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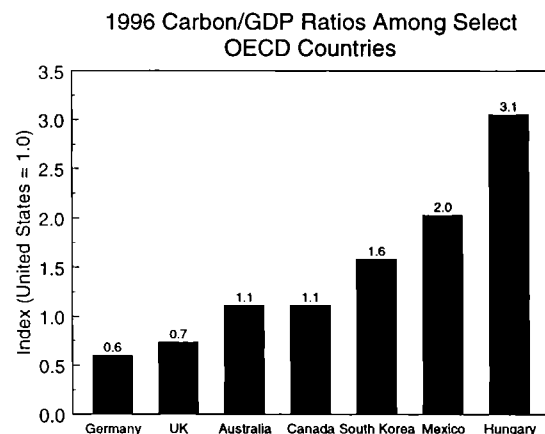
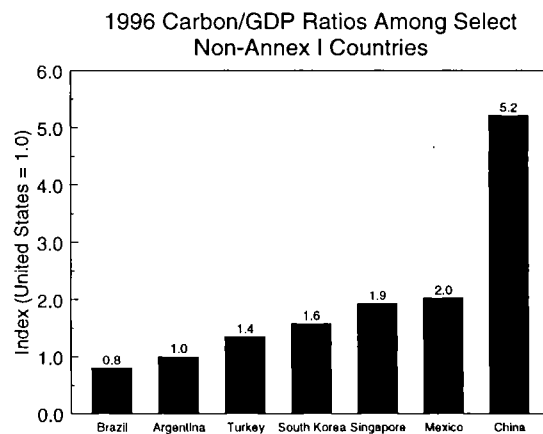
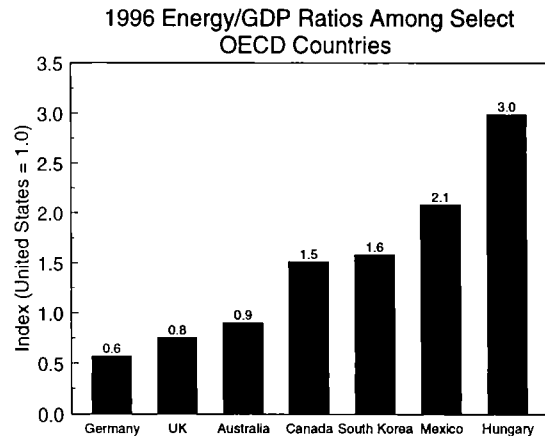
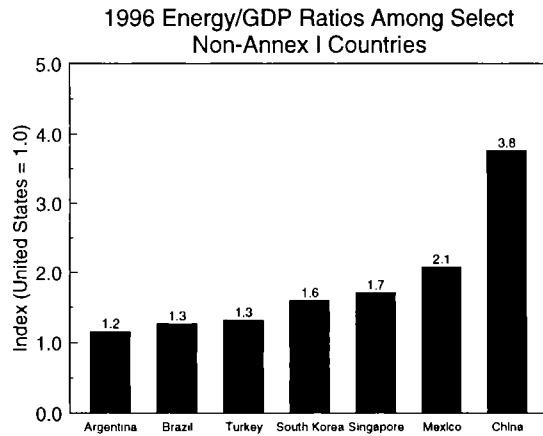
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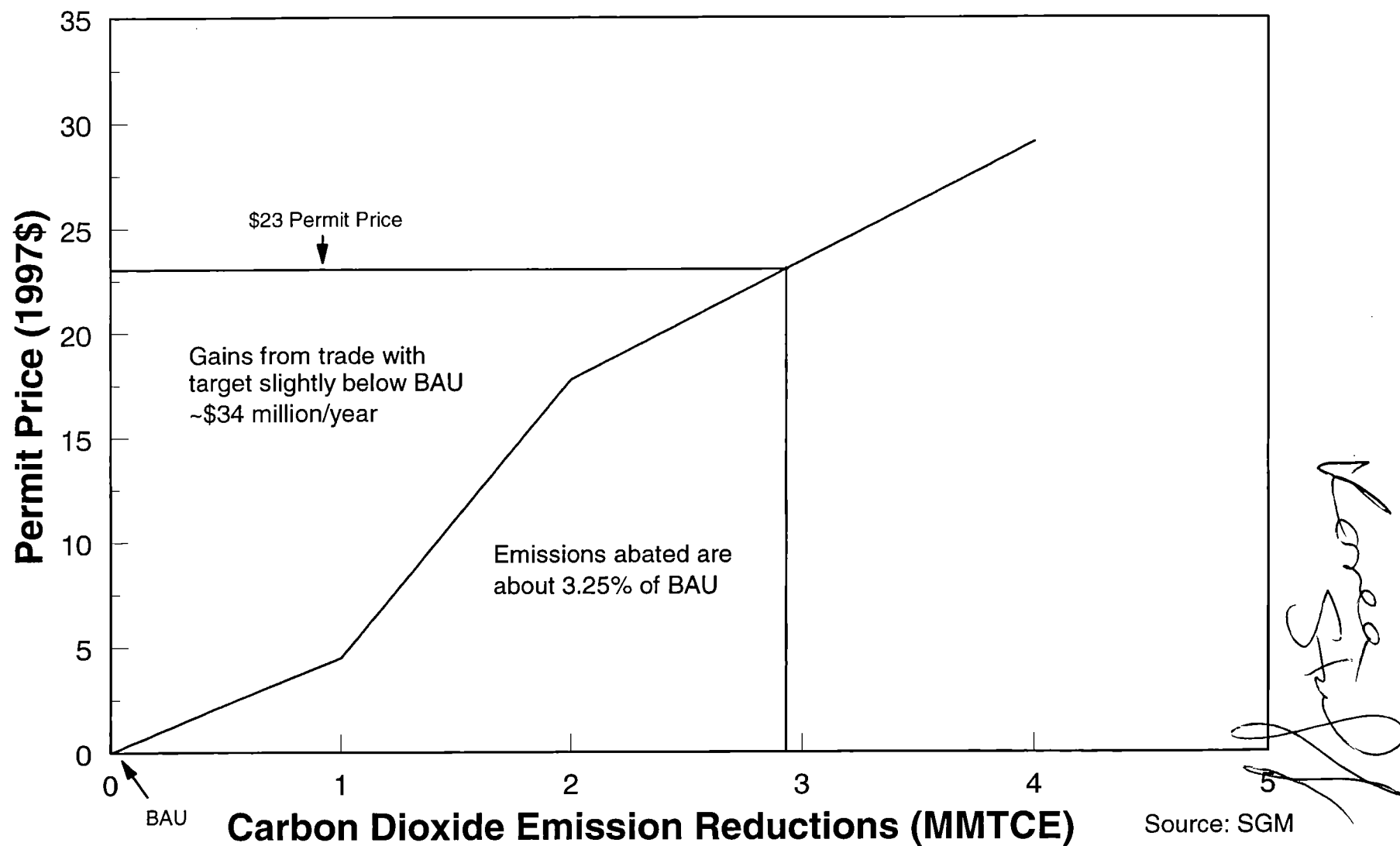
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South Korea

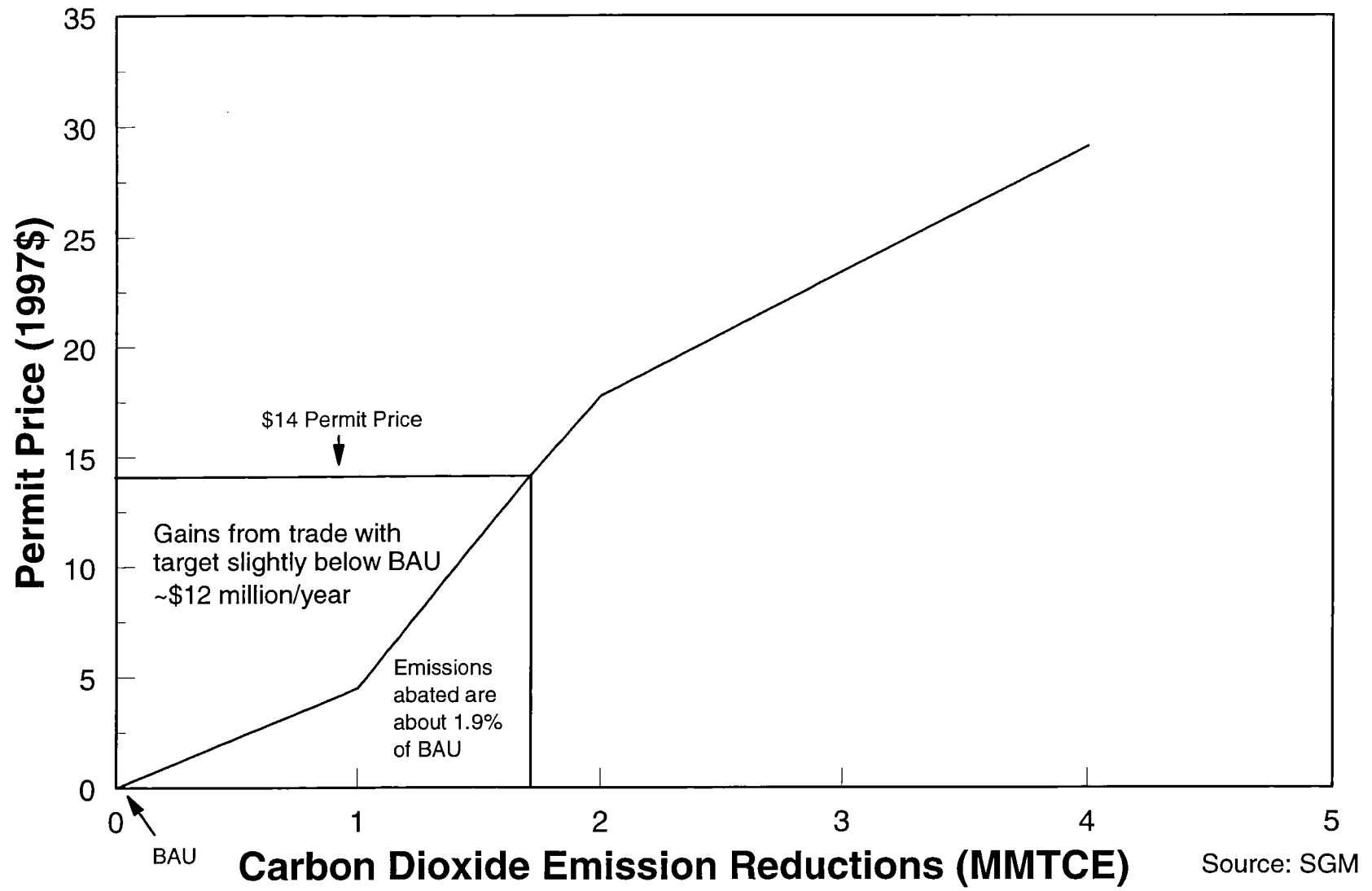


- South Korea's carbon/GDP ratio has remained fairly constant since 1980, however their energy/GDP ratio has trended upward since 1988.
- Using 1996 energy/GDP and carbon/GDP ratios as a proxy for energy efficiency, South Korea was less efficient than other OECD countries except for Mexico, and the new members of central Europe (Czech Republic, Hungary (shown above), and Poland).
- South Korea's 1996 energy/GDP and carbon/GDP ratios were higher than other Non-Annex I countries except for Singapore, Mexico, and China.

Korea's 2010 Marginal Abatement Cost Curves

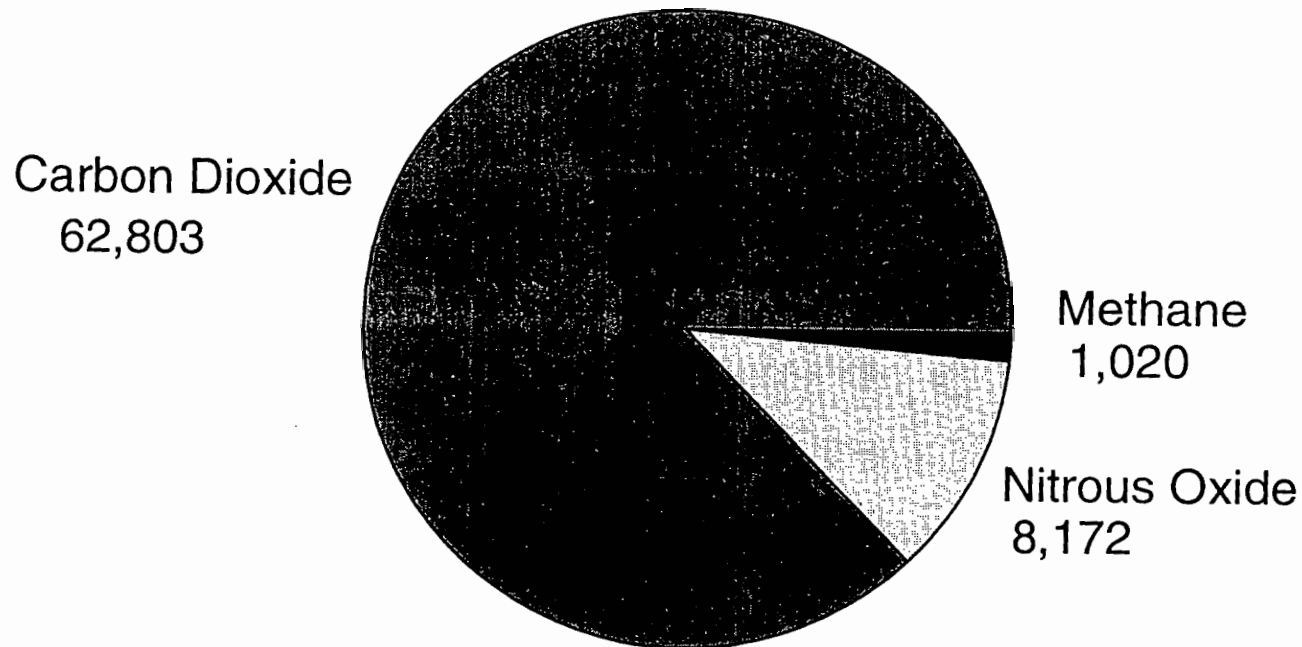


Korea's 2010 Marginal Abatement Cost Curves



Emissions Breakdown, Korea 1990

Table 3-1

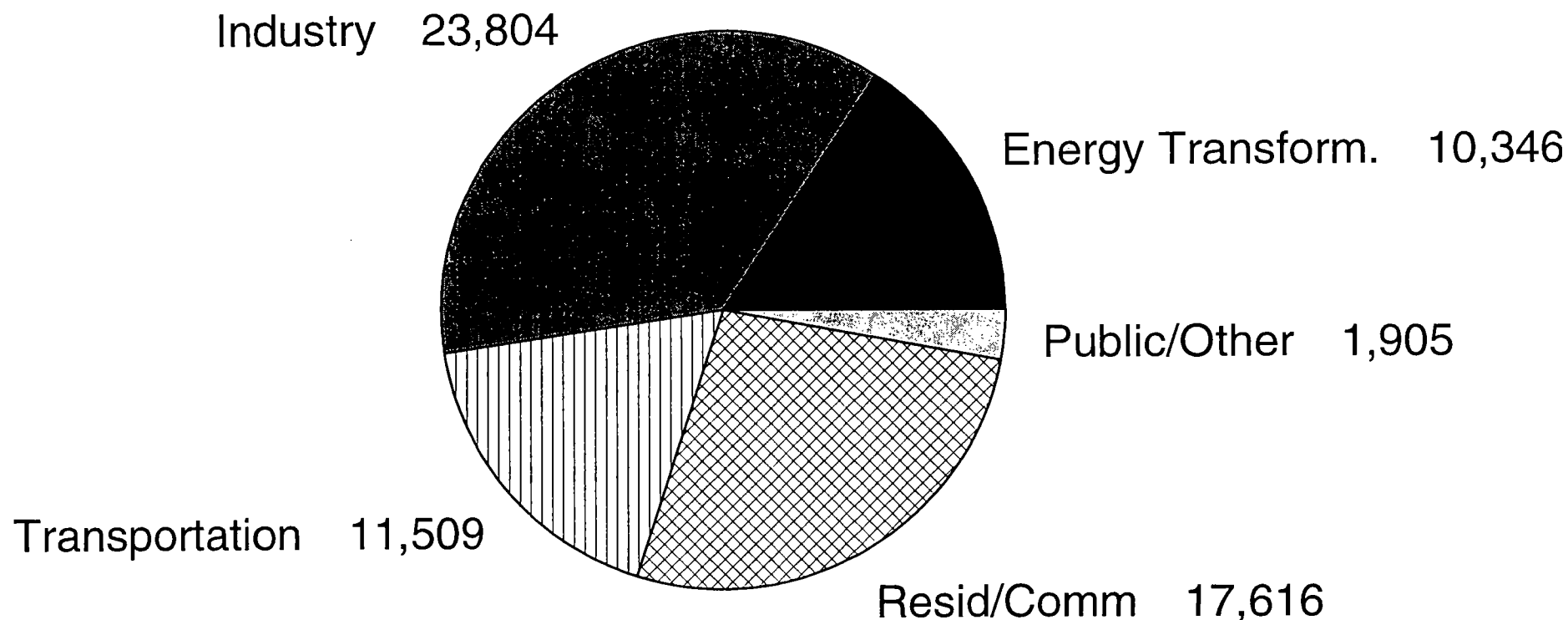


Notes: Units are MMTCE. 26,235 Gg of Carbon Dioxide, ~10% of emissions are eliminated using Managed Forests. Also, this chart does not include emissions of synthetic gases.

Carbon Dioxide Emissions, Korea 1990

Fuel Combustion Breakdown by function

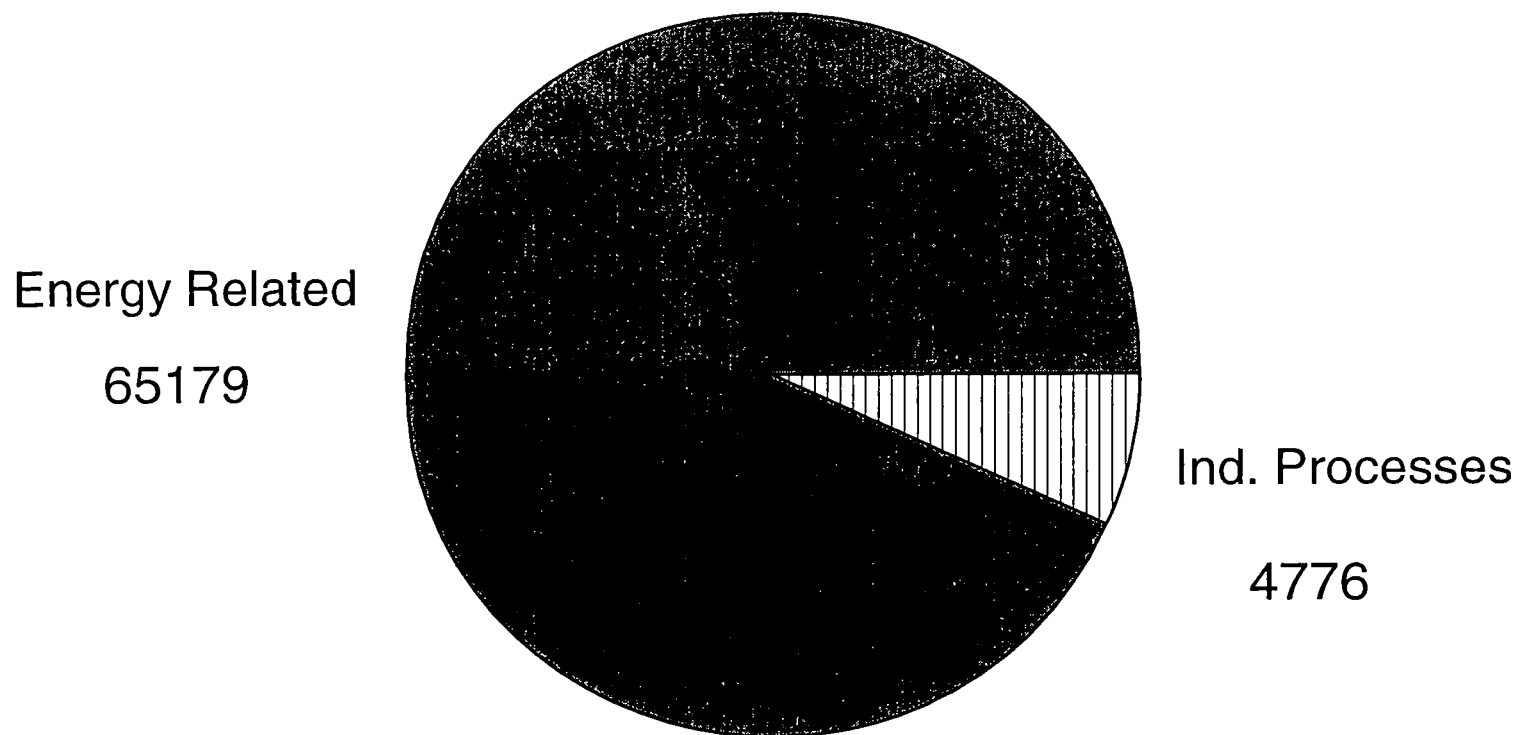
Table 3-1



Note: Units are MMTCE. This graph does not include emissions of synthetic gases.

Carbon Dioxide Emissions Breakdown by sector, Korea 1990

Table 3-1

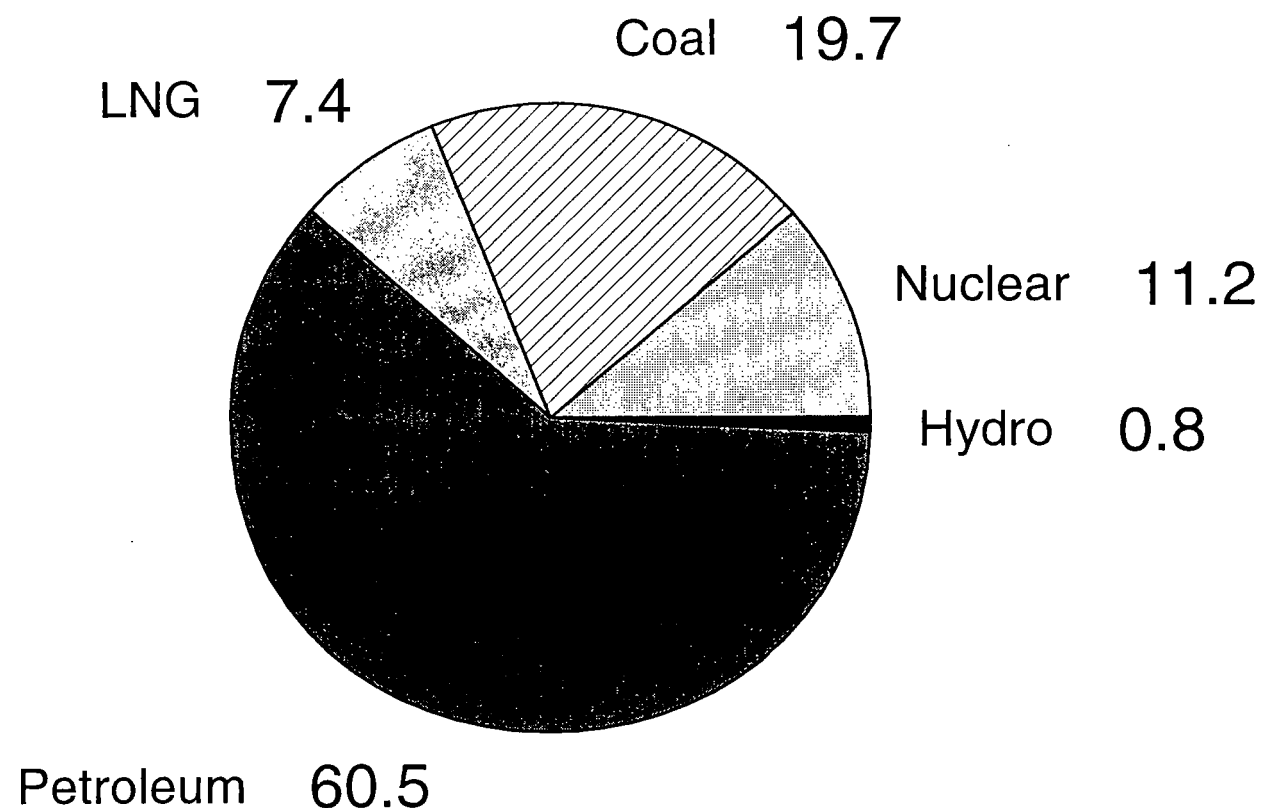


Note: This chart does not include synthetic gases.
Units are MMTCE

Share of Primary Energy Consumption, by Fuel Source

Korea, 1996

Table 2-6



Note: This chart does not include synthetic gases.

Units are percentage of primary energy consumption supplied.

National Communication of the Republic of Korea

1998 Submission of the ROK Under the United Nations
Framework Convention on Climate Change

Korea

Summary

- Heavy + Chem Manuf = 76% of Manuf
- Avg annual growth = 9.4% m'81-'90, 7.4% '91-'96
- Primary Energy Consump: 43.9 MTOE in 1980 → 165.2 in 1996
ann growth rate of 7.8% '80-'90, 10% '91-'96
Per Cap NRG consump = 3.63 TOE '96
- imports most energy resources, now 97.8% (1996)
oil used most 60.5% of total PE in 1996
coal used in steel + cement as well as power
19.7% in '96

NG as doming

Now 12 Nuke plants 11.2% of PE consump.

Total Energy Prod: shares

Nuke 36 Coal 27.6 Oil 22.7 LNG 13.5 Hydro 2.5

Total 1990 emissions 62.8 TCE

Industry 37%, Resid./Comm 27%, Transp 18%, elect. 16%

CO₂ increased ann. 7% from 1990-95

— Projections:

LEAP for energy demand - LEMP^{'92} for growth of econ

WASP for electricity dem.

~~IPCC~~ IPCC methods for CO₂

• Project

5.3% ann growth in enrg dem '96-2010

5.2% CO₂ emissions '95-2010 to 217 M TCE

- NCEC (Nat Com. for Energy Conserv) estab 1997 to implement conserv. policies

- Govt building LNG infrastructure + 16 new Nukes
Wants 29% of Total PE by 2006 w/ renewables
Tax Petrol, LNG + use funds for R+D

Planning to let oil prices $\uparrow$ to send signal

2. NRG Consump: (EC)

Overview

- Depends on budget for 97.8% of all PE consump. nrg.
- 1995 growth 8.4% nrg consumption growth 9.6%
- Per cap EC < OECD Ave.

Source of E

~~1982~~ ~~1990~~ ~~1996~~

Petrol constant at 60% ~~Petrol~~

Coal fallen to ~20% ~~Coal~~

NG $\uparrow$ to 7.4% : Huge increase due to Govt encouragement

Nuke $\uparrow$ 11.2%

Dependence on FF 87.3% (US 89.9%) (Jap 83.3%) (OECD 86.3)

Industry

Now uses 51.4% of E. 1986 used 67.869 TOE

Petrol 57.4% of this, Coal 25%, elect 13.5%

Transport

Now 22.6% EC : Mostly due to rise in private car usage (which = 30.8% of transport EC)

Res/Comm

Now only 24% (was 37.3 in 1980)

Coal replaced by oil as chief

lots of appliances have $\uparrow$ elect. usage

Public/Other

Petrol 57.6% (a fall from 85.6 in '80)

Elect 33.3% (high)

Power Generation

Nuke has skyrocketed to 36% (the most of any)
Govt has built nukes & encouraged use of Nukes + LWR.

- 3) Inventory of GHG emissions: using IPCC '90 guidelines
Major source: Korea's Yearbook of E Stats
CO₂ pretty good, but non-CO₂ data less complete

Emissions

3 biggest (worst for GH)

CO ₂ has Gl. War. Pot = 230,278 Gg CO ₂	87.7%
Methane has GWP = 28,602 Gg CO ₂	10.9%
N ₂ O has GWP = 3,702 Gg CO ₂	1.4%

- CO₂ = 230,278 Gg = 62.8 MMTCE
makes 10% of total = 256,513 Gg

Energy: Biggest (90+%) share of CO₂ emissions.

