INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

THE REPUBLIC OF KOREA 2002 REVIEW

OECD

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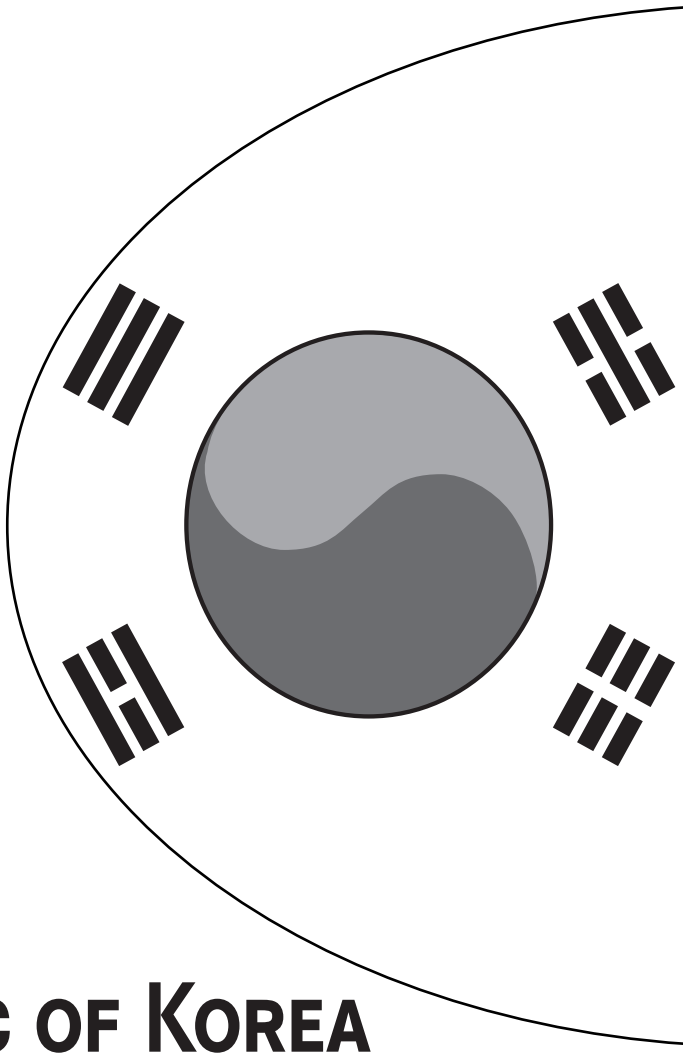

THE REPUBLIC OF KOREA 2002 REVIEW

INTERNATIONAL ENERGY AGENCY
9, rue de la Fédération,
75739 Paris, cedex 15, France

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty Member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

** IEA Member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

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SUMMARY AND RECOMMENDATIONS

The objectives of the Republic of Korea's energy policy are coherent with IEA Shared Goals. They are to:

- Maintain a stable energy supply.
- Increase market efficiency through competition.
- Establish environment-friendly energy systems.

Since the IEA's last in-depth review in 1994, Korea's energy policies have changed significantly. The government has promoted greater use of natural gas, encouraged the development of nuclear capacity and initiated steps to launch renewable energy markets. Emergency oil reserves have now expanded. To increase the efficiency of the energy market, the government has begun to withdraw gradually from direct management of the energy sector through capital ownership, licences and control, leaving the market free to allocate resources for investment. The petroleum sector has been deregulated, the electricity sector has been restructured, reform of the gas sector has begun, and a new regulatory framework is emerging for electricity and gas. To develop a cleaner system, energy policies have promoted conservation and a more efficient use of energy. They have promoted renewable energy by requiring mandatory equipment procurement rules and funds for R&D; and they have pursued public financing of R&D to develop new energy technologies.

The review commends the government's efforts to diversify the supply of energy. It also commends the government's efforts to introduce competition into the electricity sector, and to withdraw gradually from direct operations in the petroleum, electricity, gas and coal sectors. Several issues must, however, still be resolved before competition becomes effective.

Korean energy policy has long focused on increasing the supply of energy to satisfy rapidly growing demand stemming from the strong economic growth of the last thirty years. This growth was spawned by the expansion of energy-intensive industries in the 1980s and 1990s. However, investments in energy-intensive industries are expected to fall sharply in the coming years, causing energy intensity to fall from its current levels, more quickly probably than the OECD average, particularly as energy prices increasingly reflect full costs. The review acknowledges Korea's efforts to give energy service companies incentives to implement energy conservation measures, and to promote public-private partnerships to develop labelling and to facilitate improvements in energy-efficient technology. Demand-side management should be a priority.

Since the last review, Korea's carbon dioxide emissions have grown more quickly than the IEA average. At the same time, the implementation of more stringent emission standards has kept the growth of local emissions from the energy sector

(such as SO_x) relatively controlled. Korea retains its status as a "developing country" in international climate change negotiations on the basis of its low per capita income (half the OECD average). In the future, however, its role should reflect its high per capita energy consumption. Korea will need to reflect environmental costs in the price of energy or of energy-consuming equipment (such as private cars) in order to mitigate CO_2 emissions.

The review commends the Korean government for its achievements in restructuring Korea Electric Power Corporation (KEPCO), and for setting up an electricity exchange and a regulatory energy committee. It draws attention to the risks and advantages of having a single publicly-owned company holding nuclear plants and giving it a mandate to construct new baseload plants. This could distort competition. We emphasise the importance of continuing to monitor carefully the development of competition to ensure the security of supply of energy is maintained in a liberalised market. The review recommends that the government clarify and respect the implementation calendar for the remaining stages of the reform plan. In addition to greater independence for the regulator, this will require introducing more competition through a bid-based electricity market, competitive pricing of transmission and a competitive price for electricity.

The performance and safety records of Korea's nuclear power plants have been satisfactory. However, as in other countries, public concern about safety and waste disposal is growing in Korea. Greater efforts must be made to communicate with the public and to push forward plans for waste disposal.

Oil plays an essential and increasingly important role in the Korean energy sector: it represents more than half the energy supply. In 1998, the government deregulated the petroleum industry, surrendering its control over production. Today, a few large private companies constitute the refining sector and dominate the petroleum product market. There is some concern that they can artificially set prices and make it difficult for new players to enter the market. The review calls for competition in the oil sector to be more carefully monitored.

Korea has become an important player in the world gas market. The use of natural gas has grown sharply since the last in-depth review. Industry and households use natural gas increasingly for electricity production and for heating. All gas is imported in the form of liquefied natural gas (LNG), and Korea has become the second largest world importer of LNG. KOGAS, the public monopoly, is the world's largest LNG importing company. Gas industry reform was launched after the reform of the electricity sector had begun. KOGAS is to be restructured completely, by splitting it into three trading companies that will later be privatised, by privatising its subsidiaries, by instituting open access to terminals and transmission networks, and by making the retail sector competitive. The review commends the efforts made to introduce competition and to increase the efficiency of the entire gas industry. However, it strikes a note of caution concerning the implications for energy security of restructuring KOGAS, especially as an importer, and draws attention to the risks if reform plans are not clarified rapidly. Like the electricity sector, the gas sector will require an independent regulator as soon as possible.

The review recognises the importance of coal for the Korean energy sector, but points out that domestic production cannot compete with imported coal. The government needs to review its policy of supporting domestic coal consumption. Any remaining subsidies will need reform. Since the use of coal for electricity production is expected to grow in the future, there is good reason to promote the use of clean coal combustion technologies.

RECOMMENDATIONS

The Government of Korea should:

General Energy Policy

☐ Continue to diversify energy supply and to improve energy efficiency.

☐ Establish an independent regulator for both the electricity and gas sectors; clarify the relationships between the energy regulator and the Fair Trade Commission.

☐ Eliminate ceilings and restrictions on foreign investment.

☐ Eliminate price distortions by removing price ceilings and cross-subsidisation and, where necessary, by adjusting taxation to reflect environmental costs.

Energy Efficiency

☐ Make energy efficiency a high priority; strengthen energy efficiency policy through additional measures.

☐ Facilitate the process of energy pricing so that fuel prices reflect costs.

☐ Ensure Korea's standards and energy efficiency norms comply with best international practice.

☐ Develop further energy efficiency policies as part of the effort to reduce greenhouse gas emissions.

Environment

☐ Seek to strike a better balance among economic, energy, and environmental objectives; implement the recommendations on transportation made in the 1994 IEA review: full cost pricing, increasing the use of smaller vehicles, and developing public transportation systems.

☐ Accept more international environmental responsibilities, including under the United Nations Framework Convention on Climate Change (UNFCCC). Strengthen bilateral and multilateral co-operation to enhance global efforts in tackling climate change.

Renewables

☐ Assess the potential of renewable energy resources.

☐ Assess the cost-effectiveness of renewables and define accordingly objectives for technology development, industrial expansion and market deployment.

☐ Consider pricing externalities, such as air and soil pollution, and the risks associated with conventional power plants, as a factor in developing renewable electricity options.

☐ Consider increasing public participation in public-private partnerships for R&D technology projects.

☐ Consider implementing "green pricing" as a first step to creating a market for green electricity; as a second step, consider establishing a target for renewable power generation using market mechanisms such as renewable portfolio standards and tradable certificates.

Electricity

☐ Set and adhere to a firm timetable for liberalising the market, establishing an independent regulator, and privatising the generating companies.

☐ In reforming the sector, take the following steps to enhance the security of electricity supply:
- proceed with the plan to introduce a competitive, bid-based electricity market, including demand-side bidding with regulatory oversight;
- ensure appropriate financial mechanisms for the electricity market so that suppliers are sure to meet their contractual obligations;
- consider developing financial instruments, such as electricity futures contracts, to enable potential investors to hedge against market risks;
- monitor the development of competition carefully and, if necessary, consider further measures to encourage market participants to invest in generation.

☐ Include regulatory incentives to distribution companies, including least-cost procurement of energy, to make them more efficient.

☐ Eliminate price distortions favouring industrial customers; eliminating regulated energy tariffs to liberalised industrial customers can facilitate this.

☐ Consider pricing transmission services by location.

☐ Ensure that electricity tariffs fully reflect time-of-use costs for generation.

Nuclear Energy

☐ At least maintain past standards of performance and safety of nuclear plants in the future; regularly assess the rationale for the target size of the nuclear energy component in the overall energy mix.

☐ Establish construction plans for Korea's future nuclear power plants early in the newly competitive electricity market, well in advance of the lead-times for building other types of plants.

☐ Pursue efforts to gain public acceptance of the future deployment of nuclear energy; increase active participation in OECD/NEA studies and workshops in this area.

☐ Make greater use of the international market for goods and materials for operating nuclear plants.

☐ Allocate more resources to research and development on nuclear waste management.

☐ Continue with plans to establish a disposal site for low- and medium-activity nuclear waste and formulate plans for disposing of irradiated nuclear fuel.

Oil

☐ Continue efforts to develop domestic and overseas investment in upstream activity; ensure that exploration projects are economically viable.

☐ Continue efforts to diversify oil supply sources; maintain good relations with oil-producing countries.

☐ Ensure effective competition in the domestic oil market; strengthen market monitoring to prevent unfair pricing by large companies.

☐ Continue efforts to ensure the immediate implementation of the Third Stockpiling Plan in order to enlarge the emergency oil stockpile.

Gas

☐ Consider the merit of a policy to co-ordinate LNG purchases made by private gas buyers under the KOGAS brand name as a contribution to effective gas purchasing and supply security.

- ☐ Set and adhere to a firm timetable to reform the gas industry and to establish a new gas regulatory institution.

- ☐ As a solution to privatise KOGAS, consider selling KOGAS stocks progressively to private investors, but in the knowledge that four separate companies will subsequently be created. The government could retain a golden share to preserve Korean interests.

- ☐ Ensure that gas prices reflect costs.

- ☐ Closely monitor costs in the monopoly areas of the gas industry after the privatisation of KOGAS.

- ☐ Ensure the regulator's independence after the privatisation of KOGAS; ensure that the regulator is given sufficient power to regulate the market.

- ☐ Address the issue of assigning LNG sales contracts with KOGAS to several buyers, in order to satisfy the needs of both LNG sellers and financiers, without unduly prejudicing the interests of existing KOGAS shareholders.

Coal

- ☐ Negotiate with mine operators and employees to set a firm target for ending all forms of government support for domestic coal production.

- ☐ Replace the ceiling on prices for domestic coal production with direct income support, where justified on social grounds.

- ☐ Ensure that coal consumers have no obligation to buy domestically-produced coal.

- ☐ Remove the import tariff and value-added tax (VAT) on imported coal or redesign them as measures to offset the environmental impacts of coal use.

- ☐ Assess the feasibility of clean coal technologies.

Energy Technology Research and Development Activities

- ☐ Develop effective monitoring and evaluation mechanisms to measure the effectiveness of R&D programmes; ensure that the monitoring mechanism is transparent and that public expenditures on energy R&D are more visible.

- ☐ Encourage private sector commitment to R&D and actively develop new public-private research partnerships.

- ☐ Strengthen international R&D co-operation by playing a more active role in IEA Implementing Agreements.

2

CONDUCT OF THE REVIEW

This is the third in-depth review of the energy policies of the Republic of Korea, following those in 1992 and 1994, and was intended particularly to mark Korea's accession to the IEA. It began as a review of a non-member country and was completed as a review of a member country. The IEA Office of Non-Member Countries (ONMC) and the Office for Long-Term Co-operation and Policy Analysis (LTO) have worked jointly on this report.

A team of energy policy specialists visited Korea in April 2001 for discussions with government officials, energy suppliers and energy consumers. Their report draws, particularly, on information provided before, during and after that visit by the Korean Ministry of Commerce, Industry and Energy, and by the Ministry of Environment, and supplemented by published sources and IEA statistical data.

The review team was composed of:

Mr. Oliver Appert (team leader)
Director, Long-Term Office
International Energy Agency

Mr. Paul Kay
Department of Industry, Science and Resources
Australia

Mr. Noriyuki Shikata
Ministry of Foreign Affairs
Japan

Mr. Peter Wilmer
Nuclear Development Division
OECD Nuclear Energy Agency

Mr. Peter Fraser
Energy Diversification Division
International Energy Agency

Mr. Izuru Shimmura
Emergency Planning and Preparations Division
International Energy Agency

Mr. Pierre Audinet
Asia-Pacific and Latin America Division
International Energy Agency

During its visit to Korea, the team held meetings with the following organisations:

- Federation of Korean Industries (FKA);
- Korea Electric Power Corporation (KEPCO);
- Korea Energy Economics Institute (KEEI);
- Korea Energy Management Corporation (KEMCO);
- Korea Gas Corporation (KOGAS);
- Korea National Oil Corporation (KNOC);
- Korea Petroleum Association (KPA);
- Korea Power Exchange (KPX);
- LG Power;
- Ministry of Commerce, Industry and Energy (MOCIE), Energy and Resources Policy Division;
- Ministry of Commerce, Industry and Energy, Petroleum Industry Division;
- Ministry of Commerce, Industry and Energy, Power Industry Reform Division;
- Ministry of Environment;
- Ministry of Foreign Affairs and Trade.

The assistance and co-operation of all participants are gratefully acknowledged. The team is particularly grateful to the Ministry of Commerce, Industry and Energy and to the Korea Energy Economics Institute for their help throughout the review process (with special mention to Dr. Jong-duck Kim, KEEI).

Pierre Audinet managed the review and the report. Special thanks are due to the entire review team, as well as to John Cameron, Alain Bilot and Rioji Iwama. Thanks also to Anouk Honoré, Monica Petit, Marilyn Ferris and Bertrand Sadin for their assistance.

3

GENERAL POLICY AND OUTLOOK

BACKGROUND

The Republic of Korea occupies approximately 98,000 square kilometres of the southern half of the Korean peninsula, a very rugged, mountainous area of ancient volcanic outcropping. The northern half of the peninsula is occupied by the Democratic People's Republic of Korea. Approximately one-fifth of the peninsula is arable land. Proximity to the Asian land mass and to the surrounding sea makes for a temperate climate, with relatively cold, dry winters, hot, humid summers, and short, moderate springs and autumns. The principal rainfall occurs in July and August when virtually daily monsoons bring almost half the annual precipitation.

With a population of over 46 million and a 0.92% per annum rate of population growth (1999), Korea has the third highest population density in the world. The country is highly urbanised: nearly three-quarters of all Koreans live in cities and nearly one-quarter in the capital, Seoul.

The Republic of Korea is a constitutional parliamentary republic. The Assembly is composed of 299 members elected by popular vote for four-year terms.

Korea became the 29th Member country of the OECD on 12 December 1996 and was invited to become the 26th Member of the IEA in April 2001. Korea's accession to the OECD represented the culmination of 35 years of extraordinary growth, which transformed it from one of the poorest nations in the world to one of the largest economies and exporting countries. Its rapid development was driven by very high rates of savings and investment and a strong emphasis on education, which boosted the percentage of youth enrolled in universities to among the highest in the OECD area. In 1999, Korea was the ninth largest economy among IEA countries, with a GDP of more than $710 billion in 1995 US$ (using PPP) and per capita income above $15,000.

Korea was affected by the 1997 Asian economic crisis. From 1997 until 2001, economic growth was more volatile and lower than during previous years. Korea made a strong recovery from the 1997 crisis and its own recession in 1998. Output increased by nearly 11% in 1999 and 9% in 2000, but slowed in 2001 when overseas demand slackened. The Korean economy is displaying signs of maturity. It is rationalising its financial sector by applying more stringent rules to banking operations.

Energy Policy Objectives and Institutions

The Korean government has long been actively involved in the energy sector. Energy policy has been strongly driven by a desire to maintain rapid economic

growth. Before 1978, the Ministry of Trade and Industry (MTI) was responsible for energy matters. In 1978, the MTI energy division became the Ministry of Energy and Resources (MOER), and was made responsible for planning and guiding all energy-related activities, including nuclear energy (except the nuclear power safety programme, which remains under the Ministry of Science and Technology). In 1993, MOER re-merged with MTI to form the Ministry of Trade, Industry and Energy (MOTIE). In co-operation with the Economic Planning Board (EPB), MOTIE retained a strong degree of control over the formulation and implementation of energy policy. The creation of MOTIE generated a situation similar to that in the majority of IEA countries where energy policy is housed in a department responsible for broader economic and industrial policies.

President Kim Dae-Jung's administration came to power in December 1997. In March 1998, MOTIE was restructured and became the Ministry of Commerce, Industry and Energy (MOCIE). The changes included merging the Petroleum and Gas Offices, and creating a new Office of Energy Efficiency and Conservation Policy. Korea's energy sector is currently undergoing a transition, and the government is changing the nature of its involvement. At the time of the writing of this report, no independent regulatory agency existed, although new regulatory institutions are emerging. MOCIE initiated the move with the electricity sector. In 2000 it created the emerging regulatory agency, the Electricity Committee, which it continues to host and to manage.

MOCIE is responsible for making energy policy and for supervising the energy industry, for climate change issues, price control and reforms of the energy industry. The following chapters describe the roles of the other major energy institutions:

- KEMCO, Korea Energy Management Corporation.
- KIER, Korea Institute of Energy Research.
- KEEI, Korea Energy Economics Institute.
- KNOC, Korea National Oil Corporation.
- KOGAS, Korea Gas Corporation.
- KEPCO, Korea Electric Power Corporation.

Since the oil crisis of the 1970s, the security of energy supply and the stabilisation of prices have played prominent roles in Korea's energy policies. In its 2000 Blueprint, MOCIE said it aimed at "implementing policies harmonising energy, economy and environment", at a time when "the nation needs to improve energy efficiency while securing a safe supply of energy resources, thereby establishing a solid economic foundation to buffer changes in international energy market prices". Energy policy objectives, coherent with the IEA Shared Goals, were structured around the following main objectives:

- Maintain a stable energy supply by increasing oil stocks and raising emergency preparedness, expanding the energy infrastructure in a timely manner, through LNG and nuclear; and promote energy co-operation with Northeast Asia.

- Strengthen market mechanisms by privatising public utilities.

- Establish environment-friendly energy systems by reforming the tax system, inducing the use of low-polluting energy, encouraging energy-efficient technologies and developing new and renewable energy sources.

Major Developments in Energy Policy

The 1994 IEA review found that the Korean government's role was generally at the more interventionist end of the IEA country spectrum. It played a strong role in managing the major energy companies, mainly through total ownership (KEPCO, Korea Gas Corporation). It regulated the private refining industry by licensing production, by controlling refinery output and by approving imports and exports of crude oil and products. It used pricing policies to provide a low-cost energy supply to fund the nation's industrial competitiveness. At the time of the 1994 survey, no mechanisms existed to enable the public to participate in formulating policy, whereas in other IEA countries advisory committees and private non-profit policy research institutes existed.

The 1993 Economic Five-Year Plan called for economic reforms. It paved the way for further steps towards the government's withdrawal from direct control of energy assets, and for facilitating a new regulatory framework, while ensuring the major long-term objectives of energy security and efficiency. Foreign investment in the energy sector has remained largely restricted, and will probably remain modest, despite privatisation. The government's role in energy policy has clearly evolved, however, in line with the 1993 reforms.

In response to the 1998 economic crisis in which GDP shrank by 8.6% and TPES by 7.6%, the government accelerated the pace of the energy reforms that it had envisaged before the crisis.

Since then, Korea's energy policy has become more market-oriented in three main sectors:

- **Refining.** The refining industry already suffered from significant over-capacity before the downturn in demand and was hit severely by the economic crisis. In September 1998, South Korea's four downstream oil companies raised the retail price of gasoline and diesel oil following a government tax increase. In October 1998, the government decided to deregulate the refining industry totally, pushing forward its original January 1999 deadline to attract much-needed foreign investment. Foreign backing has proven to be critical in maintaining cash flows and preserving the creditworthiness of the refining industry, and has enabled corporate consolidations and sell-offs.

- **Electricity.** In 1999, the *Special Law for the Promotion of Electricity Supply Industry Restructuring* was issued. At the end of 2000, a plan for restructuring KEPCO, the partially privatised power monopoly, was negotiated with its labour unions, paving the way for the reforms. The monopoly was split into seven companies in April 2001.

- **Natural gas.** In 1999, a radical reform plan was announced to privatise KOGAS, the public monopoly that controlled natural gas imports, the natural gas wholesale market and gas sales for power production. These efforts were slowed in 2000 after strong opposition from labour unions and political parties and a change in KOGAS leadership. However, the privatisation of the gas industry has been closely linked to that of the power industry and is now likely to go forward. Two subsidiaries are to be sold to private investors by the end of 2002.

The government believes that once the electricity industry restructuring is implemented, regulatory reform of the other sectors, beginning with the gas sector, will proceed easily. Consequently, it is considering creating an independent regulatory body for *all* energy sectors.

Since 2000, in addition to structural reforms, the government has initiated a new move to promote energy efficiency in the Korean economy. This is not a new aspect of Korea's energy policy. In 1992, the IEA survey of Korea's energy policies remarked on energy conservation. Now, however, less regulated energy prices may make it easier to reduce the energy intensity of economic growth.

Energy Supply and Demand

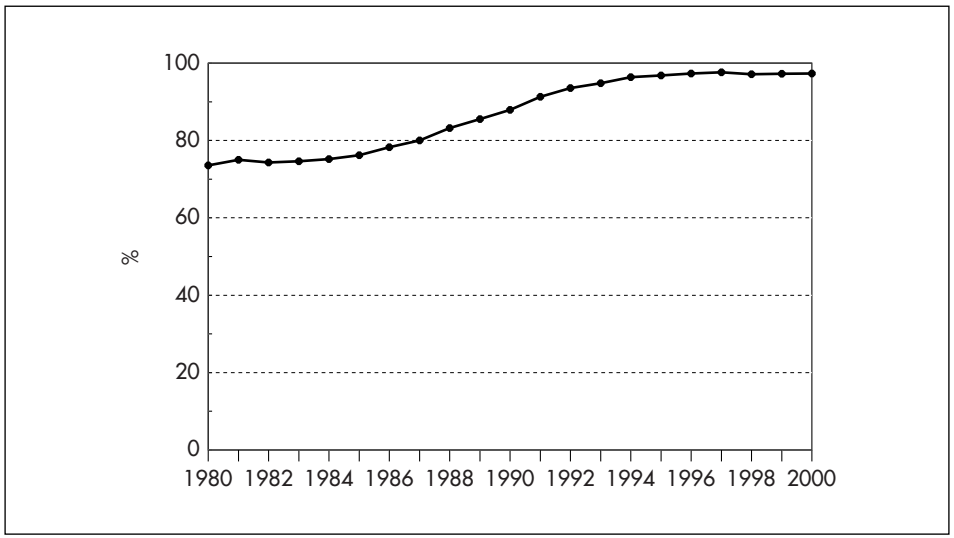
Primary Energy Supply

In 1999, Korea's net energy imports corresponded to 85% of its total primary energy supply (TPES), while nuclear accounted for 15% of TPES. Korea imports its entire supply of uranium. Depending on the year, energy imports (excluding uranium) accounted for 15 to 20% of Korea's total imports (more than 3% of GDP in 1999). Korea's net imports represent almost 10% of the total net energy imports of OECD countries. Korean energy resources are limited to low-quality anthracite, which, in 1999, accounted for less than 1% of TPES.

With rapid economic growth, TPES has increased sharply since the early 1970s. It fell in 1998 during the Asian financial crisis, but started to rise again in 1999, recovering its 1997 level, to reach 181 Mtoe in 1999. The largest increase took place between 1989 and 1997 when energy supply grew faster than economic growth (10.7% for energy supply and 7.2% for GDP per annum).

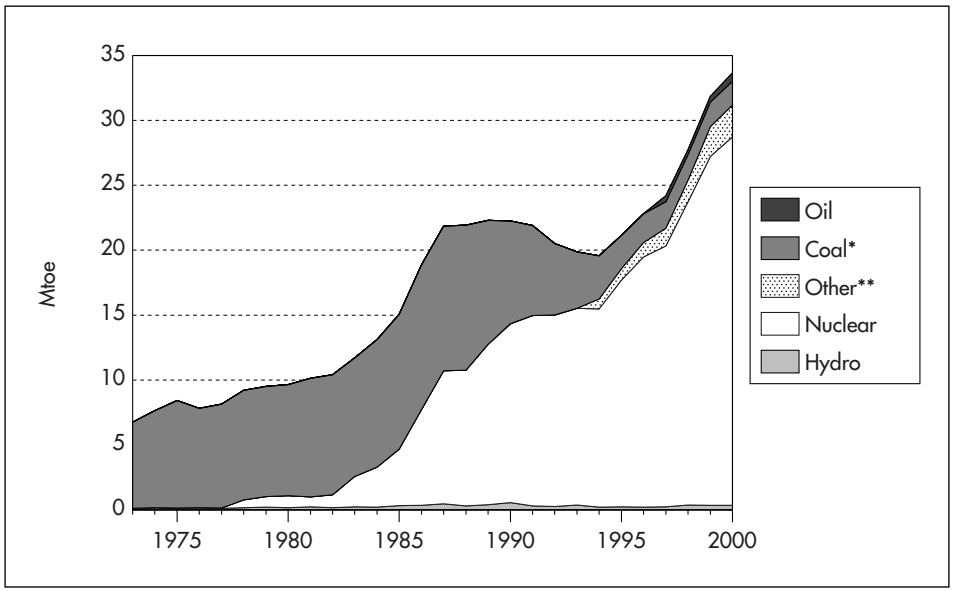
Demand for oil has been growing since the 1970s, except immediately after the two oil shocks of 1973/74 and 1979. The largest increase in oil demand, of 13.6% per year, occurred between 1989 and 1997. Coal supply has increased continuously at

Figure 1
Korea External Energy Dependence, 1980 to 2000



Source: KEEI, Monthly Review.

Figure 2
Energy Production by Source, 1973 to 2000



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.

** Data not available prior to 1990. Includes solar, wind, combustible renewables and wastes.

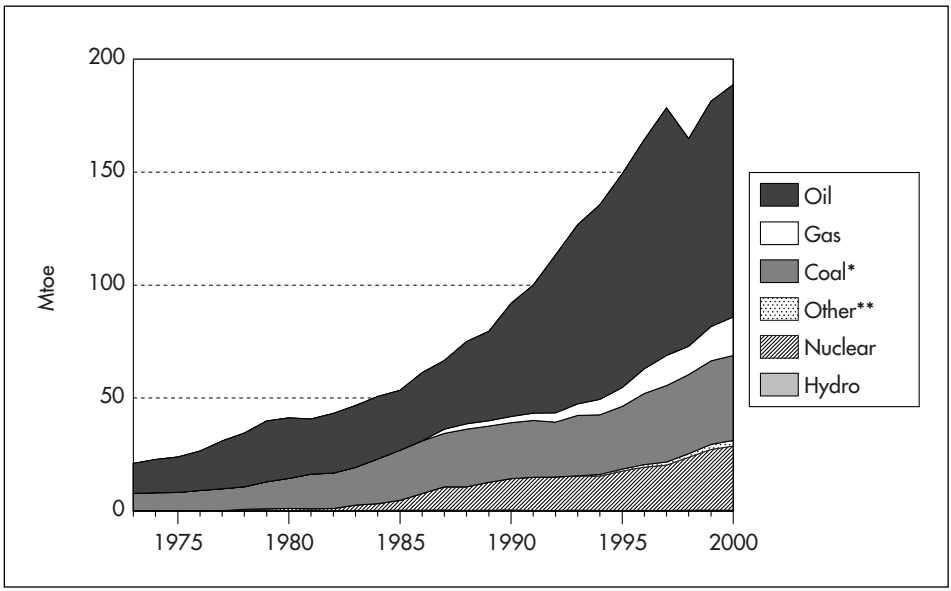
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

an annual average rate of 6.9% for the past thirty years, but the use of coal has shifted dramatically. Domestic anthracite, which was once consumed especially in the residential sector, is increasingly being replaced by natural gas. The coal now consumed in Korea is imported and used to generate power. Nuclear power did not exist in Korea before 1977, but has increased sharply since 1982, at an annual average rate of 21.5%, to reach 15% of TPES in 1999 (from 2% in 1982). Gas was introduced in 1986 in the form of LNG imports, and grew quickly, at 62.5% average growth per annum from 1986 to 1997, to reach more than 8% of TPES in 1999. The IEA has no reliable data for renewables before 1994. Since then, however, although their share of TPES remains marginal, renewables have increased sharply, at 25% per year, reaching 1.2% of TPES.

The demand for oil and gas dropped during the 1998 Asian economic crisis (minus 16% for oil and minus 6% for gas), while demand for coal, nuclear and renewables continued to grow.

The energy sector has long been structured to satisfy the rapidly increasing demand for energy generated by economic growth of the last thirty years. The Korean government has made efforts to diversify its supply sources to improve supply security, since it imports 75% of its oil from the Middle East. The government is encouraging switching from oil to natural gas, so that Korea

Figure 3
Total Primary Energy Supply, 1973 to 2000



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** Data not available prior to 1990. Includes solar, wind, combustible renewables and wastes.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

can reduce its dependency on oil and move towards a more environment-friendly fuel mix.

Final Energy Consumption

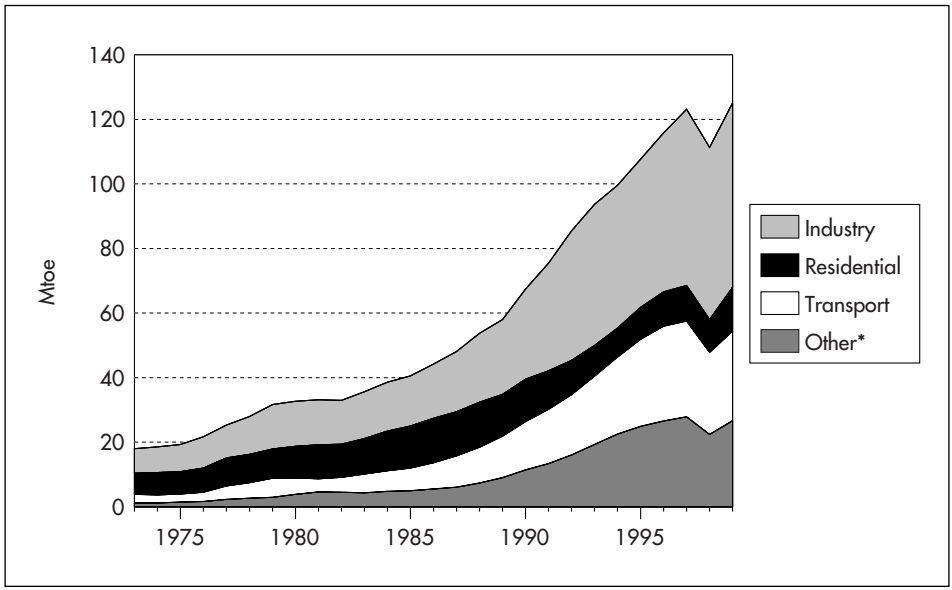
Final energy consumption increased to 125 Mtoe in 1999, quadrupling from 32.7 Mtoe in 1980. Korea is the tenth largest energy-consuming country in the world. The biggest increase took place between 1989 and 1997, when energy consumption grew more rapidly than economic growth (9.8% per annum for total final consumption compared to 7.2% for GDP). During this same period, Korea had one of the highest growth rates in the world. Consumption dropped in 1998 because of the Asian financial crisis, but bounced back to previous levels in 1999.

Oil retains the highest share of total final consumption, with 68% in 1999. Power generation represented 17%, gas 7%, and coal 5%.

