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Growth and Prospects of the Korean Economy

Annex E — Energy

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ANNEX E

CURRENCY EQUIVALENTS

US$1.00	=	Won 485.000
Won 1.00	=	US$0.0206
Won 1 million	=	US$2,061.85

ABBREVIATIONS

DHCC	-	Dai-Han Coal Corporation
EPB	-	Economic Planning Board
FFYP	-	Fourth Five-Year Plan
HML	-	Heat Management Law
IAA	-	Industrial Advancement Administration
ISWACO	-	Industrial Site and Water Development Company
ITF	-	Interdepartmental Task Force
KDI	-	Korean Development Institute
KEMA	-	Korean Energy Management Administration
KMPC	-	Korean Mining Promotion Corporation
KPDC	-	Korean Petroleum Development Corporation
MCI	-	Ministry of Commerce and Industry
MOT	-	Ministry of Transportation
R&C	-	Residential and Commercial Sector

GOVERNMENT OF KOREA FISCAL YEAR

January 1 - December 31

GROWTH AND PROSPECTS OF THE KOREAN ECONOMY

ANNEX E

ENERGY

Prepared by P. Bourcier, integrating reports by O. B. Fall (Power Consultant), W. Helt (Coal Consultant) and S. Quraeshi (Conservation Consultant)

The full report consists of the following separately bound volumes:

Main Report
Statistical Appendix
Annexes: A - Agriculture
B - Industry
C - Human Resources
D - Macro Model
E - Energy
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GROWTH AND PROSPECTS OF THE KOREAN ECONOMY

ANNEX E - ENERGY

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SUMMARY AND CONCLUSIONS

1. Korea's energy resources are limited to anthracite coal and hydro-power. Anthracite coal reserves are equivalent to about 30 years of 1975 production. Hydro-power potential is estimated to 2,000 MW of which 620 MW have already been developed. Korea's tidal power potential, which could be substantial, is under study. Although exploration for hydrocarbons has been going on for several years onshore and offshore, no commercial discovery has yet been made.

2. The performance of the energy sector and of the various subsectors over the second half of the 1960s and in the early 1970s has been generally satisfactory. Rapid growth in energy supply has been achieved without obvious misallocation of resources and the overall quality of service has been good. However, some institutional and financial problems have developed over time, partly as a result of the rapid expansion of the sector, partly as a consequence of government policies on pricing and subsector development. In the early 1970s, it appeared that the future expansion of the energy sector was to be based primarily on imported oil and nuclear power, and that domestic coal was to be progressively phased out. The increase in the relative prices of fuels and particularly of petroleum in 1973 and 1974, drastically altered this pattern and led the Government to reconsider Korea's energy policy.

3. The Government's response to the oil crisis has been quite impressive: prices of petroleum products were increased in line with international prices, a comprehensive energy conservation program was launched and policies were laid down to promote the development of domestic energy sources. These actions brought about some significant results and in 1974 the increase in final energy consumption was limited to about 7% compared to an average growth of 11.2% over the 1966-74 period. The initial energy program was subsequently consolidated in a more comprehensive energy development plan, which forms the basis of the FFYP.

4. This energy development plan confirms the main objectives of the earlier program and also provides guidelines for the development of the main subsectors: coal, power, and petroleum. The main objectives of this program are to continue to achieve economic growth while consuming less energy and to rely more on domestic resources (coal and hydro) and nuclear power than on oil. The objectives of the FFYP are for a growth of 9.1% p.a. in primary energy requirements compared to 11.5% over the previous period. This would imply a 10% reduction in income elasticity of energy consumption compared to 1974.

5. To achieve these objectives a number of policies were laid down and their implementation started in 1974 and 1975. Although the main results are expected in the next five years, some of the decisions taken in 1973 and 1974 have already brought about significant changes in energy supply, particularly in the coal subsector in which production increased by more than 25% between 1973 and 1975. The success of the government strategy will depend largely on a number of decisions and choices still to be made and on the satisfactory solution of a number of problems, issues and constraints

in the field of sector planning and coordination, energy pricing and financing and policy formulation and implementation. In addition, there are some specific problems in the various subsectors, particularly in the power subsector, which would require immediate attention and prompt corrective actions.

Sector Planning and Coordination

6. In the past, the main concern in sector development has been to ensure that the availability of energy would not become an obstacle to economic growth. Since the overall development strategy was to build up a strong export oriented industrial base, most of the efforts have been directed towards the supply of cheap energy to the critical sectors (power and industry) generally at subsidized prices, while the development of domestic resources, particularly coal, was limited to what was necessary to supply the residential and commercial market. This type of development was made possible by the continuous availability of relatively inexpensive imported energy supplies (mainly oil), so that energy constraints on economic growth were minimal until the increase in the world prices of fuels in 1973/74. However, if the Government's policy has been successful in providing adequate energy supplies, it has created a number of institutional and financial problems in the various subsectors, particularly power.

7. The overall policies proposed in the FFYP are reasonable, but they are much too general to form the base of a coordinated development program for the next few years. In particular while it appears desirable to develop domestic natural resources, to consider nuclear power generation rather than conventional oil-fired power plant and more generally to conserve energy, there are limits to what can be physically achieved in these fields within existing and foreseeable constraints. There are serious financial, technical and manpower problems which may hamper the development and/or delay the realization of the power development program.

8. It is therefore the mission's opinion that a comprehensive review of the feasibility of the coal and power development programs should be carried out.

9. Coal. The problems involved in developing coal in the next five to ten years (labor, technology, size of mines, etc.) should be assessed to devise the policies (pricing, safety, working conditions, etc.) which would be required to ensure that the objectives of the plan are achieved. This assessment should focus particularly on the creation of new mining capacity and the technical and financial assistance that KMPC could extend to private mines particularly in the initial stage when heavy equipment is required for the creation of mine infrastructure.

10. The success of the coal mining development plan will depend largely on the availability of skilled coal miners (25,000 additional miners will be required over the next five years). It is urgent that KMPC launch a training program and take actions to improve safety and working conditions in underground mines. Action should also be taken to improve housing and other services to mining communities.

11. The operation of existing mines could be improved if limited mechanization and modern mining methods were introduced, along the lines of the project developed with the assistance of the Asian Development Bank (ADB). However, this project is limited to the government-owned company and a similar effort in the private mining sector would be advisable.

12. Action should also be taken to ensure:

(a) coordination of the expansion of transport and distribution facilities with the projected expansion of mines. It would be advisable to create a coordinating committee between KMPC and the Korean railways for this purpose; and

(b) rehabilitation of the coal fired boilers at power plants to accommodate low grade coal or a mixture of coal and oil.

13. Power. The most urgent actions to be taken are:

(a) the review of the long range power development plan on the basis of future projected demand and of realistic assumptions regarding timing and costs of nuclear facilities compared to conventional plants. This exercise should include a complete least cost system expansion study, including the cost of related facilities (refinery expansion, oil terminal, pipelines, coal storage and processing, etc.). The study should be carried out with the assistance of experienced consultants;

(b) the review of the rate structure of electricity and of the financial viability of the power industry, and of the future role that the Government should plan in the financing of the power sector; and

(c) the review of the optimum level of investment in transmission and distribution to optimize system operations.

It is our understanding that the Government has already taken steps in these directions and is considering changes in KECO's organization. We feel that a final decision on these matters should await the result of the studies and that, in any case, a single entity should be responsible for power system planning in Korea.

14. Petroleum. The major problems in the petroleum industry are the adjustment of supply and demand and the impact that any shortcoming in other energy development could have on petroleum imports and thus on the balance of payments. Because of the importance of additional oil imports on the balance of payments, it is recommended that a special group be created within MCI to study the energy market situation and maintain a continuous forecast of future petroleum requirements on the basis of the results achieved in the other subsectors and primarily coal and power.

15. It is also recommended that MCI study the feasibility of public intervention in the transportation and storage of oil products to promote joint ventures and avoid duplication of facilities among the three oil companies.

16. Conservation. It is recommended that the various energy agencies dealing with energy conservation and research and development be placed under the supervision of MCI, which should promote a coordinated work program, supervise its implementation and monitor the results. It would be particularly important for MCI to create an information system in which the results gathered by energy conservation agencies would be made available to other private and public agencies as guidelines for energy conservation.

17. MCI should also organize a more unified and comprehensive energy data collection and maintenance system, in which energy data will be recorded and analyzed according to internationally accepted standards (e.g., analysis of demand by end use, segregation between primary and secondary energy, and between energy and nonenergy use).

Coordination of Demand Management Policies

18. The proposed policies of accelerated development of domestic resources and of energy conservation will bring about reductions in the overall cost of energy supplies and of foreign exchange requirements only if they are supported by adequate demand management policies in the consuming sectors. It is therefore important that the energy implications of alternative development policies in the industrial and transportation sectors as well as in the residential/commercial sector be appraised and that the trade-offs between energy consumption and additional capital expenditures or alternative technologies be assessed (e.g., trade-offs between the insulation standards of new buildings and the amount of energy required for space heating or between the utilization of low capital cost energy intensive technologies and more costly processes requiring less energy). It is unlikely that market forces alone would provide adequate and timely answers to these choices, partly because prices do not always reflect adequately the economic cost of energy, and partly because consumers may not react as rapidly as would be desirable. It would therefore be necessary for the Government to intervene on the market to provide the necessary incentive through adequate pricing and fiscal policies, regulations and allocation of resources.

19. Energy Pricing. Energy prices in Korea are generally subsidized and bear little relation to the cost of supply. This is particularly true in the coal and power subsectors. It is the mission's opinion that an adequate energy pricing policy based on the long-term marginal cost of supply of alternative sources of energy is an essential condition for the successful implementation of the energy development program outlined in the FFYP. In the coal subsector the Government should eliminate promotional discounts and set up prices that would reflect full costs (including environmental costs) of producing and utilizing coal. In the power subsector it should eliminate subsidies to industrial consumers and reflect peak load supply costs in power tariffs. In the oil subsector, adequate taxes should be imposed on fuels to reflect environmental costs of fuels utilization (because of the high sulphur

content) and to reflect the cost of stockpiling (to guard against emergencies) in the price of refined petroleum products. It is likely that these measures would raise the price of energy to consumers and that actions would be required to cushion the impact of higher energy prices on some critical sectors. It is, however, strongly recommended that these considerations do not delay the revision of energy prices and that other means of subsidizing be devised if required.

20. Resource Allocation. The participation of the Government in the financing of energy facilities has been quite extensive, particularly in the coal and power subsectors. However, the relative amount of resources allocated to the development of these two subsectors do not always appear to be based on a comprehensive analysis of the costs and benefits involved. This is more apparent in the power industry in which excess generating capacity was installed at the request of the Government and not enough resources were allocated to transmission and distribution investments thus resulting in reserve margins and system losses higher than would normally be expected. The overall review of the system development plan recommended in para. 13 should provide a framework for better resource allocation in the future.

21. In the coal sector the problem is more complex. Short-term calculations seem to indicate that the marginal cost of coal is lower than the cost of alternative fuels and, more particularly, refined petroleum products. However, these calculations are not sufficiently detailed to ensure that the resources allocated to coal development could not be used in more economic mines. The solution of this problem would require an evaluation of the long-term marginal cost of coal at various levels of production which would take into account the expected development costs of coal as well as the indirect costs associated with it (i.e., environmental cost, relocation of labor, unemployment, etc.). This study, which should draw on the experience developed in other countries and particularly Europe, should enable the Government to define an optimum coal development program and to allocate adequate resources. It would also form the basis for the determination of a realistic pricing policy for coal.

Energy Policy Formulation and Implementation

22. The formulation of a national energy policy is a complex exercise which impinges on almost all facets of the economic environment and presents planners and decision makers with a series of choices which would require a much deeper understanding of the sector than is generally available. The energy scene is changing rapidly and will continue to change, requiring the Government and energy agencies to decide on the construction of facilities that have long lead times and involve considerable investments. It is therefore essential that energy problems be formulated rationally and that a system be set up in which the consequences of these decisions could be evaluated and monitored, and in which the knowledge of the sector could be accumulated so that more responsible choices could be made in the future. This is a continuous process, which at the initial stage will require considerable political motivation and willpower but should lead in the long run to a more rational approach to energy development.

23. The formulation of an energy policy takes place at two different levels of responsibility:

(a) at the sector level, to determine future global energy requirements and potential supply sources and select policies which would ensure adequate energy supply within existing and foreseeable technological, financial, social and environmental constraints; and

(b) at the subsector level, where the overall energy policy is translated into objectives for the subsectors and least cost development plans are prepared to meet these objectives.

24. Fundamental choices are made at the sector level (political and social goals of the community, development objectives, financial constraints), and they involve the participation of all disciplines in Government, to formulate an integrated energy policy, that will provide guidelines for the development of subsectors; this suggests an organization at two levels which would include:

(a) at the ministerial level, an "Energy Committee" that would define the strategy to be followed in the energy sector. This committee should be responsible for formulating recommendations to the Government. It should include a group of experts working on a permanent or temporary assignment in an "Interdepartmental Task Force" (ITF) which would create and maintain an analytical framework for the analysis of alternative energy policies and prepare short-, medium- and long-term sector development plans; and

(b) specialized planning groups, by subsector, which would be responsible for the analysis of subsector developments within the framework of the policy defined by the ITF. These groups would provide the expertise in their particular field and would carry out feasibility studies initiated by the ITF.

25. Although a number of government and nongovernment agencies do participate in the formulation of energy policies, no single group has overall responsiblity. It is therefore recommended that the ITF be responsible to EPB and be given responsibility to carry out studies that would include:

(a) a review of the present energy situation and a critical analysis of the consequences of the recent changes in the availability and price of oil, with particular reference to their effect on the balance of payments and economic growth;

(b) an assessment of the potential domestic energy resources and of their cost, with particular reference to the potential of the coal mining industry in the short-, medium- and longer-terms (para. 21 above);

(c) an assessment of the present development strategy of individual subsectors including a judgment of their forward planning capability and recommendations for improvement, with particular reference to the power subsector and the optimization of the long range power development program (para. 13);

(d) recommendations to EPB for urgent decisions to be made in the energy sector such as changes in the relative price of individual sources of energy, allocations of resources to individual subsectors, and particularly to the power industry which accounts for more than 60% of the total projected investments in the energy sector (paras. 20 and 21); and

(e) recommendations regarding further studies which would have to be undertaken urgently to define the energy policy for the next five years, with particular reference to energy conservation and demand management policies in the consuming sectors (type of industrial and urban development, transportation policy, etc.).

The role of ITF would be mainly to evaluate the economic, financial and social impact of alternative energy policies, to recommend policy actions and monitor their implementation. However, ITF would not be a substitute for MCI in the operational and financial supervision of the subsectors.

26. The role of MCI should be widened to improve its knowledge of the various subsectors, particularly of the petroleum industry, and to improve coordination among the various subsectors and with other ministries (Finance, Construction), and other departments in MCI (industry). For this purpose, it is recommended that an energy coordination division be created within the Bureau of Energy Development which would be in charge of continuously evaluating the supply/demand balance of energy and of maintaining adequate statistical data for the purpose of further analysis. It would be of particular importance that the data bank of this division be set up in a way which would provide the possibility of demand analysis by end use and at the same time provide the basis for comparison with other countries.

1. INTRODUCTION

1.01 The UNDP project of planning assistance to the Government of Korea included about five man-months in energy resources planning. Within this framework a mission consisting of Messrs. P. Bourcier, Energy Economist in the Energy, Water and Telecommunication Department, O. B. Fall, Power Consultant (US), W. Helt, Coal Consultant (US) and S. Quraeshi, Conservation Consultant (Canada) visited Korea in February and March 1976 to review the energy sector and assist the Government of Korea in formulating the energy objective of the next Five-Year Plan (FYP).

1.02 The present report summarizes the findings of the mission and incorporates subsequent information that was made available to the Economic Mission in June 1976. Subsequent to this, both the power demand forecast and the power generation investment program of the FFYP have been revised upward. These revisions have been noted in the relevant sections of this Annex, but sufficient detailed information was not available to fully incorporate the changes in the analysis. Subsequent to the preparation of the FFYP, the investment program for the power sector is being subjected to further intensive review. Consequently corrective action is already being initiated on the major concerns expressed in this Annex.

2. ENERGY RESOURCES OF KOREA

General

2.01 The energy resources of a country are not immutably or precisely given, they can be assessed only at a particular time in relation to the existing state of knowledge and techniques, to prevailing economic conditions and to possible changes in each of these. A great deal of this depends on the country's natural endowment of actual or possible sources of energy, but the actual value of these resources depends on how they can be developed and put to use and on the costs and benefits associated with their production and utilization.

2.02 In the present state of knowledge, Korea's energy resources can be divided into three main categories. These are coal, hydroelectric power, and "noncommercial energy." In Korea, however, as elsewhere, there are some other sources of energy (wind, solar, geothermal, and tidal power) which are largely untapped because of limitations of existing technologies.

Coal

2.03 Coal, or rather anthracite, is the main domestic energy resource. Total reserves are estimated by the Korea Mining Promotion Corporation (KMPC) at about 1,500 million tons, of which over 600 million tons are recoverable (about 30 years at 1975 production rates). About 40% of the recoverable reserves are located in the Samchuck area, which contains the largest coal field while the remainder is scattered among smaller fields located along a N.E.-S.W. line dividing the country (see IBRD Map attached). In addition to the known coal fields, there are some potential coal-bearing areas which are currently being explored. In 1975, 60 million tons of additional reserves were discovered, and efforts are being made to step up the current exploration program. Plans for the 1977-81 period call for the speeding up and early

completion of the geological survey and for a doubling in the rate of exploratory drilling, which should increase from about 25 km/year to more than 60 km/year. In view of the current results, these efforts are considered adequate.

Table E 1: ANTHRACITE RECOVERABLE COAL RESERVES
(Million tons)

	Proven	Probable	Total	%
Dai Han Coal Corporation (DHCC)	52.2	88.5	140.7	27.4
Consolidated Private Mines	30.2	112.1	142.3	27.7
Others	27.6	202.9	230.5	44.9
Total	110.0	403.5	513.5	100.0

Source: MCI.

2.04 Anthracite coal deposits are located in mountainous areas, which require drift-type and shaft-type underground mines and labor-intensive mining with a relatively low productivity compared to other methods of mining. (Productivity in the Korean mines is about 1.1T/man shift compared to a maximum of about 3T/man shift in the US). The quality of coal produced in Korea is relatively poor (about 3,500 to 5,000 kcal/kg) and is not suitable for coking; coal below 3,800 cal/kg is not mined. Most of the coal is briquetted and used in the domestic sector.

2.05 A substantial part of the coal production - 31% in 1974 - is controlled by the Dai-Han Coal Corporation (DHCC), a government-owned company, which owns about 27% of the recoverable reserves. The Consolidated Coal Mines (CCM), consisting of six large coal mines unified under the Law for Coal Development, control about 15% of the production. The remainder is divided among about 230 private mines with production capabilities ranging from 50,000 t/y to about 300,000 t/y. From 1966 to 1972 total production of coal remained stagnant at about 12 million t/y. However in 1974 and 1975 coal prices were increased by 51% and 25.5% respectively, and coal production increased to 15.2 million tons in 1974 and 17.6 million tons in 1975. This was achieved by the opening of small mines (about 50,000 t/y) the number of which increased from about 100 mines in 1971 to over 190 in 1975 (para. 4.07).

2.06 Although the Government does not own the entire mining industry, it contributes substantially to the financing of new mines under a program established in 1969 whereby taxes levied on fuel oil are used to finance the capital costs of new mines. Currently the Government of Korea provides 70% and 15% of initial expenditures in the form of grant and concessionary loans respectively (para. 4.11). In addition, the program provides for government loans for working capital equivalent to about 80% of the working capital requirements for the first year of operation. This program is administered

by the Korean Mining Promotion Corporation (KMPC). KMPC is a government-owned corporation that was created in 1967 to promote the development of private mines. It assumes the following responsibilities: (i) geological survey and development study of private mines; (ii) technical and operational assistance; (iii) lending of government funds and participation in the financing of private mines; (iv) leasing, sales, and joint procurement of mining equipment; and (iv) training of mine technicians and workers and selling of mineral products.

2.07 Current prospects for coal production call for an average increase of about 5.6% p.a. to reach about 24.0 million tons by 1981. This is expected to be achieved partly through the expansion of existing mines where production should reach about 17.2 million tons in 1981 compared to about 14.9 million tons in 1975, and partly by opening new mines, which should produce about 6.8 million tons in 1981. Total investment in coal for the period 1977-81, is estimated to about W 189 billion (US$390 million) for exploration and direct production facilities. In addition, about W 200 billion (US$410 million) will be invested in transport, housing, utilities, and other facilities. To achieve the 1981 production target about 3,500 to 4,000 additional miners will be required each year. Given the current labor problems in the mining industry this may become a bottleneck unless adequate measures are taken to improve working and safety conditions at the mines. The expansion of coal production is discussed in more detail in Chapters 4 and 5.

Hydroelectric Power

2.08 Korea's total hydroeconomic potential is estimated at about 2,000 MW and is concentrated on four main river systems (Han, Naktong, Kum and Sumjin, IBRD Map 11320), of which about 620 MW have already been developed and a further 410 MW /1 is under construction or planned for completion before 1981. Most of the sites are of small size and low head and require the construction of relatively costly dams to regulate the river flows. Most of the existing and planned dams are multipurpose projects, which at least at the planning and construction stages are under the responsibility of the Ministry of Construction (MOC). The MOC hands them over to the Korea Electric Company (KECO) once they are commissioned. So far hydropower contributes about 9% of total gross power, and about 12.5% of peak output. It is not expected that hydropower will contribute substantially in the future to the total development of the power subsector.

