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# ELECTRICITY PRICING IN KOREA

## A STUDY OF PRICING INITIATIVES AS POSITIVE CONTRIBUTORS TO THE DEVELOPMENT PROCESS

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## ABSTRACT

### ELECTRICITY PRICING IN KOREA: A STUDY OF PRICING INITIATIVES AS POSITIVE CONTRIBUTORS TO THE DEVELOPMENT PROCESS

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The "economic miracle" in South Korea over the past three decades has been supported by a corresponding increase in electric generating capacity in a relatively short period of time, accomplished in a country with limited domestic energy resources and large commitments of capital to export-oriented industries. Generating capacity increased nearly 12-fold in a 12-year period during the formative stages of Korea's development from 1962 to 1973 and more than 50-fold from 1962 to the present time. For capital- and energy-short developing countries, the Korean experience is a good example of the contribution of pricing-related initiatives to development of the power sector. Besides setting prices at a level sufficient to provide resources for the power sector, a number of initiatives designed to reduce the cost of electricity supply were implemented. These pricing-related initiatives were a significant source of resources for the power sector during the 1962-73 period. More recently, implementation of time-of-day pricing and enactment of legislation aimed at improving the performance of public enterprises significantly contributed to the efficiency of the power system.

## SUMMARY

# ELECTRICITY PRICING IN KOREA: A STUDY OF PRICING INITIATIVES AS POSITIVE CONTRIBUTORS TO THE DEVELOPMENT PROCESS

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Despite the easing of international petroleum prices in the 1980s, the energy problems of developing countries continue to linger. In the power sector, two are particularly troublesome. First, capital shortages constrain development of the sector in many countries, even where sound power development strategies have been formulated. In many cases, prices have not been set at levels sufficient to generate net revenues to fund further expansion of the sector, requiring large subsidies from national governments. Second, technical, managerial, and economic inefficiencies have also drained resources from the sector and aggravated capital supply problems; correcting these inefficiencies is an energy option that has received too little attention in many countries.

The importance of addressing these electricity-related problems in developing economies cannot be overemphasized. While the future profile of international petroleum prices cannot be determined with precision, the capital cost of new generating capacity in the power sector is escalating. And, funds for expanding the sector are becoming increasingly scarce. In a recent study (see U.S. Agency for International Development, 1988), for example, it was estimated that 1,500 gigawatts of additional generating capacity will be needed in the developing world by the year 2008, assuming a 4.5 percent growth rate in total output. The estimated cost of these increments is $2.6 trillion ($125 billion annually), while expenditures on these power systems are currently only $50-$60 billion per year. With government budgets strapped and domestic credit sources limited, this suggests that resources for expanding the power sectors of countries in the developing world must increasingly come from the electric power parastatals themselves--through pricing and efficiency improvements--or from private investment in power generation.

In this paper, we examine South Korea's policy toward its electric power sector, looking at its use of pricing and complementary initiatives to mobilize resources for developing the sector, emphasizing the 1960s and early 1970s because this period of time in Korea's development most closely approximates the condition of many developing countries today.[a] Korea is an important case because it was able to resolve the energy dilemma confronting many other developing countries today. That is, the opportunity cost of investing in capital-intensive energy sectors is high, with scarce funds competing for alternative uses in social and industrial sectors to improve prospects for economic growth. Yet, the opportunity cost of not investing is also high because investment in energy is required for growth to proceed; in fact, the relationships between energy sector development (and energy consumption), industrialization, and economic growth are close. Faced with this challenge,

[a]Hereafter, Korea will be used to refer to the Republic of Korea, established in 1948 on the Southern portion of the Korean peninsula.

Korea transformed itself from an agrarian economy to one of the emerging leaders in the international economy in a short period of time, despite possessing limited indigenous energy resources, including no domestic petroleum reserves. The only significant domestic energy resources are hydropower, a low-quality anthracite coal, and various renewable energy forms.

Turning to the power sector, public policy toward power development sector was directed at obtaining as much resources for new electric generating capacity as possible from pricing and complementary initiatives during the formative stages of its development in the 1960s. For pricing alone,[b] the percentage of capital expenditures financed from within the the state power monopoly, averaged close to 50 percent from 1967 to 1973 (Section 4.1). During this period, two other initiatives were also implemented to complement the pricing strategy, reducing the cost of providing electricity. In July 1961, the three existing electric utilities were merged into one, resulting in significant economies. In addition, a number of technical efficiency improvements were introduced, including a power loss prevention program which reduced transmission line losses from nearly 30 percent in 1961 to 18 percent in 1966. Partially as a result of these two initiatives, real (in 1988 won--Korea's unit of currency) average (per kilowatt-hour of sales) operating expenses declined from 127.2 won in 1961 to 37.9 won in 1973 (Section 4.3.1). Finally, the government allowed private companies to construct generating capacity in the mid 1960s when rising living standards and rapid industrialization strained existing capacity on the central grid (Section 4.2).

Assuming a capacity cost of $760/kilowatt (1988 dollars), the estimated amount of electric generating capacity saved as a result of these initiatives during the 1960s and early 1970s is summarized in Table S.1. The estimated equivalent amount of capacity and the corresponding percentage of net capacity additions are presented for magnitude and scale only and do not necessarily represent the actual sources of resources for the Korean power sector in either a financial or economic sense.[c]

In addition to these early initiatives, a time-of-day tariff was introduced for large-voltage, industrial electricity users in December 1977. Over the decade subsequent to its introduction, an estimated 800 mW of capacity savings were realized (Section 4.3.2). More recently, the Government-Invested Enterprise Management Act was enacted in response to the Korean government's dissatisfaction with the operating performance of public enterprises. The legislation provided incentives for managers of these enterprises to improve the performance of their firms, with rewards accruing directly to the managers rather than the

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[b]The discussion refers to the overall *level* of electricity prices in relation to total costs. The *structure* of electricity prices in Korea--relative prices among different consumer groups--have historically favored "productive" sectors of the economy (i.e., export-oriented sectors) at the expense of "nonproductive" sectors. This is discussed further in Section 2.

[c]From the standpoint of the power sector alone, the capacity equivalents from the pricing initiative and construction of power plants by the private sector can be interpreted as a source of resources. However, they are a *transfer* of resources from the rest of the economy which could have been employed in other uses if not used in the power sector. The estimated capacity equivalents from efficiency improvements, on the other hand, have a different interpretation. To the extent that the savings from these improvements were passed on to the rest of the economy (i.e., electricity consumers) from the power sector--that is, electricity prices were set to cover operating expenses plus a margin sufficient to compensate capital contributors--the estimated savings from these improvements represent a *net gain* to society.

firms. The legislation had a significant impact on the power monopoly, reducing operating costs an estimated 33 percent four years after its enactment (Section 4.3.3).

**Table S.1**
**Korea Electric Power Corporation**
**Estimated Capacity Equivalents from Pricing and Related Initiatives**
**1961-1973**

| Initiative | Capacity Equivalents[a] | % of Net Capacity Additions[b] |
|---|---|---|
| Pricing | 1,055 | 27.0 |
| Improvements in Operational Efficiency | 1,004 | 25.7 |
| Construction of Private Power Plants | 1,565 | 40.1 |

Source: Section 4 in text.

[a]In megawatts. Based on $760/kilowatt (1988 dollars), the cost of constructing a 500-MW coal-fired generating plant in Korea in 1988.
[b]The ratio of the capacity savings of the three initiatives to 3,095 megawatts, the net capacity additions in Korea from 1962 through 1973, excluding capacity constructed for private use.

These initiatives were a significant source of resources for the Korean power sector, allowing the sector to expand to meet the needs of the country's industrialization program, and they were implemented without serious political or economic instability. For other developing countries, the Korean experience provides valuable lessons for resource mobilization in the power sector. Even though its political system and its pool of trained human resources are different from those of many developing countries, Korea is a source of useful lessons about possibilities for--and payoffs from--resource mobilization in the power sector through pricing and related initiatives.

# 1. INTRODUCTION

The purpose of this study is to examine pricing initiatives in the Korean power sector since the advent of formal planning in the early 1960s, emphasizing Korea's experience with (1) using pricing as a tool for financing power sector expansion and (2) complementing its pricing strategy with efficiency improvements to reduce the cost of supplying power. A study of this kind can provide valuable insights for other developing countries exploring options to eliminate the power impediment to development and can be a useful source of information for the U.S. Agency for International Development's (A.I.D.'s) policy dialogue efforts related to energy price reform, as a case study of a "success experience" with energy pricing policy initiatives.