Industry - 37% total CO₂ emiss.

Res/Com = 27%

Transp = 18%

Electric = 16%

Public = 3%

Concent produce 14841 Gg

Sinks Removal = 29073 but harvest cost 2838, so
net - 26235

CO₂ Emissions grew fastest in electricity sector, then
transport, ~~industry~~ fossil fuels, then industry.



Methane (CH_4) = 1362 Gg

Comes from energy, agric, waste mgmt, industrial proc.
↓ ↓ ↓ ↓
combustion rice livestock treat-ment chemical proc.
= 44% 36%

Rice alone is 36% of emissions.

Nitrous Oxide N_2O = 124 Gg

11.4 Gg from fuel combustion = 92%

Others

NO_x = 851 Gg Transport = 58%

CO = 1056 Gg Transportation = 600 Resid = 364

NM VOCs = 152 Gg

4) Projections:

energy demand w/ LEAP developed by TELUS

Assumes:

low pop growth 1%

Family size ↓

Cars increase to 355 from 100 (index)

Energy demand expected to be

1995 150.4 → 2000, 213.4 → 2005, 272.9

2010 328.1

ave. growth = 5.3%

• CO₂ emissions:

1995 101.1 → 2000 148.5 → 2005 187.4

2010 217.0 average growth = 5.2%

• Econ crisis adds uncertainty

5) GHG Mitigation Policies

1997 estab Nat Gte for NRG Conservation

Ration E Util. Act

• Control rests w/ MOTIE: Min of Trade, Ind. + Energy

• Data collected by Korea Energy Econ Instit.
"Byeok of NRG Stats"

• Implementation by KEMCO: Korea Energy Mgmt Corp.
including: audits, R+D, Educ, Mgmt.

• All electricity supplied by KEPCO: Korea Elec Power Co.
owned by Govt.

• All production of LNG by KOGAS, but distrib
+ sale is private.

• Tech R+D by KIER: Korea Instit. for NRG Research

(B) Targets for 161 energy-intensive products
for 190 energy-intensive ~~industries~~ companies

~~Target NRG reduction~~ should reduce by 14% of

1991 energy

Plans in '91 + '96

So they've set reductions in energy usage by govt +
by industry (company) of ~1.5%

Principle means of reductions is new or improved equip.

Industry + Regulation

- Govt sends out EMG: energy mgmt guidelines to help them increase efficiency
- audited 30 companies between '87-'91
- 1992-1996 audited ~350 companies
- requires reporting of energy-usage for new facilities before they're built.
- conducts free audits for small companies
- tax incentives for capital improvement
- building co-gen plants (elect + ~~power~~ heat)

Residential + Reg.

- insulation mandatory since '79
- large buildings built new must undergo audits
- Really large had to submit plans to reduce energy in '97
- Labelling is required on appliances of energy eff.
- Min effc requirements imposed on appliances.
- Expanding roles of
 - energy service companies (consultants)
 - district heating

Transport Sector

- labelling of cars required
- targets for fuel effc. of cars
- encouraging car pools + small-car ownership
- has progressive car emissions taxes
- oil pipeline being built

Public Sector

ESPC: NRG Savng Performance Contracting

R&D

Ten Year Plan (97-06) incorporating energy conservation tech, alternative energy tech, clean energy tech.

Main Goals: Reduce 10% energy consumption by 2006

Supply 20% total energy consumption by new + renewable sources

Renew energy

'87: New + Renewable Energy Dev + Promotion Act
+ Alternative Energy Tech Dev. Plan

Ann. growth = 23% since '93

- New big deal is incineration + solar

3 photovoltaic power plants in operation

- Chart p 68 on renewables

Demand Side Mgmt = DSM

- Govt controls prices (but Petroleum privatized in '97)
+ taxes Fossil Fuel usage

Pricing

Energy used to be subsidized, but by 2000 the ~~non-oil producing~~ price is going to be ~~adjusted~~ adjusted to world prices to capture true costs.

- Govt Requires energy suppliers to incorporate DSM programs in investment plans.

Local Energy Plan

Govt (under REUT) requires local govts to develop local energy plans.

Energy Industry

- Govts helped energy companies with Petroleum Business Fund + Energy Rationalization Fund

in 1995, unified into
Special Energy Account
funded by import surcharges
+ taxes on sales

Nukes

Leader in Nukes: by 2010 expected to be 45.5% of electricity supply, 33.1% of total power gen.
which is a reduction of 520 MMTCE of CO₂ emissions over coal.

LNG

Growing Rapidly, building pipelines + terminals
CNG vehicles are being tested + aim for 700,000 by 2001

LPG Big in cars + huge in homes.

Coal restructuring

In 1989 began closing unprofitable coal mines
+ has offered compensation for loss.

347 mines in 1988 → 11 in 1996

1988 16.5% total energy consumption → 1.5% 1996

Power Plants have to have filters

Forestry

- 10 year plans at national, regional, local.
- Designated areas as reserves (77% of total forests)
- Subsidized strengthening of forests & rebuilding
- Subsidizes cropland $\rightarrow$ forests at 80-100% of costs
- Subsidizes reforestation with superior species.

Agriculture

- Ways to grow & cultivate Rice which lower
- Methane emissions are being encouraged
- Trying to use techniques to $\downarrow$ animal emissions

Waste

Industrial waste = 130,000 Tons,
Municipal = 50,000

3 steps

1) Minimize production of waste

- Internalizing ~~collection~~ externalities of environment by incorporating special disposal costs in prices

- Limiting packaging

- Charging for waste by volume, not flat fee

2) Incineration necessary & landfills $\downarrow$

Recycling

Financial incentives to producers to use recyclable materials $\rightarrow$

Wastewater

Companies receive ratings by color & are regularly checked.

Transport

Car Exhaust

- By 98-00 up to developed country standards
- Do annual inspections
- Supporting hybrid-fueled cars.
- increasing fuel quality standards
- encouraging public transport thru

subway

Light Rail transits

Bus encouragement

Discouraging private cars thru gas taxes

Summary, Korea National Communication

Energy Consumption

- Korea gets 97.8% of its primary energy from abroad, in that it imports all its fuel since it's stopped mining domestic coal.
- Its econ growth rate in 1995 was 8.9% and energy consump growth rate was 9.6%
- It gets 87.3% of its energy from fossil fuel generation, just slightly less than US.
- Since 1980, Korea has increased the use of LNG and Nuclear power in the place of coal, which is attributed to govt efforts to encourage LNG (infrastructure construction) and Nuclear (building plants) and to discourage coal (shutting down mines). Oil has provided ~60% since 1980.
- There's been a rapid increase in the consumption of industry and transport, such that Industry uses 51.4% of the energy used in Korea, equal to 68 TOE in 1996; transportation sector uses 22.6%, which is largely composed of increasing personal car usage; residential/Comm uses 24%, which includes a rapid increase in household electricity demands due to the proliferation of appliances and a switch in the residential sector from coal to natural gas.

GHG Emissions and Removals Inventory

- Base year is 1990, and they follow IPCC guidelines
- Major source is Korea's Yearbook of Energy Statistics, which has data on consumption by sector but not industry specific.
- CO2 accounts for 88% of GWP of emissions.
- The growth rates (1990-95) of CO2 emissions are fastest in electricity generation=17% and transportation=14%. Fossil fuel combustion amounts to 37% of total CO2 emissions.

Projections

- Predict gradual increases in energy demand and emissions, with CO2 reaching 217 MTC in 2010, equal to 3.9 MTC per capita. 1995, these were 101.1 and 2.3

Mitigation

- Korea has set policies by sector: See the chart for a summary of them. The major organizations are the National Committee for Energy Conservation and the Ministry of Trade, Industry, and Energy.
- **Industrial Policy:** The govt audits some 350 countries annually and provides tax incentives for capital investment which improves energy efficiency.
- **Residential and Commercial:** Large and very Large buildings are required to submit plans to reduce energy consumption. Labelling of appliances and minimum efficiency requirements on appliances have also been instated.
- **Transport Sector:** Car efficiency targets, carpool encouragement, and progressive taxation of emissions are being used.
- Korea has also emphasized R&D over the next ten years, setting as goals a 10% reduction

in energy consumption by 2006 and supplying 2% of the energy consumed with renewable resources.

- Energy produced with renewables has increased at 23% annual rate since 1993. Incineration and photovoltaic are receiving considerable government support.
- Pricing: The government is gradually removing price controls on energy to reach world prices by 2000, and is taxing fossil fuel usage.
- Funding: Korea has a Special Energy Fund, which funds industry conversion to more efficient processes. The SEF is funded by import surcharges and taxes on energy sales.
- Korea is very proud of its nuclear electricity generation facilities. By 2010, it expects 45.5% of electricity supply to be from nuclear plants, 33% of total power.
- Coal is being phased out, down from providing 16.5% of total energy consumption in 1988 to 1.5% in 1998.
- **Forestry:** The govt subsidizes almost completely the costs of converting cropland to forests and upgrading the species in forests.
- **Agriculture:** Trying to use techniques which lower emissions of methane from rice and animals.
- **Waste:** The government is controlling production of waste through packaging regulation and progressive pricing, encouraging incineration over landfills, and providing financial incentives for recycling.
- **Cars:** The government is completing a subway in Seoul and building others in Pusan, Taegu, and Incheon. Light rail systems are being built, and emissions testing on cars is in place. Taxes on gasoline are discouraging car usage.

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Foreword

The Republic of Korea, with more than 150 countries, signed the United Nations Framework Convention on Climate Change at the United Nations Conference on the Environment and Development in June 1992. The Republic of Korea became the 47th country to ratify the convention as a non-Annex I country in December 1993.

This National Communication is a part of the Korean Government's effort to comply with Article 12 of the United Nations Framework Convention on Climate Change as well as to abide by an agreement made in 1996 when the Republic of Korea became a member of OECD.

This National Communication shows the Government's determination, as a responsible party to the Convention, to faithfully fulfill its commitments under the Convention in order to prevent global warming and to mitigate greenhouse gas emissions.

In 1994 the Government initiated a number of research projects for the preparation of the National Communication and funded participation from various government ministries and research organizations.

This National Communication consists of chapters dealing with the Republic of Korea's national overview, greenhouse gas emission inventory, policies and measures on greenhouse gases, greenhouse gas emission projection and the impact of climate change on the Korean Peninsula. It also reports the current situation on research activities, international cooperation, and enhancement of public awareness.

A. National Overview

The Republic of Korea occupies the southern half of the Korean Peninsula, which lies between east longitudes 126° and 131°52' and between north latitudes 36° and 38°27'. The land area of the Republic of Korea is 99,313 km², 46.9% of which is mountainous forest area. The forests in the Republic of Korea were devastated from firewood consumption in the wake of the Korean War, but have recovered as a result of successful afforestation since the 1970's.

The climate in the Republic of Korea is temperate, with four distinct seasons, as it is located in the middle latitudes. There are systematic seasonal influences over the Korean Peninsula from the Asian continent and the Pacific Ocean so that summers are hot and humid while winters are cold and dry. Average temperatures in August, the warmest month, range from 20 to 26 °C and average temperatures in January from -6 to 5 °C.

The Republic of Korea's population in 1996 was 45.5 million and the population density was 459 persons per km², the third highest in the world. However the effective implementation of family planning policies has slowed the population growth rate from 3.0% in 1960 to less than 1% at the present.

The Republic of Korea's economy has changed markedly in every respect over the past 30 years since the early 1970's when the Government launched a series of economic development plans. The average economic growth rate during the last decade was recorded at over 8.8% per annum, which is far higher than the moderate growth rate of around 2% of some developed economies. The high rate of economic growth inevitably led to the rapid growth of energy consumption.

The Republic of Korea's GDP was US\$ 457 billion (per capita GDP US\$10,124) in 1995. The Korean industrial structure has experienced a major shift from agriculture, forestry and fishing, and mining industries to manufacturing and service industries. The share of agriculture, forestry and fishing in total GDP sharply decreased to 6.4% in 1995 from 26.6% in 1970. Since the 1980s, the heavy and chemical industries have grown rapidly, with their share of GDP rising to 76.2% of the total manufacturing sector in 1996. The increase in

industrial activities boosted the growth of energy consumption and GHG emissions.

B. Economic Growth and Energy Consumption

Expansion of the heavy and chemical industries has been the major impetus to industrializing the economy, pushing the average growth rate to 9.4% per annum in 1981-1990 and 7.4% per annum in 1991-1996. To fuel the rapid economic growth, primary energy consumption also increased from 43.9 million TOE in 1980 to 165.2 million TOE in 1996, a growth rate of 7.8% per annum from 1980-1990 and 10.0% from 1991-1996. The combination of stable population growth and a rapidly growing economy brought about an increase in per capita energy consumption that reached 3.63 TOE in 1996. Nevertheless, the per capita energy consumption in the Republic of Korea is still lower than the average among other OECD countries. Analogous to most of the advanced countries at the early stages of their economic development, the Republic of Korea to date has been achieving a high rate of economic growth coupled with rapidly growing energy consumption.

The Republic of Korea is not endowed with significant natural resources, and anthracite coal is the only indigenous energy resource that has been commercially produced and sold. Most energy resources are imported from overseas. Since the onset of economic growth, foreign energy dependency (including nuclear power) has been high. Of particular note, it jumped from 73.5% in 1980 to 87.9% in 1990, and further to 97.8% in 1996. Not only has the absolute amount of the total energy consumption increased, but also the composition of the energy mix has changed. The demand for clean and convenient sources of energy such as oil and natural gas has increased at the expense of domestic coal since the mid-1980's.

The primary sources of energy in the Republic of Korea consist mainly of oil, coal, and natural gas. As in most countries, the major source of energy in Korea has been oil and its consumption has increased from 182,105 kBbl in 1980 to 356,349 kBbl in 1990 and to 721,063 kBbl in 1996. The increase in oil demand has come in part from the expansion of petrochemical facilities in the 1990s and in part from the inter-fuel substitution of oil for coal during the same period. In fact, oil consumption increased at 6.9% a year in the 1980's and 12.4% in the 1990's, representing 60.5% of total primary energy in 1996.

Coal is used in the steel and cement industries as well as power generation in Korea. Its consumption increased from 25,862 kTon in 1980 to 43,405 kTon in 1990 and to 50,277 kTon in 1996. The share of coal in primary energy consumption rapidly decreased from 30.1% in 1980 to 19.7% in 1996. The annual average growth rate of coal consumption

between 1991 and 1996 was only 2.4%. Such a low rate of growth demonstrates the anticipated outcome of the government's "rationalization of coal industry" policies in response to rising public concerns about environmental issues.

In 1987, 1,620.7 thousand tonnes of LNG were consumed in Korea, and its consumption has increased rapidly, reaching 9,361 thousand tonnes in 1996 (an increase of 5.8 times). The Government encouraged the expansion of LNG supply in order to reduce heavy reliance on petroleum and diversify energy sources. Consumers' preference for cleaner energy also played an important role in boosting natural gas consumption.

The electricity generation sector in Korea has expanded to meet growing electricity demand accompanying economic growth and improving living standards. On the supply side, nuclear power generation programs have been actively pursued by the Government in order to reduce the heavy reliance on fossil fuel in Korea. Since the first plant began operations in 1978, the total number of nuclear power plants has now reached 12. The total electricity generated by nuclear power plants reached 73,924GWh in 1996, about 11.2% of primary energy consumption. As of 1996, the shares of nuclear, coal, oil, LNG, and hydro in terms of total power generation were 36.0%, 27.6%, 20.7%, 13.5% and 2.5%, respectively.

Final energy consumption increased from 37.597 million TOE in 1980 to 75.107 million TOE in 1990 and to 132.033 million TOE in 1996.

The annual average growth rate of final energy consumption was 7.2% between 1981 and 1990, and 9.9% between 1991 and 1996. In 1996, the industrial sector accounted for 51.4% of total final energy consumption, while transport stood at 22.6% and residential and commercial combined for 24.0%.

Energy consumption in the industrial sector has increased and the demand for bituminous coal has steadily escalated in the steel and electricity industries. The transport sector energy consumption has surged due to the increase in the number of passenger cars during the last three decades. In the residential and commercial sector, there has been rapid inter-fuel substitution of natural gas for coal in the form of city-gas. The share of coal in this sector dropped from 61.8% in 1980 to 3.3% in 1996.

The Government to date has undertaken various measures to implement energy diversification more efficiently and instituted efficiency improvement policies in the 1990's, aiming to transform the energy consumption sectors into being less carbon-intensive. As a consequence, the share of coal in terms of primary energy has markedly dropped from 26.2% in 1990 to 19.7% in 1996, while the share of LNG has risen from 3.2% to 7.4% over the same period.

Source: Yearbook of Energy Statistics, 1997, KEEL.

C. Inventory of Greenhouse Gas Emissions and Removals

The base year for inventory of greenhouse gas emissions and removals in Korea is 1990 and the inventory methodology adopted was "IPCC guidelines for national greenhouse gas inventories in 1995." The inventories were established for six gases including direct GHGs such as CO₂, CH₄, and N₂O, and indirect GHGs such as N₂O, and NMVOC. CO₂ emissions from fossil fuel consumption in the energy sector from 1991 to 1995 were calculated with international bunkering being separately listed. In the agricultural sector, CH₄ emissions from rice paddies and livestock were calculated with a slightly different method tailored to allow for circumstances peculiar to Korea.

In order to calculate the GWP index for direct greenhouse gases, the 1996 IPCC GWP was employed. With a 100-year-time-horizon GWP index, the contribution of CO₂ 87.7% and that of CH₄ 10.9%. In particular, the contributions of GHG emissions from the energy sector to the total GWP value are 95.5% so that substantial efforts to mitigate GHG in the energy sector are certainly necessary. The reliability of the greenhouse gas emissions inventory of

		1980	1985	1990	1994	1995	1996	AAGR (%)	
								8	9
Energy Consumption (1,000 TOE)	Primary	43,91	56,29	93,192	137,235	150,437	165,209	8	1
	Final	37,597	46,993	75,107	112,206	121,850	132,033	7	0
Per Capita Energy Consumption (TOE/Person)		1.15	1.38	2.17	3.09	3.35	3.63	7	8
Dependency on Imported Energy (%)	Nuclear included	73.5	76.2	87.9	96.4	96.8	97.8		
	Nuclear excluded	71.6	68.8	73.7	85.7	85.6	86.1		
Share of Petroleum in Primary Energy Consumption		61.1	48.2	53.8	62.9	62.5	60.5		
Share of Electricity in Final Energy Consumption		7.5	9.3	10.8	11.2	11.5	11.9		
Energy Price Index		71.7	141.0	100.0	115.54	121.4	137.9		
Energy/GDP Ratio (TOE/Million Won)		0.58	0.51	0.52	0.58	0.58	0.60		
Economic Growth Rate(%)		-2.7	6.5	9.5	8.4	8.7	6.9	9	7
Growth Rate of Primary Energy Consumption(%)		1.5	5.4	14.1	8.1	9.6	9.8		
Energy Elasticity		-	0.83	1.48	0.96	1.10	1.41		

Major Energy and Economic Indicators in Korea

other sectors including agriculture, forestry, waste management and industrial processes is significantly hampered by the lack of accumulated input data. To make the emissions inventory for these sectors more reliable in the future, the Korean Government will take measures to modify ways to collect, process, and report the necessary inventory data.

In Korea, net CO₂ emissions in 1990 were 230,278 Gg, equivalent to 62.8 million TC. Total emissions were 256,513 Gg and forest removals were 26,235 Gg, which were 10% of total emissions. It should be noted, however, that the net emissions in the table did not take into account international bunkering.

In 1990, CO₂ emissions from fossil fuel combustion amounted to 238,990 Gg. CO₂ emissions from fossil fuel combustion in the industry sector contributed the largest share, accounting for 37% of total CO₂ emissions. The residential/commercial sector was the second largest source of CO₂ emissions, with a share that was 27% of the total, while the shares for transport, public, and electricity generation sectors were 18%, 3%, and 16%, respectively.

The CO₂ emissions from fossil fuel combustion increased at an annual rate of 9% during the period 1990-1995. In the same period, CO₂ emissions from electricity generation had the highest average growth rate of 17%, transport 14%, industry 9%, and commercial/residential 1%. In 1990, methane emissions were 1,362 Gg, 30.4% of which came from rice paddies.

Note: 1) non-CO emissions are those from residential and commercial sectors in 1989
 2) non-CO₂ emissions are those from public and other sectors in 1989

Category	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOCs
Net Emissions	230,278	1,362	12	851	1,056	152
1. Energy-Related Emissions	238,990	264	11	851	1,056	152
A. Fuel Combustion	238,990	17	11	851	1,056	152
1. Energy Transformation	37,934	0.3	2	193	7	N.A.
2. Industry	87,282	1	2	135	25	N.A.
3. Transport	42,198	6	2	401	600	152
4. Residential and Commercial	64,592	7	3	105	364	N.A.
5. Public and Other ²⁾	6,985	0.5	4	16	39	N.A.
6. Biomass Burning	-	2	0.02	0.6	20	N.A.
B. Fugitive Fuel Emissions	-	246	-	-	-	-
1. Coal Mining	-	230	-	-	-	-
2. Oil and Gas Systems	-	16	-	-	-	-
2. Industrial Processes	17,512	5	-	-	-	-
A. Cement Industry	14,841	-	-	-	-	-
B. Limestone and Dolomite Use	2,459	-	-	-	-	-
C. Soda Ash Use	212	-	-	-	-	-
D. Chemical Industry	-	5	-	-	-	-
3. Agriculture	-	599	1	-	-	-
A. Rice Fields	-	414	-	-	-	-
B. Enteric Fermentation	-	144	-	-	-	-
C. Animal Excrement	-	41	-	-	-	-
D. Nitrogen Fertilizers	-	-	1	-	-	-
4. Waste Management	11	495	-	-	-	-
A. Waste Incineration	11	-	-	-	-	-
B. Landfills	-	200	-	-	-	-
C. Household Wastewater	-	21	-	-	-	-
D. Industry Wastewater	-	274	-	-	-	-
5. Total	256,513	-	-	-	-	-
6. Removals (Managed Forest)	-26,235	-	-	-	-	-
7. International Bunkering	7,140	-	-	-	-	-

Greenhouse Gas Emissions/Removals in Korea (1990)

(unit : Gg)

D. Projection of Energy Demand and CO2 Emissions

The Rational Energy Utilization Act makes it mandatory to establish a 10-year National Energy Plan and to revise it every five years to reflect changes in economic circumstances and population growth. The plan is a rolling plan by nature, and a long-term energy demand projection is a part of the plan.

As a vehicle for projecting energy demand in Korea, a modified version of the LEAP model, which has been tailored to meet the Korean socio-economic structure, is employed. In parallel, a long-term electricity demand projection using the WASP model was made as a reference. IPCC methodology has been adopted for the calculation of CO2 emissions.

Economic growth is an important factor determining future energy demand. The energy demand projection was based on the assumptions of the economic growth forecast in the Long-term Economic Management Plan of 1992, with the actual energy consumption data for 1996 as a starting point.

According to the Long-term Economic Management Plan, GDP will increase by 2.37 times from 1995 to 2010, population by 1.11 times, the number of households by 1.28 times, and the number of automobiles by 3.55 times.

The projected energy demand exhibits a steady growth from 150.4 million TOE in 1995 to 328.1 TOE in 2010. The annual average growth rate of energy demand between 1996 and 2010 is projected to be 5.3%.

	1985	1990	1995	2000	2005	2010	AAGR(%)	
							86-95	96-10
Primary energy demand	56.3	93.2	150.4	213.4	272.9	328.1	10.3	5.3
Final energy demand	47.0	75.1	121.9	169.9	212.6	251.2	10.0	4.9
Energy/GDP	0.51	0.52	0.58	0.60	0.58	0.54	1.5	-0.6
Per capita energy consumption	1.4	2.2	3.4	4.6	5.7	6.6	9.3	4.6

Energy Demand Projection
per capita TOE)

(unit: million TOE, TOE/90 million Won,

The results show that the corresponding CO2 emissions would increase, at an annual average rate of 5.2%, from 101.1 million TC in 1995 to 217 million TC in 2010.

	1985	1990	1995	2000	2005	2010	AAGR(%)	
							86-95	96-10
CO2 emissions	44.0	65.2	101.1	148.5	187.4	217.0	8.7	5.2
Per capita CO2 emissions	1.1	1.5	2.3	3.2	3.9	4.4	7.7	4.5
CO2 /GDP	0.39	0.36	0.39	0.42	0.40	0.36	-0.1	-0.7

CO2 Emissions Projection
million Won)

(unit: million TC, per capita TC, TC/ 90

Energy demand forecasts vary to a great extent with changes in economic growth and investments in energy efficiency improvement. At the end of 1997, Korea is, unfortunately, experiencing serious financial difficulty, receiving IMF rescue funds.

As this financial crisis is likely to hamper economic growth and capital investment in energy efficiency improvement, a downward adjustment to the current energy consumption projection seems inevitable.

The Korean Government is now conducting a revision of the energy demand forecast taking fully into account repercussions of the current crisis on the future course of energy demand. The outcome of such revision will be made available in the next National Communication.

E. Impact of Climate Change on the Korean Peninsula

As the Korean Government recognized the potential significance of climate change, it began to fund basic researches for a climate change impact assessment. Outcomes of the government funded studies in recent years indicated that serious consequences would follow if CO₂ concentration around the Korean Peninsula doubled.

The main consequences might include changes in temperature, as well as in the amount of precipitation and river flows. According to the studies, the temperature could rise by 1.0-4.0°, and amounts of precipitation and river flows would also increase. The southern coastal areas would be transformed to a subtropical zone from a temperate zone.

While latent crop productivity might increase due to a prolonged summer season, it is anticipated that it would be difficult to maintain normal levels of production of perennial temperate zone fruits. Land areas available for cultivating semi-temperate zone vegetation would expand.

But temperate zone and semi-boreal zone vegetation would decrease exponentially in diversity and some would be in danger of extinction. Marine life around the Korean Peninsula would also face serious consequences including a decrease in the number of cold-water aquatic species.

F. Greenhouse Gas Emission Mitigation Policies and Measures

After ratifying the Climate Change Convention in December 1993, environmental consideration became an important factor in policy-making. Considering its heavy dependency on foreign imports for energy resources, the Korean Government has been undertaking a variety of measures to promote the rational use of energy and has intensified its comprehensive efforts to reduce greenhouse gas emissions to combat global warming

Energy Sector

The Government has been focusing on energy conservation policies as the most effective measures to mitigate greenhouse gas emissions. After the global oil crises of the 1970s, energy conservation policies were adopted which were later reinforced after the Rio Environment Conference of 1992.

In 1974, the Heat Management Act was enacted to implement energy conservation

policies systematically. In 1979, the Korean Government began implementing comprehensive and aggressive policies based on the Rational Energy Utilization Act, which replaced the Heat Management Act.

The National Committee for Energy Conservation was established in 1997 to implement efficient energy conservation policies. Its members consisted of experts from both private and public sectors. To help motivate energy conservation efforts, the Rational Energy Utilization Act was revised in 1997 to include a clause on early-notification of energy price changes.

Based on the Rational Energy Utilization Act, the Government enhanced its efforts to build a low-energy consumption industrial structure with various energy conservation and efficiency improvement policies for industry, transport, and residential sectors.

To illustrate, in the industry sector the Government has been promoting "the 5-Year Energy Conservation Plan of Energy Intensive Companies," replacement and renovation of old and inefficient boilers and furnaces, diffusion of high efficiency motors, and co-generation.

In the transport sector, it has been trying to improve energy efficiency in motor vehicles through mandatory fuel efficiency labelling as well as fuel economy targets.

Also in the residential sector, the Government has enhanced energy efficiency labelling, minimum energy efficiency standard and district heating systems, which aim to induce rational use of energy by residential consumers.

The Government has carried out strong inter-fuel substitution policies by way of expanding natural gas consumption, nuclear power programs, and new and renewable energy development. The expansion of gas consumption will be enhanced by the construction of new receiving terminals and a nation-wide pipeline grid.