Energy Intensity

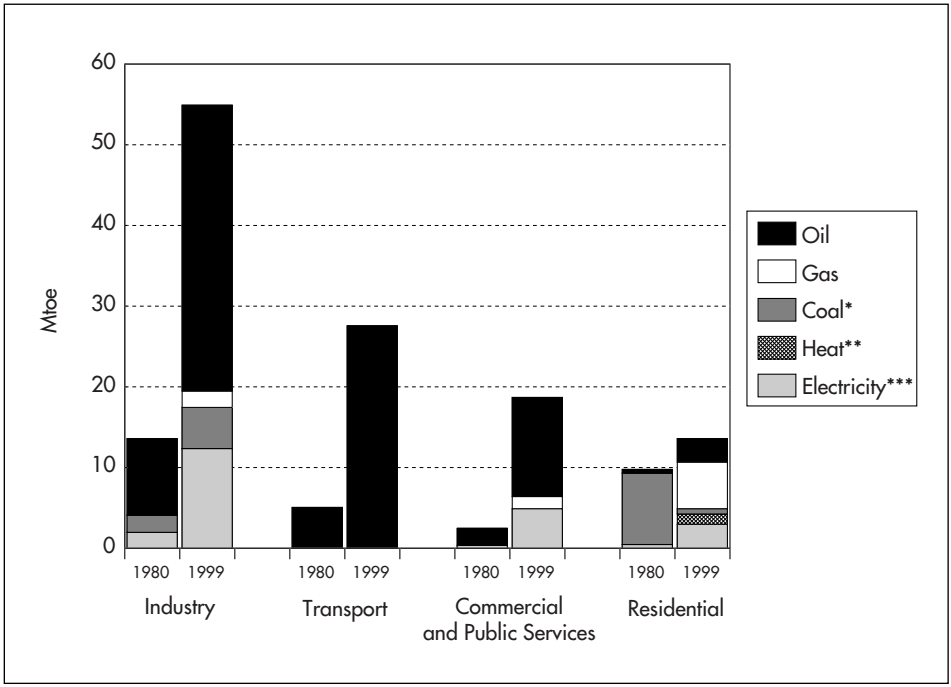
Energy intensity as measured by TPES divided by GDP remains high in Korea. In the 1990s, economic growth was led by investments in energy-intensive industries – petrochemicals, steel and shipbuilding. Expansion in the oil-consuming industries and greater use of electricity by industry and other sectors led to very high rates of growth in energy consumption. Korea's TPES grew faster than its GDP whilst its

Figure 4
Total Final Consumption by Sector, 1973 to 1999



* Includes commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

Figure 5
Total Final Consumption by Sector and by Source, 1980 and 1999



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.

** Data not available prior to 1994.

*** The Korean Administration has estimated electricity data since 1994. This may lead to some breaks in the time series between 1993 and 1994.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

TFC grew at unprecedented rates during the 1990s, the decade when these industries came online. GDP grew at an average rate of 5.8% per annum from 1990 to 1999 (8.6% from 1980 to 1989). TPES/GDP grew at 2% (it had fallen by 1% a year from 1980 to 1989) and electricity consumption/GDP at 4.7% (from 2.2% in 1980 to 1989).

Energy intensity, measured as the TPES divided by the GDP, started to fall only during the last three years of the 1990s, reflecting the increasing shares of the services sector in GDP.

Long-term Energy Supply and Demand Outlook

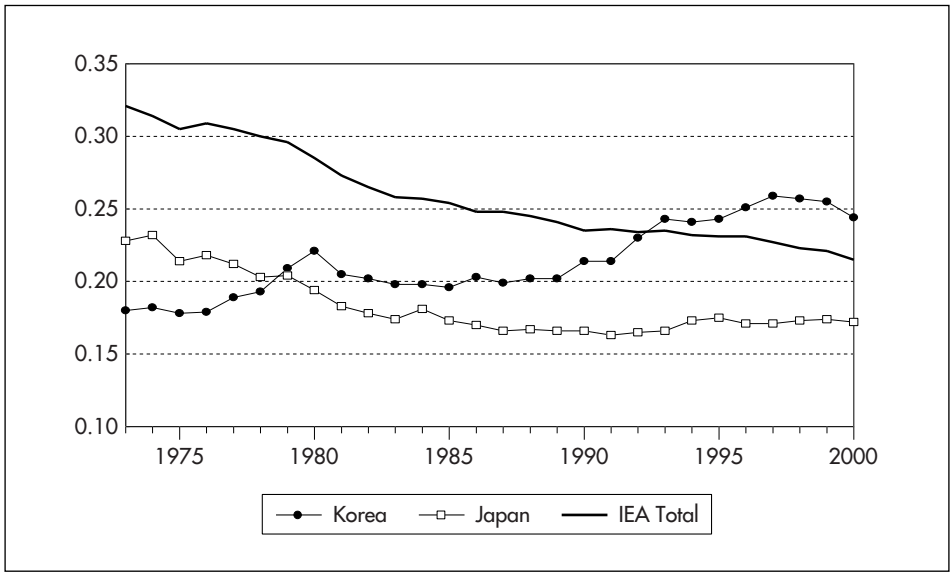
Primary Energy Supply

The government forecasts TPES to grow from 181 Mtoe in 1999 to 335 Mtoe in 2020, at an average annual rate of 3%. This represents a substantial slowing of growth compared to the recent past. This drop is due mostly to slower economic

Figure 6

Energy Intensity in Korea and in Other Selected IEA Countries, 1973 to 2000

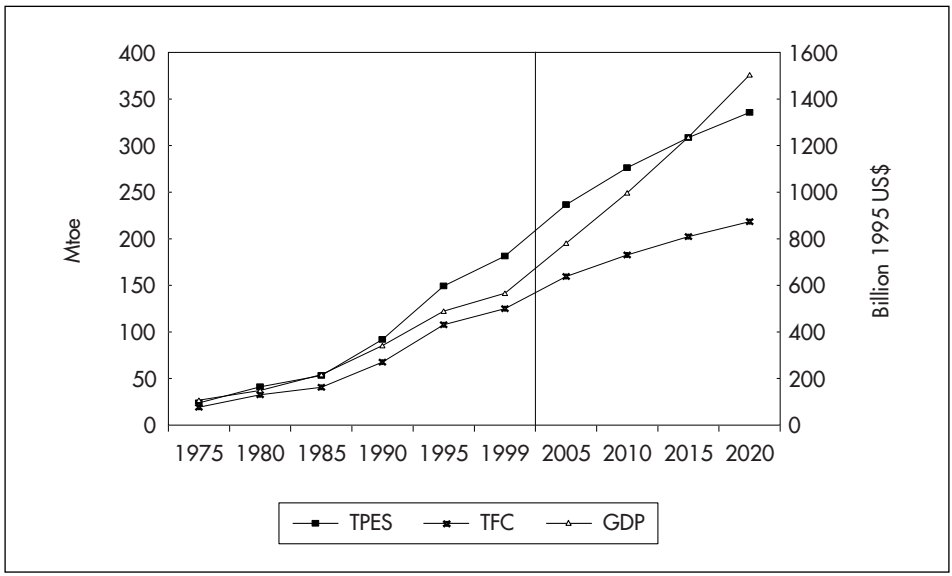
(toe per thousand USD at 1995 prices and purchasing power parities)



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001 and *National Accounts of OECD Countries*, OECD Paris, 2001.

Figure 7

Total Primary Energy Supply, Total Final Consumption and Gross Domestic Product Outlooks



Source: IEA for trends. IEA data in 1999 and KEEI growth rates for forecasts.

growth (an average of 4.9% per annum during the forecast period), to an industrial structure that will expand towards energy-intensive industries as much as in the 1990s, and a slower expansion in residential sector demand for energy (with saturation of heating, cooling and appliance ownership).

Demand for petroleum, which will remain the major fuel, is projected to grow at an average rate of 2.3% per year. Demand for natural gas is projected to grow by 5.3% per year on average. The demand for nuclear energy and coal, the major fuels for power generation, is projected to grow steadily.

Natural gas was introduced in 1986 as one of the pillars of the energy diversification policy. Domestic off-shore natural gas production will begin on a limited scale in 2003.

Final Energy Consumption

Consumption is projected to increase at an annual rate of 2.7% between 1999 and 2020, when it is projected to reach 218 Mtoe. Industry will remain the largest energy-consuming sector. The commercial sector is projected to increase its use of energy sharply – at an average yearly rate of 3.7% – making its growth in demand for energy the strongest. Demand for energy in the transport sector is projected to increase at 3.5% per year, and in the residential sector at 2.9%.

Demand for natural gas for electricity and heat generation is expected to increase faster than for other fuels. From 1990 to 2000, the average growth rate of TFC was 7.5%, with 20.1% for natural gas, and 32.4% for city gas (gas being distributed to end-users in cities through a pipeline system) in which natural gas is gradually replacing manufactured gas. The use of natural gas for heating is expected to continue to grow at high rates until the penetration of city gas reaches saturation (probably in three to five years for Seoul, five to seven years in other metropolitan areas) since it is more competitive than other types of heating fuels. City gas for industrial uses will continue to increase, and is also increasing for air-conditioning. Environmental initiatives are boosting city gas demand for automobiles.

Energy Intensity

Given its high current levels, energy intensity can only improve. It is projected to decline at an average annual rate of 1.9% through 2020. It is expected to fall faster than in the rest of the world because of a steep drop of investments in energy-intensive industries and because Korean energy prices increasingly reflect full commercial costs. The government intends to reduce Korea's energy elasticity of GDP (growth of energy supply required to fuel one unit of GDP growth) from 1.3 in 1999 to 0.8 in 2002 and 0.6 in 2010.

Energy Prices

The government intervenes far less in energy prices than it once did. For oil and petroleum products, the decision to end price regulations was taken in 1997 and

was implemented in 1998. The gas and electricity sectors are expected to evolve similarly once their state-owned incumbents are privatised by 2003. The market determines the prices at which imported coal is sold. The prices of petroleum products differ considerably, as a result of their different tax rates.

The primary objectives of the Korean energy tax system have been to raise revenues, to enable cross-subsidisation, and to stabilise prices. This has led to price distortions. It has also failed to provide any incentive for using energy efficiently, especially for industry.

Table 1 indicates that energy price levels in Korea are close to those in the OECD Pacific region. Unit revenues generated by energy taxes are larger than in most OECD countries but will drop after the envisaged tax reforms.

In 2000, the Korean government announced an oil tax reform to remove the remaining distortions. To minimise the negative economic effects of reform and to give consumers the time they need to adapt to the new system, the targets indicated in Table 1 below will be spread out over six years, from July 2001 to June 2006.

Coal Prices

The Korean government maintains a price ceiling on domestically-produced anthracite, for reasons of social equity, since low-income households still use anthracite. Anthracite, domestic or imported, is not subject to VAT.

Oil Prices

Prices of crude oil and products, and of LNG began to be deregulated in 1997 but are still subject to a number of taxes and levies. These include a tax collected for the Energy Project Special Account which is used to fund the expansion of the government's strategic oil stockpile and other projects (promoting LNG, energy conservation, phasing-out anthracite mines, developing energy R&D and renewable energy). This account replaced the Petroleum Development Fund in 1995. It is fed from surcharges on petroleum imports and kerosene sales and on LNG (won 13/litre; approximately one US cent) and LPG. The Energy Project Special Account generated $2.53 billion in 1999. LPG for cars is subsidised for the relative benefits that LPG has for the local environment (LPG-fuelled vehicles also get tax benefits). The LPG subsidy generated a rapid increase in the number of LPG-fuelled vehicles and LPG service stations. The subsidy is gradually being decreased as indicated in Table 3. The price differential between kerosene and diesel fuel in favour of kerosene has resulted in kerosene being illegally substituted for diesel. The reform is also correcting this.

Gas Prices

Natural gas consumed in Korea is imported as LNG from South-East Asia and the Middle East. Approximately half the LNG is consumed to generate power, and half as city gas. The price of natural gas is not completely deregulated, as the wholesale price charged by the public monopoly KOGAS is still subject to approval by MOCIE.

The price of natural gas for power is adjusted monthly, and the price of city gas is adjusted quarterly to reflect international market prices. Several taxes and levies are then added. Final prices vary significantly by region and by category of consumer.

Electricity Prices

Electricity prices in Korea have long been below OECD averages and OECD Pacific region averages. In 1998, industrial consumers paid prices that were 76% and 44% of the average prices in the OECD and OECD Pacific respectively. Of the six consumer groups in Korea, industry and agriculture still benefit from subsidised electricity prices. Lower electricity prices for industry is a major reason why Korean energy intensity has remained high. One important objective of the electricity sector reform is to completely remove price distortions and provide industry with an incentive to use electricity more efficiently.

Table 1
Comparison of Energy Prices

		4Q1999		
Fuel		*Korea*	*OECD*	*Ratio to OECD*
Unleaded gasoline	$ /litre	0.801	0.503	1.6
Diesel	$/litre	0.395	0.417	0.9
LFO				
Industry	$/1000 litre	360.7	187.1	1.9
Households	$/1000 litre	296.6	301.0	1.0
Electricity				
Industry	cents/kWh	4.0	5.1	0.8
Households	cents/kWh	7.6	9.9	0.8
Natural Gas				
Industry	$/10^{7}kcal	193.1	121.3	1.6
Households	$/10^{7}kcal	323.8	319.1	1.0

		3Q2000				
Fuel		*Korea*	*OECD*	*OECD Pacific*	*Ratio to OECD*	*Ratio to OECD Pacific*
Unleaded gasoline	$/litre	1.130	0.611	0.989	1.8	1.1
Diesel	$/litre	0.538	0.643	0.569	0.8	0.9
LFO industry	$/1000 l	..	292.6	285.5	..	..
Kerosene oil for households	$/1000 l	474.3	420.2	439.6	1.1	1.1
Electricity for industry	cents/kWh	0.07	..	..	..	..
Electricity for households	cents/kWh	0.10	..	..	..	..
Natural gas for industry	$/10^7 kcal	..	129.8	325.7	..	..
Natural gas for households	$/10^7 kcal	..	356.0	1,059.7	..	..

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Table 2
Energy Project Special Account
(US$ million)

	1995	*1996*	*1997*	*1998*	*1999*	*2000*
Promotion of the use of natural gas	154.6	174.0	147.2	120.7	159.1	187.5
Energy conservation	248.8	270.5	290.4	242.1	355.9	408.1
Energy technology R&D and NRSE development	55.1	66.6	72.7	50.8	68.6	77.0
Phasing-out of anthracite mines	56.8	36.4	19.3	4.3	1.0	7.2
Oil stockpiling	194.8	119.2	183.4	177.0	143.7	148.5
Oil pipeline	77.8	74.6	47.3	10.7	–	–
LPG receiving terminal	6.5	37.3	31.5	28.6	42.9	–
Overseas resources development	115.4	127.7	122.8	98.7	136.5	166.6
Gas safety management	220.6	188.7	125.9	55.1	63.7	71.6
Coal industry, etc.	941.2	1,183.2	984.2	678.7	1,047.4	926.9
Total	**2,072.1**	**2,278.3**	**2,025.2**	**1,467.1**	**2,019.0**	**1,993.8**

NRSE: New and renewable sources of energy.
LPG: liquefied petroleum gas.

Table 3
Price Differentials through Energy Tax Reform

	Transport			*Residential*		*Industrial*		
	Gasoline (litre)	*Diesel (litre)*	*LPG (litre)*	*Kerosene (litre)*	*LPG (litre)*	*LNG (m^3)*	*Bunker-C (litre)*	*LNG (m^3)*
Pre-reform	100	47	26	40	31	37	22	26
July 2001	100	52	32	43	31	37	22	26
July 2002	100	56	38	45	31	37	22	26
July 2003	100	61	43	48	31	37	22	26
July 2004	100	66	49	50	31	37	22	26
July 2005	100	70	54	53	31	37	23	26
July 2006	100	75	60	55	31	37	23	26

Source: Ministry of Commerce, Industry and Energy.

CRITIQUE

The review commends the Korean government's efforts to diversify its energy supply towards gas, coal, and nuclear power. Considering that the demand for energy is expected to grow faster than in other OECD countries and that Korea is expected to depend heavily on Middle Eastern oil for the foreseeable future, diversifying energy and improving energy efficiency are and will remain important policy objectives.

Current energy market reforms are respecting the government's plans to restructure and privatise government-owned companies. Despite the partial restructuring of KEPCO and KOGAS, however, no independent regulator has yet been established. The government has limited its efforts to establishing an Energy Committee[1] under MOCIE, initially to regulate the electricity market. It envisages extending the committee's mandate to gas in 2002. To ensure effective competition in the future in both the electricity and gas sectors, appropriate detailed rules must be established for network access, including pricing, and the market must be carefully monitored to avoid anti-competitive behaviour. An independent, competent regulator should be established immediately.

Regulatory reform is vital to meeting the dual objective of greater economic efficiency and attracting foreign investors. Korean energy markets were largely regulated until recently, but many of the restrictions have been lifted, including those for pricing oil products. Under-pricing of electricity has been largely rectified. But restrictions still exist, including those on foreign direct investment. As compared with other OECD countries, Korea still has a lot of room for further market deregulation.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Continue to diversify energy supply and to improve energy efficiency.
- ☐ Establish an independent regulator for both the electricity and gas sectors; clarify the relationships between the energy regulator and the Fair Trade Commission.
- ☐ Eliminate ceilings and restrictions on foreign investment.
- ☐ Eliminate price distortions by removing price ceilings and cross-subsidisation and, where necessary, by adjusting taxation to reflect environmental costs.

1. The Energy Committee was initially called the Electricity Committee (required by the Electricity Business Act of 2000).

4

ENERGY EFFICIENCY

TRENDS IN FINAL CONSUMPTION

Over the past decade (1989-1999), consumption growth was led by the commercial and public services sector (19% per year), industry (14%) and transport (12%). The residential sector's final consumption stagnated (rising only 0.5% per annum) as a result of a shift from coal to gas and electricity, and more efficient energy use.

All sectors recorded sharply decreased final consumption during the 1997-1998 Asian economic crisis, followed by a strong recovery in 1999.[2]

Industry is the largest final consumer of energy, representing approximately one-third of 1999 consumption. The power generation sector accounted for 23% of TFC in 1999 (13% in 1980), the transport sector accounted for 17% (13% in 1980), the commercial and public services sectors accounted for 11% (8% in 1980) and the residential sector represented 8% (26% in 1980). The growth of energy-intensive activities in other sectors explains the decrease in the residential share.

Final consumption of oil stabilised during the two oil crises of the 1970s, but rose sharply until the Asian economic crisis. Between 1987 and 1997, final oil consumption increased more than threefold. Oil maintains the largest share in final consumption, with 53% in 1982 rising to 68% in 1999. Power generation grew continuously, multiplying more than ninefold between 1971 and 1999, with just a slight decrease during the Asian economic crisis; the share of electricity in TFC almost doubled to 17%. Natural gas consumption began in 1987 and has increased since then, thanks to the development of city gas, to reach 7% of TFC. Coal consumption increased until 1988, and then began to decrease steadily. Coal represented 5% of TFC in 1999.

THE INDUSTRY SECTOR

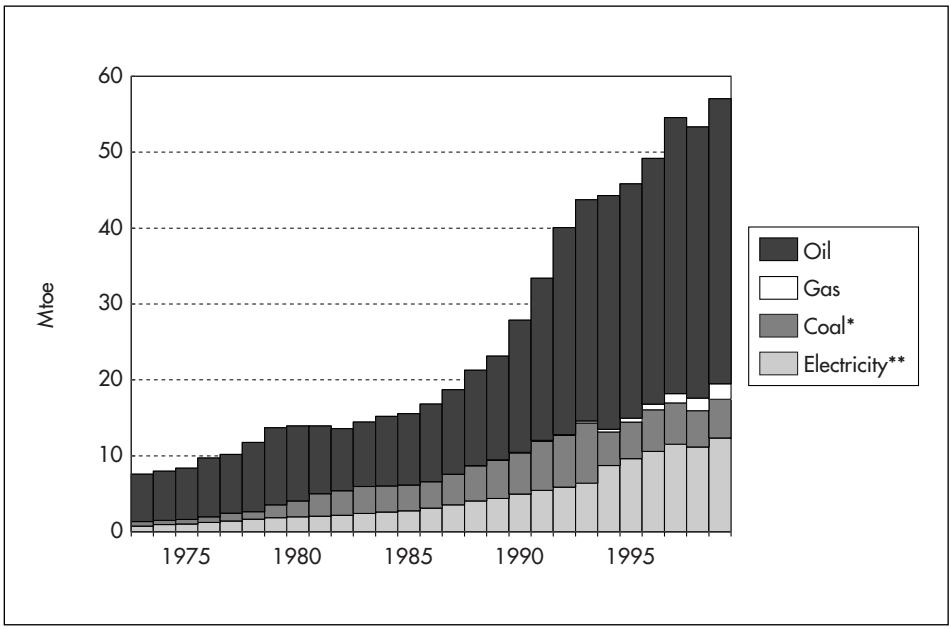
In 1999, industry represented 35% of TFC, and its energy use increased fourfold between 1982 and 1999 (from 13.2 to 57 Mtoe). The oil share of industry's TFC increased from 59% to 66% over this period. Electricity's share rose from 16% to 22%, while coal's decreased from 25% to 9%. Natural gas accounted for 4% of industrial energy use in 1999.

The manufacturing industry tends to use more energy and has increased its share of Korean GDP over the past 20 years. In 1970, light industry constituted 60.8% of

2. The Asian economic crisis brought a year of negative growth for TFC (minus 8.6% in 1998). TFC decreased in the commercial and public sectors (minus 21%), the transport sector (minus 14.4%) and the residential sector (minus 8%). Final energy consumption increased again in 1999 (by 13%).

industrial GDP compared to 39.2% for heavy industry. In 1996, however, light industry represented only 26% of industrial GDP. Manufacturing is by far the largest energy-consuming sector in Korea. The rapidly expanding chemical industry became the largest energy-consuming sub-sector in 1996. The manufacturing sector's energy consumption expanded faster than the country's TFC from 1988 to 1996. Commerce and services, transport and construction have also expanded, but industry has been the mainstay of Korea's economic growth, contributing 32% of GDP in 1994 and 34% in 1999. The Korean economy continues to rely heavily on energy-intensive industries such as steel, shipbuilding, automobile manufacturing, petrochemicals and cement.

Figure 8
Final Consumption by Source in the Industry Sector, 1973 to 2000



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.

** The Korean Administration has estimated electricity data since 1994. This may lead to some breaks in the time series between 1993 and 1994.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

THE TRANSPORT SECTOR

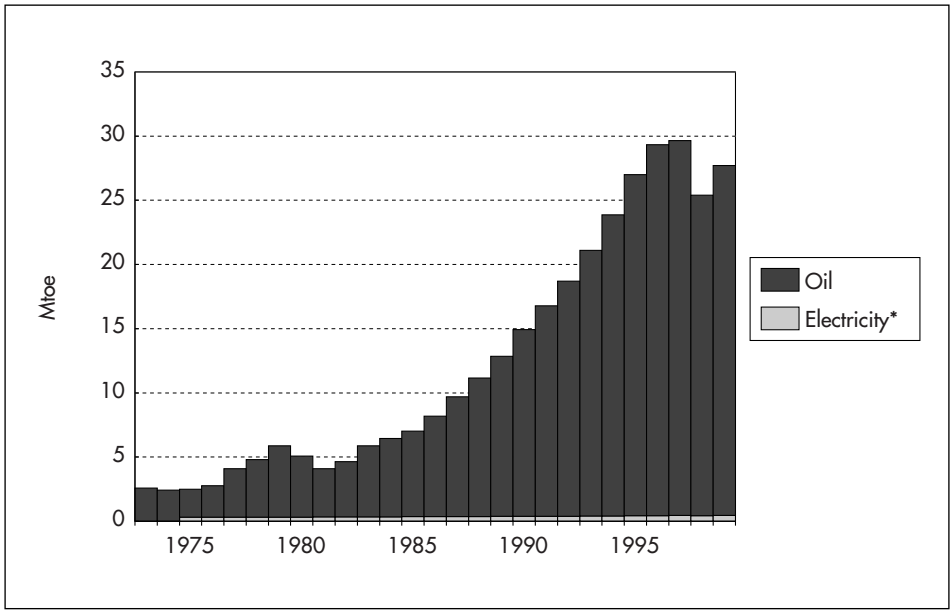
After dropping during the 1979-1981 oil crisis, energy consumption in the transport sector increased between 1982 and 1996 by 14% a year, stabilised in 1996-1997, and decreased in 1998 by 14.5% during the Asian economic crisis. Consumption rose

slightly in 1999, to 17% of TFC. In 1999, the demand for energy in the transport sector was 27.7 Mtoe, an increase of 115% from 1989.

Oil is the main fuel consumed in the transport sector. Diesel accounted for roughly 41.7% of transportation demand in 1999, while gasoline accounted for 28.3% reflecting tax differences: tax-inclusive end-use prices for gasoline were $0.9 per litre compared to $0.4 per litre for diesel. LPG and other products accounted for most of the remainder. (Because of a new subsidy, the growth of use of LPG in the transport sector doubled in the period from 1992 to 1999, rising from 6.1% a year to 12.5% in 1999.)

Road vehicles consumed substantially more energy. In 1980, energy consumed by road transport represented 20% of all transport energy consumption; in 1999 it was 73.2%. Motor vehicle registration has increased by 253% in the past decade. In 2000, 12 million vehicles were registered, 64.8% of them private cars. Rising living standards and larger disposable incomes have led to greater demand for transport services. In 1999 and 2000, slower economic growth reduced the energy consumed by private vehicles, and traffic congestion is becoming a deterrent to the use of cars in large cities such as Seoul. Nevertheless, total consumption in this sector is higher because the average car size is larger, congestion leads to poor fuel economy, and each car drives longer distances.

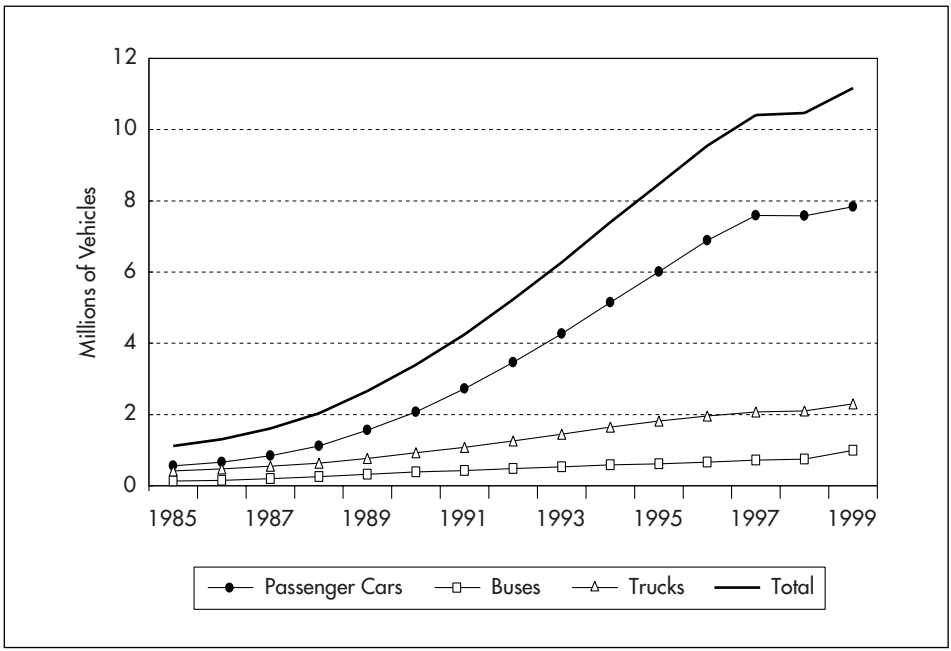
Figure 9
Final Consumption by Source in the Transport Sector, 1973 to 1999



* The Korean Administration has estimated electricity data since 1994. This may lead to some breaks in the time series between 1993 and 1994.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

Figure 10
Motor Vehicle Registrations, 1985 to 1999



COMMERCIAL AND PUBLIC SERVICES SECTORS

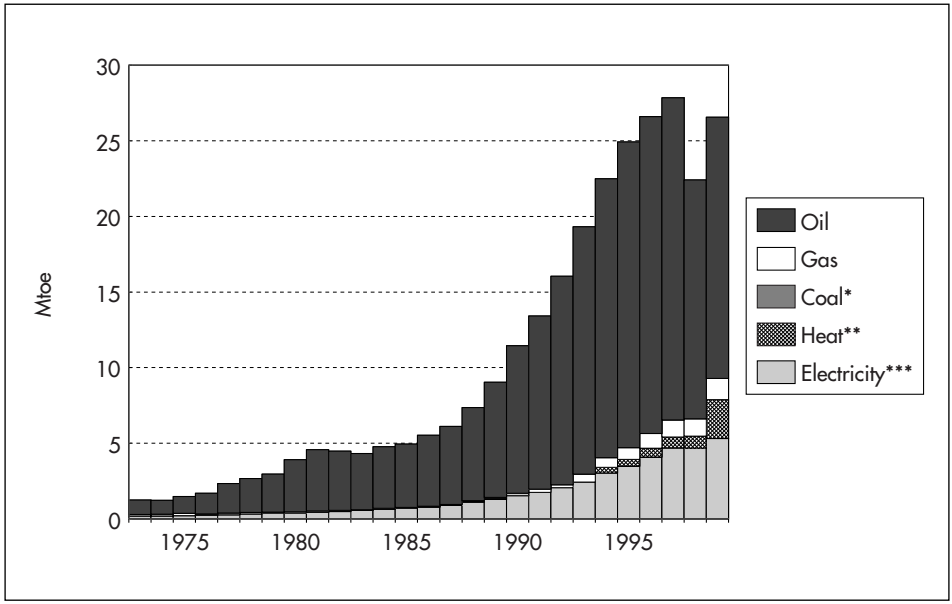
After stagnating for six years, energy consumption in the commercial sector has risen sharply since 1987 to reach almost 19 Mtoe in 1999. Between 1989 and 1997, it grew at an average 16% per annum, led mainly by the development of the wholesale and retailing trades, and because expanding finance service activities used energy to heat and cool. After the 1997 Asian economic crisis, consumption fell and had not recovered its earlier level by 1999.

Over the past ten years, fuel shares in the commercial and public services sectors have remained virtually unchanged. Oil retained the dominant fuel share, at 75%; electricity stabilised at 20%; natural gas grew to 5%.

THE RESIDENTIAL SECTOR

Energy consumption in the residential sector is closely related to per capita income. As disposable income increases, householders demand greater comfort and the use of anthracite decreases. This trend has been particularly clear in electricity where demand ballooned 37-fold between 1971 and 1999 with the increased number of electrical appliances. Fuel changes brought more efficient use of energy. Slower income growth in the 1990s – less than 6% per annum compared to nearly 11% in

Figure 11
Final Consumption by Source in the Commercial and Public Services Sector



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.
** Data not available prior to 1994.
*** The Korean Administration has estimated electricity data since 1994. This may lead to some breaks in the time series between 1993 and 1994.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

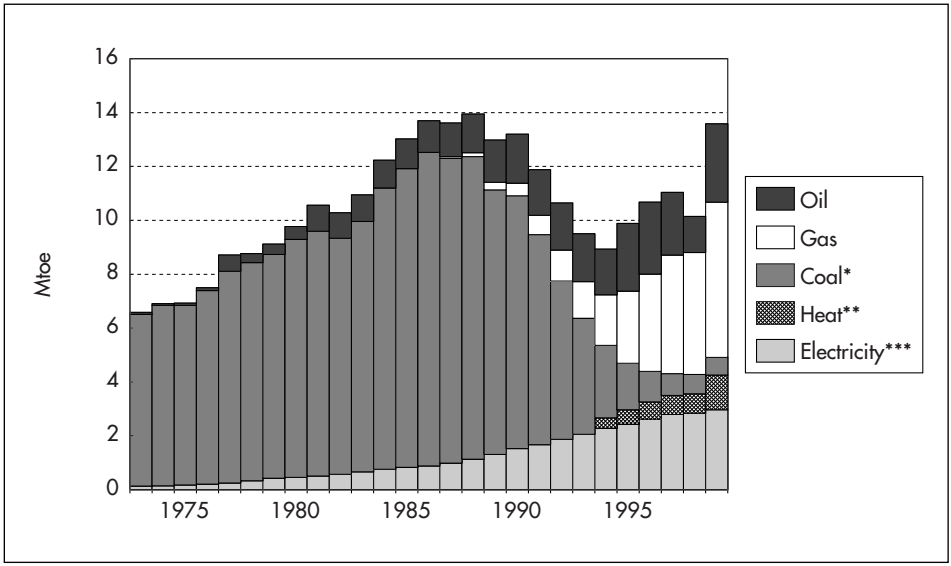
the 1980s – added to the more efficient use of energy, which explains the slow growth of final household energy consumption in the 1990s.

Coal represented 85% of residential energy use in 1986; this figure dropped to 5% in 1999, because coal was replaced by natural gas, electricity and oil. Natural gas represented 43% of the total consumption in 1999, followed by electricity (22%), and oil (21%).

ENERGY INTENSITY

Korea ranks twenty-fifth in terms of population and approximately tenth in primary energy consumption in the world, with 2% of the world total. Per capita energy consumption also increased from 0.86 toe in 1980 to 2.67 in 1999 compared to 3.26 and 3.47 in IEA countries. The general trend in energy consumption per unit of GDP in Korea differs significantly from the trend in Japan and other OECD countries, where energy intensity has been decreasing for the past twenty years. It has *increased* in Korea, mainly before 1980 and after 1989, primarily for the following reasons.

