INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

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THE REPUBLIC OF KOREA

2006 Review

INTERNATIONAL ENERGY AGENCY

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.

The IEA member countries are: 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 takes part in the work of the IEA.

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ORGANISATION OF THE REVIEW

REVIEW TEAM

The IEA's 2006 in-depth review of the energy policies of Korea was undertaken by a team of energy policy specialists drawn from IEA member countries and the IEA Secretariat. The team visited Seoul from 6 to 10 February 2006 for discussions with energy administration officials, energy industry groups and non-governmental organisations. The team greatly appreciates the candour and co-operation shown by everyone it met. In particular, the review could not have been possible without the assistance and preparation of Ms. Youn-Soo Kim from the Ministry of Commerce, Industry and Energy and Dr. Moohoun Tom Song from the Korea Energy Economics Institute.

The members of the team were:

Ms. Eva Paaske (team leader)
Deputy Director General
Energy Section, Energy and Water Resources Department
Ministry of Petroleum and Energy
Norway

Dr. Mats Nilsson (former position)
Head of Unit
Energy Markets Inspectorate
Sweden

Mr. Natsuki Shirozu
Researcher
Economic Security Division,
Economic Affairs Bureau
Ministry of Foreign Affairs
Japan

Mr. Frederik Wisselink
Senior Policy Advisor
Directorate General for Energy
Ministry of Economic Affairs
The Netherlands

Ms. Evelyne Bertel
Deputy Head
Nuclear Development Division
Nuclear Energy Agency
Organisation for Economic Co-operation and Development

Mr. Daniel Simmons
Natural Gas Expert
Energy Diversification Division
International Energy Agency

Dr. Noé van Hulst
Director
Office of Long-Term Co-operation and Policy Analysis
International Energy Agency

Ms. Jolanka Fisher
Desk Officer for Korea
Country Studies Division
International Energy Agency

Jolanka Fisher managed the review and wrote the report, with the exception of the chapter on natural gas, which was drafted by Daniel Simmons from the

IEA's Energy Diversification Division, and the chapter on nuclear power, which was drafted by Evelyne Bertel from the Nuclear Energy Agency. Monica Petit prepared the figures and Bertrand Sadin prepared the maps. Sandra Martin and Viviane Consoli provided editorial assistance.

ORGANISATIONS VISITED

The team held discussions with the following energy and environment stakeholders:

- Citizens' Movement for Environmental Justice
- Consumers Korea
- Energy Network (an association of Korean non-governmental organisations)
- Fair Trade Commission
- Korea Coal Corporation
- Korea District Heating Corporation
- Korea Electric Power Corporation
- Korea Energy Economics Institute
- Korea Energy Management Corporation
- Korea Federation for Environmental Movement
- Korea Gas Corporation
- Korea Hydro and Nuclear Power
- Korea Institute of Energy Research
- Korea National Oil Corporation
- Korea Petroleum Association
- Korea Power Exchange
- Korea Water Resources Corporation
- Ministry of Commerce, Industry and Energy
- Ministry of Construction and Transportation
- Ministry of Environment
- New and Renewable Energy Centre
- SK

REVIEW CRITERIA

The IEA *Shared Goals*, which were adopted by IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The *Shared Goals* are set out in Annex B.

EXECUTIVE SUMMARY

The progress made by Korea, the IEA's most recent member, over the last decades is nothing short of remarkable. Faced with phenomenal economic growth, the country's energy infrastructure has not only kept pace, but has also allowed Korea to maintain this growth. In recent years, as growth has stabilised towards more sustainable levels, the country has continued to thrive, particularly in the face of a changing world energy market and increased environmental concerns. As a result of this evolving environment, Korea's energy policy perspective has also changed. The government has expanded its focus from just security of supply at all costs to also encompass economic efficiency and environmental protection. As this expanded set of policy objectives matches the 3 Es of the IEA's agreed goals – energy security of supply, economic efficiency and environmental protection – the IEA applauds Korea's efforts and accomplishments. As in all IEA countries, more can be done to improve energy policies and programmes in Korea to help better achieve these three goals, but the sound framework already in place is impressive.

LIBERALISATION AND ENERGY MARKET REFORM

Perhaps the greatest challenge facing the Korean government regarding its energy policy is the lack of a clear, long-term vision for its energy markets. Although Korea was strongly committed to liberalisation of its natural gas and electricity markets, world events such as blackouts and higher prices have coupled with domestic realities to feed entrenched special interests and scepticism about the benefits of liberalisation. This has left Korea in a precarious situation. Plans for liberalisation have been stalled and gas and electricity industries are now stuck half-way between regulated vertical integration and competitive markets, to the detriment of these industries and, ultimately, the Korean customer. There are gains to be made from pressing forward with liberalisation and dangers from remaining at the crossroads. While the Korean economy to date has experienced tremendous growth, necessitating a constantly expanding energy infrastructure, the transition to lower, less predictable growth is better matched with the flexible, responsive and efficient energy system that a liberalised market can help deliver. Moreover, the lack of a clear framework for the future of Korea's gas and electricity industries adds uncertainty to the markets, undermining efficient outcomes in terms of infrastructure investments, security of supply and overall energy costs. In particular, there are concerns that the lack of a clear and comprehensive reform plan has inhibited long-term contracting for natural gas supplies.

The IEA therefore encourages Korea to set out a clear plan – with milestones and dates – for reform of its gas and electricity markets that includes the necessary ingredients for successful liberalisation. Critical to this reform process are several specific milestones, namely the establishment of a fully independent and powerful gas and power regulator; the elimination of prescriptive government planning; effective unbundling of transmission and distribution from generation and retail; a fully independent system operator; institution of effective open access on the transmission system; the establishment of market-based trading arrangements for wholesale power; removal of policies that inhibit activity from independent power producers; and the establishment of a plan for retail contestability, at least for industrial customers. An entirely separate issue is the privatisation of energy assets. Although privatisation can bring important additional benefits, it is not a critical component for liberalisation and does not need to be undertaken early in the process. It is quite possible to press forward with liberalisation while at the same time stalling privatisation. The establishment of a credible and powerful regulator is the most important first step in order to reassure market participants that the liberalised market will be monitored impartially and consistently, particularly in a situation where many assets remain state-owned.

In addition to codifying a reform plan for Korea's gas and electricity markets, the government should establish a comprehensive and co-ordinated energy strategy, and a framework that involves all stakeholders, improves co-ordination across different ministries and government entities, integrates the environmental dimensions of energy consumption into energy policy, introduces more checks and balances and enhances transparency of the policy-making process. Taken together, this would allow Korea to have a better aligned energy policy, so that different government agencies are better able to co-operate and energy policy objectives are met through effective programme implementation in all parts of the government. While Korea is working to improve policy transparency and co-ordination, particularly with respect to environmental policy, the IEA encourages the government to strengthen its efforts.

CLIMATE CHANGE, ENVIRONMENT AND EFFICIENCY

Korea is working to improve energy efficiency and lower the growth of greenhouse gas emissions, but it has not taken on any binding emissions targets under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Given the country's current level of economic development – it now has a GDP per capita above some other IEA countries – the country should consider setting out climate change-specific targets and

objectives. The rapid growth of Korea's emissions – emissions are projected to grow by 70% between 2000 and 2030 – makes setting such targets and objectives vital. Critical to limiting greenhouse gas emissions growth in the most cost-effective manner is putting a price on carbon, either in the form of a direct tax or through an emissions trading scheme where the market determines the price. Korea should ensure that greenhouse gas targets are met through flexible market-based mechanisms to make the process as dynamic and transparent as possible.

Though many other factors affect air quality, energy-related emissions, primarily from power plants and transport sources, are a major source of air pollution. Air quality in Korea is generally poor in most of its large cities, particularly Seoul, in comparison to other OECD countries. The government is therefore commended for establishing ambient air quality standards, which will help improve air quality, as well as the quality of life for Korean citizens. The government should continue to monitor these standards, and ensure that they are enforced. If necessary, stronger measures or other policies, including an emissions trading scheme, should be considered.

Improved energy efficiency has much to offer Korea. The country has relatively low energy efficiency, owing in part to its rapid development and its heavy industrial base, and although declining, energy intensity is expected to remain high. Improved efficiency could lower total energy costs, enhance energy security by lowering overall energy import needs and reduce greenhouse gas emissions. The IEA commends Korea's three-year plan to improve the overall efficiency of the country by 2007. However, as Korea's energy consumption is growing rapidly, the savings stemming from efficiency will have a relatively small impact on total consumption, which will still be 15% higher in 2007 than in 2003. The IEA encourages Korea to consider setting more ambitious efficiency targets, particularly in the transport and residential sectors. To that end, the new long-term 2020 efficiency goals for the transport and building sectors are a good first step in strengthening these targets.

The IEA applauds Korea's performance in two areas related to energy efficiency, namely fuel economy and standby power appliance standards. Korea has introduced fuel economy standards for the first time, a critical step given the country's rapidly growing car fleet. The IEA encourages Korea to monitor these standards, ensure compliance with them and establish a clear timetable for implementing more stringent standards in the future, keeping its standards in line with world best practice. With respect to appliance standards, Korea's initiative to limit standby power to one watt through the Standby Korea 2010 programme is the first implementation of the IEA's 1-watt initiative in the world and, as such, is a model for other countries. We encourage the government to work to merge

its standby standards with overall energy performance standards, reducing the administrative and regulatory burden for companies and the government, which now administer two sets of standards independently. Korea's efforts to improve the efficiency of vehicles and appliances are notable not only because of their strong effect on domestic energy efficiency, but also because, as a net exporter of these products, Korea's policies will benefit global energy efficiency. Furthermore, the vast and growing public transit network in Seoul and other Korean cities is a model for other countries, particularly as evidenced by the very high public transit usage rates.

The share of new and renewable energy sources in Korea's overall energy mix is the lowest of all IEA countries – 2.1% of total primary energy supply in 2004. Korea's targets to raise this level to 3% in 2006 and 5% in 2011 are therefore welcome. However, Korea is unlikely to meet its 2006 goal, which makes strengthening policies critical to meeting the 2011 target. To ensure the 2011 target is met, the IEA encourages the government to set a detailed timetable and monitor progress so that any necessary policy modifications can be made as quickly as possible. We also encourage the government to set a cost-effective biofuels target and put in place a flexible means of achieving the target, as this would help increase renewable energy and reduce reliance on imported oil.

One means of improving the effectiveness of policies to increase new and renewable energy deployment is by conducting more rigorous cost-benefit analysis of policies, particularly in light of long-term targets. For example, Korea's current plan provides the greatest share of funding for photovoltaics and hydrogen fuel cells, although these technologies are forecast to contribute a small share of the total new and renewable energy in the medium term. Moreover, the government's reliance on a differentiated feed-in tariff, where specific technologies are given guaranteed energy prices, may raise the overall cost of the programme. For example, solar photovoltaics receive a feed-in tariff that is more than six times that of wind. While the government provides this preferential support to develop a long-term solar photovoltaics export market, the risk is that the government is only raising the overall cost of supporting renewable energy development, and developing an industry with artificial and, therefore, unsustainable economics. The government should outline feed-in tariff levels for the long term, and consider lowering differentials in feed-in tariffs over time to avoid creating entrenched and hard-to-remove subsidies for particular technologies. In addition, the government should consider replacing feed-in tariffs with more market-based alternatives, such as a green certificate scheme. This cost-effect approach continues to promote renewables and reflect the costs of environmental externalities, but allows support levels to adapt to market conditions instead of guaranteeing a fixed and permanent subsidy.

ENERGY PRICING

Cost-reflective pricing can be the most effective means of spurring efficiency. However, in Korea, certain classes of customers, namely industrial and agricultural customers, pay energy prices that are below cost. Furthermore, subsidies are provided to domestic coal producers and consumers. This encourages inefficient consumption of resources and raises the total cost of energy for Korean customers. With respect to coal subsidies, which help maintain domestic production as a means of assuring security of supply, the lack of good-quality coal resources in Korea and the abundance of coal from diverse sources on the world market make this a very costly policy, especially considering the small volume of coal actually produced. Throughout its energy system, Korea should remove all subsidies – both to particular customer classes and across fuels – and let prices reflect true costs. This will necessitate strong political will on the part of the government, but is necessary to underpin an energy system that provides stable supply at the lowest cost over the long term.

In the electricity and gas markets, expansion of time-of-use and, preferably, real-time pricing could help lower costs and enhance security. In electricity markets, the electricity company, KEPCO, has installed advanced meters at many locations. We encourage the government to take advantage of this investment, and help design the market so that real-time pricing can be offered to as many customer classes as possible, including all industrial customers. In the gas market, Korea's seasonality of demand is a cause for concern; around four times more gas is used in the winter than in the summer, largely as a result of space heating demand. This leads to higher gas procurement costs, as producers of liquefied natural gas – which supplies nearly all of Korea's demand – supply steady off-take of natural gas through long-term contracts. Korea is working to estimate the higher actual costs and reflect them in customer pricing through surcharges. While we commend this strategy, we also encourage the government to move from estimated and administratively set price signals to a market design that allows end-use customers to see true time-varying supply costs. Such transparency would help lower overall costs as many customers could shift lower-value consumption to lower-cost periods.

OIL MARKET

Korea's oil industry has been liberalised since the 1990s and the country is now a major exporter of crude products. Although oil still makes up a relatively large share of Korea's energy use compared to most countries, particularly in the industrial sector, Korea has successfully diversified its fuels and fuel sources. With respect to the oil market, we encourage the government to continue to monitor the sector carefully and, if necessary, strengthen efforts

to prevent and penalise anti-competitive behaviour. One key area of concern is the differentiated import taxes for crude oil and oil products, which give preferential treatment to Korea's large refineries at the expense of domestic product importers. The government should remove these differentiated import tax rates. With respect to its oil stockholding obligation, the IEA applauds Korea's strong commitment; its reserves have never fallen below the 90-day net import obligation and reserves are currently well above the minimum level. To ensure ongoing compliance, the government should continue to monitor its oil loan programme so that the loans do not result in Korea's stocks falling below the 90-day level and that any effects on stock levels stemming from the loans are reflected in data submitted to the IEA in a timely and transparent manner. Most importantly, the government should ensure that loans are made solely to mitigate unexpected supply disruptions, and only under fair and transparent terms to all market participants.

UPSTREAM GOVERNMENT INVESTMENTS IN FOSSIL FUELS DEVELOPMENT

Korea relies heavily on imports to meet its energy needs, given that it has no oil reserves, a very small amount of natural gas and some low-quality coal reserves. As part of its strategy to ensure security of supply, the government has been investing in upstream development of fossil fuels, although private companies play a more leading role in upstream activities. Nevertheless, as international resource development is highly competitive and not without risk, the government should consider leaving these investment decisions to private-sector Korean companies that also value security of supply and may be better equipped to make these complex investment decisions.

NUCLEAR INDUSTRY

Despite the relative youth of Korea's nuclear industry, it is a model for other countries. The government has put in place a comprehensive regulatory framework and the industry has an excellent safety record. Furthermore, nuclear plants in Korea have an average capacity factor above 90%, which is well above the world average of less than 80%. In recent years, Korea's most notable achievement has been the selection of a site for a low- and medium-level waste disposal facility. After incorporating lessons from previous unsuccessful site selection processes in Korea, the government put in place a world class site selection process that was transparent, fair and democratic. It also provided regulatory certainty and economic incentives. Korea has developed a process that can serve as a model for other countries, an achievement the IEA applauds. We encourage the government to expand on this success in two ways. First, we encourage the government to set up a

process for selection of a high-level waste disposal facility. Although this is not an immediate concern, world experience demonstrates that selecting a high-level waste disposal facility is a very long process. Second, we encourage the government to apply the transparent, fair and democratic nature of the site selection process to Korea's overall nuclear industry, helping to inform all government decisions. Korea's nuclear industry will continue to thrive if all stakeholders are part of a transparent and open dialogue. Going forward, we also encourage Korea to pay close attention to the funding and monitoring mechanism for the financing of decommissioning. In addition, we encourage the government to ensure that the nuclear safety regulator continues to be fair and independent.

RESEARCH AND DEVELOPMENT

In a time of falling R&D budgets, the IEA applauds Korea's rising budget for energy R&D. Korea should also be commended for its commitment to international co-operation and its recent explicit linking of its R&D funding framework with its overall energy policy goals. This will help better ensure that Korea's long-term policy goals are met. As Korea continues to develop its R&D funding framework, the IEA encourages the country to make cost-effectiveness a key criterion for project selection in most cases; to fund a handful of risky projects that could have a high payoff; to better incorporate environmental goals in the project-selection process; to fund research that looks at Korea's domestic resources of wind, biomass, geothermal, ocean and coal-bed methane; and to conduct research on international experience with the energy market liberalisation process.

RECOMMENDATIONS

The government of Korea should:

General Energy Policy

- *Continue to diversify energy supply and curb oil dependence, in part through enhanced energy efficiency policies and improved policy co-ordination.*
- *Re-launch energy market reform in electricity and gas markets, noting that liberalisation does not require privatisation.*
- *Establish independent electricity and gas market regulators with powers and responsibilities consistent with best practices of IEA countries. In particular, ensure that the regulator monitors third-party access to network*

infrastructure and has the power to penalise operators who do not comply with the terms.

- *Introduce more checks and balances – including transparent policy processes that involve all stakeholders – in energy policy at all its stages.*

- *Improve co-ordination and communication between the Ministry of Commerce, Industry and Energy; the Ministry of Environment; the Ministry of Finance and Economy; the Ministry of Construction and Transportation; and other relevant bodies, to ensure that all energy-related government policies are consistent.*

- *Integrate the environmental dimensions of energy production and consumption into energy policy in a systematic way. Implement market-based mechanisms (*e.g. *carbon taxes and/or emissions trading) to provide a CO_2 price signal.*

Energy and the Environment

- *Set out climate change-specific targets and objectives and precise measures that are to be taken over the next few years to reduce the rate of growth of greenhouse gas emissions in order to participate actively in the United Nations Framework Convention on Climate Change process.*

- *Strengthen CO_2 mitigation measures, monitor all measures to ensure effective implementation and consider using an emissions trading system consistent with international trading systems, and/or a CO_2 tax.*

- *Continue to strengthen bilateral and multilateral co-operation in enhancing global efforts to tackle climate change.*

- *Assess the effectiveness of existing policy measures intended to improve air quality in all metropolitan areas and strengthen them if necessary. Use market-based mechanisms to internalise environmental costs.*

- *Continue to ensure that emissions of regional pollutants from coal-fired power plants are and remain in line with best-performing IEA countries.*

Energy Efficiency

- *Consider setting more ambitious energy efficiency targets and timetables in light of the country's rapidly growing energy use, particularly in the transport and building sectors; monitor these targets and timetables to ensure that they are met.*

- *Ensure that energy prices in all sectors reflect costs and eliminate any subsidies.*

- *Monitor compliance with vehicle fuel economy standards; ensure that fuel economy standards remain in line with best practices of IEA countries and, as quickly as possible, set a timetable for progressively tightening these standards.*

- *Monitor voluntary agreements to ensure they achieve the expected targets; if they are not being met, consider enhanced or alternative policies.*

- *Evaluate current efficiency standards for buildings and make sure that they are and remain consistent with best practices of IEA countries with a similar climate. Strengthen enforcement if necessary.*

- *Consider merging standby energy performance standards with overall energy performance standards for major appliances to reduce the regulatory and administrative burden of the policy.*

New and Renewable Energy

- *Set interim milestones and monitor progress towards meeting existing goals for the penetration of new and renewable energy, and revise or enhance policies and measures if milestones are not being met.*

- *Ensure a co-ordinated and comprehensive policy for renewables support; ensure that there is co-ordination and communication across government ministries and other entities.*

- *Evaluate all renewables promotion policies (*e.g. *differentiated feed-in tariffs) and select those that maximise cost-effectiveness.*

- *Outline feed-in tariff levels for the long term; consider lowering differentials in feed-in tariffs over time to reflect the technology learning curve and avoid entrenched oversubsidisation.*

- *Establish a realistic biofuels target and implement a comprehensive strategy to meet this target.*

Coal

- *Set a clear timetable and deadline for phasing out – with the goal of eliminating – domestic coal production and consumption subsidies; replace subsidies with direct assistance for low-income customers and regional policy measures if necessary.*

- *Promote energy security through the availability of freely traded coal on an international market, rather than through resource ownership.*

Oil

- *Continue efforts to lower oil dependence and diversify oil supply sources.*

- *Continue to closely monitor the market and, if necessary, take measures to prevent unfair practices.*
- *Work to phase out differentiated import tax rates for crude oil and petroleum products in order to increase competition by levelling the retail market playing field.*
- *Continue to ensure that oil loans to industry do not result in stocks falling below mandated IEA levels and that any transactions that result in stock level changes are reflected in data submitted to the IEA in a timely manner.*
- *Ensure that oil loans to industry are made solely to mitigate unexpected supply disruptions, and only under fair and transparent terms applying equally to all market participants.*

Natural Gas

- *Build on earlier efforts to open up the gas market by establishing a timetable for comprehensive gas market reform, beginning the process as soon as possible.*
- *Establish an independent regulator to oversee the gas market as the first step in the liberalisation process.*
- *Institute open access/regulated third-party access on pipelines and ensure the regulator monitors open access implementation and has the power to penalise network operators who do not comply with the terms.*
- *Ensure that the relevant regulator monitors the activities of the incumbent gas supplier so that these activities do not result in the abuse of market power when the market is liberalised.*
- *Effectively unbundle and regulate transmission and distribution from other parts of the value chain to enable competition while ensuring fair access.*
- *Let price signals encourage customers to use gas in ways that reduce overall seasonal variations in natural gas consumption.*
- *In the absence of sufficient price signals, implement cost-effective policy measures to smooth gas demand across winter and summer.*
- *Consider revising the existing gas emergency planning procedures to take account of structural changes in the power market that may render it less effective.*

Electricity

- *Re-launch electricity market reform as soon as possible and establish a timetable with milestones.*

- *Restructure and empower the Korea Electricity Commission to become an independent regulator with sufficient power to oversee the electricity market as the first step in the liberalisation process. Have the regulator establish network tariffs using methodologies in accordance with those of best-performing IEA countries.*

- *Effectively unbundle transmission and distribution from generation.*

- *Ensure that all undue barriers to effective competition in the generation sector are removed and that the Fair Trade Commission or the Korea Electricity Commission monitors competition. Pay particular attention to the role of independent power producers in the market.*

- *Ensure that the Fair Trade Commission or the Korea Electricity Commission monitors the activities of the Korea Electric Power Corporation so that its activities do not result in the abuse of market power.*

- *Improve economic production and efficiency by providing incentives in transmission and distribution network regulation. Consider pricing transmission by location to encourage generation to be built and demand to be located in areas where it relieves congestion.*

- *Ensure that the independent regulator closely monitors wholesale price formation.*

- *Consider implementing trading arrangements, including a bid-based pool or bilateral contracting, that rely on competitive pressure to determine prices that reflect costs and signal scarcity.*

- *Eliminate price distortions and cross-subsidies, and, where necessary, adjust taxation so that electricity generation reflects environmental costs. In particular, phase out industrial and agricultural price subsidies.*

- *Replace prescriptive government planning of the future supply mix with flexible policy and transparent informational scenarios and forecasts consistent with liberalisation.*

Nuclear Energy

- *Ensure that citizens and other stakeholders receive balanced information and take part in an open dialogue on the benefits and risks of nuclear facilities in their communities, taking advantage of best practices in other countries.*

- *Establish a detailed roadmap for the management and final disposal of spent fuel and other high-level waste, and take steps as soon as possible to begin implementation of the option selected, taking advantage of the experience gained by the recent site selection.*

- *Continue monitoring the level of decommissioning and waste disposal funds and their management in order to ensure that adequate money will be available for those actions.*
- *Continue to ensure the independence, expertise and strength of the safety authority.*

Research and Development

- *Ensure that R&D priorities and investment levels well reflect energy policy objectives.*
- *Improve links between R&D expenditures and environmental policy objectives by including environmental criteria in cost-benefit analysis.*
- *Conduct cost-benefit analysis of R&D expenditures where appropriate.*
- *biomass, ocean, geothermal and coal-bed methane.*
- *Consider increasing financial support for R&D in alternative transport fuels, such as biofuels, given the rapid rise in fossil fuel use in transport.*
- *Assess the feasibility of various advanced clean coal technologies and continue to participate in international technology development efforts.*
- *Increase research on the functioning of liberalised energy markets, possibly in co-operation with international partners.*
- *Ensure that the comprehensive R&D programme continues to support the operation and maintenance of existing and future nuclear facilities, and actively participate in international co-operation.*

COUNTRY OVERVIEW

The Republic of Korea is located in the southern half of the Korean Peninsula (see Figure 1). It occupies 98 480 square kilometres – making it slightly larger than Portugal – and has a 238 km boundary with North Korea. The county also includes about 3 000 mostly small, uninhabited islands. Korea is a mountainous country, with lowlands accounting for only 30% of the total land area. The climate is temperate, with rainfall heavier in summer than in winter. Korea has a population of 48 million, about 85% of which live in urban areas. In 2003, Seoul's population of 10.3 million people made it the world's most populated city (excluding greater metropolitan areas). Other large cities include Pusan (3.8 million), Inchon (2.6 million), Daegu (2.5 million), Daejeon (1.4 million) and Gwangju (1.4 million).

Korea, called Daehan Minguk in Korean, is a democratic republic with powers shared between the president, legislature and judiciary. The president is elected by direct popular vote for a single five-year term. The current head of state was elected in December 2002. The president has considerable executive powers and appoints the prime minister with approval of the National Assembly. He also appoints and presides over the State Council, or cabinet. The current prime minister was appointed in April 2006. The National Assembly is made up of 299 seats with members elected every four years; the last election was in April 2004.

Korea, one of the Asian Tigers, has experienced tremendous economic growth over the last decades. In the 1960s its gross domestic product (GDP) per capita was comparable to levels in poorer Asian and African countries. At about USD 21 000 in 2004 values (equivalent to about KRW[1] 20.5 million), GDP per capita is now above that of some European Union (EU) countries. After impressive growth, GDP plunged to -7% in 1998, but has since rebounded. GDP growth rates in the years from 2001 to 2005 were 3.8%, 7.0%, 3.1%, 4.7% and 3.4% respectively. The economy is dominated by manufacturing, particularly of electronic products, passenger vehicles, machinery and chemicals. Agriculture, forestry and fishing made up 25% of total GDP in 1973. This share fell to 3% by 2003.

1. On average in 2005, KRW 1 000 = USD 0.98 = EUR 0.79.

Figure 1

Map of Korea

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: IEA.

A unique aspect of the Korean economy is the existence of *chaebol*, family-controlled conglomerates. Although the dominance of *chaebol* in the Korean economy has diminished, particularly since the Asian economic crisis in the late 1990s, they remain heavily involved in the economy. The big four remaining *chaebol* are Hyundai, Samsung, LG and the SK Group.

Another important aspect of the Korean political and economic landscape is the relatively powerful position of labour unions. For example, the resistance of labour unions to economic reforms has scuttled government plans to privatise the rail system and KEPCO, the state electricity monopoly. The current union membership rate is 11%, down from over 20% in the early 1990s.

ENERGY INDICATORS

Korea has very limited supplies of indigenous natural resources. It has no domestic oil resources and only a very small amount of natural gas has been produced locally (starting in 2005). However, Korea is the world's second-largest importer of liquefied natural gas (LNG); KOGAS, the government-owned gas supplier, is the world's single largest LNG purchaser. The country does have indigenous anthracite coal resources, but imports most of its coal, which is bituminous, or hard, coal. Given Korea's exposure to rising world commodity prices, the government has estimated that the cost of energy imports in 2005 would be USD 66 billion, a 33% increase from 2004.

Recognising its high dependence on external sources of energy, Korea has successfully managed to diversify its energy supply. It has also made efforts to explore for oil both in its own territory and abroad. Security of gas supply is of growing importance owing to the rising share of natural gas in Korea's energy sector and the country's total dependence on imported LNG. Korea has successfully diversified its gas supply sources covering both the Asian Pacific and the Middle East.

SUPPLY-DEMAND BALANCE

Korea's total supply-demand balance in 2004 is presented in Table 1. Total supply was 213 million tonnes of oil equivalent (Mtoe), over 85% of which was imported. In terms of demand, 33% was for industrial consumption, 23% for electricity generation, 16% for transportation, 10% for commercial and other sectors and 8% for the residential sector. The remaining 10% is accounted for in other transformations, losses and statistical differences.

Table 1

Supply-Demand Balance, 2004

Units: Mtoe	*Total*	*Oil*	*Coal*	*Nuclear*	*Natural gas*	*Combustible renewables and waste*	*Hydro*	*Electricity*	*Heat*
Supply									
Production	38.0	0.4	1.4	34.1	0.0	1.7	0.4	0.0	0.0
Imports (net of exports)	184.0	107.8	50.2	0.0	25.9	0.0	0.0	0.0	0.0
Other	-9.0	-6.9	-1.5	0.0	-0.6	0.0	0.0	0.0	0.0
Total primary energy supply	**213.0**	**101.4**	**50.1**	**34.1**	**25.3**	**1.8**	**0.4**	**0.0**	**0.0**
Demand									
Electricity generation*	48.2	5.4	33.3	34.1	10.6	0.3	0.4	-31.5	-4.4
Industrial sector	69.9	39.9	6.9	0.0	3.9	1.1	0.0	15.2	2.9
Transportation sector	34.2	33.8	0.0	0.0	0.2	0.0	0.0	0.2	0.0
Commercial and other sectors	22.2	9.7	0.0	0.0	2.6	0.3	0.0	9.4	0.2
Residential sector	17.3	3.4	0.7	0.0	7.7	0.0	0.0	4.2	1.3
Other	21.2	9.2	9.2	0.0	0.2	0.0	0.0	2.5	0.1
Total consumption	**213.0**	**101.4**	**50.1**	**34.1**	**25.3**	**1.8**	**0.4**	**0.0**	**0.0**
Fuel as share of total		**48%**	**24%**	**16%**	**12%**	**1%**	**0%**	**0%**	**0%**

* The electricity production row shows inputs and outputs of fuel used to generate electricity, CHP and heat (84.1 Mtoe total in inputs of oil, coal, nuclear, natural gas, combustible renewables and waste, and hydro; 35.9 Mtoe in output in the form of electricity and heat). This reflects a 43% average efficiency of conversion of fuel to electricity and commercial heat.

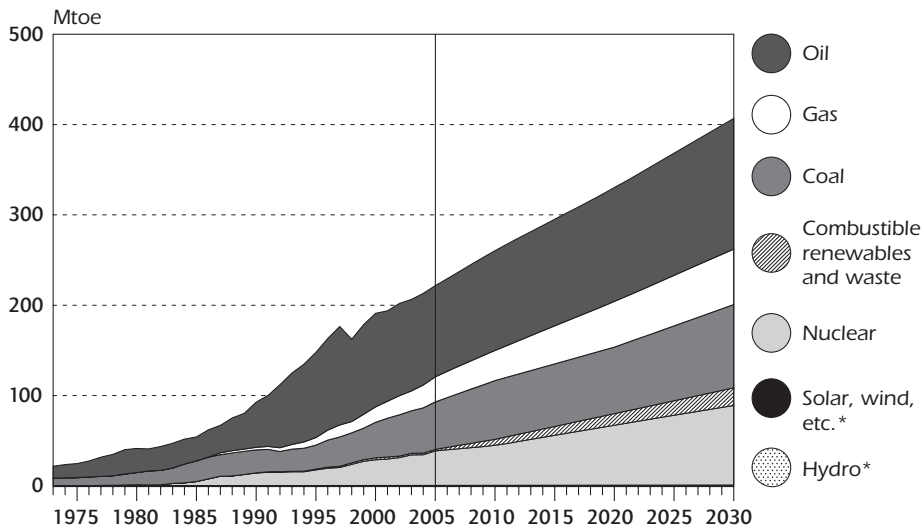
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

TOTAL PRIMARY ENERGY SUPPLY

Although total primary energy supply (TPES) is dominated by oil and coal, nuclear power and LNG also supply a significant share of the country's TPES. A breakdown of TPES by source from 1973 through projections to 2030 is shown in Figure 2. TPES increased over ninefold between 1975 and 2005, growing at an average annual rate of 7.3% since 1985 and 4.1% since 1995. The greatest average annual increase in fossil fuels over the last decade has been in natural gas, which has grown at a rate of nearly 13%. Alternatively, oil has risen at an average annual rate of 0.5% over the last decade. In 2005, Korea had the sixth-largest amount of nuclear power (38.3 Mtoe) and the sixth-largest share of nuclear in its overall TPES (17%) of the 15 IEA countries with nuclear in their energy mix.

Figure 2

Total Primary Energy Supply, 1973 to 2030



* negligible.

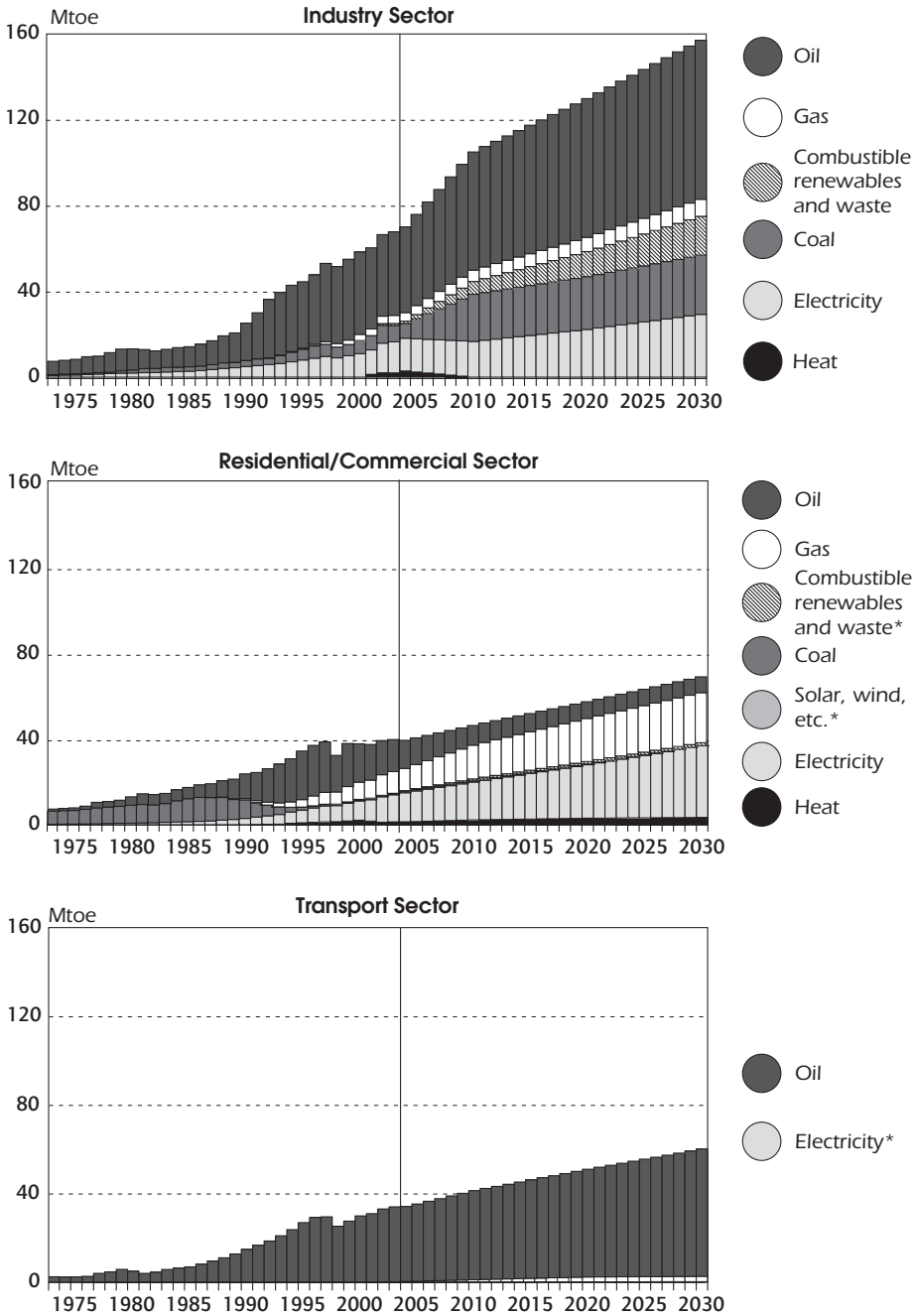
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

TOTAL FINAL CONSUMPTION

Total final consumption (TFC) in 2004 was 144 Mtoe; it has been growing at an average annual rate of over 7% for the last two decades. Nearly half (49%) of TFC was used by the industrial sector in 2004 (see Figure 3), owing to tremendous growth in the last few decades. Consumption in the industrial sector has grown at an average annual rate of 8.5% since 1984 and 5% during the last decade.

Figure 3

Total Final Consumption by Sector and by Source, 1973 to 2030



* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

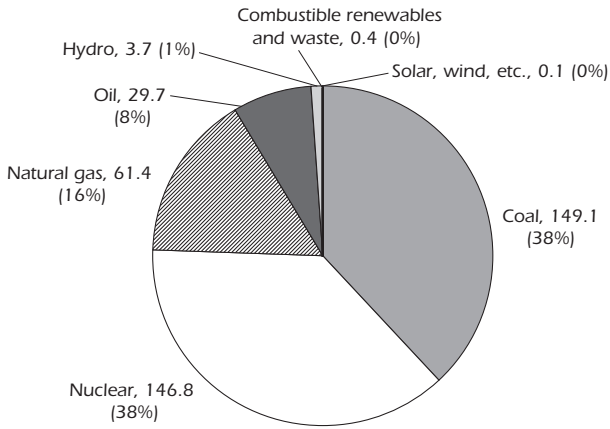
Consumption of natural gas in the industrial sector has grown elevenfold in the last decade – equal to an average annual increase of 27%. Oil accounts for a relatively large share of industrial consumption – 57% of the total in 2004. Final consumption in the transport sector reached 24% in 2004, and grew at an average annual rate of 9% between 1974 and 2004 and 4% over the last decade. Outside the transport and industrial sectors, consumption increased by 28% over the last decade. In particular, residential consumption has more than doubled since 1994.