For the expansion of nuclear power programs, 16 new units of nuclear power plants will be added to the current 12 nuclear power generation units. This will raise the share of nuclear power generation in terms of total electricity generation to 45.5% by 2010 from 36% in 1996.

The Government has targetted the supply of 2% of total primary energy by 2006 through new and renewable energy technology development. This target is supported by the "Ten-Year Energy Technology R&D Plan, 1997-2006," that integrates technology for energy

conservation, new and renewable, and clean energy into a single, systematic, and yet comprehensive energy technology development program to facilitate energy savings through technology development.

In an effort to reduce carbon dioxide emissions, the Korean Government has imposed duties on the import of petroleum products and LNG (Liquefied Natural Gas) and taxes on sales of kerosene, LPG (Liquefied Petroleum Gas) and LNG.

All revenues from these energy taxes have been deposited in the Special Energy Account and used for energy conservation, district heating, and R&D projects, which are generally considered carbon dioxide reduction measures. Even though the amount of energy taxes is not directly linked to the level of carbon content contained in different energy sources, these taxes play the role of carbon taxes.

The Government plans to allow the level of energy prices to rise gradually to those of non-oil producing OECD countries by shifting away from its low energy price policies of the past. High energy prices will send a strong signal to energy consumers that the Government is serious about controlling consumption.

There also will be incentives for saving energy and making investments in development and adoption of efficient energy technologies. In addition, the Rational Energy Utilization Act was revised in 1995 mandating energy supply companies to establish and execute demand side management (DSM) and investment plans.

Under the 1995 revision of the Rational Energy Utilization Act, major energy suppliers including Korea Electric Power Corporation and Korea Gas Corporation have developed long-term plans for DSM since 1996 to improve efficiency and control load management programs.

Forestry Sector

The Government has implemented policies to protect existing forests and to enhance the carbon pool. Included in these policies are forest planning, designation of reserve and protective forests, and control of forest fires, disease and pests as laid out in the Forest Law. In an effort to expand the carbon pool, the Government has been carrying out afforestation and reforestation with superior species.

Agriculture & Animal Husbandry Sector

The Government has been conducting and recommending agricultural policies and practices to mitigate GHG emissions from the agricultural sector. The policies in the agricultural sector include recommending agricultural practices effective in methane mitigation in rice paddies and providing guidance to farmers for methane mitigation. In the animal husbandry sector, methane emission mitigation policies include restraining enteric fermentation and promoting effective manure management.

Waste-management Sector

The Government has undertaken waste management policies for waste reduction, recycling, incineration and landfills. In order to carry out systematic management of waste the Government established the National Plan for Integrated Solid Waste Management in 1993 and revised and supplemented it in 1996. This plan aims to manage solid wastes effectively and systematically.

Sector	Policies and Measures
Energy Energy Conservation - Industrial Sector - Residential Commercial Sector - Transportation Sector Interfuel Substitution Energy Technology Development Demand Side Management	Target Energy-Intensity Level by Product Five-Year Energy Conservation Plan for Energy-Intensive Industries Cogeneration Housing Insulation, Energy Efficiency Grading System, Minimum Efficiency Standards, District Heating Fuel Efficiency Labelling Program, Fuel Economy Targets Nuclear Power Generation, LNG, NRSE Ten-Year Energy Technology R&D Plan Energy Pricing System, Long-term Plan for DSM
Forestry Sector Forestry Protection Carbon Pool Expansion	Forest Planning, Designation of Reserve and Protected Forests Afforestation, Reforestation with Superior Species
Agriculture & Animal Husbandry Sector Methane Gas Mitigation	Agricultural practices effective in methane mitigation of rice paddies Guidance to farmers for methane mitigation of rice paddies Reducing enteric fermentation and promoting effective manure management.
Waste Sector Waste Reduction Waste Recycling	Volume-based Waste Fee System, Discouragement of Disposable Product Usage, Separation/Collection System Waste Fee System, Deposit System

Summary of Greenhouse Gas Mitigation Policies and Measures

G. Future Directions

To limit future CO₂ emissions effectively, the Government will continue to implement policies that encourage voluntary participation of both public and private sectors in addition to current policies that have been carried out.

For this purpose, the Government will exploit financial incentives, and will consider and implement measures to mitigate CO₂ emissions through voluntary agreement between the Government and industry. If necessary, the Government will take further actions to enact laws promoting more effective mitigation measures.

The Government will also make efforts to enhance awareness of industry and the general public regarding UNFCCC. The significance for and potential impact of UNFCCC on Korea will be publicized through public forums, publication of pamphlets and guidebooks, and the use of mass media.

To encourage rational energy use, education opportunities for industry and the general public will be provided. Early education programs on energy conservation will be strengthened to enhance awareness among primary, middle and high school students, the future leaders of the nation.

The Government will also encourage the industrial sector to design management plans that take into account the limitation of CO₂ emissions in accordance with UNFCCC. In addition, the Government will make efforts to obtain concrete results by implementing new policies. It will also require energy suppliers to devise and carry out plant and efficiency improvements so that demand management investment can be expanded. The Government will implement measures to minimize costs and losses incurred by energy suppliers from such investments.

The role of the central and local governments will be coordinated so that regional energy plans, fully taking into account unique regional circumstances, can be established.

Support for regional energy projects will be continuously expanded and at the same time local governments will be encouraged to enhance awareness and capabilities regarding greenhouse gas issues.

Korea will make an extensive effort to expand the scope of the next National

Communication. First of all, emphasis will be given to minimizing the uncertainty of CO₂ emission forecasts and adding inventories and demand projections for the emission of greenhouse gases other than CO₂. Second, mitigation policies for each greenhouse gas and each industry will be presented, and a concrete and quantitative analysis on how each policy can contribute to mitigation will be included. Adaptation measures for climate change will also be studied.

Korea will make its best effort to mitigate and prevent climate change within its economic and social capabilities, and will strengthen bilateral and multilateral international cooperation so that these efforts can be pursued most effectively.

1 Natural Environment and Economy

1. Land Use

1.1. Geography

The Republic of Korea (ROK) occupies the southern half of the Korean Peninsula, which is split by the Demilitarized Zone, and is located in Far East Asia between China and Japan. The national boundary is defined by four points in terms of longitude and latitude. The eastern-most point is Tok-to at east longitude 131° 52'; the western-most point is Sohuksan-to at east longitude 125° 04'; the northern-most point is Songhyunjin at north latitude 38° 27'; and the southern-most point is Mara-to at north latitude 38° 06'. The land area of the ROK encompasses 99,313 km² as of 1996.

1.2. Land Use

The ROK has a rugged and mountainous terrain, of which forested areas account for 65,396 km² as of 1996, 65.9% of total land area.

	1992	1993	1994	1995	1996
Total Area	99,314(100)	99,392(100)	99,394(100)	99,268(100)	99,313(100)
Agricultural Area	22,185(22.4)	22,129(22.3)	22,025(22.1)	21,971(22.0)	21,925(22.1)
Forest Area	66,689(66.1)	65,711(66.1)	65,665(66.1)	65,506(65.8)	65,396(65.9)
Other Area	11,440(11.5)	11,552(11.6)	11,704(11.8)	11,791(12.2)	11,992(12.0)

< Table 1-1 > Land Use Categories

(Unit : ? , %)

Note: Agricultural areas include cultivated land and pastures.

Source: Land Registration Statistical Yearbook, 1997, Ministry of Internal Affairs.

Agricultural land consists of 21,925 km², 22.1% of the total area. However, as economic

development intensifies, the amount of land for agriculture and forests is diminishing and is expected to continue to fall with further development. Meanwhile, the land for residential and commercial use, such as for homes, roads, factories and parks, is anticipated to expand.

1.3. Agriculture

1.3.1. Land Use for Agriculture and Fertilizer Consumption

The area of agricultural land has decreased 29.1 thousand ha. on an annual average for the past five years as land development, including the construction of public facilities and buildings, is facilitated and, at the same time, the area of unused arable land has become larger. As of 1996, the total agricultural area was 1,945 thousand ha, 40 thousand ha. less than in 1995. Of the agricultural land area, the size of rice fields was reduced to 1,176 thousand ha., down 30 thousand ha., and uplands to 769 thousand ha., down 10 thousand ha., from the previous year.

Total agricultural area utilized in 1996 was 1,945 thousand ha, 55 thousand ha. less than in previous year. The utilization ratio of agricultural land fell to 107.9% in 1996 from 108.1% in the previous year. The primary reason for this was that the areas used for food crops was reduced by 6,000 ha. and the areas for vegetables and fruits by 49 thousand ha. The unutilized arable land area was 34.3 thousand ha. in 1996, a decline of 30.3 thousand ha. from the 1995 total as an outcome of intensive efforts to make full use of arable land.

	Total		Rice fields		Uplands	
		%		%		%
1990	2,109	100	1,345	63.8	763	36.2
1992	2,070	100	1,314	63.5	755	36.5
1994	2,033	100	1,267	62.3	765	37.7
1995	1,985	100	1,205	60.7	779	39.3
1996	1,945	100	1,176	60.5	769	39.5

< Table 1-2 > Agricultural Land Use
(Unit: thousand ?.)

Source: Statistical Yearbook of Agriculture and Forestry, 1997, Ministry of Agriculture and Forestry.

The area of rice fields has decreased gradually from 1,345 thousand ha. in 1990 to 1,176 thousand ha. in 1996. Nitrogen fertilizer used in rice farming is a major source of NO_x emission. As the area of rice fields fell, the associated nitrogen fertilizer consumption also fell. Nitrogen fertilizer comprises about 50% of total fertilizer consumption.

	Total	Nitrogen	Phosphorous	Potash
1990	998	523	223	252
1992	822	428	184	210
1994	820	424	185	211
1995	811	419	183	209
1996	788	412	175	201

< Table 1-3 > Fertilizer Consumption
(Unit: thousand tons)

Source: Statistical Yearbook of Agriculture and Forestry, 1997, Ministry of Agriculture and Forestry.

1.3.2. Livestock

Methane (CH₄) is produced by fermentation in animal intestines and microbial decay of animal excrement. The number of livestock and poultry has increased significantly since meat has become increasingly popular as a daily foodstuff. The number of livestock increased from 9,473 thousand in 1991 to 12,568 thousand in 1996. The trend is expected to continue as meat consumption grows.

		1991	1994	1995	1996
Ruminants	Native Beef Cattle	1,772	2,392	2,594	2,843
	Dairy Cattle	495	552	553	551
Others	Chickens	74,855	80,569	85,799	82,829
	Pigs	5,046	5,955	6,461	6,515
Total		82,168	89,468	95,407	92,738

< Table 1-4 > Number of Livestock
(Unit: thousand)

Source: Statistical Yearbook of Agriculture and Forestry, each year, Ministry of Agriculture and Forestry.

1.3.3. Forestry

Forests in Korea had been devastated as a result of Koreanwar and firewood consumption for fuel use in the 1960s, but have recovered to a significant degree with the Forestry Plans creating afforestation and forestry resources improvement from 1973. The first and second plans covering the 1973-1987 period were successfully implemented. The third plan for 1988-1997 focused on quality improvement of new forests and on the establishment of a sustainable management system. These plans have helped the average forest-growing stock per hectare to reach 50.21 as of the end of 1996.

	Land Area (thousand ha.)	Stock (thousand ?)	Stock per ha. (?)
1970	6,611	66,750	10.07
1975	6,635	105,352	15.88
1980	6,568	145,694	22.18
1985	6,531	179,381	27.47
1990	6,476	248,426	38.36
1996	6,448	323,780	50.21

< Table 1-5 > Variations in Land Area and Forest-Growing Stock

Source: Statistical Yearbook of Agriculture and Forestry, 1997, Ministry of Agriculture and Forestry.

By forest type, about half the forest area consists of coniferous trees and the remaining half, nonconiferous and mixed.

The areas of coniferous trees are decreasing in size, while those of nonconiferous species are increasing.

	Total	Conifers	Nonconifers	Mixed	Bamboo Stands
1990	6,286 (100)	3,078 (49.0)	1,389 (22.1)	1,809 (28.8)	8 (0.1)
1994	6,274 (100)	2,882 (45.9)	1,668 (26.7)	1,714 (27.3)	8 (0.1)
1995	6,263 (100)	2,877 (45.9)	1,668 (26.7)	1,710 (27.3)	8 (0.1)
1996	6,255 (100)	2,846 (45.5)	1,674 (26.8)	1,727 (27.6)	8 (0.1)

< Table 1-6 > Forest Land Area by Forest Type
(Unit: thousand ha.)

Source: Statistical Yearbook of Agriculture and Forestry, 1997, Ministry of Agriculture and Forestry

1.4 Coastal Areas

Except for Korea's northern border, the country is surrounded by coastal areas. To the west sits the Yellow Sea, bounded by China and the Korean Peninsula. The Yellow Sea is about 1,000 km long and about 700 km wide. Excluding Balhai, it covers about 404,000 km². The South Sea is the northern section of the East China Sea. The East Sea, 1,600 km long and 1,000 km wide, covers 1,007 thousand km².

2. Climate

2.1. Temperature

Since Korea is located in the middle latitudes, its climate is temperate with four distinct seasons. Influenced by the Asian continent and surrounding oceans, it is hot and humid in summer while cold and dry in winter.

Annual average temperatures ranged from 10.6°C to 15.9°C for the past 30 years, but in recent years (1990-1996) the average temperatures ranged from 12.2 to 13.8°C. The coldest month is January and the warmest month is August. In August, the monthly average temperature is between 20°C and 26°C. The monthly average temperature in January is

between -5°C and 5°C.

2.2. Cooling/Heating Degree Days

Cooling/Heating Degree Days are major indicators reflecting energy consumption. Cooling/Heating Degree Days are directly related to temperature.

On average, heatingdegree days in Korea are between 2,500 and 3,000 and cooling degree days are 600-700. In recent years, the greatest coolingdegree days were 909 in 1994 and the least were 451 in 1980. The greatest heatingdegree days were 3,069 in 1984, while of those in 1989, 2,475, were the least.

	Average Temperature (?)	Heating Degree-Days	Cooling Degree-Days
1980	10.8	3,081.0	451.0
1984	11.6	3,069.0	721.0
1989	13.0	2,475.0	661.0
1994	13.5	2,511.0	909.0
1995	12.2	2,738.9	646.3
1996	12.2	2,843.9	742.3

< Table 1-7 > Cooling/Heating Degree Days (in Seoul)

Source: Yearbook of Energy Statistics, Korea Energy Economics Institute.

	City	Temperature		
		Highest	Lowest	Yearly Average
Korea	Seoul	25.2	-3.3	11.7
Japan	Tokyo	27.1	5.2	15.6
U.S.A.	Washington	26.3	1.4	14.3
France	Paris	18.4	3.5	10.6
United Kingdom	London	16.5	3.8	9.7
Australia	Canberra	20.4	5.4	13.0

< Table 1-8 > Temperatures (?) of World Major Cities

Source: International Statistical Yearbook, 1997, National Statistical Office.

3. Population

3.1 Trends of Population Growth

The Republic of Korea's population in 1996 was 45.545 million. The population growth rate in the same year was recorded at 1.0%. The population growth rate, 3.0% in 1960 and 2% in 1970, has decreased to less than 1% since 1985 due to improved socio-economic conditions, changes in public attitude towards the population problem and the government's family planning policy.

Recently, the population growth rate in Korea has been around 1%, slightly higher than the 0.5% average growth rate in developed countries, but significantly lower than developing countries' 2.1%. Population density in Korea in 1996 was 459 persons per km², the third highest in the world excluding small island nations or city-states.

	1960	1970	1980	1985	1990	1994	1995	1996
Total Population (thousand)	25,012	32,241	38,124	40,806	42,869	44,642	45,093	45,545
Population Growth Rate (%)	3.00	2.21	1.57	0.99	0.99	1.01	1.01	1.00
Population Density (persons/km ²)	254	328	385	412	432	449	454	459

< Table 1-9 > Population Size and Density

Source: Korea's Major Economic Indicators, 1997, National Statistical Office.

3.2 Projected Population Growth

The Republic of Korea's population will reach 46.8 million by 2000 and 49.7 million by 2010. The population growth rate is expected to slow gradually to 0.83% between 1996-2000 and to 0.60% between 2001-2010.

	Population (million)	Yearly Average Growth Rate (%)	
		Period	Growth Rate
2000	46.8	1996-2000	0.83
2010	49.7	2006-2010	0.60

< Table 1-10 > Projected Population Growth

Source: Korea Statistical Yearbook, 1996, National Statistical Office.

4. Economy

4.1 Gross Domestic Product (GDP)

In terms of 1990 constant prices, ROK's GDP increased 7.6 times to 275.8 trillion Won in 1996 from 36.3 trillion Won in 1970. As a result, per capita GDP increased 5.2 times from 1.155 million Won in 1970 to 6.056 million Won in 1996. The ROK's GDP was US\$457 billion and per capita GDP was US\$10,124 in 1995.

Source: Economic Statistics Yearbook, each year, Bank of Korea.

	Year	1970	1975	1980	1985	1990	1994	1995	1996
GDP	Trillion Won	36.306	53.670	75.466	111.330	179.539	236.375	257.536	275.850
Per Capita GDP	Thousand Won / person	1,155	1,521	1,980	2,728	4,188	5,249	5,710	6,056

< Table 1-11 > Major Economic Indicators (1990 constant Won)

	1986		1990		1993		1994		1995	
	GDP	Per capita GDP	GDP	Per capita GDP	GDP	Per capita GDP	GDP	Per capita GDP	GDP	Per capita GDP
Japan	1,986	16,344	2,932	23,734	4,190	33,612	4,591	36,739	5,111	40,819
Germany	888	14,522	1,504	23,780	1,726	23,503	1,835	25,133	2,414	29,569
U.S.A.	4,269	17,736	5,522	22,097	6,553	25,385	6,936	26,608	7,254	27,578
France	732	13,176	1,195	21,072	1,250	21,677	1,331	22,988	1,539	26,518
Canada	364	14,356	574	21,588	553	19,094	547	18,707	566	19,103
United Kingdom	564	9,923	979	17,001	946	16,260	1,024	17,500	1,106	18,977
Australia	167	10,104	295	16,457	284	15,555	324	17,594	349	18,605
Korea	109	2,635	254	5,916	333	7,530	381	8,528	457	10,124

< Table 1-12 > GDP of Major Countries
(Unit: billion US\$ for GDP, US\$ for per capita GDP)

Note: Current price basis

Source: International Statistical Yearbook, 1997, National Statistical Office.

4.2 Economic Growth Rate

Since the 1960s when the Korean government launched a series of Economic Development Plans, high economic growth rates have been recorded. In particular, for the period 1986-1995, Korea achieved a marked economic growth of 8.8% per annum, while the developed countries showed moderate growth rates of 2-3%.

	1986	1990	1993	1994	1995
Korea	11.6	9.5	5.8	8.6	8.9
Australia	1.8	1.4	4.0	4.9	3.2
United Kingdom	4.3	0.4	2.1	3.8	2.5
Canada	3.3	-0.2	2.2	4.1	2.3
France	2.5	2.5	-1.3	2.8	2.2
USA	2.9	0.8	2.2	3.5	2.0
Germany	2.3	5.8	-1.2	2.9	1.9
Japan	2.6	4.8	0.1	0.5	0.9

< Table 1-13 > Economic Growth Rates of Major Countries (Based on 1990 constant price)
(Unit : %)

Source: International Statistical Yearbook, 1997, National Statistical Office.

4.3 Current Account Balance and Foreign Debt

Even though Korea has achieved remarkable economic growth since 1970, its current account deficit has expanded. The trade deficit is growing due to high production costs, and the non trade deficit is growing due to the rapid increase in overseas travel. Except in 1993 when Korea had a current account surplus, the deficit was growing and recorded at US\$4.5

	1986	1990	1993	1994	1995
Korea	4.6	-2.2	0.4	-4.5	-8.9
China	85.8	35.9	132.0	130.6	111.3
India	-10.4	-22.6	-23.4	-17.3	-8.7
Indonesia	-150.5	-94.3	-99.7	-147.7	-148.2
Thailand	2.4	-9.9	9.0	7.0	16.4
Turkey	40.9	48.1	-13.4	-20.3	-20.8
Argentina	-1.3	-32.5	-16.2	-3.5	-6.2
Brazil	-9.9	-16.1	-10.5	-17.3	-19.2

< Table 1-14 > Current Account Balances of Major Countries
(Unit: billion US\$)

billion in 1994 and US\$8.9 billion in 1995.

Source: International Statistical Yearbook, 1997, National Statistical Office.

Accordingly, foreign debt was also growing rapidly. Foreign loans to Korea, which stood at US\$27.2 billion in 1980, grew to US\$56.9 billion in 1994.

	1980	1990	1992	1993	1994
Korea	272	317	428	439	569
China	45	528	598	842	1,005
India	206	820	898	921	990
Indonesia	209	700	883	895	965
Thailand	83	282	396	458	610
Turkey	191	492	565	688	663
Argentina	272	622	654	706	774
Brazil	729	1,215	1,305	1,454	1,511

< Table 1-15 > Foreign Debts of Major Countries
(Unit: billion US\$)

Note: Current prices.

Source: National Account, 1996, Bank of Korea.

4.4 Industrial Structure

The Republic of Korea has experienced rapid economic growth as well as dynamic change in its industry structure. The most remarkable changes have been declines in agriculture, forestry, fishing and mining industries, stable growth in manufacturing and the emergence of service industries. As productivities of agriculture, forestry and fishing industries stagnated during 1990-1995, their share of GDP decreased from 8.7% in 1990 to 6.6% in 1995.

The manufacturing sector maintained stable annual growth of 8.0% on average between 1990-1995, while its share in GDP remained below 30%. Growth of the manufacturing sector relied on the expansion of heavy and chemical industries, which accounted for 74% of total value-added of the manufacturing sector in 1995. On the other hand, the share of light industry was 26% of the total manufacturing sector in 1995 and has been decreasing continuously. The service sector achieved an annual average growth rate of 9.0% during 1990-1995, the highest growth rate in the private sector, and its share of GDP has remained around 50% since 1990.

Note: Based on current price GDP.

Source: National Account, 1996, Bank of Korea.

Regarding industry structure, the shares of agriculture, forestry and fishing industries and manufacturing are higher than those of most other advanced countries while the share of the service sector is lower.

	Agriculture, Forestry and Fishing	Mining and Manufacturing			Service Sector	Manufacturing Structure	
		Mining	Manufacturing	Construction, Electricity, Gas, and Water		Light Industry	Heavy and Chemical Industry
1970	26.6	1.5	21.0	6.6	44.2	60.8	39.2
1975	24.9	1.6	25.9	5.9	41.7	52.1	47.9
1980	14.7	1.5	28.2	10.1	45.5	46.4	53.6
1985	12.5	1.2	29.3	10.6	46.5	41.5	58.5
1990	8.7	0.6	29.2	13.7	47.7	34.1	65.9
1992	7.4	0.4	27.8	15.9	49.7	30.6	69.4
1994	7.0	0.4	26.9	15.8	50.7	26.9	73.1
1995	6.6	0.3	26.9	16.3	50.3	26.1	73.9

< Table 1-16 > Industry Structure

(Unit : %)

Source: International Statistics Yearbook, 1997, National Statistical Office.

4.5 Employment Structure

	Agriculture, forestry and fishing	Mining and Manufacturing		Service
			Manufacturing	
Korea(1995)	7	43	27	50
Japan(1993)	6	47	36	47
Canada(1993)	4	36	23	59
U.S.A.(1993)	2	23	18	76
France(1993)	2	30	N.A.	67
Germany(1993)	1	34	25	65
Italy(1993)	3	32	N.A.	65
United Kingdom(1992)	2	33	22	65
Australia(1992)	3	29	15	67

< Table 1-17 > Industry Structures of Major Countries
(Unit :%)

	Agriculture, Forestry and Fishing	Mining and Manufacturing		Serviced and Others
			Manufacturing	
1970	50.4	14.3	13.2	35.3
1975	45.7	19.1	18.6	35.2
1980	34.0	22.5	21.6	43.5
1985	24.9	24.4	23.4	50.6
1990	17.9	27.6	27.2	54.5
1992	15.8	25.8	25.5	58.4
1994	13.6	23.9	23.7	62.5
1995	12.5	23.5	23.4	64.0

< Table 1-18 > Employment Structure
(Unit : %)

Korea's employment structure has changed with rapid industrialization. The total number of employees in agriculture, forestry and fishing has declined from 50.4% in 1970, reaching 12.5% of the total number of employees in all sectors in 1995. The share of employment in the manufacturing sector grew from 13.2% to 23.4% over the same period. Those employed in social overhead capital and other service industries increased significantly, from 35.3% in

1970 to 64% in 1995. This rapid change is attributed to the shift in industry structure from primary industry to secondary and tertiary industries within a short period.

Note: Construction, electricity, gas, and water included.

Source: Korea's Major Economic Indicators, 1996, National Statistical Office.

As far as industry employment structure is concerned, Korea had 12.5% of total employment devoted to agriculture, forestry and fishing in 1995, which was noticeably higher than in other developed countries.

Source: International Statistical Yearbook, 1997, National Statistical Office.

	Agriculture, Forestry and Fishing	Mining and Manufacturing		Services and Others
			Manufacturing	
Korea(1995)	12.5	23.5	23.4	64.0
Japan(1995)	5.7	22.6	22.5	71.7
U.S.A. (1995)	2.9	16.9	16.4	80.2
Canada(1995)	4.1	16.5	15.3	79.4
Italy(1994)	7.9	24.2	22.7	67.9
Germany(1994)	3.3	27.5	26.7	69.2
France(1994)	4.7	19.2	18.8	76.1
Australia(1994)	5.0	15.0	14.0	80.0

< Table 1-19 > Employment Structures of Major Countries
(Unit : %)

5. Transportation

5.1 Volume of Transportation

5.1.1 Passenger Transportation

Passenger transportation in the ROK can be characterized by large increases in subways and in civil aviation, moderate increases in railroad and road, and stagnation in maritime transportation. In particular, the sharp growth in civil aviation due to rising per capita income is noteworthy. The increase in the number of passengers using subways reflects that subways are becoming more popular in urban areas than buses as the main mode of transportation. Of total passenger transportation, the share of roads has decreased steadily while that of subways has increased, since bus transportation has been replaced by subway transportation. However, road transportation still carried the largest number of passengers among all modes of transportation. The share of roads in terms of passenger-kilometers is also the highest. But the share of roads in terms of passenger-kilometers is relatively lower than that of the number of passengers transported because the travel distance on roads is shorter than that of railroads and civil aviation.

Source: Statistics Korea, Ministry of Construction, and Ministry of Transportation.

5.1.2 Freight Transportation

	Passenger Total	Railway	Subway	Road	Shipping	Civil Aviation	Passenger Total	Railway	Subway	Road	Shipping	Civil Aviation
	Passengers carried in millions						Passenger-km in millions					
1975	4804	221	34	4543	6	1	52686	12926	343	38865	252	300
1980	8,545	404	65	8,039	9	1	87,626	21,640	926	64,131	401	528
1985	11,441	503	325	10,601	9	3	106,849	22,595	4,477	78,025	570	1,182
1990	14,487	645	1,102	12,722	8	11	135,336	29,864	11,229	89,712	520	4,011
1995	13,559	790	1,450	11,290	9	21	123,572	29,292	14,048	72,324	502	7,406
1996	13,803	820	1,471	11,480	9	24	124,145	29,580	12,871	72,871	547	8,288

< Table 1-20 > Trends in Domestic Passenger Transportation

The trend in freight transportation can be characterized by sharp increases in maritime

shipping, moderate increases in road transportation and stagnation in railroad transportation. The tonnage carried by vessels increased to 141 million tons in 1996 from 12 million in 1975, a ten-fold increase.

Maritime freight transportation has been facilitated by the easy access to seawaterways as the ROK is a peninsula surrounded by coastal areas. Maritime freight transportation is 46,452 million ton-kilometers, amounting to a 59% share.

The stagnation of railroad freight transportation resulted from the increase in road freight transportation. The share of railroads in freight transportation is declining as that of roads grows.

Source: Construction and Transportation Statistical Yearbook, each year, Ministry of Construction and Transportation.