Providing such case studies is one part of the energy price reform program of A.I.D.'s Office of Energy, which focuses on the challenge of *implementing* price reform in the face of political obstacles where prices are substantially below costs. This program has outlined an approach which combines energy price changes--whether gradual or instantaneous, depending on circumstances in individual countries--with other activities designed (1) to improve the efficiency of both energy supply and consumption and (2) to effect organizational changes in energy subsectors where appropriate. Such an integrated approach is likely to make energy price reform more palatable socially and politically by combining increases to "correct" energy price levels with reductions in both the "correct" level and the cost of energy services to users.

One reason for political obstacles, of course, is that the media have publicized a number of energy pricing "disasters." There are, however, countries which lack indigenous energy resources, have addressed energy pricing problems without serious political disruptions, and have attained some measure of "success" in economic development. Based on discussions with A.I.D. offices, it was decided that a useful addition in the policy dialogue process may be to point to one such country (or countries) as an example of a possible approach to resolving pricing problems. Korea is an example of such a country, being widely used as a "model of development" in many other areas besides energy pricing policy.[1] This case study is limited to the power sector, reflecting the Office of Energy's view that the most significant energy problem in most developing countries is the rising demand for electricity services, combined with capital shortages and environmental management needs.[2]

Korea's structural transformation and growth record are indeed impressive. In 1961, the year prior to implementation of formal economic planning, agriculture accounted for nearly 40 percent of total output, while manufacturing's share was less than 14 percent. Presently, agriculture accounts for 12 percent, while manufacturing's share is 30 percent.

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[1]Over the past two decades, numerous studies of Korean society and economic growth and development have been conducted. The Council on East Asian Studies of Harvard University, for example, published a ten-volume series entitled "Studies in the Modernization of the Republic of Korea, 1945-1975" in the past decade. A number of studies have been conducted under the auspices of international assistance agencies, including the World Bank, the U.S. Agency for International Development, and the Asian Development Bank. There have been numerous academic contributions. The Korea Development Institute in Seoul has also been a significant contributor to the literature on Korea's modernization and industrialization.

[2]See U.S. Agency for International Development (1988).

Over that same time frame, exports increased from 5 percent of output to more than 40 percent at present. Meanwhile, from 1961 to 1973, Korean output grew at an average annual rate of nearly 10 percent. From 1973 to the present, it has grown at an annual rate of more than 8 percent. Growth in electric generating capacity has been correspondingly impressive, increasing more than 50-fold over the same period, from 367 megawatts (mW) at the end of 1961 to 19,944 mW in 1988, excluding generating capacity used for private use (Table 1). Petroleum refining capacity is currently 790,000 barrels per day, up from the modest level of 35,000 bpd in 1964.

**Table 1**
**Korean Electricity Generation Capacity**
**Total and Percentage Composition by Prime Mover**
**Selected Years, 1961-1988**

| Prime Mover | 1961 | 1973 | 1979 | 1982 | 1988 |
|---|---|---|---|---|---|
| Total (mW)[a] | 367 | 4,272 | 8,033 | 10,304 | 19,944 |
| Percent Composition: | | | | | |
| Hydropower | 39.1 | 14.5 | 11.3 | 11.7 | 11.2 |
| Conventional Steam | 60.6 | 79.7 | 66.0 | 65.2 | 49.7 |
| Internal Combustion | 0.4 | 5.8 | 15.3 | 10.8 | 5.7 |
| Nuclear | 0.0 | 0.0 | 7.3 | 12.3 | 33.4 |

*SOURCE*: Computed from Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues.

[a]Includes the Korea Electric Power Corporation; the Industrial Site and Water Development Corporation, a government-owned enterprise; and Kyungin Energy, a private power generator. The data do not include self-generation.

This transformation into an industrialized economy was accomplished with a limited amount of indigenous resources, including limited modern energy sources. Korea has limited hydropower potential--almost fully exploited--and anthracite coal deposits which are highly developed but very poor in terms of energy content. Other renewable energy potential is also limited. Korea has thus relied to a large extent on imports of energy--primarily petroleum--throughout the course of its development.

"Lessons learned" from the Korean experience in developing an electricity strategy could potentially be useful and transferable to other countries in various stages of development. However, as in other studies of this kind, one must proceed cautiously. Besides the ability to *formulate* an economic development program, a country must be able to *implement* the policies. For a number of reasons to be discussed more thoroughly below,

the political economy in Korea in the 1960s was more conducive than most to implementing the Five Year Economic Development Plans devised by Korean planners. Despite this *caveat*, the Korean experience does provide useful technical lessons on addressing electricity-related problems for other developing countries confronting electricity as an impediment to growth; the implementation capability hinges on political will and human resources.

Before proceeding to a more in-depth discussion of these policy initiatives in Section 4, the next two sections provide a context for appreciating the role of pricing policies in the power sector, exploring Korea's energy policy in light of its overall development strategy (Section 2) and providing an overview of sources of primary energy, energy conversion, and end-use consumption (Section 3). Lessons learned from the study are presented in Section 5, including a discussion of the transferability of the Korean experience to other developing countries.

# 2. ENERGY POLICY AND ECONOMIC DEVELOPMENT STRATEGY

## 2.1. PHILOSOPHY OF DEVELOPING THE ENERGY SECTOR

The philosophy of providing resources for expanding the energy sector was part of the overall development strategy of the country, and it is best understood by briefly examining that strategy. Korea's economic development program was formulated in a series of Five-Year Economic Development Plans (FYPs), initiated in 1962 and carried forward until the present time. Laying aside the technical merits of the plans, perhaps their importance lies in the seriousness with which the business community took them. The political leadership was able to forge a consensus on the need for economic modernization and growth.[3] This and the fact that the government was blessed by a well-trained bureaucracy distinguish the Korean experience from that of many other developing countries.[4]

Throughout Korea's development, energy was prominent in economic planning. The First FYP (1962-1966), for example, emphasized the industrial sector of the economy at the expense of agriculture, with the goal to "build an industrial base principally through increased energy production." The government's broad strategy to attain these goals was to "socialize" risk in industries important to its development strategy. That is, in cases where large amounts of capital were required to develop industries, the government put up part of the capital, becoming a partner with the private sector in the ventures. In many cases, the government would sell off its ownership interests after the industry was established as a going concern to derive investment funds for further ventures. To illustrate this practice, one-half of the capital requirements for developing the first oil refinery in Korea came from the Korean government in a joint venture with Gulf Oil. After the refinery was established, the government sold off its interests to the Korean private sector. Korea's economy can thus be characterized as a hybrid, a directed market economy, one in which the government was actively involved, but did not control by coercion. A problem with this strategy was to obtain the necessary capital to finance such large-scale ventures, given the traditional role of the government in developing the infrastructure or social overhead of the economy, which includes the power sector.

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[3]In the formative stages of its development during the 1960s and 1970s, Korea's political system was highly centralized and authoritarian. The architect of both the political system and development strategy was Major General Chung Hee Park, who took control of the government in May 1961 and served as the head of state for 18 years. Whatever the drawbacks of his term as Korean leader, one of his most important contributions was providing political stability, a necessary condition for economic development.

[4]At the start of its industrialization drive in the early 1960s, Korea had (a) an excess supply of relatively highly educated labor and (b) limited natural resources. To attain this imbalance between human and indigenous natural resources in so short a period of time was impressive. At the end of Japanese colonialization of the Korean peninsula in 1945, the rate of literacy in the country was estimated to be only 22 percent. In less than 20 years by the time of the start of its export-led industrialization in the early 1960s, the literacy rate had increased to nearly 90 percent. Harbison and Myers (1964) estimated that Korea's development of human resources at the time of its rapid industrialization in the early 1960s was equal to countries with more than three times their per-capita GNP. An important aspect of Korean development was the ability of the government to take the existing stock of human resources and shift them from less to more productive sectors of the economy, increasing both the average number of hours worked per week and the productivity of the labor pool.

In developing the power sector, the government could have diverted resources from other development programs, providing subsidies for expanding the sector. It could also have engaged in deficit financing to fund power expansion. This, however, tends to be inflationary and could have slowed the growth of private saving which the government was trying to foster. Also, deficit financing was counter to the government's goal in its First FYP (1962-1966) of eliminating the budget deficit by 1964. Although the goal was achieved, it was accomplished by reducing government spending, rather than increasing taxes. Another external source of financing for the power sector could have been domestic credit sources. However, this method also has the disadvantage of taking resources away from other sectors which were targets of expansion. Finally, foreign borrowing could have been used to finance power sector expansion. Here again, the use of borrowing in one sector limits foreign borrowing in other sectors, because of limits placed on nations' ability to borrow. However, foreign borrowing was relied on heavily to finance electricity capacity expansion during the power crisis of 1967-1968 when severe shortages of electricity were experienced.

