# National Energy Futures Analysis and Energy Security Perspectives in the Republic of Korea

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## Abstract

This paper presents the status of the energy futures and securities for Republic of Korea (henceforth Korea). The first part of the paper outlines the 'past and current energy situations of Korea, covering the trends and features of energy consumption and economic growth, and energy supply structure and its overseas dependence. The second part explores the energy policies and factors affecting Korea's future energy supply and demand. It illustrates the objectives Korea pursue in the energy sector and the underlying measures Korea is pushing forward in order to attain these objectives. The deregulation policies in oil industry and Korean government plans for restructuring of electricity and gas industries toward privatization and competition are also outlined in this part. The third part discusses 'energy securities of Korea and its policy direction. The controversial issues that Korea now faces with in pushing forward its energy policies for the future are also discussed. The fourth part introduces major institutions that analyze national energy future and forecast long-term energy demand in Korea. Particularly, a detailed review of latest output that Korea Energy Economics Institute' has forecasted is given with underlying assumptions and implications. The latest forecast outputs of the demand for electricity and natural gas are also sketched briefly.

## 1. Energy situation of Korea

### 1.1 Economic growth and energy consumption

The Korean economy has grown very rapidly, with an average annual growth rate of 7.1% during the past fifteen years from 1985 to 1999. With the high economic growth, the energy consumption has grown even more rapidly as shown at the figure 1.1. Annual average growth rate of energy consumption is 8.7%, which is among the highest in the world for the same period. The dip in 1998 in the graph reflects the impacts of the financial crisis which swept over Asia at the time. The economy down-turned and energy consumption also decreased substantially during this time. But last year, 1999, both the economy and energy demand bounced back to the same growth patterns of the years before crisis.

Korean energy consumption in the '90s has grown at a higher than before the '90s. The economic growth elasticity of energy consumption after the '90s was 1.46. This means that it takes 1.46 percent increase in energy consumption for the economy to grow one percent. Before the '90s, this elasticity was 1.16. The faster growth of energy demand relative to the economic growth is due to the fact that the energy intensive industries such as petrochemical, steel and ship–building industry have led the economic growth in Korea.

**(Figure 1.1) Energy and Economic Growth in Korea**

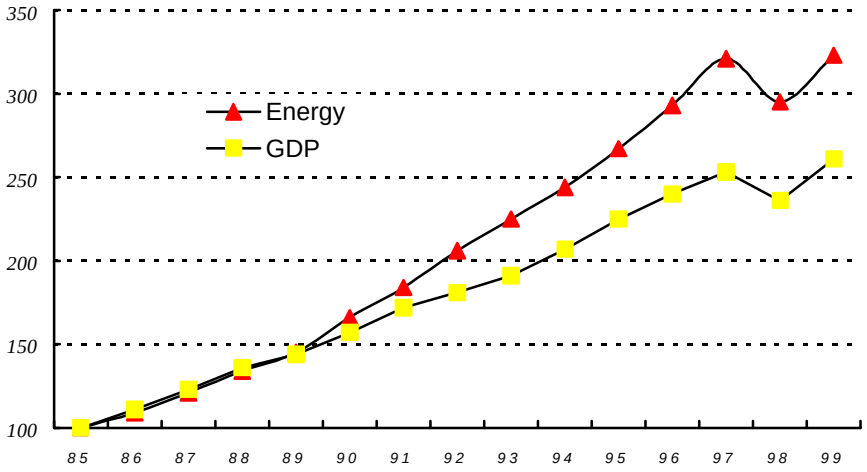
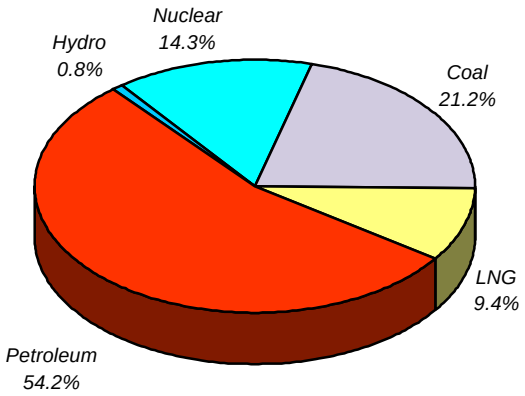



Figure 1.2 shows primary energy consumption by source in Korea. Total energy consumption is 118 million TOE as of 1998. Of this, the petroleum is the most important source of energy. Its proportion takes up more than a half of the total. Next is coal which accounts for 26%. Most of the coal consumed in Korea is the bituminous coal, which is not produced domestically. And then comes nuclear energy. It accounts for 14%. Next is natural gas, taking up 8%. The natural gas in Korea is imported only in the form of LNG (Liquefied NG) until now. Hydro electricity takes up a very small portion. Its ratio is less than 1%.

**(Figure 1.2) Energy Consumption by Energy Source(1999)**



**<Table 1.1> Major Energy/Economic Indicators**

| | 1985 | 1990 | 1995 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|
| Energy Consumption (1,000 TOE) | 56,296 | 93,192 | 150,437 | 180,638 | 165,932 | 181,363 |
| Per Capita Energy Consumption (TOE) | 1.38 | 2.17 | 3.34 | 3.93 | 3.57 | 3.87 |
| Energy/GDP Ratio (TOE/1,000$) | 0.26 | 0.27 | 0.31 | 0.33 | 0.32 | 0.32 |
| Share of petroleum in Energy Consumption(%) | 48.2 | 53.8 | 62.5 | 60.4 | 54.6 | 53.6 |
| Growth Rate of Energy Consumption (%) | 5.2 | 14.1 | 9.6 | 9.3 | -8.1 | 9.3 |
| Population(million) | 40.9 | 42.9 | 45.1 | 46.0 | 46.4 | 46.9 |
| Economic Growth Rate(%) | 6.5 | 9.6 | 8.9 | 5.0 | - 6.7 | 10.7 |

## 1.2 Overseas energy dependency

Korea imports almost all of its energy being consumed, except anthracite, which is the only fossil fuel produced in Korea. Its overseas dependency is more than 97%. This high dependency of energy has constrained Korean economy at times and has been one of the most important factors over the international trade balance as well as energy supply security. The energy imports account for about 15-20% of the 'total import costs of Korea, depending on international oil prices and its quantity. Anthracite production and consumption have decreased very sharply since 1990 due to higher cost and inconvenience of use compared to imported fuels, even though it is the only fuel being produced domestically.

**<Table 1.2> Major Indicators of Overseas Energy Dependence in Korea**

| | Overseas Dependence of energy(%) | Import amount of energy | | Middle East dependence | |
|---|---|---|---|---|---|
| | | Million US$ | % of total Import in Korea | Crude oil (%) | Natural gas (%) |
| 1985 | 76.2 | 7,290 | 27.4 | 60.0 | - |
| 1990 | 87.9 | 13,627 | 10.6 | 74.3 | - |
| 1995 | 96.8 | 18,646 | 14.4 | 77.9 | - |
| 1996 | 97.3 | 24,227 | 16.7 | 77.7 | - |
| 1997 | 97.6 | 27,117 | 19.1 | 73.9 | - |
| 1998 | 97.1 | 18,140 | 20.0 | 75.9 | - |
| 1999 | 97.2 | 22,589 | 19.4 | 72.3 | - |
| 2000 | | | | | 33.8 |
| 2005 | | | | | 52.6 |