	Freight Total	Railway	Road	Shipping	Civil Aviation	Freight Total	Railway	Road	Shipping	Civil Aviation
	Tonnage carried in millions					million ton-km				
1975	139	43	85	12	-	17,872	9,293	3,845	4,732	2.5
1980	173	49	105	19	-	23,186	10,798	4,920	7,463	5.1
1985	238	55	149	34	-	31,029	12,296	7,068	11,639	26
1990	337	58	215	64	-	44,187	13,663	9,325	21,127	72
1995	595	57	408	129	-	76,110	13,838	18,213	43,936	123
1996	621	54	426	141	-	78,647	12,947	19,114	46,452	134

< Table 1-21 > Trends in Domestic Freight Transportation

5.2 Means of Transportation

The high level of both economic and income growth was followed by the increase in transportation demand. The number of passenger cars has soared by 75 fold, from 127,000 in 1970 to 9.553 million in 1996.

	Passenger Cars	Buses	Trucks	Special Cars	Total
1970	60	15	48	1	127
1975	84	21	82	5	194
1980	249	42	226	9	528
1985	556	128	412	16	1,113
1990	2,074	383	924	11	3,395
1992	3,461	483	1,261	25	5,231
1994	5,148	582	1,644	29	7,404
1995	6,006	612	1,816	33	8,469
1996	6,893	663	1,962	34	9,553

< Table 1-22 > Number of Registered Motor Vehicles
(Unit: thousand)

Source: Construction and Transportation Statistical Yearbook, each year, Ministry of Construction and Transportation.

Among passenger cars for private, government and commercial use, the number of private passenger cars has increased drastically. The number has grown steadily from 29,000 in 1970 to 179,000 in 1980, and began to increase rapidly from 1985 to reach 6,653,000 in 1996. The number of persons per private passenger car has decreased from 1,069 in 1970 to 213 in 1980, to 23 in 1990 and to less than seven in 1996.

	Year	Cars per Thousand Persons
Korea	1994	165
Japan	1994	520
Canada	1994	629
Mexico	1992	131
USA	1993	748
France	1994	517
Italy	1991	541
United Kingdom	1993	403
Australia	1993	574

< Table 1-23 > Automobile Ownership in Major Countries

Source: International Statistics Yearbook, 1997, National Statistical Office.

Source: Construction and Transportation Statistics Yearbook, Ministry of Construction and Transportation

	1970	1975	1980	1985	1990	1995	1996
Number of Private Passenger Cars (thousand)	29	50	179	449	1,902	5,778	6,653
Number of Persons per Car	1,095	704	213	91	23	7.8	6.7

< Table 1-24 > Number of Private Passenger Cars and Persons per Car

2 Energy Consumption

1. Overview

Korea's energy consumption has increased sharply since the mid-1970s due to rapid economic growth focused on heavy and chemical industries. Primary energy consumption increased 7.8% annually from 1981 to 1990, and 10.0% annually from 1991 to 1996. Thus, primary energy consumption grew to 165.209 million TOE in 1996 from 43.911 million TOE in 1980.

Per capita energy consumption has also risen as personal income surged thanks to economic growth. Per capita energy consumption has been increasing especially, rapidly since the late 1980s. It reached to 3.63 TOE in 1996 from 1.15 TOE in 1980.

As a result Korea's dependency on foreign energy continues to increase. The dependency rate on imported energy (including nuclear power) rose from 73.5% in 1980, to 87.9% in 1990, and to 97.8% in 1996. Imported energy is currently meeting nearly all domestic energy demands. This trend is attributed to the fact that demand for high-quality energies such as petroleum and natural gas has risen while production of domestic anthracite coal has fallen sharply.

The energy/GDP ratio, which fell in the late 1980s, began to rise again from 1989. The ratio rose from about 0.5 between 1986 and 1989 to 0.6 in 1996, which is close to the 1980 level. This hike is explained by the fact that the economy depends largely on energy-intensive industries, especially heavy and chemical industries. On the other hand, the energy/GDP elasticity trend in the reverse

Source: Yearbook of Energy Statistics, 1997, KEEI.

of the energy /GDP ratio. The elasticity, which rose in late 1980s, declined in the 1990s.

		1980	1985	1990	1994	1995	1996	AAGR (%)	
								81-90	91-96
Energy Consumption (1,000 TOE)	Primary	43,911	56,296	93,192	137,235	150,437	165,209	7.8	10.0
	Final	37,597	46,998	75,107	112,206	121,850	132,033	7.2	9.8
Per Capita Energy Consumption (TOE/Person)		1.15	1.38	2.17	3.09	3.35	3.63	7.2	8.9
Dependency on Imported Energy (%)	Nuclear included	73.5	76.2	87.9	96.4	96.8	97.8		
	Nuclear excluded	71.6	68.8	73.7	85.7	85.6	86.1		
Share of Petroleum in Primary Energy Consumption		61.1	48.2	53.8	62.9	62.5	60.5		
Share of Electricity in Final Energy Consumption		7.5	9.3	10.8	11.2	11.5	11.9		
Energy Price Index		71.7	141.0	100.0	115.54	121.4	137.9		
Energy/GDP Ratio (TOE/Million Won)		0.58	0.51	0.52	0.58	0.58	0.60		
Economic Growth Rate(%)		-2.7	6.5	9.5	8.4	8.7	6.9	9.4	7.4
Growth Rate of Primary Energy Consumption(%)		1.5	5.4	14.1	8.1	9.6	9.8		
Energy Elasticity		-	0.83	1.48	0.96	1.10	1.41		

< Table 2-1 > Major Energy/Economic Indicators

Comparing Korea's energy/economic indicators with major developed countries Korea's economic growth rate and energy consumption growth rate, 8.9% and 9.6% in 1995, respectively, were much higher than OECD countries' 1.9% and 1.6% in 1995. Such high energy consumption growth in Korea, which is still in the development stage, is the result of its high economic growth. However, per capita energy consumption in Korea is lower than the average per capita energy consumption in OECD countries.

Sources: Energy Balances of OECD Countries, 1997, OECD. International Financial Statistics, 1997, IMF.

	Korea		USA		Japan		OECD	
	1990	1995	1990	1995	1990	1995	1990	1995
Economic Growth Rate (%)	9.5	8.9	0.8	2.0	4.8	0.9	2.7	1.9
Energy Consumption Growth Rate (%)	14.1	9.6	0.1	1.6	3.4	3.9	0.2	1.6
Energy/GDP Ratio (TOE/US\$1000)	0.3	0.4	0.3	0.3	0.1	0.1	0.2	0.2
Per Capita Energy Consumption (TOE/Person)	2.1	3.3	7.7	7.8	3.4	3.9	4.2	4.3

< Table 2-2 > Energy/Economic Indicators of Major Countries

With respect to electricity consumption, per capita electricity consumption in Korea, 4,006

kWh/person in 1995, was far lower than those of developed countries in the same year.

Source: Energy Balances of OECD Countries, 1997, OECD.

BP Statistical Review of World Energy, 1997. Yearbook of Energy Statistics, 1997, KEEI.

Source: Dynamic Forces in Capitalist Development, Angus Madison. BP Statistical Review of World Energy, 1997. Yearbook of Energy Statistics, 1997, KEEI.

	Korea		USA		Japan		UK	
	1990	1995	1990	1995	1990	1995	1990	1995
Per Capita Electricity Consumption (kWh/Person)	2,002	4,006	11,210	11,160	5,300	5,910	4,940	4,880

< Table 2-3 > Per Capita Electricity Consumption in Major Countries

Source: Dynamic Forces in Capitalist Development, Angus Madison. BP Statistical Review of World Energy, 1997. Yearbook of Energy Statistics, 1997, KEEI.

	1913	1950	1973	1990	1996
USA	436.5	866.0	1759.4	1930.7	2130.3
Japan	21.7	44.9	338.9	428.1	501.8
Germany	93.8	93.9	266.2	351.8	345.0
France	55.7	64.6	179.9	220.9	243.4
UK	157.5	158.3	220.8	213.3	230.1
Korea	N.A.	N.A.	25.0	93.2	165.1

< Table 2-4 > Energy Consumption of Major Countries

(Unit : Million TOE)

	1914-1950	1951-1973	1974-1990	1991-1996
USA	1.87	3.13	0.55	1.65
Japan	1.98	9.19	1.38	2.68
Germany	0.00	4.63	1.65	-0.32
France	0.40	4.50	1.22	1.63
UK	0.01	1.46	-0.20	1.27
Korea	NA	NA	8.05	10.01

< Table 2-5 > Annual Average Growth Rate of Energy Consumption in Major Countries

(Unit : %)

2. Energy Consumption by Source

In addition to rapid energy consumption growth, Korea has experienced significant changes in energy consumption structure since 1980. These changes can be summarized as the emergence of clean energy such as nuclear power and LNG, the decline of domestic coal, and the stable growth of petroleum. As a result, the shares of nuclear and LNG in total energy consumption jumped while that of coal plummeted. Petroleum consumption has maintained its share of around 60% in total primary energy.

Oil consumption increased from 182.105 million Bbl in 1980 to 721.063 million Bbl in 1996, which is twice the 1990 level. This increase was partly the result of the substitution of oil for coal. The expansion of petro-chemical facilities especially accelerated oil consumption in the 1990s.

Note : Share in parentheses. Source: Yearbook of Energy Statistics, 1997, KEEL.

The share of coal in primary energy consumption, 30.1% in 1980, rapidly decreased to

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Petroleum (kBBL)	182,105 (61.1)	189,191 (48.2)	356,349 (53.8)	621,498 (62.9)	677,209 (62.5)	721,063 (60.5)	6.9	12.4
Coal (kTon)	25,862 (30.1)	40,533 (39.1)	43,405 (26.2)	42,660 (19.4)	44,352 (18.7)	50,277 (19.7)	5.3	2.4
LNG (kTon)	- (0.0)	- (0.0)	2,329 (3.2)	5,860 (5.6)	7,087 (6.1)	9,361 (7.4)	-	26.1
Hydro Power (GWh)	1,984 (1.1)	3,659 (1.6)	6,361 (1.7)	4,098 (0.7)	5,478 (0.9)	5,201 (0.8)	12.4	-3.2
Nuclear Power (GWh)	3,477 (2.0)	16,745 (7.4)	52,887 (14.2)	58,651 (10.7)	67,029 (11.1)	73,924 (11.2)	31.3	5.7
Misc. (kTOE)	2,492 (5.7)	2,031 (3.6)	797 (0.9)	742 (0.7)	1,051 (0.7)	1,161 (0.7)	-10.8	6.5
Total (kTOE)	43,911 (100.0)	56,296 (100.0)	93,192 (100.0)	137,235 (100.0)	150,437 (100.0)	165,209 (100.0)	7.8	10.0

< Table 2-6 > Trend in Primary Energy Consumption

26.2% in 1990 and fell to 19.7% in 1996, although coal consumption grew 2.4% between 1991 and 1996. In fact, domestic anthracite consumption declined dramatically due to the

"rationalization of coal industry" policy in response to mounting environmental concerns and high cost in domestic coal production. Only imported bituminous coal consumption was increased, owing to the demand mainly from steel and electricity industries.

As a clean energy source, LNG consumption in Korea exploded since 1986 when LNG was first introduced. LNG consumption increased 177-fold in 11 years, reaching 9,361 thousand tons in 1996 from 53 thousand tons in 1986. LNG accounted for 7.4% of total primary energy consumption in 1996. Its meteoric rise is attributed to the government's policy to encourage LNG consumption, reducing the nation's heavy reliance on petroleum and diversify energy sources and also to consumers' preference for cleaner energy. The Korean Government has undertaken consistent construction of infrastructure for LNG supply, such as receiving terminals and a national pipeline network, to meet the ever-increasing demand.

Nuclear power, another clean energy source introduced in 1978, also has exhibited significant growth. Its consumption increased at an annual rate of 31.3% in the 1980s. Nuclear power generation, 73,924GWh in 1996, accounted for 11.2 % of total primary energy consumption.

Korea's dependency rate on fossil fuels was 87.3% in 1995, slightly higher than average OECD levels.

Source : BP Statistical Review of World Energy, 1997.

3. Energy Consumption by Sector

	Korea		USA		Japan		OECD	
	1990	1995	1990	1995	1990	1995	1990	1995
Petroleum	53.8	62.5	39.9	39.0	58.9	54.6	42.1	43.0
Natural Gas	3.2	6.1	23.1	27.0	10.0	11.2	20.0	22.6
Coal	26.2	18.7	27.4	23.9	17.1	17.5	22.4	20.7
Nuclear Power	14.2	11.1	8.4	8.8	12.2	15.1	9.1	11.2
Hydro Power	1.7	0.9	1.2	1.2	1.8	1.5	6.4	2.5
Reliance on Fossil Fuels	83.2	87.3	90.4	89.9	86.0	83.3	84.5	86.3

< Table 2-7 > Energy Consumption Structures in Major Countries

(Unit : %)

Sectoral energy consumption in Korea since the 1980s can be characterized by rapid increases in the industry and transportation sectors and slow or even negative growth in the

commercial/residential and public sectors. As a result of these changes in the sectoral energy consumption, the shares of the industry and transportation sectors in final energy consumption reached 51.4% and 22.6% in 1996 from 44.1% and 13% in 1980 respectively. Meanwhile, the share of the commercial/residential and public sectors shrank from 37.3% and 5.6% to 24.0% and 2.0%, respectively, during the same period.

Note: Shares in the parentheses.

Source: Yearbook of Energy Statistics, 1997, KEEI.

3.1. Industrial Sector

As economic growth has been led by the industry sector, so has energy consumption. Energy consumption in the industrial sector increased from 16,571 million TOE in 1980 to

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Industry	16,571 (44.1)	20,014 (42.6)	36,151 (46.2)	59,909 (53.4)	62,946 (51.6)	67,869 (51.4)	8.1	13.4
Transportation	4,905 (13.0)	6,707 (14.3)	14,173 (17.6)	23,860 (21.3)	27,148 (22.3)	29,792 (22.6)	11.2	13.2
Residential and Commercial	14,034 (37.3)	18,180 (38.7)	21,971 (32.3)	25,968 (23.1)	29,339 (24.1)	31,713 (24.0)	4.6	6.3
Public and Other	2,087 (5.6)	2,096 (4.5)	2,812 (4.6)	2,469 (2.2)	2,416 (2.0)	2,659 (2.0)	3.0	-0.9
Total	37,597 (100.0)	46,998 (100.0)	75,107 (100.0)	112,206 (100.0)	121,850 (100.0)	132,033 (100.0)	7.2	9.9

< Table 2-8 > Trend of Final Energy Consumption by Sector

(Unit : kTOE, %)

36.151 million TOE in 1990 (2.2 times), to 67.869 million TOE in 1996 (1.9 times the 1990 level), which accounted for 51.4% of the total final energy consumption.

Regarding energy consumption in the industrial sector, petroleum's share was significant at 57.4%, followed by coal at 25.0 % and electricity at 13.5%. As anthracite coal consumption has almost completely ceased, bituminous coal has been mainly consumed to meet the demand in steel and power generation industries. Coal consumption grew from 22.0% in 1980, 29.9% in 1990 and then fell to 25.0% in 1996,

Note: Shares in parentheses.
Source: Yearbook of Energy Statistics, 1997, KEEL.

3.2 Transport Sector

Energy consumption in the transport sector showed a marked increase compared to other sectors. It was only 4.905 million TOE in 1980, but increased to 14.173 million TOE in 1990 and to 29.792 million TOE in 1996 (2.1 times the 1990 level). Thus, the share of transport sector in final energy consumption rose from 13.0% in 1980 to 17.6% in 1990 and

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Petroleum	10,948 (66.0)	10,697 (53.4)	20,014 (55.4)	35,881 (64.5)	36,810 (58.5)	38,913 (57.4)	6.2	13.0
Coal	3,653 (22.0)	6,491 (32.4)	10,807 (29.9)	15,403 (27.7)	16,244 (25.8)	17,669 (25.0)	11.5	8.5
Electricity	1,971 (12.0)	2,812 (14.0)	5,095 (14.1)	7,398 (13.3)	8,293 (13.2)	9,179 (13.5)	10.0	10.2
City Gas	0.0 (0.0)	15.0 (0.1)	235 (0.7)	601 (1.1)	863 (1.4)	1,196 (1.8)	-	29.7
Others	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	626 (1.1)	763 (1.2)	912 (1.3)	-	-
Total	16,571 (100.0)	20,015 (100.0)	36,151 (100.0)	55,591 (100.0)	62,946 (100.0)	67,869 (100.0)	8.1	11.7

< Table 2-9 > Trend of Energy Consumption by Source in Industrial Sector
(Unit : thousand TOE, %)

to 22.6% in 1996.

Although such increases were brought about by factors in all transportation modes, the leading factor was the sharp increase of gasoline consumption caused by private passenger car expansion. Gasoline consumption, which was 759 thousand TOE in 1980, increased to 2.936 million TOE in 1990 and to 8.664 million TOE, or 30.8% of energy consumption in the transportation sector, in 1996.

Note: Shares in the parentheses.
Source : Yearbook of Energy Statistics, 1997, KEEL.

3.3. Residential and Commercial Sectors

Energy consumption in the residential and commercial sector grew moderately from 1980 to 1996 compared to those of other sectors like industry and transportation. It increased from 14.034 million TOE in 1980 to 21.973 million TOE in 1990 and to 31.713

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Petroleum	4,869 (99.3)	6,645 (99.1)	14,086 (99.4)	23,736 (99.5)	27,010 (99.5)	29,647 (99.5)	11.2	13.2
Gasoline	759 (16.7)	754 (11.3)	2,936 (20.8)	6,451 (27.2)	7,527 (27.9)	8,664 (30.8)	12.2	23.9
Electricity	34 (0.7)	62 (0.9)	87 (0.6)	124 (0.5)	138 (0.5)	145 (0.5)	9.9	8.9
Total	4,905 (100.0)	6,707 (100.0)	14,173 (100.0)	23,860 (100.0)	27,148 (100.0)	29,792 (100.0)	11.2	13.2

< Table 2-10 > Trend of Energy Consumption by Source in Transport Sector
(Unit : kTOE, %)

million TOE in 1996 (1.4 times the 1990 level). Hence, the share of the residential and commercial sector in final energy consumption fell significantly from 37.3% in 1980 to 24.0% in 1996.

One of the most dramatic changes in energy consumption patterns since the late 1970s can be seen in the residential and commercial sector. Coal, once the main source of energy, accounting for 61.8% of energy demand in the sector in 1980, became the least important source with 3.3% share in 1996. The shares of oil, gas, and electricity consumption rose from 15.8%, 0.1%, and 4.4% to 58.7%, 17.6%, and 17.2%, respectively, during the same period.

Such changes came from persistent inter-fuel substitution with the increased availability of more convenient fuels like petroleum and gas in the residential sector and also from government regulations to limit coal consumption in urban areas to reduce air pollution. The consumption of petroleum increased from 2.222 million TOE in 1980 to 8.879 million TOE

in 1990 and to 18.623 million TOE in 1996. In contrast, coal consumption increased from 8.670 million TOE in 1980 to 9.027 million TOE in 1990 and then decreased to 1.050 million TOE in 1996.

Note: Shares in parentheses.

Source: Yearbook of Energy Statistics, 1997, KEEI.

The increase in electricity demand was caused by the rapid dissemination of household appliances and home electronics products. Color TVs and refrigerators numbered more than one per household by the end of the 1980s, and washing machines numbered almost one per household by the mid-1990s.

The number of air conditioners steadily increased from 0.09 per household in 1993 to 0.13 per household in 1995, while PCs grew from 0.32 per household in 1993 to 0.61 in 1995

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Petroleum	2,222 (15.8)	3,525 (19.4)	8,879 (40.4)	15,375 (59.2)	17,632 (60.01)	18,623 (58.7)	14.3	13.1
Coal	8,670 (61.8)	11,400 (62.7)	9,027 (41.1)	2,267 (8.7)	1,514 (5.2)	1,050 (3.3)	0.4	-30.1
Electricity	611 (4.4)	1,155 (6.4)	2,421 (11.0)	4,321 (16.6)	4,801 (16.4)	5,464 (17.2)	14.8	14.5
City Gas	15 (0.1)	69 (0.4)	777 (3.5)	3,313 (12.8)	4,495 (15.3)	5,588 (17.6)	48.4	38.9
Thermal Energy	0.0 (0.0)	0.0 (0.0)	75 (0.3)	454 (1.7)	632 (2.2)	796 (2.5)	-	48.2
Others	2,517 (17.9)	2,031 (11.2)	797 (3.6)	238 (0.9)	265 (0.9)	192 (0.6)	-10.9	-21.1
Total	14,034 (100.0)	18,180 (100.0)	21,973 (100.0)	25,968 (100.0)	29,339 (100.0)	31,713 (100.0)	4.6	6.3

< Table 2-11 > Trend of Energy Consumption in Residential/Commercial Sector

(Units : TOE, %)

(doubling in two years).

Source: Study on Penetration Rate of Appliances, 1996, KEPCO.

3.4. Public and Other Sectors

	1989	1991	1993	1995
Color TV	104	127	135	137
Refrigerator	103	110	108	105
Washing Machine	65	86	91	96
Air Conditioner	9	8	9	13
PC	4	11	32	61

< Table 2-12 > Per Household Ownership Rate of Major Appliances
(Unit : %)

Energy consumption in public and other sectors, which showed a moderate increase in the 1980s, began to decrease in the 1990s. Energy consumption in these sectors increased from 2.087 million TOE in 1980 to 2.812 million TOE in 1990, then decreased to 2.659 million TOE in 1996.

Among energy sources, coal and petroleum consumption decreased while gas and electricity consumption increased. Petroleum consumption, which accounted for 85.6% of total energy consumption in these sectors in 1980 and 80.9% in 1990, fell to 1.530 million TOE in 1996, only 57.6% of total consumption. Electricity consumption was 904 thousand TOE in 1996 (33.9%), a relatively high increase from 9.5% in 1985 and 18.3% in 1990. Gas consumption has also steadily increased, reaching 153 thousand TOE in 1996, and the trend is projected to continue.

4. Power Generation

Power generation in Korea has increased tremendously over the past two decades. At the same time, it has undergone structural changes to meet increasing demand for electricity resulting from economic and income growth. Power generation rose from 37,238 GWh in 1980 to 205,493 GWh in 1996. Meanwhile, nuclear and LNG power generation surged replacing oil-fired plants which played a major role in the 1980s.

Note: Shares in the parentheses.

Source: Yearbook of Energy Statistics, each year, KEEL.

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Total Power Generation (GWh)	37,238	58,007	107,669	164,992	184,660	205,493	11.2	11.3
- Nuclear	3,477 (9.3)	16,745 (28.9)	52,887 (49.1)	58,651 (35.5)	67,029 (36.3)	73,924 (36.0)	31.3	5.7
- Coal	2,481 (6.7)	17,639 (30.4)	19,961 (18.5)	41,835 (25.4)	48,813 (26.4)	56,881 (27.6)	23.2	19.1
- LNG	-	-	9,604 (8.9)	20,046 (12.1)	21,296 (11.5)	27,050 (13.2)		18.8
- Petroleum	29,297 (78.7)	19,964 (34.5)	18,856 (17.6)	40,313 (24.5)	42,045 (22.8)	42,436 (20.7)	-4.3	14.5
- Hydro	1,984 (5.3)	3,659 (6.3)	6,361 (5.9)	4,098 (2.5)	5,478 (3.0)	5,201 (2.5)	12.4	-3.2
Generation Facilities (MW)	9,390	16,136	21,021	28,749	32,183	35,715	8.4	9.2
Transmission and Distribution Loss (%)	6.6	5.89	5.62	5.59	5.46	5.40	-	-

< Table 2-13 > Major Indicators in Power Generation Sector

Since 1978, when the first nuclear power plant began its commercial operation, nuclear power generation has increased more than 21.1% per annum. Between 1981 and 1990, the growth rate was 31.3%, accounting for more than half of the total electricity consumed in 1987.

Such expansion of nuclear power generation capacity reduced the share of thermal power generation capacity. The share of oil-fired thermal power generation has plummeted from

78.7% in 1980 to 20.7% in 1996. LNG-fired power generation, introduced in 1986, increased to 13.2% of total generation in ten years.

Such trends show that the Korean Government has taken significant steps to expand nuclear and LNG power generation capacity to ease environmental problems from fossil fuel use. Other achievements like thermal efficiency improvement and reduction of transmission and distribution losses also helped ease environmental problems.

Sources: 1. Energy Balances of OECD Countries, 1993-1994, 1997.
2. Business Statistics, 1997, KEPCO.

Source: Business Statistics, 1997, KEPCO.

	Korea		USA		Japan		UK	
	1990	1995	1990	1995	1990	1995	1990	1995
Nuclear	49.1	36.3	19.2	20.1	23.8	26.7	20.7	26.7
Coal	18.5	26.4	53.4	54.5	14.5	17.8	65.1	43.0
LNG	8.9	11.5	12.0	14.9	19.5	19.5	1.1	17.5
Petroleum	17.5	22.8	4.1	2.5	31.6	22.8	10.8	10.6
Hydro	5.9	3.0	8.5	8.8	10.5	8.4	1.6	1.6

< Table 2-14 > Power Generation Mix in Major Countries
(Based on Generation Levels)
(Unit : %)

	Korea		USA		Japan		UK	
	1990	1995	1990	1995	1990	1995	1990	1995
Efficiency in Thermal Power Plants	34.9	38.1	32.9	32.7	37.1	37.2	33.7	35.7
Losses in Transmission and Distribution	5.6	5.4	5.7	5.4	5.7	5.5	8.1	8.0

< Table 2-15 > International Comparison of Power Generation Efficiency and Transmission and Distribution Losses
(Unit : %)

3 Inventory of Greenhouse Gas Emissions and Removals

This inventory of greenhouse gas emissions and removals in Korea is based on IPCC guidelines¹⁾ with a base year of 1990. It covers direct greenhouse gases (CO₂, CH₄, and N₂O) as well as indirect greenhouse gases (NO_x, CO, and NMVOC). This chapter provides annual estimates of CO₂ emissions from fossil fuel combustion between 1991 and 1995.

1. Methods for Inventories

1.1 Overview

The emissions and removals of greenhouse gases presented herein are based on "IPCC Guidelines for National Greenhouse Gas Inventories" (UNEP/OECD/IEA/IPCC, 1995). However, a non-IPCC methodology was used to calculate methane emissions from rice fields and livestock in the agriculture sector. Emissions from international activities including air and marine transportation are listed separately as "international bunkering."

1.2 Greenhouse Gas Coverage and Base Year

Six greenhouse gases are covered: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), nitrogen oxides (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs). Non-CO₂ greenhouse gas emissions in the energy-related sector are calculated based on 1989 census data. CO₂ emissions from fossil fuel combustion are provided for the period between 1991 and 1995.

¹⁾ However, in some cases, an inventory methodology was applied different from that is recommended in IPCC Guidelines. An explanation for the difference in methodologies is given where appropriate.

1.3 Classification of Sectors

The major sectors to be addressed are the energy, industrial processes, agriculture, waste management, forestry, and land use sectors. For each sector inventories of CO₂, CH₄, N₂O, and other gases are separately listed as well as CO₂ sinks. The energy sector consists of combustion and non-combustion sub-sectors.

1.4. International Bunkering and Biomass

International bunkering is reported separately and not included in domestic totals. CO₂ emissions from biomass are assumed to be zero in accordance with the sustainable growth assumption.

1.5 Accuracy of Emissions Data

The reliability of the emissions inventory depends on input statistics and inventory methodologies. When input statistics are insufficient or emission factors are not suitable for existing data, the reliability is somewhat degraded.

The CO₂ emissions inventory from energy consumption is relatively reliable as energy consumption data has been well established since the end of the 1960's. Its reliability has been enhanced by the 1978 establishment of the Ministry of Energy and Resources, which is now a part of the Ministry of Trade, Industry and Energy.

Korea's Yearbook of Energy Statistics is the major source of data. It records not only the amount of energy consumption by sector but also the electricity sector by source. However, detailed, industry specific data on end-user energy consumption is not available nor is data on energy consumption by type of appliance and equipment.

