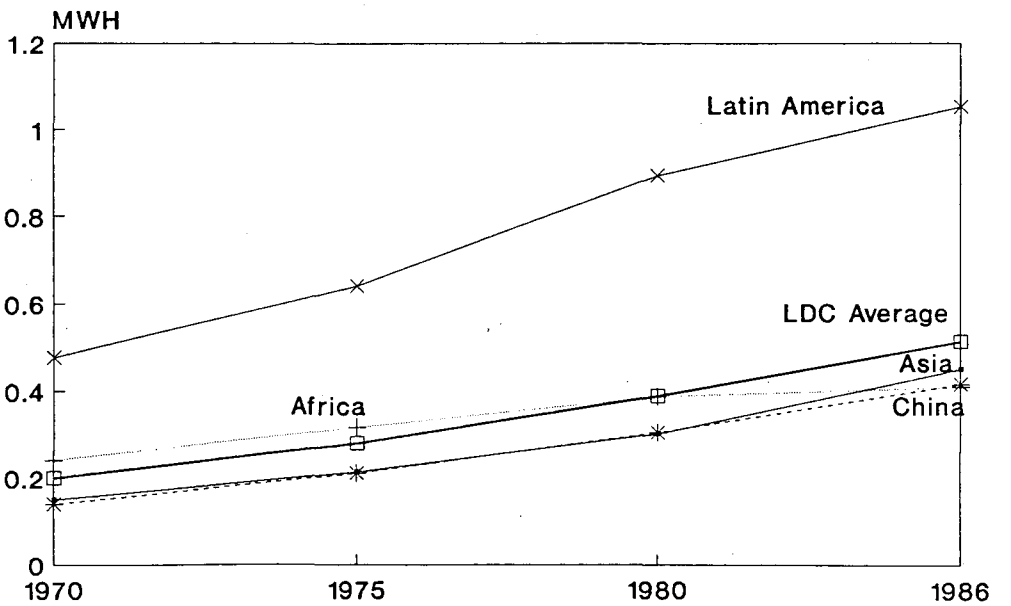
ELECTRICITY PRODUCTION

DEVELOPING COUNTRIES BY REGION



ldcelec

PER CAPITA



ldcelcp

Per capita electricity production in Latin America is over twice as high as that in other LDC regions (See Figure 2.1). Asia, China, and Africa are all at about the same level. Growth in per capita electricity production since 1970 has been highest in Asia and China, and lowest in Africa (see Table 2.2).

Table 2.2
Average Annual Growth in
Per Capita Electricity Production (%)

	1970-86	1970-80	1980-86
Asia	7.1	7.3	6.9
China	7.0	8.0	5.5
Latin America	5.1	6.5	2.8
Africa	3.4	4.9	0.9

Among the LDC regions, China and Africa are the most dependent on fossil fuels for electricity production (See Figure 2.2), followed by Asia (See Figure 2.3). The share of fossil fuels in 1986 was 77% in China and Africa, and 70% in Asia. The share of fossil fuels in Africa drops to 56% if South Africa is excluded.

Latin America is the only region where hydropower dominates electricity production (See Figure 2.3). The share of hydropower there increased from 51% to 61% between 1970 and 1986. Hydro's role has increased in China since 1970, but has declined in Asia and Africa. Asia is the only region where nuclear power has come to play a modest role: it accounted for 8% of total electricity generation in 1986.

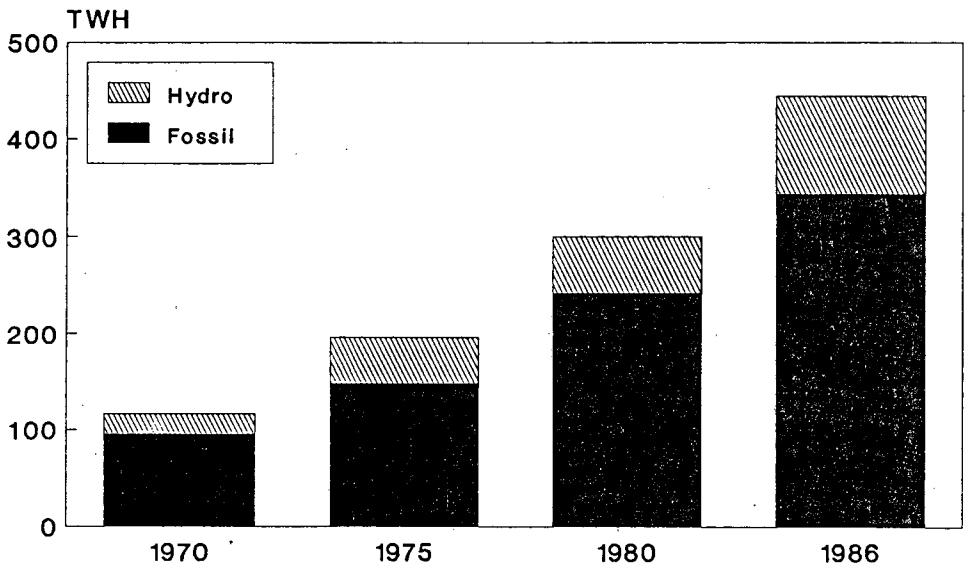
Asia has 43% of total LDC installed power capacity. Asian LDCs account for a higher share of total LDC installed electricity generating capacity than of electricity production. This reflects the presence of considerable underutilized (and perhaps outdated) capacity.* Latin America accounts for 27% of the LDC total, followed by China with 18% and Africa with 12% (see Table 2.3).

* Installed capacity statistics for some LDCs are somewhat misleading because they often include power plants that have low availability.

FIGURE 2.2

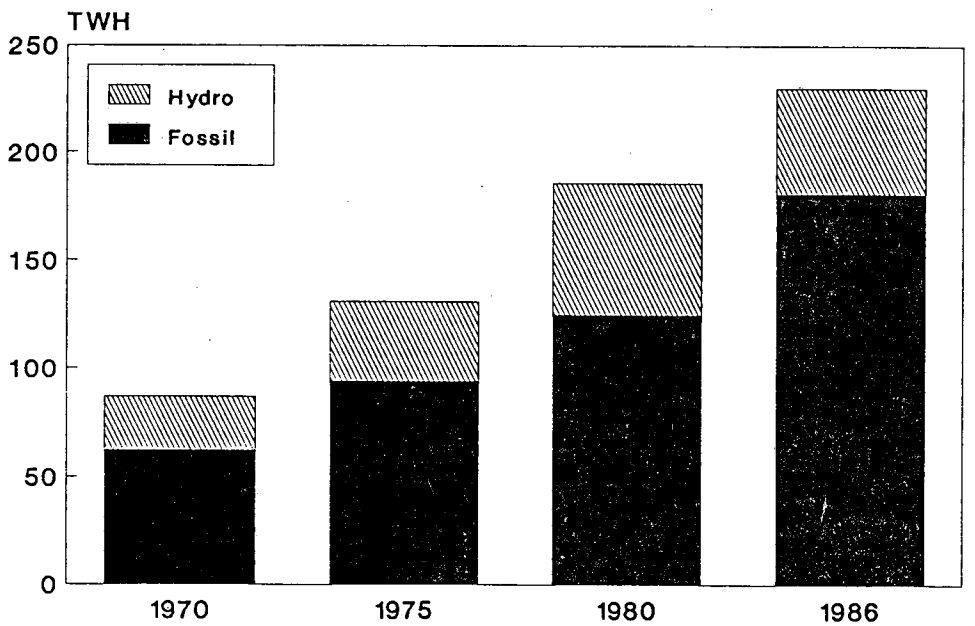
ELECTRICITY PRODUCTION BY SOURCE

CHINA



chinasou

AFRICA

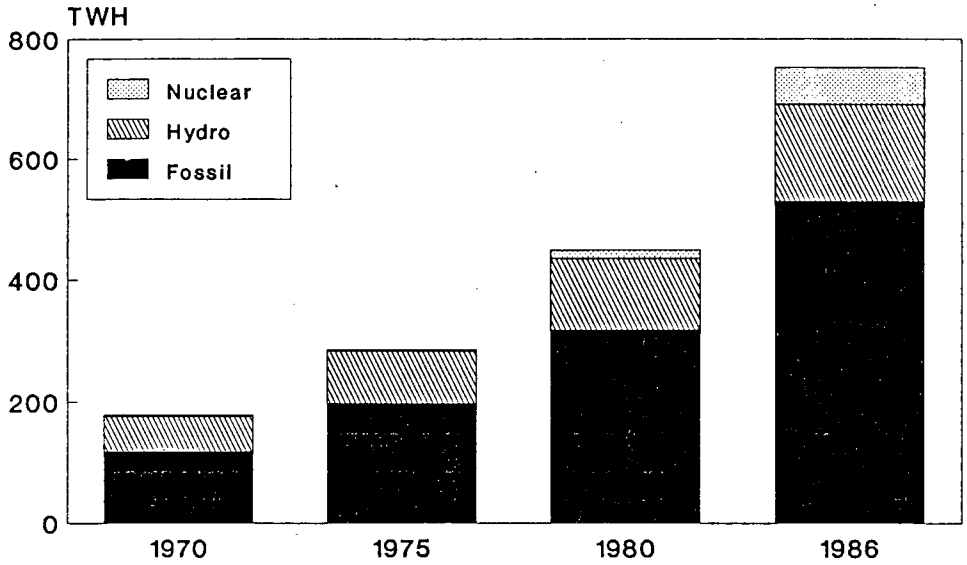


africsou

FIGURE 2.3

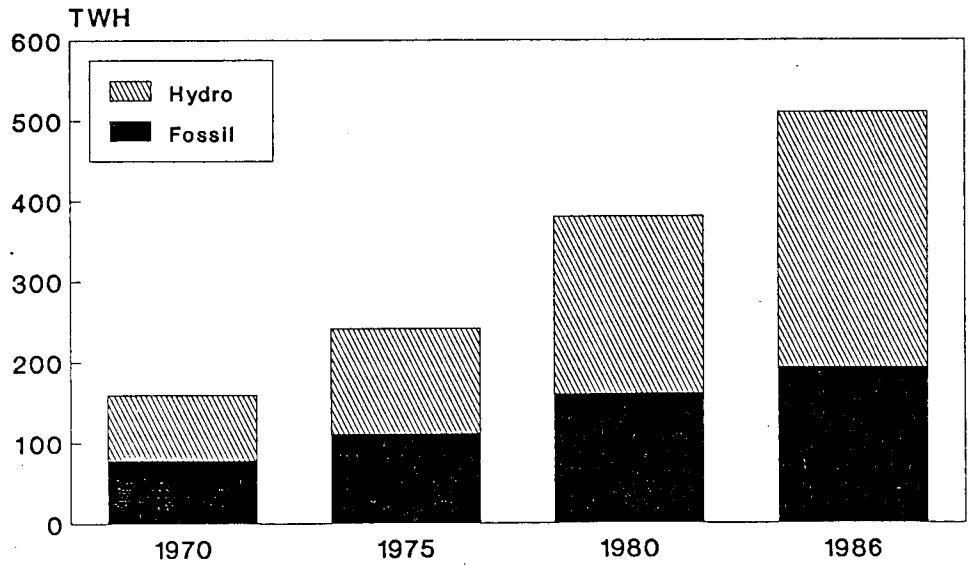
ELECTRICITY PRODUCTION BY SOURCE

ASIA



aslasou

LATIN AMERICA



latsou

Table 2.3
Net Installed Capacity of
Electricity Generating Plants in LDCs, 1986

	GW	%
Asia	212	43
China	87	18
Latin America	132	27
Africa	59	12
Total	489	100

Two-Thirds of LDC Total Installed Capacity Uses Fossil Fuels

Comparison of the statistics on installed capacity (see Table 2.4) with those on electricity production suggest that in 1986 there was underutilized fossil fuel capacity in Asia and Latin America and underutilized hydro capacity in China and Africa. This could result from part of the nominal installed capacity being unusable, hydrological conditions, or both. Asia has the most nuclear power capacity among the regions due to the recent buildup in Taiwan and South Korea.

Table 2.4
Net Installed Capacity of
Electricity Generating Plants in LDCs
According to Power Source, 1986 (%)*

	Fossil Fuel	Hydro	Nuclear
Asia	73	21	5
China	69	31	-
Latin America	45	52	1
Africa	69	29	2
Total	65	32	3

* Geothermal accounts for about 0.5% in Asia and Latin America.

3. ELECTRICITY SUPPLY IN KEY DEVELOPING COUNTRIES

This chapter presents information in the following areas: (1) Ranking of LDCs in terms of current electricity generation; (2) Growth in electricity generation since 1970; (3) Change in power sources for electricity generation since 1970; (4) Mix of power sources in 1986; (5) Power system capacity and peak demand; (6) Power system efficiency; and (7) Extent of electricity supply networks.

In most developing countries, public electricity supply is the responsibility of one or more state-owned (national or regional) companies. In some cases, private companies provide electricity supply under state regulation.

In addition to the public supply, many industries and other enterprises generate electricity for their own use. In many LDCs, this so-called "self-generation" is considerable. The main reason for the prevalence of self-generation is the power outages and brownouts that plague most LDC electricity systems. Most self-generation uses oil, though in some instances, mainly in the sugar industry, self-generation utilizes biomass residues for power generation.

Electricity Generation in 1986 in the Largest LDCs*

Electricity generation in 1986 was much higher in China than in any other LDC (see Table 3.1). Brazil and India are also major producers of electricity. The next largest — Mexico, South Korea, and Taiwan — are less than half either Brazil or India. The LDCs not among the 13 in Table 3.1 that have current annual electricity generation in excess of 20 TWh are North Korea (50 TWh), Saudi Arabia (33 TWh), Egypt (32 TWh), Iran (37 TWh), Colombia (27 TWh), and Hong Kong (21 TWh). (Values are for 1986 as reported by the UN.)

Growth in Electricity Generation Since 1970

Average growth between 1970 and 1986 in combined electricity generation for the 13 study countries was 8.8% per year. Growth varied from a low of 5.2% per year in Argentina to a high of 13.2% per year in South Korea (see Table 3.1). Other countries with average growth in excess of 10% per year were Indonesia, Malaysia, and Thailand;

* All figures in this chapter representing electricity generation include estimated industrial self-generation as well as public supply. The accuracy of the estimates, which come from either country sources or the UN, varies among the countries, and has not been verified by LBL. In some cases, the actual self-generation may be rather different from that described here. In general, most self-production relies on oil as a power source. Biomass fuels (especially sugar cane bagasse) are also used in many countries.

Pakistan, Taiwan, and Brazil were close to 10% per year.

Table 3.1
Average Growth in Electricity Generation
and Generation in 1986

	%/year			TWh
	1970-86	1970-79	1980-86	1986
China	8.8	10.0	6.9	450
India	7.7	7.0	9.2	202
Indonesia	11.2	11.7	10.5	26
Malaysia	10.1	9.2	10.4	16
Pakistan	9.5	8.4	9.7	31
Philippines	6.7	8.9	4.4	23
South Korea	13.2	16.4	9.7	70
Taiwan	9.9	12.6	6.4	63
Thailand	11.5	13.7	8.9	26
Argentina	5.2	6.4	3.6	49
Brazil	9.5	11.0	7.2	212
Mexico	7.8	8.7	6.5	98
Venezuela	9.0	10.9	4.9	48
TOTAL	8.8	9.9	7.3	1313

On average, and in most cases, growth was faster in the 1970s than in the 1980-86 period. This was especially the case in the Latin American countries. The countries with the fastest growth in the 1980s (all more than 9% per year) were India, Indonesia, Malaysia, South Korea, and Pakistan. Growth in the 1980s was much higher in the Asian countries than in Latin America.

Change in Power Sources for Electricity Generation Since 1970

China. Electricity generation from fossil fuels (primarily low-grade coal) has accounted for around 80% of total generation since 1970, with most the remainder coming from hydro (See Figure 2.3). Use of oil has declined since 1980, while use of coal has grown at nearly 7% per year. Given the large coal resource in the country and the need to use oil and natural gas for other end-uses, the reliance on coal is likely to increase. Two

nuclear power plants will be operational soon and the future of nuclear power as an alternative to coal is being debated in the country.

