2.5 Economy

2.5.1 Overall Economic Trends

(1) Gross Domestic Product

Indirectly though, overall economic trends are indicative of the changing nature and extent of the strain put on the environment by human activity. The index of overall economic dynamics most often cited these days is that of the Gross Domestic Product (GDP). Due to efforts in recent years, GDP accounting has resulted in indices at constant prices for the national economy of the Country for the years from 1990 to 1996. These data are qualified by the Statistical Office, however, as "preliminary" (partly attributable to the need of overhauling the system of economic statistics, partly to the extent of the informal economy). The latter was estimated by a government commissioned study at about 30 % in the autumn of 1997 (Ref. 2-7, pp.204-208). Therefore, for the purposes of longer-range comparison, first the "Social Product" indicator more customary in former "planned economies" is shown in Table 2.39 and Figure 2.15.

Table 2.39 Total Social Product at 1972 Prices /1960=100/ (1985-1995)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
TSP	386	414	408	386	402	364	328	287	244	240	232

Source: Ref. 2-7 (p.201)

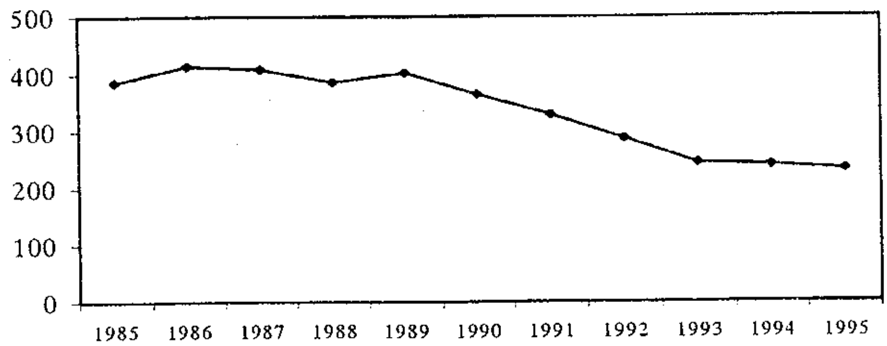


Figure 2.15 Total Social Product at 1972 Prices /1960=100/ (1985-1995)

Available preliminary GDP data at 1990 prices in 1,000 DEN cover the years from 1991 to 1996, as presented in Table 2.40 and Figure 2.16.

Table 2.40 Gross Domestic Product at 1990 Prices (1991-1996)

×1,000 DEN

Year	1991	1992	1993	1994	1995	1996
GDP	470,541	433,123	393,886	386,809	382,244	385,111

Source: Ref. 2-15 (p.6)

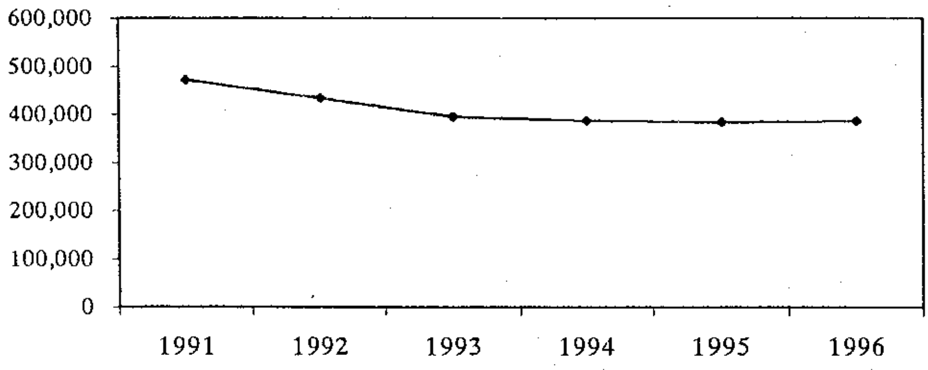


Figure 2.16 Gross Domestic Product at 1990 Prices per 1,000 DEN (1991-1996)

Table 2.41 and Figure 2.17 show the GDP per capita data in US$, which has been available for the years from 1994 to 1999 and show the trends well (for 1998 as estimated, for 1999 as projected).

Table 2.41 Gross Domestic Product per Capita / US$ (1994-1999)

Year	1994	1995	1996	1997	1998	1999
GDP / Capita	1,618	1,583	1,581	1,593	1,662	1,730

Sources: Refs. 2-8 (p.33), 2-16 (p.5)

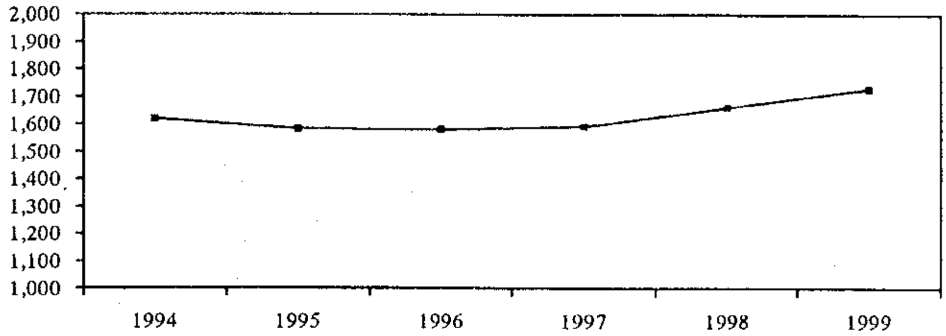


Figure 2.17 Gross Domestic Product per Capita / US$ (1994-1999)

Shown in Figure 2.15, overall economic output was on the decrease from the mid-1980's, except for 1989. From 1989, however, transition and decline in the general performance of the economy has had a double effect on the environment and environmental policies. On the one hand, bottlenecks in economic output have severely constrained resources allocable to environmental purposes. On the other hand, the contraction of economic activities has resulted, in a considerable restriction of the pollution load put by the economy on the environment. The GDP curves, especially the one for the GDP per capita, also suggest that from the mid-1990's economic decline may have turned into potential recovery and growth. As the latter is taking place, the double effect mentioned may be reversed in the coming years, both for more resources to mobilize for environmental purposes and for increasing environmental pollution.

In fact, as seen in Table 2.42 and Figure 2.18, real GDP growth rate figures (estimated for 1998, projected for 1999) well reflect a gradual resumption of growth since 1996 and the gathering momentum of the process since 1998 (in January 1999 views, 1998 rate may have been 5.0 in reality).

Table 2.42 Percentage Change of Real GDP

Year	1996	1997	1998	1999
Rate of Change (%)	0.8	1.0	6.0	5.0

Source: Ref. 2-16

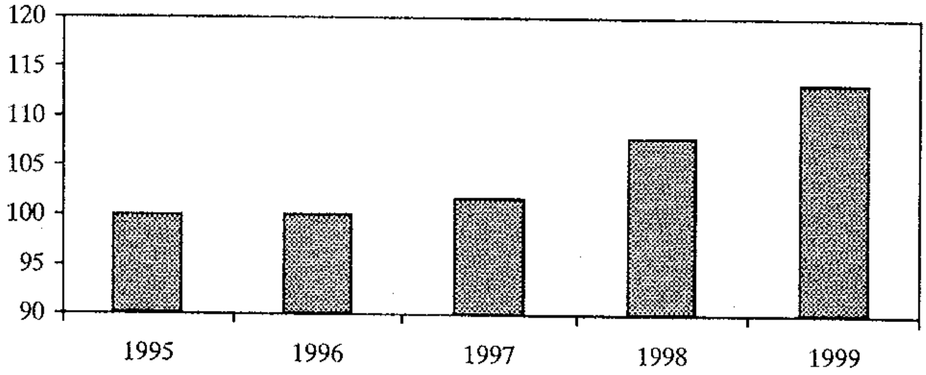


Figure 2.18 Real GDP Volumes / Year (1995=100)

Economic performance and its environmental concomitants cannot be assessed, however, by taking only overall quantitative output indicators into account. Qualitative aspects of the economy, primarily its institutional patterns have to be duly considered. The more so, since many of the critical issues in prevailing economic and environmental conditions are tied to the institutional regime of the economy and to its current transformation.

(2) Ownership Structure

One of the most important institutional features of the economy, especially for its environmental consequences, is its ownership structure. A 1998 Privatization Report of the Agency of Macedonia for the Transformation of Enterprises with Social Capital cites the results of a survey done by the Payment Operations Service. According to the findings of the survey, by the second half of 1997 over 70 % of the total revenues, 80 % of all the profits of the Macedonian economy were already generated, and 60 % of the whole labor force was employed by the private sector. By December 31 1998, 1,311 companies were privatized with a total number of nearly 200,000 employees

(198,862) and a total value of 33 million DEN. (Source: Ref. 2-14)

Since ownership relations are of utmost relevance for environmental conditions and policy regimes, the fact that the transformation of the Macedonian economy's progressed towards a market-type, privatized regime to this extent is of obvious importance for air-pollution and related policy-making.

Institutional features like settled ownership-relations, clearly defined responsibilities. Enforceable accountability is an essential ingredient for an economy with efficient environmental controls and may enhance economic efficiency as well. (The very fact that 80 % of all the profits are produced by 60 % of the total labor force in the private sector shows a higher comparative efficiency.) Environmental pollution and mitigation are caused by policies that favor soft budgets, subsidies and undervalued inputs. Low economic efficiency and high energy and material intensity are coupled, worst polluters are typically the large loss-makers (Ref. 2-5, p.94). With the extent of privatization and restructuring achieved by now, there are improved prospects for applying market-based instruments in air quality policies in the years to come. This may largely contribute to building an adequate financial base for environmental policies and to reducing central budget pressures.

As of January 1999, however, the process of privatization is not yet considered as finished: it is still going on for 181 enterprises, and for 80 enterprises it has not yet even begun. (Source: Ref.2-14) Of special interest here is the "problem companies", for which the Agency of Macedonia for the Transformation of Enterprises with Social Capital has not found (foreign) investors: Many of these companies are not only heavy loss-makers, but also some of the worst polluters. The International Monetary Fund (IMF) is helping with the privatization of 12 of such companies (with a total work force of about 50,000), but this does not resolve the situation for all of them in the same category. A number of these companies have been seeking "rescue measures" from the new Government (in office since November 30, 1998), but the Prime Minister has clearly stated the options open to them: they must either i) find a foreign investor willing to buy the company in question for one dollar and to restructure it, or ii) close down. Another potential bottleneck for the introduction of market-based environmental controls even in the sector of already privatized companies may be what has been termed the issue of "dispersed ownership": In most cases the enterprises have been bought out by the existing management and employees, without establishing "dominant ownership" i.e. the capability of introducing "clearly defined business motives, new capital, advanced know-how and improved management". (Source: Ref. 2-14) All these have serious consequences for the clean-up of past environmental mitigation and for future chances of effectively controlling some of the worst polluters.

(3) Social Product

While the weight of Skopje and its municipalities in the national economy is obvious, from available statistics it can be circumscribed largely by Social Product, National Income Investment and Fixed Assets data. The Tables 2.43, 2.44 and Figures 2.19, 2.20 reflect the share of Skopje and its municipalities in total Social Product, National Income, Investment and Fixed Assets for the year 1995, broken down by economic sectors.

Table 2.43 Share of Skopje and its Municipalities in Total Social Product / Current Prices (1995)

	Total %	Public Sector %	Private Sector %	Social Product per Capita
Skopje Total	45	46	42	161
Gazi Baba	12	15	6	231
Karpos	7	6	8	100
Kisela Voda	8	8	9	108
Center	16	16	15	372
Cair	2	1	4	49
Rest of the Economy	55	54	58	-
National Economy	100 %	100 %	100 %	100 level

Source: Ref. 2-7 (pp.278-288)

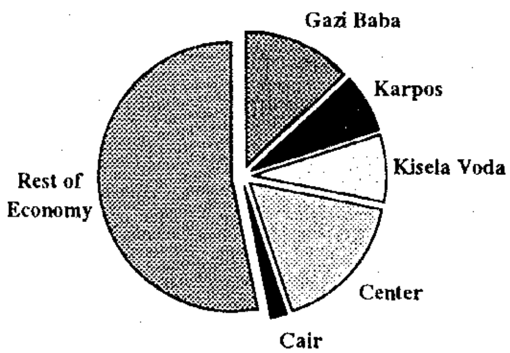


Figure 2.19 Share of Skopje and its Municipalities in Total Social Product / Current Prices (1995)

It is visible from the data showed in Table 2.43 and Figure 2.19 that Skopje and especially two of its municipalities, i.e. Center and Gazi Baba are highly preponderant in the national economy. Though there have not been data available on the temporal and more recent course of the process, it is obvious that the displayed measure of spatial concentration is a major factor in Skopje's environmental problems in its own right. The same can be observed from the National Income, Investment and Fixed Assets distributions as shown in Table 2.44 and Figure 2.20.

Table 2.44 Share of Skopje and its Municipalities in National Income, Investment and Fixed Assets / Current Prices (1995)

	National Income	Total Real Investment	Production Investment	Fixed Assets per employee
Skopje Total	47	58	55	107
Gazi Baba	13	9	10	134
Karpos	7	6	7	51
Kisela Voda	8	2	2	99
Center	17	40	35	131
Cair	2	1	1	54
Rest of the Economy	53	42	45	-
National Economy	100 %	100 %	100 %	100 level

Source: Ref. 2-7 (pp.282, 288, 560)

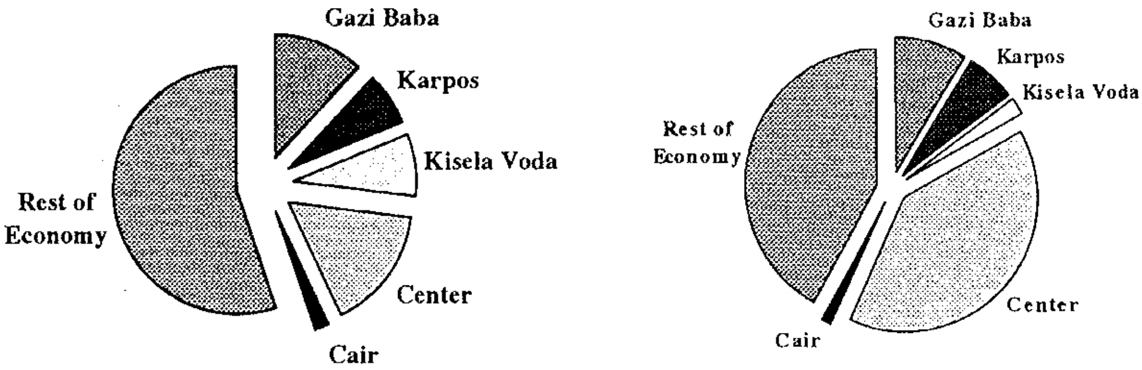


Figure 2.20 Share of Skopje and its Municipalities in National Income and Total Realized Investment / Current Prices (1995)

Even in the absence of time-series statistics, the excessive over-representation of Skopje in all the dimensions quoted can be evidenced. This is most conspicuous in the case of investments, where Center alone had as much investment in 1995 as all the rest of the Country apart from Skopje, but it is also relevant to note that there is 3.72 times more Social Product produced in Center per inhabitant than the national average. These imply on over-concentrated burden for the living environment of Skopje, especially for two of its municipalities; Center and Gazi Baba.

2.5.2 Industrial Trends

(1) Industrial Production

The same general trends are even more pronounced, if industry is considered. For a long-range view, Table 2.45 and Figure 2.21 show the total industrial production volume index in terms of Social Product accounting, from 1985 to 1995 with the base year of 1960 (=100).