Figure 12
Final Consumption by Source in the Residential Sector, 1973 to 1999



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.
** Data not available prior to 1994.
*** The Korean Administration has estimated electricity data since 1994. This may lead to some breaks in the time series between 1993 and 1994.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

- During the last two decades, Korea's economic development was faster than that of other IEA countries.

- The manufacturing sector led GDP growth for fifteen years (1981-1996), which increased Korea's energy consumption significantly. Energy intensity increased by 24% between 1988 and 1996, largely because of rapidly expanding heavy and chemical industries.

The ratio of energy supply growth to GDP growth dropped in 1999 and 2000, perhaps because of the development of services and the information technology, indicating the possibility of gradual change to come in energy intensity measured in terms of TPES per unit of GDP.

ENERGY CONSERVATION AND EFFICIENCY ENHANCEMENT POLICIES

The Rational Energy Utilisation Act, passed in December 1979 and amended several times thereafter, together with its Enforcement Ordinance enacted in

November 2000, remains the legal basis for the government's energy efficiency policy.

In 2000, MOCIE's main policy guideline was to "implement policies harmonising energy, economy and environment", with a new leading objective to initiate a "transition to a low energy consumption structure". The main conservation technique is to encourage prices that reflect costs.

The Korea Energy Management Corporation (KEMCO), the principal fund-allocating institution, is a non-profit government agency established in 1980 by MOCIE (then MOER) under the Rational Energy Utilisation Act. KEMCO is responsible for implementing conservation policies ($450 million for energy conservation were disbursed in 2000).

Energy conservation and efficiency policies are aimed at all components of the energy supply chain, from primary production to end-use. In public procurement, the Korean government gives preference to commodities produced using clean technologies. It is also implementing certification systems similar to energy efficiency labelling. In addition, pilot projects are being used to promote widespread use of successfully developed technologies. These are undertaken with the private sector through energy service companies and, increasingly through voluntary agreements with energy-intensive industries such as cement and glass.

Cross-Sectoral Policies

- A five-year conservation programme initiated in 1992 and renewed in 1997 with a special focus on energy-intensive industries. It targets 196 businesses that consume more than 30,000 toe per annum each. The aim is to reduce their overall energy consumption by 10%. Private energy service companies (ESCOs) complement KEMCO's activities. The government provides them low-interest loans on energy-efficient, clean energy equipment: efficient lighting, waste heat use and renewable energy. Since 2000, 102 ESCOs have been registered as private companies, and investments reached 85,622 million won for 519 projects through loans for energy cost reduction.

- Integrated energy suppliers of heat, power and cooling services with low-interest loans and tax incentives.

- Energy efficiency information, labelling and standards programmes.

- An Energy Boy endorsement label (energy-saving label), applied on a voluntary basis to 14 items, such as computers, fax machines, televisions and microwave ovens.

- Minimum energy efficiency performance standards, compulsory for 19 items such as induction motors, fluorescent lamps and heat-recovery ventilators.

- Information labels for energy consumption, for nine items such as electric refrigerators, electric air-conditioners and washing machines.

- Financial assistance for energy research and development through preferential long-term loans and/or tax incentives.

- Publicity campaigns and educational programmes to increase awareness of the importance of conserving energy.

- Regional energy programmes with subsidies to local governments, technological consulting, information services and education and training for civil servants.

- Local management programmes to be implemented by energy supply companies (KEPCO, KOGAS and Korea District Heating Corporation – KDHC), including peak clipping, peak shifting, load shaping and demand-side management tariff systems. Peak load in electricity, caused by summer daytime demand, especially by air-conditioning in industry and commercial sectors, is being addressed by a flexible rate system.

- The obligatory use of certified high energy efficiency equipment for eight designated types of buildings.[3]

Industry Sector

- Energy audits; between 1980 and 1998, private companies audited 3,639 firms which became eligible for financial support if they could identify energy savings higher than 5% within three years of implementing new equipment.

- Voluntary agreements to conserve energy and reduce greenhouse gases. By 2000, 212 companies in the steel, chemical, textile, paper, ceramics and food industry sectors were involved in voluntary agreements and benefited from low-interest loans and tax incentives to reduce greenhouse gas emissions. The objective is to reduce CO_2 emissions by 3,272 million tonnes, and to enhance energy efficiency by 9% in 2000-2005.

Residential and Commercial Sectors

- Insulating buildings to reduce energy use, monitor the energy use of all buildings that have consumed more than four million kWh per annum since 1992 and prepare five-year energy conservation plans for 629 buildings using more than six million kWh.

3. Centrally-heated apartment buildings with over 50 units; lodges, dormitories, youth hostels with over 2,000 square metres; public, special bathhouses, indoor swimming pools over 3,000 m^2; hospital buildings over 2,000 m^2; centrally-heated shopping malls over 3,000 m^2; office buildings, laboratories over 3,000 m^2; theatres, public gathering buildings over 10,000 m^2; schools over 10,000 m^2.

Transport Sector

- A fuel efficiency labelling programme for 317 models of domestic and imported passenger cars (as of 1998).

- Tax incentives to encourage the use of small cars. Promoting car sharing. Investments in public transport, fuel efficiency targets.

Public Sector

- Public procurement of certified high energy efficiency equipment.

- Obligatory use of certified high energy efficiency equipment for new and extended construction of public buildings.

CRITIQUE

In contrast to what has happened in other IEA countries, energy intensity in Korea has increased consistently as the economy has grown over the last decades, everywhere but in the residential sector. Korea's energy intensity was still slightly below the IEA average in 1999, but it will continue to grow quickly unless effective measures are put into place to curb demand and to increase the efficiency of energy use. Improving energy efficiency is a key to future sustainable development in Korea. "Sustainable development" is normally understood to include environmental aspects.

Energy prices have been distorted in the past in ways that led to inefficient energy use. It is essential that energy prices reflect costs. Environmental and other costs should be internalised as much as possible. Without clear price signals to the market, most energy efficiency policies will be ineffective.

Korea has developed a wide-ranging programme to implement standards and labelling for highly energy-efficient products. The government would benefit from more active international benchmarking of Korea's standards and energy efficiency norms.

Industrial investment has been active because of government actions to promote industrial development; many facilities and much industrial equipment are new and energy-efficient. There may be little room, therefore, to improve energy efficiency by introducing more modern technologies. The government must nonetheless focus on energy efficiency in this sector since even a modest percentage gain would mean large energy savings in absolute terms.

The use of energy has been increasing sharply in the industrial and commercial sectors. Cost-reflective pricing is essential in these sectors to encourage the rational use of energy. The coal use subsidy is still in effect for the residential sector,

for reasons of social equity. But the IEA considers that social objectives can be better addressed by direct support for the needy.

Little progress has been made in energy conservation in the transport sector. The dramatic increase in numbers of cars and the growth of average car size have sharply stimulated the use of energy. Since congestion and environmental problems have become acute, fuel prices may no longer fully internalise such externalities and need to be reviewed. In addition, active measures should be pursued to encourage the use of more energy-efficient cars and public transportation.

An effective monitoring tool is required. Quality data on energy use do not exist for every sector. Better quality data collection is urgently needed.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Make energy efficiency a high priority; strengthen energy efficiency policy through additional measures.
- ☐ Facilitate the process of energy pricing so that fuel prices reflect costs.
- ☐ Ensure Korea's standards and energy efficiency norms comply with best international practice.
- ☐ Develop further energy efficiency policies as part of the effort to reduce greenhouse gas emissions.

5

ENERGY AND THE ENVIRONMENT

The Ministry of Environment was created in 1990 to strike a better balance between economic and environmental objectives. In 1979, the government promulgated the Rational Energy Utilisation Act and implemented a set of energy conservation policies. In the 1990s, several measures were adopted to diversify energy sources and to improve energy efficiency. In 1997, the government established the National Committee for Energy Conservation, with both public and private members, to push energy conservation policies, among other reasons, as an effective way of reducing greenhouse gas emissions.

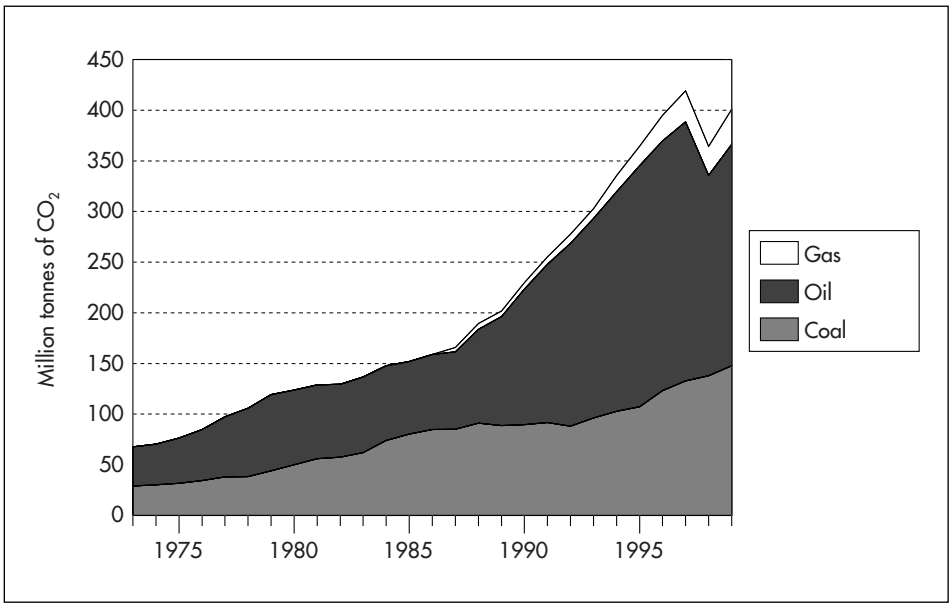
ENVIRONMENTAL TRENDS

Between 1991 and 1999, measures to curb polluting emissions from stationary sources and switching from coal to gas reduced SO_2 emissions in Korea by 40% to 0.95 million tonnes in 1999. Carbon monoxide decreased by 41% (to one mt in 1999) and hydrocarbons by 27% (to 0.15 mt in 1999) over the same period. But concentrations of particulate matter, ozone, and nitrogen dioxide have been gradually increasing (NO_2 increased by 30% between 1991 and 1999 to 1.14 mt in 1999). Technological improvements, such as more general use of catalytic converters, have largely reduced such emissions per vehicle but the improvements have been offset by the increase in the total number of vehicles on the road and their larger size. Trucks and buses produce about two-thirds of transport-related air pollutants in Korea. An improved air quality monitoring system was introduced in the latter half of the 1990s; it recorded a substantial increase of atmospheric ozone, which led to 52 ozone warnings in 2001 compared to 24 in 1997.

TRANSBOUNDARY POLLUTION AND REGIONAL CO-OPERATION

Pollutants from neighbouring countries have affected Korea. Energy-related SO_2 emissions from both China and North Korea have caused acid rain in Korea. To address such cross-border environmental problems, Korea has been actively promoting regional co-operation in North-East Asia. It played a key role in initiating the annual China-Japan-Korea Tripartite Environment Ministers' Meeting (TEMM), the first session of which was held in Seoul in January 1999. A sense of a North-East Asian Environmental Community appears gradually to be emerging.

Figure 13
CO_2 Emissions by Fuel*, 1973 to 1999



* Estimated using the IPPC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

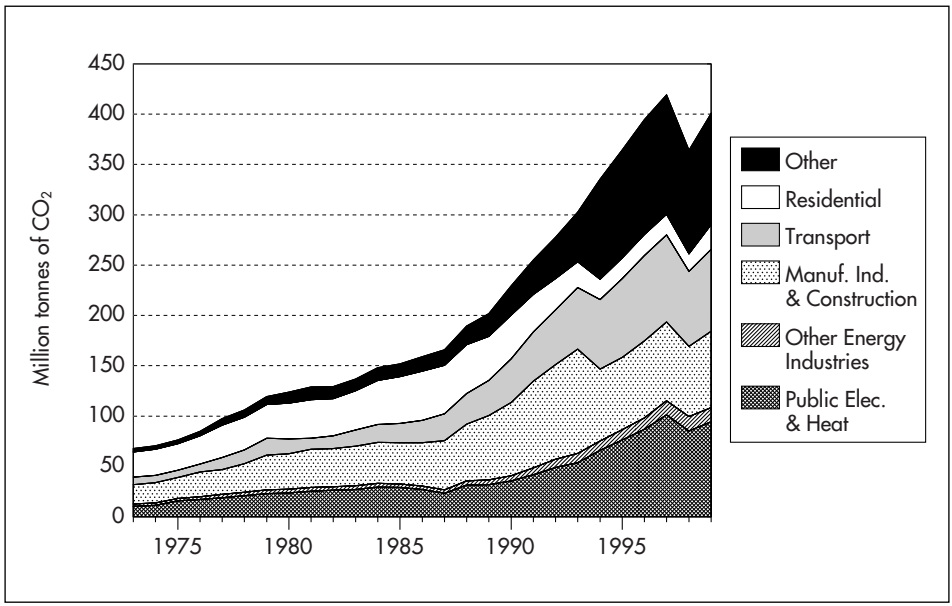
ENERGY-RELATED CO_2 EMISSIONS

Over 90% of CO_2 produced in Korea is energy-related. Carbon emissions increased by 75.5% from 1990 to 1999 when they reached 410.4 million tonnes. CO_2 emissions per unit of GDP remain high, almost double the average for IEA countries in 1999 (0.72 kg of CO_2 per 1995 dollar for Korea against 0.44 kg for IEA countries).

Energy-related CO_2 emissions increased at an annual average rate of 6.7% between 1990 and 1999. The share of coal use in total CO_2 emissions bounced back from 29% in 1995 to 34% in 1999. CO_2 emissions are projected to continue to increase substantially.

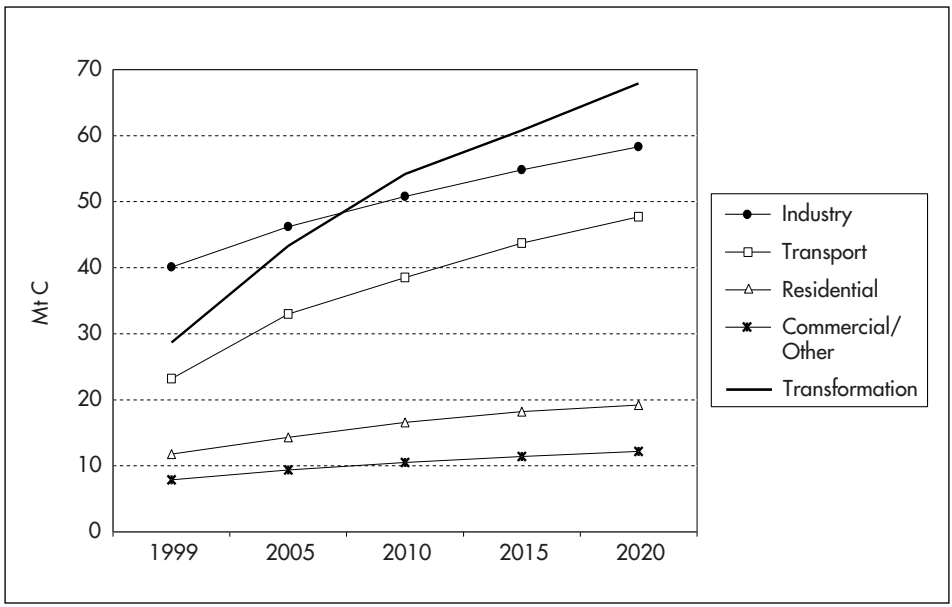
MOCIE forecasts that between 2001 and 2010, growth in energy-related CO_2 emissions in Korea will slow but that they will nonetheless continue to grow at an annual average of 4%. Growth is expected to slow to 1.9% per year in the following decade, until 2020. According to the Korea Energy Economics Institute (KEEI), CO_2 emissions from the transport and electricity generation sectors will grow fastest until 2020, primarily because of greater demand for transportation fuel and electricity generation. Increasing CO_2 emissions in electricity and transport is common among many IEA countries.

Figure 14
CO_2 Emissions by Sector*, 1973 to 1999



* Estimated using the IPPC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

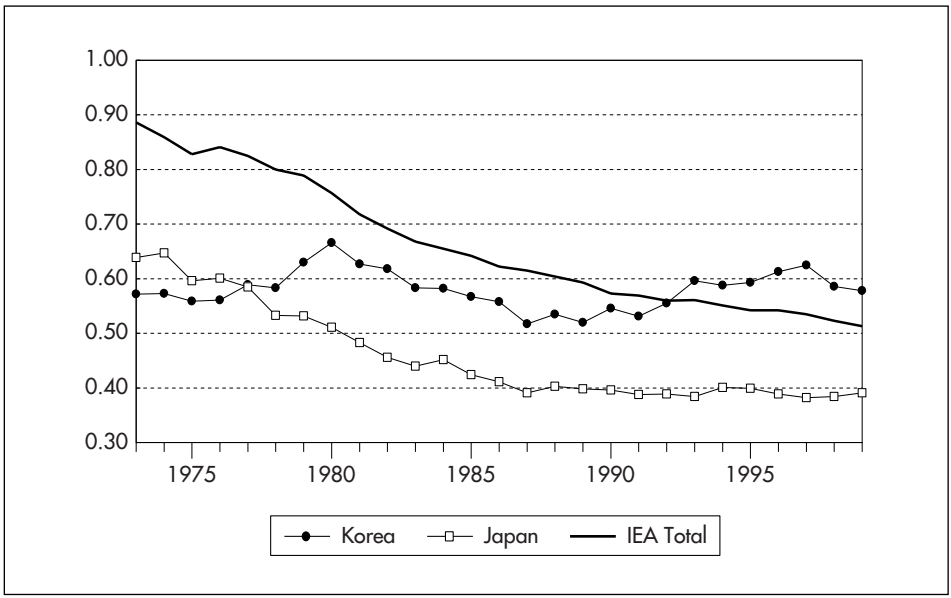
Figure 15
CO_2 Emissions Projections, 1999 to 2020



Source: KEEI/Korea Energy Review Monthly, January 2001.

Other highly industrialised countries, such as Japan, have achieved greater energy intensity reductions during periods of high growth by adopting aggressive conservation and efficiency programmes, by reducing subsidies for indigenous solid fuels, and by changing the composition of GDP.

Figure 16
Energy-related CO_2 Emissions per GDP in Korea and in Other Selected IEA Countries, 1973 to 1999
(CO_2 emissions/GDP using 1995 prices and purchasing power parities)



Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and *National Accounts of OECD Countries*, OECD Paris, 2001.

ENVIRONMENTAL POLICIES

Environmental policy related to energy focuses primarily on air quality control. The policies cover the following measures, in accordance with the Air Quality Preservation Law (1990):

- Regulating emissions.
- Using clean fuel.
- Regulating the use of automobiles.

Emissions regulations are aimed at gradually decreasing the sulphur content of petroleum products between 2000 and 2006. The cap for SO_2 emissions on gasoline-driven cars is 200 ppm from 2000, 130 ppm from 2002 and 30 ppm

from 2006. For diesel-driven cars, the targets are 500 ppm from 2000 and 430 ppm from 2002.

The 1990 Air Quality Preservation Law prohibits the construction of fossil-fuelled thermal power plants in the Seoul region using fuels other than natural gas. Natural gas is also promoted in the transport sector by deploying compressed natural gas-fuelled buses in Seoul, Pusan and other large cities. By using a package of fiscal incentives, including exemptions from value-added and acquisition taxes, the government expects to have 2,000 CNG buses by 2001, up from 119 buses in 2000, and 20,000 CNG buses by 2007. The Ministry of Environment is also considering facilitating the widespread use of hybrid cars, bio-diesel-fuelled vehicles, and di-methyl ether cars (DME).

CLIMATE CHANGE POLICIES

The Republic of Korea signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 14 December 1993. Korea submitted its first National Communication in March 1998. Korea is not an Annex I Party to the UNFCCC, and has not yet set a greenhouse gas reduction target. As a member of the UNFCCC, it has, however, participated actively in the Parties' successive conferences. Korea began to prepare its action plan to mitigate greenhouse gas emissions in 1997, and participated with other Asian countries in the Asia Least-cost Greenhouse Gas Abatement project under the auspices of the Asian Development Bank and the United Nations Development Programme-Global Environment Facility (UNDP-GEF).

In April 1998, the Korean government, led by the prime minister, established the Inter-Ministerial Committee on the Framework Convention on Climate Change to promote a dialogue among all Koreans concerned with climate change mitigation issues. In December 1998, it completed a Comprehensive National Action Plan to reduce GHGs and to make use of the Kyoto Flexible Mechanisms. Korea has adopted the principles of:

- Common but differentiated responsibility.
- Partnership among government, industry, and the public.
- Inclusion of all gases in every sector.

Korea seeks to appear as a potential partner for Clean Development Mechanism projects. It is also active internationally and domestically in assessing the potential benefits of its participation in emissions trading.

In her November 1999 address at COP5 (the fifth Conference of the Parties to UNFCCC) in Bonn, Myung Ja Kim, Minister of the Environment, said that Korea is interested in new criteria for a binding approach that would index GHG emissions targets to economic growth.

Korea has been implementing some policies and measures to mitigate GHGs, especially voluntary agreements between government and industry. Many Korean companies now participate in Voluntary Agreement Programmes to reduce emissions under the Comprehensive National Action Plan. More than 200 non-governmental organisations are involved in energy conservation efforts. In September 2000, the Presidential Commission on Sustainable Development was established, and, in September 2001, Korea hosted an experts' meeting to discuss participation by developing countries in the climate change mitigation framework.

In an effort to address global climate change, the Korean government has been promoting energy conservation and the use of nuclear energy, natural gas and new and renewable energy resources. A fund for fuel switching was secured for the Energy Project Special Account, begun in 1995, through a tax on petroleum and LNG, a sales tax on kerosene, and a safety management surcharge on LNG and LPG. Despite increasing government expenditures to promote natural gas, coal will probably remain a fuel of choice once the electricity market is liberalised and competitive, because it is relatively inexpensive and easy to purchase.

CRITIQUE

The 1990 Air Quality Preservation Act helped to reduce SO_2 emissions but has not been successful in reducing nitrogen dioxide and small-particle emissions. Changes to the fuel structure so far, with the introduction of gas and nuclear energy, have gone some way to reducing the environmental issues. The future seems less rosy, because coal use may grow in the liberalised energy market and the use of fuel for transport is expected to increase sharply. SO_2 emissions from transport could become a serious issue, because the sulphur content allowed in car fuel in Korea is higher than in most IEA countries. The projected growth in energy demand is higher than for other IEA Members. Policies to improve energy efficiency should be strengthened. Domestic standards for environmental regulations should be made consistent with international norms. The transport sector should receive priority. The points made in the IEA's 1994 in-depth review of Korea on this sector remain valid. Road charges and the price of fuels and other services for car use should reflect costs, including infrastructure and environmental costs. The use of energy-efficient vehicles and public transportation should be further encouraged.

Korea's position on climate change issues is quite special. It joined the OECD in 1996 and is therefore perceived by many to be an industrialised nation. Yet, its per capita income is one-half the average of industrialised nations. Its per capita energy use is about the same as in those countries. Under the UNFCCC, Korea still belongs to the category of "developing countries". It is encouraged to act as a model for other developing countries by showing that sustainable development is possible without increasing GHG emissions.

Renewable energies such as wind power and solar energy, are considered to have potential, but before they can be used in a broad way, substantial technological

development will be necessary to reduce their cost. Gas use is expected to grow as gas infrastructure expands. Currently, however, gas is more expensive than coal. Unless fuel prices adequately reflect environmental costs, the use of coal to generate electricity is likely to grow rapidly as the market liberalises. The principle of full-cost energy pricing is a key instrument for addressing environmental problems. Promoting renewable energy through a renewable portfolio standard, combined with trading in renewable energy certificates, would also help meet environmental and other energy goals at low cost.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Seek to strike a better balance among economic, energy, and environmental objectives; implement the recommendations on transportation made in the 1994 IEA review: full cost pricing, increasing the use of smaller vehicles, and developing public transportation systems.

- ☐ Accept more international environmental responsibilities, including under the United Nations Framework Convention on Climate Change (UNFCCC). Strengthen bilateral and multilateral co-operation to enhance global efforts in tackling climate change.

6

RENEWABLE ENERGY

MAJOR DEVELOPMENTS AND POLICIES

Renewables hold a marginal share in Korea's primary energy supply, at 1.3% in 1999 (excluding large hydro) compared to 3.9% in IEA countries on average. The use of renewables is growing quickly, however, since their share was only 0.6% in 1995. Promoting them both as a source of energy security and as cleaner energy is an important energy policy objective in Korea. More than 92% of renewable energy is now produced from municipal and industrial waste.

Table 4
Renewables: Supply by Source, 1999
(1,000 toe)

	Waste	*Bio Fuel*	*Solar Heating*	*Small Hydro-power*	*Photovoltaic*	*Wind Power*	*Total*
Supply	1,760.5	64.9	42.1	27.1	4.5	1.5	1,900.6
Per cent	92.7	3.4	2.2	1.4	0.2	0.1	100.0

Source: KEMCO.

Table 5
Installation of Renewable Energy by Source, 1999

Renewable Source	*Dissemination Status*
Solar heating	Residential solar hot water system: 178,000 units Golf clubs, fish farms, etc.: around 3,000 units
Bio fuel	Facilities using methane: 104 facilities
Photovoltaic	Photovoltaic energy on islands and special purposes (telecommunications, navigation light): 3.7 MW Plants in Hodo (100 kW), Hahwado (60 kW), and Marado (30 kW)
Wind power	Wind-power turbines: 15 units (6,478 kW)
Waste	Facilities using waste energy: 473 units
Small hydropower	Small hydropower plants: 24 units (42,164 kW)

Source: KEMCO.

The initial effort dates to 1987 when MOCIE introduced the New and Renewable Energy Development and Promotion Act in an attempt to further reduce Korea's dependence on imported fossil fuels, especially petroleum. The act encouraged installing waste-incineration facilities that generate heat and power and residential solar heaters for home water heating. It also promoted small hydro-electric plants and facilities to use methane gas. The act constituted the initial framework for the development of new and renewable technologies in Korea.[4]

The government's initial development goals were:

- 1988-1991 – to establish a research base through R&D projects partially funded by government (alternative energy would represent 0.5% of TPES by the close of the period).

- 1992-1996 – to establish a basis for using renewable technologies with demonstration and dissemination projects (alternative energy would represent 0.6% of TPES).

- 1997-2001 – to focus R&D efforts on priority technology (alternative energy would represent 1.3% of TPES).

- 2002-2006 – to commercialise energy (alternative energy would represent 2% of TPES).

Between 1988 and 1998, public money was invested in around 300 projects in eleven research areas including photovoltaics, bio-energy, waste energy, wind power, solar, ocean and geothermal power, hydrogen and small hydro projects. (Fuel cells and clean coal use were also funded).

Higher oil prices in 1999 and 2000 and the government's growing interest in measures to mitigate greenhouse gas emissions in the 1990s again drew policy-makers' attention to renewables. In 1999-2000, the government projected two scenarios for renewable energy demand and supply. In the business-as-usual scenario, renewable energy would continue to cover 1.2 to 1.3% of total energy needs until 2010, renewables growing at about the same rate as other fuels. The second scenario, assuming intensified R&D on renewables, projects them to represent 3% of the total energy demand in 2005 and 5% in 2010.

In February 2001, the government announced an Alternative Energy RD&D Basic Plan[5], as a renewed framework for further development of renewables. Wind and photovoltaic power are targeted as top-priority technology areas on which the government will focus its R&D support. Other areas targeted are solar thermal, waste and biomass.

4. The Korean government does not differentiate between renewables and other cleaner and alternative sources of energy, such as fuel cells, or integrated gas combined cycle turbines.
5. Research, Development and Dissemination.

Table 6
Shares of New and Renewable Energies by Type (%) – intensified R&D scenario

	Biomass, including waste to energy	*Solar Thermal*	*Small Hydro*	*PV*	*Wind*	*Fuel Cell*	*IGCC*	*Land Fill Gas*	*Transport*	*Total*
1999	96.1 (1,760)	2.2 (42)	1.4 (27)	0.2 (4.5)	0.1 (1.5)	–	–	–	–	100
2005	72.3	1.0	0.5	0.2	0.2	7.6	7.7	0.2	10.3	100
2010	65	1.0	1.0	2.8	0.3	6.5	11.8	0.2	11.4	100

Notes: Figures in parentheses are thousand toe.
The Korean government associates renewables with new energy sources such as fuel cells and Integrated Gasification Combined Cycle (IGCC), which is why they figure in the table.

Source: KEEI.

Table 7
Disseminating Goals per Renewable Energy Source, 2001-2006
(1,000 toe)

	1995 (A)	*2001*	*2006 (B)*
Waste	804.5	4,265.0	7,258.0
Bio fuel	59.2	148.0	167.0
Solar thermal	22.1	129.0	214.0
Small hydropower	20.4	64.0	97.0
Photovoltaic	2.2	15.0	31.0
Wind power	0.1	21.0	33.0
Total	**908.5**	**4,642.0**	**7,800.0**

Source: MOCIE, 2001.

From 2001 to 2006, the government plans to invest around $800 million to help broaden the dissemination of renewable energy technology. It envisages the following measures:

- Providing financial support and preferential tax treatments as incentives for the research, development, demonstration and dissemination of renewable technologies; financial assistance includes low-interest loans (5.5% with a three-year grace period and five years to repay) for companies that install renewable energy technologies; a company can deduct up to 10% of its investment in R&D on renewables from its corporate tax.

- Introducing renewable portfolio standards (RPS) and making it mandatory for wholesale purchasers of electricity to buy at least 1% of their electricity from

renewables. So far, this concerns only KEPCO. The government is also planning to require public institutions, government complexes, schools, golf courses and hotels to buy renewable energy equipment. The aim is to meet 2% of the total energy demand from public institutes through renewable energy sources.

- Establishing a mechanism by which surplus electricity sold to KEPCO's grid from renewable energy facilities will be purchased at rates that provide sufficient incentives to make renewable energy projects viable.

OUTLOOK

MOCIE has set a target of a 2% share of new and renewable energy in total primary energy supply by 2003, and a target of 3% by 2006.

Korea's renewable energy potentials are as follows:

Biomass and Wastes

At the end of 1999, some 100 industrial and municipal waste incinerators were producing locally-consumed steam in Korea. The incinerators provided clear benefits for energy production, but the air pollution they cause has gradually become a matter of concern.

The government is now reviewing the possibility of producing methane from landfills. Fourteen large-scale landfill sites with an overall estimated gas generation potential of 647,000 cubic metres present attractive opportunities for project development.

Wind Power

The coastal, island, and mountain areas of Korea have an average wind speed of 4 to 5.6 metres per second. By the end of 1999, 15 wind plants had been installed with a total capacity of 6.4 MW, generating electricity at a cost of ten US cents per kWh.[6] Technological development has improved reliability, increased the size of turbines and thereby contributed to lower costs.

Solar Thermal

The southern coastal area has the greatest economic potential for solar thermal, which can be used in greenhouses, fish farms, swimming pools and industrial heat processes. The government aims to expand the residential use of solar water-heating systems in rural areas in small- and medium-sized cities. So far, 178,000 units of residential solar thermal water-heaters have been deployed, producing 0.4 Mtoe in 1999.

6. Capital cost only, excluding operation and maintenance.

Photovoltaic

The 88 inhabited Korean islands are the main potential sites for photovoltaic off-grid generation. Basic research on photovoltaic systems has been completed, and they are coming into use. PV power systems are being used for unattended lighthouses, emergency highway lighting and demonstration photovoltaic electrification on isolated small islands: Hawhado (60 kW), Marado (30 kW) and Hodo (100 kW) (see Table 5). Total installed capacity of photovoltaic systems amounted to 3.7 MW in 1999. At 0.65 cents to $1 per kWh, the cost of photovoltaic generation is still considered too high to compete with conventional power generation.

CRITIQUE

In 1999, renewable energy represented 2.3 Mtoe of Korea's primary energy supply although the economic feasibility of several renewable energies in Korea has yet to be established. The costs of generating electricity from renewables are still too high to compete with conventional power generation without some kind of financial support. The government needs to assess the potential of renewables and make market expansion plans for them accordingly.

Renewable energy, such as wind power and solar energy, is considered to have potential. Substantial technological development leading to reduced costs will, however, be needed before these forms of renewable energy can play a significant role.

There is growing concern that lack of commercial viability will delay the use of new energy technologies. The 1994 IEA review called for more partnerships between the government and the private sector to develop technologies and to help support the expansion of the renewable energy market. The number of partnerships has clearly increased and the government has taken the right direction. But strong government support will be needed to enable the private sector to invest in renewable energy and to facilitate the market deployment of developed technologies. For example, investment in solar thermal energy infrastructure should be enhanced, and a demonstration project of solar thermal energy technology should be launched.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Assess the potential of renewable energy resources.
- ☐ Assess the cost-effectiveness of renewables and define accordingly objectives for technology development, industrial expansion and market deployment.

☐ Consider pricing externalities, such as air and soil pollution, and the risks associated with conventional power plants, as a factor in developing renewable electricity options.

☐ Consider increasing public participation in public-private partnerships for R&D technology projects.

☐ Consider implementing "green pricing" as a first step to creating a market for green electricity; as a second step, consider establishing a target for renewable power generation using market mechanisms such as renewable portfolio standards and tradable certificates.