India. Electricity generation from coal has increased from about 40% to 60% of total public generation since 1970 (See Figure 3.1). Generation from hydro was comparable to that from coal in 1970, but was less than half as much by 1986 despite a doubling in hydro generation. As in the case of China, coal is the major energy resource in India. Its use will continue to grow as more mine-mouth thermal plants are constructed. Generation from natural gas increased considerably in 1986 as previously flared gas began to be used in power plants, but it still accounts for a small share. Natural gas is found in several regions of the country, and its use will increase as pipelines and other infrastructure are completed to better utilize the resource. Self-production based on coal and oil is significant.*

Indonesia. Self-generation that primarily uses oil has continued to account for a sizable amount of total electricity generation, though the share has fallen since 1970. In recent years, generation from hydro and coal has grown in share, but oil (including self-generation) still dominates with a share of about 60% of total generation. Much of the coal available for power generation is on the island of Sumatra and much of the gas is on the island of Kalimantan. The demand for power is mostly on the heavily populated island of Java. Given the geographic mismatch in sources and demand, oil continues to be a major source for power generation.

Malaysia. Electricity generation from oil increased from 1970 through 1983, but has declined since (See Figure 3.2). Large-scale use of natural gas began in 1985, and accounted for 15% of total generation in 1986. The natural gas reserves in Malaysia are three times those of oil, hence the government is very interested in using this resource. Additional gas-fired power plants may be built and some of the oil generation may be substituted with natural gas. However, the low price of fuel oil and the fact that the price of natural gas is tied to that of oil may reduce the relative economic advantage of gas-based power plants. Malaysia also has lignite reserves and plans are afoot to use these for power generation. Hydro-electricity generation has also increased considerably from its early-1980s level and the potential for additional hydropower is extensive in Sabah and Sarawak. However, the demand is mostly on peninsular Malaysia, and without a cable to transmit electricity this potential will remain unutilized.

Pakistan. Electricity generation has relied on a mix of natural gas and hydro for many years. For most of the 1970s, the two supplied roughly even amounts, but in the

* Most of the larger steel and cement plants operate on coal and have their own generating stations. Recently the government has liberalized its policy to allow power-starved industry to install its own diesel generator sets.

1980s hydro has grown faster than gas and now dominates. Oil use has grown steadily since 1980, and the contribution of nuclear power is now noticeable. Fuel oil use has increased several-fold from a very small base because of the scarcity of natural gas. The use of fuel oil was also helpful since the Pakistan's refineries had to export fuel oil in order to meet the demand slate, which was skewed toward diesel products. Pakistan also has substantial coal reserves which are being exploited for power generation. (Note: Estimates of self-generation are very rough.)

Philippines. Dependence on oil for public electricity generation has declined from 81% in 1978 to only 36% in 1986 (See Figure 3.3). Generation from hydro and geothermal has grown, and use of coal has been important since 1985. Coal will continue to play a larger role in power generation. The country has extensive coal reserves whose quality is still being determined, but they are large enough to support several thousand megawatts of capacity. A nuclear power plant which was built during the Marcos era has been idle for several years with no immediate prospects for operation. There was no growth in generation in the 1984-86 period due to economic stagnation and political/social upheaval. Self-production is significant because of the large mining activity and the abundance of isolated islands in the country.

South Korea. Dependence on oil has also fallen considerably in South Korea — from 76% of public generation in 1982 to only 19% in 1986. Generation from imported coal has grown substantially, while nuclear power grew to claim a 44% share of public generation in 1986. With installed capacity of over 5000 MW, South Korea ranks with Taiwan in having the most nuclear power capacity among the LDCs. Current plans call for a total of 9400 MW of nuclear capacity to be in operation by the end of 1996.[1] The long-term plan also calls for an increase in coal-fired capacity from 3700 MW in 1986 to 6900 MW in 1996, and it is possible that some of the planned nuclear capacity may instead be coal-fired plants.

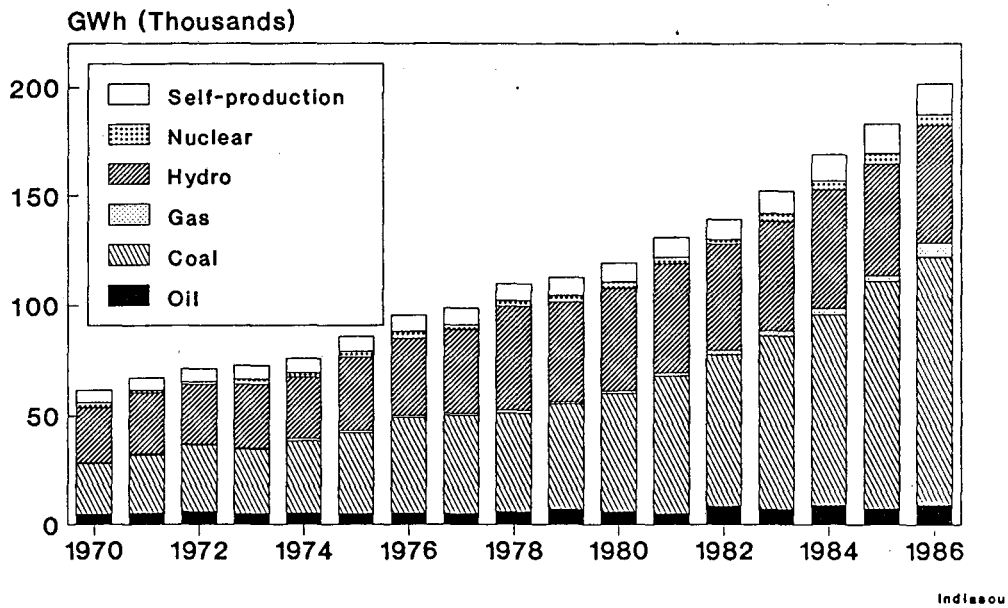
Taiwan. The experience in Taiwan is similar to that of South Korea: decline in generation from oil and increased use of imported coal and nuclear power (See Figure 3.4). These accounted for 34% and 42% respectively of public electricity generation in 1986. The recent slowdown in the nuclear construction program may necessitate increased use of coal in the future.[2]

Thailand. Generation from oil has also fallen sharply in Thailand, but in this case most of the growth has come from natural gas, which accounted for 39% of public generation in 1986. Natural gas was discovered in larger quantities in the early 1980s, and plans are to expand its use for electricity generation. Generation from coal and indignous lignite increased beginning in 1985.

FIGURE 3.1

ELECTRICITY GENERATION BY POWER SOURCE

INDIA



INDONESIA

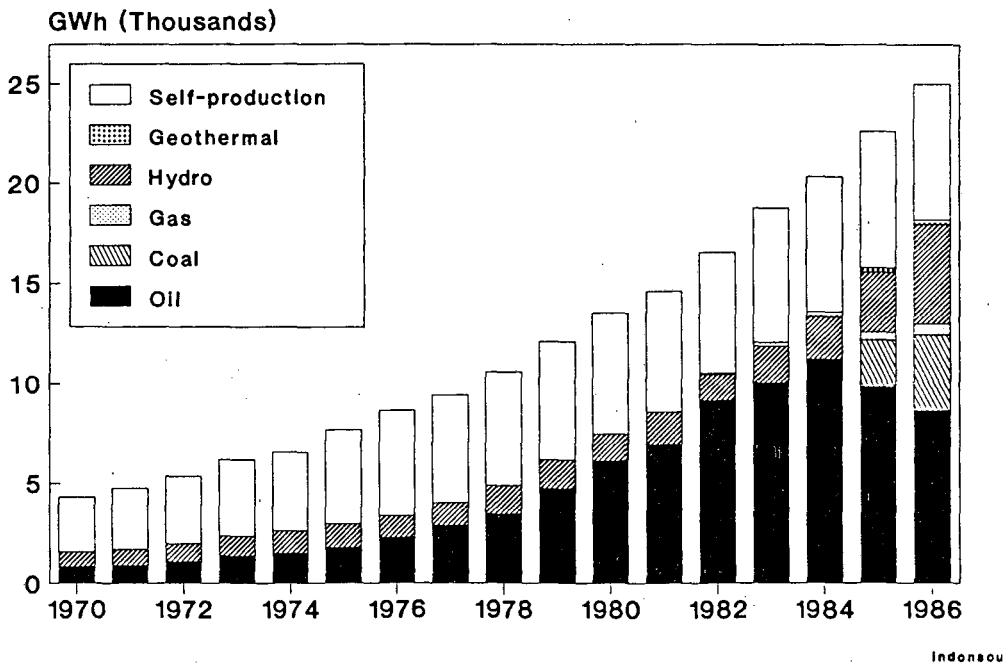
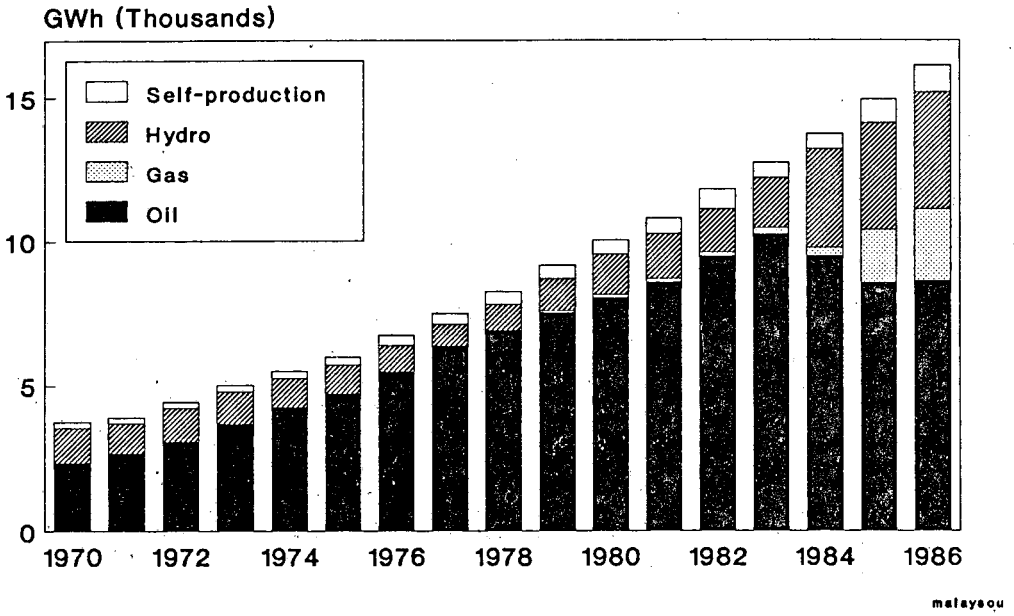


FIGURE 3.2

ELECTRICITY GENERATION BY POWER SOURCE

MALAYSIA



PAKISTAN

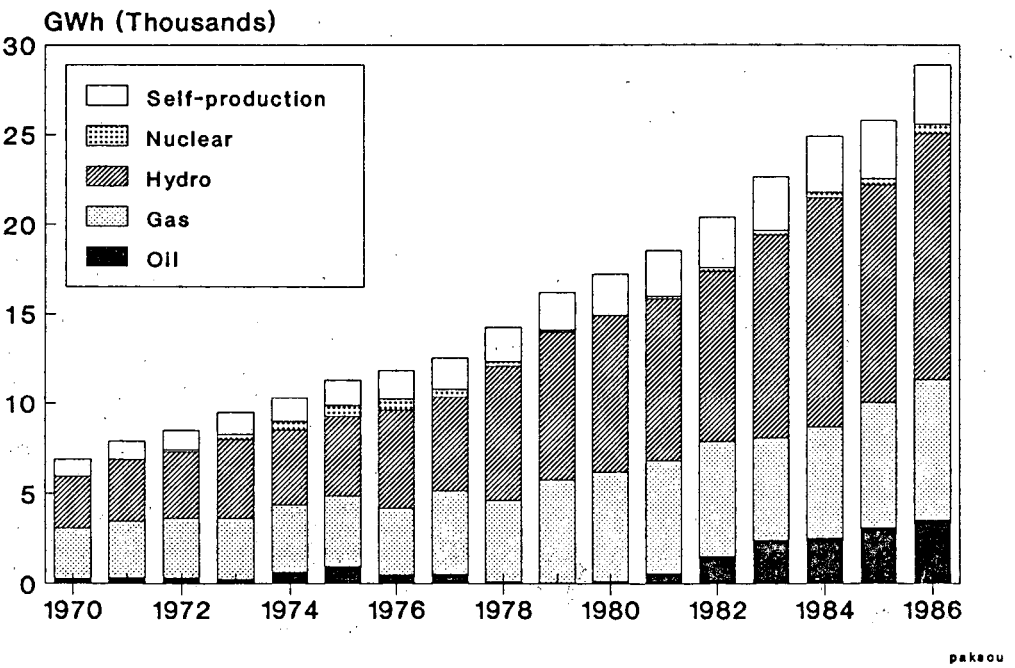
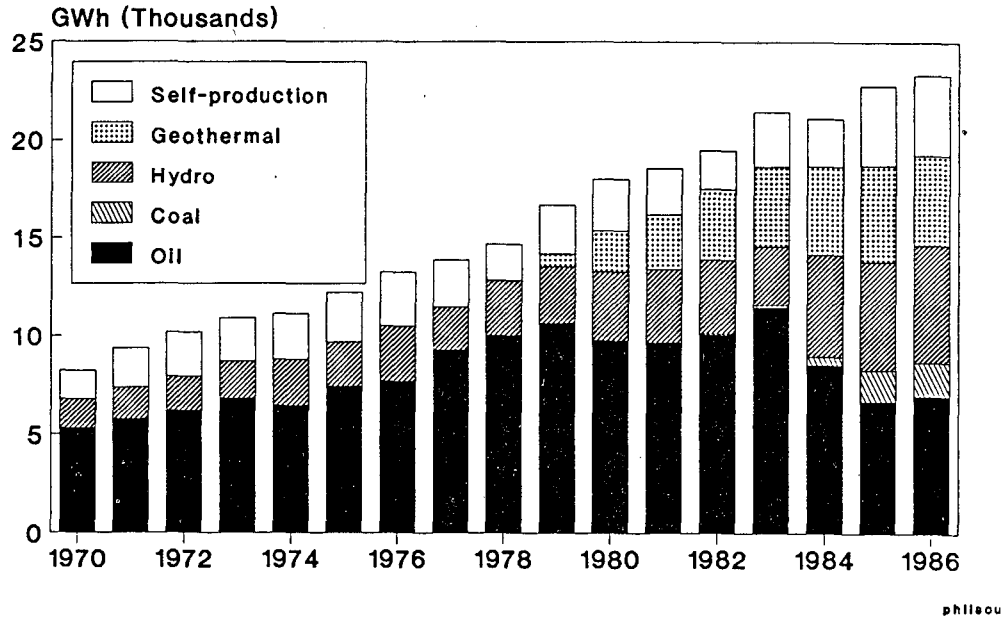