Noncommercial Energy

2.09 Korea uses relatively large quantities of noncommercial energy (firewood, animal and agricultural waste). Total consumption in 1974 was estimated at about 3.0 million tons of oil equivalent (TOE). As is to be expected, most of the production/consumption of noncommercial energy takes

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/1 Excluding pumped storage projects, whose potential is estimated to 1,500 MW until 1976.

place in rural areas and there is no transport of noncommercial energy with the possible exception of charcoal. Since Korean forest resources are rather limited the production of noncommercial energy from firewood has been strongly discouraged by the Government. However the Government is considering the creation of "tree farms" for the purpose of charcoal production. No action has been taken so far.

Other Potential Energy Resources

2.10 Hydrocarbons. Korea has not yet discovered hydrocarbons on or offshore. An oil strike was reported in the beginning of 1976, in the south-eastern part of the country, but it has not yet been confirmed. Although potential hydrocarbon-bearing areas have been identified, they have not been fully explored because the ratification by the Japanese Diet of an offshore agreement between Korea and Japan has been delayed. Limited drilling activity has been going on since the early 1970s; although several holes were drilled no productive wells were discovered. It is expected that during the Fourth Five-Year Plan (FFYP) the agreement with Japan will be ratified and that systematic exploration will start with the assistance of foreign oil companies.

2.11 Tidal Power. The western coast of Korea, and particularly the Bay of Inchon, experiences very high amplitude tides (8 to 9 m) and could be suitable for tidal power generation. It is the mission's understanding that a feasibility study of the Inchon site is currently under way, but no result is yet available. Total tidal potential has been estimated by the International Atomic Energy Agency (IAEA) at about 1,600 MW (IAEA Market Survey for Nuclear Power in Developing Countries), but in view of the technical and financial problems involved in the exploitation of tidal power, the IAEA team did not consider that it could be developed in the foreseeable future. However the Government of Korea has decided to sponsor additional studies of the potential of tidal power in the light of the relative price increase of energy after 1973.

2.12 Uranium. Although exploration has been going on since 1970, no substantial quantities of radioactive fuel have yet been discovered.

Conclusions

2.13 Korea's domestic energy resources are limited, and there is relatively little prospect that new sources will be discovered and developed in the short and medium term (1980-85). Besides coal, the most promising prospects are in offshore oil once the legal problems with Japan have been resolved. Korea has little if any experience in offshore exploration and it is therefore expected that exploration and possible development will be undertaken by foreign oil companies under a production-sharing agreement./1 However, it is not anticipated that any substantial offshore discovery could be developed commercially before the early 1980s. Similarly, if the onshore discovery proves commercially exploitable, it will take about four to six

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/1 The Government of Korea is considering the creation of Korean Petroleum Development Corporation (KPDC) which would play an identical role to KMPC in the petroleum industry.

years to substitute domestic for imported oil. Korea will therefore remain dependent on its domestic coal and on imported fuel supplies (petroleum and refined petroleum products and nuclear fuel) within the next five-year plan.

2.14 Overall, the FFYP put the emphasis on the development of domestic resources, and more particularly on coal and hydropower. This appears to be justified in the medium term. For the longer term the Government of Korea has already launched a rather comprehensive R&D program, which should particularly look into the technical and economic feasibility of nonconventional sources (wind, solar energy, geothermal, etc.) The resources allocated to the program are about W 44 billion (US$490 million) which appear adequate since the program is based on the adoption by Korea of techniques developed abroad and modified to suit local conditions./1

3. THE GROWTH AND PATTERN OF ENERGY CONSUMPTION AND ENERGY

General

3.01 In order to measure aggregate changes in energy production and consumption it is necessary to express the various forms of energy in terms of a common unit of measurement. For the purpose of this report, energy volumes have been expressed in terms of tons of oil equivalent (TOE). The conversion factors applied for other forms of energy than petroleum and refined products are given in Appendices 1-8.

3.02 The analysis of energy requirements and of the changes in the structure and volume of consumption and production should distinguish between internal final consumption (IFC) /2 of secondary energy (electricity and fuels) and primary energy requirements /3 (coal, hydropower, petroleum and natural gas and nuclear fuels). In this paper we have analyzed first the evolution of the final consumption and then the evolution of primary requirements. We also attempted to limit our analysis to the internal consumption of energy and have excluded, as far as possible, nonenergy uses of energy products (mainly metallurgical coal and petrochemical feedstocks) and exports.

/1 More recent figures indicate that this amount may have been reduced to about W 7 billion which would be low compared to the task at hand. However, the Mission had no opportunity to check whether this reduction was not offset by corresponding increases in the research budget of other sectors, and cannot therefore, make a judgment on the adequacy of the FFYP allocations for energy R&D.

/2 Internal final consumption is equal to the consumption of end users after deduction of consumption for energy transformation and losses.

/3 Primary energy requirements are equal to internal final consumption plus consumption for energy transformation and losses.

Evolution of Internal Final Consumption of Energy

3.03 Total Internal Final Consumption. From 1966 to 1974 total internal energy consumption in Korea grew from about 10.4 million TOE to about 18.1 million TOE at an average rate of 7.2% p.a. Per capita consumption grew from .360 TOE to .540 TOE, over the same period at an average rate of 5.2% p.a. Since 1966 the share of noncommercial energy in total demand has been decreasing consistently from 3.9 million TOE to 2.9 million TOE. In 1974, it accounted for only 16.2% of total internal final consumption compared to 37.5% in 1966. Final consumption of commercial energy grew at 11.2% p.a.

3.04 Final Consumption of Commercial Energy. The share of the principal commercial fuels, by source of final consumption of energy, has changed considerably from 1966 to 1974, as shown below. With the exception of coal consumption, the consumption of fuels rose considerably over the period, the amount of electricity and of petroleum directly used for energy increasing four to five times. This was mainly due to the rapid increase in the demand of the industrial and transportation sectors and to the substitution of petroleum products for coal in the residential/commercial sector and in the transportation sector. As a result, the share of coal in total demand fell from about 71% in 1966 to 43% in 1974.

Table E 2: COMMERCIAL ENERGY CONSUMPTION BY FUELS

	1966		1974		Average
	'000 TOE	%	'000 TOE	%	growth per annum %
Electricity	260	4.0	1,193	7.9	21.0
Coal	4,586	70.7	6,249	41.2	4.0
Petroleum	1,638	26.3	7,726	50.9	21.4
Total	6,484	100.0	15,168	100.0	11.2

Source: MCI.

3.05 The structure of demand by sector also changed markedly over the period 1966-74 as shown in Table E 3. The relative share of the industrial and transportation sectors increased from 19.5% and 11.5% respectively in 1966 to 35.7% and 13.5% respectively in 1974. The share of the residential/commercial sector declined from 58 to 46%. This is the reflection of the development policy followed by the country with strong emphasis on industrial development (sector output measured at 1970 prices quadrupled from 1966 to 1974) and restraint on private consumption.

Table E 3: COMMERCIAL ENERGY CONSUMPTION BY SECTOR
('000 TOE)

	1966				1974				Change in Consumption 1966-74				
	Coal	Petro-leum	Elec-tricity	Total	Coal	Petro-leum	Elec-tricity	Total	Coal	Petro-leum	Elec-tricity	Total	%
Industry	417	640	214	1,271	251	4,146	1,015	5,412	(166)	3,506	802	4,142	47.7
Transportation	172	583	-	755	-	2,051	-	2,051	(172)	1,468	-	1,296	14.9
Others	357	340	3	700	124	594	5	723	(233)	254	2	23	0.2
Subtotal	946	1,563	217	2,726	375	6,791	1,020	8,186	(571)	5,228	804	5,461	62.8
Residential/ Commercial	3,640	75	43	3,758	5,874	935	173	6,982	2,234	860	129	3,223	37.2
Total	4,586	1,638	260	6,484	6,249	7,726	1,193	15,168	1,663	6,088	933	8,684	100.0

Source: Mission estimates based on MCI data.

3.06 The comparison of total energy growth with GNP growth measured at 1970 prices over the same period shows that total energy grew at a somewhat lower rate than GNP (7.2% compared to 10.5%) but that commercial energy consumption grew at a higher rate than GNP (11.2% compared to 10.5%). At the same time, the commercial energy intensity of the economy (consumption of commercial energy per unit of GNP) increased slightly, from 3.77 TOE/million Won to 3.98 TOE/million Won.

Table E 4: COMPARATIVE EVOLUTION OF ENERGY AND GNP

	1966	1974	Average rate of growth
GNP at 1970 prices (billion Won)	1,270	3,810	10.5%
Total energy (including noncommercial) '000 TOE	10,372	18,102	7.2%
Commercial energy '000 TOE	6,484	15,168	11.4%
Total energy intensity TOE/million won	6.23	4.75	
Commercial energy intensity TOE/million won	3.77	3.98	.7%
TOE per '000 US$ of GNP	1.83	2.00	1.1%

Source: Table E 3, and IBRD, "Current Economic Position and Prospects of the Republic of Korea," Report No. 768-KO, May 28, 1975.

Table E 5: MAIN PRODUCING SECTORS, CONTRIBUTION TO GNP, COMMERCIAL ENERGY CONSUMPTION, AND ENERGY INTENSITY

	Contribution to GNP (Billion Won)		Commercial Energy Consumption ('000 TOE)		Energy Intensity TOE/ Million Won	
	1966	1974	1966	1974	1966	1974
Industry	339	1,394	1,271	5,412	3.76	3.88
Transportation	75	237	755	2,051	10.06	8.30
Others	1,306	2,184	700	723	0.54	0.33
Total	1,719	3,825	2,726	8,186	1.58	2.14

Source: Table E 3, IBRD, "Current Economic Position and Prospects of the Republic of Korea," Report No. 768-KO, May 28, 1975.

Table E 6: ANALYSIS OF CHANGES IN COMMERCIAL ENERGY, 1966-74

	K_1Q /a	KQ_1/b	KQ/c	Total
Industry	3,925	54	167	4,146
Transportation	1,625	-105	-227	1,293
Others	421	-249	-150	22
Total	5,971	-300	-210	5,461
%	109.3	-5.4	-3.9	100.0
All sectors	3,302	974	1,185	5,461

/a Changes resulting from increase in output alone.

/b Changes resulting from increase in energy coefficient alone.

/c Changes resulting from changes in energy coefficients applied to increases in output.

Note: This table has been derived from the following equations:

$$K_1 = E_1/Q_1$$

$$K_2 = E_2/Q_2$$

in which

K_1 = energy coefficient in 1966
K_2 = energy coefficient in 1974
Q_1 = output at 1970 prices in 1966
Q_2 = output at 1970 prices in 1974
E_1 = energy consumption in 1966
E_2 = energy consumption in 1974

If $Q = (Q_2 - Q_1)$ is the change in output,
$E = (E_2 - E_1)$ the change in energy consumption and
$K = (K_2 - K_1)$ the change in energy coefficient

we can write

$$E = E_2 - E_1$$
$$E_1 = K_1Q_1$$
$$E_2 = K_2Q_2 = (K_1 + K)(Q_1 + Q)$$
$$E_2 = K_1Q_1 + KQ_1 + KQ + K_1Q$$
or $$E = KQ_1 + KQ + K_1Q$$

Source: Mission estimates.

The above figures indicate that although less energy (commercial and noncommercial) is required to produce one unit of GNP, Korea's economy is becoming more commercial energy-intensive and that this trend is likely to continue in the future as changes in the structures of demand, by fuel and by sector occur. In particular, it is likely that substitution of commercial energy for noncommercial energy in the residential sector and an increase in the energy demand in the transportation sector will cause the consumption of energy per unit of GNP to rise above the 1974 levels unless conservation measures are applied.

3.07 A more detailed analysis of the increase in commercial energy demand by the main producing sectors (Tables E 5 and E 6) shows that most of the increase resulted from an increase in output and that changes in energy coefficient in these sectors had only a marginal effect. The same method of analysis applied to all sectors (last line of Table E 6) shows a different distribution of the impact of these parameters on the increase of demand. This is due to the fact that all sectors have not grown at the same pace and that the faster increase in the industrial sector has raised the energy coefficient for the entire economy more than proportionally.

3.08 In the residential sector, the increase in demand may be attributed partly to the substitution of commercial energy for noncommercial energy which, in terms of calorific units (not taking account of relative efficiencies) account for about 30% of the increase and partly to the increase in population and in real disposal income.

3.09 The above analysis is limited to the main producing sectors, mainly because of the availability of data. For the same reason the changes in the efficiency resulting from interfuel substitution and changes in technology have not been taken into account. However it provides a clearer picture of the variations in the pattern of growth and structure of consumption that will be useful in projecting future energy requirements.

Evolution of Primary Energy Requirements

3.10 So far we have analyzed the final demand for energy (how energy is utilized). We now turn to primary energy requirements (how energy is produced). The main difference in the two analyses is the treatment of electricity. In the analysis of final demand, electricity is treated as a fuel, whereas in the analysis of primary energy requirements we are concerned with the way electricity is generated and with the various losses incurred in generation and transmission./1

3.11 Total Primary Energy Requirements. From 1966 to 1974 primary energy requirements grew from 11.2 million TOE to about 20.3 million TOE at an average rate of 8.0% p.a. If noncommercial energy is excluded, the annual

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/1 Energy consumption and losses also occur in the transformation production and distribution of petroleum and coal. However these have been omitted in this report because of the lack of reliable data.

rate of growth of commercial primary energy would be about 11.5% p.a., showing an income elasticity of about 1.10, which is comparable to elasticities observed in Japan, the Republic of China, and in countries in Western Europe (France, Germany, etc.).

3.12 Commercial Primary Energy Requirements. The structure of primary energy demand by source of commercial energy has changed considerably. The share of coal, which accounted for 71% of total demand in 1966, declined to about 38.6% in 1974, while the share of petroleum increased from 24.7% to 59.6%. Similarly the structure of consumption by sector changed. While most of the coal was used in the residential sector, its relative contribution to industry and power generation declined considerably. (In 1966 coal accounted for 78% and 39.5% of thermal power generation and industrial requirements respectively; in 1974 its share was only 5.2% and 5.7%.) This was due partly to the increase in the demand for coal in the residential sector, to the relative stagnation of domestic coal production (para. 4.08), to the comparative technical and economic advantages of petroleum for power generation and industrial use, and to the availability of relatively low cost petroleum supplies until the end of 1973.

Table E 7: STRUCTURE OF COMMERCIAL PRIMARY ENERGY REQUIREMENTS ('000 TOE)

	1966				1974			
	Hydro	Coal	Petro-leum	Total	Hydro	Coal	Petro-leum	Total
Power generation	310	579	164	1,053	320	179	2,932	3,431
%	29.4	55.0	15.6	100.0	9.3	5.2	85.5	100.0
Others	-	4,486	1,638	6,224		6,249	7,726	13,975
%		73.7	26.3	100.0		44.7	55.3	100.0
Total	310	5,165	1,802	7,277	320	6,428	10,658	17,406
%	4.2	71.0	24.8	100.0	1.8	37.0	61.2	100.0

Source: MCI.

3.13 Import Dependence. Primary energy requirements were met by domestic production (hydropower and coal) and imports (petroleum). However as time passed the ratio of domestic production to total demand declined from 75% in 1966 to 40% in 1974. If noncommercial energy is included, the ratios would be 84% and 48% in 1966 and 1974 respectively. In 1974 imports of fuels accounted for 16.2% of total import compared to 7% in 1966. In this Korea followed the same pattern as most nonoil producing countries which replaced domestic solid fuels by imported oil due to its relatively low cost and its convenience.

Recent Evolution of Total Energy Requirements

3.14 Since Korea is largely dependent on imports (para. 3.11), it was hit hard by the increases in the world prices of fuels of 1973 and 1974. The Government of Korea however reacted promptly and launched an interim energy program calling for increased development of domestic resources and nationwide energy conservation. At the same time longer-term plans were prepared that have been aggregated in the FFYP.

3.15 Development of Domestic Resources. The main target of the program was to increase production of domestic coal. For this purpose, the Government increased the price of coal by some 51% and 25.5% in 1974 and 1975 respectively. As a result coal production increased from about 14 million tons in 1973 to over 17 million tons in 1975 (para. 4.08). Current coal production is adequate to meet the demand of the traditional and low-cost residential housing sector. In the medium-term it is not expected that it could be developed sufficiently to allow the economical substitution of coal for petroleum in the industrial and power generation sectors. It is therefore likely that the main result of the increased availability of coal will be to slow down the substitution of petroleum products for coal in the residential and commercial sectors. This is desirable for two main reasons. First, the current supply/demand mix for petroleum products is well balanced and an increase in the demand of middle distillates (kerosene and light fuel oil) could create imbalances which would require additional refinery investments and/or imports of high-priced refined petroleum products. Second, there are in the short term no practical alternatives to the use of coal in the residential sector, and it is therefore advisable that coal production be allocated by priority to space heating and other residential uses.

Energy Conservation Program

3.16 The energy conservation program was decided upon as early as November 1973 and was followed up by additional energy conservation measures in October 1974, and January 1975. The program's objectives are for 10% fuel conservation in industry and power generation under the provision of the Heat Management Law (HML), and 2% and 17% fuel conservation in transportation and residential and commercial sectors respectively under a nationwide education and guidance program. In addition, the price of energy was increased in 1974 and 1975 to reflect the increased cost of imported fuel.

3.17 The HML, which provides for training in heat management, the establishment of energy consumption standards and of heat management committees in about 1,400 plants and for the inspection of consumers' plants is administered by the Industrial Advancement Administration (IAA) and the Korean Energy Management Administration (KEMA) under the supervision of MCI. IAA and KEMA provide technical assistance to large energy users and recommend methods which could be used to improve efficiency and conserve energy. KEMA's staff is qualified and the "heat audit" performed is suitable to identify important and most urgent improvements needed at users' plants. However the total staff and the current budget are limited in relation to the 1,500 industrial plants that are expected to be covered by KEMA's audit teams. (In 1975, complete audits and simple audits were provided to only 100 and 200 plants respectively and

KEMA's test equipment is not entirely adequate for the type of measurement that the audit teams should perform.)

3.18 Although IAA and KEMA's efforts have been useful, it is difficult to assess their results because of the relatively short time elapsed since the programs went into effect. KEMA estimates that if the recommended improvement had been carried out, the resulting savings would have been about 14.5% of 1974 consumption. This is not confirmed by the increase in total energy consumption of more than 8% that was recorded in 1975. This is particularly true for refined petroleum products (diesel oil and Bunker C) which increased by 13% and 9.9% respectively from 1974 to 1975. Although the current rates of increase are lower than the historical trend they are still considerably higher than the rates observed in other countries and than the projected rate of growth for the period 1974-81. This can be explained by three main factors, the low level of fuel prices, the lack of incentives to implement the recommended improvements and inadequate coordination.

3.19 The price of energy has been used to subsidize consumers indirectly, in the residential (coal) and industrial sector (electricity and refined petroleum products). Although prices have been increased in 1974 and 1975, they are still low by comparison to energy prices in other countries and the structure of prices is not conducive to efficient resource allocation. Although some energy prices reflect import parity, particularly for petroleum products, prices and fiscal measures are not widely used to enforce the government energy conservation policy, except in transportation in which gasoline is heavily taxed. We believe that consumers should pay the full cost of the service they are buying (supply of energy) and that energy prices should be related to the long-term marginal cost (LTMC) of supply. If prices of energy do not reflect LTMC, the analysis of the feasibility of improvements in energy efficiency will be distorted and may lead to negative decisions regarding their implementation.

3.20 The "Heat Audit" carried out by KEMA and the resulting recommendations are only indicative. Plant managers, as we understand it, are under no obligation to implement the changes recommended by KEMA. Since prices alone have not been a sufficiently strong incentive for them to take action (para. 3.19) alternative incentives should be used.

3.21 Although the reaction of the Government and to some extent of the business community to the increase of world prices has been rather impressive, responsibilities for program implementation and monitoring are divided among several agencies dealing simultaneously with energy conservation, research and development and environmental protection. This has had a detrimental effect on the efficiency of the overall program, particularly in industry, where it is not obvious that the right priorities are dealt with first and where insufficient attention is given to implementation and monitoring of results.

3.22 Conservation in the residential and commercial sector is usually much more complex than in the industrial sector since the number of consumers is larger and since it is extremely difficult to change the pattern of consumption of households over a short period of time without creating social

inequities. The "Guidance and Enlightenment Program" of the Government of Korea calls for voluntary actions (less light and heat at home, less use of private cars, walking more than 2 km from home to office and school, etc.) whose efficiency is difficult to assess in the short term. However, the target of 17% savings set out in the program appears to be high particularly in a country where a number of households already do not consume large amounts of energy and where there is little "fat" to eliminate. While such efforts are advisable, even if they have limited effects in the short run, it would seem more adequate in the future to put the emphasis on such energy conservation potential as improved building standards, more careful urban planning, use of district heating, and restricted access to low-cost but very energy-intensive appliances.

3.23 In transportation, very substantial increases in the price of gasoline (which is now sold at about US$1.90/gallon) and restrictions on the use of official and private cars have caused the consumption of gasoline to fall sharply from 1973 to 1975 (1975 consumption is about 45% below the 1973 level). However, a number of car owners, mostly taxis in the Seoul area, have been switching from gasoline to liquified petroleum gas (LPG), whose consumption increased from 740,000 tons in 1973 to 1,600,000 tons in 1975.