ELECTRICITY PRODUCTION

In 2005, generators in Korea produced 391 TWh of electricity (see Figure 4). Coal and nuclear combined provided over three-quarters of Korea's electricity. Natural gas fuelled 16% of generation. Consistent with Korea's spectacular economic growth over the past three decades, electricity generation in 2005 was nearly 20 times larger than in 1975. Over the last decade, growth has been much more moderate, but still quite high compared to other IEA countries. Total electricity consumption has grown at an average annual rate of 8%. When broken down by fuel, coal, natural gas and nuclear have grown by an average annual rate of 12%, 12% and 8%, respectively.

Figure 4

Electricity Generation, 2005*



Total = 391 TWh

* estimates.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006.

ENERGY INTENSITY

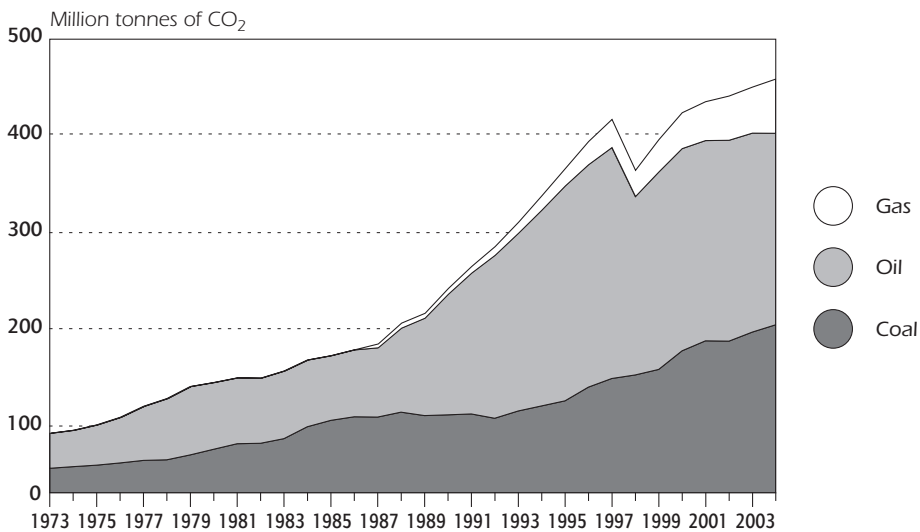
Korea's energy intensity, a measure of energy use per unit of GDP, has not been falling steadily over the past few decades, as it has for many IEA countries. Instead, energy intensity, which was flat until around 1990, grew to a peak in 1997 and has been declining since. Nonetheless, it remains above both the IEA average and the average of IEA Pacific countries (Australia, Japan, Korea and New Zealand); it is expected to be 33% above the IEA Pacific average and 25% above the full IEA average in 2010.

CO_2 EMISSIONS

As shown in Figure 5, emissions of carbon dioxide (CO_2) have grown dramatically in recent years, more than doubling between 1990 and 2004, at an average annual rate of 5.2%. Owing to the steep economic slow-down in the late 1990s, CO_2 emissions dropped dramatically in 1997, but rebounded quite quickly.

Figure 5

CO_2 Emissions by Fuel*, 1973 to 2004



* estimated using the IPCC Sectoral Approach.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2006.

FORECASTS

ENERGY

The government has developed total primary energy supply (TPES) forecasts for 2011, 2015 and 2020 under two different scenarios, the business-as-usual (BAU) scenario and the policy scenario. The results of these forecasts are shown in Table 2. Under the BAU scenario, total TPES is predicted to rise by nearly 70% between 2001 and 2020; it is expected to rise by 37% between 2006 and 2020, equivalent to an average annual rate of 2.3%. In comparison, under the policy scenario, TPES is predicted to be almost 7%, or 22 Mtoe, below the BAU case in 2020. The policy case assumes that in addition to existing policies, planned policies are also implemented. However, proposed government policies to expand energy supply from new and renewable energy sources are not reflected in the policy case.

CARBON DIOXIDE

Carbon dioxide (CO_2) emissions rose by nearly 90% between 1990 and 2000, equivalent to an average annual increase of 6.6% (see Table 3). Through 2030 the rate of increase is expected to slow. The largest increases in energy-related CO_2 emissions come from natural gas, whose emissions are forecast to nearly double between 2000 and 2010. Between 2000 and 2030 emissions from natural gas are predicted to increase by more than three-and-a-half times.

ENERGY POLICY OBJECTIVES

Korea's overall energy policies seek to achieve sustainable development through energy security, energy efficiency and environmental protection (the 3 Es). This policy marks a change from Korea's historical energy policy goals, which had focused on ensuring a stable energy supply to sustain economic growth and maintain a high-quality lifestyle for Korean citizens. Korea's energy policies now promote stable energy supply, market efficiency through competition and the implementation of an environment-friendly energy system with the end-goal of sustainable development.

ENERGY DIVERSIFICATION

As a peninsula with very limited domestic energy resources, Korea is particularly concerned with security of supply and energy diversification. To that end, the government is focused on the extended use of natural gas, bituminous coal and nuclear power. It is also aiming to reduce its reliance on

Table 2

Forecasts of TPES, 2001 to 2020

Units: Mtoe							*Average annual change*		
Fuel	*Scenario*	*2001*	*2006*	*2011*	*2015*	*2020*	*2001-2006*	*2001-2020*	*2006-2020*
Coal	BAU case	45.7	52.4	65.6	67.1	72.0	2.8%	2.4%	2.3%
	Policy case	45.7	52.4	60.2	59.1	62.6	2.8%	1.7%	1.3%
	Difference	*0*	*0*	*5.4*	*8.0*	*9.4*			
Oil	BAU case	100.4	124.2	136.8	145.9	157.7	4.3%	2.4%	1.7%
	Policy case	100.4	116.3	125.4	131.8	139.6	3.0%	1.7%	1.3%
	Difference	*0*	*7.9*	*11.4*	*14.1*	*18.1*			
LNG	BAU case	20.8	29.3	31.1	39.3	45.8	7.1%	4.2%	3.2%
	Policy case	20.8	31.2	33.2	41.7	48.0	8.4%	4.5%	3.1%
	Difference	*0*	*-1.9*	*-2.1*	*-2.4*	*-2.2*			
Hydro	BAU case	1	1.1	1.2	1.2	1.2	1.9%	1.0%	0.6%
	Policy case	1	1.1	1.2	1.2	1.2	1.9%	1.0%	0.6%
	Difference	*0*	*0*	*0*	*0*	*0*			
Nuclear	BAU case	28	32.6	41.2	45.3	50.6	3.1%	3.2%	3.2%
	Policy case	28	32.6	43.5	47.8	52.0	3.1%	3.3%	3.4%
	Difference	*0*	*0*	*-2.3*	*-2.5*	*-1.4*			
Firewood, etc.	BAU case	2.3	3.7	5.2	5.7	6.9	10.0%	6.0%	4.6%
	Policy case	2.3	4.0	5.8	6.8	8.6	11.7%	7.2%	5.6%
	Difference	*0*	*-0.3*	*-0.6*	*-1.1*	*-1.7*			
Total	**BAU case**	**198.2**	**243.3**	**281.1**	**304.5**	**334.2**	**4.2%**	**2.8%**	**2.3%**
	Policy case	**198.2**	**237.6**	**269.3**	**288.4**	**312.0**	**3.7%**	**2.4%**	**2.0%**
	Difference	***0***	***5.7***	***11.8***	***16.1***	***22.2***			

Notes: "BAU"= business as usual. The forecasts presented here differ from the BAU forecasts presented in Annex A so that they can be compared with the policy case scenario.
Source: *The Second National Energy Plan, 2002-2011*, Korea, 10 December 2002.

Table 3

CO_2 Emissions by Fuel*, 1980 to 2030

Units: $MtCO_2$	*Actual*			*Forecast*			*Percentage change (average annual change)*							
	1980	*1990*	*2000*	*2010*	*2020*	*2030*	*1990-2000*		*2000-2010*		*2000-2020*		*2000-2030*	
Oil	74	133	223	230	262	302	68%	(5.3%)	3%	(0.3%)	17%	(0.8%)	35%	(1.0%)
Coal	48	86	157	241	273	342	82%	(6.2%)	54%	(4.4%)	74%	(2.8%)	118%	(2.6%)
Natural gas	0	6	40	78	118	143	524%	(20.1%)	97%	(7.0%)	196%	(5.6%)	261%	(4.4%)
Combustible renewables and waste	0	0	8	5	5	5			-39%	(-4.8%)	-39%	(-2.4%)	-39%	(-1.6%)
Total	**122**	**226**	**428**	**555**	**658**	**792**	**89%**	**(6.6%)**	**30%**	**(2.6%)**	**54%**	**(2.2%)**	**85%**	**(2.1%)**

* estimated using the IPCC Sectoral Approach based on the BAU scenario.

Sources: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2006 and country submission.

imported oil, as well as to diversify its oil import sources in order to reduce risks from volume and price fluctuations of crude oil.

OVERSEAS RESOURCE DEVELOPMENT

The government is involved in overseas resource development as a means of ensuring security of supply. The country began its overseas resource development businesses in 1977; as of the end of August 2006, 199 projects were under way. There were a number of successful cases reported, such as the development of the Vietnam 15-1 oilfield and the Donghae-1 continental shelf gas field. Korea is planning to continuously develop overseas oilfields and mineral resources, launching a Caspian Sea oilfield development project, and participating in the resource development business, particularly in western China's development project.

ADDRESSING CLIMATE CHANGE

Korea joined the United Nations Framework Convention on Climate Change (UNFCCC) in December 1993 and ratified the Kyoto Protocol in November 2002. Under the agreement, Korea does not have a greenhouse gas (GHG) emissions target and there is no timetable for the country to take one on. Nevertheless, the government is promoting various voluntary GHG reduction policies and measures in many sectors, recognising that energy savings and the resulting GHG savings correspond not only to international co-operation but also to the long-term development direction of Korea's economy. In particular, the government is accelerating the transition of the economy to industries that consume less energy, and reinforcing its efforts to save energy in each economic sector. To promote its efforts, the government has organised the Inter-Ministerial Committee on the UNFCCC, headed by the prime minister.

DEVELOPMENT AND DISSEMINATION OF NEW AND RENEWABLE ENERGY TECHNOLOGIES

The government has set a target for new and renewable energy to comprise 5% of primary energy consumption by 2011. As this share was only about 2.1% in 2004, which is lower than that of other developed countries, and was mostly waste and hydropower, not wind power and photovoltaics, in December 2003 the government established the *Basic Plan for New and Renewable Energy Technology Development and Dissemination*. This programme aims to set up concrete technology development plans and dissemination targets for each year. In addition to targeting the development

of existing renewable energy technologies, the government is planning to establish the base for a transition to a hydrogen economy.

IMPROVED ENERGY EFFICIENCY

The high economic growth in Korea has induced a substantial increase in energy demand. Recently, however, the country's energy intensity has been trending down, stimulated by the government's energy efficiency policies. In 2004, the government launched a three-year plan from 2005 to 2007 to improve energy efficiency. The plan spans 18 ministries and includes 88 work plans. It focuses on regional energy planning, voluntary agreements with industry, development of energy services companies, promotion of mass transit, implementation of vehicle fuel economy standards, development of household appliance standards and labels, and the promotion of district heating. In total, the government hopes to save almost 18 Mtoe over the period, with most savings coming from the industrial sector, equivalent to about 2.7% of annual energy consumption over the three-year period.

RESTRUCTURING OF GAS AND ELECTRICITY INDUSTRIES

In 1999, Korea announced its plans for restructuring the electricity and gas industries. As part of this effort, in 2001 Korea's state-owned electricity company, KEPCO, was split into six companies (five thermal power generation companies and Korea Hydro and Nuclear Power). The natural gas industry has not undergone significant reform; plans to split the state-owned gas company, KOGAS, into three companies have been postponed. While liberalisation of the gas and electricity industries remains a policy goal of the government, it has not established timetables or detailed plans for these efforts. The government is currently preparing new restructuring plans.

ENERGY CO-OPERATION IN NORTH-EAST ASIA

Owing to North-East Asia's abundant natural resources, particularly in far-east Russia, Korea is actively promoting North-East Asian energy co-operation to secure sufficient energy supply resources. The government plans to diversify the country's energy supply routes as it actively participates in the regional development of energy resources, such as oil and natural gas, and to import these resources through pipelines, reducing dependence on the Middle East. In addition, in November 2005 the government organised the *Senior Officials Meeting for Energy Co-operation in North-East Asia*, an inter-governmental consultation body as a base for North-East Asian energy co-operation.

ENERGY SECTOR STRUCTURE AND INSTITUTIONS

Responsibilities for energy policy development and implementation are spread across a number of government institutions. In addition, the government is planning to establish the National Energy Committee, to be chaired by the president and to include non-governmental experts, to deliberate and mediate major energy policies and plans.

GOVERNMENT AND REGULATORY INSTITUTIONS

The Ministry of Commerce, Industry and Energy (MOCIE) is the primary government body for energy policy. Within MOCIE, the Energy Policy Office handles most energy matters, including those related to nuclear energy. MOCIE is the principal agency for energy policy planning, supervision of the industrial sector, climate change matters and price controls, among others. Transport matters are mostly handled by the Ministry of Construction and Transportation. Policy related to finance and taxation is generally handled by the Ministry of Finance and Economy.

As part of its liberalisation efforts, in 2001 Korea established the Korea Electricity Commission (KOREC) to take charge of the regulations in the electric power sector. In 2001, through the Electricity Business Act, KOREC was established in its current form, and now regulates generation, transmission, distribution, independent power producers (IPPs), generation companies and the Korea Power Exchange (KPX), in addition to overall industry functions. While KOREC is under MOCIE, deliberations and decision-making on activities such as authorisation and licensing of electricity businesses are conducted separately, and are not affected by government intervention. KOREC has its own secretariat, though shares some staff with MOCIE. KOREC's nine commissioners are appointed by the president on the recommendation of MOCIE, and cannot be dismissed except in cases of dereliction of duty or imprisonment. Final decisions are made by MOCIE following the rulings or deliberations of KOREC; normally MOCIE's minister does not overrule the decisions of KOREC. There is no regulatory commission for the gas industry.

The Fair Trade Commission (FTC) is Korea's anti-trust agency, monitoring monopoly problems and unfair business practices, whereas KOREC manages technical and professional competition policy. Since 2001, the FTC and KOREC have had memoranda of understanding outlining their respective roles, duties and functions in the electricity industry.

QUASI-GOVERNMENT INSTITUTIONS

The Korea Energy Economics Institute (KEEI) develops energy policies related to the production of energy statistics and demand and supply overviews, energy conservation and climate change, the petroleum industry, the gas industry, the electricity industry and the new and renewable energy industry, among others. It is financed directly by the government.

The Korea Institute of Energy Research (KIER), a government-funded research institution, is Korea's major energy technology research institute. It is divided into five major research departments, namely energy conservation, energy efficiency, energy environment, new and renewable energy and technology expansion. KIER aims to develop technologies in the energy sector.

The Korea Energy Management Corporation (KEMCO) plays a key role in achieving Korea's research and development (R&D) policy goals for energy efficiency, energy conservation, clean energy and new and renewable energy technologies. It also manages R&D planning and financial support and management. Within KEMCO, the New and Renewable Energy Centre (NREC) works on R&D in the renewables field. The Korea Atomic Energy Research Institute (KAERI) conducts studies related to nuclear power.

ENERGY INDUSTRY

There is significant state ownership in Korea's downstream energy industry. While the oil and coal industries have been largely liberalised, gas and electricity remain primarily under government ownership.

Oil

The state-owned and operated Korea National Oil Corporation (KNOC) is responsible for Korea's strategic oil reserves, as well as for the exploration, development and production of oil and natural gas. Private companies are active in most other areas, including the downstream market and wholesale imports. Major oil companies in Korea include SK (previously Yukong), GS Caltex (previously LG Caltex), Inchon Oil Refinery (previously Gyeongin Energy), S-Oil (previously Sangyong Oil Refinery) and Hyundae Oil Bank (previously Hyundai Oil Refinery).

Natural gas

Korea's natural gas market has not been liberalised. The upstream natural gas sector is dominated by the Korea Gas Corporation (KOGAS), a state-owned and operated company. The retail market is made up of 32 local city gas

companies. The central government oversees the wholesale market; local governments and provinces oversee the retail market.

Coal

The Korea Coal Corporation (KCC), formerly known as the Dai Han Coal Corporation, was established as a government-financed company in 1950. The KCC is responsible for supporting and developing the domestic coal market, including the workforce and new technologies. The KCC also manages supply and demand for domestic anthracite (all bituminous coal is imported). Currently, the KCC runs three of the country's eight anthracite mines (the remaining five are privately owned). As for overseas coal development, in compliance with the government's policy to develop overseas energy projects, private Korean companies and the Korea Resources Corporation (KORES) are currently involved in 15 overseas bituminous coal projects.

Electricity

Korea's electricity industry is dominated by the Korea Electric Power Corporation (KEPCO). KEPCO is a majority state-owned vertically integrated utility; the government has a 50% holding in the utility. In April 2001, KEPCO was separated into six power generation subsidiaries (gencos), Korea Hydro and Nuclear Power (KHNP), which owns the nation's nuclear plants and large hydroelectric dams, and five state-owned generation companies, which took over ownership of the country's thermal power plants. KEPCO retained the national transmission and distribution grids and owns all six generation companies. At the same time, a power market, the state-owned Korea Power Exchange (KPX), was established. Currently the six generation companies sell their output into a power pool and KEPCO alone purchases power from the pool. There are plans for the five thermal generation companies to be privatised. There are no plans for KEPCO or Korea Hydro and Nuclear Power (KHNP), which owns the nuclear plants that supply 40% of Korea's electricity, to be further privatised.

District heating

The Korea District Heating Corporation (KDHC), a state-owned company formed in 1985, supplies about 60% of all heat sales in Korea. The government is working to diversify the combined heat and power (CHP) market. Currently, 21 companies provide CHP; approximately 15% of these companies are privately owned.

LIBERALISATION

Korea's liberalisation plans for the gas and electricity industries have been postponed.

NATURAL GAS

The original plan for liberalising the natural gas market was set out in 1999 and put into legislation in 2001. Under the original plan, KOGAS was to have been spun off into three separate import companies. According to revised plans for liberalisation, KOGAS will remain a state-owned company, but the government is working on revised policies to encourage new entry from private companies. Recent policy changes have opened up the market. Some companies that use gas can now import gas directly – bypassing KOGAS – if the gas is for captive use (*i.e.* the company's own use). Additionally, the government is working to institute regulated third-party access (TPA) on natural gas pipelines. Currently, companies other than KOGAS wishing to use the pipeline can only do so through negotiated TPA. For example, Posco, Korea's largest steel company, signed a contact with KOGAS in 2005 for negotiated TPA to bring in gas for its own use.

ELECTRICITY

The government's electricity privatisation programme has been suspended twice since the industry's restructuring in 2001 when KEPCO generation assets were split into six generation companies. In 2003, the government offered a majority shareholding in one of these generation companies, Korea South-East Power (KOSEPCO), but many international bidders withdrew their bids, leaving a sole bid from a local consortium. After that, the privatisation plan was scrapped and the government turned to an initial public offering (IPO) to divest KOSEPCO, rather than pursue an outright sale to a single buyer or consortium. The aim was to sell a stake of about 30% in the generation company before July 2004. However, in May 2004, KEPCO announced a delay, citing weakness in the Korean stock market, once again derailing the privatisation timetable. The current plan under discussion is to continue to try to privatise KOSEPCO. Although a part of the original reform plan, there is now no plan to liberalise the demand side of the market. This would create a single-buyer model, similar to earlier stages of European liberalisation, and to the United States experience with independent power producers (IPPs).

SECURITY OF SUPPLY

OIL

Korea is highly dependent on imported oil resources – it produces less than 0.4% of its own consumption – and nearly all of its imported oil comes from non-OECD countries. As part of its overall strategy to improve energy security through international project development, the government is securing over 700 million barrels of overseas oil reserves, equivalent to just under one year of domestic consumption. It is also continuing to work to diversify its import sources. Since joining the IEA in 2002, Korea's oil stocks have never fallen below the IEA's 90-day net import requirement.

NATURAL GAS

Korea depends entirely on imports of liquefied natural gas (LNG) to meet its natural gas demand. The bulk comes from four countries, namely Indonesia, Malaysia, Oman and Qatar, which together supplied over 90% of total LNG imports in 2004. Complementing its overseas oil development projects, Korea is securing over 90 million tonnes (Mt) of gas, or 120 billion cubic metres (bcm), equivalent to about four years of annual LNG imports. The government is also working to improve natural gas security through additional storage capacity. It plans to increase its total storage capacity rate from 8.8% of annual consumption to 12.7% by 2017.

COAL

Over 90% of Korea's coal consumption is supplied in the form of imported bituminous coal – the country imported 69 Mt of bituminous coal in 2005, up from 57 Mt in 2004, primarily from Australia, China and Indonesia. The country's domestic resources are only in the form of anthracite coal, a low-quality coal. To enhance security of supply, as well as regional economic stability, the government maintains subsidised production and consumption of domestic anthracite coal, although it has been streamlining the industry. There are currently seven mines operating in Korea.

ELECTRICITY

Total installed capacity in Korea was over 60 000 MW at the beginning of 2005; over 17 000 MW came from the country's 19 nuclear power plants. In 2005, average demand was just over 39 000 MW; peak load was over 54 000 MW, corresponding to a reserve margin of 14%. The government expects electricity demand to grow steadily at 4% to 5% per year and the

Basic Plan for Long-term Electric Power Demand and Supply, released in December 2004, seeks to maintain a 15% to 17% reserve margin. As part of this plan, nine nuclear power plants are scheduled to be built in Korea from 2005 to 2017.

PRICES, TAXES AND SUBSIDIES

Taxes as a percentage of total energy prices in 2005 are presented in Table 4. In addition to excise taxes that vary by source, the 10% value-added tax (VAT) is also levied on most energy sources.

OIL

Starting in 1997, petroleum prices were completely liberalised. Taxes on unleaded gasoline make up slightly less than 60% of the total retail price, similar to rates in many European countries, including Hungary, Ireland, Italy and Poland. Taxes on diesel make up about half of the final retail prices, which is a similar rate to many European countries, but much higher than Korea's neighbour, Japan, where diesel taxes make up 36% of the final retail price. Taxes on liquefied petroleum gas (LPG) comprise 45% of the final retail price.

Through taxation policy, the government has been modifying the relative prices of oil products progressively since 2001 in order to conserve energy and promote a transition to a less energy-intensive economy. The government plans to raise the relative prices of diesel and LPG, which represented 47% and 26%, respectively, of the gasoline price in July 2000 to 80% and 50%, respectively, by July 2006, similar to the relative rates of other non-oil-producing OECD countries. Part of this policy is a response to the increased use of diesel for passenger vehicles. The prohibition against diesel-fuelled passenger vehicles was lifted as from January 2005. The additional increase of the relative diesel price reflects the negative environmental impacts from diesel passenger vehicles. Only taxis are authorised to use LPG in Korea. The relative tax advantage of LPG reflects its higher efficiency, assuming engines are factory-designed for LPG and are not after-market conversions.

In addition to retail taxes, Korea also imposes import duties (ex-tax prices shown in Table 4 already include these import duties). Crude oil is taxed at 1% and petroleum products are taxed at 5%, providing a tax advantage for Korean refineries relative to product importers.

Table 4

Energy Prices and Taxes, 2005

	*Ex-tax price**	*Excise tax*	*VAT/ other tax*	*Total tax*	*Total price*
Regular unleaded gasoline (KRW per litre)	555	744	130	874	1 428
Regular unleaded gasoline (USD per litre)	0.54	0.73	0.13	0.85	1.39
Percentage of total price	*39%*	*52%*	*9%*	*61%*	*100%*
Automotive diesel for non-commercial use (KRW per litre)	560	419	98	517	1 077
Automotive diesel for non-commercial use (USD per litre)	0.55	0.41	0.10	0.51	1.05
Percentage of total price	*52%*	*39%*	*9%*	*48%*	*100%*
Liquefied petroleum gas for households (KRW per litre)	395	263	66	329	723
Liquefied petroleum gas for households (USD per litre)	0.39	0.26	0.06	0.32	0.71
Percentage of total price	*55%*	*36%*	*9%*	*45%*	*100%*
Light fuel oil for industry (KRW per 1 000 litres)	594 060	200 625	79 469	280 094	874 154
Light fuel oil for industry (USD per 1 000 litres)	580.14	195.92	77.61	273.53	853.67
Percentage of total price	*68%*	*23%*	*9%*	*32%*	*100%*
High sulphur fuel oil for industry (KRW per tonne)	388 794	15 837	40 463	56 301	445 095
High sulphur fuel oil for industry (USD per tonne)	380	15	40	55	435
Percentage of total price	*87%*	*4%*	*9%*	*13%*	*100%*
Kerosene for households (KRW per 1 000 litres)	590 463	200 625	79 109	279 734	870 196
Kerosene for households (USD per 1 000 litres)	576.62	195.92	77.25	273.18	849.80
Percentage of total price	*68%*	*23%*	*9%*	*32%*	*100%*
Low sulphur fuel oil for industry (KRW per tonne)	384 203	15 824	40 003	55 827	440 030
Low sulphur fuel oil for industry (USD per tonne)	375	15	39	55	430
Percentage of total price	*87%*	*4%*	*9%*	*13%*	*100%*
Natural gas for electricity generation (KRW per 10^7 kcal)	332 270	43 563	0	43 563	375 833
Natural gas for electricity generation (USD per 10^7 kcal)	324.48	42.54	0	42.54	367.02
Percentage of total price	*88%*	*12%*	*0%*	*12%*	*100%*
Steam coal for industry (KRW per tonne)	..	..	..	..	73 730
Steam coal for industry (USD per tonne)					72
Percentage of total price					*100%*
Electricity for industry (KRW per kWh)	..	..	..	..	60
Electricity for industry (USD per kWh)					0.06
Percentage of total price					*100%*
Electricity for households (KRW per kWh)	..	..	..	..	91
Electricity for households (USD per kWh)					0.09
Percentage of total price					*100%*

* ex-tax prices include import duties.

Sources: *Energy Prices and Taxes*, IEA/OECD Paris, 2006 and country submission.

NATURAL GAS

Cost-based rates for natural gas are set by KOGAS, based on the imported price of LNG. These prices vary for industrial and residential customers. Rates vary bimonthly for industrial customers, but are fixed annually for residential customers and do not vary according to season, despite the wide swings in seasonal residential consumption. In addition to the cost of LNG imports, rates include other additional domestic costs associated with LNG importing, including import tariffs and levies, handling charges, a special excise tax and a safety management fund contribution.

COAL

Coal prices are set by each importer or coal mine, three of which are owned by the government. Prices are not regulated by the government. Between 2003 and 2005 there were no import duties on bituminous coal. However, in order to raise money for the government budget, a 1% import duty commenced in 2006. Although the government levies a 10% VAT on all bituminous coal, this tax can be reduced in direct correlation to any sales taxes that are also levied; the overall tax rate for VAT and sales taxes is 10%.

There are no subsidies provided for imported bituminous coal, but production and consumption subsidies are given for domestic anthracite coal. The overall amount of subsidies is increasing, but this is because as subsidised mines are closed, the government is paying social subsidies to former employees. Although the government is considering replacing consumption subsidies for low-income coal users with social subsidies that are not correlated to coal consumption, it does not yet have plans to implement this change.

ELECTRICITY

Cost-based electricity rates are set by KEPCO, subject to approval by MOCIE, and vary for industrial, commercial and residential customers. Some groups, including war veterans and low-income customers, receive subsidised electricity rates. A 10% VAT rate is applied to electricity bills.

CRITIQUE

The rapid evolution of Korea's energy infrastructure and its resulting effect on the economy are remarkable. The country's per-capita GDP is now above that of EU countries such as Greece or Portugal. Using one illustrative example of Korea's rapid growth, its electric power capacity has grown from less than 400 MW in 1962 to nearly 60 000 MW by 2005, and the country is now

operating one of Asia's first 765-kV high-voltage transmission lines. Electricity demand continues to grow at a robust 4% to 5% per year. Since the last in-depth review in 2002, Korea has continued this progress by addressing issues critical to long-term sustainable economic development, including energy efficiency, environmental protection and energy supply security and diversity. In short, we applaud Korea's expanded energy policy goals, particularly as they correspond directly with the IEA's overall policy goals of economic efficiency, environmental protection and energy security. Despite this progress, further efforts are necessary, particularly in the areas of market development and economic efficiency. Greater efforts focused on limiting GHG emissions are also necessary.

Korea has very limited supplies of indigenous natural resources. It has no oil reserves, a very small amount of natural gas and some low-quality coal reserves. The country therefore depends heavily on energy imports. Energy security is of paramount importance in Korea's energy policy. Since joining the IEA in 2002, Korea's oil stocks have always been above the IEA's 90-day net import requirement. It has also successfully managed to diversify its energy supply by extensive use of natural gas, bituminous coal and nuclear power. In particular, the nuclear programme is impressive. Furthermore, Korea has actively promoted diversification of supply channels and overseas resources development (*e.g.* in the Caspian Sea, eastern Siberia and South-East Asia). However, the Korean economy's dependence on oil imports is still relatively high compared to that of similar economies in the OECD. The government should do more to diversify its energy supply and curb oil dependence. In particular, given its still high energy intensity – above both the IEA and IEA Pacific averages – further efforts are necessary to improve energy efficiency. In general, Korea's high priority on energy security is commendable; to complement this, the IEA encourages Korea to strengthen its focus on economic efficiency and environmental protection.

In the area of energy market reform, Korea launched a commendable step-wise liberalisation and privatisation plan for the electricity sector in 1999, followed by a similar plan for the gas industry. However, reform has since come to a near stand-still. This partly stems from difficulties experienced with the earlier reform process, but a more fundamental barrier is the government's lack of political will. It is now not clear if and how the reform will be taken forward.

Liberalisation of Korea's energy markets is not a prescription to correct failed energy markets. Korea has to date successfully met the country's rapidly increasing demand for electricity and natural gas. As the country was experiencing rapid economic growth, the government was able to support this growth and build sufficient capacity at an impressive rate. It pioneered the liquefied natural gas (LNG) market. Despite this success, progressing towards liberalisation is important for two reasons. First, although Korea's economy is

still growing at a fast pace, it is no longer growing at such a rate that energy infrastructure needs to be built as quickly as possible, with a reduced regard for balancing efficiency. Instead, as Korea's economic growth moderates – coupled with greater variability in economic growth rates – this should be matched with a more flexible, responsive and efficient system, which is what a liberalised market would provide. The potential benefits of liberalisation are also underscored by Korea's experience with its economic recession at the end of the 1990s, which resulted in difficulties financing new infrastructure and was an important trigger for the liberalisation process. Second, Korea's energy market currently sits at a crossroads, stuck halfway between vertically integrated, state-owned utilities and liberalisation. This is a worst-case situation, exacerbating inefficiency by adding significant uncertainty to the market.

In this context, restarting liberalisation would allow Korea to achieve its policy objectives at a lower economic cost than if the current situation continues. The stalled liberalisation process means that Korea's current natural gas and electricity markets rely on government planning and government-owned, vertically integrated utilities. In the future, as economic growth moderates, this structure is likely to lead to overcapacity of generation assets and relatively lower operational efficiency. Furthermore, access to capital markets for long-term investment can be reduced in the absence of an open energy market, as experienced by Korea during the Asian economic crisis. Liberalisation of Korea's electricity and gas markets could bring substantial economic efficiency benefits to the country, relying on competitive pressures – rather than central planning – to reduce the overall cost of the energy system by building less capacity that goes unused, operating existing capacity more efficiently and accessing the capital market more easily and cheaply.

Liberalisation of Korea's natural gas and electricity markets does not require privatisation. The country can hold its energy system as government assets, while still gaining much of the benefits of competition and liberalisation. Many IEA countries retain government ownership of major energy assets. Although privatisation is, in principle, preferable as it prevents government influence in company decisions and provides greater incentives for companies to operate competitively, liberalisation without full privatisation does not necessarily undermine the benefits of liberalisation if state-owned companies operate competitively and are insulated from government influence. For example, New Zealand maintains a large part of its energy industry as state-owned enterprises (SOEs). Three of its five electricity companies, its transmission company and its major coal company are SOEs. These companies are operated independently from the government, are subject to the same rules and regulations as private companies and compete on equal terms with private companies. Government ministers represent the SOEs' shareholders, and dividends are paid to the government treasury. Another example of liberalisation without full privatisation is Nord Pool. The member countries of Nord Pool, Norway, Sweden, Finland and

Denmark, all retain majority or full ownership of the largest generation company in each country, but these companies compete in a fully liberalised market framework with other generation companies, including private ones, municipally owned utilities, partially state-owned companies and others. In addition, the transmission grids in these countries are state-owned companies, except in Finland where the government has a majority stake in Fingrid.

Although less than in electricity markets, state-owned gas companies also operate within the framework of competitive, liberalised markets. In the Netherlands, for example, Gasunie Trade and Supply is 50% state-owned; the remaining 50% is split evenly between Shell and Esso, two private companies. Gasunie competes with other fully private gas supply and trading companies. The Netherlands' high-pressure gas network is 100% owned by the government. Taken together, these gas and electricity examples show that privatisation is not a prerequisite or requirement for liberalisation. The government can retain state ownership of major energy assets, certainly during the transition to a fully liberalised market, while still establishing market rules that let government-owned assets compete in the market – resulting in economic efficiency gains for the entire Korean energy industry.

While privatisation is not a requirement for successful liberalisation, the establishment of strong, independent regulators at the outset of liberalisation is. For competition to flourish, market players must have confidence that a regulatory commission independent from the government is monitoring the market. A regulator that makes predictable decisions based on transparent market rules – and not changing political whims – encourages market participants to enter and remain in the market, helping increase competition. This is particularly true in a market with state ownership of energy assets, to prevent undue government preference or influence. Not only does an independent regulator ensure that competing companies behave according to the rules, it also ensures that monopoly network businesses provide fair and open access to all competitors, as well as have incentives to operate efficiently and invest in infrastructure.

When and in what order an independent regulator is established is critical to the success of a competitive market. The regulator must be established first, so that once the market rules have been set by the government, responsibility for enforcing them in a fair manner is delegated to an independent authority. Given that market participants will not enter a market where regulation and enforcement of rules are likely to change, an independent regulator is a first step in the liberalisation process, not the final step. While Korea has established a regulator for the electricity market, the Korea Electricity Commission (KOREC), the regulator is not fully independent from the government. The government and the regulator share staff and there is a perception that KOREC lacks true authority and autonomy – a situation that may explain some of the difficulties Korea experienced with its liberalisation plan in the past. Before progressing with liberalisation, KOREC should be fully separated from the government and given strong and independent

authority so that once the government has established the market rules, KOREC can implement them fairly and transparently. In addition, while the market design should create incentives for market players to behave according to market rules, the regulator must have the power to penalise bad behaviour, such as when electricity and gas network operators do not comply with open access rules. In this case, Korea can look to the United States, where the government recently enhanced the penalty authority of the federal regulator, strengthening deterrence from illegal and uncompetitive behaviour.

As Korea's energy policies continue to evolve, it is important to have a co-ordinated and comprehensive approach to policy formulation. Currently, much energy policy is encompassed by MOCIE's long-term energy supply and demand projections, which seem to be used as high-level planning documents that inform when and where new infrastructure will be built, but do not necessarily incorporate market dynamics, environmental concerns or other stakeholder issues. For this reason it is very positive that the government plans to establish the National Energy Committee, a high-level government group that includes significant non-government participation. This committee should be established as quickly as possible, and should be designed so that it ensures comprehensive and effective stakeholder involvement, introduces greater checks and balances and increases transparency in Korea's energy policy-making framework. In developing this committee and improving transparency and stakeholder involvement, Finland can provide a useful example. In Finland, while the Ministry of Trade and Industry has ultimate responsibility for energy policy and initiates all new policy developments, other ministries contribute through consultation and delegation of responsibilities. For example, its national climate strategy was shaped by the work of six different ministries (industry and trade, transport, agriculture, environment, foreign affairs and finance). The inter-ministerial group regularly consulted with stakeholders through the presentation of drafts and strategies to both industry and the public.

The National Energy Committee is also an opportune forum to ensure effective co-ordination and communication between all government ministries responsible for energy and the environment, so that all government policies are cost-effective and consistent. While MOCIE is the lead government agency on energy policy, as in many other IEA countries other ministries also have some responsibility for energy policy. However, there is currently no co-ordination protocol between these government offices. For example, there is currently no implementation protocol for the government's plan to improve energy efficiency, although the plan will require integrated and co-ordinated implementation by various government agencies, including MOCIE, the Ministry of Environment, the Ministry of Finance and Economy and the Ministry of Construction and Transportation. Developing a robust co-ordination protocol that can be used for the new energy efficiency policy and other future energy policies will ensure efficient and effective implementation and bring long-term benefits to the country. Again, Finland can be used as a model for this co-ordination, particularly its experience in developing its national climate strategy.

While Korea is currently a party to the UNFCCC and the Kyoto Protocol, as a non-Annex I country, it does not have any greenhouse gas emissions targets. Nonetheless, the IEA commends Korea for beginning to focus on greenhouse gas emissions, given its rapid economic growth and its commensurate rise in GHG emissions. The country is promoting voluntary greenhouse gas reduction policies and measures in many sectors. In addition, the government is working to accelerate the transition of its economy to industries that consume less energy and has organised the Inter-Ministerial Committee on the UNFCCC, headed by the prime minister. Building on these efforts, and noting the country's current level of economic development, Korea should consider taking on a greenhouse gas emissions target and work to establish a systematic means of addressing climate change and signalling the cost of greenhouse gas emissions, such as through carbon taxes or emissions trading. Introducing a price signal for carbon that reflects its environmental costs would give market participants incentives to reduce emissions tied to low-value uses.