7

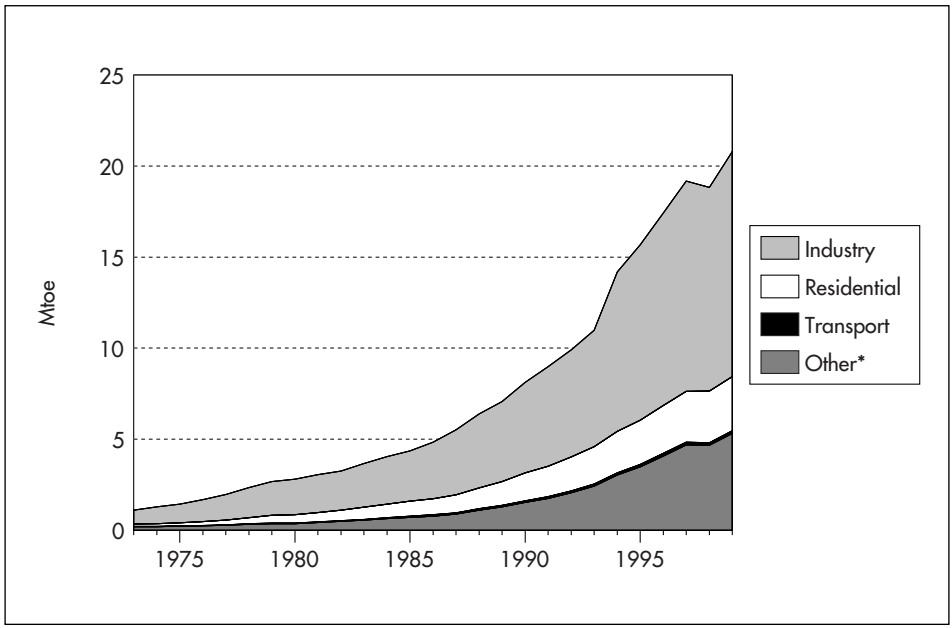
ELECTRICITY AND NUCLEAR

CONSUMPTION AND PRODUCTION OF ELECTRICITY

Electricity demand has grown much more quickly in Korea than the OECD average, in line with the country's higher economic growth. In 2000, its peak electricity demand of 41 GW and electricity sales of 240 TWh ranked Korea seventh among OECD countries. The growth rate of Korea's electricity consumption has been the highest in the OECD: an average of 10.8% per annum between 1973 and 2000 compared to 3.2% for the OECD average. Demand actually fell in 1998 because of the Asian economic crisis but recovered in 1999. Demand in 2000 grew by 11.3%, faster than GDP, which grew by 9%.

The residential demand for electricity in Korea is low, whereas industrial demand comprises a major share of the total demand. The residential consumption of approximately 800 kWh per person per annum is about 37% of the OECD average. Industry accounts for 55% of electricity consumption, compared with an OECD average of 38%. This large share accounts for Korea's relatively high electricity intensity, approximately one-third higher than the OECD average.

Figure 17
Final Consumption of Electricity by Sector, 1973 to 1999

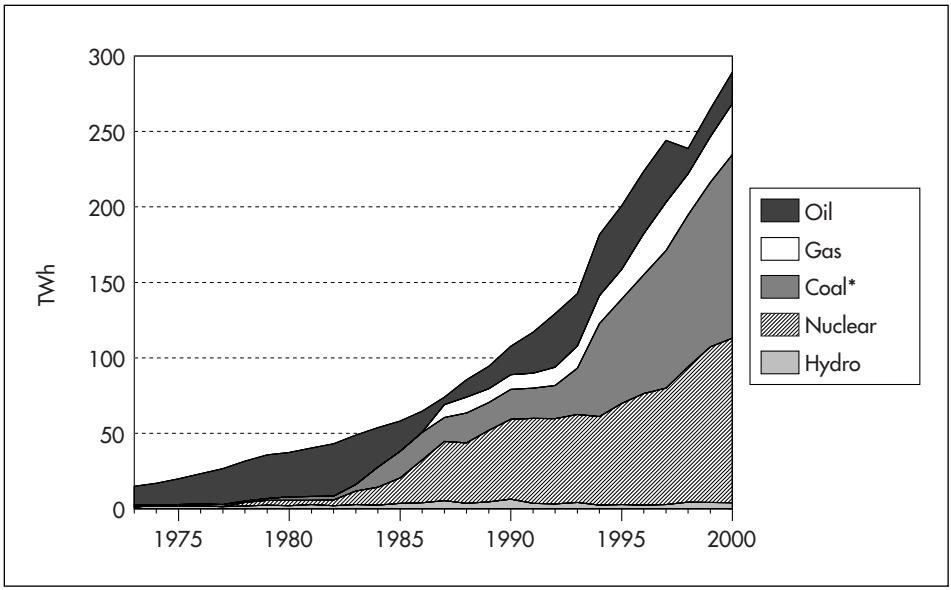


* Includes commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

In 2000, there were 46 GW of capacity available to meet peak demand. Generating capacity barely kept pace with the expansion of demand until 1997. Very low reserve margins, of between 3 and 10%, prevailed during the period 1990-1997. Adding 15 GW of new generating capacity over the period 1998-2002 should, however, create adequate reserves for the next few years.

The fuel mix for domestic electricity generation in 2000 is dominated by nuclear (41%), followed by coal (37%), gas (11%), oil (10%), and hydroelectric power (2%). Strong growth in electricity demand, averaging 11.6% per year (1989-1999), is expected to continue (Figure 18).

Figure 18
Electricity Generation by Source, 1973 to 2000



* The IEA revised all data on coal from 1994. This may lead to some breaks in the time series between 1993 and 1994.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

In 2000, nuclear energy provided 41% of power generated in 16 power plants mostly for baseload. The government has supported the development of nuclear power to increase energy security by decreasing dependence on fossil fuels, which are almost entirely imported. Four more nuclear plants are under construction, and current plans call for building another eight plants by 2015.

Coal-fired generation, mostly with imported bituminous coal, is inexpensive and is used for baseload and midload operation. Domestic anthracite coal is used for a small portion of coal-fired generation. The government obliges KEPCO to purchase

it at nearly twice the cost of imported coal. In order to meet its anticipated ongoing obligation to burn anthracite, KEPCO recently built new power plants at Donghae using advanced coal-burning technology (circulating fluidised bed).

Gas-fired power generation provides power during the summer months to help meet peak load and to reduce the environmental impact of electricity production. Its high cost, despite the use of efficient combined-cycle power plants, means that its share of power production is larger than is economically optimal. However, until 2006, KEPCO is obliged to purchase a (negotiable) minimum amount of natural gas under a "take or pay" arrangement with KOGAS, the government-owned gas monopoly.

Of the other types of power generation, oil-fired generation facilities are largely older plants used for meeting midload demand. Their contribution has dropped, but lower fuel costs mean they are often preferred to natural gas. Hydroelectric power is also used for meeting peak demand. About half of all hydro capacity is pumped storage hydro, meaning that water is pumped into reservoirs during off-peak hours to be used to generate electricity during peak hours. Table 8 summarises the total capacity, capacity factor and fuel cost for different types of power generation.

Table 8
Power Production in Korea, 2000

Type	*Gross Capacity (MW)*	*Gross Production (TWh)*	*Capacity Factor (%)*	*Fuel Cost (won/kWh)*	*Fuel Cost (cent/kWh)*
Nuclear	13,716	108.9	90	4.35	0.31
Imported coal	12,740	92.2	83	13.27	1.0
Domestic coal	1,291	5.3	47	48.79	3.7
Gas	12,698	28.1	25	87.05	6.6
Oil	4,866	26.1	61	52.57	4.0
Hydro	1,549	4.0	29	0	0
Pumped storage hydro	1,600	1.6	11	17.8	1.3
Total (or average)	**48,451**	**266.4**	**63**	**18**	**1.4**

Note: Costs refer to KEPCO plants only.
Sources: Ministry of Commerce, Industry and Energy and KEPCO.

Transmission and International Trade

The high-voltage transmission network is a well-developed 345 kV/154 kV system. A high-voltage direct current (HVDC) link exists with Cheju Island in the south. Much of the network is relatively new: the transmission and distribution

losses, 4.7% of total electricity supplied, are thus better than the OECD average of 6.8%. KEPCO has begun to develop a 765 kV system that will reduce transmission losses further. There is a pronounced flow of power towards Seoul from power plants in the southern and eastern parts of the country.

No interconnections exist with other countries. In 1948, North Korea severed the ties that previously existed with it.

Industry Structure

KEPCO

The Korea Electric Power Corporation (KEPCO), a majority-state-owned company that owns 94% of generating capacity and 100% of transmission and distribution, entirely dominates the electricity system in Korea. With 48 GW of generating capacity, it is the fourth-largest power-generating company in the OECD. Moreover, KEPCO has a further 12 GW under construction or in advanced planning that will come into service before 2005.

KEPCO's non-nuclear generating assets have been divided into five wholly-owned subsidiaries (Table 9): Korea South-West Power Co. Ltd (KOSEPCO), Korea Midland Power Co. Ltd. (KOMIPO), Korea Western Power Co. Ltd. (KOWEPCO), Korea Southern Power Co. Ltd. (KOSPO), and Korea East-West Power, Ltd. (KEWESPO). The number of companies was determined partly by the need to balance a minimum scale of efficiency with the risk of collusion if too few companies were created. The companies were to be divided relatively equally so that each would have a similar mix of generating capacity by fuel type and location. The government has stated that it will phase in privatisation.

The nuclear company known as Korea Hydro and Nuclear Power Co. Ltd. (KHNP) will remain public. It owns 536 MW of hydropower.

Table 9
KEPCO Generating Subsidiaries

	KOSEPCO	*KOMIPO*	*KOWEPCO*	*KOSPO*	*KEWESPO*	*KHNP**
Operating capacity (MW)	6,100	6,138	6,346	4,910	5,800	14,252**
Under construction (MW)	1,600	1,600	1,600	2,800	1,700	4,000
Capacity (MW)	7,700	7,738	7,946	7,710	7,500	18,252
Number of plants	7	7	8	8	8	18**

* Remains public.

** Includes 11 hydropower plants with 536 MW capacity.

Note: These figures include plants to be built by 2006.

Source: Ministry of Commerce, Industry and Energy.

Independent Power Producers

A few independent producers have long-term arrangements for supplying power to KEPCO (Table 10). Gas-fired independent producers are increasing thanks in part to the privatisation of the Anyang and Buchon district combined heat and power facilities and the first of four new IPP gas plants that began operating in 2000. The Korea Water Resource Corporation sells most of the hydropower and sells its surplus water to KEPCO as hydropower. Legislative changes setting favourable prices for the sale of power under contract to KEPCO have encouraged co-generation facilities.

Table 10
Independent Power Production, 2000

Companies	*Capacity (MW)*	*Sales to KEPCO (TWh)*
Gas	2,872	2.3
Hydro	1,012	2.4
Co-generators (26 sites)	2,824	4.7
Total	**6,708**	**9.4**

Source: KEPCO: Gas figure includes 900 MW from Anyang/Buchon privatised during 2000.

KEPCO has additional contracts with four producers for LNG-fired power plants to come into service by 2005. The approximately three GW of additional capacity provided by those plants is about 10% of what KEPCO has been planning to build during this period. The first of these plants came into service during 2000.

Wholesale Electric Power Exchange

The Korea Power Exchange (KPX) was established in April 2001 as a non-profit corporation responsible for operating both the electricity system and the electricity market. Members manage the exchange, principally the generation and supply businesses and direct-purchase consumers. As a system operator, KPX is responsible for balancing the electricity system and managing the supply of ancillary services. As a market operator, it is responsible for measuring, invoicing, settlement and payment of electricity transactions, enacting and amending market rules.

KPX currently operates a cost-based power pool that is mandatory for all generators producing 20 MW or more. The cost-based pool distinguishes between baseload and general generation. Variable costs are recovered through Baseload Marginal Price (BLMP) and System Marginal Price, respectively. The two types of generation are paid for by capacity fees based on actual capacity: 7.17 won or US 0.5 cent/kWh for baseload, 21.49 won or 1.6 cents/kWh for general. The pool operates as a day-ahead market.

A mandatory two-way bidding pool is currently being designed and is due to replace the cost-based pool in 2003. It will allow demand-side and supply bidding. It is not yet known whether the market will include capacity fees. The design is based on the Australian national market. But many other electricity markets operating in OECD countries now allow trading outside the pool on a bilateral basis; these are known as "voluntary" systems (see Table 11).

Table 11
Organisation of Electricity Pools in OECD countries

Market	*Participation*	*Demand-side Bidding*	*Capacity Mechanisms*
Australia: NEMMCO	Mandatory	Yes	No
Korea: current/planned	Mandatory/Mandatory	No/Yes	Yes/?
Spain	Voluntary*	Yes	Yes
UK (England and Wales): NETA	Voluntary	Yes	No
Netherlands	Voluntary	Yes	No
Norway, Sweden, Finland, Denmark: Nordpool	Voluntary	Yes	No
US: PJM Interconnection Association	Voluntary	Yes	Yes

PJM: Pennsylvania, New Jersey, Maryland.

* Spain's system is voluntary but provides significant financial incentives for participation through its capacity payment system.

Electricity Prices and Costs

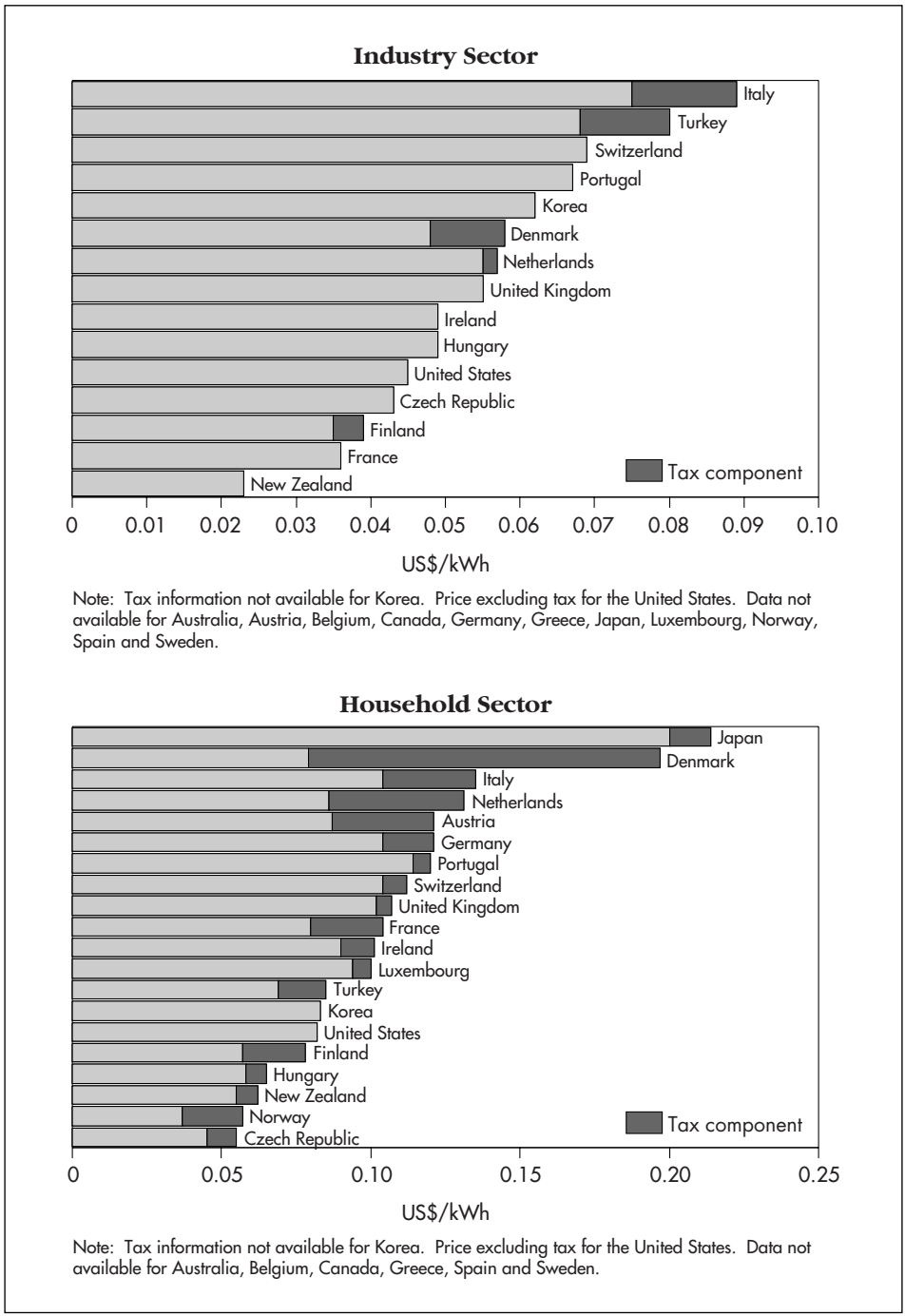
When measured in simple exchange rate terms, industrial and household electricity prices in Korea are below the average for OECD countries (Figure 19). Government policies which accept low rates of return on equity and lower dividends for government shares partly explain these lower prices.

It was necessary to increase prices to cover the costs of KEPCO's rapid decade-long expansion. The company tripled in size over ten years. External factors also led to higher costs. These included the devaluation of the won in late 1997, higher fuel costs, and foreign-denominated interest payments, which led to rate increases (5.9% in July 1997, 6.5% in January 1998, 5.3% in November 1999 and 4% in November 2000).

Tariffs vary not by location but by the voltage at which the customer receives electricity. The basic structure is a two-part tariff, where customers pay for capacity (in kW) and for energy (in kWh). Commercial, educational and industrial tariffs also vary by season.

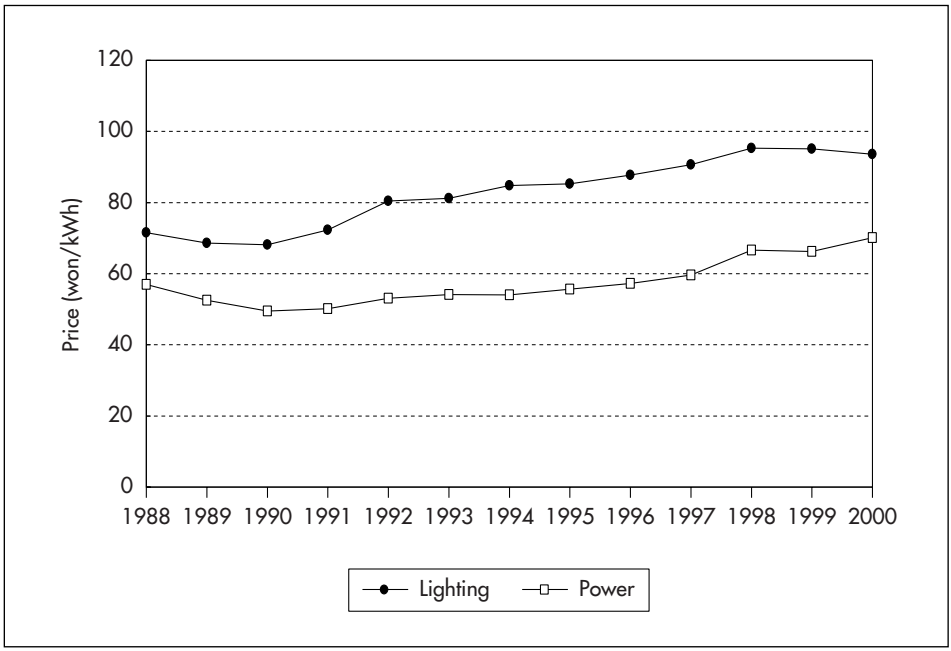
Optional time-of-use tariffs have been broadened by offering a highly preferential rate for late-night use of electricity. The response was greater than expected, and led to an 11 p.m. peak in electricity demand.

Figure 19
Electricity Prices in IEA Countries, 2000



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Figure 20
Lighting (small consumer) and Power (large consumer)
Average Price/kWh, 1988 to 2000



Source: Korean Energy Economics Institute.

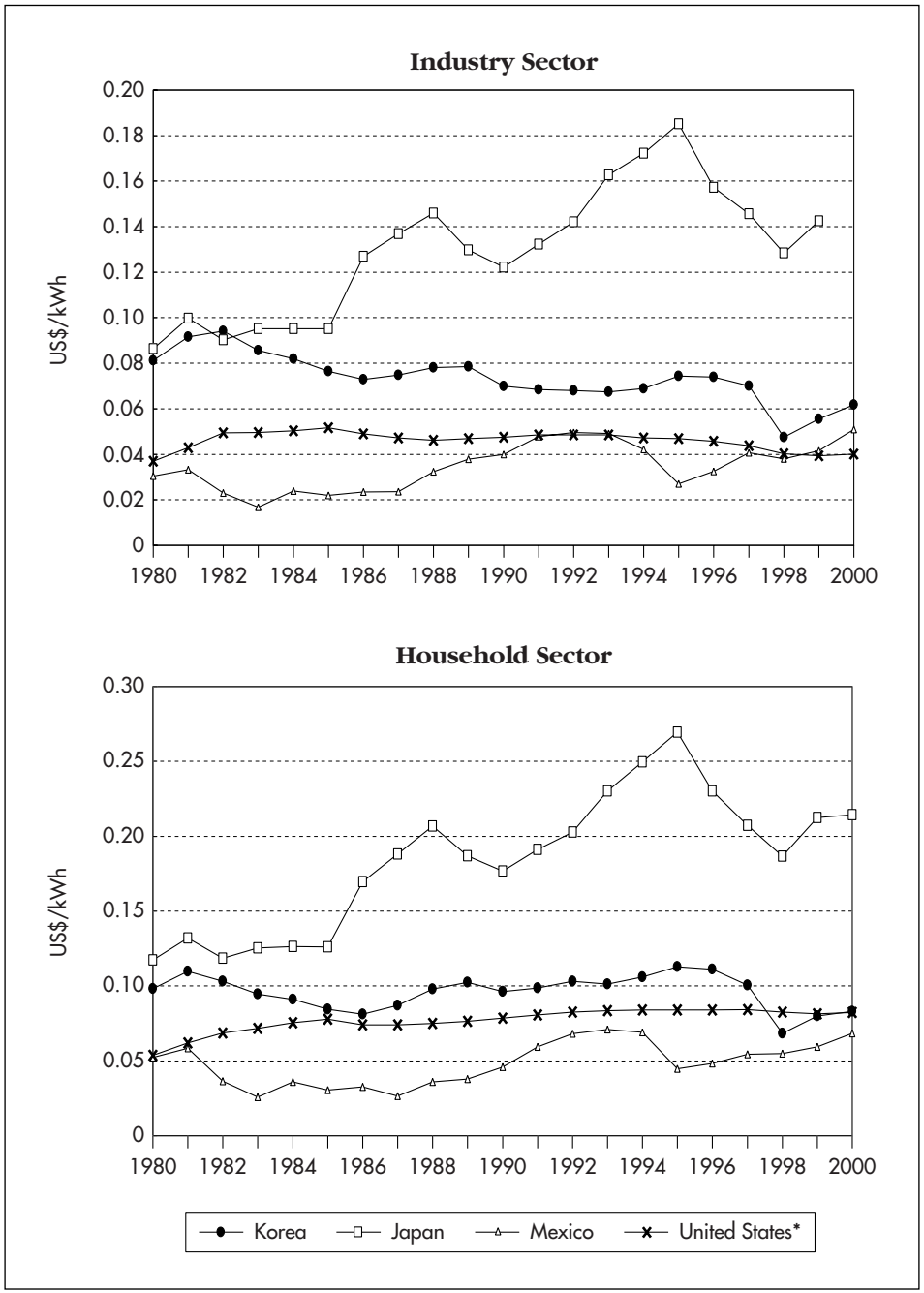
Tariffs contain large price distortions (Table 12). The ministry estimates that farmers pay only 48% of the cost of electricity, and that industry, which accounted for 57% of sales in 2000, paid 96%. By contrast, average payments from commercial customers were nearly 34% above costs. Recent tariff increases have been aimed at increasing industrial rates while holding domestic tariffs steady, partly to redress this imbalance.

Table 12
Prices *vs.* Costs for Different Customer Categories, 2000

	Household	*Commercial*	*Education*	*Industry*	*Agriculture*	*Street Lighting*	*Total*
Average price (won/kWh)	94.72	106.04	90.16	58.30	43.04	65.92	74.65
Ratio to generation cost (%)	108.90	133.70	116.40	96.10	48.00	101.30	106.40
Share of total sales (%)	**18.80**	**19.90**	**1.00**	**57.30**	**2.30**	**0.70**	**100**

Figure 21

Electricity Prices in Korea and in Other Selected OECD Countries, 1980 to 2000



* Price excluding tax.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Fuel costs make up the largest share of total costs. As fuels are imported under contracts in foreign currency, power costs are sensitive to fluctuations in exchange rates. In 2000, KEPCO's fuel costs for coal, oil and LNG were 34,243 won ($30.30) per tonne, 34,328 won ($26.21) per barrel, and 388,955 won ($343.90) per tonne, respectively.[7] The prices for imported coal and oil are competitive compared with other countries, but natural gas prices in Korea are the highest in any OECD country. This is due primarily to the use of costly LNG, but also to KOGAS's high charges for KEPCO's use of LNG, and to Korea's higher import duties and taxes on natural gas. (Japanese utilities reduce their LNG costs by importing it directly to their own facilities rather than through a gas utility.)

Electricity consumers pay higher costs because of several quasi-governmental functions, such as:

- Supplying below-cost electricity to agricultural and fishing consumers and to remote areas; this amounts to a subsidy of about 150 billion won ($113 million).
- Supporting the nuclear power R&D budget, a substantial fraction of the total R&D budget of 219 billion won ($165 million) and other research activities.
- Purchasing domestic coal at a premium over imported coal, amounting to a subsidy of 78 billion won.
- Demand-side management programmes.
- Support for areas adjacent to power plants (63 billion won).
- Support for the LNG industry.
- Support for the district-heating network.
- Promoting electric power source development.
- Research and public information for electrical safety.

The government's Electric Power Industry Basis fund now supports the costs of these activities, which were formerly borne by KEPCO. The annual cost of approximately 1 trillion won ($755 million) is paid by taxing electricity consumers 6.5% of the retail cost of their electricity.

7. Converted at "average" 2000 exchange rates of 1,130 won = $1.

Policy Framework

The Basic Plan for Restructuring the Electricity Supply Industry

The Korean electricity sector is in the early stages of a long process of restructuring, privatising and liberalising. In January 1999, the government adopted the Basic Plan for Restructuring the Electricity Supply Industry as part of its general regulatory reform policy. The plan called for a four-phase reform process.

Phase 1 (Current System) ran through the end of 1999, and Phase 2 (Power Generation Competition) through 2002. Phase 3 (Wholesale Competition Phase) will run through 2009, with Phase 4 (Retail Competition) post 2009.

Several major components of the plan are now being implemented:

- In December 2000, legislation was passed so that KEPCO could be restructured and privatised.

- In April 2001, KEPCO's non-nuclear generation was broken into five wholly-owned generating subsidiaries, which are to be privatised beginning in 2002. The government has not decided whether the companies will be fully or partially privatised. It indicated recently that both foreign and domestic firms would be able to invest in the subsidiaries. Combinations of public offerings and trade sales are currently being considered. Two combined heat and power plants providing district heating in Anyang and Buchon were privatised in 2000.

- The nuclear plants, along with 536 MW of hydro capacity, have been placed in a separate government-owned company.

- A cost-based electricity pool and power exchange (KPX) began operating in April 2001.

- An Electricity Committee, created within MOCIE, fulfils several regulatory functions.

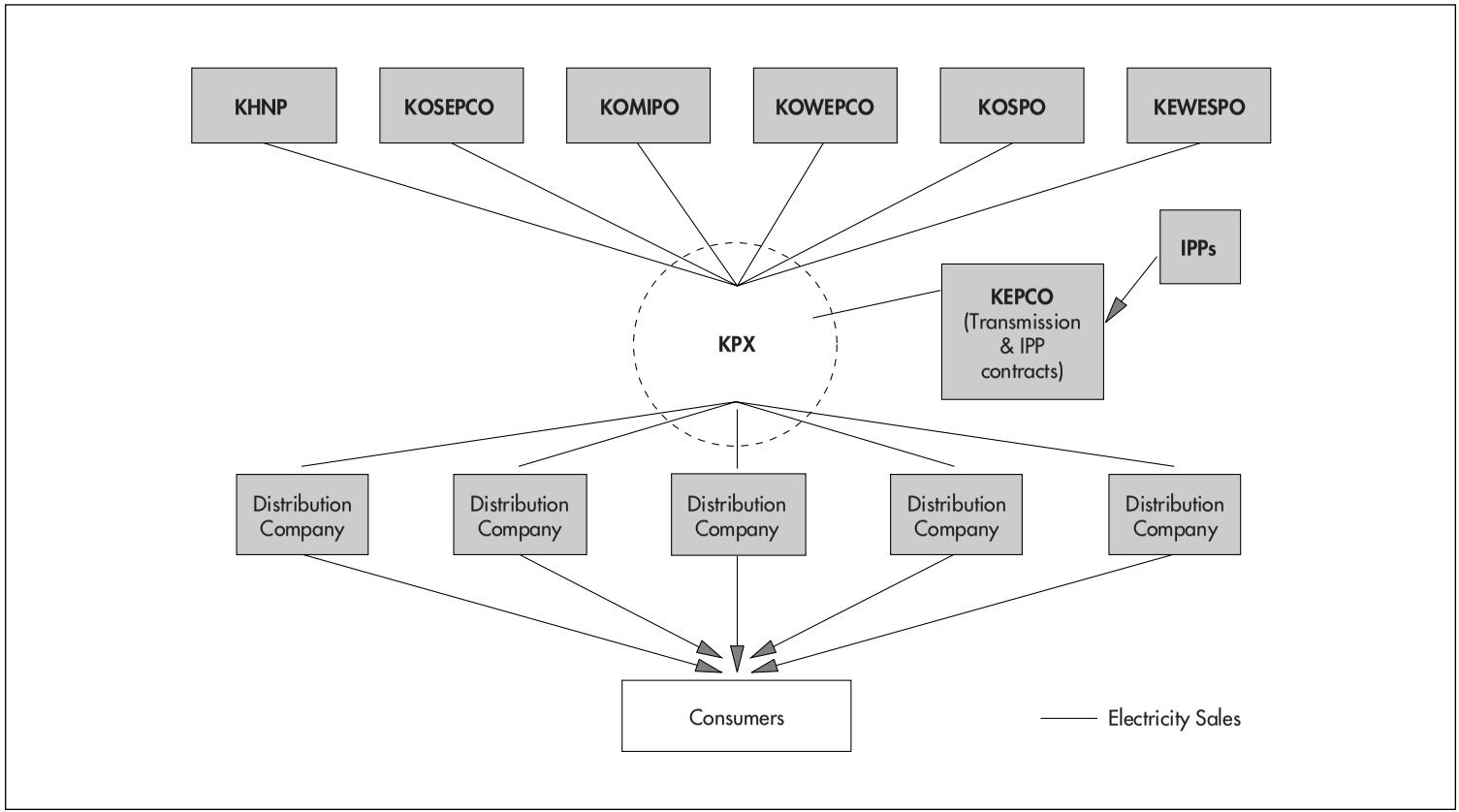
- Legislation has been passed that permits the government to liberalise the electricity market by presidential decree.

The distribution subsidiaries are to be created by the end of 2002. Once this has been completed, the market structure will be as shown on Figure 22.

Final decisions have yet to be made concerning liberalisation of consumer markets. The current proposal is to liberalise consumers according to the schedule in Table 13.

The proposal projects that when small consumers are liberalised in 2009, they will have the option of switching suppliers but not of buying directly from the market. Table 14 compares the market opening in Korea with that of other countries using nuclear power.

Figure 22
Restructuring KEPCO, end 2002



Source: KEPCO.

Table 13
Planned Electricity Liberalisation Schedule

Year	*Demand*	*Number of Customers Liberalised*	*Share of Consumption (cumulative)*
2003	50 MW and above	139	24.2%
2004	5 MW and above	1,539	41.2%
2009	100 kW and above	91,400	71.2%
	below 100 kW	14.9 million	100%

Table 14
Status of Electricity Market Reform in OECD Countries with Nuclear Power

Country	*2000 Nuclear Generation Share (%)*	*Retail Market Opening %*	
		2001	*2003*
Belgium	57	35	100
Canada	12	Varies by province*	Varies by province*
Czech Republic	18	0	40
Finland	32	100	100
France	77	33	35
Germany	30	100	100
Hungary	40	0	33**
Japan	29	30	30
Korea	41	0	24
Mexico	4	0	0
Netherlands	4	35	100
Slovakia	47	0	0
Spain	28	54	100
Sweden	39	100	100
Switzerland	38	0	30***
United Kingdom	23	100	100
United States	20	Varies by state*	Varies by state*

* Wholesale markets are open. Retail market opening at provincial or state level varies from 0 to 100%.
** Proposed.
*** Planned market opening over the period 2002-2008. Subject to referendum.
Source: IEA.

Legal Framework

The basic plan has already resulted in major changes to the Electricity Business Act, finally passed in late 2000. The following sections summarise this and other major legislation affecting Korea's electric power sector.

Economic Regulation

The Electricity Business Act assigns ultimate regulatory responsibility to the Minister of Commerce, Industry and Energy. It creates an Electricity Committee to be the regulatory body within MOCIE, primarily to "deliberate and resolve" the key regulatory functions of the minister before final approval is granted. The committee consists of up to nine members named by the President of Korea for terms of up to three years, and a secretariat. Committee members cannot be removed except for physical or mental incapacity or crimes resulting in imprisonment.

The Electricity Committee must "deliberate and resolve" the following issues before the President can give final approval:

- Granting, revoking or acquiring permission to run an electricity business (including generation, transmission, distribution and sales).
- Transmission and distribution charges, and regulated retail sales.
- Regulations for operating the electric power market.