The non-CO₂ emissions inventory from energy consumption is not as reliable as other statistics because IPCC emission factors are not suitable for the currently available data. To apply the IPCC non-CO₂ emission factors requires final energy consumption data by sector as well as by end-user, but there is no data satisfying such requirements at the moment. The best available data is from Korea's "Energy Census" which has been conducted once every

three years. In order to produce the most reliable non-CO₂ emissions inventory of residential and commercial, and public sectors the data from "Energy Census, '89" has been utilized.

The reliability of the non-CO₂ emissions inventory of other sectors including agriculture, forestry, waste management and industrial processes is significantly hampered by the lack of accumulated input data. To make the emissions inventory for these sectors more reliable in the future, the Korean Government will take measures to modify ways to collect, process, and report the necessary inventory data.

2. Overview of Emissions and Removals of Greenhouse Gases

2.1 Overview of Greenhouse Gas Emissions and Removals

Table 3-1 shows greenhouse gas emissions and removals for 1990. Although it provides a full account of CO₂ and non-CO₂ emissions in the energy sector, the table does not cover a significant portion of other sectors which do not have relevant data available. For the next National Communication, the Korean Government will make efforts to refine and provide an emissions inventory for sectors which are not covered in this report.

Note: 1) non-CO emissions are those from residential and commercial sectors in 1989

Category	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOCs
Net Emissions	230,278	1,362	12	851	1,056	152
1. Energy-Related Emissions	238,990	264	11	851	1,056	152
A. Fuel Combustion	238,990	17	11	851	1,056	152
1. Energy Transformation	37,934	0.3	2	193	7	N.A.
2. Industry	87,282	1	2	135	25	N.A.
3. Transport	42,198	6	2	401	600	152
4. Residential and Commercial ¹⁾	64,592	7	3	105	364	N.A.
5. Public and Other ²⁾	6,985	0.5	4	16	39	N.A.
6. Biomass Burning	-	2	0.02	0.6	20	N.A.
B. Fugitive Fuel Emissions	-	246	-	-	-	-
1. Coal Mining	-	230	-	-	-	-
2. Oil and Gas Systems	-	16	-	-	-	-
2. Industrial Processes	17,512	5	-	-	-	-
A. Cement Industry	14,841	-	-	-	-	-
B. Limestone and Dolomite Use	2,459	-	-	-	-	-
C. Soda Ash Use	212	-	-	-	-	-
D. Chemical Industry	-	5	-	-	-	-
3. Agriculture	-	599	1	-	-	-
A. Rice Fields	-	414	-	-	-	-
B. Enteric Fermentation	-	144	-	-	-	-
C. Animal Excrement	-	41	-	-	-	-
D. Nitrogen Fertilizers	-	-	1	-	-	-
4. Waste Management	11	495	-	-	-	-
A. Waste Incineration	11	-	-	-	-	-
B. Landfills	-	200	-	-	-	-
C. Household Wastewater	-	21	-	-	-	-
D. Industry Wastewater	-	274	-	-	-	-
5. Total	256,513	-	-	-	-	-
6. Removals (Managed Forest)	-26,235	-	-	-	-	-
7. International Bunkering	7,140	-	-	-	-	-

< Table 3-1 > Greenhouse Gas Emissions/Removals in Korea (1990) (nit : Gg)

2) non-CO₂ emissions are those from public and other sectors in 1989

shares of energy & diff fuels

Note: 1) non-CO emissions are those from residential and commercial sectors in 1989

Category	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOCs
Net Emissions	230,278	1,362	12	851	1,056	152
1. Energy-Related Emissions	238,990	264	11	851	1,056	152
A. Fuel Combustion	238,990	17	11	851	1,056	152
1. Energy Transformation	37,934	0.3	2	193	7	N.A.
2. Industry	87,282	1	2	135	25	N.A.
3. Transport	42,198	6	2	401	600	152
4. Residential and Commercial ¹⁾	64,592	7	3	105	364	N.A.
5. Public and Other ²⁾	6,985	0.5	4	16	39	N.A.
6. Biomass Burning	-	2	0.02	0.6	20	N.A.
B. Fugitive Fuel Emissions	-	246	-	-	-	-
1. Coal Mining	-	230	-	-	-	-
2. Oil and Gas Systems	-	16	-	-	-	-
2. Industrial Processes	17,512	5	-	-	-	-
A. Cement Industry	14,841	-	-	-	-	-
B. Limestone and Dolomite Use	2,459	-	-	-	-	-
C. Soda Ash Use	212	-	-	-	-	-
D. Chemical Industry	-	5	-	-	-	-
3. Agriculture	-	599	1	-	-	-
A. Rice Fields	-	414	-	-	-	-
B. Enteric Fermentation	-	144	-	-	-	-
C. Animal Excrement	-	41	-	-	-	-
D. Nitrogen Fertilizers	-	-	1	-	-	-
4. Waste Management	11	495	-	-	-	-
A. Waste Incineration	11	-	-	-	-	-
B. Landfills	-	200	-	-	-	-
C. Household Wastewater	-	21	-	-	-	-
D. Industry Wastewater	-	274	-	-	-	-
5. Total	256,513	-	-	-	-	-
6. Removals (Managed Forest)	-26,235	-	-	-	-	-
7. International Bunkering	7,140	-	-	-	-	-

< Table 3-1 > Greenhouse Gas Emissions/Removals in Korea (1990) (unit : Gg)

2) non-CO₂ emissions are those from public and other sectors in 1989

2.2 Global Warming Potential (GWP)

Table 3-2 shows the result of GWP for direct greenhouse gas emissions with a 100-year time horizon, which was calculated in accordance with the IPCC guidelines. It indicates that CO₂ emissions have the largest share of GWP, 87.7%, followed by methane and nitrous oxide.

Source : Korea Energy Economics Institute

	Emissions(Gg)	GWP Index	GWP	Share (%)
Carbon Dioxide (CO ₂)	230,278	1	230,278	87.7
Methane (CH ₄)	1,362	21	28,602	10.9
Nitrous Oxide (N ₂ O)	12	310	3,720	1.4
Total			262,600	100.0

< Table 3-2 > GWP of direct GHGs with 100-year time horizon.

(unit: Gg-CO₂)

3. Carbon Dioxide (CO₂)

3.1. Overview

Carbon dioxide emissions are mainly from fossil fuel combustion, industrial processes and waste management, and their major sinks are forests. However, CO₂ emissions from this source are not considered as there is no significant land use change in Korea.

The net CO₂ emissions in Korea for 1990 were 230,278 Gg (equivalent to 62.8 MtC), while total emissions were 256,513 Gg and forest net removals 26,235 Gg, 10% of total emissions. International bunkering of 7,140 Gg is not included in the net emissions calculation.

4. Power Generation

Power generation in Korea has increased tremendously over the past two decades. At the same time, it has undergone structural changes to meet increasing demand for electricity resulting from economic and income growth. Power generation rose from 37,238 GWh in 1980 to 205,493 GWh in 1996. Meanwhile, nuclear and LNG power generation surged replacing oil-fired plants which played a major role in the 1980s.

Note: Shares in the parentheses.

Source: Yearbook of Energy Statistics, each year, KEEL.

	1980	1985	1990	1994	1995	1996	AAGR (%)	
							81-90	91-96
Total Power Generation (GWh)	37,238	58,007	107,669	164,992	184,660	205,493	11.2	11.3
- Nuclear	3,477 (9.3)	16,745 (28.9)	52,887 (49.1)	58,651 (35.5)	67,029 (36.3)	73,924 (36.0)	31.3	5.7
- Coal	2,481 (6.7)	17,639 (30.4)	19,961 (18.5)	41,835 (25.4)	48,813 (26.4)	56,881 (27.6)	23.2	19.1
- LNG	-	-	9,604 (8.9)	20,046 (12.1)	21,296 (11.5)	27,050 (13.2)		18.8
- Petroleum	29,297 (78.7)	19,964 (34.5)	18,856 (17.6)	40,313 (24.5)	42,045 (22.8)	42,436 (20.7)	4.3	14.5
- Hydro	1,984 (5.3)	3,659 (6.3)	6,361 (5.9)	4,098 (2.5)	5,478 (3.0)	5,201 (2.5)	12.4	-3.2
Generation Facilities (MW)	9,390	16,136	21,021	28,749	32,183	35,715	8.4	9.2
Transmission and Distribution Loss (%)	6.6	5.89	5.62	5.59	5.46	5.40	-	-

< Table 2-13 > Major Indicators in Power Generation Sector

Since 1978, when the first nuclear power plant began its commercial operation, nuclear power generation has increased more than 21.1% per annum. Between 1981 and 1990, the growth rate was 31.3%, accounting for more than half of the total electricity consumed in 1987.

Such expansion of nuclear power generation capacity reduced the share of thermal power generation capacity. The share of oil-fired thermal power generation has plummeted from

3.2. Energy Sector

In 1990, CO₂ emissions from fossil fuel combustion reached 238,990Gg. The energy sector, the primary fossil fuel combustion sector, consists of industry, transport, residential and commercial, public, and energy transformation sub-sectors. The energy transformation sub-sector incorporates electric power generation. This sub-sector separately includes CO₂ emissions from electricity consumption in industry, transport, residential and commercial and public sectors.

CO₂ emissions from fossil fuel combustion in the industry sub-sector had the largest share, accounting for 37% of total CO₂ emissions. The combined total of emissions from residential and commercial sub-sectors was the second largest with a share of 27%, followed by 18% in the transportation sub-sector, 3% in public sub-sector, and 16% in energy transformation sub-sector.

3.3. Industrial Process and Waste Management Sectors

Carbon Dioxide emissions data are not readily available for all sub-sectors, but are available for some individual industries. Cement production is the main source of CO₂ emissions, with total emissions amounting to 14,841Gg in 1990. There are two processes emitting CO₂ in cement production: one is the soda ash utilization process and the other is the limestone and dolomite utilization process. CO₂ emissions from the soda ash utilization process were 212 Gg, and those from limestone & dolomite use 2,459Gg. In addition, CO₂ emissions from waste incineration in the waste management sector were 1Gg. The next National Communication will cover more industries for the calculation of CO₂ emissions.

3.4. Removals of Carbon Dioxide

Land use change is not significant in the forestry sector in Korea and less than 10,000 ha per year has been converted to other uses. Thus, the change in greenhouse gas emissions by land use change was not calculated. As a result, the net CO₂ removals by forests are determined from differences between "total sinks from tree growth" and "total emissions from harvests."

Total carbon dioxide removals by forests in 1990 were 29,073Gg, while CO₂ emissions

by harvest were 2,838 Gg. Net CO₂ removals by forests were 26,235 Gg).

Source : Korean Forestry and Greenhouse Gases, 1996, Forestry Research Institute

3.5. Trend of CO₂ Emissions from Fossil Fuel Combustion (1990-1995)

Table 3-4 shows that CO₂ emissions from fossil fuel combustion increased at an annual

Categories	Annual Carbon Emissions and Removal (kTC)	Annual CO ₂ Emissions and Removal (Gg)
	A	B=(A*44/12)
Emission Removal	7,929	29,073
Emission by Harvest	774	2,838
Net Removal	7,155	26,235

< Table 3-3 > Annual Carbon Dioxide Removal by Forests (1990)

rate of 9.4% from 1991-1995. For the same period, CO₂ emissions from electricity generation had the highest annual average growth rate of 17.9%. Those from transportation, industry, and residential and commercial increased annually at 13.9%, 8.8%, and 1.4%, respectively. Emissions from the public and other sectors declined at an annual average rate of 7.9% from 1991 to 1995.

Source : Korea Energy Economics Institute

	1990	1991	1992	1993	1994	1995	AAGR(%) (91-95)
Energy Sector	238,990	262,559	285,793	313,986	342,746	374,104	9.4
Energy Transformation	37,934	44,455	52,295	59,688	76,378	86,472	17.9
Industry	87,282	101,317	110,889	121,988	127,703	132,768	8.8
Transportation	42,198	48,142	55,206	62,930	71,040	80,868	13.9
Residential/Commercial	64,592	61,804	62,302	64,389	62,648	69,374	1.4
Public and Others	6,985	6,841	5,101	4,991	4,977	4,622	-7.9
International Bunkering	7,140	9,907	12,527	14,782	16,100	17,899	20.2

< Table 3-4 > Trend of CO₂ Emissions from Fossil Fuel Combustion

(unit : Gg)

4. Methane (CH₄)

Following IPCC guidelines, the sectoral methane emissions calculation takes into account the energy, agricultural, waste management, and industrial process sectors. In the energy sector, methane emissions come from fuel combustion and fugitive processes, in the agriculture sector, from rice fields and livestock, and in the waste management sector, from waste and waste-water treatment. Methane emissions also result from some chemical industry processes. The total amount of methane emissions in Korea for 1990 were 1,362 Gg. Those from the agriculture sector were 599Gg, 44% of the total, and waste management emissions were 495Gg, 36% of the total.

The largest single agricultural sub-sector emitting methane in 1990 was rice farming at 414 Gg, 30% of total emissions. Since the methane emission factors differ from region to region, it is necessary to use regional coefficients. Since 1993, the National Institute of Agricultural Science and Technology has continuously monitored and recorded methane emissions from water management, organic (straw) amendment, rice-based cropping system, and rice cultivation while the National Honam Agricultural Experiment Station and the National Yeoungnam Agricultural Experiment Station have engaged in various researches on emission mitigation methods in paddy fields since 1994. Those researches produced a set of emission factors derived from actual Korean agricultural circumstances.

When both the emission factors from IPCC Guidelines and the Korea-specific emission factors are applied, the amount of methane emissions based on the IPCC Guidelines are larger by 19% than those estimated by applying the Korean factors. Using the Korea-specific factors, the amount of methane emissions in 1990 from rice fields in Korea were 414Gg.

Methane emissions from livestock have their origins in enteric fermentation of ruminants and anaerobic decomposition of animal excrement. They also come from various sources including anaerobic decomposition of organic wastes, wastewater management, the anaerobic treatment of wastewater containing organic materials and fuel combustion processes - though the amount is not significant - when hydrocarbon in fuel is not completely burned. Methane emissions from fermentation of ruminants, animal excrement, and landfills were calculated based on IPCC guidelines.

Source : National Institute of Agricultural Science and Technology, 1995

Water Management Mode	Methane Emission Factors (gm ⁻² d ⁻¹)		Methane Emissions (CH ₄ Gg)	
	IPCC Methodology (IPCC default value)	Actual Measurement	IPCC Methodology	Measurement Inference
Continuous flooding (NPK only)	0.391-0.466	0.273	69.63	42.53
Intermittent flooding (Fall amendment of rice straw)	0.234-0.280	0.236	422.99	371.73
Total	-	-	492.62	414.26

< Table 3-5 > Methane Emissions from Rice Fields (Comparisons between IPCC Guidelines and Actual Measurement)

5. Nitrous Oxide (N₂O)

Nitrous oxide is produced from fuel combustion, use of nitrogen fertilizers, and industrial processes. Industrial processes produce nitrous oxide as a by-product in nitrous acid and adipic acid production. However, NO emissions from nitrous acid production are not included in this report due to the lack of data as production of nitrous acid only began in 1992.

N₂O emissions in 1990 totaled 12.4 Gg, of which 11.4 Gg came from fuel combustion, accounting for 92% of total emissions. Emissions from nitrogen fertilizers were negligible.

6. Other Greenhouse Gases

IPCC guidelines provides inventory methodologies for CO, NO_x, and NMVOCs as non-CO₂ gases. These are indirect climate-related greenhouse gases affecting formulation of ozone, which, in turn, influences the lifetime of greenhouse gases, such as CH₄, and N₂O, in the atmosphere.

Only CO, NO_x, and NMVOC emissions from energy consumption were calculated. Other greenhouse gas emissions in industrial processes, agriculture and the waste management sectors could not be incorporated due to lack of data. Since the calculation of non-CO emissions heavily depends on fuel type, combustion technology, vehicle type, heating technology, and boiler technology, their inventory require high precision data. The 1989 energy census data were used to calculate non-CO emissions as they are the most reliable and comprehensive available.

NO_x emissions from fuel combustion were 851 Gg, CO emissions 1,056 Gg, and NMVOCs emissions 152 Gg. The transport sector emitted 600 Gg of CO, more than half of the total emissions. The residential sector, with small-scale combustion facilities, emitted 364 Gg of CO, or 34% of total emissions. Due to declining coal consumption and wide use of LNG, carbon monoxide emissions from residential and commercial and public sectors are falling. Nitrogen oxide emissions in 1989 amounted to 85 Gg. The transport sector emitted the largest amount of NO_x, nearly half of the total. The power and industry sectors rank as the second and third largest sources of NO_x emissions. However, only transportation sector emissions were calculated and they were 152 Gg in 1989.

4 Projection of Energy Demand and CO₂ Emissions

1. Assumptions

The Rational Energy Utilization Act made it mandatory to establish a "Basic 10-Year National Energy Plan" and to revise it every fifth year to reflect changes in economic circumstances and population growth as a rolling plan. As a part of the plan, an energy demand forecast has been made and updated.

The energy demand forecast used a modified version of LEAP (Long-range Energy Alternative Program) which was developed by the TELLUS Institute in the U.S.A. The model adopts a bottom-up approach and forecasts energy consumption by sector and projects national energy demand by summing up sectoral energy consumption. The LEAP model is one of the most widely used models in the world. It is similar to other models, such as MEDEE and STAIR.

Assumptions made regarding some key variables affecting energy demand are as follows

- ? Population growth is less than 1% and the population is about 49,683,000 in 2010.
- ? The number of households increases from 12,961,000 in 1995 to 13,967,000 in 2000 to 16,561,000 in 2010. The average number of family members decreases from 3.5 in 1995 to 3 in 2010, as the small-family trend continues.
- ? The gross domestic product increases from 257.5 trillion Won in 1995 (1990 constant prices) to 357.7 trillion Won in 2000 to 610.9 trillion Won in 2010.
- ? Shrinkage of agriculture, forestry, and fishing (a side-effect of Uruguay Round), but steady growth in manufacturing, and expansion of service sector.
- ? Growth of energy-intensive manufacturing industries will slow after 2000.
- ? Number of vehicles increases steadily from 8,469,000 in 1995 to 15,148,000 in 2000, then slows down.
- ? Number of passenger cars increases from 5,792,000 in 1995 to 11,088,000 in 2000 and to

24,297,000 in 2010.

	1995	2000	2010
GDP (1990 constant prices, trillion won)	257.5 (100)	357.7 (139)	610.9 (237)
Population	44,851,000 (100)	46,789,000 (104)	49,683,000 (111)
Number of households	12,961,000 (100)	13,967,000 (108)	16,561,000 (128)
Number of cars	8,469,000 (100)	15,148,000 (179)	30,062,000 (355)

< Table 4-1 > Projections of Economic and Social Indicators

Note: The values in parentheses are relative magnitude. 1995=100.
Source: Korea Energy Economics Institute.

2. Energy Demand

A projection for energy demand in Korea is shown in < Table 4-2 >. The energy demand is expected to grow from 150.4 million TOE in 1995 to 213.4 million TOE in 2000, to 272.9 million TOE in 2005, and to 328.1 million TOE in 2010 to support economic growth. The annual average growth rate from 1996 to 2010 is projected at 5.3%.

	1985	1990	1995	2000	2005	2010	AAGR(%)	
							86-95	96-10
Primary energy demand	56.3	93.2	150.4	213.4	272.9	328.1	10.3	5.3
Final energy demand	47.0	75.1	121.9	169.9	212.6	251.2	10.0	4.9
Energy/GDP	0.51	0.52	0.58	0.60	0.58	0.54	1.5	-0.6
Per capita energy consumption	1.4	2.2	3.4	4.6	5.7	6.6	9.3	4.6

< Table 4-2 > Energy Demand Projection
Won, per capita TOE)

(unit: million TOE, TOE/90 million

Source: Korea Energy Economics Institute.

[Figure 4-1] Energy Demand Projection

3. CO₂ Emissions

The projected CO₂ emissions are shown in < Table 4-3 >. CO₂ emissions in Korea are expected to grow from 101.1 million TC in 1995 to 148.5 million TC in 2000 to 187.4 million TC in 2005, and to 217.0 million TC in 2010 as energy demand for economic growth increases. The annual average growth rate of CO₂ emissions from 1996 to 2010 is projected at 5.2%.

	1985	1990	1995	2000	2005	2010	AAGR(%)	
							86-95	96-10
CO ₂ emissions	44.0	65.2	101.1	148.5	187.4	217.0	8.7	5.2
Per capita CO ₂ emissions	1.1	1.5	2.3	3.2	3.9	4.4	7.7	4.5
CO ₂ /GDP	0.39	0.36	0.39	0.42	0.40	0.36	-0.1	-0.7

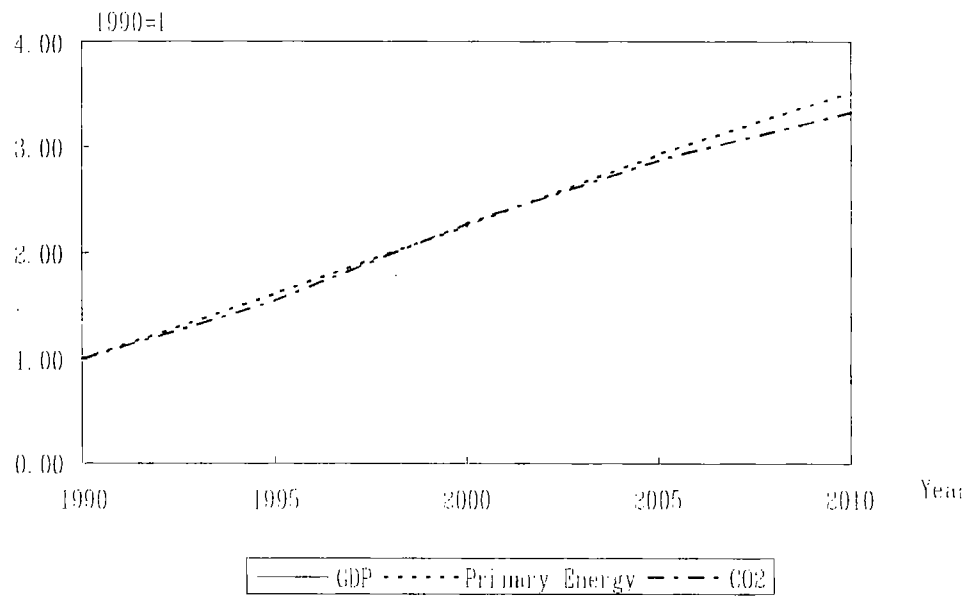
< Table 4-3 > CO₂ Emissions Projection
capita TC, TC/ 90 million Won)

(unit: million TC, per

[Figure 4-2] CO₂ Emissions Projections

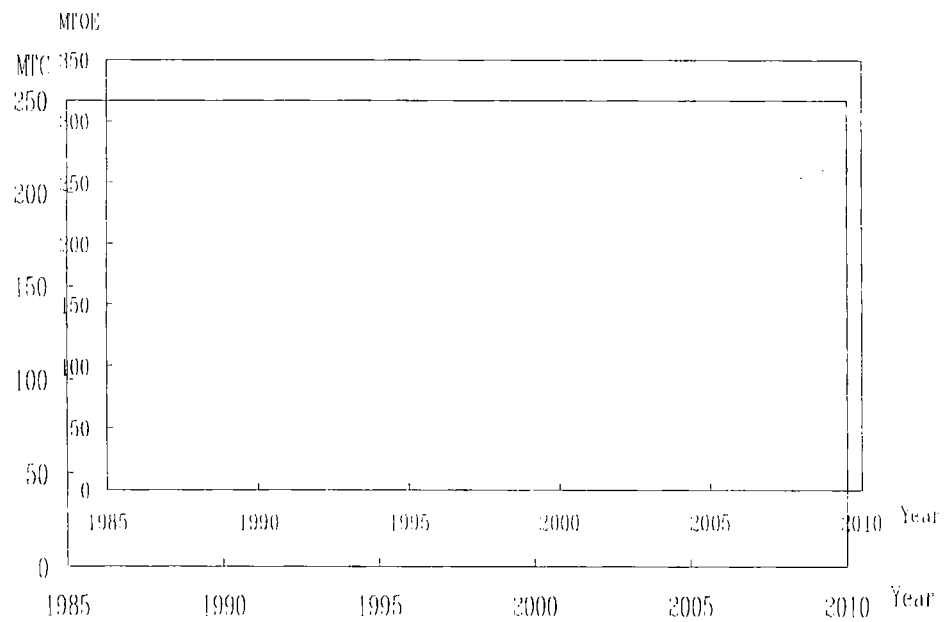
Chapter : Summary

CO2 Emissions Projection



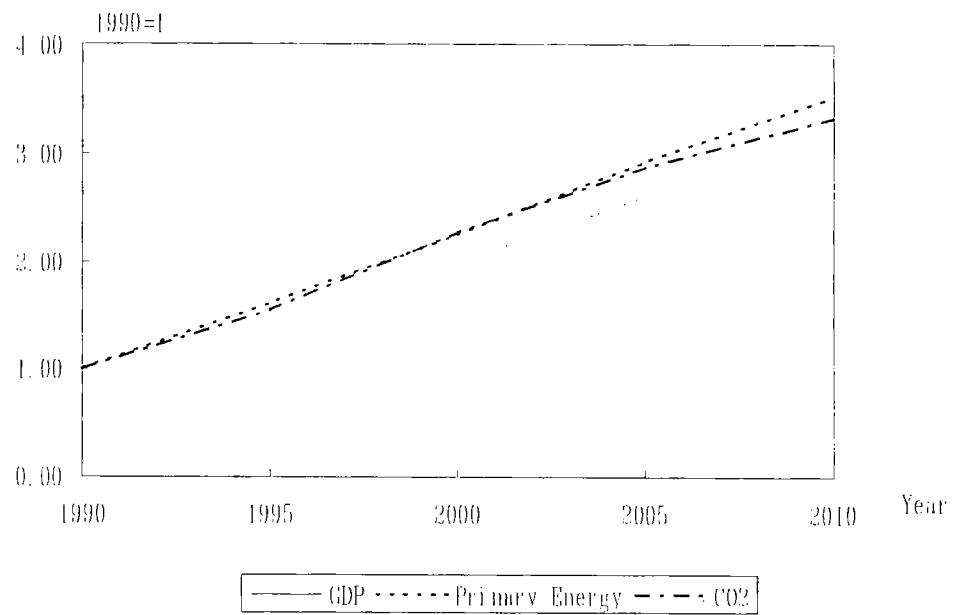
Chapter 4

[Figure 4-1] Energy Demand Projection



[Figure 4-2] CO2Emissions Projections

[Figure 4-3] Comparison of GDP, Primary Energy Demand, and CO2Emissions



4. Uncertainty

Projection of energy demand and CO₂ emissions involves intrinsic uncertainty. No model can predict these with absolute accuracy. Assumptions on socio-economic variables required for projection also have a sizable margin of error. Thus projection results can change significantly depending on models and assumptions.

One of the most important variables used for energy demand projection is GDP, especially for countries with high dependency on foreign trade, as well as a heavy industry-oriented economic structure. Projected GDP growth rates are borrowed from a report of Korea Development Institute (KDI hereafter). Since the projected numbers on key macro indicators from the KDI's report were the only available data, they were utilized as the future macro indicators. Unfortunately, however, the Korean economy is now facing financial turmoil that had not been expected, so the projected economic growth rates used in this report will have to be adjusted in the next National Communication along with corresponding energy demand and CO₂ emissions.

Reading this report, one should bear in mind that the actual economic growth rates at least between 1998 and 2000 must be below the projected and assumed economic growth rates, but to an uncertain degree.

Demand for electricity increases as income grows. Liberalization and introduction of competition by deregulation in the electricity industry would lower prices and reduce investment for demand side management and conservation. However, the range of demand increase is difficult to measure at the present.

Korea is located in the middle latitudes of the northern hemisphere. This location causes a significant difference between temperature and humidity in summer and winter. In summer, electricity is required for space cooling, and natural gas and petroleum products are used for space heating in winter. The seasonal variation in energy consumption due to climate change is likely to influence energy demand significantly, but it could not be properly incorporated in the demand projection, for there is no precise forecast on climate change.