Table 2.45 Total Industrial Production Volume/ Social Product/ 1960=100

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Volume	942	1,010	1,035	1,017	1,061	948	785	661	569	509	455

Source: Ref. 2-7 (p.201)

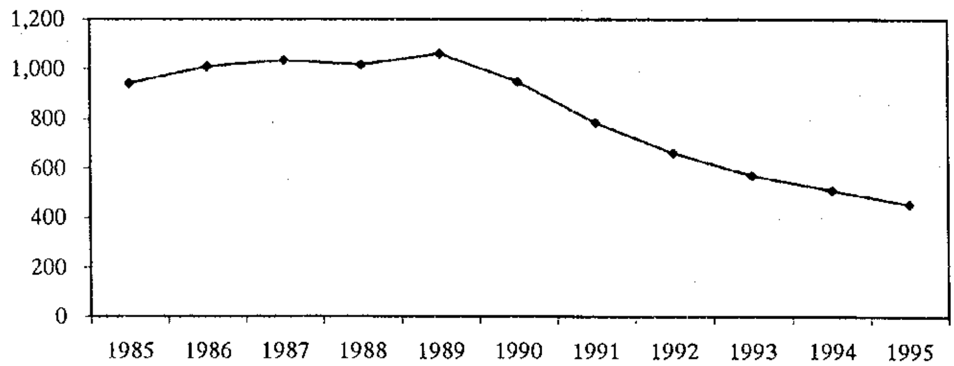


Figure 2.21 Total Industrial Production Volume/ Social Product/ 1960=100 (1985-1995)

Not only has industrial production declined, the share of industry in the economy as a whole has shrunk. This is shown in Table 2.46 and Figure 2.22.

Table 2.46 Share of Industry and Mining in the GDP in 1990 DEN per 1,000 (1990-1996)

Year	1990	1991	1992	1993	1994	1995	1996
Share %	32	29	26	25	23	22	23

Sources: Refs. 2-7 (p.237), 2-15 (p.6)

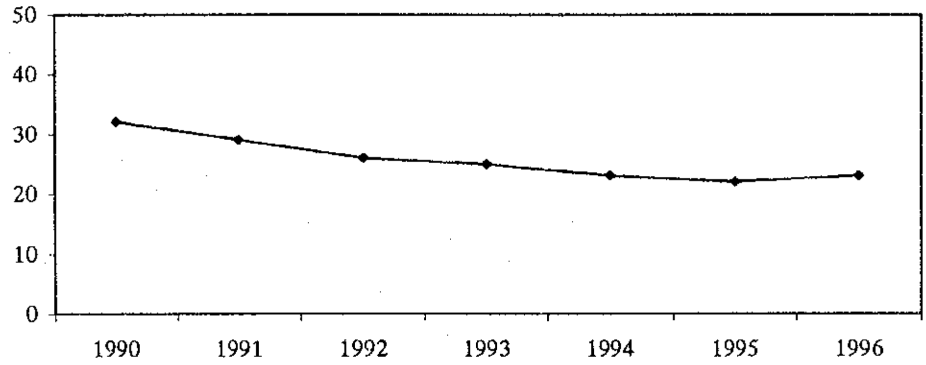


Figure 2.22 Share of Industry and Mining in the GDP in 1990 DEN Per 1,000 (1990-1996)

For ascertaining any plausible future trend with the given shape of the above curves in Figure 2.22, the figures for 1997 and 1998 are important. The above indicators do not include data for 1997 and 1998, but as shown in Table 2.47 and Figure 2.23, Total Volume Indices are of orienting value:

Table 2.47 Index of the Total Volume of Industrial Production (1996=100) (1991-1998)

Year	1991	1992	1993	1994	1995	1996	1997	1998
TVIP	167	141	121	109	97	100	102	107*

Source: Ref. 2-15 (pp.3, 7), * Preliminary figure calculated from the 1998. I-X./1997. I-X. data

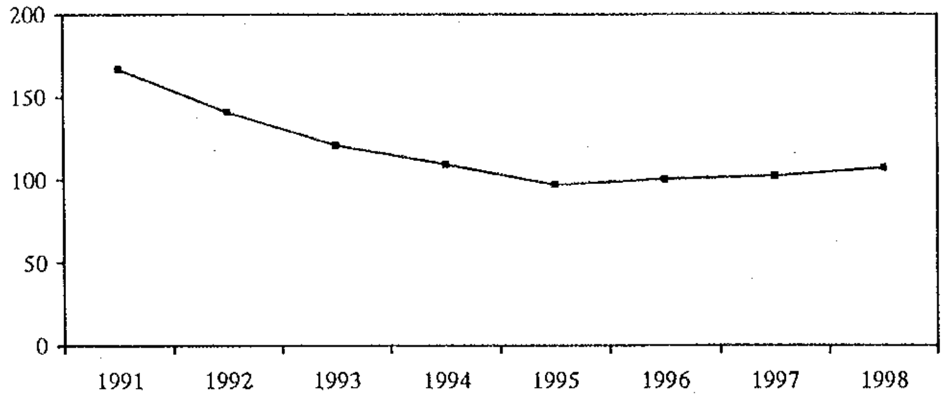


Figure 2.23 Index of the Total Volume of Industrial Production(1996=100)(1991-1998)

(2) Centralization of Industry

If the foregoing presents a contoured view of industrial trends in general, much of it goes also for the centralization of industry in Skopje. Tables 2.48, 2.49 and Figures 2.24 to 2.26 below document the degree of spatial concentration of industry in and within Skopje, largely along the same lines as it is evidenced for the economy as a whole.

Table 2.48 Share of Skopje and its Municipalities in Mining and Industry / % of Social Product / Current Prices (1995)

Social Product	Skopje Total	Gazi Baba	Karpos	Kisela Voda	Center	Cair	Rest of the Economy
Share (%)	36	16	4	8	7	1	64

Source: Ref. 2-7 (p.278)

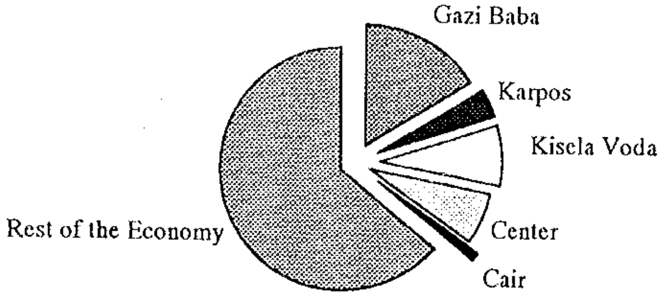


Figure 2.24 Share of Skopje and its Municipalities in Mining and Industry / % of Social Product / Current Prices (1995)

Table 2.49 Share of Skopje and its Municipalities in Mining and Industry / % of National Income and Investment / Current Prices (1995)

	Skopje Total	Gazi Baba	Karpos	Kisela Voda	Center	Cair	Rest of the Economy
National Income (%)	39	18	4	9	7	2	61
Investment (%)	36	10	12	3	11	0	64

Source: Ref. 2-7 (p.278)

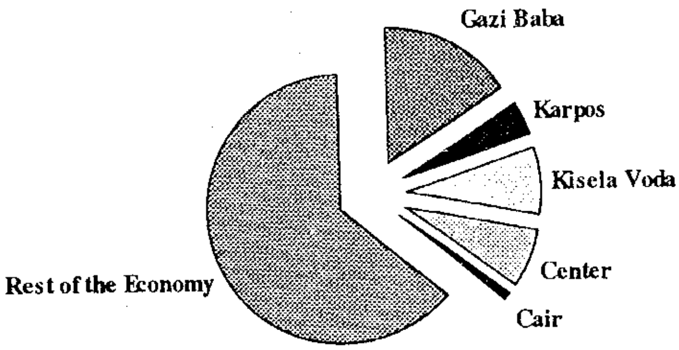


Figure 2.25 Share of Skopje and its Municipalities in Mining and Industry / % of National Income Index / Current Prices (1995)

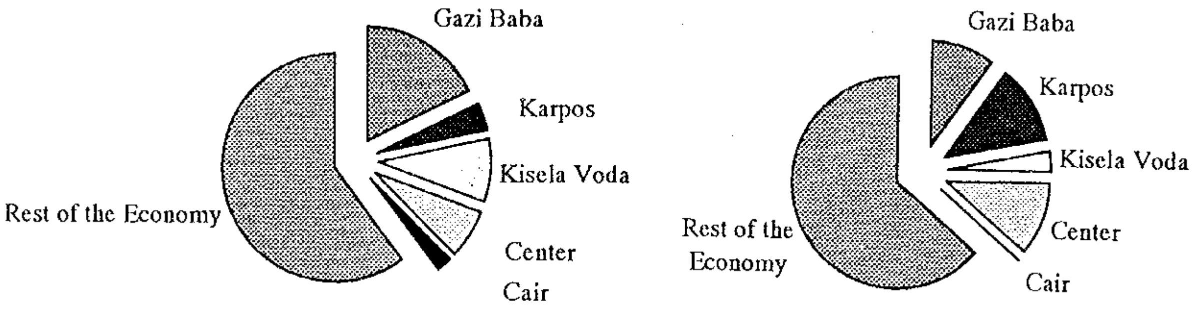


Figure 2.26 Share of Skopje and its Municipalities in Mining and Industry / % of Investment Index / Current Prices (1995)

If mining were not included in the statistics, the weight of Skopje and that of its two municipalities, Gazi Baba and Center, would be even more pronounced. There have been no data available on the temporal process of industrial concentration, but it is reasonable to assume that the displayed industrial indicators are plausible predictors of air pollution concentration for the years before and after 1995. For the winter season of 1992 (the worst years for heavy air pollution in Skopje) a survey of the Institute of Mining found that by far the largest emission load of SO_2, NOx, CO and CO_2 by kg/h was emitted from Gazi Baba municipality: 55 %, 50 %, 93 % and 64 %, respectively, of Skopje's total emission (and 13 %, 16 % for the total SO_2, NOx emissions in the Country). (Ref. 2-5, p.42)

2.6 Energy

2.6.1 Energy Sector

(1) Energy Balance

Long-term trends in the energy balance are presented in Table 2.50. On the whole, it can be stated that the energy system has several unfavorable characteristics. Liquid fuels (a large share) have to be fully imported. Lignite reserves are rather limited (55 to 65 % of solid fuel demand has to be provided by import). The supply of gas is affected by several international and domestic factors, while hydroelectric facilities are in need of reconstruction and extension.

(2) Electric Power

In the mid-1990's the productive capacities of the electric power system consisted of three thermal power stations with an installed capacity of 1,010 MW and a total output of 965 MW, of which 755 MW was coal-based, 210 MW was crude oil-based; six hydroelectric stations with a total installed capacity of 390 MW (and 721 million reservoir m^3) and six distributive hydroelectric stations with a total installed capacity of 30 MW (and 117 million reservoir m^3), utilizing about one fifth of total hydroelectric potential. (Ref. 2-17, p.19)

(3) Gas Supply

Of special importance are the gas pipeline and the communal heating systems.
The first phase of the gas pipeline system, from the Bulgarian border to Skopje was already completed. The trunk length of the pipeline is 165 km, with a working pressure of 40 kgf/cm^2 and with a capacity of 800 million m^3 in the main line. However, regular operation is expected to start no earlier than the year 2002.
The district heating system of Skopje has a connected consumption per customer unit of approximately 550 MW. Its annual production amounts to 650 million kWh of heating energy, consuming approximately 70,000 t of low sulfur fuel oil. Fuel conversion to gas was made experimentally in 1998 for four months, covering about 10 % of total time-proportional production by about eight million m^3 of gas, but totally gas-fueled operation is expected to start no earlier than the last part of the year 2001. Planned gas consumption for 2002 is approximately 300 million m^3 (Sources: Refs. 2-18 p.341, 2-6).

Since gas has fundamental environmental advantages over liquid and solid fuels, the conversion to gas has a high position on the list of environment-related investment projects, which include (Source: Ref. 2-20, pp.7, 8):
- Adjustment of facilities based on natural gas
- Development of a countrywide natural gas distribution network (communal use included)
- Expansion of the surface excavation site "Oslomej West"
- Reconstruction of existing hydroplants (88 %, i.e. about 323 million DEN of all industrial and mining investments going on in 1998 are spent on hydroelectric energy - Ref. 2-19)
- Construction of the "Kozjak" hydroplant

Table 2.50 The Energy Balance / E(GWh) (1980-1995)

Energy	1980	1985	1990	1995	1995 %
A. Production (1+2)	1,908,480	3,458,507	5,638,572	6,068,341	98.10
1. Thermal Plants	451,430	2,368,378	5,148,310	5,267,441	85.16
1.1 Coal	193,230	2,334,798	5,145,985	5,258,918	
1.2 Crude Oil	258,200	33,580	2,325	8,523	
2. Hydro Plants	1,457,050	1,090,129	490,262	800,900	12.95
2.1 Accumulative	1,373,883	1,014,029	430,968	699,630	
2.2 Distributional	83,167	76,100	59,294	101,270	
B. Import	2,376,400	1,990,704	40,137	117,300	1.90
Disposable (A+B)	4,284,880	5,449,211	5,678,709	6,185,641	100.00
C. Electric Energy	490,167	722,983	1,036,451	1,182,759	19.12
1. Own Consumption	51,480	180,772	373,764	383,361	
2. Mines, Stations, RP	14,814	82,185	145,277	169,746	
3. Distributional Consumption				7,200	
4. Transfer Losses	128,764	131,296	112,950	122,534	
5. Distribution Losses	295,109	328,730	404,460	499,918	
D. Net Production (A+B+C)	3,794,713	4,726,228	4,642,258	5,002,882	80.88
E. Demand (1+2+3+4)	3,794,713	4,725,228	4,649,257	5,002,912	80.88
1. Distributive	1,179,307	1,581,657	1,929,492	2,795,328	45.19
1.1 Households	1,019,153	1,381,012	1,672,312	2,381,626	
1.2 Services	160,154	200,645	224,924	366,778	
1.3 Public			32,256	46,924	
2. Industry	1,052,303	1,285,827	1,314,133	984,686	15.92
2.1 100 kV	229,265	277,069	239,958	180,832	
2.2 35 kV	235,853	242,157	210,937	119,873	
2.3 10 kV	551,185	726,601	822,359	636,649	
2.4 0.4 kV	36,000	40,000	40,879	47,332	
3. Metallurgy	1,548,469	1,845,575	1,378,274	1,209,565	19.55
3.1 Steel	814,856	1,118,174	636,338	140,774	
3.2 Chrome	632,075	599,704	597,161	567,182	
3.3 Ferro Metals		8,134	3,237	372,934	
3.4 Copper	57,792	71,829	90,368	84,059	
3.5 Lead and Zinc	43,746	47,734	51,170	44,616	
4. Transport (railway)	14,634	12,169	27,358	13, 333	0.22

Source: Ref. 2-18

(4) Trend in Energy Production and Consumption

Long-term trends in energy production are shown in Figures 2.27 and 2.28.

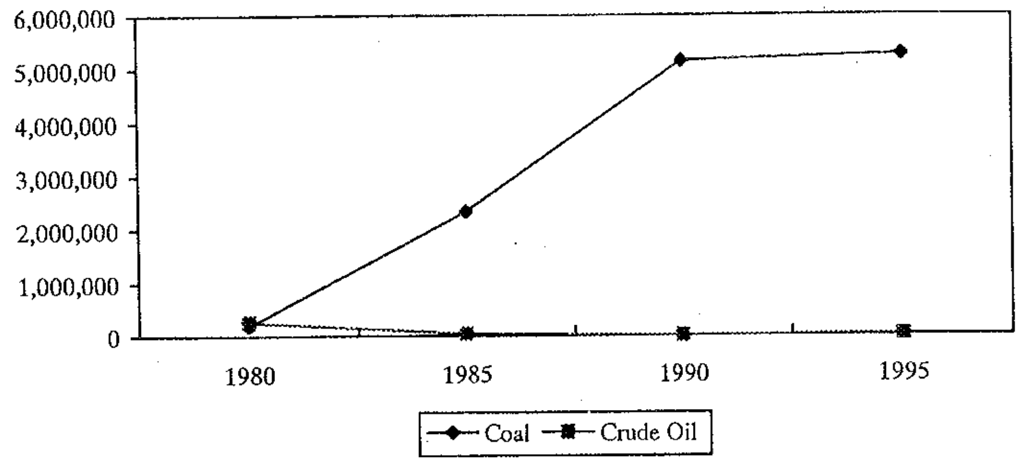


Figure 2.27 Coal- and Crude Oil-based Thermal Plant Production / E(GWh) (1980-1995)

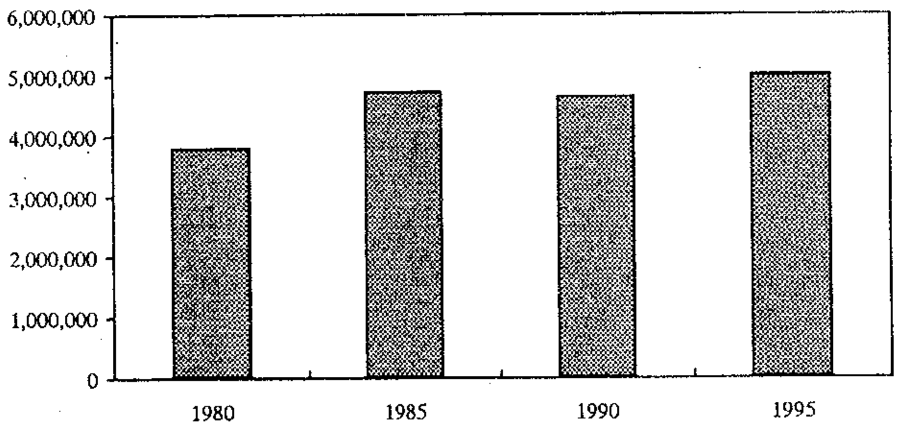


Figure 2.28 The Net Production of Electric Energy / E(GWh) (1980-1995)

More detailed trends in electric energy generation and consumption are shown in Tables 2.51, 2.52 and Figures 2.29, 2.30. The average growth rate of production in the period from 1991 to 1996 was 3 %.