Given these priorities and impediments, the government's policy was to finance expansion of government enterprises, including the power parastatal, from within the corporations themselves. The government's February 1964 revision of the First FYP stated that

> ...investment resources for the expansion of such Government-run or controlled projects as the railroad, communications, and electricity must be financed within the relevant corporations themselves by means of their management rationalization and the upward adjustment of public utility charges.

The government called upon the managers of the major infrastructural government-invested enterprises to rationalize both the price of services and the efficiency of input use. The Korean approach was to use the power parastatal itself to the maximum extent possible to develop the power sector through the pricing mechanism and methods complementary to pricing, to both reduce the cost of electricity production and provide power more efficiently out of the existing system, thereby reducing capacity requirements.

Turning to electric power as an input to industrial production, the policy was no different from that of other resource strategies such as financial or foreign exchange policies: electricity was provided on favorable terms to "productive" sectors at the expense of "nonproductive" sectors, where the former are defined as those industries directly or indirectly producing for export markets (i.e., those actually earning foreign exchange or providing inputs for exporters). Financial policy had the same purpose. With institutionalization of formal planning in 1962, so-called "policy loans" were made to export-oriented sectors, providing financing at preferential interest rates. It was not until the early 1980s that financial liberalization moved financial policy more toward market determination of interest rates and allocation of capital, rather than government fiat. Similar allocation policies were used for foreign exchange. Access to foreign currency was made available on a priority basis--oftentimes at favorable, subsidized exchange rates--to export-oriented industries. Here too, these policies prevailed until the economic reform momentum of the 1980s.

Data limitations (i.e., sectoral cost data) preclude precise estimation of the price subsidy to power users in "productive" sectors. An indication of the extent of preferential

power rates for productive sectors is presented in Table 2 where the ratio of the average price of electricity for each individual consuming sector to the household sector is presented for selected years from 1961 to 1987. The fact that the average rate for large power users was only 36 percent of that of households in 1961, for example, is merely indicative, suggesting the presence of a subsidy. However, if one assumes that prices were based on costs for all of the years in the table, the data suggest that, relative to household users, the cost of serving large power users more than doubled over the period (from 36 to 77 percent): an unlikely possibility. Similar arguments can be made for the other sectors listed in Table 2.[5]

**Table 2**
**Korea Electric Power Corporation**
**Relative Sectoral Electricity Prices**
**Selected Years, 1961-1987**
**(In Percentages)**

| Sector | 1961 | 1973 | 1979 | 1982 | 1987 |
|---|---|---|---|---|---|
| Household Lighting | 100 | 100 | 100 | 100 | 100 |
| Street Lighting | 45 | 53 | 90 | 121 | 101 |
| Small Power (<500 kW) | 83 | 55 | 115 | 140 | 123 |
| Large Power (>500 kW) | 36 | 34 | 61 | 81 | 77 |
| Agriculture | 25 | 28 | 37 | 40 | 50 |

SOURCE: Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues.

## 2.2. RESPONSES TO THE INTERNATIONAL OIL PRICE SHOCKS

The rapid industrialization of the economy in the 1960s--and with it a rising standard of living--forced Korea to switch from using firewood as the primary fuel, substituting modern energy forms for it. At first, emphasis was placed on developing domestic coal resources through enactment of a series of coal promotion laws. By the mid-1960s, however, the economy experienced electric generating capacity shortages, threatening attainment of Korea's growth targets. After relaxing restrictions on power use in April 1964, limitations were again

[5]A similar argument can be made for petroleum product pricing also. Here, however, high excise taxes were imposed on gasoline to discourage consumption, making the distortion in relative prices among different sectors (e.g., gasoline for transport vs. heavy fuel oil for industry) even more pronounced than the power sector. The tax on gasoline was 200 percent in 1961, raised to 300 percent in 1974, and subsequently lowered to 130 percent in 1981. A ten percent tax on heavy fuel oil was imposed in 1965 and lifted entirely in 1981. Because of its importance as a heating and cooking fuel in the residential sector, coal prices have historically been subsidized.

imposed in June 1967, lasting until September 1968. As a result of this experience, the government recognized that a lack of indigenous energy resources could be an impediment to growth in the longer run. Several measures were taken to address the problem. First, nuclear power was explored as an electricity generation option, with increased emphasis during the 1970s in the wake of the international energy emergencies. Second, the government encouraged the substitution of imported petroleum for coal because of limited coal resources, even though the government tried to stimulate domestic coal production. As a result, imported petroleum accounted for more than one-half of total primary energy supply by 1973 (discussed in Section 3).

Because of Korea's heavy reliance on petroleum imports and its promotion of energy-intensive, heavy and chemical industries (HCI) beginning in the early 1970s, economic growth was seriously jeopardized by the oil price shocks of the 1970s, particularly the second shock in 1979. Just as the government completed its switch from coal to petroleum as the major fuel source in Korea and as the HCI drive was initiated, the international price of petroleum started its rise. Exacerbating this increase was the depreciation of the Korean currency (the won) against the dollar. Table 3 quantifies the impact by providing the average cost of crude petroleum to Korea in nominal dollars per barrel, the average exchange rate of the won to the dollar, and the average cost of crude in won per barrel for selected years from 1970 through 1982. The annual average percentage increase in the cost of crude (won per barrel)

**Table 3**
**The Cost of Crude Petroleum to Korea**
**Selected Years, 1970-1982**

| Year | Dollars/ Barrel | Exchange Rate | Won/ Barrel |
|---|---|---|---|
| 1970 | 1.72 | 310.6 | 534.2 |
| 1971 | 2.09 | 347.2 | 725.5 |
| 1972 | 2.38 | 392.9 | 935.1 |
| 1973 | 2.95 | 398.3 | 1,175.0 |
| 1974 | 9.80 | 404.5 | 3,963.8 |
| 1975 | 11.28 | 484.0 | 5,459.5 |
| 1979 | 17.96 | 484.0 | 8,692.6 |
| 1980 | 30.92 | 607.4 | 18,781.7 |
| 1981 | 35.58 | 681.0 | 24,231.0 |
| 1982 | 34.06 | 731.1 | 24,900.6 |

*SOURCE*: Computed from Korea Energy Economics Institute, *Yearbook of Energy Statistics*, Various Issues, International Monetary Fund, *International Financial Statistics*, Various Issues.

to the Korean economy from 1973 to 1979 was more than 33 percent, with exchange rate depreciation accounting for only 3.2 percent of the annual increase. Because the exchange rate depreciated at an annual average rate of nearly 14 percent from 1979 to 1982, however, the annual increase in the cost of crude to the Korean economy was more than 35 percent over that period.

Korea's responses to the oil shocks were almost immediate. After three weeks of study, a Presidential Emergency Decree was issued on January 14, 1974 to deal with the problems of rapidly rising petroleum prices. Unlike many other oil-importing nations which ameliorated the price shocks to domestic consumers by subsidizing the price of energy, the Decree increased the price of petroleum to more or less international levels, which meant a significant increase in the price of electricity. The effects of this pricing policy were to free up government savings for further expansion of the heavy and chemical industries and to increase the rate of inflation.

The government was also forced to formulate a new, long-range energy policy. It moved to increase energy security and to reduce the nation's dependence on oil, a policy shift directly opposite the petroleum for coal emphasis in the late 1960s and early 1970s. As part of this longer term response, the government enacted the Heat Management Law after the first oil shock in January 1974. The legislation created the Korea Energy Management Association (KEMA), a public corporation responsible for energy demand management. In response to the second oil shock, the Energy Rationalization Law was enacted in 1980, superceding the Heat Management Law. This law created a public corporation, the Korea Energy Management Corporation (KEMCO), to replace KEMA. KEMCO's responsibilities are similar to its predecessor's, emphasizing supply- and demand-side efficiency of the energy system.

A major focus of government policy in response to the shocks was the coal sector, attempting to further increase domestic production by increasing coal prices in 1974 and 1975. After the second shock in 1979, the government's policy was to substitute both domestic anthracite and imported bituminous coal for petroleum. In 1982, the cement industry changed its fuel from heavy oil to coal and the government began encouraging the use of coal and LNG in the industrial sector instead of heavy fuel oil.