Projections of energy demand and CO₂ emissions fully reflect official government energy plans for Korea, including supply of and demand for petroleum, natural gas, and electricity.

Plans include equipment and facility investment on the supply side. A change in economic and social conditions, however, may change government investment plans that will, in turn, work as a constraint in the supply side. Thus, there is also uncertainty in government plans.

Fluctuation of future energy prices enlarge the margin of error of energy demand projections because energy prices directly affect energy consumption. As energy prices are not easily predictable even with a reasonable degree of accuracy, especially for the long term, when there's a significant change in energy prices, one should expect a sizable shift in energy demand.

The unmeasurable change in consumption patterns, the unpredictable speed of development in energy technology, and changes in economic and social conditions increase uncertainty in energy demand projections.

5 Greenhouse Gas Emissions Mitigation Policies

1. Energy Sector

1.1. Energy Conservation and Efficiency Improvement

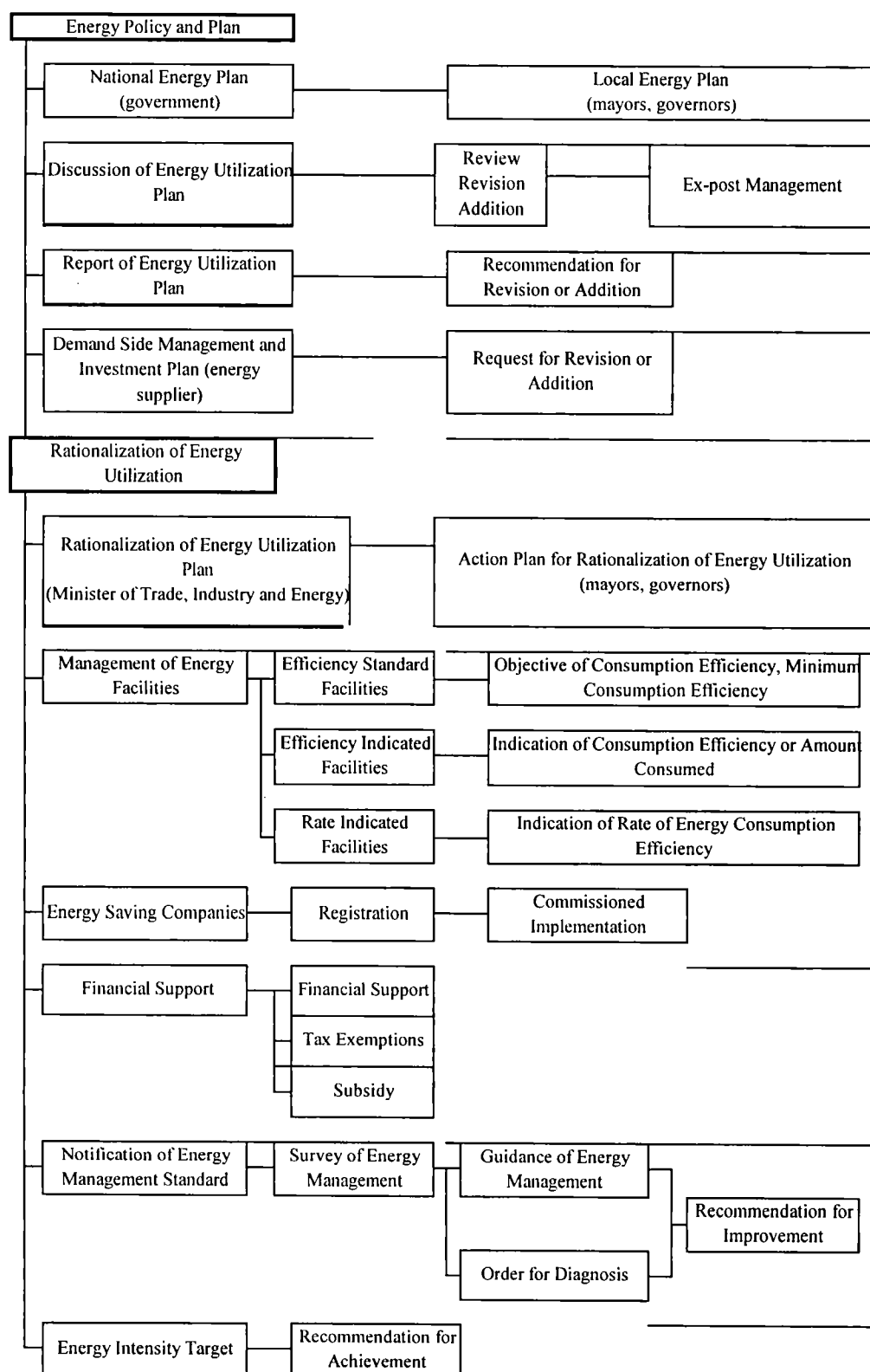
1.1.1. Legal Background

The Korean Government has been pursuing energy efficiency and conservation policies since the two oil crisis in the 1970s. The efforts were reinforced to a great extent following the Rio Conference on Environment and Development in 1992.

The Government enacted the Heat Management Act in 1974 to systematically implement energy conservation policies. Also, in 1979, it promulgated the Rational Energy Utilization Act, which calls for more comprehensive and aggressive policies than did the Heat Management Act.

Recognizing the urgency of energy conservation need, the National Committee for Energy Conservation was established in 1997 to drive forward more effective implementation of energy conservation policies. In addition, the Rational Energy Utilization Act was revised in the same year to incorporate a 'pre-notification system of energy prices', which is expected to make consumers more responsive to energy prices than otherwise. Starting from 1998, the Government plans to ban the production and sale of appliances and equipment which do not meet the Minimum Efficiency Performance Standards.

The foregoing constitutes the legal framework under which the Government is striving to transform Korea into a low energy consuming society by establishing and enforcing various energy conservation and efficiency improvement policies in industry, building, transportation, and residential sectors.



< Table 5-1 > Flowchart of Rational Energy Utilization Act

1.1.2. Government Energy Institutions and Policy Processes

The Korean Government has long intervened actively in the energy sector. Prior to 1978, the Ministry of Trade and Industry (MTI) was responsible for energy related matters. In 1978, the Energy Division of MTI was separated to form the Ministry of Energy and Resources (MOER). This Ministry had responsibility for planning and guiding all energy-related activities, with the exception of the nuclear power safety program, which remained under the responsibility of the Ministry of Science and Technology. In 1993, MOER was again merged with MTI to form the Ministry of Trade, Industry and Energy (MOTIE). In cooperation with the Ministry of Finance and Economy, MOTIE maintains a strong degree of *control* over all aspects of energy policy formulation and implementation. In addition, the Government has directly funded major energy corporations and research institutes.

1) Korea Energy Economics Institute (KEEI)

KEEI conducts basic research on conservation and energy efficiency policy for the Government. Data collected and analysis conducted by KEEI help the Government formulate its short- and long-term energy conservation policy.

KEEI provides comprehensive national energy data, including the "Yearbook of Energy Statistics," to the central and local Governments.

2) Korea Energy Management Corporation (KEMCO)

KEMCO is the Government agency in charge of implementing the energy efficiency and conservation policies and programs developed by the Government. Established in 1980, KEMCO has a wide range of programs related to the major end-use sectors. These programs fall in the following areas:

- energy audits and technical guidance
- research, development and demonstration
- education, training and information services
- management of energy-using equipment and appliances

financial and technical support for R&D and efficiency investments
coordination and promotion of R&D for new and renewable energy
total energy supply, i.e., cogeneration and district heating projects

KEMCO has a staff of 780 in its main office in Seoul, 12 branches, and three separate centers: the Urban Mass Energy Supply Center, R&D MCER (R&D Management Center for Energy and Resources), and the Industrial CHP Center. Technical personnel account for 60% of the total staff. KEMCO's combined annual budget is about US\$ 25 million, of which about 70 percent comes from the Government and the balance comes from revenues for services rendered.

3) Korea Electric Power Corporation (KEPCO)

The electricity sector in Korea is monopolized by the Government-owned Korea Electric Power Corporation (KEPCO). KEPCO is responsible for all aspects of electricity supply in Korea. It operates 85 percent of installed capacity and all transmission and distribution facilities. There has been an increasing number of private power producers who are authorized to run power plant for their own use but are required to sell excess supply of electricity only to KEPCO

4) Korea Gas Corporation (KOGAS)

The Government, through its ownership of the Korea Gas Corporation (KOGAS), plays a significant role in the gas sector. KOGAS owns and operates all the LNG receiving terminals and the natural gas trunk and branch pipeline network. However, the distribution and sale of natural gas in Korea is conducted by private companies which have the exclusive right to operate within a defined area.

5) Korea Institute for Energy Research (KIER)

Established in 1981, KIER is the main energy technology research institute in Korea. It is funded by the Government and industries. It has 350 employees, of which 270 are researchers.

KIER is divided into two principal divisions: the Energy Conservation Research Center and the Alternative Energy Research Center. The latter is further divided into Combustion Equipment, Building Energy and Industrial Energy Research Departments. The Energy Technology Policy Division conducts analyses for the purpose of setting priorities in research and development activities. KIER also develops building and appliance standards on behalf of MOTIE and KEMCO.

6) Korea District Heating Corporation (KDHC)

KDHC was established by the Government in 1985 to supply district heating systems to Korea. It was restructured as a public corporation in 1992 based on the Integrated Energy Supply Act. KDHC is the largest 'district heating utility company' in Korea.

The private sector and local Governments may participate in district heating projects. The Government, through KDHC, supports district heating schemes through the provision of loans with favorable terms from the Special Energy Account.

KDHC began supplying district heating to southern Seoul in 1987. There are currently seven district heating systems, all built within the past 10 years, and six of these are owned and operated by KDHC. At present, about 4 percent of the heating market is supplied by district heating. The Government plans to increase this figure to 15 percent nationwide by 2001.

1.1.3. Industrial Sector

1) Establishment of Energy-Intensity Targets by Product

The Government has established energy intensity targets by product and has been encouraging energy-intensive industries to achieve these targets. Based on the 1992 Five-Year Energy Conservation Plan, the Government specified annual energy-intensity targets for 161 energy-intensive products from 1992 to 1996.

Meanwhile, the Korea Energy Management Corporation collects and analyzes energy consumption data of energy-intensive products. It distributes the results to other companies producing similar products to help guide their voluntary efforts in improving energy efficiency.

Classification	1984~ 90	1991	1992	1993	1994	1995	1996
Number of Companies	424	30	178	176	176	176	176
Number of Products	759	5	161	158	158	155	155
Savings(1,000TOE)	700	-	705	668	998	900	810
Rate of Improved Intensity(%)	6.6~ 8.8	-	2.2	1.9	2.7	2.4	2.0

< Table 5-2 > Outcome of Industrial Energy-Intensity Improvement Efforts

2) Five-Year Energy Conservation Plan for Energy-Intensive Industry

The First Five-Year Energy Conservation Plan for Energy-Intensive Industry was launched in 1992, targeting energy-intensive companies using more than 20,000 TOE per year. During the planned period, 2,344 billion Won was invested in energy conservation and efficiency improvement projects. It is estimated that the conservation effects from this plan amount to a 14% reduction, compared to 1991.

Classification	1992	1993	1994	1995	1996	Total
Savings (%)	2.6	2.4	3.6	3.3	2.9	14.8
Investment (100 mil. Won)	7,538	5,519	3,606	3,395	3,382	23,440

< Table 5-3 > Implementation of First Five-Year Energy Conservation Plan for Energy-Intensive Industries

With the completion of the first plan in 1996, the Second Five-Year Energy Conservation Plan (1997-2001) is underway, targeting at 190 companies using more than 30,000 TOE per

year. These companies account for 54 percent of the energy use in the industrial sector. The goal of the second plan is to save 10 percent of total energy consumption.

Sector	Chemicals	Metals	Ceramics	Paper	Textile	Food	Total
Number of Companies	55	48	24	25	24	14	190
Ratio(%)	29	25	12	14	12	8	100
Energy Savings (1,000 TOE)	10,366	15,035	5,288	1,100	1,713	460	33,962
Ratio(%)	31	44	16	3	5	1	100

< Table 5-4 > The Second Five-Year Energy Conservation Plan for Energy-Intensive Industries

To achieve this goal, the Government will set annual energy conservation targets and invest a total of 3,097.8 billion Won in the plan.

Year	1997	1998	1999	2000	2001	Total
Savings(%)	2.3	2.0	2.4	1.9	1.3	9.9
Savings(1,000TOE)	791	652	871	619	434	3,367
Investment (100 mil. Won)	3,374	2,699	15,305	5,928	3,672	30,978

< Table 5-5 > Investment Plans and their Corresponding Energy Conservation Potential

As seen in Table 5-6, the energy conservation target for the chemicals and chemical products industry is set at 11% with an investment of 715.6 billion Won, while that for the metals industry is set at 6.8% with an investment of 1,588.6 billion Won.

Year	Chemicals	Metals	Ceramics	Paper	Textile	Food
Savings(%)	11.0	6.8	12.7	17.8	15.7	15.5
Savings(1,000 TOE)	1,138	1,023	670	196	268	72
Investment (100 mil. Won)	7,156	15,886	3,024	2,994	772	790

< Table 5-6 > Energy Conservation Plan by Industry

The principal means to achieve these targets include replacement or retrofitting of equipments, improvement of operation and process efficiency, waste heat recovery, and heat insulation.

Classification	Replacement, Retrofitting	Improvement of Operations and Processes	Waste Heat Recovery, Heat Insulation	Operation Management	Fuel Substitution, Others	Total
Savings (1,000 TOE)	1,329 (39.5)	514 (15.2)	507 (15.1)	414 (12.3)	603 (17.9)	3,367 (100)
Investment (100 mil. Won)	21,328 (68.8)	2,711 (8.8)	1,147 (3.7)	2,864 (9.2)	2,928 (9.5)	30,978 (100)

< Table 5-7 > Energy Conservation Plan by Measure

Note: () denotes the percentage.

The Government will continue to improve energy intensity for 106 major products by establishing and enforcing energy conservation targets for these products.

Industry	Products	Energy Intensity(Mcal/T)		
		1997	2001	Improvement(%)
Chemicals	Ethylene	4,862	4,636	4.6
Metals	Crude Steel	5,316	5,118	3.7
Ceramics	Cement	261	256	2.0
Paper	Vellum Paper	3,151	3,046	3.3
Textiles	Polyester	1,734	1,527	11.9
Food	Sugar	856	820	4.2

< Table 5-8 > Improvement of Energy Intensity by Product

Note: Energy intensity is weighted average of similar products.

3) Preparation of Energy Management Guidelines

In accordance with Article 24 of the Rational Energy Utilization Act, the Government prepares the Energy Management Guidelines and distributes them to as many companies as possible to help them use energy more efficiently. Audits and consultations mainly focus on small and medium companies that have relatively poor energy management. Under this

program, 30 companies (two each from 15 different industrial subsectors) were selected and required to take energy audit each year between 1987 and 1991. In 1992, the program was expanded to cover all industrial subsectors. In 1996, 350 companies were audited and provided technical guidance and consultation.

Classification	1991	1992	1993	1994	1995	1996
Covered Industry	Chemicals-Food	All Industries	All Industries	All Industries	All Industries	All Industries
Number of Companies	30	250	187	455	350	350
Compliance Rate(%)	62.8	60.5	57.0	80.0	80.0	70.0

< Table 5-9 > Registration of Energy Management Standards Enforcement

In accordance with Article 11 of the Rational Energy Utilization Act, the Government requires that companies prepare and submit energy utilization plans before the start of operations when they construct new factories or expand factories which consume more than 1,000 TOE per year or 40,000 MWh per year. This requirement aims to encourage these major users to install energy-efficient facilities.

Classification	1991	1992	1993	1994	1995	1996
Number of Submissions	24	17	21	23	37	30
Energy Consumption (1,000 TOE/year)	2,300	7,520	1,273	1,135	5,794	5,075
Savings (1,000 TOE/year)	159	76	174	204	797	428

< Table 5-10 > Energy Utilization Plans

4) Energy Audit Program for Industry

Energy audits have been conducted by KEMCO since 1980, which maintains six specialized audit teams for the chemical, metal, ceramic, textile, pulp and paper, and food industries. Audits are provided free of charge to small and medium companies, while some fee is charged for large company audits. Audit teams recommend necessary efficiency improvement measures based on cost and benefit analysis of equipments and management.

KEMCO audited 61 large companies and 350 small and medium companies in 1996. Execution of the program resulted in the energy savings equivalent to 125,000 TOE. The Government plans to continue its energy audit program.

	1980-1991	1992-1994	1995	1996	Total
Number of Companies	1,245	1,048	405	411	3,109

< Table 5-11 > Energy Audit Program

5) Improvement of Industrial Equipment Efficiency

The Government is making an effort to improve the efficiency of equipment used in industry by encouraging the replacement and retrofit of old and inefficient boilers, kilns, furnaces, and motors by high efficiency ones. These efforts include tax incentives and financial assistance.

Each year, 30 billion Won has been paid for the replacement or retrofit of old and inefficient equipments. In addition, 5 percent of total replacement/retrofit investment is tax deductible from corporate tax or income tax.

The Government selected development of high-efficiency motors as one of its high priority research projects in 1993. The Government plans to replace all motors with the high-efficiency ones by 2006 through extensive efforts in development and commercialization.

In addition to including motors in its efficiency standards list, the Government has ordered energy suppliers such as KEPCO to include high-efficiency motors in demand-side investment plans.

6) Co-generation Plants

A total of fourteen co-generation plants are already in commercial operation at twelve industrial complexes in such areas as Ulsan, Yuchon, and Gumi to provide heat and electricity. Construction of additional five cogeneration plants is expected at the Daesan and Jinju industrial complexes.

Number of Cogeneration Plants	Number of Consumers	Generation	
		Heat(Gcal/h)	Electricity(MW)
14	474	4,320	1,047

< Table 5-12 > Cogeneration Plants in Industrial Complexes (1996)

Concerning the development of new industrial complexes, the Government has called for mandatory consultations to determine the feasibility of constructing co-generation plants and providing favorable financing, so as to boost the number of co-generation plants to 33 by the year 2001.

7) Funding for Energy Conservation Facilities

Under the Rational Energy Utilization Act, the Government provides funds to industrial, building, transport, and residential sectors in order to promote energy conservation.

A special fund has been reserved for energy conservation facilities since 1980. Total funds raised reached 2,780.9 billion Won in 1996. The fund is divided into three categories: facilities, R&D, and operations. Interest rates on the fund range between 5 and 10%. More fund will be made available, to 258.3 billion Won in 1997 and to 305.0 billion Won in 1998.

1980-1991	1992	1993	1994	1995	1996	Total
19,746	1,146	1,376	1,863	1,699	1,979	27,809

< Table 5-13 > Funding for Energy Conservation Facilities

(Unit : 100
mil. won)

1.1.4. Residential-Commercial Sectors

1) Insulation

The use of insulation in new building construction has become mandatory since 1979. Since 1984, the Government has provided financial support for insulation retrofits in old buildings. Between 1984 and 1996, insulation retrofits in 24,265 residential dwellings were financed by the Government, costing 71.1 billion Won. In 1997, this fund will provide 2 billion Won.

Classification	1984-1990	1991	1992	1993	1994	1995	1996	Total
Financial Assistance (100 mil. Won)	534	50	30	24	27	20	26	711
Number of Households	19,685	1,606	903	615	628	414	414	24,265

< Table 5-14 > Financial Support for Housing Insulation

2) Building Audits

Since 1990, large buildings which use more than 4 million kWh per year have been designated for intensive audits and supervision. Buildings which reduce their electricity use by 10 percent from the previous year would retain 20 percent of the savings through reduced electricity charges.

Between 1980 and 1996, KEMCO conducted 299 in-depth audits of large buildings and 1,674 audits of public buildings.

Classification	1980-1990	1991	1992	1993	1994	1995	1996	1997 (planned)	Total
In-depth Audits	225	12	10	14	16	9	13	10	309
Audits of Public Buildings	984	120	120	120	120	120	90	70	1,744
Total	1,209	132	130	134	136	129	103	80	2,053

< Table 5-15 > Annual Energy Audits(unit : number)

3) Energy-Efficient Design for New Buildings

Beginning in 1985, the Government requested that building permit applications for large buildings be accompanied by an energy efficiency plan for each building. This request was intended to encourage builders to go beyond the prescribed minimum energy efficiency standards. Since 1992, new buildings with an area greater than 10,000 ? must energy efficiency plans.

The energy efficiency standards for building design has changed to a unified efficiency standard based on energy saving performance from the previous separate standards for walls, ceilings, and windows, etc. Energy efficiency standards were established in 1995 for hotels, hospitals, public baths and indoor swimming pools.

4) Management of Energy Intensive Buildings

Since 1992, large buildings which use more than 4 million kWh per year have been designated for intensive audits and supervision. As of 1996, 236 buildings (i.e., hotels, banks, offices, department stores, hospitals, and others) were being supervised and audited under this program.

In 1997, 85 buildings using more than 10 million kWh/year were required to submit Five-Year Plans for Energy Savings. The energy consumption of these buildings accounted for around 53% of the total consumed by the 236 energy-intensive buildings. Buildings that reduce electricity consumption by 10% compared to the previous year are rewarded by reduced electricity fees.

5) Equipment and Appliance Standards and Labelling

The Government has implemented a number of labelling and standard measures to improve energy efficiency of equipment and appliances as well as passenger vehicles. Beginning in 1992, labelling which specifies energy use and intensity must be affixed to six types of products including refrigerators, air conditioners and passenger cars. This rating/labelling system is intended for raising public awareness on energy efficiency.

From 1994, minimum efficiency standards have been applied to energy-intensive products such as refrigerators, air conditioners, incandescent and fluorescent lamps, and electric ballasts. In 1997, the Government publicly announced products in five energy-intensive product categories which fell below the minimum efficiency standards and recommended their producers (or importers) to meet the standards.

From 1998, in an effort to strengthen the enforcement of the minimum efficiency standard, the Government will authorize the Minister of MOTIE to ban production and sales of the

appliances and equipments that fall below the minimum energy efficiency standards with no apparent reason.

6) Energy Service Companies (ESCOs)

Enhancing the role of energy service companies (ESCOs) in the energy conservation market has been identified as a high priority. As of 1997, 12 ESCOs had been registered. In order to further boost ESCO activities and to encourage third-party financing, the Government has provided soft loans and tax incentives for investments in energy efficiency projects.

In 1996, the Energy Saving Mart was inaugurated to provide a match-making venue for ESCOs, major energy consumers and their most promising potential customers. Encouraged by the success of this program, the Government now is planning to hold the event on an annual basis.

	1994	1995	1996	1997	Total
Financial Assistance	43	28	57	230	358

< Table 5-16 > Financial Assistance to Energy Service Companies
(unit : 100 mil. Won)

Another major program undertaken in 1996 was Energy Savings Performance Contracting. Under this program, energy efficiency investments are made by ESCOs, and the resulting savings are divided among the participants.

7) District Heating (DH)

District heating is considered an efficient mean of energy conservation and pollution reduction. The role of district heating has expanded as a result of the Government's district heating mandate. In 1992, Korea's integrated Energy Supply Act called for nationwide expansion of the district heating system.

As of 1996, 620,000 households in Seoul metropolitan area, equivalent to 6 percent of the residential market, were supplied with district heating. By the year 2001, district heating will

be supplied to 1.8 million households, which will by then account for 15 percent of the residential market.

In 1996, the fuel used in DH for 627,000 households was around 513,000 TOE. Using conventional central heating instead of DH, the energy use would have been 969,000 TOE. In 1997, the amount of fuel saved due to DH is expected to be 1.9% of the combined total of residential and commercial energy consumptions, or 655,000 TOE.

1.1.5. Transportation Sector

1) Fuel Economy Rating/Labelling Program for Automobiles

The Fuel Economy Rating Labelling Program has been applied to 267 models of general vehicles and jeeps fueled by gasoline, LPG and diesel to provide consumers with better information on relative fuel efficiency. This program will soon be extended to buses.

2) Establishment of Fuel Economy Targets

The Government has established fuel economy targets to encourage manufacturers to make energy-efficient vehicles. The goal is to improve fuel economy for all classes of vehicles by 5 percent in 1996 and 10 percent by 2000 over the 1991 base year.

Class(cc)	1996	2000
less than 800	23.4	24.6
800-1,100	20.3	21.3
1,101-1,400	17.3	18.1
1,401-1,700	15.4	16.1
1,701-2,000	11.4	12.0
2,001-2,500	9.9	10.4
2,501-3,000	8.5	8.9

< Table 5-17 > Fuel Economy Targets in Passenger Cars

(unit: Km/ l)

3) Passenger Vehicles' Operation day Management System

The dramatic increase in the number of cars since the mid-1980s has resulted in heavy traffic and an energy-intensive society. To cope with these problems, public employees have participated in the voluntary 'Passenger Vehicles' Operation day Management System' to encourage those with private vehicles not to drive their cars every 10th day and ride to work with a colleague. Under the program, when the last digit of a vehicle's licence plate is the same as the last digit of the date, then the owner should not drive his car on that day. This Program has also been promoted in large companies and is encouraged through a variety of public information campaigns.

The Government also encourages car owners to ride with a colleague (car pool) and to use public transportation. It is considering offering such incentives as toll-charge discounts for car pool participants.

4) Education for Economical Driving

The Government is promising on education program on economical driving the new licensees and commercial vehicle drivers.

Pamphlets and videotapes have been supplied to driver testing centers and private driving schools as educational materials. In 1995, more than 100,000 drivers were shown the videotapes. In 1996, the total number of drivers in the program reached to about 300,000.

5) Promoting Small Car Ownership

To decrease energy consumption in the transportation sector, the Government encourages the purchase of smaller and more fuel-efficient cars.

~~The Government is providing various incentives including tax reductions for smaller car,~~ such as a 2% registration fee instead of the 5% for large and medium-sized vehicles and a 50% deduction in the license fee. Tax incentives for light weight vehicles include reductions in automobile tax, registration tax, license tax, integrated insurance premium, discounts on highway tolls and parking charges, and exemption from the special surcharges on a second family car.

6) Progressive Emissions Tax by the Automobile Engine Size

The Government has imposed progressive emissions taxes to reduce the demand for motor vehicles and control the demand for large cars.

The emissions tax on private cars with engine size above 3,000 cc is 370 Won/cc, while that on private cars with engine size less than 800cc is 100 Won/cc. Households with more than one car pay double the tax on the additional car.

Class	Passenger Car	Jeep
over 3,000cc	370	230
3,000cc ~ 2,500cc	310	200
2,499cc ~ 2,000cc	250	180
1,999cc ~ 1,500cc	220	160
1,499cc ~ 1,000cc	160	160
999cc ~ 800cc	120	120
under 800cc	100	120

< Table 5-18 > Automobile Tax by Engine Size

(unit : Won/cc)

7) Construction of National Oil Pipeline

The construction of a nationwide oil pipeline network is expected to mitigate traffic by reducing the numbers of oil tankers on expressways by 7,000 per day, saving transportation costs as well as reducing air pollution.

Pipelines between the southern and northern areas of the country and the construction of a storage facility in Taejon were completed in June 1995 and were put in operation in the area south of Taejon. Since the Sungham storage facility were finished in June 1997, the national pipeline grid is now operating in its entirety along a south-north line traversing Korea.

1.1.6 Public Sector

1) Promotion of Energy Savings Performance Contracting

Energy Saving Performance Contracting (ESPC) has been introduced to the public sector under this program. The rewards of energy conservation are distributed among the public

sector and ESCOs.

As of June 1997, this type of contract was being tested in the pilot phase. Based on the results of the pilot project, contracts will be revised and expanded to all public-sector buildings to stimulate implementation of this program as a mean of energy conservation.

2) Encouraging the Public Sector to Use Energy-Efficient Appliances

Beginning in 1997, the Government made it a priority for the central Government agencies and local administrations to use energy-efficient equipment and appliances, such as high-efficiency motors and 26mm slim-type fluorescent lamps. The Government will closely monitor the effects of such energy-saving activities and provide related information through workshops and other public campaigns.