3.24 The main reason for the switch from gasoline to LPG appears to be the relative price of the two fuels, LPG prices being about 34% lower than gasoline prices. Since the equipment required to use LPG is rather inexpensive, taxi companies decided to substitute LPG for gasoline. This is extremely indicative of the response of consumers to prices in a rather competitive environment and of the shifts in demand which may result from variations in the relative prices of fuels. In this particular case since it was difficult to increase the cost of LPG, which is also used in the residential sector, the substitution could have been avoided, or slowed down by instituting a tax on taxis using LPG instead of gasoline.

4. THE DEVELOPMENT OF THE FUEL AND POWER INDUSTRIES

General

4.01 In this section a brief account is given of recent developments in the main fuel and power industries, namely coal, electric power supply, and petroleum. Within the limit of available data the growth of production, consumption, and productive capacity is analyzed together with a review of the main changes that have occurred in the institutional setup.

The Institutional Framework of the Energy Sector

4.02 Industry Ownership and the Role of the Government. The energy sector consists of a mix of publicly owned, semipublicly owned, and private companies which are under the supervision of the Ministry of Commerce and Industry (MCI). While all companies are theoretically autonomous, each with its own Board of Directors, the influence of government in their development

and operations is very strong. The main areas in which government intervention is felt are pricing of various sources of energy, financing of energy-related facilities, particularly in the coal and power subsectors, and the determination of long-term sector objectives.

4.03 Energy prices are controlled by the Government at the producer and consumer levels. For example, the Government determines the price of coal, power, and petroleum products, and companies require government approval to increase prices. In the petroleum subsector, which is owned in joint venture with foreign oil companies, the government pricing policy has generally been in line with international prices. However in the coal and power subsectors, the government pricing policy appears to have been more concerned with keeping inflation under control and providing relatively inexpensive energy as an incentive to industrial development than with problems of adequate resource allocation and of the financial viability of power and coal companies. This policy has created serious financial problems in the power subsector and in the coal subsector while the petroleum subsector has generally generated sufficient resources to finance expansion.

4.04 Partly because of the inadequate level of prices and partly because of difficulties in mobilizing domestic and external resources for the financing of energy projects, the Government has been heavily involved in providing financial resources for the development of coal mines and of power facilities through a complex system of subsidies and budget allocations. While the policies followed in the coal subsector appear generally satisfactory, the constraints imposed by complex financial arrangements have led to some difficulties in the realization of Korea's first nuclear plant and to delay in the second one.

4.05 Although the objectives of the successive five-year plans are more indicative than mandatory, most energy-related industries are strongly influenced by MCI and the Economic Planning Board (EPB) when planning for future expansion. In some instances, particularly in the power sector, the Government decided unilaterally on the construction of new facilities because it felt that the objectives proposed by KECO were not adequate. Such decisions have had a somewhat detrimental influence on the management and operation of the sector since energy agencies, and more particularly KECO, have had to absorb excess capacity or bear the consequences of decisions which were not fully justified.

4.06 Sector Planning. Korea follows an indicative planning system, somewhat similar to the French system of the 1960s. Under current procedures energy industries are required to prepare five-year development plans, which are discussed with MCI and subsequently with EPB. The main purpose of the discussions is to ensure the consistency of the objectives of the energy sector with overall economic development and of the financial requirements of the sector with projected resources. Although MCI is expected to provide overall sector coordination among the various subsectors, its role appears to have been limited mainly to bilateral discussions with each of the subsectors to ensure that demand would be met, rather than to the review of alternative development strategies based on long-term considerations. Despite some

obvious overinvestment in the power sector, this sytem was considered adequate until the increase in oil prices of 1973 and 1974 which led EPB to reconsider the main features of the country's energy policy and to reassess the development of the sector for the next five years (1977-81). EPB is currently moving away from the concept of meeting the demand at any cost and is increasingly concerned with the optimum allocation of resources in the energy sector to provide adequate supply at least cost. The main areas in which EPB is considering changes in development policies are power and energy conservation. The problems of pricing, financing, and planning are discussed in more detail in the subsector sections below.

The Coal Mining Industry

4.07 The Growth of Production and Consumption. As we have seen in Chapter 2, coal was until recently the main source of energy in Korea and currently accounts for about 40% of total primary energy, excluding noncommercial fuels. Table E 8 gives the past production and consumption of domestically produced coal.

Table E 8: PAST PRODUCTION AND CONSUMPTION OF COAL
('000 Metric tons)

	Production				Consumption		
	DHCC /a	CMM /b	Private	Total	R/C /c	Others	Total
1966	4,704	1,111	5,798	11,613	8,466	6,697	11,769
1970	4,454	1,704	6,236	12,394	10,115	1,876	11,991
1972	3,809	1,853	6,741	12,403	10,513	1,811	12,324
1973	4,245	2,256	7,070	13,571	13,017	1,719	14,736
1974	4,408	2,902	7,888	15,198	13,660	1,290	14,950

/a Dai-Han Coal Corporation.

/b Consolidated Coal Mines.

/c Residential/Commercial.

Source: MCI.

4.08 From 1970 to 1974, the production of coal stagnated at about 12 million t/y. However in 1974 and 1975 substantial production increases were achieved, 12.5% in 1974 and 15.6% in 1975. These increases were accompanied by an increase in the number of mines, particularly the small ones, which grew from 142 in 1971 to 242 in 1974-75. The increase in production and in the number of mines took place after two subsequent increases in the price of coal, increases of 51% and 25.5% in 1974 and 1975 respectively. Although other parameters may have influenced the increase in

coal production, it is significant that both the number of mines and the level of production of private mines have been quite responsive to the increase in price. This indicates that the short-term elasticity of production to prices may be quite high (0.73 in 1974-75 for private mines). However, the optimum level of coal prices required to maximize production in the long term should be studied further (paras. 6.18-6.21). If production appears to be quite responsive to prices, at least in the short term, consumption appears to be rather inelastic and the level of demand to be determined more by the availability of coal than by the level of prices. Although prices increased by 51% between 72 and 74, consumption increased by 21% over the same period.

4.09 The average size of coal mines in Korea is small; 80% of the mines have a productive capacity of 50,000 MT/Y or less and the average production was of about 71,000 MT/Y in 1975. Because of the structure of the coal seams and of the difficulty involved in underground mining of anthracite, productivity is low compared to what is achieved in modern strip mines. Efforts have been made to increase current productivity of 1.1 t/man shift, but it appears that prospects for significant improvements are limited (the maximum production ever achieved in such mines was 3t/man shift). Mining companies have therefore not felt sufficiently confident in the future of the coal mining industry to invest in mechanization, and the Government has not done enough to assist small mines in obtaining sophisticated equipment and particularly boring machines which are costly and might be beyond the financial possibility of small mines. This problem of low mechanization is rather important since the coal mining industry has experienced considerable labor problems (high turnover) partly because of the hard working conditions and the risks involved in underground mining, partly because of the relative stagnation of coal production in the past. Although miners have favorable wage rates compared to workers in other sectors, steps will have to be taken to improve safety and general working conditions if the targets of production for 1981 are to be achieved.

4.10 The residential-commercial sector absorbs about 90% of the domestic coal production principally for space heating and other domestic purposes. Coal is generally used in briquettes in appliances that are particular to Korea (floor heating) and which can hardly use any other kind of fuel. This is a very significant feature of the coal market, since on the one hand it provides a large and stable market for domestic coal, but on the other hand it requires that sufficient quantities of coal are produced each year to meet the residential demand. As indicated in Table E 8, the spread between residential consumption and domestic production is very narrow and any slowdown in production would very likely create shortages of coal in the residential sector. The Government is very conscious of this problem and considers coal an "essential commodity" in much the same fashion as rice. Therefore the Government of Korea has taken specific steps to ensure that adequate financial resources are made available to maintain and develop coal production and to ensure that current and future requirements are met satisfactorily. These measures fall into three main categories: pricing, government subsidies, and mandatory coal allocation by end-use sector.

4.11 Coal Pricing. The current average price of coal is about W 6,400/MT (US$13.2/t) delivered to the distributors. This price, on a straight calorific basis, is equivalent to US$30.6 per TOE. It is our understanding that the price is calculated to cover direct production and transport costs (including depreciation of mining equipment but excluding recovery of the development cost of mines, shaft, tunnels, gangways) and to provide a profit to the mine owner of about 10%. This, however, was not the case in 1966-73, when coal prices were actually below production costs. It was only in 1974 that the price of coal exceeded production cost by a small margin (3%) and in 1975 by about 20%. For the period 1967-73, for which detailed estimates are available, the cost of production of anthracite increased about threefold. This was mainly due to an increase in labor and overhead as shown in Table E 10. The increase in labor cost alone was responsible for 60% of the total increase in price. This is very significant, since it has been a continuing trend in the coal mining industry all over the world and therefore the prime reason for introducing mechanization, particularly in the construction of mine infrastructure (shaft, access tunnels, etc.). Since future increases in labor costs at rates similar and probably higher than those observed in the past are unavoidable, the only way to prevent the production cost of coal from increasing accordingly is to substitute machines when and where economically justified. This problem would warrant a long-term study of the marginal cost of producing coal as explained in para. 6.19. In the meantime, if coal production is to be maintained at the level achieved in 1974 and 1975, prices will have to be increased to reflect variations in costs and maintain a sufficiently attractive return to the producers. In this respect, while it is perfectly understandable for the Government to subsidize the price of coal which is used by the poorest segment of the population, it does not seem reasonable to do it by maintaining producers prices below production cost. Low retail prices would encourage consumption and therefore require increases in domestic production, which can only be achieved if potential and existing producers have sufficient financial incentives to expand existing mines and create new ones. This would be of particular importance in the next five years, in which substantial increases in production are projected.

Table E 9: COAL PRODUCTION COST AND PRICES
(W/t)

	1966	1970	1971	1972	1973	1974	1975
Production Cost (A)	1,561	3,189	3,745	4,497	4,035	4,923	5,308
Prices (B)	1,420	2,541	2,930	3,370	3,370	5,100	6,400
Ratio B/A	0.91	0.80	0.78	0.75	0.83	1.03	1.20

Source: MCI.

4.12 Financing Coal Development. Coal mining requires heavy capital investments at the outset, which the Korean coal mining companies could not possibly cover from their own resources, nor could they borrow from financial institutions because of the relatively poor financial prospects resulting from government pricing policies (para. 4.11). The Government of Korea has therefore decided to subsidize the creation of new mines and the expansion of existing ones to maintain production at a level sufficient to supply the residential sector. The Government of Korea provides grants and concessionary loans equivalent to up to 70% and 15% respectively of the cost of getting a mine into production. The remaining 15% have to be provided by the mine owner(s). This subsidy is administered by the Korean Mining Promotion Corporation (KMPC) which draws its funds from the Government and particularly from the proceeds of a special tax levied on Bunker C. This policy has been instrumental in the increase in production in 1974 and 1975.

Table E 10: COAL PRODUCTION COSTS 1967-1973

	1967		1973		Change 1967-73	
	W/t	%	W/t	%	W/t	%
Labor	824.8	41.7	2,066.0	51.2	1,241.2	60.3
Materials	332.3	16.8	375.0	9.3	42.7	2.1
Administration	104.8	5.3	189.5	4.7	4.7	4.1
Overhead	302.6	15.3	601.5	14.9	298.9	14.5
Subtotal	1,564.5	79.1	3,232.0	80.1	1,667.5	81.0
Nonoperating costs	54.5	2.7	282.5	7.0	228.0	11.2
Marketing	359.0	16.2	520.5	12.9	161.5	7.8
Subtotal	413.5	20.9	803.0	19.9	389.5	19.0
Total	1,978.0	100.0	4,035.0	100.0	2,057.0	100.0
US$/t	4.08		8.30		4.20	

Source: MCI.

4.13 This policy is a good example of government intervention which can efficiently serve several purposes. On the one hand, by increasing the cost of Bunker C by 5%, it discourages consumption of refined oil products. On the other hand, it provides resources for the development of domestic resources which can be substituted for imported oil in the residential sector. It can be argued however that the tax could be extended to kerosene and liquified petroleum gas (LPG), which are not taxed although they are direct substitutes for coal on the residential market. So far the proceeds of the tax on Bunker C have been adequate to support increased production, but the level of the tax may need to be adjusted to provide sufficient resources to cover future expansion.

4.14 Mandatory Allocation of Coal to End Use Sectors. Because coal is an essential commodity in the residential sector, the Government has limited non-residential uses of domestic coal. In view of the importance of the residential sector and of the social implications of coal shortages, this policy appears justified until alternative sources of supply have been developed. However, it has created considerable problems in the operation of coal-fired power plants which were designed to use a mixture of a given quality of coal and of heavy fuel oil in the ratio 90-10, and are now using coal of lower grade and or coal-oil mixtures which are not in accordance with their design specifications, thus lowering efficiency and creating maintenance problems. If this policy is maintained, and it is likely that it will, then steps should be taken to modify the boilers on the basis of more liquid fuels utilization.

The Power Industry

4.15 Existing Organization. There are three operating companies: (i) KECO - owned about 50/50 by government and private interests - which is the sole distributor of electric power throughout the entire country and currently owns and operates the bulk of the country's total generating capacity. Except for multipurpose projects, KECO is presently responsible for the planning and construction of all power projects; (ii) the Kyongin Energy Company, a private generating company with an installed capacity of 325 MW whose entire output is sold to KECO; and (iii) the Industrial Site and Water Development Company (ISWACO) which owns and operates the 200 MW Soyanggang multipurpose project and sells its power output to KECO. ISWACO is presently constructing the 90 MW Andong multipurpose project. Relations between the various ministries and government agencies and the operating companies are summarized in the following paragraphs.

4.16 The Ministry of Commerce and Industry (MCI) is the main government authority responsible for energy matters. As provided in the Electric Enterprise Law No. 2509 of February 8, 1973, it regulates and supervises the electric industry. Under this law, the MCI has authority to sanction all power projects other than multipurpose and nuclear projects (para. 4.17). MCI also has authority to license electric suppliers and to establish and enforce industry technological standards. The MCI supervises KECO's activities. It approves its budget and exercises the Government's stockholder's rights in consultation with the Economic Planning Board (EPB) and the Ministry of Finance (MOF). The MCI also recommends government action on electric rates and is the final arbiter for consumers' and public complaints.

4.17 The Ministry of Construction (MOC) has jurisdiction over the survey, development and use of water resources throughout the country. Directly or through ISWACO under its supervision, it constructs, owns and operates all multipurpose projects./1 The power output from such projects is sold to KECO

/1 Hydro projects specifically for power generation are carried out by KECO with MOC's approval.

under contractual arrangements which are finalized at a late stage when the projects are virtually completed. This exemplifies KECO's minimal involvement in the development of multipurpose projects. Indeed, it appears that there is a lack of coordination at the planning stage between the MOC and the MCI and this could lead to suboptimal project selection and design.

4.18 The Ministry of Science and Technology (MOST) is responsible for the licensing, regulation and supervision of nuclear power activities. However, the design, procurement, construction and operation /1 of nuclear power plants are at present KECO's responsibilities./2

4.19 KECO's Organization. KECO's Board of Directors is composed of up to eight members elected at the general meeting of stockholders for a period of three years. The President and Executive Vice-President are members of the Board and are appointed from the directors by the President of the Government of Korea upon recommendation by MCI. The remaining directors are vice presidents in charge of the company's various departments. The Board has the dual function of laying down policies and of carrying out the management of the company. However, the law does not provide for much delegation of authority to KECO and final approval remains with MCI.

4.20 In the present organization, five vice presidents share the supervision of the various company's departments. One vice president is in charge of the Planning,/3 Safety and General Affairs Departments. Another is in charge of Finance /4 and Purchase and Supply./5 A third is in charge of Power Generating /6 and Atomic Power./7 A fourth supervises Business and Distribution /8

/1 Beginning in 1977 when the first nuclear power reactor is expected to be commissioned.

/2 The Government of Korea is considering establishing a separate organization to construct, own, and operate nuclear power plants. This would not be a helpful step with regard to integrated development planning for the sector. This problem is analyzed further in para. 6.30.

/3 In charge of load forecasts, system planning, financial planning, budget, and cost control.

/4 Deals with accounts, collections, and funding.

/5 Controls the domestic and overseas purchases in liaison with the Office of Supply of the Republic of Korea (OSROK).

/6 Deals with operation and maintenance of generating plants.

/7 Deals with the planning and construction of nuclear power plants.

/8 Deals with the supply of electricity distribution and controls 20 branch offices.

and Rural Electrification./1 A fifth looks after Transmission and Substation /2 and Power Development./3

4.21 Access to Electricity Supply. The electrification process is fairly well advanced in Korea. About 63% of the population had access to electricity supply by the end of 1973 (90% in urban areas; 47% in rural areas). The average household used 580 kwh and 564 kwh in 1973 and 1974 respectively for lighting and other residential purposes.

4.22 Pattern of Consumption. Total consumption was about 14,048 GWh during 1974 (excluding consumption by self-producers), representing a per capita consumption of 420 kwh, which is about 25% of the world average and 10% and 70% of the per capita consumption in Japan and Brazil respectively in 1973. Over 80% of that consumption was used by industry as shown in Table 11 below:

Table E 11: ELECTRICITY USE IN 1974

	Gwh	%
Lighting		
Residential	1,074	12.1
Street lighting	41	-
Public	718	5.4
Subtotal	2,463	17.5
Industry	11,585	82.5
Total	14,048	100.0

Source: KECO.

As might be expected, the system load factor is rather favorable, standing at 66% in 1974 even though there is no repression of peak demand. Peak load generation was 2,911 kw and 3,351 kw in 1974 and 1975 respectively.

/1 Deals with the planning and implementation of rural electrification programs.

/2 In charge of the operation and maintenance of existing transmission facilities and of the construction of new transmission and distribution facilities.

/3 In charge of the construction of new power generating stations other than nuclear ones.

4.23 Past Growth of Electricity Consumption. Growth of electricity consumption has been rapid in the past - 21.5% average increase per annum over the period 1966-75 - with sales to large industrial consumers growing particularly rapidly, reflecting the government policy of promoting industry. Table 12 below summarizes the past growth of KECO's sales by tariff categories and also indicates losses and generation.

Table E 12: PAST GROWTH OF ELECTRICITY SALES AND GENERATION /a

	1966		1974		Average Growth Rate 1966-1974
	(Gwh)	(%)	(Gwh)	(%)	(%)
Sales Category					
Lighting	502	(16.7)	1,853	(13.2)	17.5
Small power	311	(110.3)	966	(6.8)	15.1
Large power	2,165	(72.0)	11,169	(79.5)	22.8
Agriculture	30	(1.0)	60	(0.5)	9.0
Total Sales	3,008	(100.0)	14,048	(100.0)	21.3
T & D losses	664		1,864		13.7
Auxiliaries use	213		923		20.0
Gross generation	3,885		16,835		20.1

/a Excluding self-producers.

Source: KECO.

Latest available data on actual sales show a considerable slowdown in growth. For 1974 as a whole, sales were 14,050 Gwh, or 13.6% higher than during 1973. Sales of electricity dropped considerably, however, during the second half of 1974, when sales were only marginally higher than in the previous year. The sluggishness in the development of power sales observed during the second half of 1974 can be directly attributed to the general slowdown in economic activity and it is expected that sales will grow again at higher rates as the economy recovers its momentum. Total sales in 1975 were 16,630 Gwh, 18.4% higher than in 1974.

(a) Generation

4.24 Existing Facilities. As of December 31, 1974, the total installed generating capacity in Korea was about 4,820 MW, of which 13% was hydro, 79% was steam, and the 8% balance was diesel and gas turbine. Table E 13 below shows the breakdown by plant categories and by ownership.

Table E 13: GENERATING CAPACITY AT END OF 1974

	KECO (MW)	Kyongin (MW)	MOC (MW)	Producers (MW)	Total (MW)	Total (%)
Hydro	420	-	200	-	620	(13)
Steam	3,320	325	-	176	3,821	(79)
Diesel/Gas Turbine	259	-	-	121	380	(8)
Total	3,999	325	200	297	4,821	(100)

Source: KECO.

Of the 3,821 MW of steam capacity, 82% are oil fired and 18% are coal fired. Hydro stations are generally of relatively small size and low head. When comparing the 4,524 MW of capacity available to KECO (from its own plants and its purchases) with KECO's peak load requirements of 2,922 at generator terminals in 1974, one finds that total generating capacity exceeds considerably what would normally be required to ensure adequate security of supply. However, most of this excess is the result of the Government of Korea's decision to disregard KECO's long-term load forecast and to add 1,600 MW to the system's generating capacity in 1967, and to create three independent power companies whose output had to be absorbed by KECO. Part of this excess has already been absorbed, but it will take until 1981, according to current development plans, before reserve margins are brought down to an acceptable level (see para. 6.35).

4.25 In the early 1970s, Korea decided to embark on a very large nuclear generating program aimed at achieving more than 50% nuclear generation by 1986. The first nuclear plant, Ko-Ri #1, with an installed capacity of 600 MW, is expected to go on stream by mid-1977, according to current plans. Although construction has been carried out efficiently, the plant has been delayed by strikes of equipment suppliers and lack of coordination among foreign contractors and there are some doubts that this schedule can be adhered to. The second nuclear power plant which was scheduled for 1978-79 has now been delayed until 1982, because of problems in securing adequate financing and of a complete review of KECO's long-term development plans (see para. 6.32).

(b) Transmission and Distribution

4.26 The status of transmission and distribution facilities is summarized in Table E 14.

Table E 14: TRANSMISSION AND DISTRIBUTION FACILITIES ON 12/31/74

	Line Length (Km)	Substation Capacity (MVA)
345 kV facilities	189.3	/a
154 kV facilities	2,004.8	3,752.8
66 kV facilities	3,501.7	1,844.3
22 kV facilities	1,032.3	884.8
Subtotal transmission	6,728.1	6,481.9
Distribution facilities	6,730.5	3,164.8

/a Under construction.