The effects of the oil price shocks were especially severe in the electric power sector which relied heavily on petroleum as a source of fuel at the time of the first oil price shock. Two important measures were taken to reduce this dependence. First, the government tried to directly reduce it by substituting coal and nuclear power generating capacity for petroleum. Additionally, pumped storage hydroelectric plants were built; liquefied natural gas was imported from Indonesia; and other renewable energy sources such as tidal power were explored. As a result, one-half of KEPCO's electric power generation is currently nuclear-based. Second, the government tried indirectly to reduce dependence by reducing the demand for electricity. An important measure in this regard was to implement a peak-load pricing scheme for large industrial power users in December 1977 (discussed in detail below).

## 2.3. TOWARD IMPROVED ECONOMIC EFFICIENCY

As with other sectors of the economy (World Bank, 1987), the emphasis of energy policy in the 1980s has been on increases in efficiency--economic, technical, and managerial--and energy security. The attempt to improve managerial efficiency is best illustrated by passage of the Government-Invested Enterprise Management Act in 1983, providing incentives for managers in publicly owned enterprises to improve performance (to be discussed in detail below). In the power sector, the goal became allocative efficiency in pricing, reducing the cross-subsidies which existed to promote industrialization in the 1960s and 1970s. In the petroleum sector, retail prices were partially decontrolled in 1986, as a forerunner of full decontrol in the 1990s. Several measures for increasing energy security have been initiated or are under study. One of the most important is diversifying oil supply sources, which began after the the second oil price shock in 1979. Oil exploration efforts have been ongoing with Japanese and other international interests for several years, both in Korea and abroad. A petroleum stockpiling program was also initiated in response to the events of the 1970s. Finally, in a move to improve the efficiency of the petroleum sector, the government recently announced a plan of phased decontrol of petroleum refining, an industry which has historically been protected from foreign competition. In the heavily regulated coal sector, pricing policy has been reevaluated in light of the recent change in the price of coal relative to competing fuels such as petroleum and natural gas, especially in the residential sector, causing significant fuel switching away from coal.

## 3. ENERGY IN THE KOREAN ECONOMY: AN OVERVIEW

### 3.1. PRIMARY ENERGY SOURCES

Because of its limited energy resource base, Korea has had to rely on energy imports to fuel its industrial development. Table 4 shows the extent of that reliance by providing the sources of primary energy supply by type for selected years from 1961 to 1988, divided between domestically produced and imported energy.

**Table 4**
**Korean Primary Energy Supply**
**Domestic and Imports**
**Amount and Percentage Composition by Type**
**Selected Years, 1961-1988**

| Source/Type | 1961 | 1973 | 1979 | 1982 | 1988 |
|---|---|---|---|---|---|
| Total (000 TOE) | 9,748 | 25,010 | 43,241 | 45,625 | 75,351 |
| *Percent Domestic:* | | | | | |
| Coal | 31.9 | 28.5 | 20.4 | 21.4 | 27.4 |
| Hydropower | 1.7 | 1.3 | 1.3 | 1.1 | 1.2 |
| Noncommercial | 57.8 | 14.7 | 6.7 | 5.3 | 1.6 |
| Subtotal | 91.4 | 44.5 | 28.5 | 27.8 | 30.1 |
| *Percent Imports:* | | | | | |
| Coal | 0.5 | 1.7 | 7.0 | 12.5 | 5.9 |
| Petroleum | 8.1 | 53.8 | 62.8 | 57.7 | 47.1 |
| Nuclear | 0.0 | 0.0 | 1.8 | 2.1 | 13.3 |
| LNG | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 |
| Subtotal | 8.6 | 55.5 | 71.5 | 72.2 | 69.9 |

*SOURCE*: Computed from Korea Energy Economics Institute, *Yearbook of Energy Statistics*, Various Issues.

More than two-thirds of Korea's primary energy requirements were imported in 1988. This percentage has grown from 8.6 percent in 1961 when domestic, noncommercial energy provided nearly 60 percent of total primary energy requirements. The growth in imports was attributable to petroleum, which accounted for 47.1 percent of all energy requirements in 1988. This figure is substantially below the peak of 1979, when petroleum accounted for nearly two-thirds of total energy supply. Most recently, the imports of coal and nuclear fuel

have increased substantially, as Korea has moved away from petroleum-based electricity generation. Because of the low quality of domestic coal, industry has relied increasingly on imports of a higher-quality bituminous coal. Groundbreaking for Korea's first nuclear power plant in 1971 antedated the first petroleum price shock, but the nuclear program took on new significance after the two oil price shocks of the 1970s. Nuclear fuel accounted for more than 13 percent of total energy supply in 1988 (Table 4); nuclear generating capacity comprised a third of Korea's total capacity in 1988 and nearly one-half of total generation. Korea began looking into the feasibility of importing LNG as early as 1979; in 1983, a contract was signed with Indonesia to purchase LNG primarily for power generation as another way of diversifying away from imported petroleum. In 1988, LNG accounted for nearly four percent of total energy supply.

## 3.2. ENERGY CONVERSION

Presently, the Korean power sector is dominated by KEPCO, a government-invested enterprise and sole distributor of electricity in the country.[6] It was created by reorganizing the Korea Electric Company Limited (KECO) through enactment of the Korea Electric Corporation Law in December 1980 to raise revenues for additional power development projects, to improve the financial structure of the firm, and to improve managerial efficiency in the power sector. The legislation allowed KEPCO to purchase all privately held stock in the corporation by the end of 1981. More recently, the government has allowed a minority of KEPCO's outstanding stock to be sold to the public; public trading commenced in the latter part of 1989. KECO was formed in June 1961 through merger of the three electricity supply companies in existence since the war-time period.[7]

In addition to KEPCO, there are two other firms involved in electricity generation in Korea, excluding private firms generating power for their own use. The Kyungin Energy Company is a privately owned firm with an installed capacity of 325 mW. It sells its entire output to KEPCO. The Industrial Site and Water Development Corporation (ISWACO) is a government-invested enterprise with 798 mW of hydroelectric generating capacity. Its power is also sold to KEPCO. Thus, the Korean power sector is a dual power production and distribution system. Power production is diversified with (1) KEPCO, (2) the privately owned Kyungin Energy Company, and (3) another government-invested enterprise (ISWACO). The distribution system, on the other hand, is monopolized by KEPCO. Prices are controlled under public utility-type regulation by the Ministry of Energy and Resources.

Petroleum refining operations commenced in 1964 with the opening of a 35,000 barrel-per-day refinery. The government contributed one-half of the capital requirements of the refinery through the Korea Oil Corporation as a joint venture with foreign petroleum

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[6]The public sector in Korea is categorized in four groups on the basis of the degree of government equity ownership. The four groups include governmental enterprises (governmental departments), government-invested enterprises such as KEPCO, subsidiaries of GIEs, and other government-backed enterprises. This will be discussed at greater length in Section 4.4.3.

[7]Unless otherwise noted, KEPCO will be used to refer to the power parastatal throughout the remainder of the paper.

interests, but subsequently sold its interest in the refinery. Presently, there are five privately owned refining companies in Korea with a total capacity of 790,000 barrels per day. However, only the largest refinery (Honam) operates as a joint venture with foreign companies.

The Korean coal sector is a mix of a government-invested enterprise, private mining companies, and coal imports. Domestic coal is mined by the Korea Coal Corporation (Daehan Coal Corporation) and private mining companies. In 1972, there were eight government-owned mines and 136 private mines. The number of government mines declined to seven in 1987, while the number of private mines increased to 356, accounting for nearly 80 percent of domestically produced coal in 1986. Approximately one-half of domestically produced coal is used in the manufacture of charcoal briquets for use in household heating and cooking. Briquetting is a competitive enterprise. As of January 1988, there were 230 briquetting plants in operation, owned by 221 different companies. The Korean Mining Promotion Corporation (KMPC), a government-invested enterprise, assists the mining industry and administers a coal mining subsidy program established in the late 1960s. Funds for the subsidy are obtained from the government, primarily from the proceeds of a special tax on heavy fuel oil (Bunker C).

Energy pricing has historically been administered by the government. There are a number of factors which impinge on the prices approved by the government. Energy taxes--particularly on petroleum--are an important source of revenue for the Korean government. Subsidies have been used for both income distribution reasons and to promote development goals. The procedure for determining energy prices involves interaction between energy suppliers and government agencies. Energy producers submit a proposal for price increases to the Ministry of Energy and Resources (MER). If there is more than one producer, the producers' association submits the proposal. MER reviews the proposal and, if it agrees with it, sends it to the Price Stabilization Committee of the Economic Planning Board for approval. If approved by the Board, it then goes to the Cabinet for approval, becoming effective by a presidential decree.