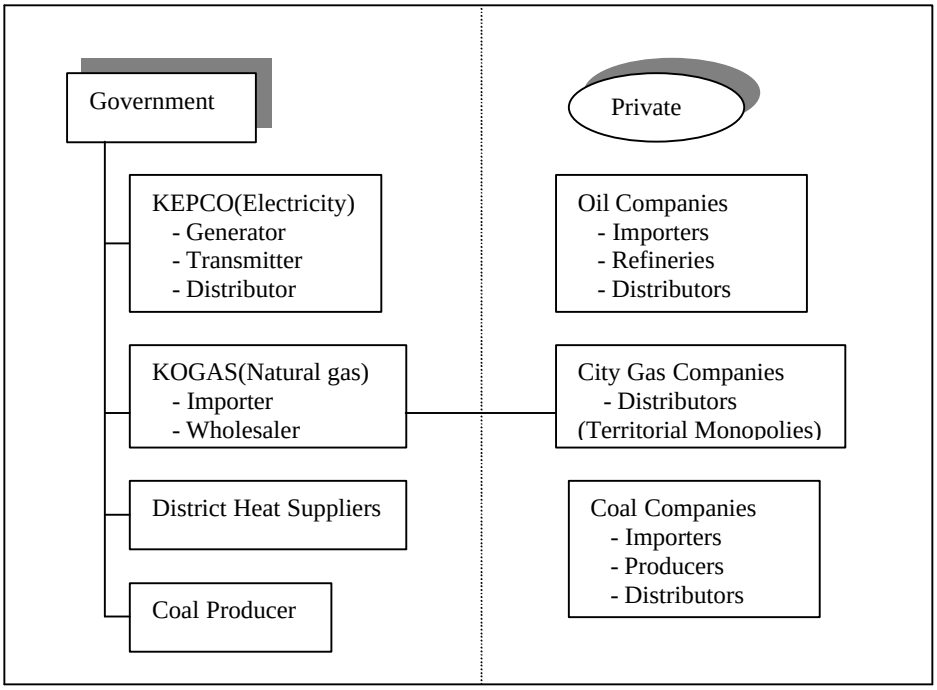
Note: Natural gas is based on long-term contracted quantity of Korea Gas Company

Korea's oil has been imported mainly from the Middle East, especially Saudi Arabia. Currently, dependency on the Middle East for oil runs more than 73% of the total import. Many policies have been derived to reduce our high dependency on Middle East - mainly diversification of oil import source but it has not been very successful. Natural gas is currently imported mostly from the Asian region such as Indonesia and Malaysia. We expect, however, that natural gas will increase its dependency on the Middle East as Korea started to import from Oman this year and by the long term supply contract with Qatar, which is scheduled to start in 2002.

### 1.3. Structure of Energy Supply in Korea

The electricity and district heating are all managed by public firms. In case of natural gas industry, the import and wholesales businesses are managed by a public firm, while the retail business, that is city gas, is privately owned. Coal industry is mixed. Coals are produced both by public and private companies. However, the coal has been decreased very sharply and the government has subsidized coal producers no matter whether they are public or private in order to protect the employees of mines and residents of mine area. All area of oil industry, from import and refinery to distribution and retailing, is all privatize.

**(Figure 1.3) Current Energy Supply Structure of Korea**




KEPCO(Korea Electric Power Company) is a vertically integrated electricity company. It is a generator, transmitter and also distributor. In generation part, there are 5 independent producers (IPP) in Korea but all of them should sell their electricity to KEPCO. Transmission and distribution are completely owned by KEPCO, a public company. Government controls all aspects of KEPCO's management from profit to electricity prices.

KOGAS is the only importer and wholesaler of natural gas, and operates all LNG receiving terminal and main transmission pipelines of Korea. Government also controls all KOGAS activities. Import of natural gas should be approved by the government, and profits and wholesale price are also controlled by the government. Retailers, that is, city gas companies are private companies. But the prices of city gas and their profits are controlled by the government, because they have territorial monopolies. Government assures their monopoly territory with entry barriers for other companies not to penetrate their supply areas and then government controls the city gas companies.

The current structure of energy industry is anticipated to change, and this change would affect significantly on the energy demand in the future through price changes. Most crucial changes anticipated of all are the government's restructuring plans for electricity and natural gas industry, which are currently in process. They will significantly influence the future energy demand through their consequential changes in market environment and prices.

## 2. The energy policies and factors affecting Korea's future energy supply-demand.

### 2.1 The objectives for the energy futures

There are many plans and policies for energy future in Korean government. The objectives Korea pursues with these plans and policies could be summarized by three categories as follows.

The first objective is to establish environmentally friendly energy system. Environment has been an important issue not only for the clean life and health of the mankind but also for economic development and growth. The pressures to restrict $CO_2$ emissions and other pollutants through economic sanctions would be higher by the treaty of climate change. Korea is not involved in the annex 1 group in the treaty, which has a duty to reduce $CO_2$ emission to the promised level within a certain time. But international society has increasingly pressed Korea to get involved in annex 1 group. So, Korean government is preparing for the day that Korea becomes a country of annex 1 group. As we know well, the pollutants causing the global warming, especially $CO_2$, are mostly emitted by energy uses. Therefore, this preparation requires strong and aggressive energy policies, which in turn, require reformative change in energy use and energy system.

The second objective that Korea pursues for the future energy is to strengthen the market mechanism. As we saw in the structure of energy industry at the section 1, the government intervenes in almost all energy sectors from import and supply to price settings through the state-owned energy companies and regulations. Korea has pursued market economy policy from its earlier stage of economic development for non-energy sectors. But in contrast to non-energy sectors, the energy sector has been traditionally guided by the government. One of the reasons for such government guidance is that Korean economic development was led by energy intensive industries, and since we lack indigenous energy resources, it was felt that careful planning on energy supply was necessary for successful economic development. Moreover, it was inevitable for energy industry to start from a state monopoly in early stages of economic development because private sector lacked the capital and technologies necessary to build and manage huge energy utilities.

As the economy has been developing, however, regulated prices and supplies have distorted the market and allocation of the resources. Accordingly, the Korean government is loosening its grip on the energy sectors and taking measures to introduce market mechanism by facilitating competition where possible. Current government of the president Kim has been pushing energy industry to the direction of privatization and competition. Before Kim's government, oil industry already planned and had pushed the deregulation but, this has been accelerated after Kim's government. The plans for restructuring the electric power and natural gas industry were announced in the year 1999. The laws related to the plans are awaiting the passage of the national assembly. The restructuring of these industries would affect greatly on overall energy market in the future.

The third objective is to maintain stable energy supply. This objective is the one that we have been pursuing for a long time. Unless we have some kind of new energy source that we can use without exhaustion, this would be our semi-permanent objective in Korea. But even if the future objective is the same as in the past, the measures to attain the objective should be changed as the market situation change. Under free market environment, the way to achieve the stability of energy supply should be changed. That is, through market forces rather than through the direct intervention of government to the energy market.

**2.2. The measures for the energy future**

The measures Korean government is taking in order to attain these three objectives described in section 2.1 are as follows;

First is to remove price controls. This means no government intervention in the price settings of energy companies. Many energy prices have been set for the social and other purposes such as the protection of poor people and promotion of export industry rather than on the cost basis. But when one of the social purposes is attained through price control or price subsidy, it will have an adverse impact in terms of efficient resource allocation.

Second measure is to reform energy tax system. The current energy tax system lacks a consistent principle. Many energy taxes have been imposed for the social or other economic and political consideration, just like the regulated prices of energy. Such taxes distort energy market, and without a tax reform, the measure for price deregulation will not achieve efficient energy resource allocation. In other words, even if prices are set competitively, it wouldn't constitute a fair competition without a nondiscriminatory tax system in the market

The government is currently considering a tax system that levies tax according to energy heat contents. The government is also planning to introduce new tax system according to carbon contents emitted from energy use. So, we, at the KEEI, is investigating the tax system with the principle of taxing according to heat and carbon contents in order to achieve fair competition in the free market and to induce low pollutant energy use. This new tax system will significantly affect energy industries and consumer behaviors in the future.

Third measure is to encourage energy efficiency technologies and new & renewable energy development for environment. Many policies have been introduced to promote efficiency in energy consumption aimed at improving environments such as financial supports for the developments of efficiency technologies and new & renewable energy, and strengthening

efficiency standards. These policies are thought to be strengthened more in the future. Forth measure is continuance of some traditional measures of direct government intervention for stable energy supply.

**<Table 2.1> Major Objectives and Measures of Energy Policy in Korea**

| Policy Objectives | Measures |
|---|---|
| • Establish environmentally-Friendly energy system<br>• Strengthen market mechanism<br>• Maintain stable energy supply | - Remove price control<br>- Reform tax system for fair competition and induce to low pollutant energy use<br>- Privatize public utilities<br>- Encourage energy efficiency technology and new & renewable energy development<br>- Strengthen oil stock and emergency preparedness, heighten safety |

## 2.3 Deregulation and Restructuring plans of energy industry

### 2.3.1 Oil industry

Many regulations and controls of government for the domestic market were now removed in oil industry. Only a few years ago, oil imports and new refinery construction and expansion of existing refineries had to be approved by the government, even though they were private companies. There were also price controls. The prices for almost all petroleum products should be approved. The profit of importer and refinery were regulated and margin at every step of distributions was also regulated. But, the deregulation program of oil industry, started in 1995 gradually abolished many of the regulations for oil industry. At present, there are just a few regulations like duties of oil stockpiles and reporting of sales and purchases to the government for emergency preparedness and controls for public safety. Companies now can freely import oil and construct refinery. Companies can decide their own prices for the petroleum products they sell. Even foreigners can import oil and construct and manage refinery and can be involved in retailing without regulation barriers. But because of short history and little experience of free market for oil industry, the government has sometimes intervened or wants to intervene in the market, especially in setting of the prices, and also the companies are not accustomed to decide themselves on the price or other market activities. It is expected that it will take some time for Korean oil industry to have a fully free and competitive market.

