SOFIA INITIATIVE ON LOCAL AIR QUALITY

BULGARIA, CZECH REPUBLIC, HUNGARY, POLAND, ROMANIA, SLOVAKIA, SLOVENIA

REDUCTION OF SO_2 AND PARTICULATE EMISSIONS

SYNTHESIS REPORT

CHAIR:
MINISTRY OF ENVIRONMENT AND WATERS
REPUBLIC OF BULGARIA

SECRETARIAT:
THE REGIONAL ENVIRONMENTAL CENTER
FOR CENTRAL AND EASTERN EUROPE

THE REGIONAL ENVIRONMENTAL CENTER
for Central and Eastern Europe

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Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia

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Szentendre

MAY 1998

THE REGIONAL ENVIRONMENTAL CENTER

for Central and Eastern Europe

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The Regional Environmental Center for Central and Eastern Europe (REC) is a non-partisan, non-advocacy, not-for-profit organization with a mission to assist in solving environmental problems in Central and Eastern Europe (CEE). The Center fulfills this mission by encouraging cooperation among nongovernmental organizations, governments, businesses and other environmental stakeholders, by supporting the free exchange of information and by promoting public participation in environmental decisionmaking.

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I trust this Report will prove invaluable to those who read it; decisionmakers, environmental managers, and specific interest groups, as well as to the follow up work of the Sofia Initiative on Local Air Quality.

Dimiter Kantardjiev
Chairman, Sofia Initiative on Local Air Quality
General Director, National Center for Sustainable Development of Bulgaria
Ministry of Environment and Waters, Bulgaria

Preface

This Synthesis Report presents a summary of the findings of the SILAQ Working Group on the reduction of SO_2 and particulate air pollution. Its primary purpose is to provide an up-to-date overview of the progress achieved in the reduction of SO_2 and particulate emissions in the SILAQ countries: namely, Bulgaria, the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia.

Each country has developed a national strategy for the control of air pollution, but the approaches used vary from one country to another. Therefore, an exchange of the experiences and lessons learned is beneficial to all participating parties. Moreover, lessons learned can also be used by other countries from Central and East Europe (CEE) and the Newly Independent States (NIS) in developing their own strategies for air pollution control.

This Report is divided into seven sections: Section 1 presents the background of the SILAQ project. Section 2 focuses on the rationale for reducing SO_2 and particulate matter pollution, including a discussion of the health impacts of the surveyed pollutants and an overview of ambient air quality in the SILAQ countries.

Existing levels of SO_2 and particulate emissions in the SILAQ countries as well as major pollution sources are discussed in Section 3.

Section 4 provides an overview of the regulatory framework regarding SO_2 and particulate emission control. This includes a more general discussion of the institutional framework, existing environmental legislation and monitoring networks, while specific standards regarding ambient air quality, source specific emission standards, and fuel quality are presented in more detail.

Section 5 reviews the various technical and policy options available for the reduction of emissions, including technological measures, policy options, and the use of economic instruments. Details of the current strategies adopted by the SILAQ countries are included.

Section 6 discusses the main driving forces behind the implementation strategies adopted, including harmonization with EU legislation and compliance with international agreements, as well as other related factors.

Section 7 concludes the report with an overview of the further work required and the key assistance needs, as well as a discussion of the importance in exchanging experiences among the SILAQ countries.

Executive Summary

Background

This Synthesis Report presents a summary of the findings of the Sofia Initiative on Local Air Quality (SILAQ) Working Group on the reduction of SO_2[1] and particulate air pollution. Its primary purpose is to provide an up-to-date overview of the progress achieved in the reduction of SO_2 and particulate emissions in the SILAQ countries: namely, Bulgaria, the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia, and to facilitate an exchange of experiences and lessons learned.

The SILAQ Initiative focused on two specific areas: (1) the promotion of unleaded gasoline throughout the Central and East European (CEE) region, and (2) the significant reduction of sulfur and particulate emissions. The latter aspect concentrated on local air pollution rather than on transboundary air pollution. While SO_2, NO_x and particulate matter pollution is usually discussed jointly, this Report addresses only SO_2 and particulate matter.

This Report has been prepared by the Regional Environmental Center for Central and Eastern Europe, in cooperation with the Bulgarian Ministry of Environment and Waters, based on a significant amount of data collected by the SILAQ countries, and a number of assessments, studies and reports concerning existing policies and approaches to the reduction of sulphur oxides and particulate matter pollution. The chair of the SILAQ Initiative is the Bulgarian Ministry of Environment and Waters.

Health Impacts

Health effects from exposure to air pollution include: irritation and annoyance, loss of organ functions (e.g. reduced lung capacity), morbidity and mortality. Some effects can be acute and reversible, while others develop gradually into irreversible chronic conditions. The respiratory system and the eyes are the main organs affected by air pollution.

There is conclusive evidence, based on epidemiological research studies and analysis of medical insurance records in countries with heavily polluted areas, that shows a link between different acute and chronic health effects, and the incidence of significant particulate matter and SO_2 pollution. In polluted areas the prevalence of persistent coughing and respiratory tract infections is 2-3 times higher than in areas where pollution is less extensive. A similar relationship is also shown for areas where mortality results from lung cancer. In Hungary, for instance, acute respiratory diseases are known to be the cause of between 23 and 25 percent of all sick-leave cases. Among the acute respiratory diseases, catarrh in the lower respiratory tract (e.g. bronchitis, pneumonia) warrants particular attention.

SO_2, primarily resulting from the combustion of sulfur-containing fuels as well as from production processes in the chemical industry, is the precursor of sulfate particulates which can irritate eyes and the respiratory tract, reduce lung function, aggravate emphysema, asthma, and chronic bronchitis and may result in mortality. Particulates originate from a variety of mobile and stationary sources, and vary in terms of physical composition, chemical content, and size. Particulate matter can lead to pulmonary irritation and respiratory diseases. The effects of particulate matter vary considerably depending on its composition, and can be potentially carcinogenic and mutagenic. The most harmful elements to human health tend to be small particulates, owing to their ability to reach the lower regions of the respiratory tract, and which can contribute to negative effects on the respiratory system, aggravation of existing respiratory and cardiovascular diseases, anomalies in the body's defense systems to foreign substances, damage to lung tissue, carcinogenesis and premature death.

