6.3 Estimation of Energy Conservation Potential in Targeted Equipment

In chapter 5, we estimated the energy intensities of equipment in 2000 and 2003. In this section of 6.3, based upon the estimation above, we estimate the energy conservation potential of each targeted equipment, which is the difference in energy consumption in the Reference Scenario and that in each of other two Scenarios.

Table 6.3.1 and Figure 6.3.1 show the energy consumption of seven types of equipment in 2000 and 2003 in each Scenario. In addition, energy conservation potentials are shown in Figure 6.3.2.

6.3.1 Lighting

In. "scenario E.C," electricity consumption decreases from 1,235 TJ in 1997 to 1,222 TJ in 2000 and then levels off to 1,223 TJ in 2003. Similarly in. "scenario A.E.C," it decreases to 1,165 TJ in 2000 and then levels off to 1,157 TJ in 2003.

These levels of consumption are 7% in 2000 and 15% in 2003 in "scenario E.C," and 12% in 2000 and 19% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.2 Air compressors

In "scenario E.C," electricity consumption decreases from 2,798 TJ in 1997 to 2,723 TJ in 2000 and then increases slightly to 2,803 TJ in 2003. In "scenario A.E.C," it decreases to 2,639 TJ in 2000 and then increases to 2,730 TJ in 2003.

These levels of consumption are 14% in 2000 and 22% in 2003 in "scenario E.C," and 17% in 2000 and 24% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.3 Motors

In "scenario E.C," electricity consumption decreases from 10,416 TJ in 1997 to 9,443 TJ in 2000 and then increases slightly to 9,550 TJ in 2003. In "scenario A.E.C," it continues to decrease to 8,786 TJ in 2000 and to 7,602 TJ in 2003.

These levels of consumption are 17% in 2000 and 24% in 2003 in "scenario E.C," and 23% in 2000 and 40% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.4 Transformer

In "scenario E.C," electricity consumption decreases from 2,370 TJ in 1997 to 2,327 TJ in 2000 and then levels off to 2,335 TJ in 2003. Similarly in "scenario A.E.C," it decreases to 2,245 TJ in 2000 and then levels off to 2,276 TJ in 2003.

These levels of consumption are 9% in 2000 and 16% in 2003 in "scenario E.C," and 12% in 2000 and 19% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.5 Heating (Air conditioning)

In "scenario E.C," fuel consumption increases from 57,770 TJ in 1997 to 58,961 TJ in 2000 and then to 61,025 TJ in 2003. Similarly in "scenario A.E.C," it decreases to 56,309 TJ in 2000 and then increases to 57,571 TJ in 2003.

These levels of consumption are 6% in 2000 and 11% in 2003 in "scenario E.C," and 10% in 2000 and 16% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.6 Boilers

In "scenario E.C," fuel consumption decreases from 112,165 TJ in 1997 to 111,870 TJ in 2000 and then increases slightly to 115,622 TJ in 2003. Similarly in "scenario A.E.C," it decreases to 91,875 TJ in 2000 and then increases slightly to 93,952 TJ in 2003.

These levels of consumption are 8% in 2000 and 13% in 2003 in "scenario E.C," and 25% in 2000 and 30% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

6.3.7 Industrial furnace

In "scenario E.C," fuel consumption decreases from 11,694 TJ in 1997 to 10,922 TJ in 2000 and to 10,831 TJ in 2003. All consumption is in heating furnaces of the iron and steel industry. Similarly in "scenario A.E.C," it decreases to 9,099 TJ in 2000 and to 8,979 TJ in 2003.

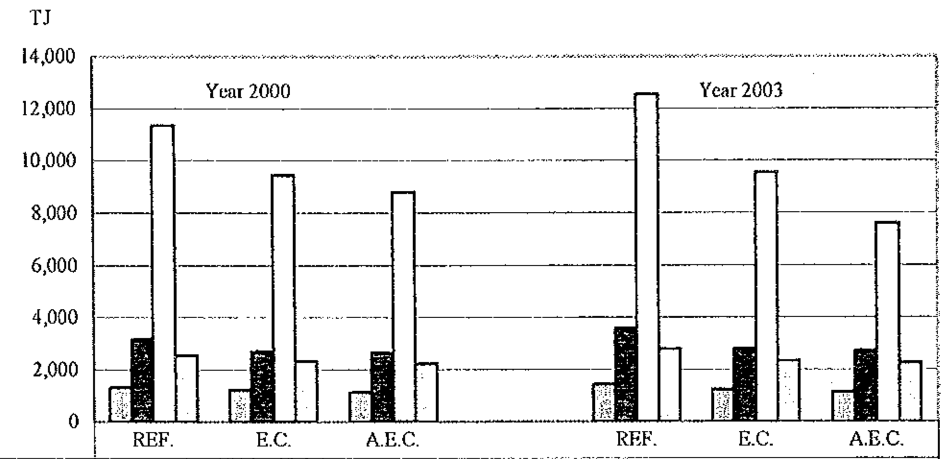
These levels of consumption are 12% in 2000 and 19% in 2003 in "scenario E.C," and 27% in 2000 and 33% in 2003 in "scenario A.E.C," lower than those in "scenario REF," respectively.

Table 6.3.1 Energy Consumption in Seven Types of Equipment in Targeted Industries in 1997, 2000, and 2003

Scenario	Equipment	Share in Total (%)*	Energy consumption (TJ)			EC or AEC / REF	
			1997	2000	2003	2000	2003
EC	Lighting	3.34	1,235	1,222	1,223	0.93	0.85
	Compressor	7.58	2,798	2,723	2,803	0.86	0.78
	Motor	28.20	10,416	9,443	9,550	0.83	0.76
	Transformer	6.42	2,370	2,327	2,335	0.91	0.84
	Heating	16.75	57,770	58,961	61,025	0.94	0.89
	Boiler	32.53	112,165	111,870	115,622	0.92	0.87
	Furnace	3.39	11,694	10,922	10,831	0.88	0.81
AEC	Lighting			1,165	1,157	0.88	0.81
	Compressor			2,639	2,730	0.83	0.76
	Motor			8,786	7,602	0.77	0.60
	Transformer			2,245	2,276	0.88	0.81
	Heating			56,309	57,571	0.90	0.84
	Boiler			91,875	93,952	0.75	0.70
	Furnace			9,099	8,979	0.73	0.67
REF	Lighting			1,318	1,434		
	Compressor			3,170	3,592		
	Motor			11,351	12,566		
	Transformer			2,564	2,794		
	Heating			62,874	68,307		
	Boiler			121,986	133,472		
	Furnace			12,471	13,339		

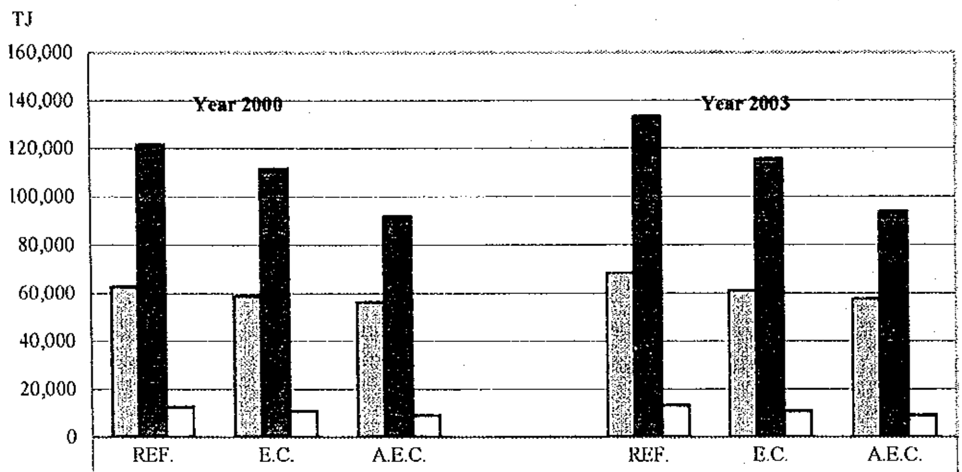
* Shares in total electricity consumption for lighting, air compressor, motor, and transformer, and in total fuel consumption for heating, boiler, and furnace in 1997, respectively.

Figure 6.3.1-1 Energy Demand Forecasting for 4 Electricity-related Equipment



	REF. (2000)	E.C. (2000)	A.E.C. (2000)	REF. (2003)	E.C. (2003)	A.E.C. (2003)
Lighting	1,318	1,222	1,165	1,434	1,223	1,157
Compress.	3,170	2,723	2,639	3,592	2,803	2,730
Motor	11,351	9,443	8,786	12,566	9,550	7,602
Transf.	2,564	2,327	2,245	2,794	2,335	2,276

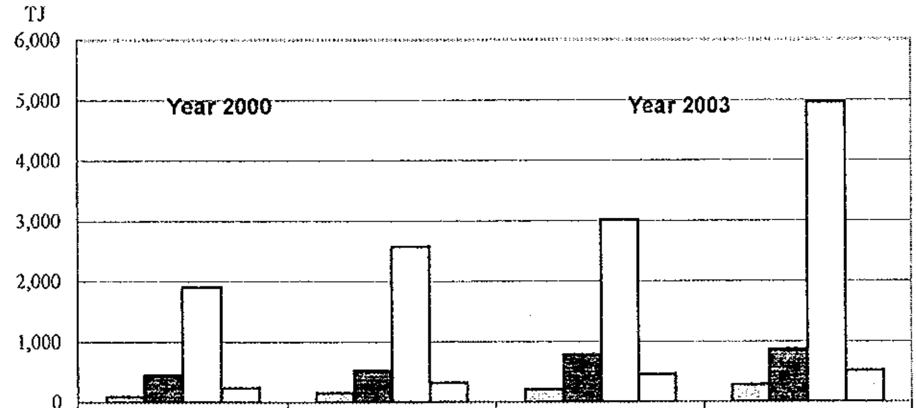
Figure 6.3.1-2 Energy Demand Forecasting for 3 Heat-related Equipment



	REF. (2000)	E.C. (2000)	A.E.C. (2000)	REF. (2003)	E.C. (2003)	A.E.C. (2003)
Heating	62,874	58,961	56,309	68,307	61,025	57,571
Boiler	121,986	111,870	91,875	133,472	115,622	93,952
Furnace	12,471	10,922	9,099	13,339	10,831	8,979

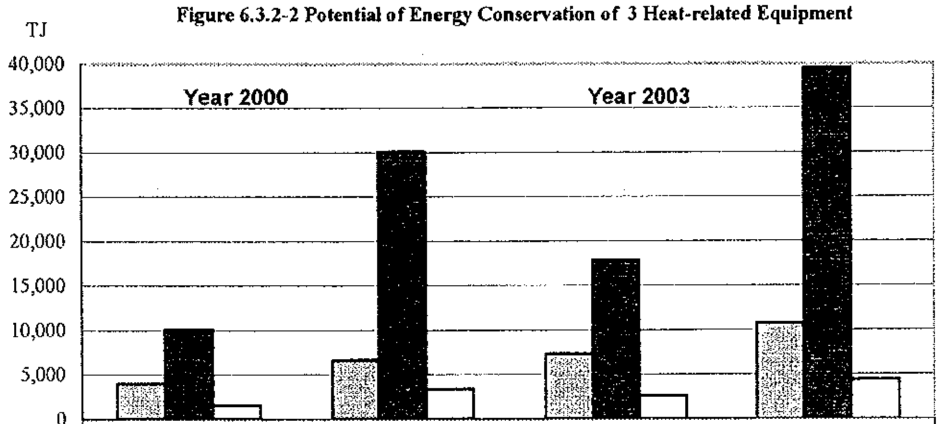
Source: JICA Team

Figure 6.3.2-1 Potential of Energy Conservation of 4 Electricity-related Equipment



	E.C.	A.E.C.	E.C.	A.E.C.
Lighting	96	153	211	277
Compress.	447	531	789	862
Motor	1,908	2,565	3,016	4,964
Transf.	237	319	459	518

Figure 6.3.2-2 Potential of Energy Conservation of 3 Heat-related Equipment



	E.C.	A.E.C.	E.C.	A.E.C.
Heating	3,913	6,565	7,282	10,736
Boiler	10,116	30,111	17,850	39,520
Furnace	1,549	3,372	2,508	4,360

Source: JICA Team

7. POSSIBLE EFFECTS OF ENERGY CONSERVATION ON ENVIRONMENTAL IMPROVEMENT

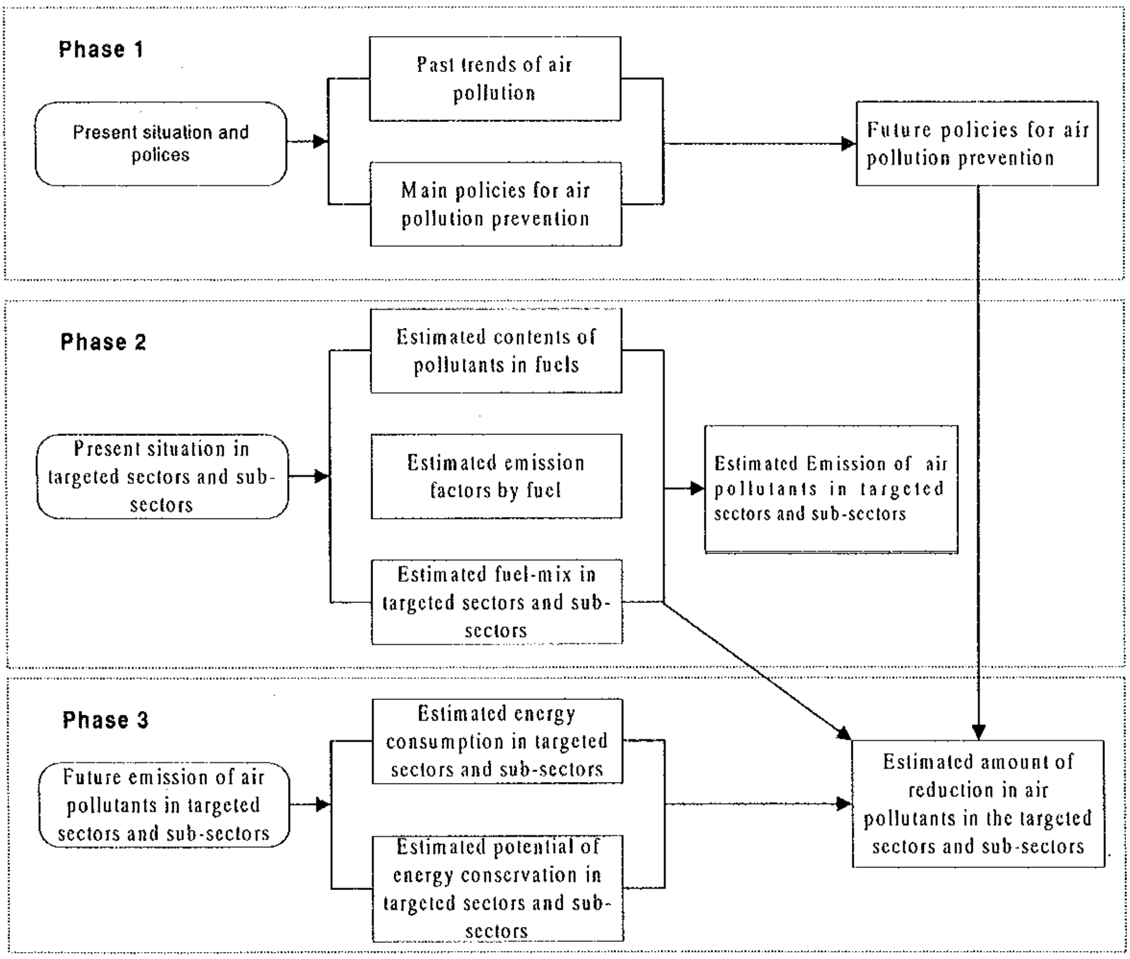
7. POSSIBLE EFFECTS OF ENERGY CONSERVATION ON ENVIRONMENTAL IMPROVEMENT

7.1 Introduction

The main purpose of this Chapter is to estimate the possible effects of energy conservation on environmental improvement in the targeted sectors and sub-sectors.

The study consists of three categories of investigation: First, to review the present situation of air pollution and policies for atmospheric pollution prevention. Second, to estimate air pollution emission factors by targeted sector and sub-sector. Third, to estimate emissions of main pollutants into the atmosphere using a scenario. The methodology of the study is shown in Figure 7.1.1.

Fig. 7.1.1 Methodology of the study



7.2 Present Situation of Air Pollution and Policies for Air Pollution Prevention

In this section, the present situation of air pollution in Poland is overviewed. Air-protection policies are introduced from several viewpoints such as emissions of major air pollutants, sources of air pollution and quality of the air.

7.2.1 Conditions and Trends

Since 1990, there has been a substantial decline in emissions of air pollutants in Poland. Emissions of carbon dioxide (CO_2) have decreased from 381million tons in 1990 to 344 million tons per annum in 1996, which corresponds to an average annual rate of decline of 1.7%. The emissions of other major air pollutants, i.e., SO_2, NO_2, and dust also show a falling trend and their average annual declines in the period 1990-1996 have been 4.9%, 1.7%, and 7.1%, respectively, and level of emissions of these pollutants dropped to 2,368 thousand tons, 1,154 thousand tons, and 1,250 thousand tons in 1996.

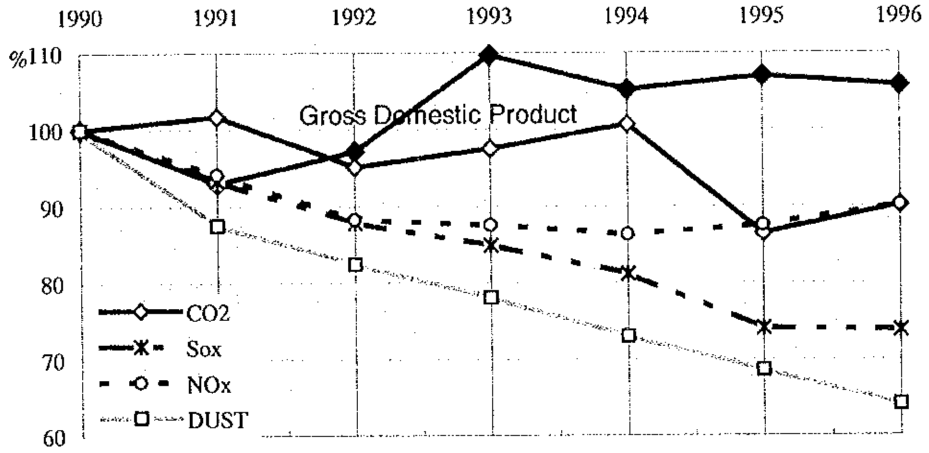
Changes in the emissions of major air pollutants between 1990 to 1996 are shown in Table 7.2.1. This falling trend can also be seen in Figure 7.2.1. Figure 7.2.1 shows a 28% decline of emissions of sulfur dioxide, and respective declines of 10%, 38%, and 10% in those of nitrogen dioxide, dust, and carbon dioxide between 1990 to 1996. Against constant growth rate of GDP has increased from 59 billion US$ to 69.1 billion US$ (at constant price of 1990), corresponding to an average annual growth rate of 2.7% in the same period.