Table 2.51 Trends in Electric Energy Generation / GWh (1986-1996)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
GWh	4,159	4,226	3,871	4,686	5,754	5,770	6,046	5,591	5,924	6,133	6,630

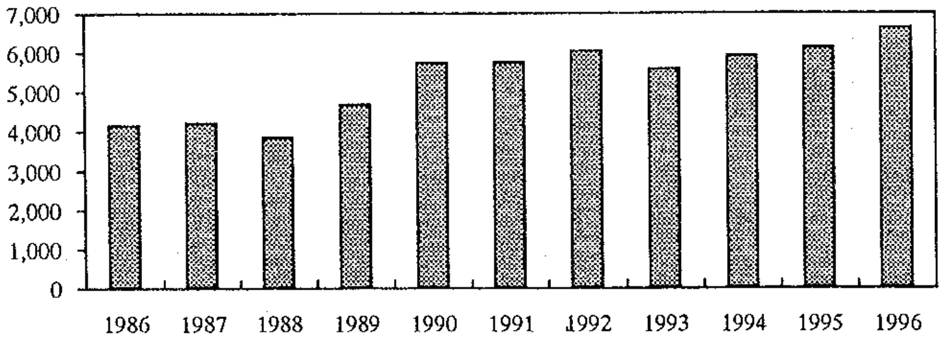


Figure 2.29 Trends in Electric Energy Generation / GWh (1986-1996)
1,000 MWh = 1 GWh

Table 2.52 Trends in Electric Energy Consumption / 1970=100 (1986-1996)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Rate	232	219	211	225	211	191	214	204	187	172	182

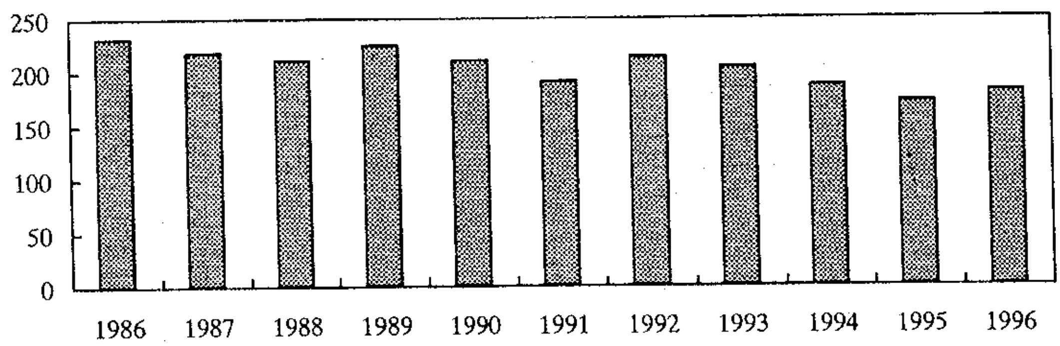


Figure 2.30 Trends in Electric Energy Consumption / 1970=100 (1986-1996)

Source: Ref. 2-7 (p.380)

Fuel consumption of industry by fuel type and the industrial consumption of electric energy from 1992 to 1996 are shown in Table 2.53 and Figure 2.31.

Table 2.53 Fuel Consumption of Industry by Fuel Type and Industrial Consumption of Electric Energy / GWh and 10-100 t (1992-1996)

Year	1992	1993	1994	1995	1996
Electric Energy	3,053	2,913	2,679	2,454	2,603
Coke / 100 t	727	734	657	701	871
Pit Coal / 100 t	175	182	184	320	530
Brown Coal / 10 t	761	674	596	584	560
Lignite / 100 t	1,924	1,662	1,654	1,089	1,231
Liquid Fuels / 100 t	304	302	280	298	282
Heavy Oil / 100 t	1,066	1,263	1,069	934	1,313

Source: Ref. 2-7 (p.399)

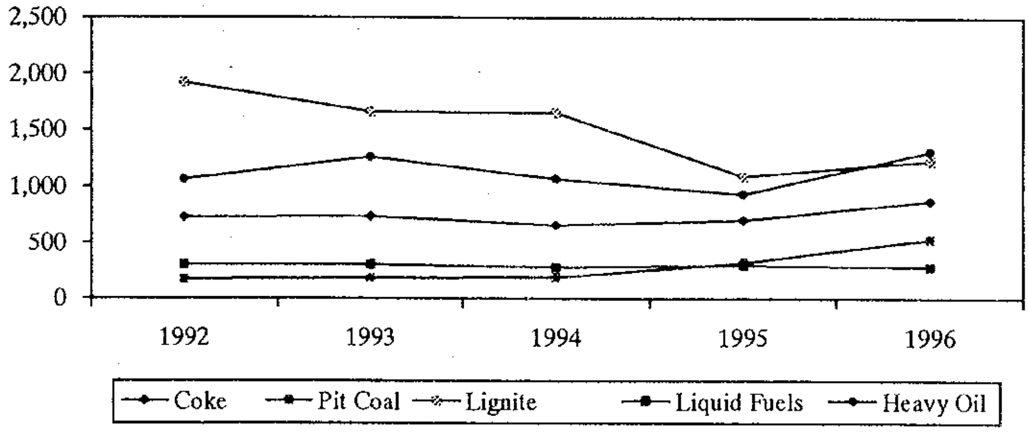


Figure 2.31 Fuel Consumption of Industry by Fuel Type (except brown coal) / 100 t (1992-1996)

(5) Fuel Consumption of Vehicles

Most recent vehicle statistics are kept on record by the Ministry of Interior, but these have not yet been released. The newest data published by the Statistical Office refer to the year 1996. Trends in urban traffic from 1986 to 1996 are shown in Table 2.54 and Figure 2.32.

Table 2.54 Trends in Urban Traffic / 10^5 Passengers (1986-1996)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Passengers	1,573	1,572	1,639	1,607	1,429	1,229	1,300	1,386	1,279	1,222	1,231

Source: Ref. 2-7 (p.7)

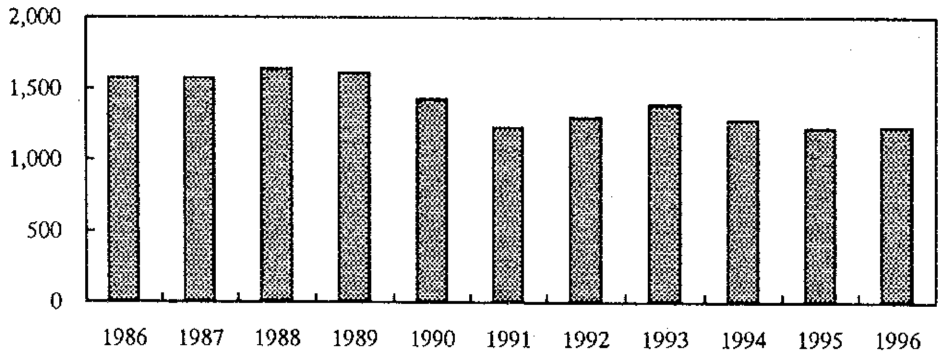


Figure 2.32 Trends in Urban Traffic / 10^5 Passengers (1986-1996)

Aggregate trends in the number of registered motor vehicles and trailers (motorcycles, passenger cars, buses, commercial vehicles, special vehicles, tractors and working vehicles, trailers) for from 1992 to 1996 are shown in Table 2.55 and Figure 2.33.

Table 2.55 Aggregate Trends in Registered Motor Vehicles and Trailers (1992-1996)

×1000

Year	1992	1993	1994	1995	1996
Vehicles, Trailers	324,044	336,842	298,941	327,269	325,017

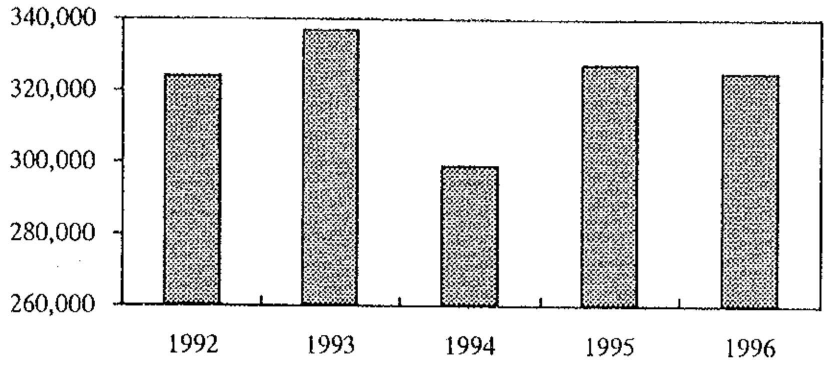


Figure 2.33 Aggregate Trends in Registered Motor Vehicles and Trailers ×1,000 (1992-1996)

Aggregate consumption of diesel in road transport, freight transport and urban traffic from 1990 to 1996 are summarized in Table 2.56 and Figure 2.34 Unleaded gasoline consumption in 1998 is said to be no more than 2 % of total consumption. Unleaded gasoline is planned to be phased out by 2007 (with two years extension of transition time).

Table 2.56 Aggregate Consumption of Diesel / Road Transport, Freight Transport and Urban Traffic (1990-1996)

(ton)

Year	1990	1991	1992	1993	1994	1995	1996
Consum.	83,419	72,019	62,414	53,418	54,141	48,786	47,068

Source: Ref. 2-7 (p.453)

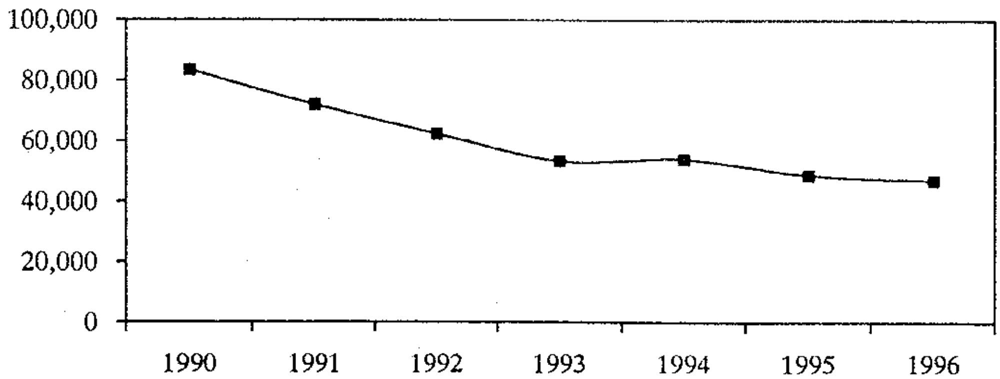


Figure 2.34 Aggregate Consumption of Diesel/ Road Transport, Freight Transport and Urban Traffic / ton (1990-1996)

In the mid-1990's the average age of vehicles was 12 years. The situation has worsened since the beginning of the decade. For example, the average age of buses was around 6 years in 1991 and it has grown to 14 years in 1998. (Source: Ref. 2-6)

Relevant public sector investment-projects are underway in the traffic and transportation infrastructure. According to Office of Payment's data, 46 % of all the investments in the first half of 1998 were made in transport and communication facilities. Major investments in the transportation field include: the Kumanovo-Beljakovce - Bulgarian border railway, the Skopje-Tetovo highway and the Gradsko-Stobi highway.

In Skopje in 1996, 152,182,000 passenger kilometers and 139,003,000 ton-kilometers were traveled in road transport and in freight transport, respectively. The number of motor vehicles and trailers in Skopje in 1996 is summarized in Table 2.57.

Table 2.57 Motor Vehicles and Trailers in Skopje (1996)

Type	Motorcycle	Cars	Buses	Commerc.	Special v.	Tractors	Trailers
Numbers	1,250	111,151	1,076	7,112	1,911	178	1,499

Source: Ref. 2-7 (p.460)

2.7 Future Socio-economy

2.7.1 Setting Target Year

(1) Target Year

The Study Team set up a target year as 2008, 10 years later, for the purpose of implementing the Study. It is necessary to forecast future socio-economy in order to estimate emission sources and air pollution in the target year.

The Study Team and the Counterpart, as well as other parties concerned had discussed issues such as future scenarios, the organization plan and systems.

For example, as in the case of the Macedonia Academy of Science, the year 2020 was set to be the future target under the National Development Strategy (NDS). However, where environment-related problems are concerned, there is a need to address the problems at an early stage. Taking into consideration the long-term target of NEAP, the target year is therefore set at the year 2008, ten years from now.

It is necessary to set early, middle and long-term objectives (as shown by NEAP) for environmental measures and to carry out step by step all possible measures at present. In order to ensure the efficiency of such measures, facilities and equipment planning should be completed at an earlier stage.

(2) National Development Strategy

One of the critical ingredients for reliable forecasting is the existence of long-range time series for trend analysis of essential socio-economic processes. The most representative recent attempt at long-term forecasting, is the NDS report states in its chapter on Future Scenarios to the year 2020: "There are no good long-term time series of data" available. (Ref. 2-18, p.299). There are, however, projections based on approximate or indirect evidence, at varying degrees of "Optimism/pessimism" and plausibility, as well as policy statements and targets which may be of value in making judgments about the probable future course of socio-economic change. Representative base-scenarios for trends in essential socio-economic processes can be cited mainly from the NDS, supported by the United Nations Development Program and by the United Nations Department of Economic and Social Affairs.

2.7.2 Annual Growth Rate of GDP

(1) Forecast of GDP Growth Rate

Long-term global projections of the NDS, building on the foregoing trends envisage the status of the Country by the year 2020 as a full member of the European Union, with a modern democratic state and a developed, export-oriented market economy.

Demographic prognoses set the probable size of the population at 2,218,700 for the year 2019. (Ref. 2-18, p.137) This amounts to a linearly calculated annual increase of about 11,000, resulting in an increase of about 150,000 to the year 2008. Such a growth would imply a population size of 2,087,000 for 2008, about 7 to 8 % larger than the population of the mid-1990's. If effective policies of decentralization and other processes do not act to the contrary, the population concentrated in Skopje may grow at a faster rate, producing a capital with nearly half a million inhabitants by 2008. Increased tourism and transit traffic/transport, as expected, may considerably add to total size of the population generating pollution and being exposed to it in Skopje.

A scenario for GDP growth forecasts an annual average rate of 5.2 % for the period to 2002. Thereby the GDP per capita would reach US$ 2,783 by 2002, a level about

50 % higher than the amount for 1996. An optimistic scenario assumes 6 % rate average growth for the years from 1997 to 2002, the pessimistic one posits a rate of 4.2 %. (Ref. 2-18, pp.302-303) For the years from 2001 to 2010 the average annual rate of real growth is expected to be around 6 %. (Ref. 2-18, p.337) Inserting actual, estimated and policy-projected figures, respectively, for the years from 1996 to 1999 (Ref. 2-19), and base-scenario ones for the years from 2000 to 2008, annual growth rates can be tabled as follows.

Table 2.58 Annual Growth Rate of GDP (1996-2008)

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rate	0.8 [a]	1.0 [a]	6.0 [b]	5.0 [c]	5.2	5.2	5.2	6.0	6.0	6.0	6.0	6.0	6.0

Note; a: actual, b: estimated, c: policy-projected

According to the NDS, the real GDP during the period of 1989-2002 attendant growth rates are presented as shown in Figures 2.35 and 2.36.