3) Inclusion of Energy Conservation Category in the Management Assessment of Government-Invested Organizations

From 1986, the Government began to consider the energy conservation achievements index as an important factor when evaluating the overall performance of Government-invested organizations with a view to enhancing energy conservation awareness followed by energy conservation oriented management practices.

In 1997, the energy conservation index was given more weight in the assessment, and applied to all Government-invested organizations.

1.2. R&D in Energy Technology Development

1.2.1 Ten Year National Plan for Energy Technology Development

The Government has set out a Ten-year National Plan for Energy Technology Development (1997-2006) which incorporates the following three areas: energy conservation technology, alternative energy technology, and clean energy technology.

The main goals of the plan are to reduce total national energy consumption by 10% in 2006, and to supply 2% of the total national energy consumption by new and renewable energy in 2006 through the investment of 2,047 billion Won.

This plan targeted twenty one major technologies of which characteristics are firstly the high energy conservation potential, secondly environmental friendliness, and lastly the high capital investment cost which keep private companies from making R&D investments.

Classification	Key Development Programs
Energy Conservation Technology (12)	Industrial furnace, Mass energy, Unused energy, Separation technology, Dryer, Small cogeneration, Energy conversion storage, Energy conservation building technology, Air-conditioning and ventilation system, Lighting system, Induction motor, Application of motors
Alternative Energy Technology (4)	Solar, Thermal, Photovoltaic, Fuel Cell, IGCC
Clean Energy Technology (5)	Fluidized-bed combustion, coal-ash utilization, New catalyst technology, Post-combustion processing technology, Co2 separation and recovery technology

< Table 5-19 > Ten-Year Technology Energy Development Plan

1.2.2. New and Renewable Energy

Since the Second Oil Crisis in 1978, the Government has put great effort into developing and encouraging the use of indigenous new and renewable energy to reduce Korea's import-dependence on fossil fuels such as petroleum.

In 1987, the Government enacted the New and Renewable Energy Development & Promotion Act. The Alternative Energy Technology Development Plan was established based on this Act to develop and disseminate twelve major alternative energy technologies such as solar thermal, and photovoltaic power, bio energy, small hydro power, fuel cells, wind power, coal gasification, waste and geothermal energy, and hydrogen technology.

Five percent of the total investment in these projects is tax deductible in order to promote and expand the use of new and renewable energy. Loans are provided at 5% interest on up to 80% of the total investment. Golf courses and outdoor shooting ranges are required to install solar hot water systems. Pilot projects on photovoltaic power plants on remote islands and in isolated areas are underway to create demand for new and renewable energy and to improve their reliability.

The Government has invested 99 billion Won in new and renewable energy R&D technologies, working with the private sector. From 1988-1996, investment was made for 242 projects in 11 research areas including photovoltaic power, fuel cells, bio energy and waste energy. As a result, the annual growth rate of new and renewable energy has been around 23% over the last five years.

Classification	1991	1993	1995	1996	Annual Growth Rate (92-96)
Total Energy Demand	103,622	126,879	150,437	165,209	9.6%
New and Renewable Energy	413	649	909	1,162	23.0%
Share(%)	0.40	0.51	0.60	0.07	-

< Table 5-20 > New and Renewable Energy Consumption by Year
(unit: 1,000 TOE)

The total amount of new and renewable energy from waste energy, bio energy, small hydro power, and photovoltaic power was 1,162,000 TOE in 1996. Waste energy accounted for more than 90% of those.

Classification	Solar Energy	Bio Energy	Waste Energy	Small Hydro Power etc.	Total
Amount(1,000 TOE)	35	51	1,056	20	1,162
Share(%)	3.0	4.4	90.9	1.7	100

< Table 5-21 > Use of New and Renewable Sources of Energy by Sector(1996)

Prior to 1988, new and renewable energy usage consisted only of small hydro power plants and facilities using methane gas. However, since 1989, incineration facilities and residential solar hot water systems have come to the forefront in the new and renewable energy consumption. Since 1988, the Government has invested 79.2 billion Won in photovoltaic power facilities, 33.9 billion Won in waste power facilities, and 5.7 billion Won in small hydro power facilities.

Classification		1988-1993	1994	1995	1996	Total
Facility Fund	Waste	301.4	2.9	9.5	2.9	338.8
	Solar Energy	318.9	137.2	114.8	221.4	792.4
	Small Hydro Power	28.5	13.9	10.36	4.5	57.3
	Methane Gas	32.0	2.8	7.1	2.2	44.3
	Alternative Fuel	26.5	5.2	5.5	6.2	43.6
	Wind Power	2.4	-	-	-	2.4
subtotal		709.8	184.1	147.4	237.4	1,278.9
Operation Fund		22.7	3.5	2.5	4.9	33.7
Total		732.6	187.6	149.9	242.3	1,312.6

< Table 5-22 > Financial Support for Expansion of New and Renewable sources of Energy Consumption by Year and Category(1988-1995)

According to the Ten-year National plan for Energy Technology Development, the Government is aiming at the supply of 2% of total energy demand by new and renewable energy. To realize this plan, the major focus of R&D development has been placed on advanced and applicable technologies such as solar thermal, and photovoltaic power, fuel cells, and the combined power of coal gasification technology, in joint research by industry, academia and research institutes.

	1st stage	2nd stage	3rd stage	4th stage
Period	1988-1991	1992-1996	1997-2001	2002-2006
Development goals	Establishing research basis	Establishing basis for utilization	Developing high-priority technology	Commercializing technology
Dissemination goals (the ratio of alternative energy to total energy)	Securing basic technology (0.5%)	Creating demand, initiating demonstration dissemination (0.6%)	Creating market (1.3%)	Expanding dissemination (2.0%)

< Table 5-23 > Plans for New and Renewable Sources of Energy Technology Development

1.2.3. Current Situation and Planning for New and Renewable Energy

1) Photovoltaic Power

Three photovoltaic power plants are in operation. A photovoltaic power plant of 100 KW on Ho island in Chungnam was built with domestic materials and equipment in 1993, and another facility on Hawha island in Chunnam was upgraded from 25 KW to 60 KW. To publicize photovoltaic power plants, a new exhibition center was opened in 1997 at Jungyeo Park in Kwangju city.

The electricity generation costs of photovoltaic plants are similar to those of diesel power plants. Photovoltaic power plants, however, do not have the same noise and transportation problems as diesel power plants and require relatively low maintenance costs. The Government concluded that photovoltaic power plants are the most appropriate power systems for small islands with less than 50 households so that beginning in 1998, the Government plans to build such plants on 100 small, remote islands.

2) Solar Thermal Energy

Different from other heating systems, solar thermal types require relatively low initial investment cost and have proven to be economical. The Government is making efforts to spread residential use of solar hot water systems in rural areas and small and medium-sized cities.

3) Bio Energy

Bio energy technology consists of ethanol fuel production and methane gas from biomass. Methane gas conversion technology is being used in liquor factories and food industries. The construction of pilot plant for ethanol fuel products came to completion in May 1993, which has production capacity of 1 kl per day.

Although ethanol fuel is inferior to gasoline in economic terms, the Government is determined to continue its effort for technology development in this area and later to institutionalize a mechanism through which the user of this fuel for automobiles will be enhanced.

4) Energy from Municipal Waste

Concerning energy from waste, the Government continues to disseminate municipal solid waste incinerators linked with district heating and industrial waste incinerators. Combustible waste from municipal waste has a calorific value of more than 5,000 kcal/kg, with high conversion potential into heat energy. Installation of incinerators are of increasing popularity as technologies for utilizing heat from waste incinerators and associated air pollution prevention are developing.

Four hundred and ten industrial waste incinerators have been installed across the country. In 1993, the Waste Management Law was revised to encourage industrial complexes to use their waste as a feedstock for waste heat production. New industrial complexes with areas of greater than 500,000 ? are required to install collective industrial incinerators. In the future, the Government will promote the spread of industrial incinerators to solve waste disposal problem and at the same time to make most of the heat energy generated from waste incineration.

5) Wind Power

Energy generated from wind power would be economically feasible if the average wind speed is more than 4~5m/sec. In Korea, wind energy resources are available in Moslpo, Cheju island, small islands in the southwest, and near Daekwallyong pass.

A feasibility study for a pilot-phase wind power generation plant at Wolyung, Cheju Island is underway. Depending on the outcome of the study, the Government will decide whether to build the power plant using both photovoltaic and wind power in the small islands which do not have an access to the national electricity power distribution network. In addition, the Government along with Cheju provincial government, is currently constructing a wind power plant with the installed capacity of 5,200 kWh as a pilot phase local energy project. The total investment cost for the project is 12 billion Won for three years from 1996 to 1999.

	Dissemination Status
Solar Heat	o Residential Solar Hot Water System: 84,000 units (as of the end of '96)
Photovoltaic Energy	o Photovoltaic Energy for Islands and Special Purposes : 7,600 units (total 2,161kW) -Ho Island : 100kW('92), Hahwado Island 60kW('95), Marado Island 30kW('91)
Bio Energy	o Facilities using Methane Gas : 93 units
Waste Energy	o Municipal Waste : 11 units o Industrial Waste : 410 units
Small Hydro Power	o Research for potential areas : 150 MW o Small Hydro Power : 37 MW(20 units)
Wind Power	o 170kW, 80kW at Muan, Chunnam('94.11) o 100kW, 30kW and 20kW at Wulyong, Cheju ('95.4) o 250kW at Jungmoon, Cheju('92.10)

< Table 5-24 > Utilization of New and Renewable Energy by Source

1.2.4. Energy Conservation Technology

The Government has long supported the development of energy conservation technologies which could have economic value with great energy saving potential in the near term. From 1992-1996, 111 of 289 projects were completed and 23 among these are now in practical utilization.

	1992	1993	1994	1995	1996	Total
Project	11	111	60	34	73	289

<Table 5-25 > Projects for Energy Conservation Technology

Based on the 10-Year National Plan for Energy Technology Development, the

Government will systematically support the development of 12 technologies with high energy saving potential and 32 general technologies.

	1st Stage	2nd Stage	3rd Stage
Period	1992-1996	1997-2001	2002-2006
R&D Strategies	Focus on tasks which can be utilized in the near term Establish research base among industry, academia and research institutes and secure technological basis. Among the research tasks, the results of 22 tasks are being utilized.	Secure technical potential with focus on high priority programs (to account for 70% of total conservation volume) Initiate utilization and dissemination of the results of R&D, and establish institutional base. Establish the basis for international cooperation for the third stage of high- priority programs.	Develop future-oriented and large-scale technology led by the high-priority programs (mid-entry through international cooperation) Achieve conservation goal through the realization of the potential For programs other than high-priority programs, maximize the research capabilities of the private sector through various measures, thereby enhancing conservation.

< Table 5-26 > Energy Conservation Technology Development

1.2.5. Clean Energy Technology

Clean energy technologies such as clean burning coal, heavy oil upgrading through desulphurization, and anti-pollution facilities are in the development stage. Forty-five projects have been underway since 1994 and three have been completed.

Under the 10-year national plan, five technologies including state-of-the art fuel combustion, improved combustion processes and new catalysts have been selected and financed as major programs to achieve clean energy technology by 2006.

Classification	1994	1995	1996	1997	Total
Projects	19	4	12	10	45
Investment	23	25	36	74	159

< Table 5-27 > Clean Energy Technology Development
number, 100 mil. Won)

(unit :

1.3. Demand Side Management

1.3.1. Pricing System

The Government has played a central role in the price-setting process for most forms of energy. It imposes customs tariffs, VAT, special excise tax, traffic tax, and other surcharges on primary energy sources such as oil, LNG, and coal to limit energy consumption and increase revenues. In the case of oil, a surcharge of \$1.70 and a 5% customs tariff per barrel, and 10% VAT on all types of oil is imposed at the time of import.

Until 1994, prices of petroleum products were regulated by the Government. Between February 1994 and December 1996, the Petroleum Price Fluctuation System, which closely linked domestic prices with international market prices, was used. Petroleum prices were deregulated from 1997 through the revision of the Petroleum Business Law.

Class	Tax	Crude Oil	Gasoline	Diesel	Kerosene	B-C	LPG	LNG
Import	Customs Tariff	5%						1%
	Surcharges	1.70\$/B						\$16.25/ton
Sale	Special Excise Tax				60 Won/l		40 Won/kg	40 Won/kg
	Auto Tax		455 Won/l	85 Won/l				
	Education Tax		68.2 Won/l	12.7 Won/l	9 Won/l			
	Surcharges		90 Won/l		20 Won/l		4.5 Won/kg	4.5 Won/kg
	VAT	10%						

< Table 5-28 > Energy Taxes and Surcharges

1.3.2. Restructuring Energy Pricing Policies

In the past, it was believed that setting energy prices at low levels was needed to ensure industrial competitiveness as well as price stabilization. Thus, Korea's domestic energy prices were maintained at somewhat low levels. However, keeping energy prices low has had an undesirable effect on efforts to improve energy efficiency and reduce the environmental impact of energy consumption.

Under these circumstances, the Government recently revised its energy-pricing policies with a view to ensuring that domestic energy prices fully reflect not only the production and distribution costs, but also the social costs including environmental cost.

With the new energy-pricing policies, the level of energy prices will be adjusted gradually to the average energy prices of non-oil-producing advanced countries by the year 2000 in order to facilitate energy conservation and improvement of energy efficiency and to mitigate the environmental impact of energy consumption.

To legally facilitate these policies, the Government revised the Rationalization of Energy Utilization Act in 1997 and in the near future will announce targeted prices by energy source annually and adjust prices by taxation, etc. The revenue generated by this system is to be used for investment in energy conservation facilities and development of alternative energy technologies.

1.3.3. Investment Plan for Demand Side Management

Under the 1995 revision of the Rationalization of Energy Utilization Act, energy suppliers are required to develop and implement DSM investment plans. Accordingly, major energy suppliers such as KEPCO, KGC and KDHC have developed long term plans for DSM since 1996 to improve efficiency and control load management programs. KEPCO, for example, has invested some 45 million US dollars in such DSM programs as Load Management, Time-of-Use Rate System, Discount System for Voluntary Curtailment, and Rebates for Efficient Lighting Appliances.

The Government's target is to increase DSM investment annually by 1% of total sales and It also requires energy suppliers to incorporate DSM programs in their investment plans.

	KEPCO	KGC	KDHC
Efficiency Improvement	- Dissemination of High Efficiency Lighting Appliances - Advertisements for Saving Electricity - Development of Research Projects	- Advertisements for Energy Savings - Investment in DSM Projects - Development of Energy Saving Equipment	- Research on the Optimum System of End-user Equipment
Load Management	- Installation of Electronic Meters - Voluntary Savings and Summer Vacation Price Adjustment - Dissemination of Ice Storage Systems - Dissemination of Economic Vending Machines - Midnight Power Service	- DSM Research - R&D for Gas Cooling System and Combined Equipment - Subsidy on Energy Saving Design for Gas Cooling - Research on CNG Vehicles	- Research on Heat Use Pattern and Forecast of Heat Loads - Introduction of DH in old apartments
1996	403	16	1
1997	541	43	3

< Table 5-29 > DSM Projects by Energy Suppliers

1.3.4. IRP

The purpose of IRP is to promote efficient energy use and to minimize social costs by considering demand and supply together. The Government plans to establish detailed categories and measures for IRP and to develop an action plan.

The Government continues to support basic IRP research and exchange information among Government, energy suppliers, and consumers. The Government encourages all parties concerned to draw up agreements for reasonable targets.

1.4. Local Energy Plan

The central Government helps local Governmental bodies establish their own unique and independent local energy plans. The local energy plans aim to develop an environment-friendly energy program and improve the economy and welfare of local residents by taking full account local economic, natural, and social circumstances.

Under the Rationalization of Energy Utilization Act, local Governments are now required to develop local energy plans. In 1995, feasibility studies on local energy plans were carried out for 10 local autonomous bodies. Local Government officials were invited to take training courses on local energy planning.

In the future, the central Government plans to provide loans and subsidies, along with technical assistance from KEMCO, To support the local Governments' energy planning projects.

	1996	1997
Local Energy Plan	10	-
Local Energy Infrastructure	-	24
Pilot Project for Local Energy	-	50

< Table 5-30 > Initial Support for Local Energy Development Projects
(unit: 100 mil. Won)

1.5. Financial Support for Energy Industry

Until 1995, the Government had provided financial support for implementing energy policies from five funds including the Petroleum Business Fund and the Energy Rationalization Fund. In 1995, these funds were unified into one special account, called the Special Energy Account, by the Special Energy Account Act legislated in 1994 in order to improve the transparency and efficiency of financial support in the energy sector.

Revenue for the Special Energy Account comes from import surcharges on petroleum and LNG, sales surcharges on diesel and safety management surcharges on LNG and LPG. Special Energy Account expenditures are allocated for the following areas: petroleum storage facilities, long-range pipeline, LNG pipeline, energy conservation, development of technologies, the dissemination of collective energy, restructuring of the coal industry, and fostering the alternative energy industry.

The budget of the Special Energy Account has been increased by more than 10% annually in reflection of the serious concern of the Government for energy and environment issues. As seen in Table 5-31, funding for petroleum and gas decreased by 12.6% (from 661.4 billion Won in 1995 to 578.2 billion Won in 1997). While funding for restructuring of the coal industry increased by 14.6%.

	1995	1996	1997
Petroleum and Gas Business	6,614	7,359	5,782
Energy Rationalization Business	2,474	2,869	3,626
Coal Industry	5,580	5,863	6,393
Mineral Development	410	590	533
Others	410	387	1,190
Total	15,078	16,477	18,729

< Table 5-31 > Budget of Special Energy Account
(mil. Won)

(unit : 100)

Loans from the Special Energy Account are provided at low interest rates, depending on the type of business. Loans for expansion of LNG supply facilities, LPG import terminals,

and construction of pipelines for city gas are provided at 7% interest. Loans related to safety and distribution structure are provided at 6% interest. Loans are provided at 5% interest to high-risk projects such as petroleum development, development of energy technologies, and projects related to energy conservation and environment improvement.

In addition to financial support, the Government provides a variety of tax incentives to projects for the efficient implementation of energy policies. To accelerate the development of energy technology, 5% of such investment is tax deductible from income or corporate tax. A reserve fund for technology development is treated as a business expenditure. Investment for replacement of worn-out equipment and funding for energy conservation equipment is also tax deductible at 5% of the total investment.

1.6. Nuclear Power Generation

1.6.1. Historical Background

Under the Electricity Business Act, ~~the first nuclear power plant (NPP) in Korea~~ was built in 1978. In the 1980s, NPPs were operating commercially and provided a large share of electricity supply, more than half of the total power generated in 1987.

In the 1990's, Korea achieved technological self-reliance in this key energy sector after having induced foreign technology and succeeding in co-designing nuclear power plants. The development of Korea's standard nuclear power plant model was thus successfully achieved.

1.6.2. Current Situation and Plan for the Future

~~Korea now ranks among the top 10 countries in the world in the use of nuclear energy and is recognized as a country that is outstanding and successful in the development and application of NPP.~~

As of August 1997, 12 NPPs were operating commercially. They supplied 73.9 TWh, 36% of the total electricity supply, in 1996 and are expected to 45.5% of the total electricity supply in 2010.

	1978	1987	1996	2000	2005	2010
Power Generation(GWh)	2,324	39,314	73,924	100,510	132,960	186,000
Share of Total(%)	7.4	53.1	36.0	37.5	38.9	45.5

< Table 5-32 > Nuclear Power Generation by Year

Korea surpassed the cumulative total of 500TWh generated by nuclear power plants in February 1995, a monumental achievement contributing to economic development and environmental preservation. It would have taken 180 million tons of anthracite or 120 million tons of oil to produce that much power if these fuels had been used.

In accordance with the nation's long-term electricity demand and supply plan, which was finalized in December 1995, generators No. 3 and 4 of the Ulchin Nuclear Power Plant, generators No. 2, 3, and 4 of the Wolsong Nuclear Power Plant and generators No. 5 and 6 of the Yongkwang Nuclear Power Plant are under construction. Under the same plan, generators No. 5 and 6 of the Ulchin Nuclear Power Plant are scheduled to be built for dedication in 2003 and 2004, respectively, and eight more units are planned to be located at three different sites, which are yet to be chosen.

In 2010, nuclear power plants will account for 33.1% of the total power generation facilities in Korea as compared with 26.9% in 1996. In terms of electricity produced, Korea will depend on nuclear reactors for 38.9% in 2005 and for 45.5% in 2010.

Korea will continue promoting environment-friendly nuclear power generation to meet the ever-increasing demand for electricity in the course of economic development and the improvement of the nation's living standard. Nuclear power generation also helps Korea to raise its degree of self-reliance in the supply of electricity.

	1978	1987	1996	2000	2005	2010
Power Generation(MW)	587	5,715	9,616	13,716	18,716	26,329
Share of Total(%)	8.5	30.1	26.9	26.0	27.5	33.1

< Table 5-33 > Nuclear Power Plant Construction Plan

1.6.3. Contribution to CO₂ Reduction

As stated above, nuclear power plants represented 26.9% of the total power generation facilities in 1996 and will reach 33.1% in 2010, which would mean a drastic reduction of carbon dioxide emissions.

The cumulative total of electricity generated by nuclear power plants is expected to reach 1,760TWh during the 1997-2010 period, thus, there will be reduced carbon dioxide emissions of about 520 million tons as compared with that which coal-fired power plants would emit if they were to generate the same amount of electricity.

1.7. LNG as a Clean Energy

1.7.1. Demand for and Supply of LNG

Demand for LNG began in earnest in 1987 and has since expanded at an average annual rate of 20%. Consumption of LNG is expected to continue increasing until the early 2000s, as the Government maintains its focus on setting up a nationwide distribution pipeline network.

	1987	1990	1993	1996	Average Annual Growth Rate(%)	
					1988-1990	1991-1996
City Gas	75	575	1,847	4,561	97.2	41.2
Power Generation	1,537	1,741	2,518	4,622	4.2	17.7
Total	1,612	2,316	4,365	9,183	13.0	25.8

< Table 5-34 > Trend of LNG Consumption
(Unit : thousand tons)

(Unit :

	1997	2001	2006	2010	Average Annual Growth Rate(%)	
					1998-2001	2001-2010
City gas	7,038	10,764	14,604	17,422	11.2	5.4
Power Generation	5,970	7,280	6,500	7,200	8.4	-0.1
Total	13,008	18,004	21,104	24,622	15.9	4.0

< Table 5-35 > Mid- and Long-Term LNG Demand Projection

1.7.2. LNG Supply Facilities

The distribution pipeline network for supplying LNG across the country was expanded from 242 km as of the end of 1990 to 1,309 km by the end of 1996, and is expected to reach 2,313 km by the year 2006. Meanwhile, the construction of LNG receiving terminals, which began with just one such facility with three 100,000-kiloliter storage tanks in 1987, included two receiving terminals having 10 storage tanks at 1996 year-end. By the year 2010, a total of three large-scale receiving terminals with 53 storage tanks are planned to be in operation.

	1987	1996	2010
Number of Storage Tanks	3	10	53
Number of Receiving Terminals	1	2	3

< Table 5-36 > LNG Terminals and Storage Tanks

Note: Capacity of a storage tank is 100,000 ? .

A total of US\$2.96 billion had been invested through the end of 1996 in construction projects for the supply of LNG country-wide, and another US\$6.51 billion will be invested by the year 2010 for expanding the distribution pipeline network and building receiving terminals.

	1996	1997-2010	Total
Receiving Terminals	1,309.0	4,530.5	5,839.5
Distribution Pipelines	1,207.8	1,007.2	2,215.0
Total	25,168	55,377	80,545

< Table 5-37 > Investment in LNG Facilities
(Unit: billion Won)

1.7.3. Requirement for LNG Use

Since 1988, the Government mandated the use of clean energy in areas where pollution is above, or likely to be above, the regulated standard based on the Environment Conservation Act. Currently, in large cities including Seoul, Pusan and Taegu, buildings with a boiler capacity of more than 0.2 ton, apartment complexes larger than 59.5m sup 2 , and power plants are required to use LNG. This requirement will be expanded to six metropolitan areas and 18 small and medium-sized cities from September 1998.

1.7.4. Plan for Boosting the Ownership of CNG Vehicles

The Government is promoting CNG as a fuel for motor vehicles since it emits much less CO₂, CO, HC than gasoline and generates much less smog and NO_x than diesel fuel.

The development of CNG motor vehicles started in 1991. From 1996-1998, sixty CNG motor vehicles will be in service in restricted areas on a pilot basis. The service area for CNG vehicles will include 21 cities, six metropolises and industrial areas from 1998-2001.

The Government will concentrate on the development of CNG vehicles as substitutes for medium- and large-size vehicles equipped with diesel engines. After 2001, more than 700,000 CNG motor vehicles will be in service.

	Stage 1	Stage 2	Stage 3
Period	1996~ 1998	1998~ 2001	after 2001
Objective	Pilot Basis	Dissemination Period	Common Usage
Area, Number of CNG Motor Vehicles	7 Areas, 60	21 Cities, 150,000	Nationwide, 700,000

< Table 5-38 > Phased Plan for Promoting CNG Vehicle Ownership

1.7.5. Promotion of Gas-fired Air Conditioner Use

The Government has encouraged installation of gas-fired air conditioners to reduce electricity consumption in summer and the to mitigate seasonal gap in LNG demand. The Government provides financial support for gas air conditioner installation. Buildings larger than specified in related regulations are required to install gas air conditioners.

	1993	1994	1995	1996	1997.7	total
Number of Buildings with Gas Fired Air Conditioners	1,869	494	543	550	308	3,764
Capacity (thousand RT)	511	128	153	164	93	1,049
Substitution Effects for Power (thousand kW)	230	58	69	74	42	473

< Table 5-39 > Ownership of Gas-fired Air Conditioners

1.8. Expansion of LPG Consumption

1.8.1. LPG (Receiving) Terminal

Currently, Korea's two LPG (receiving) terminals have a combined capacity of 420,000 tons. They are located in Ulsan and Yeochun. New terminals with a combined capacity of 430,000 tons will be constructed in Incheon and Pyongtaek by 1999 to secure a stable supply

of LPG, which is a more environment-friendly energy sources than coal.

The Pyongtaek receiving terminal, which will have a 190,000 ton capacity, will start operation from March 1999. The construction of Incheon terminal with a 240,000 ton capacity will be completed by December 1999.

1.8.2. LPG for Motor Vehicles

LPG was introduced as fuel for taxicabs in 1972 based on the Petroleum Business Act. and Its use was expanded to trucks as the Government promoted LPG as an automotive fuel. The Government relaxed the relevant regulations to allow a large number of LPG supply stations to be built.

The Government aims to mitigate environmental pollution and diversify fuel sources with the use of LPG which produces less greenhouse gas, SOx and smoke than gasoline or diesel. According to a 1994 study by the TNO Road-Vehicle Research Institute, automobiles using LPG emit 13% less CO₂ than automobiles using gasoline.

LPG consumption as an automotive fuel has increased at an annual rate of 10.0% from 1987 to 1990 and 7.2% from 1990 to 1996.

1987	1990	1993	1996	Average Annual Growth Rate (%)	
				1988-1990	1991-1996
777	1,036	1,195	1,581	10.0	7.2

< Table 5-40 > Trend of LPG Consumption as Automotive Fuel

(Unit
: thousand tons)

1.8.3. LPG as Household Fuel

The main household fuels in Korea were coal and oil until the mid 1980s. A dramatic switch to LPG occurred in the late '80s as most households came to use LPG or CNG. In 1996, the gas dissemination rate reached 98.2%. The construction of national LNG pipelines has promoted the usage of LNG instead of LPG. However, use of LPG as a household fuel is expected to increase steadily mainly in small cities and in rural areas where LNG is not yet available.

1987	1990	1993	1996	Average Annual Growth Rate (%)	
				1988-1990	1991-1996
871	1,595	2,147	2,378	22.3	6.9

< Table 5-41 > Trend of LPG Consumption as Household Fuel
(Unit: thousand tons)

1.9. Rationalization of Coal Industry

1.9.1. Background

Demand for domestically produced anthracite, at one time the major household fuel in Korea, began to decrease after peaking in 1986, as the people showed a growing preference for cleaner fuels such as gasoline, LNG, etc. as a result of an improved standard of living. In addition, because of a growing awareness of environmental pollution caused by anthracite, policymakers became concerned with its use as a household fuel.