Table 7.2.1 Emissions of Air Pollutants of Poland

Item	1990	1991	1992	1993	1994	1995	1996	'96/90
CO_2 (million tons)	381	388	363	372	384	330	344	-1.7
SO_2 (Thousand tons)	3,210	2,995	2,820	2,725	2,605	2,376	2,368	-4.9
NO_2 (Thousand tons)	1,280	1,205	1,130	1,120	1,105	1,120	1,154	-1.7
Dust (Thousand tons)	1,950	1,707	1,608	1,522	1,423	1,337	1,250	-7.1

Source: 1. From 1990 to 1995, the data of SO2, NO2, Dust from GUS "Environmental Statistics Year Book 1998"
2. The data of CO2 from "Second National Report" except for 1996
3. The data of 1996 from the Institute of Environmental Protection (IOS)

Figure 7.2.1 Changes in Emissions of Pollutants between 1990 to 1996 against GDP (percentage of 1990 figure)

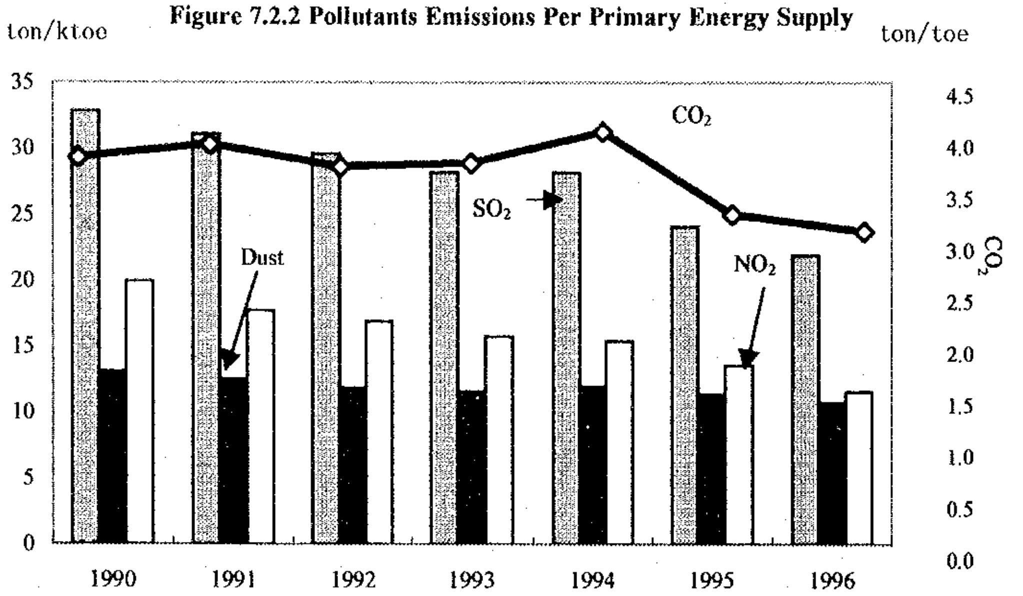


Source: JICA Team

Figure 7.2.2 shows the trend of emissions of pollutants per unit of primary energy supply. A falling trend of emissions of pollutants is also observed. CO_2 emissions per primary energy supply fell from 3.9 ton/toe in 1990 to 3.18 ton/toe. A falling trend can also be seen for other air pollutants. The major reason for this development is as follows:

- Changes in the production structure towards an increase of the share of processing industries of all industries (from 77.6% in 1992 up to 82% in1995);
- Changes in fuel mix (increase of oil share from 13.4% in 1995 to 14.4% in 1996, natural gas from 7.3% up to 7.7% and decrease of hard coal share from 59.8% to 59.2%);
- Foreign Investment in industrial modernization (from 1990 to 1997, the total value of foreign direct investment in Poland is estimated at 20,587.7 million USD at the end of 1997. Only in 1997 the future investment plans of major foreign investors amounted to 10,777.1 million USD);
- Investment in environmental protection (in 1996, total of 4,100 million PLN were invested in environmental protection, in which, 49% for water protection, 45% for air protection, and 6% for protection of the land).

Figure 7.2.2 Pollutants Emissions Per Primary Energy Supply



Source: JICA Team

7.2.2 Emissions of Air Pollutants by Source

(1) Emissions of pollutants in public power plants

In Poland, the level of pollutant emissions into the air is mainly determined by emissions from the processes of fuel combustion. In this regard, power plants in Poland are particularly sources of air pollutants, with over 75% of demand for primary energy being met by burning hard and brown coal.

Changes in emissions of major air pollutants from 1990 to 1996 are shown in Table 7.2.2 though 7.2.4. SO_2 emissions fell from 1,570 million tons in 1990 to 1,195 million tons in 1996, which corresponds to an average annual rate of decline of 4.4%. NO_2 emissions increased from 370 thousand tons in 1990 to 360 thousand tons in 1996.

Dust emissions show a trend of a rapid decline from 570 thousand tons in 1990 to 157 thousand tons. The reason for these changes are that nearly all public power stations have installed electrostatic precipitator and some power plants have installed flue gas desulfurization units.

(2) Emissions of pollutants in other sectors

Industry, household, commercial, transportation, and agriculture sectors are the major consumers of final energy carriers, and hence the majority of pollutants are emitted in these sectors. Tables 7.2.2 through 7.2.4 also show the emissions of major pollutants from each of sector.

(*Note:* household, commercial, agriculture sector are bundled in "Other source" in environmental statistics book)

Table 7.2.2 Annual Emissions of Sulur Oxides by Source (1990-1996)

(Thousand ton)

Source	1990	1991	1992	1993	1994	1995	1996	'96/90
Public power plants	1,570	1,480	1,310	1,290	1,270	1,223	1,195	-4.4
	(49)	(49)	(46)	(47)	(49)	(51)	(50)	
Industrial sector	770	665	670	635	575	584	606	-3.9
	(24)	(22)	(24)	(23)	(22)	(25)	(26)	
Other sources	760	760	750	750	710	527	521	-6.1
	(24)	(25)	(27)	(28)	(27)	(22)	(22)	
Mobile sources	110	90	90	50	50	42	46	-13.5
	(03)	(03)	(03)	(02)	(02)	(02)	(02)	
Total	3,210	2,995	2,820	2,725	2,605	2,376	2,368	-4.9

Source: GUS "Environmental Statistics Year Book 1998",IOS "Polish National Environment Report"

Note: Figures in parentheses show percentage share of total

Table 7.2.3 Annual Emissions of Nitrogen Oxides by Source (1990-1996)

(Thousand ton)

Source	1990	1991	1992	1993	1994	1995	1996	'96/90
Public power plants	370	395	370	380	380	377	360	-0.5
	(29)	(33)	(33)	(34)	(34)	(34)	(31)	
Industrial sector	330	315	260	190	180	214	246	-4.8
	(26)	(26)	(23)	(17)	(16)	(19)	(21)	
Other sources	100	100	100	130	125	115	131	4.6
	(08)	(08)	(09)	(12)	(11)	(10)	(11)	
Mobile sources	480	395	400	420	420	414	417	-2.3
	(38)	(33)	(35)	(38)	(38)	(37)	(36)	
Total	1,280	1,205	1,130	1,120	1,105	1,120	1,154	-1.7

Source: GUS, "Environmental Statistics Year Book 1998", IOS "Polish National Environment Report"

Note: Figures in parentheses show percentage share of total

Table 7.2.4 Annual Emissions of Dust by Source (1990-1996)

(Thousand ton)

Source	1990	1991	1992	1993	1994	1995	1996	'96/90
Public power plants	570	470	420	345	260	193	157	-19.3
	(29)	(28)	(26)	(23)	(18)	(14)	(12)	
Industrial sector	860	690	640	630	645	625	623	-5.2
	(44)	(40)	(40)	(41)	(45)	(47)	(49)	
Other sources	520	520	520	520	490	490	470	-1.7
	(27)	(30)	(32)	(34)	(34)	(37)	(37)	
Mobile sources		27	28	27	28	29	29	1.4
	(00)	(02)	(02)	(02)	(02)	(02)	(02)	
Total	1,950	1,707	1,608	1,522	1,423	1,337	1,279	-6.8

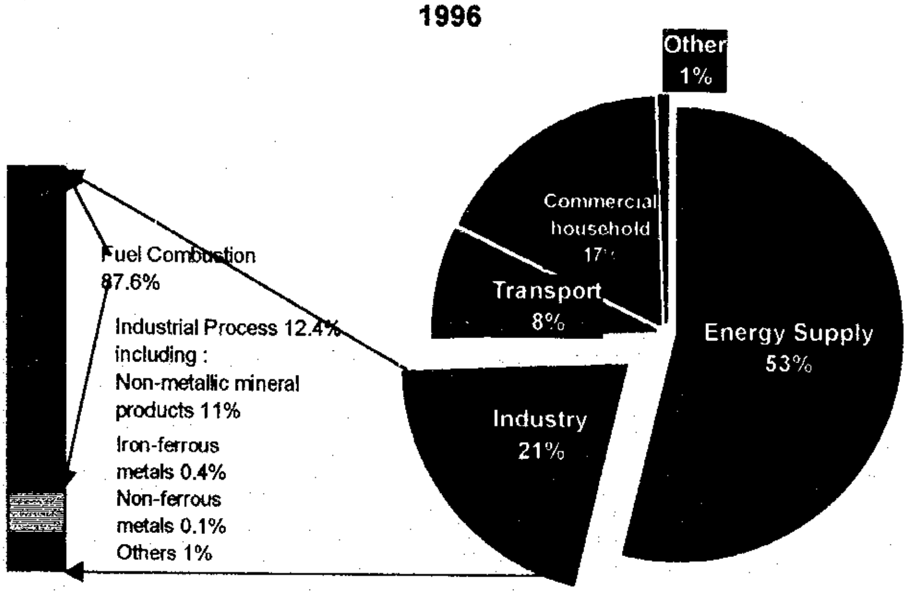
Source: GUS "Environmental Statistics Year Book 1998", IOS "Polish National Environment Report"

Note: Figures in parentheses show percentage share of total

(3) Share of Emission

Figure 7.2.3 shows the share of each sector for emissions of carbon dioxide. Carbon dioxide is emitted in the energy conversion (53% in 1996), industry (21% in 1996), household and commercial sector (17%) and transport sector (8%). In the industrial sector, carbon dioxide is mainly emitted in fuel combustion (87.6%) and industry processes (12.4%).

Figure 7.2.3 Share of CO_2 in Different Economic Sectors 1996



Source: GUS "Industry Statistics Year Book of Poland 1997";Institute of Environmental Protection, Poland "Data Table"

7.2.3 Standard for Air Pollution Prevention

Table 7.2.5 shows the present environmental quality standards for air in Poland as this standard is running from June 1998, but data used in this study are from before 1998. The previous standard is also shown in Table 7.2.6. For reference, Japanese ambient air quality standards are also shown in Table 7.2.7.

Under Japanese law, ambient air quality standards are represented by five substances, i.e., Sulfur dioxide, Carbon monoxide, Suspended particulate, nitrogen dioxide, and Photochemical oxidants. In addition, harmful substances such as Cadmium, Lead, Fluorine, Hydrogen chlorine and Chlorine in soot and dust are also limited. However, the standard value varies by type of facility and local government, which are entitled to add more stringent standards to the central government's criteria.

Because of differences in targeted items, it is not correct to compare both standards, but in general, the Polish standard seems as severe as the Japanese standard.

Table 7.2.5 ***National Ambient Air Quality Standards*** **for the main air pollutants in Poland (1)**
(Maximum Permissible Concentrations)

SUBSTANCE	NORMAL AREA			PROTECTED AREA		
	D_{30} µg/m³	D_{24} µg/m³	D_{year} µg/m³	D_{30} µg/m³	D_{24} µg/m³	D_{year} µg/m³
SO_2	500	150	40	350	125	30
From 2005		125	30			
NO_2	500	150	40	330	100	25
PM10	280	125	50	200	100	40
From 2005		50	30		50	30
From 2010			20			20

Note: D_{30}: Polish *Air Quality Standard* for 30 minutes concentration
D_{24}: Polish *Air Quality Standard* for 24 hours concentration
D_{year}: Polish *Air Quality Standard* for annual concentration
This standard is applied after May 1998

Source: National ambient Air Quality Standards

Table 7.2.6 ***National Ambient Air Quality Standards*** **for the main air pollutants in Poland (2)**

SUBSTANCE	NORMAL AREA		PROTECTED AREA	
	D_{24}	D_a	D_{24}	D_a
	µg/m³	µg/m³	µg/m³	µg/m³
SO_2	200	32	75	11
NO_2	150	50	50	30
PM10	120	50	60	40

Note: D_{24}: Polish *Air Quality Standard* for 24 hours concentration
D_a: Polish *Air Quality Standard* for annual concentration
This standard was valid until May 1998

Source: GUS "Air Pollution in Poland in 1995"

Table 7.2.7 Ambient Air Quality Standards in Japan

Substance	Standard values	Measuring methods
Sulfur dioxide	Daily average of hourly values shall not exceed 0.04ppm, and hourly values shall not exceed 0.1ppm.	Conductometric method
Carbon monoxide	Daily average of hourly values shall not exceed 10ppm, average of hourly values in eight consecutive hours shall not exceed 20ppm.	Nondispersive infrared analyzer method
Suspended[1] particulate matter	Daily average of hourly values shall not exceed 0.10 mg/m3, and hourly values shall not exceed 0.20mg/m3	Mass/concentration method based on filtration collection. Alternatively, the light-scattering method the piezoelectric micro-balance method, or the β-ray attenuation method yielding results linearly related to the values of the mass/concentration method
Nitrogen[2] dioxide	Daily average of hourly values shall be within the range between 0.04ppm and 0.06ppm or below	Colorimetry employing Saltzman reagent (with Saltzman's coefficient being 0.84)
Photochemical[3] oxidants	Hourly values shall not exceed 0.06ppm.	Absorptiometry using neutral potassium iodide solution, or coulometry.

Notes: 1. Suspended particulate matter shall mean airborne particles of 10 microns or less in diameter.

2. a) In an area where the daily average of hourly values exceeds 0.06ppm, efforts should be made to achieve the level of 0.06ppm by 1985.
   b) In an area where the daily average of hourly values is within the range between 0.04ppm and 0.06ppm, efforts should be made so that the ambient concentration be maintained around the present level within the range or does not significantly exceed the present level.
3. Photochemical oxidants are oxidizing substances such as ozone and peroxiacetly nitrate produced by photochemical reactions (only those capable of isolating iodine from neutral potassium iodide, excluding nitrogen dioxide).

Source: Environment Agency Government of Japan, "Quality of the Environment in Japan 1990"

7.2.4 Air quality

In Poland, the set of stations for monitoring atmospheric pollution is called the basic network. In 1997, within this network there were 94 stations. The network monitors mainly concentrations of SO_2, NO_2, dust, tropospheric ozone and CO.

Manual methods of measurement and identification of pollutant's concentrations are mostly applied. About 15% of sites use automatic meters.

(1) Sulfur Dioxide

Figure 7.2.4 shows a comparison of annual mean concentration of sulfur dioxide for each of the provinces of Poland between 1993 to 1997 at monitoring sites. As shown in the figure, it is considered that six urban sites have a clear downward trend and for the remaining urban and rural sites the trend is not clear.

Figure 7.2.5 also shows the concentrations of sulfur dioxide in 1997 for each monitoring site. From this map, it is understood that mean annual SO_2 concentration in SLASK region is higher than other regions. The reason is that most of the heavy industry of Poland is located in this region. The map shows also high differences of SO_2 concentrations in warm and cold seasons. They differed by four times.

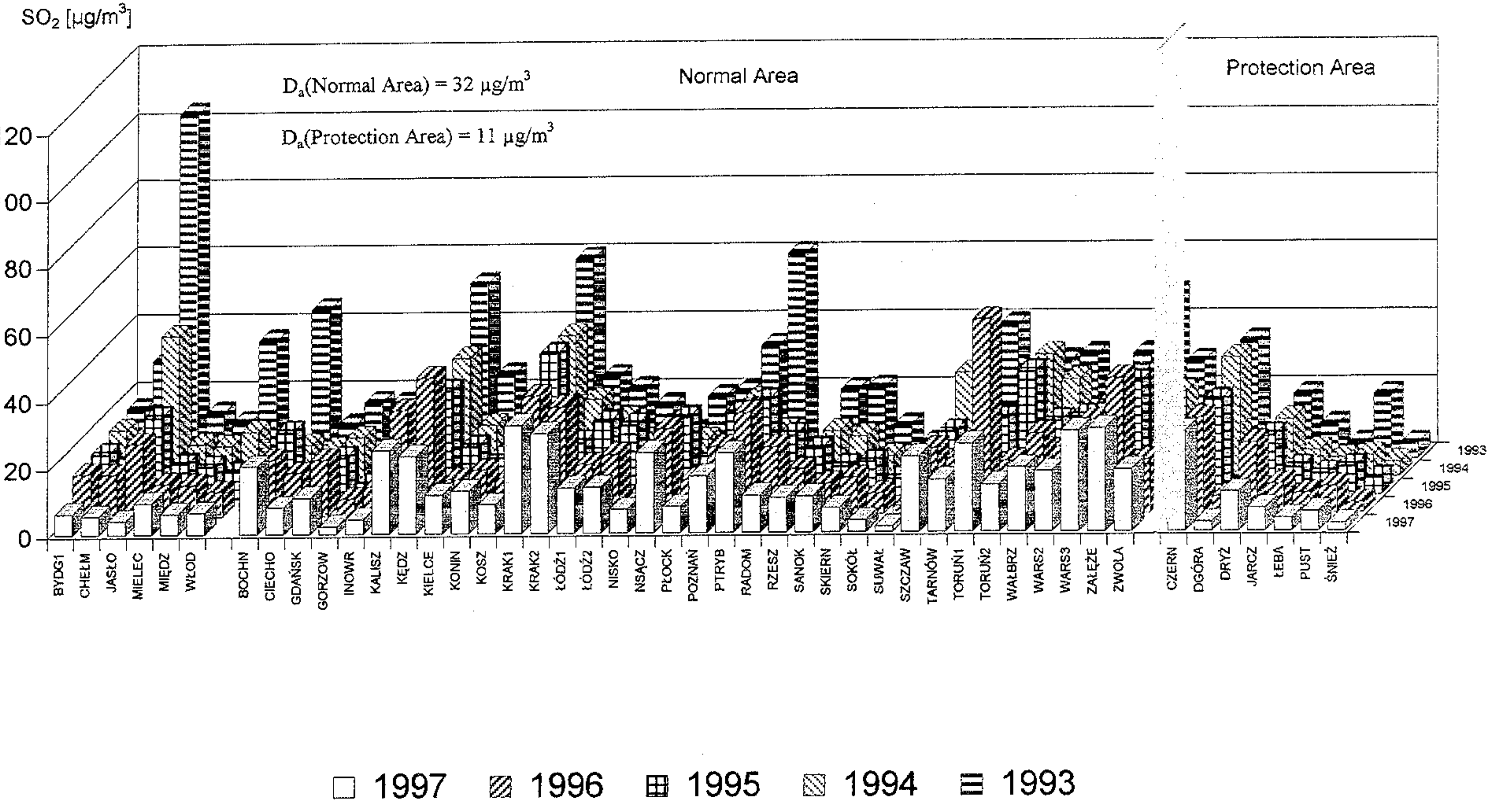
(2) Nitrogen Dioxide

Figure 7.2.6 shows a comparison of annual concentration of nitrogen dioxide for each province of Poland between 1993 to 1997 at monitoring sites. As shown in the figure, it is considered that the NO_2 concentrations at nearly 96% of the sites have similar trends and only two sites have a clear declining trend.

As with sulfur dioxide, a map is used to explain the distribution of nitrogen dioxide. Figure 7.2.7 shows annual and seasonal mean concentrations of nitrogen dioxide in 1997 assumed from measurements in the national network of basic stations. From this map, it is can be seen that the concentration of NO_2 in SLASK region is also higher than in other regions. Differences between cold and warm seasons were not so distinct as the case of SO_2. In urban areas they were of the 1.3 order, but in rural areas they reached two times.

Figure 7.2.8 shows ratio of annual mean to permissible concentrations AQS (previous National Air Quality Standard) for the main air pollutants in 1997 (based on data from the National Network of Basic Stations of Poland). Mean annual SO_2 concentrations in urban areas are within 1.7-54 $\mu g/m^3$ range. Nearly 98% of the results were below half of the permitted concentration for a given area. Excess concentration (above standard) occurred at 7% of the sites, mainly cities in the SLASK region. In rural areas concentrations were low. Mean annual NO_2 concentrations were from 7 to 42 $\mu g/m^3$. There were no above- standard results. Concentrations lower than half-standard were noticed at approx. 70% of the sites. In rural areas they were within 4-21$\mu g/m^3$ range. Measuring dust by weight and other methods presented mean annual concentrations of 13-90 $\mu g/m^3$. Excesses over the standards were noticed at more than 50% of the sites.