Source: KECO, Statistics of Electric Power in Korea, 1975.

The development of transmission and distribution facilities - together with a geographically well-balanced development of generating capacity - has permitted a reduction in line losses from 15.7% in 1966 to 12.1% in 1974. The 154-kV transmission network - which interconnects all major generating stations and load centers of Korea with the exception of the islands - has, until recently, been generally adequate as the system backbone for bulk supply. It will be progressively superseded by a 345-k transmission system, which will interconnect the main generation plants and particularly the first nuclear plant at Ko-Ri. Transmission and distribution (T and D) systems have been given second priority in the past, receiving only 23% of the total power sector investment during the 1962-73 period. Between 1973 and 1975, however, additions to T and D were substantial, due particularly to the construction of the 345-kV transmission system and to substantial additions to the number of transmission substations (19.5%) and distribution facilities (38% and 49% respectively for distribution lines and substations). Despite these additions, T and D losses are still too high and should be cut down to about 10%. It is expected that the commissioning of the 345-kV system will improve operations, but KECO should carry out an analysis of its system to determine how T and D losses could be further reduced.

(c) Electricity Pricing and Financial Performance

4.27 As shown in Table E 15, KECO's financial situation has gradually deteriorated over the past several years, particularly since 1971. It reached a critical stage in 1973 with a negative internal contribution to investments (about 60%), a rate of return on investments which has dropped to about 6% (from about 9% in 1970), a debt service coverage of only 0.7, and an operating ratio of 0.95. The main reasons for this unfavorable trend are temporary overinvestment in generation facilities; insufficient tariff adjustments for

achieving reasonable portions of investment financed internally; and, as a consequence, excessive borrowing at comparatively short-term and high-interest rates. This situation became worse in 1974 despite an increase in tariff, which brought the average income per kwH from W 7.3 in 1973 to W 10.7 in 1974, the operating surplus dropped from 10.9% in 1973 to 2.5% in 1974. Because of its relatively poor financial performance, KECO's management has been heavily criticized, and the Government of Korea is seriously considering a reorganization of the power subsector. KECO appears to have the technical and economic capability of carrying out adequate system planning and of implementing its development program, as evidenced by its past performance in load forecasting and system development. However, although KECO is actively preparing its next five-year development plan, some crucial issues (mix of generating plants, powe: pricing, KECO's structure, etc.) are still being reviewed by MCI and EPB. Unless these issues are resolved it is unlikely that KECO's performance will improve in the future.

The Petroleum Industry

4.28 General. Although Korea has no hydrocarbon resources, it has a large petroleum industry including refining, transport, and distribution, which is supplied from petroleum imported principally from the Middle East. The role of the petroleum industry is primarily to supply the domestic market, but it has also been exporting significant quantities of refined oil products to neighboring countries, principally Japan and Singapore. However as the petrochemical sector grows, it is expected that exports of petroleum products will be gradually phased out.

4.29 Growth of Petroleum Production and Consumption. The first petroleum production facility was created in 1964, when the Ulsan refinery owned by a joint venture of the Korean Oil Corporation (KOC) - a government owned company - and Gulf Oil Corporation, went on stream with a capacity of 35,000 b/d (about 1.75 million ton/y). Since 1964, the Ulsan refinery has expanded to about 215,000 b/d (10.75 million tons/y). Two more refineries have been created, owned by the Honam Oil Company and Caltex Oil Corporation (US), and the Kyongin Energy Corporation and Union Oil Corporation (US) respectively. The current refining capacity is about 435,000 b/d (21.75 million t/y). This remarkable increase of about 28.6% p.a. was required to supply domestic demand for fuels, which grew from 1.8 million tons in 1966 to about 10.6 million tons in 1974 (at an average rate of 25% p.a.), and to meet the growing requirements of the petrochemical industry, which accounts for about 14% of total demand and has been growing at nearly 35% p.a. Exports (principally subcontracting and balancing) have been growing at about 21.5% p.a. from about 350,000 tons in 1966 to about 1.7 million tons in 1974. However, exports in 1974 were about 16% lower than in 1973. The two largest refineries are located on the southern coast, partly because of the deep-water access, which makes it possible for very large crude carriers (VLCCs) to unload directly though a system of buoys and partly for strategic reasons. The third refinery is located at Inchon on the northwestern coast close to the Seoul market and the Kyongin power plant, which it was intended to serve originally.

Table E 15: KOREA ELECTRIC COMPANY (KECO)
Summary of Financial Data

	Rate of Return on Average Net Fixed Assets in Operation (after deduction of income tax and dividends-assets revaluation up to 1974). (1)	Percentage of Total Investments financed through Net Internal Cash Generation (after deduction of income tax and dividends) (2)	Debt Service Coverage (times Total Debt Service covered by Gross Internal Sources (3)	Ratio Long-Term Debt/Equity (4)	Operating Ratio (Operating Expenses including Interest divided by Operating Revenues) (5)	Tariff Increase (6)
ACTUAL						
1970	9.3%	8.8%	1.5	62:38	0.80	-
1971	6.4%	-	1.2	66:34	0.90	-
1972	6.5%	(38.1%)	0.8	72:28	0.93	15.0%
1973	5.8%	(60.2%)	0.7	74:26	0.95	5.6%
1974 (provisional)	4.5%	(15.7%)	0.9	61:39	0.95	30% and about 36%/a

/a Effective December 7, 1974, electricity rates were increased 42.4% except for domestic consumption - rates were further increased in December 1975.

Source: IBRD.

4.30 The Kyongin refinery is a simple refinery which produces a limited range of products, mostly fuels. The two others are more complex refineries, producing fuels and petrochemical feedstock. Around the Ulsan refinery a large industrial complex including petrochemical and fertilizers has been created which absorbs a substantial part of the refinery production.

4.31 Petroleum products are transported through a combination of pipeline, railways, and coastal tankers. The most important mode is coastal transport, although the two southern refineries are now using a military pipeline to supply the Seoul area.

4.32 Consumption of Petroleum Products. The structure of demand by end use changed considerably from 1966 to 1974 as shown below. In terms of average growth per annum, the most important increase was recorded in the power generation and residential-commercial (R/C) sectors, in which demand increased significantly faster than total demand. This is mainly due to the substitution of heavy fuel oil for coal in the power generation sector and to the develoment of modern housing units, mostly multistoried buildings, using fuel oil for space heating. Contrary to most countries transportation demand grew at a lower rate than total demand mostly because private ownership of cars has been discouraged (Korea has only about 200,000 road transport vehicles, of which fewer than 50% are private cars), and gasoline prices have been kept at a high level. Demand in the industrial sector has grown faster than sector output, measured at 1970 prices, reflecting the decline of coal and the development of energy-intensive industries: construction material, metallurgy, etc.

Table E 16: STRUCTURE OF PETROLEUM CONSUMPTION BY END USE SECTOR
(Fuel only)

	1966		1974		Difference		Average growth p.a.
	'000T	%	'000T	%	'000T	%	%
Power generation	164	9.1	2,932	27.5	2,768	31.2	43.4
Industry	640	35.5	4,146	38.9	3,506	39.5	26.3
Transportation	583	32.3	2,051	19.2	1,468	16.6	17.0
R/C	75	4.2	935	8.8	860	9.7	37.0
Others	340	18.9	594	5.6	254	3.0	7.2
Total	1,802	100.0	10,658	100.0	8,856	100.0	25.0

Source: MCI.

4.33 The change in the structure of demand by sector is reflected in the structure of demand for individual products, as shown in Table E 17.
The most remarkable change is the very large increase in the demand of Bunker

C (heavy residual fuel oil), which, as already mentioned, is explained by the rapid growth of petroleum demand in the power generation and industrial sector and the relatively small increase in gasoline as a result of the government policy of restricting access to private car ownership. So far market requirements and refinery yield have been matched satisfactorily, without inbalances requiring imports of products. In the future, however, if the internal demand for light fuels (gasoline, kerosene, and LRFO) and for petrochemicals grows faster than heavy fuel oil requirements, Korea may have to import light products or to install more sophisticated equipment (reforming and cracking) in existing refineries.

Table E 17: STRUCTURE OF TOTAL DEMAND /a BY PRODUCTS

	1966		1974		Difference		Average growth p.a.
	'000 m^3	%	'000 m^3	%	'000 m^3	%	%.
Energy products							
LPG	9.6	0.5	293.9	1.7	283.4	2.0	50.3
Gasoline	343.5	13.5	697.9	4.2	354.4	2.5	9.3
Kerosene	135.6	5.3	385.1	2.3	249.5	1.8	14.9
Diesel	661.6	26.0	2,918.3	17.5	2,256.7	16.0	20.4
L.R.F.O./b	451.4	17.7	693.5	4.2	242.1	1.7	5.2
Bunker C	767.6	30.1	8,821.8	53.0	8,054.2	57.1	35.7
Jet fuel	124.7	4.9	617.8	3.7	493.1	3.5	22.2
Subtotal	2,494.0	98.0	14,427.4	86.6	11,933.4	84.6	24.6
Nonenergy Products	52.0	2.0	2,222.0	13.4	2,170.0	15.4	59.5
Total	2,546.0	100.0	16,649.4	100.0	14,103.4	100.0	26.5

/a Includes exports.

/b LRFO = Light Residual Fuel Oil.

Source: MCI.

4.34 The impressive growth of total petroleum demand (including exports) slowed down somewhat after 1970; the average rate of increase between 1970 and 1974 was only 11.7% compared to an average rate of about 25% from 1966 to 1974. This was due partly to somewhat slower growth in industrial production and to the increase in the price of petroleum of 1973-74 (para. 4.35). However in 1973, when GNP and industrial production increased at rates even

higher than those of the late 1960s, total petroleum demand increased by 19% and total domestic demand by 17%. The increase in petroleum prices of October 1973 and subsequent Government of Korea action put an abrupt stop to petroleum growth, and in 1974 total demand increased by only 1.6% and domestic demand by about 4%.

4.35 The Impact of the Increase in World Petroleum Prices. Since Korea imports the totality of its petroleum requirements, it was severely hit by the increase in world oil prices. The petroleum import bill increased from about US$300 million in 1973 to about US$1,120 million in 1974, and the share of petroleum in total imports increased from about 7% in 1973 to 16.2% in 1974, surpassing food imports for the first time in ten years. Currently petroleum imports account for about 25% of all export earnings excluding fuels.

4.36 On the internal market the increase in the cost of petroleum supplies was reflected by an increase in the price of domestic products, and more particularly of light products (gasoline, kerosene); as a result the consumption of gasoline and kerosene in 1974 dropped below the level of 1973. In 1975 gasoline consumption continued to drop by 6.4%, while kerosene demand exceeded the 1973 level by 3.6%.

Table E 18: COMPARISON BETWEEN FUEL COSTS /a AND OUTPUT IN THE MANUFACTURING SECTOR

	Billion W	Ratio Fuel Cost/Sector Output %	US$ million
Sector output 1974 /b	1,962.4		4,045
Petroleum cost			
Power generation /c	91	4.6	187.6
Transportation /d	39.8	2.1	82.0
Industry /e	161.4	8.2	332.7
Total	292.2	14.9	602.3

/a Valued at US$80/t c.i.f.
/b Measured at 1974 market prices.
/c 80% of total oil used in power generation.
/d 50% of total oil used in transportation.
/e 100% of total oil used in industry.

Source: Mission estimates.

Demand for other products slowed down in 1974 but resumed growing in 1975, though at somewhat lower rates than previously. The increase in the price of refined products was accompanied by energy conservation measures. These measures, which affect all sectors, do not appear to have had a lasting effect on consumption, particularly of heavy fuels.

4.37 The reaction of the Government, as well as the pricing policy of petroleum products followed in the past, have been instrumental in cushioning the impact of the increase in the cost of petroleum supplies. However, it is apparent that the world recession that followed the 1973 and 1974 increase in the world price of petroleum has been instrumental in keeping consumption under control, and that resumption of economic growth would result in further growth in petroleum demand, since on the one hand interfuel substitution is potentially limited and on the other hand the cost of fuels, even after the price increase, is a comparatively small component of the cost of industrial products. A simple comparison of the cost of petroleum used directly and indirectly in industry and of the value of the output of the manufacturing sector in 1974 shows that fuel costs account for 14.9% of the total, of which direct fuel expenses, those directly perceived by the industrialist, are only 8% (Table E 18, p. 30).

4.38 This is also evident in the schedule of taxes on oil products, which favors kerosene and heavy fuel oil on which no taxes and 5% taxes are levied respectively, compared to a tax rate of 20% on light fuel oil, 40% on diesel fuel and 300% on gasoline. The Government's pricing policy has been understandably to promote industrial development by providing low cost energy to the productive sector and by taxing heavily the nonproductive ones. It is, however, questionable whether such a policy can be continued when the main potential for energy savings is in the industrial sector and when any meaningful conservation policy should be supported by a more realistic approach to pricing of petroleum products, in which prices would reflect the cost to the community of petroleum supplies.

5. CURRENT SITUATION AND FUTURE PROSPECTS

General

5.01 Chapters 2 and 4 describe the evolution of the sector and of particular subsectors (power, coal and petroleum) and analyze the main changes that occurred in the structure and volume of supply and demand. The purpose of this Chapter is to review the energy program proposed for the next five years (1977-81) to assess the policy recommendations included in the FFYP, and to determine what issues constraints and problems are or might become obstacles to the efficient operation of the energy sector. This section is based on information collected by the Mission in February 1976, and on the discussions held in Washington in May 1976 on the draft FFYP. Since this date, the Government has finalized the plan and has modified some of its earlier projections in the light of further studies. Although the Mission has access to the new aggregate numbers, it has not had the opportunity of reviewing the subsector data. We have not therefore revised our earlier analysis, which we still consider adequate in substance, but we have incorporated some footnotes which indicate where possible the main changes between the draft FFYP and its final version.

Prospects for the Development of the Energy Sector

5.02 General. The energy consumption and production projections used below have been derived from information submitted to the mission in February-March 1976, and from additional information submitted during the visit of a Korean delegation to the Bank in May 1976.

5.03 Projected Structure of Final Demand in 1981. Total final consumption in 1981 is expected to be of about 29.0 million TOE, which corresponds to an average increase of 6.7% p.a. over the 1974 consumption. Per capita consumption would be about .740 TOE showing an increase of about 35% over the 1974 figure. The share of noncommercial energy in total final demand would be 7.9%, compared to about 16% in 1974.

(a) Commercial Energy

5.04 The distribution of final energy by source of final consumption should be as follows (Table E 19).

Table E 19: STRUCTURE OF FINAL CONSUMPTION OF COMMERCIAL ENERGY /a

	1974		1981		Average Growth
	'000 Toe	%	'000 Toe	%	p.a. %
Electricity	1,193	7.9	3,230	12.3	15.3
Coal	6,249	41.2	8,954	34.0	5.3
Petroleum	7,726	50.9	14,153	53.7	10.1
Total	15,168	100.0	26,337	100.0	8.2

/a On the basis of the final FFYP, total final consumption in 1981 should be:

	'000 TOE	%
Electricity	3,370	11.3
Coal	8,954	30.0
Petroleum	17,501	58.7
	29,825	100.0

which appears more realistic, particularly for petroleum. However, no detailed analysis of these figures is yet possible as no breakdown by end uses was provided.

Source: Mission estimates derived from MCI data as of March 1976.

The share of coal in total demand will continue to decline, while the share of petroleum will continue to increase, though at a much slower pace than over the 1966-74 period. The increase in the share of electricity will be comparable to the increase observed between 1966-74.

5.05 The comparison of total energy growth with GNP growth shows an elasticity of energy to GNP of 0.95 compared to 1.08 over the previous period and a decrease in energy intensity per unit of GNP (Table E 20).

Table E 20: COMPARATIVE PROJECTION OF GNP AND ENERGY

	1974	1981	Average growth p.a. %
GNP at 1970 prices	3,825	6,825	8.6
Total energy (including noncommercial energy) '000 TOE	18,568	28,591	6.7
Commercial energy	15,634	26,337/a	8.2
Total energy intensity TOE/million Won	4.85	4.2/a	-
Commercial energy intensity TOE/million Won	4.08	3.86/a	-
TOE/000 US$ of GNP	1.98	1.87/a	-

/a Using the higher values given in the footnote to Table E 19, these values become:

Total energy intensity	4.70
Commercial energy intensity	4.36
TOE/'000 US$ of GNP	2.11

Source: Mission estimates.

5.06 Table E 21 (p. 34) shows that the structure of final consumption of commercial energy by sector is not expected to change over the next five to six years, and therefore the responsibility of each sector in total increase of demand will be proportional to its share in total demand.

5.07 Table E 22 (p. 35) summarizes the projections of the respective shares of the main producing sectors in GNP and of their energy consumption in 1981. These figures show that less energy would be required in 1981 to

Table E 21: COMMERCIAL ENERGY CONSUMPTION BY END-USE SECTOR
('000 TOE)

	Actual - 1974				Projected - 1981				Change in Consumption 1974-81				
	Coal	Petro-leum	Elec-tricity	Total	Coal	Petro-leum	Elec-tricity	Total	Coal	Petro-leum	Elec-tricity	Total	%
Industry	251	4,146	1,015	5,412	415	7,238	2,843	10,496	164	3,092	1,828	5,084	45.3
Transportation	-	2,051	-	2,051	43	4.200	-	4,243	43	2,149	-	2,192	19.6
Others	124	594	5	723	-	841	13	854	(124)	247	8	131	1.2
Subtotal	375	6,791	1,020	8,186	458	12,279	2,856	15,593	83	5,488	1,836	7,407	16.1
Residential/ Commercial	5,874	935	173	6,982	8,539	1,874	373	10,786	2,665	939	200	3,804	33.9
Total	6,249	7,726	1,193	15,168	8,897	14,153	3,229	26,379	2,748	6,427	2,036	11,211	100.0

Source: Mission estimates based on draft FFYP projections. See note to Table E 19 above.

produce one unit of GNP, which implies that in the absence of profound structural changes, energy would be used more efficiently and that energy conservation will be developed. Energy intensity in industry is projected to decrease by about 19%, despite the deepening of the industrial structure and the development of the domestic production of raw materials and intermediate goods. In transportation and other sectors the situation will not change. A more detailed analysis of the projected final consumption shows that while the projected growth in output is responsible for most of the growth in energy demand, the projected reduction in energy intensity in industry has a considerable impact on future demands (Table E 23 below).

Table E 22: MAIN PRODUCING SECTORS, CONTRIBUTION TO GNP, COMMERCIAL ENERGY CONSUMPTION AND ENERGY INTENSITY

	Contribution to GNP (Billion Won)		Commercial Energy Consumption '000 TOE		Energy Intensity TOE/million W.	
	1974	1981	1974	1981	1974	1981
Industry	1,394	3,214	5,412	10,496	3.88	3.26
Transportation	247	472	2,051	4,243	8.30	8.98
Others	2,184	3,139	723	848	0.33	0.30
Total	3,825	8,625	8,186	15,587	2.14	1.80

Source: Mission estimates based on draft FFYP projections. See note to Table E 19 above.

Table E 23: ANALYSIS OF CHANGES IN FINAL DEMAND FOR COMMERCIAL ENERGY 1974-81 /a

	K1 Q	KQ1	K Q	Total
Industry	7,061	-864	-1,128	5,069
Transportation	1,867	168	153	2,188
Others	315	-65	-29	221
Total	9,243	-761	-1,004	7,478

/a The symbols used in this table are similar to those in Table 6.

Source: Mission estimates based on draft FFYP projections. See note to Table E 19 above.

(b) Projected Primary Energy Requirements

5.08 The total primary energy requirement should increase from about 20.3 million TOE in 1974 to about 34.6 million TOE in 1981 at an average rate of 7.9% p.a. (including noncommercial energy). Commercial primary energy requirements should increase from about 17.4 million TOE to 32.3 million tons at about 9.2% p.a., showing an income elasticity of about 1.07 to GNP, slightly lower than over the preceding period.

5.09 The share of coal in total primary energy requirements should remain almost constant, while the share of petroleum will continue to increase. Hydropower is expected to increase slightly, and be complemented by nuclear power which would contribute about 2.2% to the total energy supply.

5.10 The ratio of domestic primary energy production to total demand will decrease from 39% in 1974 to about 34% (excluding noncommercial energy) and from 48% to 38% if noncommercial energy is included.

Main Features of the Proposed Energy Policy Over the Next Five Years

5.11 The FFYP contains the basic objective of the proposed Korean Energy Policy over the next five years and of the main policy actions that will be required to achieve these. The main objectives are a stable supply of energy, the maximum development and exploitation of domestic energy resources and a rational utilization of energy. To achieve this the following policy actions are recommended:

(a) Stable Supply of Energy

5.12 Since Korea's dependence on imports will continue to increase during the next five-year plan it is recommended that a long-term procurement plan for imported energy be drawn up (petroleum and coal) and that adequate storage facilities be developed. At the same time exploration for and development of domestic resources (mainly coal and hydroelectricity) should be accelerated and potential tidal power resources should be accelerated.

(b) Maximum Exploitation of Domestic Energy Resources

5.13 The FFYP recommends that the development of domestic energy resources be supported by adequate pricing policies, particularly in the coal mining industry, and that adequate measures be taken for the financing of coal mines (tax on refined oil products), modernizing mining technology, and improving the working and living conditions of coal miners. (These measures are discussed in more detail in Chapter 6).

(c) Rational Utilization of Energy

5.14 The Korean economy should become more energy-conservation oriented and steps should be taken to improve energy efficiency at user plants, promote energy conservation in the residential commercial sector, and develop new and more efficient energy utilization techniques based on the results of research and development studies carried out in developed countries.