### 3.3. END-USE CONSUMPTION

The end-use energy consumption data presented in Table 5 show Korea's evolution from a traditional, agriculturally based economy in the early 1960s to a modern one at present. Consumption of petroleum and electricity replaced noncommercial fuels over the 1961-88 period, with traditional fuels accounting for less than two percent of final energy consumption in 1988 down from more than three-fifths of the total 27 years earlier. Coal accounted for approximately the same percentage of end-use consumption in 1988 as it did in 1967; however, the composition changed. Relatively higher-quality imported bituminous coal, used in power generation and certain manufacturing processes, has accounted for an increasingly larger share of coal consumption over the period shown in the table.

The annual average rate of growth in energy consumption from 1961 to 1988 was 7.0 percent and, since annual population growth over that period was 1.8 percent, per-capita energy consumption grew at an average annual rate of 5.2 percent. Dividing the data in Table 5 into 1961-73, 1973-79, 1979-82, and 1982-88 subperiods, reflecting pre-shock, shock,

and post-shock periods, the largest increase in both total and per-capita final energy demand was in the 1973-79 period, growing at average annual rates of 8.4 and 6.8 percent, respectively (population grew 1.6 percent annually during this six-year period). The heavy and chemical industry drive initiated by the Korean government in the early 1970s, emphasizing petrochemical industries (i.e., the large increase in petroleum used for nonenergy purposes in Table 5), largely explains the increase in petroleum use after the first international oil price shock in 1973. Indeed, industrial petroleum use for both energy and non-energy purposes (which was nearly 43 percent of total energy consumption in 1979) increased at an annual rate of more than 14 percent during the 1973-79 period, despite the rapid rise in petroleum prices in late 1973. On the other hand, per-capita energy consumption actually declined at an annual rate of .03 percent during the three-year period following the second oil price shock.

**Table 5**
**Korean Energy Consumption by Type of Fuel**
**Total and Percentage Composition by Type**
**Selected Years, 1961-1988**

| Fuel | 1961 | 1973 | 1979 | 1982 | 1988 |
|---|---|---|---|---|---|
| Total (000 TOE) | 9,271 | 22,364 | 36,971 | 38,711 | 60,971 |
| Percentage Composition: | | | | | |
| Petroleum: | | | | | |
| Energy | 8.1 | 41.4 | 46.8 | 40.2 | 45.3 |
| Nonenergy | 0.0 | 4.9 | 7.2 | 7.5 | 8.0 |
| Coal: | | | | | |
| Anthracite | 29.6 | 30.6 | 23.1 | 23.1 | 18.9 |
| Bituminous | 0.3 | 1.9 | 7.8 | 14.5 | 14.8 |
| Electricity | 1.1 | 4.8 | 7.2 | 8.4 | 10.5 |
| Town Gas | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 |
| Noncommercial | 60.8 | 16.4 | 7.8 | 6.2 | 1.9 |

*SOURCE*: Computed from Korea Energy Economics Institute, *Yearbook of Energy Statistics*, Various Issues.

## 4. SUCCESS EXPERIENCES WITH PRICING AND RELATED INITIATIVES IN THE POWER SECTOR

Before proceeding to a discussion of these initiatives and their estimated benefits, it may be instructive to look at the overall performance of KEPCO from 1962 to the present. In contrast to the power parastatals in many developing economies, KEPCO has historically been operated as a business, required to cover all operating expenses, including debt service, and to earn returns sufficient to attract additional capital. Table 6 provides evidence of this with some summary financial indicators for KEPCO from 1962 to the present, comparing them with those of U.S. investor-owned electric utilities (IOUs) over the same period.[8] The data suggest that KEPCO has been a financially sound utility since Korean economic planning commenced in 1962.

An obvious indicator of financial performance is the overall level of prices: the amount of revenue derived from each kilowatt-hour (kWh) of electricity sales. Throughout the period from 1962 through 1988, the average price of electricity obtained by KEPCO was consistently higher than that obtained by U.S. IOUs. Comparison of average revenues, however, does not capture differences in costs for U.S. utilities and KEPCO. A more telling comparison in Table 6 is the one based on rate base returns. The nominal return on rate base (including inflation) for KEPCO exceeded that of IOUs in all periods. On a real basis (nominal return less the rate of inflation), however, KEPCO's returns were larger than those of U.S. IOUs only during the 1980s. Here again, comparing earned returns across countries is a bit misleading because of differences in the cost of capital, even though the basic ratemaking approach for KEPCO and U.S. IOUs is the same.[9] A more country-neutral financial indicator is the interest coverage ratio, which measures the extent to which a firm is able to pay interest on its outstanding debt. The coverage ratio for KEPCO was approximately 2.0 both prior to the international oil shocks and after the easing of petroleum prices in the early 1980s, but was considerably lower in the intervening periods, lower than those of U.S. IOUs until the mid 1980s but exhibiting a similar pattern over the 1962 through 1988 period.[10]

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[8]The U.S. electric utility industry consists of (1) IOUs, (2) publicly owned municipal systems, state and county power projects, and joint action agencies, (3) rural electric cooperatives (RECs), and (4) federal power projects. IOUs are owned by private shareholders and regulated by individual state regulatory commissions in the states in which they sell power and the Federal Energy Regulatory Commission for interstate power transactions. The investor-owned segment accounts for approximately three-quarters of the industry on the basis of end-use sales.

[9]The basic approach is based on embedded (or average) costs, setting the overall level of revenues to recoup operating expenses and a fair return on invested capital (the rate base) for both IOUs and KEPCO. In recent years, there has been movement to varying degrees toward the use of marginal ratemaking principles in both the United States and Korea.

[10]As a rule of thumb, a coverage ratio of 2.0 is considered acceptable by the financial community.

## 4.1. THE ROLE OF PRICING IN FINANCING THE POWER SECTOR

The data in Table 6 suggest that, in contrast to many of the electric power parastatals in the developing world today,[11] the overall level of KEPCO's prices were set to maintain financial viability. In this section, KEPCO's pricing policy is addressed in more depth by looking at the amount of KEPCO's expenditures on plant and equipment that were self-financed and, therefore, were not required to be financed from other domestic or foreign savings. Also, an estimate of the amount of capacity equivalent implied by KEPCO's pricing strategy is provided.

**Table 6**
**KEPCO and U.S. Investor-Owned Utilities**
**Comparison of Financial Indicators**
**1962-1988**

| Category | 1962-73 | 1974-79 | 1980-82 | 1983-88 |
|---|---|---|---|---|
| Average Price of Electricity (¢/kWh)[a] | | | | |
| KEPCO | 2.04 | 4.33 | 9.13 | 8.03 |
| U.S. IOUs | 1.74 | 3.28 | 5.42 | 6.55 |
| Nominal Return on Rate Base (%)[b] | | | | |
| KEPCO | 11.2 | 11.7 | 26.5 | 16.7 |
| U.S. IOUs | 7.4 | 8.6 | 10.2 | 10.8 |
| Real Return on Rate Base (%)[c] | | | | |
| KEPCO | (5.0) | (10.8) | 10.8 | 13.0 |
| U.S. IOUs | 3.4 | 0.6 | 1.8 | 7.4 |
| Interest Coverage Ratio[d] | | | | |
| KEPCO | 1.96 | 1.21 | 1.23 | 2.05 |
| U.S. IOUs | 3.01 | 1.93 | 1.75 | 1.89 |

*SOURCES:* Computed from Korea Electric Association, *Electrical Yearbook*, Various Issues, Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues, Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry*, Various Issues, and U.S. Energy Information Administration, *Financial Statistics of Selected Electric Utilities* (called *Statistics of Privately Owned Electric Utilities in the United States, Classes A and B Companies* in earlier years), Various Issues.

[a]Defined as average revenues per kilowatt-hour of electricity sold in nominal dollars for all customers classes. The period averages are arithmetic averages of individual years in the period. The values for KEPCO were converted from won to dollars using the average exchange rate for individual years.

[b]Defined as the ratio of electric operating income to the average rate base for the year. The latter is defined as the beginning- and end-of-year average electric plant in service plus an allowance for working capital. Working capital is one-eighth of operation and maintenance expenses, excluding purchased power.

[c]The same as footnote b reduced by the inflation rate as measured by the implicit price deflator. Numbers in parentheses denote negative returns.

[d]Defined as the ratio of electric operating income to interest expense on long-term debt. For U.S. "combination utilities" providing more than one utility service, interest expense was apportioned to electricity based on the ratio of total electric plant to total utility plant.

[11]See Hill (1987), for example.