The committee is also responsible for investigating suspected prohibited activities by electricity business operators and for proposing solutions. Prohibited activities include:

- Submitting false data to KPX in order to set unfairly high prices.
- Unfair discrimination in access to transmission and distribution.
- Misappropriating information from transmission and distribution operations to infringe unfairly on activities of other electricity businesses.
- Inappropriately allocating costs for transmission and distribution facilities.
- Delaying or failing to comply with an order concerning operating facilities.

The Electricity Committee also has arbitration responsibilities for disputes concerning terms of access to power networks and related matters. More broadly, it has a mandate to review the introduction of competition and the protection of consumers. The minister may also ask it to investigate specific issues.

MOCIE is responsible for a long-term power development plan that designates which facilities are to be developed. Individual businesses must also establish and submit plans to MOCIE for its approval.

Access and Obligation to Supply

The Electricity Business Act establishes a regulated third-party access system for transmission and distribution. Generators and suppliers may not refuse to supply electricity without justification. The regulated third-party access system is consistent with practices in the majority of OECD countries (Table 15).

Table 15
Electricity Network Access in IEA Countries

Regulated Third-Party Access	*Negotiated Third-Party Access*
Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Greece, Hungary, Ireland, Italy, KOREA, Luxembourg, Norway, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United State	Germany, Japan, New Zealand

Retail Supply and Liberalisation of the Consumer Market

Suppliers must offer "basic" terms of supply at regulated prices and "alternative" terms for demand control.

Transmission Pricing

Transmission costs will be recovered from both generators and consumers, depending on zone. Price levels will be based on cost of service, but will include performance-based incentives.

Siting

Extensive legislation exists on the siting of power plants. The Act on Special Cases Concerning Electricity Source Development and the Act on Assistance to Electric Power Plants Neighbouring Areas were enacted to try and expedite the approval of new power plants. Concern about expediting construction is understandable, given the rate of growth in demand and the time required to develop new plants (see Table 16).

The Special Cases Act streamlines the approval process by having MOCIE co-ordinate consultations with eleven other government ministries. The Assistance to Neighbouring Areas Act is designed to promote the acceptance of new KEPCO power plants by creating an assistance fund for people and companies living within five kilometres of a power plant. Assistance in 2000 amounted to 63 billion won ($48 million).

Such assistance may become even more important since the Local Authority Act gives back to authorities the power to block the construction of new plants. One local authority recently blocked a coal-fired independent power project proposed by the steelmaker Pohang Iron and Steel Corporation (POSCO).

Table 16
Timelines for Approvals and Construction of Power Plants in Korea
(months)

Type	*Feasibility*	*Approvals*	*Preparation for Construction**	*Pre-construction Total*	*Construction*	*TOTAL*
Nuclear (LWR)	12	20	57	89	66	155
Coal (800 MW)	12	20	46	78	44	122
Pumped storage	12	20	49	81	52	133
LNG	12	20	40	72	30	102

* Includes tendering of main contracts and site preparation.
Source: Ministry of Commerce, Industry and Energy.

The need to have local approval of power plants might eventually become a barrier to the long-term development of nuclear power, which generates considerable public concern. Of the twelve nuclear plants currently under development, however, nine have already obtained local government approval.

NUCLEAR ENERGY

Overview

Korea has 16 nuclear power plants in operation at four sites. These are all owned by Korea Hydro and Nuclear Power Company Limited (KHNP), and were previously owned by the parent Korea Electric Power Corporation (KEPCO) (Table 17). Twelve plants are pressurised-water reactors (PWR), and the others are CANDU Pressurised Heavy-Water Reactors (PHWR).

In 2000, these plants constituted 28% of Korea's electricity generating capacity and generated 41% of demand. The mean plant availability factor in the same year was 90.4%, a figure in excess of the world average for plants of similar design.

Four additional plants were under construction at the end of 2000 (Table 18).

Eight more plants are to be commissioned by 2015. Four will be built on a site adjacent to the existing plants at Kori, and the two others will be built in Wolsong.

Korea plans to have nuclear power plants account for 33% of generating capacity in 2015, or 44.5% of the country's electricity needs.

Nuclear Industry Structure

The government intends to keep KHNP and its subsidiary, the Korea Nuclear Fuel Cycle (KNFC), in the state sector for the immediate future. KEPCO's subsidiary

Table 17
Operating Nuclear Power Plants

Plant		*Year of Commissioning*	*Capacity (MW)*
PWR			
Kori	1	1978	587
Kori	2	1983	650
Kori	3	1985	950
Kori	4	1986	950
Yonggwang	1	1986	950
Yonggwang	2	1987	950
Yonggwang	3	1995	1,000
Yonggwang	4	1996	1,000
Ulchin	1	1988	950
Ulchin	2	1989	950
Ulchin	3	1998	1,000
Ulchin	4	1999	1,000
PHWR			
Wolsong	1	1983	679
Wolsong	2	1997	700
Wolsong	3	1998	700
Wolsong	4	1999	700

Table 18
Nuclear Power Plants under Construction

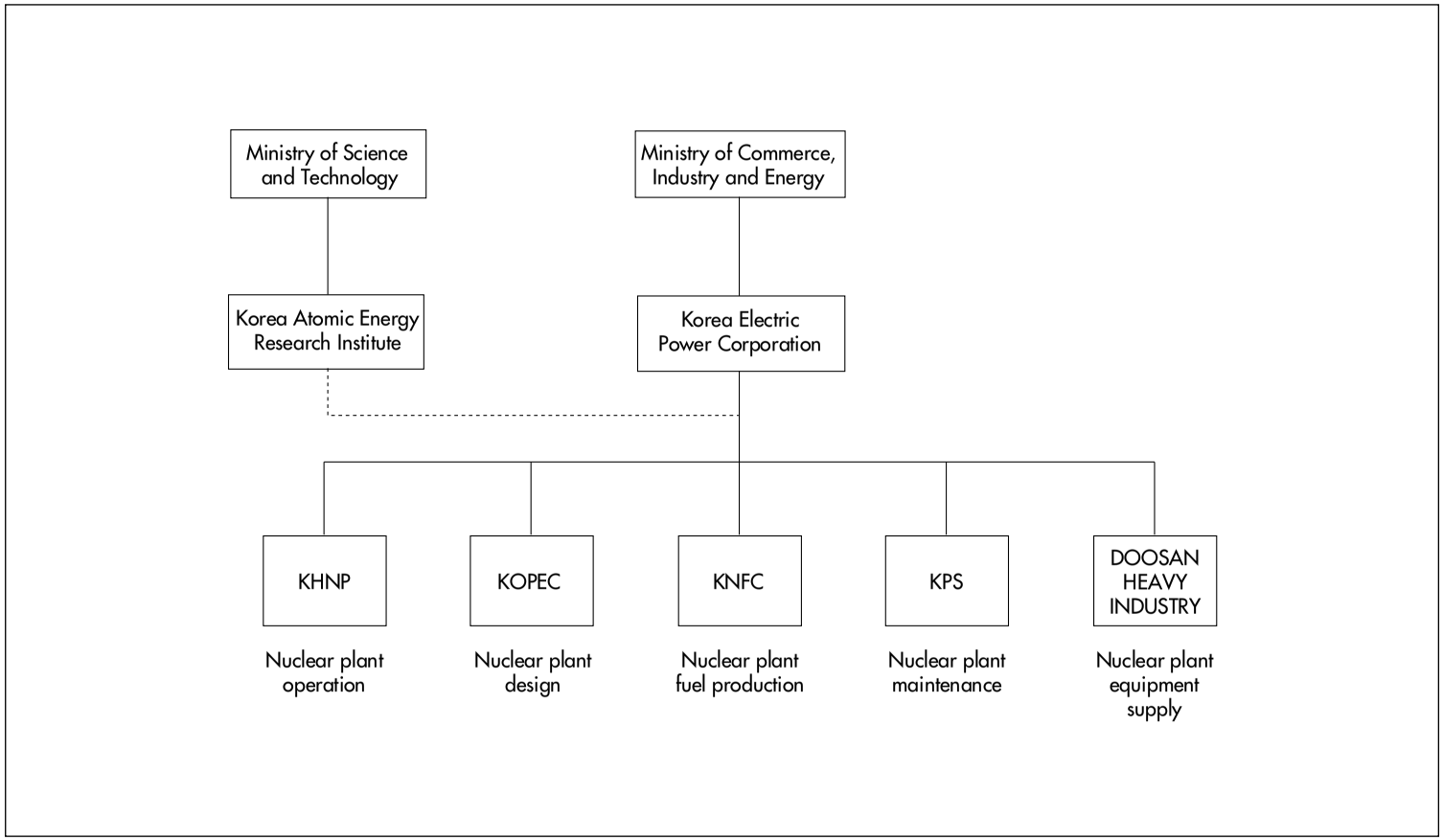
Plant		*Planned Year of Commissioning*	*Capacity (MW)*
PWR			
Yonggwang	5	2002	1,000
Yonggwang	6	2002	1,000
Ulchin	5	2004	1,000
Ulchin	6	2005	1,000

HANJUNG was sold to the Doosan Group on 1 April 2001, and the subsidiaries, Korea Power Engineering Company (KOPEC) and Korea Plant Service Engineering Company (KPS) will be privatised at a time yet to be defined.

Governmental Responsibilities for Nuclear Energy

The Atomic Energy Act designates the Atomic Energy Commission (AEC) as the highest decision-making body on policy issues and the utilisation of nuclear energy.

Figure 23
Nuclear Industry Structure



The AEC is composed of from nine to eleven members representing government, academia and industry, and is chaired by the Prime Minister.

MOCIE has responsibility for nuclear energy within the broad framework of its energy portfolio. The Ministry of Science and Technology (MOST) plays the role of scientific developer and safety regulator. The Korea Atomic Energy Research Institute (KAERI), under the auspices of MOST, is responsible for nuclear R&D.

The state utility, KEPCO, and its successor organisation KHNP are accountable to MOCIE.

Within the Ministry of Science and Technology, the Nuclear Safety Commission is responsible for safety regulation.

The Nuclear Safety Commission consists of from six to nine members appointed by the Minister of Science and Technology, who also acts as its chair.

Comprehensive Nuclear Energy Promotion Plan

The Atomic Energy Act stipulates that the Korean government must update the Comprehensive Nuclear Energy Promotion Plan (CNEPP) every five years, in order to promote the peaceful uses of nuclear energy and to secure nuclear safety. The first phase of the CNEPP was launched in 1997 and covered up to 2001; the second phase was launched in July 2001.

The CNEPP has four major policy goals:

- Provide a stable electricity supply by developing nuclear energy as the primary source of power generation.
- Achieve high-level technological capabilities in nuclear reactors and proliferation-resistant fuel cycle technology.
- Build the nuclear industry as one of the major export industries, promoting the private sector participation.
- Expand nuclear technology applications to medicine, agriculture and industry, and support basic nuclear research.

Security of Nuclear-Generated Electricity

No information is available on the investments made to support ongoing nuclear plant operations, but the data on plant availability indicate that high standards are evidently being achieved. Costs are met directly by KHNP.

KHNP procures uranium, mainly on the basis of diversified long-term supply contracts. It uses the uranium spot market for some commercial and operational purposes. Enrichment services are procured from the United States, Russia, the United Kingdom and France. KEPCO Nuclear Fuel Company (KNFC) produces all fuel.

Figure 24

Organisation of Governmental Responsibility for Nuclear Energy

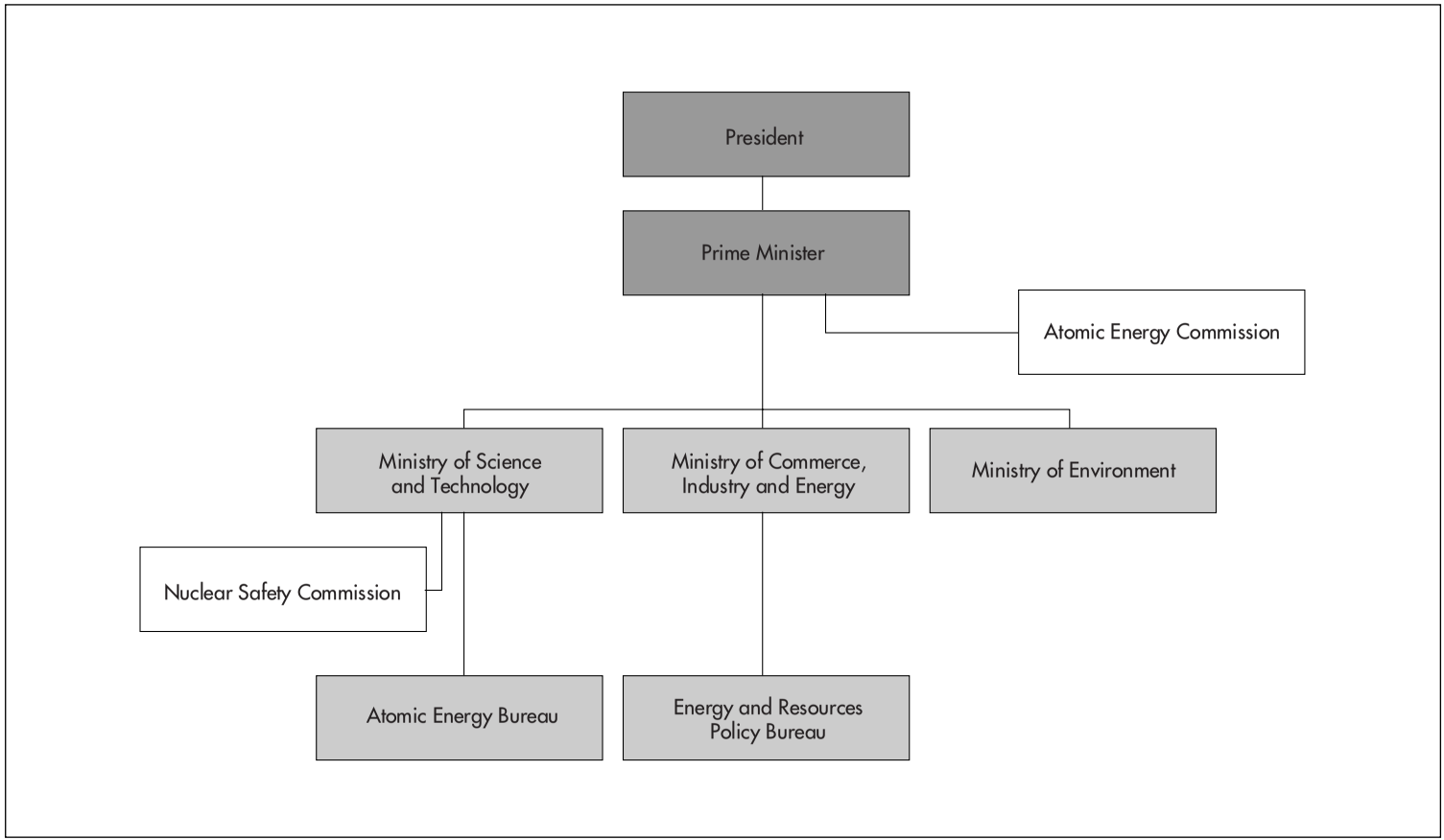
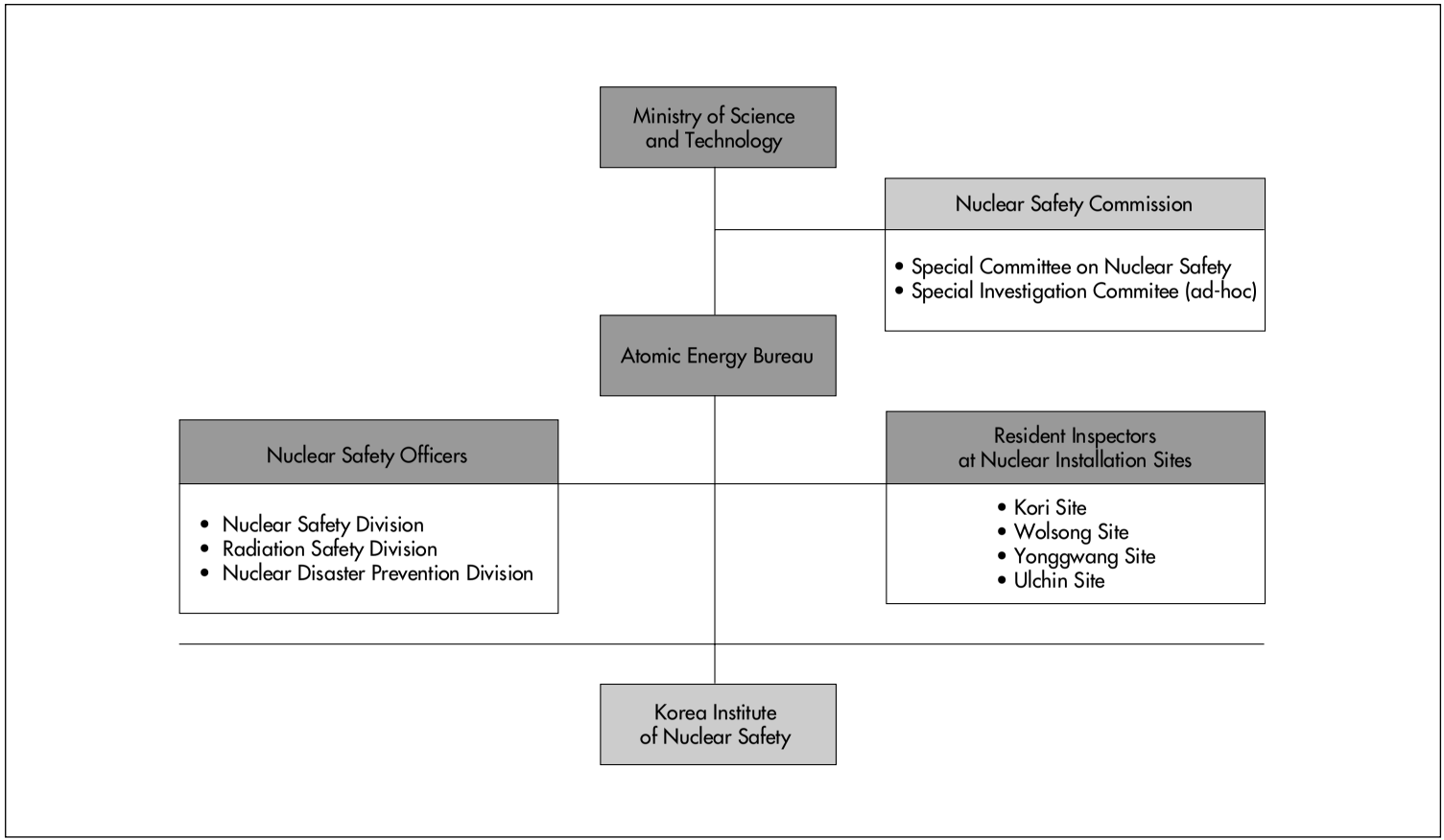


Figure 25
Organisation of Nuclear Safety Regulation



Nuclear Waste

MOCIE is responsible for nuclear waste management policy. Low- and medium-level nuclear waste and irradiated nuclear fuel are stored at nuclear plant sites. In 1998, the AEC approved a radioactive waste management plan that specifies the construction of a low- and intermediate-level radioactive waste repository by 2008. Spent fuels are to be stored at each nuclear power plant site until interim facilities are built in 2016. However, no local community has offered itself as a suitable storage site for low- and intermediate-level waste. There are currently no plans for the longer-term management of irradiated fuel. Storage capacity, which could be a heavy burden to electricity generation cost, is not currently saturated.

Nuclear Plant Decommissioning

The average age of Korean nuclear power plants is about eleven years. The oldest plant, a PWR at Kori, is 23 years old and will probably continue to be used after it reaches its initially-intended life span of 30 years. Current indications from elsewhere in the world show that it could remain operational for 60 years.

KAERI is conducting research on decommissioning. The generating company is responsible for decommissioning and for managing all radioactive waste. A provisions account was created in 1983 to meet the costs of the long-term liabilities involved.

Nuclear Power Development in Korea

Korea introduced nuclear energy in collaboration with major international vendors, including Westinghouse, Atomic Energy of Canada Limited, Combustion Engineering and Framatome. In accordance with national policy, independent design and construction have now been undertaken. Most recent plants have used the Korean Standard Nuclear Plant design (KSNP, based on the Combustion Engineering System 80 design). An Advanced PWR (APR-1400), formerly known as the Korean Next Generation Reactor (KNGR) with a 1,400 MW capacity, will be introduced starting with two units at Shin-Kori. Korea is also engaged in developing reactors, including KALIMER, the Korean liquid-metal reactor project.

Specific programmes to improve the performance of Korean nuclear plants, including the nuclear fuel cycle, do not exist.

KEDO, the Korean Peninsula Energy Development Organisation, contracted with KEPCO to provide two KSNP-design PWR units on a turnkey basis to North Korea.

Nuclear Education and Training

Korea has sufficient numbers of trained, qualified personnel to run its nuclear programme at present. However, as its programme continues to thrive, personnel shortages are expected to develop. Action has already been taken by MOST to set up intensive training courses to avoid future shortfalls of trained manpower.

CRITIQUE

The Korean electricity sector is in the early stages of a long process of restructuring, privatisation and liberalisation. In January 1999, the government released the Basic Plan for Restructuring the Electricity Industry in Korea, which proposed to introduce competition gradually in electricity generation and the retail supply of electricity.

The implementation of this plan has been delayed by at least one year. There have, however, been several important milestones in recent months. These include the privatisation of two district heating power plants in June 2000; the passage of necessary legislation in December 2000 and April 2001; the division of KEPCO generation into one nuclear-hydro company and five companies using fossil-fuel or pumped storage generation; and the launch of the cost-based power pool under the Korea Electric Power Exchange (KPX). The Electricity Committee will be in place shortly. The design of the wholesale pool market is to be completed within a few months.

The revised schedule is still far from certain, however. The terms and schedule for privatising generating companies, the date for launching the bid-based wholesale market, the date for the regulator to become independent of MOCIE, and the final timetable for liberalising the consumer market are still very unclear. In light of the rapid growth in demand for power and the difficulties in siting new plants, investors would like to see a clearer process and timetable.

Developing financial markets and mechanisms for electricity contracts would also enhance the security of electricity supply. The government must continue to monitor developments in these areas and be prepared to take further measures.

Successful market liberalisation must include removing price distortions for regulated prices. Currently, industrial consumers pay less on the whole than the total cost of electricity through cross-subsidies. Once the market is liberalised, they should cease to benefit in this way.

Similarly, transmission pricing should vary by location to reflect congestion costs and thereby encourage generators to locate their facilities closer to high-load areas. This would indirectly encourage the development of autoproduction and combined heat and power generation in an economically efficient way.

Current legislation defines no clear requirements for the regulator to become independent of MOCIE. The MOCIE minister will still have final authority over rates after review by the Electricity Committee. Given the past history of cross-subsidies, it is important to insulate rate-setting responsibility from short-term political pressure.

Structural Reform of KEPCO

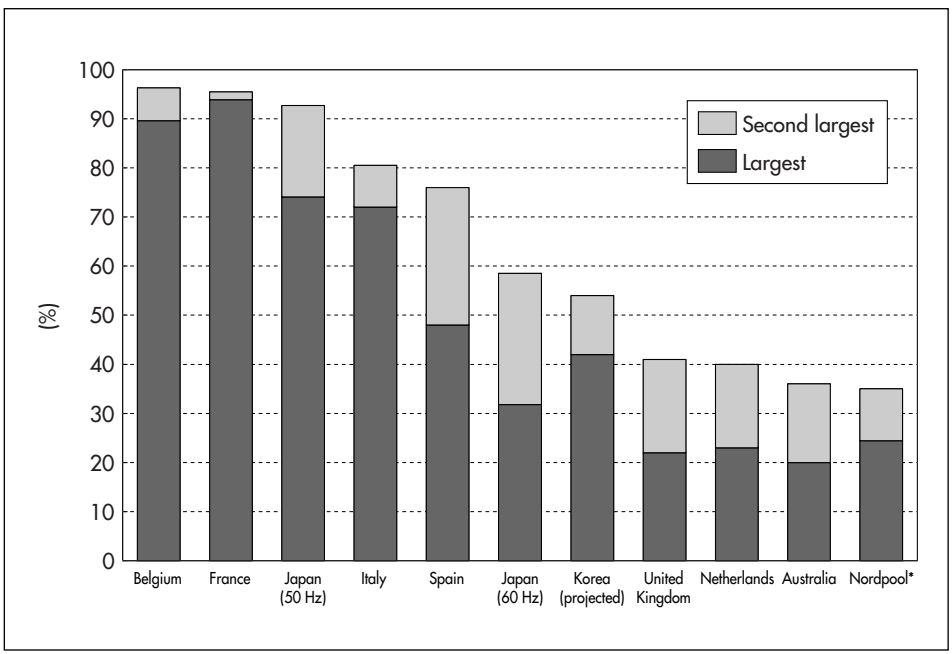
The creation of a structure to make workable competition possible is an important part of reform. Dividing KEPCO's fossil-fired generating assets into five companies of comparable size and geographical scope provides a very sound basis for competition among them once they are privatised.

The vagueness of the privatisation plans, however, remains a cause for concern. The delays to date also make it less clear whether all of these units will be fully privatised before the bid-based market is launched. Selling off only some generating subsidiaries would spawn concerns about whether the newly privatised entities can compete with those still in public ownership. Furthermore, the regulator will have to oversee KEPCO's transmission business carefully to ensure that there is no cross-subsidisation with its generating businesses.

The decision to create a separate independent market and system operator will help limit KEPCO's ability to discriminate in favour of its own facilities. The decision to allow market participants to hold some of its capital will increase confidence and reduce investor uncertainty about the fairness of the market's operation.

The relationship between the government and KHNP, its nuclear and hydropower business, will require special attention. The government's decision to create a single company providing 42% of the country's electricity could prove operationally advantageous for that generator, but the market will be more concentrated than in some other OECD countries (Figure 26). There is less concern that KHNP will be able to manipulate prices during peak hours because of its limited peakload

Figure 26
Market Share of the Two Largest Generators in Selected OECD Countries



* The Nordic Power Exchange.
Note: 1998 data. The United Kingdom market includes England and Wales only. The Japanese market is divided by transmission frequency. Australia includes Victoria, New South Wales, ACT and South Australia.
Sources: IEA and company annual reports.

capacity. Current projections foresee that the nuclear share in power generation will begin to increase by a few per cent. One way to deal with this would be for the nuclear generator and distributors to enter into a contract to cover some portion of the nuclear company's production to reduce the incentive to influence prices. Such an arrangement should provide KHNP with incentives for improving its efficiency.

The presence of KHNP could also have an impact on private investment in the electricity sector. The government's current intent is to have nuclear power find its place in the liberalised market, and have the nuclear company make its own decisions on plant expansion to meet additional baseload demand. Still, nuclear power development remains an important policy priority and has profound market implications. At the margin, the decisions taken by KHNP will affect investment decisions by the privately-owned generators. In planning nuclear power development, both KHNP and the government will clearly need to be transparent.

Entry and Exit

Given the importance of introducing competition, the licensing and permit system for new generators must be clear, neither excessively costly nor dilatory, and still meet public policy objectives. Similarly, the licensing and permit system for independent brokers and electricity retailers to enter the market should not be unnecessarily restrictive.

Transmission Access and Pricing

Non-discriminatory access to the transmission system is critical to the success of a competitive electricity market. The decision to separate KEPCO's transmission and distribution business from the major generators will reassure other generators that they are not being discriminated against. The choice of regulated third-party access to the transmission system for Korea reflects a growing consensus among IEA countries that regulated access provides the most transparent means of assuring non-discriminatory pricing and terms of transmission.

Transmission pricing has a number of objectives: to recover both sunk and operating costs for the network, to provide incentives to operate the network efficiently and to expand it appropriately, and to avoid price distortions. The proposed Korean transmission pricing plan would use a cost-of-service approach, with performance incentives to recover costs from customers, and "zonal" pricing differentiated by region to encourage the efficient location of generators. Some other reforming countries have adopted this same practice (see Table 19).

Transmission pricing will be regionally differentiated. The definition of transmission line usage will be used to calculate line costs on the basis of averages

Table 19
Comparison of Transmission Pricing in Selected IEA Electricity Markets

Country	*Regulation of Average Price*	*Pricing by Location*
Australia	Price cap (based on replacement cost)	Zonal
Finland	Rate of return	Zonal
KOREA	Rate of return/incentive	Zonal
Netherlands	Price cap	Postage stamp
New Zealand	Revenue cap (based on replacement cost)	Nodal
Norway	Price cap	Postage stamp (differentiated by region)
Spain	Price cap	Postage stamp
Sweden	Rate of return	Postage stamp (differentiated by region)
United Kingdom (England and Wales)	Price cap	Postage stamp (+ zonal capacity charges on generators)
United States (PJM Interconnection Association)	Rate of return	Nodal

of MWs transmitted over the line during an assessment period (the peak-load period when electricity consumption is concentrated).

Transmission prices will be determined on the basis of total cost of service, where the transmission company's total costs (depreciation expenses, operation expenses, return on assets, etc.) are appropriately allocated to transmission network users. This method is easy to apply and guarantees the recovery of transmission costs but lacks incentives for the company to minimise costs. Therefore, performance-based incentive regulation will be used.

Regionally-differentiated zonal transmission rates will provide an economic signal in the siting of power plants. Generators located in zones where generation exceeds loads will pay higher charges than those in zones where loads exceed generation. The converse will be true for zonal transmission charges on loads. This will provide an incentive to build power plants near Seoul, where the largest loads are concentrated, and reduce the need to invest in new transmission lines.

Transmission price includes congestion costs and losses that the system operator (Korea Power Exchange) levies equally on all customers. Both KPX and KEPCO will

be responsible for managing congestion losses, giving customers price signals to encourage efficient investment in transmission.

Regulation of Distributors

The economic regulation of the distribution business will include regulating both the distribution network and the retail supply business to captive customers. The government's stated intention to move away from cost-of-service regulation to an incentive system such as price caps is a good one.

For the vast majority of customers, however, the more important regulatory role will be to ensure that the distributor purchases electricity for its customers in a cost-effective manner. If the government can successfully create a competitive generation market, market prices for generated electricity will be a good indicator for comparing the cost of electricity purchased by the firms.

As these retail supply businesses begin to compete with one another, avoiding discrimination by the distributor in favour of the affiliated suppliers will become an important regulatory issue. Operating completely separate distribution and supply businesses could increase public confidence in the fairness of the market, a benefit that would outweigh the increased administrative costs of separation.

Cost-Reflective Pricing

The government has acknowledged that electricity prices do not reflect costs in several ways. The government's acceptance of low dividends means that prices have been somewhat lower than they would have been if ordinary private shareholders had owned the company. Electricity price distortions favour agricultural and industrial customers at the expense of commercial and residential customers. The government has already raised rates to industrial consumers in an attempt to redress this particular distortion, although commercial consumers still appear to be paying a larger share than others. The government has also indicated its intention to provide "postage-stamp" transmission pricing (electricity costs the same wherever the customer lives), even though there is a pronounced difference in the cost of supplying the Seoul area and other regions of the country.

Many industrial consumers will be in a position to benefit from market prices in the near future. Once an industrial customer has been liberalised, there is no longer a need to offer it a regulated rate.

Time-of-Use Pricing

Coming growth in commercial and residential demand can be expected to lead to much sharper peaks in daytime demand. The recently introduced time-of-use electricity pricing is already having a perversely large effect of shifting peak demand to 11 p.m. While the system obviously needs further adjustment, the results demonstrate the value of pricing for encouraging a higher load factor and a more economical system.

Liberalisation of Electricity Consumers

Liberalising electricity consumers is expected to create additional economic efficiency by requiring the electricity market to offer competitively priced services to meet individual consumer needs.

The government has developed a proposal for liberalising the situation of customers over a six-year period beginning in 2003. Several countries have adopted such a phased approach. The main open question is whether Korea is moving quickly enough to full retail competition. While the experience with full retail competition in OECD countries is still limited, it is quickly becoming more common. In 2001, the retail electricity supply was fully liberalised in Austria, Germany, Norway, Sweden, Finland, the United Kingdom, some Canadian provinces and several states in the United States. Within the next few years, full liberalisation is expected in several states in Australia, in Belgium, Denmark, New Zealand, the Netherlands, Spain and Switzerland.

By the time Korea has finished restructuring it, KEPCO will be able to benefit from others' experience with full retail liberalisation. The first priority should be to announce a firm timetable for liberalising the larger consumers. For smaller consumers, the government should carefully study the experience with full retail liberalisation elsewhere, and the experience with larger consumers in Korea. The date for full liberalisation should be advanced if feasible.

Security of Supply

The government intends to continue to co-ordinate the development of new generating capacity in Korea, although how it will do so has not been made explicit. Continuing the role of co-ordinator reflects a concern over the security of the long-term electricity supply. Will the electricity market build sufficient capacity to meet the needs of an expanding economy? What role, if any, should the government play in ensuring the security of supply?

The electricity market mechanism will help to ensure reliability in the short run. Whenever available supplies closely match demand, prices will respond by rising. The price rise will be mitigated by the willingness of some customers to reduce their electricity demand, much as customers under interruptible contracts do today. The inclusion of demand-side bidding in the market, as is currently planned, will also help. At other times, when available supply greatly exceeds demand, market prices could be expected to fall.

Concerns have been expressed in some electricity markets that uncertainty about future prices for electricity could discourage investment. The power outages in California in early 2001 fuelled these concerns. Other liberalised markets have not replicated the failure in California. A study of those markets shows that adequate investment and security of supply can be obtained in liberalised markets, but that policies and regulations play a key role. A key task for governments is to ensure that policies and regulations provide an adequate framework for investment. This

requires minimising price distortions and regulatory risk, and providing an efficient administrative process for authorisations.