### 2.3.2 Power industry

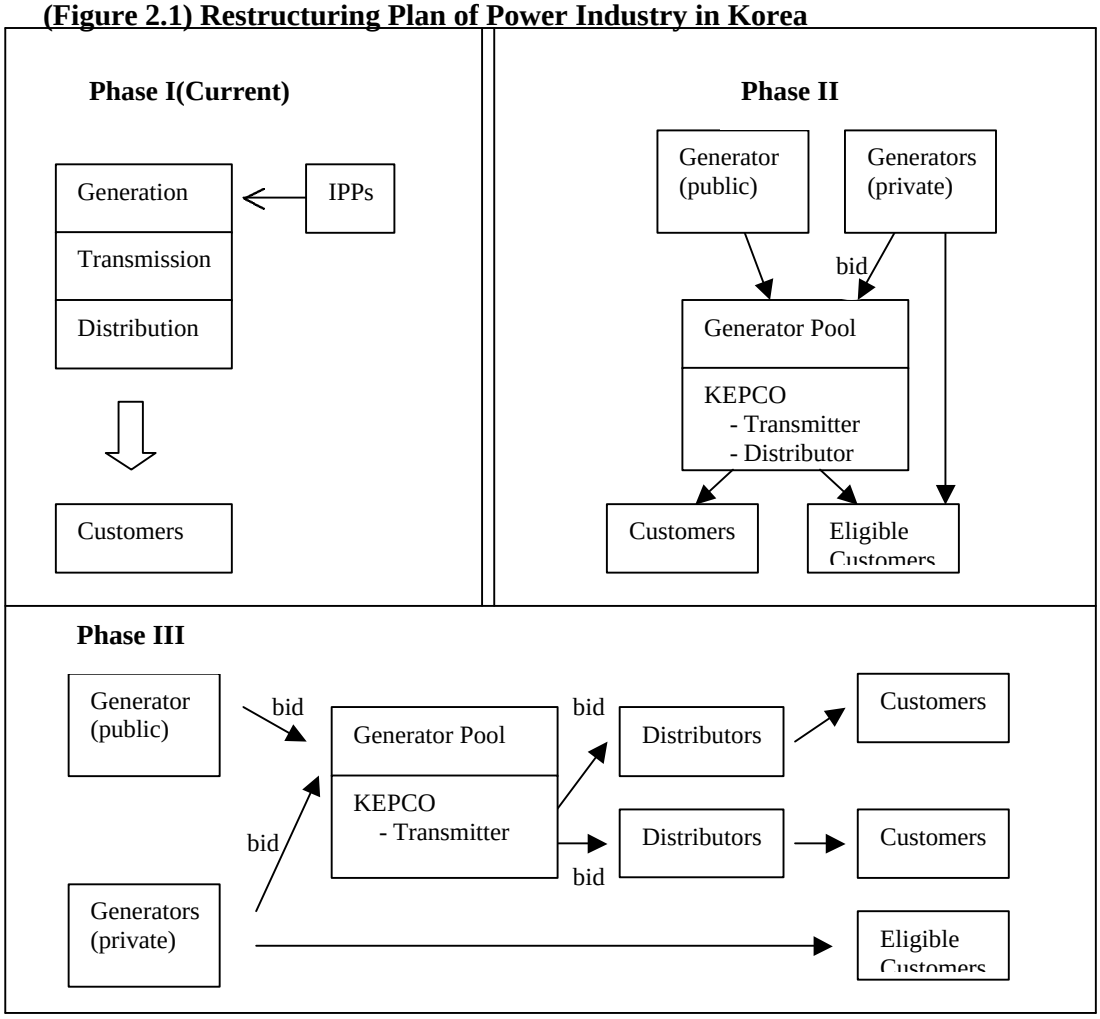
Currently KEPCO has a monopoly over power generation, transmission and distribution. There are a small number of privately owned power generators providing KEPCO with electricity. As the first phase of restructuring, there will be a complete separation of the

power generation sector from KEPCO. The generation sector will be divided into several(6) private power generation companies. KEPCO will still maintain its monopoly power over transmission and distribution sectors. The generation companies(gencos) will engage in competition amongst themselves in supplying the electricity to KEPCO. Only the direct trading of electricity to large eligible customers by gencos will be permitted at this stage.

As the next stage, projected to commence in 2003, the distribution sector will be separated from KEPCO and privatized. The private generation sector will compete to supply electricity to distribution companies. The transmission network of KEPCO will be opened up so that the distribution companies may freely use the network.

As for the last stage that will start from 2009, the distribution network will be opened for a full-scale competition. At this stage, the general end-users can directly choose from several power distribution companies as their supplier of electricity.

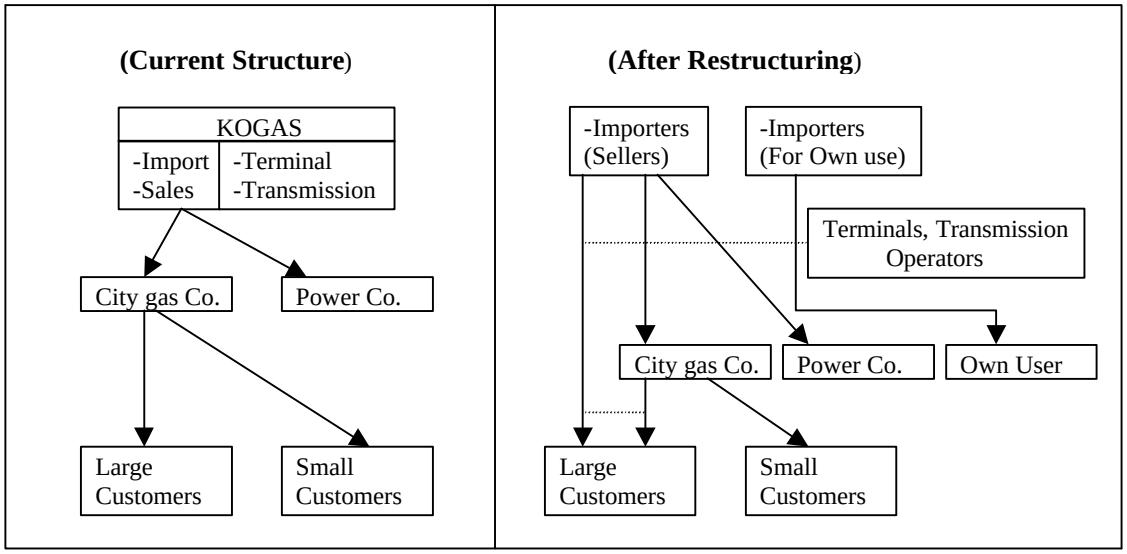
**(Figure 2.1) Restructuring Plan of Power Industry in Korea**



### 2.3.3 Gas industry

Currently KOGAS, which is the only importer and wholesaler, owns LNG receiving terminals and main pipeline network. The government wants to introduce competition in the gas industry where competition is possible, just as in the electricity industry. To this end, government is going to separate the import and sales part of KOGAS function from its facility operation, and infuse competition in the import and sales area. Access to the KOGAS owned facilities, that is, for receiving terminals and transmission pipeline, will be open on an non-discriminatory basis. This is planned to be done by the year 2003. The government also plans to introduce competition in retail sector of natural gas industry in several steps. First it will allow competition in facility construction. That is, the distribution pipeline where it is not yet constructed will be allowed to construct by anyone who first request to do it. Eventually, a full-scale retail competition will be introduced, but the timing of it will be determined at a later date by first observing the progress of wholesale competition.