FIGURE 3.3

ELECTRICITY GENERATION BY POWER SOURCE

PHILIPPINES



SOUTH KOREA

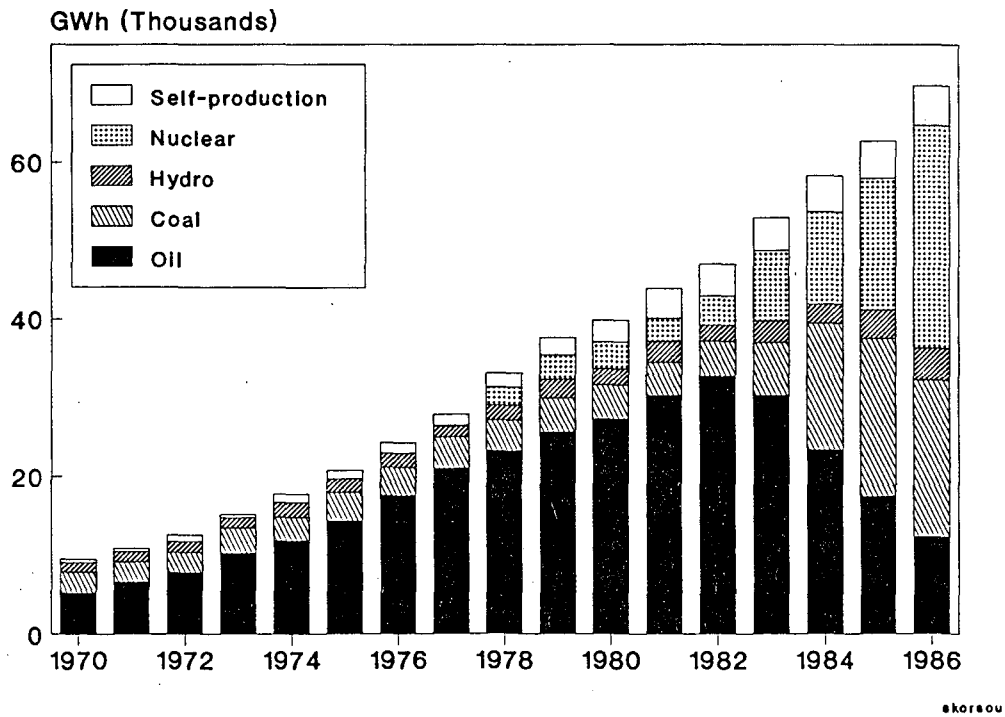
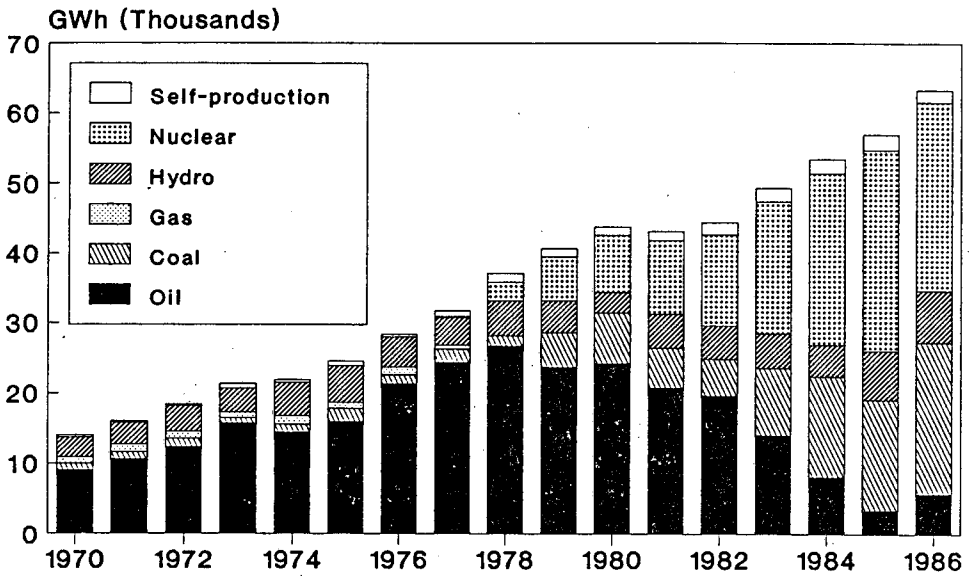


FIGURE 3.4

ELECTRICITY GENERATION BY POWER SOURCE

TAIWAN



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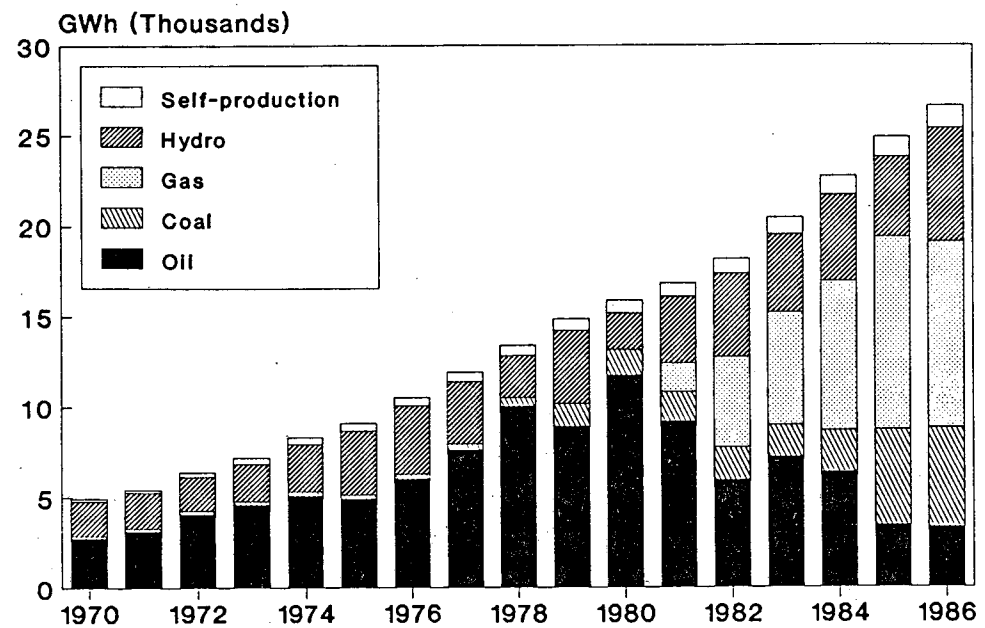
THAILAND



thaisou

Argentina. Generation from oil fell from 61% of public generation in 1973 to 16% in 1986 (See Figure 3.5). Hydro has accounted for most of the growth (from a share of 9% in 1970 to 47% in 1986), though generation from natural gas and nuclear power has also increased in the 1980s. Because of several major natural gas discoveries across the country and the import of natural gas from Bolivia, its use for power generation is likely to increase in the future.

Brazil. Over 90% of Brazil's electricity has and continues to come from hydropower. Generation from coal and oil has grown in recent years, but remains relatively minor. Nuclear power came into use in 1985, but output through 1986 was minimal. The hydro resource is sufficient to supply the bulk of Brazil's electricity needs for at least the next decade.

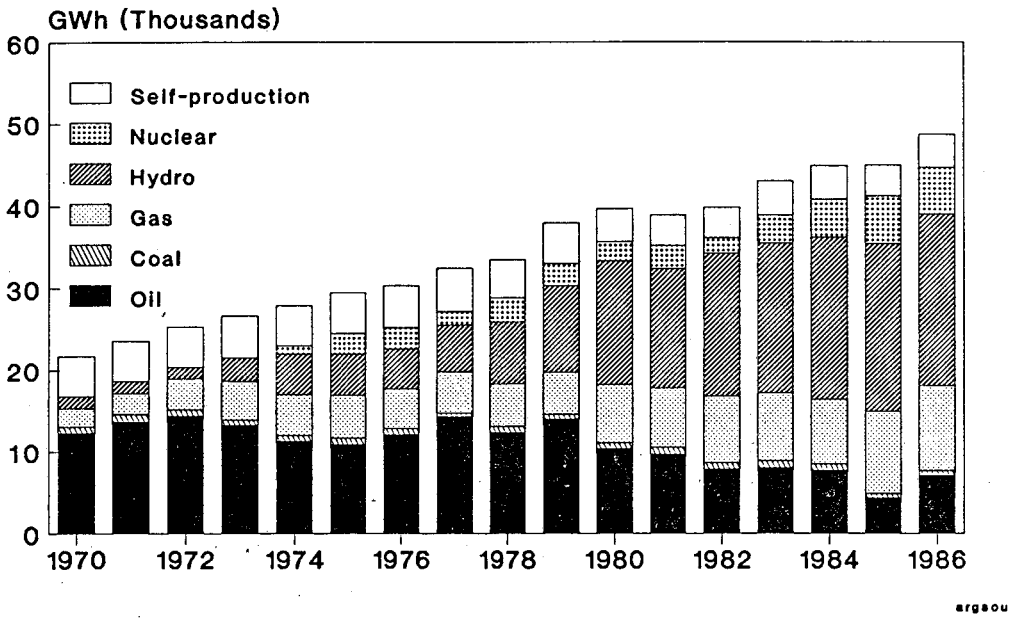
Mexico. Dependence on oil for public electricity generation has increased since 1970 to about 57%, as generation from hydro and natural gas has not kept up with the growth in overall generation (See Figure 3.6). In recent years, the demand for Mexican oil exports has declined. Since much of the natural gas is produced from wells associated with oil production, this has forced the utility companies to use more oil than before. In recent years there has been some use of coal, and geothermal electricity production has also grown.

Venezuela. The proportion of public generation accounted for by hydropower increased from 32% in 1970 to 50% in 1986. The other main source is natural gas; generation from gas has grown, but its share has declined from around 58% to about 30%.

FIGURE 3.5

ELECTRICITY GENERATION BY POWER SOURCE

ARGENTINA



BRAZIL

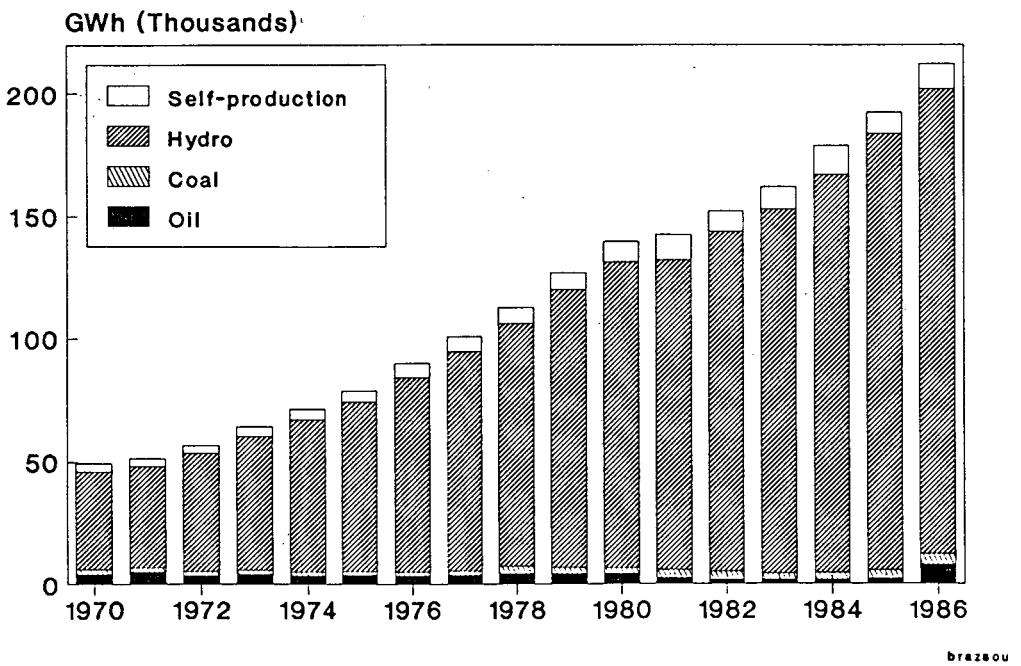
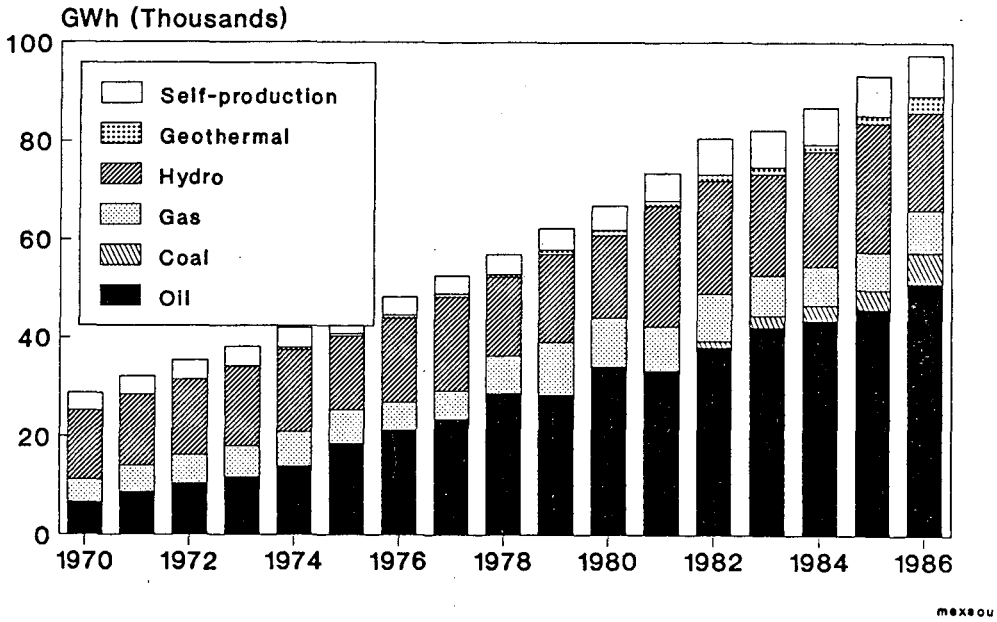


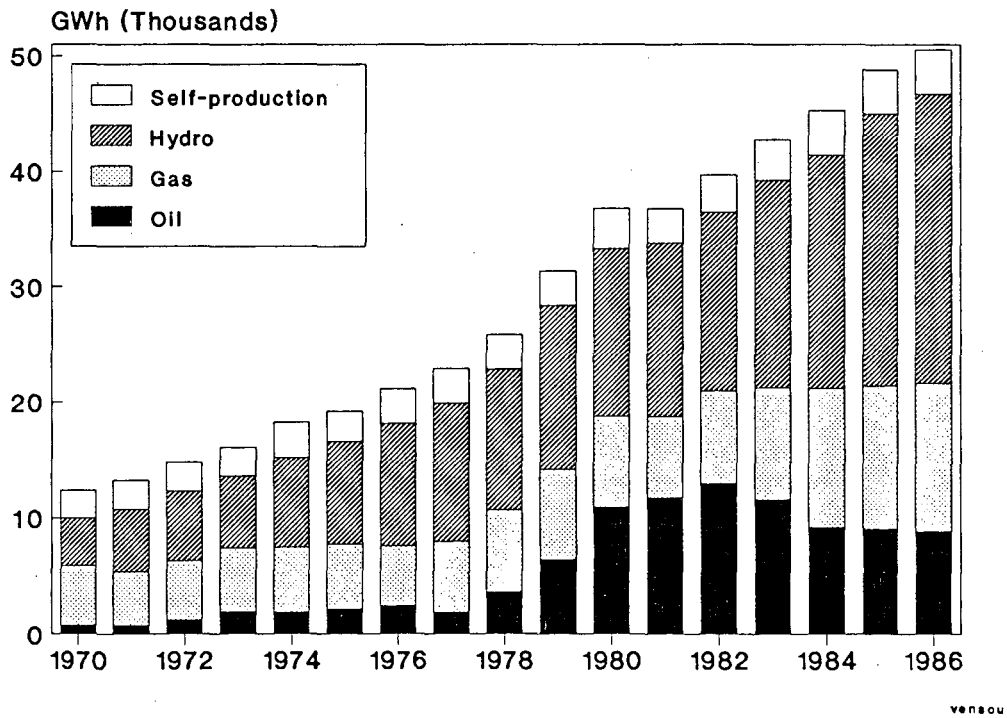
FIGURE 3.6

ELECTRICITY GENERATION BY POWER SOURCE

MEXICO



VENEZUELA



Summary. Combining the data for the 12 countries for which we have data back to 1970 (China is not included here), we find that:

- The share of oil in total public electricity generation declined from 27% in 1970 to 17% in 1986;
- The share of hydro went from 48% to 44%;
- The share of coal grew from 15% to 22%;
- The share of natural gas declined from 8% but then rose in the 1980s; and
- The share of nuclear power went from 2% to 9% (See Table 3.2).

Table 3.2
Power Sources for Public Electricity Generation, 1970-86
Combined Data for 12 Developing Countries

	1970	1980	1986
		(percent)	
Oil	27	30	17
Hydro	48	47	44
Coal	15	14	22
Natural gas	8	6	8
Nuclear	2	4	9

The decline in oil prices in early 1986 brought an increase in oil use for electricity generation in 1986 in a few oil-importing countries: the Philippines, Taiwan, Argentina, and Brazil. We expect data for 1987 will show a greater increase.