In Korea, there are some reasons to be hopeful about attracting adequate investment. First, the government is taking several steps to make investment in the power sector more attractive, particularly by restructuring KEPCO, creating a competitive electricity market and setting up an independent regulator. Second, the government has taken a number of steps to make Korea more open to foreign investment in all energy sectors. Third, and just as important, expected strong growth in electricity demand makes the sector that much more attractive for investment.

Another element that could be included in the reform to enhance security of supply is to give consumers and suppliers some responsibility for security. Liberalised electricity customers could be asked to pay more for a firm guarantee of supply from their supplier. The supplier could be held liable for delivery failures. The premium customers who were willing to pay for security of supply would help finance the necessary investments. The development of financial instruments, such as electricity futures contracts, would help investors to hedge against such risks.

Given the potential system-wide effects of a generator's failing to deliver, the electricity system and market operator (KPX) must play two complementary roles. As system operator, KPX will be responsible for mitigating the impact of a failure to deliver. As market operator, KPX must ensure that a non-performing supplier can be held liable for increased system costs, caused by his non-performance.

The government's main task will be to monitor market development and assess the adequacy of expanded generation facilities. If problems emerge, the government may need to consider further measures to encourage market participants to invest in generation.

Of course, as the owner of the nuclear generating assets and the transmission assets of KEPCO, the government itself will continue to be a market participant for the foreseeable future. The investment plans of KHNP will play an important role; the company's investments must meet the test of the market rather than be motivated simply by the desire to ensure an adequate generation supply.

Nuclear Energy

The Korean nuclear energy programme has been very successful. It has high capacity and an excellent safety record, and produces electricity at competitive cost. By enhancing energy security and diversity and reducing overall emissions from the power generation sector, it plays an important part in meeting national energy policy objectives. It has also resulted in builders of nuclear plants being able to supply nearly all the needs of the nuclear generator.

Public acceptance of nuclear energy is problematic in Korea, as in many other countries. Gaining public support for national policies will require education,

consultation and inducement and using the best practices available both nationally and internationally.

Nuclear power plant operation is focused in the domestic market; the supply of supporting goods and services is not competitive. Local monopolies supply most nuclear fuel cycle services, plant design, equipment, and maintenance support. Operating costs could be trimmed if the practice were adopted (as in other OECD countries), of exposing supporting materials and services to a more competitive environment. Some Korean suppliers could potentially compete internationally.

Extending plant life has a great economic potential in Korea. Providing electricity for 20 years at the marginal cost of nuclear generation would significantly reduce market prices.

The future of Korea's nuclear programme need not be constrained at this time by the absence of a disposal facility for radioactive wastes, because interim storage capacity would safely meet foreseeable needs. The sector would benefit if the country's research and development effort went beyond developing a reactor and managing the nuclear reaction to encompass total management of the fuel chain. It would also be appropriate to establish plans soon to address public concerns on this matter, since opposition to the construction of more storage may arise later in the decade.

The present arrangement, in which a provision is included in company accounts for meeting the cost of long-term liabilities (such as decommissioning) has been acceptable for a state-owned monopoly. Within the framework of a smaller company (KHNP) and with the prospect of privatisation in the longer term, however, this arrangement needs to be reconsidered.

Korea's economic and social dependence on nuclear energy increases the sector's responsibilities to ensure the population's protection. Safety management is a major issue. Whilst the nuclear safety regulator of Korea is independent of the energy policy-maker and operator, it would be better to make the regulator even more independent of political influences.

RECOMMENDATIONS

The Government of Korea should:

Electricity

- ☐ Set and adhere to a firm timetable for liberalising the market, establishing an independent regulator, and privatising the generating companies.

☐ In reforming the sector, take the following steps to enhance the security of electricity supply:
  - proceed with the plan to introduce a competitive, bid-based electricity market, including demand-side bidding with regulatory oversight;
  - ensure appropriate financial mechanisms for the electricity market so that suppliers are sure to meet their contractual obligations;
  - consider developing financial instruments, such as electricity futures contracts, to enable potential investors to hedge against market risks;
  - monitor the development of competition carefully and, if necessary, consider further measures to encourage market participants to invest in generation.

☐ Include regulatory incentives to distribution companies, including least-cost procurement of energy, to make them more efficient.

☐ Eliminate price distortions favouring industrial customers; eliminating regulated energy tariffs to liberalised industrial customers can facilitate this.

☐ Consider pricing transmission services by location.

☐ Ensure that electricity tariffs fully reflect time-of-use costs for generation.

Nuclear Energy

☐ At least maintain past standards of performance and safety of nuclear plants in the future; regularly assess the rationale for the target size of the nuclear energy component in the overall energy mix.

☐ Establish construction plans for Korea's future nuclear power plants early in the newly competitive electricity market, well in advance of the lead-times for building other types of plants.

☐ Pursue efforts to gain public acceptance of the future deployment of nuclear energy; increase active participation in OECD/NEA studies and workshops in this area.

☐ Make greater use of the international market for goods and materials for operating nuclear plants.

☐ Allocate more resources to research and development on nuclear waste management.

☐ Continue with plans to establish a disposal site for low- and medium-activity nuclear waste and formulate plans for disposing of irradiated nuclear fuel.

8

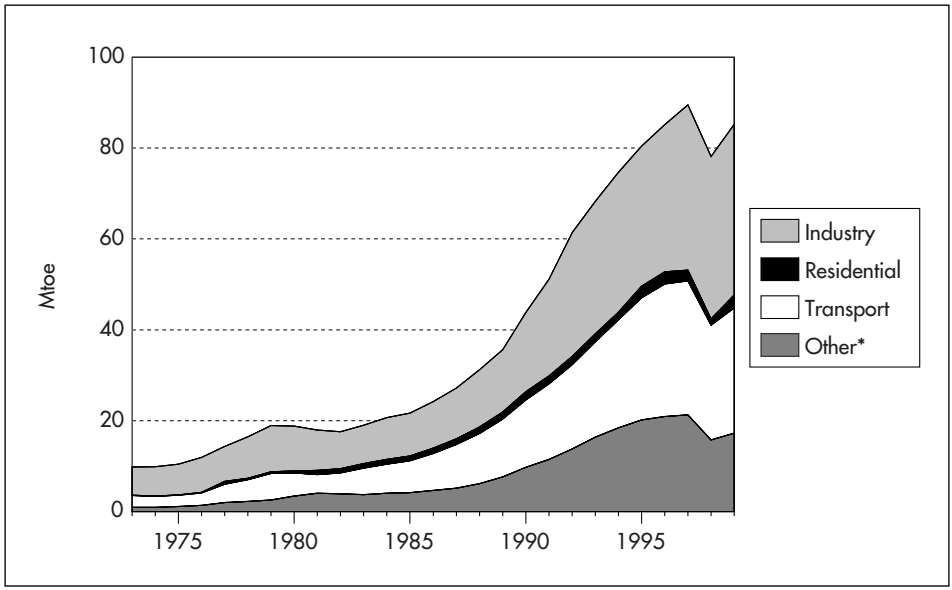
OIL

OIL DEMAND

Oil accounted for 55% (100 Mtoe) of Korea's total primary energy supply in 1999, down from 64% in 1974 because of energy diversification. Korea is the world's sixth largest oil consumer and fourth largest oil importer. Korea has no domestic oil reserves and therefore imports all its crude oil. In 1999, it imported 120 Mt of crude, three-quarters of it from the Middle East. It relied completely on Middle Eastern oil in 1980. External oil dependency then decreased to 57% in 1985 before increasing again in the 1990s to the current level. Diversifying the sources of supply remains an important policy objective. In 1999 Korea imported some 20 Mtoe of oil products, of which naphtha accounted for 12 Mt.[8] Korea exports oil products, mostly sulphur-rich diesel and fuel oil, which amounted to some 40 Mt.

Petroleum products accounted for 68% of total final consumption in 1999, which is much higher than the OECD average of 53%, because of the large size of Korea's chemical industry. The industry sector consumed some 40% of oil products; the

Figure 27
Final Consumption of Oil by Sector, 1973 to 1999



* Includes commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

8. Though naphtha is an energy product, its importance as a feedstock for the Korean petrochemical industry leads Korean authorities not to perceive or count it as such.

Table 20
Oil Imports (estimates for 2000; thousand metric tonnes)

	Crude Oil	*Motor Gasoline*	*Kerosene*	*Gas/ Diesel Oil*	*Fuel Oil*	*Other*	*Total (Crude Oil and Products)*
Saudi Arabia	36,351	–	78	–	–	5,646	42,075
Islamic Republic of Iran	11,536	–	–	–	–	612	12,148
United Arab Emirates	17,617	–	182	–	–	2,938	20,737
Kuwait	8,495	–	170	–	–	2,909	11,574
Indonesia	4,794	–	–	–	2,674	236	7,704
Oman	7,233	–	–	–	–	–	7,233
Qatar	6,187	–	20	–	–	788	6,995
Other	29,627	85	549	389	1,087	5,800	37,537
Total Imports	**121,840**	**85**	**999**	**389**	**3,761**	**18,929**	**146,003**

Source: *Oil Information*, IEA

chemical industry took more than 70% of that (or some 30% of total final consumption of oil products). Consumption by the transport sector is increasing fast, accounting for 24% of total final consumption of oil products.

MOCIE forecasts growth in oil product demand from 95 Mt in 2000 to 123 Mt by 2010, with an increase of 3% per annum (Table 21).

Table 21
Projection of Oil Product Demand (thousand metric tonne equivalent)

	1999	*2000*	*2005*	*2010*	*Rate of Increase (%)*			
					2000	*00-05*	*06-10*	*00-10*
Total	88,273	94,851	110,919	122,542	7.1	3.9	2.0	3.0
Gasoline	7,489	7,984	9,930	11,278	6.6	4.8	2.6	3.8
Other kerosene	9,939	10,795	13,314	15,123	8.6	5.0	2.6	3.9
Gas diesel oil	16,900	18,056	20,845	22,775	6.8	3.6	1.8	2.7
Distillate fuel oil	424	468	443	477	10.4	0.7	1.5	1.1
Low sulphur fuel oil	227	224	414	447	1.5	10.5	1.5	6.4
High sulphur fuel oil	17,458	19,619	23,401	25,616	12.4	5.0	1.8	3.5
Aviation gasoline	2,064	2,229	2,854	3,667	8.0	5.5	5.1	5.4
Naphtha	25,754	26,991	29,235	31,400	4.8	2.1	1.4	1.8
White spirit	92	113	135	148	22.5	6.6	1.8	4.4
LPG	6,639	6,959	8,640	9,733	4.8	4.6	2.3	3.5
Bitumen	1,287	1,413	1,658	1,723	9.8	4.3	0.8	2.7

Source: MOCIE.

THE OIL INDUSTRY

The state enterprise KNOC engages in exploration, development and production of oil and natural gas, and builds and maintains Korea's strategic oil stocks. But private companies dominate the Korean oil market. The major oil companies are SK Corp. (formerly Yukong), LG-Caltex (formerly Honam), S-Oil (formerly Ssangyong Oil) and Hyundai Oil. SK Corp. is 100% Korean-owned. Caltex owns a 50% stake of LG-Caltex. In 1999, Hyundai sold 50% of its interest in its refining operation to International Petroleum Investment Corporation of the UAE. S-Oil is 35% owned by Saudi Aramco. DOPCO (Daehan Oil Pipeline Corporation), which delivers oil products via pipeline to the Seoul metropolitan area, was privatised in 2000. The Korean government sold DOPCO's public shares to major refineries.

Table 22
Major Korean Oil Companies

SK Corporation

Founded in 1962, SK Corp. was Korea's first oil refining company. In subsequent years, it has continued to grow and develop in line with the Korean economy. SK Corp. has a daily production capacity of 810,000 barrels and operates a nation-wide network of 3,670 gas stations. After restructuring to enhance competitiveness, SK Corp. has become the leading oil refiner in Korea, with a 33.8% share of the domestic market.

LG-Caltex Oil Corporation

Since the Yosu complex was built in 1969 with an initial capacity of 60,000 barrels per day (b/d), LG-Caltex has increased its daily processing capacity to 650,000 b/d. LG-Caltex has also upgraded facilities, establishing the world's largest Residue Fluid Catalytic Cracking Unit (RFCCU) with a capacity of 70,000 b/d. This was followed by a succession of key investments, such as the gas oil hydro-sulphurising (GO-HDS) and whole cracked naphtha hydro-desulphurising (WCN-HDS) facilities.

Inchon Oil Refinery Co., Ltd.

The initial processing capacity of Inchon Oil was 60,000 b/d. In 1992, to meet increasing domestic demand, Inchon Oil completed construction of a second crude distillation unit, which expanded processing capacity to 275,000 b/d. Built in 1997, the HDS facility desulphurs 50,000 barrels of kerosene and diesel per day. This facility enables Inchon Oil to cope with domestic environment guidelines flexibly.

S-Oil Corporation

S-Oil has a refining capacity of 525,000 barrels per day. It completed the Bunker-C Cracking Center in 1997. The center is composed of a vacuum distillation unit (135,000 b/d), a hydrocracker (65,000 b/d), a vacuum residue hydro-desulphurisation unit (43,000 b/d), a middle hydrocracker (35,000 b/d), a residue FCC unit (65,000 b/d), and many other refining plants.

Hyundai Oil Refinery Co., Ltd.

In 1989, Hyundai Oil built a refinery at Daesan, which could process 110,000 barrels of crude oil per day to meet the growing demand. For the first time in Korea, a refinery introduced upgrading facilities, such as a hydrocracker and delayed coker. With these, Hyundai Oil helped to resolve the imbalance in the supply of light and heavy oil products and preserve the environment by minimising sulphur content. With the completion of an additional refinery at Daesan in 1996, Hyundai Oil tripled its refining capacity from 110,000 barrels to 310,000 barrels of crude oil per day.

Exploration and Production

Korean overseas petroleum development projects were launched after the two oil shocks. Since 1980, 26 Korean companies have participated in 93 overseas projects in 35 countries. Currently, a total of 56 overseas exploration and production projects are in progress in 21 countries. As of the end of June 1999, Korean companies had invested $2.7 billion in overseas E&P projects. The Korea National Oil Corporation (KNOC) invested $656 million, of which 30% was government-funded. The private corporations invested $2 billion. The return has amounted to some 70% of the total amount invested. With these projects, Korea had developed a 620 million barrel capacity as of the end of June 1999.

Exploration has also taken place on Korean territory. An offshore oil exploration project was begun in 1969. Over 20 offshore wells have been drilled to date, although no oil has yet been found. However, gas reserves were found at the Gorac site on the southeast coast in l998.

Oil and gas exploration and development in Korea and offshore are carried out under concessions issued by MOCIE. Concession contracts define conditions such as exploration and production periods. They also cover economic terms such as the environmental protection charge (refundable guarantee), and corporate tax. There are no restrictions on who can participate in exploration. To date, however, the government has only released exploration acreage to KNOC, which can seek other Korean or overseas partners if they wish. Partners joining a project do so on the basis of a production-sharing agreement.

Refining

In the past, for security reasons, the Korean government has tried to maintain refinery capacity at 30% over domestic petroleum demand. In line with these policies, domestic oil refiners have expanded. Korean refineries have a high capacity use factor.

The Korean refining sector expanded its crude distillation capacity largely in the mid-1990s. In October 1998, restrictions on new construction and expansion of refining facilities were abolished. Simultaneously, foreigners were allowed to invest in refining businesses. By the end of 1999, the combined official crude refinery capacity of the nation's five oil refineries stood at 2.4 million b/d, the world's fifth largest refining capacity that year. The relatively young Korean refining industry has not yet amortised its investment, but it operates very efficiently and is very competitive internationally. Its capacity can be easily augmented by "de-bottlenecking". The nation's actual crude distillation capacity is estimated to surpass official capacity slightly, as some oil refiners have already de-bottlenecked their refining facilities.

Domestic oil refiners are also equipped with secondary facilities, which include heavy oil cracking facilities (247,000 b/d), heavy oil desulphurising facilities

(145,000 b/d), naphtha reforming facilities (187,400 b/d) and kerosene-diesel desulphurising facilities (658,500 b/d). Domestic oil refiners intend to construct new heavy oil cracking facilities (hydrocrackers) totalling 90,000 b/d and heavy oil desulphurising facilities 130,000 b/d.

As environmental regulations become more stringent both at home[9] and abroad, switching of fuels from oil to gas is expected to occur mostly in power generation, reducing the demand for bunker-C oil, while increasing the demand for low-sulphur fuels. As demand for high-sulphur heavy oil is forecast to be stable or to decrease slowly, domestic oil refineries will have to expand their heavy oil cracking and desulphurising facilities to fit the changing pattern of demand for oil products.

Deregulation and the economic crisis that began in 1997 have accelerated industry restructuring. Four domestic oil refiners including SK, LG-Caltex, Hanwha Energy (currently Inchon Oil Refinery) and Hyundai Oil Refinery have merged their many direct sales agents into four petroleum sales firms, and Ssangyong Oil Refining (currently S-Oil Corporation) has brought its direct sales agents under its headquarters.

Distribution and Storage

The bulk of oil and petroleum products are imported through five main ports: Ulsan, Onsan, Daesan, Yosu and Inchon. Imported and refined petroleum products are distributed to storage facilities near major consuming areas by barge, rail, tank car, and pipeline (see Table 23). The products are then delivered through marketing channels from storage facilities. Korea has no crude oil pipelines.

Table 23
Petroleum Product Pipelines in Korea

Pipeline	*Length (in km)*	*Diameter (in inches)*	*Daily Capacity (in tonnes)*
Ulsan-Taegu	101	12	8,000
Daesan-Chonan	93	12	10,300
Inchon-Koyang	31	14	9,000
Inchon-Kimpo	24	12	8,000
Yochon-Sungnam	461	10-12	31,300
Onsan-Sungnam	439	18-24	46,000

Source: MOCIE.

9. In July 2001, the maximum sulphur content permitted in heavy fuel oil decreased from 0.5% to 0.3%.

Trade

Korea has become one of the major exporters of petroleum products in Asia. After refinery capacity was expanded in 1995 and 1996, product exports began rising very sharply.

Exports of products jumped from 257,300 b/d in 1994 to 812,600 b/d in 1998. Exports of refined products increased slightly in 1999, by 0.4%, as a result of the faster-than-expected recovery of domestic oil consumption. Diesel and high-sulphur bunker-C oil were among the major export items. In l999 they accounted for 57.2% of the nation's total exports of petroleum products.

After refinery capacity expansion projects were completed in 1996, imports of petroleum products began to slow. They were up 2.9% in 1996 and fell by 17.9% in 1997. In 1998, imports fell by a further 5.4%, reflecting the Asian financial crisis. They increased by 11% in 2000, stimulated by the economic recovery, together with the growing domestic demand for petroleum products. The share of imported products in the nation's overall petroleum consumption fell from 32% in 1996 to 26.6% in 1999. Since the beginning of 1999, imports of low-sulphur bunker-C oil have increased sharply to meet growing demand for environmental reasons.

Liberalisation of the Oil Market

The Korean government has relaxed its controls over the petroleum industry since 1995, as shown below.

Distance Limits on the Operation of Service Stations

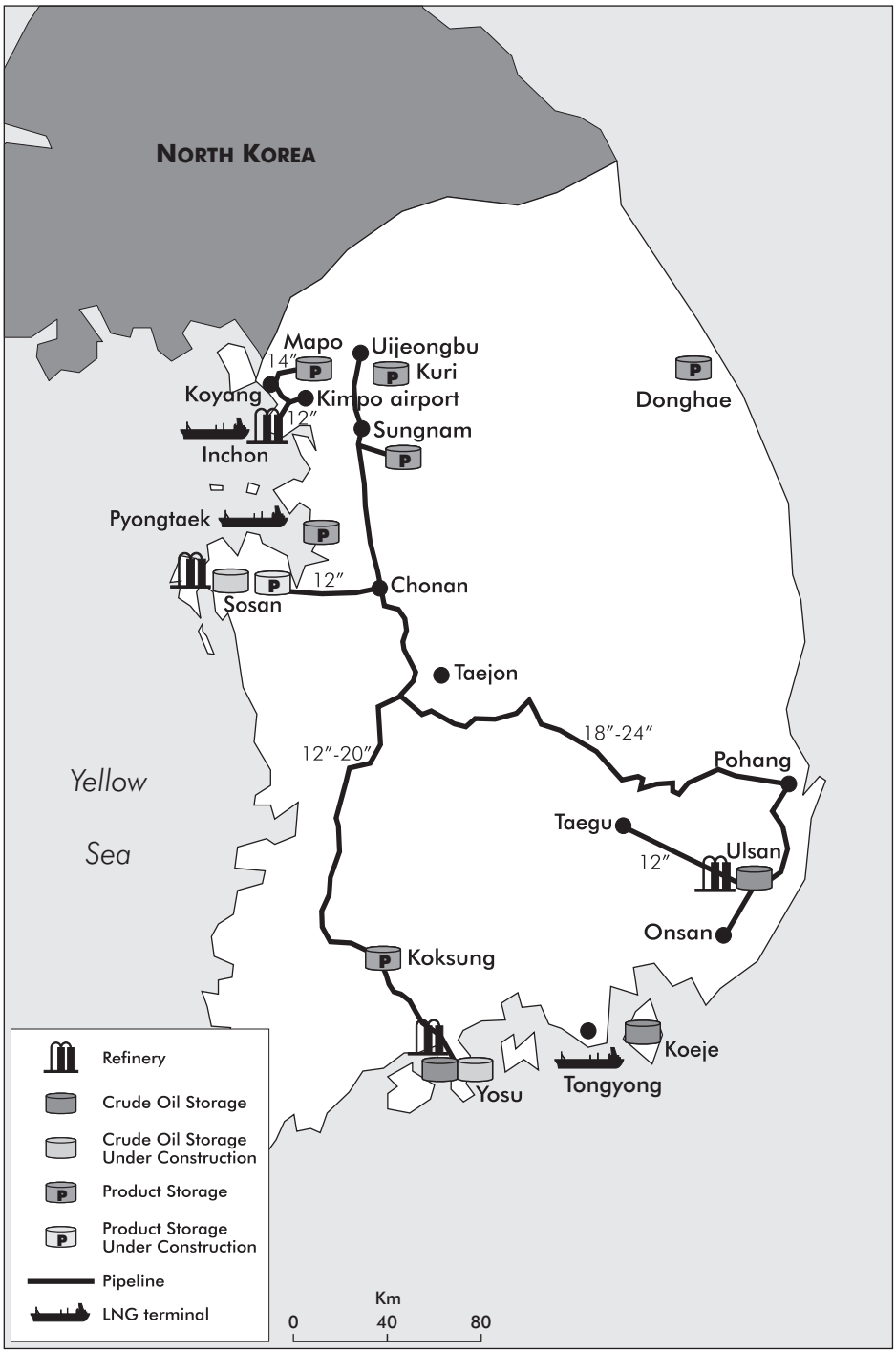
The regulation prohibiting the operation of service stations within a specified distance of each other was abolished in 1995.

Abolition of Government Price-setting for Petroleum Products

Under the Petroleum Price Fluctuating System, the government determined prices for certain petroleum products on the basis of average costs calculated with cost data from domestic refineries. The products covered by this mechanism were reduced gradually. Jet and solvent prices were deregulated in 1983, followed by asphalt in 1988, premium gasoline and naphtha in 1989, and regular gasoline and kerosene in 1991. A price-setting mechanism was reintroduced for gasoline and kerosene in 1994. But in January 1997, all petroleum product price controls were lifted.

Prices for all petroleum products are now determined by the market, but they include a 5% tariff on crude oil imports, and a 7% tariff on imported petroleum products. A transportation tax or special excise tax is levied on the consumption of petroleum products. Surcharges are also charged on imports and sales of petroleum products to finance the Energy Project Special Account.

Figure 28
Map of the Korean Oil Infrastructure



Liberalisation of Export-Import Business of Petroleum Products

Until 1997 when the requirement was abolished, all traders were required under the Petroleum Business Act to have government permission to trade in petroleum products, in order to avoid over-dependence on Middle Eastern oil by a particular importer. Approvals were, in practice, rarely refused.

Opening the Retail Petroleum Product Business to Foreigners

As of January 1997, the regulation on marketing petroleum products was liberalised. In May 1998, the retail business was opened to foreigners. Domestic and foreign firms could enter the oil refining business. Clearance procedures that had been mandatory for new construction and expansion projects of refining facilities were streamlined.

Deregulation in Retail Business

In early 1998, direct transactions became possible between oil refiners and service stations; previously, service stations had to purchase products through traders.

EMERGENCY PREPAREDNESS

Korea's emergency reserves consist of both government and industry stocks. The Korea National Oil Corporation (KNOC) Act established KNOC and made it responsible for maintaining government stocks. Under the Petroleum Business Act, the Minister of Commerce, Industry and Energy sets the amount of oil to be stored by oil companies doing business in Korea. Under its current Third Stockpiling Plan, the Korean government intends to increase the share of government oil stocks.[10]

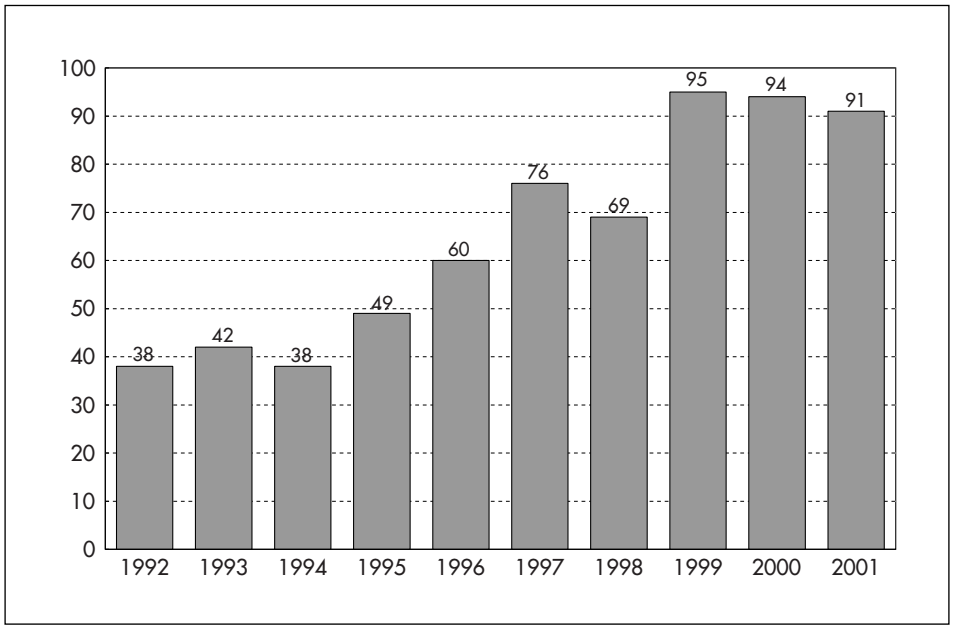
IEA statistics indicate that Korea met the IEA requirement for stocks equal to 90 days of net imports throughout the second half of 2000. The latest IEA data show a total stock level of around 92 days as of January 2001.

CRITIQUE

The Korean government forecasts average growth in oil demand of 3.5% per annum over the next decade. This is not as fast as in the past, but is still high compared with most IEA countries. The share of oil in primary energy supply is still large, although it has been lowered by diversification. Ensuring a stable oil supply

10. KNOC also developed an original way of filling its storage capacity. In june 1999, KNOC and Statoil agreed to store 8 million barrels of Norwegian crude oil owned by Statoil at oil storage terminals owned by KNOC and leased to Statoil. This represents four days of net imports for Korea and counts towards Korea's IEA stock-building obligation.

Figure 29
Emergency Oil Reserves, 1992 to 2001
(days of net imports coverage, as of 1 July every year)



remains a key energy policy objective. Korea has been actively exploring for oil both in traditional producing countries and on its own territory. Such efforts should continue. Oil will remain the major fuel in Korea's primary energy supply for the foreseeable future owing to the large chemical industry and increased demand in the transport sector. It therefore remains important to diversify Korea's supply sources and to maintain good relations with the oil producers.

It is commendable that many oil sector regulations have been lifted. This has stimulated industry restructuring and increased efficiency. A new concern has arisen that certain companies now have considerable market influence, and may, for example, control prices to their advantage. It is important that the competition authority monitor the market closely to ensure fair competition.

Korea must cover oil demand entirely with imports. Given its continuing high dependence on oil from the Middle East, Korea is highly vulnerable to disruptions of its oil supply and oil security is, therefore, an important element in the overall energy policy.

There will be temporary fluctuations below its 90-days requirement, caused by growth or seasonal changes in demand during the next few years. Increasing government oil stocks will lessen this problem. The Korean government's commitment to increase its stocks is encouraging.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Continue efforts to develop domestic and overseas investment in upstream activity; ensure that exploration projects are economically viable.
- ☐ Continue efforts to diversify oil supply sources; maintain good relations with oil-producing countries.
- ☐ Ensure effective competition in the domestic oil market; strengthen market monitoring to prevent unfair pricing by large companies.
- ☐ Continue efforts to ensure the immediate implementation of the Third Stockpiling Plan in order to enlarge the emergency oil stockpile.

9

GAS

GAS DEMAND

Korea is the world's second largest importer of liquefied natural gas, and the world's seventh largest importer of natural gas (piped gas and LNG). Its entire demand for natural gas is currently met through LNG imports. Gas use grew sharply in the 1990s, increasing its share in TPES from 3% in 1990 to 9% in 2000, when 19 bcm were consumed.

The residential heating sector accounted for almost 40% of the total gas demand in 1999, followed by electricity generation (23%), industry (14%) and commercial and public services (10%). Public combined heat and power plants accounted for 15% of gas consumption. Twenty city-gas companies supply gas to 7.2 million homes nation-wide, but the number of companies is decreasing because of a consolidation movement that is currently under way.

Since heat is a large component of gas use, gas consumption is subject to large seasonal fluctuations. The average monthly peak demand in winter is two-and-a-half times higher than the monthly average in summer.

Wholesale natural gas is sold in Korea at prices approved by the Minister of Commerce, Industry and Energy in consultation with the Minister of Finance and Economy. The tariff is composed of the import cost of LNG and the cost of supply services (including re-gasification, storage and transmission), which varies by location, reflecting different infrastructure costs. The price of wholesale gas is relatively lower in the Seoul area, where the gas infrastructure has been amortised.

GAS SUPPLY

The Korea Gas Corporation (KOGAS), the state-owned monopoly LNG importer, was created in 1983, and LNG was introduced in Korea in 1986. Import volumes have increased steadily and KOGAS is now the world's largest LNG importer. Now partly privatised, KOGAS manages import, storage, transmission and wholesale distribution of LNG in Korea.

In 1998, Korea imported most of its LNG from Indonesia (65%) and Malaysia (25%), with smaller volumes from Brunei, and the United Arab Emirates. Imports from Qatar (Ras Laffan LNG) began in 1999 and from Oman in 2000. The pattern of external dependency is therefore changing. Dependency upon Middle Eastern suppliers is growing: they provided 35% of total LNG imports in 2000 compared to 4% two years earlier.

Korea has contracted to purchase nearly 17 million tonnes of LNG under seven long-term contracts (see Table 24). The contracts are very rigid, have long lives and take-or-pay clauses. Korea also imports spot volumes to cover its winter peak demand. Spot LNG sales amounted to 18 cargoes in the winter of 2000-2001.

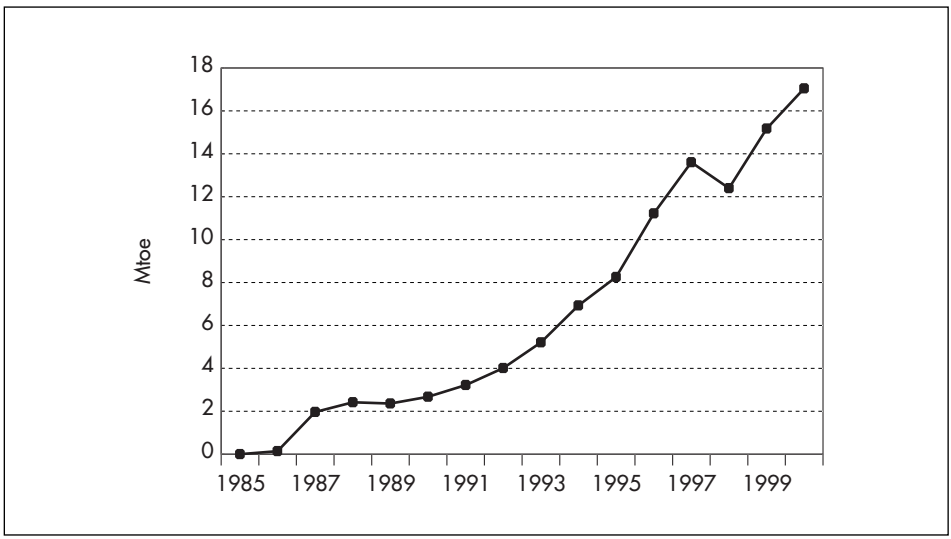
Table 24
Existing Long-term LNG Contracts

Source	*Project Name*	*Amount (million tonnes/year)*	*Agreement Period*
Indonesia	Arun III	2.3	Dec. 1986 – Nov. 2007
Indonesia	Korea II	2	Jul. 1994 – Jun 2014
Indonesia	Badak V	1	Jan. 1998 – Dec 2017
Malaysia	MLNG II	2	Jun 1995 – Mar 2015
Qatar	Ras laffan	4.8	Aug 1999 – Dec. 2024
Oman	OLNG	4.06	Feb. 2000 – Dec. 2024
Brunei	BLNG	0.7	Apr. 1997 – Mar. 2013

Source: KOGAS.