The Country successfully survived strong economic stagnation. Economic growth is expected to follow. To maintain this optimistic scenario, international cost plus quality product competitiveness and scientific technologies are deemed essential.

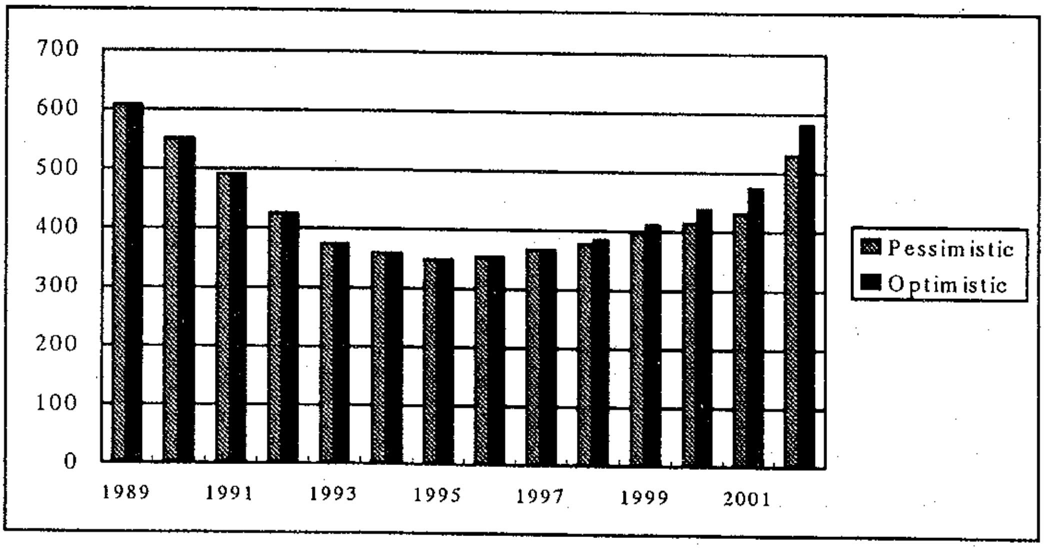


Figure 2.35 Real GDP Movement in Macedonia in a Period 1989-2002

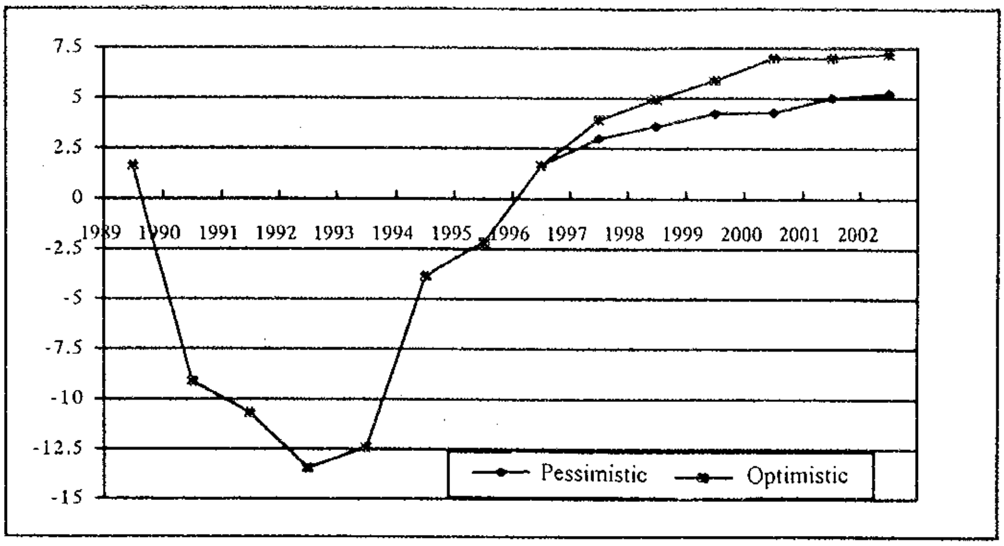


Figure 2.36 GDP Growth Rates

(2) Index of Industrial Production

The industrial scenarios of the NDS forecast a moderate 2 % average growth rate for total industrial production for the years from 1996 to 2000, and a rate of 6 % for the period from 2001 to 2010. This prognosis, however, seems to considerably underestimate the growth potential of Macedonian industry, especially for the years from 1996 to 2000. When compared to most recent actual and estimated/projected statistics of industrial output, it seems justifiable to adjust the respective figures to a more dynamic trend of growth. Recent statistics support the view that the likely rise in industrial production may well approximate the yearly average of 5-6 % in the years from 1996 to 2000 period. It may well even exceed the 6 % yearly level in the years from 2001 to 2010. Comprehensive indicators suggest that the decline of industrial production may have bottomed out in 1995 and since then industrial recovery has been on the increase. The mid-1990's may have been a turning point for industrial production as well. If the trend reported by government statistics for the years from 1995 to 1998 is extrapolated at an officially projected 7 % rate of growth for 1999 and at an 8 % rate afterwards (where the new Government inaugurated in December 1998 has set its target), then the total volume of industrial production may follow the trend depicted in Figure 2.37.

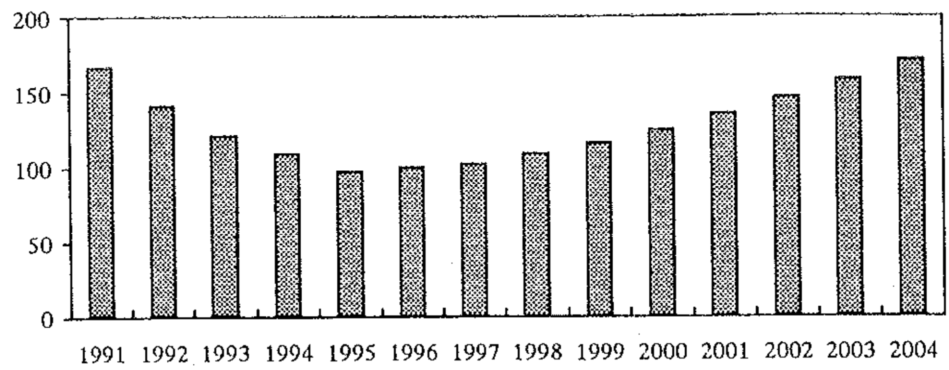


Figure 2.37 Index of the Total Volume of Industrial Production (1996=100) (1991-2004) (for 1999-2004 extrapolated)

If the trajectory displayed will materialize, the total volume of industrial production may re-approach its 1991 level by 2004, i.e. within about five years.

Even when industrial production resumes the early 1990's levels, it does not necessarily put the same pollution load on the environment as it did in the early 1990's. It is reasonable to suppose, however, that in the coming years the polluting effects of industry are going to grow. Simultaneously, it is a justifiable expectation that the abating capabilities of industry will grow, hopefully at a rate adequately countering the rising pollution potential of expanding industrial production and possibly avoiding the grave environmental mitigation and air quality emergencies of the early 1990's. The latter expectations can be met only if the control policies and mechanisms for the build up of needed abating capabilities are put in place in time essentially a market-based regime to keep pollution levels low and to exact adequate revenues from those industrial actors who exceed prescribed limit levels. Such considerations highlight the critical opportunity in the coming few years.

2.7.3 Forecast of Fuel Consumption

It is the supply and demand of energy that is the barometer of economic growth. It is advantageous because it also includes an informal part of the economy.
Without grappling with energy conservation now, energy consumption will grow larger, generally corresponding to economic growth.

According to the NDS prognosis, energy production would grow by 2 % during the years from 1996 to 2000, and by 4 % in the period of 2001 to 2010. Basic metal industries and chemical industries, both highly relevant for future levels of air pollution, are expected to grow at faster rates: at 1.5 % for 1996-2000 and at 5 % for

2001-2010, and at 2 % for 1996-2000 and at 7.5 % for 2001-2010, respectively (Ref. 2-18, p.336). In the light of the foregoing considerations, however, these estimates may be in need of upward adjustment as well. Toplifikacia forecasts the trend, evaluating every possible data hypothetically on the amount of consumed energy in Skopje of each fuel from 1995 to 2020 and from 2000 to 2010. The results are shown in Data Book, Table D2.1. In addition, Figure 2.38 shows these data in terms of heating values.

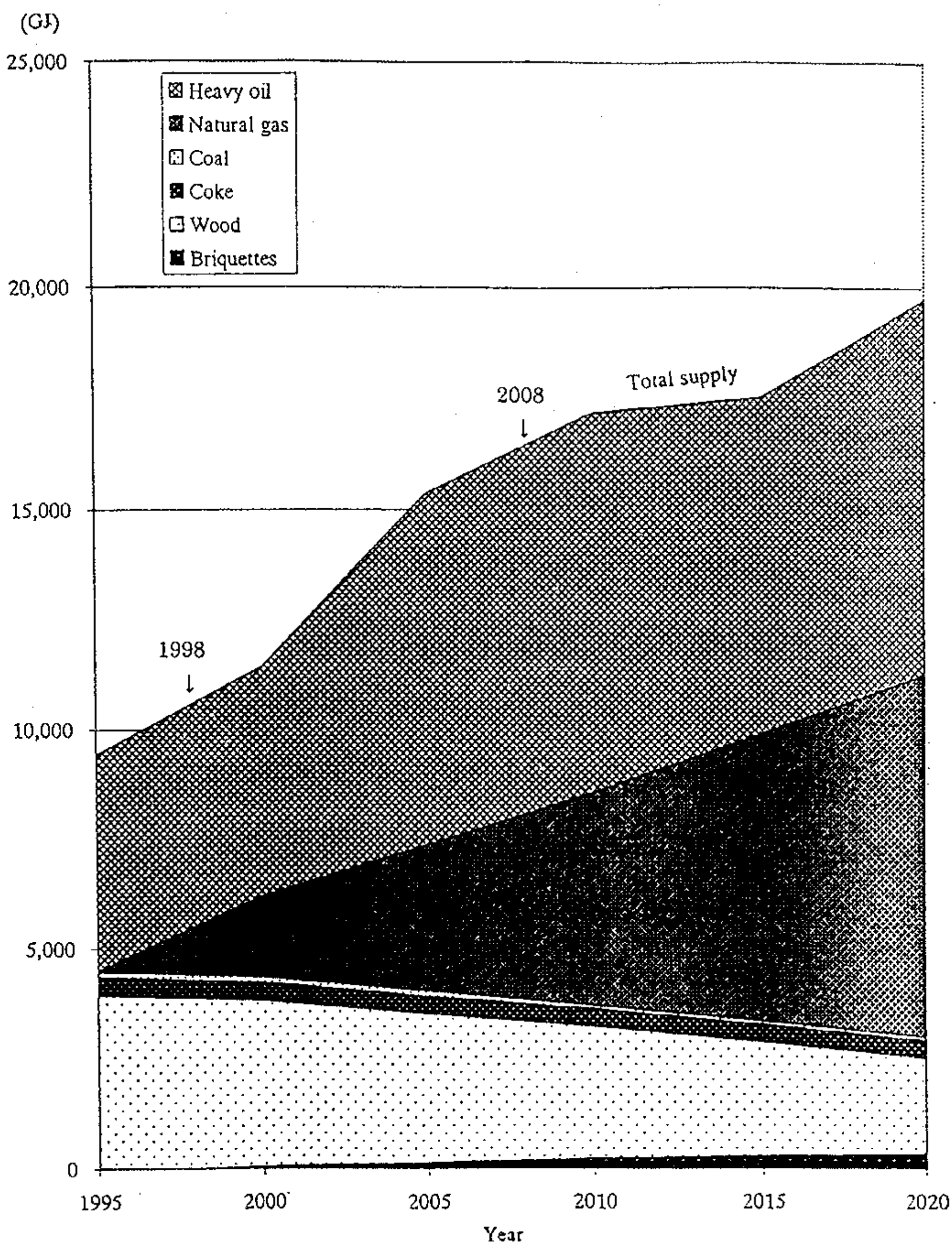


Figure 2.38 The Expected Trend in Fuel Consumption in Skopje (GJ based on heat values)

It is estimated that fuel consumption will increase 73 % (in units of heating value) from 1998 to 2008.
The calculated result shows the increasing use of heavy oil by 3,272 GJ and about 47% in total against an increase of total consumption 6,944 GJ. Consumption of natural gas will be expected to be 4,213 GJ, but fire wood use will decrease by 20%.

Scenarios such as the above are supported by recent reports on investment and employment. Employment has been slowly increasing since early 1998 (for the first time since the beginning of economic transition and restructuring), and investment, including foreign direct investment, increased in the first half of 1998 by 15 to 20 % as compared to the same period of 1997. The growth effects of these investments on industrial production volume (e.g. in cement, metal, leather, textile and other industry, located to large part in Skopje) are expected to be felt by the second half of the year 2000 (Ref. 2-19, pp.9, 13-14, 21). The effects of enhanced international economic cooperation, with other countries including the Republic of China (ROC), may produce an additional major momentum on industrial growth, still not reckoned with in pre-1999 forecasts. (According to reports upon the recent diplomatic recognition of ROC by the Republic of Macedonia, ROC may provide up to US$ one billion of interest-free loan as well as US$ 600 million untied development aid to Macedonia in four years.)

Chapter 3

Chapter 3 Selection of the Model City

3.1 Present State of Air Pollution in Macedonia and Bases for Selection of the Model City

3.1.1 Present State of Monitoring Equipment in Skopje City

(1) Ambient Air Quality Monitoring

Figure 3.1 shows a location map of measuring points in Skopje.
The Republic Hydrometeorological Institute (RHI, nine locations) and Institute for Public Health (IPH, seven locations) are conducting monitoring using British samplers.
Measurement of SO_2 and Black Smoke (BS) are based on manual measuring method. As for SO_2, one is based on the pararosaniline method, and the other, the acidic method. Both comply with International Standard Organization (ISO) standards and World Health Organization (WHO) selected methods.
The air pollutants in ambient air are collected by means of an absorption reagent in a glass bulb with an air pump. There is either one fixed sampling train or an automated eight-bubbles sampling trains.
The absorption reagent is subject to sampling periodically. These are then sent to the RHI for analysis.
Measurement of BS is done by the spot density method, which is practiced in European Union (EU) as a basic method. BS is collected in a spot on filter paper and is measured by using an optical densitometer.
The sampling cycle of ambient air quality is 24 hours which means one measurement datum for every 24 hour.
Total acid is monitored at points No. 1 to 3 of the IPH. Multiple samplers are used.
The sampling equipment consists vinyl tubes used in inlet tubes and pipes while filter holders are made of plastic or aluminum. The filters are cellulose and have large air-flow resistance. They remove dust and monitor BS concentration. CO concentration in air is monitored two seasons per year (April and November) at four intersections in the central area of Skopje.
The Karpos IV (No. 6) measuring point of the RHI monitors SO_2, BS, NOx, O_3 and Ox for 24 hours. Additionally, the RHI has been monitoring concentrations of particulate substances and Pb and other heavy metals at intersections and monitoring points in Skopje.
SO_2 and other pollutants are analyzed by the following methods:

SO_2:	Absorptiometry (Pararosaniline method)
Total Acid:	Neutralization titration method
NOx:	Absorptiometry (Saltzman method)
Ox and O_3:	Absorptiometry (5%-KI solution method)

CO:	Absorptiometry (Palladium chloride solution method)
Pb:	Filter collection controlled potential electrogravimetry
Heavy metals:	Atomic absorption spectrometry