**(Figure 2.2) Restructuring Plan of Gas Industry in Korea**




## 3. Energy security and controversial issues

### 3.1 Energy security and its measures

Energy security is a broad and abstract concept, however it can be interpreted in Korea as something that gets heightened by securing stable energy supply to keep its economy in gear because Korean economy is highly energy intensive, and because of its heavy dependence on foreign sources.

There are several traditional measures for securing stable energy supply taken in Korea. Among the notable measures is the direct government intervention in energy import and domestic supply. In preparation for unexpected regional import supply problems or regional energy price hike, the diversification of import sources and the encouragement of direct

investments in overseas energy development are other measures that have been pursued. For energy sources that can be stored such as oil, the government imposed compulsory oil stockpile program on oil refinery firms. On the demand side, public campaign inducing energy conservation is another effort to heighten energy security in Korea.

These days however, the views toward securing stable supply sources are being changed. It was believed in the past that securing stable energy supply is best delivered by direct government control and central planning. This belief is being discarded fast internationally and also in Korea, as the adverse effects of government control has been gradually recognized. Lack of competition resulted in inefficient public utility firms and also inefficient and inflexible market environment, and the deprivation of the opportunity to adapt to changing environment by energy users contributed to energy consumption inefficiency. It is current international tendency to privatize public utilities and invite competition wherever is possible. Korea is also entrusting the role of securing energy supply to the market forces, departing from central intervention, as can be seen from the electricity and gas industry restructuring plans and deregulation of oil industry that has already taken place.

However, to avoid domestic energy market and economy being directly exposed to the instabilities of international energy market, the government needs to keep applying some measures for energy supply stability, such as oil stockpile requirement for emergency and energy conservation.

### 3.2 Controversial issues

Under the current government-controlled energy markets, for social and political consideration, there are some cross-subsidies across different energy markets and across different socio-economic classes. When markets are liberalized and competition introduced, such cross-subsidies may no longer be possible or the extent of which will be very limited. This will raise the energy costs to those who are being subsidized. Even though the elimination of cross-subsidy will enhance the energy consumption efficiency, raising cost to socially disadvantaged class of people can be socially burdensome issue. Also, the restructuring process itself will cause instability to the job security for those working in the restructured energy industry.

In addition to such problems arising from restructuring, Korea is experiencing an increasing problem of finding sites for nuclear power plants, because of growing public resistance to accommodating nuclear power plants. In a sense, this opposition is naturally following from the improvement of the standard of living, triggering heightened concerns for environment. But the growing NIMBY (not in my back yard) phenomenon contributed to that effect also. More often than not, residents ask for unacceptably high compensation for accommodating such plants. Also, with rising concerns for environment, Korean economy is expected to experience added difficulties in attaining sustained growth while addressing the environmental issue, especially the pressure from the treaty of climate change. On both the energy security aspect and environmental aspect, it will be necessary for Korean economy to transform itself from the current high energy-intensive status to energy-efficient economy. But it will be a painful process, having to sacrifice economic growth potential at least for several years, which can also bring forth many unsettling outcry.

## 4. Long - term energy demand forecasting of Korea

### 4.1. Institutions analyzing energy future in Korea

For efficient and effective energy systems, long range plans are necessary as the investments for infrastructure are extremely costly and take a long time. The government is required by law to establish a national energy plan every five years for which the projection period covers 10 years. In addition to the national energy plan, the government is also required to set up long-term plans for electricity and natural gas supply and demand. The government branch responsible for these duties is the Ministry of Commerce, Industry and Energy (MOCIE).

There are three institutions in Korea that are officially involved in performing energy demand forecast and drawing up the long-term plans in cooperation with MOCIE. They are Korea Energy Economics Institute(KEEI), Korea Electric Power Corporation(KEPCO) and Korea Gas Corporation(KOGAS). KEEI is the government's think-tank for energy policies. It has been and will be involved in formulating all past and future national plans. The nature of these plans is not that of an action plan. Rather, those of policy directions and strategies on national energy futures. Included in the plan is energy demand forecast for 20 years, future directions of energy industries, and government's energy policies. The most recent plan was issued in 1997 and the formulation of the subsequent plan is scheduled in 2002.

The law also dictates the government to make long-term plans for electricity and natural gas supply and demand, and for their facility investments. The government is to forecast the demands for electricity and natural gas every two years. For the electricity demand, KEPCO undertakes the forecast, which spans 15 years. KEPCO consults the forecast result with MOCIE, which in turn announces the final forecast result after deliberation. KOGAS follows the same process as KEPCO in forecasting the natural gas demand, but its projection covers only 10 years. The long-term plans also include investment plans for facilities based on the demand forecasts, and policy discussions for the supply and demand of electricity and natural gas industries.

### 4.2 Long-term energy demand forecast

As explained above, there are three institutions in Korea that are officially involved in performing energy demand forecast in cooperation with MOCIE. That is, KEEI for all energies, KEPCO for electricity and KOGAS for natural gas. In this section, the latest output of KEEI forecast and its implications will be reviewed in detail. The demand forecast of KEPCO and KOGAS will be summarized briefly in the section 4.3

#### 4.2.1 The methods approached

KEEI forecasts all energy demands on a continuous basis with its own model. Current KEEI model has its origin on MEDEE and LEAP models. It uses a disaggregated bottom up approach for estimation. On its base, it forecasts the energy demand by sectors. The sectors included are four - industrial, transportation, residential, and commercial & other sectors. (Each sector is divided into several sub-sectors or activities, and each sub-sector is given an appropriate energy intensity factor. This intensity is multiplied by activity and then by summing up, we have energy demand for each sector. Based on the forecast of each

sector ' s demand, final energy demand is derived by combining them. And then, after converting electricity, city gas and district heating into primary energy sources, we have the primary energy demand.

KEEI has analyzed the future energy demand with several scenarios for the economic growth and energy efficiency, but this paper reviews only the scenario of business as usual (BAU).

### 4.2.2 Major assumptions

#### a) Economic growth rate

Over the past 30 years, Korea has developed from a relatively low income agrarian economy into a highly urbanised upper middle income country. Between 1970 and 1999, Gross Domestic Product (GDP) grew at a very high rate. In the wake of the financial crisis in 1997, the growth rate of GDP in Korea had fallen dramatically to an all time low in 1998, -6.7%. Korean Economy, however, has started to bound again since the first quarter of 1999, and had reached again the high growth rate of 10.7% in the year 1999.

According to the latest estimates from Bank of Korea and KDI(Korea Development Institute), the leading government institute for macro economic in Korea, economic growth rate in Korea is projected to keep a relatively high level for several coming years and then gradually slow down in the long run. They estimated that average annual growth rate (AAGR) of GDP will be 5.8% for the year 2001-2005, 5.1% for 2006-2010, 4.0% for 2011-2020, and 3.0% for 2021-2030. Over the projection periods of 30 years, it is estimated that AAGR will be 4.14%.

**<Table 4.1> The Projection of Long-term GDP Growth Rate**

| | 1999 | 2000 | `01-`05 | `06-`10 | `11-`20 | `21-30 |
|---|---|---|---|---|---|---|
| Average annual Growth rate(%) | 10.7 | 6.4 | 5.8 | 5.1 | 4.0 | 3.0 |

Source: Bank of Korea, KDI, 1999.12

#### b) Industry structure

Korea has experienced dynamic changes in its industry structure with its economic growth. The most remarkable changes have been the declining of agriculture, forestry, fishing and mining industry, and the stable growth in manufacturing and service industry. The growth of manufacturing sector has relied on the expansion of heavy and chemical industries, while the light industry has been decreasing continuously. This trend of industrial structural change is expected to continue in the future. In terms of GDP ratio, agriculture & fishing sector will be reduced from 6.2% in 1998 to 3.0% in 2030. The share of service industry will be rising from 63.7% in 1998 to 70% in 2030. The share of manufacturing industry will also rise up to the year 2010 and then start to decline reduce gradually. It is anticipated, however, that high-tech and knowledge intensive electronics and information industries will be expanded, while energy intensive industries such as steel and petrochemical industry will be contracted in the long run.