Figure 7.2.4 Trend of Annual Concentration of Sulfur Dioxide between 1993 to 1997



Source: Ministry of Environmental Protection, Natural Resources and Forestry, "Air Pollution in Poland in 1997"

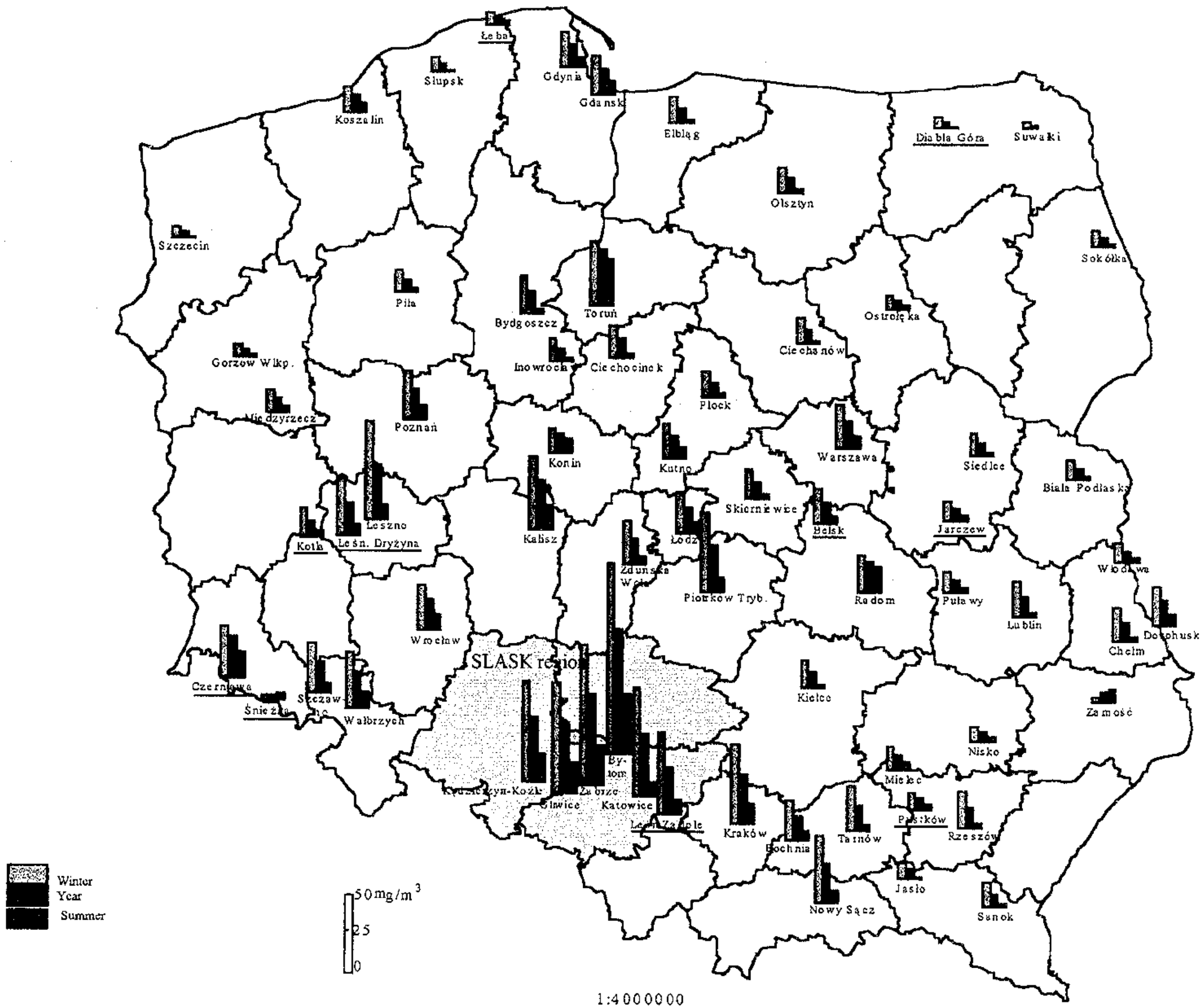
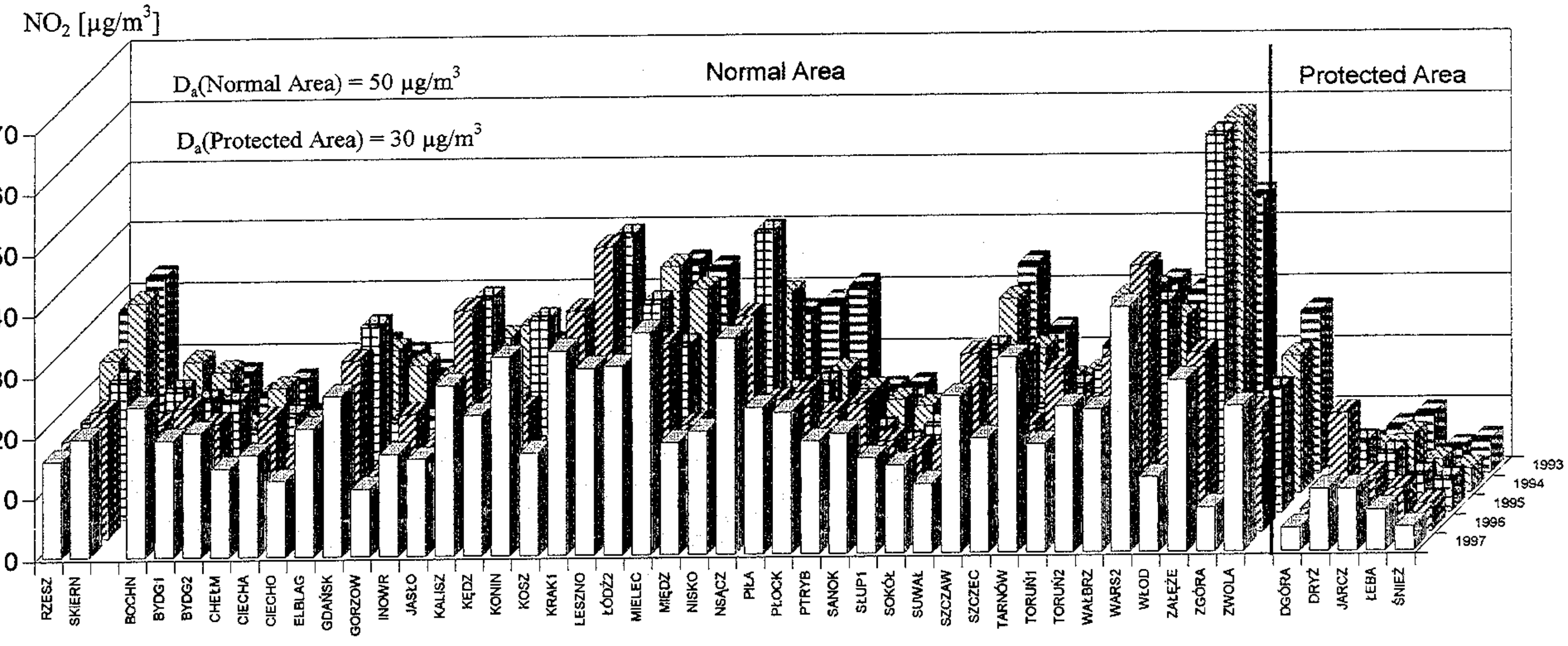


Figure 7.2.5 Annual and Seasonal Mean SO_2 Concentrations in 1997 Determined from Measurements in the *National Network of Basic Stations* of Poland

Source: Ministry of Environmental Protection, Natural Resources and Forestry,"Air Pollution in Poland 1998"

Figure 7.2.6 Trend of Annual Concentration of Nitrogen Dioxide between 1993 to 1997



□ 1997 ▨ 1996 ⊞ 1995 ▧ 1994 ☰ 1993

Source: Ministry of Environmental Protection, Natural Resources and Forestry, "Air Pollution in Poland in 1997"

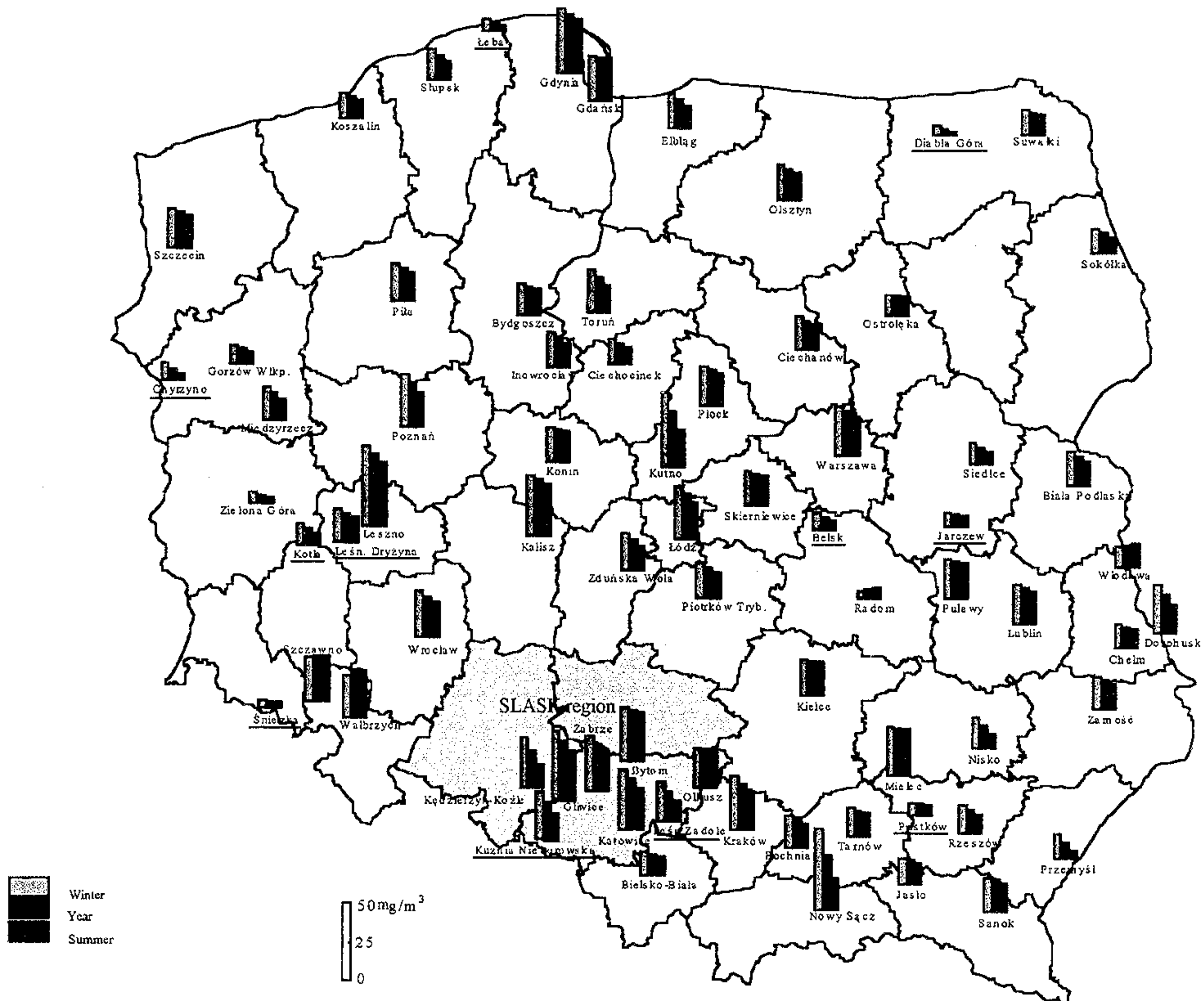


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Figure 7.2.7 Annual and Seasonal Mean NO_2 Concentrations in 1997 Determined from Measurements in the *National Network of Basic Stations* of Poland

Source: Ministry of Environmental Protection, Natural Resources and Forestry,"Air Pollution in Poland 1998"

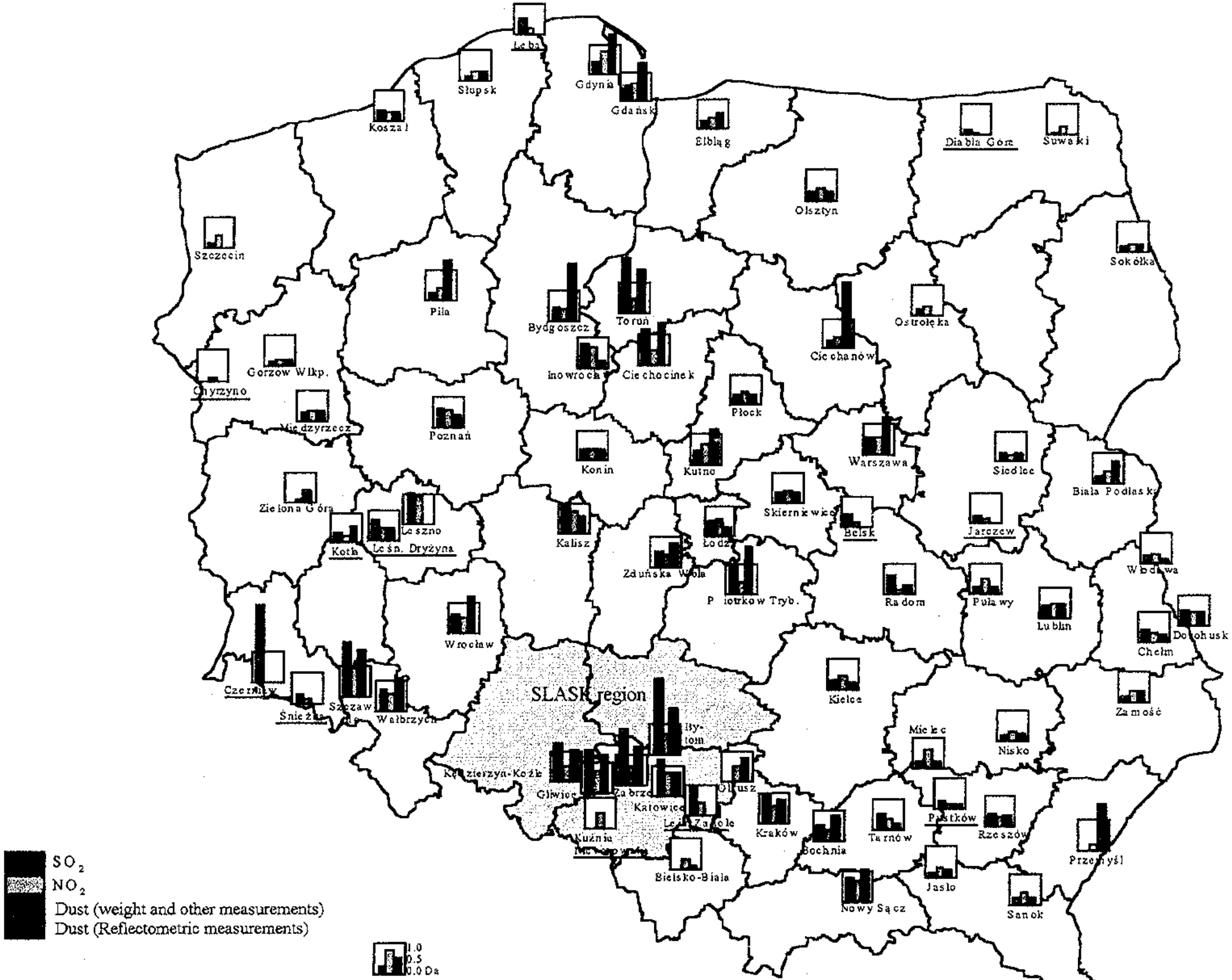

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Figure 7.2.8 Radio of Annual Mean to the Permissible Concentrations D_a for the Main Air Pollutants in 1997

(Based on data from the National Network of Basic Stations of Poland)

7.2.5 Policies and Measures

In the national economy policy, environmental protection is in the first priority. Since 1991, Poland has faced the task of complying with European Union environmental legislation. On air pollution and air quality, Poland faces the following two quite separate challenges in meeting the requirements of EU legislation.

- ❒ A significant number of urban areas violate current EU limit values for annual exposure to particulate, while many more have average levels of particulate above the target values of EU;

- ❒ Poland has to reduce total SO_2 emissions to meet agreed targets for 2000, 2005, and 2010 and to ensure that power plants and other major sources of sulfur dioxide emissions meet specific emission standards.

All policies of environmental protection center on this task. Selected main policies and measures are summarized below.

(1) Selected Main Policies

In 1991, the Polish Parliament approved the National Environmental Policy, which sets out the following priority objectives for air protection:

1) Medium-term objectives (to the year 2000):

- ❖ Limiting emissions of sulfur dioxide to 2.9 million tones;
- ❖ Limiting emissions of oxides of nitrogen to 1.3-1.4 million tons;
- ❖ Limiting emissions of particulate by 50% from 1990 level;
- ❖ Increasing the mean efficiency of dust removal to 96%
- ❖ Limiting emissions of volatile organic compounds, hydrocarbons, heavy metals, and other pollutants;
- ❖ Taking action to combat global climatic change that matches international efforts in this field.

2) long-term objective (to the year 2010)

- ❖ Total elimination of individual coal-fired burners in urban agglomerations and spa areas;
- ❖ The introduction of catalytic converters to all cars produced and in use;
- ❖ Reductions in emissions of sulfur dioxide, oxides of nitrogen, and carbon dioxide to levels agreed at international meetings.

At the beginning of 1995, the Polish parliament estimated that it would take three years to implement the above policy and to approve the *Executive Program to the National Environmental Policy for the Year 1994-2000* presented by the government.

In 1996, Polish parliament approved *the Assumptions underlying Poland's Energy Policy to the Year 2000.*

The basic direction in energy policy in the next few years is energy-saving aimed at:

- ❖ Modernization of the most energy-intensive industrial sector, specially iron and steel industry, and chemical industry;
- ❖ Introduction of clean coal technologies;
- ❖ Increasing the efficiency of energy use and gradually replacing certain energy carriers with others that are more environmental friendly;
- ❖ Improving the quality of fuels, above all hard coal, and the application of ecological combustion technologies;
- ❖ Creation of conditions for the rational use of renewable sources of energy;
- ❖ Protection of the environment through reduced emissions of particulates and gases from low sources;
- ❖ Reducing expenditure on heating buildings.

Concrete measures of the Polish government are shown in Table 7.2.8, selected measures are as following:

- ❖ Introduction of modern technology for continuous casting of steel;
- ❖ Recovery of heat from metallurgical processes;
- ❖ Increasing of gas supplies for heating of households and use of gas as an alternative power source in power plant;
- ❖ Improvement of liquid fuel quality;
- ❖ Production of petrol with ethanol content;
- ❖ Increasing hard coal calorific value and reduction of pollutants in coal.

(2) Selected main measures

In Poland, the basic instrument of environmental financial policy is a system of fees and fines. This system was established in the 1990s and the main core of the system is provided by institutional *FUNDS for Environmental Protection and Water Management* (c. 2,500 at local level, 49 at province level and central fund).

Fees are collected for emissions of pollution, as well as permits for changes to the natural environment. According to a new standard for emission fees for air pollution, 0.30PLN per kg-SO_2, 0.15PLN per ton-CO_2, 0.30PLN per kg-NO_2 and 0.20PLN per kg-dust will be paid by user.

Fines are collected for exceeding established pollution standards. Fines are ten times than fee. For example, 30PLN per kg-SO_2, 15PLN per ton-CO_2 and 30PLN per kg-NO_2 must be paid by economic entities.

In accordance with binding regulations, 10% of the resources from fees and fines remains in Local Funds, about 54% are directed to Province Funds, and 36% goes to the National Fund. Cooperating with the funds are banks, most notably the *Bank for Environmental Protection (BOS)*.

In recent years, the Polish government has established a number of organizations and agency to undertake tasks relating to environmental protection.

- Establishment *Agency for Techniques and Technologies* to support implementation of modern technologies;
- Development of regional institutions transferring new technologies;
- Building of *National Service System* for small and medium-sized companies to support them in gaining access to advisory, training, financial, information services, and as technological audits;

Main measures for environmental protection are summarized on the Table 7.2.7.