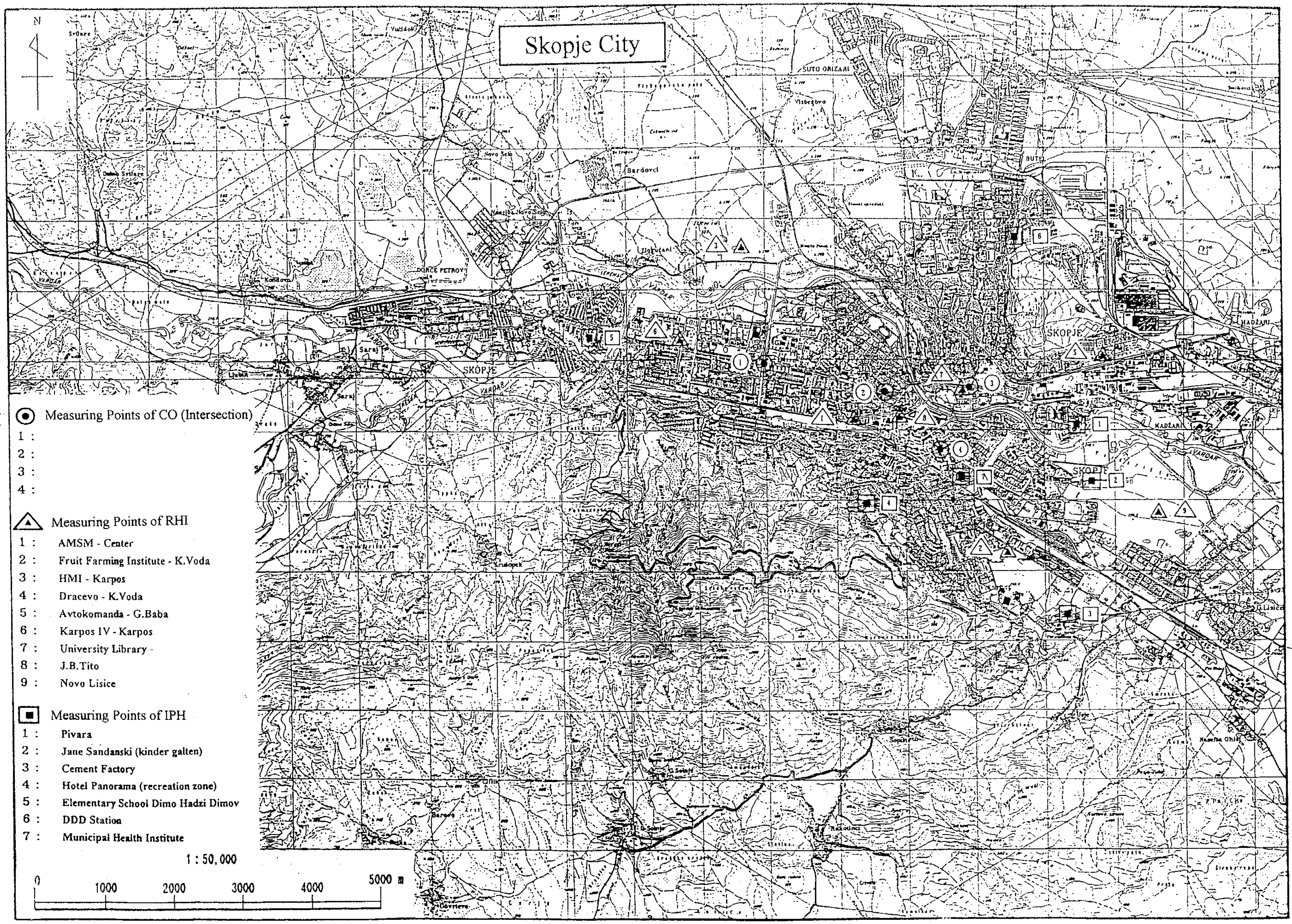


Figure 3.1 The Location Map of Measuring Points in Skopje

(2) Meteorological Observation

The meteorological observation point in Skopje is monitoring surface meteorology, such as wind direction, wind speed, temperature, humidity and rainfall at HMI-Karpos (No.3) measuring point of the RHI.

At the airport, upper meteorology such as vertical distribution of wind direction, wind speed and temperature is additionally monitored every day at 1:00 a. m..

The RHI collects these data and meteorological data from the Landsat and supplies meteorological information to the general public.

Data accumulation and processing of ambient air quality and meteorological data are performed as routine work without any problem. However, data are not adequately utilized or accumulated in accordance with the intended purpose.

(3) Air Emission Sources Monitoring

Each plant has an emission standard decided in accordance with its scale and other factors. At present, however, the plants have no obligation to monitor an air emission concentration.

Only some large plants monitor emission sources. Those plants and factories that monitor emission sources are cement plants, central heating plants, iron and steel mills and some others.

Monitoring ports of air emission are mostly small holes for classical monitoring equipment. Proper selection of monitoring positions and sufficiently large sampling ports must be provided for appropriate sampling of probes and dust samplers for automatic continuous monitoring. Careful consideration is required in determining monitoring positions for flow velocity monitoring and for dust sampling.

The monitoring items of these main plants and mills are as follows:

1) Cement Plant

Exhaust gas temperature

SO_2 : Infrared absorption method

NOx: Infrared absorption method

Dust: Light-scattering method

Air emission is monitored every week.

2) Central Heating Plant

Exhaust gas temperature and flow rate

SO_2 and CO (Infrared absorption method, portable equipment)

Dust (Collection on filter paper, and monitoring intensity of light reflection of photoirradiation)

Exhaust gas temperatures and flow rates are continuously monitored. Other items are monitored when appropriate.

3.1.2 Present State of Monitoring Equipment in the Major Cities

Throughout Macedonia, the RHI has installed the sam e monitoring equipment (British samplers) as those in Skopje in other 11 cities. Similarly, the IPH has installed sampler in six cities. Alarm announcement and regulation of vehicular traffic will be carried out in case the air pollution condition worsens in the industrial cities such as Skopje and Veles, in an effort to control air pollution.

The RHI monitors the meteorology of almost the whole of Macedonia by maintaining point networks (Data Book, Figures D3.1 to D3.5).

(1) Veles

Two automatic continuous AQM stations owned by "MHK Zletovo" in Veles are installed in two locations in the city. Data acquisition center is located at the plant.

The monitoring results are sent to the center by a radio telemeter system.

The data are collected and processed by a computer. The processed information is displayed on electric light signs in the city through a public information system.

The following items are monitored:

- SO_2: Ultraviolet pulse fluorescence method
- NOx: Chemiluminescence method
- SPM: Beta ray absorption method
- Wind direction and speed, Temperature, Humidity and Dust fall

SO_2 and NOx monitors are calibrated by permeation tube.

As in Skopje, SO_2 and BS are monitored by existing system in two points in the city and dust fall, in six points.

(2) Bitola

The Bitola MPGC thermal power plant has installed its own three British samplers for the continuous monitoring of air pollution. However, this monitoring point is located near the plant and does not indicate typical values for the city.

SO_2, BS and dust deposits are measured. As for stack gas measuring, SO_2, NOx and dust are automatically and continuously measured.

(3) Tetovo

As for AQM equipment, only the sampler is used. Emission source monitoring is not done periodically at metal chemical plant "JUGOHROM".

(4) Kavadarci

There is no automatic continuous monitoring station of air pollution and exhaust gases emitted by factories. Only classical monitoring is done.

(5) Other Major Cities

As for other cities, similar to Tetovo and Kavadarci, monitoring equipment for AQM and air emission are either insufficient or do not exist.

3.1.3 Laboratory Facilities of the Related Organization for the Monitoring

Field survey of the RHI, the IHP, and Institute of Environment "Zelezara" (IEZ), as well as civilian laboratories of the cement plant, "MHK Zletovo" metal smelting plant in Veles and "FENIMAK" ferro-alloy factory in Kavadarci, were conducted.

(1) The RHI Laboratory Facilities

Basic laboratory equipment is installed at the RHI laboratory. However, some of the equipment has become obsolete, has failed or is lacking in parts. In future, the equipment must be repaired and expanded in the early stage includes ion analyzers such as ion chromatography and an ion meter, atomic absorption spectrophotometer, UV/VIS spectrophotometer, microwave sample digestor, water purifying apparatus (ordinary pure water and ultra pure water), samplers of soils and underground water, and glassware etc. (Data Book, Table D3.1).

(2) The IHP Laboratory Facilities

Basic laboratory equipment is installed at the IHP laboratory. The numbers of laboratory equipment are also adequate. Many direct-reading balances are installed and some of them can weigh down to 0.01 mg. However, as high sensitivity is required, the installation of a dedicated balance table is desired. Moreover, similar to the RHI, the IHP also wishes for an expansion of the equipment.

(3) The IEZ Laboratory Facilities

Recently, installing better analysis equipment has been accomplished with the help of Poland and Hungary Aid for Reconstruction Economy (PHARE).
However, addition and expansion of the equipment would be desirable since they are basically

as insufficient as the RHI and the IPH.

3.1.4 Present State of Air Pollution in Macedonia

(1) Assessment of Precision for the Existing Sampler

1) Cross-check of the Existing Sampler

Cross-check by using SO_2 standard gas was performed on existing British sampler to obtain both correlation and reliance of planned continuous monitors.
Cross-check is also important for comparison of yearly and seasonal averages with the results of simulations.
SO_2 standard gas concentration was maintained at about 0.1 to 0.3 ppm and the sampling time was about 24-hour, the same as existing samplers.

a) Cross-check by SO_2 Standard Gas

i) Test Method

The gas was simultaneously led to a plural number of existing samplers and was measured by SO_2 continuous monitor. The variables likely to affect the reading are adsorption by the sampling tube and the filter holder, gas leakage, flow meter reading error, the analytical method, and the data processing method.

- Testing Laboratory
  RHI
- Test Period
  October 23 to November 10, 1997
- Test Method

<Examination for the Present Condition of Samplers>
Each time four of the inlet tube of existing samplers were carried to the laboratory and were simultaneously subject to a 24-hour test operation. Also recorded were the pressure loss due to filters and the laboratory temperature. A leakage was also conducted.
The following samplers were used for examination.

RHI: Existing measuring points No.1 to 9
IPH: Existing measuring points No.4 to 7
(No.1 to 3 points were not used because they were for total acid.)

<SO_2 Standard Gas Generation>

Standard gas was made by means of a permeation tube in which a constant volume of SO_2 gas is released from the liquefied SO_2 into a PTFE tube depending on temperature variation. SO_2 gas was diluted by purified air to the desired concentration prior to being let into samplers or continuous monitors.

Figures 3.2 and 3.3 show the SO_2 standard gas generation and testing method respectively.

SO_2 standard gas concentration : 0.259, 0.504, 0.761 mg/m^3
(0.097, 0.190, 0.286 ppm)

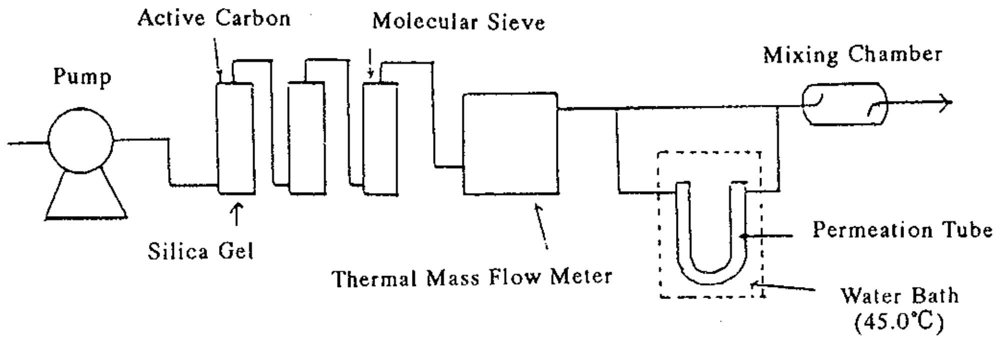


Figure 3.2 SO_2 Standard Gas Generation

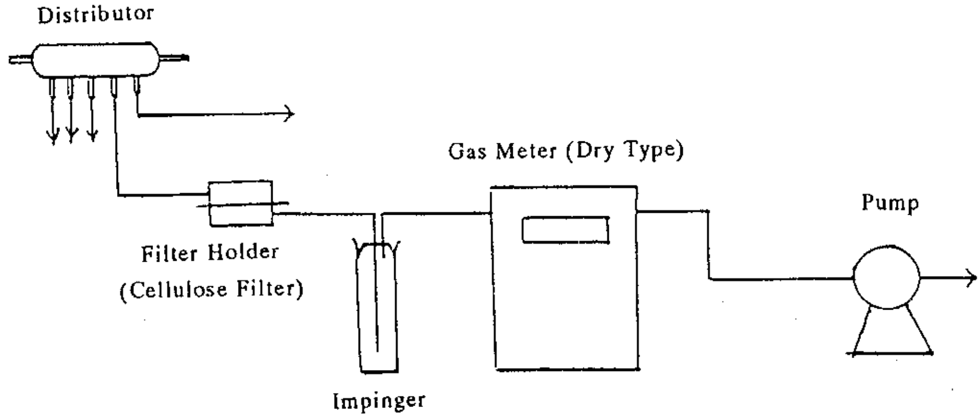


Figure 3.3 Testing Method

<SO_2 Concentration Analysis>

The analytical method conformed to the Pararosaniline method. Concentration analysis was practiced at both the IPH and the RHI.

<Improvement Examination of Samplers>

Comparative examinations were carried out on sampler with replaced PTFE tube and with a non-replaced one for the evaluation of the effect of gas adsorption using SO_2 standard gas. The PTFE tube was believed to be less adsorptive.

Table 3.1 Effect of Tube Material on Gas Adsorption

Item	Existing Sampler	Improved sampler
Inlet tube	PVC tube	PTFE tube
Filter holder	Plastic/Aluminum	Hyprene
Filter	Cellulose filter	PTFE filter

(Remarks) Cellulose fiber shows a higher flow resistance than PTFE fiber.

ii) Results

The results were classified with respect to two types of samplers, the IPH and the RHI.
The cross-check results of existing samplers by SO_2 standard gas are shown in Data Book, Table D3.2.
As for comparison between standard gas concentration and actual reading, the results are shown in Figure 3.4. Necessary corrections were made on accumulated flow meter, gas pressures, absorbing liquid evaporation and temperature.

Conclusions:

- The reading values of the RHI were found somewhat higher than standard gas concentrations without correction being made on the effect of evaporation of the adsorption liquid.
- While admitting that the reading value is subject to various conditions, a value nearly identical to standard gas concentration was obtained.
- The results of the sampler improvement examinations after changing materials of tubes and filters to PTFE were not evaluated since other error factors were large.
- Fluctuation factors should continuously be studied to enhance data accuracy.

Cross-check of the existing samplers by SO_2 standard gas has identified some matters to be studied and considered in future. Evaluation of the existing data should be made based on the results of the examination.