**<Table 4.2> Projection of Industry Structure in Korea**

(Unit: %)

| | 1998 | 2000 | 2010 | 2020 | 2030 |
|---|---|---|---|---|---|
| Agriculture & fishing | 6.2 | 6.5 | 4.2 | 3.2 | 3.0 |
| Manufacturing | 30.0(100%) | 30.0(100%) | 30.3(100%) | 28.2(100%) | 26.9(100%) |
| - Light industry | (17.8%) | (16.3%) | (11.6%) | (9.3%) | (8.1%) |
| - Heavy industry | (82.2%) | (83.7%) | (88.4%) | (90.7%) | (91.9%) |
| Service sector | 63.7 | 63.4 | 65.5 | 68.6 | 70.1 |
| Total GDP | 100 | 100 | 100 | 100 | 100 |

Note: Light industry includes food, textile and etc.
Heavy industry includes petrochemical, machinery, electronics, steel and etc.
Source: KIET, 1999.12

### c) Population

The population of Korea in 1999 was 45 million. The population growth rate has decreased gradually from 3.0% in 1960 to less than 1.0% in 1999 due to improved socio-economic conditions, change public attitude towards the population problem and the government ' s family planning policy. But population density of Korea is still high, 459 persons per $km^2$, the third highest in the world excluding small island nations or city-states.

According to the latest estimate of National Statistic Bureau, Korea's population will reach 50.62 million by 2010 and 52.74 million by 2030. The population growth rate is expected to slow down gradually to 0.95% for 1996-2000, 0.69% for 2001-2010, 0.34% for 2011- 2020 and 0.07% for 2021-2030.

**<Table 4.3> Projection of Population**

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Population(million) | 45.09 | 47.28 | 50.62 | 52.36 | 52.74 | 0.95 | 0.69 | 0.34 | 0.07 |

Source: National Statistic Bureau, 1999

### 4.2.3 Energy demand forecast by sector

### 1) Industry Sector

Energy demand of industry sector is derived by the value-added and energy intensities for the value-added on each business in the industry. The business is classified into 12 types, Agriculture & Fishing, Mining, Construction, Food & Beverage, Textile & Leather, Wood , Paper & Printing, Petrochemical, Non-Metallic mineral product, Basic metal product, Fabricated metal & machinery and Others.

Energy intensity on each business is projected by the regression analysis equation which is usually explained by variables such as real energy price, product mix variables, and so on with past data. As shown at the table 4.4, energy intensities are expected to improve in many businesses, especially in energy intensive industries such as Petrochemical, Non-Metallic mineral product and Basic metal product parts. We presume the automation and substitution of machinery for labor will worsen energy intensity in most labor intensive industries, which is the main reason that the energy intensity in these industries would high in the future. This phenomenon is most pronounced in Agriculture & Fishing industry.

**<Table 4.4 > Energy intensity forecast by business type**

(Unit; $10^3$ TOE/ value added, billion won in `90 constant price)

| | 1995 | 2000 | 2010 | 2020 | 2030 | AAGR |
|---|---|---|---|---|---|---|
| Agriculture & Fishing | 0.190 | 0.216 | 0.300 | 0.399 | 0.410 | 2.2% |
| Mining | 0.195 | 0.154 | 0.251 | 0.285 | 0.326 | 1.5% |
| Construction | 0.066 | 0.063 | 0.062 | 0.061 | 0.060 | -0.3% |
| Food & Beverage | 0.249 | 0.198 | 0.245 | 0.253 | 0.239 | -0.1% |
| Textile & Leather | 0.744 | 0.899 | 1.096 | 1.126 | 1.106 | 1.1% |
| Wood | 0.410 | 0.565 | 0.735 | 0.925 | 1.078 | 2.8% |
| Paper &Printing | 0.626 | 0.684 | 0.841 | 0.967 | 1.028 | 1.4% |
| Petrochemical | 1.837 | 2.108 | 1.592 | 1.423 | 1.303 | -1.0% |
| Non-Metallic mineral product | 1.629 | 1.615 | 1.645 | 1.576 | 1.525 | -0.2% |
| Basic metal product | 2.036 | 2.133 | 1.487 | 1.227 | 1.127 | -1.7% |
| Fabricated metal & machinery | 0.095 | 0.093 | 0.106 | 0.110 | 0.111 | 0.4% |
| Others | 1.462 | 3.226 | 3.515 | 3.496 | 3.406 | 2.4% |

The energy demand in the industry sector is expected to increase 2.3 times from the 1995 level to 144.3million TOE in 2030. The demand will increase at a rate of 2.4% per annum over the projection period but the rate will slow down to 2.7% for 2000-2010, 1.7% for 2010-2020, and 1.2% for 2020-2030.

**<Table 4.5> Energy Demand Forecast in Industry by business type**

(unit; million TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | AAGR(%) |
|---|---|---|---|---|---|---|
| Agriculture & Fishing | 3.2 | 4.4 | 6.8 | 10.2 | 13.2 | 4.1 |
| Mining | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | -1.3 |
| Construction | 1.9 | 1.9 | 3.0 | 4.3 | 5.5 | 3.0 |
| Manufacturing | 56.9 | 74.4 | 95.8 | 110.4 | 121.0 | 2.2 |
| - Petrochemical | 23.6 | 35.3 | 43.7 | 50.0 | 52.2 | 2.3 |
| - Non-Metallic mineral product | 6.2 | 6.2 | 8.5 | 9.2 | 9.2 | 1.1 |
| - Basic metal product | 14.3 | 17.4 | 18.2 | 18.2 | 18.2 | 0.7 |
| - Fabricated metal & machinery | 3.4 | 4.7 | 10.5 | 16.4 | 22.5 | 5.5 |
| - Others | 9.4 | 10.8 | 14.9 | 16.6 | 18.8 | 2.0 |
| Industry Total | 62.9 | 83.2 | 108.8 | 128.3 | 144.3 | 2.4 |
| Ratio of energy intensive business | 70.1% | 70.8% | 64.8% | 60.0% | 55.2% | - |

The energy demand share of manufacturing in industry sector will decline to 83.9% in 2030 from 90.4% in 1995 due to the rapid increase of energy demand in Agriculture & fishing and Construction business and the slow increase in energy intensive business in manufacturing. The share of the value-added for Agriculture & fishing in the industry was expected to decline as shown at the table 4.2. But higher energy intensity anticipated in the sector makes energy consumed more. The demand share of energy intensive business in manufacturing will also decline to 55.2% in 2030 from 70.1% in 1995 as energy intensities in those businesses will be improved. This reflects strong energy efficient programs and policies to transit Korea's industry into low energy consuming structure being enforced.

### 2) Transport Sector

Energy demand of transport sector is derived with transport volume and energy intensity by transport mode. Transport sector is divided into several sub-sectors because energy requirements by transport modes are caused by different purpose. So the transport sector is first divided into two sub-sectors, passenger and freight transport, and then each sub-sector is again broken into commercial and private uses and by transport modes as shown in table 4.6.

**<Table 4.6 > Breakdown of Transport Sector**

| | | | | Energy intensity |
|---|---|---|---|---|
| Passenger | Road | Commercial | Bus | Person-km |
| | | | Taxi | |
| | | Private | Passenger car | |
| | | | Jeep | |
| | | | Bus | |
| | Railway | Commercial | Railway | |
| | | | Electric railway | |
| | | | Subway | |
| | Shipping | Commercial | Vessel | |
| | Civil aviation | Commercial | Aircraft | |
| Freight | Road | Commercial | Truck | Ton-km |
| | | Private | Truck | |
| | Railway | Commercial | Railway | |
| | | | Electric railway | |
| | Shipping | Commercial | Vessel | |
| | Civil aviation | Commercial | Aircraft | |

The road transportation energy is forecasted by considering future evolution of various determinants, such as the number of vehicles, the average mileage per vehicle, and the fuel economy for each type of vehicle. These determinants are projected independently by using their relationships with such variables as GDP, population, fuel price, and so on. Most important variable for the road transportation energy is, however, the number of vehicle. The number of vehicle has been increasing rapidly in Korea, and as observed in many advanced countries, it is shown to increase in the form of an S-shape and will reach to the saturation level at a certain point in the future. We assume that the saturation point is around 2020 in Korea.