Table 7.2.8 Selected main measures in the air protection

Measures	Objective	Instruments	Implementation
Technological restructuring	❖ Establishment Agency for Techniques and Technologies to support implementation of modern technologies ❖ Development of regional institutions transferring new technologies ❖ Building of National Service System for small and medium-sized enterprises to support them in gaining access to advisory, training, financial, information services, and technological audits ❖ Introduction of clean production principles on enterprises as well as environmental management system	❖ Order of Minister of Industry and Trade (M.O.E.) ❖ Program of support for regional institutions active in technology transfer ❖ Program for organization and support of enterprise ❖ Economic instruments	Under execution since 1996
Reduction of energy intensity in industry	❖ Restructuring of most energy-intensive industrial sector: iron and steel industry, heavy chemical industry ❖ Liquidation of environmentally damaging production branches (production of pig iron, pipes, rolling of products) ❖ Growth of continuous steel casting ❖ Recovery of heat from metallurgical processes ❖ Liquidation of energy intensive technologies, introduction of modern high energy efficient process, exchange of energy carriers into oil and gas (chemical synthesis sector)	❖ Restructuring programs for individual sectors ❖ Program for restructuring of the iron and steel industry sector ❖ Program for restructuring of "Great chemical synthesis" for the years 1995-2005	Under execution since 1992
Environmental investments	❖ Change of the primary fuel consumption structure towards growth of gas consumption ❖ Increase of gas supplies for heating of households and use of gas as an alternative power source in power energy sector ❖ Improvement of liquid fuel quality ❖ Production of petrol with ethanol content	❖ Program for sector restructuring	
Support for environmental projects	❖ Increase of hard coal calorific value and reduction of pollutants in coal	❖ Program Hard coal mining, state and sector policy for the years 1996-2000	Since 1996

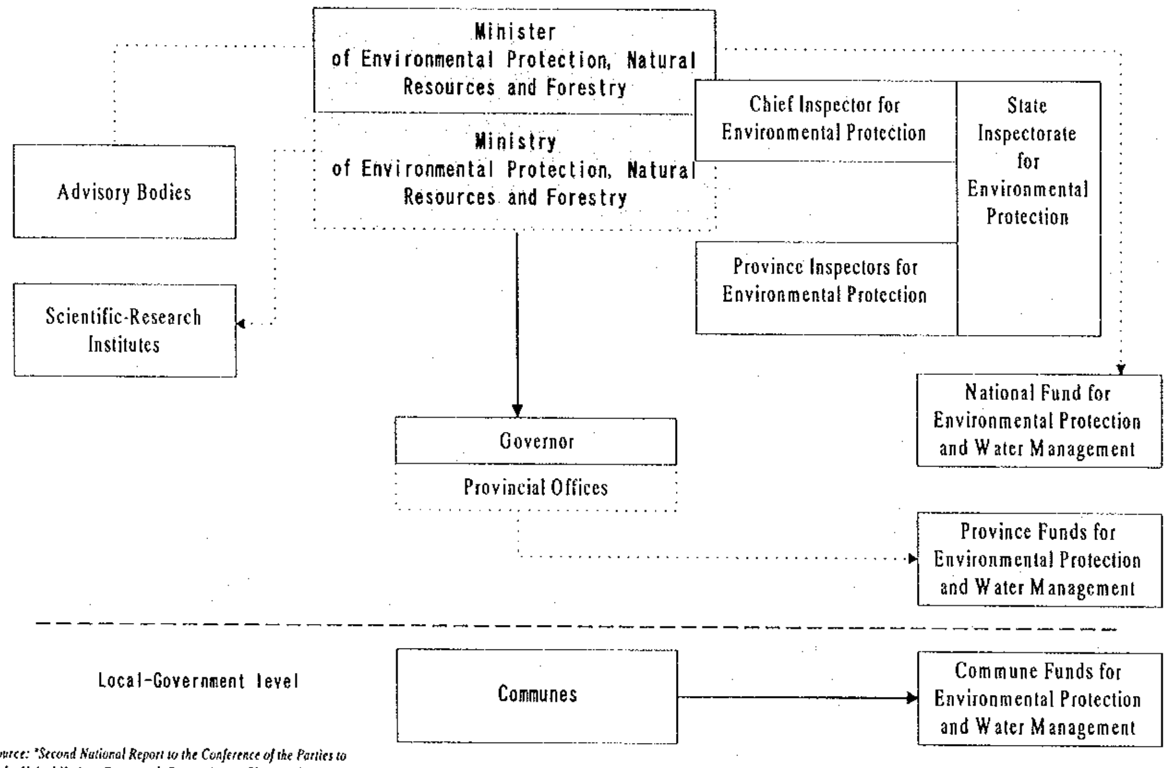
Source: Reference with National Fund for Environmental Protection and Water Management *"Second Nation Report to the Conference of the Parties to the United Nations Framework Convention on Climate Change", 1998*
"Agenda 21 Poland"

7.2.6 Organization structure of environmental management

The supreme body of the State Administration for coordinating and supervising overall activities in the field of environmental protection is the Minister of Environmental Protection, Natural Resources and Forestry, who fulfils their functions by means of an executive structure – the Ministry. The control upon decisions being undertaken is carried out by country. Inspectors for environmental protection through chief inspectors for environmental protection and provincial inspectors for environmental protection.

Financial support for ecological activities is assured by the National Fund for Environmental Protection and Water Management, and their respective provinces and Commune Funds. Research backup includes the scientific/research institutes supervised by the Minister. Organization chart of environment management in Poland is shown in Figure 7.2.8.

Figure 7.2.9 Organization chart of environmental management in Poland



Source: "Second National Report to the Conference of the Parties to the United Nations Framework Convention on Climate Change"

7.3 Emission Factors and Present Emissions of Air Pollutants in Targeted Sectors and Sub-sectors

7.3.1 Introduction

The amount of pollutants emitted into the atmosphere by an industrial plant is a function of the difference between emissions from its source and pollution kept by special devices. The amount of industrial pollution can be assessed on the basis of measurements or the balance of materials, according to the technologies applied. Because of the costs, emission measurement is not common. In Poland, only the best companies, mostly public power plants can afford to take constant, automatic measurements. Therefore, emission assessments for large groups of sources, are based on emission factors, which are generalized.

Emission factor for industry measures emission per unit of fuel or output. In every plant there are two emission sources:

(1) Boilers, converting fuel into electricity or heat (steam). They have different capacities;
(2) Technological processes, specific for a given sector.

As for the targeted sector, there are no obligatory emission factors in Poland. In this study, SO_2 and NO_2 emission factors come mainly from burning fuels. Emission factor for CO_2 depends only on carbon content of the fuel.

In this study, Emission factors for main air pollutants are estimated by the Institute of Environmental Protection. The emission factor for carbon dioxide was calculated using formulas resulting from a regression analysis as a function of calorific content and chemical composition of fuels used in Poland, broken into sectors and sub-sectors of the national economy. Emission factors for SO_2 and NO_2 are based on information of the Ministry for Environmental Protection, Natural Resources and Forestry named "Emission factors for polluting substances introduced into the air from energy processes of fuel burning".

7.3.2 Estimated Emission Factors for Main Air Pollutants by Fuel

The emission factors used for calculating air pollutant (SO_2 and NO_2) emission volumes and greenhouse effect gas (CO_2) are shown in Table 7.3.1.

Tab.7.3.1 Emission Factors for chosen fuels for targeted sectors and sub-sectors.

Sector	Fuels	CO2 (ton/TJ)	SO2 (ton/TJ)	NO2 (ton/TJ)
Meat products	Natural gas	55.400	0.004	0.056
	Coal	94.400	0.660	0.175
	Petroleum products	72.815	0.140	0.118
Vegetable oil	Natural gas	55.400	0.004	0.056
	Petroleum products	72.800	0.140	0.118
Dairy products	Natural gas	55.400	0.004	0.056
	Coal	94.400	0.660	0.175
	Petroleum products	72.800	0.140	0.118
Chemicals	Natural gas	55.200	0.004	0.125
	Coal	96.200	0.660	0.310
	Petroleum products	78.028	0.241	0.210
Glass	Natural gas	55.000	0.004	0.330
	Coal	92.500	0.660	0.300
	Petroleum products	72.900	0.140	0.200
Bricks	Natural gas	55.500	0.004	0.180
	Coal	94.200	0.660	0.200
	Petroleum products	77.973	0.242	0.300
Iron &Steel	Natural gas	57.100	0.004	0.900
	Coal	90.700	0.660	0.150
	Petroleum products	79.945	0.249	0.199
Tractor	Coal	95.800	0.660	0.200
	Petroleum products	72.434	0.143	0.300

Source: The Institute of Environmental Protection

7.4 Forecast of Emission Volume by Targeted Sector and Sub-sector

7.4.1 Introduction

The forecasting air pollutants emitted was employed for the future energy demand estimated in Chapter 6 of this report and the emission factors explained in section 7.3.2.

Future fuel-mix by each targeted sector and sub-sector are estimated based on the present energy balance table of Poland and final energy consumption data from Energy Market Agency of Poland and the macro-economic model. The following are assumed in forecasting emission volumes:

- Effect of fuel-mix change on improving environment is not included in of the results;
- From global options, effect of electricity conservation on improvement environment will be also included in the results although emissions of pollutant are emitted from power plants;
- Effect of investment in environmental protection on improving the environment will not be included in the results;
- Contents of pollutants in each fuel will not be changed until 2003.

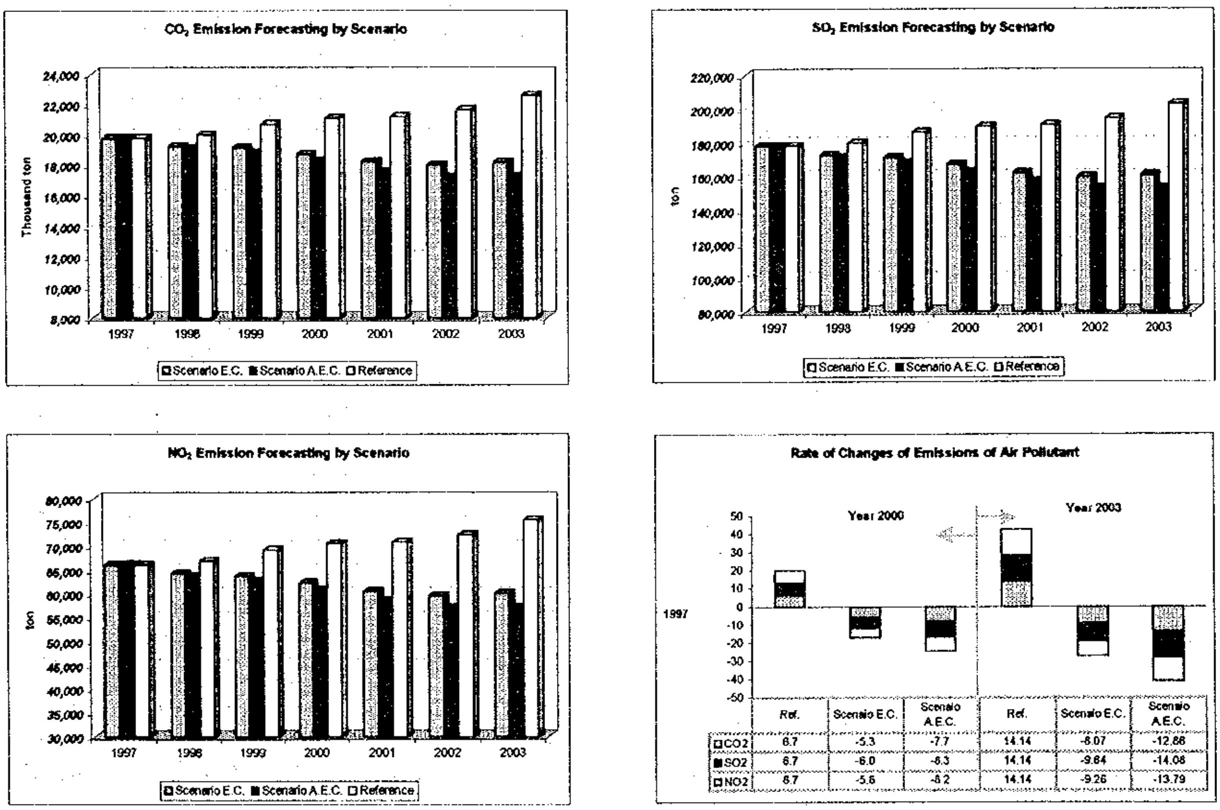
7.4.2 Iron and Steel

As shown in the Figure 7.4.1, CO_2 emissions for each scenario in 2003 are 18.2 million tons for the "scenario E.C", and 17.3 million tons for the "scenario A.E.C." Comparing these figures with the level in 1997, the figures are lower by 5% and 8%.

SO_2 emissions in each scenario in 2003 are 161 thousand tons for "scenario E.C." and 153 thousand tons for "scenario A.E.C.," which correspond to 90% and 86% of the levels in 1997.

NO_2 emissions of each scenario in 2003 are 60 thousand tons and 57 thousand tons for the "scenario E.C." and "scenario A.E.C." NO_2 emissions are also lower than the level in 1997.

Figure 7.4.1 Effect of Energy Conservation on Improved Air Quality for Iron and Steel Industry



Source: JICA Team

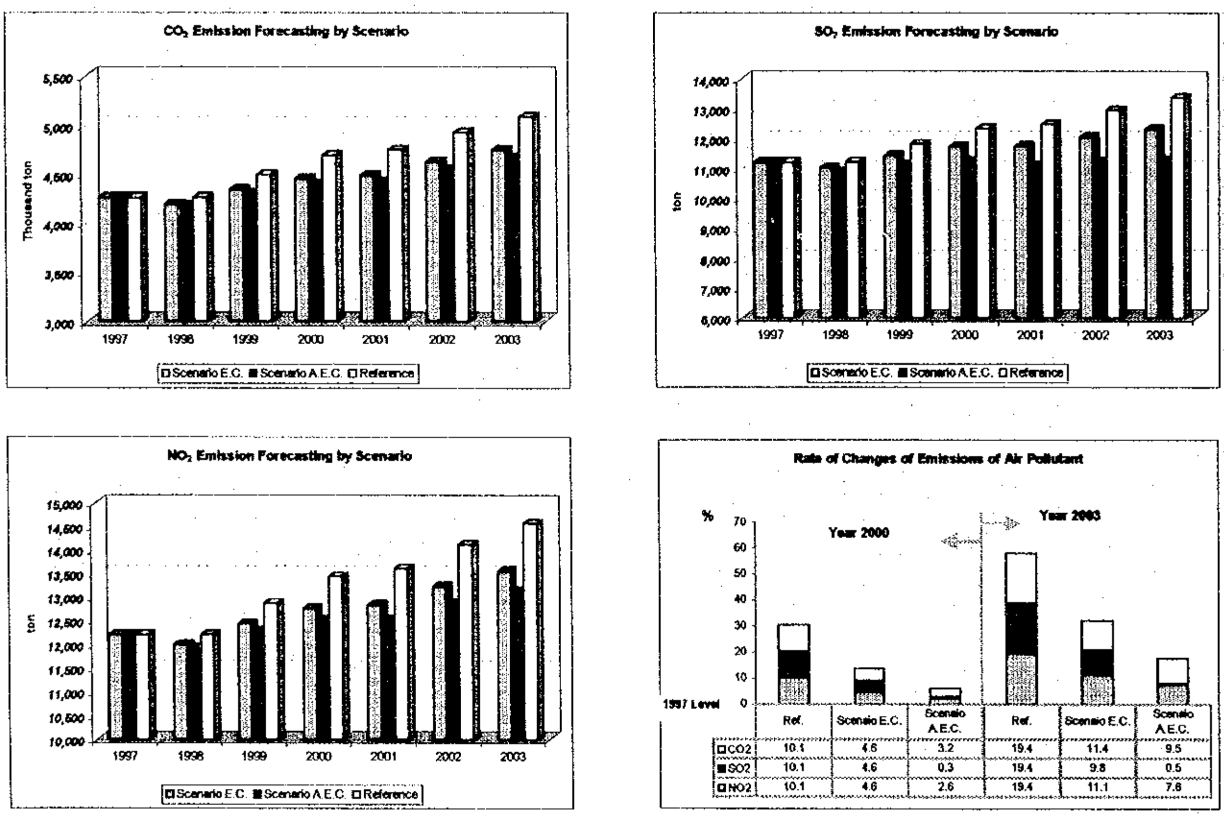
7.4.3 Ammonia

It is estimated that in 2003, CO_2 emissions will increase with the rise of energy consumption in both scenarios. It will be 11% and 9.5% higher than the level in 1997 in 2003 for "scenario E.C." and "scenario A.E.C.," but as shown in Figure 7.4.2 for the reference scenario, in 2003 it will be 19% higher than the level in 1997.

The total SO_2 emissions are estimated to increase by 10% and 0.3% from 1997 to 2003 for the "scenario E.C" and "scenario A.E.C" The main cause of the growth is the rapid increase in production of ammonia.

The total NO_2 emissions are estimated to increase by 11%, 8% and 19% in the same period for the "scenario E.C.," "scenario A.E.C." and "Reference scenario."

Figure 7.4.2 Effect of Energy Conservation on Improved Air Quality for Ammonia Sector



Source: JICA Team

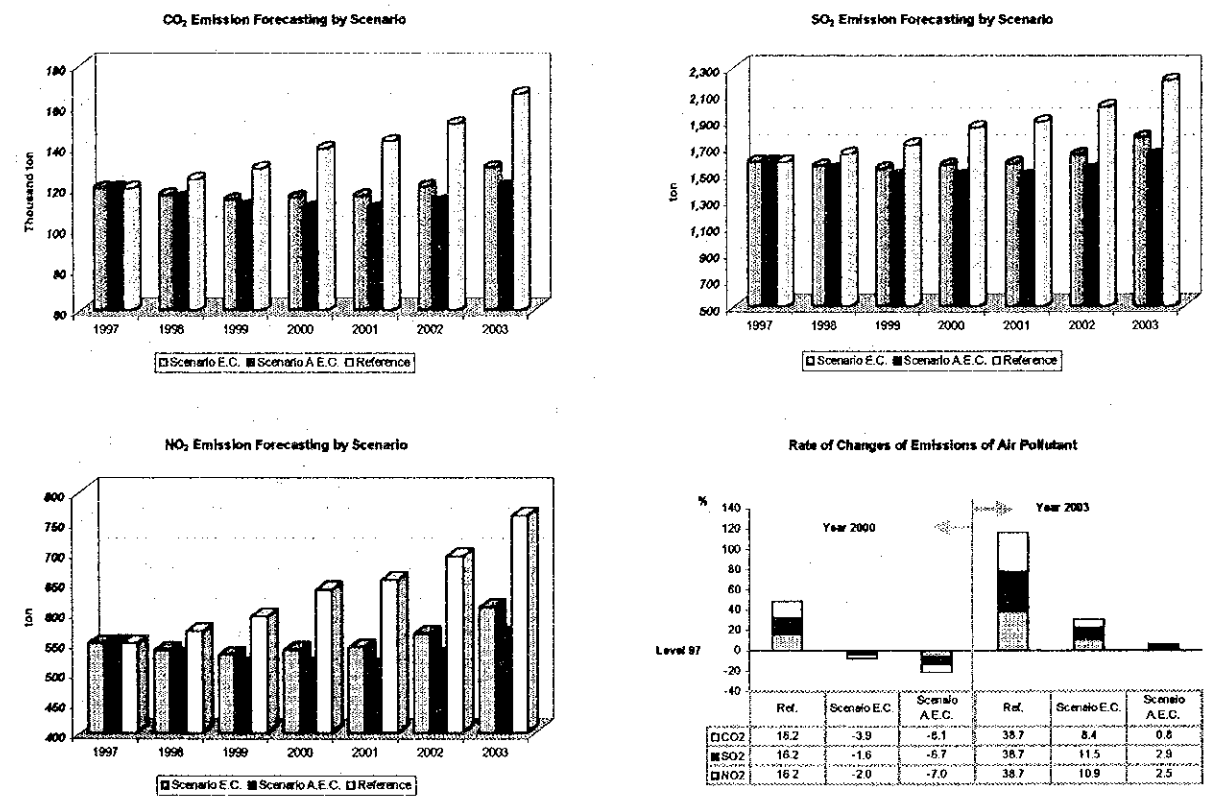
7.4.4 Tractors

According to the simulation results shown in Figure 7.4.3 CO_2 emissions in 2003 are 130 thousand tons and 121 thousand tons for the "scenario E.C." and "A.E.C." Compared with the level of 1997 it will be higher than 8% and 1%.

SO_2 emissions in 2003 are 1,771 tons for the "scenario E.C.," 1,635 tons for the "scenario A.E.C." and 1,846 tons for the "Reference scenario." Comparing these figures and the level in 1997, the reference scenario exceeds it by more than 39%, but the two energy conservation scenarios are estimated to be higher than 11% and 3%.

It is estimated that NO_2 emissions will increase by 11%, 3% from 1997 to 2003 for the "scenario E.C.," and "scenario A.E.C." and be the same percentage as SO_2 emissions for the "Reference scenario."