It should be noted that SO_2 and particulates have a compounded negative effect on health, as particulates carry SO_2 to the lower part of the respiratory system which would

[1] Throughout this Report SO_2 is used to indicate all sulfur oxides (SO_2 and SO_3).

not otherwise be reached. High levels of SO_2 and particulates can increase the occurrence of asthma, in particular among children. A similar tendency is observed with regard to lung cancer. As a result, there has been a tendency in recent years to focus regulatory measures on controlling small particles, with a diameter of less than 10 micrometers.

Finally, it should be mentioned that significant negative economic consequences arise from SO_2 and particulate pollution, including deforestation, acidification of water bodies and soils, and deterioration of concrete structures and historic sites.

Air Pollution Levels

Economic recession in the SILAQ countries has brought about a downward trend in the levels of emissions, for both particulate matter and SO_2. This trend appears to be continuing to decline despite economic recovery, due to the restructuring and modernization of production systems and the impact of new environmental legislation and regulations.

SO_2 emissions have clearly declined, with a strong downward trend identified in the Czech Republic, Slovakia, Slovenia and Romania. Levels of compliance were found to be satisfactory, with the exception of Bulgaria and some regions in Poland, where standards were consistently exceeded.

The comparison of data on SO_2 and particulate concentrations shows that non-compliance with particulate matter limits is a more serious problem in the SILAQ countries. Concentrations of particulate matter tend to exceed standards often by several times, particularly in Bulgaria, Romania and Slovakia.

Concentrations above the upper threshold value are registered mainly in residential areas where the impact of industry is combined with that of fuel combustion from households.

However, a rise in industrial activity and total energy consumption in the SILAQ countries, consistent with economic recovery, is expected to lead to a rise in SO_2 and particulate emissions, particularly in those countries where preventive measures have yet to be taken.

Sources of Pollution

In terms of total SO_2 emissions per country, Bulgaria emerges as the greatest producer of SO_2 pollution, closely followed by Poland and the Czech Republic. The same three countries also had the highest levels of particulate emissions. The high levels of emissions in comparison with developed industrialized countries, is a result of the SILAQ countries' dependency on fossil fuels, particularly the low heat, and high sulfur and ash-laden local lignites. In addition, the economies are characterized by low levels of energy efficiency, due in many cases to the use of obsolete technologies. Finally, because of the financial constraints, emission control devices available on the market have yet to be widely implemented.

The main sources of SO_2 pollution have been identified as power generation and district heating plants. The share of power, cogeneration and district heating sources has actually increased as a percentage of the total SO_2 emission levels. The share of commercial, institutional and residential combustion sources tends to remain relatively constant, with residential combustion the most serious small-scale source responsible for urban pollution. Non-combustion and other SO_2 sources have a negligible share in the total level of emissions.

Particulate emissions have decreased in each country during the surveyed period. Transport emissions have been found to have increased in all the SILAQ countries due to the change in transportation patterns and the shift towards increased road use. In contrast to SO_2 emissions, in analyzing the sources of particulate matter emissions, large power plants cannot be considered the main sources, due to the installation of high efficiency electrostatic filters. In terms of particulate emissions, residential heating and industrial combustion are the most significant sources. Mobile sources are an important source of particulate matter pollution, especially the use of diesel engines.

Overall, power plants, co-generation and district heating facilities remain among the main contributors to poor air quality. In reviewing power plants, the medium and large-scale plants using solid fuels tend to dominate the energy supply market. However, in some countries discharges from residential and commercial combustion processes tend to be the major contributors of particulates.

Legislative and Regulatory Framework

Over the last 3 years, the SILAQ countries have harmonized most of their principal domestic legal acts with those of the European Union (EU). New air pollutant limits introduced across the region are very close or even identical to their EU counterparts, while in other countries, new regulations are now under development or consideration.

The two key issues related to the legislative and regulatory framework are the necessary improvements required in the institutional framework, and the actual adoption of new environmental legislation and standards.

Most of the SILAQ countries have traditionally well-established institutional frameworks for environmental protection and particularly air pollution control. The respective Ministries of Environment formulate, co-ordinate and implement environmental protection activities at the state level. They also control the activities of the regional bodies and coordinate research and development in the field of environmental protection. Regional bodies are responsible for guiding and enforcing environmental control at the local level, and for monitoring the quality of air, water and soil, while the responsibility and decisions for actions at the local level lie with different local authorities.

The need to strengthen the institutional framework is recognized in all of the SILAQ countries. At the national level, the most often reported problems are the lack of personnel and funds available to Ministries. At the regional level, in addition to these problems, there is a lack of administrative capacity and experience to deal with environmental issues.

In most cases, a comprehensive environmental framework law has been established that introduces the "polluter pays" principle, specifies the administrative framework and the responsibilities of authorities at a national and regional level, and arranges financial mechanisms to support environmental projects. Framework laws are usually supplemented by sets of other laws and subordinate regulations, including laws on air quality, and protection that introduces air quality standards. The air pollutants regulated in most of the SILAQ countries include: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), particulate matter and lead (Pb in aerosols). The successful enforcement of these regulations requires the well-designed and efficient functioning of the institutional framework and monitoring systems.

All SILAQ countries have established air monitoring networks but most require investments for the construction of new stations and for the purchase and installation of modern equipment.

The relevant standards establish requirements for ambient air quality, emission levels from specific sources, and the quality of fuels used. The health-related ambient air quality standards are specified for key pollutants for short, medium, and long-term. Air quality standards adopted in the SILAQ countries are among the most stringent in the world, and this should be kept in mind when discussing compliance with local standards in the SILAQ countries

Poland has the most stringent ambient air quality standard for SO_2 (0.032 mg/Nm^3). Bulgaria and Slovenia operate standards of 0.05 mg/Nm^3, while the remaining SILAQ countries introduced standards of 0.06 mg/Nm^3. In terms of particulate matter, the standards range from 0.05 mg/Nm^3 in Poland to 0.15 mg/Nm^3 in Bulgaria. In general, the adopted EU standard values are less strict than those of the SILAQ countries, although they account for the combined effect of SO_2 and particulates.