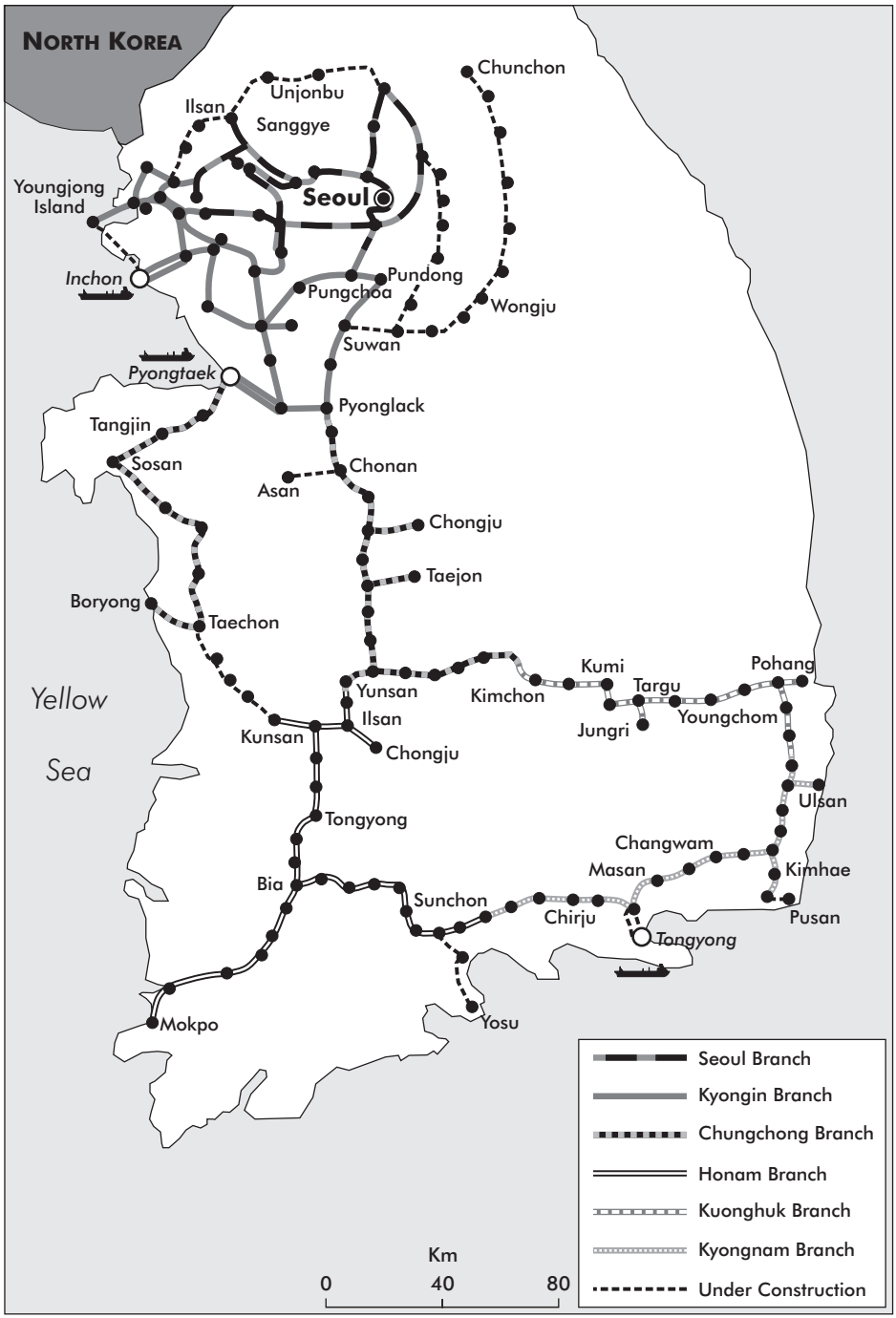
Security of supply came into question last year when Exxon-Mobil's LNG complex in North Aceh, Indonesia, was forced to stop production from March to September for security reasons. The shut-down had some direct short-term impact on the stability of the natural gas supply in Korea, as Exxon-Mobil had contracted to provide

Figure 30
Natural Gas Net Imports, 1985 to 2000



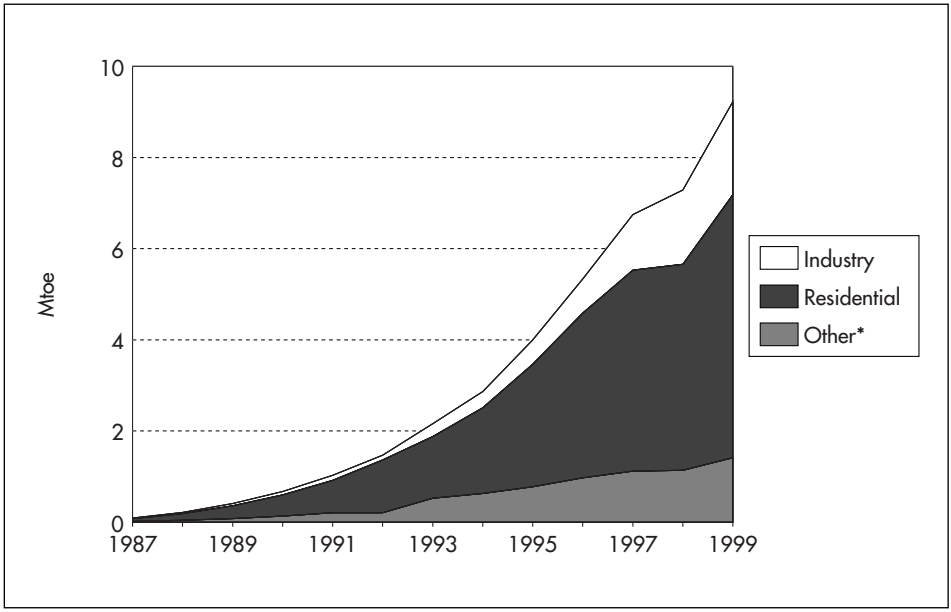
Source: KEEI.

Figure 31
LNG Terminals and Trunkline Network



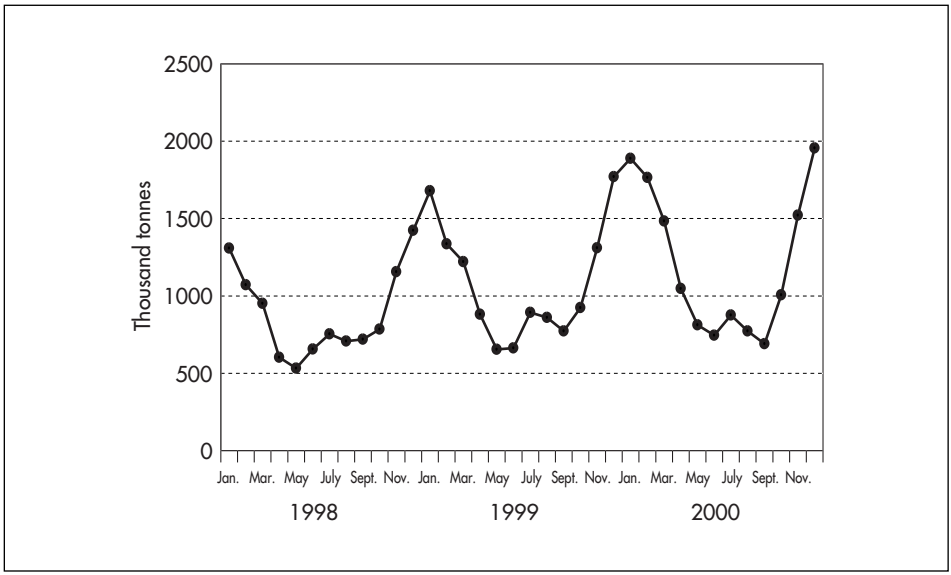
Source: KOGAS.

Figure 32
Final Consumption of Gas by Sector, 1987 to 1999



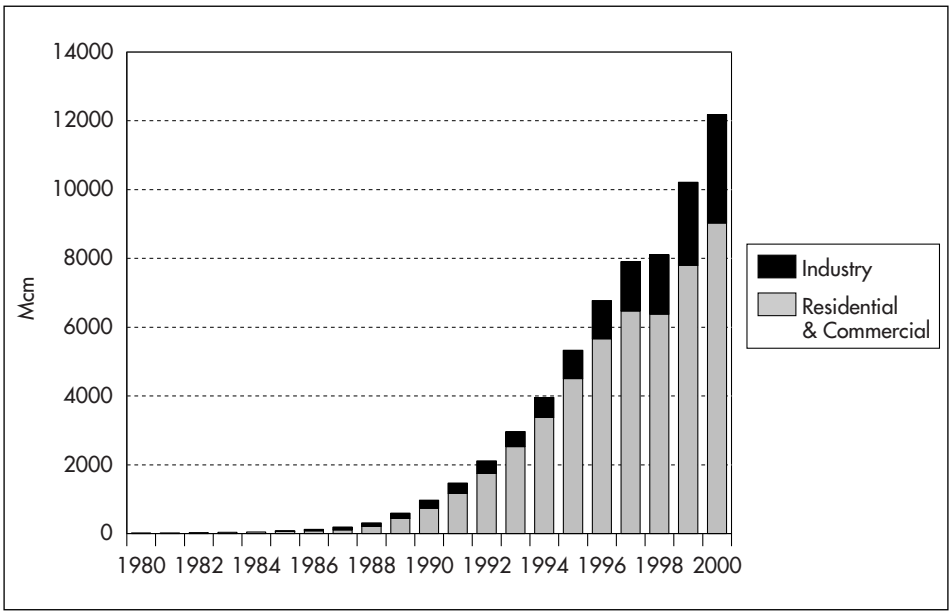
* Includes commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

Figure 33
Monthly Total LNG Consumption, 1998 to 2000



Source: KEEI.

Figure 34
City Gas Consumption by Sector, 1980 to 2000



Source: KEEI.

3.3 million tonnes of LNG per annum. During the shut-down, Bontang in Indonesia and the North West Shelf in Australia provided additional supply from their spare capacity, demonstrating excellent co-operation among the region's LNG players.

Korea has very limited indigenous gas reserves. A small offshore project in the southeast is being developed, and production could begin in 2002. The gas field's recoverable reserves are estimated to range from 170 to 200 billion cubic feet. KNOC plans to launch full-fledged commercial production of this field as of 2003. The company began working on a basic design of the production facilities in 1999, and started building a production platform, pipelines and inland receiving bases in 2000. Three-dimensional seismic surveys showed seven to eight similar geological structures within a radius of 15 kilometres of the Gorae V well. The $320-million Tonghae-1 development project undertaken by Korea National Oil Corporation (KNOC) involves developing an offshore gas deposit from Ulchin in southeastern Korea. This is a relatively minor development, however, and would cover only 2% of Korea's gas demand.

OUTLOOK

The MOCIE long-term plan forecasts an average increase in total LNG demand of about 5% per year up to 21 mt/year in 2010. City gas is expected to be the backbone of future growth in gas demand. MOCIE estimates that total demand for

city gas will reach 15 million tonnes by 2010, increasing at an annual average of 6%. Industrial sector demand will increase at a higher rate than that for household use. By the end of 2002, KOGAS aims to extend its transportation pipeline network to 2,450 km (from the current 1,994 km), which will make it possible to increase the consumption of natural gas in Korea's major cities. The pattern in Korea still resembles that of a developing country, where lack of infrastructure slows market development. The market is far from being saturated, especially in the industrial and residential sectors.

Gas demand for electricity generation is expected to reach 6 million tonnes by 2010, growing at an annual average of 1.9%. According to the Fifth Long-term Power Development Plan (LPDP), KEPCO will build 22 new gas-fired power plant units by 2015. By that year, an estimated 24% of electricity will be generated by gas-fired plants. Total gas-fired generation capacity will expand from 12,698 MW in 2000 to 18,850 MW in 2015.

Demand for compressed natural gas (CNG) used in vehicles will also contribute to the future growth of natural gas consumption. Air pollution in Korea's urban centres is largely due to motor vehicles, and the use of natural gas could help reduce it.[11] The government has embarked on a programme to convert buses to CNG, and plans to have around 2,000 CNG buses in operation by the end of 2002. The government considers having a total of 5,000 intra-municipal CNG buses in operation by the end of 2002 in major Korean cities. It plans to use a package of fiscal incentives, including exemption from VAT and acquisition taxes, to promote the replacement of 20,000 diesel buses with buses run on CNG by 2007, particularly in the larger cities, such as Seoul and Pusan. The Ministry of Environment ultimately plans to make CNG buses mandatory in the metropolitan areas.

To cover the expected growth in gas demand, Korea is exploring two supply options: additional LNG imports and gas imports by pipeline.

The Korea Pipeline Natural Gas Consortium, led by KOGAS, has completed a preliminary feasibility study of a gas pipeline from the Kovyktinskoye gas deposit in the Irkutsk region of Russia. The goal is to have an $11 billion, 4,100-km pipeline system supplying a total of 21 million tonnes per year via Mongolia to China and the Korean peninsula by 2008. China is expected to take 14 million tonnes, and South Korea to take seven. After 2010, depending on demand in China and Japan, the Irkutsk pipeline could supply gas at a price that is competitive with LNG, according to the Pipeline Consortium.

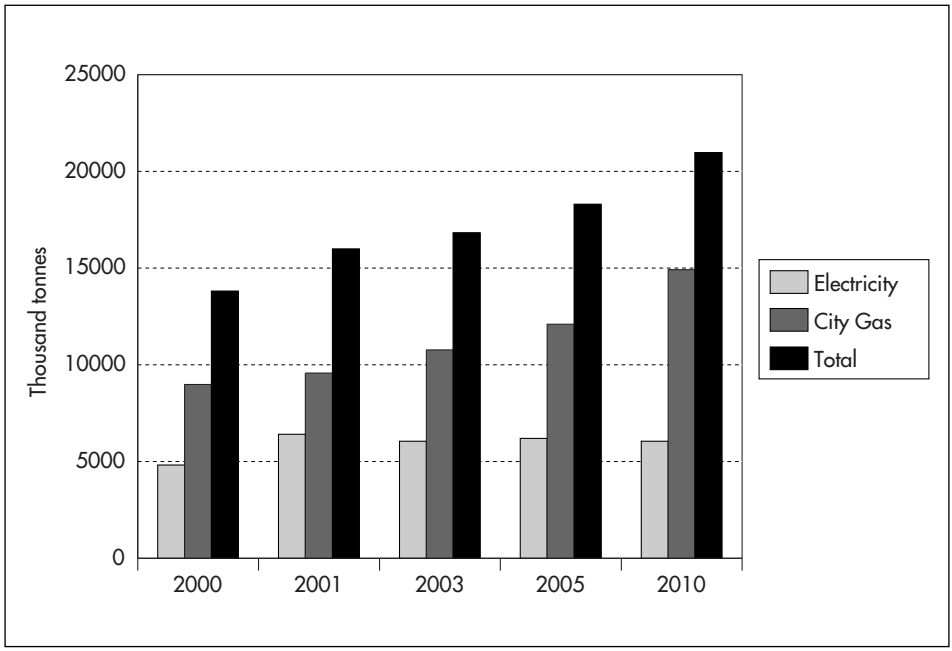
As for LNG, although the contracts with Qatar and Oman will help satisfy demand until approximately 2004-2005, Korea will probably require additional spot cargoes for peak winter demand. After 2005, additional LNG volumes will be needed. MOCIE aims to seek stability and flexibility in LNG imports by diversifying its

11. According to KEEI, motor vehicles are responsible for more than 80 per cent of air pollution in Seoul.

regional import sources. KOGAS is participating in LNG development projects in countries such as Qatar, Oman and Australia, and in Alaska.

Because demand for natural gas is increasing, KOGAS plans to expand capacity at its two existing LNG terminals, Pyongtaek and Inchon, and to build a new terminal at Tongyong. To increase its coverage of peak demand, KOGAS will build 37 additional LNG tanks with 100,000 cm^3 capacity, giving a total of 56 tanks by 2010. The new Tongyong receiving terminal is expected to be completed in 2008. To feed industrial gas supply, Pohang Iron and Steel Corporation (POSCO) signed a letter of intent in October 1998 with Mitsubishi Corporation of Japan to build still another LNG receiving terminal at Kwangyang. Although the terminal was planned to come into operation in 2003, it will probably be delayed.

Figure 35
Natural Gas Demand Forecast, 2000 to 2010



Source: KOGAS.

GAS INDUSTRY REFORMS

The Korean government announced plans to reform the gas industry after the July 1998 policy directive to privatise public companies. Restructuring plans were completed in November 1999. The changes to KOGAS are designed to improve efficiency in resource allocation by introducing competition, to promote the development of the gas industry and to enhance service quality and consumer choice. The government proposes to introduce gas-to-gas competition by

unbundling imports and sales activities from the operation of terminals and transmission facilities and instituting an open access regime for receiving terminals and the transmission network. The partial privatisation of KOGAS before separating it into different private entities led to an initial public offering of 43% of its equity that was completed in November 1999. KOGAS is now listed on the Seoul and New York stock exchanges. Competition in the retail sector and outsourcing are expected to improve the competitiveness of the gas market.

Current plans to reform the gas sector include the following measures:

- Separate import and wholesale businesses from KOGAS and create three trading companies (which will close out existing long-term purchasing agreements for LNG to Korea) by April 2002.

- Privatise two of the trading companies and keep the others in the hands of KOGAS until it is fully privatised by the end of 2002.

- Establish an independent regulatory body by the end of 2002.[12]

- Privatise the four KOGAS subsidiaries[13] and outsource services by the end of 2002.

- Open access to all KOGAS facilities (terminals and transmission network) by 2003.

- Final privatisation of KOGAS by the end of 2002.

- A three-phase introduction of competition in natural gas retail services, with deadlines to be defined:
  - competitive supply to large consumers,
  - city-gas supply business to be split between operating facilities and sales,
  - supply competition to small consumers.

- Introduce supply service by LNG tank-lorries to areas not being supplied by the distribution network, with a deadline to be defined.

KOGAS is still pursuing the concept of strategic alliances with foreign partners. Four groups of companies, including Shell, which has offered to buy 15% of the equity shares in KOGAS in return for an LNG contract, are currently considering alliances.

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12. Korea initially envisaged creating a Gas Committee in 2002, after the creation of an Electricity Committee in 2001. The project was abandoned later to broaden the responsibilities of the Electricity Committee to gas and to change its name to the Energy Committee.
13. Korea Gas Maintenance Engineering Co., Ltd. (maintenance of gas facilities); Korea Gas Engineering and Construction Co., Ltd. (designing and engineering of gas facilities); Kogas Marine Co. Ltd (LNG carrier tugging services); Korea LNG, Ltd. (investment in gas upstream business).

MOCIE has yet to finalise the privatisation schedule and accompanying measures: amount of government shareholding, price determination, allocation of LNG importing contracts, regulatory institutions. The ministry is now consulting other ministries and a wide range of interest groups about the best way to implement the changes. KEEI has been asked to recommend how KOGAS's seven contracts with LNG suppliers are to be divided up among the privatised companies after the reform.

The successful deregulation of the LNG and pipeline gas industry in Korea will require third-party access to the LNG receiving terminals. The plan is to enable third parties to access LNG terminals for a fee. POSCO, which has not yet built its own terminal, anticipates using the KOGAS terminal to import 500,000 tonnes of LNG.

CRITIQUE

Though existing long-term contracts currently satisfy gas demand, the supply needs to be expanded and further diversification should be pursued.

Delay and uncertainty about the pace and type of gas reforms have left the negotiation of new LNG volumes for the next eight years in limbo.

Future demand growth will depend on Korea's economic growth, which has been negatively affected by the slowdown of the world economy in 2001. However, the large potential demand in Korea could require large additional supplies after 2004 or 2005.

MOCIE has restrained KOGAS from entering into new long-term LNG contracts before resolving how it will be broken up and privatised. Delaying gas reforms will create supply problems. KOGAS should not be restricted from engaging in new contracts where necessary.

Negotiating additional LNG quantities will require strong bargaining skills of the buyers. When the import structure is reformed, KOGAS will no longer be the world's largest – and therefore most powerful – LNG importer. Moreover, the three new trading companies that will result from the KOGAS break-up may find themselves bidding against each other for supply, and this could increase LNG import prices. The government will have to monitor future gas purchase plans to secure the best price on the international market. It would be effective to use the KOGAS brand name, since the company has a very successful record of LNG sales negotiations. Regulatory efforts will have to be enforced to preserve supply diversity.

Splitting the seven existing contracts among the three trading companies will be extremely difficult. Existing suppliers will certainly not agree to have their long-term contracts reassigned without solid guarantees.

As in several other IEA countries, Korea's demand is strongly seasonal. Measures are being taken to smooth the demand curve, but they should be cautious and not carried out at the expense of energy efficiency and conservation.

KOGAS, MOCIE and KEPCO recognise the difficulties imposed by Korea's highly seasonal demand profile. It has proven difficult to adjust seasonal demand, although additional LNG storage capacity has been built in recent years. Other tools being envisaged by MOCIE and KOGAS to flatten demand fluctuations but yet to be implemented are interruptible gas supply contracts and demand-side management in industry. The increasing use of gas in the power sector and for cooling purposes should help to solve the problem, as gas for both purposes is used mainly during the summer months. But there is a real risk of a general increase in gas consumption per unit of output, which would put pressure on energy conservation goals.

Gas reforms are useful for introducing greater efficiency into the gas economy, but, as elaborated below, there are risks involved in the process that has been selected in the Korean situation. Security of supply can also become an issue if the reform schedule is not fully clarified.

The government is commended for having successfully introduced natural gas into the Korean energy market, as this has contributed significantly to energy supply security. The government is also commended for its willingness to make the gas market competitive.

Gas supply security will be challenged if the reform schedule is not clarified rapidly, and there are clear indications of delays in the implementation of reforms. Gas reforms have been linked to the implementation of reforms in the electricity sector, which were delayed by the difficulties of restructuring KEPCO, the public monopoly. The difficulties connected with restructuring KOGAS now increase the risk of delaying gas industry reforms:

- Securing potential buyers for KOGAS's restructured entities will be difficult, given KOGAS's high indebtedness (nearly $4.6 billion in 2001). The company share price has declined significantly since the public offering. On several occasions, the government has envisaged the possibility of a guaranteed return for the private entities that would emerge after privatisation, but this, of course, runs counter to the principles of privatisation. Competitive pressures are being introduced to drive prices down, but government guarantees would make lower prices unlikely.

- Since KOGAS is already partially private, the government is accountable to the private shareholders, which could make restructuring difficult (as was the case for British Gas).

- As happened at KEPCO, KOGAS's restructuring is being debated by its staff of 2,400. The labour unions have indicated their concerns about the proposed changes and have announced that they would like an open hearing on the matter. Examining other precedents in Korea, such as the privatisation of KEPCO, it is

clear that Korean labour unions can be persuaded to accept the introduction of competition and can cope with gradual structural change. The potential labour problem should be addressed directly or it may risk delaying the reform.

- There is considerable political debate in Korea about the rationale for restructuring the gas industry, and this debate is slowing the implementation of the plans. The government solution – the four-company plan – involves a complex process compared with the more common and simpler solution of selling company stock to domestic and foreign private investors in a phased, gradual fashion.

The uncertainties could harm Korea's security of gas supply.

- The reform plan introduces the potential for change into the structure of the gas supply industry and makes responsibility for new LNG supply contracts uncertain. This has the effect of preventing new contracts from being signed so long as the regulatory environment remains unclear. The expiration of the Exxon-Mobil contract in 2007 means that some 5 to 6 million new tonnes of gas will need to be contracted for by 2010. Uncertainties about reform should be addressed promptly, to send the right signals to the market so that market players can choose the best options without delay.

- Many of the details of deregulating KOGAS remain to be negotiated, and a government task force has been created to do this. The fact that KOGAS will retain at least one long-term LNG contract or retain responsibility for operating LNG terminals for a while should not hamper competition in the gas market.

Uncertainties about the reform schedule, about how KOGAS liabilities will be handled, and about the regulatory measures that will accompany market expansion (coverage of trade risk, requirements for supply diversification balance, etc.) could negatively affect future investment in gas infrastructure.

For the domestic market, the Korean government will need to ensure that an arm's-length relationship is established between the newly privatised KOGAS and an independent regulator.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Consider the merit of a policy to co-ordinate LNG purchases made by private gas buyers under the KOGAS brand name as a contribution to effective gas purchasing and supply security.

- ☐ Set and adhere to a firm timetable to reform the gas industry and to establish a new gas regulatory institution.

- ☐ As a solution to privatise KOGAS, consider selling KOGAS stocks progressively to private investors, but in the knowledge that four separate companies will subsequently be created. The government could retain a golden share to preserve Korean interests.

- ☐ Ensure that gas prices reflect costs.

- ☐ Closely monitor costs in the monopoly areas of the gas industry after the privatisation of KOGAS.

- ☐ Ensure the regulator's independence after the privatisation of KOGAS; ensure that the regulator is given sufficient power to regulate the market.

- ☐ Address the issue of assigning LNG sales contracts with KOGAS to several buyers, in order to satisfy the needs of both LNG sellers and financiers, without unduly prejudicing the interests of existing KOGAS shareholders.

10

COAL

COAL SUPPLY

Reserves

At the end of 1998, Korea had an estimated 82 Mt of reserves of medium-quality, high-ash anthracite coal. The current reserve-to-production ratio is 19 years. Most reserves are distributed along a line running from northeast to southwest. Some lignite reserves exist but are not mined.

Production

Coal production has been falling for some years. In 2000, it stood at 4.1 Mt, slightly down from 4.2 Mt in 1999, and less than one-quarter of total production in 1990 (17.2 Mt). After 2006, production is expected to decrease further and then be maintained at around 3 million tonnes. Most of the output is anthracite. The three largest operations – Kyungdong, the state-owned Dai Han Coal Corporation, and Dongwon – produce over half of the annual output. Small private mine operators produce the rest.

Most of the coal fields are located in mountainous areas, and require labour-intensive underground mining. Production costs are higher than those of imports because low levels of mechanisation and generally thin seams keep productivity low. Labour costs have risen. Mining conditions are dangerous. In 1999, nine deaths and 60 major injuries were recorded, and accidents caused 71,321 lost working days.

The government is rationalising the coal mining industry. Between 1989 and 1995, it closed 384 small mines. This caused the loss of over 33,000 jobs. The government intends to sell its coal interests by 2005.

Table 25
Korean Coal Production
(Mt)

1980	*1985*	*1990*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000e*
18.6	22.5	17.2	5.7	5	4.5	4.4	4.2	4.1

e: estimate.
Source: *Coal Information*, IEA/OECD Paris, 2001.

Domestic production is supported by a variety of government-funded measures, including direct subsidies for production, a tariff of 1% on imported coal, a 10% VAT on imported coal, and low-interest loans to coal producers. The government also:

- Provides loans through the Korea Mining Promotion Corporation.
- Conducts mineral surveys and analyses.
- Imposes a ceiling on the price of domestically produced coal, which is offset by direct assistance to Dai Han Coal Corporation.

Financial assistance is also provided when uneconomic mines are closed and subsidies are paid to produce coal briquettes that are traditionally used for home heating and cooking.

Subsidies rose in the 1990s. In 1990, a total of 152.1 billion won ($115 million) was paid in production subsidies, and 431.7 billion won ($381.6 million) in 1999. Assistance for mine closures fell over the same period, from 37.5 billion won ($28 million) in 1990 to 1.2 billion won in 1999 ($1.1 million). Production subsidies in 1999 were therefore about $93 per tonne.

COAL DEMAND

The use of coal was promoted by the government after the 1973 oil shock. Consumption of coking coal has increased since the Pohang Iron and Steel Corporation (POSCO) began operating in 1973 and has since kept pace with pig-iron production. Coal was first used to generate electricity in 1982. Locally-produced anthracite is shaped into yongtang briquettes, which are used for under-floor heating in traditional houses and burned in cooking stoves. Six power stations with a total capacity of 1,420 MW burn domestic coal. One of these is a 400 MW atmospheric pressure circulating fluidised bed plant, and the others are pulverised fuel plants.

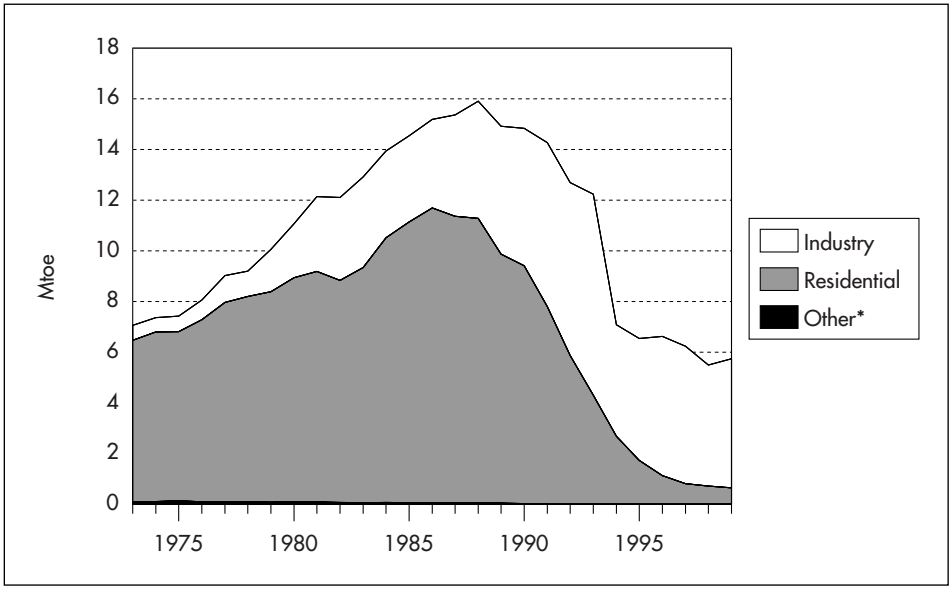
Coal consumption has roughly tripled since the 1980s, but coal's market share fell after the growth of nuclear power, LNG and oil for transport. In 1999, total coal consumption was 61.5 Mt, of which 54.6 Mt was imported. The total was 43.7 Mt in 1990. About 50% of the coal supply is used to generate electricity (30.8 Mt in 1999). Industry consumes about 45% of the coal supply: 27.2 Mt in 1999, of which 18.5 Mt is consumed in steel-making and the remainder is consumed in the cement industry and in industrial boilers. About 2% is used for residential purposes (1.1 Mt in 1999).

The pattern of coal consumption has changed considerably. In 1990, only about 18% was used to generate electricity, while nearly 40% was used in industry and 43% was used for residential purposes. The output share of coal in electricity production rose from 18.5% in 1990 to 41.1% in 1999. The consumption of coal for electricity generation is expected to continue to grow while residential and industrial use is expected to go on declining. By 2010, coal is expected to generate about 35% of the electricity produced. Growth in the iron and steel industry and the cement industry slowed during the 1990s. Overall, the use of coal is projected to grow from 35 Mt in 1995 to as much as 90 Mt in 2010.

Figure 36
Korean Coal Fields and Major Coal Terminals

Source: IEA Coal Research: The Clean Coal Centre (coal fields), World Coal (terminals).

Figure 37
Final Consumption of Coal by Sector, 1973 to 1999



* Includes commercial, public service and agricultural sectors.
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

IMPORTS

Strong demand for imported coal continued as the economy recovered from the economic crises of 1997 and 1998. Imports increased by 12.8% from 54.6 Mt in 1999, to 61.6 Mt in 2000. Approximately 35 Mt of imported coal for power generation was unloaded at terminals near Korean power stations. The largest are dedicated coal terminals at Samchonpo, Honam, Ko-jung and Inchon. A further 19 Mt of hard coking and semi-soft coal was unloaded at Pohang and Kwangyang. About 7 million tonnes were consumed in the cement and other industries and unloaded at several coastal ports.

Most imported coal requires no inland transport. Domestic coal is transported by road and rail. Korea has asked North Korea to agree to move Chinese coal by rail through its territory. Chinese imports have increased dramatically in recent years so that, if North Korea agrees to this proposal, it could have a major impact on Korea's traditional pattern of coal trade and transport.

The government has encouraged Korean investment in foreign mine projects since the 1970s, and has participated directly in development projects through the state-owned Korean Resources Corporation. By 2001, 17.7% of the total supply came from joint venture projects, to which the government provides loans. The government target for coal imports from joint ventures of 30% by 2006 is not expected to be met.

Table 26
Korean Coal Imports
(thousand tonnes)

	1990	*1995*	*1997*	*1998*	*1999*	*2000e*
Coking coal	**13,100**	**17,151**	**17,394**	**17,978**	**17,227**	**18,862**
Imports from:						
Australia	5,100	8,410	9,709	9,829	9,437	10,641
Canada	4,500	4,251	3,907	3,663	3,057	4,097
US	3,500	2,324	2,254	2,164	1,586	707
China	0	1,072	707	1,313	2,134	2,781
Indonesia	0	44	74	251	625	209
South Africa	0	696	549	466	80	0
Russia	0	347	194	256	308	394
Other	0	0	0	36	0	33
Steam coal	**11,588**	**28,758**	**34,652**	**35,607**	**37,342**	**42,777**
Imports from:						
Australia	3,506	9,464	12,769	15,723	12,249	12,019
Canada	1,250	2,156	1,992	2,696	2,364	1,647
US	1,235	2,150	1,301	323	185	713
China	1,000	7,209	8,181	6,725	11,611	30,210
Indonesia	397	3,375	5,263	6,264	6,104	3,384
South Africa	4,200	3,535	4,317	3,341	4,071	2,503
Russia	0	533	533	418	561	2,171
Vietnam	0	223	54	86	124	67
Other	0	108	54	0	5	60
Total	**24,688**	**45,909**	**52,046**	**53,585**	**54,569**	**61,639**

e: estimate.
Source: *Coal Information*, IEA/OECD Paris, 2001.