**<Table 4.7> Projection of the number of vehicle**

(Unit: Thousand)

| | 1998 | 2000 | 2010 | 2020 | 2030 | AAGR |
|---|---|---|---|---|---|---|
| Car | 7,581 | 8,825 | 16,571 | 21,860 | 23,928 | 3.66% |
| Bus | 750 | 863 | 1,319 | 1,487 | 1,520 | 2.24% |
| Truck | 2,139 | 2,183 | 2,630 | 2,802 | 2,878 | 0.93% |
| Total | 10,470 | 11,871 | 20,466 | 26,149 | 28,326 | 3.16% |

The energy demand for non-road transportation including railway, shipping and civil aviation is derived by future evolution of traffic volume and energy intensities (energy consumption per unit volume of traffic) for each transport mode. These determinants are also projected with the consideration of overall transport structure in the future. Traffic volume of civil

aviation is projected to show most rapid increase among transport modes, while railway will show a very slow increase same as the present trend. Shipping volume that is dependent on the industry activities and export & import in Korea is projected to increase steadily in the future.

The energy demand of transportation is expected to increase 2.3 times in 2030 to 62.56 million TOE from 1995 level with average annual growth rate 2.4% over the projection period. The road transport has held a majority of share of energy demand in transport sector and this trend will continue in the future, though its share will be reduced somewhat, to 77.2% in 2030 from 86.4% in 1995. The energy demand of transport sector will also show high rate of increase 4.1% per annum between 1995-2010, and then slow down to 1.2% between 2010-2030, as the number of vehicle in leading energy consuming sector, road transport, increases at a high rate up to the saturation year 2020. Another factor for slower increase after the year 2010 or 2020 is that the average mileage of the vehicles in Korea which is longer than that of most advanced countries is expected to get shortened, approaching to the level of those countries after 2020.

**<Table 4.8> Energy Demand Projection of Transportation**

(Unit: million TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | AAGR |
|---|---|---|---|---|---|---|
| Gasoline | 7.53 | 9.87 | 18.27 | 22.78 | 22.55 | 3.18% |
| Diesel | 12.67 | 13.21 | 18.60 | 19.63 | 19.66 | 1.26% |
| Heavy fuel | 3.20 | 3.93 | 5.57 | 6.90 | 8.32 | 2.77% |
| Jet oil | 1.85 | 2.48 | 4.49 | 6.40 | 8.99 | 4.62% |
| LPG | 1.76 | 2.17 | 2.49 | 2.62 | 2.54 | 1.04% |
| Electricity | 0.14 | 0.18 | 0.39 | 0.47 | 0.50 | 3.74% |
| Total | 27.15 | 31.84 | 49.80 | 58.80 | 62.56 | 2.41% |

The demand of gasoline and jet oil will increase faster than other transport energy, due to the high growth in the number of private car and traffic volume of civil aviation. The difference of energy demand between passenger transport and freight transport will be expanded to 63:47 in 2030 from 53:47 in 1995, as the increasing speed of energy demand in passenger transport surpasses that of energy demand in freight transport.

**<Table 4.9> Energy Demand Projection of Transportation by Sub-sector**

(Unit: million TOE)

| | Mode | 1995 | 2000 | 2010 | 2020 | 2030 | AAGR |
|---|---|---|---|---|---|---|---|
| Passenger | Road | 12.44 | 15.78 | 26.36 | 31.18 | 30.56 | 2.30% |
| | Railway | 0.33 | 0.43 | 0.60 | 0.71 | 0.78 | 2.44% |
| | Shipping | 0.11 | 0.13 | 0.19 | 0.24 | 0.28 | 2.77% |
| | Civil aviation | 1.52 | 2.08 | 3.89 | 5.61 | 7.98 | 4.84% |
| | Total | 14.41 | 18.43 | 31.04 | 37.73 | 39.60 | 2.93% |
| Fright | Road | 8.69 | 8.39 | 11.77 | 12.49 | 12.59 | 1.06% |
| | Railway | 0.13 | 0.14 | 0.17 | 0.18 | 0.19 | 1.03% |
| | Shipping | 3.59 | 4.47 | 6.23 | 7.60 | 9.18 | 2.72% |
| | Civil aviation | 0.32 | 0.40 | 0.60 | 0.80 | 1.01 | 3.30% |
| | Total | 12.74 | 13.40 | 18.76 | 21.07 | 22.96 | 1.70% |

### 3) Residential Sector

Energy use in the residential sector consists of space heating, cooking, electrical appliance and lighting. Energy demand in the residential sector is basically derived with the number of household and energy intensities by the type of energy use.

Energy demand for space heating is influenced by various factors such as climate condition, dwelling type, heating space, household income, energy price and so on. Among those factors, the climate condition such as temperature and heating degree day is most important in shaping the energy demand for heating, because the winter is rather harsh and cold in Korea. The past analysis has shown that the fluctuation of residential energy demand has a close relation with heating degree day. It is, however, assumed that the heating degree day in the future is the same as the past average trend, for it is unpredictable and random. Apart from that factor, there are three important determinants for heating energy use in a household; the number of persons per household, household space and energy price. So, energy intensity for heating in the residential sector was derived with these factors.

Energy demand for cooking is influenced by the number of household, persons per household, income and cooking appliances and their efficiencies. There are two kinds of energy for cooking, fossil fuel and electricity. Energy efficiency is not influential factor in energy demand analysis for cooking, because city gas and LPG have been distributed to almost all households as cooking fuel in Korea and efficiency improvement of gas appliances is limited. And electricity demand from the cooking appliances is not classified as cooking energy but as energy from the electric appliance of household in this analysis. So, energy intensity of cooking was derived with the number of person and income per household.

The electricity demand of household depends on distribution rate of electric appliance and its

using time, technology and efficiencies. Major electric appliances in household are T.V, refrigerator, air conditioner, washer, cleaner, computer and electric oven. The electric appliances are distributed slowly at early stage and rapidly in short period as the income increases and the price is dropped, and then the demand saturated at a certain point. Those are substituted for high quality and bigger appliances after the saturation point of distribution. So, the distribution rate of each appliance was predicted from a Gomperz function which explains well those appliance distribution curves.

The major assumptions in forecast residential energy demand are as shown in table 4.10. The number of household is assumed to increase from 14.7million in 1995 to 20.1million in 2030. The growth rate of household is expected to be slowed as the population growth rate. The persons per household will decrease from 3.47 in 1995 to 2.91 in 2010 and 2.63 in 2030. On the other hand, the dwelling space per household will increase from 58.9$m^2$ in 1995 to 68.1$m^2$ in 2010 and 80.4$m^2$ in 2030.

**<Table 4.10> Projection of Major Indicators for Residential Energy**

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Population(million) | 45.09 | 47.28 | 50.62 | 52.36 | 52.74 | 0.95 | 0.69 | 0.34 | 0.07 |
| Household(million) | 12.99 | 14.66 | 17.41 | 19.09 | 20.06 | 2.45 | 1.73 | 0.92 | 0.50 |
| Persons per Household | 3.47 | 3.22 | 2.91 | 2.74 | 2.63 | -1.46 | -1.03 | -0.58 | -0.42 |
| Dwelling space Per household($m^2$) | 58.9 | 60.6 | 68.1 | 74.9 | 80.4 | 0.56 | 1.18 | 0.94 | 0.72 |

Energy demand for residential sector is projected to increase 2.3 times in 2030 to 48.1 million TOE. The share of petroleum products among residential energies will decline significantly (61.1% in 1995 to 29.3% in 2030), while the share of energies being supplied by grids such as city gas, district heat and electricity will show a rapid increase for their convenience, low pollution and increase in income over the projection years. This phenomenon will be remarkable in the city gas - its share will rise from 17% in 1995 to about a half of total energy consumed in residential sector in 2030. It is expected that coal (anthracite) will not be consumed after 2010 in the residential sector.

Heating energy will keep its dominant share in the future (79% in the 2030) with slight downing of its share in the residential energy. The share of cooking will also be down while other uses such as air conditioning and electric appliances will rise. Particularly, the energy demand for air conditioning is expected to increase very rapidly with its average annual growth rate of more than 10%, by the 2020, increasing its share from less than 1% just before the year 2000 to around 3% in the 2030 in the residential energy.