A separate set of requirements concerning SO_2 and particulates relates to the emission standards applied for different sources. The primary target of these standards are the power and heat generation plants, and a generally flexible approach has been adopted towards existing power plants. Compliance with the standards established for new units are to be adhered to by existing plants on an individual basis after feasibility and environmental impact studies. In the intermediate period (usually until the end of 1998) existing plants will have to install emission control devices, and switch to alternative fuel mixes, etc. The deadlines for meeting the final standards are within the first decade of the next century. Comparison of the standards show that the values adopted in the SILAQ countries are comparable with EU standards. Other source-specific emission standards apply to metal smelters, steel works, refineries, and cement plants.

Fuel quality standards regulate the sulfur content of fuels. With regard to fuel standards, the EU Directive 93/12/EEC of March 23, 1993 for *the Sulfur Content of Certain Liquid Fuels* should be taken as a reference point for comparison. Interestingly, whereas air quality standards exist with relatively uniform values in the SILAQ countries, large deviations exist for fuel quality standards. For example, Slovenia has adopted strict and comparatively stringent values for liquid fuels, while Slovakia has applied relatively stringent standards for all liquid fuels since the beginning of 1998. At the same time, Romania and Bulgaria have set different standard values for light, medium and heavy fuel oil.

New legislation, however, may fail to meet its objectives, unless a broad mix of policy instruments are implemented alongside, including so-called economic instruments, regulations and guidelines

Implementation of Air Pollution Control Strategies

Most of the SILAQ countries' main efforts in reducing SO_2 and particulate emissions have been concentrated in the following directions:

- Development and introduction of new legislation, harmonized with the standards of the European Union;
- Development of national action plans and strategies;
- Improvements in monitoring and control systems;
- Introduction of new economic instruments;
- Implementation of new cleaning systems and new combustion technologies.

Successful measures used to reduce local air pollution in urban areas have included the regulation of fuel for domestic heating (e.g. low sulfur content in oil and coal), introduction of natural gas instead of coal and oil, development of district heating, and in some cases, restriction of the use of cars in city centers. Fly ash and dust removal installations in industrial sources and large boilers have resulted in major improvements, while cost-effective energy conservation measures and the substitution of fossil fuels with renewable energy sources have considerable potential for the larger reduction of emissions.

Technologies that ensure the removal of air pollutants are generally expected to grow in importance. The technology most commonly used to remove SO_2 is known as flue gas desulfurization (FGD). The most commonly used dust-cleaning systems are 'dry types' — electrostatic precipitators and bag filters. These have most commonly been used in the metallurgical and energy sectors in recent years. The 'wet-absorption type' systems are most commonly found in the chemical industries.

Within the SILAQ countries, different cleaning systems are operated or are in the process of being implemented. Wet working lime-limestone systems tend to be more commonplace, however, dry cleaning systems tend to offer a number of clear advantages that indicate interest in these systems will grow in the near future.

Besides 'end-of-pipe' technologies, other methods to reduce the air pollution from combustion processes include: changing the fuel mix, including the use of additives; increasing the conversion efficiency; introducing low emission combustion or conversion processes; and fuel cleaning.

In terms of actual emission controls, Hungary, the Czech Republic, Poland, Slovenia and Slovakia have already introduced a number of cleaning systems, with the main installations at industrial plants in Slovenia completed, and those in the Czech Republic, Hungary and Slovakia due for completion in 1998. Installations in Poland will be completed next year. Bulgaria and Romania are still at an earlier stage of implementation.

However, progress in implementing technical measures to deal with particulate and SO_2 emissions has been slow and the potential to reduce emission levels by other means such as changing the fuel mix, reducing energy consumption and the installation of different pollution control devices are areas that should still be explored. Furthermore, 'end-of-pipe' measures are no substitute for the preventive approach which perhaps has to be the more serious long-term policy measure. A clear shift from technical based measures towards government and policy-related options is being noted in the SILAQ countries, as the benefits other measures like the decommissioning of old, coal-fired power plants, converting to natural gas, the use of renewable energies and the implementation of new state-of-the-art technologies, can have on air quality improvement are realized.

Use of Economic Instruments

Economic instruments are playing an increasingly important role in environmental policy in the SILAQ countries. A variety of economic instruments have been in use in the region for several years with a mixture of new instruments being introduced more recently and older instruments being revised. These instruments include: pollution charges and taxes (for air, water, waste), non-compliance charges ("environmental fines"), product charges (e.g. on gasoline), deposit refund systems, import tariffs (e.g. for old cars), and tax differentiation or exemption (e.g. lower taxes for unleaded gasoline/petrol and tax relief for environmental equipment or investments). Some countries are now considering the introduction of tradable pollution permits.

Environmental charges for the use or pollution of air, water and waste, together with pollution fines and fuel taxes are common revenue raising tools for national and regional environmental funds in all the SILAQ countries except Romania (which has yet to establish its own fund). Levels of emission charges are typically low, but are now being revised in the process of approximation with the EU.

Environmental fines for non-compliance with emission standards are used in most of the countries. In the Czech Republic, Poland and Slovakia, they are used in addition to emission charges. In Bulgaria, Hungary and Romania, environmental fines are charged only for non-compliance with emission standards. The Environmental charges and fines adopted in Poland are among the highest in the world.

Economic instruments complement command and control mechanisms and, allow for environmental problems to be addressed more quickly, more effectively and in a more cost-efficient manner. If the rates of economic instruments are set high enough, both a reduction in the level of pollution and the prevention of the over-exploitation of natural resources can be achieved. However, until market mechanisms are fully effective, these regulations will remain the most important and best options to properly address environmental issues and in particular air pollution in the short run.

International Commitments

Much of the desired progress will be achieved by the CEE countries as a result of the meeting of obligations stipulated in various international conventions, and due to the harmonization of domestic regulations with those of the European Union.

All existing environmental policy and legislation in the SILAQ countries is now being revised and refined according to the goals of the EU's Fifth Environmental Action Program *Towards Sustainable Development*. Also of importance are those international environmental laws and conventions which have been signed over the course of the last ten years, including the *Convention on Long-Range Transboundary Air Pollution* and its associated *Sulphur Protocol*, the *Vienna Convention for the Protection of Stratospheric Ozone* and associated *Montreal Protocol*, and the UN *Framework Convention on Climate Change*.