Figure 7.4.3 Effect of Energy Conservation on Improved Air Quality for Tractor Sector



Source: JICA Team

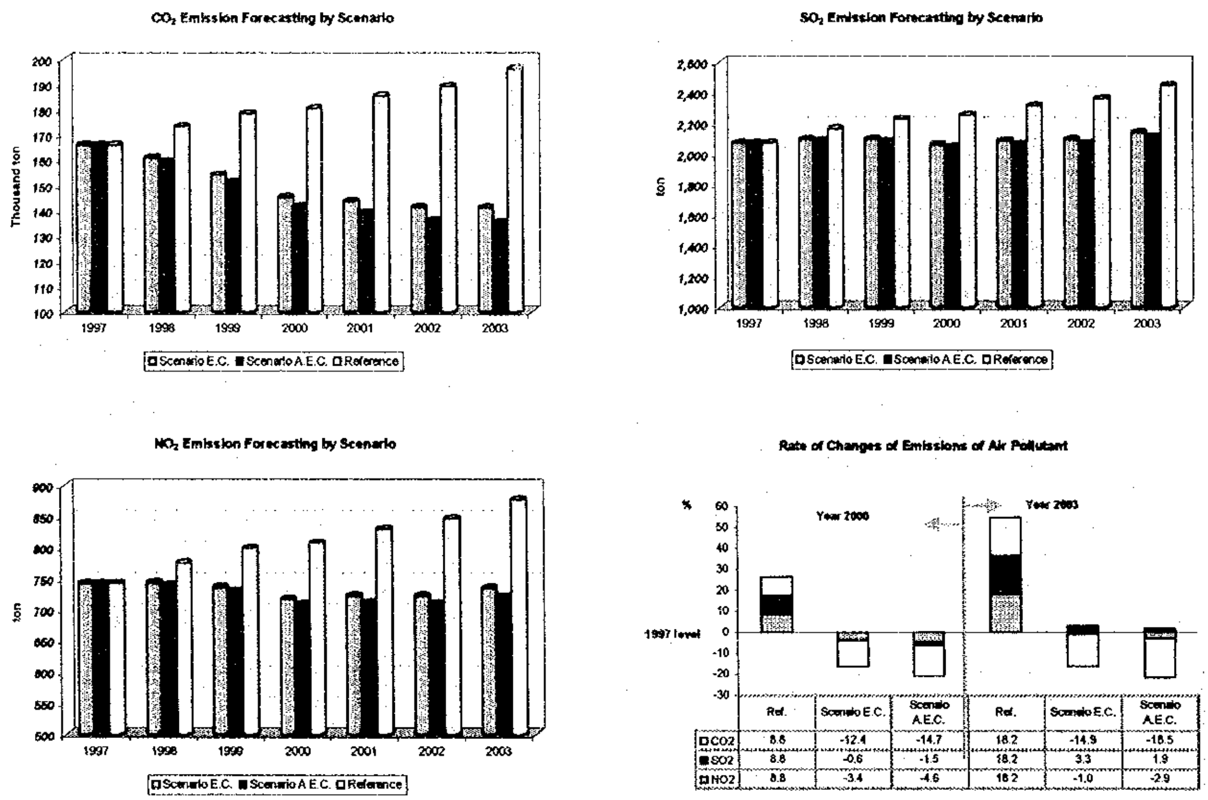
7.4.5 Trucks

Figure 7.4.4 is a forecast of air pollutant emissions. CO_2 emissions will be caused mainly by coal, and it will decrease from 166 thousand tons in 1997 to 141 thousand tons in 2003 for "scenario E.C." and 135 thousand tons for "scenario A.E.C.," because production of trucks will increase to 173% of the 1997 level in 2003. Comparing the "Reference scenario," CO_2 emissions will grow about 18% in 2003.

It is estimated, in 2003 that SO_2 emissions will reach 2,141 tons for "scenario E.C." and 2,113 tons for "scenario A.E.C.," and 2,451 tons for the "Reference scenario."

It is assumed up to year 2003, as shown in the Figure 7.4.4, NO_2 emissions will also increase to 735 tons in 2003 for "scenario E.C.," 721 tons for "scenario A.E.C." and 878 tons for the "Reference scenario."

Figure 7.4.4 Effect of Energy Conservation on Improved Air Quality for the Truck Sector



Source: JICA Team

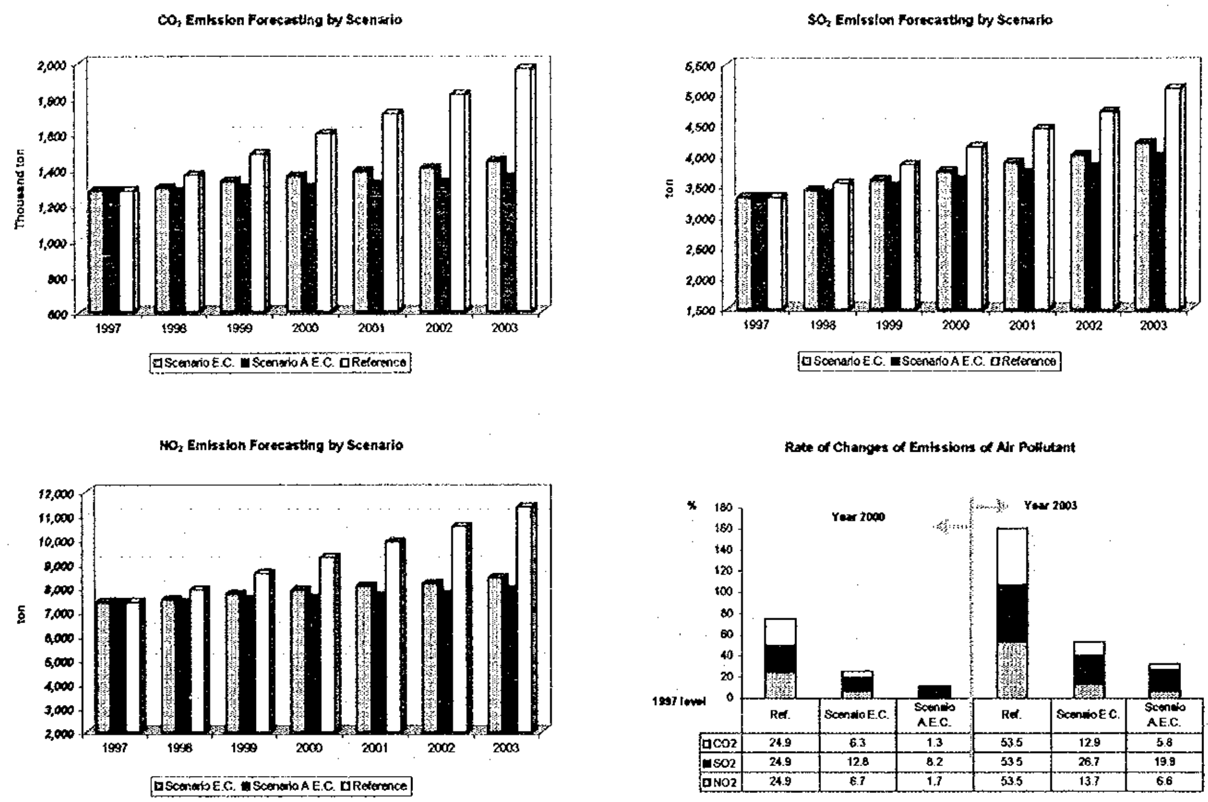
7.4.6 Glass

It is estimated that in 2003, CO_2 emissions will increase with the rise in energy consumption in both scenarios. It will be 13% and 6% higher than the 1997 level in 2003 for "scenario E.C." and "scenario A.E.C.," but as shown in the Figure 7.4.5 for the "reference scenario," in 2003 it will be 54% higher than the level of 1997.

The total SO_2 emissions are estimated to increase by 27% and 20% from 1997 to 2003 for the "scenario E.C." and "scenario A.E.C." The main cause of the growth is a rapid increase in the production of glass.

The total NO_2 emissions are estimated to increase by 14%, 7% and 54% in the same period for the "scenario E.C.," "scenario A.E.C." and "Reference scenario."

Figure 7.4.5 Effect of Energy Conservation on Improved Air Quality for the Glass Industry



	Ref.	Scenaio E.C.	Scenaio A.E.C.	Ref.	Scenaio E.C.	Scenaio A.E.C.
CO2	24.9	6.3	1.3	53.5	12.9	5.8
SO2	24.9	12.8	8.2	53.5	26.7	19.9
NO2	24.9	6.7	1.7	53.5	13.7	6.6

Source: JICA Team

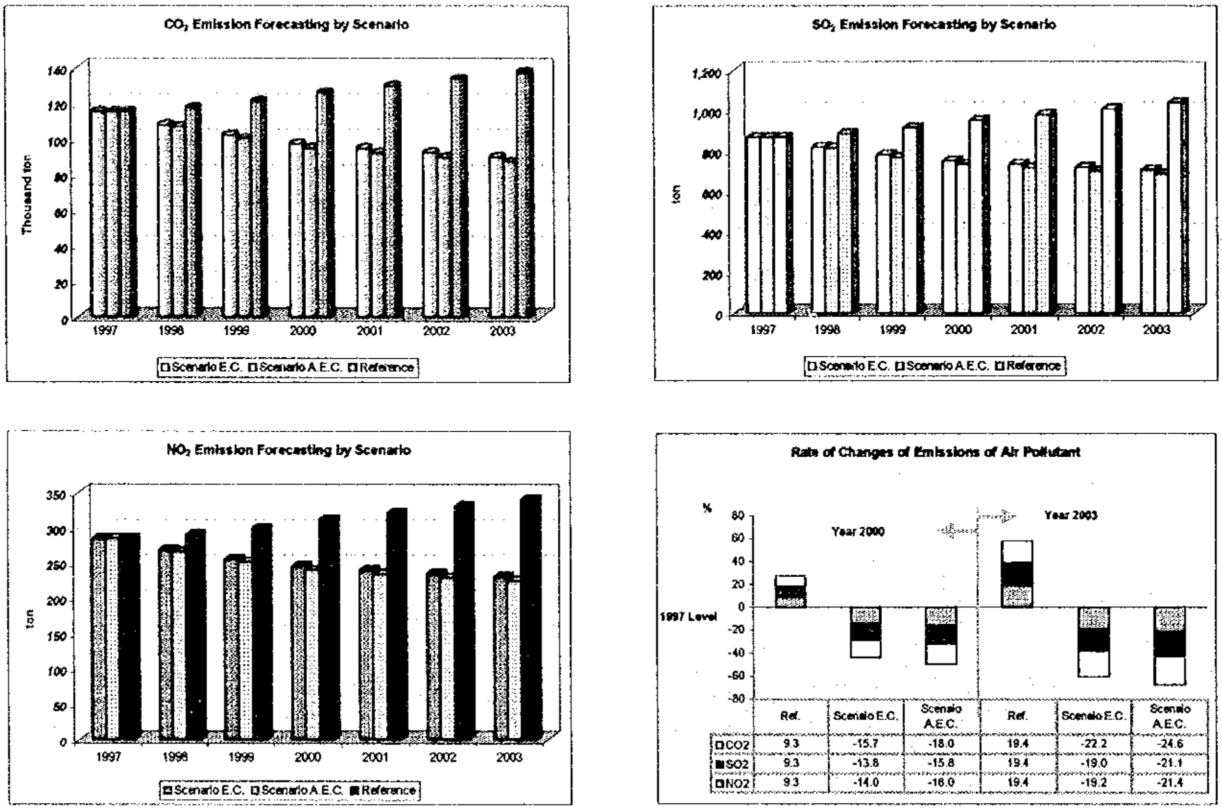
7.4.7 Silicate Lime Block

As shown in the Figure 7.4.6, CO_2 emissions of each scenario in 2003 are 90 thousand tons for the "scenario E.C." and 87 thousand tons for the "scenario A.E.C." Comparing these figures with the level in 1997, the figures are lower by 22% and 25%.

SO_2 emissions of each scenario in 2003 are 705 tons for "scenario E.C." and 686 tons for "scenario A.E.C.," which correspond to 81% and 79% of the level in 1997.

NO_2 emissions of each scenario in 2003 are 231 tons and 224 tons for the "scenario E.C." and "A.E.C." NO_2 emissions are also lower than the level in 1997.

Figure 7.4.6 Effect of Energy Conservation on Improved Air Quality for Silicate Lime BlockProducts



	Ref.	Scenaio E.C.	Scenaio A.E.C.	Ref.	Scenaio E.C.	Scenaio A.E.C.
CO2	9.3	-15.7	-18.0	19.4	-22.2	-24.6
SO2	9.3	-13.8	-15.8	19.4	-19.0	-21.1
NO2	9.3	-14.0	-16.0	19.4	-19.2	-21.4

Source: JICA Team

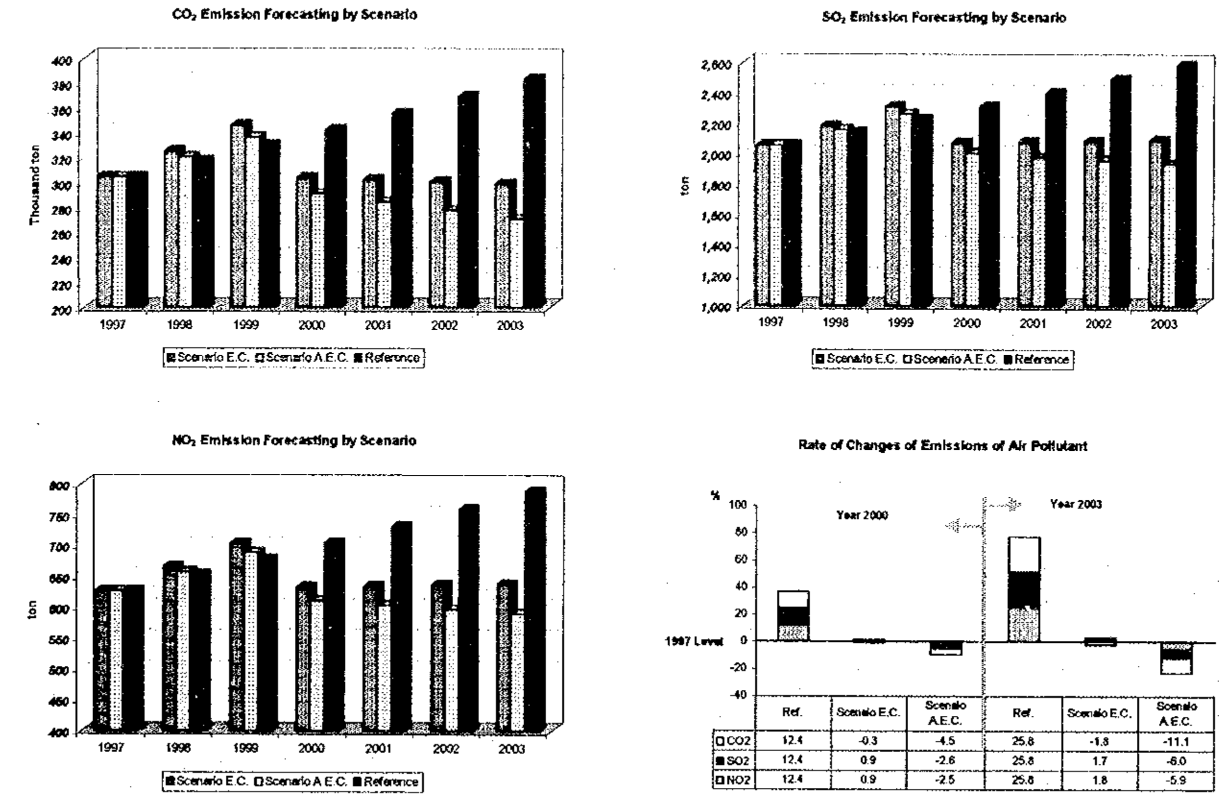
7.4.8 Vegetable Oil

As shown in Figure 7.4.7 CO_2 emissions will change from 305 thousand tons in 1997 to 299 thousand tons and 271 thousand tons in 2003 for "scenario E.C." and "scenario A.E.C." and comparing the "Reference scenario," CO_2 emissions will grow about 26% in year 2003.

It is estimated that in 2003 SO_2 emissions will fall from 2,058 tons in 1997 to 2,094 and 1,935 thousand tons in 2003 for energy conservation scenarios, but SO_2 emissions will exceed 26% of the level in 1997 for the "Reference scenario."

It is assumed up to year 2003, as shown in the same Figure, NO_2 emissions will also fall from 626 to 638 and 590 tons in 2003 for the two energy saving scenarios

Figure 7.4.7 Effect of Energy Conservation on Improved Air quality for the Vegetable Oil Processing Sector



Source: JICA Team

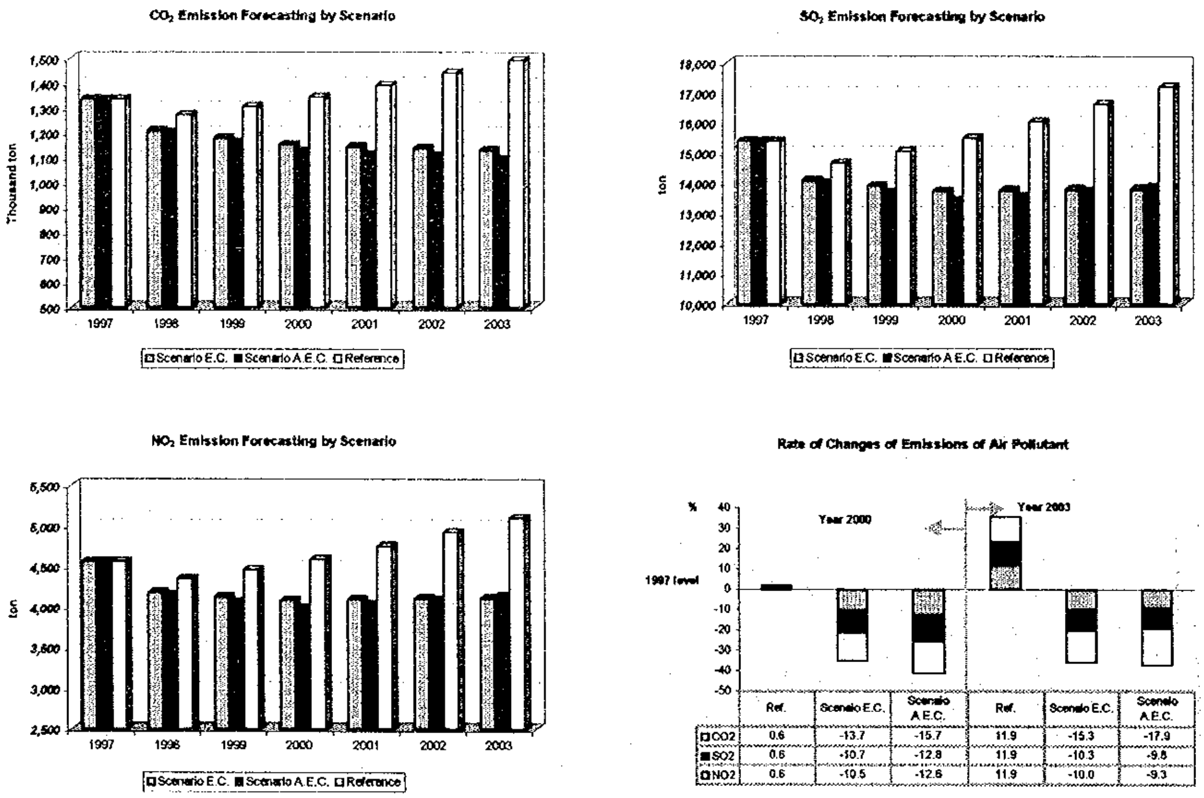
7.4.9 Meat and Poultry Processing

It is assumed that in 2003, CO_2 emissions will reach 1,132 thousand tons and 1,094 thousand tons for the "scenario E.C." and "scenario A.E.C." These figures will be 15% and 18% lower than the level in 1997, as shown in the Figure 7.4.8 for the "Reference scenario," in 2003 it will be 12% higher than the level in 1997.

The total SO_2 emissions will be 9.6% and 10% lower than 1997 level in 2003 for the "scenario E.C." and "scenario A.E.C."

The total NO_2 emissions are estimated to decline 10%, 11% and increase by 12% in the same period for the "scenario E.C.," "scenario A.E.C." and "Reference scenario."