5.15 In addition to these facilities, specific targets and policies have been set for each of the fuel and power industries (Chapter 6).

Proposed Investments in the Energy Sector

5.16 The proposed investment plan for the FFYP is summarized in Table E 24 (p. 38).

5.17 The total cost of the energy program at 1975 prices, including interest during construction, is estimated at about W 2,740 billion (US$5.65 billion), of which about 84% is for power facilities, the remainder for coal, 7%; petroleum, 6%; and others 3%. Total investment in the energy sector should account for about 16.5% of gross investments, of which the power industry alone will account for 13.8%.

5.18 It is expected that this program will be financed by government funds, internal cash generation, domestic and foreign borrowings and foreign investments. (See following pages, Table E 25).

5.19 As indicated in Table E 25 (p. 39), the financing of the energy and power programs is heavily dependent on foreign borrowings and investments. Cash generation particularly in the power industry covers only a minimal part of the total expenditures.

Evaluation of the 1977-81 Energy Program

5.20 Supply-Demand Projections. To some extent the FFYP forecast resembles the "technical fix-scenario" in the 1974 study of the US energy outlook by the Ford Foundation. The forecast appears to be predicated on an improvement in the efficiency of the economy in the utilization of energy (lower elasticity of demand for commercial energy to GNP than in previous plans, lower energy use per unit of GNP). A comparison of the historical trends with the current forecast shows that the forecast for total primary energy requirements and for final demand in the four main consuming sectors (power generation, industry, transportation and residential) is somewhat lower than the extrapolation of the past trends (Table E 26 p. 40).

Table E 24: SUMMARY INVESTMENT PLAN IN THE ENERGY SECTOR 1977/1981

	Billion Won	Percentage	US$ Million
Power			
Generation	1,350	49.4	2,783
T and D	824	30.2	1,699
Others	125	4.6	258
Subtotal	2,299	84.2	4,740
Coal	189	6.9	390
Petroleum			
Refining	129.0	4.7	266.0
Transport	32.0	1.2	66.0
Subtotal	161.0	5.9	332.0
Noncommercial energy	3.0	1.1	6.6
R&D	44.0	1.6	90.7
Energy conservation	35.0	1.3	73.0
Total	2,731.0	100.0	5,632

Source: Draft FFYP projections as of June 1976.

Table E 25: SUMMARY FINANCING PLAN
(million US$/%)

	Government Funds	%	Internal Cash Generation	%	Domestic Loans	%	Foreign Loans	%	Foreign Investments	%	Total Amount	%
1. Power	1, 227.6	88.4	604.3	62.4	931.3	87.0	1,993.8	92.6	-	-	4,757.9	84.3
%	25.7		12.7		19.6		42.0				100.0	
2. Coal	127.0	9.2	116.8	12.1	128.4	12.0	17.5	0.8			389.7	6.9
%	32.6		30.0		32.9		4.5				100.0	
3. Petroleum	25.1	1.8	92.4	9.5	11.4	1.0	136.1	6.3	66.9	100.0	331.9	5.9
%	7.6		27.8		3.4		41.0		20.2		100.0	
4. Noncommercial energy	0.5	-	3.8	0.4	-	-	2.4	0.1	-	-	6.7	1.1
5.	5.8	0.4	80.3	8.3	-	-	4.5	0.2	-	-	90.6	1.5
6. Energy conservation	2.1	0.2	70.8	7.3	-	-	-	-	-	-	72.9	1.3
Total	1,383.1	100.0	968.4	100.0	1,071.1	100.0	2,160.2	100.0	66.9	100.0	5,649.7	100.0
%	24.5		17.1		19.0		38.2		11.1		100.0	

Note: This table is based on information received in June 1976.

Source: EPB, draft FFYP projections.

Table E 26: COMPARISON OF HISTORICAL TRENDS WITH THE CURRENT FORECAST OF DEMAND FOR COMMERCIAL ENERGY IN 1981

	Extrapolation of past growth rates	Extrapolation of past elasticity to GNP	Current Forecast
Total fuel requirements ('000 Toe)	30,368	29,321	26,337 /a 29,825 /b
Electricity (million kWh)	52,405	42,668	37,337 /a 38,953 /b

/a May 1976 figures.

/b Current projections.

Note: The figures used in the final FFYP are more in line with the projection of the past elasticity with respect to GNP.

Source: Mission estimates.

5.21 Table E 26 shows that on the basis of May 1976 projections, demand for fuels and electricity are about 10.2% and 12.5% lower respectively than the extrapolation of past elasticities to GNP. Since energy consumption per capita in Korea is still relatively low, particularly in the residential-commercial sector, this would imply that a strong effort is made to conserve energy, as is indicated in the FFYP. However, energy conservation measures do take time to bring about substantial energy savings, and the current projections may be too optimistic in considering that the growth trends of energy consumption will be changed so rapidly. This is evidenced by the rate of growth of energy consumption between 1974 and 1975 when demand elasticities to GNP were about the same as in the previous period (about 1.0 for fuel demand and 2.2 for electricity.) It is therefore interesting to analyze what the FFYP targets mean in terms of energy savings; if past trends had continued, energy intensity would have grown from an estimated 4.08 TOE/million Won in 1974 to about 4.30 TOE/million Won in 1981. However, current projections are predicated on the assumption that this growth will not occur and could be deferred to the future, and that energy intensity will actually decline, "saving" the equivalent of about 3 million tons of oil by 1981.

Relationships Between Energy Demand and Sectoral Development

5.22 The demand for energy is a derived demand and as such, the level and structure of energy consumption depends on the structure and growth of the whole economy. Macro-economic indicators (unit of energy per unit of GNP, and/or sectoral output) show that the 1977-81 period should be characterized by a slower growth of energy consumption than would have been expected if past trends had continued. The order of magnitude of these "savings," 11.3% of the estimated 1981 consumption, is an ambitious goal even if development policies in end-use sectors (industry, power generation, transportation, etc.) are geared to energy conservation and if no drastic changes occur in the structure of demand. It is not obvious that the main objectives of the FFYP satisfy these conditions.

(a) Overall development strategy of the FFYP

5.23 The FFYP should be a step toward building of an industrial structure of the developed nation type and a step toward social improvement and social equity. This growth pattern, which aims at an equilibrium between export-oriented industries and domestic markets, should be accompanied by structural and organizational reforms both in the Government and in private enterprises to promote more efficiency in the allocation of resources and to give more autonomy to public and semipublic enterprises while promoting more efficient management. While the Government is expected to retain a substantial role in the economy, more attention will be given to market mechanisms and particularly prices.

5.24 The overall policy statement of the guidelines for the FFYP implies a number of structural changes which are not fully reflected in the demand projection for energy. Although the projections show a relative increase of demands in Industry and Transportation and a corresponding decrease in residential consumption, it appears that the energy implications of the proposed policies may not have been investigated thoroughly and that the current energy demand projections may not present an adequate picture of what the future may be. This can be better explained by analyzing each of the end-use sectors.

(b) Power generation

5.25 Current demand projections are based on the assumption that only one nuclear plant will be operational by 1981. Therefore the bulk of incremental power generations will come from conventional, oil-fired steam- and combined-cycle plants, thus increasing the requirements for fuel oil. It is estimated that power generation in 1981 will require about 6.8 million TOE and will account for about 32% of total oil requirements (energy use only).

(c) Industry

5.26 The manufacturing sector is projected to grow at about 13.6% p.a. over the 1975-81 period, with heavy and chemical industries growing at 17.2% and light industries at about 10.6% p.a., compared to 18.8%, 19.8%, and 18.1%, respectively over the 1971-75 period. In heavy industry the emphasis

will be on basic metallurgy (ferrous and nonferrous) machinery and chemicals. At the same time energy consumption in manufacturing (excluding metallurgical coke) is expected to grow at about 10% p.a., with an income elasticity of about 0.74 compared to about 1.0 over the past period. Although a more detailed study would be required to make a definite judgement on the adequacy of projected energy requirements compared to projected output in the industrial sector, it would seem likely that the projected demand of the industrial sector has been underestimated, even if substantial improvement in the energy efficiency of existing plants and of new facilities can be achieved by 1981. It would therefore be advisable to carry out detailed energy demand analysis for the principal industrial branches (ferrous and nonferrous metallurgy, building materials, food, etc.) to check whether the projections derived from econometric and statistical models are consistent with the objectives of the industrial sector.

5.27 A summary analysis shows that if past trends had continued, total consumption in industry will have reached about 12.5 million TOE in 1981. The current projection therefore means that "savings" of about 2 million TOE will be achieved between 1977 and 1981. Taking into account existing plant and assuming that the energy conservation target of 10% will be achieved this means that energy efficiency of new plant should be 20% better than the efficiency of old plant. This appears unrealistic.

	Million TOE
- Projected industry demand according to past trends	12.5
- Current projections	10.5
Savings	2.0
- Savings due to conservation (10% of 1974-75 demand)	.5
- "Savings" on new plants	1.5

The "savings" on new plant would account for about 30% of the projected incremental demands and would mean an incremental energy intensity of 3.1 compared to 3.9 in 1974/75. In our opinion even if the conservation program is carried out successfully, it is unlikely that this objective will be achieved and we believe that total demand in industry should be on the order of: 11.5, 12.0 million TOE.

(d) Transportation

5.28 Korea so far has been successful in keeping car ownership under control and in monitoring effectively the consumption of gasoline. According to the national energy conservation program, this policy is to be continued in the future, and the share of energy demand for transportation is projected to remain below levels observed in countries at similar stages of development.

(e) Residential and commercial sectors

5.29 The growth in real income expected over the next five years will be reflected in increased demand for housing, transportation, and other services. It is also likely that the modern housing sector (high-rise apartment buildings) will continue to develop at a rapid pace particularly in the major cities (housing expenditures are expected to increase by 50% over the 1971-76 period). These changes will undoubtedly influence the structure of energy demand in the residential-commercial sectors, which in 1981 will still account for more than 40% of total final consumption. However, it is projected that the income elasticity of the residential and commercial sector will remain the same, which is not the normal pattern of growth./1 This implies that strong conservation policies will be implemented. Such policies may to some extent be contradictory to the objectives of the FYP, which foresees considerable improvements in the quality of life, and might create some problems of policy coordination.

5.30 In the above paragraphs we have highlighted some of the "inconsistencies" that could exist between sectoral development objectives and projected energy requirements. Some of these "inconsistencies" result from the lack of coordination between the energy sector and other sectors of the economy and among the various energy subsectors when estimating future energy requirements. Although MCI, EPB, KDI, and KECO use simple econometric and statistical models to estimate future fuel and electricity consumption, the framework in which projections are made fails to integrate fully external parameters that will eventually influence future supply and demand patterns. Implicitly these models assume that past relationships between production of goods and services and energy consumption, and between past price and income elasticities, will remain the same in the future. As already explained, this is not likely to occur as the changes in relative prices of energy and the new strategy of industrial development will focus more on the domestic market than on exports, and the increase in real income will bring about changes which will affect energy supply and demand in the future and which will require adequate government policies to maintain acceptable economic growth with less energy.

Sector Investments

5.31 Total investment in the energy sector is estimated to be about W 2,730 billion, of which W 66 billion will be supplied by foreign investors, who will account for about 16.5% of total gross investment and about 45% of total investment in the manufacturing and power sector, compared to about 8.5% and 29% over the 1970-76 period. The incremental capital output ratio /2 should increase from about US$300/TOE over the 1970-76 period to about

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/1 Past experience shows that while residential energy uses (house heating, light, appliances, etc.) taper off after average income reaches a critical level, energy use associated with nonenergy purchases increases considerably

/2 Measured in terms of incremental investments per TOE of total energy requirements.

US$400/TOE during the 1977-81 period. The main reasons for this increase are the large investment in power generation (about W 2,300 billion compared to W 400 billion over the 1972-76 period) and the increase in investments in the coal mining industry (more than double). Power investments alone will account for more than 13% of total investment, which is about 10 to 20% higher than figures observed in other countries at similar stages of development. About half of the investment in power generation is for nuclear plants which would be commissioned after 1981. Despite a drastic postponement of nuclear plant in comparison with previous plans, the proposed construction schedule still appears short, and the need for additional generation somewhat overestimated. It would therefore be advisable to reconsider the energy sector investment after a comprehensive study of the development of the power sector has been carried out.

5.32 It is difficult to make a judgement on the structure and magnitude of investments in the energy sector until the study referred to above has been carried out. However, the current investment program appears to be responsive to the need of the sector and to allocate resources according to priorities, particularly in the coal mining industry. A more detailed analysis of the investment plan of each of the subsectors is provided in Chapter 6.

Energy Sector Financing

5.33 The most striking feature of the energy sector financing plan is the low contribution of internal cash generation and the heavy reliance on domestic and foreign borrowings (19% and 38.2% respectively of total expenditures). Since the financial situation of the coal mining industry and of the power industry is rather poor it may be difficult to mobilize these resources if drastic steps are not taken to improve the financial viability of coal mines and power companies. This is linked to the overall energy pricing policy and to the Government's policies of subsidizing coal development.

Conclusions

5.34 As indicated in the previous paragraphs, it appears that overall final demand for energy and total primary energy requirements in 1981 have been somewhat underestimated. On the basis of past development and of the targets of the FFYP it would appear likely that total final demand in 1981 would be about 30 million TOE (excluding noncommercial energy) and that total primary energy requirements (including noncommercial energy) would be about 38.3 million TOE as shown below in Tables E 27 and E 28./1

/1 It is interesting to note that in the final FFYP, the projection of primary energy consumption has been raised to about 37.0 million TOE.

Table E 27: ESTIMATES OF TOTAL FINAL DEMAND FOR COMMERCIAL ENERGY IN 1981 ('000 TOE)

	Coal	Petroleum	Electricity	Total	%
Industry	415	9,000 /a	2,843	12,258	40.8
Transportation	43	4,200	-	4,243	14.1
Others	-	841	7	848	2.8
Subtotal	458	14,041	2,850	17,349	57.7
R/C	8,539	3,807 /b	373	12,719	42.3
Total	8,997	17,848	3,223	30,068	100.0

/a Based on a petroleum intensity of 2.8, equivalent to 90% of the petroleum intensity over in 1974.

/b Based on a total growth for R/C purposes at the same rate as per capita income over the 1977-81 period.

Source: Mission estimates.

Table E 28: PRIMARY ENERGY REQUIREMENTS IN 1981 ('000 TOE - %)

		%
Coal	10,139	26.5
Hydro-nuclear	1,272	3.3
Petroleum	24,614	64.3
Noncommercial energy	2,254	5.9
Total	38,279	100.0

Source: Mission estimates.

The above estimates represent an increase of 14% and 10.7% over the draft FFYP estimates for internal final demand and primary energy requirements respectively. Since the production of domestic energy resources is limited, most of this difference would have to come from increased imports of petroleum. The incremental volume of petroleum required in 1981 would be about 3.7 million tons, equivalent to about 75,000 bpd.

Main Issues, Problems and Constraints in the Energy Sector

5.35 Overall Performance of the Energy Sector. From a demand supply point of view the performance of the energy sector has been generally satisfactory, continuous growth has been achieved at high rates, and at present

there is no evidence of sectoral or regional energy shortages, although in some areas, and particularly in the coal industry, the spread between supply and demand is very narrow, considering the seasonal fluctuations of the market. However, if total demand for energy has generally been met, it is not obvious that the current and projected mix of fuels correspond to the optimum use of resources and that the current and projected policies would form an adequate framework in which the development of the sector could be optimized. The main problems, issues and constraints appear to be in the field of sector planning and coordination, energy pricing and resources allocation, and policy formulation and implementation.

5.36 Sector Planning and Coordination. In the early 1970s, it appeared that the future expansion of the energy sector would be based primarily on imported oil and nuclear power and that domestic coal would be progressively phased out. This is evidenced by a comparison of the objectives of the 1966 energy development plan and of the actual realization. (Table E 29)

Table E 29: COMPARISON BETWEEN LONG-TERM OBJECTIVES AND ACTUAL REALIZATION

	1966 Objectives for 1974	1974 Actual Realization	Difference %
Coal, demand ('000 MT)			
Power plant	3,920	420	(89)
Others	17,000	15,616	(8)
Total	20,920	16,036	(23)
Petroleum demand ('000 m^3)	10,721	14,724	+37
Total ('000 TOE)	17,572	18,674	+6.3

Source: MCI.

While total demand for fuel in 1974 was within 6% of the overall 1966 projection, the demand for individual fuel was off by -25% and +37% respectively for coal and petroleum. In this Korea has followed a pattern similar to other countries in which imported petroleum supplies have been substituted for domestic coal. The substitution of petroleum to coal, particularly in power generation and industry, has been rather successful, partly because of the solution adopted to acquire the necessary expertise in the field of petroleum (joint ventures with foreign

oil companies), partly because relatively inexpensive petroleum supplies were available. In this situation, with a limited number of choices, energy planning was limited to adjusting supply to demand and did not require sophisticated analysis, particularly in a dynamic economy in which temporary excess capacity could be absorbed rapidly. However, the increase of world oil prices has drastically changed the supply patterns and has necessitated a second conversion from an oil-based energy supply to a different mix of fuels, and from an energy-intensive economy to energy conservation, which would involve difficult choices among alternative technologies and sources of supply and alternative sectoral development policies based on a thorough analysis of the costs and benefits associated with these alternatives.

5.37 Although some work has been done in this direction over the past two years and is reflected in the FFYP, it does not appear that MCI has followed the kind of integrated approach that would be required or developed proper coordination procedures among the various energy subsectors and with the "client" sector - industry, transportation, urban development. The approach to sector planning and policymaking is still based largely on subsector considerations without sufficient attention to intersectoral relationships and tradeoffs between energy consumption and alternative investments. It is significant to note that at a time when the problems of the sector would require an integrated approach, the Government of Korea's policy appears to be one of creating new institutions rather than strengthening existing ones, particularly in the power industry and in energy conservation. We do not believe that this kind of measure is the right answer to the current problems and we would recommend that an effort be made to improve coordination within the sector and among the various fuel and power industries and the client sectors to create a system in which some "central agency" would provide the framework of macroeconomic indicative planning, and the "decentralized agencies" would have full operational responsibilities under the supervision of MCI.

5.38 The energy policy guidelines of the FFYP present a "catalog" of recommendations, which are for the most part reasonable. However, these recommendations do not form the framework of an energy policy, since they do not distinguish among priorities, do not analyze the relationship of the energy sector to the economy as a whole, and do not integrate subsector policies in an effort to achieve a common objective. For example, it is stated that the production of coal should be maximized; however, this policy is not reflected in the policy statements of other fuel industries (petroleum) and/or of the client sectors and particularly of the residential-commercial sector. In fact, while the draft plan sets objectives for the energy sector, it appears to assume that the sector is independent from the rest of the economy and that the development strategy in industry and/or in the residential sector would not affect substantially the future energy supply demand pattern. It is the mission's opinion that the current approach to sector planning is largely based on short-term and operational considerations and that it does not deal adequately with sector development problems in the medium and longer term. This is particularly true in the coal and power industries, in which insufficent attention is given to the evaluation of the relative costs of coal compared to petroleum and of alternative

power generation modes (nuclear versus conventional oil and coal-fired plants). This also applies to the petroleum industry for which demand projections appear to be low and do not reflect past trends.

5.39 Energy Pricing. Energy prices in Korea have been used to promote industrial development (power) and to subsidize the poorest segments of the population (coal), and little attention has been given to the role of prices in resource allocation. At present energy prices, with the exception of petroleum products, are not generally related to the economic cost of developing and exploiting energy resources. This may lead to inefficiencies and inappropriate cost-benefit evaluation of alternative development projects, particularly at a time when the Government is recommending its energy supply policy and is promoting a strong energy conservation program.

5.40 In a pure market economy, prices play a critical role in handling changes and the price mechanism should ideally discourage potential users and provide incentive to potential producers so that the volume and structure of supply and demand are optimum at all times. Pure market economies seldom exist, however, and there are many ways the price system may convey wrong or untimely "signals" to consumers and producers, particularly when changes in relative prices are as important as they have been in the past two years. Government intervention would therefore be required to correct some of the deficiencies of the price system and specifically to take account of externalities that may not be perceived by the consumers and the producers (environmental costs, cost of reconversion of labor, training costs, etc.). Government intervention necessarily means interference with prices and market decisions, and the main problem is to select which decision should be interfered with. It is our opinion that to the extent feasible energy prices should be related to long-term marginal costs (LTMC) of supply. Except for petroleum products this would mean a substantial increase in current prices of coal and power, which may create some sectoral adjustment problems, and it is likely that actions would be required to cushion the impact of higher energy prices on some critical sectors (export-oriented industries, R and C). It is, however, strongly recommended that these considerations do not delay the revision of the structure of energy prices and that alternative means of subsidizing consumers (if it is actually required) be devised.

5.41 As we have seen in para. 5.40, the price structure should reflect the long-term marginal cost of supply, including external costs. However, in the short term, prices based on LTMC may not be sufficient to ensure the financial viability of energy enterprises (power sector) or to provide sufficient incentives to attract new producers (coal mining industry). It is our opinion that producer prices should cover the full cost of production and provide a reasonable return on the capital invested and enable utilities to finance a reasonable part of their future expansion and to secure resources on the financial market. The adequate level of prices in each subsector to ensure financial viability would have to be determined in relation to each subsector investment plan and to existing and forecast financial commitments. A more detailed discussion of the pricing policy of each subsector is given in Chapter 6.