A quantitative indicator to address the first issue is the self-financing ratio, which is provided for KEPCO in selected intervals from 1967 through 1988 in Table 7. The ratio is calculated as the percentage of total capital expenditures accounted for by internally generated funds. Internal funds are defined as the amount of cash flow generated by KEPCO from its power operations. In Table 7, the self-financing ratio is defined two ways. For any year in the "individual years" category, the data represent the ratio of current-year internal sources of funds to current-year capital expenditures. For the "three-year average," capital expenditures are averaged for a three-year period beginning the year prior to the current year and ending a year later.

**Table 7**
**KEPCO's Self-Financing Ratio**
**1967-1988**

| Category | 1967-73[a] | 1974-79 | 1980-82 | 1983-88[b] |
|---|---|---|---|---|
| Individual Years[c] | 45.5 | 40.3 | 37.8 | 93.9 |
| Three Year Average[d] | 42.3 | 38.8 | 38.6 | 76.1 |

*SOURCE:* Computed from Korea Electric Association, *Electrical Yearbook*, Various Issues, Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues, and Korea Electric Power Corporation, *Annual Financial Information*, Various Issues.

[a]Consistent data prior to 1967 are not available. The percentage for the three-year average covers the 1968-1973 period.

[b]The percentage for the three-year average covers the 1983-1987 period.

[c]For the periods indicated, the average of current-year internal funds flow to current-year capital expenditures.

[d]Same as footnote a except capital expenditures are a three year average of expenditures for preceding, current, and year-ahead for any given year.

During the formative years of Korea's development preceding the first oil price shock, nearly one-half of expenditures on plant and equipment was financed by KEPCO itself. The results deteriorated slightly during the international oil price shock years, but rebounded substantially with the easing of international petroleum prices in the 1980s. The 93.9 percent self-financing ratio over the 1983-1988 period for the "individual years" calculation reflects in large measure the last two years of the period: the ratios in 1987 and 1988 were 120.3 and 181.5 percent, respectively. The three-year average calculation is significantly lower, of course, because it does not include 1988's internal funds generation.

To address the second issue, the capacity equivalent implied by Korea's pricing policy is estimated by taking the difference between (1) the actual amount of KEPCO's internal savings and (2) the amount which would have been realized if pricing policy was formulated

simply to recover financial costs, which include interest charges.[12] Using this approach, the estimated real savings in terms of capacity from KEPCO's pricing strategy was 586 billion won (1988 won) from the year economic planning was implemented in 1962 to the year of the first international petroleum price shock in 1973. Using the 1988 dollar-to-won exchange rate, the estimated savings was $802 million. Putting this amount into a generating capacity equivalent results in 1,055 mW, using the 1988 cost of a 500-mW coal plant ($760/kW) as the equivalent. To the extent that other generating types and/or capacities are used as the measuring equivalent, the estimated capacity savings would differ from this estimate.[13]

## 4.2. THE ROLE OF PRIVATE POWER

Electric generating capacity shortages plagued the Korean economy up until April 1964 when restrictions on power use were lifted because the power expansion program initiated with the First FYP materialized. By the mid-1960s, however, increased load commitments due to Korea's rapid industrialization and rising living standards again led to capacity shortages, threatening attainment of Korea's growth targets contained in the Second FYP (1967-71). As a result, limitations on power use were again put into place in June 1967, lasting until September 1968.

An important outgrowth of power rationing was a decision to allow construction of power plants by private companies by amending the Second FYP. During the 1972-1973 period, more than two-thirds of new generating capacity coming on line in the central grid was planned and constructed by the private sector. In total, 1,565 mW of capacity were built by three private companies as a result of amending the Second FYP. Eventually, two of the three companies merged with KEPCO. Presently, the one private firm with 325 mW of capacity still exists, but sells its output to KEPCO.

## 4.3. COMPLEMENTS TO PRICING: IMPROVING PERFORMANCE THROUGH EFFICIENCY-ENHANCING INITIATIVES

### 4.3.1. Supply-Side Initiatives

Two major actions were taken to improve the efficiency of the electricity sector during the 1960s. As discussed in Section 3, Korea's three electric power companies were merged into one company, the Korea Electric Company (KECO), in June 1961 to improve the technical, managerial, and economic performance of the power delivery system. Establishing

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[12]In very general terms, a firm can (1) price above operating costs, which requires no operating subsidies, but may require some external funding; (2) price at a level sufficient to cover operating expenses, thus eliminating the requirement of the government to subsidize operating losses, but requiring external financing for capital expansion and/or improvement; or (3) price below operating costs, requiring both operating and capital subsidies. Here, the second alternative is assumed rather than the third; the latter, of course, would result in a greater estimated capacity equivalent.

[13]Korea's current power development program is limited to nuclear, coal-fired, and, to a lesser extent, gas turbine units. The 1988 dollar cost/kW for a 900-mW coal plant is $549. For nuclear units, the estimated costs are $1,481 and $1,640 for 1,000-mW and 650-mW units, respectively.

a nationwide electric distribution grid, introducing system-wide planning, reducing managerial overhead, and expanding lower-cost categories of service resulted in substantial savings. The second major initiative was implementing a program to reduce power losses on the system. The government created a Power Loss Prevention Committee as part of a long range plan to improve the efficiency of the power delivery system. As a result, the power loss rate decreased from 29.4 percent in 1961 to 18.1 percent in 1966. Although other supply-side efficiency initiatives were undertaken during the 1970s and 1980s, the 1962-73 period is emphasized here, corresponding to the period used for estimating savings attributable to KEPCO's pricing strategy in the previous section.[14]

Table 8 presents KEPCO's operating results for two years prior to the reorganization of the power sector and five years after. With the exception of 1963, operating expenses as a percentage of electric revenues dropped markedly after the reorganization, declining to 66.9 percent in 1966 from the 86.6 and 94.1 percent levels prior to the reorganization and power loss prevention program. Similarly, operating expenses per kWh sales dropped significantly in the early to mid 1960s. Besides reorganization of the power sector and improvement in transmission and distribution efficiency, a number of other factors could have contributed to the decrease in operating costs, but this does not seem to be the case. For example, the percentage of KEPCO's generation accounted for by low-cost hydroelectric units actually declined in the early 1960s, from 37 percent in 1961 to 25 percent in 1966, primarily at the expense of coal- and heavy oil-fired units. And, the real price of coal and petroleum increased during the period. Another possible explanatory factor for the decline in average costs is an increase in customer density. However, a rural electrification program was initiated in 1965, tending to reduce customer density. Wages also increased during the period. Using a monthly wage index, the cost of labor more than doubled over the five-year period from 1961 to 1966. The load factor also declined from 66.2 to 63.7 percent over the 1961-1966 period, tending to increase operating costs. On the other hand, the conversion efficiency of generating plants, which increased from 19.5 to 24.5 percent from 1961 to 1966, tended to lower costs on the system.

An approach to quantifying the effect of the 1961 reorganization and power loss prevention program on KEPCO's efficiency, accounting for these various influences on the cost of production, would be to estimate a short-run cost function using data prior to the changes, then using the estimated function to forecast operating costs after the changes occurred. The forecasted cost could be compared with the actual cost incurred by KEPCO

[14]In response to the oil price increases of the 1970s, conservation programs were initiated within the power sector, proving to be quite effective in improving the efficiency of power generation. Inefficient generating plants were scrapped and more efficient ones were constructed. Operating and maintenance procedures were improved. Auxiliary uses of electricity within the plants were reduced. During the fourth plan period (1977-1981), significant improvements were also made in plant construction methodology. Previous projects using foreign technology on a turnkey basis were changed to a non-turnkey basis. Almost one-half of the equipment was now domestically produced with Korea moving toward self-reliance on power plant construction technology. Finally, the emphasis of Korean power planning in its first two FYPs was on constructing new capacity to accommodate output targets, to the detriment of transmission and distribution facilities. In the third and fourth plans (1972-1976, 1977-1981), this policy was reversed. During these two plan periods combined, the transmission and distribution sector accounted for more than 35 percent of total investment in the power sector.

during the period, providing an estimate of the effect of the efficiency improvements. Data limitations prior to 1961, however, preclude this approach.