Figure 7.4.8 Effect of Energy Conservation on Improved Air Quality for Meat and Poultry Products Sector



	Ref.	Scenalo E.C.	Scenalo A.E.C.	Ref.	Scenalo E.C.	Scenalo A.E.C.
CO2	0.6	-13.7	-15.7	11.9	-15.3	-17.9
SO2	0.6	-10.7	-12.8	11.9	-10.3	-9.8
NO2	0.6	-10.5	-12.6	11.9	-10.0	-9.3

Source: JICA Team

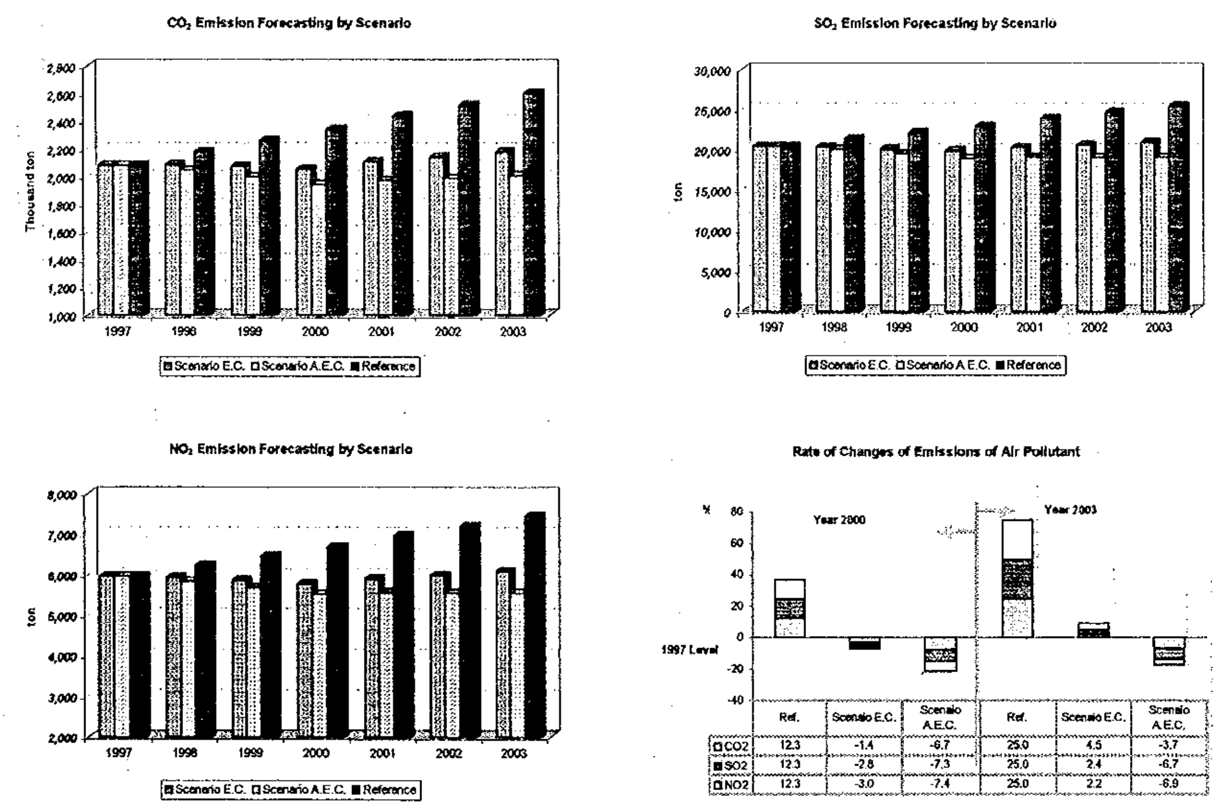
7.4.10 Dairy Products

Figure 7.4.9 is a forecast of air pollutant emissions. CO_2 emissions will decrease from 2,087 thousand tons in 1997 to 2,182 thousand tons and 2,011 thousand tons in 2003 for "scenario E.C." and "scenario A.E.C." Comparing the "Reference scenario," CO_2 emissions will grow about 25% in the year 2003.

It is estimated SO_2 emissions will fall from 21 thousand tons in 1997 to 19 thousand tons in 2003 for "scenario A.E.C.," but SO_2 emissions will exceed 25% for the "Reference scenario."

It is projected up to the year 2003, as shown in the same Figure, NO_2 emissions will increase to 6,094 and decrease to 5,550 tons in 2003 for "scenario E.C." and "scenario A.E.C.," and grow from 5,963 in 1997 to 7,454 tons for the "Reference scenario."

Figure 7.4.9 Effect of Energy Conservation on Improved Air Quality for Dairy Products Industry



Source: JICA Team

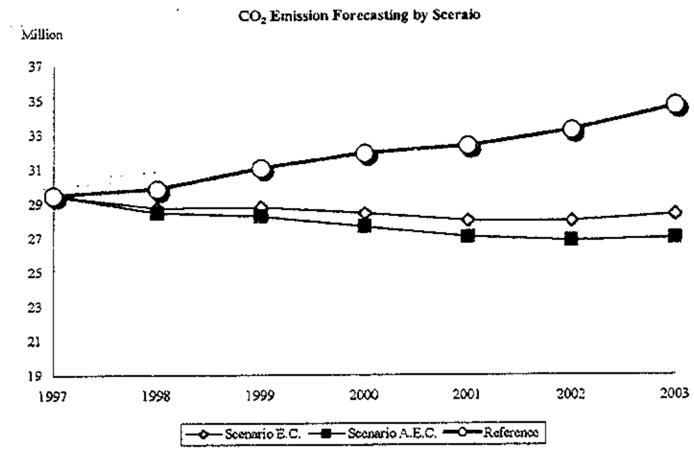
7.4.11 Conclusions

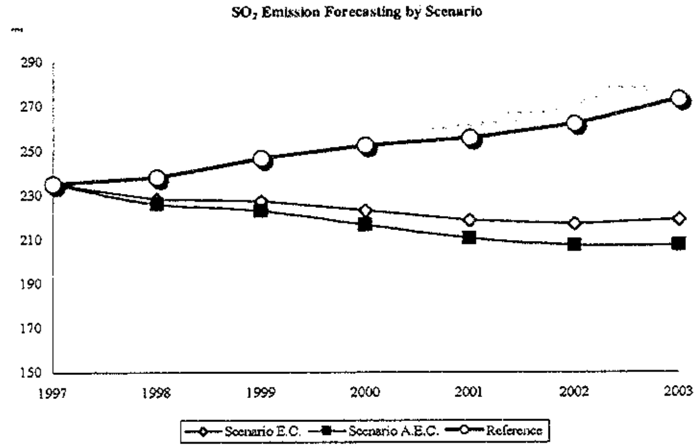
The possible effects of energy conservation on environmental improvement in targeted sector and sub-sector have been estimated with the two scenarios. Figure 7.4.10 shows the estimated air pollutants emitted from 1997 to 2003 in three scenarios. CO_2 emissions will decrease from 29,469 thousand tons in 1997 to 28,366 thousand tons and 26,994 thousand tons in 2003 for "scenario E.C." and "scenario A.E.C." Comparing the "Reference" scenario, CO_2 emissions will grow about 18% in the year 2003.

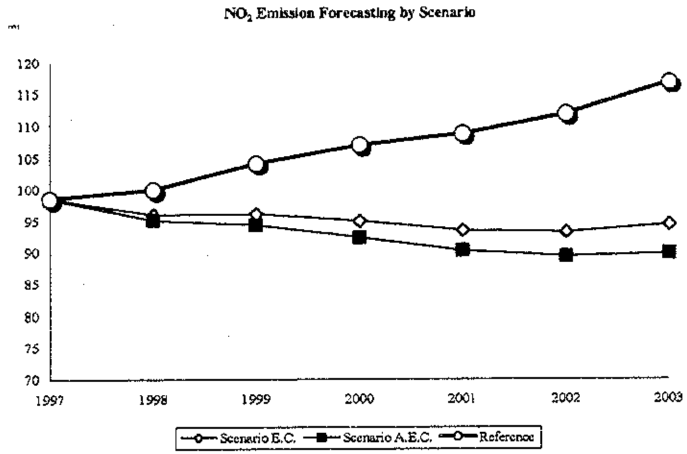
It is estimated SO_2 emissions will fall from 235 thousand tons in 1997 to 219 and 208 thousand tons in 2003 for energy conservation scenarios but SO_2 emission will increase to 273 thousand tons in the year 2003 for the "Reference scenario."

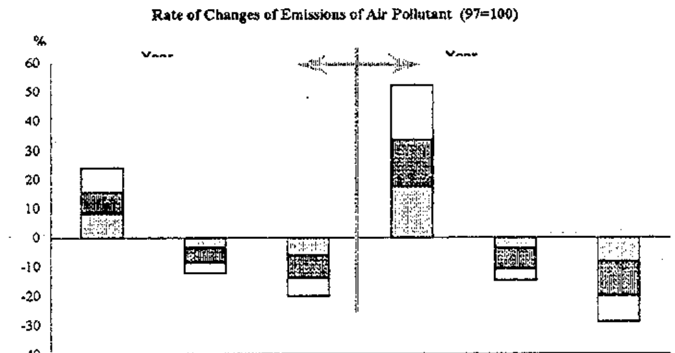
It is assumed, as shown in the same Figure, NO_2 emissions will fall from 99 in 1997 thousand tons to 94 thousand tons and 90 thousand tons in 2003 for "scenario E.C." and "A.E.C." and will grow to 18 thousand tons for "reference scenario."

Figure 7.4.10 Effect of Energy Conservation on Improved Air quality for the Targeted Sectors and Sub-sectors









	Ref.	Scenaio E.C.	Secnaio A.E.C.	Ref.	Scenaio E.C.	Scenaio A.E.C.
NO2	8.6	-3.6	-6.2	18.56	-4.14	-8.78
SO2	7.3	-5.1	-7.8	16.07	-6.87	-11.68
CO2	8.2	-3.5	-6.1	17.54	-3.74	-8.40

Source: JICA Team

8. EVALUATION OF POLICY SCENARIOS BY THE COST/BENEFIT ANALYSIS OF THE ENERGY CONSERVATION POLICIES

8. EVALUATION OF POLICY SCENARIOS BY THE COST/BENEFIT ANALYSIS OF ENERGY CONSERVATION POLICIES

8.1 Purposes and Method of Analysis

8.1.1 Purposes

In this chapter a cost/benefit analysis is performed for an energy conservation master plan for the industrial sector of Poland, which is regarded as a public project. The purposes of this chapter are to quantitatively compare the costs of promoting energy conservation policies in the industrial sector and its benefits (effects), and to provide policy decision-makers with materials to evaluate two scenarios by indicating which scenario will bring about greater social welfare through the master plan.

8.1.2 Method of evaluation

The evaluation method in this chapter is similar to the method used in Chapter 4. The costs put in the master plan of the industrial sector at a time point (i) is set as C (Costs), while the present value, at a time point (i), of the benefits brought about by the master plan during a certain period is set as B (Benefits).

If B > C, the implementation of the master plan is judged to improve the social welfare.

(1) Items Included in Cost/Benefit Calculations

The following items concerning costs and benefits are targeted for the evaluation.

<Costs>

- Administrative costs and office costs required to implement the energy conservation master plan for the industrial sector
- Costs for energy conservation measures at factories

<Benefits>

- Saved energy through the implementation of energy conservation measures in the industrial sector
- Effects on environmental improvements attained in the field of air pollution

(2) Assumption of Figures for Calculation

The following assumption was made regarding figures for calculating the costs and benefits.

a. Costs (C)

Costs of equipment and facilities for energy conservation at factories are the same as those in

Chapter 4.

With regard to administrative costs and office costs necessary to implement the energy conservation master plan, they are assumed mainly based on Japanese data, and converted into PLN at the same exchange rate as in the case of investments in technical measures for energy conservation .

b. Benefits (B)

b-1. Evaluation period for B

This period shall be 10 years.

In Chapter 4, the period was set at five years, which is the investment recovery period in Poland in the near future (assumed from the period of commercial loans). This period is that on benefits from investments in private factories. Because the evaluation in this chapter concerns social benefits, however, it is set at 10 years -- the assumed economic life of equipment and facilities established/installed based for the measures. This assumed figure is based on the fact that depreciation periods for equipment and facilities in Poland range from eight to 12 years (Reference 1).

b-2. Discount rates used for converting the total amount of B brought about during the 10 years to the present value

This rate shall be 3% for 2000, and 2% for 2003.

In Chapter 4, the discount rates are set at 10% and 7%, respectively. The rate is that on benefits at each private factory, as mentioned above. Interest rates for commercial loans in the real term in each evaluation year (the nominal interest rates less increase rates in the wholesale prices) are employed.

In this Chapter, however, the discount rates used must be the "social" discount rate.

The "social" discount rate is usually the interest rate for long-term government bonds maturing over more than 10 years (such as U.S. Treasury Bond) of the country concerned. Because such bonds do not exist in Poland at present, however, long-term, low-interest rates for energy conservation investments assumed in Chapter 4 ---- 3% per annum for the year 2000 and 2% per annum for the year 2003 ---- are also used in this chapter. This is because long-term, low-interest rates from governmental agencies are considered to represent the "social" discount rates for Poland.

As stated in Chapter 4, these interest rates are about 0.3 times the assumed market interest rate of

10% (for 2000) and 7% (for 2003). When NFEP&WM determines its interest rates to companies and local governments, 0.3 to 0.8 times the official discount rate are used. We adopt the lowest value (0.3) for assuming the social discount rate. In this connection, the present official discount rate is almost equal to market interest rates, and we assume that such relations will continue in the near future (Note).

(Note) As of March 1999, the interest rates were determined to be 50% to 95% of the rediscount rate. We, however, assumed 3% and 2%, which are 30% of the commercial rates in 2000 and 2003, respectively, considering that an economic incentive should be large enough to accelerate energy conservation.

b-3 Monetary expression of benefits

First, the benefits of energy saved are calculated using the prices of individual energy carriers. As for these prices, reference should be made to Chapter 3.

Second, in general, in the monetary expression of the effects of improvement in environment pollution brought about by a technical or policy measure, the "abatement costs" (costs to reduce pollutant emissions) or the "damage costs" (damages caused by polluting the environment, which are regarded as costs) are used (Reference 2, 3, 4). If some tax has already been imposed on pollutants in the country, however, it may also be considered reasonable to think that the amount of the tax represents the social welfare lost as a result of the country's environmental pollution, using such amounts for the purpose.

Here, the environmental improvement effects due to energy conservation measures are converted into money based on environment fees in Poland. Fees are set annually. The fees for 1998 were as follows (for details, see Chapter 7), and they are used for the estimation in this Chapter.

- CO2: 0.15 PLN/ t-CO2
- SO2: 300 PLN/ t-SO2
- NO2: 300 PLN/ t-NO2

(3) Items to be paid attention in the estimation

In the cost/benefit analysis of a public project, it is necessary to regard both costs and benefits as social (not private) ones, as already stated (Reference 5 and 6). The following consideration is carried out in this regard:

a. Considering targets to be counted as costs

In the A.E.C. scenario, costs of energy conservation measures at factories include portions of investments implemented on the basis of economic incentives provided by the government (long-term, low-interest loans). We assume the source of this fund source to be the fee imposed on environmental pollution. According to economic theories, the economic efficiency of a country may deteriorate (in other words, resource allocations may be distorted) upon collecting such a fee, or generally by imposing a tax, so it is contended that the decline of economic efficiency must be counted as cost. In this study, however, it is not counted as cost for the following reasons:

a-1. The aforementioned fee collection system has been in force since the early 1960s. Given no changes in other conditions, therefore, the utilization of this fee collection system, based on the proposal made in this study, is not considered as a decline in the economic welfare of Poland below the conventional level.

a-2. Even if the cost is accounted for based on the view that its appropriateness/non-appropriateness should be examined by going back to the system that already exists; first, an accurate estimation of the related amount involves great difficulties in the realms of methodology, data, and information. Second, if an estimation is carried out, using study results in the U.S. and Norway as reference materials, the amount is inferred to be about 50% of the total fund lent to factories (enterprises) (Reference 2).

If the amount is assumed to be of this scale, it is smaller than the total benefits. As such, the amount is believed unlikely to influence the results of the evaluation in this chapter (For instance, the amount in the year 2000 will be 69 million PLN and the economic incentives 138 million PLN, totaling 207 million PLN. It will be larger than the total benefit brought by the incentives provided in targeted industries).

b. Consideration of need for estimating the shadow price

When we evaluate both costs and benefits as social ones, we should estimate the "shadow prices," indicating the reasonable levels of prices and exchange rates, if, for instance, prices of equipment utilized for energy conservation, or energy prices used for evaluating benefits (saved energy), are substantially lower than their levels under free competition, because of government regulations, and if the exchange rate is set at a relatively high level by the government. In this chapter, however, this estimation is not carried out for the following reasons:

b-1. First, with regard to prices to be used for calculating the costs, regulations have no longer been implemented in both domestic as well as external transactions in Poland.

b-2. Next, as for the prices of various energy carriers to be used for benefit calculations, first, it has bee arranged that electricity prices (rates) will be set through direct negotiations between suppliers and users after the beginning of 1999 ---- in Poland, adoption of such a system has already been referred to as price liberalization, although the results of negotiations require the government's approval. We assume values for 2000 and 2003 based on this arrangement.

Second, gas prices have already reached the level that almost fully reflects its supply cost, according to our estimate, because of repeated increases since the beginning of the 1990s. In 2000, gas prices will be somewhat below the cost, but in 2003, they are assumed to be at a level that fully reflects cost.

Third, coal prices that we assume are based on the government's plan announced in June 1998. The coal prices were set at internationally competitive levels , based on the premise that the cost of coal production will be reduced through rapid rationalizations between 1998 and 2002.

Thus, we can summarize that the current Polish energy market is somewhat under government control -- gas prices will also remain at the government's discretion in the short term, while coal prices are virtually positioned within the government's rationalization programs as mentioned above, although they have been arranged, in principle, to be fixed at international prices. Nonetheless, because the energy prices we assumed for the years 2000 and 2003 are at levels reflecting supply costs, or quite close to such levels, it is considered unnecessary to estimate the shadow prices for not only electricity but also gas and coal.

b-3. With regard to the exchange rate, furthermore, the so-called crawling peg formula has been adopted since 1991. This is a system by which the government sets upper and lower limits for changes in the exchange rate, and manages the rate so that it will move only within these limits.

According to economic theories, it is necessary to estimate the exchange rate by showing the Shadow Exchange Rate (SER), apart from the official exchange rate, if the foreign exchange market is subject to government control (in many cases to maintain the exchange rate at a relatively high level) (Reference 5).

For the following reasons, however, in our calculations in this chapter, we will use the exchange rates we have assumed for 2000 and 2003.

First, concerning the method of estimating the SER, there are the following methods: <1> To estimate the index of international market prices of equipment and facilities to their domestic prices and to adopt it as the SER, and <2> to estimate the price index, based on the weighted average of customs tariffs for international trade items and to use it for the SER, as the simplified method for <1>. Both, however, have their own problems. Particularly concerning <1>, there is such a large problem due to the limited availability of data and information, while in the case of <2> there are many problems resulting from simplification, even if data are available (Reference 5).

Next, concerning the foreign exchange policy of the Polish Government, it is believed highly likely that the foreign exchange rate will be much lower in the near future. In other words, the exchange rate will be approaching its realistic level. The following are our projections.

As stated earlier, the Polish Government has adopted the crawling peg system, and based on this system, PLN was cut systematically through the method of lowering the central level of rate fluctuations in relation to a basket of five foreign currencies -- U.S. dollars, British pound sterling, French francs, German mark, and Swiss francs -- by a fixed rate each month.

Specifically, the rate had been 1% by the end of 1997, but it was reduced to 0.85% at the outset of 1998. Beginning at the end of October 1998, furthermore, margins from the central level to the upper and lower limits were expanded from 10% to 12.5%, in line with the curtailment of the official discount rate from 24% to 22% (until the end of 1997, the margin to both the upper and lower limits had been 7%).

If the firm foreign exchange rate of PLN after the start of the year 1998 (the trend toward a high PLN rate) is taken into account, the aforementioned development testifies to the Polish Government's efforts to diminish the depreciation of PLN' s actual rate. In fact, based on the prediction contained in the budget plan for 1999 (January - December), announced on Oct. 30, 1998, the depreciation of the PLN' s rate to the U.S. dollar diminished from 21.7% in 1997 to 7.5% in 1998 (according to tentative estimates), and it is expected to further decrease to about 5% in 1999 (according to the mean value of the forecast range).

With these developments considered for reference, we assume that the PLN' s exchange rate against the U.S. dollar would decrease by 5% annually in 1999 and 2000, by 4% annually in 2001 and 2002, and by 3% in 2003. As a result, the PLN' s exchange rate will be US$1 = 3.89 PLN in 2000 and US$1 = 4.34 PLN in 2003.