5.42 Resource Allocation. Although the global amount allocated to the energy sector appears to be generally adequate, it is not obvious that the amount allocated to each subsector and within each subsector to specific projects has been determined on the basis of an adequate evaluation of the relative costs and benefits involved. This problem is more developed in Chapter 6, in which each subsector investment plan and more particularly those of the power and coal industry are discussed.

5.43 Energy Policy Formulation and Implementation. The formulation of a national energy policy is a complex exercise which requires an insight into almost all facets of the economic environment and presents planners and decisionmakers with a series of choices which would require a much deeper understanding of the sector and of its relationships with the whole economy than is generally available. The energy scene is changing rapidly and will continue to change, requiring the Government of Korea and energy agencies to make choices among alternative energy development strategies and to decide on the constructions of facilities that may come on stream five to ten years after the decision is made and that would involve considerable investments. It is therefore essential that energy problems be formulated rationally and that a system be set up in which the consequences of these decisions could be evaluated and monitored, in which knowledge of the sector could be accumulated so that more responsible choices could be made in the future. This is a continuous process, which at the initial stage will require considerable political motivation and willpower but should lead in the long run to a more rational approach to energy development.

5.44 As we have seen in the previous sections such a system does not exist yet in Korea. Planning, pricing and more generally, development policy are decided upon at the subsector levels, and the energy plan is more an addition of individual investment program than a concerted effort to determine the best supply-demand pattern in the future. What is basically lacking is an evaluation of the alternative supply-demand options open to the country in the short, medium and longer term and an investment of the physical, technical, financial, and environmental constraints which may affect the development of the energy sector. As a result there are subsector development policies, but there is at present no energy policy.

5.45 To remedy this situation, we would recommend that an Energy Committee be created at the ministerial level to be responsible for the formulation of a medium- and long-term development policy for the energy sector. This committee would appoint a temporary or permanent Interdepartmental Energy Task Force (ITF), which would create and maintain an analytical framework in which alternative energy plans could be formulated and evaluated in a consistent and coherent way. The ITF could be responsible to EPB and should be given the responsibility of:

(a) carrying out and/or sponsoring studies to optimize the development of the sector within the next four to five years (short term);

(b) preparing an evaluation of the various supply-demand options open to the country in the medium and longer term and formulating alternative development plans.

5.46 The main items to which the ITF should give special attention in the short term are developed in Chapter 6 for each of the subsectors. The medium-term plan (five to ten years) referred to above should include:

(a) an analysis of alternative demand scenarios based on anticipated technological and structural changes in the main and use sectors. This analysis should take account of anticipated changes in the relationships between the energy sector and other sectors of the economy and should be carried out under various assumptions of future economic growth;

(b) an assessment of the energy supply options open to the country which should include: a comprehensive evaluation of the geological data available and of whatever further exploration work is required; an assessment of the cost and feasibility of developing domestic resources, particularly coal, and of the resource cost of imported supplies;

(c) the selection of optimum supply-demand schemes in relation to existing and foreseeable financial, social, environmental, and political constraints. This would require the use of an iteration process, in which a number of feasible schemes and their impact on the economy would be evaluated;

(d) the formulation of policies in the field of pricing, resource allocation, and energy conservation to ensure that the objectives selected above would be achieved in time.

5.47 In particular, the ITF should have the responsibility of recommending what role the Government should play in energy pricing, resource allocation, and industry regulations. Some of these items are developed in Chapter 6.

6. PROJECTED DEVELOPMENT OF THE FUEL AND POWER INDUSTRIES

General

6.01 In the previous chapter we reviewed the overall development plan of the energy sector. We now turn to the plans for the individual subsectors.

The Coal Mining Industry

Projected Growth of Consumption and Production

(a) Projected Final Consumption of Coal

6.02 Over the 1974-81 period the final consumption of domestic coal (excluding power generation) will grow from about 14.7 million tons to about 23.7 million tons, at an average rate of 6.2% p.a. compared to a rate of about 3.3% p.a over the 1966-74 period. The principal reasons for this increase are a projected improvement in the availability of coal to the R and C sector and accelerated, though limited, substitution of coal for petroleum products in industry. The structure of demand will not change substantially, residential use will account for about 90% of total demand, and the remainder will be divided among industrial, transportation, and other sectors. In addition to domestic coal, imported coal will be used as a fuel particularly in power generation, which by 1981 is expected to absorb about 775,000 TOE compared to less than 200,000 in 1974 because of the addition of a new coal-fired plant in 1979.

6.03 The coal demand forecast is predicated on the assumption that no dramatic change will occur in the coal market, which appears reasonable. While it is true that oil products would to some extent be substituted for coal in the modern residential sector, this should be more than offset by the substitution of coal for noncommercial energy, whose share in total residential and commercial demand should decline from about 30% in 1974 to about 17% in 1981.

(b) Domestic Coal Supply

6.04 Coal supply in 1975 was about 17.5 million tons, and it is expected that it will reach about 24 million tons by 1981. The coal development program prepared by MCI indicates that the increase in production will be achieved primarily from new sources as shown below (Table E 30).

Table E 30: DOMESTIC COAL PRODUCTION PROGRAM
('000 metric tons)

	1974	%	1981	%	Difference	%
Korean Coal Corporation	4,270	28	5,060	21.0	(790)	8.7
Existing private mines	10,605	71	12,120	50.5	1,515	16.8
New sources	125	1	6,820	28.5	6,695	74.5
Total	15,000	100	24,000	100.0	9,000	100.0

Source: MCI.

This program is rather ambitious and represents a considerable increase above previous estimates, which projected a total coal production of about 16 million tons in 1981. The 1974 and 1975 production figures show that while the targets for existing mines are generally exceeded by 5 to 10%, those for the development of new sources have not been achieved. (The 1975 production from new sources was about 770,000 tons, compared to targets of 990,00 tons.) It appears that if the target production of 24 million tons is to be achieved by 1981, a very strong effort will have to be made in both exploration and development of new mines.

6.05 Assuming that the average production of new mines is equivalent to the present mean production of about 50,000 to 60,000 tons, an increase of 6.5 million tons will require the opening of about 120 mines, i.e., about 15 to 20 mines each year and the recruitment, training and employment of about 25,000 additional miners. This is a considerable task, which will require substantial investments and coordination between the coal mining industry the and other sectors, mainly transportation.

(c) Industry Performance and Management

6.06 MCI coal development plan outlines the main features of the coal mining industry development strategy over the 1977-81 period. These are:

- increased exploration and completion of geological survey;
- maximization of coal production by modern mining techniques;
- expansion of existing coal transport facilities; and
- establishment of a coherent coal support system for the coal industry.

As already mentioned in Chapter 2, the increase in coal exploration has already had substantial results. It is expected that the continuation of this program will lead to the discovery of new reserves. However, it is unlikely that a substantial part of these new reserves can be exploited commercially before 1979-80.

6.07 The coal production maximization program includes on the one hand an improvement of the methods and techniques used in the construction of mine infrastructure (vertical and inclined shafts) and on the other hand improvement of mining techniques (gallery structure, mechanization) and of the overall working conditions for mine labor (level of wage, safety, training, etc.). The expansion of transport and other infrastructures includes primarily an improvement of rail transport and distribution. To support this program, MCI also proposes the creation of a special fund for storage, an extension of the tax on Bunker C oil and of the tax incentive program and financial support from the Government for the development of new mining capacity.

(d) Proposed Investments in the Coal Mining Industry

6.08 Table 31 summarizes the total investment program in the coal mining industry for 1977-81 which amounts to about W 190 billion (US$390 million), equivalent to about W 38 billion per year, compared to about W 16 billion per year between 1972 and 1976.

Table E 31: SUMMARY INVESTMENT PROGRAM IN THE COAL MINING INDUSTRY 1977-81 /a

	Billion Won	%	Million US$
Total investment of which	188.9		
Government finance	61.5	32.6	127.0
Internal cash generation	56.7	30.0	117.0
Domestic loans	62.3	32.9	128.0
Foreign loans	8.4	4.5	18.0
Total	188.9	100.0	390.0

/a This does not include about 100 billion won in transportation for projects mostly related to coal transport by rail.

Source: MCI and KMPC.

6.09 Total investment related to the projected production increase shows a direct incremental cost of about W 29,000 (US$60) per ton which is reasonable considering the type of mines in Korea. Total investment per incremental ton of anthracite (including utilities infrastructure and housing) amounts to W 55,000 (US$114). The main share of investment including government assistance is expected to flow to privately owned mines, which should provide most of the incremental production. Total government assistance in the form of direct subsidies and loans should account for about 60% of total investments in the private coal sector, which is a substantial increase above the 1974-76 period in which total government assistance amounted to about 36% of total investment in the private sector.

Evaluation of the Coal Mining Industry Development Plan

(a) General

6.10 The policy objectives set out in MCI's plan appear to be satisfactory. Increased domestic coal production and increased allocation to the residential and commercial sector should to some extent slow down the substitution of oil for coal which took place in the 1966-74 period. The program is consistent

inasmuch as it not only takes into account the development of additional capacities, but also the expansion of related facilities such as housing, transport storage, etc., and recognizes the need for a periodic reevaluation of the tax on Bunker C, which is one of the main sources of coal development financing.

6.11 The emphasis on the development of domestic coal resources appears to be economically justified. According to the information available, the incremental resource cost of coal should be of about W 13,000/ton (US$27/t), equivalent to about US$62/TOE compared to an average resource cost of about US$100 for petroleum products.

(b) Supply-Demand

6.12 Within the framework of the government program to conserve petroleum and to develop domestic resources, the coal program is rather critical. Since most of coal demand is in the residential and commercial sector, it is important that sufficient production capacity be developed in time to avoid shortages that would eventually cause some of the residential-commercial consumers to switch to liquid fuels as they have done in the past. Because of the relative importance of the residential-commercial sector, a marginal shift to liquid fuels by 5% of the coal consumers would mean an increase of 500,000 TOE in the demand of medium distillates, which are already in rather short supply. To avoid this, the Government would have to take the necessary actions to ensure that the production targets are met.

6.13 Although the coal development program appears to be well thought out and the cost of the facilities to be provided appears to be realistic, the time schedule is very tight. The increase in capacity of 1974 and 1975 appears to have been achieved by the reopening of marginal mines which had been closed when business was poor. It is to be expected that further increases beyond the 1975 level will necessarily proceed at a slower pace, since most of the available labor and equipment on the market have been used already.

6.14 Over the past ten years, the coal industry has been declining; most of the private mines would have progressively shut down if the Government had not heavily subsidized the coal industry. In the next five years, however, it is expected that the coal mining industry will start expanding again; this will require adjustments not only in the attitudes of mine owners but also in the institution dealing with training, mine safety and productivity, and in the availability of qualified labor. If the coal mining industry is to provide a substantial share of total energy requirements in Korea, it will have to create stable and safe working conditions for its workers and adequate housing and community services for their families.

6.15 The role of KMPC in the success of this program will be preponderant. Besides its normal operation, KMPC will have to take up new responsibilities and/or to expand existing ones considerably along the following lines:

(i) KMPC already provides technical assistance and joint procurement services to private coal mines. It is recommended that this effort be increased to provide specialized assistance in the work required to open new mines (leasing of large boring machines with qualified crews to bore shaft and tunnels) and mechanization and improvement of operations in existing mines. As explained above, the problem is less to improve productivity by using more capital-intensive techniques, but rather to avoid medium-term shortages of manpower and high labor costs which would make coal uneconomical in the long run.

ii) Mine workers' underground working conditions are unsafe, their living conditions are poor, and although MCI coal development program recognizes the need to improve these conditions to secure a long-term labor force, the amount of investment allocated to safety, housing, and education is only 8.5% of the total coal investment plan. It is strongly recommended that training procedures be improved and that safety standards be set to reduce drastically the high rate of casualties. KMPC should have a leading role in formulating training and safety procedures and standards and in monitoring their efficient implementation.

6.16 Even if coal production targets are achieved, coal would still have to be treated, stored, transported, and distributed to the consumers. The transport-distribution system in Korea is antiquated and should be modernized to include better and more efficient storage and loading facilities, which should cut down the cost of handling. An effort should also be made to improve coal transport (coastal and railway) and to avoid bottlenecks such as railcar availability and long turnaround time.

6.17 So far the use of coal has been limited to the traditional housing sector for use in individual appliances. While the Korean floor heating system is relatively efficient, it may not be the most efficient way in which coal could be used, particularly in the modern housing sector, which is developing rapidly in the principal cities. Coal has not been used in large central heating units yet, partly because of the Government's choice to earmark coal for the poorest and partly because of the poor quality of the coal available. Since it is now expected that total coal production will be ample to cover demand, it would be worthwhile to develop designs (district heating plants, total energy plants) based on the utilization of domestic coal. Although its physical characteristics are not very good, there are no reasons why coal could not be used in large boilers, if it is prepared properly, and if the boiler is designed for that particular quality of coal.

Coal Pricing

6.18 The current price of coal covers direct operating costs, including depreciation of equipment, and provides a return of about 10% to the mine owners. However, it does not reflect the cost of exploration and development of new mines, which are largely financed through government subsidies and loans. We believe that this policy is not adequate since on the one hand it may lead to the development of mines which are uneconomical, and

on the other hand it provides a large subsidy to consumers and thus does not encourage them to use coal efficiently.

6.19 The main concern of the Government appears to be to maximize coal production, and not to develop energy resources that bear an economic cost lower than alternative sources (domestic or imported). Although preliminary calculations seem to indicate that the resource cost of coal is on average lower than the cost of alternative sources, mainly refined petroleum products, it is not obvious that this is true for the marginal mine, and therefore some resources may be allocated to the development of uneconomical coal deposits. In the absence of a detailed study of the future cost of coal, it is impossible to estimate the extent to which such deposits could be developed. We would therefore recommend that a comprehensive study of the long-term resource cost of coal by main deposit (or by area) be carried out to arrive at a supply curve for coal that would relate the resource cost of coal to the quantity produced through time. This study should take into account not only the direct cost associated with the development of the coal mining industry (investment in new mines, equipment, utilities, training expenditures, etc.), but also the indirect costs which may result from the closing of a number of uneconomical mines (retraining of mine workers, resettlement expenditures, unemployment and retirement benefits, etc.). The results of this study should enable the Government to decide on an optimum rate of development or possibly decline of the coal mining industry through time in which the resource cost of the marginal ton of coal should be equal at all time to the cost of the alternative fuel.

6.20 This study will also provide the basis for a rational coal pricing policy, both for producers and consumers. It is understandable that the Government may wish to retain control over the development of coal production and may wish to continue to subsidize the development of new mines and/or the expansion of old ones, provided this is done within the limits of economic feasibility. However, it is potentially dangerous to subsidize consumers' prices, and this for two reasons. First, the subsidy favors those consumers who use larger volumes of coal rather than the poorest segment of the population, and second, it may lead to uneconomical choices regarding fuel utilization, which could prevent interfuel substitution or changes in technology that would have taken place if the relative prices of energy sources had reflected their respective resource costs. We therefore believe that it would be advisable to increase progressively the price of coal (in line with the results of the study mentioned in para. 6.19) and to find alternative income redistribution procedures for the poorest segment of the population.

6.21 The main objective of the current pricing policy is to promote the use of coal as a substitute for refined petroleum products, which appears to be justified in the short term. However, because of the lack of information on what the resource cost of coal might be and how it would compare to the cost of alternative fuels, this policy may lead to some inefficiencies in resource allocation in the longer term. The study referred to in para. 6.19 should therefore be undertaken as soon as possible.

Financing Coal Development

6.22 A substantial part of the government resources allocated to the financing of coal development is derived from a tax on heavy fuel oil (5% of the tax reference price of US$12.7/bl as of November 1975). According to current oil demand projections, this tax should yield about US$205 million (W 100 billion) over the 1977-81 period. This amount accounts for about 80% of the total government resources to be allocated to the coal mining industry (Table E 25, p. 39). It is likely, therefore, that the tax rate would have to be adjustd in the future or that new taxes could be levied on refined petroleum products, which are not currently taxed, but which compete directly with coal, namely kerosene and LPG. It is currently estimated that a tax of about 10% on these two products would provide enough resources to make up for the gap between total requirements and the proceeds of the Bunker C tax. A 10% tax would increase the final price of kerosene and LPG by about 8% and would be a deterrent to an increase in the demand of refined petroleum products in the residential-commercial sector.

6.23 Mandatory Coal Allocation to End-Use Sectors. As mentioned in Chapter 4, we believe that a decision should be made regarding the allocation of domestic coal to powerplants and that the boilers of those plants to which coal is allocated should be modified to perform more efficiently. From a more general standpoint, mandatory coal allocation was required because of temporary shortages of coal and insufficient storage and transport facilities. The 1977-81 coal program provides funds for the allocation of adequate storage capacity which should eventually eliminate the need for coal allocation to end-use sectors. However, if this allocation program is continued in the future, the coal users whose supply could be discontinued should be fully aware of it and should also be aware of the various qualities of coal that might be allocated to them in order to decide on what adjustments may be required for their coal burning facilities.

6.24 A Possible Program for the Coal Mining Industry. The coal development program for the FFYP appears suitable to deal with the problems created by the increase in the cost of oil supplies in the short term, but it does not provide a rational framework for the long-range development of the coal mining industry and its integration into a national energy development plan. It therefore appears that two different types of actions are required.

(a) A first series of actions aiming at improving the operation and performance of the coal mining industry under the responsibility of KMPC. This would include the introduction of new technologies, the mechanization of the most promising mines, mine workers' training and improvement of working and safety conditions, and modernization of transport storage and distribution facilities. KMPC seems to have the capacity of handling these problems with the possible guidance of foreign mines experts and programs.

(b) An assessment of the role that the coal mining industry is to play in the long-range economic development of the country and the formulation of adequate policies to ensure that it would play this role efficiently. This

includes first an assessment of the long-term resource cost of coal at various production levels and the determination of an optimum coal development program. While it is expected that most of the expertise for such a study could be provided by Korean staff, we believe that some guidance from experts of countries in which the coal industry has experienced the same type of development would be useful in setting the objectives of the study and in deciding on the methodology to be used.

6.25 Taking account of the projected growth of coal demand in the residential-commercial sector, it is unlikely that large volumes of coal could be substituted for oil in the power generation and industrial sectors within the next five years. However, since the increase in the world price of oil and more particularly in the past two years, a number of oil importing countries have started to look for long-term coal supply contracts and have even been investigating the feasibility of the purchase of foreign coal mines. This is an area which would be worth investigating for Korea, where coal could possibly be an alternative to nuclear power.

Power Industry

Development Prospects

(a) Power Demand Forecasts

6.26 According to current demand projections, power demand should grow as indicated below (Table E 32):

Table E 32: POWER DEMAND PROJECTION 1974-81

	Actual 1974	Projected /a 1981	Average rate of growth p.a.%
Gross power generation (GWh)	16,835	43,418	14.5
Power sales (GWh)	14,048	37,337	15.0
Peak demand (MW)	2,922	7,288	14.0
System load factor %	65.8	68.0	
System efficiency %	83.5	88.2	

/a As already indicated, these figures have now been increased to:

Gross power generation (GWh)	45,308
Power sales (GWh)	38,963
Peak demand (MW)	7,666
System load factor (%)	68.0

Source: KECO.

The above projections indicate a slower growth than over the 1966-74 period when power sales grew at an average rate of about 21% p.a. and a lower income elasticity (1.74 compared to 2 over the previous period). While the completion of the 345 KV transmission system is expected to improve total system efficiency substantially (about 6%), total system load factor is not expected to improve by above 3.5% and to reach 68% in 1981.

6.27 The structure of demand is not expected to change substantially, and demand for industrial and large commercial uses (large and small power) will continue to account for more than 85% of total power sales as shown below (Table E 33).

Table E 33: PROJECTED STRUCTURE OF FINAL DEMAND IN 1981

	GWh	%
Lighting	4,317	11.6
Small power	6,904	18.5
Large power	25,966	69.5
Agriculture	150	.4
Total	37,337	100.0

Source: KECO. See note to Table E 32 above.

(b) Supply Forecast

6.28 According to KECO's long-term development plan, total generating capacity is expected to grow from 4,720 MW in 1975 to about 9,905 kW by 1981 /1 at an average rate of 13% p.a. slightly lower than peak demand. By 1981, however, generating capacity will still exceed peak requirements by about 26%. The increase in generating capacity is expected to be achieved primarily by the introduction of one nuclear power plant of 600 MW, the completion of 3 hydro power plants and 2 pumped storage power plants, with capacity of 400 MW each, and of conventional thermal-power plants.

6.29 It is also expected that the transmission system will be expanded by the completion of the 345 KV transmission lines, which would reduce losses and improve the quality of service. The supply forecast of the FFYP is a revision of previous power development plans prepared by KECO, which were modified in the light of new consumption, of demand growth, and of a reassessment of the role of nuclear generation.

(c) Power Industry Performance and Management

6.30 The draft FFYP indicated that over the 1974-81 period, the management and financial performance of the power industry should be improved. Regarding management, the Government of Korea has been considering the creation of a separate company to be responsible for the development and operation of nuclear

/1 Now revised to 10,052 MW.

power plants, and the possibility of splitting up KECO into two or more companies. Regarding the financial performance of the power industry sector, the draft FFYP recommended that electricity rates be increased to reflect costs and that the financial performance of KECO be improved. However these recommendations have so far not been translated into definite policy actions except for the creation of a nuclear development agency.

(d) Power Industry Investments

6.31 The power industry investment program, at 1975 prices, for the period 1977-81 is about 2,300 billion (US$4.75 billion) of which W 1,350 billion (US$2.8 billion) are for power generation and W 824 billion (US$1.7 billion) are for transmission. They would represent an incremental cost of about 540 per kW installed, and of $345 for transmission which appears high.