**<Table 4.11> Energy Demand Projection of the Residential Sector**

(Unit; $10^3$ TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Anthracite | 1,418 | 365 | 19 | - | - | -23.78 | -25.54 | 25.54 | - |
| Petroleum | 11,621 | 11,247 | 14,887 | 15,669 | 12,681 | -0.65 | 2.84 | 0.51 | -2.09 |
| LPG | 1,518 | 1,621 | 1,818 | 1,747 | 1,380 | 1.32 | 1.15 | -0.39 | -2.33 |
| City gas | 3,655 | 6,211 | 10,893 | 16,628 | 22,624 | 11.19 | 5.78 | 4.32 | 3.13 |
| Electricity | 2,434 | 3,196 | 4,949 | 6,639 | 7,948 | 5.60 | 4.47 | 2.98 | 1.82 |
| Heat energy | 610 | 935 | 1,511 | 2,124 | 2,714 | 8.91 | 4.92 | 3.46 | 2.48 |
| Others | 265 | 179 | 317 | 546 | 761 | -7.55 | 5.90 | 5.58 | 3.36 |
| Total | 21,521 | 23,754 | 34,395 | 43,355 | 48,107 | 1.99 | 3.77 | 2.34 | 1.05 |

**<Table 4.12 > Energy Demand Projection of Residential Sector by Use Type**

(Unit; $10^3$ TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Heating | 17,526 | 18,855 | 27,515 | 34,650 | 38,026 | 1.47 | 3.85 | 2.33 | 0.93 |
| Cooking | 1,561 | 1,702 | 1,931 | 2,065 | 2,133 | 1.75 | 1.27 | 0.68 | 0.32 |
| Air conditioning | 111 | 208 | 500 | 926 | 1,398 | 13.35 | 9.17 | 6.36 | 4.21 |
| Lighting | 590 | 704 | 1,042 | 1,378 | 1,671 | 3.60 | 4.00 | 2.84 | 1.95 |
| Electric appliance | 1,733 | 2,284 | 3,408 | 4,335 | 4,878 | 5.68 | 4.08 | 2.44 | 1.19 |
| Total | 21,21 | 23,754 | 34,395 | 43,355 | 48,107 | 1.99 | 3.77 | 2.34 | 1.05 |

**4) Commercial & Others Sector**

Commercial & others sector includes wholesale and retail trade business, food, hotel and hospital business and public services such as government and public institutions. Energy in this sector is mainly consumed through building. So, the energy demand is derived with building space and its intensity by business type. Building space was estimated with its

elasticity for GDP and through analysis of the cases of advanced countries.

**<Table 4.13> The Projection of Building Space**

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Building space($m^2$) | 350.2 | 473.1 | 725.2 | 927.9 | 1,075.3 | 6.2 | 4.4 | 2.5 | 1.5 |

The energy demand in the commercial and other sector is expected to increase more than three times by the 2030 from the level of 1995 - highest growth than other sectors. This reflects that the share of service sector in the structure of Korean industry rises steadily in the future. The share of petroleum will also be down significantly and other energy such as city gas and electricity will increase as shown in the projection of energy demand in residential sector.

**<Table 4.14 > Energy Demand Projection of the Commercial Sector**

(Unit; $10^3$ TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| Anthracite | 97 | 27 | - | - | - | -22.4 | - | - | - |
| Petroleum | 5,916 | 6,376 | 7,874 | 9,063 | 9,888 | 1.5 | 2.1 | 1.4 | 0.9 |
| City gas | 964 | 1,771 | 3,645 | 4,862 | 5,732 | 12.9 | 7.5 | 2.9 | 1.7 |
| Electricity | 3,176 | 5,239 | 9,048 | 12,894 | 15,353 | 10.5 | 5.6 | 3.6 | 1.8 |
| Heat energy | 31 | 67 | 188 | 354 | 518 | 16.4 | 10.9 | 6.6 | 3.9 |
| Others | 50 | 78 | 145 | 225 | 313 | 9.4 | 6.4 | 4.5 | 3.4 |
| Total | 10,234 | 13,558 | 20,900 | 27,399 | 31,804 | 5.8 | 4.4 | 2.7 | 1.5 |

### 4.2.4 Total energy demand forecast

Final energy demand in Korea is projected to increase to 213.9 million TOE in 2010 and to 286.8million TOE with annual average growth rate 2.5% over the projection time. The growth rate of the demand in the future will show a significant decline in contrast to the one in the `90 energy demand. The shares of city gas, electricity and heat energy will be higher and the city gas will be the fastest growing energy in terms of energy demand as before. Though the growth rates of heat energy and other energy such as new and renewable energy will be also high, they will remain as minor energy in the future (3.3% of final energy demand in 2030). The shares of petroleum and coal will be down but petroleum will keep its position as the main energy source.

**<Table 4.15> Final Energy Demand Projection of the Korea**

(Unit; $10^3$ TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 | 96-`30 |
| Coal | 17,758 (14.6%) | 19,575 (12.8%) | 21,243 (9.9%) | 21,961 (8.5%) | 22,123 (7.7%) | 2.0 | 0.8 | 0.3 | 0.1 | 0.6 |
| Petroleum | 82,876 (68.0%) | 99,960 (65.6%) | 138,616 (64.8%) | 162,319 (62.9%) | 172,268 (60.1%) | 3.8 | 3.3 | 1.6 | 0.6 | 2.1 |
| City gas | 5,482 (4.5%) | 10,765 (7.1%) | 19,615 (9.2%) | 27,716 (10.7%) | 35,485 (12.4%) | 14.5 | 6.2 | 3.5 | 2.5 | 5.5 |
| Electricity | 14,041 (11.5%) | 19,279 (12.7%) | 29,512 (13.8%) | 38,730 (15.0%) | 47,417 (16.5%) | 6.5 | 4.3 | 2.8 | 2.0 | 3.5 |
| Heat energy | 641 (0.5%) | 1,001 (0.7%) | 1,699 (0.8%) | 2,478 (1.0%) | 3,232 (1.1%) | 9.3 | 5.4 | 3.8 | 2.7 | 4.7 |
| Others | 1,051 (0.9%) | 1,800 (1.2%) | 3,178 (1.5%) | 4,676 (1.8%) | 6,262 (2.2%) | 11.4 | 5.8 | 3.9 | 3.0 | 5.2 |
| Total | 121,849 | 152,381 | 213,862 | 257,879 | 286,787 | 4.6 | 3.4 | 1.9 | 1.1 | 2.5 |

The demands of natural gas and nuclear will increase higher than those of other energies in the primary energy in the future.

Energy demand per capita will continue to increase and will be doubled in 2020 from the level of 1995. On the other hand, energy intensity for GDP is expected to be improved after 2000 and then will keep its improvement. This means Korean industries will shift into the structure of low energy intensity in the future from the one of high energy intensity. This reflects the current and future policies for improvement of energy efficiency, and the reducing of energy intensive industry such as petrochemical and metal industry and surge of low energy industry such as high tech and knowledge intensive industries in the long run.

**<Table 4.16> Primary Energy Demand Projection of the Korea**

(Unit; $10^3$ TOE)

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 | 96-`30 |
| Coal | 28,694 (19.0%) | 39,688 (20.8%) | 52,266 (19.3%) | 58,728 (17.7%) | 66,167 (17.6%) | 6.7 | 2.8 | 1.2 | 1.2 | 2.4 |
| Oil | 94,023 (62.3%) | 106,581 (55.8%) | 146,042 (53.9%) | 169,502 (51.0%) | 180,868 (48.1%) | 2.5 | 3.2 | 1.5 | 0.7 | 1.9 |
| Natural gas | 9,346 (6.2%) | 16,671 (8.7%) | 30,640 (11.3%) | 42,591 (12.8%) | 53,745 (14.3%) | 12.3 | 6.3 | 3.3 | 2.4 | 5.1 |
| Hydro | 1,033 (0.7%) | 1,055 (0.6%) | 1,074 (0.4%) | 1,082 (0.3%) | 1,098 (0.3%) | 0.4 | 0.2 | 0.1 | 0.1 | 0.2 |
| Nuclear | 16,758 (11.1) | 25,294 (13.2%) | 37,985 (14.0%) | 55,642 (16.7%) | 68,123 (18.1%) | 8.6 | 4.2 | 3.9 | 2.0 | 4.1 |
| Others | 1,051 (0.7%) | 1,800 (0.9%) | 3,178 (1.2%) | 4,676 (1.4%) | 6,262 (1.7%) | 11.4 | 5.8 | 3.9 | 3.0 | 5.2 |
| Total | 150,904 (100%) | 191,090 (100%) | 271,186 (100%) | 332,221 (100%) | 286,787 (100%) | 4.8 | 3.6 | 2.1 | 1.3 | 2.6 |