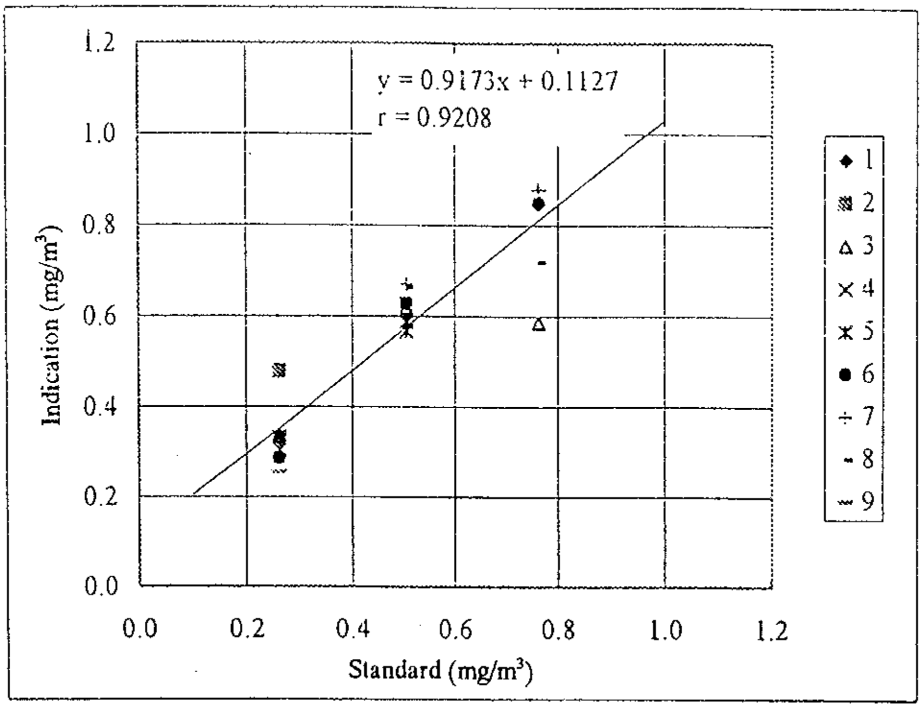


Figure 3.4 (1) Cross-check Result of Existing Samplers by Standard SO_2 Gas Management: RHI

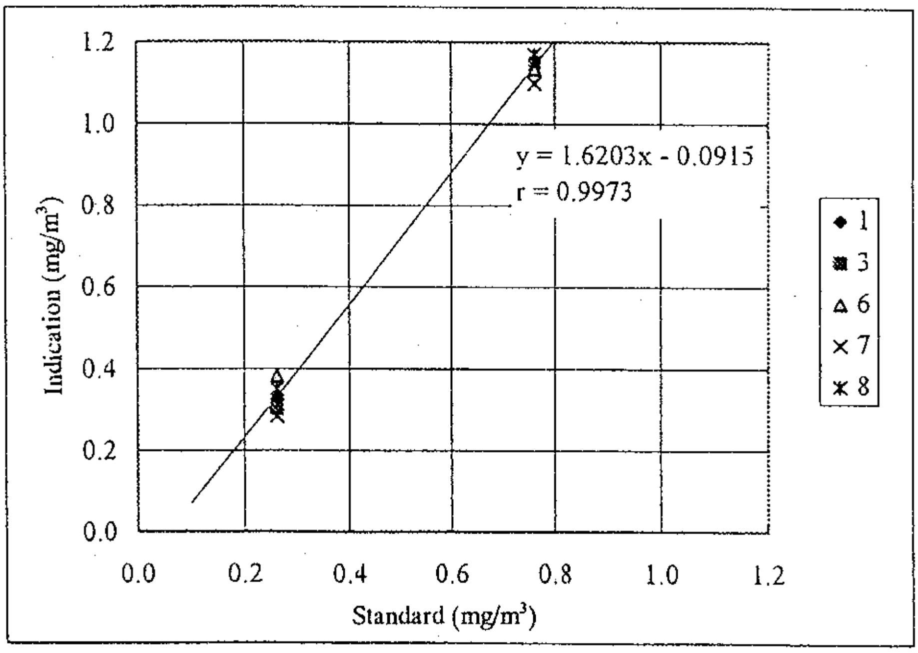


Figure 3.4 (2) Cross-check Result of Existing Samplers by Standard SO_2 Gas Management: RHI Improvement of Pipe and the Others

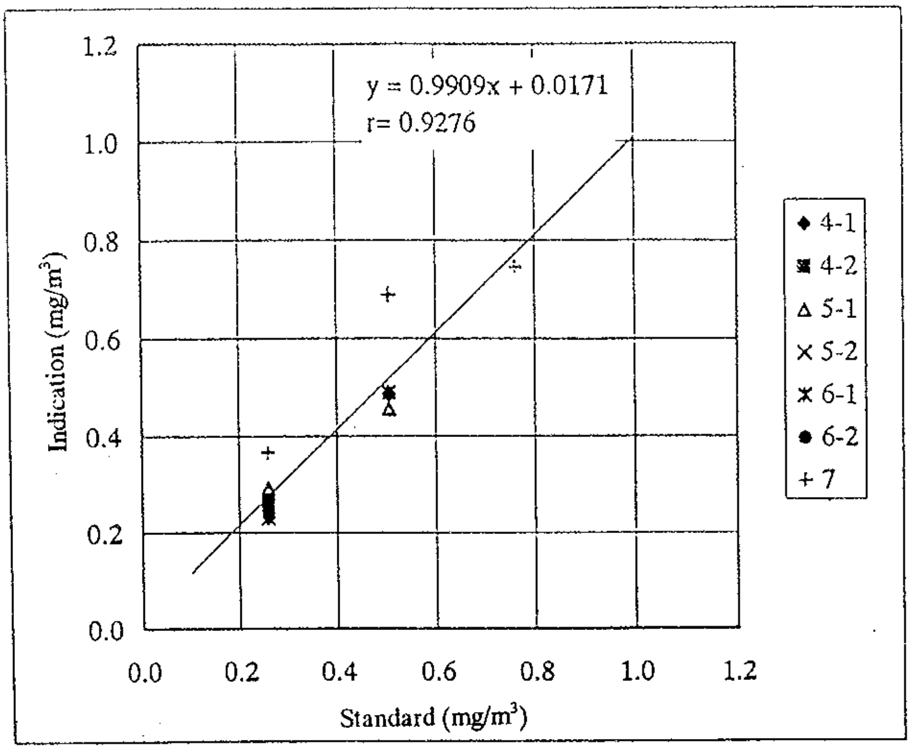


Figure 3.4 (3) Cross-check Result of Existing Samplers by Standard SO_2 Gas
Management: IPH

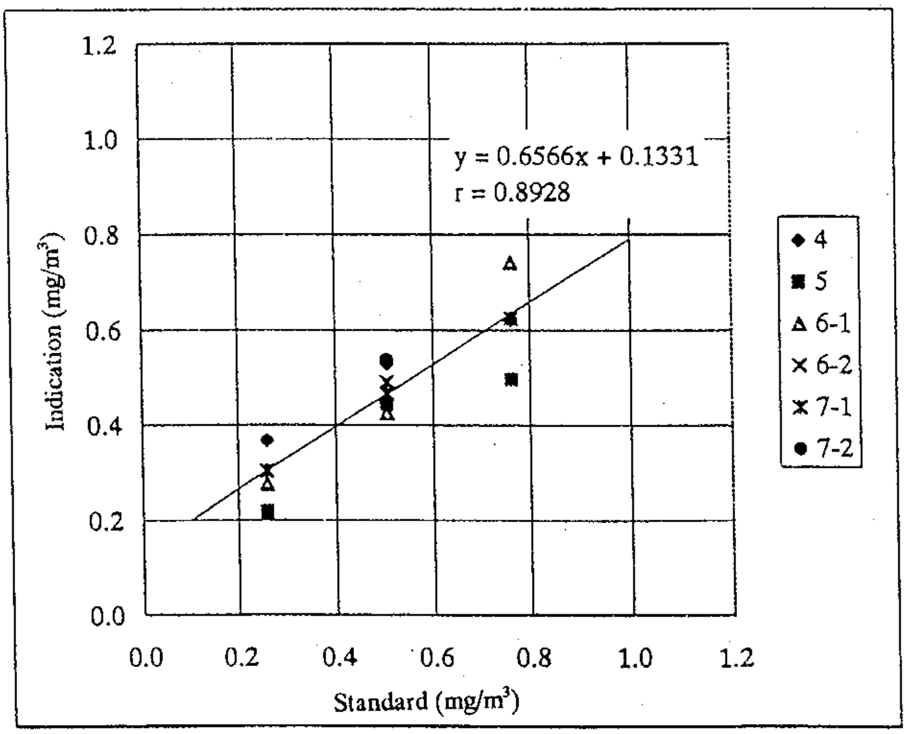


Figure 3.4 (4) Cross-check Result of Existing Samplers by Standard SO_2 Gas
Management: IPH Improvement of Pipe and the Others

b) Instrumental Error of Dry Gas Meters and its Error Factors

Monitoring and analytical data contain various errors. A study of error factors must be made and efforts must be made to minimize errors in advance to obtain accurate data.
The following error factors can be considered with the existing sampler:
- Handling of absorption solution
- Instrumentation errors of dry gas meter
- Evaporation of absorption solution
- Handling such as sample fractionation
- Temperature and pressure loss inside tube
- Titer of standard solution when producing calibration curve
- Equipment to measure absorbance
- Stability, coloring conditions and measuring conditions of reagent blank

i) Test Method of Dry Gas Meter Instrumental Errors

<Gas Meter Used in Experiment>
- Reference gas meter: Wet experimental gas meter
- Type: WE-1A
- Emission quantity: 1 liter (one period)
- Measurement range: Minimum 5, maximum 300 liters/h
- Operating pressure: 0.05 kg/cm^2
- Instrumental error: +0.2% (at 100 liters/h)

<Existing Dry Gas Meter>
- Measurement range: Minimum 40, maximum 6,000 liters/h

The Study Team examined these error factors through joint works with the Counterpart. Figure 3.5 shows the test method of dry gas meter.

Three dry gas meters were used, Gas Meters No.4 to 6 of the IPH.
Test period: November 5 to 8, 1997
Test location: RHI
Suction flow rate: About 1.5 to 2 liters/min
Suction time: 5 to 24 hours
Evaluation method: Integrating flow rate is compared after pressure compensation

Examinations were made repetitively by the Counterpart on data errors while conducting experiments, in addition to examinations made by them on instrumental errors of dry gas meters.

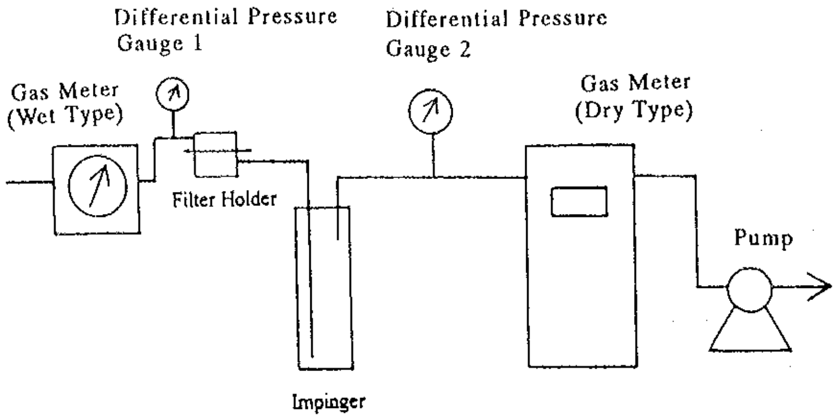


Figure 3.5 Test Method of Dry Gas Meter Instrument Errors

ii) Result of Error Factors

<Instrumental Error of Dry Gas Meter>

Table 3.2 shows the result of the instrumental error of dry gas meters.

Table 3.2 Result of the Instrumental Error of Dry Gas Meters
(Sampler: RHI)

No.	Dry Type Gas Meter			Wet Type Gas Meter		Error	
	Flow (L)	Pressure (mmH_2O)	Correction (L)	Flow (L)	Pressure (mmH_2O)	(L)	(%)
4	442.2	154	435.6	389.8	12	45.8	11.7
4	2421.8	154	2385.7	2127.7	12	258.0	12.1
5	759.6	240	742.0	674.7	12	67.3	10.0
6	654.9	90	649.2	617.8	12	31.4	5.1

Note) Instrumental error and differential pressure of Wet Type Gas Meter was ignored.

Instrumental errors of dry gas meters with wet experimental gas meters were 9.73% (average value) after compensating for differential pressure. In instrumental error calculations, the differential pressure of the wet gas meter was in a decompressed state of about 12mm H_2O. Gas meter instrumental errors and pressure compensation will be needed to obtain accurate data.

<Other Error Factors>

The RHI and the IPH studied and gave consideration to the error factors. As general consideration, the following observations were made:

*Consideration of Analytical Techniques

Views are divided as to which level consideration should be given while doing the routine work. When the establishment and stricter enforcement of regulations in future are considered, analytical and monitoring data will be extremely important. These data are the foundation of implementing environment administrative works. Consideration to analytical techniques is necessary, such as the method for suitable sample fractionation in accordance with concentration, the use of spectrophotometer instead of calorimeter if calorimeter is used at present, and the preparation of an analysis manual, because the coloring intensity of the SO_2 pararosaniline method greatly varies depending on the coloring conditions (temperature and standing time).

*Management and Handling of Reference Solutions and Absorption Liquid

If a management manual has not been compiled, a management manual for reference and absorption solutions should be written. Reference liquid with a guaranteed titer should be used, discarding reference liquid that is old. Reasonable care should be exercised to prevent contamination of absorption liquid before they are used.

*Flow Rate Compensation and Evaporation Compensation of Absorption Liquid

Flow rate compensation of sample air and evaporation compensation of absorption liquid is included, in addition to instrumental error compensation of dry gas meters in order to obtain accurate data. In flow rate compensation, care should be exercised for air temperature, pressure losses inside tubes, and vapor pressure of absorption liquid. Air pressure compensation is not a large factor. Evaporation compensation problems of absorption liquid can be solved by accurately compensating to a fixed volume during analysis. The only caution to be exercised is to clean the impinger with a small amount of distilled water when the absorption liquid is exchanged and to store the absorption liquid in a clean storage container.

*Others

Impingers that are available at present are cylindrical impingers obtained by cutting glass tubes into pieces. The absorption efficiency can be improved by changing them to nozzle-type impingers. Empirically, improvements are about 2%. Leakage sometimes becomes a major problem with the British sampler (hereinafter referred to as "existing sampler"). All the samplers used in the examination showed no leak and were in good condition.

c) Recommendation for Working of Existing Samplers

The results, which put together causal errors found in existing samplers. Evasion of errors, using standard gases and automatic continuous monitoring instruments, are very important for the engineers of the RHI and the IPH who carried out the examination collaboratively.
The results should be utilized for the forthcoming monitoring by existing sampler in order to get more accurate data.

2) Comparison of Existing Samplers with Simplified Samplers

The comparison of existing samplers with simplified samplers was made at the time of wide-area investigation of environmental concentration distribution by simplified samplers shown in Section 3.4 (p.3-46).

The comparison of existing samplers with simplified samplers is shown in Data Book, Table D3.3. Figure 3.6 compares daily variations of SO_2 concentration of the existing and simplified samplers. Figures 3.7, 3.8 and 3.9 show a comparison of daily variations of SO_2 concentration (average values), a correlation of daily variations and a correlation of daily variations excluding lowest two days. Generally, the following observations can be made on the relationship between existing and simplified samplers in the results of SO_2 monitoring.

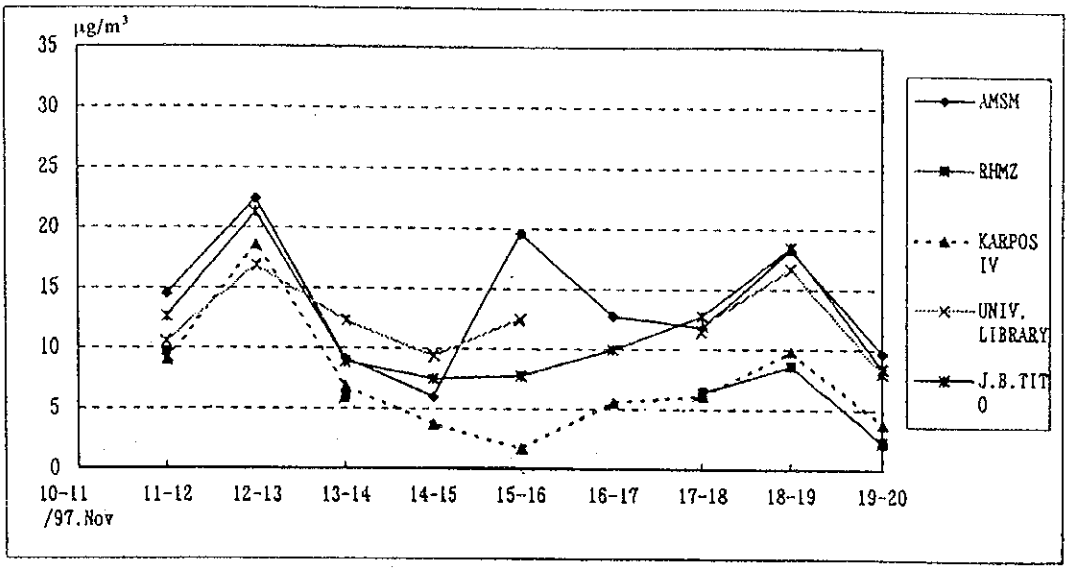
a) Figure 3.6 shows daily variations of SO_2 concentration at five selected points.
The behaviors of existing and simplified samplers do not necessarily coincide and this can be explained by the following:
- The SO_2 concentration level was unexpectedly low.
- The samplers of the two types were not installed perfectly at the same points.

b) By averaging data of the various points, daily variation diagrams correlate more readily. However, the data from the simplified samplers showed higher concentration than these of existing samplers.

c) The average correlation factor between the two types of the samplers was 0.76. Excluding lower concentration, however, the correlation becomes 0.85. As a result, the simplified samplers were effective at comparatively high concentrations.

The comparison test was performed in extremely low concentration compared with the high concentration of Skopje during winter. The relationship between the two types cannot be evaluated just based on these data. It is desirable that the Macedonian side should make a final evaluation after extending the sampling period or making a comparative study when the concentration is high.