RECOMMENDATIONS

The government of Korea should:

- *Continue to diversify energy supply and curb oil dependence, in part through enhanced energy efficiency policies and improved policy co-ordination.*
- *Re-launch energy market reform in electricity and gas markets, noting that liberalisation does not require privatisation.*
- *Establish independent electricity and gas market regulators with powers and responsibilities consistent with best practices of IEA countries. In particular, ensure that the regulator monitors third-party access to network infrastructure and has the power to penalise operators who do not comply with the terms.*
- *Introduce more checks and balances – including transparent policy processes that involve all stakeholders – in energy policy at all its stages.*
- *Improve co-ordination and communication between the Ministry of Commerce, Industry and Energy; the Ministry of Environment; the Ministry of Finance and Economy; the Ministry of Construction and Transportation; and other relevant bodies, to ensure that all energy-related government policies are consistent.*
- *Integrate the environmental dimensions of energy production and consumption into energy policy in a systematic way. Implement market-based mechanisms (*e.g. *carbon taxes and/or emissions trading) to provide a CO_2 price signal.*

ENERGY AND THE ENVIRONMENT

BACKGROUND

Now that Korea's economy, after rapidly growing, has begun to increase more slowly, the government's current policy which focuses on security of energy supply has expanded to also encompass environmental protection. As such, the government has enhanced its environmental policies relating to energy. The focus is currently on energy conservation and efficiency improvements, maintenance of the share of nuclear in the energy mix, fuel switching from oil to natural gas and liquefied petroleum gas (LPG), and promotion of renewable energy, including development of a hydrogen economy in 2040.

Energy and environment policy is principally managed by two government offices, namely the Ministry of Environment (MOE) and the Ministry of Commerce, Industry and Energy (MOCIE). According to the *Energy Use Rationalisation Act*, MOCIE must consult MOE before it establishes its *National Energy Plan*, which includes environment-friendly energy resources.

MOCIE incorporates environmental concerns when establishing and pursuing energy-related policies, and has recently created an energy and environment division in light of the importance of environmental factors in energy policies. In addition, according to the *Community Energy System Act*, MOCIE must consult with other relevant departments when it establishes its basic community energy supply plans or designs community energy supply areas. To deliberate on important energy policy issues related to electricity and new and renewable energy, the Council on Power Policy and the Council on New and Renewable Energy Policies were organised according to relevant laws.

CLIMATE CHANGE

Korea is one of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) and ratified the Kyoto Protocol. Korea is classified as a non-Annex I country, meaning that it does not currently have a greenhouse gas (GHG) emissions target under the protocol. (Turkey and Korea are the two IEA countries that do not have mandatory GHG emissions targets under the protocol.)

TRENDS IN CO_2 EMISSIONS

As shown in Table 5 and Figure 6, energy-related emissions of carbon dioxide (CO_2) have grown dramatically in recent years, more than doubling between 1990 and 2004, equivalent to an average annual growth rate of 5.2% (the average annual growth rate between 1984 and 1990 was 7.4%). Owing to the steep economic slow-down in the late 1990s, CO_2 emissions dropped dramatically in 1997, but rebounded back above 1997 levels within three years.

Table 5

Energy-related CO_2 Emissions by Fuel*, 1984 to 2004

Units $MtCO_2$					*1984-1990*		*1990-2004*	
	1984	*1990*	*1994*	*2004*	*Total growth*	*Average annual growth*	*Total growth*	*Average annual growth*
Coal	73.8	133.3	216.4	211.5	81%	10.4%	59%	3.4%
Oil	73.0	86.3	96.1	185.8	18%	2.8%	115%	5.6%
Natural gas	0	6.4	16.0	60.0			842%	17.4%
Combustible renewables and waste	0	0	2.8	4.9				
Total	**146.8**	**225.9**	**331.3**	**462.1**	**54%**	**7.4%**	**105%**	**5.2%**

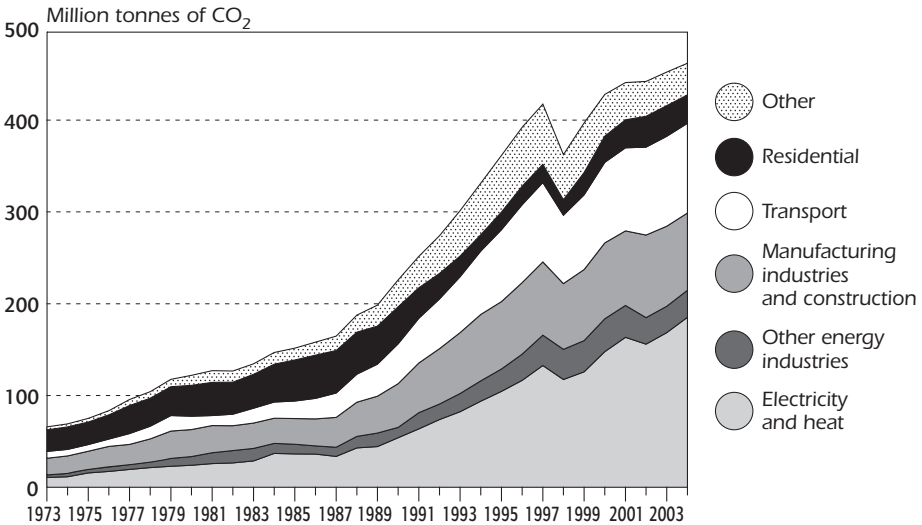
* estimated using the IPCC Sectoral Approach.

Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2006.

Figure 6 shows CO_2 emissions by sector. Reflecting its rapid development, in 1984 the residential sector was the largest CO_2-emitting sector in Korea. In 2004, the largest share of total emissions came from the electricity and heat sector (40%), followed by the transport sector (21%) and the industrial sector (18%).

Figure 6

CO_2 Emissions by Sector*, 1973 to 2004



* estimated using the IPCC Sectoral Approach.

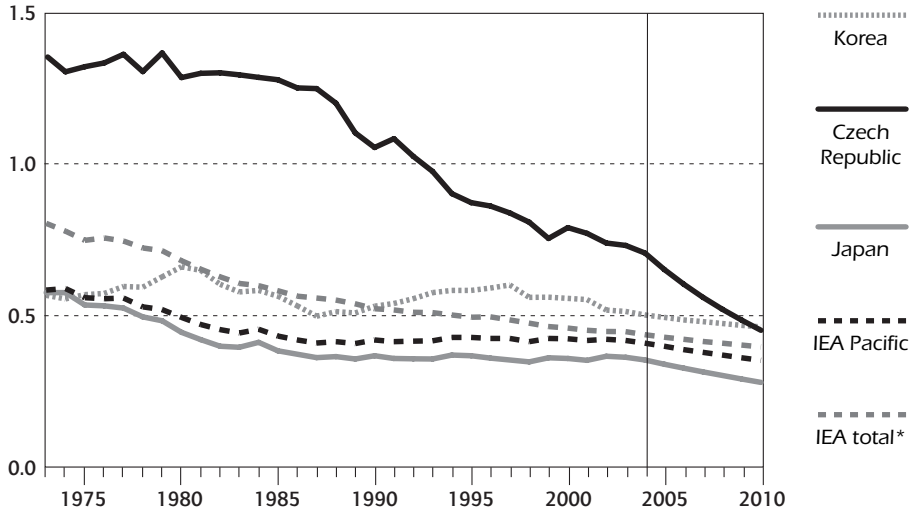
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2006.

Compared to its neighbour Japan, as well as to the IEA average and IEA Pacific average, Korea's energy-related CO_2 emissions per unit of GDP (a measure of CO_2 intensity) are relatively high (see Figure 7). In 2004, Korea's ratio was over 40% higher than Japan, nearly 23% higher than the IEA Pacific average and 15% above the IEA average. In comparison to the Czech Republic, which has a similar fuel mix, Korea's CO_2 intensity is about 30% lower. Korea's CO_2 intensity has been falling since 1997, and is expected to continue to fall at a relatively steady rate through 2010.

Figure 7

Energy-related CO_2 Emissions per GDP in Korea and in Other Selected IEA Countries, 1973 to 2010

(tonnes of CO_2 emissions per thousand USD GDP using 2000 prices and purchasing power parities)



* excluding Luxembourg and Norway throughout the series, as forescast data are not avaible for these countries.

Sources: *Energy Balances of OECD Countries,* IEA/OECD Paris, 2006; *National Accounts of OECD Countries,* OECD Paris, 2006; and country submissions.

PROJECTED EMISSIONS

Under a business-as-usual scenario, CO_2 emissions from the energy sector are forecast to grow by 85% from their 2000 levels by 2030, equivalent to an average annual increase of 2.1% (see Table 3 in Chapter 3). The faster growth rates come before 2010; post-2010 growth rates are expected to slow to 2020, slowing even further to 2030. The largest increase in energy-related CO_2 emissions is expected to come from natural gas, whose emissions are forecast to nearly double between 2000 and 2010; gas emissions are expected to increase more than three-and-a-half times between 2000 and 2030.

POLICIES AND MEASURES TO REDUCE EMISSIONS

In 2004, Korea submitted its second national communication to the UNFCCC. It outlined the policies and measures it had already implemented or adopted. The policies and measures for the energy and transport sectors are summarised in Table 6. The government is working to reduce energy-related greenhouse gas emissions by improving energy efficiency in the transport, building and appliance sectors (discussed in more detail in Chapter 5), expanding the use of renewables (discussed in Chapter 6) and nuclear (discussed in Chapter 11), and promoting fuel switching from oil to natural gas by securing gas supply (discussed in Chapter 9).

Table 6

Summary of Policies and Measures by Sector

Sector		*Promotional strategy*	*Policies and measures*
Energy	Demand	Integrally managed energy conservation policy	3-year plan for energy audit Expansion of voluntary agreements (VA) Expansion of energy service companies (ESCOs)
	Supply	Improvements in energy efficiency	High-efficiency equipment certification programme Energy efficiency standards and labelling programme
	Building	Expansion of renewables and clean energy use	Formation of market demand/improved economics for renewables Expansion of integrated energy supply project Stable supply of natural gas Stable supply level of nuclear energy Promotion of landfill gas projects
	Transportation fuel	Improvement of energy efficiency in buildings	Promotion of compressed natural gas buses and compact cars Development of diesel cars
Transport		Efficient management of national transportation system and traffic demand	Promotion of efficient transport mode sharing Reduction of traffic congestion areas Expansion of public transportation services Traffic demand management Regulation on idle running vehicles and restriction on car use
		Establishment of logistics information network	Establishment of comprehensive logistics information network Promotion of logistics standardisation

Source: *Second National Communication of the Republic of Korea under the United Nations Framework Convention on Climate Change*, abridged from Table 4-2, p. 47, December 2003.

In April 1998, the government established the UNFCCC Response Committee, chaired by the prime minister, and formulated detailed and practical national plans to mitigate GHG emissions. It is also promoting the *Third Comprehensive Plan* (covering 2005 to 2007), which undertakes 90 tasks in the three major sectors with the participation of 19 government departments, the Korea Energy Management Corporation (KEMCO), the Environmental Management Corporation (EMC) and other relevant organisations. The first sector includes projects to establish a basis for implementation of the convention on climate change. The second sector includes sectoral GHG emissions reduction projects. The third sector includes projects to establish a basis for adaptation to climate change. The Office of the Prime Minister oversees the implementation of these tasks. The successful implementation of the first and second national plans resulted in a decrease of the GHG emissions growth rate. The growth rate fell from 5% to 3% per year between 2002 and 2004.

In addition, Korea has finished reviewing the necessary elements for a pilot domestic emissions trading scheme for greenhouse gases. It is still to be decided when it will be ready for implementation.

International participation

Korea participated in the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) hosted by the Asian Development Bank with a number of Asian countries. It also joined the Renewable Energy and Energy Efficiency Partnership (REEEP) in March 2005 to help promote international co-operation in securing low-carbon energy technologies. It also plans to participate in the Carbon Sequestration Leadership Forum (CSLF) this year. Korea is a member of the Asia-Pacific Partnership on Clean Development and Climate. This partnership comprises a group of six Pacific countries whose efforts are intended to complement those of the UNFCCC.

As a non-Annex I country, Korea is eligible to sell clean development mechanism (CDM) credits on the international market. CDM credits, known as certified emissions reductions (CERs), can be sold by developing countries without GHG targets and used by other countries to meet their targets. Korea is the third-largest seller of CERs, making up 15.6% of expected average annual CERs sold from registered projects. Most credits sold by Korea come from a nitrous oxide mitigation project, but more recent CDM projects include solar and hydropower projects. Korea has recently filed a formal request to the UNFCCC to establish a clear set of guidelines concerning the transfer of CER credits from non-Annex I countries to Annex I countries.

AIR QUALITY

Air quality and vehicle emission standards are discussed in this chapter. Policies to reduce energy consumption in the transport sector and to increase the use of public transportation are discussed in Chapter 5.

CURRENT AMBIENT AIR QUALITY

As Korea has rapidly developed, its air quality has been affected by energy-sector pollutant emissions. The Seoul metropolitan area, in particular, has suffered from a sharp increase in vehicle emissions. Despite this growth in vehicle emissions, emissions of major air pollutants, most notably sulphur oxides (SO_x) and particulate matter (PM_{10}), but also nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs), are beginning to decouple from GDP growth. Sulphur dioxide emissions per unit of GDP are half the OECD average and the country is well below the OECD average for NO_x emissions per unit of GDP, placing Korea in the middle range of OECD countries.[2] Despite continued economic growth in Korea, emissions of SO_x and particulates have fallen between 1999 and 2003; emissions of NO_x, CO and VOCs have begun to increase less quickly (see Table 7).

Table 7

Emissions of Air Pollutants, 1999 and 2003

Units: kt	*1999*	*2003*
SO_x	546	499
Mobile sources	*46*	*53*
Stationary sources	*500*	*446*
NO_x	974	1 167
Mobile sources	*569*	*681*
Stationary sources	*405*	*486*
Particulates	92	91
Mobile sources	*33*	*41*
Stationary sources	*59*	*50*
CO	806	858
Mobile sources	*685*	*734*
Stationary sources	*121*	*124*
VOC	644	731
Mobile sources	*120*	*141*
Stationary sources	*524*	*589*

Source: *2005 Environment White Paper*, Ministry of Environment, Korea as reproduced in the *Environmental Performance Review of Korea*, OECD Paris, 2006.

2. *Environmental Performance Review of Korea*, OECD Paris, 2006.

Despite reductions in emissions and improved air quality in many cities, air quality remains poor, especially in the Seoul metropolitan area, in particular with respect to nitrogen oxides, particulates and ozone. Pollution levels of NO2 and particulates are slightly higher than in many large cities in other OECD countries.

AMBIENT AIR QUALITY STANDARDS

As from January 2001, air quality standards have been tightened (see Table 8). The new sulphur dioxide (SO_2) standard brings Korea's standard closer to international levels. Its one-hour SO_2 standard of 393 μg per m^3 is less stringent than the EU standard (350 μg per m^3), but significantly more stringent than the Australian standard (570 μg per m^3) and United States standard (655 μg per m^3). Korea's stricter PM_{10} standard, 70 μg per m^3, is still above those applied in the EU (20 μg per m^3), the United Kingdom (40 μg per m^3) and California (20 μg per m^3). The Korean government plans to introduce more stringent standards in 2007, considering the harmful effects of PM_{10} on the human body.

Table 8

Ambient Air Quality Standards

	Before January 2001	*After January 2001*	
SO_2	0.03 ppm (79 μg/m^3)	0.02 ppm (52 μg/m^3)	Annual standard
	0.14 ppm (367 μg/m^3)	0.05 ppm (131 μg/m^3)	24-hour standard
	0.25 ppm (655 μg/m^3)	0.15 ppm (393 μg/m^3)	1-hour standard
PM_{10}	80 μg/m^3	70 μg/m^3	Annual standard

Note: ppm = parts per million.
Source: Country submission.

Korea plans to establish a basic plan for air quality that will set standards at 40 μg per m^3 for PM_{10} down from 69 μg per m^3 in 2003, and 22 parts per billion (ppb) for sulphur dioxide, down from 38 ppb, to reduce PM_{10} by 53%, and reduce SO_2, NO_x and VOCs by 39% in the Seoul metropolitan area by 2014, as compared to 2001.

The government enacted the *Special Act on Metropolitan Air Quality Improvement* in 2003 and established the Metropolitan Air Quality Management Office in 2005 as a special organisation for the improvement of air quality in the Seoul metropolitan area.

The government is planning to promote facility management standards for major emitters of hazardous air pollutants, such as the petrochemical industry, from 2006 to 2013.

Coal-fired power plants

At 40%, a significant share of Korea's power is generated from coal. In order to minimise the sulphur emissions from coal-fired power plants, emission standards have been in place since January 1999, limiting emissions of SO_2, particulates, ammonia, CO and NO_x. New emission standards to take effect from 2010 are currently being established.

MONITORING AND ENFORCEMENT

Air quality and pollutant emissions are monitored by the national government, as well as by local governments. Businesses that exceed the allowed limit are fined. Local governments report on regional air quality to the national government on a monthly basis.

The government plans to introduce the total air pollution load (TAPL) management system in businesses with high pollutant emissions levels in stages from July 2007 so that businesses can reduce emissions on the basis of pollution load rather than the level of pollutants. In addition, the government introduced the emissions trading system, in order to cost-effectively reduce pollutants, by allowing businesses whose emissions level was below their allowances to sell their allowances to other businesses.

Since it established its *Basic Plan on Hazardous Air Pollutants Management* in February 2004, the government has been monitoring 25 particularly hazardous pollutants in the air through the inspection of discharge sources and emission levels for 48 priority items among 206 total substances. In addition, through the 1999 introduction of a reporting system for the discharge of toxic and hazardous chemical substances, the government has expanded the number of industries required to report from 2 to 36.

VEHICLE EMISSION STANDARDS

The sharp increase in motor vehicles has led to a rise in the discharge of pollutant emissions from the transport sector. In particular, the number of cars grew by 40% between 1997 and 2003. Although the Seoul metropolitan area only represents 12% of Korea's total area, 46% of the country's total population and 47% of all cars are in the area, making air quality in metropolitan Seoul worse than in other OECD countries.

To manage vehicle emissions, MOE established the ten-year *General Plans for Vehicle Emissions Reductions*. The first plan ran from 1996 to 2005 and the second plan is currently being established. In 2006, emission standards for petrol and liquefied petroleum gas (LPG) vehicles were tightened to the low-emission vehicle (LEV) level of the United States, and standards for diesel vehicle emissions were tightened to Europe's EURO-4 level. From 2008, Korea

plans to apply the vehicle emission standards proposed for developed countries such as the United States and Europe.

In addition to more stringent emission standards, modifications to monitoring and enforcement are being planned. A defect checking system, close car inspections and mandatory on-board diagnostics are being implemented to further reduce vehicle emissions. The length of time between required emissions inspections will be reduced from 12 years to 6 years.

The government will expand the number of regions where close vehicle inspections are required. Currently they are required in Seoul, six other metropolitan cities and all of Gyeonggi Province (15 cities). From 2008, they will be required in all cities with a population above 500 000.

To meet car emission standards, fuel quality has also been improved continuously since 1991, and will be reinforced to the level of developed countries such as the United States and Europe from 2006 as follows:

- The benzene content in gasoline has moved from 6% in 1993 to 4% in 1998 and to 1.5% in 2002. It fell to 1.0% in 2006, modelling the standard in California.

- The sulphur content in diesel has fallen from 2 000 parts per million (ppm) in 1993 to 500 ppm in 1998 and to 430 ppm in 2002. It fell to 30 ppm in 2006, modelling the standard in the EU.

LOW-EMISSION VEHICLES

To reduce pollutants from public buses, which run most frequently in large cities, bus fuels are being changed to natural gas in major domestic cities through tax incentives and subsidies for natural gas buses and gas-filling stations. In addition, the government plans to provide 23 000 natural gas vehicles for public use.

CRITIQUE

Korea ratified the Kyoto Protocol in November 2002. As a non-Annex I country Korea does not have any mandatory greenhouse gas emission targets; however, the government has begun to implement measures to reduce the growth of emissions in three major sectors through the participation of 19 government departments, actions the IEA commends. Furthermore, the country is among the leaders in clean development mechanism (CDM) projects, helping to expand the market for CDM credits.

Despite rapid economic development that puts Korea closer to Annex I countries than non-Annex I countries, the country has not taken on any binding Kyoto greenhouse gas (GHG) emissions commitments nor set any internal targets. Total GHG emissions, of which energy-related emissions are the largest component, increased at a rapid rate from 1990 to 2004. Although the rate of increase is slowing, emissions are still projected to grow by 70% from 2000 to 2020. Given this increase, more ambitious efforts to reduce emissions should be made so that Korea starts on a path that allows it to further reduce GHG emissions growth. The IEA encourages Korea to set specific climate change targets and objectives to be achieved within the next few years in order to slow the growth of GHG emissions, and to ensure that these targets and objectives are met. The climate change plan should include detailed milestones with dates.

Korea's current policies and measures to limit greenhouse gas emissions are commendable, but require proper implementation to be fully effective. To the extent feasible, the government should set targets for each policy and monitor implementation to ensure that the policies deliver real results and are cost-effective. When developing policies and measures in the future, the government should make sure that cost-effectiveness is a key selection criterion.

The most cost-effective means of managing GHG emissions in the energy sector is by providing a price signal for carbon – either through a tax or emissions trading – so that the market can incorporate the environmental cost of CO_2 emissions into its activities. Korea's climate change action plan foresees the adoption at a later stage of a CO_2 emissions trading system after a pilot plan for a GHG emissions trading system has been completed. However, the trading scheme's implementation has not proceeded. Furthermore, Korea does not plan to introduce a CO_2 tax. In addition to strengthened GHG mitigation policies, the IEA encourages Korea to link a carbon tax or emissions trading scheme to a future GHG emissions target. The benefit of an emissions trading scheme could be greater when linked to the international market. Therefore, the design of an emissions trading scheme should ensure its compatibility with international regimes.

Since the 2002 in-depth review, Korea has increased its international participation and undertaken important initiatives in various collaborative projects, diplomatic co-operative efforts and partnerships, including the Carbon Sequestration Leadership Forum and the Asia-Pacific Partnership on Clean Development and Climate. The IEA applauds these efforts and encourages Korea to continue to enhance them as many policies and measures to mitigate the effects of climate change are developed through international co-operation.

Korea has taken aggressive action on ambient air quality. The country has introduced stringent air quality standards, and emissions of harmful pollutants are now decoupling from economic development. The IEA

compliments these efforts, particularly as Korea is committed to maintaining world-best vehicle emission standards for the long term. Nonetheless, air quality in many cities, particularly the Seoul metropolitan area, remains below OECD levels to the detriment of human health and long-term economic development. We encourage the country to continue to monitor air quality and energy-related emissions, particularly as vehicle ownership is likely to continue to rise at a fast rate, and to strengthen existing policies and measures if necessary. The government should make the greatest use possible of market-based mechanisms to internalise the environmental costs of air pollutants. Although generally more difficult for mobile sources of pollutants, market-based mechanisms, such as emissions trading schemes, are very effective at dramatically reducing emissions of air pollutants from stationary sources. The success of the Acid Rain Programme implemented in the United States following the 1990 Clean Air Act highlights the large benefits of using market-based mechanisms – in this case an emissions trading scheme – to manage environmental problems.

Harmful emissions from coal combustion are greater than emissions from other fossil fuels. For this reason, and because coal-fired power plants make up a large share of total electricity generation, Korea has put in place measures to limit emissions and protect the environment, a commendable strategy. The IEA encourages Korea to continue to monitor emissions from coal-fired power plants and ensure that they are in line with those of best-performing IEA countries.

RECOMMENDATIONS

The government of Korea should:

- *Set out climate change-specific targets and objectives and precise measures that are to be taken over the next few years to reduce the rate of growth of greenhouse gas emissions in order to participate actively in the United Nations Framework Convention on Climate Change process.*
- *Strengthen CO_2 mitigation measures, monitor all measures to ensure effective implementation and consider using an emissions trading system consistent with international trading systems, and/or a CO_2 tax.*
- *Continue to strengthen bilateral and multilateral co-operation in enhancing global efforts to tackle climate change.*
- *Assess the effectiveness of existing policy measures intended to improve air quality in all metropolitan areas and strengthen them if necessary. Use market-based mechanisms to internalise environmental costs.*
- *Continue to ensure that emissions of regional pollutants from coal-fired power plants are and remain in line with best-performing IEA countries.*

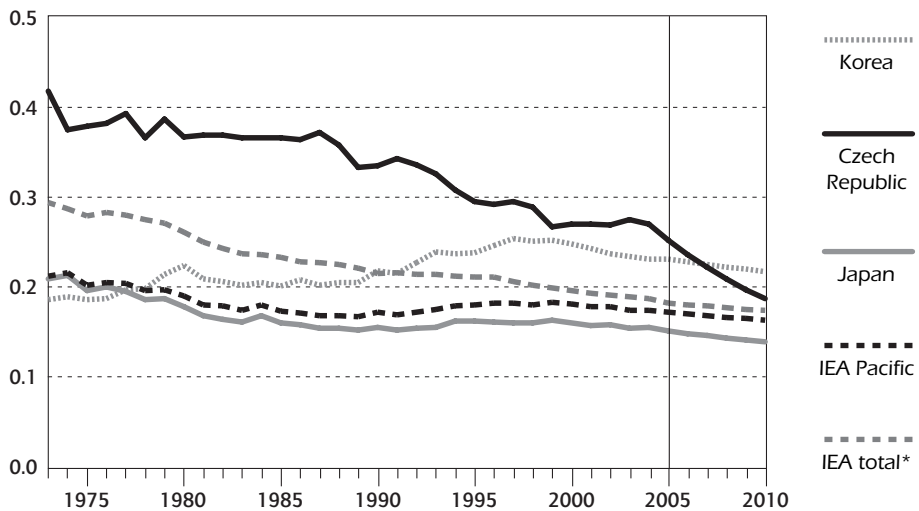
ENERGY INTENSITY MEASURES

Relative to its Pacific neighbour, Japan, the IEA Pacific as a whole and the IEA in total, Korea's energy intensity, a measure of energy used per unit of GDP, is somewhat high (see Figure 8). It is nearly 50% higher than Japan's, one-third higher than the IEA Pacific average and one-quarter higher than the IEA as a whole. Korea's energy intensity is lower than that of the Czech Republic, a country with a similar fuel mix. Korea's energy intensity has been declining relatively steadily since its peak in 1997, falling at an average annual rate of 1.3% between 1997 and 2004, following a declining trend that began in the

Figure 8

Energy Intensity in Korea and in Other Selected IEA Countries, 1973 to 2010

(toe per thousand USD at 2000 prices and purchasing power parities)



* excluding Luxembourg and Norway throughout the series, as forecast data are not available for these countries.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006; *National Accounts of OECD Countries*, OECD Paris, 2006; and country submissions.

late 1980s. Despite this declining trend, which is expected to continue through 2010, Korea's energy intensity is still expected to remain above most countries through 2010. The Czech Republic is expected to fall below Korea in terms of energy efficiency by 2007.

GOALS AND STRATEGIES

In 2000, the Ministry of Commerce, Industry and Energy (MOCIE) set a policy goal to convert Korea's economy into a low energy-consuming structure. It also required the implementation of policies harmonising energy, the economy and the environment.

Following the original broad energy efficiency goals, the government set specific energy efficiency targets, including sectoral targets. On 28 December 2004, 18 government departments together established the *General Energy Conservation and Efficiency Improvement Plan* to enhance Korea's energy intensity and energy efficiency. According to the plan, a total of 17.6 Mtoe will be saved from 2005 to 2007, so that Korea's energy intensity is expected to improve from 0.359 toe per thousand USD in 2004 to 0.328 in 2007, an improvement of 8.6%. By 2012 energy intensity is expected to fall to 0.294.[3] Without the measures, Korea estimates that energy intensity would decline by only 3.8%. The itemised conservation targets are outlined in Table 9. Assuming the full savings are realised, this would mean that total consumption in 2007 would be 15% higher than in 2003, as opposed to 19% higher.

The industrial sector aims to save almost 10 Mtoe over three years with the expansion of energy conservation voluntary agreements (VAs), the high-efficiency equipment programme, the development of alternative energy for agriculture and the improvement of the efficiency of freezing and refrigerating facilities for fishery products. With the enhancement of the efficiency of logistics systems, the expansion of public transportation and the improvement of the efficiency of vehicles, the transport sector aims to save 1.3 Mtoe. Furthermore, the residential, commercial and public sectors are aiming to save 6.5 Mtoe through, among other things, a minimum efficiency standards programme, Standby Korea 2010.

In July 2006, the government also set long-term sectoral energy consumption reduction goals for the transport and building sectors. It set a goal of reducing emissions by 7% in the transport sector and by 6% in the building sector by 2020, as compared with projected emissions.

3. Energy intensity values differ from IEA data because of differences in GDP calulation methodology.

Table 9

Energy Conservation Targets, 2005 to 2007

Sector	2003 consumption		Major policies	Three-year targeted conservation	Estmated 2007 consumption without savings		Estmated 2007 consumption with savings	
	Mtoe	Share of total		Mtoe	Mtoe	Change from 2003	Mtoe	Change from 2003
Industrial sector	67.7	48%	Expansion of voluntary agreements (VAs) Investment in conservation facilities through energy management examination Increased support for energy service companies (ESCOs)	9.865	87.4	29%	84.1	24%
Transport sector	34.2	24%	Expansion of public transportation Execution of the average energy efficiency programme Promotion of hybrid and compact cars Operation of the electronic toll collection system (ETCS) and the intelligent transportation system (ITS)	1.271	37.9	11%	37.4	10%
Residential, commercial and public sectors	39.9	28%	Tightening of minimum efficiency standards and expansion of subjective items Decrease in standby power and introduction of power-saving office equipment Continuous promotion of community energy system Intensification of discussions on energy use planning Tightening of construction planning standards Requirement to append the energy efficiency assessment statement to the sale and purchase of buildings	6.498	43.0	8%	40.8	2%
Total	**141.7**			**17.634**	**168.3**	**19%**	**162.4**	**15%**

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

INDUSTRIAL SECTOR

Expansion of voluntary agreements

Korea is focusing on voluntary agreements (VAs) as a major component of its energy efficiency strategy. Under voluntary agreements, which began in 1998, a company sets its own energy conservation targets, proposes implementation methods and executes the plan. For the government's part, it provides incentives in the form of either direct financial support or tax incentives. The government also performs the preliminary energy assessment. Voluntary agreement periods cover five years and the target indicator is the efficiency improvement rate or the emissions reduction rate of CO_2. There are no penalties for non-compliance, although companies that do not comply with the standards will be publicly named and may lose incentives.

To date, 80% of companies with consumption of 2 thousand tonnes of oil equivalent (ktoe) or more have signed VAs; 1 288 companies are taking part in the programme, equivalent to nearly 60% of total industrial energy consumption. According to government analysis, 990 companies have made some progress towards their commitments, representing savings of about 1.76 Mtoe. The government has spent KRW 645.2 billion on incentives over the life of the programme.

Currently voluntary agreements do not have an additionality requirement such that government incentives only reward improvements above what would happen in a business-as-usual scenario. The government is considering imposing such an additionality requirement or providing enhanced incentives for "stretch goals".

Energy audits

By measuring and analysing the actual use of energy in large companies or buildings that consume significant amounts of energy, loss factors are determined and improvement measures can be proposed. The government offers free energy audits for small and medium-sized companies, while other companies can purchase the audit. As a result of the 6 200 audits the government performed between 1980 and 2004, the government estimates that a 10% average energy savings rate has been achieved, equivalent to savings of 3.5 Mtoe over the period.

Energy service companies

The Korean government provides two types of support for energy service companies (ESCOs). It provides money directly to ESCOs to support preliminary work for still-unproven efficiency technologies and provides

funding directly to industrial companies to pay for ESCO services. The government pays the initial investment cost and then collects repayment based on subsequent energy savings. Once the government's initial investment has been repaid, the remaining benefits flow directly to the customer.

RESIDENTIAL AND COMMERCIAL SECTORS

Building codes and efficiency audits

Korea is working to enhance its building energy codes, which are currently at a relatively low level compared to other IEA countries. The current heating energy consumption level required by code is about 123 kWh per m^2-year for residential buildings and 116 kWh per m^2-year for non-residential buildings. In comparison, the code level for residential buildings in Germany is 70 kWh per m^2-year. To improve Korea's building energy codes, in July 2005 the Korea Institute of Construction Technology was tasked with investigating building energy efficiency assessment standards and strengthening current codes and policies. The investigation will be finished in December 2006. On the basis of its results, the government will prepare action plans and implement them in 2007. In addition, the current programme, which requires a building energy savings plan for new buildings over a certain size, will be strengthened and expanded to other building types. In addition, a performance-based energy code, which limits total energy use per unit area, will be implemented in these buildings. The government is currently working to implement more stringent building insulation standards that will become tighter over time. Insulation standards, which are currently mandatory for all new buildings, will also be expanded to apply to significant renovations of existing buildings. As Korea's current energy efficiency standards for windows are poor compared with other IEA countries, the government plans to introduce more stringent standards. In addition, the government is studying whether to mandate that all real estate transactions for large buildings include an energy efficiency certification, with the associated document attached to all sale and purchase transactions. In 2007, the government mandated that energy audits be conducted every five years for buildings with energy consumption above 2 ktoe per year. Buildings that achieve outstanding energy performance can be exempted from this requirement.

District heating

Korea is a world leader in district heating, an energy-efficient means of heating homes and providing heat to industrial facilities. In 1985, the Korea District Heating Corporation (KDHC) was established as a state-owned enterprise to provide district heating to Korean households and combined heat and power (CHP) to Korean businesses. Since then, district heating and

cooling has rapidly expanded. About 1.4 million Korean households are now supplied with district heating and cooling, covering nearly 10% of the market – three times as many as in 1994. The district heating market has been liberalised and there are now ten district air heating and cooling businesses in 24 regions along with 20 energy businesses in 15 industrial estates. KDHC has about 60% of the residential district heating and cooling market.

Appliance labelling and standards

Korea is actively working to promote energy efficiency standards and labelling for appliances. The energy efficiency standards and labelling programme, launched in 1992 and subsequently reviewed in 2004, requires companies to label the energy efficiency of products in 18 categories, including refrigerators, air-conditioners and cars. The comparative energy labels range from 5 (least efficient) to 1 (the most efficient or "target" level) and no product with a rating less than 5 may be sold after the effective date.

The government also has a programme to certify and label high-efficiency products, which was introduced in 1996. The programme covers 34 items including inductor motors, boilers, pumps and lighting equipment. In 1999, the government started the standby power saving programme, a voluntary system that initially labelled products in 14 categories, including computers, printers, copying machines, televisions and video-cassette recorders (VCRs). In 2004, the government endorsed a national programme which set the target of limiting standby power to 1 watt for electronic appliances by 2010, and launched a detailed implementation strategy. This relies upon voluntary agreements in the first phase (2005 through 2007), then the use of measures such a consumer warning labels for products that do not meet the 1-watt target (2008 and 2009), and finally regulations from 2010 onwards. The programme currently covers 18 products and is anticipated to be expanded to 30 products by 2010 (see box).

Standby Korea 2010

In 2004, Korea's prime minister set a goal that the standby power of all electronic products be reduced to 1 watt by 2010, a goal that was later codified into its Standby Korea 2010. Both the United States and Australia have similarly set a 1-watt goal, although the United States has not set a compliance date and Australia strives to meet the target a bit later, by 2012.

Following the prime minister's declaration, the Standby Power 1W Programme Promotion Committee was established including

22 organisations from government, consumers' groups and the electronics industry. In late 2004, the government gave priority to 1-watt compliant products during the government procurement process and announced that it would offer full assistance in developing, procuring and disseminating standby power-saving technologies.

In 2005, Korea officially established Standby Korea 2010, setting out three phases. The first phase, covering 2005 to 2007, sets no mandatory requirements that appliances be compliant, but gives standby power performance recommendations. The second phase, covering 2008 and 2009, requires some products to be compliant, but is generally a transition phase to the final phase. During phase two, products that do not meet the recommended performance levels will be labelled with a large yellow sticker reading: "WARNING: This product fails to meet the Korean Government Standby Product Specification". From 2010, the start of the final phase, appliances that fail to meet the standby standards will be banned from manufacture and sale in Korea.

Not all appliances are required to meet a 1-watt standard. Depending on the product class, standby power consumption limits range from 0.3 watts to 5 watts, once the regulations are fully implemented in 2010.

Source: *Standby Korea 2010: Korea's 1-watt Plan*, Ministry of Commerce, Industry and Energy and Korea Energy Management Corporation.

TRANSPORT SECTOR

Fuel economy

In addition to energy efficiency labelling for vehicles, the government has introduced its first mandatory fuel economy standards; previously the government had set only voluntary targets. In January 2006, regulations entered into force requiring car manufacturers to meet average fuel economy standards of 12.4 km per litre for vehicles with engines of less than 1 500 cubic centimetres (cc) and 9.6 km per litre for vehicles with engines over 1 500 cc. It also provides incentives for the manufacturers that achieved the target energy consumption efficiency by 2006.

Although it is impossible to directly compare all fuel economy standards, those currently required in Korea are more stringent than those imposed in the United States. However, they are generally less stringent than those to enter into force in 2008 in the EU and those in place in Japan (see Table 10), which are expected to become more stringent. Japan currently has the most stringent fuel economy standards in the world. In 2012, proposed EU standards would become the most stringent in the world.

Table 10

Comparison of World Fuel Economy Standards

Region	*Vehicle type*	*Future fuel economy stabdard*		*Compliance year*
		Country-specific units	*Equivalent (in km/l)*	
United States	Car	27.5 mpg	11.7	current
	Light truck	24.0 mpg*	10.2	2011
European Union	Car: earlier phase	140 g CO_2/km	17.2-19.0	2008-2009
	Car: later phase**	120 g CO_2/km	20.1-22.2	2012
Japan	Car (gasoline)	15.1 km/l*	15.1	2010
China	Car: earlier phase	7.2-16.4 l/100 km	6.1-13.8	2005
	Car: later phase	6.2-14.7 l/100km	6.8-16.1	2008
Korea	Car<1 500 cc engine	12.4 km/l	12.4	2006-2009
	Car>1 500 cc engine	9.6 km/l	9.6	2006-2009

Note: mpg = miles per gallon.