ENVIRONMENTAL STANDARDS

Emission standards for coal-fired power plants since January 1999 are as follows:

- Sulphur dioxide emissions, 430-777 mg per cubic metre.
- Particulates, 50 mg per cubic metre.
- Nitrogen oxides, 718 mg per cubic metre, and lower in some urban areas.

Standards also apply to ammonia and carbon monoxide emissions from coal-fired plants.

Standards for sulphur dioxide emissions and particulates are comparable to some in Europe, but those for nitrogen oxides are generally less strict.

Before restructuring, KEPCO announced its intention to recycle 40% or more of the coal ash produced from power generation by developing utilisation technologies. Coal ash can be recycled for light building materials and concrete.

KEPCO has installed flue gas desulphurisation on new coal-fired plants since the mid-1990s and some existing plants are being retrofitted.

OUTLOOK

The outlook for coal in Korea depends very much on the end-use. There are three main groups of end-users: iron and steel-making, power generation, other industry.

POSCO, the world's second largest steel-maker after Japan's Nippon, operates two integrated steel mills at Pohang and Kwangyang. Steel is produced for export and for the ship-building and car industries. About 30% of coal imported by POSCO is thermal coal for its captive power stations. The remainder is used for steel-making. At least some of the coal classified as coking could also be classified as thermal grade PCI coal for use in pulverised coal injection into blast furnaces. POSCO purchases all of its coal through long-term contracts of five to ten years, settled on an annual basis.

POSCO is the only Korean steel-maker to use coal. Other Korean steel mills process steel from ingots, using mostly electric-arc furnaces. POSCO has been operating at full capacity for some years, and growth in its coal consumption will be limited regardless of growth in demand for iron and steel.

The government's vision provides for expansion of coal-fired generation. But if it is clear that imports will grow, the outlook for price is less clear. Before it was broken up, KEPCO had already decided to purchase more coal on the spot market to reduce fuel costs. Its break-up and the liberalisation of the electricity market could bring further changes and greater pressures to reduce costs. Korea currently buys about 20% of its coal on the spot market. This share will probably increase; 30% or more is considered possible. At present, spot purchases are made mainly from China, South Africa and Indonesia.

The amount of coal consumed by the cement industry has fluctuated greatly with domestic economic activity. In 1998, for example, the amount fell by about a quarter, from about 5 million tonnes the previous year. The industry is now exporting, which may help stabilise demand. By contrast, the use of coal in industrial boilers has remained relatively stable, at about 2 million tonnes per year.

Government influence on coal imports and use, other than environmental regulation, should be reduced as the government holdings in major users are reduced. The government's remaining 3% share of POSCO was sold in 2000, and its share in KEPCO was reduced from more than 70% in 1996 to 53.2% by 1999.

CRITIQUE

Coal subsidies in Korea are equivalent to those in some other IEA countries, but they are decreasing gradually. It will be important to maintain the momentum for closing non-viable mines.

Coal production is subsidised in several IEA countries, but subsidies are being reduced steadily under programmes negotiated with companies and employees. In some cases, supply security is used to justify ongoing subsidies, but the reliability of the international coal market is considered sufficient to assure security. In practice, production is being maintained in most cases for social reasons; this would also appear to be the case for Korea.

Subsidy levels are a cause for concern. Production is now about the same as in France and is approaching that of Japan. The level of subsidies for production is now about that of France and slightly lower than in Japan.[14] But those two countries have firm plans to reduce production,[15] while production in Korea is expected to stabilise at about 3 Mt per year.

Domestic coal mining may be maintained for social reasons. Electricity generators and general industry could come under pressure to take up coal formerly consumed in the residential market for domestic coal.

Until 1990, the residential market was the primary consumer of domestic coal production, but residential consumption has fallen since then, and production has stabilised at around 4 million tonnes since 1997. In 2000, the residential sector consumed only about a quarter of domestic coal production. The government should not now be tempted to force electricity generators and general industry to consume increasing quantities of domestic coal. It is possible that by 2010, domestic production could account for approximately 5% of the coal used in electricity production and industry at costs that are considerably higher than those of higher-quality imported coal. The production level of domestic coal should be determined by its economic viability in competition with imported coal.

Korea is the world's second largest importer after Japan of both steam and coking coal. Its sources of supply are diversified and it has benefited from the highly competitive international coal market by switching suppliers according to availability and price. The bulk of its steam coal has historically come from Australia, and Australian imports have remained stable. Korea has met the growth in coal demand by dramatically increasing imports from China, which replaced

14. This judgment is made comparing direct production subsidies in 1999 with calculations of producer subsidy equivalents in France and Japan. The producer subsidy equivalent for Korea is probably considerably higher, but there is insufficient information to make an accurate calculation. In 1994, the IEA estimated that the producer subsidy equivalent in Korea was rising rapidly, but was then about half the level of Japan.
15. France intends to end production in 2005 and Japan's last coal mine, operated by the Taiheiyo Coal Mine Co., was to be closed at the end of January 2002.

imports from Indonesia and South Africa in 1999-2000. South Africa has a transport cost disadvantage in the Asia-Pacific market, so its loss of market share in Korea is understandable on commercial grounds.

The reliability of Chinese exports has yet to be tested. China's exports constitute only a small proportion of its production, but they may be reaching a level where they are taking coal from the growing Chinese power generation market. This poses little risk for Korea, however, as its coking coal (for steel-making, where security of coal supply and quality are more critical considerations than for steam coal for power generation) comes mainly from Australia and Canada, both considered secure sources. Chinese coking coal imports have grown very modestly.

Korea historically settles term contract prices after settlements in Japan, and normally at a lower price. As demand in Korea rises, however, settlements there have become increasingly independent of those in Japan. Both Korea and Japan understand the production costs of its suppliers because they invest in coal mines in Australia, Indonesia and China and exchange market information with suppliers. The market is very transparent. Liberalising the Korean electricity market will increase pressure on buyers to look to the spot market for lower-priced supplies. Korean buyers may be less prepared to pay premiums for security of supply, but imports have continued to grow steadily despite fluctuations in the economy, encouraging investment in supply capacity.

The outlook for coal in Korea is very favourable. Policy should be adjusted to enhance the benefits of using low-cost coal.

Local environmental concerns will remain important, but greenhouse gas emissions pose little challenge to the future of coal because of Korea's limited commitments under the Kyoto Protocol. The market is highly competitive, and prices are likely to remain low relative to other fuels. In light of this, it makes little sense to maintain a high-cost domestic industry.

Coal is a low-cost source of energy that will help Korean industry maintain its international competitiveness and it should therefore continue to play a major part in underwriting Korea's economic growth. In this respect, any benefits of the revenue tariff and VAT on coal imports may be outweighed by adding to the cost structure of the economy. Replacing them with environmental taxes to offset the external costs of coal use might be considered. Other options might include an environmental tax on the use of coal combustion products to fund investment in industry energy efficiency measures.

Korea has taken important steps to address local pollution from coal-fired power plants, which are required to use low-sulphur coal. Flue gas desulphurisation is likely to be installed on all new coal-fired plants; standards apply to emissions of nitrogen oxides from power generation; and ambitious targets have been proposed for recycling coal ash. In the longer term, Korea has announced that it will take steps to mitigate greenhouse gas emissions.

Reducing subsidies, eliminating residential use of coal, using low-sulphur coal and improving its thermal efficiency generally would all be important in reducing local pollution and addressing the greenhouse gas issue. Applying advanced clean coal technologies might also be considered. Korea has already developed fluidised-bed combustion as a means of using domestic coal. The government could help position coal-fired power for restrictions on greenhouse gas emissions by assessing the appropriateness of advanced coal-fired power-generating technologies. As a Member of the IEA, the Korean government could take advantage of participation in coal-related IEA Implementing Agreements, particularly the Clean Coal Centre, and Korean coal users could contribute to the work of the IEA Coal Industry Advisory Board.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Negotiate with mine operators and employees to set a firm target for ending all forms of government support for domestic coal production.
- ☐ Replace the ceiling on prices for domestic coal production with direct income support, where justified on social grounds.
- ☐ Ensure that coal consumers have no obligation to buy domestically-produced coal.
- ☐ Remove the import tariff and value-added tax (VAT) on imported coal or redesign them as measures to offset the environmental impacts of coal use.
- ☐ Assess the feasibility of clean coal technologies.

11

ENERGY TECHNOLOGY R&D ACTIVITIES

POLICY OBJECTIVES

Most research and development in Korea in the 1960s and 1970s were aimed at adapting technologies from developed countries. In the 1980s and 1990s, national R&D programmes were modified to catalyse industrial restructuring through domestic innovation. Public resources are being used increasingly to stimulate public-private partnerships. The primary emphases in the energy field are nuclear energy, developing new and renewable energy sources, energy conservation and efficiency and the environment.

Nuclear energy R&D comes under the auspices of the Ministry of Science and Technology (MOST) and is guided by the Mid-and-Long-term Nuclear R&D Programmes that were developed in 1992 to ensure strong, systematic nuclear technology development. The R&D goal is to catch up with the major industrialised countries in nuclear power technology by the early 2000s. The government intends to establish a sound technological base in the country so that nuclear energy can serve as a reliable supply source and so that the country's technology can progress effectively through domestic R&D efforts. R&D focuses on advanced nuclear reactors, monitoring the nuclear fuel cycle to avoid nuclear proliferation and other advanced nuclear technologies to secure nuclear safety. Extensive research has also been carried out on radioisotope production and applications, developing new radio-pharmaceuticals and the utilisation of radioisotopes in agriculture, industry and medicine.

The Five-Year National Plan for Energy Conservation Technology Development (1992-1996) was followed by the Ten-Year National Plan for Energy Technology Development (1997-2006). This latter plan was designed to promote the development of technologies in three main areas: energy conservation, new and renewable energy, greenhouse gas emissions reduction. These projects seek to meet the following targets by the year 2006:

- Reduce total energy consumption by 10% (from 1996).
- Boost new and renewable energy supply to 2% of TPES.
- Mitigate greenhouse gases.
- Secure resource stability.

Administration of Research and Development

MOCIE and MOST are involved in government energy R&D. MOST is responsible for fundamental research planning and nuclear research. MOCIE is responsible for

R&D programmes to meet specific energy policy objectives, and for general R&D planning and supervision.

The following institutions, most of which are public, carry out major energy R&D activities:

- Korea Institute of Energy Research (KIER), the principal public institute for energy technology research. KIER carries out R&D on all primary and final energy, and is government-funded (by MOCIE and KIER). It is divided into five major departments: energy conservation research, energy efficiency research, energy environment research, new and renewable energy research, and technology transfer.

- Korea Electrotechnology Research Institute (KERI), a major national research institute supported by the government. KERI concentrates on the electricity technology and conducts a wide spectrum of R&D programmes on electric power supply, energy efficiency, environmental protection, electrophysics, electric equipment, superconductivity, power-line telecommunication, and advanced materials.

- Korea Atomic Energy Research Institute (KAERI), funded by MOST to carry out nuclear research.

- Other government-supported research institutes include the Korea Institute of Science and Technology (KIST), the leading Korean institute for research in fundamental and applied science, which plays an essential role in developing energy-efficient industrial technology, and the Korea Institute of Geology, Mining and Minerals (KIGAM), the leading Korean geoscience and resource research institute, which provides support in analysing geophysical data on offshore oil and gas, and also develops technology to store LNG in natural repositories.

- The Korea Energy Management Corporation (KEMCO), which plays a key role in implementing R&D policy objectives for energy efficiency, energy conservation, and cleaner energy technologies. KEMCO is responsible for planning, financing and managing R&D.

- Companies like KEPCO (with the Korea Electric Power Research Institute – KEPRI), KOGAS, and others (LG and Samsung).

- The Korea Energy Economics Institute (KEEI), Korea's principal energy policy research organisation. KEEI conducts basic research on energy policy options. It provides energy information and statistics and produces energy balances; formulates policies for the government on reforms in the electricity and gas supply industries, energy efficiency and demand management; it produces energy supply and consumption forecasts; and is also involved in climate change studies.

Ten-Year National Plan for Energy Technology Development (1997-2006)

The Ten-Year National Plan for Energy Technology Development (1997-2006) concentrates on:

- Energy efficiency – developing technologies improving the effectiveness of production, conversion, storage and transportation, and the utilisation of energy; promoting more efficient energy facilities in the industry, building, transportation and electricity sectors.

- Diversification – developing technologies for solar thermal energy and photovoltaic power, bioenergy, wind power, small hydropower, fuel cells, coal liquefaction and gasification, ocean energy, waste energy, coal-mixed fuel, geothermal energy and hydrogen technology.

- Clean energy – developing technologies for reducing emissions of environmental pollutants (SO_x, NO_x, CO_2, particles) from fossil-fuel combustion.

KEMCO organises Technical Expert Research Groups (TERGs) to co-ordinate and manage the R&D programmes of the Ten-Year National Plan. Under the plan, the government provides loans at 4% interest to new and renewable energy producers and research organisations for up to 90% of the total investment.

The government considers energy conservation and new and renewable energy important, but these subjects receive only a fraction of the total R&D expenditure in the energy sector in Korea. Private enterprises contribute a large part of the total gross domestic expenditure on energy R&D (59% of the 798 billion won or $602 million in 1997). Energy R&D represents 6.6% of the country's total R&D expenditure.[16]

Implementing Agreements

The Republic of Korea is participating in twelve IEA Implementing Agreements as shown in Table 29.

CRITIQUE

Considering Korea's heavy dependence on imported energy and its high energy intensity, it is understandable that the government places much emphasis on energy R&D to improve energy efficiency, to facilitate energy diversification and to develop

16. OECD, *Basic Science and Technology Statistics*, 1999, Paris.

Table 27

Ten-Year National Plan for Energy Technology Development (1997-2006)

High Priority and General Programmes

	High Priority	*General*
Industry	– Chemical separation technology – Dryer – Energy conversion & storage – Heating, ventilating and air-conditioning (HVAC) – Combustion	– Dyeing and finishing machinery – Paper machinery – Process control and automation – Chemical reaction processes – Heat exchange
Steel industry	– Industrial furnace	– Structure material – Functional materials
Building	– Energy conservation building technology – Mass energy	– Building energy management – Building envelope insulation – Building automation system
Transportation		– Low-mass and fuel-efficient vehicles – 21C alternative car
Electricity	– Lighting system – Induction motor – Small co-generation – Application of motor	– Consumer & office automation – Refrigeration – Customer electricity management – Electric exchange – Energy storage – Electric heat – Superconductivity power equipment – Demand-side management
New & renewable energy	– Photovoltaic – Fuel cell – Solar energy – Wind power – Waste energy	– Bioenergy – Clean coal technology
Clean energy	– Fluidised bed combustion – Coal ash utilisation technology – Combustion treatment technology – New catalysts for oil refining – CO_2 separation and recovery	– Pulverised coal combustion – Regeneration and treatment of used catalyst – Biocatalytic desulphurisation and process development for oil refining – Fixation and utilisation of CO_2

indigenous energy. The government has developed well-organised, detailed R&D programmes, the priority and balance of which appear consistent with its energy policy objectives.

Table 28
KEMCO Investment in Energy Technology Development Projects, 2001
(million won)

Technology	*Number of Projects*	*Investment by*		
		KEMCO	*Project Performer*	*Total*
Energy conservation	127	21,022	9,910	30,932
New and renewable energy	44	14,849	8,743	23,592
Clean energy	37	5,909	3,712	9,621
Natural resources	55	6,396	2,507	8,903

Note: $1 = 1,325 won.
Source: KEMCO.

Table 29
Korea's Participation in IEA Implementing Agreements

Contracting Party	*Implementing Agreements*
Ministry of Trade, Industry and Energy (name changed to Ministry of Commerce, Industry and Energy)	Energy and Environmental Technologies Information Centres (EETIC) Energy Technology Data Exchange (ETDE) Demand-Side Management Photovoltaic Power Systems
Korea District Heating Corporation	District Heating and Cooling
Korea Automotive Technology Institute (KATECH)	Hybrid and Electric Vehicles
Korea Institute of Energy Research (KIER)	Energy Technology Systems Analysis Programme (ETSAP)
Korea Electric Power Corporation (KEPCO)	Advanced Fuel Cells Fluidised Bed Conversion Greenhouse Gases R&D Programme High-Temperature Superconductivity
Korea Basic Science Institute	Toroidal Physics and Plasma Technologies of Tokamaks with Poloidal Field Divertors (ASDEX Upgrade)

In the past, the government played an important role in identifying priority technologies and areas of R&D focus. The rapid liberalisation of the energy market now in progress gives the government a good opportunity to review its R&D policies and programmes to ascertain whether they are adequately designed to use the market mechanism most effectively. An effective monitoring and evaluation system appears necessary to assess this aspect of R&D programmes. In particular,

the right signals must be sent to the market so that potential investors can respond promptly. Evaluation will require setting quantitative and measurable goals and developing effective tools.

It will be increasingly important to involve the private sector in R&D activities to facilitate the process of technology deployment. The Korean government has actively used public-private partnerships in energy R&D, giving various incentives to private-sector participation. With market liberalisation, the government may need to redefine its role and improve its policy measures to stimulate private initiatives more effectively, using the full potential of market-oriented mechanisms. Newly-privatised state enterprises may need special attention so that they do not become heavily dependent on government support.

Korea has participated actively in many international R&D activities. The country has a good technology base in many energy areas and can make a valuable contribution to international co-operation. In return, it can enjoy significant benefits from such co-operation to enhance domestic R&D and use its resources efficiently. In this regard, it is important to ensure that domestic R&D activities are designed to achieve maximum synergies with international partners. In each area, the domestic and international technology base and future potential should be thoroughly assessed, and government R&D activities should be well focused.

RECOMMENDATIONS

The Government of Korea should:

- ☐ Develop effective monitoring and evaluation mechanisms to measure the effectiveness of R&D programmes; ensure that the monitoring mechanism is transparent and that public expenditures on energy R&D are more visible.

- ☐ Encourage private sector commitment to R&D and actively develop new public-private research partnerships.

- ☐ Strengthen international R&D co-operation by playing a more active role in IEA Implementing Agreements.

A

ANNEX

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	1999	2000	2005	2010	2020
TOTAL PRODUCTION		**6.76**	**22.25**	**31.85**	..	..	..	..
Coal		6.65	7.92	1.89	..	..	..	..
Oil		–	–	0.45	..	..	..	..
Gas		–	–	–	..	..	..	..
Comb. Renewables & Wastes[1]		–	–	2.22	..	..	..	..
Nuclear		–	13.78	26.86	..	..	..	..
Hydro		0.11	0.55	0.36	..	..	..	..
Geothermal		–	–	–	..	..	..	..
Solar/Wind/Other		–	0.00	0.08	..	..	..	..
TOTAL NET IMPORTS[2]		**13.03**	**68.67**	**147.75**	..	..	..	..
Coal	Exports	0.12	–	–	..	..	..	..
	Imports	0.45	15.89	33.45	..	..	..	..
	Net Imports	0.34	15.89	33.45	..	..	..	..
Oil	Exports	1.04	3.73	39.69	..	..	..	..
	Imports	14.28	55.41	145.33	..	..	..	..
	Bunkers	0.56	1.58	6.51	..	..	..	..
	Net Imports	12.69	50.10	99.13	..	..	..	..
Gas	Exports	–	–	–	..	..	..	..
	Imports	–	2.68	15.17	..	..	..	..
	Net Imports	–	2.68	15.17	..	..	..	..
Electricity	Exports	–	–	–	..	..	..	..
	Imports	–	–	–	..	..	..	..
	Net Imports	–	–	–	..	..	..	..
TOTAL STOCK CHANGES		**1.29**	**0.90**	**1.76**	..	..	..	..
TOTAL SUPPLY (TPES)		**21.07**	**91.82**	**181.37**	..	..	..	..
Coal		7.56	24.73	37.00	..	..	..	..
Oil		13.40	50.04	99.69	..	..	..	..
Gas		–	2.72	15.16	..	..	..	..
Comb. Renewables & Wastes[1]		–	–	2.22	..	..	..	..
Nuclear		–	13.78	26.86	..	..	..	..
Hydro		0.11	0.55	0.36	..	..	..	..
Geothermal		–	–	–	..	..	..	..
Solar/Wind/Other		–	0.00	0.08	..	..	..	..
Electricity Trade		–	–	–	..	..	..	..
Shares (%)								
Coal		*35.9*	*26.9*	*20.4*	..	..	..	..
Oil		*63.6*	*54.5*	*55.0*	..	..	..	..
Gas		–	*3.0*	*8.4*	..	..	..	..
Comb. Renewables & Wastes		–	–	*1.2*	..	..	..	..
Nuclear		–	*15.0*	*14.8*	..	..	..	..
Hydro		*0.5*	*0.6*	*0.2*	..	..	..	..
Geothermal		–	–	–	..	..	..	..
Solar/Wind/Other		–	–	–	..	..	..	..
Electricity Trade		–	–	–	..	..	..	..

0 is negligible, – is nil, .. is not available.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	1999	2000	2005	2010	2020
TFC	**17.99**	**67.45**	**125.04**	..	..	..	..
Coal	7.07	14.84	5.75	..	..	..	..
Oil	9.81	43.82	85.25	..	..	..	..
Gas	–	0.67	9.22	..	..	..	..
Comb. Renewables & Wastes[1]	–	–	0.11	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	0.00	0.07	..	..	..	..
Electricity	1.10	8.12	20.79	..	..	..	..
Heat	–	–	3.85	..	..	..	..
Shares (%)							
Coal	*39.3*	*22.0*	*4.6*	..	..	..	..
Oil	*54.6*	*65.0*	*68.2*	..	..	..	..
Gas	–	*1.0*	*7.4*	..	..	..	..
Comb. Renewables & Wastes	–	–	*0.1*	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	–	*0.1*	..	..	..	..
Electricity	*6.1*	*12.0*	*16.6*	..	..	..	..
Heat	–	–	*3.1*	..	..	..	..
TOTAL INDUSTRY[3]	**7.56**	**27.89**	**57.04**	..	..	..	..
Coal	0.58	5.43	5.09	..	..	..	..
Oil	6.22	17.42	37.55	..	..	..	..
Gas	–	0.07	2.04	..	..	..	..
Comb. Renewables & Wastes[1]	–	–	–	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	–	0.00	..	..	..	..
Electricity	0.76	4.97	12.36	..	..	..	..
Heat	–	–	–	..	..	..	..
Shares (%)							
Coal	*7.7*	*19.5*	*8.9*	..	..	..	..
Oil	*82.2*	*62.5*	*65.8*	..	..	..	..
Gas	–	*0.3*	*3.6*	..	..	..	..
Comb. Renewables & Wastes	–	–	–	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	–	–	..	..	..	..
Electricity	*10.1*	*17.8*	*21.7*	..	..	..	..
Heat	–	–	–	..	..	..	..
TRANSPORT[4]	**2.60**	**14.93**	**27.70**	..	..	..	..
TOTAL OTHER SECTORS[5]	**7.82**	**24.64**	**40.30**	..	..	..	..
Coal	6.48	9.41	0.65	..	..	..	..
Oil	1.02	11.56	20.15	..	..	..	..
Gas	–	0.60	7.18	..	..	..	..
Comb. Renewables & Wastes[1]	–	–	0.11	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	0.00	0.07	..	..	..	..
Electricity	0.33	3.06	8.29	..	..	..	..
Heat	–	–	3.85	..	..	..	..
Shares (%)							
Coal	*82.8*	*38.2*	*1.6*	..	..	..	..
Oil	*13.0*	*46.9*	*50.0*	..	..	..	..
Gas	–	*2.4*	*17.8*	..	..	..	..
Comb. Renewables & Wastes	–	–	*0.3*	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	–	*0.2*	..	..	..	..
Electricity	*4.2*	*12.4*	*20.6*	..	..	..	..
Heat	–	–	*9.5*	..	..	..	..

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	1999	2000	2005	2010	2020
ELECTRICITY GENERATION[6]							
INPUT (Mtoe)	**3.26**	**25.09**	**62.67**	**..**	**..**	**..**	**..**
OUTPUT (Mtoe)	**1.27**	**9.26**	**22.79**	**..**	**..**	**..**	**..**
(TWh gross)	14.83	107.67	264.98	..	..	..	..
Output Shares (%)							
Coal	*9.0*	*18.5*	*41.1*	..	..	..	..
Oil	*82.3*	*17.5*	*7.0*	..	..	..	..
Gas	*–*	*8.9*	*11.4*	..	..	..	..
Comb. Renewables & Wastes	*–*	*–*	*–*	..	..	..	..
Nuclear	*–*	*49.1*	*38.9*	..	..	..	..
Hydro	*8.7*	*5.9*	*1.6*	..	..	..	..
Geothermal	*–*	*–*	*–*	..	..	..	..
Solar/Wind/Other	*–*	*–*	*0.0*	..	..	..	..
TOTAL LOSSES	**2.96**	**23.23**	**51.14**	**..**	**..**	**..**	**..**
of which:							
Electricity and Heat Generation[7]	1.99	15.83	35.91	..	..	..	..
Other Transformation	0.06	4.61	8.02	..	..	..	..
Own Use and Losses[8]	0.92	2.80	7.21	..	..	..	..
Statistical Differences	**0.12**	**1.14**	**5.18**	**..**	**..**	**..**	**..**

INDICATORS

	1973	1990	1999	2000	2005	2010	2020
GDP (billion 1995 US$)	93.22	341.55	566.33	–	..	..	..
Population (millions)	34.10	42.87	46.86	–	..	..	..
TPES/GDP[9]	0.23	0.27	0.32	..	..	..	..
Energy Production/TPES	0.32	0.24	0.18	..	..	..	..
Per Capita TPES[10]	0.62	2.14	3.87	..	..	..	..
Oil Supply/GDP[9]	0.14	0.15	0.18	..	..	..	..
TFC/GDP[9]	0.19	0.20	0.22	..	..	..	..
Per Capita TFC[10]	0.53	1.57	2.67	..	..	..	..
Energy-related CO_2 Emissions (Mt CO_2)[11]	66.8	233.8	410.4	..	..	..	..
CO_2 Emissions from Bunkers (Mt CO_2)	2.1	5.9	22.1	..	..	..	..

GROWTH RATES (% per year)

	73–79	79–90	90–99	99-00	00–05	05–10	10–20
TPES	11.2	7.9	7.9	..	..	..	..
Coal	7.9	6.8	4.6	..	..	..	..
Oil	12.3	5.8	8.0	..	..	..	..
Gas	–	–	21.0	..	..	..	..
Comb. Renewables & Wastes	–	–	–	..	..	..	..
Nuclear	–	29.2	7.7	..	..	..	..
Hydro	10.5	9.6	–4.6	..	..	..	..
Geothermal	–	–	–	..	..	..	..
Solar/Wind/Other	–	–	43.4	..	..	..	..
TFC	9.9	7.1	7.1	..	..	..	..
Electricity Consumption	15.9	10.6	11.0	..	..	..	..
Energy Production	5.8	8.0	4.1	..	..	..	..
Net Oil Imports	13.3	5.8	7.9	..	..	..	..
GDP	8.5	7.6	5.8	..	..	..	..
Growth in the TPES/GDP Ratio	2.5	0.2	2.0	..	..	..	..
Growth in the TFC/GDP Ratio	1.3	–0.5	1.2	..	..	..	..

Please note: Rounding may cause totals to differ from the sum of the elements.

Footnotes to Energy Balances and Key Statistical Data

1. Comprises solid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. Total net imports include combustible renewables and waste.
3. Includes non-energy use.
4. Includes less than 1% non-oil fuels.
5. Includes residential, commercial, public service and agricultural sectors.
6. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
7. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear and 100% for hydro.
8. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
9. Toe per thousand US dollars at 1995 prices and exchange rates.
10. Toe per person.
11. "Energy-related CO_2 emissions" specifically means CO_2 from the combustion of the fossil fuel components of TPES (i.e. coal and coal products, peat, crude oil and derived products, and natural gas), while CO_2 emissions from the remaining components of TPES (i.e. electricity from hydro, other renewables and nuclear) are zero. Emissions from the combustion of biomass-derived fuels are not included, in accordance with the IPCC greenhouse gas inventory methodology. Also in accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 1999 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

B

ANNEX

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The Member countries* of the International Energy Agency (IEA) seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1 **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2 Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3 **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the Polluter Pays Principle.

4 **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

IEA Members wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5 **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6 **Continued research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7 **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8 **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9 **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

C

ANNEX

GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention and abbreviated subsequently, this glossary provides a quick and central reference for many of the abbreviations used.

AEC	Atomic Energy Commission
bcm	billion cubic metres
b/d	barrels per day
BLMP	baseload marginal price
cal	calorie
CHP	combined production of heat and power; sometimes, when referring to industrial CHP, the term "co-generation" is used
CO_2	carbon dioxide
CNEPP	Comprehensive Nuclear Energy Promotion Plan
CNG	compressed natural gas
DME	di-methyl ether
EPB	Korean Economic Planning Board
ESCOs	energy service companies
FKA	Federation of Korean Industries
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GJ	gigajoule, or 1 joule $\times 10^9$
GO-HDS	gas oil hydro-sulphurising
GW	gigawatt, or 1 watt $\times 10^9$
HVAC	heating, ventilating and air-conditioning
HVDC	high-voltage direct current
IPP	independent power producer
IT	information technology

J	joule; a joule is the work done when the point of application of a force of one newton is displaced through a distance of one metre in the direction of the force (a newton is defined as the force needed to accelerate a kilogram by one metre per second). In electrical units, it is the energy dissipated by one watt in a second
KAERI	Korea Atomic Energy Research Institute
KATECH	Korea Automotive Technology Institute
KDHC	Korea District Heating Corporation
KEEI	Korea Energy Economics Institute
KEMCO	Korea Energy Management Corporation
KEPCO	Korea Electric Power Corporation
KEPRI	Korea Electric Power Research Institute
KERI	Korea Electrotechnology Research Institute
KEWESPO	Korea East-West Power, Ltd.
KHNP	Korea Hydro and Nuclear Power Co., Ltd.
KIER	Korea Institute of Energy Research
KIGAM	Korea Institute of Geology, Mining and Minerals
KIST	Korea Institute of Science and Technology
KNFC	Korea Nuclear Fuel Cycle
KNGR	Korean Next Generation Reactor
KNOC	Korea National Oil Corporation
KOGAS	Korea Gas Corporation
KOMIPO	Korea Midland Power Co., Ltd.
KOPEC	Korea Power Engineering Company
KOSEPCO	Korea South-West Power Co., Ltd.
KOSPO	Korea Southern Power Co., Ltd.
KOWEPCO	Korea Western Power Co., Ltd.
KPA	Korea Petroleum Association
KPS	Korea Plant Service Engineering Company
KPX	Korea Power Exchange
KSNP	Korean Standard Nuclear Plant
KV	kilovolt
LNG	liquefied natural gas
LPG	liquefied petroleum gas; refers to propane, butane and their isomers, which are gases at atmospheric pressure and normal temperature
LTO	Long Term Co-Operation and Policy Analysis Office of the IEA
LWR	light water reactor

mcm	million cubic metres
MOCIE	Ministry of Commerce, Industry and Energy
MOER	Ministry of Energy and Resources (in 1993 re-merged with MTI to become MOTIE)
MOST	Ministry of Science and Technology
MOTIE	Ministry of Trade, Industry and Energy (in 1998, became MOCIE)
Mt	million tonnes
MTI	Ministry of Trade and Industry (in 1978, the energy division became MOER)
Mtoe	million tonnes of oil equivalent; see toe
MW	megawatt of electricity, or 1 watt $\times 10^6$
MWh	megawatt-hour = one megawatt $\times$ one hour, or one watt $\times$ one hour $\times 10^6$
NEA	the Nuclear Energy Agency of the OECD
NEMMCO	National Electricity Market Management Company
NETA	new electricity trading arrangements
NRSE, N&RE	new and renewable sources of energy
OECD	Organisation for Economic Co-operation and Development
ONMC	Office of Non-Member Countries of the IEA
PHWR	pressurised heavy water reactor
PJM	Pennsylvania, New Jersey, Maryland
POSCO	Pohang Iron and Steel Corporation
ppm	parts per million
ppp	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, i.e. estimates the differences in price levels between different countries
PWR	pressurised water reactor
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well
RFCCU	residue fluid catalytic cracking unit
RPS	renewable portfolio standards
SB	single buyer
SLT	Standing Group on Long-Term Co-operation of the IEA.
TEMM	(China-Japan-Korea) Tripartite Environment Ministers' Meeting
TERGs	Technical Expert Research Groups

TFC	total final consumption of energy; the difference between TPES and TFC consists of net energy losses in the production of electricity and synthetic gas, refinery use and other energy sector uses and losses
toe	tonne of oil equivalent, defined as 10^7 kcal
TPES	total primary energy supply
TW	terawatt, or 1 watt $\times$ 10^{12}
TWh	terawatt $\times$ one hour, or one watt $\times$ one hour $\times$ 10^{12}
UAE	United Arab Emirates
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax
WCN-HDS	whole cracked naphtha hydro-desulphurising
won	Korean unit of currency (won 13 = approximately one US cent)

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