We can assume that these levels may represent approximately the average levels of the PLN' s exchange rates, which, we foresee, will be under the floating rate system for the future, reflecting the Polish Government's systematic arrangements for depreciating the PLN.

Finally, even if the level of the SER should be two times 3.89 PLN and 4.34 PLN in 2000 and 2003, respectively (in other words, should PLN be substantially lower than these levels), the ratio of total benefits to total costs would be at least around five, because the total benefits of energy conservation are as much as more than ten times the total costs. This being the case, the conclusion of our study in this chapter would not be affected.

8.2 Estimation of the Costs

Items to be calculated as costs are various administration and office costs as well as the costs of investments at factories.

8.2.1 Administration costs

Here, a cost estimation is carried out for the following items. Further details of the policies taken up here, their roles, and implementation programs are described in Chapter 10.

a. Establishment and operation of the center for promoting energy conservation
This center is assumed to execute the following tasks. The establishment and the development of the center are applied to both scenarios.

-- Development of staffs for self energy audits in factories
-- Training and education of managers
-- Development of experts for factory energy audits
-- Selection of energy conservation model plants and guidance of their activities
-- Introduction and dissemination of energy conservation technologies and equipment
-- Other publicity and dissemination activities

As for costs for implementing these activities of the center, we account for personnel expenses (for not only Polish staff but also foreigners), costs of equipment/facilities, office charges, and costs for preparing study reports, to calculate tentatively. The results are shown in Table 8.1.

In this table, the activities of the center are classified in the following five fields: (1) Education and training, (2) factory energy auditing, (3) technological transfer, (4) preparation of manuals, and (5) publicity. Important points in the estimation of costs for each of these items are described hereunder.

First, we assume that its activities will start in the middle of 1999. Accordingly, current costs (costs disbursed every year, such as costs for the staffs of the center and general administration costs) are set at half of the usual year's level. As for costs for items for which package purchasing is required when starting work (such as purchasing costs of training/educational equipment/materials), total amounts are reckoned in the cost calculation.

Second, costs for training and education and the factory auditing include personnel expenses for foreign experts.

Third, in connection with costs for training and education to be implemented in cooperation with

Table 8.1 Estimate of Administration Costs

(1) Costs financed by the Poles (Unit : 1,000PLN)

Organization	Activities	Cost items	Nationality	Number	1999	2000	2001	2002	2003	2004	Note
E.C.T.C	Traning; education	Man-power (Permanent staff)	Polish	10/y	193	385	385	430	430	430	(a) (b) (c)
		Man-power (Outside expert)	Polish	4/y	5	10	10	6	0	0	
		Facilities; equipment	Polish		324	0	0	0	0	0	(d)
		Space; laboratory			467	934	934	1,042	1,042	1,042	(e)
		Mnagement costs			99	133	133	148	147	147	
		Total			1,087	1,462	1,462	1,625	1,619	1,619	
	Auditing	Man-power (Outside expert)	Polish	40/y	13	26	26	29	29	29	
		Travelling costs			0	1	1	1	1	1	
		Others (Technology fee, various costs)			2	5	5	5	5	5	
		Management costs			1	3	3	4	4	4	
		Total			16	35	35	39	39	39	
	Providing information (Technology transfer)	Collecting information			16	32	32	36	36	36	(f)
		Computer			65	0	0	0	0	0	(g)
		Space			93	187	187	208	208	208	(h)
		Management costs			17	22	22	24	24	24	
		Total			192	241	241	269	269	269	
	Dissemination(A) (Preparing reports)	Reports (Printing, others)			3	7	7	7	7	7	
		Travelling costs			2	3	3	4	4	4	
		Management costs			1	1	1	1	1	1	
		Total			6	11	11	12	12	12	
	Dissemination(B) (Public relations)	Poster			28	57	57	63	63	63	(i)
		Video tape			36	72	72	80	80	80	(i)
		Exibition			137	275	275	307	307	307	(i)
		Total			202	404	404	450	450	450	(i)
		Total			1,503	2,152	2,153	2,395	2,389	2,389	
ESCO		Man-power (Permanent staff)	Polish	3/y	0	0	0	133	133	133	(j)
		Travelling costs			0	0	0	4	4	4	
		Management costs.			0	0	0	14	14	14	
		Total			0	0	0	151	151	151	
Gonernment	Designating energy intensive factories	Checking,etc.			68	136	136	152	152	152	(k)
		Man-power (Permanent staff)	Polish	2/y	32	63	63	70	70	70	
		Management costs			10	20	20	22	22	22	
		Total			109	219	219	245	245	245	
	Energy managers	Examination,etc.			134	267	267	298	298	298	(k)
		Man-power (Permanent staff)	Polish	2/y	32	63	63	70	70	70	
		Management costs			27	53	53	60	60	60	
		Total			192	383	383	428	428	428	
	Advisory committee	Man-power (Permanent staff)	Polish	3/y	43	86	86	96	96	96	
		Materials for discussion			0.8	1.6	1.6	1.8	1.8	1.8	
		Experts as member	Polish	10/y	3	6	6	7	7	7	
		Management costs			5	9	9	11	11	11	
		Total			52	104	104	116	116	116	
	Cooperation with Business Ass.				52	104	104	116	116	116	
	Cooperatin with Labor Union				52	104	104	116	116	116	
	Joint R.& D.				52	104	104	116	116	116	
	Model factories				0	0	1,250	1,250	0	0	(l)
Grand total (E.C.)#					1,711	2,568	3,818	4,260	3,003	3,003	
							8,096			10,266	(m)
Grand total (A.E.C.)##					2,012	3,170	4,420	4,932	3,676	3,676	
							9,602			12,283	(m)

(2) Costs financed by foreign governments or international organizations

Organization	Activities	Cost items	Nationality	Number	1999	2000	2001	2002	2003	2004	Note
E.C.T.C	Traning; education	Man-power (Outside expert)	Foreg.(A)	4/y	0	0	3,242	3,617	3,617	3,617	(n)
			Foreg.(B)	10/y	0	0	486	542	0	0	(n)
		Facilities; equipment	Foreign		0	0	6,483	0	0	0	
		Dispatching trainees	Polish	2/y	0	0	52	58	58	58	(n)
		Total			0	0	10,263	4,217	3,675	3,675	

(Note) (a) Figures in ( ) are in 1,000 PLN for 2002, 2003, and 2004 while others are in 1,000 PLN for 1999, 2000, and 2001.

(b) Including the costs of all man-powers for auditing, dissemination, providing information, and qualification examination.

(c) Figures in [ ] are in US$/day or month.

(d) Figures in < > are in 1,000yen/y.

(e) Costs for renting all office space of ECTC. Not including the costs of space for exibiting data and information on technology transfer.

(f) Purchasing study reports, magazines, and other information.

(g) Computer for organizing database, transmitting data, and others.

(h) Space for exibiting data and information on technology transfer.

(i) Including management costs.

(j) For coordinating fatory energy audits made by ECTC and companies.

(k) Not included in the costs of ECTC.

(l) Supervised by "Foreign experts (B)" shown in (2) below. Assuming that half of all costs for "model factories project" is subsidised by the Government.

(m) Total costs for three years of 1999, 2000, and 2001, and 2002, 2003, ans 2004, respectively.

(n) Not including costs for "experts" and "trainees" to come to and from Poland.

----- Total not including the costs of "Designating energy intensive factories" and "Energy managers."

---- Total including the costs of two activities mentioned above.

Exchange rates : For 1999, 2000, and 2001 ---- 1 US$ = 120 yen = 3.89 PLN (1 PLN = 30.85 yen)

For 2002, 2003, and 2004 ---- 1 US$ = 120 yen = 4.34 PLN (1 PLN = 27.65 yen) other countries, among total training/educational costs, we assume that these expenses will be required beginning in 2001. These expenses include costs for inviting foreign experts, costs for purchasing equipment and facilities based on cooperation with foreign governments, and costs for dispatching trainees to other countries.

b. Other policy items

In addition to the above, a cost calculation similar to the above was made in regard to the following policy items. Of these, b-1. and b-2. will be applied only to the A.E.C. scenario. For outcome of calculations, refer to Table 8.1.

b-1. Development of ESCO
b-2. Designating energy intensive factories
b-3. Qualification of energy managers and their allocation at factories
b-4. Establishment and management of deliberative councils (advisory committee) on energy conservation
b-5. Cooperation with business associations
b-6. Cooperation with labor unions
b-7. Joint R. & D.
b-8. Model factories

8.2.2. Investment Costs for Technical Measures for Energy Conservation

Regarding technical measures for energy conservation judged to be economically feasible, among the various measures to be implemented by each sector and sub-sector, the total costs are estimated.

We estimate total costs by multiplying costs per one unit of product required for each measure (in the case of the iron and steel industry, for instance, a PLN per 1 ton of crude steel) by the output of the product at the factory to which the measure is applied (similarly, b tons of the crude steel production in 2000). The estimated amounts are shown in Table 8.2.

For individual energy conservation measures expected to be implemented in each target year, see Chapter 4 and Chapter 5, and for costs for these measures, refer to Chapter 4.

Table 8.2 Comparison of Two Scenarios on the "Cost / benefit analysis"

(Unit : 1,000 PLN)

	2000		2003	
	E. C.	A.E.C.	E.C.	A.E.C.
(Costs)				
Administration costs[A1] ;				
ECTC	5,808	5,803	7,173	7,173
ESCO	0	0	453	453
Designating ene. intensive factories	0	547	0	735
Allocating energy managers	0	958	0	1,284
Advisory committee	260	260	348	348
Cooperation with business assn.	260	260	348	348
Cooperation with labor union	260	260	348	348
Joint R.& D.	260	260	348	348
Model factories	1,250	1,250	1,250	1,250
Total	8,098	9,598	10,268	12,287
Investments for energy conservation[A2]				
Iron and steel	98,364	103,703	361,751	367,459
Chemicals				
Ammonium	38,589	64,183	11,661	42,616
Machinery				
Truck	1,250	1,250	596	596
Tractor	4,365	9,428	0	0
Non-metallic minerals				
Glass	61,554	152,605	57,243	57,243
Silicate lime block	2,257	2,257	1,376	1,376
Food processing				
Vegetable oil	4,683	6,371	5,250	7,355
Meat products	26,344	27,964	32,677	32,677
Dairy products	17,687	25,912	9,991	15,876
Total	255,093	393,673	480,545	525,198
Manufacturing Total	765,279	1,181,019	1,441,635	1,575,594
Grand total[A=A1+A2]	773,377	1,190,617	1,451,903	1,587,881
(Benefits)				
Energy conservation	7,249,608	8,853,759	5,881,501	7,049,302
Environmental improvement	113,549	138,094	88,448	106,215
Total	7,363,157	8,991,853	5,969,949	7,155,517
Manufacturing total[B]	22,089,471	26,975,559	17,909,847	21,466,551
(Evaluation)				
B / A	29	23	12	14
B - A	21,316,094	25,784,942	16,457,944	19,878,670

(Note) Administration costs are total for the period of 1999-2001 and 2002-2004, respectively.

8.3 Estimation of the Benefits

Next, benefits consist of saved energy and environment improvement effects.

8.3.1 On Saved Energy

The benefits of energy conservation measures are assessed by converting saved energy into monetary figures, based on various energy prices. For the energy conservation potential of each target industry, see Chapter 6, while for details about energy prices, see Chapter 3.

Results of estimation are shown in Table 8.2.

8.3.2 On Environmental Improvement Effects

Environmental improvement effects are estimated, using fees for pollutants, as stated above. Results of estimation are shown in Table 8.2.

8.4 Evaluating the Results of Analysis

As can be seen in Table 8.2, first, benefits greatly surpass costs in both scenarios. It can be stated, therefore, that the two master plans based on these scenarios will increase the economic welfare of Poland.

Next, when the two scenarios are compared, the benefits under the E. C. scenario will be 29 times the costs in 2000, while those under the A.E.C. scenario will be 23 times; therefore, the former is expected to be slightly larger than the latter. As for the state in 2003, however, benefits will be 12 times and 14 times, respectively, so the A.E.C. scenario will slightly surpass the E.C. scenario.

There are two reasons for the substantial excess of benefits over costs in both scenarios: (1) Of the four constituent factors of each scenario, the energy conservation effect of "improvement of management" is assumed to be fairly large, and (2) effects of "modernization and rationalization" are assumed to make a fairly large contribution to energy conservation.

In other words, the favorable results arose, because improving management does not entail much cost, and also because modernization and rationalization are related to "indirect" measures, and based on its definition, energy saving benefits from them are a "free rider," so to speak.

Because energy conservation measures through modernization/rationalization investment represent "indirect" measures, we carry out a trial calculation for the case in which the effects of modernization and rationalization are removed to clarify effects of "direct" measures only. Table 8.3 shows results of such sensitivity analysis.

Based on this table, if energy conservation effects of modernization and rationalization are removed, the aforementioned ratio in 2000 will decline from 29 times and 23 times to 25 times and 20 times, respectively, and it will further decrease to 10 times and 11 times in 2003.

Table 8.3 Sensitivity Analysis of the Effect of Two Components on the Benefit

		2000		2003	
		E.C.	A.E.C	E.C.	A.E.C
(T)Total Benefit (Shown in Table 8.2)	1000 PLN	22,089,471	26,975,559	17,909,847	21,466,551
	(T)/Cost*	29	23	12	14
(B)Benefit excluding "Modernization and Rationalization"	1000 PLN	19,053,753	23,933,533	13,837,271	17,493,256
	(B)/Cost*	25	20	10	11

* Cost ("Grand total") shown in Table 8.2

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9 EVALUATION OF POLICY SCENARIOS BY THE FORECAST OF MACRO-ECONOMY AND ENERGY DEMAND AND SUPPLY

9 EVALUATION OF POLICY SCENARIOS BY THE FORECAST OF MACRO-ECONOMY AND ENERGY DEMAND AND SUPPLY

In this study we have developed a model for forecasting energy demand and supply with the macro-economic model for Poland. The purpose is to evaluate the effects of domestic energy policy quantitatively from the viewpoint of the national economy.

The model is composed of two sub-models, which are energy supply and demand models and the macro-economic model and both are linked strongly to each other. Here, we call the entire model the "Macro-Energy Model for the Poland; MEMP"

Poland switched over from a planned economic structure to a market oriented economic structure in 1989 and privatized production gradually with the abolition of the price controls. The process is still progressing at this moment.

In the first half of the 1990s, because of system confusion and reform, the Polish economy was facing high inflation, high unemployment, deficit with international trade balance, and other economic problems. However, Poland has taken off relatively early, although most countries, whose economic systems were planned before 1990, are still in a stagnant economic situation. Annual economic growth in the last few years has exceeded 5% in Poland.

On the other hand, energy demand in Poland has remained almost flat since 1990. Energy demand in 1996 was 20% smaller than the figure in 1988, which was the peak. The improvement of energy efficiency in the conversion sector and the industrial structure changes are the major reasons for this. The MEMP is designed and built considering such a situation of the macro economy and energy supply and demand.

The composition of this chapter is as follows. First, we describe the MEMP in section one. Next, we introduce several simulations using the model in section two, and section three points out policy implications based on the simulation studies.

9.1 Development of the MEMP

In this section, we outline the Macro-Energy Model for Poland: MEMP.

9.1.1 Model

(1) Structure of the entire model

a. Basic design

The basic concept of MEMP is as follows.

First, the variables of the equations in the model for the macro economy and energy supply and demand are solved simultaneously.

Second, it should be possible to simulate the influence on the macro economy of energy policy.

Third, the model should be easy to use.

Fourth, the model is based on econometrics with the time series data.

Fifth, the entire model of MEMP is composed of two sub-models, which are a macro-economic model and an energy supply and demand model

Also, for the macro-economic model, present issues in the Polish economy became the key factors, too.

Those issues are the following.

1) The present Polish economy is in transition.
2) Dynamic investment increases capital asset imports.
3) The government financial balance is falling into deficit.
4) A subsidy for the energy industry is one of the reasons for the above deficit.

Moreover, model for energy supply and demand includes the following.

1) It should be possible to grasp a series of energy flows from primary energy requirements to final energy consumption.
2) Energy demand should be able to react accurately to the domestic energy price, which is a main energy policy item.
3) In the industrial sector, it should be possible to grasp energy intensity denominated by a physical numerical value.

There are the following four paths linking the macro-economic model and the energy supply and demand model.

1) Macro-economic indices including general prices (the explanatory variables for the energy demand function, the explanatory variables for the production forecast in the industry).
2) The energy imports and exports (the coal exports and petroleum and natural gas imports in the GDE component).
3) The income of the energy industry (a part of the government income and expenditure).
4) Domestic energy prices (the explanatory variables for the price indices and for the energy demand functions).

1) Macro economic indices are endogenous variables in the macro-economic model and are handled as an exogenous variable to the energy supply and demand model. To be opposite, the variables relating to 2) energy trade, 3) profit of the energy industry, and 4) energy prices are the endogenous variables in the energy supply and demand model and the exogenous variables in the macro-economic mode (Figure 9.1).

Although details are described in the section 2nd in this chapter, the productivity improvement of the energy industry is also a linking path between the two models. As for this, we assume that the revenue and the cost of the energy industry are not equal, and even if the revenue expands due to the energy price rise, the cost of energy industry is restrained by the productivity improvement.

Consequently, the profit, value added, of the energy industry expands, and it brings about the reduction of the government subsidy and the government can invest that incremental value added to the domestic market through the government expenditure. The influence caused by the productivity improvement on the domestic market is as big as what we can not be ignored.

b. Characteristic

MEMP, which was constructed with the basic design explained above, has the following characteristics.

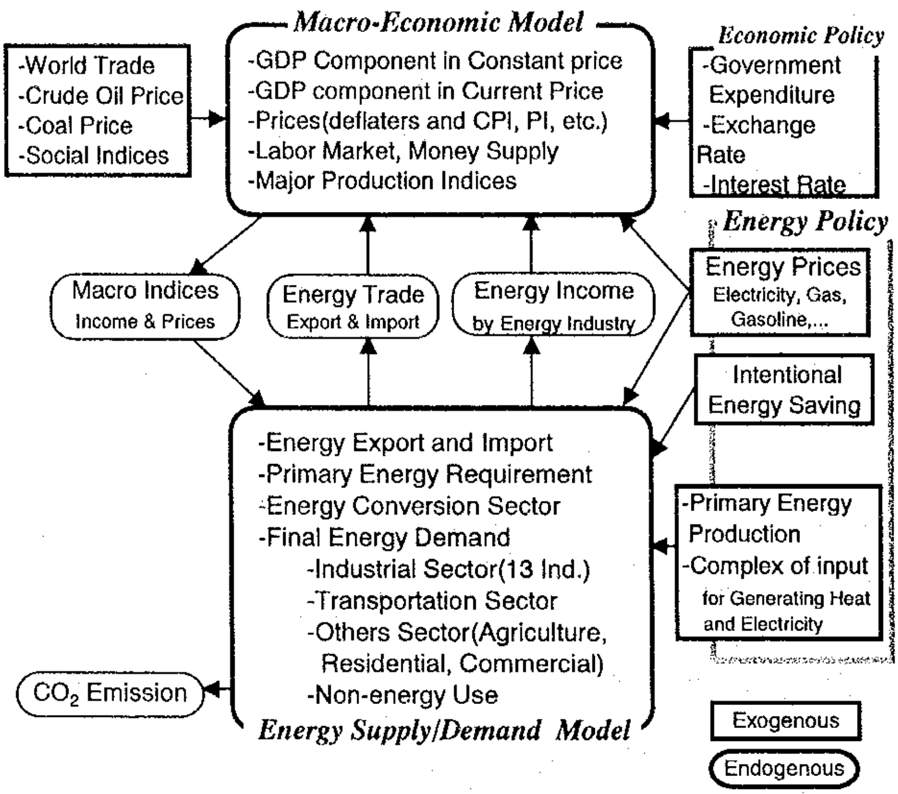
First, the model is composed of the estimation formula group, which uses time series data.

Second, it is possible to appraise the model with tests to compare the results obtained by the model and actual figures, in other words, we can check the performance of the model through the tests.

Third, because the endogenous variables of the macro-economy and the energy supply and demand are solved simultaneously in the model, the impacts by the energy policy on the economic activity can be consistently and easily simulated.

Fourth, the model is easily operated on a personal computer, because it is compact.

Figure 9.1 Flow Chart of Macro-Energy Model (MEMP)



c. Exogenous and endogenous variables

The number of variables handled in the MEMP, which is the model of the simultaneous equation system, is 265, of which 196 variables are endogenous and 69 are exogenous. The number of equations, which are composed in the model of definitive formulas and structural functions, is 196.