Mix of Power Sources in 1986

Table 3.3 shows the mix of power sources used for public electricity generation in the 13 countries and a few others in 1986. China and India are the only countries where coal dominates the picture. Oil is most significant in Indonesia, Malaysia, and Mexico, while gas is important in Thailand, Pakistan, and Venezuela. Nuclear is prominant only in South Korea and Taiwan.

Table 3.3
Shares of Public Electricity Generation in 1986
by Power Source* (%)

	Oil	Gas	Coal	Hydro	Nuclear
China	14	1	65	21	-
India	5	4	60	29	3
Indonesia	66	2	-	25	-
Malaysia	56	19	-	25	-
Pakistan	14	30	-	54	2
Philippines	36	-	9	31	-
South Korea	19	-	31	6	44
Taiwan	12	-	34	12	42
Thailand	13	41	21	22	-
Argentina	16	23	1	47	13
Brazil	4	-	2	94	-
Mexico	57	10	7	22	-
Venezuela	20	30	-	50	-
Nigeria	3	65	-	31	-
Egypt**	46	27	-	28	-

* If self-production were included, the share of oil would be larger, considerably so in some countries. We have not included it here because of uncertainty regarding the data.
** 1985

Power System Capacity and Peak Demand

In many countries the power system is unable to meet the peak demand for electricity. This necessitates load shedding and often requires industries to have their own power generation capacity. The statistics in Table 3.4 on peak load and installed capacity overstate the surplus capacity that is actually available, as the figures on installed capacity are often much higher than the capacity that is actually available. In part this is because installed hydro capacity is typically much greater than the capacity that is available on average (Venezuela is an example of this situation). But it also reflects the non-availability of thermal power plants due to equipment problems.

In India in 1985, the installed public utility capacity was about 41,000 MW, but the peak availability was only about 26,000 MW, below the peak demand of 34,000 MW. The estimated electricity shortage in 1986 (expressed as percent of the peak load) was 25% in Pakistan, 20% in Bangladesh, 15% in India, 10% in Sierra Leone, and 8% in the Philippines.[3] China is also plagued by shortage of electricity supply.

Table 3.4
Peak Load and Installed Generating Capacity

	Peak Demand	Installed Capacity	Year
	(Megawatts)		
India*	34112	41069	1985
Indonesia	2494	4568	1984
Malaysia	2219	3319	1984
Pakistan	4268	5107	1984
Philippines	3049	5196	1984
South Korea	9915	18060	1986
Taiwan	7925	11960	1984
Thailand	4202	6805	1986
Venezuela	6700	16173	1986

Source: Asian Development Bank. *Asian Electric Power Utilities Data Book 1985*; and country sources (Korea, Thailand)
Note: Statistics refer to public utility system.
* Estimated

Power System Efficiency

The efficiency of electricity generation and transmission and distribution in most LDCs is very low relative to the efficiency found in industrial countries. This contributes to a relatively high consumption of energy per kWh actually utilized.

Technical problems plaguing LDC power systems include low equipment availability, high losses, frequent outages, fluctuating voltages, and poor maintenance. Many thermal power plants in LDCs operate well below their design capacity and at low efficiency, and the amount of time they are out of operation is often high. In China, for example, power plants using coal operate at an average of 29-31% efficiency despite having relatively little

pollution control equipment.[4] (This is well below the level of around 36% typical of modern power plants.)

System losses, which reflect utility use, transmission and distribution losses, theft, and poor metering, are over 20% in many countries, including India, Indonesia, Pakistan, and the Philippines. System losses are much less (12-13%) in South Korea, Taiwan, and Brazil.

Increasing power system efficiency is a major priority of international lendors to the power sector of developing countries, but many LDC utilities lack the technical, financial, and organizational resources and capabilities to make effective use of new technology. A recent evaluation of about 300 power projects financed by the World Bank between 1965 and 1983 shows a declining trend in power sector performance in spite of Bank involvement.[5] Success in this area will somewhat moderate growth in primary energy consumption for electricity supply, though the outlook for effecting significant improvements in many countries is not promising, as many utilities lack the qualified manpower to meet the requirements for both expanding the system and operating existing systems.

Extent of Electricity Supply Networks

Expansion of the electricity system in rural areas has been a major focus in most LDCs, though it is costly and often beset with problems. The percentage of the population served with electricity varies greatly among developing countries depending on the degree of urbanization and the extent of rural electrification (See Table 3.5).* In Taiwan, the coverage is virtually 100%, and it is over 95% in South Korea. In Latin America, much of the rural population lacks electricity, but the urban population is relatively high, so the share of the population with electricity is in the 50-80% range. In countries with very large rural populations such as India and Indonesia, the coverage is less than 25%. In much of Africa, it is even lower.

* The figures in Table 3.5 are estimates for 1982. Considering the increase in the urban population and the growth in rural electrification since then, values for 1988 are probably 5-10% higher.

Table 3.5
Extent of Electrification in Selected Developing Countries
1982 Estimates

	Share of Total Population With Electricity	Rural Population, 1985
	(percent)	
Taiwan	99	29
South Korea	95	43
Mexico	81	30
China	60	79
Brazil	65	32
Colombia	54	33
Philippines	52	63
Senegal	36	58
Indonesia	16	78
India	14	77
Kenya	6	84
Bangladesh	4	85

Source: Flavin, C. *Electricity for a Developing World.* Worldwatch Institute, 1986.
(Data are from the World Bank and the Population Reference Bureau).

The urgent need in many countries to achieve power system rehabilitation and service improvements may limit the ability of utility companies to extend new services. The study done within the World Bank cited above calls for greater emphasis on efficiency and restructuring issues rather than concentrating on system expansion. If priority is placed on serving productive sectors, particularly industry and agriculture, this may lead to less rural electrification and a slower expansion of supply to domestic customers than would otherwise be planned.

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1. Korea Electric Power Corporation. *KEPCO Annual Review '88.*

2. Ehrenreich, S. Pacific Region Coal Trade. Presented at Chinese-American Symposium on Energy Markets and the Future of Energy Demand, Nanjing, China, June 1988.

3. Streicher, A. and P. Sharafi. Private-Sector Power Generation in Developing Countries. Hagler, Bailly & Co., 1987.

4. Hu, Z. Electrical Energy Sources and Consumption in China. Electric Power Research Institute, Beijing, 1988.

5. Munasinge, M., *et al. A Review of World Bank Lending for Electric Power.* The World Bank, Washington, D.C., 1988.

4. ELECTRICITY CONSUMPTION IN KEY DEVELOPING COUNTRIES*

This chapter presents information in the following areas: (1) Electricity consumption and economic growth; (2) Comparing per capita electricity consumption; (3) The changing sectoral composition of electricity consumption; (4) Industrial electricity intensity; and (5) Residential electricity intensity.

Electricity Consumption and Economic Growth

As countries in Asia and Latin America have developed over the past two decades, electricity consumption has grown considerably faster than production of goods and services, as measured by the Gross Domestic Product (GDP). This is due to mechanization of industrial and agricultural production and increased use of electricity in residences and other buildings. In countries with relatively inexpensive hydro-electric power, electricity-intensive industries such as aluminum processing were developed; this accelerated growth in consumption. In Brazil in the 1970s, the government even encouraged industrial customers to substitute hydro-electricity (of which there was excess capacity) for imported fuel oil. Another factor that has encouraged rapid growth in electricity consumption is that electricity is typically sold for less than its full production cost in order to encourage economic development and provide electricity to people who could not afford to pay the full cost.

The extent to which electricity consumption grows faster than the economy depends in part on the stage of economic development in which a country finds itself. The ratios between average growth in electricity consumption and growth in GDP (measured in constant prices) in the 1970-86 period in the 13 LDCs were mostly between 1.6 and 1.9 (See Table 4.1). The ratio was lower in two of the wealthier Asian LDCs (Taiwan and Malaysia), reflecting these countries having achieved a more mature phase of economic development. The ratio was very high in Argentina and Venezuela, where GDP growth was very low but growth in electricity consumption was nonetheless strong. The ratio was also low in China, where GDP grew from a very low level in 1970, but electricity has been in short supply.

* Under electricity consumption we include industrial self-generation, though in some cases the estimates are of uncertain accuracy. It is likely that the available statistics tend to understate the actual amount of self-generation.

Table 4.1

Average Annual Growth in Electricity Consumption and in GDP

	Between 1970 and 1986			Between 1980 and 1986		
	Electricity (%)	GDP (%)	Ratio Elec/GDP	Electricity (%)	GDP (%)	Ratio Elec/GDP
China	8.8*	8.2	1.1	6.9	11.1	0.6
India	7.4	3.9	1.9	8.9	4.9	1.8
Indonesia	10.6	6.4	1.6	9.5	4.1	2.3
Malaysia	9.2	6.5	1.4	7.7	4.3	1.8
Pakistan	9.0	5.4	1.7	10.4	6.5	1.6
Philippines	6.4	3.7	1.7	2.9	-0.3	-
South Korea	13.4	8.4	1.6	9.6	8.3	1.2
Taiwan	10.0	8.2	1.2	6.2	6.7	0.9
Thailand	11.7	7.3	1.6	9.0	5.0	1.8
Argentina	4.4	1.2	3.6	1.8	-0.8	-
Brazil	10.1	5.8	1.8	7.3	2.7	2.7
Mexico	7.0	4.3	1.6	4.1	0.7	5.9
Venezuela	9.0	1.5	6.1	4.4	-1.2	-

* Refers to generation.

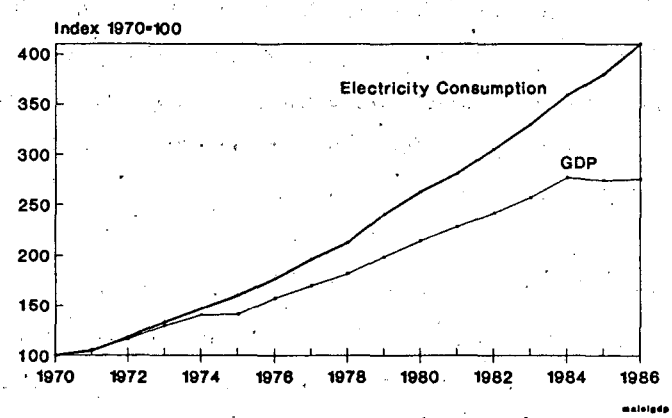
Between 1980 and 1986, the ratio between electricity growth and GDP was lower than that of the entire 1970-86 period in some countries (China, South Korea, Taiwan), higher in others (Indonesia, Malaysia, Brazil, Mexico), and about the same in India, Pakistan, and Thailand. For Korea and Taiwan, the lowering in the electricity/GDP ratio may reflect the further maturing of their economies and the introduction of new and more efficient manufacturing processes. In China, much of the rapid GDP growth in the 1980s came from sectors that were not especially electricity-intensive (rural and light industries). In the countries with increased electricity/GDP ratios, both electricity and GDP growth were lower in the 1980s than in the 1970s, but electricity growth did not slow down nearly as much as GDP growth.

Electricity consumption has grown much faster than GDP in times of strong economic growth. In many cases, it has also continued to increase during periods of little or no growth or even decline in GDP. Examples of this were Malaysia in 1985 and 1986, the Philippines in 1983-85, and Brazil in 1982-83 (See Figure 4.1). In Argentina in the

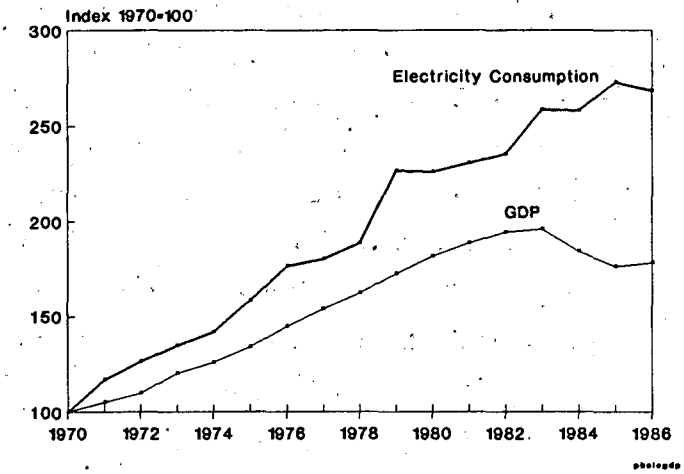
FIGURE 4.1

ELECTRICITY USE AND GDP

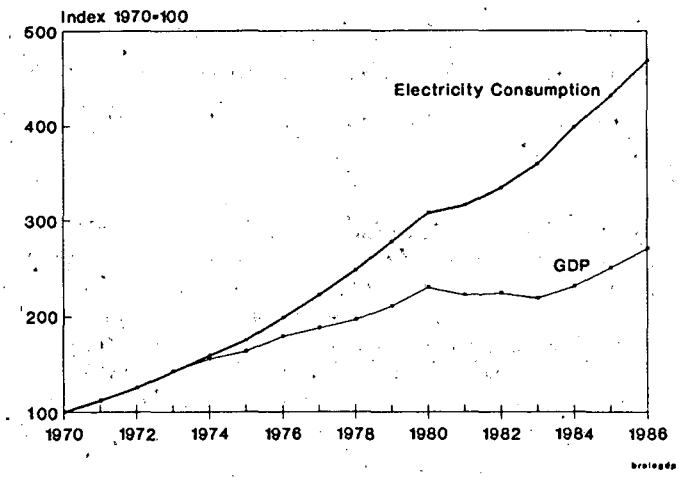
MALAYSIA



PHILIPPINES



BRAZIL



1984-86 period, on the other hand, electricity consumption and GDP both showed the same pattern of no growth (See Figure 4.2). The only country which had a period of no growth in electricity consumption despite growth in GDP was Taiwan in 1981-82 (See Figure 4.2). This was a result of increase in electricity prices and other measures designed to curb the demand for oil-fueled electricity.

Comparing Per Capita Electricity Consumption

Figure 4.3 shows the trends in per capita electricity use between 1970 and 1986. Among the 12 countries, the increase has been most marked in South Korea (use in 1986 was 5.8 times the 1970 level), Thailand (use in 1986 was 5 times the 1970 level), and Taiwan (use in 1986 was 3.5 times the 1970 level). Taiwan had much higher use per capita in 1970 than did Korea, while Thailand was at a very low level then.

Per capita electricity use in the Latin American countries (especially Venezuela) is much higher than in all of the Asian countries except for Taiwan, Korea, and Malaysia, but it has not increased very much except in Brazil and, to a lesser extent, Venezuela. The higher level of use reflects the higher income per capita and degree of urbanization in Latin America. The Latin countries all had greater per capita electricity use already in 1970 than all of the Asian countries except Taiwan. Argentina, Mexico, and Venezuela had little growth in per capita electricity use in the 1980-86 period, however.