**Table 8**
**Korea Electric Power Corporation**
**Operating Results**
**1959-1966**

| Year | Operating Expenses as % of Revenues | Unit Operating Results[a] (Real 1988 Won) | | |
|---|---|---|---|---|
| | | Revenues | Expenses | Margin |
| 1959 | 86.6 | 174.3 | 151.0 | 23.3 |
| 1960 | 94.1 | 155.9 | 146.6 | 9.3 |
| 1961 | 82.6 | 154.0 | 127.2 | 26.8 |
| 1962 | 75.9 | 115.9 | 88.0 | 27.9 |
| 1963 | 89.2 | 84.0 | 74.9 | 9.1 |
| 1964 | 77.8 | 71.8 | 55.8 | 15.9 |
| 1965 | 67.9 | 86.2 | 58.6 | 27.7 |
| 1966 | 66.9 | 85.9 | 57.5 | 28.4 |

*SOURCE:* Computed from Korea Electric Association, *Electrical Yearbook*, Various Issues, and Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues.

[a]Defined as operating results per kWh-sales.

An alternative to estimating a cost function is to compare the operating margin (from Table 8, operating expenses as a percentage of revenues) prior to and after the changes, assuming that the difference is attributable to the organizational changes and efficiency improvements. That is the approach taken here to estimate the savings. From Table 8, the difference between the percentage of revenues accounted for by operating expenses for years after 1961 and a three-year average (1959-1961) of that percentage prior to the changes (87.8 percent from the data in Table 8) is the basis for estimating the capacity equivalent. Similar to the estimate of the capacity equivalent implied by Korea's pricing strategy (Section 4.1), the effects of these supply-side initiatives were estimated over the 1962-73 period. Given these assumptions, the efficiency improvements led to a real savings of 558.0 billion won (1988 won). Using the 1988 dollar to won exchange rate, the corresponding real (1988) dollar savings is $763 million. This translates into 1,004 mW of capacity equivalent, using KEPCO's 1988 $760/kW cost of a 500-mW coal unit.

### 4.3.2. Demand-Side Management: Time-of-Day Pricing

A number of short- and long-term initiatives were taken in response to the petroleum price shocks of the 1970s, including implementation of a mandatory time-of-day (TOD) electricity tariff for large-volume consumers in December 1977.[15] Prior to introduction of the tariff, rates for industrial customers had no time element associated with them; that is, they were simply based on the quantity of electricity consumed, irrespective of the time of day and season of the year that the consumption took place. Based on a cost study, electricity rates for these larger-voltage consumers were set to more closely match supply costs over time. The resulting TOD tariff differentiated rates on the basis of both season of the year (summer and winter) and time of day, including peak, shoulder (or intermediate), and off-peak periods.[16] The rate structure prompted significant changes in the consumption patterns of large-volume electricity users. From its introduction in December 1977 through December 1987, the tariff is estimated to have saved 800 mW of peak load (Korea Electric Power Corporation, 1988).[17]

### 4.3.3. Improving Managerial Efficiency

The international petroleum price shocks of the 1970s caused severe macroeconomic problems in the Korean economy at the beginning of the 1980s. Besides inflationary pressures, the external debt of the country increased significantly because of foreign borrowing to finance energy imports, contributing to a drain on the availability of capital in the private sector. To help alleviate some of these problems, an attempt was made to improve the efficiency of Korea's public sector, which consists of 85 corporations, classified in 4 categories on the basis of the degree of government equity ownership. They include (1) governmental enterprises (government departments such as the Office of Monopoly and Office of Railroads); (2) government-invested enterprises (GIEs) in which the government owns at least one-half of the equity and upper-level management is appointed by the

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[15]Originally, industrial customers with 500 kilowatts (kW) or more of maximum demand were affected, but the threshhold level was reduced to 300 kW in March 1980.

[16]The ratio of rates in the peak, intermediate, and off-peak periods were initially 5:2:1. Since May 1987, they have been set at a 2.5:1.6:1 ratio. The history of changes in the rate structure is as follows:

| Date | Ratio |
|---|---|
| December 1977 | 5:2:1 |
| June 1979 | 7:2.5:1 |
| February 1980 | 5:2:1 |
| December 1981 | 5:1.5:1 |
| April 1983 | 3:1.5:1 |
| May 1987 | 2.5:1.6:1 |

[17]Measuring customer response to an electricity rate structure based on time of consumption poses a particularly difficult methodological problem (Hill, 1990b, for example). The 800 mW of estimated capacity savings is based on a comparison of load curves before and after the rate structure was implemented. This is the weakest measure of effects because it does not account for other factors which may have affected consumption, besides the tariff *per se*. However, a more precise measure of the influence of a time-varying rate structure on consumption requires detailed consumption data for consumers both prior to and after the introduction of the tariff; the data were not available for this estimate.

government; (3) subsidiaries of GIEs; and (4) other government-backed enterprises. The most important of these are GIEs; 25 of the 85 government corporations are GIEs, accounting for nearly one-half of the public enterprise sector in terms of budget, employment, and sales. GIEs' participation in the economy is extensive, including banking and finance (five GIEs), services (10), manufacturing (five), and construction (five). KEPCO is one of the largest GIEs in terms of employment, paid-in capital, and annual budget.

The public sector was perceived to suffer from excessive bureaucracy, inaccountability of management, and a poor incentive structure. For example, administrative decisionmaking, such as determining wages and salaries and staffing levels, were decided by the government. Similar to the public sector in many other developing countries, the turnover rate of experienced personnel was high because of inadequate incentives and more attractive opportunities elsewhere. As a result, the financial performance of GIEs was less than expected from Korean planners. In 1982, for example, the rate of return earned by GIEs was 3.7 percent in comparison with more than 10 percent for Korean industry as a whole.

Based on a series of studies to determine if the performance of GIEs could be improved, the Government-Invested Enterprise Management Act (GIEMA) was enacted in December 1983. The act was aimed at providing managerial autonomy and improving accountability of the GIEs. The most important part of the legislation was a grading or evaluation system, using four basic principles:[18]

1. Management was to be evaluated, not the company.
2. Short- and long-term performance should be considered.
3. Only areas under the control of management should be evaluated.
4. Public, not private, profitability should be considered.

From every indication, GIEMA has been accepted by management of the GIEs and has contributed to an improvement in their performance. The reasons for GIEMA's apparent success cut across government policymakers and the management of the GIEs themselves. A major factor was the degree of political commitment to it. Officials at upper levels of government supported the legislation and management of GIEs responded favorably to the incentives in the legislation (Song, 1988).

As for GIEMA's impact on KEPCO, consider KEPCO's operating results for the 1980s in Table 9. Average operating expenses (i.e., total operating expenses divided by kWh sales) declined from 64.8 won/kWh in 1983, the year prior to implementation of GIEMA, to 42.9 won/kWh in 1988, resulting in a decline in the percentage of operating revenues accounted for by operating expenses. A number of factors other than KEPCO management's response

[18]Two kinds of performance indicators are used to evaluate the performance of managers: quantitative indicators, accounting for 70 percent of the grade, and qualitative indicators accounting for the remainder. For manufacturing GIEs, the former include profitability and various financial measures of performance, while the latter include indicators associated with long-term corporate planning, research and development, and management information systems. For banks, profitability is not included as a quantitative indicator, but an indicator of deposits is included. Qualitative indicators for banks also include the quality of service. Based on an evaluation of performance, the managers of the best firms receive an amount equivalent to three months pay ("outstanding firms" which grade 95 or more), while managers of firms which perform the worst ("poor firms") get one extra month's salary. Excellent, good, and satisfactory managers get 2 1/2, 2, and 1 1/2 extra months pay, respectively.

to GIEMA could explain the decrease, foremost among them being a large decrease in KEPCO's fuel costs over the period, reflecting the easing of international petroleum prices. Other improvements in operating performance not directly related to enactment of GIEMA, such as better conversion efficiency of generating units placed on line during the mid 1980s, could also account for the decline.

**Table 9**
**Korea Electric Power Corporation**
**Operating Results**
**1983-1988**

| | Cost Indicators | | Calculation of Cost Savings | | |
|---|---|---|---|---|---|
| | %[a] | Amount[b] | Actual[c] | Forecast[d] | % Change |
| 1983 | 79.5 | 64.8 | | | |
| 1984 | 70.2 | 54.8 | 35.58 | 42.09 | 15.5 |
| 1985 | 69.4 | 52.0 | 32.97 | 41.14 | 19.9 |
| 1986 | 65.3 | 45.7 | 26.78 | 37.74 | 29.0 |
| 1987 | 64.7 | 42.0 | 25.10 | 37.77 | 33.5 |
| 1988[e] | 72.1 | 42.9 | | | |

*SOURCE:* Computed from Korea Electric Association, *Electrical Yearbook*, Various Issues, and Korea Electric Power Corporation, *Statistics of Electric Power in Korea*, Various Issues.

[a]Operating expenses as a percentage of revenues.

[b]Real (1988 won) average operating expenses.

[c]Actual average operating expenses (in won), excluding depreciation, purchased power, and taxes.