As for exogenous variables, although there are 69, most of them are dummy variables and with little statistical effect. In the simulation, the most important exogenous variables are 20.

1) World economy
   1)-1 world trade
   1)-2 industrial export price index in the world
   1)-3 crude oil price
   1)-4 coal export price

2) Domestic economic policy
   2)-1 interest rate

2)-2 government expenditure (current expenditure, fixed capital formation)
2)-3 exchange rate
2)-4 international balance of payments (services balance, income transfer)

3) Energy policy
3)-1 secondary energy prices (coal, petroleum products, electricity, gas, and heat)
3)-2 primary energy production (coal, crude oil, natural gas, etc)
3)-3 energy input for generating electricity and heat (CHP and DH)
3)-4 energy efficiency in the conversion sector

4) Social indices
4)-1 population
4)-2 active population (labor force)
4)-3 time trend
4)-4 dummy variable for transition

(2) Outline of macro-economic model

a. Characteristics of model

The macro-economic model applies econometric methodology, and Keynsian economic theory is adopted as the fundamental concept. We made an effort to reflect the following four characteristics in the model, considering the present status of the Polish economy.

They are 1) the Polish economy is still in a period of transition to a market-oriented economy, 2) capital investment has been dynamically implemented, but it has also invited expansion of imports of capital goods, 3) although the government fiscal budget is in a deficit at present, it is necessary to balance it in the future, and 4) one of the causes of the government financial deficit is a subsidy to the energy industry. To reflect them on the model, we considered following mechanism.

b. Interpretation and modeling of transitional economy

The general characteristic of the transition economy is stagflation which is inflation and depression at the same time. In other words, it is a difficult situation in which prices soar and income declines. According to economic indices around 1990, Poland is not an exceptional case. Considering this situation theoretically, it is possible to interpret it as follows.

We try to think of soaring prices and declining income separately, first, for soaring of prices, in a planned economy, the price of the goods was politically set cheaper than the market equilibrium price. The evidence is the long lines to buy goods in front of stores. Since the price was set a lower level than the market equilibrium one, demand exceeded supply, creating queues.

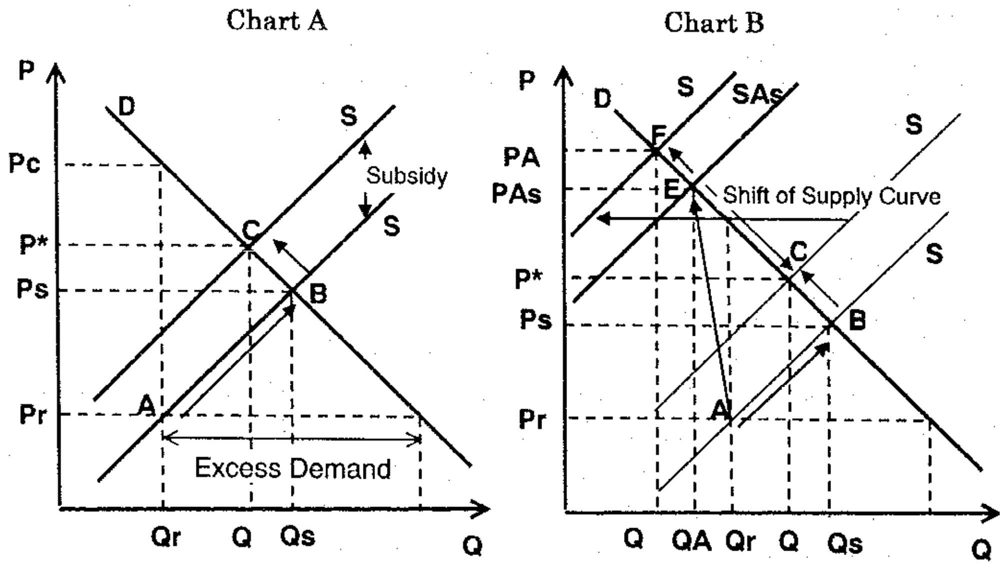
Since the switch to a market economy is the process of the transition from regulated low prices to the market equilibrium price, in the transition period, price rises are inevitable. This process can be considered as the shift to point B from point A in Chart A of Figure 9.2. Moreover, reducing the subsidy by the government moves the equilibrium point in the market from B to C and the price will rise like Pr→Ps→P *.

On the other hand, in terms of income and production, many production facilities tend to be abolished during the transition period. Direct investment from western developed country expands with the reconsideration of old production facilities and the production system. The new capital and management system investigates the availability of old facilities, and when they judge efficiency to be low there are some cases more than 30 percent of old productive capacities being shut down. As for the phenomenon on the production side in the transition period, capital stock decreased. In other words, we can judge that a shift of the supply curve to the left happens. Chart B of Figure 9.2 shows this relation.

In the figure, the supply curve under the planned economy is S and the supply curve immediately after the transition is SA. The figure shows that the decrease of supply capacity shifts the equilibrium price in the market up while income declines. The price rise and the income decline occur simultaneously, because the equilibrium point in the market moves from A to E. The change of the price is a rise from Pr to PAs.

Looking at it dynamically, because the supply curve shifts to the right side with the progress of investment, actual price rises might not result in PAs.

Figure 9.2 Price and Output Change during the Economic Transition



Understanding the present situation theoretically in this way, we use the following variable in the model. First, we adopt a transitional economy dummy variable as an explanatory variable in the equations. The reason is as follows. The consumers did not consume as much of their income and saved under the planned economy. The saved funds were expended after the economic structure changed to a market-oriented economy.

Moreover, we tried to use the supply and demand environment in the market (the relative relation between the potential GDP and observed GDP) as the explanatory variable for the price change. However, because the available of the data were insufficient, we abstracted this idea.

c. Dynamic investment and imports of capital goods

The present Polish economy is growing due to the expansion of private final expenditure and private equipment investment, which is domestic demand. However, the latter, private equipment investment, has increased imports of capital goods. Considering such a situation, we take private investment as the explanatory variable for the import function, excluding energy imports, as followed.

$$MOT = 7871 + 0.539 * (CP + I) - 21261 * (PM/CPI) - 4866 * (DUM89)$$

(1.63) (5.60) (-9.35) (-2.69)

OLS (1987-1996) AR2: 0.935 SD: 1,574.35 DW: 0.951

In the formula above, *MOT* is the value of imports without energy, *CP* is private final expenditure, *I* is investment, *PM* is import price deflator, *CPI* is consumer price index, and *DUM89* is a dummy for 1989.

d. Government budget deficit

At present, the government budget is in deficit. This means that the various subsidies have become a load on the government. The energy price is not an exception and it is lower than the supply cost in the domestic market. The government subsidy makes up for the difference.
The financial deficit brings about an increase in the money supply domestically and leads to a rise in domestic prices. Then, it reduces the value of currency externally.

On the other hand, as a condition for the joining the EU, every country fixes the ratio of government financial deficit to GDP to within 3%. Therefore, in the future of the Polish economy, we assume that income and expenditure in the government finance will be balanced in the model simulations. Concretely, tax and income are prescribed by GDP component growth, and expenditure by the government is fixed with income.

Government investment, government development expenditure, is set as an exogenous factor and government consumption, current expenditure, is computed as the value government investment is from deducted total income.

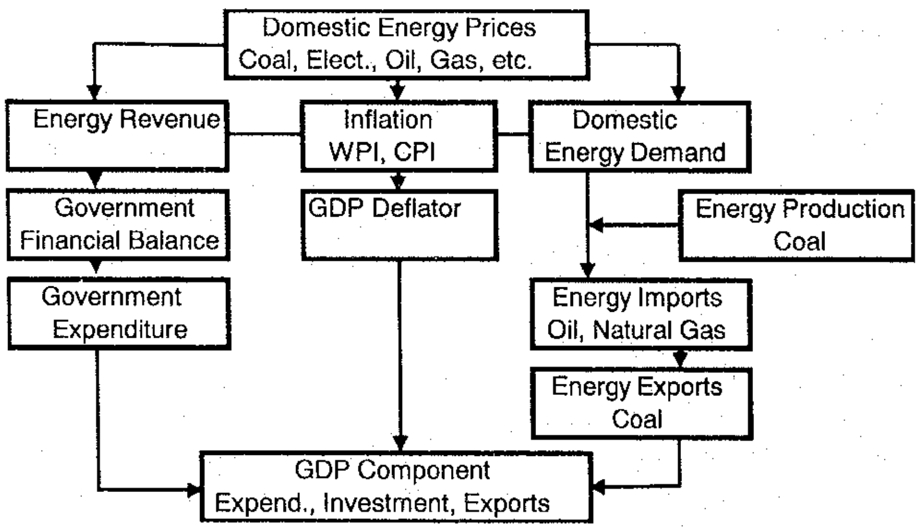
The subsidy on secondary energy prices is expected to decrease gradually, which is the assumption adopted here. To include this supposition in the model, we install the mechanism where by the growth rate of production costs of the energy industry is smaller. In other words, the government subsidy would be reduced by the productivity improvement in the energy industry.

e. Influence on the domestic economy energy prices

There are three influential paths that the change of energy prices exerts on the domestic economy in the model. The first path is the way the energy industry's productivity improvement changes the financial income of the government. The second path is the general price, which cooperates with changes of energy price. The third path is domestic energy demand, which is a function of energy prices influenced by the quantity of coal exports and of oil and gas imports.

For example, increasing domestic energy prices brings about the following change in each path. In the first path with financial income, the rise of energy prices increases government income through the energy industry's productivity improvements. This reduces the speed of increase of the money supply and restrains general price rises. Moreover, the difference between income expanding (the price rise multiplied by quantity) and the production cost (the production cost in the base year multiplied by the rate of increase of cost) becomes additional profit to the energy industry according to the price increase. The expansion of this profit prompts the enlargement of the domestic economy through government expenditure.

Figure 9.3 Flow Chart of Impact on Economy of Domestic Energy Prices



In the second path related to general prices, the rise of domestic energy prices brings about increased prices for every service and commodity through wholesale and consumer prices. These prices rises reduce the purchasing power of the consumer and it act on GDP growth as a negative factor in a constant price base.

As for energy supply and demand, which is the third path, the rise of the domestic energy price restrains domestic energy demand, and this affects exports, and weak demand leads reduces import of oil and gas.

Concretely, it contributes to coal exports. In the export market, coal is traded at the international price. Therefore, the increase of coal exports provides the additional value added and supports acts as the element to GDP growth

The three paths are summarized by the following figure (See Figure 9.3).

(3) Outline of energy supply and demand model

The energy supply and demand model computes energy demand in every demand sector based on the macro-economic variables that are projected by the macro-economic model.

The energy model gathers them and computes the total final energy demand. By adding the losses of the energy conversion sector, such as electricity, petroleum products, and city gas supplier, to this value, we can calculate primary energy supply.

The estimation formula, which is incorporated into this model, is a flow-type demand function. This demand function assumes the concept that energy demand is determined by income, price, and technological progress.

The production level individual industries and secondary energy prices, which are not calculated in the macro-economic model, are estimated in the pre-step of this model based on the price indices and the GDE components.

This energy supply and demand model creates a future energy balance table, of final energy consumption and primary energy supply.

But, because the data on the supply side such as production for coal, crude oil, and natural gas and the power supply composition are strongly related to energy policy, we handle them as exogenous variables.

a. Domestic energy prices

All domestic energy prices are included in the assumptions of the simulation, because they are also major political issues. After classifying energy sources by demand sector such as industry, residential, and commercial, and by energy carrier; coal petroleum products, gas, electricity, and heat, we handle these domestic energy prices as exogenous variables in the model.

b. Production level of the main industries

Based on the component of GDE, which is calculated in the macro-economic model, the model estimates production level, in terms of physical production level, of major industries.

These show the domestic industrial structure. Production and domestic energy price, which are obtained here, are used as the presupposition of energy demand functions.

c. Energy consumption in the industrial sector

The industrial sector is composed of the following 13 categories: 1) irons steel, 2) chemicals, 3) nonferrous metals, 4) ceramic industry (non-ferrous minerals), 5) transportation machinery, 6) general machine, 7) mineral, 8) food and cigarettes, 9) paper and pulp, 10) timber and wood, 11) construction, 12) textiles, and 13) others. Energy demand in each sub-sector is computed by the production amount, which represents each category of business, and the relative energy price. By aggregating them, the total energy demand in the industrial sector is computed.

The procedure of the estimation for each energy carrier is as follows. We initially compute the demand for coal, petroleum product, electricity, and heat respectively, then we recognize the residual amount compared to the total for gas, which is equal to the figure after deducting coal, petroleum products, electricity, and heat from the total.

d. Energy consumption in the transportation sector

The transportation sector is classified for road transportation, railways and aviation. The petroleum product for road transportation is the biggest energy source in this demand sector followed by electric power for railways.

Therefore, the model has demand functions for the petroleum products and the electric power, and handles coal and heat as exogenous variables. The demand for petroleum products and electric power are computed by the GDP components and relative price of energy.

e. Energy consumption for agriculture

Petroleum products, coal and electricity are consumed in the agricultural sub-sector. The model does not estimate an individual energy source, but does estimate total energy consumption first, based on GDE and the relative price of coal. Then it estimates the individual energy demand using the share functions.

f. Energy consumption in the residential/commercial sector

When observing energy data in the past carefully, the classification between residential and commercial sectors does not seem to be strict, although the residential/commercial sector is usually divided into these two sub-sectors. Therefore, the model computes total energy demand with both sectors first, using GDE and relative energy price, then estimates the share of each sub-sector to the total.

By energy source, this sector consumes electric power, petroleum product, gas, and heat. As for the demand for electricity for residential use, the equation is a function of family size and the number of customers in addition to the energy price and income.

g. Non-energy use

In the energy data base here which depends on the energy balance table edited by the Polish Energy Information Center, raw materials for the chemical industry are also included the "non-energy", in addition to lubricant and asphalt, although such an approach is not an international standard.

Therefore, we add the production of the chemical industry to the demand function for non-energy as an explanatory variable.

(4) List of the equations

The structural equations and the definitive formulas adopted in the model are listed on the sheet attached at the end of the chapter. The values in parent theses are *t* value, AR2 shows the adjusted coefficient of regression, SD is a standard error and DW is the Durbin-Watson value.

The meanings of the variable code shown on the equations are also explained in the attached papers at the end of the chapter.

9.1.2 Data

(1) Data collection

The data used in model development is principally based on statistics published in Poland, mainly issued by the central statistical bureau, GUS. However, in the date relating to energy, we referred to the statistics that the former Polish Energy Information Center uses.

In addition, because the statistical data formed are available only after the year of 1990, the number of the data sample is not enough to build an econometric model with time series data. Therefore, we rearranged and estimated the data before 1990 with using other data sources as follows.

In the macro-economic statistics, the data issued by the World Bank is quite useful, and the energy balance table developed by the OECD/IEA is also very informative for energy data.

(2) Variable code and value

In a preparing model, the number of data series collected is more than 400. These data are attached at the end of this chapter with the variable code. Also, the rows and columns in the energy balance table, which is adopted in the model, are compressed, compared to the form processed by the former Polish Energy Information Center.

Each element in the matrix of the energy balance table is given by a code as shown the following table (See Table 9.1)

Table 9.1 Code of Variables in the Energy Balance Table

No.		Code	1 Coal CL	2 Crude Oil CR	3 Petroleum Products PT	4 Gas GA	5 Hydro HY	6 Electricity EL	7 Heat HE	8 Total TT
1	Production	PD	CLPD	CRPD	-	GAPD	HYPD	-	-	TTPD
2	Import	IM	CLIM	CRIM	PTIM	GAIM	-	ELIM	-	TTIM
3	Export	EX	CLEX	-	PTEX	GAEX	-	ELEX	-	TTEX
4	Stock Change and Bunker	SC	CLSC	CRSC	PTSC	GASC	-	-	-	TTSC
5	*Total Primary Energy Requirement*	*PR*	*CLPR*	*CRPR*	*PTPR*	*GAPR*	*HYPR*	*ELPR*	-	*TTPR*
6	Statistical Difference	SD	CLSD	CRSD	PTSD	GASD	-	ELSD	HESD	TTSD
7	Electricity and Heat(incl.CHP,DH)	EH	CLEH	-	PTEH	GAEH	HYEH	ELEH	HEEH	TTEH
8	Gas Work	GW	CLGW	-	PTGW	GAGW	-	-	-	TTGW
9	Petroleum Refinery	PT	CLPT	CRPT	PTPT	GAPT	-	ELPT	HEPT	TTPT
10	Coal Transformation	CL	CLCL	-	-	GACL	-	-	-	TTCL
11	Own Use	OW	CLOW	-	PTOW	GAOW	-	ELOW	HEOW	TTOW
12	Distribution Loss	LO	CLLO	-	PTLO	GALO	-	ELLO	HELO	TTLO
13	*Total Final Energy Consumption*	*FL*	*CLFL*	-	*PTFL*	*GAFL*	-	*ELFL*	*HEFL*	*TTFL*
14	*Industrial Sector*	*IN*	*CLIN*	-	*PTIN*	*GAIN*	-	*ELIN*	*HEIN*	*TTIN*
15	Iron/Steel	IR	CLIR	-	PTIR	GAIR	-	ELIR	HEIR	TTIR
16	Chemical	CH	CLCH	-	PTCH	GACH	-	ELCH	HECH	TTCH
17	Non-ferrous Metal	NF	CLNF	-	PTNF	GANF	-	ELNF	HENF	TTNF
18	Non-metallic Mineral	NM	CLNM	-	PTNM	GANM	-	ELNM	HENM	TTNM
19	Transport Equipment	TE	CLTE	-	PTTE	GATE	-	ELTE	HETE	TTTE
20	Machinery	MA	CLMA	-	PTMA	GAMA	-	ELMA	HEMA	TTMA
21	Mining and Quarrying	MN	CLMN	-	PTMN	GAMN	-	ELMN	HEMN	TTMN
22	Food and Tobacco	FO	CLFO	-	PTFO	GAFO	-	ELFO	HEFO	TTFO
23	Paper, Pulp and Print	PA	CLPA	-	PTPA	GAPA	-	ELPA	HEPA	TTPA
24	Wood and Wood Products	WO	CLWO	-	PTWO	GAWO	-	ELWO	HEWO	TTWO
25	Construction	CN	CLCN	-	PTCN	GACN	-	ELCN	HECN	TTCN
26	Textile and Leather	TX	CLTX	-	PTTX	GATX	-	ELTX	HETX	TTTX
27	Other Industry	OI	CLOI	-	PTOI	GAOI	-	ELOI	HEOI	TTOI
28	*Transportation Sector*	*TR*	*CLTR*	-	*PTTR*	-	-	*ELTR*	*HETR*	*TTTR*
29	Road	RO	-	-	PTRO	-	-	ELRO	-	TTRO
30	Rail	RA	CLRA	-	PTRA	-	-	ELRA	-	TTRA
31	Air and Sea	RT	CLRT	-	PTRT	-	-	ELRT	HERT	TTRT
32	*Other Sector*	*OT*	*CLOT*	-	*PTOT*	*GAOT*	-	*ELOT*	*HEOT*	*TTOT*
33	Agriculture	AG	CLAG	-	PTAG	GAAG	-	ELAG	HEAG	TTAG
34	Commercial(non-specified)	CM	CLCM	-	PTCM	GACM	-	ELCM	HECM	TTCM
35	Residential	RE	CLRE	-	PTRE	GARE	-	ELRE	HERE	TTRE
36	*Non-Energy Use*	*NE*	*CLNE*	-	*PTNE*	*GANE*	-	-	-	*TTNE*

(note)' -' means figure is not available.

9.1.3 Performance of the model

We checked the performance of the entire model using a "final test" which is the most severe test of an econometric model. The "final test" is a methodology to verify model performance in terms of how much the endogenous variables in the model an trace the past observed data successfully, while using past recorded data for exogenous variables.

According to the test results from 1991 to 1995, we confirmed that the performance of the model was good. The average error percentages in the test period for the major endogenous variables are as follows. For GDP, it is 3.1%, private final consumption (CP) is 1.4%, consumer price index (CPI) of price series is 3.0%, and wholesale price index (WPI) is 3.4%. Moreover, as for energy figures, the average error percentage of primary energy supply is 1.5%, the final energy consumption is 1.5%, and figure for industrial sector is 3.1%. The differences between the actual observed figures and the figures estimated by the model and the final test is shown are the following chart (See Figure 9.4).

Figure 9.4 Model Performance in Final Test