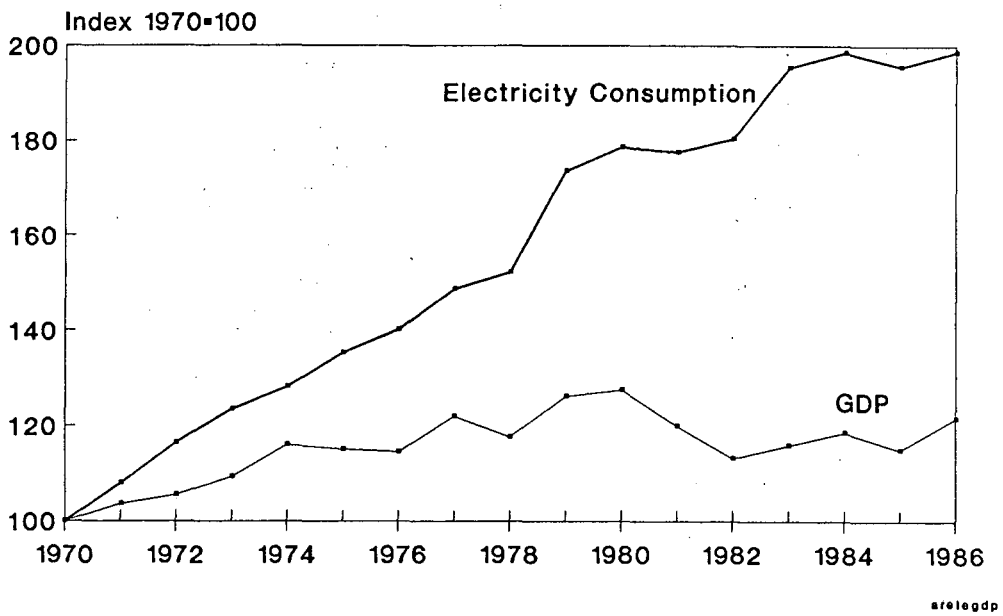
The differences in per capita electricity use can be partly explained by differences in per capita GDP. Figure 4.4 shows how these two variables are related across countries.* The top graph uses 1980 "purchasing power parities" to convert per capita GDP to a common unit;[1] the bottom graph uses 1980 exchange rates. The former is a more accurate reflection of the relative domestic purchasing power of local income (though it seems that this method leads to a rather high estimate of per capita GDP for China and Mexico). It suggests that South Korea, Taiwan, and Venezuela have relatively high electricity use for their level of per capita GDP. This is not surprising, since they all have a relatively high share of GDP coming from electricity-intensive industries. This phenomenon is not evident (except for Taiwan) when exchange rates are used.

* Perfect cross-country comparability of GDP estimates cannot be achieved. One area of difficulty is differences in the national accounting systems and in the coverage and reliability of underlying statistical information among various countries. Another is the problem of converting GDP data to a common unit (conventionally the U.S. dollar). The use of official exchange rates to convert national currency figures to the U.S. dollar does not measure the relative domestic purchasing power of currencies. Use of "purchasing power parities" instead of exchange rates as conversion factors results in a different ordering of countries. In general, use of this method reduces the difference in per capita GDP estimates between the poorer and wealthier countries.

FIGURE 4.2

ELECTRICITY USE AND GDP

ARGENTINA



TAIWAN

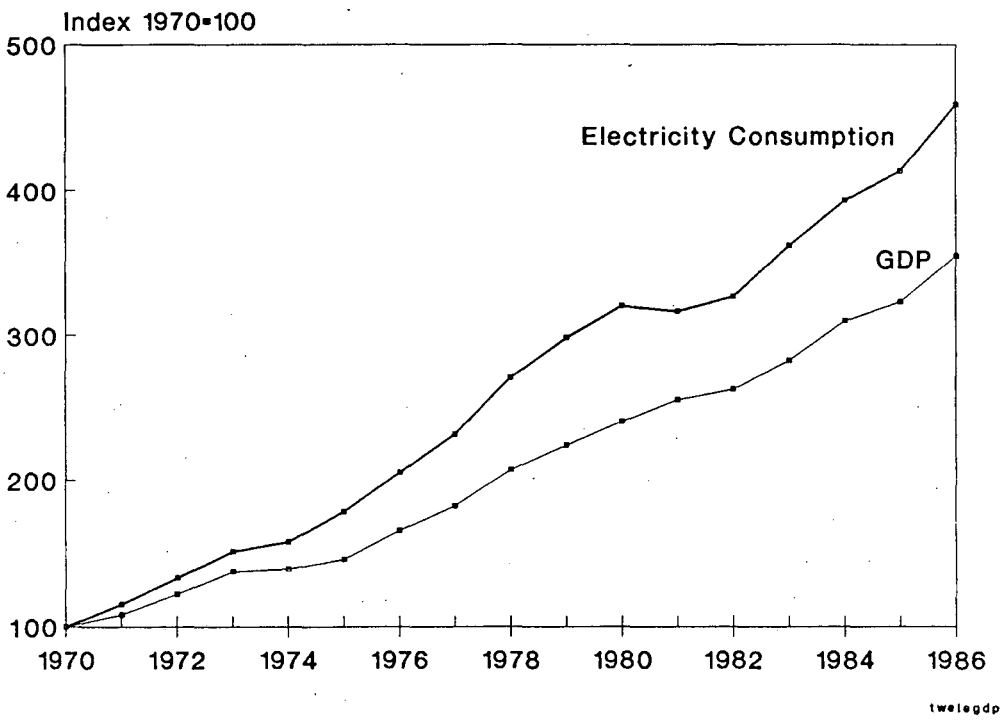
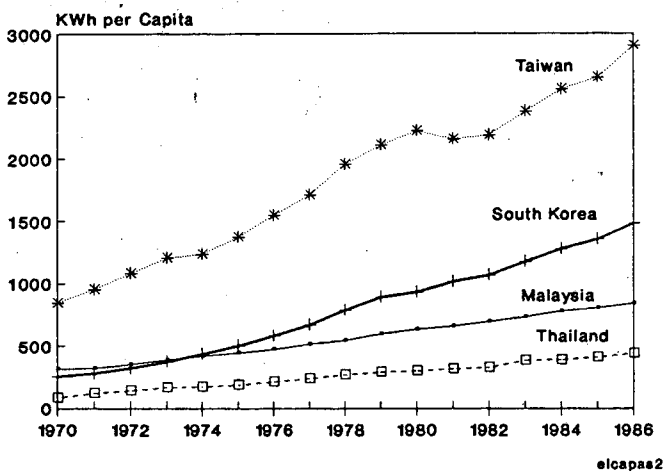
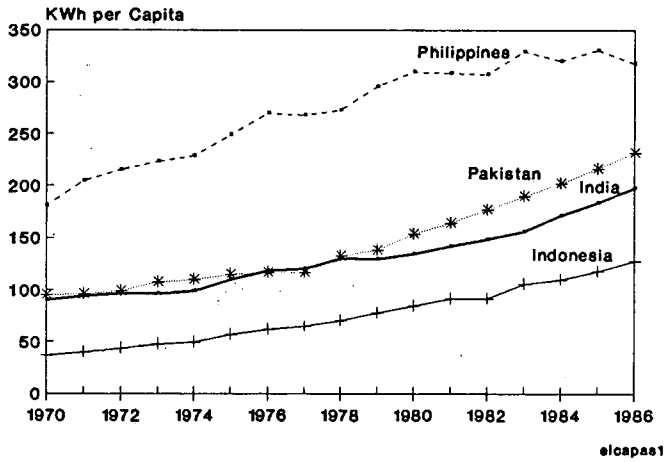


FIGURE 4.3

PER CAPITA ELECTRICITY USE





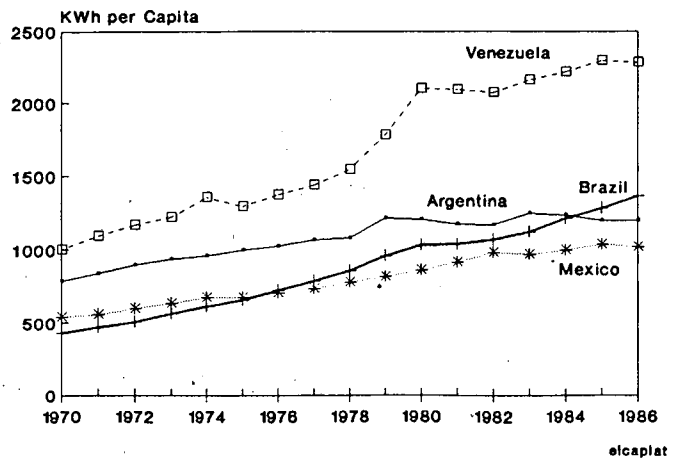
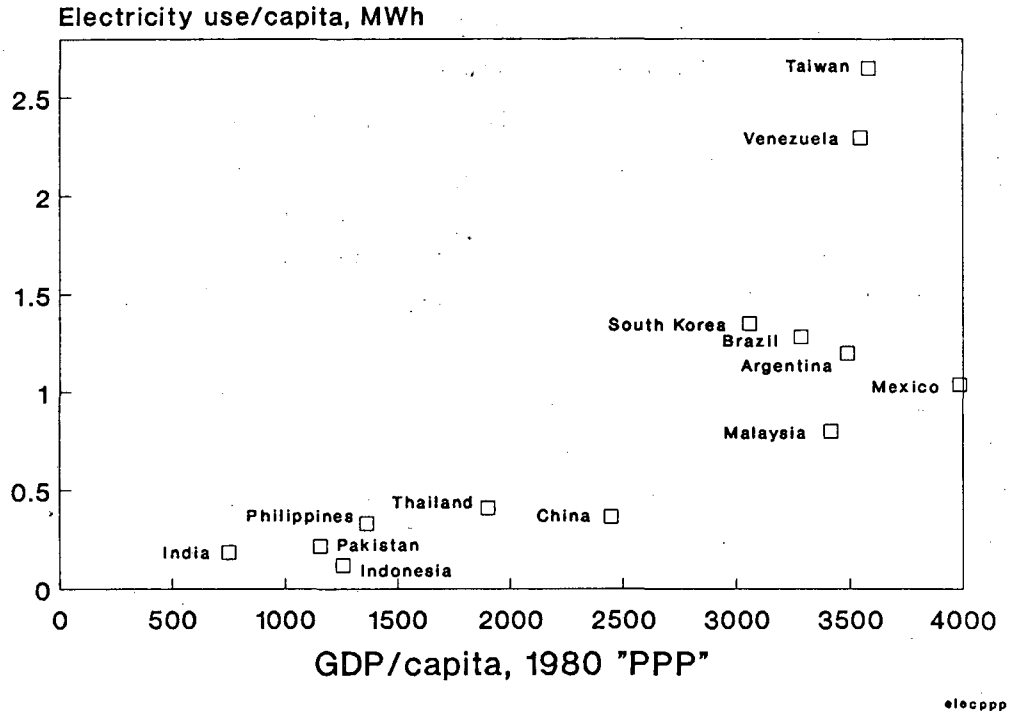
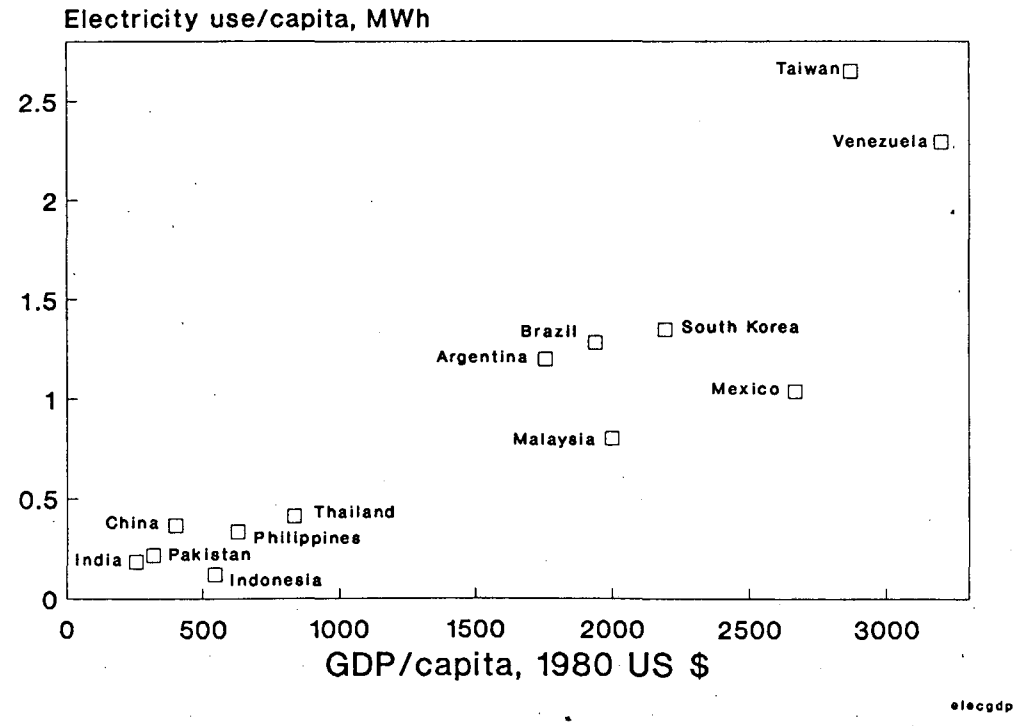


FIGURE 4.4

ELECTRICITY USE AND GDP, 1985





The Changing Sectoral Composition of Electricity Consumption

The industrial sector (including self-generation) dominates electricity consumption in nearly all developing countries, but its share of total consumption has generally declined in the face of faster growth in the residential and service (commercial and public) sectors.* Between 1970 and 1986, electricity consumption in the residential and commercial sectors grew faster than consumption by industry in all of the 12 countries except Argentina and Brazil (See Table 4.2). This reflects increasing household income and rapid growth in personal and business services. In Brazil, residential and commercial electricity use grew fast, but industrial electricity use was strongly promoted.

Combining the data for the 12 countries where our data go back to 1970 (for China, our data begin in 1980), we find that industrial electricity consumption averaged growth of 8.3% per year in the 1970-86 period, while the residential and commercial sectors averaged 9.9% and 8.7% per year respectively. Agricultural electricity use (for irrigation) increased at an average rate of nearly 12% per year. (India alone accounted for 60-65% of the total agriculture electricity use for the 12 countries.)

* The electricity sales classifications used by the various countries are not identical. In some cases, agriculture appears to be included in industry. In most countries, the category "Public" appears to include government buildings, but in some cases it may only include street lighting and special public facilities. In these countries, government buildings are apparently included in the "Commercial" category.

Table 4.2
Sectoral Average Growth Rates for Electricity Consumption, 1970-86
(% per year)

	Industrial	Residential	Commercial	Public	Agric.
India	6.0	10.6	7.3	7.2	12.3
Indonesia	9.6	12.2	15.3	12.0	-
Malaysia	6.8	13.6	11.7	5.3	-
Pakistan	7.2	15.6	9.8	10.5	7.5
Philippines	5.0	8.1	6.0	25.3	-
South Korea	13.1	17.4	13.0	9.7	-
Taiwan	9.5	9.9	11.9	12.3	11.7
Thailand	11.1	15.1	17.4	12.2	20.6
Argentina	4.7	4.1	4.1	4.2	4.9
Brazil	10.7	9.5	8.7	9.3	18.8
Mexico	7.2	9.3	5.3	5.3	9.1
Venezuela	8.8	10.1	11.1	7.0	-
TOTAL	8.3	9.9	8.7	8.3	11.7

As a result of the different growth rates, the sectoral shares of electricity consumption have changed in many countries. Among the 12 countries, there are three general patterns evident:

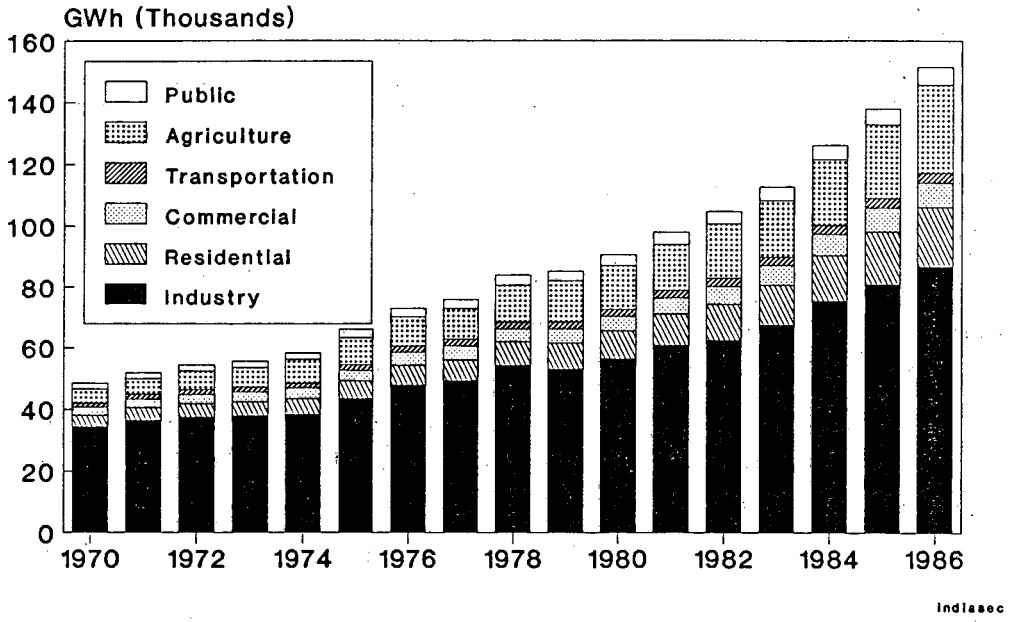
(1) In most of the Asian countries, the share of industry has declined substantially, while those of the residential and commercial sectors have increased. Between 1970 and 1986, the combined share of the residential, commercial, and public sectors increased from 17% to 22% in India (See Figure 4.5), from 30% to 40% in Indonesia (see Figure 4.5), from 37% to 56% in Malaysia (see Figure 4.6), from 23% to 41% in Pakistan (see Figure 4.6), from 39% to 50% in the Philippines (see Figure 4.7), and from 34% to 51% in Thailand (see Figure 4.8). The high shares in Malaysia, the Philippines, and Thailand reflect the relatively developed state of the urban buildings sector and growth in household appliances.