* estimated by local government authorities. ** This European Community target is now under consideration.

Sources: IEA and country submissions.

Korean manufacturers and importers will be given a grace period until 2010 in order to comply with the new fleet-wide fuel economy standards. After that period, manufacturers and importers failing to comply will be issued an order of improvement. However, there are no penalties assigned to these orders – they function more as a public shaming.

Public transit and mode shifting

The use of public transport in Seoul is very high – workers commuting by subway represent 36% of all workers; workers commuting by subway or bus comprise 62% of all commuters. In Pusan, the subway rate is 14% and in Inchon the combined subway-bus rate is 20%. Korea is working to further expand public transport usage through a variety of measures, including enhanced public transit service and financial and other incentives to encourage the use of public transport.

Korea is rapidly expanding its public transport service. It plans to add over 80 km of light rail service in five cities between 2001 and 2008. In 2004, the government drew up plans to build 22 rapid transit bus routes measuring 540 km by 2012, all located in the Seoul metropolitan area. In addition to an enhanced light rail service, the government is expanding the rail service

between large cities. The government is working to better integrate the public transport system by making all public transport tickets interchangeable between different modes of transportation.

The government has a number of policies in place to further promote public transport. Private-sector companies are given fiscal incentives to discourage their employees from driving to work. Government workers are required to leave cars at home one day out of five. Tolls are being introduced in heavily congested traffic areas. Targeted fuel taxes have been introduced in the area to reduce road traffic, to encourage changes in the composition of the vehicle fleet towards non- and low-emission vehicles and compact cars, the introduction of more buses fuelled by compressed natural gas (CNG), hybrid cars and biofuels, and the continued development of mass transportation. In addition, the government has implemented pricing of toll roads, car parks and insurance policies that provides steep discounts for smaller vehicles.

CRITIQUE

While Korea has focused on economic development, it has made significant efforts to respond to the increase in energy intensity that has accompanied its rapid economic rise. Most notable and commendable are its effort to develop a public transport system to reduce energy consumption growth from transportation. Not only has the government invested in co-ordinated transit infrastructure, particularly in buses and express bus lanes, but it has also created clear incentives that have reduced single-passenger vehicle transport and encouraged the purchase of smaller cars. The government requires its employees to leave their cars at home regularly and has implemented pricing regimes for toll roads, parking lots and insurance policies that encourage the purchase and use of smaller vehicles. Transport policy is a difficult issue for nearly all IEA countries, but in this case Korea has made remarkable and quick progress that can serve as a model for other countries, as public transport usage in the Seoul metropolitan area is currently above 60%. Similarly, Korea has leveraged its position as an electronics and appliance exporter and now exports highly energy-efficient products, particularly with respect to standby power. Furthermore, the country's urban concentration has meant that it relies heavily on co-generation and district heating, a very efficient energy source.

Korea's progress in energy efficiency is not limited to the transport sector. In December 2004, 18 government departments together established the *General Energy Conservation and Efficiency Improvement Plan* to improve Korea's energy intensity and energy efficiency by 8.6% over three years (between 2005 and 2007), leading to 2007 consumption that is 15% higher than 2003 consumption rather than 19% higher. While the targets are ambitious, when considered in the context of Korea's expected growth, they will leave Korea with relatively high energy intensity compared to other IEA

countries. Despite Korea's considerable progress to date to improve energy efficiency, notably the adoption of a detailed strategy to limit standby power consumption to one watt for electronic equipment, the IEA encourages the government to continue to actively focus on energy intensity, and to consider setting more ambitious targets. In particular, targets for the transport and residential sectors, if fully achieved, deliver relatively small benefits. The government should consider strengthening these targets, and implementing detailed energy efficiency strategies covering these sectors. To that end, the new long-term 2020 efficiency goals for the transport and building sectors are a good first step in this direction.

The single most powerful tool for encouraging energy efficiency is through transparent and cost-based prices, which send signals to customers to consume the right amount of energy at the right time. While transparent, liberalised markets are the most effective means of delivering such signals, cost-based prices under the current energy system can also be effective. Critical to this is the removal of all subsidies for energy customers. For example, as discussed in Chapter 10, industrial electricity customers receive subsidised rates. KEPCO should increase prices to industrial customers so that they are in line with costs in order to encourage efficiency. Furthermore, all energy subsidies to low-income consumers should be removed, such as subsidies for coal briquettes, and replaced with direct social subsidies for low-income households that do not distort incentives, as discussed more extensively in Chapter 7.

The IEA applauds Korea for implementing mandatory fuel economy standards for vehicles for the first time in 2005, standards that are stricter than those in the United States, Australia and Canada. The country should monitor implementation of the standards and ensure adequate enforcement. If it is found that companies do not comply with the standards, the government should impose a more effective compliance mechanism. In addition, although the Korean standards are currently comparable with those in other countries, the government should ensure that they evolve to keep up with world best standards. To provide regulatory certainty to vehicle manufacturers, the government should also establish a clear timetable for implementing more stringent standards over the long term as quickly as possible. As Korea is a major vehicle exporter, its fuel economy standards could have a large impact on the fuel economy of other countries' car fleets, giving its fuel economy policy decisions the power to impact world energy use. The government should also consider developing policies for reducing the fuel consumption of particular components, most notably air-conditioners, as the use of many car accessories and components are not included in standard fuel economy tests despite their consumption of considerable fuel in on-road conditions. This could further improve the efficiency of Korea's car fleet and, consequently, the global car fleet.

Voluntary agreements with industry are a critical part of Korea's existing energy efficiency improvement plan – it is projected that they will deliver over half of the improvements between 2005 and 2007. In addition to setting adequately ambitious targets, the other keys to successful voluntary agreements are setting specific and measurable targets. Furthermore, in order to ensure that voluntary agreements deliver the promised reductions, the government must carefully monitor and verify their results at regular intervals. If they are found not to be delivering the promised reductions, the government should consider more stringent penalties beyond public naming and removal of fiscal incentives. In addition, the government should ensure that companies do not receive incentives for efficiency improvements that would have been cost-effective without government involvement, as government resources should be spent on making improvements to the efficiency of private companies that would not take place in a business-as-usual scenario.

As in many IEA countries, the efficiency of buildings is an area where Korea can focus its efficiency efforts. Korea's climate makes building efficiency particularly important for improving the country's overall energy intensity. The government should evaluate the current efficiency of buildings and benchmark it to that of other countries. If necessary, the government should introduce more stringent building standards, ensuring they are complemented with effective monitoring and enforcement. Window efficiency, in particular, is an area where building standards could be improved. Korea's standards for the efficiency of buildings should also remain in line with those of other best-performing IEA countries over the long term.

Korea's Standby 2010 programme is a model for other countries. The government has taken the initiative to spur reductions in standby power consumption and its efforts will have an impact not only on the energy efficiency of Korean appliances, but also on world residential energy efficiency as Korea is a major exporter. As the government further develops its standby power policies, it should consider better integrating them with overall energy performance standards for major appliance classes. Currently, active power use and standby power use are regulated separately under different regulations and by separate government offices. The government should consider setting total energy use standards, covering all appliance modes, for major appliance categories in order to reduce the administrative and regulatory burden of the policy for both the government and the affected manufacturers. For all other appliances not covered by a comprehensive performance standard, the government should consider adopting a uniform 1-watt standby standard, replacing the differentiated standby standards currently in place.

RECOMMENDATIONS

The government of Korea should:

- *Consider setting more ambitious energy efficiency targets and timetables in light of the country's rapidly growing energy use, particularly in the transport and building sectors; monitor these targets and timetables to ensure that they are met.*
- *Ensure that energy prices in all sectors reflect costs and eliminate any subsidies.*
- *Monitor compliance with vehicle fuel economy standards; ensure that fuel economy standards remain in line with best practices of IEA countries and, as quickly as possible, set a timetable for progressively tightening these standards.*
- *Monitor voluntary agreements to ensure they achieve the expected targets; if they are not being met, consider enhanced or alternative policies.*
- *Evaluate current efficiency standards for buildings and make sure that they are and remain consistent with best practices of IEA countries with a similar climate. Strengthen enforcement if necessary.*
- *Consider merging standby energy performance standards with overall energy performance standards for major appliances to reduce the regulatory and administrative burden of the policy.*

NEW AND RENEWABLE ENERGY

SUPPLY

Korea's share of renewables in its total primary energy supply (TPES) is the lowest of all IEA countries – 1% in 2005 (see Figure 9). Over 80% of the 2.1 Mtoe of renewables in Korea's 2005 TPES came from combustible renewables and waste. The remainder came from hydro (15%) and wind and solar (2%).

Although the share of renewables in Korea's TPES remains very low, it has been increasing at a relatively fast rate since the early 1990s (see Figure 10), rising at an annual rate of over 7% over the last decade. The largest increase was in combustible renewables and waste, which grew at nearly 8% per year. Over the same period, hydro grew at nearly 3% per year and solar and wind grew at over 6% per year.

OBJECTIVES AND INSTITUTIONS

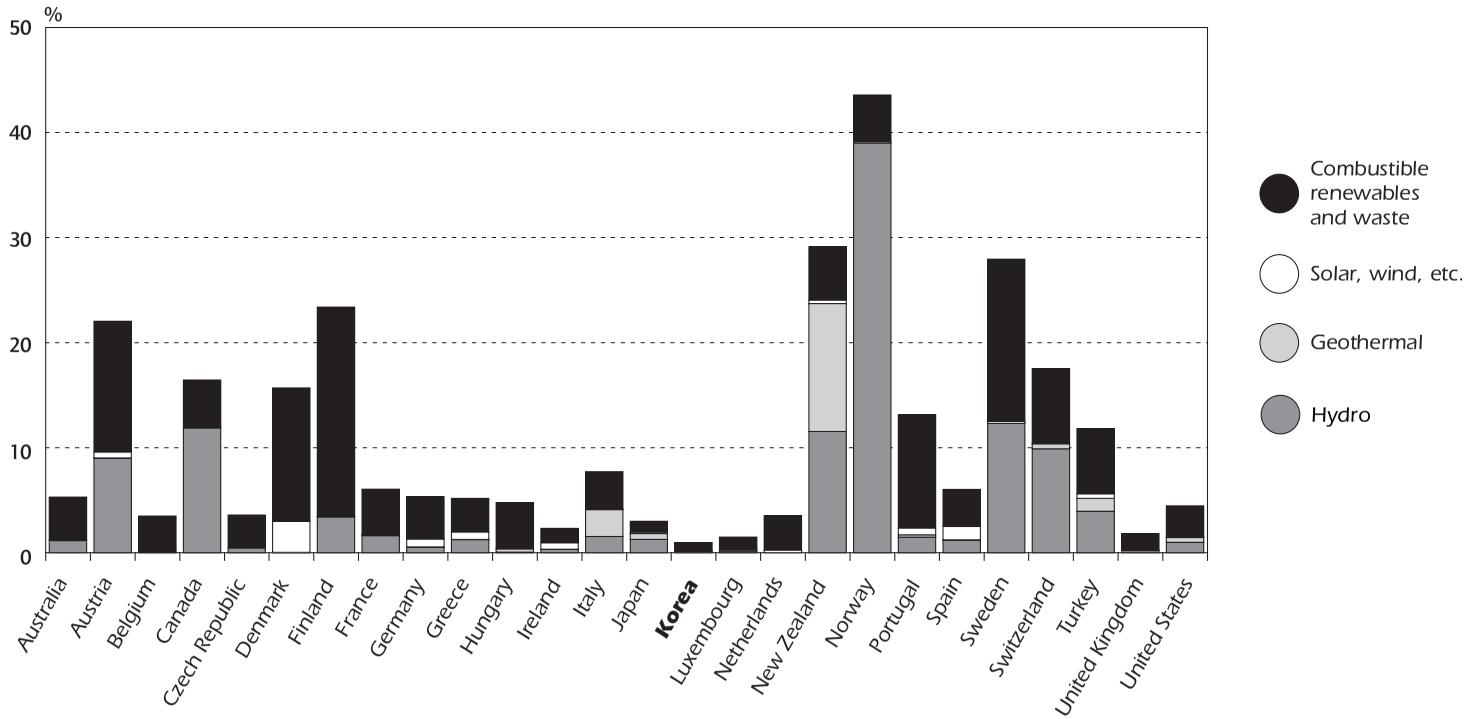
In December 2003, the government set two targets for penetration of new and renewable energy[4] (NRE), targets of 3% of TPES in 2006 and 5% of TPES in 2011 (see Table 11). These targets, along with technology-specific targets, are detailed in the government's *Second Basic Plan for National Energy*. To achieve these targets, the government passed the *Second Basic Plan for New and Renewable Energy Technology Development and Dissemination*, which was modified from the *Basic Plan for Alternative Energy Development and Dissemination*. The targets call for an increase in the share of renewable energy provided from sources such as wind and solar, and a reduced share provided by waste. The fuel-specific targets are only indicative to provide guidance on funding priorities.

The Ministry of Commerce, Industry and Energy (MOCIE) is principally responsible for new and renewable energy development and dissemination, in co-operation with the Ministry of Environment (MOE) and KEPCO.

4. New and renewable energy includes small hydro, solar photovoltaics, wind, bioenergy (including combustible renewables and waste), geothermal, ocean and fuel cells, among other technolologies.

Figure 9

Renewable Energy as a Percentage of Total Primary Energy Supply in IEA Countries, 2005*

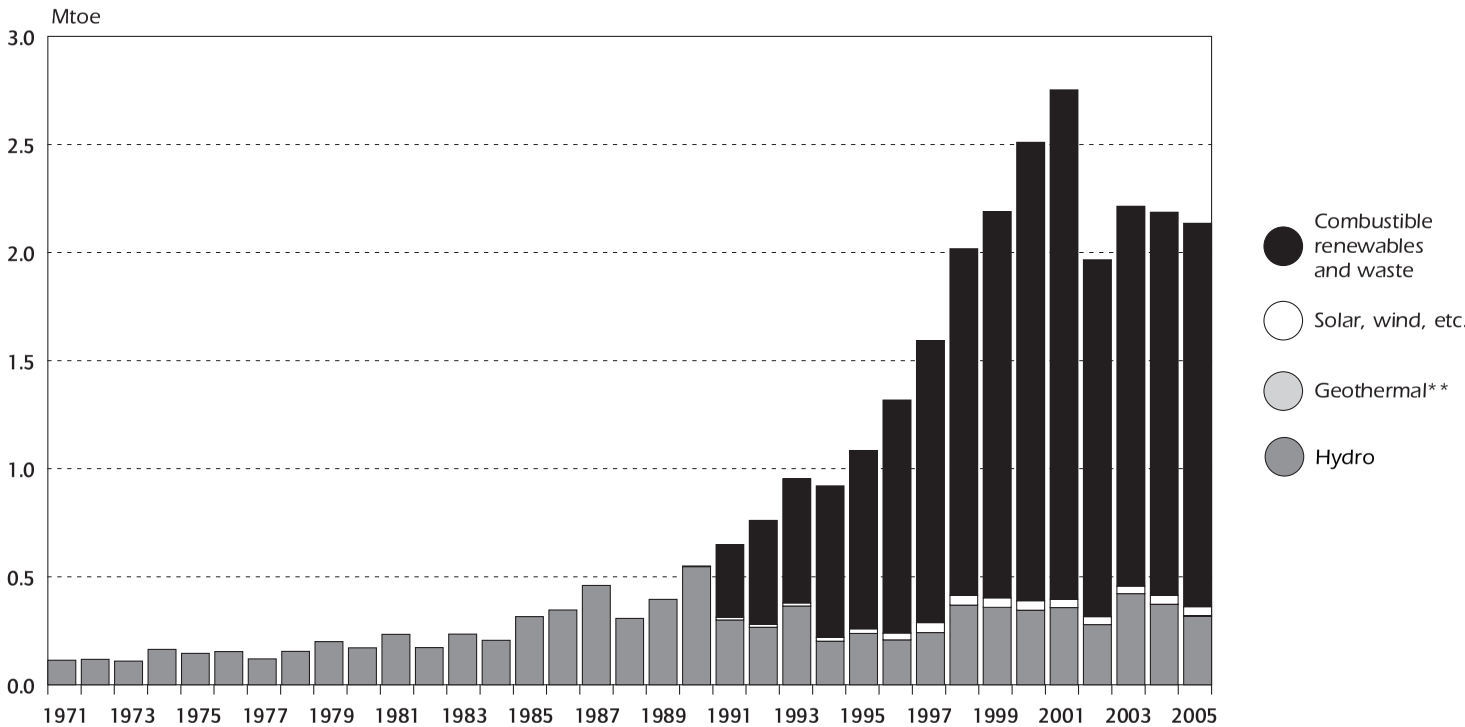


* estimates.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006.

Figure 10

Renewable Energy in Total Primary Energy Supply, 1971 to 2005*



* estimates.

** negligible.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006.

Table 11

New and Renewable Energy Targets, 2006 and 2011

	2006 target			*2011 target*		
	ktoe	*Share of NRE*	*Share of total energy consumption*	*ktoe*	*Share of NRE*	*Share of total energy consumption*
Solar thermal	102	1.4%	0.04%	318	2.4%	0.12%
Biomass	495	7.1%	0.21%	1 050	7.9%	0.39%
Waste	5 050	72.1%	2.13%	7 540	56.5%	2.80%
Photovoltaic	22	0.3%	0.01%	341	2.6%	0.13%
Wind	126	1.8%	0.05%	1 311	9.8%	0.49%
Small hydro	111	1.6%	0.05%	446	3.3%	0.17%
Fuel cells	0	0.0%	0.00%	147	1.1%	0.06%
Geothermal	12	0.2%	0.01%	161	1.2%	0.06%
Ocean	1	0.0%	0.00%	432	3.2%	0.16%
Hydrogen	–			1	0.0%	0.00%
Coal	–			375	2.8%	0.14%
Subtotal	*5 919*	*84.5%*	*2.49%*	*12 122*	*90.9%*	*4.50%*
Hydro	1 082	15.5%	0.46%	1 213	9.1%	0.45%
Total NRE	**7 001**		**2.95%**	**13 335**		**4.95%**
Total all sources	***237 589***			***269 323***		

Source: Country submission.

POLICIES AND MEASURES

The government is planning to invest over KRW 6 trillion (KRW 9.1 trillion, including loans) between 2004 and 2011 to achieve its 5% NRE supply target for 2011. The government has designated hydrogen fuel cells, photovoltaics and wind as areas to receive the largest share of government support – 70%. Funding in the form of loans is focused mostly on solar photovoltaics and biomass. The government sees photovoltaics as a potential export market for Korean industry.

ELECTRICITY SECTOR

Feed-in tariffs

One of the government's principal means of promoting new and renewable energy is through a differentiated feed-in tariff programme. The government guarantees fixed rates for five years for small hydropower, biomass and waste, and guarantees the rates for 15 years for wind and photovoltaics. The feed-in tariff varies by technology according to the rates in Table 12. The tariff for photovoltaics is nearly seven times larger than the rate paid for wind, which receives the second-highest subsidy. The government is considering gradually lowering the feed-in tariff for photovoltaics to take into account technology development.

Table 12

Differentiated Feed-in Tariffs

Technology	*Feed-in tariff*	
	KRW/kWh	*USD/kWh*
Photovoltaics	716.40	0.700
Wind	107.60	0.105
Small hydro	73.70	0.072
Tidal/ocean	62.81	0.061
Landfill gas	61.80	0.060

Source: Country submission.

According to the process described in Chapter 10, renewable electricity generators bid into the Korea Power Exchange (KPX). The government compensates eligible renewable energy generators for any shortfall between the pool price and the feed-in tariff. In 2002, the government set an upper limit of support for renewables at 250 MW for wind and 20 MW for solar. The guaranteed feed-in tariff is granted on a first-come, first-served basis up to the limit.

The government has paid KRW 11.7 billion in subsidies since the programme began in 2002, up through 2004, to 110 MW of renewable power (40 different power plants). The total power generated by the support system was 664 662 MWh as of the end of April 2005.

The government is considering introducing more market-based methods for promoting renewable power generation, including setting a renewable portfolio standard (RPS) with a green certificate system.

Other support

In addition to the feed-in tariff, between 1996 and 2004 the government provided KRW 234.8 billion in direct support for the construction and operation of renewable power plants, with the aim of providing 31 765 tonnes of oil equivalent (toe) in energy savings per year. The government provides the funds required for the construction and operation of facilities for new and renewable energy, such as solar thermal energy and photovoltaic energy. The range of the government's support is up to 100% of the required funds, and the support conditions include 2.0% of the annual percentage rate (APR) and a ten-year redemption period via amortisations after a five-year deferment period.

For companies making investments in new and renewable power generation facilities, a one-time deduction of 10% of the investment amount can be made from the builder's individual income or corporate tax. In addition, 65% of the customs levied on 26 different items in four categories (solar thermal energy, photovoltaic energy, wind power and fuel cell energy) can be deducted.

BUILDING SECTOR

100 000 photovoltaic houses project

To promote solar power, both to reduce domestic fossil fuel use and to develop a long-term export market, the government is supporting the construction of 100 000 homes that rely on solar photovoltaic power for some of their power needs. To meet this goal, the government has provided subsidies totalling KRW 72.8 billion to 332 projects between 2001 and 2004, and the total established capacity is 837 kW, from which 285 toe per year of energy are expected to be saved, equivalent to about KRW 120 million in oil imports per year.

Public-sector buildings

In 2002, to promote the dissemination of new and renewable energy, the government passed legislation requiring that all newly built public buildings (including federal and local government buildings) with over 3 000 m^2 of gross area allocate over 5% of their construction costs to the establishment

of new and renewable energy facilities. In 2004, the government provided KRW 5 billion to ten model businesses, the energy production capacity of which is estimated to be 805 toe. New markets, valued at KRW 100 billion to KRW 200 billion, are expected to be created from this development annually.

TRANSPORT SECTOR

The government has not set a biofuels target, but is providing funding for research on biofuels development.

CRITIQUE

Korea has set ambitious goals for the penetration of new and renewable energy into its energy mix, a step the IEA commends. Furthermore, since the last in-depth review the government has increased its financial support for renewables. The IEA commends these efforts, as they will help lower Korea's reliance on fossil fuels and imported energy, and enhance the country's energy security at the same time as it puts action behind its environmental goals.

Korea's share of renewables in its total primary energy supply (TPES) is the lowest of all IEA member countries. Thus the IEA commends Korea's bold target for 3% of TPES to be supplied by new and renewable energy in 2006, rising to 5% in 2011. However, given that in 2004, new and renewable energy accounted for 2.1% of Korea's TPES, it is unlikely that forthcoming data will show that Korea met its 2006 target. Furthermore, this will make meeting its longer-term 2011 target even more challenging than originally envisioned, necessitating that Korea step up its renewables promotion policies and modify the implementation of existing policies so that government policies and funding bring the largest gains in the supply of renewables. To ensure the 2011 target is met, the government should establish a detailed timetable, with monitoring at regular intervals so that policies can be revised and strengthened if interim milestones are not met.

In the current funding plan, photovoltaics and hydrogen fuel cells receive the largest share of funding. However, photovoltaics and, in particular, hydrogen fuel cells are expected to make up a relatively small share of total NRE in 2011 compared with other sources such as wind and geothermal. Thus the funding scheme for hydrogen and photovoltaics highlights the country's commitment to reduce the unit cost of these technologies so that they can make up a larger share of Korea's energy supply in the long term. Nevertheless, the current funding allocation scheme underscores the need for Korea to undertake rigorous cost-benefit analysis when deciding how to allocate government funding for renewables. While it is understandable that the government wants to encourage development of the domestic photovoltaics market in order to develop this high-tech export market, the risk is that the government is only raising the overall cost of promoting renewables, and developing an industry

with artificial and, therefore, unsustainable economics. To avoid this outcome, the government should undertake cost-benefit analysis of various renewable fuels – including environmental and other benefits – when deciding how to allocate NRE funds and subsidies.

Currently, the government has various measures to directly support renewables deployment, including a feed-in tariff, direct support, tax benefits and R&D funding. While various measures are often warranted, an *ad hoc* approach to renewables deployment – where policies are added one by one without co-ordination – often results in inefficient government investment. A better approach is a streamlined promotion policy with clearly defined government authority, roles and responsibilities. Establishing an efficient renewables promotion policy will also require comprehensive cost-benefit analysis and co-ordination across MOCIE, the Ministry of Science and Technology and other relevant ministries and entities.

Korea's feed-in tariff is one of the government's main policy tools to achieve its NRE target. It is a differentiated feed-in tariff, in order to take into account the difference between power generation cost and sale prices for various NRE technologies. Direct subsidies for installations as well as tax incentives are also provided for projects. As the guaranteed feed-in tariff for photovoltaics is more than six times that of wind, this policy works to ensure that all technologies, regardless of cost, have an equal opportunity to receive feed-in tariffs and supply renewable power. In general, these differentiated feed-in tariffs are provided so that technologies at different stages of cost and development can attain critical mass and sufficient market penetration to become economic. However, differentiated feed-in tariffs could lead to over-subsidisation of technologies because as a technology becomes more economically viable, its feed-in tariff does not evolve to reflect it. Furthermore, there is a risk of creating entrenched oversubsidisation that is difficult to remove rather than short-term development support that is eliminated when the particular technology reaches market maturity or is proven unviable. As has been seen in the global coal industry, as well as in all industries that receive subsidies, it is politically difficult to remove a subsidy once it has been given. As a result, it is important that the government outline feed-in tariff levels for the long term. The IEA is pleased to see that the government is considering lowering differentials in feed-in tariffs over time to reflect the technology learning curve. This would help avoid entrenched oversubsidisation for particular technologies as it may be difficult for the government to introduce feed-in tariff reductions in the future.

Additionally, feed-in tariffs can be a very expensive way of funding technology development. As an example, Korea's USD 0.70 per kWh feed-in tariff rate for solar photovoltaics would provide a payment of USD 1 600 annually per 2-kW panel[5], equivalent to a ten-year simple payback time, a favourable rate considering that payments are guaranteed for 15 years and the operational

lifetime of a solar panel is about 20 years. The government should consider more market-based alternatives to feed-in tariffs, such as, for example, establishing a green certificate scheme like the mandatory renewable energy target in Australia. Under this and other green certificate schemes, the government sets a target for a certain percentage of power to come from renewables and, possibly, new energy sources, but leaves it to market participants to procure the power most cheaply in a way that automatically lowers support for renewables as technologies advance. This flexible, market-based approach continues to promote renewables and reflects the costs of environmental externalities, but allows support levels to adapt to market conditions instead of guaranteeing a fixed and permanent subsidy.

While the government has begun to focus on biofuels, no targets for biofuels penetration have been set. A successful biofuels policy would help reduce Korea's reliance on oil, particularly relevant as the country relies relatively heavily on imported oil in its total energy supply. The government should enhance its biofuels policy, in particular by establishing realistic and cost-effective targets along with clear timetables and milestones for implementation. The government should put in place promotion policies and measures that allow the biofuels target to be met in a flexible, market-based and cost-effective manner.

RECOMMENDATIONS

The government of Korea should:

- *Set interim milestones and monitor progress towards meeting existing goals for the penetration of new and renewable energy, and revise or enhance policies and measures if milestones are not being met.*
- *Ensure a co-ordinated and comprehensive policy for renewables support; ensure that there is co-ordination and communication across government ministries and other entities.*
- *Evaluate all renewables promotion policies (*e.g. *differentiated feed-in tariffs) and select those that maximise cost-effectiveness.*
- *Outline feed-in tariff levels for the long term; consider lowering differentials in feed-in tariffs over time to reflect the technology learning curve and avoid entrenched oversubsidisation.*
- *Establish a realistic biofuels target and implement a comprehensive strategy to meet this target.*

5. This calculation assumes a 10% load factor and a USD 15 000 cost for a 2-kW unit.

SUPPLY-DEMAND BALANCE

Over the last decade total primary energy supply of coal has nearly doubled, to over 50 Mtoe (see Table 13). At the same time, the country's domestic production has steadily declined, falling by over half, from over 3 Mtoe in 1994 to 1.37 Mtoe in 2004, and now represents just 2.7% of total coal supply.

Table 13

Coal Supply-Demand Balance, 1994 to 2004

Units: Mtoe	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Supply											
Domestic production	3.09	2.47	2.16	1.98	1.92	1.85	1.79	1.65	1.42	1.41	1.37
Imports (net of exports)	25.35	28.01	29.80	32.23	33.47	33.04	38.45	39.00	43.95	45.42	50.25
Other*	–3.03	–4.00	–1.84	–1.89	–2.10	–0.05	–0.79	2.19	0.29	0.26	–1.53
Total	*25.41*	*26.48*	*30.11*	*32.32*	*33.29*	*34.83*	*39.45*	*42.85*	*45.67*	*47.09*	*50.09*
Demand											
Electricity generation**	10.64	11.85	14.83	17.09	18.77	20.04	23.58	26.15	27.78	31.02	33.34
Industry	4.43	5.01	5.68	5.65	4.99	5.21	6.12	6.65	8.33	7.60	6.85
Residential	2.12	1.37	0.90	0.65	0.58	0.53	0.57	0.58	0.56	0.56	0.66
Other***	8.22	8.25	8.70	8.93	8.95	9.06	9.18	9.47	9.00	7.91	9.23
Total	*25.41*	*26.47*	*30.11*	*32.32*	*33.29*	*34.83*	*39.45*	*42.85*	*45.67*	*47.09*	*50.09*

* may be negative as it includes stock changes. ** includes CHP and heat plants; reported as coal input, not electricity output. *** includes losses and statistical differences, among other things.

Korea is the ninth-largest coal-consuming country in the world, and total coal consumption is likely to continue to increase as it has over the last 30 years. In 2005, total coal consumption was 85 Mt, 90% of which was imported (see Table 14). After Japan, Korea is the world's largest importer of both steam coal and coking coal. Of the imported bituminous coal, electricity generation makes up the largest share of consumption; 43 Mt was used for power generation in 2004. Of the remainder, 20 Mt was used for coking coal for Posco and 8 Mt for cement production and co-generation. The world's second-largest iron foundry, Posco, operates steel works in Pohang and Gwangyang, producing

steel for export and for the local shipbuilding and vehicle manufacturing industries. Anthracite coal, mainly in the form of briquettes, is used in residential and commercial heating, as well as for small industrial applications.

Table 14

Coal Consumption, 1990 to 2005

Units: Mt	*1990*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Anthracite coal	21.5	6.3	5.4	4.2	4.6	5.0	6.2	7.1	7.7	8.6	8.1	9.2
Bituminous coal	21.9	38.1	44.9	49.7	51.3	54.1	60.3	63.7	68.3	70.5	74.0	75.8
Total	43.4	44.4	50.3	53.9	55.9	59.1	66.5	70.8	76.0	79.1	82.1	85.0

Source: Country submission.

COAL INDUSTRY

While coal trade is largely liberalised, there is significant government involvement relating to domestic production.

IMPORTS

As shown in Table 15, in 2005, Korea imported 77 million tonnes (Mt) of hard coal (including both anthracite and bituminous coal). Recently, imports have come primarily from Australia, China and Indonesia, but also from other countries, including Canada and Russia. Although most imported coal is bituminous, the country does import some anthracite coal, about 4.6 Mt in 2004.

The import market is liberalised. There are no price controls or import duties on bituminous coal. Private-sector and other government-owned companies import coal from the world market for their own needs directly or through a private intermediary, mostly under medium- or long-term contracts. In particular, each electricity generating company (genco) operates its own ports and storage terminals. Most customers buy coal on long-term contracts; on a volume basis 20% of coal is bought on the spot market and the rest is bought on long-term contracts. In light of the rapid price rise for bituminous coal, Korean power and steel companies are increasing the weight of their long-term contracts to ensure stable supply. In particular, Posco relies heavily on advance contracting, purchasing all its coal requirements with five- to ten-year contracts.

Table 15

Hard Coal Imports, 1995 to 2005

Units: kt	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005**
Total imports	45 831	46 074	51 997	53 586	54 569	63 724	64 967	70 114	71 699	78 963	76 759
Steam coal from:											
Australia	9 464	9 933	12 769	15 723	12 249	12 019	13 345	14 398	13 809	17 695	18 913
China	7 209	7 439	8 181	6 725	11 611	20 210	24 888	24 483	26 005	20 351	17 666
Indonesia	3 375	1 997	5 263	6 264	6 104	5 277	4 620	6 927	8 121	13 457	15 382
Russia	533	554	533	418	561	2 197	1 699	2 566	2 097	4 087	3 046
United States	2 150	2 056	1 301	323	185	166	71	335	171	530	365
Vietnam	223	150	54	86	124	68	67	156	367	513	358
Canada	2 156	1 860	1 992	2 696	2 364	1 647	2 114	1 244	741	280	276
Non-specified/other	35	17	192	31	73	62	0	2	73	242	126
South Africa	3 535	3 842	4 317	3 341	4 071	2 503	264	0	0	0	0
Total steam coal imports	*28 680*	*27 848*	*34 602*	*35 607*	*37 342*	*44 149*	*47 068*	*50 111*	*51 384*	*57 155*	*56 132*
Coking coal from:											
Australia	8 410	9 520	9 709	9 829	9 437	10 641	11 396	12 589	12 535	12 442	12 162
Canada	4 251	4 147	3 907	3 663	3 057	4 097	3 337	3 298	3 026	4 206	3 947
China	1 072	975	707	1 313	2 134	2 781	2 341	3 736	3 781	3 638	3 173
United States	2 324	2 652	2 254	2 164	1 586	1 419	571	0	0	533	795
Russia	347	259	195	257	308	394	187	327	937	956	461
Non-specified/other	7	51	0	36	0	34	61	45	36	33 89	
Indonesia	44	0	74	251	625	209	6	8	0	0	0
South Africa	696	622	549	466	80	0	0	0	0	0	0
Total coking coal imports	*17 151*	*18 226*	*17 395*	*17 979*	*17 227*	*19 575*	*17 899*	*20 003*	*20 315*	*21 808*	*20 627*

* estimates.

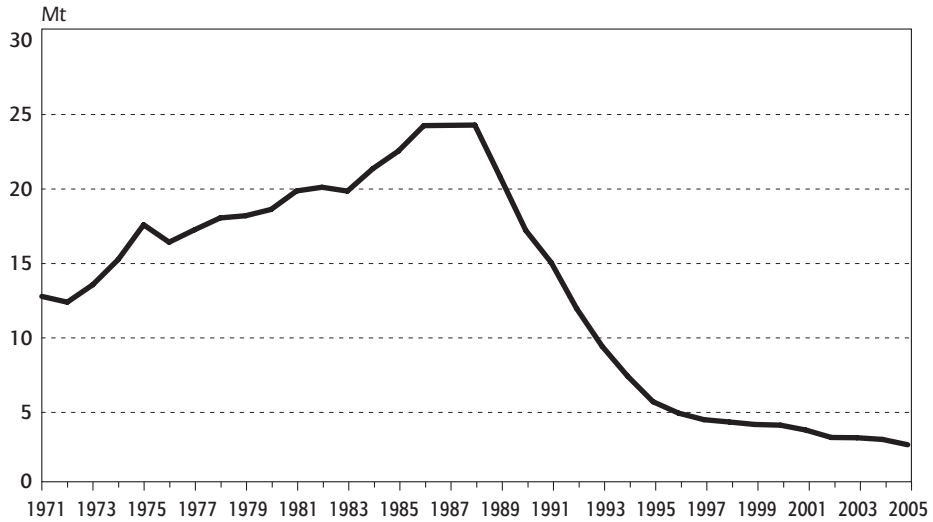
Sources: *Coal Information*, IEA/OECD Paris, 2006 and country submission.

DOMESTIC PRODUCTION

Korea has about 1.4 billion tonnes of coal resources, all of which is low-quality anthracite. Korea currently has seven domestic coal mines producing anthracite coal, three of which are operated by the state-owned Korea Coal Corporation (formerly the Dai Han Coal Corporation). This represents a significant decrease from the 347 mines in operation in 1988, a result of the government's policy of rationalising domestic coal production. Between 1988 and 2005, annual production fell from a high of over 24 Mt to below 3 Mt (see Figure 11). About two-thirds of production comes from the four

Figure 11

Domestic Coal Production, 1971 to 2005*



* estimates.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006.

private mines; the remainder comes from the government-owned mines. Currently there is no plan to privatise any of the state-owned coal mine operations.

Although the government has been rationalising the industry, and still plans to close one or two more mines, it currently does not plan to fully phase out domestic production. Coal production is uneconomic in Korea – anthracite production costs are higher than the cost of imports and the industry relies on subsidies. Nevertheless, the government intends to stabilise supply and demand of anthracite coal, maintaining a minimum annual production volume, given that it is the country's only abundant energy resource. The level of the minimum annual production volume has not yet been set. In addition, closing mines is politically painful, as rationalisation of the industry remains unpopular. As part of its mine closure activities, the government provides financial support to affected regions.

INTERNATIONAL PROJECTS

Given Korea's growing reliance on coal, and a rising world market price that has had a significant negative impact on the country's economy, Korea has begun to promote investments in overseas coal resource development projects

in order to ensure stable coal supply. Through the state-owned Korea Resources Corporation, Korean Coal Corporation and some private-sector Korean companies, the country participates directly in investments. In 2003, 17.7% of the country's total coal supply was provided through joint international projects. The government's target for coal imports from joint projects in 2006 is 30%. However, the government believes this will be difficult to achieve.

COAL-FIRED ELECTRICITY GENERATION

Making up nearly 40% of total generation, coal plays a dominant role in electricity generation. In absolute terms, consumption of coal for power generation is expected to increase in the future. Korea's coal-fired power plants are relatively efficient compared with the OECD average; utilisation rates are 85%, similar to the high rate of Korea's nuclear power plants. Given the county's reliance on coal-fired power generation, Korea is now focusing more attention on clean coal technologies, which further reduce emissions of sulphur dioxide (SO_2), nitrous oxides (NO_x) and carbon dioxide (CO_2). For more information, see Chapter 12.

TAXES AND SUBSIDIES

Coal is subject to a 10% value-added tax (VAT), but this is offset by any other sales taxes levied on consumption. There are no import duties or taxes levied specifically on imports.