**<Table 4.17> Projection of Major Energy Indicators**

| | 1995 | 2000 | 2010 | 2020 | 2030 | Average Annual Growth Rate(%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 96-00 | 01-10 | 11-20 | 21-30 |
| GDP(`95 trillion won) | 377 | 461 | 784 | 1,160 | 1,559 | 4.1 | 5.5 | 4.0 | 3.0 |
| Population(million) | 45.1 | 47.3 | 50.6 | 52.4 | 52.7 | 0.9 | 0.7 | 0.3 | 0.1 |
| Per capita energy(TOE) | 3.34 | 4.04 | 5.36 | 6.34 | 7.13 | 3.9 | 2.9 | 1.7 | 1.2 |
| Energy/GDP | 0.40 | 0.41 | 0.35 | 0.29 | 0.24 | 0.8 | -1.8 | -1.9 | -1.7 |

## 4.3 Forecast on Demand of Electricity and Gas

### 4.3.1 Electricity

Table 4.19 shows some essential result of electricity demand forecast by KEPCO. This forecast was announced in January of 2000. It assumes that the economy is growing on average at 5.2% annually. The short term GDP growth figures are based on the government's target as of August 1999, and the long term figure is based on the projection by Korea Development Institute (KDI). The assumption over the future economic forecast here is different with the one used in KEEI forecast in section 4.2.2. This is because KEEI could refer to the revised assumption of KDI as KEEI analyzed its latest forecast later than that of KEPCO. The share of heavy industry is assumed to take up about 90% in 2015. This figure is from the study of industry structure performed by Korea Institute for Industrial Economics and Trade (KIET).

The electricity demand is expected to increase from 237,194Gwh in 1999 to 426,769Gwh in 2015, displaying an average annual growth rate of 3.7% during this period.

**<Table 4.18> Major Assumptions**

| | 1999 | 2000 | `01-`05 | `06-`10 | `11-`15 | `99-`15 |
|---|---|---|---|---|---|---|
| GDP Growth rate(%) Per annum | 6.0 | 4.7 | 5.8 | 5.2 | 4.4 | 5.2 |
| Industry Structure | 1998 | | 2000 | 2005 | 2010 | 2015 |
| - Light Industry(%) | 17.9 | | 17.0 | 13.9 | 11.8 | 10.4 |
| - Heavy Industry(%) | 82.1 | | 83.0 | 86.1 | 88.2 | 89.6 |
| Population(thousands) | 46,430 | | 47,280 | 49,120 | 50,620 | 51,680 |

**<Table 4.19> Electricity Demand Forecast**

| | 1999 | 2000 | 2005 | 2010 | 2015 | AAGR (`99-`15%) |
|---|---|---|---|---|---|---|
| Nuclear | 103,217 | 101,238 | 126,364 | 153,156 | 190,125 | 3.9% |
| Coal | 80,817 | 89,983 | 124,443 | 144,099 | 149,022 | 3.9% |
| Natural Gas | 30,130 | 28,816 | 44,326 | 43,328 | 46,267 | 2.7% |
| Petroleum | 17,341 | 26,191 | 28,286 | 31,778 | 30,683 | 3.6% |
| Hydro & Others | 5,689 | 4,399 | 5,993 | 12,406 | 10,672 | 4.0% |
| Total | 237,194 | 250,627 | 329,412 | 384,173 | 426769 | 3.7% |

### 4.3.2 Natural Gas

For natural gas demand forecast that KOGAS announced in January, 2000, the base assumptions used for GDP growth rate, household numbers and penetration rate of city gas were based on the projection by KIET. Population figure was from National Statistic Bureau ' s projection. Based on these assumptions, natural gas demand is forecasted to increase from 12,655 thousand tons in 1999 to 20,971 thousand tons in 2010, with average annual growth rate 4.7%. It is expected that the natural gas demand will continue to grow for its convenience of usage and tightening of environmental regulation. However, due to almost complete penetration of city gas in large town areas and contraction in the planned magnitude of gas-powered plants, the rate of growth is expected to slow down. The annual demand growth rate from 1987 to 1999 was 18.7%. In contrast, the same figure will only be 4.7% from 1999 to 2010

**<Table 4.20> Natural Gas Demand Forecast**

| Major Assumptions | 1999 | 2000 | 2005 | 2010 | AAGR (`99-`10) |
|---|---|---|---|---|---|
| - GDP Growth Rate(%) | 6.5% | 5.5% | 5.5% | 4.8% | 4.9% |
| - Household(thousand) | 13,717 | 14,002 | 15,445 | 16,708 | 1.8% |
| - Population(thousand) | 46,858 | 47,275 | 49,123 | 50,618 | 0.7% |
| - Distribution Rate of City Gas(%) | 58.4% | 59.8% | 70.5% | 75.5% | - |
| Natural Gas Demand ($10^3$ tons) | 12,655 | 13,806 | 18,300 | 20,971 | 4.7% |
| - City Gas | 7,886 | 8,986 | 12,098 | 14,917 | 6.0% |
| - Electricity | 4,769 | 4,820 | 6,062 | 6,054 | 2.2% |

## 5. Conclusion

To recapitulate, there are two elements that will have significant impacts on Korea ' s energy demands. These are the market liberalization process and the prospect of new energy tax system. They present uncertainty over energy futures, and depending on how they are played out, the energy demand will vary a great deal. The question is how effective and fast the transition to free market environment will take place, from their currently controlled state. This will change the nature of energy price determination, which will in turn affect the energy demand. For social and political consideration, the speed and degree of such planned change can be modified along the way. Also, with rising concerns for environmental impact of energy use, an energy tax reform is anticipated in the near future in an effort to convert Korea ' s energy intensive economy into an energy efficient economy. Depending on the outcome of this reform, the energy demand can vary significantly also.

Energy security in terms of maintaining a stable energy supply has been the area that

government should take charge of. Under the circumstance of free energy market that Korea is pushing forward, however, the ways to preserve energy security is forced to change, though the role of government is still important. Environmental problems, the scarce lands and safety for energy facilities are other matters of energy security that Korea is facing with. Nuclear has been the important alternative energy source to ease the energy supply instability and environmental problems caused by fossil fuel uses in Korea. But the plans for construction of nuclear power plant are facing a strong resistance from the public and social activity groups, which makes the plans very uncertain. If the nuclear power plants fail to expand as the current planned, energy security problems in Korea would be aggravated in the future. On the contrary, if the expansion program of nuclear power carry out successfully, other types of security problems such as radiation accidents may occur.

When we look into the energy sector of Northeast Asia, our understanding would be that the energy future of Korea has common features with China and Japan in the region. They also have the high dependency for oil on Middle East, and share the same types of accelerated environmental problems and the expansion of nuclear and natural gas use. The fast growing energy demand in the future in Korea as well as China and Japan would make energy security more unstable in the region. The region's reliance on the Middle East for oil import is expected to increase further in the future, hence a major issue in the region will be the security of energy (especially oil) supply. Due to high coal dependency (China) and high oil dependency (Korea, Japan), the region is as vulnerable as any other regions to energy-environment issues and is likely to become center of interests in future environmental negotiations. China, Japan and Korea all have very active plans for the nuclear power due to the scarcity of energy in the region, while most of other regions reduce or stop using the nuclear powers. The safety issues and public resistance for nuclear power is likely to be accelerated more in the future as is expanded to meet an increasing energy demand. Up to now, natural gas would be a best alternative choice to resolve those problems. However, most countries of Northeast Asia will be faced with financing problems because it is costly to import and construct infrastructures for natural gas. When North Korea launches its economic developments in coming years, it will also be confronted with the same problems in the energy sector.

It is necessary to seek some form of common action plans among Northeast Asian countries against those problems just discussed. There are rooms for better energy utilization and cost reduction by cooperation with other countries in the region that benefits all involved parties. In addition to financial benefits, current concerns over unstable energy supply and environmental problems would be best and most efficiently handled by consuming energy together through the common energy infrastructures and increasing energy trade within the region. This requires mutual cooperation among the countries in the region for promoting the development of energy in East Siberia where the potential of energy supply, especially environmentally friendly energy, is immense. On the demand side, technical and financial cooperation among countries in the region would be also desirable.

To explore the possibility of efficient and mutually beneficial cooperation, a thorough investigation over the situation and concern of each country is necessary. As a stepping-stone for such cooperation, this paper outlines the status of the energy futures and securities for Korea with the hope of facilitating regional cooperation of energy policies.