(2) In South Korea and Taiwan, electricity consumption in the residential and commercial sectors has also grown substantially, but the growth of manufacturing has been

FIGURE 4.5

ELECTRICITY CONSUMPTION BY SECTOR

INDIA



INDONESIA

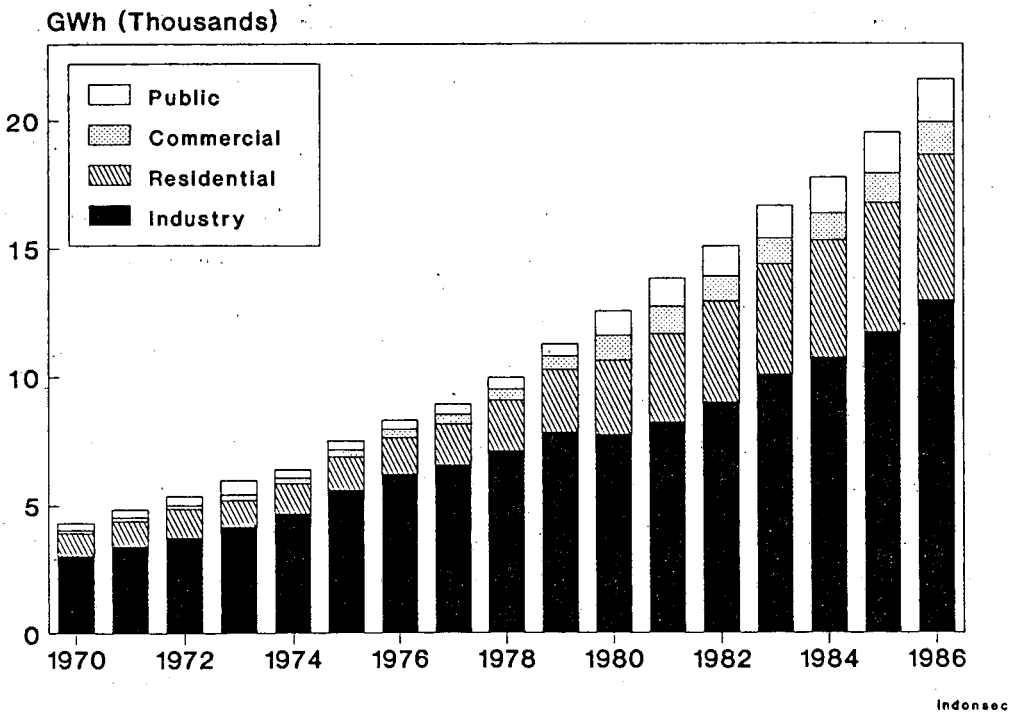
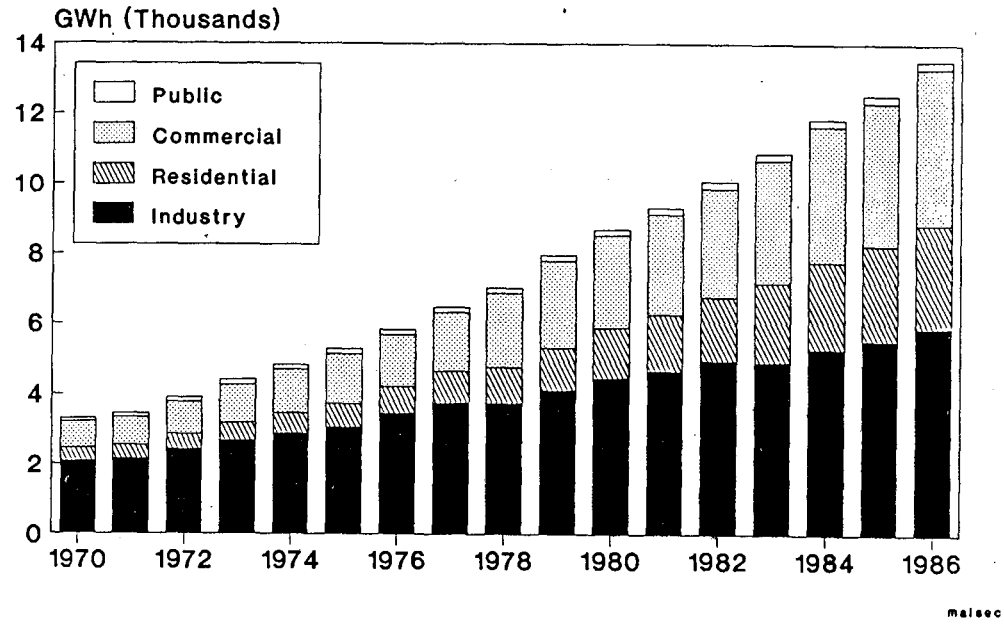


FIGURE 4.6

ELECTRICITY CONSUMPTION BY SECTOR

MALAYSIA



PAKISTAN

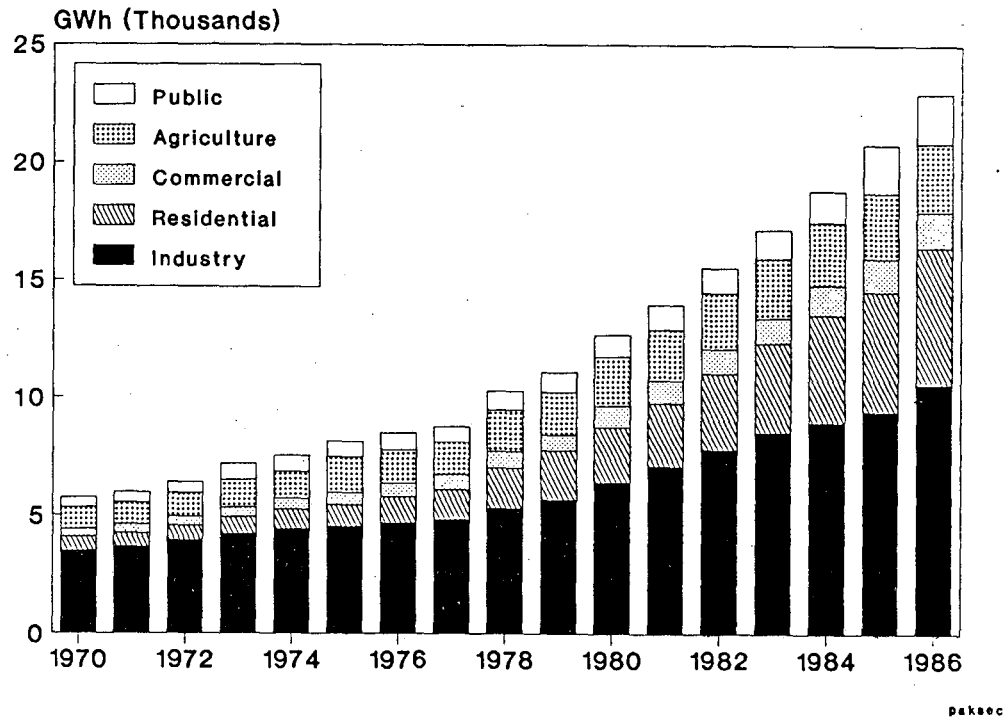
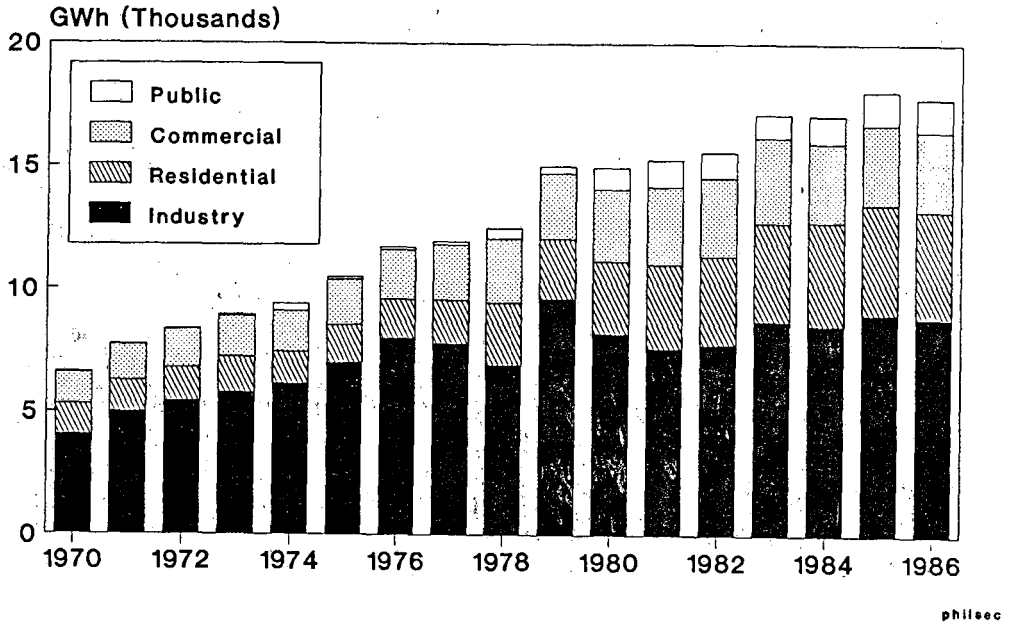


FIGURE 4.7

ELECTRICITY CONSUMPTION BY SECTOR

PHILIPPINES



SOUTH KOREA

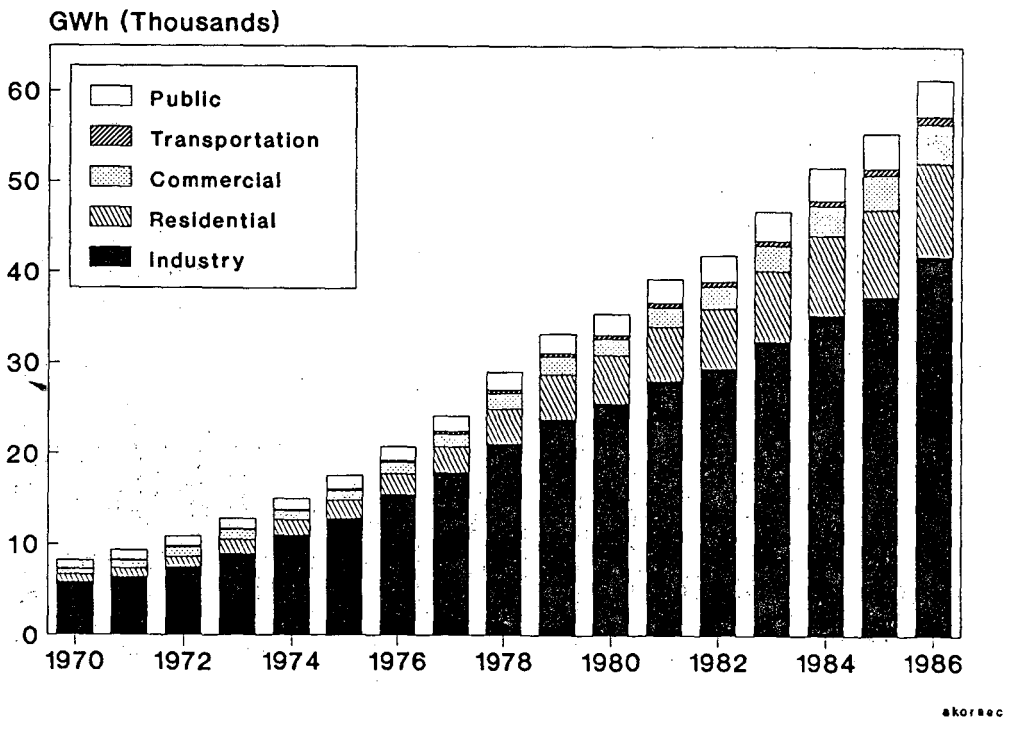
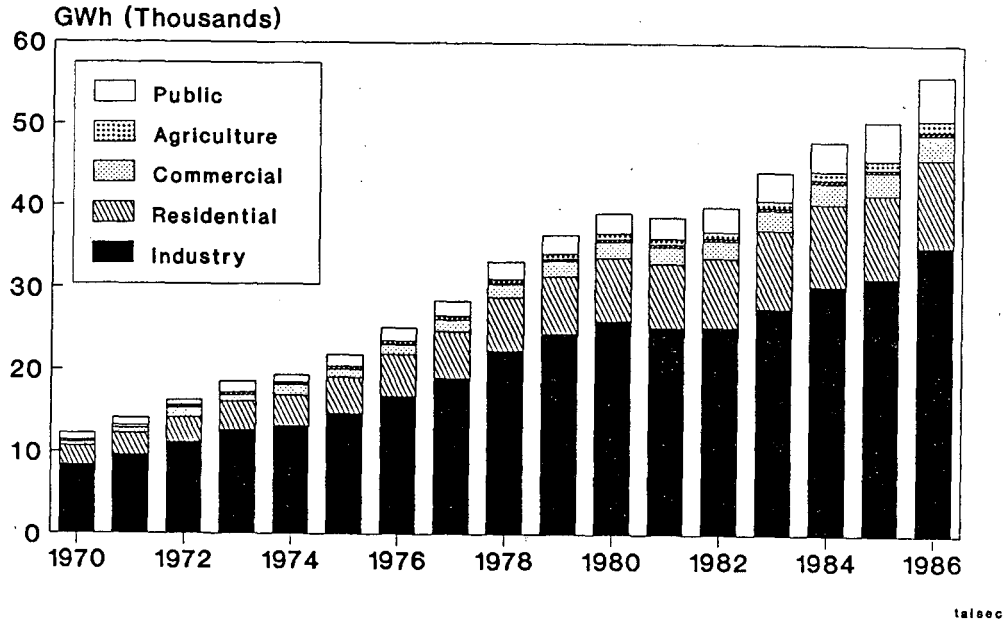


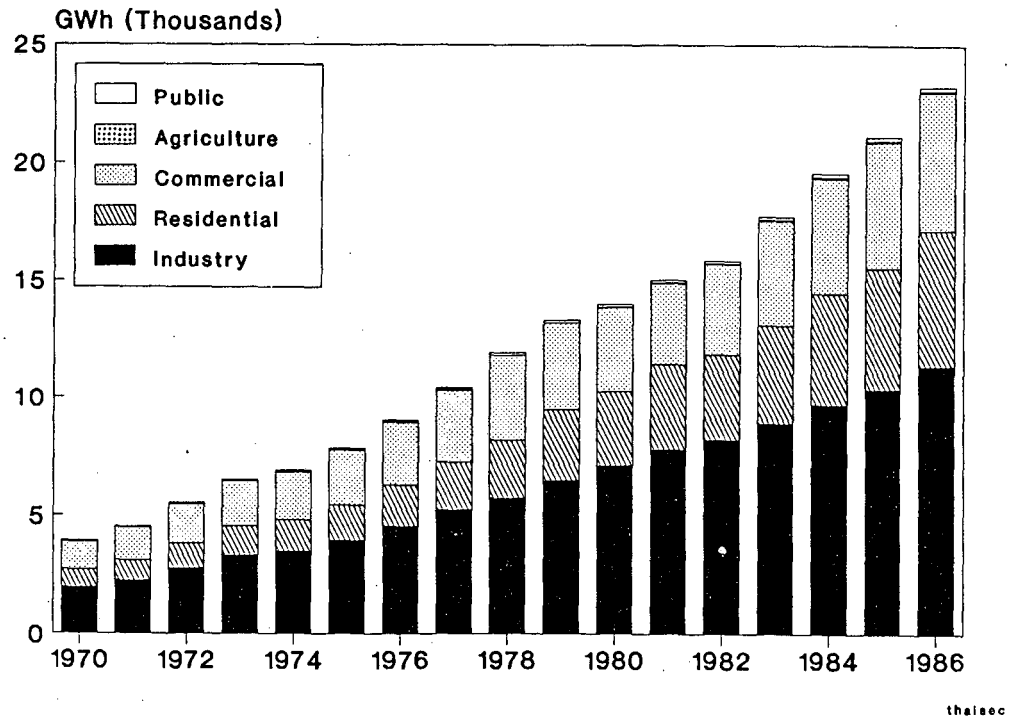
FIGURE 4.8

ELECTRICITY CONSUMPTION BY SECTOR

TAIWAN



THAILAND



such that the share of industry in total electricity consumption has declined only slightly: from 71% to 68% in South Korea (see Figure 4.7), and from 68% to 63% in Taiwan (see Figure 4.8). The relatively high share of industry for the level of development reached by these countries reflects the presence of much electricity-intensive manufacturing industry (much of the product of which is exported).