Evaluation of the Power Development Plan

(a) General

6.32 The power development plan for the 1977-81 period has to be reviewed in the light of the long-term development program (1975-86) which was prepared in 1975 and was predicated on the introduction of nuclear power on a large scale starting with the completion of KORI #1 in 1977 and the completion of one nuclear plant each year after 1979. According to this program, nuclear power should have accounted for more than 30% of total power generation in 1986 - this program however was based on rather unrealistic construction times for nuclear plants (between five and six years). Following the delays in the realization of KORI #1 and in the completion of contractual arrangements for KORI #2 it became obvious that the nuclear program, as originally conceived was no longer feasible and that new development plans would have to be drawn up. The power development plan of the draft FFYP is the result of the revision of the previous program.

(b) Supply and Demand

6.33 According to current projections power demand will continue to grow at a faster rate than total energy demand, however the extremely rapid growth of the 1960s will slow down and stabilize at about 15%. Peak demand will grow at a slightly lower rate than kWh demand and total system factor should improve. There are some doubts that these projections adequately reflect what may happen in the future. The reduction in demand growth by about five percentage points, would imply a drastic reduction in the elasticity of electricity demand to GNP which is not reflected in the results of 1975 and the provisional results of 1976 in which electricity demand continued to grow at much the same rate as previously. However, if actual demand exceeds projection it should not become too critical since current power supply is more than adequate, mainly because the current reserve margins are above what would normally be required.

6.34 Table E 34 summarizes the projected power demand-supply situation in 1981 and includes our own interpretation of the figures included in the draft FFYP.

Table E 34: PROJECTED POWER SUPPLY DEMAND SITUATION IN 1981

	Draft FFYP	IBRD
Total sales (GWh)	37,337	37,337
Rate of T and D losses (%)	9	9
Net generation (GWh)	41,030	41,030
Rate of plant use (%)	5.5	5.5
Gross generation (GW)	43,418	43,418
Average generation (MW)	4,956	4,956
Peak demand (MW)	7,288	7,288
Annual load factor (%)	68	67.8
Dependable capability (MW)	9,040	
Installed capacity (MW)	9,905	9,905
Reserve margin (%)	24	36

Source: KECO; mission estimates.

According to Table E 34, the calculation of the reserve margin by the power company and the Bank differs considerably. One explanation may be found in an apparent double counting. According to KECO's calculation, the reserve margin is calculated on dependable capacity, which excludes projects which are being completed within the year and plants which are likely to run into problems. It appears that the concept of reserve margin might therefore have been misunderstood and that its evaluation has not been correct. The generating plant reserve margin is the amount of "spare" generating capacity required to cover the risk of plant forced outage and is usually expressed as the excess of installed capacity over the maximum system demand, divided by the latter. If this definition is applied to the figures of Table E 34 the plant reserve margin is about 38.0%.

Total installed capacity MW = 9905 (1)

System peak demand (MW) = 7288 (2)

Spare generating capacity (1)-(2) = 2617 (3)

Reserve margin = (3):(2) = 36%

6.35 In Table E 35 the projected peak demand figures included in the draft FFYP are used to compute the projected reserve margin and to compare it with what would normally be required in the Korean system (an average of 20% before maintenance has been used since the system is predominantly thermal). The problem of reserve margin has been controversial in Korea as KECO and other government agencies (EPB, MCI) have not always agreed about plant

capacity and on the methodology for reserve margin calculations. In the past reserves margins have exceeded requirements. It appears that this trend will continue in the future (Table E 35); however, it is difficult at this time to make a judgment, as the basis of these estimates, and more particularly of the dependable capacity, is not always clear.

Table E 35: COMPARISON OF THE DRAFT FFYP RESULTS WITH AVERAGE INDUSTRY STANDARDS

	1975	1976	1977	1978	1979	1980	1981
Peak demand (MW)	3,351	3,930	4,488	5,109	5,751	6,517	7,288
Average reserve margin (15%)	670	786	900	1,020	1,150	1,300	1,460
Required generation (MW)	4,021	4,716	5,388	6,129	6,901	7,817	9,905
Projected installed capacity (MW)	4,720	5,110	6,430	6,942	7,242	8,552	9,905
Excess generating capacity (MW) (5)=(4)-(3)	699	394	1,042	813	341	735	1,157

Source: KECO and mission estimates.

(c) Power Investments

6.36 The incremental per kW installed during the next five years is estimated at about US$815 at 1975 prices, which appears to be high compared to an average estimated cost of about US$600 for a representative group of developing countries. Table E 36 lists the assumptions used by KECO in preparing its investment plan.

Table E 36: RELATIVE COST OF GENERATION
(1975 prices)

	'000W/kW	US$/kW
Gas turbine	97.0	200
Combined cycle	145.5	300
Oil (300 MW)	169.7	350
Coal (200 MW)	218.2	450
Hydro	485.0	1,000
Nuclear (000 MW)		
L.W.R.	485.0	1,000
H.W.R.	630.5	1,300
Pumped hydro	145.5	300

Source: KECO.

While the estimated cost of thermal generation appears realistic the cost of nuclear plants is clearly overestimated. Recent estimates made in various countries appear to indicate that the cost of nuclear plant of the capacity to be installed in Korea should be about US$500-550 (in 1974 $). If these costs are taken into account, then the competitive edge of nuclear generation on conventional oil and coal fired plant appears clearly as shown below (Table E 37).

Table E 37: COMPARATIVE GENERATING COSTS
FOR A BASE LOAD PLANT

	Capital Cost $/kW	Capacity Factor %	Capital Charge ¢/kWAh	Fuel Cost ¢/kWh	Total
Oil (300 MW)	350	75	0.83	2.87	3.70
Coal (300 MW)	450	75	1.11	2.30	3.41
Nuclear (600 MW)	600	80	1.30	0.60	2.90

6.37 If the apparent excess capacity is absorbed and therefore the construction of 1,000 to 1,200 MW delayed, and if the cost estimates for nuclear plants are brought to more realistic levels, total generation investment over the 1977-81 period could be reduced by as much as 25%. However, it

would require more detailed studies before a final judgment could be made. It should also be noted that the unexpectedly rapid growth of the economy in 1976 has absorbed some of the excess capacity, justifying a somewhat larger investment outlay than implied by the above calculations.

(d) Mix of Generating Plants

6.38 The long-term development plan is based on the development of a large nuclear generating capacity, of which the first unit KORI #1 should come on stream in 1976 and the second and third in 1982 and 1983 respectively. Completion of KORI #1 is now scheduled for the end of 1976, and it should reach full power by mid-1977. Although somewhat optimistic, this could be achieved if everything goes well. However, the completion of two nuclear plants in 1981 and 1983 is doubtful, since we are not informed of any firm contract. Until nuclear plants are built, the main source of generation will be conventional oil-fired plants. Current projections are based on a four-year construction schedule which appears to be tight. However, if the completion of one or two units slips by one year, there is still enough spare capacity to meet the demand. However, it appears that a complete revision of the long-term power development plan is required and that it should be based on a more realistic and coherent assessment of future demand, generating capacity versus peak requirement and mix of generating plant taking account of the respective costs of generation of each made.

(e) System Operation

6.39 The power industry policy has so far been to meet the demand without lowering the quality of service. As already indicated, this has been done mainly by increasing generating capacity, sometimes beyond what was required. Transmission and distribution investments have not followed the same trend and until 1973-74, the amount of resources allocated to T and D was clearly insufficient to create and maintain a good balance between generation and transmission. This has resulted in high system losses, overloading and consequent risk of failure of equipment. However, in its 1977-81 investment plan, T and D investment accounts for about 40% of total investment which appears adequate considering the composite cost of generating plant included in the program. It appears that KECO has not undertaken any comprehensive analysis of its system (generation, transmission and distribution) to determine its optimum development at least cost and risk. In particular, it is doubtful that any serious consideration has been given to such problems as system stability and frequency variations under emergency conditions. These problems should be reviewed periodically and taken into account in the formulation of short-, medium- and long-term development plans.

6.40 It is the mission's opinion that the problems raised by the determination of an adequate system capacity including transmission and of the optimum mix of generating capacity are complex and should not be decided upon on an ad hoc basis. Past experience has shown that hasty decisions had deep repercussions on the overall performance of the power industry and could create long lasting financial and managerial difficulties. It is therefore recommended that the long-term development plan of the power industry be reviewed jointly by KECO, MCI and EPB to determine the least cost system development to meet the demand during the FFYP and beyond.

).41 The main purpose of this exercise would be to arrive at a long-term ;ystem development plan, that would supersede current plans and would be)ased on the evaluation of the relative costs and benefits associated with ılternative modes of power generation, alternative generation/transmission ıix and alternative time schedules. In particular it would be essential that :he problems of quality of service and of loss of load probability (proba-)ility of one or several power generating plants to get out of order) be ;tudied in detail. Considerable saving in power generation capacity can be ıchieved, if one accepts the risk of interruption of service during a reason-ıble period of time. How much can be accepted and which are the loads that ;hould be shed, should a power plant drop out of the system, depends largely)n the relative economic cost of the production losses incurred during the .nterruption and the incremental cost of providing additional generation :apacity to avoid interruption of service.

).42 To our knowledge such a study has not been carried out, as it was ıssumed that power needs should be satisfied at any cost. In the meantime :ECO should review its short-term development program (two to three years) ınd determine how the current excess generating capacity could be absorbed ınd whether any addition to existing capacity (other than those already :ommitted) should be decided upon before the review of the long-term develop-ıent plan is available.

Utility Management and Financial Performance

(a) General

).43 Although KECO is theoretically an independent company, its manage-ıent and performance have been strongly influenced by government decisions :egarding generating capacity, utility financing and power pricing. Recently :ECO has come under considerable criticism for less than adequate performance ınd various plans have been formulated for a reorganization of the power .ndustry. Most of these plans call for division of responsibility among ;everal agencies dealing with nuclear power, conventional generation and T ınd D. Although it is true that sector performance has been less than ıdequate, KECO should not be held entirely responsible for it. As already ıentioned, the current excess capacity resulted from the creation - outside :ECO - of large generating capacity that KECO had to absorb later on. The)oor financial performance is mainly due to inadequate pricing of power for /hich KECO cannot be accountable.

).44 It is mentioned in the draft FFYP that the main objectives of the)ower industry in the coming years will be to rationalize utility management ınd to improve the financial situation of the power industry. Instead of ;plitting up responsibilities for sector planning and operation among several ıgencies, better utility management could be achieved by consolidating ·esponsibility, implementing national power pricing policies and formulating ·ational and consistent utility management criteria.

(b) Sector Planning and Operation

6.45 The Korean power system is an integrated one and should, for the time being, remain so. Some decentralization may be considered at a later stage but only after the current problems have been solved and long-term objectives have been agreed upon. We believe that a single agency should retain control of Total System planning and operation and that its planning department should be reinforced possibly with external assistance to give more emphasis to economic and financial considerations than is presently the case. Since power is a service industry it is natural that the objectives of the power subsector should be determined jointly by KECO, MCI and EPB, but KECO should retain control on how this objective could be best achieved within anticipated technical and financial constraints. The analysis of various possible investment strategies should be a first step in this direction.

(c) Power Pricing

6.46 The current power pricing policy does not appear to reflect the cost of supplying power to the various users, nor does it provide an efficient tool for optimum resources allocation as indicated in a recent study of electricity rates by Professor Westfield. In addition, and despite the increase of electricity prices in 1975, current price levels do not provide KECO with sufficient internal resources to finance a reasonable part of its investment program. Under such circumstances it is very difficult to expect that management would be very efficient, any improvement of the management capability of KECO should be accomplished within the framework of a comprehensive revision of power pricing policy.

6.47 Several approaches could be followed to define tariff structures which would achieve adequate resource allocations, Professor Westfield considers in his report that the rate structure should be based on short-term incremental fuel costs. We do not believe that this is entirely adequate for a system such as the Korean system in which substantial changes are likely to occur in the structure and volume of generation in the future. It would seem more adequate to base the rate structure on long-term marginal cost of supply which should provide a better tool for resource allocation. In any case the study of Professor Westfield was a step in the right direction which should be followed up. Considerable literature is available on energy pricing and KECO, with the possible assistance of consultants should undertake a comprehensive tariff study as soon as the results of the analysis of long-term development plans are available.

6.48 The current level of prices does not enable KECO to generate sufficient resources internally to finance a reasonable part of its investment program; current financing projection indicates that KECO would contribute only 12.5% of its total investment program out of internal cash generation. Consequently KECO has to rely on government subsidies on the one hand and on borrowing (on rather unfavorable terms and conditions) on the other hand. In our opinion this situation has three detrimental effects. First, KECO's management cannot measure efficiently results against objectives, since any

policy action is distorted by the low level of prices (conservation), second, KECO access to domestic resources is limited since potential investors are discouraged by the poor return on their investment and thirdly KECO's contracting policy is affected by financial considerations which may lead to less than optimum contractual arrangements as it was the case for KORI #1 for which engineering and procurement had to be divided among the two main sources of finance. There is no mandatory rule as to what internal cash generation should amount to and special studies would have to be carried out to determine what KECO's contribution to the financing of its development program should be, and what effect this would have on electricity rates. However, it is obvious that the problem is urgent and that active consideration should be given to progressive increase in electricity prices and to the establishment and maintenance of adequate procedures for the automatic revision of electricity rates to account for cost variations.

(d) Utility Management Criteria

6.49 In the above paras. 6.43 to 6.48 we have advocated more managerial and financial autonomy in the power industry and a more realistic approach to energy pricing. While we believe that this should ultimately lead to better performance, it does not mean that the power industry should not be supervised at all. Power generation and transmission is a monopoly and as such rate determination and financial performance should be defined within the framework of rational utility management criteria which would limit KECO's profit to a reasonable level and would lead to optimum resource allocation and efficient performance without providing KECO with windfall profits. This implies inter alia the definition of minimum and maximum criteria for return on net fixed assets, internal cash generation in terms of percent financing of future investments, of adequate accounting practices such as revaluation of assets and of adequate reporting procedures to keep power companies' shareholders and MCI informed of the financial and operational situation of the company. To our knowledge although such rules exist, they are not applied consistently and in the absence of consistent criteria to appraise the power industry's performance and efficiency it is difficult for MCI to make any objective judgment on its overall performance to identify the areas where corrective actions should be taken.

Energy Conservation and Fuel Policy

6.50 Since the increase in the world prices of fuels it has been Korea's policy to conserve energy and a strong program has been launched and implemented that has brought about significant results. On the power industry however, little has been done, and there are no indications that power companies, and particularly KECO, have embarked on a coordinated effort to improve overall energy efficiency in power plants and to promote energy conservation measures at the consumer end, although some guidance is given to consumers on how they could reduce their peak demand. There are two main areas in which action could be taken immediately, improvement of efficiency of coal fired boilers presently using a mixture of liquid and solid fuel different from what they were designed for and an intensive campaign to reduce peak demand.

6.51 As already noted, some of the boilers do not operate with the solid/liquid fuel mixture they were designed for. This has resulted in higher maintenance and lower efficiency. It is recommended that steps be taken either to modify the boilers or to allocate enough coal of the proper quality to the power plants so that they can operate efficiently. If not enough coal is available it might be more advisable to convert certain boilers permanently to oil and allocate enough coal to a lesser number of plants. Over the past peak demand has brought somewhat more rapidly than power sales, and it is projected that until 1985 both should grow at about the same rate. Since peak demand is a determining factor in sizing total generating capacity and is usually satisfied by plants with lower fuel efficiency, it is KECO's interest to maintain peak demand as low as possible both from an investment and energy conservation point of view. KECO has a program of peak demand control which provides for visits to main users and for assistance in finding ways to reduce peak demand. However, since this program is not supported by financial incentives and/or penalties (which should be provided by adequate rates), it has had little if any effect so far. Understandably it is difficult, in the framework of the present rate structure, to achieve an efficient control of peak demand, but this problem should be kept in mind when deciding on revisions of the tariff structure.

6.52 A Possible Action Program for the Power Industry. From the above discussion, it appears that the problems affecting the power industry are primarily institutional although they influence both the technical and financial performance of the power industry. Partial solutions such as rate increases could possibly bring about temporary relief but they would not resolve the main issues, which are: what role should the power industry play in the Korean economy and what is the best way to ensure that it would play this role effectively. The mission believes that a single power agency should be solely responsible for the development of the power industry under the supervision of MCI until such time when operational considerations may require decentralization of operational responsibilities to a regional level. In any case a single organization should retain control of total system planning in the country and should have the power to enforce its decision. To achieve this, power enterprises (KECO at present) should be given more autonomy in deciding on its optimum development plan and on the level and structure of rates required to achieve its objectives and remain financially viable. For this purpose we would recommend the following program.

(a) A critical analysis by the Korean Government of the exact role which the power industry is to have in the long-term economic development of the country; i.e., should it remain in the public sector or should it be controlled by private interests, should it remain under the control of one enterprise, or should it be divided into several regional or functional branches, should KECO retain control of the nuclear program, etc. In the previous paragraph, we have indicated what we believe should be done. However, some of the decisions required have to be made within the overall

political, social and financial context of the country and may not coincide with our recommendations. It should, however, be clear that whatever the decisions made by the Government, one single entity should retain control over total system planning and investment coordination; and management procedures and performance criteria consistent with the government decision should be established and implemented.

(b) A revision of the power subsector long-term development program on the basis of the analysis of alternative development strategies.

(c) The reinforcement of power system planning, particularly in economic and financial planning, possibly with external assistance to create and maintain a system in which alternative projects could be evaluated in a rational and consistent way.

(d) A comprehensive tariff study which would on the one hand recommend the most adequate tariff structure to ensure efficient resource allocation, and on the other hand would determine the level of electricity rate to ensure the financial viability of the power subsector in the long run and would recommend adequate management and performance criteria for the power industry.

(e) Operational studies to analyze system load flow and stability, subtransmission and distribution systems, and total system operation.

It is obvious that this program would have to be spread over a relatively long period of time and that its implementation would be progressive. However, we believe that it is essential that the principle of autonomy of power enterprises (KECO or others) should be recognized as soon as feasible and that the revision of the power subsector long-term development plan takes place before the end of this year if uneconomical decisions are to be avoided.

The Petroleum Industry

Petroleum supply/demand forecast

(a) Total internal consumption

6.53 The future internal consumption of refined petroleum products is somewhat difficult to estimate accurately since on the one hand it will depend on what happens in other sectors. Slower growth in coal production would increase demand for refined petroleum products and on the other hand the difference between energy and nonenergy use is not always very clear and

some double counting may occur in the estimates of future consumption. How these difficulties can be resolved depends largely on the quality and reliability of the time series available and of the knowledge of the evolution of demand by end use. In the case of Korea, time series are not very useful mainly because of the relatively short time during which petroleum products have been used in significant quantities, and because most of the information on demand by end use is held by private or semiprivate oil companies which do not wish to release what they consider to be "confidential business information." These difficulties are reflected in various levels of demand projected by various agenies (MCI, KDI) within the framework of the FFYP. These projections, however, include exports and the consumption of refined petroleum products for energy as well as for nonenergy uses, which somewhat distort the results. In addition, various agencies use different units of measurements, without indication of the conversion factor which makes meaningful comparison difficult. Table E 38 below summarizes the draft FFYP projections.

6.54 These projections however have not been derived from an analysis of petroleum use by sector but have been computed as a residual after other sources of energy (coal, hydropower, nuclear and noncommercial energy). As we have indicated in para. 5.34 we believe that this has led to underestimation of petroleum demand in 1981. In Table E 38 we have made an attempt to allocate the projected demand of the plan to various end use sectors.

(i) Power generation. Demand for petroleum was computed on the basis of the operational data supplied by KECO and of the projected additions to power generation.

(ii) Industry. The projected demand is based on documents prepared by various agencies in charge of energy conservation. The comparison of the demand figure with the projected output of the industrial sector shows incremental petroleum intensity of 1.89 compared to 2.97 in 1974. Since there is no indication that future industrial development would be less energy intensive than in the past, it appears that demand may be underestimated. If one accepts the energy conservation target of 10% of industrial consumption as feasible, the extrapolation of the past, taking account of energy conservation would indicate a total petroleum demand in industry of about 9 million TOE.

(iii) Transportation. The projected demand in Table E 39 is based on the continuation of past trends as they are no indication of basic changes in this sector.

(iv) Residential Commercial. Over the past the consumption of petroleum in the sector has been moving very rapidly; the projected demand in Table E 38 would mean a considerable slowdown which does not appear justified in a period of

sustained growth. However, it is likely that higher prices of petroleum would tend to discourage consumption and that the rapid growth of the past will not continue in the future. We have therefore estimated that total demand in the residential sector would move at a similar pace as private consumption and that petroleum demand would bridge the gap left after allocation of coal and noncommercial energy.

	'000 TOE
Total projected demand	14,973
- Coal	8,539
- Noncommercial energy	2,254
- Petroleum	3,807
- Electricity	373
Total	14,973

This would mean a rate of growth of petroleum of about 22% p.a. which is still substantially lower than those observed over the past. (From 1974 to 1975 the demand for kerosene and LPG grew at more than 30% p.a.)

(v) Other. The projected demand in Table E 38 is based on past trends.

On the basis of the above the total demand for petroleum products in 1981 is estimated to be:

Energy use:

Power generation	6,766
Industry	9,000
Transport	4,200
R/C	3,807
Other	841
Total	24,614
Nonenergy use	4,091
Total	28,705

equivalent to 225.7 million barrels compared to 196.6 million barrels in the plan./1 Total import requirements would then be:

/1 The final FFYP projects import requirements at 233.6 million barrels in 1981.

energy and nonenergy use: (1)	225.7
reserve product (increment) (2)	-
reserve crude (increment) (3)	0.3
losses 0.045 of (1) + (2) =	10.0
Total	236.0

which is about 12% higher than the draft plan forecast. On that basis the elasticity of petroleum to GNP would be: 1.6 compared to 2.4. This is due to the fact that less substitution of petroleum for coal would take place particularly in power generation where the first nuclear plan will be introduced and also to the result of the energy conservation program.