[d]Forecasted average operating expenses from cost equation estimated with data prior to 1984.

[e]Forecast for 1988 was not possible because of insufficient data.

A short run cost function was estimated to control for the factors that could have accounted for KEPCO's performance and are unrelated to passage of GIEMA. In the estimation, annual short run production costs were explained by KEPCO's sales, an index of wages, the price of energy, transmission and distribution losses, and the conversion efficiency of KEPCO's generating units. The estimated equation was used to forecast operating costs over the 1984 to 1987 period. In Table 9, the forecasted results are compared with the actual costs incurred by KEPCO over the period. The results show a significant cost savings for KEPCO attributable to passage of GIEMA. In 1984, the first year after enactment of the legislation, the operating cost savings were an estimated 15.5 percent. Those savings increased to nearly 20 percent in 1985, 29 percent in 1986, and over a third in 1987, the last year for which data were available.[19]

[19]The results of the estimation using data from 1965 to 1983 are:

| Variable | Coefficient | T-Statistic |
|---|---|---|
| Sales | -0.1512 | -0.5842 |
| Wages | 0.2736 | 0.8635 |
| Energy | 0.8912 | 6.1321 |
| TD | 0.6647 | 2.2521 |
| Effic | -0.3825 | -0.7101 |
| R-squared | | 0.9945 |
| Adjusted R-squared | | 0.9929 |
| F-statistic | | 630.0913 |

Dependent variable=short run average cost,
Sales=total sales,
Wages=index of wages in Korea,
Energy=wholesale price index of all energy,
TD=transmission and distribution losses, and
Effic=total conversion efficiency of KEPCO's generating units.

# 5. LESSONS LEARNED

## 5.1. ELECTRICITY PRICING AND THE AVAILABILITY OF RESOURCES FOR THE POWER SECTOR

The power sector poses especially difficult problems in many developing economics. Power is necessary for growth and development to proceed, but the investment requirements in this capital-intensive industry have high opportunity costs where other social programs are competing for scarce funds to improve the welfare and standard of living of the population. Yet, the very electricity shortages (leading to power rationing and brownouts) caused by inadequate capacity in the power sector contribute to stagnant living conditions.[20]

Historically, the solution to this problem has simply been to build new generating capacity to meet the social and industrial power needs of the country. Two considerations are important in explaining why this may not be feasible in the future. First, environmental concerns have placed new fossil-fueled generating stations under increased scrutiny. Second, capital shortages are a constraint in many developing economies. Contributing to this latter problem is the escalating overnight cost of new electricity generating capacity and exchange rate rationalization urged by international assistance agencies, tending to increase the capital cost of new generating capacity. With national budgets strained by other pressing social needs and domestic credit sources scarce, the aforementioned scenario suggests that resources for expanding electricity generating capacity in many developing economies will have to come from inside the electric utilities themselves.

Korean planners addressed this problem early in the development process by recognizing the importance of electricity pricing for providing resources for expansion at a time when the government was diverting a large amount of its resources into export-oriented industries and infrastructural development to promote growth. During the formative stages of its development in the 1960s and early 1970s, nearly one-half of the total amount of expenditures on capital additions and improvements in Korea's power sector were generated by the power parastatal itself through its pricing practices, despite the fact that the average price of electricity declined from 93 to 40 (real 1988) won from 1960 to 1973. This was possible because Korean planners complemented their pricing strategy with initiatives designed to reduce the cost of providing electricity. The average cost (operation and maintenance expenses) declined from 87 to 32 won over this same period, translating into an estimated capacity equivalent of 1,004 megawatts.

The international oil price shocks of the 1970s prompted other technical efficiency initiatives and conservation and load management programs. Besides passing on the oil price increases to consumers as a conservation-inducing initiative (the inflation-adjusted average price of electricity obtained by KEPCO increased by more than 50 percent from 1973 to 1975 and more than 20 percent from 1979 to 1980), other conservation activities were the direct outgrowth of the oil price shocks. Creation of the Korea Energy Management Association

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[20]For estimates of the impact of power shortages on economic growth in several economies, see U.S. Agency for International Development (1988).

in 1974, superceded by the Korea Energy Management Corporation in 1980, led to substantial energy savings through conservation efforts. The Government-Invested Enterprise Management Act, enacted in 1983, gave managers of public enterprises the incentive to reduce costs on the power system, resulting in a 33 percent cost savings for KEPCO by the fourth year of its existence. A TOD tariff for high-voltage power users was implemented in 1977. In the decade since its introduction, an estimated 800 mW of capacity was saved.

The TOD pricing initiative is one more step in the evolution of electricity pricing, moving from (1) average cost-based rates, to (2) marginal cost-based rates (to varying degrees), including TOD pricing, and, most recently, to (3) real-time pricing, even more closely reflecting the actual cost of supplying electricity to different consumer groups at any point in time (Hill, 1990). For many utilities in the developing world, however, there is an important step which must be added to this evolutionary process: moving from subsidized to cost-based electricity prices, whatever measure of cost that allows these utilities to maintain their financial integrity.[21] Where KEPCO is exploring improvements in economic efficiency by setting prices which more closely reflect the incremental cost of providing electricity, many utilities in the developing world have pursued different courses, lagging considerably behind in using cost-based prices as a mechanism to ration electricity consumption. From this standpoint, the single most important lesson of the Korean experience for utilities in the developing world is fundamental: the utility should be operated as a business by setting rates which reflect cost, allowing the utility to maintain or, in many cases, attain financial and economic viability. For the power sectors in many developing countries, this first-order priority of rationalizing electricity prices can perform this same conservation-inducing function, slowing load growth, reducing capacity requirements, and decreasing the need for capital and operating subsidies from national governments and reducing foreign debt exposure in the process.

## 5.2. TRANSFERABILITY OF RESULTS

Perhaps more so than any other country, studies of Korea's modernization, industrialization, and export-led development strategy have been examined as a potential model by other developing countries exploring alternate development strategies over the past two decades. In this paper, these studies were extended to include Korea's energy strategy, emphasizing the power sector.

Even though its political system and pool of human capital are different from those of many countries, Korea is a source of useful lessons about possibilities for--and payoffs from--resource mobilization in the power sector through pricing and related initiatives. Most importantly, at a time when the government was diverting a large portion of its resources into export-oriented industries and infrastructure to promote growth and development, it recognized that electricity pricing and related initiatives were important for providing

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[21] In a recent study of electricity pricing practices in 37 developing countries (Hill, 1987), for example, it was shown that 32 out of 37 electric power parastatals in developing countries were not setting the overall level of electricity tariffs properly, not only contributing to demand growth and, hence, more capacity needs, but also resulting in a deficiency in net revenues for funding further expansion. In many cases, not only were prices inadequate to fund capacity expansion, but prices were set at levels insufficient to recover operating expenses, necessitating operating subsidies from national budgets.

resources for expansion of the power system. To realize this resource potential, power production in Korea was treated as a business: (a) capital contributors were compensated for their investment; (b) KEPCO financed a large portion of its investment requirements from its own operations; (c) technical and managerial efficiency was emphasized.

As with any study of this kind, the challenge is to ascertain those aspects of Korea's electric power development strategy that are uniquely Korean and those that can be generalized for use by other countries. It is evident that the *technical framework* used to provide resources for the development of Korea's power sector is transferable. Pricing strategies based on long run marginal cost and technical efficiency assessments are part of the portfolio of assistance initiatives used by multilateral development agencies. Also, some of these same agencies have facilitated studies of private power possibilities as an option for mitigating capacity shortages of state-owned power monopolies.

What is not as readily transferable to other countries, however, is the ability to *implement* a power development program based on sound economic and financial principles, which requires both a political commitment and a pool of trained and motivated policymakers, analysts, and technical personnel. In many countries, years of providing operating and/or capital subsidies to the power sector require a painful adjustment period to allow the sector to operate in a business-like manner, an adjustment which many politicians are reluctant to pursue because of (a) the political consequences (price increases, for example, may lead to civil unrest) and/or (b) unfamiliarity with its importance or methods of implementation.

The Korean experience with power development viewed in this broader political context suggests that, besides providing a technical framework for power development, international development agencies should concentrate more on providing assistance with constituency-and consensus-building for reforms directed at any sector, including power, and with strategies for implementing the program in the face of serious political and economic obstacles. Rather than the historical "top down" approach to policy reform, using the threat of financial sanctions to force reforms on host governments, a more effective approach may be to focus on the longer run, emphasizing education for--and participation by--local staff of a host government on the intricacies of policy reform and its implementation.

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