(3) In the Latin American countries the share of industry did not change greatly between 1970 and 1986: from 52% to 54% in Argentina (see Figure 4.9), from 55% to 59% in Brazil (see Figure 4.9), from 62% to 61% in Mexico (see Figure 4.10), and from 62% to 60% in Venezuela (see Figure 4.10). The increase in Brazil reflects the substitution of electricity for oil that was promoted in the early 1980s.

Combining the data for the 12 countries, we find that the share of industry declined from 63% in 1970 to 59% in 1986 (See Table 4.3). The residential share grew from 16% to 19%, while the commercial sector share remained at 9-10%. If we exclude Brazil, a large consumer and one of the few countries where industrial electricity demand grew faster than residential, the combined residential share grows from 14% to 18% and the decline in industry's share is greater.

Table 4.3
Sectoral Shares of Electricity Consumption, 1970-86 (%)
Combined Data for 12 Countries

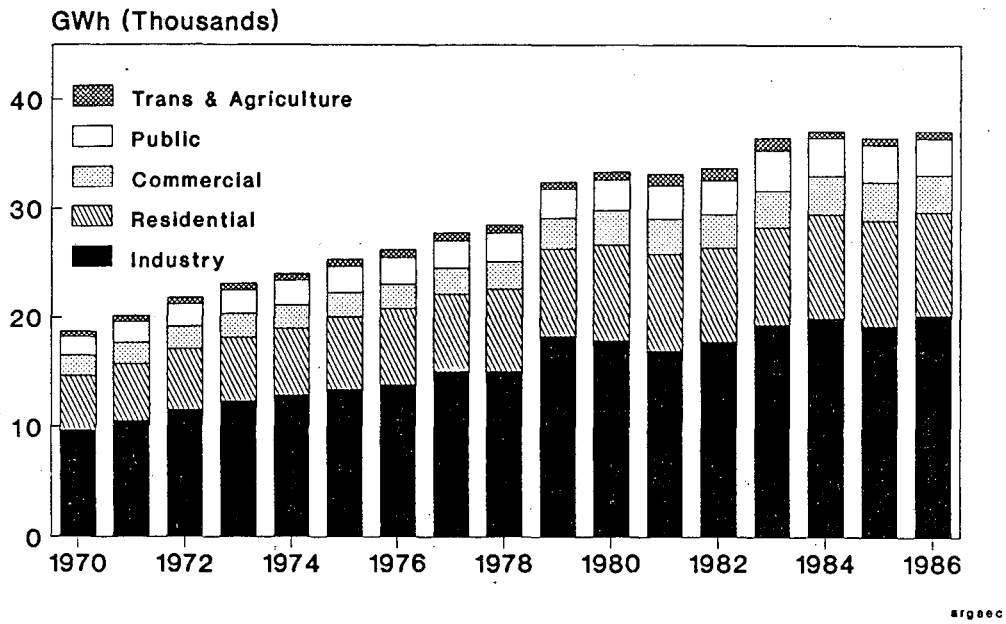
	1970	1980	1986
Industry	63	60	59
Residential	16	18	19
Commercial	9	10	9
Public	7	7	7
Agriculture	4	5	6
Transportation	1	1	1

In **China**, heavy industry still dominates electricity consumption, but its share of the total has declined since 1980 (See Table 4.4).[2] This occured as a result of lowered growth in heavy industry output (in part due to increased imports of high-energy-content raw and semi-finished materials), development of consumer goods industries, growth in

FIGURE 4.9

ELECTRICITY CONSUMPTION BY SECTOR

ARGENTINA



BRAZIL

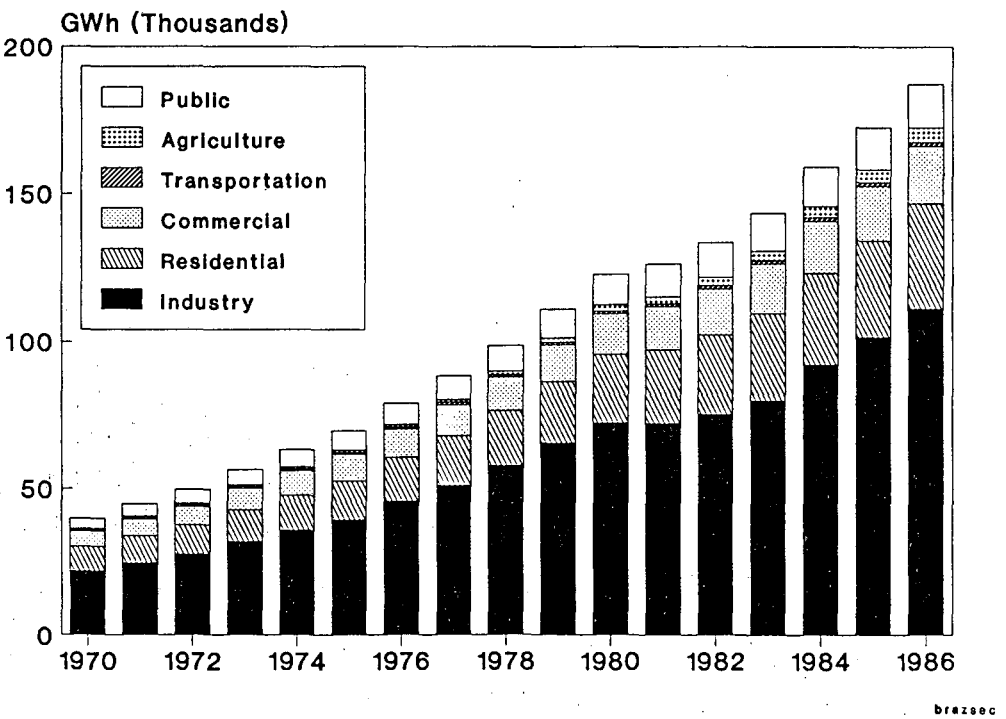
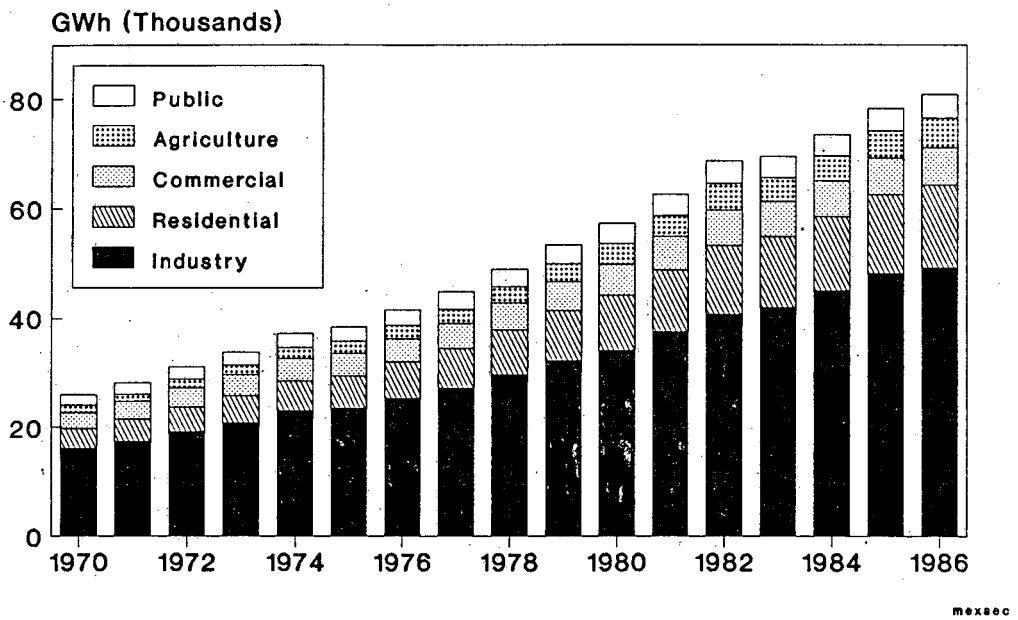


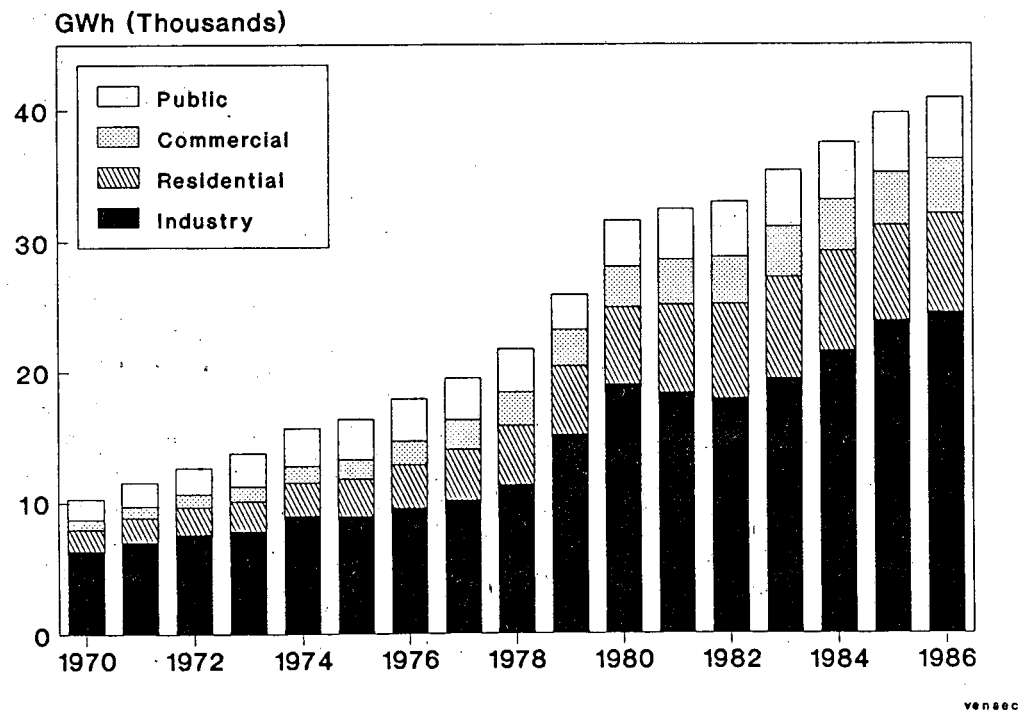
FIGURE 4.10

ELECTRICITY CONSUMPTION BY SECTOR

MEXICO



VENEZUELA



small-scale economic activity in rural areas, and growth in urban household consumption. Between 1980 and 1985, rapid growth in electricity consumption occured in light industry (10.4% per year), in village/town enterprises (27.7% per year), and in municipal and household consumption (13.8% per year). These growth rates compare to the average of 6.7% per year for total electricity consumption.

The growth rate in village/town enterprises was much greater than that of urban industries. As a result, electricity consumption growth was higher in rural areas than in cities. This is in contrast to the pattern in every other developing country.

Table 4.4
China: Sectoral Shares of Electricity Consumption (%)

	1980	1985
Agriculture	10.4	7.2
Industry	80.0	79.1
Heavy	(65.2)	(58.8)
Light	(12.6)	(15.0)
Village/town enterprises	(2.1)	(5.3)
Residential/Services	8.9	11.5
Transport	0.6	0.9
Total (TWh)	252	348

Industrial Electricity Intensity

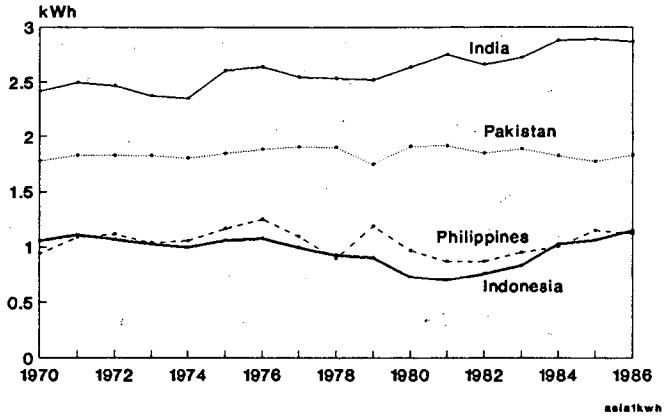
Industrial electricity consumption (including self-producers) per 1985 $ of manufacturing GDP* rose significantly in Latin America during the 1970-86 period but did not increase greatly in the Asian countries except Thailand (See Table 4.5 and Figure 4.11). There has been a modest overall decline between 1970 and 1986 in Malaysia (-24%) and Taiwan (-18%).

* Industrial electricity consumption per unit of manufacturing GDP (value-added) is a less useful indicator than consumption per unit of physical output, but the latter is not possible when one is considering the industrial sector as a whole. Constructing a constant price series for manufacturing value-added over a long period is problematic due to changes in the structure of output. Converting local manufacturing output to a common currency also introduces some uncertainty. Thus, comparisons of the levels of industrial electricity intensity among countries are not exact.

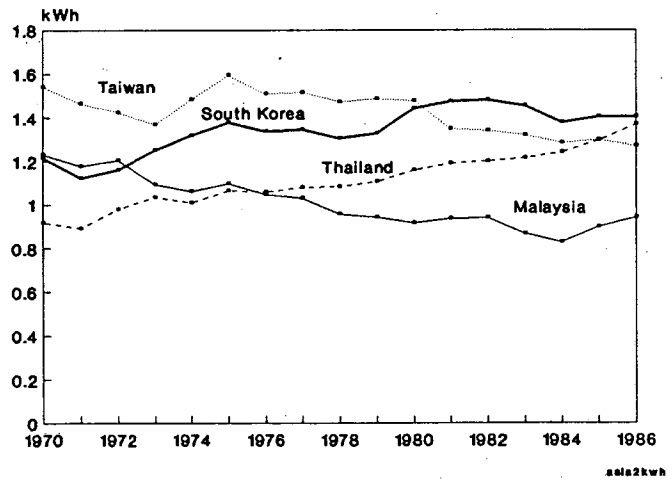
FIGURE 4.11

INDUSTRIAL ELECTRICITY CONSUMPTION PER 1985 $ MANUFACTURING GDP

ASIA 1



ASIA 2



LATIN AMERICA

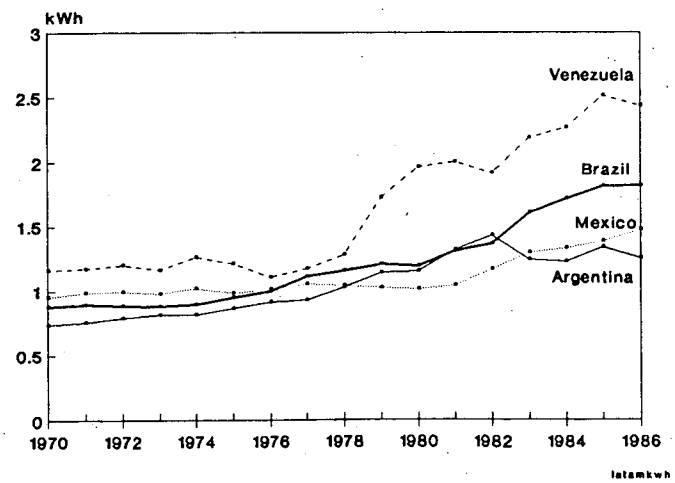


Table 4.5
Industrial Electricity Intensity
(kWh per 1985 $ of manufacturing GDP)

	1970	1980	1986
India	2.42	2.63	2.87
Indonesia	1.06	0.73	1.15
Malaysia	1.23	0.91	0.94
Pakistan	1.78	1.91	1.83
Philippines	0.94	0.97	1.12
South Korea	1.22	1.44	1.40
Taiwan	1.54	1.48	1.27
Thailand	0.92	1.16	1.37
Argentina	0.74	1.15	1.25
Brazil	0.88	1.19	1.81
Mexico	0.95	1.01	1.47
Venezuela	1.16	1.96	2.43

There are several key factors that shape industrial electricity intensity. Change in the structure of the manufacturing sector can have a substantial impact on industrial electricity intensity, particularly if there is growth in electricity-intensive industries such as aluminum and steel. In Venezuela, for example, intensity rose dramatically in 1979, when aluminum and steel output increased by factors of 2.5 and 1.9, respectively.