Table 16

Domestic Production Subsidies, 1996 to 2004

	1996	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Production subsidy (billion KRW)	225	212	197	205	144	122	102	91	78
Production (Mt)	4.95	4.51	4.36	4.20	4.15	3.82	3.32	3.30	3.19
Production subsidy per unit (KRW/tonne)	45 506	46 854	45 127	48 868	34 771	32 015	30 741	27 653	24 350
Production subsidy per unit (USD/tonne)	44.44	45.76	44.07	47.72	33.96	31.26	30.02	27.01	23.78

Source: Country submission.

The government provides subsidies for domestic coal and coal briquette producers. It provides direct production subsidies, to both private and state-owned producers, of nearly KRW 80 billion annually, equivalent to over KRW 24 000 per tonne of coal produced in 2004 (see Table 16). Implementation of the Coal Industry Rationalisation Policy has brought about a steady decline in production subsidies since 2000. Total production subsidies, including insurance benefits, support for production reductions, social benefits and health premiums, among other things, fell from over KRW 350 in 1996 to KRW 196 in 2004.

In addition, the government also gives energy subsidies as social welfare benefits to low-income users of briquettes for residential and commercial purposes, such as heating and cooking. The government is considering revising the consumption subsidy scheme, replacing it with social subsidies unrelated to coal consumption. However, the government has concerns that this might confuse subsidy recipients.

CRITIQUE

In addition to its reliance on nuclear, Korea also relies heavily on coal, helping improve its security of supply as there are abundant and diverse sources of coal on the international market. In light of the large role the fuel plays, Korea is working to reduce coal's negative environmental effects, in part by investing in research to develop clean coal technologies, a laudable policy. Coal consumption in Korea is expected to grow, in part because Korea has no greenhouse gas emission targets under the Kyoto Protocol, which would put pressure on coal, a greenhouse gas-intensive fuel.

Korea benefits from an economically efficient bituminous coal market, as the market is largely liberalised and free from price controls and import taxes that distort consumption patterns. Companies contract directly for coal and manage transport individually. Many companies have opted to procure most of their coal on long-term contracts, evidence that market participants are actively addressing security of supply concerns. The government is also seeking to enhance security of supply through direct investment in foreign resource development projects. While this is understandable given rising world prices, the government should tread carefully in such investment decisions, as investing in international resource development is highly competitive and not without risk. The government should consider leaving resource investment decisions to private-sector Korean companies, which also value security of supply and may be better equipped to make these complex investment decisions.

The IEA commends Korea for its efforts to date to reduce subsidies for its uneconomic domestic coal industry. Experience in many IEA countries demonstrates that it is difficult to sell the policy to the public. Although rationalisation of the industry will benefit the Korean economy in the long

term, it does so at the great expense of individual citizens in the short term. It is even more difficult to maintain the necessary commitment to the policy during its politically painful implementation. Korea's long-term commitment to continue reducing subsidies for domestic production is laudable. Nonetheless, more needs to be done so that subsidies are completely phased out. Although anthracite is Korea's only significant energy resource, maintaining minimal production does little to enhance security of supply. The international coal market is well diversified and well established. In this context, continuing to subsidise an uneconomic coal industry adds to the cost of the overall energy sector, diverting economic resources that could be better used elsewhere. The government should therefore establish a firm timetable for phasing out production and consumption subsidies as soon as possible – with the goal of eliminating them. Subsidies should be replaced with direct targeted social assistance (both to former coal mine workers and to coal customers) as needed. Korea can look to the experience of both Japan and France; both countries implemented coal sector reform plans that have completely eliminated coal subsidies.

RECOMMENDATIONS

The government of Korea should:

- *Set a clear timetable and deadline for phasing out – with the goal of eliminating – domestic coal production and consumption subsidies; replace subsidies with direct assistance for low-income customers and regional policy measures if necessary.*
- *Promote energy security through the availability of freely traded coal on an international market, rather than through resource ownership.*

Korea's oil consumption has grown dramatically in recent years, more than doubling since 1990 and the country is now the ninth-largest oil consumer in the world. The country relies nearly exclusively on imports and uses a relatively large share of its oil in the industrial sector.

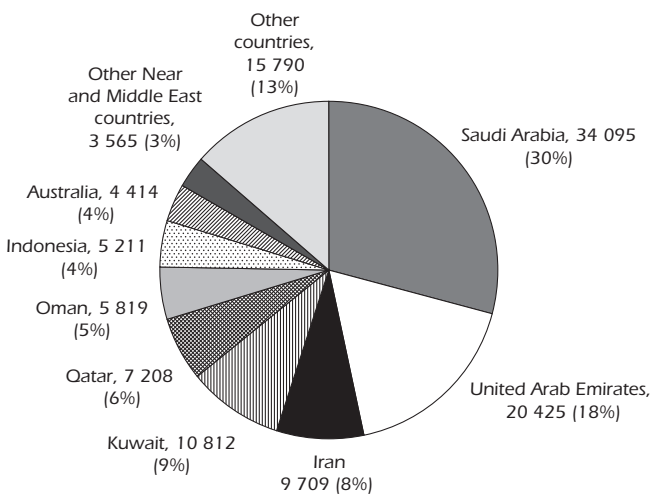
SUPPLY-DEMAND BALANCE

IMPORTS

Less than 0.5% of Korea's oil supply comes from domestic supply; a small oilfield went into production in 2004. As shown in Figure 12, Korea imported over 117 million tonnes (Mt) of oil from 30 countries in 2005. (Some of this oil was subsequently exported as refined product.) Over 96% of imports came from non-OECD countries and over 80% from Middle Eastern countries, but the countries of origin are relatively well diversified. After Saudi Arabia and the United Arab Emirates, six other countries combined provide a third of all imports.

Figure 12

Oil Imports by Country of Origin, 2005*



Total = 117 048 kt

* estimates.

Source: *Annual Oil Statistics*, IEA/OECD Paris, 2006.

CONSUMPTION

Compared to most IEA countries, Korea uses a very large share of oil for the industrial sector. Over 40% of all oil consumed was in the industrial sector (see Table 17), nearly double the IEA average. (Similarly, within the industrial sector oil provides 60% of energy consumption, a relatively large share.) A large share of oil used in Korea is used for the petrochemical industry. At 37%, transport makes up the next largest share of oil consumption, compared to an IEA average of over 50%.

Table 17

Oil Consumption by Sector, 1974 to 2004

Units: Mtoe	*1974*	*1984*	*1994*	*2000*	*2001*	*2002*	*2003*	*2004*
Industry	6.5	9.2	30.8	38.4	37.8	38.0	38.9	39.9
Share	*49%*	*35%*	*37%*	*42%*	*41%*	*41%*	*42%*	*43%*
Transport	2.4	6.4	23.7	29.9	30.9	32.9	33.8	33.8
Share	*18%*	*24%*	*29%*	*32%*	*34%*	*36%*	*36%*	*37%*
Electricity generation	3.3	5.5	7.8	5.9	6.4	5.7	5.8	5.4
Share	*25%*	*21%*	*9%*	*6%*	*7%*	*6%*	*6%*	*6%*
Other	1.0	5.1	20.1	17.9	16.7	16.0	15.0	13.1
Share	*8%*	*20%*	*24%*	*19%*	*18%*	*17%*	*16%*	*14%*
Total	**13.2**	**26.1**	**82.5**	**92.1**	**91.8**	**92.6**	**93.5**	**92.2**

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

OUTLOOK

The government forecasts oil TPES to grow to over 110 Mtoe by 2010, over 125 Mtoe by 2020 and nearly 145 Mtoe by 2030, corresponding to an average annual growth rate between 2004 and 2030 of 1.4%, compared with an average annual growth rate of 5.2% between 1990 and 2004.

INDUSTRY STRUCTURE

Korea's oil industry was largely liberalised in the 1990s, removing import and export restrictions on oil and oil products. Prices have been fully liberalised since 1997. The industry is now dominated by five private companies. In the refining sector, the government previously maintained 30% excess refinery capacity to provide supply security. This policy was terminated in 1998.

Apart from the state-run Korea National Oil Corporation (KNOC), which is responsible for domestic exploration, development and production of oil and natural gas as well as for Korea's strategic oil reserves, private companies

dominate Korea's oil market. The five major oil companies in Korea are SK (previously Yukong), GS Caltex (previously LG Caltex), Inchon Oil Refinery (previously Gyeongin Energy), S-Oil (previously Sangyong Oil Refinery) and Hyundae Oil Bank (previously Hyundai Oil Refinery).

The oil industry is subject to general business regulation by the Fair Trade Commission. The five major oil companies in Korea jointly established the Korea Petroleum Association, an industry trade group working on regulation and liberalisation issues.

WHOLESALE, REFINING AND RETAIL ACTIVITIES

The five major oil companies import some petroleum products, but primarily crude oil for their refineries. Although imports are dominated by these five major oil companies, which import 23.5% of all oil and oil products, in total there are 41 companies importing petroleum. In May 2006, over 83% of all imports were of crude oil.

Crude oil and petrochemicals are imported through five major ports, namely Ulsan, Onsan, Daesan, Yeosoo and Inchon. Imported or refined petrochemicals are transported to storage facilities near major consumption areas by tankers, trains, tank cars and transport pipelines. (Korea does not have crude oil pipelines.) Afterwards, the petrochemicals are distributed through distribution paths. Petrol is distributed to over 11 000 service stations, which are a mix of stations owned by the major importers, stations owned by other importers and independent stations.

Refining

Combined, the five Korean refineries have capacity totalling over 2.74 million barrels per day (see Table 18). The country has the second-, third- and seventh-largest oil refineries in the world; the smallest refinery in Korea is bigger than Japan's largest. The country's refineries have a relatively high average utilisation rate of 86%.

Korea's oil companies are planning major refining investments. Two hydrocrackers, which are used to produce jet fuel, diesel, relatively high-octane gasoline fractions and LPG, are being built. One is expected to be operational in 2007 and the second, being built by GS Caltex, should be operational in 2008. In total, Korean refineries plan to invest KRW 2.5-2.8 trillion (USD 2.4-2.7 billion) for refinery upgrades over the next five years.

Exports

About a third of Korea's total refinery output is exported, making Korea a rival of Singapore in terms of the volume of oil products it exports to Asia and elsewhere. In 2004 it exported over 31 Mt of products from its refineries, as shown in Table 19.

Table 18

Oil Refining Capacity and Production, 2004 and 2005

Units: thousand barrels per day	*Domestic sales volume*		*Market share*		*Refining capacity*		*Actual production*		*Capacity utilisation*	
	2004	*2005*	*2004*	*2005*	*2004*	*2005*	*2004*	*2005*	*2004*	*2005*
SK	562	570	34.0%	34.0%	840	840	723	797	86%	95%
GS Caltex	502	491	30.4%	29.3%	650	650	612	604	94%	93%
Inchon Oil	93	102	5.6%	6.1%	275	275	102	140	37%	51%
S-Oil	267	271	16.2%	16.2%	580	580	538	516	93%	89%
Hyundae Oil Bank	228	242	13.8%	14.4%	390	390	284	308	73%	79%
Total	**1 652**	**1 676**	**100.0%**	**100.0%**	**2 735**	**2 735**	**2 259**	**2 365**	**83%**	**86%**

Source: Country submission.

Table 19

Petroleum Exports, 1970 to 2004

Units: kt	*1970*	*1980*	*1990*	*2000*	*2001*	*2002*	*2003*	*2004*
Gas/diesel oil	22	0	1 401	12 929	12 123	10 218	8 152	9 139
Residual fuel oil	394	0	1 815	10 796	10 062	5 260	6 882	6 836
Kerosene-type jet fuel	0	0	0	4 139	4 981	5 298	3 489	5 740
Naphtha	120	0	374	5 748	6 027	5 288	3 644	3 666
Petrol	32	0	4	1 692	1 895	1 816	1 587	2 154
Bitumen	0	11	5	524	554	883	1 101	1 271
Lubricants	0	0	0	362	358	446	809	1 156
Other kerosene	0	0	12	2 564	2 326	1 319	1 698	994
Other products	1	0	102	1 010	681	480	529	395
Total	**569**	**11**	**3 713**	**39 764**	**39 007**	**31 008**	**27 891**	**31 351**

Sources: *Annual Oil Statistics*, IEA/OECD Paris, 2006 and country submission.

UPSTREAM ACTIVITIES

Domestic production

Korea has some small offshore oil and gas fields that it has been developing since 1970. Among 37 fields where exploration drills were made, gas was found in 11 fields and signs of both oil and gas were found in five. The costs of these explorations totalled USD 379 million, about 36% of which was paid by foreign companies. Production in 2004 totalled 437 thousand tonnes (kt), less than 0.5% of Korea's total oil supply.

International activities

The government and Korean companies began investing in overseas oil development projects in 1981. To date, private companies have invested USD 3.5 billion and KNOC has invested USD 1.7 billion. In total, Korea has secured overseas oil and gas reserves totalling 701.76 million barrels of oil and 91.15 Mt of gas (759.3 million barrels if converted to oil), as of end-December 2004. In total, Korean-developed crude oil projects supplied 3.8% (86 000 barrels per day) of Korea's total imports. The government hopes to raise this percentage to 10% by 2008.

OIL STOCKHOLDING

Under the IEA's oil stockholding requirement, like all IEA countries Korea must hold 90 days of net oil imports as emergency stocks. Since becoming a member of the IEA in 2002, Korea has always been compliant with its obligation. As of January 2006, Korea's stock levels were at 109 days, with 56 days held by government-owned stocks and the remainder held by industry. KNOC manages Korea's government-owned stocks and the country's overall compliance with the stockholding requirement.

Oil loans to industry

KNOC provides short-term oil loans to industry, a practice that can affect Korea's overall stockholding level as the loans come from KNOC's emergency stocks. Korea has provided the loans to industry since the 1980s, in case of an emergency such as disrupted oil supply owing to a natural disaster, unexpected loading and unloading delays and marine disasters. Most oil that is loaned to industry is returned within one to three weeks.

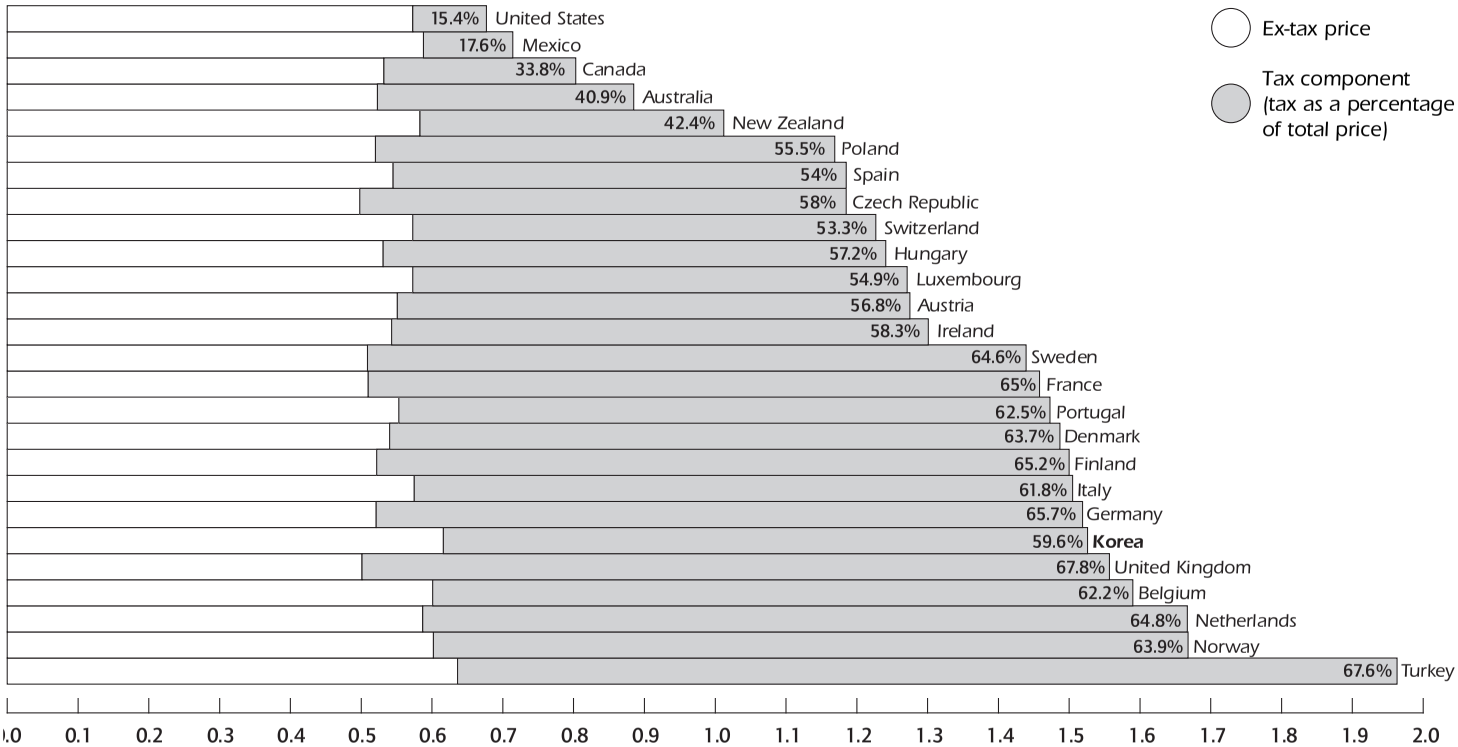
PRICES AND TAXES

Petroleum taxes and import tariffs are charged on petroleum imports and then additional taxes are levied on the retail sale of the final product. Korea has higher import taxes on petroleum products than on crude (5% versus 1%), providing a financial benefit to products refined in Korea versus products imported directly. As all the major oil refiners have retail arms, this policy can protect the country's domestic refineries-retailers.

As shown in Figure 13, Korea's all-in unleaded petrol prices are in the middle of the range for IEA countries. Taxes make up slightly less than 60% of the total price, the sixth-highest share of IEA countries.

Figure 13

OECD Unleaded Gasoline Prices and Taxes, First Quarter 2006



Note: data not available for Greece, Japan and the Slovak Republic.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2006.

CRITIQUE

At the same time as Korea's energy usage has rapidly increased, Korea has been committed to security of supply and diversifying its resources. While the country still relies on the Middle East for the majority of its imports, it has managed to diversify its oil supplying countries at the same time. In addition, although oil still represents a relatively large share of Korea's energy use compared to most other IEA countries, particularly in the industrial sector, the country has also successfully diversified its fuels. This diversification has helped make Korea less vulnerable to the recent oil price spikes. We applaud these efforts, and encourage the country to continue its efforts to diversify fuels and import sources.

Almost 80% of Korea's oil imports come from the Middle East and through the Strait of Malacca, making it possible for localised international events to have significant negative effects on Korea's oil supply. To temper this sensitivity to world market events, the government, via the state-run Korean National Oil Company (KNOC), is involved in overseas exploration and production projects in over a dozen countries, often in partnership with other Korean oil companies – although private companies play a more leading role in upstream activities in general. The mission of KNOC is to stabilise domestic supplies, through development of more oil resources, oil stockpiling and improvements to the structure of the oil market. We commend the government for focusing on international efforts to help diversify and stabilise supply. When making direct investments in international projects, however, we urge the government to tread lightly as investing in international resource development can be a risky enterprise. It might be better left to private Korean companies more accustomed to making these complex, capital-intensive decisions.

Five private companies dominate Korea's oil market. The country has the second-third- and seventh-largest oil refineries in the world and is now a major exporter of refined products. While refinery concentration levels do not raise concerns about anti-competitive behaviour, as in every market, the responsible authority should monitor the market closely and, if necessary, strengthen efforts to prevent and penalise anti-competitive behaviour. Korea's differentiated tariffs on imported crude oil versus petroleum products (1% versus 5%) provide a benefit to Korea's large refineries at the expense of domestic product importers, and can also have wider effects on the Asian product market. To level the playing field in Korea's liberalised market, the government should realign the tax rates, removing the preferential rate for crude oil.

The IEA applauds Korea's strict compliance with its oil stockholding obligation. The country is well above its obligation, taking on more than its fair share of the burden – helping to ensure that any collective action by IEA member countries to release oil stocks can successfully mitigate an emergency supply shock. We note that, although they have not done so to date, Korea's

oil loans to industry have the ability to affect Korea's oil stock levels and, therefore, its compliance with its obligation. As such, Korea should continue to ensure that any transactions that impact stock levels are duly reflected in data transmitted to the IEA in a timely and transparent manner.

While any issues related to the effect of oil loans on stock levels can be fully and easily mitigated, the IEA is concerned that such loans could unduly distort the market, to the benefit of some market participants at the expense of others. Oil loans to industry should be made only in the event of an unexpected supply disruption, not to mitigate high prices or for other reasons. As such, KNOC should ensure that strict and transparent criteria applying to all market participants on equal terms are in place to govern when such loans are provided.

RECOMMENDATIONS

The government of Korea should:

- *Continue efforts to lower oil dependence and diversify oil supply sources.*
- *Continue to closely monitor the market and, if necessary, take measures to prevent unfair practices.*
- *Work to phase out differentiated import tax rates for crude oil and petroleum products in order to increase competition by levelling the retail market playing field.*
- *Continue to ensure that oil loans to industry do not result in stocks falling below mandated IEA levels and that any transactions that result in stock level changes are reflected in data submitted to the IEA in a timely manner.*
- *Ensure that oil loans to industry are made solely to mitigate unexpected supply disruptions, and only under fair and transparent terms applying equally to all market participants.*

SUPPLY AND DEMAND

DEMAND

Korea consumed an estimated 31 billion cubic metres (bcm) of gas in 2005, up from 28.7 bcm in 2004. As shown in Table 20, gas consumption has grown rapidly since the first LNG shipments arrived in 1986, increasing from 5.6% to 12.5% of TPES between 1995 and 2005. The largest use of gas in Korea is for power generation (42% in 2004) where it has now overtaken the use of oil. The government has recently stated its intent to increase the use of nuclear generation in the power sector, which could, in future, lead to a decline in gas consumption (for more discussion of growth in nuclear power, see Chapter 11).

Table 20

Consumption of Natural Gas by Sector, 1990 to 2004

Units: Mtoe	*1990*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Electricity generation	2.0	4.2	5.4	6.3	4.9	5.7	5.8	6.7	7.6	7.6	10.6
Share	*75%*	*51%*	*50%*	*48%*	*40%*	*38%*	*35%*	*37%*	*37%*	*35%*	*42%*
Residential consumption	0.5	2.7	3.6	4.4	4.5	5.8	6.2	6.4	7.9	8.5	7.7
Share	*17%*	*33%*	*34%*	*34%*	*37%*	*39%*	*37%*	*35%*	*38%*	*39%*	*31%*
Industrial consumption	0.1	0.5	0.7	1.2	1.6	2.0	2.9	3.1	3.4	3.7	3.9
Share	*3%*	*7%*	*7%*	*9%*	*13%*	*14%*	*17%*	*17%*	*17%*	*17%*	*16%*
Other	0.1	0.8	1.0	1.1	1.1	1.4	1.8	2.0	1.8	1.8	2.8
Share	*5%*	*10%*	*9%*	*9%*	*9%*	*10%*	*11%*	*11%*	*9%*	*8%*	*11%*
Total	**2.7**	**8.2**	**10.7**	**13.0**	**12.2**	**14.9**	**16.7**	**18.2**	**20.7**	**21.6**	**25.1**
Total (bcm)*	3.0	9.3	12.2	14.9	13.9	16.9	18.9	20.5	23.4	24.3	28.7

*consumption values in bcm are calculated using a different methodology from values reported in Mtoe.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2006 and country submission.

The average annual growth of gas use in the domestic sector was 30% in the period 1990 to 2000 and gas has now virtually replaced coal in cooking and heating, significantly improving air quality in major urban areas as well as indoors in all areas. Residential gas use now makes up the second-highest proportion of total gas consumption. Now that residential gasification is relatively mature, growth rates in this sector are unlikely to be matched in the

future. Indeed, growth has slowed in recent years, to 5.5% per year between 2000 and 2004. Owing to government promotion and support, a relatively high proportion of gas is used in the residential sector (31% in 2004) when compared with other IEA countries dependent on liquefied natural gas (LNG), such as Spain and Japan (both 12% in 2004).[6] This places a strain on LNG supplies because the majority of the gas is used for space heating, which has a very seasonal usage profile. (For more information, see the box on seasonality later in the chapter.)

At 16%, total industrial demand for gas is just half of that used in the residential sector. Meanwhile, oil use in the industrial sector is among the highest in the IEA. One of the reasons for this is that the government has only recently completely decontrolled pricing in the oil sector. Price controls had in the past given oil a competitive advantage over LNG, which is priced according to international oil markets. Now that the reform of oil pricing is almost complete, growth of gas consumption in the industrial sector between 2000 and 2004 has averaged 7.4% per year. (For more information on oil pricing, see Chapter 8.)

SUPPLY

Korea has a growing gas industry that is heavily dependent on imports. Korea, like its neighbour Japan, is unusual among IEA countries in that it has no import pipelines and therefore relies almost exclusively on importing gas in liquefied form; LNG imports account for nearly all of Korean supply. Korea began importing LNG in 1986 and by 2005 had become the second-largest importer of LNG after Japan. In contrast to Japan, almost all Korean LNG supply is imported by one company, KOGAS, the state-owned monopoly, making it the largest commercial LNG buyer in the world.

Domestic production

In 1998, the Korea National Oil Corporation (KNOC) discovered the Donghae-1 gas field in Korean waters. A small gas field off the south-east coast of Ulchin, Donghae-1 has been in production since July 2004. Recoverable gas reserves are estimated at up to 7 bcm, with 2.6 million barrels of condensate. The field supplies 1.42 million cubic metres per year, plus 1 500 barrels per day of condensate. It cost over USD 320 million to develop. While significant as the first source of domestic gas, the field provides less than 2% of annual gas consumption.

6. In Japan, the industrial and power sectors use the largest share of gas, while in Spain, the power sector is by far the largest user. Both of these sectors have less seasonal demand requirements than the domestic sector, which is dominated by space heating.

Imports

Because of its extremely high dependence on imported gas supply, Korea has traditionally placed security of supply at the top of its policy agenda. KOGAS imports from Qatar, Oman, Indonesia, Malaysia, Brunei, Australia and Russia, among others. Long-term contracts, primarily from Qatar, Oman and Yemen, provide equity participation in LNG projects. Table 21 shows imports by country from 2001 to 2005.

Table 21

LNG Imports by Country, 2001 to 2005

Units: kt	*2001*		*2002*		*2003*		*2004*		*2005*	
Qatar	4 942	31%	5 151	29%	5 838	30%	5 896	27%	6 228	28%
Indonesia	4 028	25%	5 020	28%	5 137	26%	5 410	24%	5 565	25%
Malaysia	2 253	14%	2 30	13%	2 808	14%	4 594	21%	4 708	21%
Oman	3 928	24%	4 061	23%	4 810	25%	4 443	20%	4 335	19%
Brunei	591	4%	769	4%	548	3%	899	4%	594	3%
Others	422	3%	525	3%	293	2%	911	4%	874	4%
Total	16 164		17 828		19 434		22 153		22 304	

Source: Country submission.

Most LNG imports into Korea are delivered according to long-term contracts, usually 20 to 25 years in duration. As has been standard until recently, long-term supply of LNG to Korea is organised on a take-or-pay basis.[7] All contracts are linked to international oil product prices, but approximately one-third also apply an S-curve in the formula. This S-curve serves as a financial collar – gas prices rise with oil prices up to a predetermined cap and gas prices fall with oil prices down to a predetermined floor. These contracts were designed to insulate buyers from high oil-driven gas prices but provide insurance to suppliers to cover the high investment costs of LNG infrastructure. Long-term contracts have allowed Korea to ensure security of supply through binding supply agreements, but put the onus on Korea to secure downstream demand. KOGAS, the importing company, has to pay for the LNG whether it is needed or not.

7. Take-or-pay contracts require sellers to supply contracted volumes of gas and buyers to pay for the contracted volumes, whether the buyer takes them or not. There is typically a flexible component to the contract that can be requested if needed. Take-or-pay contracts are not standardised across the industry but are tailored to fit individual circumstances and generally provide both sides with significant flexibility.

Korea is more active in the spot LNG market than its neighbour, Japan, largely because of Korea's very seasonal demand for gas. Korea buys spot gas in winter in addition to its take-or-pay commitments, which are sufficient for gas demand in the summer (see box).

Seasonality of demand

Nearly 40% of gas used in Korea supplies commercial and residential users. The demand for gas in these sectors is strongly seasonal as most of the energy is used in the winter for space heating. Seasonality is often expressed by a turn-down ratio (TDR), which is calculated by taking the demand in the maximum demand month and dividing by the demand in the minimum month. The city gas sector (including residential, commercial and industrial customers) has a TDR of 4, meaning that four times as much gas is consumed in the peak winter month than in the lowest summer month. Within the city gas sector, residential gas use has a TDR of almost 10. The corresponding profile for gas-fired power generation (which covers 42% of total gas demand) is relatively flatter throughout the year, which means that it cannot offset the very high city gas winter peak demand. Winter peak power consumption is generally higher than in the summer, and peak power is most often provided by gas-fired generation, so gas used for power generation has a TDR of 2. In 2004, Korea had a TDR for its total gas usage of 2.63. For comparison, Japan has a turn-down ratio of about 1.4.

Difficulties in managing a high TDR are exacerbated by Korea's source of gas, LNG. The economics of LNG production dictate that it should be produced at a fixed rate throughout the year; the LNG market is not designed to respond to customers that need larger amounts of gas at certain times of the year. In addition, all LNG importing countries are in the northern hemisphere and therefore experience peak heating season at the same time, compounding the problem.

Storage can help manage highly seasonal gas demand. However, Korea – like its neighbour, Japan – is at a disadvantage when compared to many other countries because it does not have any geological capacity to store gas for long periods of time. Whereas most IEA countries have access to depleted oil or gas fields, or even old converted coal mines, Korea only has access to LNG storage, which is very expensive when used as long-term storage. Storing gas as LNG requires keeping the gas at –162°C, which has very large energy requirements and is thus very costly.

Given Korea's circumstances, managing the seasonality of its gas supply has been expensive. KOGAS has chosen to contract for long-term capacity throughout the year and buy spot cargoes from the international market in the winter, when global LNG spot market prices are at their highest. While

this might be the least expensive strategy for securing sufficient winter supplies, it has risks because it relies on there being sufficient LNG volumes available on the global market. Although the spot LNG market has been growing, it still represents a small fraction of the overall LNG market. The majority of LNG from existing facilities and facilities under construction is still sold under long-term contracts. Thus, volume risk is especially great for the coming few years as the global LNG market is not yet mature or liquid enough to guarantee volumes at any price. It is generally expected that the volume risk will ease over time as this market grows. Growth of the global spot LNG market would likely benefit Korea as it would be able to off-load more of its seasonality risk to the spot market.

For a discussion of some strategies to reduce Korea's turn-down ratio, see the later section on demand response and managing seasonality.

OUTLOOK

DEMAND

The city gas sector (including industrial, commercial and residential sectors) is expected to provide the bulk of the growth in gas demand over the period to 2010 and beyond. As shown in Table 22, the government forecasts that the share of gas used for power generation will fall by nearly half, from 41% in 2004 to 21% in 2017, representing an absolute fall of annual consumption of over 2 000 tonnes over the period. Within the city gas sector, industrial consumption is expected to grow faster than the sector as a whole. As industrial demand volumes are much more stable throughout the year than residential demand, this will help temper seasonality. Nevertheless, the forecast fall in gas used for power generation is likely to, on balance, increase the seasonality of the country's gas usage.

Table 22

Annual Natural Gas Demand Outlook, 2004 to 2017

Units: kt	*2004 (actual)*	*2007*	*2010*	*2015*	*2017*	*Average anual growth rate*			
						2004-2007	*2004-2010*	*2004-2015*	*2004-2017*
City gas	12 504	15 386	17 983	22 722	24 893	7.2%	6.2%	5.6%	5.4%
Share	*59%*	*64%*	*71%*	*78%*	*79%*				
Power generation	8 818	8 572	7 348	6 554	6 764	-0.99%	-3.0%	-2.7%	-2.0%
Share	*41%*	*36%*	*29%*	*22%*	*21%*				
Total	**21 322**	**23 958**	**25 331**	**29 276**	**31 657**	4.0%	2.9%	2.9%	3.1%

Source: Country submission

SUPPLY

Korea has been reviewing three major regions for upstream investment, namely the Caspian Sea, Russia and Central America. Recently these efforts have focused on major pipeline supply sources in Russia – Kovykta gas in the Irkusk region, Chavyanandgas in the Sakha Republic and the Sakhalin Islands gas fields. Different options have been under review for over 20 years, but the Kovytka option now looks more promising. The pipeline route would transport gas via China, from where it would be shipped across the Yellow Sea and on to Korea, supplying an expected 10 bcm per year to Korea. The China National Petroleum Corporation and Russia's Gazprom signed a memorandum of understanding in March 2006 outlining the route, volumes and possible timetable. However, no firm plans have been made.

In the meantime, LNG will continue to supply nearly all of Korea's gas needs. In recent years, KOGAS, the state-owned gas company, has changed from its old policy of signing long-term take-or-pay deals to a more flexible policy that relies increasingly on shorter-term contracts and spot purchases. (For more information, see the later section on restructuring and liberalisation.) As a result, projected gas demand compared to existing long-term contracts indicates a growing supply gap, as shown in Figure 14. Projections indicate that the shortfall may be as much as 8 Mt per year by 2010, a figure that does not include the 1 Mt of existing LNG contracts that will have to be renewed by that time.

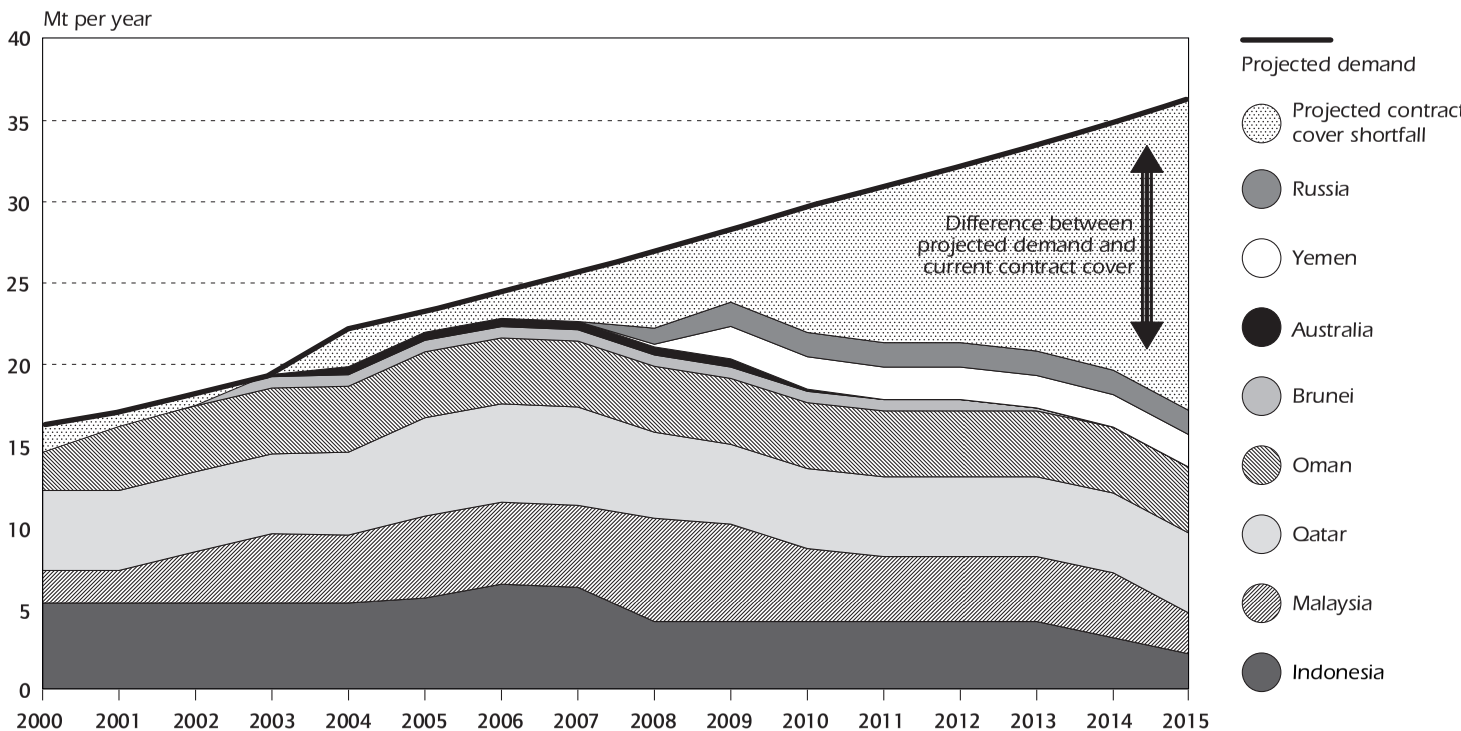
In addition to reduced long-term contracting, events in Indonesia have also added concerns about future security of supply. Recently, there have been problems with LNG exports from Indonesia, where gas production seems to be negatively affected by a combination of government policy, underinvestment and social unrest. Indonesia accounts for 25% of supply to Korea, and a similar proportion of supply to Japan, leaving the two largest LNG importers in the world looking to back up their Indonesian supply commitments with supply from other sources. This situation has also put pressure on the global LNG market at a time when Korean demand is increasing and old LNG contracts supplying nearly 2 Mt per year will be coming up for renewal over the next five years.

PIPELINE AND LNG NETWORK

Korea's gas infrastructure is constantly expanding to accommodate the rapid increase in TPES. Figure 15 shows Korea's current natural gas infrastructure. At the start of 2005, Korea had 33 storage tanks with a capacity of 1.88 Mt of LNG. This storage system is equivalent to 8.8% of total annual demand. The gas trunk-line network currently measures 2 452 km, providing gas to 75 cities

Figure 14

Projected Demand and Total Contract Cover, 2000 to 2015



Sources: Country submission, industry information and EEi demand forecasts.

Figure 15

Map of Natural Gas Infrastructure

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: Country submission.

and regions, while the total distribution system is 24 365 km long. The proportion of the population with access to a grid connection is 69%.