As a result of the drastic decreases in industrial output during the transition process and new national environmental legislation and regulations, all the SILAQ countries are likely to meet their commitments to international conventions and laws. As regards compliance with EU requirements, various forms of technical and financial assistance is being made available to the accession countries by the European Commission.

Other Considerations for the Implementation Process

The transition process has accorded responsibility to a number of new environmental stakeholder groups besides the state. Economic reform and the approximation of EU legislation has delegated greater power to local authorities by broadening their rights and responsibilities both for pollution control and in promoting investments and measures for pollution abatement. Private companies are also now expected to mobilize financing for investment in environmentally friendly technologies and production, in order to remain competitive on the international market. Meanwhile, the government's role is now to set realistic environmental targets, and regulations; to allow time for compliance; enforce regulations; and to balance external incentives (such as prices and taxes).

The removal of subsidies and respective increases in energy prices to realistic market levels creates incentives to promote energy efficiency, and to decrease the energy intensity of the national economy and industrial production.

There is also a general tendency toward the decline of heavy industry and increased light industry and service-sector activities in the SILAQ countries.

Nevertheless, there are still many other barriers to overcome on the path to reform, and further improvements will have to be made in terms of the environment and air quality.

Progress in Implementation

A number of investment projects have been implemented since 1995 related to dust cleaning and desulfurization systems in the metallurgical and energy sectors. These projects have often been implemented with external technical or financial support.

To date, dust precipitation systems have been implemented or are in the process of being implemented in the metallurgical plants of Bulgaria, while in Poland, Slovakia, Slovenia and Romania, dust cleaning systems have been introduced predominantly in the energy sector. Flue gas desulfurization has been introduced in Slovenia, Poland, the Czech Republic, and Hungary, and these experiences could be used for projects in Bulgaria, Romania and other countries.

A number of further projects are likely in the coming years.

Recommendations

Based on experience in the implementation of the various programs for the reduction of air pollution, the following measures could be undertaken in order to facilitate further progress in the SILAQ countries:

- Activities in the field of raising public awareness, including the preparation of a “status report” for official and public use;
- Developing a set of core case studies demonstrating the adverse impact on human health and the environmental losses in selected “hot spots”;
- Improved air quality monitoring, especially with regard to small size particulate matter;
- short-term monitoring projects and data assessment related to specific local air quality problems;
- Experience sharing in the field of innovative regulatory approaches and implementation instruments;
- Experience sharing in harmonizing environmental legislation, and monitoring and control systems with EU, including the difficulties, impacts, and lessons learned;
- Workshops focusing on experiences in the application of economic incentives in air quality management;
- Experience sharing on the effective mobilizing and use of financial resources, including information on potential sources of external assistance;
- Study tour and workshops on SO_2 and particulate matter reduction, as well as on local air quality management (including East-East experience transfer);
- Improving the understanding of the impact of emission sources on ambient air quality;
- Developing case studies to assess the role of various pollution sources, and dissemination of the outcome of the studies;
- The development of indicators and criteria for the assessment of the effectiveness and constraints of various flue gas desulfurization systems;
- Preparing feasibility studies addressing options for SO_2 and particulate matter emission reduction;
- Implementation of industrial-scale installations;
- Feasibility studies and demonstration projects on fuel cleaning (i.e. sulfur removal);
- Demonstration projects for clean technologies in coal fired units burning coal with a high sulfur content;

- Dissemination of information on low-cost measures for local air quality management;
- Promotion of energy efficiency measures and other "win-win" approaches.

For the individual environmental "hot spot" areas identified, the following activities might also be undertaken:

- Preparation of integrated air quality management plans and action programs that include industry, power generation, traffic, and households;
- Identification of least-cost approaches;
- Preparation of feasibility studies;
- Development of financial plans and funding applications;
- Demonstration projects of low-cost measures, cleaner technologies, energy efficiency, and other win-win approaches integrating the efforts of the responsible national authorities;
- Assessment of the operational efficiency of pollution abatement technologies and management approaches;
- Dissemination of the results of projects successfully implemented.

Such programs and measures can only take place with the specific financial support of donors and expert assistance from different countries and institutions. The Regional Environmental Center could play a coordinating role in such a multinational program.

Follow-up

One of the main objectives of the SILAQ Initiative has been to identify valuable information on local air pollution control strategies and their implementation, and to facilitate the exchange of this information. The parties involved gained from one anothers' experiences and expect to benefit from this knowledge in improving local air quality. It can also be said that the policy measures and experiences of Western partners has had a catalytic effect on the SILAQ countries. It is clear that the use of incentive-based policies can lead to improved community health.

In summarizing, the actions thus far taken, such as the approximation of legislation, the projects implemented, and the workshops and regular meetings, seem to indicate a good basis for future activities. In CEE, significant progress has already been made in reducing pollutant emissions. International cooperative projects, such as the work of the SILAQ group, could facilitate further progress in the coming years. The country studies and data presented above provide a significant resource for future knowledge transfer, not only among the countries of Central and Eastern Europe but conceivably also for the Newly Independent States.

Reduction of SO_2 and Particulate Emissions

1. Introduction

Since 1989, nearly all the countries of Central and Eastern Europe (CEE) and, more recently some from the former Soviet Union have undertaken the radical transition from centrally planned to free-market economies. Often referred to as "economies in transition", the transition process is characterized not only by drastic changes in economic and social structure, but also by substantial changes in legislation and regulatory frameworks. Environmental legislation has been no exception, with an increasing number of measures and regulations targeted towards the more efficient use of natural resources and toward mitigating negative impacts on the environment.