Rapid introduction of new factories can exert a downward pull on industrial electricity intensity if these facilities are more modern and efficient than the existing industrial plant. This may have been a factor in Taiwan and Malaysia.

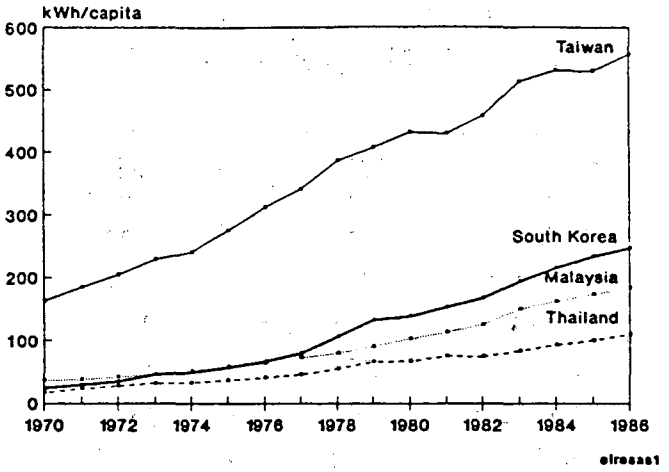
Improvement in end-use efficiency as a result of energy management and introduction of new equipment and new processes (generally not for energy-saving purposes) also acts to depress electricity intensity. Countries that have major efforts in this area include Taiwan, South Korea, Thailand, and the Philippines.

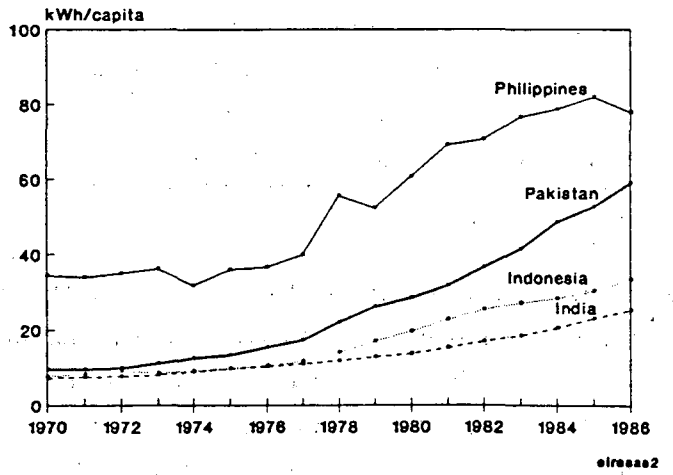
Residential Electricity Intensity

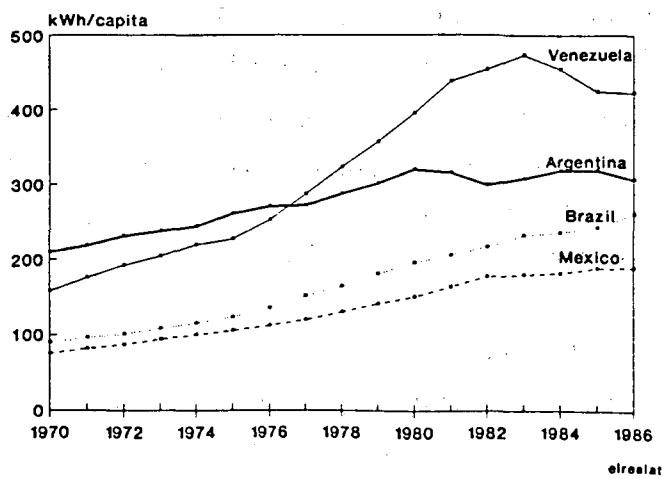
Residential electricity use per capita has grown at a high rate in most of the countries. Growth has been most rapid in Taiwan, which at 560 kWh in 1986 also has the highest level among the study countries (See Table 4.6). (This compares with residential

FIGURE 4.12

RESIDENTIAL ELECTRICITY USE/CAPITA







non-heating electricity use of 690 kWh in Italy, 975 kWh per capita in Japan, 1210 kWh in West Germany, and about 3045 kWh per capita in the U.S.)

Table 4.6
Residential Electricity Intensity
(kWh/capita)

	1970	1980	1986
India	7	14	25
Indonesia	8	20	33
Malaysia	37	103	184
Pakistan	10	29	59
Philippines	34	61	78
South Korea	25	139	248
Taiwan	163	431	557
Thailand	17	68	110
Argentina	210	320	307
Brazil	90	195	261
Mexico	75	150	190
Venezuela	158	395	422

Growth has also been strong since the late 1970s in most of the Asian countries, especially in South Korea, Malaysia, Pakistan, and more recently, Thailand (See Figure 4.12). For Pakistan, the strong growth is partly a result of increase in household income resulting from remittances from the large number of Pakistanis working in the Middle Eastern oil-exporting countries. (This was also a factor in India and several other Asian countries.) In the case of Thailand, the increase in the rate of growth in the 1980s reflects that country having reached a "take-off" point in terms of appliance use.

Growth has been less in the Latin American countries, except in Venezuela in the 1975-81 period. Compared to Asia, homes in the Latin American countries had more appliances and higher use per capita already in 1970. There has been little increase since 1982 except in Brazil, where prices are relatively low, and intensity has declined in Venezuela. This reflects the poor economic performance of these countries in this period.

The growth in residential electricity intensity has been caused by increased ownership of appliances in already-electrified homes and by increase in the number of homes that have electricity. The relative importance of these factors varies among the countries, with the former being more important in the more developed countries. In countries where rural electrification has been a major focus, such as Pakistan and Thailand, the latter has been an important factor.

Ownership of major appliances such as refrigerators has increased rapidly in Asia in recent years (See Table 4.7). In Beijing, saturation went from 2% to 62% in only six years once the economic reforms brought increase in disposable income. Air-conditioning has not spread very far yet except in Taiwan, but this could be a major area of growth in the future.

Taiwan is the only country with residential use more than 500 kWh per capita, though Venezuela is close. In both cases, the use of air-conditioning in homes has significantly boosted demand. Most of the Asian countries still have a level of use below 100 kWh per capita. In Indonesia and India, where rural electrification has not spread very far, residential use is less than 40 kWh per capita.

Table 4.7

Saturation of Refrigerators and Air Conditioners

(% of households)

	Year	Refrigerators	Air Conditioners
ASIA			
Bangkok	1984	62	12
	1976	26	4
Taiwan	1984	95	32
	1975	63	6
Singapore	1982	96	11
	1977	88	8
Beijing	1987	62	
	1984	15	
	1981	2	
South Korea	1985	95	14
Kuala Lumpur	1980	70	9
Indonesia Urban	1984	26	2
Philippines Urban	1979	44	3
India Urban	1984	18*	2*
LATIN AMERICA			
Argentina	1980	50*	
Brazil	1984	74	
	1980	50	
Mexico	1980	46*	
Venezuela	1980	62*	6*

Source: Gandhi, S., Ketoff, A., and Sathaye, J. (1987). Trends in Saturation of Refrigerators and Air Conditioners in Developing Countries. Lawrence Berkeley Laboratory.

* Estimated

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5. GOVERNMENT POLICY AND ELECTRICITY IN DEVELOPING COUNTRIES

Electricity supply is strongly influenced by government policy in all developing countries. Government also shapes electricity consumption through setting of tariffs and policies regarding rural electrification.

The choice of fuels for electricity generation is conditioned by each country's endowment of energy sources, but there are policy choices regarding the priority given to various indigenous energy resources and the type of fuels that are imported. Since 1973, utility companies that relied on fuel oil for electricity generation have moved away to use other fuels. Utility companies in the East Asian countries have moved to coal and nuclear-fueled generation. Use of imported coal for power generation has become common in these Asian countries. Elsewhere, in countries endowed with natural gas resources, utility companies have used that fuel to displace fuel oil. Natural gas use is economical because the capital cost of new gas-fired power plants is lower, and natural gas is priced lower than fuel oil.

Electrification has been pursued to spur industrial development and, in the rural areas, to provide electricity to rural dwellers and/or agricultural customers. The stated political goal of providing electricity to rural consumers is to achieve various socioeconomic objectives -- education, better health services, sanitation, community entertainment, etc. These are easier to pursue when economic growth is strong but much harder to defend when the economy is stagnating. The goal of providing electricity for agricultural water pumping, which has been effective, is to raise agricultural productivity and, as a consequence, rural incomes.[1]

The efficiency with which electricity is produced and supplied to consumers varies with the level of sophistication of each electric utility company. It is also influenced by the administrative, financial and political environment in which the company operates. Electricity is being supplied and used inefficiently in many areas. Long transmission and distribution systems with inadequate equipment to maintain voltages and power factors result in high line losses. These contribute to the 20% or higher line losses reported in many poorer LDCs. Theft of electricity and unreliable accounting of electricity sales add to the losses.

Power Sector Problems

Except in a few Latin American and East Asian economies, there is inadequate electricity generation capacity in the developing countries. As LDCs modernize, electricity use in the commercial and residential sectors is rising sharply, and in some countries it has outstripped that in the industrial sector. Combined with rural electrification, this has caused electricity demand to grow at over 7% a year. Over the past 20 years, the demand has increased faster than electricity supply, and many developing countries face critical power shortages.[2]

Capital shortage is pervasive in many developing country economies. Capital needs for the electric power sector can consume up to 40% of total government outlay. Since the electric utilities in developing countries are mostly owned and operated by the government, the countries' power expansion requirements have become a major financial burden to the national budget. In most developing countries, over 20% of the development budget has been devoted to the power sector, a proportion that represents more that 60% of the budget for all energy activities. Moreover, because much of the capital invested in the power sector is borrowed from the international market, the government's ability to raise funds for other development activities has been drastically curtailed. In many countries, outstanding loans for the power sector represent over 40% of the national foreign debt. The ability to borrow capital is influenced by the overall economic debt situation of the country and by the utilities' own financial condition.

A recent analysis of the capital requirements to support the electric power sector shows that if the current low efficiency of generation and supply of electricity were to persist, the total capital needs in the LDCs would increase from roughly $80 billion a year to $360 billion by 2008.[2] Improvements in capacity utilization, reduced transmission and distribution losses, and improved efficiency of end-uses could reduce the capital needs by a factor of 2.8 to about $130 billion by 2008.

Financial viability of electricity companies, government owned or private, depends on the price that they are allowed to charge their customers. Too low administered prices do not allow companies to earn an adequate rate of return to pay off their loans. During periods of rapid international price increases, governments have slowed the increase in the administered prices, leading to unprofitable operation of electricity companies.

The electricity sector is owned and operated by government para-statal corporations in most developing countries. The wholesale prices of fuels are set by the government also. These are often not high enough to pay for the utility companies' expenses. The government then subsidizes the operation of the company through other means. This is compounded by the non-payment or deliberate delayed payment for fuels purchased from another government company. For example, government-owned electric utility companies

cannot afford to pay the refinery for fuel, since they are unable to collect adequate revenue for the electricity sold to subsidized customers.[3]

Historically, government owned electricity companies evolved as a means not only to serve their primary function of energy supply, but also as a source of employment in underdeveloped areas of the country. Large multi-purpose hydro-electric projects were begun as a means to stimulate regional development. The historical and current situation is somewhat similar to that in the U.S. with the Tennessee Valley Authority (TVA) and the Bonneville Power Administration (BPA). What is perhaps different is that TVA and BPA were small compared with the privately operated utility industry in the U.S., and that the developing nations have difficulty exercising the degree of continuing oversight required to ensure efficient operation of government owned companies.

Environmental issues that historically have been given scant consideration are also beginning to influence the choice of power plants. Hydropower plants in Thailand, China, and elsewhere have been delayed by public opposition on ecological grounds. Global environmental concerns such as CO2 and global warming are also beginning to be heard. These are being raised by public interest groups who are in a position to influence the lending agencies through their political representatives.

Power Sector Reforms

In order to improve the operation of the electric utility companies and minimize the detrimental impacts of power supply, major policy reforms coupled with improved planning methods will be needed. These include:

1. Reform of electricity tariffs to better reflect costs;
2. Encourage private sector involvement in power generation, which would help to raise additional revenue and capital;
3. Reduce demand through conservation and end-use efficiency improvements;
4. Provide electricity at least cost by improved forms of generation and end-use;
5. Reduce production costs by technical, managerial and operational efficiency improvements.
6. Improved pollution control and consideration of environmental impacts.

Electricity tariffs can be set to satisfy various criteria. These include ensuring the financial viability of utility companies, the collection of sufficient revenue in order to support capital needs, and socioeconomic equity to provide relief to the poor. Prices that reflect the marginal cost of generation also provide an incentive for using electricity more efficiently.

Socioeconomic equity plays a strong role in the pricing of electricity. Preferential electricity tariffs for residential customers are often accompanied by even lower tariffs for agricultural customers. This is not unlike the situation in some developed countries where low lifeline rates for small amounts of electricity consumption are offered by electric utility companies. Raising rates in the developing countries to reflect the long-run marginal cost of electricity supply has been difficult and has provoked social disturbances. Higher rates can also dissuade customers from paying their utility bills, which makes revenue collection difficult.

The utility sector is short of capital and needs to improve its management in order to reduce losses and increase plant availability. Increased involvement of the private sector can help achieve both these aims.[2] One way to achieve this is to let private companies generate and sell electricity to the utility company in a manner somewhat similar to that in the United States. Another way is to seek private capital through the issuance of bonds for the construction of electricity facilities.

In the developed countries, utility companies have offered rebates and other incentives to improve the efficiency with which electricity is used. Similar programs need to be started in the developing countries. A recent study of Michigan has shown that at a cost less than the *short-run* marginal cost of generating electricity, the state's utility companies could save 3400 GWh by 2005 in the residential sector alone.[4] Studies for Thailand,[5] Pakistan,[6] and Brazil[7] have also shown a considerable savings potential.

Power plant availability averages about 80% in the United States. In the smaller developing countries, it may average as low as 40%; in India and Pakistan, it has averaged around 55 to 60%. This means that at least 25% better plant utilization could be attained if availability were to be increased to U.S. average levels. While the administrative, political and regulatory environment in which plants operate in the developing countries makes it difficult to reach the same levels as the U.S. standard, even a 15% improvement would substantially improve plant utilization and reduce operating costs. In order to achieve these levels, utility operation would have to improve through training and better incentives to encourage employee performance.

Environmental issues are emerging as a major concern. The deleterious impacts of hydro dams and nuclear power are forcing governments and utility companies to reevaluate their options for new power plants. More efficient generation and use of electricity, and increased penetration of renewable electricity technologies would help reduce the environmental impact.

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