The gas trunk lines connect the distribution system to the three LNG receiving terminals owned by KOGAS. Combined, these LNG terminals have a peak regasification capacity of 6 976 tonnes per hour. In addition to the LNG terminals owned by KOGAS, a fourth LNG regasification terminal at Gwangyang is owned by Posco, a large steel manufacturer. It was completed in July 2005, and has a storage capacity of 1.7 Mt. In total, these four LNG terminals have an annual intake capacity of 104 bcm (see Table 23).

The domestic infrastructure network is still being expanded, but at a slower rate than in the past. This is because the domestic market is approaching economic saturation, when the marginal costs of connecting new customers in remote locations outweigh the value.

Table 23

Capacity of LNG Regasification Terminals

Units: bcm/year	*Capacity*
Gwangyang	24.3
Inchon	37.9
Pyeong Taek	26.1
Tong Yeong	15.3
Total	**103.5**

Note: Numbers do not sum owing to rounding.

Sources: *Natural Gas Information*, IEA/OECD Paris, 2006 and country submission.

INDUSTRY ORGANISATION AND POLICY

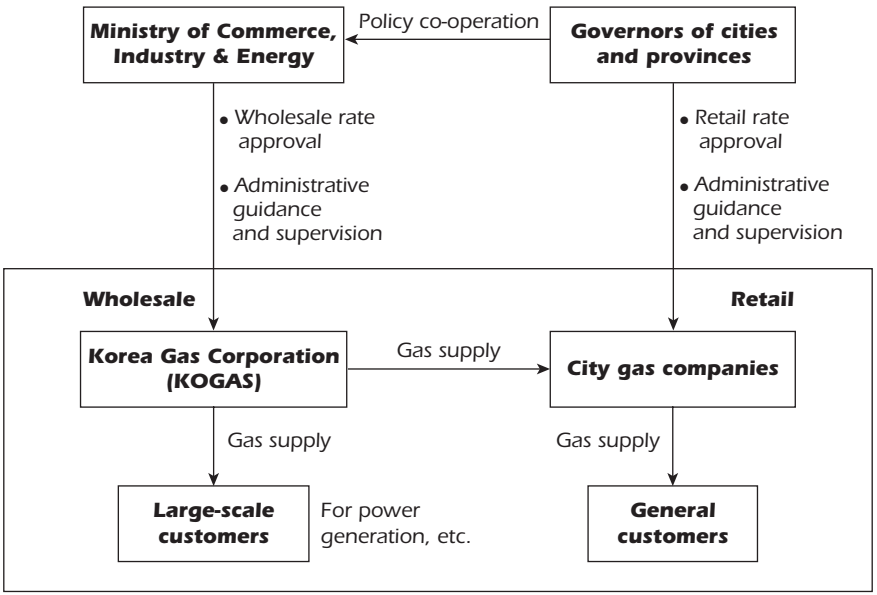
HISTORY

Korea's domestic gas sector came into being in 1983 as a result of government efforts to promote diversification away from coal and oil in the domestic sectors. Korea's natural gas business was classified into a wholesale sector and a retail sector through the *Korea Gas Corporation Act* and the *City Gas Business Act*. At this time, the government set up Korea Gas Corporation (KOGAS) as a state-owned company to control all aspects of the wholesale natural gas industry. Figure 16 shows the current organisational structure of the natural gas industry.

Under the terms of the *Korea Gas Corporation Act*, MOCIE provides administrative guidance and supervision for KOGAS. In turn, the company is granted a monopoly to import, store and distribute gas through main trunk lines in Korea. Both the city gas companies and power companies buy gas

Figure 16

Natural Gas Organisational Structure



Source: Country submission.

directly from KOGAS. The city gas companies are overseen on the municipal level by governors of cities and provinces. Each of the 33 city gas companies has an exclusive suppliers licence for its region, and is therefore a geographically defined monopoly. There are seven city gas companies operating in the Seoul metropolitan area with approximately seven million customers between them.

KOGAS and the various ministries have overseen the successful development of the gas industry in Korea from 1983 to 1999. The gas industry was developed with a strong focus on security of supply. The gas consumption growth rate from 1990 to 2000 was 20%, reflecting strong policy measures in support of diversification away from oil. This was achieved at a cost, as Korean gas prices are among the highest in the IEA, in large part because the country relies almost entirely on expensive imported LNG. Towards the end of the 1990s, the government policy regarding natural gas shifted from its overwhelming focus on energy security towards encouraging better economic efficiency.

Upstream hydrocarbon investment is handled by Korea National Oil Corporation, KNOC, which was set up in 1979 and initially known as the Korea Petroleum Development Corporation. The company is funded by the government, and seeks to invest in domestic and foreign upstream hydrocarbon exploration and production. In terms of foreign investment, the

company is involved in exploration in Nigeria, Yemen, Kazakhstan and Russia, as well as in production in some of the large oilfields in Vietnam, Libya and Indonesia. KNOC currently holds equity interests in 32 blocks in 15 different countries. Six projects are currently in production and four are in the development stage.

RESTRUCTURING AND LIBERALISATION

The 1997 election ushered in a new era in Korean energy policy. The new government decided to bring in liberal policies based on the recognition that competitive forces could increase efficiency of resource allocation and management efficiency while also promoting technological development and improving quality of service. The *Basic Plan for Restructuring the Gas Industry* was announced in November 1999 with the aim of enhancing competition in the gas sector. The plan was submitted to the national assembly at the end of 2001, and foresaw the splitting of KOGAS into three subsidiaries, two of which were then to be sold. The law recognised KOGAS as a monopoly that should be exposed to competition. As a means to reduce its market share to spur gas market competition, KOGAS was prohibited from signing more long-term contracts so that other companies could enter the market. In addition, the plan stipulated that open access would be implemented on LNG receiving terminals and pipelines. The retail sector currently comprises many regional or local monopolies that are not able to operate outside their geographic area and compete with each other; competition was also to have been introduced in stages to the retail market after the wholesale sector had been liberalised. 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. The original liberalisation plan included the establishment of a regulatory commission specifically for the gas industry. Currently, the Fair Trade Commission (FTC) handles general business oversight, but there is no gas industry regulator.

Since 1999, the original reform plan has been postponed indefinitely. The decision not to proceed with reform partly stems from California's experience with liberalisation of its energy sector and the subsequent blackouts. Although a new plan is currently being prepared, no plan has been released nor is there a date for when the new plan is to be released. There is less convergence regarding the fate of KOGAS, with proposals to allow new entrants, to split the company, or both. At the end of 2004, the government had a 26% equity stake in KOGAS. The other major owners were KEPCO (24.5%) local governments (9.9%) and private investors (38.8%). KOGAS is listed on the Seoul and New York stock exchanges.

Exemptions from the KOGAS monopoly

Despite the lack of an industry-wide restructuring plan, there have been changes to the industry that open it up to players other than KOGAS. Some companies are able to negotiate in order to import gas directly if it is for the company's "own use". In 2005, the Korean steel company Posco completed an LNG receiving terminal at Gwangyang in the southern part of the country. Together with K Power, a joint venture between SK and BP, Posco has contracted to import 1.15 Mt per year of LNG. In the first deal of its kind, Posco has negotiated third-party access rights to the KOGAS high-pressure system from Gwangyang to Pohang. A further large industrial group, GS, is currently expanding its gas-fired power generation facilities and has also secured a licence to import LNG.

Long-term contracting

As Korea has recently reformed some parts of its power and gas sectors and, consequently, it is now more difficult to predict gas demand patterns, particularly over the long term. In the past, it was easier for KOGAS to influence how much gas was used in the electricity sector. KOGAS could work with KEPCO, the electricity utility, to determine how much gas-fired power to dispatch given existing gas supply. Now, however, managing gas use in the electricity sector is more difficult. Generators are dispatched according to costs, which are adjusted monthly. As the relative cost of natural gas varies compared to oil, gas may not be dispatched as predictably (particularly in winter, when gas often becomes more expensive relative to oil). Furthermore, the variety of gas pricing categories – oil-indexed, oil-indexed with an S-curve or spot gas-priced – adds to the variability of gas pricing, which further increases variability in gas-fired power being dispatched. Thus the introduction of marginal cost dispatch for power plants makes their operation more sensitive to the fuel cost; different LNG-pricing mechanisms make Korea's gas demand pattern more difficult to predict over the long term.

Uncertainty also stems from how the reform process might evolve, as it is not clear what will happen to KOGAS and its restored monopoly on gas imports and sales. For example, KOGAS could be unbundled and broken up into smaller companies, requiring that any long-term contracts be assigned to different entities. There is a general fear that KOGAS could be left with high-priced long-term contracts, creating a disincentive for the company to sign any new long-term contracts.

In addition, Korea had assumed that pipeline gas may be available from Russia starting around 2012. This also reduces incentives to sign rigid long-term contracts.

Taken together, these factors have led KOGAS to adopt a particularly cautious approach to long-term LNG contracts, and to prefer to buy considerable

volumes from the spot market or sign shorter contracts, with terms of 10 to 15 years. As discussed in the earlier section on the outlook for supply, current long-term contracts will not cover projected demand. In 2005 KOGAS contracted for a further 6 Mt per year of gas. The most recent demand forecasts made by the Korea Energy Economics Institute (KEEI) in January 2006 project an LNG demand of 30 Mt in 2010.

DEMAND RESPONSE AND MANAGING SEASONALITY

Currently, Korea does not have a pricing structure in place to allow customers to modify their demand in response to the market price in real time. KOGAS passes through all supply costs with a one- or two-month lag, so any demand response is not in response to actual prices but rather in response to past prices. In order to provide price signals that reflect the higher cost of procuring much larger amounts of gas in winter, the government has initiated a system of surcharges for winter gas use by power generation companies. However, the effect of these price signals is reduced because higher gas prices for power generators are passed through directly to generators' electricity costs. Although large electricity customers have higher winter rates, these rates are administratively set and do not directly relate to the higher gas costs. Residential customers do not see any seasonal variation in prices. (For more information, see the section on electricity prices and rates in Chapter 10.)

In the absence of a market-based system, KOGAS and KEPCO, together with MOCIE have developed programmes that allow them to divert the use of gas away from low-priority domestic customers in winter. In the past, KEPCO would try to minimise the use of gas for power generation in winter by switching fuels from gas to oil products to allow more gas to flow to the city gas companies. However, this process has become more difficult in recent years as the power sector has been gradually liberalised, giving KEPCO less direct control over dispatch of generation assets and what fuels generation assets use. This has resulted in less predictable demand profiles among power generators, namely a weakening of administratively controlled demand response without replacement by a market response.

To guard against demand-side interruptions over the longer term, the government is working to reduce its turn-down ratio through a variety of solutions. For city gas use, the government is considering promoting gas-fired air-conditioning, hoping to increase gas demand in the summer towards winter levels. In addition, the government is introducing policies to encourage more summer industrial consumption at the expense of oil products.

As a further security measure, the government plans to increase the amount of storage capacity from 1.88 Mt to 3.89 Mt by 2017, which would cover approximately 12% of demand.

Emergency planning

In order to manage emergency situations resulting from severe LNG supply imbalances in winter, Korea has an emergency LNG supply and demand management system. The management system has four levels, corresponding to inventory stock levels. When stocks are at 700 000 tonnes, level 1 ("concern") is put into action. When stocks are at 600 000, level 2 ("cautious") is put into effect. At 330 000 tonnes, level 3 ("warning") is implemented. Finally, when stocks fall below 200 000 tonnes, the level 4 ("serious") plan is enacted.

PRICES AND RATES

Natural gas prices in Korea are based on the *City Gas Law* and are regulated by the government to prevent abuse of monopoly position. Wholesale gas rates are approved by MOCIE, while rates for city gas companies are approved by their provincial government. The commodity cost is passed through to the users of gas with various factors added, including import tariffs and levies, handling charges and taxes, as well as a contribution to the safety fund. KOGAS adjusts the price of the commodity every two months for domestic consumers and every month for power plants. Local city gas companies design retail prices by adding location-specific supply costs to the wholesale price paid to KOGAS so that the companies can recover their costs, including a fair rate of return. As discussed in the section on demand response, power generators face a surcharge in winter designed to reduce gas consumption when the peak heating season occurs for domestic consumers. Residential and industrial customers do not face the same surcharge.

KOGAS does not earn any profit on sale of the commodity, only a handling charge. Instead, it is allowed to recoup its costs for infrastructure and personnel through a rate of return that gives a reasonable profit.

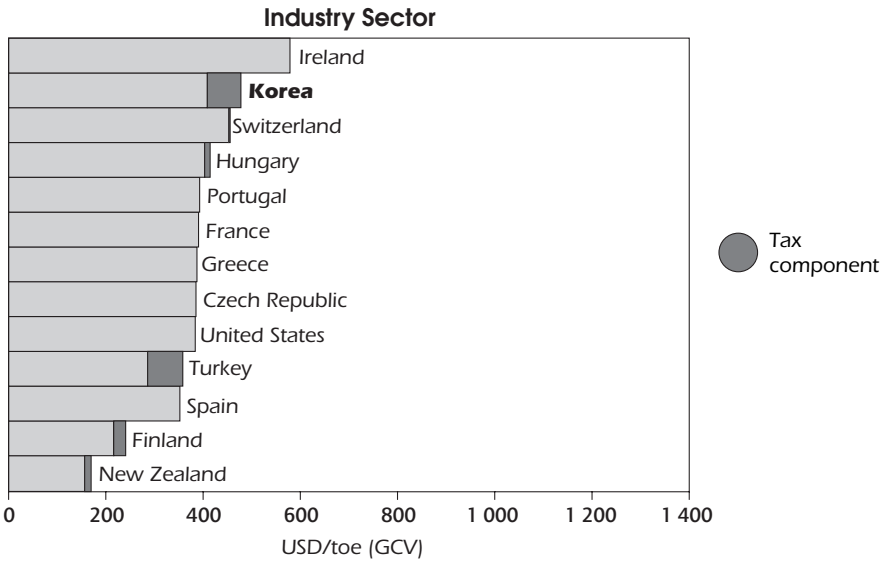
As compared with prices in thirteen IEA countries reporting data, Korea's industrial gas prices were the second-highest in the first quarter of 2006 (see Figure 17). In part, this reflects the high costs of imported LNG. In contrast, residential gas prices were the ninth-highest out of 17 reporting IEA countries.

CRITIQUE

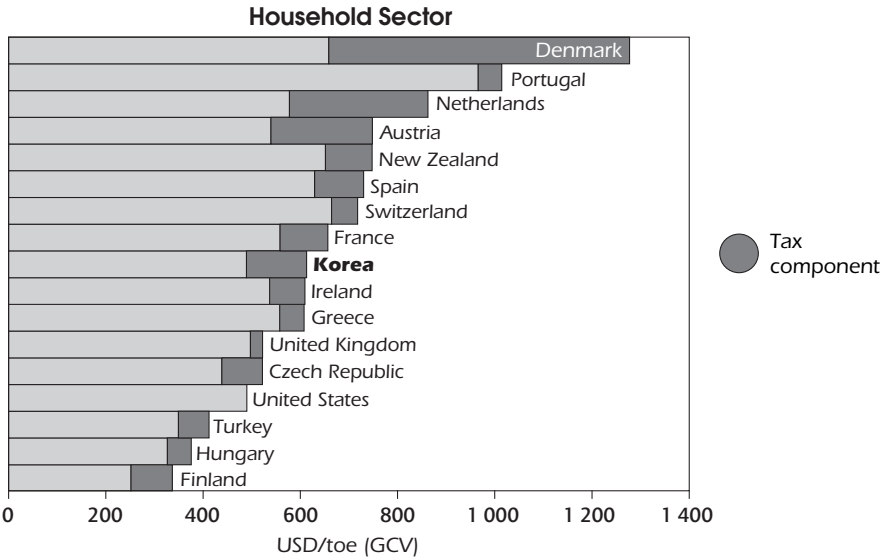
Along with Japan, Korea was a pioneer in the LNG importing business. KOGAS is now the largest importer in the world. Through far-sighted policy action, Korea has successfully reduced its oil dependence in the electricity sector by promoting natural gas. The government has also virtually eliminated the use of coal in domestic heating and cooking. These successful policies have

Figure 17

Natural Gas Prices, First Quarter 2006



Note: Tax information not available for the United States. Data not available for Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Japan, Luxembourg, the Nertherlands, Norway, Sweden and the United Kingdom.



Note: Tax information not available for the United States. Data not available for Australia, Belgium, Canada, Germany, Italy, Japan, Luxembourg, Norway and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2006.

increased Korea's security of energy supply through fuel diversification, and at the same time increased the quality of the air breathed by its citizens. Furthermore, the country continues to invest in import and transportation capacity, ensuring adequate infrastructure to underpin reliable gas delivery.

Korea's gas market is currently dominated by KOGAS, the state gas company, which has control over nearly all gas imports. Traditional, top-down government control of the gas industry has promoted security of supply, while assigning lower priorities to economic efficiency and environmental results. This policy has a cost – a more expensive gas sector overall – and this cost is likely to rise in the future if policies remain unchanged. As the international gas market develops, Korea will be less able to compete effectively than if it had a robust, competitive market with market players competing to supply gas at the lowest cost and also able to adapt to an evolving international market. As Korea's general economy develops, it will require a flexible and adaptable domestic natural gas sector that a competitive market is best able to provide. The greatest benefits of competition in Korea's gas import sector are likely to come from increased efficiency in company operations, but liberalisation will also help enable better responsiveness to international markets at a time when those international markets are changing dramatically. Furthermore, reliance on an international spot market could help lower Korea's high seasonality, or volume, risk in the longer term, when the spot market is deeper and more liquid. For these reasons, the IEA encourages Korea to restart the liberalisation process that it started, but has since brought to a halt. This would build on Korea's earlier efforts to open up the market by allowing some companies to import gas for their own use.

In addition to the benefits a liberalised market could bring, the current limbo the industry is in – and the uncertainty that this brings – makes achieving Korea's highest priority, security of supply, a greater challenge. The gas market is caught between vertical integration and competition, with potential adverse effects on the procurement policy of KOGAS as it has discouraged the company from signing long-term LNG supply contracts. The company is now more hesitant to sign long-term deals, in part because of greater uncertainty of gas demand for power generation, but also because the company may not want to take the risk of being left with higher-priced deals if KOGAS is ultimately broken up or privatised. While the current KOGAS strategy exposes the LNG importer to less volume risk over the long term, the consequence is that Korea must accept a lower long-term security of supply. Although the country's current lack of long-term contract cover is not an immediate cause for concern, it may signal adverse effects of the current uncertainty in the gas sector. Confirming and detailing plans for liberalisation would help remove the uncertainty, underpinning appropriate investment and contracting for the long term. Given the benefits of a liberalised gas market as seen in the United States, the United Kingdom, Spain and other IEA countries where robust regional gas markets can manage economic and world gas market

perturbations, along with the negative consequences of remaining at a precarious standstill, the IEA urges Korea to press on with reform as a matter of urgency to restore confidence. The government should elaborate a timetable that shows the steps required in order to liberalise the Korean gas market, and implement it as soon as possible.

One argument against liberalisation of Korea's gas market is that it will lower Korea's buyer power, reducing the power of KOGAS to negotiate preferentially priced deals on the international market because of its large size and gas needs. First, liberalisation of Korea's gas market does not require breaking up KOGAS into many tiny companies. In fact, the economies of scale of natural gas will likely lead to a small number of still-large competitors. While LNG suppliers may prefer to deal with larger companies, as long as a company wants to purchase enough gas to help underwrite an individual LNG liquefaction train, new suppliers are more likely to be swayed by pricing terms than by contract size. In addition, in the recent SK-BP-Posco LNG deal, LNG was purchased on very attractive terms for the buyer, showing that super-sized deals are not required to get good LNG terms or prices. Finally, any drawbacks from reduced buyer power should be more than outweighed by the efficiency benefits of liberalisation. Korea's gas import companies are likely to be operated more efficiently – and more cheaply – than a company operating without competitive pressure.

Of foremost importance to successfully liberalising Korea's market is the establishment at the start of a fair and independent regulator to oversee competition and give existing and potential market participants confidence. This entity needs to have independent funding and staff, as well as clear long-term gas policy goals. One of the primary functions of the regulator is to ensure fair and non-discriminatory access to monopoly assets. The IEA is pleased to see Korea enable limited competition in the gas sector by permitting some companies to import for their own use. We encourage Korea to formalise this policy by removing the KOGAS monopoly on imports, while simultaneously implementing regulated third-party access to its pipelines. Experience from other IEA countries has shown that regulated third-party access is often more effective than negotiated third-party access. For example, Germany has recently implemented regulated TPA after it concluded that negotiated TPA did not provide sufficient access to the network. In addition, in the 1980s the United States began moving towards open access on its pipelines, after experience with negotiated access to pipelines proved cumbersome, discriminatory and ineffective. A gas industry regulator is critical to ensuring that third-party access is effectively implemented. Another important function of the regulator is to prevent abuses of market power in the gas market, for instance by ensuring that actors involved in upstream activities are not able to influence the prices at which they sell into Korea. Checks and balances, including an effective arbitration and appeals process, should be introduced into the regulatory system to ensure that the regulator is effective and accountable.

Following the establishment of a credible regulator, another key to effective liberalisation is to unbundle the vertically integrated monopoly, separating and regulating gas transport and distribution. Companies involved in the competitive market will need access to the national network, which is a natural monopoly, and these activities of KOGAS should be effectively unbundled from the competitive aspects of the market, so that one market participant cannot gain unfair advantages over any others.

Regardless of the pace of liberalisation, a policy that can and should be implemented immediately is improved market pricing and transparency. Korea's policy to promote natural gas has been so successful that Korea is now faced with a supply challenge stemming from the seasonality of its gas demand. Residential demand makes up a very large proportion of overall gas demand, but this consumption is mostly used for space heating and thus only occurs in winter. The Korean turn-down ratio (TDR), a measure of seasonality, is twice that of Japan. This leads to very high procurement expenses as KOGAS must buy a large amount of spot cargoes to cover incremental winter demand, which is costly as sellers prefer steady off-take of gas year-round. The average price of Korean LNG could therefore be reduced if Korea could lower its TDR. This could be achieved by smoothing demand across the year – by reducing winter demand, increasing summer demand or both. The first-best solution to help smooth load is to expose customers to the prices incurred by their consumption. Korea is working to estimate the actual costs, by imposing seasonal surcharges on customers. The IEA applauds this policy, as it gives customers a signal to shift lower-value consumption to lower-cost periods. As the industry moves to a more liberalised market with competition on the supply side, we encourage the government to move from estimated and administratively set price signals to a market design that allows end-use customers to see true time-varying supply costs. Effective market design would allow LNG importers to pass higher seasonal costs on to consumers in a transparent way, inducing them to change their consumption patterns in order to achieve lower prices. There are many power generators and other customers who could participate in the demand side of this market more effectively than at present.

Although prices that signal winter gas scarcity are the best solution, the government could also work to reduce the difference between summer and winter demand through other government policies and measures. Japan has done this by introducing gas-powered air-conditioning units, and Korea is considering implementing this policy. Another option is to implement differentiated seasonal pricing for residential, commercial and industrial customers, as is already done for gas for power generation. In particular, policies to encourage industrial demand to switch from oil to gas in summer months could help reduce seasonality. However, when implementing policies to reduce seasonality of demand, Korea should pay particular attention to the overall costs of the policy. For example, while encouraging summer gas

demand may lower the seasonality cost of procuring gas, it may do so at a total cost that outweighs the benefit because more gas in total needs to be purchased. In the absence of true market signals that best determine the optimum level of seasonal gas consumption, other policies should be used carefully. Nonetheless, as KOGAS currently faces a predicted shortfall in the volume of gas contracted on a long-term basis, any reduction in winter demand or smoothing of the overall seasonal curve would benefit security of supply.

The current storage capacity of KOGAS equals about five days of supply at peak winter demand. If there is a disruption to either the supplies of LNG or the transportation and distribution system, this amount of storage may not be sufficient for domestic heating and electricity supplies. Many IEA countries that do not have sufficient interconnections to other countries prepare emergency plans in the case of such an event. Korea has such a plan, co-ordinated through MOCIE, an important and commendable achievement. As the country moves to a more liberalised market, the government should ensure that its emergency gas supply plan matches existing market conditions and can adapt to future market realities. Traditional top-down emergency plans may not be optimal for Korea's current gas industry.

The Korean gas market has much to gain from the globalising LNG market, as this will enable it to effectively use gas storage in the United States or Europe, rather than building its own storage at a much greater expense. Furthermore, the country can shift more of its seasonality risk to the international market, as a liquid spot market would allow for more flexible seasonal supply options. As Korea's domestic market is reformed to be more open to competition, this will improve the country's ability to compete on the international market because a flexible gas sector can respond more easily to evolving market realities. Moreover, a liberalised market can help improve the operational efficiency of Korea's import market – resulting in lower overall prices for Korean customers. In addition, in today's tight LNG market, and with worries about the long-term viability of Indonesian gas exports putting pressure on the market, KOGAS will have to be vigilant that it does not overpay when contracting the missing gas. A more liberalised market will put greater competitive pressure on participants to procure gas as cheaply and efficiently as possible.

RECOMMENDATIONS

The government of Korea should:

- *Build on earlier efforts to open up the gas market by establishing a timetable for comprehensive gas market reform, beginning the process as soon as possible.*

- *Establish an independent regulator to oversee the gas market as the first step in the liberalisation process.*
- *Institute open access/regulated third-party access on pipelines and ensure the regulator monitors open access implementation and has the power to penalise network operators who do not comply with the terms.*
- *Ensure that the relevant regulator monitors the activities of the incumbent gas supplier so that these activities do not result in the abuse of market power when the market is liberalised.*
- *Effectively unbundle and regulate transmission and distribution from other parts of the value chain to enable competition while ensuring fair access.*
- *Let price signals encourage customers to use gas in ways that reduce overall seasonal variations in natural gas consumption.*
- *In the absence of sufficient price signals, implement cost-effective policy measures to smooth gas demand across winter and summer.*
- *Consider revising the existing gas emergency planning procedures to take account of structural changes in the power market that may render it less effective.*

CAPACITY, PRODUCTION AND DEMAND

HISTORICAL AND CURRENT CAPACITY AND GENERATION

Korea's total electricity generation was over 365 TWh in 2005 (see Table 24). The country has over 60 000 MW of installed electricity capacity, which is split between six different companies, all subsidiaries of KEPCO, the state-owned utility, plus independent power producers (see Table 25). Nuclear, coal and LNG each make up more than a quarter of total capacity.

Table 24

Installed Capacity and Generation by Source, 2005

Fuel used	*Installed capacty*		*Annual generation**		*Capacity factor***
	(MW)	*Share of total*	*(TWh)*	*Share of total*	
Nuclear	17 716	28%	146.8	40%	94.6%
Bituminous coal	16 840	27%	129.1	35%	87.5%
Anthracite coal	1 125	2%	5.8	2%	58.9%
Natural gas (LNG)	16 447	26%	57.5	16%	39.9%
Oil	4 710	8%	16.1	4%	39.0%
Pumped storage	2 300	4%	1.5	0%	7.4%
Hydro	1 583	3%	3.7	1%	26.7%
Other	1 537	2%	4.2	1%	31.2%
Total	**62 258**		**364.6**		

* data presented in this table come directly from Korea, whereas 2005 estimated generation data reported in Chapter 3 have been modified according to IEA methodology.

** actual generation as a share of the maximum rated generation.

Source: Country submission.

As Korea has no network interconnections with other countries, its internal reserve margin is an important measure of security of supply. As shown in Figure 18, peak demand has increased rapidly since 1977, growing at an average rate of nearly 10% per year between 1977 and 2005. Peak demand

Table 25

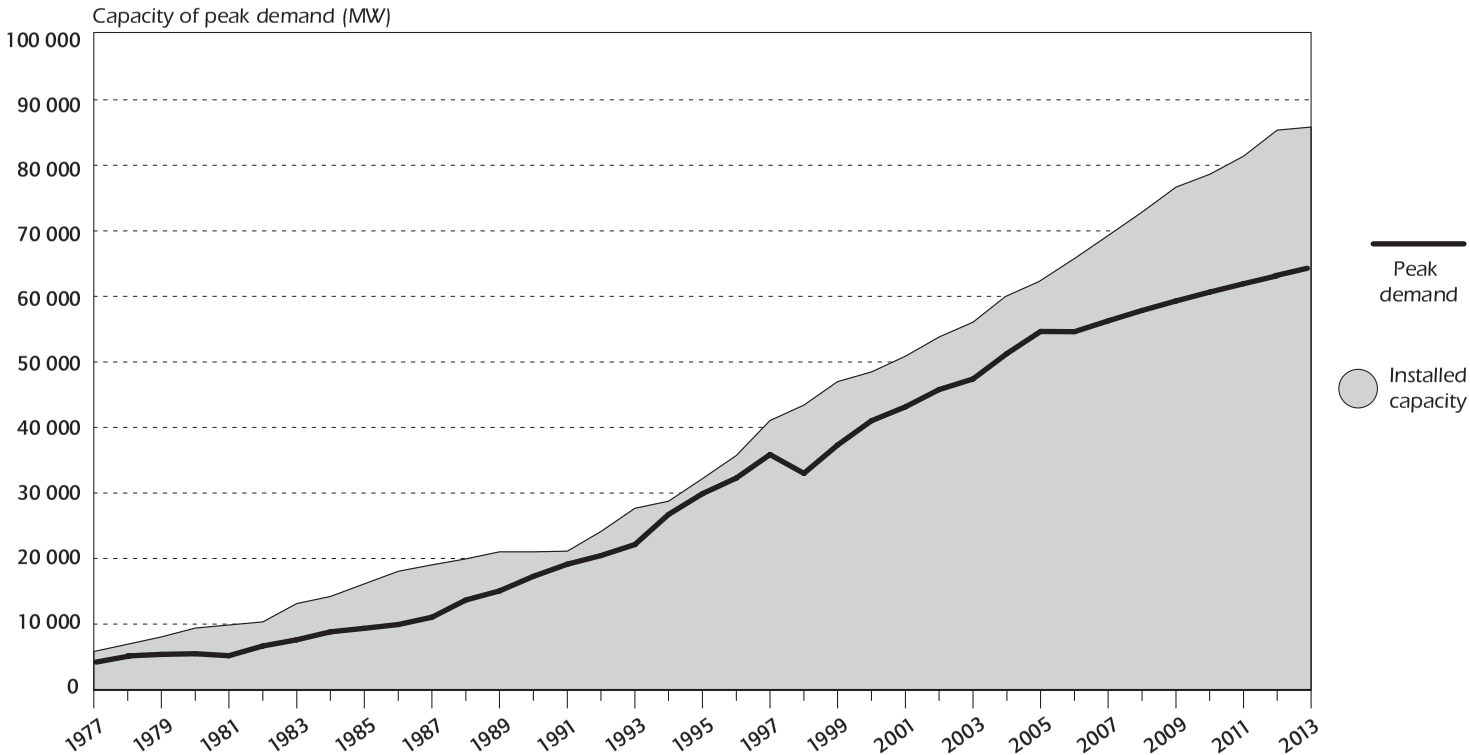
Installed Capacity by Company and Fuel Type, 2005

Units: MW	*Total capacity*	*Share of total*	*Nuclear*	*Bituminous coal*	*Anthracite coal*	*LNG*	*Oil*	*Pumped storage*	*Hydro*	*Other*
Korea Hydro and Nuclear Power (KHNP)	18 250	29%	17 716						534	
Korea East-West Power (EWP)	8 000	13%		3 000	400	2 100	1 800	700		
Korea Southern Power (KOSPO)	7 571	12%		3 000		3 600	565	400		6
Korea Western Power (WP)	7 280	12%		3 000		2 280	1 400	600		
Korea South-east Power (KOSEP)	7 194	12%		4 840	325	900	529	600		
Korea Midland Power (KOMIPO)	7 497	12%		3 000	400	3 841	255		1	
Independent power producers(IPPs)	6 466	10%				3 726	161		1 048	1 531
Total	**62 258**		**17 716**	**16 840**	**1 125**	**16 447**	**4 710**	**2 300**	**1 583**	**1 537**

Sources: KEPCO, *Annual Report*, 2005 and country submission.

Figure 18

Installed Capacity and Peak Demand, 1977 to 2013



Source: Country submission.

Table 26

Reserve Margin, 1977 to 2013

	Reserve margin		*Reserve margin*
1977	38%	1996	11%
1978	35%	1997	14%
1979	50%	1998	32%
1980	72%	1999	26%
1981	91%	2000	18%
1982	55%	2001	18%
1983	73%	2002	18%
1984	61%	2003	18%
1985	73%	2004	17%
1986	82%	2005	14%
1987	72%		Estimated
1988	46%	2006	20%
1989	39%	2007	23%
1990	22%	2008	26%
1991	10%	2009	29%
1992	18%	2010	30%
1993	25%	2011	31%
1994	8%	2012	35%
1995	8%	2013	34%

Source: Country submission.

was 4 187 MW in 1977 and grew above 54 000 MW by 2005, mirroring its rise from an undeveloped rural country to an economic powerhouse. Although growth in peak demand has tempered recently, it has still been growing at a robust average annual rate of nearly 6% over the past five years. Peak demand is expected to grow by 18% between 2005 and 2013, equivalent to an average annual rate of 2.1%. Consistent with its rapid growth, Korea's reserve margin – a measure of installed capacity above peak demand – has varied widely, from a high of over 90% in 1981 to a low of 8% in 1994 and 1995 (see Table 26). Over the last ten years the reserve margin has been above 10%, and in the coming decade it is expected to grow to the 20% and 30% range.

INDUSTRY HISTORY AND LIBERALISATION

HISTORY

Korea's electricity sector is dominated by the Korea Electric Power Corporation (KEPCO). The company started under the name Korea Electric Company (KECO), following the merger of three regional electricity companies in 1961. In 1982 the company was renamed KEPCO, and became a government-owned corporation encompassing generation, transmission, distribution and retail businesses. In 1989, it was listed on the Korea Stock Exchange and 21% of the company's shares were sold to the public.

RESTRUCTURING AND LIBERALISATION

In April 2001 KEPCO's generation assets were spun off as six subsidiaries of KEPCO, one of which holds all the country's nuclear and hydro assets (KHNP). Following this restructuring, the government planned to privatise five of the six companies (excluding KHNP) but these plans were abandoned following two separate efforts. First, in 2003 the government tried to sell a majority stake in the Korea South-East Power (KOSEPCO) subsidiary, but the effort was terminated when only one company put in a bid. Then the government intended to sell a 30% stake in KOSEPCO through an initial public offering (IPO) to the public before July 2004, but delayed and then cancelled the plan, citing weakness in the Korean stock market. In addition to privatising KEPCO's six generation subsidiaries, or gencos, the original liberalisation plan included implementation of open, or third-party, access to transmission lines, privatisation of the distribution network and the elimination of regional retail monopolies.

The government is still planning to privatise and liberalise the electricity industry, but no timetable has been released. There are three main goals for liberalisation, namely to introduce competition into the current monopoly industry, thereby increasing efficiency; to continuously guarantee long-term, inexpensive and stable electricity supply and to promote consumer convenience through expansion of customer choice for electricity. The current liberalisation plan will only liberalise the generation market. The demand side will remain a regulated monopoly with KEPCO operating wholesale purchases and retail sales to customers.

REGULATOR

The Korea Electricity Commission (KOREC) was established in 2001, and modified to its current structure in 2004. KOREC regulates generation, transmission, distribution, independent power producers (IPPs), generation

companies and the Korea Power Exchange (KPX), in addition to overall industry functions. KOREC is not separate from MOCIE; it is an independent unit within MOCIE and the two entities share staff. KOREC's nine commissioners are appointed by Korea's president on the recommendation of MOCIE, and cannot be dismissed except in cases of dereliction of duty or imprisonment. MOCIE can either accept or reject KOREC's decisions. Thus far MOCIE's minister has not overruled any decisions of KOREC, although it has full legal authority to overrule decisions and direct KOREC policy and decision-making. The KPX's operating expenses are covered through electricity trading fees.

The Fair Trade Commission (FTC) is Korea's anti-trust agency, monitoring monopoly problems and unfair business practices, whereas KOREC manages technical and professional competition policy. Since 2001, the FTC and KOREC have had memoranda of understanding outlining their respective roles, duties and functions in the electricity industry.

INDUSTRY STRUCTURE

GENERATION

Unbundling of KEPCO's generation assets

In 2001 KEPCO established six gencos, all of which it owns (the generation assets of the gencos are listed in Table 25). Gencos are separated from KEPCO and handle their own administrative services independently. However, KEPCO evaluates performance. Each company has an independent board of directors, of which KEPCO has one-seventh of the voting rights.

Electricity pool and generation dispatch

Generation is dispatched through a cost-based pool operated by the Korea Power Exchange (KPX). The pool is mandatory for all generators with a few exceptions, such as generators in island areas. Generators above 20 MW are designated as "centrally dispatched generators" and are thus operated according to dispatch instructions. KPX, which was established in 2001, administers the hourly market; handles trading, metering and settlements; and is responsible for operation of the grid.

Unlike a standard electricity pool, where generators submit offer prices, generators in the KPX pool only bid in their availability. On a day-ahead basis, generators make offers of availability on an hourly basis to the KPX. Generators' costs are fixed. Each month they are set administratively by the Cost Assessment Committee, which is operated by the KPX, on the basis of fuel and other operating costs. KPX dispatches generation for each hour according to the available bid stack in the pool, starting with the cheapest generation until all

demand is met. Individual generators are paid the marginal price – the bid price of the most expensive generator dispatched – except for nuclear and coal. These resources, which cover nearly 80% of supply, are paid an administratively set baseload price that is lower than the cost-based marginal price. Given that the system marginal price does not take into account location or transmission constraints, generators are not penalised or rewarded for their distance or proximity to demand. The country is considered as one zone, with no separate nodal or zonal prices. The government is not currently considering replacing the cost-based, regulated dispatch mechanism with a competitive price pool or other trading arrangements.

In addition to marginal price payments, also known as the electricity volume price, generators receive capacity payments. The capacity payment is paid to all generators who submit capacity offers, whether or not they are dispatched. Unlike some capacity payments, which are tied to available capacity over a longer time period and paid on a capacity basis (*i.e.* payments are made per installed kW), Korea's capacity payments are based on offered capacity (in kW). Capacity payments are provided to ensure recovery of capital costs and to underpin further investment.