Sofia Initiatives

The Third Conference of Environment Ministers, held under the auspices of the "Environment for Europe" process in Sofia during October 1995, resulted among other things, in the adoption of the so-called Sofia Initiatives. The aim of these Initiatives was to accelerate the implementation of the Environmental Action Program (EAP) for Central and Eastern Europe through policy, regulation and investment measures. The Initiatives summarized the achievements and proposals for future work in the Central and East European countries in 4 major areas:

- Economic instruments
- Local air pollution
- Biodiversity
- Environmental impact assessment

SILAQ Background

The Initiative for the general improvement of *Local Air Quality* in Central and Eastern Europe (addressed hereafter by this Report) focused on two specific areas: (1) the promotion of unleaded gasoline throughout the CEE region, and (2) the significant reduction of sulfur and particulate emissions. The Initiative concentrated on local air pollution rather than on transboundary air pollution, since most of the countries participating are signatories of the Convention on *Long-Range Transboundary Air Pollution (LR-TAP)* and are active participants in the UN Economic Commission for Europe (ECE) working group dealing with transboundary air pollution. While SO_2[1], NO_x and particulate matter pollution is usually discussed jointly due to the similarities in emission sources and the technologies introduced to reduce their emission, this Report addresses only SO_2 and particulate matter. However, when discussing mitigation measures, the value in combining different emissions reduction mechanisms have not been omitted.

The Sofia Initiative on Local Air Quality (SILAQ) has aimed to promote cooperation among air pollution control experts at national and municipal levels in developing and implementing activities for measurable improvements in air quality in highly polluted urban areas. The Initiative has tended to rely on "East-East" experience sharing and in introducing closer cooperation with Western partners. The objective of the Initiative has been to identify the areas where the greatest environmental benefit can be achieved at the least cost, and on this basis concentrated on:

- The exchange of information on local air pollution control strategies and their implementation;
- The harmonization of policies, standards and regulations among the participating countries (with regard to international practices and approximation to EU standards);
- The development and implementation of national or municipal strategies for the least-cost reduction of airborne lead, particulate matter and sulfur, as well as to promote public information and participation.

[1] Throughout this Report SO_2 is used to indicate all sulfur oxides (SO_2 and SO_3).

Participating Countries

Though the Initiative was open to all countries involved in the Environment for Europe process, the core countries within the Working Group included Bulgaria, the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia. This Synthesis Report is based largely upon information collected from questionnaire surveys conducted by Bulgaria, Poland, Romania, Slovakia, and Slovenia as well as those Country Reports submitted by the Czech Republic, Romania and Hungary. While the Report focuses mainly on the SILAQ countries it also provides illustrative examples and emission trends for other CEE and EU countries. Also taken into consideration are the results of the workshop held in Bratislava between January 20-22, 1998, and discussions and materials provided by participants from the REC, the World Bank, and the US EPA.

It is well understood in transition countries that the reform process has provided a "window" of opportunity for the implementation of new legislative, regulatory and economic instruments aimed at improving the quality of environmental management. This is why broad consensus exists among these countries that reform should have two objectives: firstly, to improve the economic performance of a country through price liberalization, privatization, establishment of capital markets, fiscal reform and decentralization, and secondly, to ensure a sound basis for sustainable development by introducing economic and environmental criteria at all levels of the decisionmaking process.

Within such a political, legislative and economic context, the SO_2 and particulate reduction issue seeks to promote proper solutions and to incorporate these initiatives within overall policy targets.

2. Rationale for the Reduction of SO_2 and Particulate Air Pollution

Good air quality is a prerequisite for the sound health and well-being of humans and ecosystems. Polluted air not only affects human health, ecosystems and materials in a variety of ways, but also transports the pollution across long distances and across different media (land and water). The health effects from exposure to air pollution can include: irritation and annoyance, loss of organ functions (e.g. reduced lung capacity), morbidity and mortality. Some effects can be acute and reversible, while others develop gradually into irreversible chronic conditions. The respiratory system and the eyes are the main organs affected by air pollution.

2.1. HEALTH IMPACTS OF SO_2 AND PARTICULATE AIR POLLUTION

Considerable attention has been given in recent years to epidemiological studies and research into the health effects of ambient air pollution. Studies have covered different acute and chronic health effects which occur as a result of particulate matter and SO_2 pollution.

Linking Pollution and Health

In a number of cases it has been confirmed that the prevalence of persistent coughing and phlegm is significantly related to air pollution including that arising from SO_2 and NO_x. Various statistical analyses have reported on the relationship between the prevalence of chronic bronchitis and SO_2 and NO_x air concentrations. In polluted areas the prevalence of persistent coughing and phlegm is 2-3 times higher than in areas where pollution is less extensive. Such a relationship is also derived for areas where mortality results from lung cancer. A relationship between air pollution and respiratory diseases has been proved in Hungary and Bulgaria (see Box 1 and 2 opposite), while statistical analysis of medical insurance records in countries with polluted areas, and the associated costs of medical treatment, has also been used to indicate the existence of adverse health effects.

Combined Effect

The situation is further worsened by a similar occurrence resulting from concentrations of particulate matter. It should be emphasized that SO_2 and particulates act synergetically. Thus particulates carry SO_2 to the lower part of the respiratory system which would not otherwise be reached (SO_2 would normally be absorbed by the walls of the upper respiratory tract). Chemical reactions between SO_2 and particulate matter can form new compounds such as sulfuric acid and ammonium bisulfate, known as acidic aerosols. The human health effects of these compounds include bronchospasms in asthmatics (caused by acute exposure), and acute and chronic bronchitis (caused by chronic or cumulative exposure). SO_2 is the precursor of sulfate particulates which can irritate eyes and the respiratory tract, reduce lung function, aggravate emphysema, asthma, and chronic bronchitis and may result in mortality.

BOX 1: Health Effects of SO_2 and Suspended Particulates in Hungary

Acute respiratory diseases are known to be the cause of between 23 and 25 percent of all sick-leave cases in Hungary. A clear relationship between the prevalence of the disease and the levels of SO_2 and suspended particles has been verified by epidemiological studies carried out among school children. Among all acute respiratory diseases, catarrh in the lower respiratory tract (e.g. bronchitis, pneumonia) warrants particular attention, since it can significantly affect future health status. High levels of SO_2 and particulates can increase the occurrence of asthma, in particular among children. A similar tendency is observed with regard to lung cancer. In 1994, 3.2 percent of deaths in Hungary was traced to chronic respiratory diseases. The rate is comparatively constant. Prognosis and therapy for such diseases can be effective but costly. Country-wide surveys of the prevalence of these diseases are recommended.

BOX 2: Health Effects of SO_2 Emissions and Particulates in Bulgaria

Urban population constitutes around 30-32 percent of the total population of Bulgaria. The inhabitants of these cities are endangered by SO_2 and particulate pollution. The respiratory tract tends to be most often affected and the most significant problem in both the country as a whole, and in particular among its cities.