Existing Sampler



Simplified Sampler

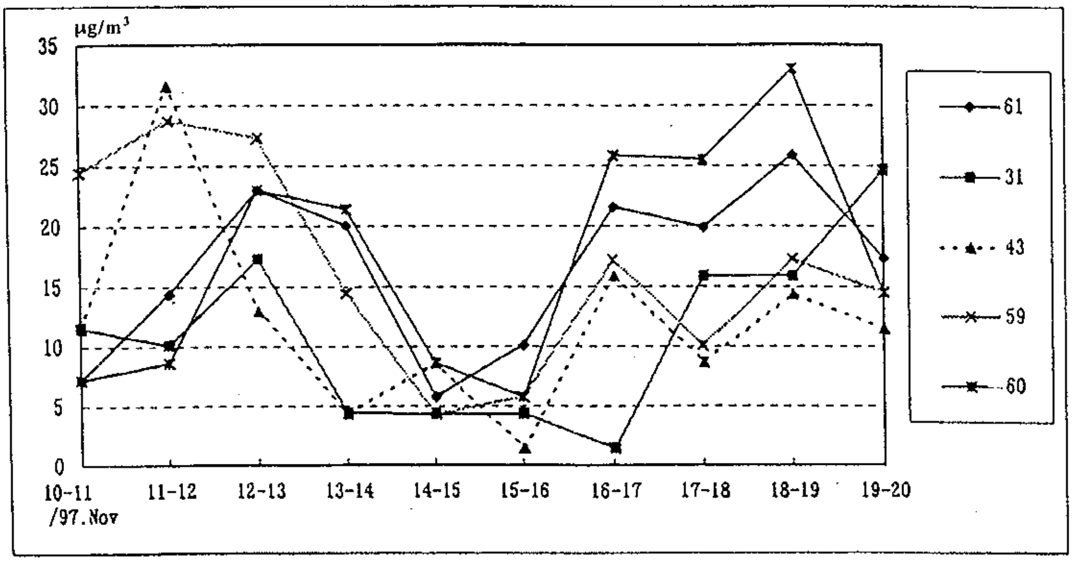


Figure 3.6 Daily Variations of SO_2 Concentration

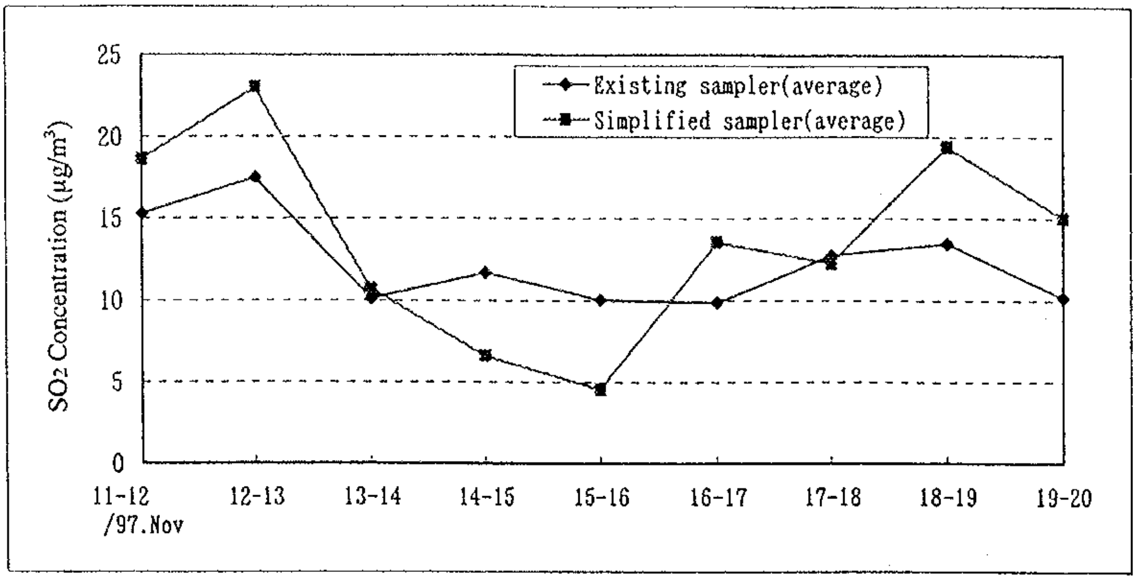


Figure 3.7 Comparison of Daily Variations of SO_2 Concentration (Average values)

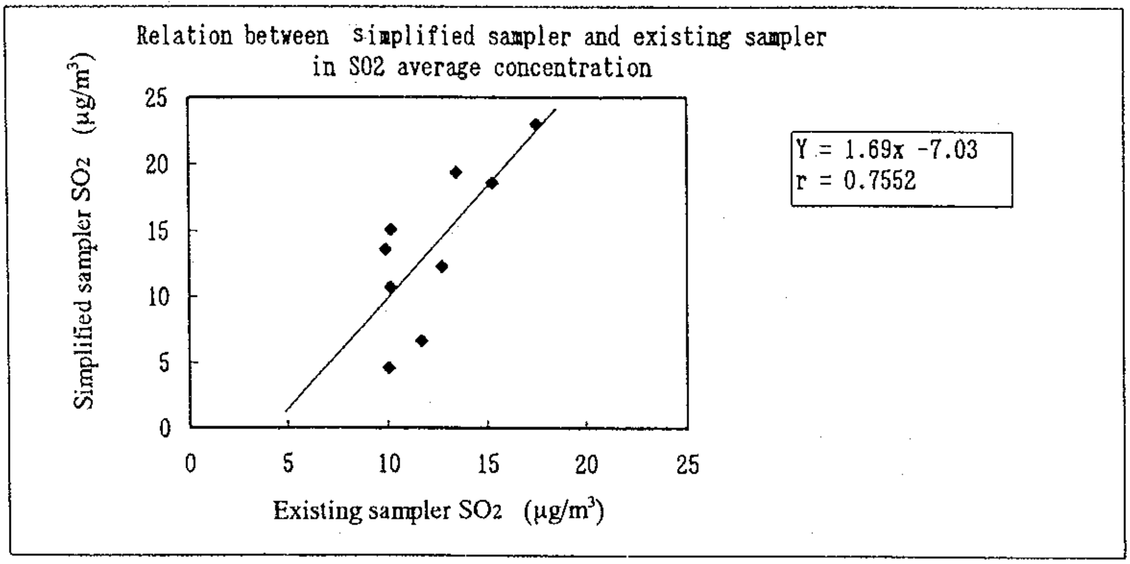


Figure 3.8 Correlation of Daily Variation

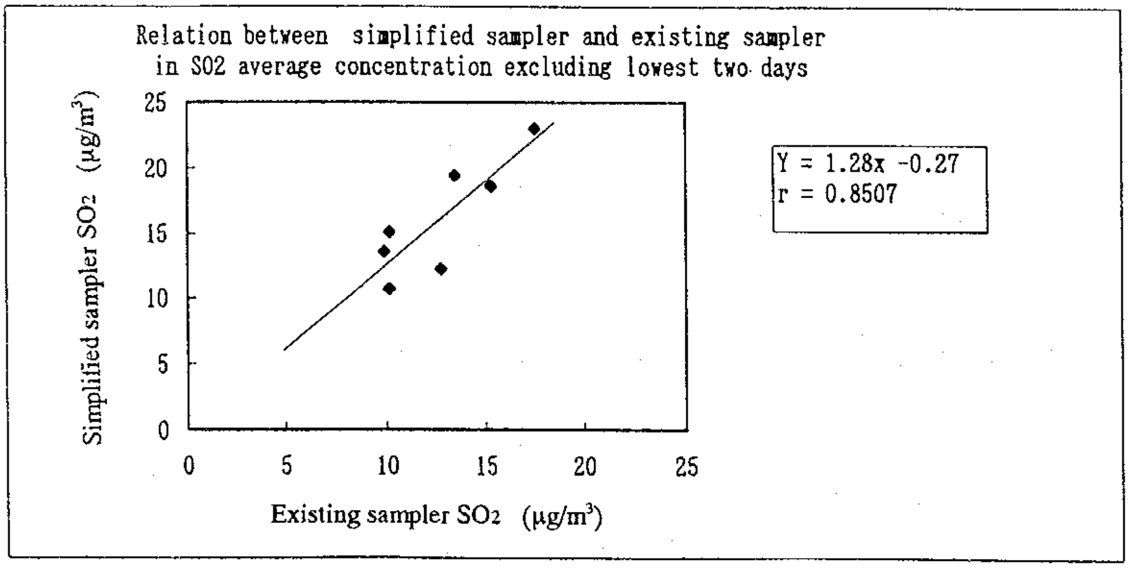


Figure 3.9 Correlation of Daily Variation Excluding Lowest Two Days

3) Comparison of AQM Station with Existing Sampler

The RHI and the IPH have continued measurement by the existing samplers in all over Macedonia as well as in Skopje.

Measurement data by the existing samplers were extracted in order to compare them with data obtained by automatic continuous monitoring instruments. The data accumulated for three months, from April when the automatic continuous monitoring was started to June is used for comparison. Data comparison on SO_2 and BS measured by the existing samplers and automatic continuous monitoring instruments are shown in Data Book, Table D3.4.

SO_2 data obtained by automatic continuous monitoring equipment tend to indicate higher value than that of the existing samplers. There was significant tendency in data obtained in May and June. For BS, the data for automatic continuous monitoring tend to show concentration value twice as high. The relation between SPM and mass is seemed to vary with seasons, since the existing samplers measure the degree of black color of SPM on a filter paper optically. On the other hand, SPM monitor measures particles less than 10 μm in mass directly. There is a basic difference in the equipment.

4) Database Consolidation of Existing Monitoring Points

Setting the data at existing sampling points in order Table 3.3 shows the measured values of SO_2, BS, CO and so on, which were collected from the IHP in Skopje.

There were some cases where the concentrations of SO_2 and BS exceed Maximum Permitted Concentration (MPC) mainly during heating season and it was especially in January and February that BS frequently exceeds MPC. As for dust fall, on the other hand, the concentrations more often exceeded MPC in April, May and June rather than in January to March. As for CO, it was remarkable that 62 cases out of the 84 total data exceeded MPC. As for Pb, there were no cases where the concentrations exceed MPC in this survey.

Table 3.3 Air Quality in Skopje (1998)

Pollutant	Month	No. of Measuring Points	No. of Samples	Concentration			No. of Samples above MPC
				Average (mg/m³)	Minimum (mg/m³)	Maximum (mg/m³)	
SO_2	January	7	208	0.0691	0.0117	0.1881	3
	February	7	196	0.0567	0.0000	0.2556	2
	March	7	217	0.0480	0.0000	0.3068	10
	April	7	198	0.0257	0.0000	0.2122	3
	May	7	208	0.0249	0.0000	0.3289	2
	June	7	201	0.0181	0.0000	0.1393	0
	Jan.-June	7	1228	0.0404	0.0000	0.3289	20
BS	January	7	207	0.0794	0.0039	0.2738	123
	February	7	188	0.0556	0.0048	0.2556	91
	March	7	208	0.0204	0.0027	0.0793	17
	April	7	202	0.0116	0.0011	0.0379	0
	May	7	215	0.0091	0.0011	0.0270	0
	June	7	205	0.0084	0.0025	0.0195	0
	Jan.-June	7	1225	0.0308	0.0011	0.2738	231
Dust Fall	January	30	30	209.2	74.5	607.0	3
	February	30	29	93.1	32.0	188.1	0
	March	30	29	217.7	89.9	651.0	5
	April	30	29	314.9	131.9	840.0	14
	May	30	28	203.3	53.3	392.8	5
	June	30	30	296.2	72.9	830.3	11
	Jan.-June	30	175	222.4	32.0	840.0	38
CO	-	4	84	5.97	0.45	57.47	62
Pb	-	1	7	0.0004	0.0000	0.0007	0

Note) MPC: Maximum Permitted Concentration

(2) Meteorological Characteristics of the Major Industrial Cities

1) Outline of Meteorological Characteristics

Table 3.4 shows the meteorological characteristics of the major industrial cities. Figure 3.10 shows the windrose.

The followings are concluded from the meteorological characteristics of each city:

- They are influenced by the topographical characteristics of the basin or valley in common, and the condition in which the atmosphere remains stagnant, is a factor for serious air pollution in winter.
- Wind blows along the valley and wind speed is generally low.
- Temperature inversion occurs frequently in winter, and also in summer depending on meteorological conditions.
- The precipitation is the smallest and fog appears most frequently in Skopje. This is very unfavorable from the aspect of influence that air pollution has on human body.

Table 3.4 Meteorological Characteristics of the Major Industrial Cities

		Skopje	Veles		Bitola		Tetovo	
Temperature (°C)	Mean Annual	12.5	13.4		11.3		11.0	
	Mean Annual during the Winter	Below 0	3.2		5.7 *		0.9	
	Absolute Maximum	41.5	-		17.0 **		-	
	Absolute Minimum	-25.6 (January)	-		-29.4 (January)		-	
Temperature Inversion Characteristic in Winter Time		A temperature inversion of 10 °C sometimes occurs between the mountainous area and the lowland areas.	The frequency of occurrence of temperature inversion is much lower than the other three cities.		Temperature inversion occurs frequently.		Temperature inversion occurs frequently from late autumn to early spring. It also occurs in summer time.	
Wind Direction	Predominance	W	N	NW	N	S	N	NE
	Frequency (%)	12.4	16.8	15.2	18.9	13.4	22.0	9.0
Average Wind Speed (m/s)		2.5	2.7	2.0	2.2	3.7	1.5	2.2
Fog (days/year)		63	13		21		34	
Duration of the Solar Radiation (hrs/year)		2102	2148		2344		1876	
Annual Average Precipitation (mm)		365	469		599		784	
Climatic Characteristics		The average altitude of basin is 260 m, with its topographic and climatic characteristics of the valley. Strong temperature inversion layer occurs during the winter period and under anticyclone conditions.	The frequent penetrations of cold continental air mass during the winter period of the year, result in low air temperature. The wind direction is largely influenced by topography.		The average altitude is 660 m and the climate is influenced by the Mediterranean climate. The temperature shows the characteristics of the continental climate with extreme temperature fluctuations.		The altitude is 462 m. Because of the high mountainous areas in the north and north west, the influence of the Adriatic-sea climatic does not reach the valley.	

Note: The evaluational periods of each data do not necessarily coincide. Source: NEAP

* Annual average of minimum temperature

** Annual average of maximum temperature

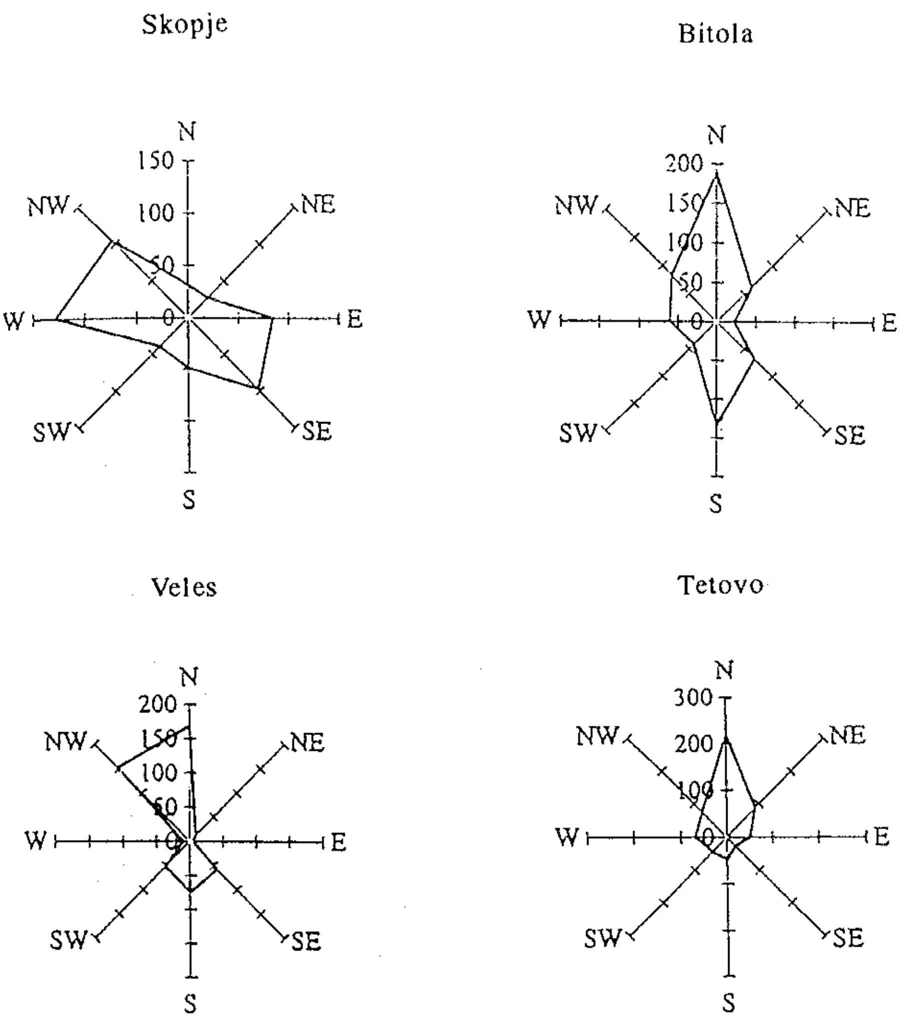


Figure 3.10 Windrose of the Major Industrial Cities

Source: NEAP

2) Meteorological Condition in Skopje

The MPC for the quantities of dust fall is 300 mg/m^2 per day and it can be seen that only in April the average value exceed the norm. However, from each measuring point, most of the maximum values exceed the standard value (Data Book, Table D3.5 and Figure D3.6).