Independent power producers

Previous government policy allowed independent power producers (IPPs) to sell their power into the market through power purchase agreements (PPAs); KEPCO was required to establish PPAs with IPPs. As a result, IPPs comprise about 10% of total capacity, accounting for 4.4% of total generation in 2004. Since 2001, when the power pool was established, government policy no longer allows PPA contracts, and KEPCO is no longer required to contract new PPAs with IPPs.

All IPPs above 20 MW must – and any IPP can – bid into the power pool under the same procedures as KEPCO gencos. Like gencos, IPPs bid their availability on the basis of costs set administratively by the Cost Assessment Committee and receive the capacity payment in addition to energy payments.

Distributed generation

In May 2004, the government implemented the community energy supply (CES) system. Through this programme, distributed generation[8] resources can be built, connected to the grid and operated without going through the electric power market. As of the end of 2004, two providers had obtained CES business licences and were preparing to launch their businesses.

8. Distributed generation includes sources of electricity, usually small, that are connected to the distribution grid, not the transmission grid. These sources produce electricity locally, in the same region as load centres where the electricity is consumed.

TRANSMISSION

Korea's electricity grid has no interconnections with other countries (see Figure 19); its interconnection with North Korea was cut in 1948. KEPCO owns over 28 000 km of transmission lines (662 km of 765-kV lines, 7 990 km of 345-kV lines and 19 990 km of 154-kV-and-below lines). It is a relatively young transmission network, with very low line losses; its transmission and distribution loss factor is 4.5%, lower than the OECD's average of 6.8%. In addition to 345- and 154-kV high-voltage transmission lines, in 2002 it began operating a super-high 765-kV transmission system, which has further reduced transmission losses. A high-voltage direct current line connects the island of Jeju to the mainland.

Korea's generation is centred in southern and eastern Korea, and must be transmitted to the metropolitan centres in northern Korea. This imbalance causes congestion on the network, but there are no market prices that reflect locational differences and transmission congestion. Better data about transmission congestion, coupled with the low line losses, could indicate whether the transmission system is well utilised or over-built in some areas.

DISTRIBUTION AND RETAIL

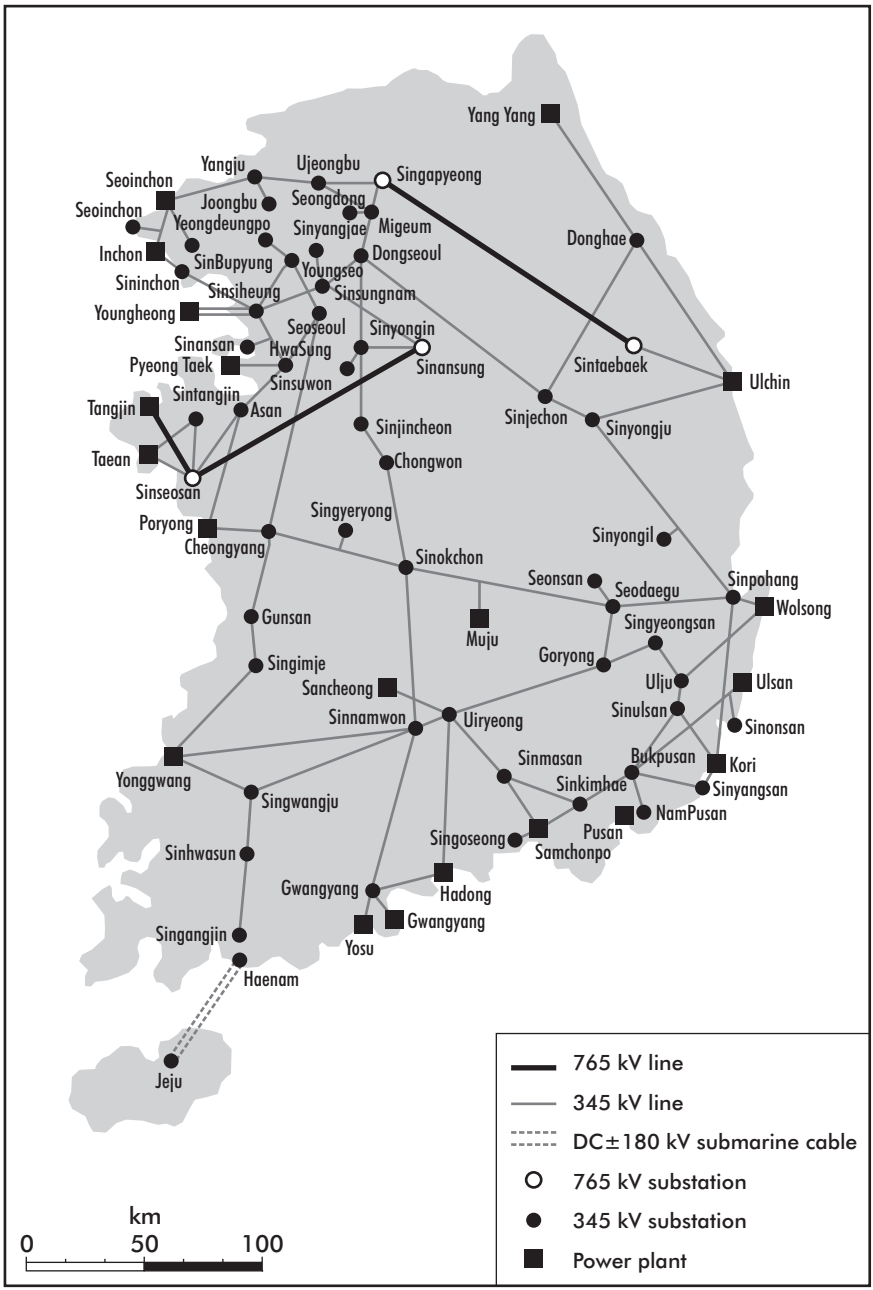
KEPCO also owns the distribution network and is responsible for retail supply. It purchases power directly from KPX and supplies it to customers at government-approved rates. In 2005 it supplied over 330 terawatt-hours (TWh) to over 17 000 customers (see Table 27). The manufacturing sector accounts for just over half of total sales, public and commercial sectors account for over a quarter and the residential sector accounts for the remainder. Information on retail rate structures and electricity prices is provided later in this chapter in the section on prices and rates.

PLANNING AND INFRASTRUCTURE INVESTMENT

Biannually, the government develops a *Basic Plan of Long-term Electricity Supply and Demand* (BPE), based on information obtained from generation companies. By law, the government is required to provide a long-term electricity supply and demand outlook to inform gencos on capacity investment and to ensure reliable electricity supply. In addition, KPX produces long-term demand forecasts. The government confirms the KPX forecast by review and approval of subcommittee and consultation with an expert group. Gencos implement autonomous electricity business decisions according to the direction of electricity supply and demand policy proposed in the BPE. On the basis of the forecast, the group puts together an electricity capacity plan,

Figure 19

Map of Major Power Plants and Transmission Lines



Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: Country submission.

Table 27

Number of Retail Customers and Retail Sales, 2000 to 2005

		2000		2001		2002		2003		2004		2005	
Residential sector	Thousands of customers	11 511	77%	11 904	76%	12 427	75%	12 704	76%	12 853	75%	12 981	75%
	Millions of kWh sold	44 968	19%	52 289	20%	58 469	21%	62 432	21%	65 490	21%	69 555	21%
Commercial and public sectors	Thousands of customers	3 190	21%	3 426	22%	3 761	23%	3 767	22%	3 902	23%	4 038	23%
	Millions of kWh sold	57 195	24%	63 282	25%	68 786	25%	73 322	25%	80 383	26%	87 912	26%
Manufacturing sector	Thousands of customers	275	2%	288	2%	301	2%	304	2%	306	2%	310	2%
	Millions of kWh sold	137 372	57%	142 160	55%	151 196	54%	157 845	54%	166 223	53%	174 945	53%
Total	**Thousands of customers**	**14 976**	**100%**	**15 619**	**100%**	**16 490**	**100%**	**16 776**	**100%**	**17 062**	**100%**	**17 329**	**100%**
	Millions of kWh sold	**239 535**	**100%**	**257 731**	**100%**	**278 451**	**100%**	**293 599**	**100%**	**312 096**	**100%**	**332 413**	**100%**

Source: KPX.

Table 28

Planned Capacity Additions, 2006 to 2017

Units: MW	*Planned additions*	*Description*
Korea Hydro and Nuclear Power (KHNP)	9 600	8 nuclear reactor units
Korea Southern Power (KOSPO)	1 400	2 bituminous coal-fired units (1 000 MW) 2 oil-fired units (400 MW)
Korea East-West Power (EWP)	1 500	3 bituminous coal-fired units (1 500 MW)
Korea Western Power (WP)	1 900	2 bituminous coal-fired units (1 000 MW) 2 pumped-storage hydro units (600 MW) and 1 combined cycle turbine unit (300 MW)
Korea South-East Power (KOSEP)	2 400	2 bituminous coal-fired units (1 600 MW) 2 pumped-storage hydro units (800 MW)
Korea Midland Power (KOMIPO)	2 500	2 bituminous coal-fired units (1 000 MW) 2 pumped-storage hydro units (500 MW) 2 orimulsion units (1 000 MW)
Independent power producers (IPPs)	4 652	
Total	**23 952**	

Source: *Second Basic Plan for Long-term Electricity Supply and Demand*, MOCIE.

which details any required new generation, including size, fuel type and location. The average result is a 15% to 18% reserve margin.

The BPE gives a broad outline for new capacity to be built in Korea. In line with the plan, KEPCO subsidiaries make investments in new power plants, subject to approval by MOCIE. Investments in new plants can be made outside the plan, but they also need MOCIE approval and are not likely to be built. Although the BPE is less prescriptive than the *Long-term Power Development Plan* that it replaced, it is not merely an indicative plan, but also outlines future electricity market developments, down to the plant level.

New transmission and distribution investment is done at the discretion of KEPCO, subject to approval by MOCIE and KOREC.

Currently, the six gencos are building substantial new capacity, with over 19 000 MW of new capacity expected to be on line by 2017 (see Table 28). When additions by IPPs are included, the expected new capacity grows to nearly 24 000 MW.

ELECTRICITY PRICES AND RATES

WHOLESALE PRICES

As discussed earlier in the section on the electricity pool and generation dispatch, generators are paid on the basis of two components, a capacity payment and an energy payment. These two payments are different for baseload generators, such as coal and nuclear, and other generators (see Table 29). Between 2002 and 2004, the average payments to baseload generators have remained relatively steady, but the premium paid to non-baseload generators rose from 36% to 59%.

Figure 20 shows the monthly weighted-average marginal price, or energy payment, made to generators between 2001 and 2005. Reflecting the design of the system, the baseload marginal price has remained nearly constant, while the marginal price for non-baseload, or peaking units, fluctuated more widely. Generally, these prices are higher in winter than in summer owing to higher night-time power demand in the winter.

Table 29

Wholesale Electricity Payments, 2002 to 2004

		2002 price/kWh		*2003 price/kWh*		*2004 price/kWh*		*2005 price/kWh*	
		KRW	USD	KRW	USD	KRW	USD	KRW	USD
Baseload power generator	Capacity payment (CP)	21.49	0.021	21.49	0.021	20.49	0.020	20.49	0.020
	Baseload marginal price (BLMP)	18.54	0.018	18.27	0.018	19.17	0.019	19.28	0.019
	Total	40.03	0.039	39.76	0.039	39.66	0.039	39.77	0.039
General power generator	Capacity payment (CP)	7.17	0.007	7.17	0.007	7.17	0.007	7.17	0.007
	System marginal price (SMP)	47.35	0.046	50.48	0.049	55.79	0.054	61.97	0.061
	Total	54.52	0.053	57.65	0.056	62.96	0.061	69.14	0.068

Note: All payments were converted using the 2005 average exchange rate, USD 1 = KRW 1 024.
Source: Country submission.

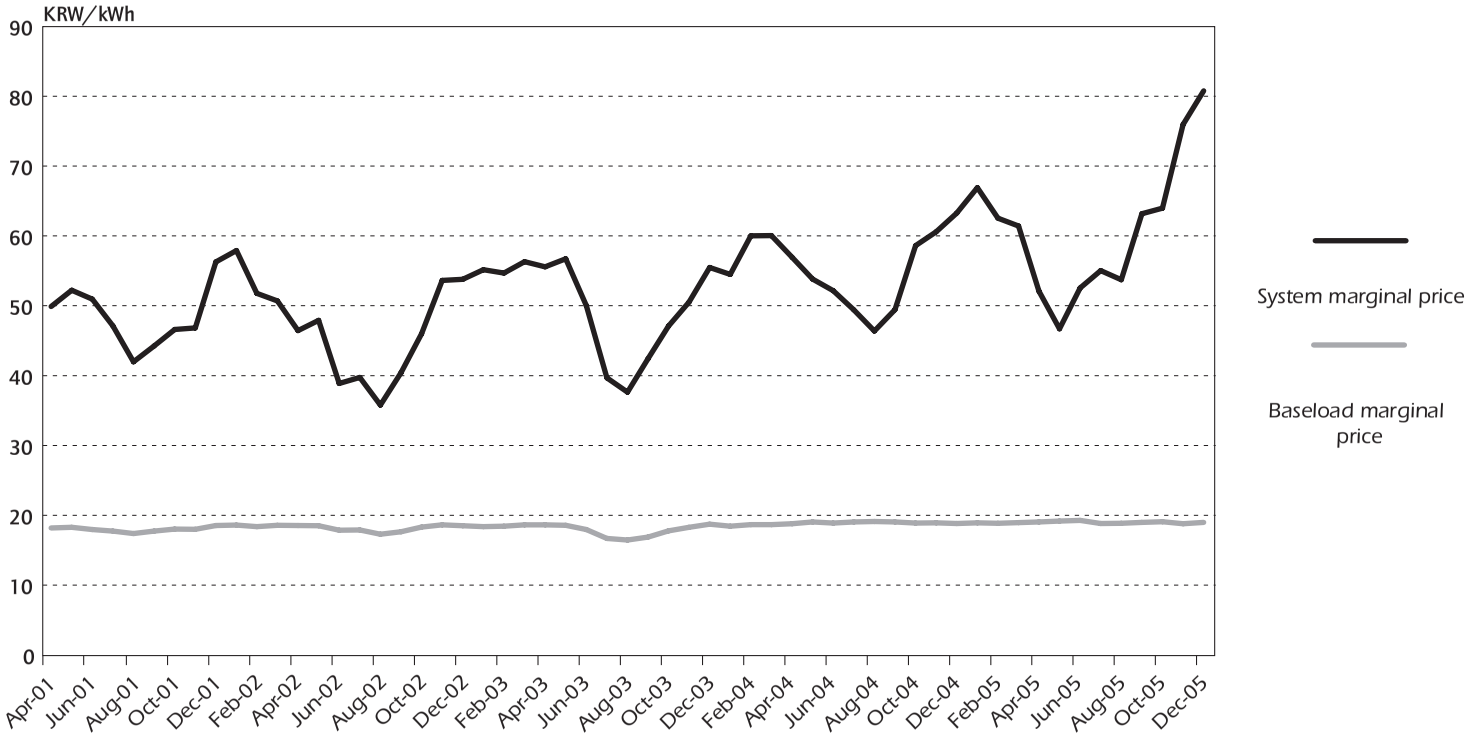
RETAIL RATES

KEPCO retail rates are applied according to a two-part tariff for all customer classes, namely a basic charge applied on each residence or peak kW and a power demand charge assessed on each kWh.

KEPCO offers only one residential rate structure for all customers, which is a tiered rate schedule where both basic and power demand charges cost more as usage per customer increases. For industrial customers, KEPCO offers a variety of rate services. Smaller industrial customers (300 to 999 kW) can choose from two rate

Figure 20

Monthly Wholesale Electricity Prices, 2001 to 2005



Source: Country submission.

structures, both of which charge higher rates in summer than during the rest of the year, but which do not vary within the day. Larger customers (above 1 000 kW) can choose from a variety of rate structures, all of which are time-of-use rates that charge higher prices during the summer and peak times of day. None of these rates vary in real time, which would directly reflect the hourly cost-based prices derived from the electricity dispatch mechanism.

In addition to residential and industrial rates, KEPCO offers separate rates for a number of customer classes according to type of energy use. In particular, the agricultural sector receives very low rates. Its fixed charges represent only 8% to 23% of those for small industrial customers and rates for electricity per kilowatt-hour delivered represent 39-68% of rates for small industrial customers. These rates are very low, as the standard industrial rates are already below actual cost. Overall, the rate differentials for classes of customers with different costs have been decreasing since 2002. Plans are under way to reorganise these rates to a voltage- and cost-based rate system in the medium and long term. Average 2004 rates by customer class are presented in Table 30.

Table 30

Electricity Tariffs by Customer Class, 2004

	Residential	*General*	*Educational*	*Industrial*	*Agricultural*	*Street lights*	*Average*
All-in residential rate (KRW/kWh)	90.94	96.85	89.05	60.23	41.95	65.33	74.58
Levelised rate (residential rate = 100%)	100%	106%	98%	66%	46%	72%	82%

Source: Country submission.

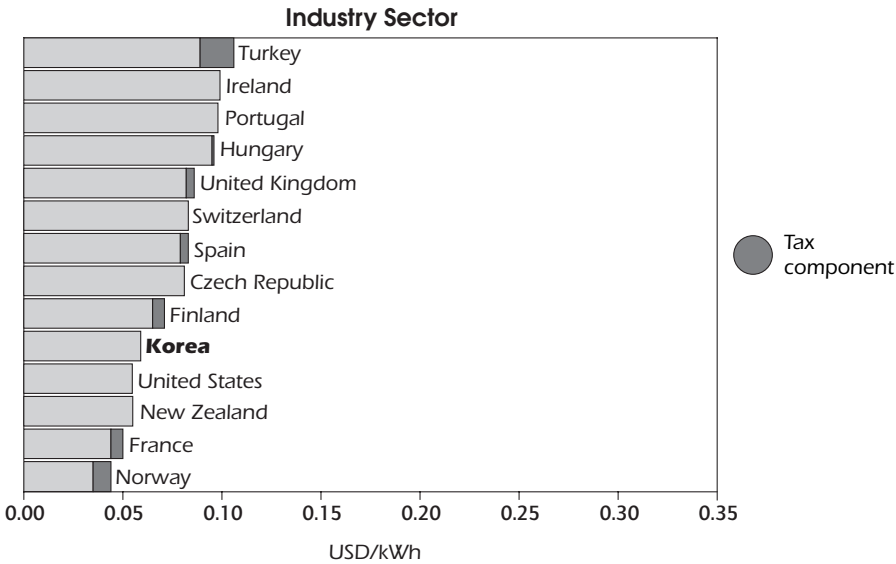
Korea's industrial retail electricity rates are relatively low when compared with other IEA countries (see Figure 21), despite the reliance on high-priced LNG. Industrial rates are the fifth-lowest of 14 reporting countries. Residential rates are very low compared to other IEA countries. Of 16 reporting countries, Korea's residential rates are above only Norway. This partly reflects the exchange rate in Korea, but also the very low rate of return the government accepts for government-held equity.Although KEPCO does not offer real-time pricing, it does have 300 000 one-way digital meters capable of remotely recording consumption every 15 minutes. These meters covered over 70% of total consumption in 2005.

CRITIQUE

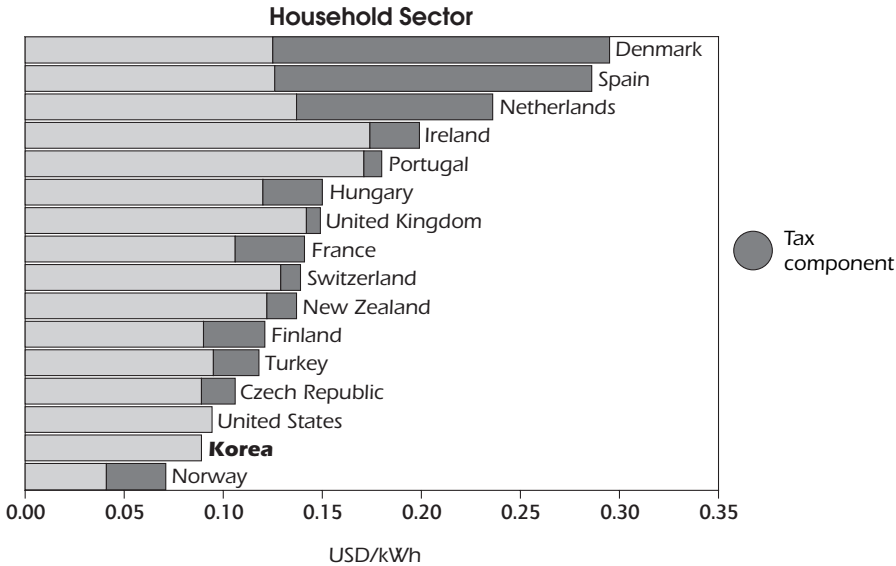
Korea's electricity portfolio is well diversified, providing significant security of supply to the country. In addition, the country has a well-run nuclear industry, underpinning baseload capacity. Korea has maintained a healthy reserve

Figure 21

Electricity Prices in IEA Countries, 2005



Note: Tax information not available for Korea. Price excluding tax for the United States. Data not available for Australia, Austria, Belgium, Canada, Denmark, Germany, Greece, Italy, Japan, Luxembourg, the Nertherlands and Sweden.



Note: Tax information not available for Korea. Price excluding tax for the United States. Data not available for Australia, Austria, Belgium, Canada, Germany, Greece, Italy, Japan, Luxembourg, and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2006.

margin during the rapid growth of its electricity sector, a notable achievement. Furthermore, the government is taking steps to bring electricity pricing in line with actual costs, helping improve the efficiency of the system by providing the right incentives to customers. In order for the Korean economy to gain the benefits of a more efficient electricity system, the government has also set the stage for a competitive, liberalised electricity market. Its generators have been split into six separate generation companies, partially unbundling their operations from transmission and distribution. A system and market operator, KPX, has been designated, and a regulator, KOREC, has been established. With this solid foundation in place, now is the time for the government to take the critical steps necessary to establish a robust, effective market that will benefit Korean customers in the long term.

Korea's electricity system rests precariously halfway between a regulated monopoly system and a liberalised market. (This is discussed more fully in Chapter 3.) Korea has moved from a rapidly developing economy to a more stable market-based one, making a liberalised electricity market a perfect complement that will allow the economy to continue to grow over the long term as the electricity sector will be more flexible and able to adapt to changing economic realities. It is imperative that the government establish as soon as possible a detailed and firm timetable for completing the reform of its electricity sector – focusing on liberalisation rather than privatisation. In addition to other milestones, the timetable should include firm dates for completion of the following steps:

- Transfer of full and independent regulatory power to KOREC.
- Full and effective unbundling of generation and retail from the monopoly business of transmission and distribution.
- Restructuring of the governance of the KPX to make it a fully independent and credible market operator.
- Establishment of a framework for investment in transmission network infrastructure.
- Institution of effective open access, also called regulated third-party access, to the transmission network; elimination of any incentives or ability for KEPCO to discriminate against any particular transmission customers.
- Elimination of any rules or policies that prohibit or discourage independent power producers from entering the market.
- Implementation of market-based trading arrangements for wholesale power.
- Establishment of a plan to allow retail contestability, at least in the industrial sector.

Taken together, these steps, once completed, would result in a market where the monopoly parts of the electricity industry (transmission and distribution) are separated from the competitive aspects (generation and retail supply), thereby creating the right incentives for competition in generation and retail supply. It also establishes a level playing field for all competitors, namely the existing government-owned generation companies (gencos), existing independent power producers (IPPs) and potential new entrants. An effective regulatory agency, KOREC, that is independent from the government and existing gencos provides confidence to the market and encourages new entry, which is particularly important while KEPCO subsidiaries remain state-owned. Similarly, the market and system operator must be fully independent from the government and market participants, and clear and fair rules for access to the transmission network should be established, in order to assure existing IPPs and potential new entrants that they will be able to access the market and will not be discriminated against in favour of government-owned gencos. Finally, the industry will not gain the efficiency benefits of a liberalised market unless generators have incentives to lower their costs. Market-based trading arrangements would provide generators with greater incentives to operate more efficiently and lower their costs, as well as to invest in infrastructure more efficiently. These steps, described in more detail in the following paragraphs, would put in place the necessary framework for a truly competitive market.

Privatisation of generation assets would add to the benefits of the liberalised market; it would further reinforce incentives to operate efficiently and competitively. However, as discussed extensively in Chapter 3, it is not a necessary first step. Countries such as New Zealand, Norway, Sweden, Finland and Denmark all retain majority or full state ownership of the largest generation company in each country. Instead, it is critical to first get the market rules and incentives right. Although privatisation is not immediately necessary, KOREC and the Fair Trade Commission should vigilantly monitor KEPCO and its subsidiaries to ensure that they operate independently and fairly, and do not abuse any market power positions.

An effective and credible regulator provides confidence to the market and is a necessary precondition for the development of a competitive and efficient market. The IEA commends Korea for establishing a regulator, the Korea Electricity Commission, and encourages the government to take the necessary steps to make it sufficiently powerful and fully independent from the government – free of influence from market participants and government policy makers – looking to the best practices of IEA countries. Most importantly, powers to regulate the wholesale market and ensure no undue barriers bar the access and entry by independent power producers, to monitor transmission network access and to establish network tariffs should be established as soon as possible. KOREC should be restructured, such that its staff, its budget and its policy mandate are not accountable to any government ministries. Following the establishment of a detailed timetable and roadmap for liberalisation, transfer of power and responsibility to the regulator should be the next step.

Korea has taken the difficult step of restructuring its generation market, partially unbundling generation into six separate gencos, which is a commendable achievement. The government should now strengthen this separation, by fully and effectively separating KEPCO from the gencos, and the gencos from each other, in order to establish incentives for efficient operation of generation assets and to remove incentives for KEPCO to treat a genco preferentially over other state gencos or independent power producers. In order for effective competition to develop, each genco must operate individually – free from influence by or competing incentives from KEPCO and its other generation subsidiaries. The government should effectively unbundle its generation companies, and eliminate any other barriers for independent power producers to participate in the market.

At the same time as effective unbundling is implemented, KOREC should ensure that the KPX operates the electricity market fully independently from the government, from KEPCO and from gencos. Of critical importance is ensuring that KEPCO manages the transmission network such that all market participants, including KEPCO subsidiaries, IPPs and future new entrants, are treated equally. Open access, or third-party access, should be implemented on the transmission system and the system operator should apply this policy fairly, under KOREC oversight. This is particularly important given that the major generators are currently all subsidiaries of KEPCO. For competition in the wholesale power market to develop, there must be transparent and regulated access to the transmission grid. Existing and future generators must be confident that they will have access to the grid in order for them to enter the market or make new investments.

Network regulation by KOREC should provide incentives for efficient operation of and investment in assets. One way of maintaining economic efficiency in distribution and transmission networks is for an independent regulator to undertake some kind of systematic international benchmarking of network costs. In addition, overall network infrastructure costs would be reduced if generators had incentives to build generation close to load. Currently, neither network access charges nor electricity market prices provide any incentive for generation to be built in the places where it is most needed. Transmission and distribution network regulation and market rules should be modified such that they include locational incentives. Korea should consider pricing transmission by location – by including a locational aspect in hourly electricity prices – to encourage generators to build in places that would relieve congestion and lower losses. Given that there is some congestion in Korea's network, such pricing would initially have a substantial effect on price separation.[9]

9. Price separation in electricity markets often reflects, among other things, transmission constraints. For example, one region might have heavy electricity demand but limited local generation (a so-called "load pocket"). If transmission lines that bring power into this load pocket are congested and there is location pricing, prices in the load pocket will diverge, rising above the price in neighbouring regions.

Locational pricing would give market participants signals for where to build new capacity. It would also give signals to the transmission system operator on when and where to build new network infrastructure, reducing the risk of building a gold-plated, inefficient network.

Prices that reflect costs and scarcity are the glue that hold markets together and ensure that they deliver the benefits of efficiency to the economy and Korean customers. Currently, Korea operates a pool that uses administratively set generation prices to manage dispatch. It is hard to enable effective competition among generators under such arrangements. As an alternative to this regulated mechanism for determining wholesale prices, Korea should consider trading arrangements, including a market-based pool or bilateral contracting, that rely on competitive pressure to determine wholesale prices that reflect costs and signal scarcity.

Retail electricity prices that directly reflect the costs associated with consuming the electricity, including operating costs, transmission costs and environmental costs, lead to more efficient consumption. Thus the IEA commends Korea's policy to reduce cross-subsidies and price subsidies across customer classes with similar cost profiles. The government should continue this effort, in particular removing subsidies for industrial and agricultural customers, who currently pay less than the cost of the electricity they consume. Subsidised electricity prices encourage inefficient consumption, leading to greater investment needs and higher infrastructure costs. Removal of subsidies will lower the overall cost of the electricity system – to the benefit of Korean customers.

In addition to eliminating subsidies, tariff structures should reflect cost structures. For example, fixed-cost components of electricity tariffs should fund fixed costs directly. Revenue should be collected for transmission and distribution and should be used solely for that purpose; specific revenue streams should not cross-subsidise other uses. To cover environmental costs associated with specific fuels or technologies, the government should consider taxes or other economic instruments. The costs of generating electricity vary with demand and, as a result, with time. Ideally, customers should be charged prices that reflect the cost of the electricity at the time it was consumed. Korea should take full advantage of the advanced meters installed at many demand locations. Not only do these meters allow KEPCO to charge time-of-use rates to industrial customers, which Korea already does, but in harnessing the meters' full power, this equipment offers a unique opportunity to use demand response effectively, for example to efficiently reduce demand during peak hours. Opening the retail sector and allowing retail contestability would spur demand-side participation and increase the efficiency of the system.

It is worth noting that Korea's gas and power sectors have competing goals. The country uses significantly more gas in the winter than in the summer,

raising gas procurement costs significantly. Smoothing gas consumption more evenly between summer and winter months would lower overall costs per unit of gas. However, electricity costs are higher in the summer than in the winter because of peak electricity usage. KEPCO is working to reduce these costs by charging higher rates to some customers for summer electricity consumption. This has the effect of putting downward pressure on gas consumption in the summer, as much peak electricity capacity is from gas – in opposition to the gas sector goal of raising summer gas consumption. Competitive market prices for both gas and electricity would result in an outcome that optimises both gas and electricity consumption, lowering overall costs for energy in Korea.

Should the electricity industry move to a more liberalised market, prices would reflect scarcity and replace government planning as the mechanism for infrastructure investment. It would also set the stage for a flexible electricity system that can adapt to a changing economy. Even more than the benefits of liberalisation from operational efficiency, a liberalised market can bring tremendous gains from improved investment in infrastructure and the ability to match investment decisions to market realities quickly and effectively. Currently, however, the government manages investment in generation through planning, by developing framework plans that outline the size, location and fuel type of new generation for the medium and long term. This may undermine the transition to a liberalised market as new entrants are not able to take business decisions based on competitive conditions, but will be forced to conform to government prescriptions – resulting in poor infrastructure investment decisions and higher prices for customers. While the government should continue to provide scenarios and forecasts that give information to market participants, it should refrain from making plans that determine investment and crowd out investment that does not conform to its plan. A transparent electricity policy gives market participants added comfort to undertake investments, particularly during the transition to a liberalised market.

RECOMMENDATIONS

The government of Korea should:

- *Re-launch electricity market reform as soon as possible and establish a timetable with milestones.*
- *Restructure and empower the Korea Electricity Commission to become an independent regulator with sufficient power to oversee the electricity market as the first step in the liberalisation process. Have the regulator establish network tariffs using methodologies in accordance with those of best-performing IEA countries.*

- *Effectively unbundle transmission and distribution from generation.*
- *Ensure that all undue barriers to effective competition in the generation sector are removed and that the Fair Trade Commission or the Korea Power Exchange monitors competition. Pay particular attention to the role of independent power producers in the market.*
- *Ensure that the Fair Trade Commission or the Korea Electricity Commission monitors the activities of the Korea Electric Power Corporation so that its activities do not result in the abuse of market power.*
- *Improve economic production and efficiency by providing incentives in transmission and distribution network regulation. Consider pricing transmission by location to encourage generation to be built and demand to be located in areas where it relieves congestion.*
- *Ensure that the independent regulator closely monitors wholesale price formation.*
- *Consider implementing trading arrangements, including a bid-based pool or bilateral contracting, that rely on competitive pressure to determine prices that reflect costs and signal scarcity.*
- *Eliminate price distortions and cross-subsidies, and, where necessary, adjust taxation so that electricity generation reflects environmental costs. In particular, phase out industrial and agricultural price subsidies.*
- *Replace prescriptive government planning of the future supply mix with flexible policy and transparent informational scenarios and forecasts consistent with liberalisation.*

OVERVIEW

EXISTING POWER PLANTS

Korea's history with nuclear power began in the late 1970s, when the country's first nuclear plant went on line. Nuclear energy now provides nearly 40% of Korea's electricity supply. Twenty nuclear units are in operation on four sites representing a total net installed capacity of 16.8 GW_e (see Table 31). All nuclear power plants are owned and operated by Korea Hydro and Nuclear Power (KHNP), a subsidiary of KEPCO.

Table 31

Nuclear Power Plants in Operation, 2005

Name	*Type*	*Capacity (MWe)*		*Date connected to the grid*	*Expected operational lifetime (years)*	*Net power generated (MWh, 2005)*	*Capacity factor (using net capacity)*	*Capacity factor (using gross capacity)*
		Net	*Gross*					
Kori-1	PWR	556	587	1977	30	4 149 468	85%	81%
Kori-2	PWR	605	650	1983	40	5 151 505	97%	90%
Kori-3	PWR	895	950	1985	40	7 562 165	96%	91%
Kori-4	PWR	895	950	1985	40	8 397 183	107%	101%
Younggwang-1	PWR	900	950	1986	40	8 302 854	105%	100%
Younggwang-2	PWR	900	950	1986	40	7 302 404	93%	88%
Younggwang-3	PWR	950	1 000	1994	40	8 675 552	104%	99%
Younggwang-4	PWR	950	1 000	1995	40	7 754 978	93%	89%
Younggwang-5	PWR	950	1 000	2001	40	7 748 431	93%	88%
Younggwang-6	PWR	950	1 000	2002	40	7 137 129	86%	81%
Wolsong-1	PHWR	629	679	1982	30	4 296 276	78%	72%
Wolsong-2	PHWR	650	700	1997	30	5 641 290	99%	92%
Wolsong-3	PHWR	650	700	1998	30	5 997 857	105%	98%
Wolsong-4	PHWR	650	700	1999	30	5 657 871	99%	92%
Ulchin-1	PWR	920	950	1988	40	8 245 040	102%	99%
Ulchin-2	PWR	920	950	1989	40	6 582 355	82%	79%
Ulchin-3	PWR	960	1 000	1998	40	7 651 745	91%	87%
Ulchin-4	PWR	960	1 000	1998	40	8 003 006	95%	91%
Ulchin-5	PWR	960	1 000	2003	40	7 321 599	87%	84%
Ulchin-6	PWR	960	1 000	2005	40	6 010 963	71%	69%
Total		**16 810**	**17 716**			**137 589 671**	**93%**	**89%**

Note: PWR = pressurised water reactor; PHWR = pressurised heavy water reactor.
Source: International Atomic Energy Agency.

Korea's oldest power plant, Kori-1, which began operation in 1977, is slated to close in 2008. However, an extension of its operation lifetime is being

considered. The Ministry of Science and Technology has completed a revision of the *Nuclear Power Act* such that the lifetime of a power plant can be extended if it is deemed safe by a technological assessment.

The performance of the units currently in operation is very satisfactory. Safety records are excellent with an average capacity factor above 90% since 2000 (the capacity factor is 89% when using gross capacity), as compared with a world average just below 80%. No nuclear accidents have been recorded in any Korean nuclear facility.

According to Korean data, nuclear electricity is the country's cheapest available electricity option, with total generation costs of about KRW 40 per kWh as compared with 42 for coal, 57 for hydro and more than 80 for gas (LNG). Low nuclear generation costs result mainly from the efficient co-ordination and operation of Korea's nuclear programme and the standardisation of the plants, whereas high gas-fired generation costs are caused by high prices of imported LNG.

FUTURE CONSTRUCTION

As shown in Table 32, four units of 1 000 MW_e each are already under construction, to enter operation by 2012. Preparations are being made for four more power plants, totalling an additional 5 600 MW by 2015. Finally, two additional units totalling 2 800 MW are planned and expected to go on-line by 2015. In total, this would add nearly 10 000 MW of capacity, bringing Korea's total installed nuclear capacity to over 25 GW_e by 2015. Four of the planned eight units are of a new Korean design, APR1400 pressurised water reactors, with an expected operational lifetime of 60 years.

Table 32

Proposed Nuclear Power Plants

Name	*Type*	*Capacity (MW)*	*Expected commercial operation year*	*Expected operational lifetime (years)*	*Status*
Shin'Kori-1	PWR	1 000	2010	40	Under construction
Shin'Kori-2	PWR	1 000	2011	40	Under construction
Shin'Wolsong-1	PWR	1 000	2011	40	Under construction
Shin'Wolsong-2	PWR	1 000	2012	40	Under construction
Shin'Kori-3	PWR	1 400	2012	60	Preparations for construction
Shin'Kori-4	PWR	1 400	2013	60	Preparations for construction
Shin'Ulchin-1	PWR	1 400	2014	60	Preparations for construction
Shin'Ulchin-2	PWR	1 400	2015	60	Preparations for construction
		1 400	2015		Planned
		1 400	2015		Planned
Total		**12 400**			

Note: PWR = pressurised water reactor.
Source: Country submission.

SOCIAL ACCEPTABILITY

The government is planning to actively enhance the social acceptability of nuclear power generation. According to the *National Energy Act*, a national energy commission will be organised – including the government, environmental organisations and experts, among others – to discuss nuclear policies in general in order to minimise social conflict and win public trust in and support for nuclear power.