Average annual SO_2 concentrations vary a great deal in Bulgaria depending on location, from accepted safety limits to levels with dangerous health implications. Among the most polluted regions in Bulgaria are Asenovgrad, Dimitrovgrad, Kardjali, Pernik, Zlatitsa and Pirdop. Health problems are complicated by the fact that in those regions with high concentration sof SO_2, the concentration of particulates is also high. Such regions where the synergetic effect of both pollutants occurs are Kardjali, Pirdop-Zlatitsa, and Dimitrovgrad.

The diseases of the respiratory system most frequently occur in cities with high levels of pollution from chemical and cement industries, such as Devnia, Dimitrovgrad and Vratsa. In some cities (for example, Dimitrovgrad, Devnia, Vratsa, Kremikovtsi) the occurrence of pneumonia is significantly higher than the country average and is expected to further increase. Chronic respiratory diseases (including sinusitis, pharingyitis, bronchitis, and laryngitis) are commonly high in cities with chemical industries and refineries (such as Devnya, Bourgas and Stara Zagora), as well as in regions with non-ferrous industries (including Kardjali, Plovdiv, Asenovgrad, Zlatitsa, Eliseina). In cities where highly developed chemical industries are found (Devnia, Bourgas, Vratsa and Rousse), bronchial asthma can be observed with higher frequency. The number suffering from asthmatic disorders is particularly high in Devnia — exceeding the country average by more than double. A relationship between abnormal psycho-neurological development and air pollution, as well as poor lung activity and the retarded growth of children has been recorded in Dimitrovgrad. High levels of particulates resulting in neurological and psychological diseases with continuous impact on the mental ability of children has been found in Plovdiv, Asenovgrad, Kuklen, Kardjali and Pernik.

Source: National Report on the Reduction of Emissions of SO_2 and Particulates in the Republic of Bulgaria

Particulates

Particulate matter can lead to pulmonary irritation and respiratory diseases. It must be pointed out, however, that the effects of particulate matter vary considerably since it tends to be composed of many different substances of varying sizes and quantities that can be potentially carcinogenic and mutagenic. Elemental carbon, polyaromatic hydrocarbons (PAHs) and toxic base metals are among the constituents of particular matter of greater importance with regard to human health.

Particulates originate from a variety of mobile and stationary sources, and vary in terms of physical composition, chemical content, and size. The most harmful to human health tend to be small particulates owing to their ability to reach the lower regions of the respiratory tract and contribute to the negative effects on breathing and respiratory systems, aggravation of existing respiratory and cardiovascular diseases, anomalies in the body's defense systems to foreign substances, damage to lung tissues, carcinogenesis and premature death. As a result of these linkages particulates with diameter of 10 micrometers and lower have begun to be regulated. In the US, for example, the focus has shifted to particulate matter (PM) of 2.5 micron diameter and smaller. This results in a very different set of control measures compared with those for total suspended particulates (TSP). While SILAQ countries adhere to EU norms, the EU will almost inevitably be moving toward regulating even smaller particles, and thus when investing in control devices in the SILAQ countries, this should also be kept in mind.

EU Trend

The studies and methods used in assessing health effects, developed in the US, the EU, and elsewhere, can be adapted for the SILAQ countries. Levels of exposure throughout these countries need to be defined since the available data collected from the questionnaire surveys is insufficient. Further studies might therefore take place.

Finally, it should be mentioned that aside from the health risks associated with the inhalation of gases and particles, there are also significant economic consequences arising from SO_2 and particulate pollution. These include deforestation, acidification of water bodies and soil, and the accelerated deterioration of building materials, including historical monuments and buildings.

TABLE 1: Annual Average SO_2 Concentrations in Ambient Air [$\mu g/Nm^3$]

	1990	1991	1992	1993	1994	1995	1996
Bulgaria Air quality standard — 50µg/Nm³ (0.05 mg/Nm³)							
Eliseina	***185***	***197***	***102***	***174***	***315***	***167***	***351***
Zlatitza	***232***	***569***	***178***	***197***	***16***	***106***	***78***
Pernik	***230***	***260***	***156***	46	***72***	***100***	48
Kardjali	***95***	***77***	***90***	***115***	***96***	***57***	***62***
Asenovgrad	***251***	***158***	***189***	***112***	***135***	***117***	***134***
Czech Republic Air quality standard — 60µg/Nm³ (0.06 mg/Nm³)							
Prague	47	69	44	50	41	31	34
Ostrava	34	34	25	28	22	19	28
Teplice	51	59	41	44	34	31	31
Poland Air quality standard — 32µg/Nm³ (0.032 mg/Nm³)							
Warsaw	20	20	15	20	13	140	16
Bialystok	17	13	8	6	5	5	6
Katowice	***84***	***89***	***75***	***84***	***53***	***39***	***39***
Krakow	***68***	***65***	***60***	***59***	***39***	***39***	***41***
Lodz	27	***33***	24	26	20	20	18
Romania Air quality standard — 60µg/Nm³ (0.06 mg/Nm³)							
Bucharest	4	8	9	4	7	29	35
Baia Mare	***65***	38	12	16	12	18	
Ploiesti	24	15	12	10	15	16	24
Craiova	6	7	7	7	7	9	6
Slovakia Air quality standard — 60µg/Nm³ (0.06 mg/Nm³)							
Bratislava	—	—	25	33	20	31	28
Kosice	—	—	22	19	20	29	25
Banska Bystrica	—	—	33	47	27	24	25
Zilina	—	—		48	34	28	32
Prievidza	—	—	50	53	39	37	49
Slovenia Air quality standard — 50µg/Nm³ (0.05 mg/Nm³)							
Ljubljana	—	***59***	***51***	39	27	23	25
Maribor	—	38	47	42	30	28	24
Celje	—	***88***	***57***	***54***	49	32	24
Trbovje	—	***111***	***69***	***71***	49	48	37
Sostanj	—	***57***	49	48	38	29	34

Note: bold italic figures indicate air quality standards have been exceeded

2.2. AMBIENT AIR QUALITY

Data collected from the questionnaire surveys concerning the annual average SO_2 and particulate matter concentrations for selected cities in each SILAQ country are summarized in Tables 1 and 2 respectively. The air quality standards adopted by these countries are also shown and those concentrations exceeding the national standard are indicated in black italic.