6.55 The apparent elasticity of the growth of petroleum demand to the growth in GNP, according to this forecast would be of about 1.22 compared to an average of 2.4 over the 1966-74 period.

Table E 38: PROJECTED CONSUMPTION OF PETROLEUM PRODUCTS 1974-81/a
'000 TOE/%

Internal Demand (Energy Use)	1974		1981		Average Rate of Growth
Power generation	2,932	27.5	6,766	32.3	13.5
Industry	4,146	38.9	7,238	34.7	8.3
Transportation	2,051	19.2	4,200	20.0	10.7
Residential/Commercial	935	8.8	1,874	9.0	10.3
Others	594	5.6	841	4.0	5.1
Subtotal	10,658	100.0	20,919	100.0	10.1
Internal Demand (Nonenergy Use)	1,768		4,091		12.6
Total	12,426		25,010		10.5

/a The sectoral allocation was estimated by the mission.

Source: MCI

(b) Supply

6.56 As shown in Table E 38 the structure of demand by end use sectors is not expected to change considerably and, therefore, the product mix should remain similar to the current one, with heavy and light fuel oils accounting for about 75% of total demand.

6.57 Since no hydrocarbons have yet been discovered in Korea or in the surrounding waters, internal demand will have to be satisfied entirely from imports. Understandably, the problems of securing long-term supply contracts at relatively low cost has been of great concern to the Government of Korea, which has been trying to consolidate its trade relations with oil exporting countries, (Korean contractors are very active in Iran and Saudi Arabia), and to attract investments by oil producers (an agreement negotiated with the National Iranian Oil Company (NIOC) provides for NIOC's participation in the financing of Korea's fourth refinery which should come on stream by 1980).

6.58 Because of the relative slowdown of demand for petroleum products in 1973 and 1974, the current refining capacity is ample to satisfy the demand until mid-1977. Beyond 1977 three successive expansions of existing refineries are foreseen; 60,000 b/d, 40,000 b/d and 40,000 b/d respectively in 1978, 1979 and 1981. This with the addition of fourth refinery of about 100,000 b/d in 1980 should provide sufficient capacity to meet the projected demand and to maintain a reserve margin of about 10 to 15% which could cover additional requirements if demand grows faster than currently anticipated. It is our understanding that the construction of the fourth refinery has already been decided, although its location is not yet known. This decision is linked to the Government of Korea's policy to attract investment from oil producing countries, but it may not represent the least cost solution and it would probably have been less costly to expand refineries rather than build a completely new one. The current refinery expansion program is a drastic reduction of the 1974-75 expansion program which called for the addition of about 500,000 b/d between 1977 and 1981.

Projected Sector Performance and Institutional Changes

6.59 Besides the establishment of a stable petroleum supply base and the expansion of the refinery capacity to meet the anticipated demand, the Government of Korea is considering a reform of the petroleum industry which would strengthen the role of the Government and would promote more exploration activity particularly off-shore.

(a) The Role of Governments in the Petroleum Industries

6.60 The petroleum industry is supervised by MCI in much the same way as other energy industries. However, the three main oil companies in Korea have retained considerable independence from MCI, mainly because they have been able to expand without government assistance. Although MCI has the power of approving expansion plans, market strategies and retains control over the prices of petroleum products, it has so far not interfered directly with the operation of the sector. This policy may have been justified in the past when the main problem was to balance supply and demand at reasonable costs, it does not appear to be fully justified any longer. Although the

petroleum industry is efficient and well organized, its interests may not necessarily coincide with the country's interest and procedures should exist whereby the objectives of the industry and of the Government of Korea could be discussed and agreement could be reached on actions to be taken. Such procedures have been established in many European countries and particularly in France, and have worked efficiently to the mutual satisfaction of the government and of the industry. First the MCI needs to know more about the structure of the market for petroleum products and of the parameters that influence the level and structure of demand, it also needs to decide which are the sectors in which the consumption of petroleum products should be discouraged and how this could be achieved. (It is rather pointless to launch a public awareness campaign about energy and particularly petroleum products' conservation if at the same time, the local petroleum distributors launch an advertising campaign to promote their use). The Government of Korea has also a role to play in the determination of the level of strategic stock it wants to keep, their location and financing as well as in the selection of the most economical transport system for refined products (for example, the feasibility of a refined produce pipeline between the Inchon terminals and Seoul should be investigated). These assignments normally should come under the responsibility of MCI within the framework of its supervision of the petroleum industry. The Petroleum Section of MCI may not have the required expertise to carry out this assignment and it would be advisable for MCI to use outside assistance at least in the initial stage.

(b) The Role of Government in Petroleum Exploration and Development

6.61 The Government of Korea is currently considering the creation of a Korean Petroleum Development Corporation (KPDC) which would perform for the petroleum industry services similar to those of KMPC for the coal mining industry. Initially, it would seem that the main role of KPDC would be to organize and follow up exploration activities onshore and particularly offshore, and to undertake, probably in association with foreign oil companies, the development of commercial discoveries. This initiative is extremely interesting and timely, since the increase in the price of petroleum has opened new prospects for exploration. However, the practices of the petroleum industry are complex and Korea has so far little technical, legal and operational expertise in these matters. Considerable experience has been built up in the development of the oil and gas fields of the North Sea and it would be advisable for the Government of Korea to use some independent oil consulting firm of world repute to advise them on the most adequate course of action. In our opinion, it would be desirable to create a limited team with sufficient qualification and experience to review the problems associated with systematic exploration for oil and to recommend solutions to the Government of Korea. This team could subsequently handle negotiations with potential bidders for exploration perimeters and with potential contractors should hydrocarbons be discovered.

Projected Investments in the Petroleum Industry

6.62 Investments in the petroleum industry are projected at W 161 billion (US$331 million). This amount appears adequate. However it is difficult to make a judgment as nothing is known yet on the degree of complexity of the projected expansions and of the new refinery.

Pricing of Petroleum Products

6.63 Although the prices of petroleum products have been increased to reflect the increase in the cost of petroleum supplies and do reflect import parity, the Government of Korea and the petroleum industry are considering a new revision of the price system of petroleum products in which the ex-refinery price would be based on the price of products in the Persian Gulf plus transport to Korea. Retail and wholesale prices would then be equal to ex-refinery prices augmented by transport and distribution costs and taxes. Pricing of petroleum products is a very complex problem since it involves the costing of joint products for which no cost breakdown is possible, and therefore unless prices are set at what the market can bear, any prices' system would have to be a compromise between the price fixing authorities and the petroleum industry.

(a) Ex-refinery Prices.

6.64 It could be argued that refineries could possibly sell their production on the external market and therefore that they should sell petroleum products at international prices. This, however, may lead to refinery yields which are more related to the international market than the internal market and may also lead to excessive investment in refining capacity and reliance of export markets to fully utilize capacity as it had been the case in the past. A second approach to pricing of petroleum products is to consider refining in much the same way as power generation and to set prices at a level which will enable the refining company to earn an adequate return. In this case, however, the refiners have little incentive to improve productivity and to run an efficient and cost conscious operation. In the case of Korea the first method appears more suitable, (particularly if MCI supervises effectively the operation and development of the petroleum industry). This practice should partly eliminate cross subsidies among products, however, it may lead to higher costs of petroleum products than would be required to ensure a reasonable return to the refineries. For example products are transported by small tankers at a much higher cost than petroleum and therefore a system in which products' prices are based on posted prices in the Persian Gulf plus transport might integrate a transport element higher than the actual cost of petroleum transport from the Gulf to the Korean refineries.

(b) Retail Prices

6.65 Retail prices to consumers should reflect the actual cost of supply to the users including external costs which may not be directly perceived by the consumers (pollution, environmental protection, etc.). Since prices are controlled by the Government, and normal market forces do not play a significant role in the determination of prices, MCI is responsible for determining prices for each product which would cover direct and indirect costs and avoid misallocation of resources. This problem is particularly complex in the petroleum industry because the allocation of cost among various products is necessarily arbitrary. While the total cost of petroleum supply can be estimated it is practically impossible to find out how those costs should be allocated to any one product. The reliance on international prices should provide some guidance for the allocation of processing costs, however, it would not provide an efficient answer for the allocation of external cost associated with the use of petroleum products. For example diesel oil is

used in road transport, and the cost of diesel to road transport companies should include taxes to cover road user charges (road construction and maintenance), however, diesel oil is also used for rail transport, power generation and industry, in which a tax on road usage is not justified. Therefore, if prices are to reflect costs, a certain element of discrimination would have to be introduced in the price structure and several levels of prices set for the same product according to its different uses. This can only be achieved through a comprehensive analysis of the end use demand for each product and of the cost incurred in its production, transport, distribution and utilization. To our knowledge, MCI has not carried out such a study in determining the current prices and taxes of refined petroleum products. As a result while the overall level of prices appears to be generally adequate, it is likely that there are some cross subsidies among products which if they are not corrected may create some undesirable shift in the demand which could require additional refining and/or secondary processing facilities which could otherwise be avoided. One example of these shifts is the substitution of LPG for gasoline in private cars. It is therefore recommended that MCI carry out a comprehensive study of petroleum prices to determine the adequate level of prices at the various stages of the production and distribution process.

A Possible Program of Action for the Petroleum Industry

6.66 The petroleum industry in Korea is going through a period of transition in which it will have to adapt to a period of slower growth. A number of actions have been taken by the Government of Korea and other agencies which will ultimately influence the level and structure of demand and supply. However, it is difficult at present to estimate accurately the magnitude of these changes, since most of the new policies have only been formulated recently and have not yet brought about significant results. Under these circumstances two different types of action could be considered which would deal with short- and long-term issues respectively.

(a) Short Term

6.67 As explained above, the main problem is to monitor the result of the overall energy program and to adjust the supply and demand of petroleum products. This would require a continuous follow-up of the development of other energy subsectors and of the main consuming sectors (transportation, power generation, industry) to appraise their development and assess future petroleum requirements. This "permanent market survey" could be undertaken by MCI, within its overall supervision of the energy sector. It would, however, be advisable to create a special group within the Bureau of Energy Development, which would gather and process the available information and would issue periodic reports on the development of the total energy supply/demand situation. One of the main assignments of this group would be to assess the results of the energy conservation program and to analyze the respective evolution of the demand for each source of energy in the main end use sectors.

(b) Long Term

6.68 The higher cost of petroleum supplies and the relative importance of petroleum in total imports, would warrant a reassessment of the role of

MCI in the petroleum industry. It would seem advisable that the role of the refinery division in the Bureau of Energy Development be expanded and that this division carry out an analysis of the future development of the petroleum industry and of the role that the Government should play to ensure that the industry would adequately serve the needs of the country. This would require that MCI undertake a study of the various aspects of the industry, refinery, transport, storage, distribution and utilization and assess for each of them whether government intervention is required to promote a more efficient development, or whether private enterprises alone could come up with least cost development plans. It is expected that the role of MCI would be particularly significant in transport, storage and distribution in which private companies might be reluctant to cooperate.

6.69 The above study, and the results of the market analysis carried out by the coordinating group referred to in para. 6.62 should then enable MCI to better analyze the cost of supply of petroleum products and to formulate a more adequate pricing policy.

(c) Exploration and Development

6.70 It is recommended that the KPDC be created initially with a limited staff to investigate the possibilities that exist to improve the quality and coverage of current exploration ventures and the opportunity to attract new companies. One of the first assignments of KPDC would be to review the type of agreement which could be entered into with foreign oil companies and to determine which one would be most adequate to Korea. Since Korea has little experience in the oil industry it is not recommended that a local exploration and petroleum development capability be developed until such time as actual production would warrant it.

KOREA

ENERGY SECTOR REVIEW

PAST AND PROJECTED PRIMARY ENERGY REQUIREMENTS

	1966		1974		Annual	Projected 1981		Annual
	000 Toe /a	%	000 Toe /a	%	rate of growth %	000 Toe /a	%	rate of growth %
Hydro /b	310	2.8	320	1.6	-	450	1.3	-
Coal	5,165	46.2	6,428	31.6	2.8	10,959	31.4	-
Petroleum	1,802	10.1	10,658	52.4	24.8	20,413	58.5	-
Nuclear	-					822	2.4	-
Noncommercial Energy	3,888	34.9	2,934	14.4	(3.2) /c	2,254	6.5	-
Total	11,165	100	20,340	100	7.8	34,989	100	-

/a 1 ton of oil equivalent (Toe) is equal to 23,256 ton of anthracite.

/b Hydropower generation is estimated on the basis of 3,134 kcal./kwh. and 2,140 kcal./kwh. in 1966 and 1974 respectively.

/c Annual rate of decline.

Source: MCI.

March 15, 1977

KOREA

ENERGY SECTOR REVIEW

STRUCTURE OF FINAL DEMAND FOR FUELS
1966-1981

	1966	%	1974	%	1981	%
I. Electricity						
(Million kwh.)	3,008		13,800		37,337	
('000 Toe /a	260	2.5	1,193	6.6	3,229	11.0
II. Fuels ('000 Toe)						
Coal	4,586	44.2	6,249	34.6	8.954	31.3
Petroleum	1,638	15.8	7.726	42.6	14,153	49.5
Subtotal	6,224	60.0	13,975	77.2	23,107	80.8
Noncommercial energy	3,888	37.5	2,934	16.2	2,254	7.9
Total	10,372	100.0	18,102	100.0	28,590	100.0

/a Converted at 0.865 kcal/kwh.

Source: MCI.

March 15, 1977

KOREA

ENERGY SECTOR REVIEW

STRUCTURE OF PRIMARY ENERGY DEMAND 1966-1981

	1966		1974		1981 FYP	
	'000 Toe	%	'000 Toe	%	'000 Toe	%
Power generation	1,053	9.4	3,431	16.9	9,180	26.5
Industry	1,057	9.5	4,397	21.6	7,653	22.0
Transportation	755	6.8	2,051	10.1	4,243	12.3
Residential/Commercial	7,603	68.1	9,743	47.9	12,667	36.7
Others	697	6.2	718	3.5	841	5.3
Total	11,165	100.0	20,340	100.0	34,584	100.0

Source: MCI.

March 15, 1977

KOREA

ENERGY SECTOR REVIEW

SUPPLY OF PRIMARY ENERGY 1966-1981

	1966	1974	1981
Total primary energy requirements			
Coal	5,165	6,428	10,959
Oil	1,802	10,658	20,413
Hydro/nuclear	310	320	1,272
Noncommercial energy	3,888	2,934	2,254
	11,165	20,340	34,898
Supply of primary energy			
Domestic			
Coal	5,165	6,428	10,142
Hydro	310	320	450
Noncommercial energy	3,888	2,934	2,254
Subtotal	9,363	9,682	12,846
Domestic ratio: supply/demand	84%	48%	37%
Imports (net)			
Oil	1,802	10,658	20,413
Nuclear	-	-	822
Coal	-	-	817
Subtotal	1,802	10,658	22,052
Imports ratio: supply/demand	16%	52%	63%

Source: MCI.

March 15, 1977

KOREA

ENERGY SECTOR REVIEW

PRIMARY ENERGY CONSUMPTION BY SECTOR IN 1966

	Hydro		Coal		Oil		Subtotal Commercial Energy		Noncommercial Energy		Total	
	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%
Power generation												
'000 Toe	310	100.0	579	11.2	164/a	9.1	1,053	14.5			1,053	9.4
% of Total	29.4		55.0		15.6						100.0	
Industry												
'000 Toe			417	8.1	640	35.5	1,057	14.5			1,057	9.5
% of Total			39.5		60.5						100.0	
Transportation												
'000 Toe			172	3.3	583	32.3	755	10.4			755	6.8
% of Total			22.8		77.2						100.0	
Residential/commercial												
'000 Toe			3,640	70.5	75	4.2	3,715	51.0	3,888	100.0	7,603	68.1
% of Total			47.9		1.0				51.1		100.0	
Others												
'000 Toe			357	6.9	340	18.9	697	9.6			697	6.2
% of Total			51.2		48.8						100.0	
Total	310	100.0	5,165	100.0	1,802	100.0	7,277	100.0	3,888	100.0	11,165	100.0
% of commercial energy	4.2		71.0		24.8		100.0					
% of total energy	2.8		46.3		16.1		65.2		34.8		100.0	

/a The figure reported by KECO for this year is somewhat higher (i.e. 280,000 Toe) MCI's figure has been used for consistency.

Source: MCI and mission's estimates.

KOREA

ENERGY SECTOR REVIEW

PRIMARY ENERGY CONSUMPTION BY SECTOR IN 1974

	Commercial Energy						Subtotal Commercial Energy		Noncommercial Energy		Total	
	Hydro		Coal		Oil							
	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%
Power generation	320	100.0	179	2.8	2,932/a	27.5	3,431	19.7			3,431	16.9
% of Total	9.3		5.2		82.5		-				100.0	
Industry	-		251	3.9	4,146	38.9	4,397	25.3			4,397	21.6
% of Total			5.7		94.3						100.0	
Transportation					2,051	19.2	2,051	11.8			2,051	10.1
% of Total					100.0		-				100.0	
Residential/commercial			5,874	91.4	935	8.8	6,809	39.1	2,934	100.0	9,743	47.9
% of Total			60.3		9.6				30.1		100.0	
Others			124	1.9	594	5.6	718	4.1			718	3.5
% of Total			17.2		82.8						100.0	
Total	320	100.0	6,428	100.0	10,658	100.0	17,406	100.0	2,934	100.0	20,340	100.0
% of commercial energy	1.9		36.9		61.2		100.0					
% of total energy	1.6		31.6		52.4				14.4		100.0	

/a Includes oil consumption of power plants outside KECO's generation system.

Source: MCI and mission's estimates.

June 15, 1976

KOREA

ENERGY SECTOR SURVEY

PROJECTED PRIMARY ENERGY CONSUMPTION BY SECTOR IN 1981

	Nuclear and Hydro		Coal		Petroleum		Subtotal Commercial Energy		Noncommercial Energy		Total	
	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%	'000 Toe	%
Power generation	1,272	100.0	774	7.1	5,906	28.9	7,952	24.4			7,952	22.7
% of Total	16.0		9.7		74.3						100.0	
Industry			1,075	9.8	6,578	32.2	7,653	23.4			7,653	22.0
% of Total			14.0		86.0						100.0	
Transportation			43	0.4	4,200	20.6	4,243	13.0			4,243	12.2
% of Total			1.0		99.0						100.0	
Residential/commercial			9,067	82.7	1,874	9.2	10,941	33.5	2,254		13,195	37.8
% of Total			68.7		14.2				17.1		100.0	
Others					1,855	9.1	1,855	5.7			1,855	5.3
% of Total					100.0						100.0	
Total	1,272	100.0	10,959	100.0	20,413	100.0	32,644	100.0	2,254	100.0	34,898	100.0
% of Commercial energy	3.9		33.6		62.5		100.0					
% of Total energy	3.6		31.4		58.5				6.5		100.0	

Source: MCI and Mission estimates.

March 15, 1977

KOREA

ENERGY SECTOR REVIEW

	Past and Projected Final Energy Demand by Sector							
	Actual				Average rate of growth per annum	198[illegible]		Average rate of growth per annum
	1966	%	1974	%	%		%	%
I. Electricity (million Kwh)								
Residential/commercial	501	16.6	1,996	14.5	19.0	4,317	12.0	15.0
Light industry	311	10.4	3,130	22.7	33.0	6,192	17.3	10.2
Large industry	2,166	72.0	8,615	62.5	19.0	24,898	70.4	16.5
Agriculture	30	1.0	59	0.3	19.0	100	0.3	7.8
Total	3,008	100.0	13,800	100.0	21.0	35,507	100.0	14.5
II. Fuels ('000 Toe)								
Residential/commercial								
Coal	3,640	41.9	5,874	60.3	6.0	9,067	68.7	6.4
Petroleum products	75	1.0	935	9.6	37.0	1,874	14.2	10.5
Noncommercial energy	3,888	51.1	2,934	30.1	(-3.6)	2,254	17.1	(3.8)
Total	7,603	100.0	9,743	100.0	3.1	13,195	100.0	4.4
Industrial								
Coal	417	39.5	251	14.7	6.9	1,075	14.0	23.2
Petroleum products	640	60.5	4,146	85.3	26.3	6,578	86.0	6.8
Total	1,057	100.0	4,397	100.0	21.0	7,653	100.0	8.2
Transportation								
Coal	172	22.7	-	-	-	43	1.0	
Petroleum products	583	77.2	2,051	100.0	17.0	4,200	99.0	10.7
Total	755	100.0	2,051	100.0	13.5	4,243	100.0	10.7
Others								
Coal	357	51.2	124	17.2	(14.1)			
Petroleum products	340	48.8	594	82.8	7.2	1,855	100.0	17.8
Total	697	100.0	718	100.0	-	1,855	100.0	17.8
Total fuel demand								
Coal	4,586	45.4	6,249	36.9	4.9	10,185	38.4	7.2
Petroleum products	1,658	16.2	7,726	45.7	21.4	14,507	54.6	9.4
Noncommercial energy	3,888	38.4	2,934	17.4	(-3.6)	2,254	7.0	(3.8)
Total	10,122	100.0	16,909	100.0	7.0	26,946	100.0	7.0

Source: MCI mission's estimates.

June 15, 1976

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