The precipitation causes the cleaning of the atmospheric air on one hand, but also brings about the increase of the quantities of dust fall on the other hand. It is distinctive that the temperature inversion occurs frequently and intensity of the inversion is large in January (Data Book, Table D3.6 and Figure D3.7). Especially in 1993, when grave air pollution was caused, the temperature inversion lasted for a long period. In addition to topographical inversion, subsidence inversion which occurs in high atmospheric pressure and ground inversion which is resulted from the cooling of the ground by heat radiation, are also considered to be factors of serious air pollution in Skopje.

(3) Ambient Air Quality Characteristics of the Major Cities

1) Comparison of Skopje with Veles on Concentration of SO_2 and BS

The following can be summarized by the data on the annual acquisition charts and the monthly fluctuations of SO_2 and BS from 1990 to 1994 (Data Book, Table D3.7 and Figure D3.8).

- The measuring points in Skopje and Veles showed higher concentrations than those from the other points in annual average and annual maximum values of SO_2.
- Skopje showed a high concentration in BS but not similar to Veles. This indicates that Skopje is affected more by automobiles and household heating during the heating season, in addition to emissions by stationary sources.
- The number of days exceeding MPC was several times more with BS than with SO_2.
- Concentrations of SO_2 and BS in Skopje by season, showed prominently high concentration during the heating season. On the other hand, in Veles, BS showed a behavior similar to that of Skopje, but a high concentration of SO_2 was recorded even during the non-heating season. Clearly a difference exists in the conditions of pollution sources.
- In Skopje, dynamic fluctuations also showed that high-concentrations during winter were influenced by meteorological conditions, such as stagnation, in addition to the influence by central heating plants and the heating of individual household.
- One characteristic with Skopje was that its peak value varies from one year to another.

2) Concentration Distribution of Air Quality and High Concentration

a) Average Concentration Distribution of Ambient Air Quality (Data Book, Figure 3.9)

The isopleth chart indicates the following:

- The points of AMSM (No.1) and University Library (No.7) in the center of the city register the highest concentration. The concentration level gradually lowers from the center of the city to the suburbs.
- A slight variance exists between the concentration distributions of SO_2 and BS.
- The concentration distributions can be explained by topography, wind direction and speed, population density, traffic conditions and conditions of pollution sources such as plants.

b) High Concentration Pollution and its Causes in January 1993

According to the time variation charts, serious high concentration pollution continued for a long time. This phenomenon can be explained by the continuation of meteorological conditions which caused the formation of an inversion layer and stagnation of pollutants near the surface (Data Book, Figures D3.10 and D3.11).

As for the cause for the continuation of these meteorological conditions, the NEAP explained that Macedonia was covered under an anticyclone of 1,035 hPa causing a continuation of a subsidence inversion layer, strong radiation cooling due to fair weather such that weak winds and calm occurred after a record amount of snow cover to form a ground inversion layer and that temperature inversion continued during the night and day on January 10 to 12. Judging from the topographical conditions of Skopje, an topographical inversion is a possible depending on meteorological conditions.

As for another factor for the high concentration, temperature lowered to -20.4℃ during strong radiation cooling, causing an increase in heating fuel consumption, which triggered serious air pollution by interaction.

The concentration variation patterns of SO_2 and BS are similar. However, a time difference of one or two days exists in their peak values (Data Book, Figure D3.12).

c) SO_2 and BS Concentrations

The IPH collected the data of 1996 which are given in Data Book, Tables D3.8 to D3.11.

The SO_2 concentration shows 0.031 mg/m^3 as the annual average, 0.059 mg/m^3 as the maximum value of monthly average values in December and 0.135 to 0.228 mg/m^3 as a maximum monthly concentration range.

The monthly average SO_2 concentration increases during winter. No seasonal feature can be seen since MPC exceedance per month appears even during summer. On the other hand, a prominent trend with BS is that the monthly average and maximum concentrations increase during winter. Another characteristic is that the number of days exceed MPC concentrates during the heating season.

Moreover, the RHI has performed its monitoring for more than 25 years, on four measuring points, on seven points since 1991, and on nine points at present. The data in Tables 3.5 and 3.6 are precious data as these are the statistically arranged data of SO_2 and BS from 1984 to 1994. Figures 3.11 and 3.12 show the number of days exceeding MPC of SO_2 and BS for the period from 1991 to 1994 by measuring points and by years, on which the condition of air pollution in Skopje could be seen.

The followings can be concluded from the data which the RHI collected:

- As for SO_2, the average annual values change by years for each point.
- The central city area indicates a high SO_2 and BS concentration.
- The average number of days with BS concentration higher than MPC is much bigger than the one for SO_2 concentration, for all the measuring points in the city and for all the years.
- In 1994, when levels of SO_2 and BS concentrations were generally low and the number of days with concentrations higher than MPC was small, the winter was mild.
- The SO_2 and BS concentration values vary within the years due to the meteorological conditions.

These results indicate that in addition to large impacts by meteorological conditions, pointary sources influence SO_2 greatly. As for BS, stationary sources, residential heating (firewood) and vehicles have a greater influence.
The present status of air pollution in Macedonia is comparable to the time when Japan had serious air pollution and the level of BS pollution is higher in Macedonia than in Japan when it suffered from air pollution.

Table 3.5 Air Quality Level for SO_2

	A M S M (1)					Fruit Farming Institute (2)					H M I (3)					Dracevo (4)				
	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}
1984	70	99	238	44	355	56	98	220	27	27	19	99	168	12	262	17	98	69	1	162
1985	79	96	417	70	644	56	98	236	38	38	13	100	113	2	215	15	84	118	2	155
1986	73	95	387	52	772	74	98	255	68	68	60	100	365	43	702	3	99	26	0	65
1987	79	97	343	60	1293	62	100	250	47	47	45	98	257	22	461					
1988	86	97	332	74	518	69	99	224	52	52	46	97	254	20	529					
1990	100	95	508	81	963	47	98	211	21	21	74	99	442	55	744	22	97	110	4	267
1991	59	99	224	39	395	25	98	92	1	1	37	99	200	15	348	15	95	71	0	107
1992	49	98	229	27	505	24	100	101	3	3	28	100	173	12	344	9	95	42	0	125
1993	92	99	787	59	1130	32	100	236	12	12	57	99	585	30	924	12	88	60	1	259
1994	52	46	207	14	256	20	99	47	0	0	11	62	81	0	101	5	100	18	0	94

	Avtokomanda (5)					Karpos IV (6)					University Library (7)				
	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}
1984															
1985															
1986															
1987	87	94	340	72	528										
1988															
1990															
1991	42	93	196	14	372	33	98	198	17	341	72	94	355	50	600
1992	36	62	136	4	288	22	95	129	3	222	50	93	272	32	650
1993	68	98	513	44	788	50	74	582	24	817	75	92	694	43	1094
1994	26	98	111	3	208	7	93	35	0	56	39	85	182	11	414

$\bar{C}$ - average annual concentration µg /m³
C_{98} - 98-percentile value
% - % of realisation
MPC - number of days > MPC = 150 µg /m³
C_{max} - max. annuel value µg/m³

Source : NEAP

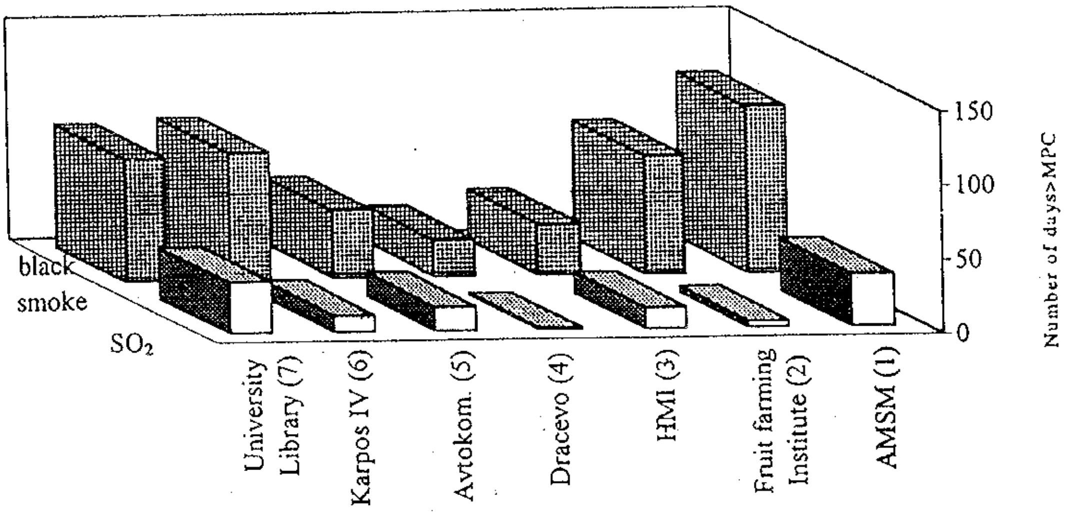
Table 3.6 Air Quality Level for BS

	A M S M (1)					Fruit Farming Institute (2)					H M I (3)					Dracevo (4)				
	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}
1984	49	100	188	125	272	49	98	181	121	212	25	99	103	52	179	22	92	71	37	123
1985	59	96	318	120	439	50	98	231	103	328	38	99	197	78	294	23	84	130	39	265
1986	55	96	309	98	702	43	98	239	89	292	28	100	168	44	375	14	99	14	0	31
1987	60	96	240	134	292	22	92	179	39	149	26	98	112	53	237					
1988	45	97	161	110	217	51	100	227	108	274	30	99	161	51	356					
1990	61	95	306	156	511	60	98	248	126	366	41	98	179	76	438	24	99	132	50	215
1991	57	99	223	129	322	40	98	187	78	280	29	99	115	54	241	24	96	107	41	152
1992	50	97	232	110	425	36	100	158	76	270	22	100	121	30	315	15	87	86	19	187
1993	65	99	407	123	718	42	99	233	94	311	27	98	209	35	385	19	81	111	17	248
1994	75	46	290	88	362	64	98	164	71	270	16	62	116	16	164	16	100	74	19	122

	Avtokomanda (5)					Karpos IV (6)					University Library (7)				
	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}	$\bar{C}$	%	C_{98}	MPC	C_{max}
1984															
1985															
1986															
1987	48	93	194	98	280										
1988															
1990															
1991	22	93	81	25	120	45	97	176	107	302	47	95	159	101	231
1992	19	64	62	15	89	39	93	193	79	398	36	94	171	72	226
1993	39	98	253	75	420	50	72	336	62	544	48	95	252	80	556
1994	32	97	132	65	173	44	94	225	97	342	44	92	213	80	346

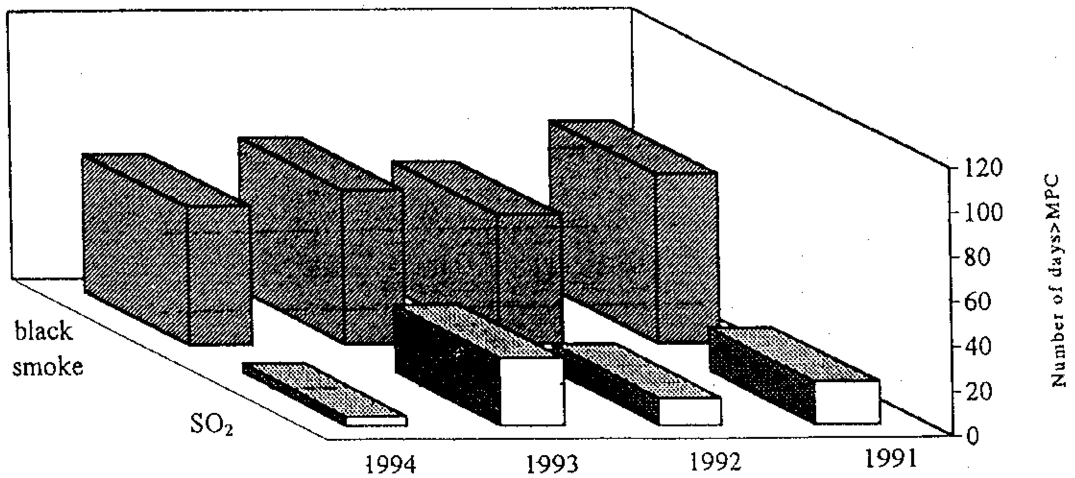
$\bar{C}$ - average annual concentration µg /m³
C_{98} - 98-percentile value
% - % of realisation
MPC - number of days > MPC = 50 µg/m³
C_{max} - max. annuel value µg/m³

Source : NEAP



Source: NEAP

Figure 3.11 Number of Days Exceeding MPC for SO_2 and BS for Period from 1991 to 1994 by Measuring Points



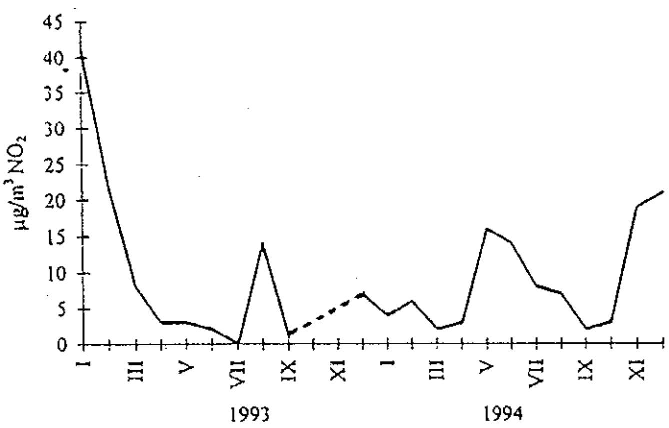
Source: NEAP

Figure 3.12 Number of Days Exceeding MPC for SO_2 and BS for Period from 1991 to 1994 by Years

d) NO_2 Concentration

At the measuring point of Karpos IV (No.6) in Skopje, the RHI measures NO_2 concentrations, using existing sampler. Figure 3.13 shows the variation diagram of monthly mean NO_2 concentrations of the period from 1993 to 1994. It can be seen from the figure that the number of days that exceed MPC in the period is six. Observing for each month, the values of January in 1993, in which the temperature inversion continuously occurred, were extremely high.

According to automatic continuous monitoring data, the maximum of hourly value is approximately three times higher than the value of daily mean. From this fact, it can be said that the number of times that MPC is exceeded based on hourly value are numerous.



	1993	1994
$\bar{C}$	11	9
%	72	94
C98	80	45
MPC	5	1
Cmax.	119	123

Source: NEAP

Figure 3.13 Average Monthly Concentration of NO_2 (Karpos IV)

e) CO Concentration

Table 3.7 shows the results of the CO concentration survey at four intersections measured by the IHP. Compared with reference values ($3mg/m^3 \fallingdotseq 2.6ppm$ at 20℃), the CO concentration is three times higher than that to the average and is more than ten times higher than that to the