SO_2 Concentrations

The data in Table 1 indicates that the actual annual averages of SO_2 concentrations in Slovakia and Romania are below the standard values (of 0.06 mg/Nm^3). In Romania, SO_2 tends to be one of the most effectively monitored pollutants with more than 150 monitor-

TABLE 2: Annual Average Particulate Concentrations in Ambient Air [µg/Nm³]

	1990	1991	1992	1993	1994	1995	1996
Bulgaria Air quality standard — 150µg/Nm³ (0.15 mg/Nm³)							
Sofia	***284***	***235***	***222***	***169***	***187***	142	***154***
Plovdiv	***206***	***239***	***222***	***200***	***194***	***229***	***229***
Pleven	***523***	***253***	***362***	***425***	***390***	***326***	***263***
Pernik	***256***	136	***214***	***304***	***299***	***347***	***318***
Stara Zagora	***231***	***219***	***210***	***208***	***202***	***207***	***247***
Czech Republic Air quality standard — 60µg/Nm³ (0.06 mg/Nm³)							
Prague	56	63	59	***66***	58	52	53
Ostrava	***72***	***75***	56	59	56	56	58
Teplice	55	56	44	46	44	38	39
Poland Air quality standard — 50µg/Nm³ (0.05 mg/Nm³)							
Warszawa	50	***51***	41	38	42	42	42
Bialystok	23	20	19	22	18	16	18
Katowice*	***143***	***144***	***135***	***125***	***99***	***106***	***120***
Krakow	56	47	46	47	39	42	46
Lodz	33	46	40	39	33	27	26
Romania Air quality standard — 75µg/Nm³ (0.075 mg/Nm³)							
Bucharest	***84***	74	72	***83***	***115***	***86***	64
Baia Mare	55	50	***217***	45	51	53	0
Ploiesti	***76***	***81***	***128***	***118***	***123***	***120***	***116***
Craiova	***101***	***102***	66	***78***	***84***	***97***	***95***
Slovakia Air quality standard — 60µg/Nm³ (0.06 mg/Nm³)							
Bratislava	—	—	43	40	46	37	47
Kosice	—	—	48	55	47	42	—
Banska Bystrica	—	—	***82***	***81***	***85***	***76***	***83***
Zilina	—	—	—	***73***	***63***	***64***	***72***
Prievidza	—	—	—	***73***	***69***	***76***	***73***
Slovenia Air quality standard — 70µg/Nm³ (0.07 mg/Nm³)							
Ljubljana	—	—	—	—	—	54	57
Maribor	—	—	—	—	—	53	55
Celje	—	—	—	—	—	62	70
Vnajnarje	—	—	—	—	—	27	29
Prapretno	—	—	—	—	—	27	40

Note: Bold italic figures indicate air quality standards have been exceeded

* Measurements in Katowice are for total suspended particulate

ing stations located across the country. Some towns collect time-series data that cover a 30 year period. A decrease in concentrations is shown and the threshold levels set with WHO guidelines are rarely exceeded.

SO_2 Standards

Among the SILAQ countries, Poland has the most stringent ambient air quality standard for SO_2 (0.032 mg/Nm^3). Bulgaria and Slovenia enforce standards of 0.05 mg/Nm^3, however, many cases of noncompliance have been found in Bulgaria. In some places the standard was not only exceeded but concentrations were found to be consistently above the national standard, for example in Eliseina, Zlatitza and Kardjali. In Slovenia, limits were exceeded at the beginning of the surveyed period but during the last three years, compliance has improved with no single standard now exceeded. In general, there is a downward trend in concentrations of SO_2 in SILAQ countries, but this is by no means consistent.

Table 2 indicates that some cities in Romania and Slovakia tend to meet standards for particulate matter concentration while others do not comply with them on a regular basis. Slovenia is the only country where all values of particulate matter concentration are within the accepted norms.

SO_2 vs. Particulate Pollution

The conclusion drawn in comparison with the data on SO_2 is that non-compliance with particulate matter limits is a more serious problem in the SILAQ countries. Concentrations of particulate matter are several times greater than the standard values, particularly in Bulgaria where standards are lax compared with other SILAQ countries. In most settlements, the average annual concentrations exceed the permitted norms for particulate matter. Concentrations above the upper threshold value are registered mainly in residential areas where the impact of industry is combined with that of fuel combustion from households. The highest concentrations in the surveyed period are found in Pleven where nearly 92 percent of concentrations are above the 24 hour norm. Even in settlements where no particulate emission sources exist, high particulate concentrations have been recorded in comparison with other settlements where large point sources are located. The reason for this is poor city planning. The situation is further worsened by the continuing existence of particulate matter in the lower layers of air due to the 'closed' relief of some regions (e.g. such as the Sofia and Pirdop valleys in Bulgaria).

Mobile Sources

When discussing particulate matter, along with generation facilities and residential combustion, mobile sources should also be discussed. The parameters of diesel fuels have a direct bearing on the particulate emissions of diesel engines, however, this seems to be less significant than other issues such as engine adjustment, load and maintenance. The actual trend in legislation relating to the quality of diesel fuel, such as a lower sulfur and aromatic content will reduce the emissions of all harmful substances. Diesel exhaust is a complex mixture of a great variety of compounds and from a toxicological point of view, particulate matter appears to be the most relevant component concerning population exposure. The concentration of particulate matter is about 10-20 times higher than in exhaust from gasoline-fuelled vehicles, and the diameter of particulates fall within that range which causes harm to the respiratory tract.

The systematic measurement of air pollutants in Romania takes place in more than 50 towns. Data shows that the concentrations of particulate matter tend to exceed the standard values in highly industrialized towns such as Hunedoara, Alba Iulia, Baia Mare, and Gheorgheni, with a levels more than 25 percent higher. For a greater number of towns, however, the level is some 12.5 percent lower.

Although the examples given show the correlation between air pollution and health effects and help to improve understanding, further studies on these problems are still necessary. Those studies presented perhaps should be considered a start in the systematic monitoring of detrimental effects, particularly for "hot spot" areas where public sensitivity is high, and health and environmental losses considerable.