Meanwhile, the government is implementing the *Act on the Support of Areas Surrounding Power Plants* as part of its efforts to enhance the social acceptability of nuclear power. In particular, it is significantly expanding the financial support provided to surrounding areas in 2005. The government has also established the Korea Nuclear Power Culture Foundation to publicise and educate people on the peaceful use of nuclear power.

KEY ACTORS IN KOREA'S NUCLEAR INDUSTRY

In addition to Korea Hydro and Nuclear Power (KHNP), which operates Korea's nuclear power plants, under the Ministry of Science and Technology (MOST) there is an independent division that is in charge of regulating safety matters. This division, the Nuclear Safety Commission, although part of MOST, is an independent body in charge of nuclear safety issues; it receives scientific and technical support from the Korea Institute of Nuclear Safety, which formulates safety regulations for nuclear power plants. Furthermore, MOST runs the Korea Atomic Energy Research Institute, which conducts basic nuclear power studies. KHNP, a state-owned entity, is responsible for all costs related to waste disposal, including site selection.

Regarding the financing of decommissioning, KHNP is responsible for accumulating a fund to cover expenses when needed. The government monitors the fund and verifies that it reflects reliable, up-to-date cost estimates.

The government has organised the Korea Atomic Energy Commission under the direction of the prime minister to deliberate and decide on key issues related to the use of nuclear power. The commission consists of 9 to 11 commissioners, including the prime minister who chairs it, and the commissioners who are appointed by ministers of related departments and by the president.

In the private sector, the Korea Power Engineering Company is responsible for nuclear reactor systems and general plant design. The Korea Nuclear Fuel Company produces Korea's nuclear fuel, Korea Plant Service and Engineering carries out power plant engineering, and the Doosan Heavy Industries and Construction Company produces major equipment such as nuclear reactors and turbines. Doosan is one of the rare companies in the world that is capable of supplying the heaviest nuclear reactor equipment, reactor vessel and steam generators.

NUCLEAR FUEL CYCLE

URANIUM IMPORTS AND ENRICHMENT

Korea imports uranium from many countries, including Australia, Canada and Russia. Uranium enrichment is carried out in France, Russia, the United Kingdom and the United States. Fuel fabrication services are done domestically.

WASTE MANAGEMENT AND DISPOSAL

Korea does not currently reprocess its spent fuel and has 7 286 tonnes of spent fuel in storage. All nuclear waste, including spent fuel, is stored on-site at each of the four power plant sites. It is expected that on-site capacity will become exhausted around 2008, starting with the Ulchin site. Following on numerous unsuccessful attempts to select a site for disposal of low- and intermediate-level waste, the government developed a completely revised process (see box). On the basis of the results of local referenda, a site in south-eastern Korea, a district of Kyoung-Ju City, was selected in November 2005.

Funds to cover future costs associated with decommissioning, including disposing of low- and intermediate-level waste and spent fuel, are deposited into special accounts managed by KHNP. The *Electricity Business Act* requires KHNP to deposit these costs into the fixed liability in the company's accounts as a provision for future needs. The government reviews these accounts every five years, benchmarking them to case studies from other countries in order to confirm that the funds will fully cover expected costs. In addition, the accounts are audited by an independent company.

Selection of a low- and medium-level radioactive waste disposal site

Between 1986 and 2005, Korea made nine unsuccessful attempts to select a site for the construction of a low- and intermediate-level radioactive waste disposal facility. After determining that much of the failure of the previous attempts was the result of the lack of a transparent and democratic process, in 2004 a more democratic process incorporating a referendum was implemented. Again, the 2004 attempt was unsuccessful, as no applications were filed. Government review found that, among other things, there were broad safety concerns, concerns that the site would evolve into a high-level waste disposal site, a lack of broad public participation in the process and a distrust that promised incentives would materialise.

As a result, in December 2004, the Atomic Energy Commission established a revised national policy for radioactive waste management. The essence of the revised policy was that construction of a low- and intermediate-level radioactive waste disposal facility would be implemented first while the policy for spent fuel management would be established later through national consensus after sufficient nationwide discussion. In March 2005, the *Special Act on Support for a Low- and Intermediate-level Radioactive Waste Disposal Facility Hosting Region* was passed. On the basis of the revised national policy and the act, a new siting process was prepared that addressed many of the issues identified in the review of earlier attempts:

- The facility will only include a low- and intermediate-level waste repository, excluding a spent fuel-related facility.
- Geological investigation will be performed before launching siting procedures.
- A special siting committee to oversee the entire procedure will be organised.
- Fair site-selection criteria will be publicly announced in advance.
- A special law to legally bind incentives will be enacted. The host municipality will receive special subsidies amounting to KRW 300 billion, charges levied on the radioactive wastes to be brought in the facility for the financial support of the host region. Furthermore, KHNP's head office will be relocated in the host region and a proton linear accelerator centre is also to be built there.

Four applications were filed to MOCIE. After determining that all four sites were acceptable after safety and feasibility evaluations, on 15 September 2005 MOCIE officially requested that the sites initiate referendum processes. Local referenda were held in each location on 2 November 2005, and a district in Kyoung-Ju City was selected as it received the highest approval rating (it had the second-highest voter turnout rate, 70.8%; the highest voter turnout rate was 80.2%).

Building on its successful site selection effort, the government has set two future tasks:

- First, to successfully build and operate the waste facility, during which stakeholders (*e.g.* residents and experts) have the opportunity to participate from an early stage of the project to confirm the safety of the facility.
- Second, to establish a roadmap for nationwide discussion of spent fuel policy.

CRITIQUE

Korea's nuclear energy industry is a model for other countries – a commendable achievement, particularly in light of its relative youth. The industry, which started in the mid-1970s, has reached full maturity and covers design, building and operation of nuclear power plants, maintenance services, fuel fabrication and radioactive waste management. The nuclear energy regulatory framework implemented by Korea is comprehensive and in line with best international practices. The performance of the units in operation is good, and its safety record is excellent with no nuclear accident reported in any facility. Furthermore, it has had an average capacity factor above 90% since 2000, which is a notable achievement given the world average of just below 80%.

In the field of radioactive waste management and disposal, the Korean nuclear industry and the government took a critical step forward in 2005 with the successful selection of a site for low- and intermediate-level waste disposal. After reviewing and taking lessons learned from its previous site selection attempts, the government modified the process such that it was more transparent and democratic, fully involving the public that will be directly affected by the facility. The IEA applauds this effort. Korea's process includes the key components of successful nuclear waste disposal policy, namely transparent, fair and clear selection criteria; public participation; democratic involvement; regulatory certainty and economic incentives.

Regarding the broader public debate, including on nuclear power in general in addition to waste disposal, the government should continue to ensure that there is open, informed, public debate. The nuclear industry will benefit in the long term if Korean citizens and other stakeholders receive balanced information and are able to take part in an open dialogue on the benefits and risks of nuclear facilities in their communities and on Korea's overall supply-demand balance. A transparent, democratic process is likely to enhance public confidence in the relevance of nuclear energy, taking into account its risks and benefits assessed in perspective with alternative options for meeting energy needs. The public debates taking place in Finland and the United Kingdom regarding the role of nuclear in the supply mix might provide Korea with insight on ways to achieve a balanced, open forum for discussion.

Although capacity for long-term storage of spent fuel is not an immediate concern, it is essential to initiate the very long process of choosing and implementing a solution for disposal of high-level waste. The fleet of Korean reactors is rather young, averaging less than 30 years and the first plant shutdowns are not expected for another one or two decades. Nonetheless, as in other OECD countries, measures should be taken as soon as possible to ensure the safe final disposal of all types of radioactive waste, including spent fuel. Plant life management and decommissioning are important issues that

must be tackled very early in the process to acquire relevant scientific knowledge and technical know-how. Korea should use the experience gained during selection of a site for a low- and intermediate-level waste disposal facility to develop, well in advance of its necessity, a process for selecting a high-level waste disposal site.

Regarding the financing of decommissioning, Korea has established a robust system for ensuring sufficient funds to cover future costs. Nonetheless, the government should continue to closely monitor the amount and availability of these funds. In addition, the government could assess alternative options for managing, auditing and guaranteeing the decommissioning fund, in particular if and when nuclear power plant owners begin competing in a liberalised electricity market.

Attention should be paid to the independence of the nuclear safety authority, as independence is essential for safe and reliable long-term operation of nuclear facilities, particularly in the context of a liberalised electricity market. The limited numbers of actors in the nuclear energy field, and their close links with governmental bodies, have some advantages in term of effectiveness, as suggested by the excellent economic performance of Korea's nuclear power plants. However, introducing competition at some stages of the fuel cycle (*e.g.* fuel fabrication) could lead to even lower costs.

RECOMMENDATIONS

The government of Korea should:

- *Ensure that citizens and other stakeholders receive balanced information and take part in an open dialogue on the benefits and risks of nuclear facilities in their communities, taking advantage of best practices in other countries.*
- *Establish a detailed roadmap for the management and final disposal of spent fuel and other high-level waste, and take steps as soon as possible to begin implementation of the option selected, taking advantage of the experience gained by the recent site selection.*
- *Continue monitoring the level of decommissioning and waste disposal funds and their management in order to ensure that adequate money will be available for those actions.*
- *Continue to ensure the independence, expertise and strength of the safety authority.*

R&D POLICY OBJECTIVES AND STAKEHOLDERS

The overall objective of Korea's energy R&D policy is to support the *National Energy Plan*. The specific objectives, as detailed in the *Five-Year National Plan for Energy Conservation Technology Development* and the *Ten-Year National Plan for Energy Technology Development* are to achieve the following:

- Reduce total energy consumption by 10%.
- Boost new and renewable energy supply (*e.g.* hydrogen, solar and biomass) to 2% of TPES by 2006.
- Secure clean fossil fuel technology (*e.g.* sulphur dioxide and carbon dioxide reduction technologies).

Responsibilities for energy R&D are shared between the Ministry of Commerce, Industry and Energy (MOCIE) and the Ministry of Science and Technology (MOST). The government established the Science and Technology Innovation Headquarters within MOST in order to improve oversight and management of science and technology funding. Within this organisation, most energy issues are handled by the co-ordinator for energy and the environment.

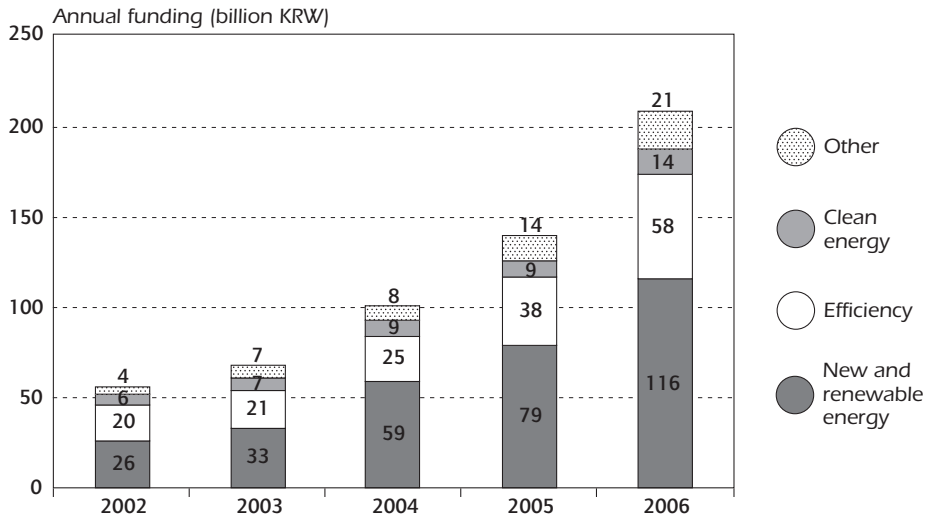
The Korea Energy Management Corporation (KEMCO), the Korea Science and Engineering Foundation (KOSEF) and Electric Power Industry Technology Evaluation and Planning (ETEP) also work on R&D management. Private-sector R&D participation comes from many companies, most notably Samsung, LG, Hyundai and SK, as well as small and medium-sized enterprises. Korea's major universities, Seoul National University, the Korea Advanced Institute of Science and Technology (KAIST) and Pohang University are also actively involved in energy R&D. Government research institutions are also part of the R&D network.

FUNDING

Energy R&D represents approximately 1.6% of Korea's overall R&D budget (information technology makes up the largest share, at 15%). Compared to other IEA countries, Korea's energy R&D expenditures as a share of GDP are relatively low. For example, Japan's energy R&D expenditures as a share of GDP are nearly two-and-a-half times greater. However, as shown in Figure 22, annual funding for energy-related R&D has increased significantly since 2002, nearly quadrupling to over KRW 200 billion (about USD 200 million) – a trend that is rare in IEA countries. The largest increase has been in funding for new and renewable energy technologies, which has grown nearly fivefold.

Figure 22

Energy-related R&D Funding, 2002 to 2006*



* estimates.

Source: Country submission.

POLICIES AND MEASURES

Broadly speaking, Korea's energy R&D funding is focused on four areas, namely new and renewable energy; energy efficiency; clean technologies (which include technologies that reduce greenhouse gas emissions) and nuclear energy. An overview of non-nuclear R&D programmes is provided in Table 33. Most energy R&D projects are undertaken as joint public-private partnerships.

NEW AND RENEWABLE ENERGY SOURCES

One of the key growth areas of energy R&D funding is new and renewable sources of energy (NRSE). Within this category, the government is funding projects focused on hydrogen fuel cells, solar photovoltaics and wind. The largest share of funding is for hydrogen (29.3% of total renewables funding), reflecting the government's goal to have a hydrogen economy by 2050. Following hydrogen, research into photovoltaics receives 15.2% of funding, bioenergy 10.6%, wind 10.2%, coal liquefaction and gasification 8.4% and solar thermal 6.4%. Total R&D for new and NRSE is forecast to grow from USD 86 million to USD 303 million.

ENERGY EFFICIENCY

Following NRSE, energy efficiency receives the next-largest share of government funding for non-nuclear energy R&D. The government is funding projects on small district heating and cooling technologies, efficiency

Table 33

Non-nuclear Energy R&D Projects

Development	Energy-saving technologies	*Five areas: industry, building, transportation, electricity, furnace-metal.*
	Alternative energy technologies	*Eleven areas, including: photovoltaics, photopile, biomass, fuel cells, wind power, small hydropower and solid waste.*
	Clean energy technologies	*Three areas: clean coal, clean air and CO_2 technologies.*
	Resource technologies	*Six areas, including: non-metallic minerals treatment, advanced materials technology and domestic anthracite coal utilisation technology.*
Practical application	Pilot projects for energy technology applications	*Pilot application of technologies that were already developed but avoided by companies owing to lack of reliability and economic profitability.*
	Pilot projects for alternative energy dissemination	*Pilot supply to local authorities and public organisations to secure the alternative energy technologies' reliability and economic profitability.*
	Financing for alternative energy	*Support for financing to disseminate alternative energy technologies.*
	Assessment of alternative energy	*Promotion of alternative energy by standardisation and specification through test and assessment.*
Infrastructure	International co-operation	*Participation in the IEA's R&D programmes and technological co-operation with developed countries with advanced technologies in particular areas.*
	Technology information exchange	*Collection, processing and distribution of energy technology information.*
	Academic promotion	*Support of graduate-level students.*

Source: Country submission.

renovations, heat pumps, new materials and motors, among others. Research on the efficiency of buildings and building components, particularly lighting, are also high-priority funding areas.

CLEAN TECHNOLOGIES

Two major efforts are being funded under the clean technologies category. The government is funding research into after-treatment technologies for coal burning in order to reduce air pollutants, such as SO_x and NO_x, and air discharges from incineration. The other major area of focus is CO_2 separation and utilisation, such as oxy-fuel combustion, waste heat recovery, reactive separation and CO_2 sequestration, in order to demonstrate the viability of these technologies as carbon mitigation strategies.

NUCLEAR

With respect to nuclear R&D, while MOCIE manages nuclear power generator construction and operation, MOST handles fundamental base technology development.

MOCIE is actively promoting R&D projects to help launch domestic nuclear power generators in overseas markets, by localising and enhancing the functions of nuclear power facilities through use of the funds for electric power industry infrastructure established under the *Electricity Business Act*. In 1998, it formulated the *Nuclear Power Generator Technology Enhancement Plan (1999-2006)* to improve the stability and economic efficiency of domestic nuclear power reactors. MOST promotes the medical and industrial use of non-diffusive nuclear fuel cycle, radiation, and radioactive isotopes; and advanced researches on safety regulations for nuclear power use.

In 2004, investments in nuclear R&D include KRW 38 billion from MOCIE and KRW 198 billion from MOST. In 2005, MOCIE planned to provide an additional KRW 59 billion and MOST KRW 185 billion.

Korea also provides funding for the international fusion R&D project, as discussed in the section on international co-operation below.

FISCAL R&D INCENTIVES

The government provides incentives to encourage energy R&D in the private sector. Companies receive a 15% income and corporate tax deduction on R&D investments.

SELECTION, MONITORING AND ASSESSMENT

Since the last in-depth review, Korea has focused on improving its R&D funding mechanism, in particular the independence of the monitoring and assessment processes. The government is establishing a project investigator (PI) model with a performance management component, similar to the model used in Europe and the United States. By monitoring efforts of commercialisation of technologies for five years following the completion of the projects, the government hopes to improve the effectiveness of its R&D funding. The revised review process will include an interim assessment, as well as a final assessment that looks at performance results, including post analysis and surveys.

INTERNATIONAL CO-OPERATION

Korea is a member of 15 IEA implementing agreements (IAs), including IAs related to climate change, district heating and cooling, environment, hydrogen, fuel cells, demand-side management, coal-bed methane and wind

energy. In addition, Korea is also a member of the International Partnership for the Hydrogen Economy (IPHE), the Energy Working Group of Asia-Pacific Economic Co-operation (APEC), the Asia-Pacific Partnership (APP) and the Carbon Sequestration Leadership Forum (CSLF). Since June 2003, the government has been participating in the construction of ITER, a collaborative international project to build a nuclear fusion reactor.

CRITIQUE

Unlike most IEA countries, Korea's energy R&D budget has been increasing, an achievement that the IEA applauds. The country has explicitly linked its energy R&D objectives to its overall energy policy objectives, which is an important first step in creating an effective R&D policy. The country's active involvement in international co-operation helps improve the value of its investments. The IEA encourages Korea to build on this significant progress, so that its energy R&D policies enable the country to meet its long-term energy policy objectives.

By directly linking its R&D policy with its energy policy objectives, Korea can gain greater benefits from its R&D expenditures. The IEA is pleased to see that Korea has linked these objectives together, and encourages the country to ensure that the individual projects that the country funds, and the amount provided to each project, well match the country's R&D policy objectives. The IEA also encourages Korea to build upon its existing work on CO_2 sequestration and coal-bed methane mitigation to improve links between the country's R&D expenditures and its long-term environmental policy objectives.

Linking R&D expenditures with energy and environmental goals will require good oversight of the R&D funding process, including ensuring that selections are based on transparent criteria measured by independent parties. The government's revamping of the entire project-selection process is therefore commended. An effective process, including rigorous cost-benefit analysis and environmental criteria, is critical to a successful policy. At the same time, the government should ensure that some funding goes to more risky projects that could have a very high pay-off. A good R&D portfolio for a relatively large country like Korea should include a mix of low risk-low reward projects and high risk-high reward projects. Thus, cost-benefit analysis should be used where appropriate.

Given Korea's limited domestic fossil fuel resources and its long-term renewable energy target, the country should ensure that new and renewable energy research takes into account Korea's domestic resources of wind, biomass, geothermal, ocean and coal-bed methane, among others. The results of this research should be incorporated into policy decisions. In particular, Korea's efforts on coal-bed methane research are notable, and the IEA encourages the government to continue to focus on this technology. Increased investment in research on

alternative transport fuel would also help better inform policy decisions, particularly as Korea's use of fossil fuels in the transport sector is growing rapidly.

To ensure a successful transition to a liberalised energy market, Korea should leverage the experience and lessons learned from other countries, particularly from the markets of Nord Pool in the Nordic countries, PJM in the Mid-Atlantic region of the United States and NEMMCO in Australia, through research into these reform efforts and market functioning. In addition, Korea should also look at the experience of New Zealand, an island without imports of gas or electricity. The government should undertake rigorous research and analysis of the various liberalisation models and processes, taking care to understand what aspects of these different models best suit Korea's circumstances.

Nuclear energy is an important element to reach the goals of the Korean energy policy in terms of security of supply, environmental protection and economic competitiveness. Adequate R&D programmes are necessary to maintain and enhance the performance of existing power plants and improve the management of radioactive waste sites. We are pleased to note that Korea continues to invest in nuclear R&D at a high level to ensure it remains a world leader in its domestic nuclear industry, as well as in the world market for nuclear technology.

RECOMMENDATIONS

The government of Korea should:

- *Ensure that R&D priorities and investment levels well reflect energy policy objectives.*
- *Improve links between R&D expenditures and environmental policy objectives by including environmental criteria in cost-benefit analysis.*
- *Conduct cost-benefit analysis of R&D expenditures where appropriate.*
- *Conduct analysis of domestic resource potential, including wind, solar, biomass, ocean, geothermal and coal-bed methane.*
- *Consider increasing financial support for R&D in alternative transport fuels, such as biofuels, given the rapid rise in fossil fuel use in transport.*
- *Assess the feasibility of various advanced clean coal technologies and continue to participate in international technology development efforts.*
- *Increase research on the functioning of liberalised energy markets, possibly in co-operation with international partners.*
- *Ensure that the comprehensive R&D programme continues to support the operation and maintenance of existing and future nuclear facilities, and actively participate in international co-operation.*

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	2003	2004	2010	2020	2030
TOTAL PRODUCTION		**6.76**	**21.91**	**37.89**	**38.03**	**51.52**	**79.94**	**108.49**
Coal		6.65	7.58	1.41	1.37	–	–	–
Oil		–	–	0.50	0.44	–	–	–
Gas		–	–	–	–	–	–	–
Comb. Renewables & Waste[1]		–	–	1.73	1.75	6.80	12.77	19.43
Nuclear		–	13.78	33.79	34.07	44.27	66.67	88.39
Hydro		0.11	0.55	0.42	0.37	0.45	0.50	0.66
Geothermal		–	–	–	0.00	–	–	–
Solar/Wind/Other		–	0.00	0.04	0.04	..	..	..
TOTAL NET IMPORTS[2]		**13.03**	**68.51**	**170.55**	**177.07**	**209.03**	**249.83**	**298.33**
Coal	Exports	0.12	–	–	–	–	–	–
	Imports	0.45	15.73	45.42	50.25	65.01	73.64	92.23
	Net Imports	0.34	15.73	45.42	50.25	65.01	73.64	92.23
Oil	Exports	1.04	3.73	28.57	32.14	–	–	–
	Imports	14.28	55.41	137.26	139.98	116.45	131.80	150.76
	Bunkers	0.56	1.58	6.32	6.96	6.00	6.00	6.00
	Net Imports	12.69	50.10	102.37	100.88	110.45	125.80	144.76
Gas	Exports	–	–	–	–	–	–	–
	Imports	–	2.68	22.73	25.91	33.57	50.39	61.35
	Net Imports	–	2.68	22.73	25.91	33.57	50.39	61.35
Electricity	Exports	–	–	–	–	–	–	–
	Imports	–	–	–	–	–	–	–
	Net Imports	–	–	–	–	–	–	–
TOTAL STOCK CHANGES		**1.86**	**2.24**	**–2.14**	**–2.05**	**–**	**–**	**–**
TOTAL SUPPLY (TPES)		**21.64**	**92.65**	**206.30**	**213.05**	**260.55**	**329.76**	**406.82**
Coal		8.13	25.56	47.09	50.09	65.01	73.64	92.23
Oil		13.40	50.04	101.20	101.43	110.45	125.80	144.76
Gas		–	2.72	22.00	25.28	33.57	50.39	61.35
Comb. Renewables & Waste[1]		–	–	1.76	1.77	6.80	12.77	19.43
Nuclear		–	13.78	33.79	34.07	44.27	66.67	88.39
Hydro		0.11	0.55	0.42	0.37	0.45	0.50	0.66
Geothermal		–	–	–	0.00	–	–	–
Solar/Wind/Other		–	0.00	0.04	0.04	..	..	..
Electricity Trade		–	–	–	–	–	–	–
Shares (%)								
Coal		*37.6*	*27.6*	*22.8*	*23.5*	*25.0*	*22.3*	*22.7*
Oil		*61.9*	*54.0*	*49.1*	*47.6*	*42.4*	*38.1*	*35.6*
Gas		*–*	*2.9*	*10.7*	*11.9*	*12.9*	*15.3*	*15.1*
Comb. Renewables & Waste		*–*	*–*	*0.9*	*0.8*	*2.6*	*3.9*	*4.8*
Nuclear		*–*	*14.9*	*16.4*	*16.0*	*17.0*	*20.2*	*21.7*
Hydro		*0.5*	*0.6*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
Geothermal		*–*	*–*	*–*	*–*	*–*	*–*	*–*
Solar/Wind/Other		*–*	*–*	*–*	*–*	*..*	*..*	*..*
Electricity Trade		*–*	*–*	*–*	*–*	*–*	*–*	*–*

0 is negligible, – is nil, .. is not available.
Forecast data for combustible renewables and waste include solar, wind and other.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2003	2004	2010	2020	2030
TFC	**17.40**	**63.99**	**141.72**	**143.69**	**192.81**	**238.35**	**286.34**
Coal	6.49	11.37	8.16	7.51	22.58	24.95	27.67
Oil	9.81	43.82	87.74	86.79	104.46	121.05	138.94
Gas	–	0.67	14.01	14.51	22.08	28.95	33.76
Comb. Renewables & Waste[1]	–	–	1.06	1.45	6.80	12.77	19.43
Geothermal	–	–	–	0.00	–	–	–
Solar/Wind/Other	–	0.00	0.03	0.04	..	..	..
Electricity	1.10	8.12	27.35	29.06	34.55	47.49	63.04
Heat	–	–	3.37	4.33	2.34	3.14	3.50
Shares (%)							
Coal	*37.3*	*17.8*	*5.8*	*5.2*	*11.7*	*10.5*	*9.7*
Oil	*56.4*	*68.5*	*61.9*	*60.4*	*54.2*	*50.8*	*48.5*
Gas	–	*1.1*	*9.9*	*10.1*	*11.5*	*12.1*	*11.8*
Comb. Renewables & Waste	–	–	*0.7*	*1.0*	*3.5*	*5.4*	*6.8*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	..	..	..
Electricity	*6.3*	*12.7*	*19.3*	*20.2*	*17.9*	*19.9*	*22.0*
Heat	–	–	*2.4*	*3.0*	*1.2*	*1.3*	*1.2*
TOTAL INDUSTRY[3]	**7.37**	**25.17**	**67.68**	**69.92**	**104.84**	**129.68**	**156.88**
Coal	0.39	2.71	7.60	6.85	21.97	24.59	27.56
Oil	6.22	17.42	38.95	39.87	55.00	64.60	74.04
Gas	–	0.07	3.74	3.94	5.32	6.63	7.97
Comb. Renewables & Waste[1]	–	–	0.94	1.13	5.92	11.65	18.08
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	..	..	..
Electricity	0.76	4.97	14.49	15.25	16.63	22.22	29.23
Heat	–	–	1.96	2.89	–	–	–
Shares (%)							
Coal	*5.3*	*10.8*	*11.2*	*9.8*	*21.0*	*19.0*	*17.6*
Oil	*84.4*	*69.2*	*57.5*	*57.0*	*52.5*	*49.8*	*47.2*
Gas	–	*0.3*	*5.5*	*5.6*	*5.1*	*5.1*	*5.1*
Comb. Renewables & Waste	–	–	*1.4*	*1.6*	*5.6*	*9.0*	*11.5*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	..	..	..
Electricity	*10.3*	*19.7*	*21.4*	*21.8*	*15.9*	*17.1*	*18.6*
Heat	–	–	*2.9*	*4.1*	–	–	–
TRANSPORT[4]	**2.60**	**14.93**	**34.16**	**34.25**	**41.48**	**51.12**	**60.23**
TOTAL OTHER SECTORS[5]	**7.43**	**23.89**	**39.88**	**39.52**	**46.49**	**57.56**	**69.23**
Coal	6.08	8.67	0.56	0.66	0.61	0.36	0.11
Oil	1.02	11.56	14.96	13.12	9.22	7.80	7.42
Gas	–	0.60	10.14	10.34	15.77	20.16	23.40
Comb. Renewables & Waste[1]	–	–	0.12	0.31	0.88	1.13	1.35
Geothermal	–	–	–	0.00	–	–	–
Solar/Wind/Other	–	0.00	0.03	0.04	..	..	..
Electricity	0.33	3.06	12.66	13.60	17.67	24.97	33.44
Heat	–	–	1.40	1.45	2.34	3.14	3.50
Shares (%)							
Coal	*81.9*	*36.3*	*1.4*	*1.7*	*1.3*	*0.6*	*0.2*
Oil	*13.7*	*48.4*	*37.5*	*33.2*	*19.8*	*13.5*	*10.7*
Gas	–	*2.5*	*25.4*	*26.2*	*33.9*	*35.0*	*33.8*
Comb. Renewables & Waste	–	–	*0.3*	*0.8*	*1.9*	*2.0*	*2.0*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	*0.1*	*0.1*	..	..	..
Electricity	*4.5*	*12.8*	*31.8*	*34.4*	*38.0*	*43.4*	*48.3*
Heat	–	–	*3.5*	*3.7*	*5.0*	*5.5*	*5.1*

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2003	2004	2010	2020	2030
ELECTRICITY GENERATION[6]							
INPUT (Mtoe)	**3.30**	**26.60**	**79.30**	**84.10**	**96.06**	**132.03**	**173.85**
OUTPUT (Mtoe)	**1.27**	**9.06**	**29.66**	**31.53**	**37.76**	**51.85**	**68.74**
(TWh gross)	14.83	105.37	344.85	366.61	439.04	602.91	799.35
Output Shares (%)							
Coal	*9.0*	*16.8*	*38.9*	*38.8*	*39.1*	*36.8*	*36.8*
Oil	*82.3*	*17.9*	*9.2*	*8.0*	*9.0*	*3.9*	*4.0*
Gas	*–*	*9.1*	*12.3*	*16.2*	*12.0*	*15.9*	*15.9*
Comb. Renewables & Waste	*–*	*–*	*0.6*	*0.1*	*..*	*..*	*..*
Nuclear	*–*	*50.2*	*37.6*	*35.7*	*38.7*	*42.4*	*42.4*
Hydro	*8.7*	*6.0*	*1.4*	*1.2*	*1.2*	*1.0*	*1.0*
Geothermal	*–*	*–*	*–*	*–*	*–*	*–*	*–*
Solar/Wind/Other	*–*	*–*	*0.0*	*0.0*	*..*	*..*	*..*
TOTAL LOSSES	**4.13**	**28.58**	**63.52**	**65.00**	**67.74**	**91.41**	**120.48**
of which:							
Electricity and Heat Generation[7]	2.03	17.53	46.16	48.15	55.90	76.99	101.56
Other Transformation	1.09	6.64	8.45	7.45	7.85	9.01	11.95
Own Use and Losses[8]	1.01	4.41	8.90	9.40	3.98	5.41	6.97
Statistical Differences	0.11	0.09	1.06	4.35	–	–	–

INDICATORS

	1973	1990	2003	2004P	2010	2020	2030
GDP (billion 2000 USD)	77.30	283.60	585.90	613.10	798.42	1181.85	1667.12
Population (millions)	34.10	42.87	47.85	48.08	49.22	49.96	49.33
TPES/GDP[9]	0.28	0.33	0.35	0.35	0.33	0.28	0.24
Energy Production/TPES	0.31	0.24	0.18	0.18	0.20	0.24	0.27
Per Capita TPES[10]	0.63	2.16	4.31	4.43	5.29	6.60	8.25
Oil Supply/GDP[9]	0.17	0.18	0.17	0.17	0.14	0.11	0.09
TFC/GDP[9]	0.23	0.23	0.24	0.23	0.24	0.20	0.17
Per Capita TFC[10]	0.51	1.49	2.96	2.99	3.92	4.77	5.80
Energy-related Emissions (Mt CO_2)[11]	65.8	225.9	452.4	462.1	554.7	658.1	CO2 792.2
CO_2 Emissions from Bunkers (Mt CO_2)	2.1	5.9	23.8	26.1	24.3	26.7	29.8

GROWTH RATES (% per year)

	73-79	79-90	90-03	03-04	04-10	10-20	20-30
TPES	10.8	7.9	6.4	3.3	3.4	2.4	2.1
Coal	6.9	7.0	4.8	6.4	4.4	1.3	2.3
Oil	12.3	5.8	5.6	0.2	1.4	1.3	1.4
Gas	–	–	17.4	14.9	4.8	4.1	2.0
Comb. Renewables & Waste	–	–	–	0.9	25.1	6.5	4.3
Nuclear	–	29.2	7.1	0.8	4.5	4.2	2.9
Hydro	10.5	9.6	-2.0	-11.8	3.1	1.1	2.9
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	20.8	17.1	–	–	–
TFC	9.8	7.0	6.3	1.4	5.0	2.1	1.9
Electricity Consumption	15.9	10.6	9.8	6.3	2.9	3.2	2.9
Energy Production	4.9	8.4	4.3	0.4	5.2	4.5	3.1
Net Oil Imports	13.3	5.8	5.7	-1.5	1.5	1.3	1.4
GDP	8.3	7.8	5.7	4.6	4.5	4.0	3.5
Growth in the TPES/GDP Ratio	2.3	0.2	0.6	-1.3	-1.0	-1.6	-1.3
Growth in the TFC/GDP Ratio	1.4	-0.7	0.5	-3.1	0.5	-1.8	-1.6

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, liquid biomass, biogas 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 main activity producer utilities (formerly known as public) 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 2000 prices and exchange rates.

10 Toe per person.

11 "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. 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 2004 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.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 26 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 IEA members wish to retain and improve the nuclear

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

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.)

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 in each chapter, this glossary provides a quick and central reference for many of the abbreviations used.

ALGAS	Asian Least-cost Greenhouse Gas Abatement Strategy
APR	annual percentage rate
BAU	business as usual
bcm	billion cubic metres
BLMP	baseload marginal price
cc	cubic centimetre
CDM	clean development mechanism
CER	certified emissions reduction
CHP	combined production of heat and power; sometimes when referring to industrial CHP, the term "co-generation" is used
CO_2	carbon dioxide
CO	carbon monoxide
CNG	compressed natural gas
CSLF	Carbon Sequestration Leadership Forum
EMC	Environmental Management Corporation
ESCO	energy service company
EU	European Union
EUR	Euro (€); EUR 1 = KRW 1 272 = USD 1.24 (average exchange rate in 2005)
EWP	Korea East-West Power
FTC	Fair Trade Commission
GDP	gross domestic product
genco	generation company
GHG	greenhouse gas
GW_e	gigawatt of electric capacity

GWh	gigawatt-hour = 1 gigawatt × 1 hour
IA	implementing agreement
IEA	International Energy Agency
IEP	International Energy Program
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
KAERI	Korea Atomic Energy Research Institute
KCC	Korea Coal Corporation
KDHC	Korea District Heating Corporation
KOREC	Korea Electricity Commission
KEEI	Korea Energy Economics Institute
KEMCO	Korea Energy Management Corporation
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro and Nuclear Power
KIER	Korea Institute of Energy Research
kcal	kilo-calorie, or 1 calorie × 10^3, equivalent to 10^{-7} toe
km	kilometre, or 1 metre × 10^3
KNOC	Korea National Oil Corporation
KOGAS	Korea Gas Corporation
KOMIPO	Korea Midland Power
KORES	Korea Resources Corporation
KOSEPCO	Korea South-East Power
KOSPO	Korea Southern Power
KPX	Korea Power Exchange
KRW	Korean won; KRW 1 000 = USD 0.98 = EUR 0.79 (average exchange rate in 2005)
kt	thousand tonnes
ktoe	thousand tonnes of oil equivalent; see "toe"
kV	kilovolt, or 1 volt × 10^3
kW	kilowatt, or 1 watt × 10^3
kWh	kilowatt-hour = 1 kilowatt × one hour = 1 watt × 10^3 × one hour
ℓ	litre
LEV	low-emission vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
m^2	square metre
m^3	cubic metre

MOCIE	Ministry of Commerce, Industry and Energy
MOE	Ministry of Environment
MOST	Ministry of Science and Technology
mpg	miles per gallon, 1 mpg = 0.4251437 km/ℓ
Mt	million tonnes
$MtCO_2$	million tonnes of carbon dioxide
Mtoe	million tonnes of oil equivalent; see "toe"
MW	megawatt, or 1 watt × 10^6
MW_e	megawatt of electric capacity
MWh	megawatt-hour = 1 megawatt × one hour
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NRE	new and renewable energy
NREC	New and Renewable Energy Centre
OECD	Organisation for Economic Co-operation and Development
PHWR	pressurised heavy water reactor
PJM	an independent system operator in the United States (it has expanded to cover states in addition to Pennsylvania, New Jersey and Maryland, the origin of the name)
PM_{10}	particulate matter (particles less than or equal to 10 micrometres in diameter)
PPA	power purchase agreement
ppb	parts per billion
ppm	parts per million
PWR	pressurised water reactor
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well
REEEP	Renewable Energy and Energy Efficiency Partnership
RPS	renewable portfolio standard
SMP	system marginal price
SO_2	sulphur dioxide
SO_x	sulphur oxides
SOE	state-owned enterprise (in New Zealand)
TAPL	total air pollution load

TDR	turn-down ratio
TFC	total final consumption of energy
toe	tonne of oil equivalent, defined as 10^7 kcal
TPA	third-party access; in some regions the term "open access" is used in place of TPA
TPES	total primary energy supply
TWh	terawatt-hour = 1 terawatt × 1 hour = 1 watt × 10^{12} × 1 hour
UK	United Kingdom
ULEV	ultra-low-emission vehicle
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	US dollar ($); USD 1 = EUR 0.80 = KRW 1 024 (average exchange rate in 2005)
VA	voluntary agreement
VAT	value-added tax
VOC	volatile organic compound
WP	Korea Western Power
μg	microgram, or 1 gram × 10^{-6}

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