In 1989, the Government began to encourage the reduced production of anthracite and the closure of coal mines based on the Coal Business Act. The public concern about pollution from the use of anthracite has also increased.

As a result, the Government has intensified its policy to reduce the production of coal, extending support to those who comply with this policy. The Government also enacted the Special Act for supporting the development of the areas surrounding closed mines in 1995.

1.9.2. Support for the Closure of Coal Mines

The Government has offered support to offset a portion of the losses incurred in the closure of coal mines and for the welfare of out-of-work miners, who if left unprotected would likely face social and economic problems.

The Government also took steps for the protection of those who closed their coal mines, and for the reforestation of areas where there had been coal mines. A total of 387.6 billion Won was spent by the Government for these purposes during the period 1989 to 1996. Over this period, the number of coal mines was reduced from about 347 in 1988 to 11 in 1996.

	1988	1990	1992	1994	1995	1996
Number of Mines	347	215	115	45	27	11
Production (thousand tons)	24,295	17,217	11,970	7,438	5,720	4,951

< Table 5-42 > Trend of Coal Production(Unit: thousand tons)

The share of anthracite in total energy consumption fell from 16.5% in 1988 to 1.5% in 1996. The significance of anthracite in the nation's energy resource mix is now minimal.

	1994	1995	1996	Total
Amount	106	366	229	702

< Table 5-43 > Support for Closed Mines

(Unit: billion won)

1.10. Adoption of Low-Sulphur Standards for Petroleum Products

The Government strengthened its regulations on the sulfur content in diesel fuel from 1.0% prior to 1981 to 0.4% in 1981 and to 0.2% in 1993. In fact, as of July 1997, all areas in Korea were subject to regulations which call for sulfur levels of less than 0.1%.

Another regulation limiting sulfur levels in Bunker C oil to 1.0% is in effect in 42 districts. Furthermore, this two regulation will be enforced country-wide from July 1998. At the same time, regulations for limiting sulfur content to under 1.0% for Bunker-B were reduced to 0.5% in selected parts of the country from July 1997.

Regulations on gasoline for automobiles will also be upgraded so that they are comparable to those in advanced countries by the year 2000, while the sulfur content for diesel fuel will be reduced further to 0.05% sometime in 1998.

1.11. Installation of Emission Abatement Facilities in Power Plants

The Government has mandated the installation of emission abatement facilities in power plants and strengthened emission standards by power generation source to reduce

environmental pollutants. Th SO_x emissions should be reduced to less than 1,200 - 1,650 ppm in anthracite coal plants, and to less than 500 ppm in bituminous plants by 1998. From 1999, these emissions should be reduced to less than 150-700 ppm and 150-270 ppm for existing plants and to less than 120 ppm for new plants.

	Fuel	1995- 1998		after 1999	
		Existing Plants	New Plants	Existing Plants	New Plants
SO _x (ppm)	Anthracite	1,200~ 1,650	120	150~ 700	120
	Bituminous	500		150~ 270	
	Heavy Oil	1,200		150~ 180	
Dust (mg/s?)	Coal	100~ 200		50~ 150	
	Heavy Oil	60~ 200		40~ 150	

< Table 5-44 > Emission Standards Regulation

The seven-year plan (1995-2001) calls for the installation of FGD (flue gas desulphurization) facilities, dust collectors, and waste water sites. The plan involves an investment of 2,035 billion Won.

	SO _x	Dust	NO _x	Waste Water	Others
Facility	Flue Gas Desulphurization Facility	Dust Collector	Low NO _x Burner	Waste Water Site	Waste Burner Measuring Equipment etc.
Investment	1,714.4	220.8	50.8	32.34	17.2

< Table 5-45 > Abatement Facilities and Investment

(Unit: billion won)

1.12. Establishment of Environment-Friendly Industrial Structure

The Government enacted a law related to the promotion of environment-friendly industry in 1995. It is fully committed to developing environment-friendly policies in regard to industrial development, including the establishment of standards for energy and industrial water consumption, and mandatory recycling for various sectors and product categories, as well as encouraging companies to develop their own plans to cope with the changing industrial and global environment.

	1996	1997	Total
R&D on Clean Production Technology Development	40	120	160
Investment in Clean Production and Environmental Facilities	320	452	772
Total	360	572	932

< Table 5-46 > Financial Support for Environment-Friendly Industry
(Unit: billion won)

Another major focus of Government policy will be to help develop cleaner production technologies and supportive measures for such activities to not only reduce pollution but improve productivity as well. Such efforts will be particularly essential in businesses involved with dyeing, plating and heat-treatment. The Government will establish a center for providing information and support for the development of clean manufacturing technologies for the benefit of small-size companies.

A civic headquarters for the promotion of environment-friendly management has been established at the Korea Chamber of Commerce and Industry for conducting educational courses and related promotional activities. Industrial companies, meanwhile, are adopting environment-friendly management practices in recognition of the launching of the ISO 14001 certification system, and the Government is offering financial and tax incentives to those who qualify for such certification.

2. Forestry Sector

2.1. Policies for Protection and Conservation of Existing Forests

To maintain and enhance a quality of natural environment, policies for protection and conservation of existing forests are fundamental. Included in these policies are forest planning system, designation of reserve and protected forests, and control of forest fires,

disease, and pests as required by the Forest Law.

2.1.1. Forest Planning System

To achieve forest sustainability through efficient management, the Forest Law provides for a forest planning system which regulates various management practices including reforestation, silvicultural practices, harvesting, and disease and pest control. Ten-year forest plans at the national, regional, and operational level are established every decade. The preparation of private forest management plans is fully subsidized by the government and in most cases, commissioned through Forestry Cooperatives, a specialized forest management organization. These plans play an important role in sustainable management of carbon sink sources. Private forests managed under the forest plans take priority in governmental assistance through subsidies, loans, and various tax systems.

2.1.2. Designation of Forest Reserves

In Korea, the forest reserve system was established to restrict conversion of forests to other uses, especially for maintaining and enhancing timber production and other public benefits. Forest reserves are essential for the conservation of carbon sinks and accounted for 77% (almost 5 million ha) of total forests in 1996.

2.1.3. Designation of Protected Forests

Protected forests are designated to conserve the forest ecosystems and to enhance environmental benefits including recreation and watershed. Timber harvesting is restricted to maintain the maximum amount of carbon sinks. These regions include natural parks, protected forests for public benefit, wildlife habitats, and natural ecosystem reserves. They accounted for 23% (1.5 million ha) of all forest land in Korea in 1996.

2.1.4. Control of Forest Fires, Diseases, and Pests

Forest fires eliminate carbon sink and immediately discharge greenhouse gases into the atmosphere. In Korea, most forest fires are caused by carelessness. Prevention activities including campaigns are emphasized, and facilities for early detection, prevention, and

control have been reinforced through advanced equipment including helicopters and operation of specialized fire control forces. In fire-damaged areas, reforestation projects are immediately initiated under governmental assistance including subsidies covering all reforestation costs.

Forest diseases and pests reduce growth and result in reduced capacity of absorbing carbon dioxide, even in deceased stock, which emits carbon dioxide. In Korea, active control measures against various diseases and pests have been undertaken. In private forests, total control costs for control of major diseases and pests are subsidized by the government, and 90% of reforestation costs are in damaged and degraded areas.

2.1.5. Acid Rain Damage Control

To monitor forest degradation by acid rain, survey systems have been strengthened through enlargement of plots being surveyed at various stages, and the establishment of advanced monitoring systems is in progress. Research on predicting acid rain damage, rehabilitation techniques and various projects to recover damaged forests are underway. To strengthen cooperation among countries in Northeast Asia for the control of acid rain damage, several joint research projects are being undertaken.

2.1.6. Prevention of Erosion and Rehabilitation of Deforested Lands

Preventive erosion control projects have been undertaken in areas which are vulnerable to landslides on a yearly basis. Since 1997, such projects have also emphasized landscape enhancement in communities in mountainous areas which are vulnerable to landslides. The development of a computer-aided erosion control plan and mechanized technology is also being emphasized. Forestry Cooperatives is initiating a specialized forest engineering group.

2.1.7. Promotion of Forestation Conservation Campaign

Traditional and unique forest-related characteristics are being identified to promote forests as cultural assets for the general public. Also environmental education is focusing on the importance of forests, and understanding of conservation is being enhanced through direct contact with forests.

2.1.8. Strengthening International Cooperation for the Conservation of Global Forests

Various ongoing forest-related issues, such as reduced forested lands, sustainable forest management, internationalization of environmental values of forests, conservation and management of biological diversity, and forest policies, are being emphasized to achieve more effective results. The possibility of support for and participation in the World Commission on Forests and Sustainable Development will be explored and Korea, as a member of the OECD, will increase its forest-related assistance to developing countries.

2.1.9. Strengthening of Research for Forest Environments

Evaluation of the public benefits of forests has been undertaken continuously. Korea will continue to develop new technologies for protection and management of forests with strengthened policies and extended organizations and manpower.

2.2. Policy Measures for Enhancing Carbon Pool

2.2.1. Afforestation

In Korea, the Government encourages the conversion of abandoned crop land in rural areas into forests. When crop land is converted, subsidies for costs ranging from 90% to 100% of the total are provided. Afforestation for pollution prevention and noise reduction are also encouraged in urban areas.

2.2.2. Reforestation with Superior Species

Forests mainly consisting of species with low growth can be cut and reforested with superior species to create larger amounts of carbon in the long term. In Korea, reforestation has been actively undertaken to convert natural forests with inferior species to plantation forests to achieve greater potential of carbon sink. Ninety percent of total reforestation costs in private forests are subsidized by the Government.

2.2.3. Policy Measures for Silvicultural Practices

To enhance biomass, various silvicultural practices such as removing shrubs and vines, and fertilization are actively pursued. Forests being tended accounted for 240,000 ha in 1996. In private forests, 80% of costs for silvicultural practices are subsidized by the Government.

2.2.4. Improving Timber Utilization

Timber plays an important role in carbon reservoir and demand for timber is increasing continuously in Korea. To increase the carbon storage capacity, new policies on improved utilization of timber, like multiple uses for small-size timber and timber treatment for increased longevity of wooden products, are being pursued.

In addition to the above policies, to increase public benefits including the role of carbon sinks and to develop forest resources, development funds with loan rates of 3%, significantly lower than current bank rates, as well as tax breaks, including income and inheritance taxes, are provided to support reforestation and silvicultural practices.

3. Agriculture and Animal Husbandry Sector

3.1. Agricultural Sector

The Korean Government has been conducting and recommending agricultural policies and practices to mitigate GHG emissions from the agricultural sector.

3.1.1. Recommending Effective Agricultural Practices for Mitigating Methane Emissions from Rice Paddies.

An improved incorporation method using organic materials involves incorporation of rice straw or compost. Incorporation of rice straw into rice paddies in autumn reduces methane emissions by 27%, and using rice straw compost instead of rice straw reduces methane

emissions by 38.5% compared to incorporation of rice straw just before transplanting. The number of rice paddies using these agricultural practices is increasing.

When chemical nitrogen fertilizer is added to rice paddies, entire layer application is recommended. Deep layer application of nitrogenous fertilizer, instead of surface application, reduces methane emission by about 50% on average over the growing season compared to unfertilized rice paddies.

During the rice growing season, methane emissions have been reduced through water management techniques like intermittent flooding and mid-summer drainage, which are effective in mitigating reduced soil redox potential to oxidized states. Ninety-one percent of rice paddies are managed with intermittent flooding, contributing to mitigation of methane emissions by 52.1% in paddies with compost incorporation and by 45.6% in rice paddies with rice straw added just before transplanting.

The Korean Government is trying to decrease the area of transplanted rice and to increase that of directly seeded rice. For direct seeding on dry paddies, where rice straw was incorporated one month before seeding and managed with intermittent flooding after emergence, methane emissions were reduced by more than 50% compared to transplanting. The cultivated area of direct seeding in dry paddies reached 57,200 ha in 1997. There are plans to increase cultivated areas of direct seeding in dry paddies to 500,000 ha by 2004. It is expected that a more than 30% reduction of methane emissions from rice paddies, even in presently cultivated rice paddies, will be maintained.

3.1.2. Promotion of Low Level Methane Emission Rice Cultivars

As it has been observed that certain rice cultivars have achieved low methane emissions, a phased development scheme has been set up. The first step is to select the rice cultivars low in methane emissions from among the recommended cultivars. The second step is to study the characteristics of the selected cultivars. The third step is to adopt development plans for the rice varieties contributing to methane mitigation. Plans for rice varieties with lower methane emissions and superior characteristics like greater productivity are already being established and put into practice.

3.1.3. Education and Information Diffusion on Methane Mitigation Measures for Rice Paddies

Technical propagation projects to reduce methane emissions of rice paddies have been

carried out aggressively by the Rural Development Administration with technical education, public information and on-site demonstration. Technical bulletins for rice cultivation include agricultural practices for GHG mitigation. Winter education and training programs for farmers also include agricultural practices for GHG mitigation. Newly developed agricultural practices effective in GHG mitigation will also be disseminated via agricultural magazines.

3.2. Livestock

The Korean Government is proceeding with strategies to mitigate methane production from livestock.

3.2.1. Methane Emission Mitigation by Enteric Fermentation

Methane production by enteric fermentation is the result of normal fermentation and animal digestion and contributes a large share of atmospheric methane. Ruminants are the biggest producers of methane among animals.

1) Determination of Number of Animals Causing Environmental Pollution

As the result of a WTO agreement, the number of livestock animals in Korea is expected to decline. The Korean Government also advises farmers to maintain only a reasonable number of animals to meet their income needs as well as to achieve abatement of methane.

2) Feeding High Quality Roughage and Improving Feed Value of Low Quality Roughage

When ruminants are fed good quality roughage, it reduces environmental pollution and improves animal performance.

The Korean Government is preparing a policy to encourage farmers to utilize pasture and idle paddy fields during winter, which produce high quality roughage.

3) Improvement of Animal Performance

Improvement of animal performance can increase methane emission per head but it can decrease methane emission per unit. The Korean Government is considering nutritional approaches such as improved formula feed and feed additives.

4) Inhibition of Methane Producing Bacteria by Adding Chemicals

In an ongoing research project, it has been found that methane production by enteric fermentation can be possibly reduced by adding sodium nitrate, ionophore or lipids.

3.2.2. Methane Emission Mitigation by Manure Management

1) Improvement of Animal Barn Facilities

Methane production from manure mostly comes from barns, manure storage and treatment facilities and manure-spread pasture. Methane production can be reduced by using saw-dust. If saw-dust is used in free stall barns as bedding, and manure is kept in storage facilities in a solid state and fermented completely by aerobes, it can be spread on pastures without methane emission. The Korean Government is considering strategies to stabilize the demand and supply of saw-dust and to find substitute materials.

2) Development of a New Manure Management System for Reducing Methane Emission.

When water pollution from animal manure drew greater public attention, a private company developed a new manure treatment system. This system is now recommended by the Government.

4. Waste Sector

4.1. Present Status of Waste Generation

The generation of waste decreased from 1991 to 1993, but has increased steadily since 1993. The amount of industrial waste (IW) has rapidly increased and began to outweigh that of municipal waste (MW) in 1993. Municipal waste gradually decreased from 1.3kg/day/person in 1994 to 1.1kg/day/person in 1995.

Item		1991	1992	1993	1994	1995	1996
Total		158	144	141	147	148	180
Municipal Waste		92	75	62	58	47	50
Industrial Solid Waste	Total	66	69	78	88	100	130
	General	47	48	55	85	95	125
	Specific	18	21	22	3	4	5
Daily Generation Rate of Municipal Waste per Capita(kg)		2.3	1.8	1.5	1.3	1.1	1.1

< Table 5-47 > Annual Amount of Waste Generation
(unit: thousand Ton/d)

(unit:

Data: Ministry of Environment (MOE), Environmental Quality in Korea, 1997

4.2. Policy Direction for Waste Management

The final objective of waste management in Korea is to reduce the burden waste places on the environment, thereby conserving nature and allowing people to live under environmentally pleasant conditions. Rather than simply treating wastes, it has become necessary to introduce an innovative system of resource recycling to conserve the natural habitat to be shared with future generations.

Therefore, waste minimization policies in Korea have been considered as more important than any other. We believe in the generally-accepted hierarchy of solid waste management: preventing and/or reducing the generation of waste at its source; improving the guidelines for waste disposal, such as reducing related hazards; and encouraging re-use, recycling and recovery.

The National Plan for Comprehensive Waste Management is based on this concept.

Waste Type	Year	Recycling	Incineration	Landfill
MSW	1995	23.7	4.0	72.3
	1998	30.0	15.0	55.0
	2001	35.0	20.0	45.0
ISW	1995	61.2	6.3	32.0
	1998	65.0	10.0	25.0
	2001	68.0	12.0	20.0

< Table 5-48 > National Targets for Solid Waste Management
(unit :%)

Data : MOE, Environmental Quality in Korea, 1997

4.3. Policies for Waste Reduction

The primary objective of waste management policies is to minimize waste at the source. Current policies are briefly explained in the following section.

4.3.1. Reduction at Production Stage

1) Reduction of Industrial Waste

The Waste Management Act was revised in August 1995 to incorporate the reduction of industrial waste. Present regulations emphasize improving production processes and recycling waste in order to reduce waste as a by-product of production. The Act applies to companies generating hazardous wastes of over 200 ton/yr. The number of companies falling under the law are about 600 in four fields. Although this number accounts for only about 1%

of total companies generating hazardous industrial waste, these 600 companies generate over 86% of the total hazardous waste.

2) Product Charge System

The product charge system was implemented by the "Act Related to Promotion of Saving and Reutilization of Resources" of July 1993. Under the system, environmental costs of products and raw materials which involve difficulties in collection and recycling are incorporated into their final product prices. As a result, the environmental costs are distributed equally and products are managed in an environmentally sound way. Items covered by this system are 28 items of 10 products including bottles of insecticides and other items containing hazardous substances.

4.3.2. Reduction at Distribution Stage

The "Act Related to Promotion of Saving and Reutilization of Resources" and the "Detailed Enforcement Regulation on Packaging Methods and Materials" emphasize avoiding unnecessary packaging and replacing disposable packing materials with reusable or easily recyclable ones. Also, excessive packing is regulated by the ratio of the space occupied by the product to the total package and the number of wrappings. PVC and other EPS packaging materials are discouraged.

Packaging waste has increased annually at an average rate of 7.0% and accounts for 32% of total municipal solid wastes. The use of plastic packing materials is increasing steadily, and they are projected to exceed 23% of total package wastes in 2001.

4.3.3. Reduction at Consumption Stage

1) Volume-based Waste Fee System

The Volume-based Waste Fee System was introduced nationally on January 1, 1995, to reduce municipal wastes and stimulate recycling programs (Table 5-4). Unlike a flat collection fee, unit fees vary according to the volume of solid wastes generated.

According to statistics from 16 cities and provinces, since the introduction of the system, solid municipal waste has decreased by 29.4% (49,191 ton/d to 34,726 ton/day), while recyclable increased by 28.5% (8,927 ton/day to 11,468 ton/day).

The daily generation rate of municipal waste was reduced to 1.01kg/person (Table 5-4).

Item	Reduction Rate in Waste (%)	Increase Rate of Recyclables (%)	Daily Generation Rate of Waste (kg/person)
Average	29.4	28.5	1.01
Large-size Cities	24.9	33.2	1.10
Provinces	35.6	22.6	0.90

< Table 5-49 > Outcome of Volume-based Waste Fee System

Data : MOE, Environmental Quality in Korea, 1997

2) Reduction of Food Wastes

The per capita generation rate of food waste is a reduction to 0.27kg/day and the rate of the amount to be recycled is an increase to over 21%. To achieve these targets, the generation of food waste must be reduced at all stages including production, distribution, and consumption.

Item		Unit	1993	1995	1996
MW	Generation	Ton/d	62,940	47,774	46,194
	Generation per capita	Ton/d/person	1.48	1.07	1.01
Food Waste	Generation	Ton/d	19,764	15,075	16,260
	Generation per capita	Ton/d/person	0.46	0.34	0.35
	Percent in total wastes	%	31.4	31.6	35.2

< Table 5-50 > Trend of Food Waste Generation

Data : MOE, Environmental Quality in Korea, 1997

Those specifically required to reduce food waste were identified as restaurants serving over 100 persons per day and/or restaurants with service areas larger than 100sq. m. These restaurants should reduce food waste moisture content to below 75% and/or recycle food waste by producing animal foods and/or composting. Also, the central government will financially support local, city, and provincial governments' construction of recycling facilities for food waste.

3) Discouragement of Disposable Products

As disposable products (cups, forks, razors, etc.) are widely used because of their convenience, quantities have increased dramatically. The use of such products is not encouraged and restaurants, commercial bath houses, and accommodations are discouraged from freely supplying them to customers as specified in the Act Related to Promotion of Saving and Reutilization of Resources.

4.3.4. Reduction at Disposal Stage

1) Establishment of Separation/Collection System

Although the separation/collection system is more widely accepted now, its results are insufficient to minimize the generation of solid waste. It is necessary to clarify the role and responsibility of each participant in the separation, collection, and transportation of solid waste process. In addition, local governments need to establish efficient separation/collection plans and set up achievable recycling targets.

2) Development of Various Treatment Technologies

The Korean Government plans to reduce landfill waste and increase the incineration rate. According to the National Plan, the use of landfills for municipal waste should decrease from 72.3% in 1995 to 45% in 2001. Meanwhile, the incineration rate of municipal waste should increase from 4.0% in 1995 to 20% in 2001. Presently, most methane gas generated from landfills is emitted into the atmosphere without treatment. According to a Korean Government plan, all landfill sites will be sanitary landfills by 2001. The generated methane will be recovered to be used as fuel or incinerated to reduce the greenhouse effect.

Incineration technology should also be developed to meet the huge demand for incineration plants which are to be constructed in the near future (Table 5-6). In the case of small-scale incineration facilities, it is possible to design and manufacture them using domestic technology. Large-scale incinerators, however, have been constructed with the help of advanced incineration technology from developed countries. Based on technical agreements with developed nations, current proposals are to develop domestic technology to construct large-scale incineration plants. Also, the Korean Government is strongly supporting recycling technology which converts food waste into valuable resources and municipal solid wastes into compost.

Item		Total	Yearly Investment			
			Until 1995	1996	1997	After 1998
Investment	Total	11,315	395	178	624	10,118
	Financing Subsidy	10,742 573	- 395	- 178	624 -	10,118 -
Incineration Plants		52	9	2	1	40

< Table 5-51 > Construction Plans of Incineration Plants for Municipal Solid

Wastes

(unit : 100 million won)

Source : MOE, Environmental Quality in Korea, 1997

It is expected that greenhouse gases generated from landfills would greatly decrease as a result of the introduction of a variety of technological treatments and effective management policies for solid wastes.

4.4. Waste Recycling

It is expected in Korea that paper, scrap iron, plastics, scrap tires, lubricants, scrap electronic products and furniture are to be recycled because of their high rate of disposal. The distribution and consumption of these goods are also significant. Relatively high market values are received for these recycled products.

4.4.1. Separation/Collection System for Recyclables

The five classes ? paper, scrap iron, glass, cans and plastics ? in the separation/collection system make it simple for high-rise apartment residents to separate items. Two or four classes of recyclable in the separation/collection system are available in other residential areas. Recyclable bottles are identified by an imprinted mark, leading to easy separation, collection, and recycling.

4.4.2. Deposit Refund System for Acceleration of Recycling

The objective of the deposit system is to accelerate recycling. Manufacturers and/or importers are required to deposit the recovery and collection cost of products which are generated in high quantities but easily recyclable. The deposit is returned to the manufacturers and importers according to recycling records. Presently, 12 products from six categories are controlled under

the deposit system.

4.4.3. Enhancement of Recyclability of Products

Car and electronics manufacturers and/or importers producing over certain quantities are legislatively classified as category one companies. Evaluation of their progress regarding structure and raw materials of products in terms of recyclability during the course of the production process is required. Category one companies are required to improve structures and materials for easy disposal and recycling.

4.4.4. Establishment of Regional Recycling Zones

The nation is divided into five regional recycling zones: Sudo, Chungcheong, Honam, Kyungnam, and Donghae. The regional zones should maintain storage centers for recyclables. The main role of the storage centers is to control the demand/supply of recyclables along with collection and recovery of them within the regions. The Korea Resource Recycling Corporation (KRRC) also participates in the collection of recyclables generated from some regions which are avoided by private companies because of economic viability. In addition, the KRRC maintains intermediate processing facilities for recyclables to improve their quality. Presently, the KRRC plays an important role in offering information on recycling technology and regional demand/supply. Information centers are now established to keep the process working smoothly.

4.4.5. Acceleration of Recycling through Manufacturer and Government Cooperation

The Government encourages establishment of co-operative systems among similar manufacturing industries to share the same recovery and sales system for wastes. Also, standard recovery methods are used to recover by-products generated during the course of production through cooperation between manufacturers and government. It is necessary to develop a policy for recycled products to be purchased primarily by the Government, resulting in market expansion for recycled products.

4.4.6. Expansion of Recycling Industries and Public Recycling Facilities

In order to increase the number of industries which re-use materials and produce recyclable products, it is necessary to support them financially from a special fund to improve the environment (15 billion Won in 1995). Also, these companies are offered loans on a first priority basis from an industry base fund made up of funds for small and medium-size companies and from a fund for pollution prevention. A variety of policies are being pursued to support companies which recycle. Among these policies are installation of public storage facilities for recyclable materials within greenbelt regions, financial support of small companies using recycling technology, special support of companies using first-class technology and management techniques, and inducements to create investment by the private sector in specific fields of advanced technology.

4.4.7. Utilization of Recycled Waste

It is mandatory for some companies, including paper mills and glass, plastic and steel manufacturers, to re-use waste as a raw material to some extent.

Recyclables		Until 1995	1996~ 1997	From 1998
Paper		47	50	55
Glass		42	47	52
Steel cans		20	30	40
Plastics	PET	10	25	55
	Others	5	10	20

< Table 5-52 > Target Utilization Rates for Recyclables by Sector
(unit : %)

Data: MOE, Environmental Quality in Korea, 1997

4.4.8. Recycled Products Marketing

The mandatory purchase of Environment Ministry-designated recycled products has been expanded to include 114 public agencies, including central and local governments, government-invested institutes, etc. The number of mandatory recycled products to be purchased has been expanded to 24 items, including 14 storable products (e.g., solid soap)

and 10 non-storable products (e.g., slag cement from high-temperature furnaces).

4.5. Industrial Wastewater Management

4.5.1. Management of Industrial Wastewater Sources

Wastewater generated from industrial complexes is managed by the Office of Environmental Management, and that from other sources is managed by local governments.

Central monitoring teams from the Ministry of Environment were formed to support the local monitoring systems. In 1996, wastewater generated from 1,621 factories was investigated. It was reported that 287 companies had violated discharge standards.

Depending on the type of wastewater treatment system and to what degree companies violate the standards, they are assigned blue, green, yellow, and red color codes and are managed separately. This tiered management system was introduced to encourage self-regulated management and appropriate management of each wastewater treatment system. Industries are classified into one of five groups ? ranked first to fifth-based on the quantity of wastewater produced.

The number of regular checks conducted are according to the company's ranking.

4.5.2. Consignment of Wastewater Treatment

Since August 1987, professional wastewater treatment companies have been consigned to treat wastewater discharge rates of lower than 10m³/day. Also, the wastewater should be treatable by physical treatment methods. In cases where the physical and chemical composition of wastewater varies significantly, professional wastewater treatment companies also can be used. The quantity of wastewater treated by professional treatment companies reached 508,000m³ in 1995 and 467,000m³ in 1996. The Water Quality Preservation Act was revised in January 1996 to apply the same regulations to other facilities which generate wastewater (e.g., incineration plants, drying facilities, condensation facilities, etc.).