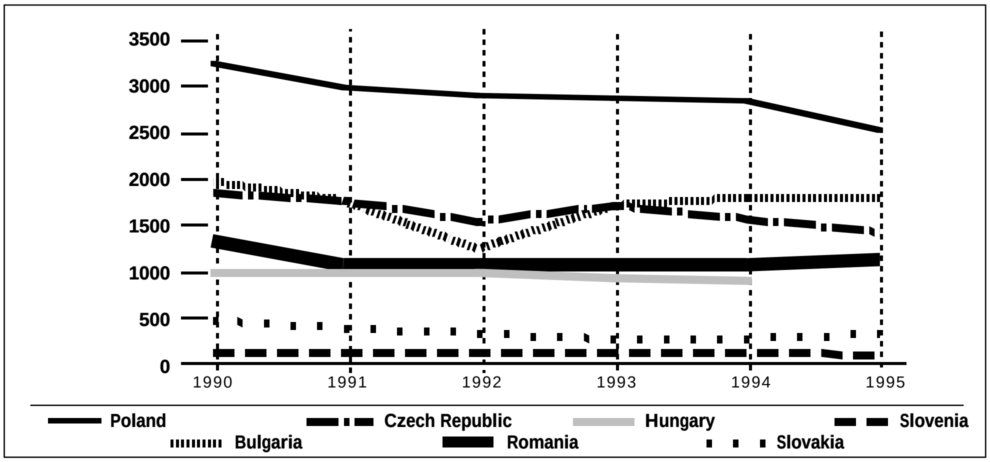
Other Standards

When discussing the health impacts, it should be mentioned that the air quality standards adopted in the SILAQ countries are among the most stringent in the world. The annual air quality standard for example in the EU and the National Ambient Air Quality Standards (NAAQS) in the USA for SO_2 emissions is 0.08 mg/Nm^3. This fact has to be kept in mind when defining compliance with local standards in the SILAQ countries and should be considered in terms of the potential consequences (economic, administrative, etc.) of these narrower limits.

Pollution Reduction Benefits

Different measures must therefore be introduced to reduce the effects on health resulting from exceeding standards. In addition to these adverse effects, SO_2 and particulate pollu-

Figure 1.
Trends in SO_2 emissions (kt)



tion contributes to acid rain, damage and defoliation of forests, soil and water acidification, acceleration of corrosion, and erosion. Therefore, SO_2 and particulate emissions reduction will have multi-dimensional benefits. In addition to the improved health status of the population, a decrease in pollution levels will reduce work absence (arising from health problems), and the costs of health insurance and protection. Reduction of emissions will also have a positive impact on agricultural production, leisure activities, and forestry.

Research into the effects of SO_2 and particulate matter should perhaps continue in order to gain further knowledge of the issue, with the results being communicated to the public and to decisionmakers. Workshops with public health officials, the development of new standards, public awareness campaigns and education might be envisaged as end-results. The protection of human health should be a preventive process and the ultimate objective.

In this respect, trends in SO_2 and particulate emissions, the main emission sources and the respective mitigation measures should be well identified and analyzed, a notion made all the more important by the fact that recent data reported by the US Environmental Protection Agency (US EPA) at the SILAQ workshop held in Bratislava in January 1998, show that losses arising from fine particulate emissions in terms of health and the environment could be much higher than previously expected. The following chapters aim to report on some of these trends and measures.

3. Pollutant Emissions of SO_2 and Particulates

Economic recession in the SILAQ countries has brought with itself a downward trend in the levels of emissions. Although the SILAQ countries vary in size and differ as emitters, the observed trends are similar — general decreases in both particulate matter (PM) and SO_2 emissions, which even with economic recovery, appear to be continuing to decline. The reasons for this are the restructuring and modernization of production systems and the impact of new environmental legislation and regulations. The following sections examine the nature and reasons for the declines in levels of emissions, as well as the main responsible sources.

TABLE 3: Total Annual Emissions of SO_2 [kt]

Country	1990	1991	1992	1993	1994	1995	1996
Bulgaria	2,020	1,678	1,128	1,426	1,480	1,497	1,420
Czech Republic	1,876	1,776	1,538	1,419	1,278	1,091	946
Hungary	1,010	913	827	757	741	—	660
Poland	3,210	2,995	2,820	2,725	2,605	2,337	
Romania	1,311	1,041	952	928	912	932	—
Slovakia	543	446	380	325	239	239	226
Slovenia	195	181	190	183	177	119	110

Figure 2.
SO_2 emissions by sector, 1990 [%]

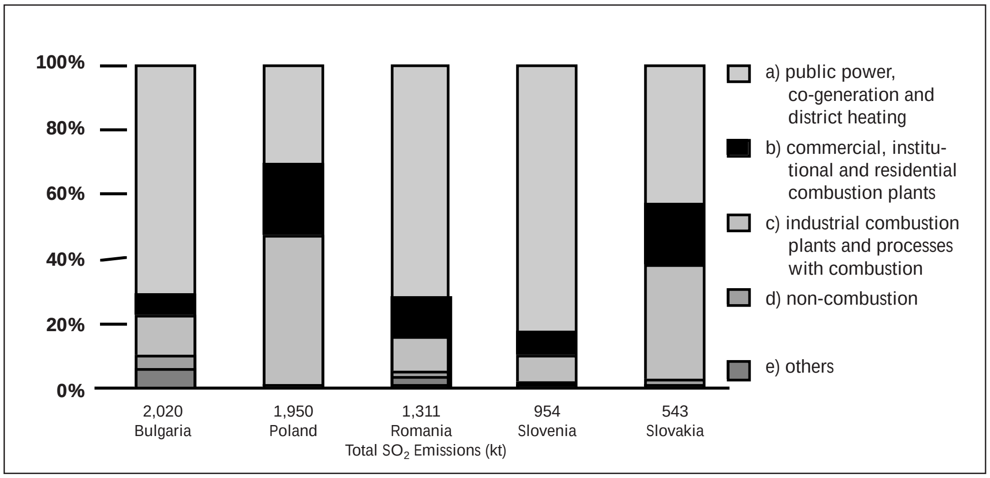
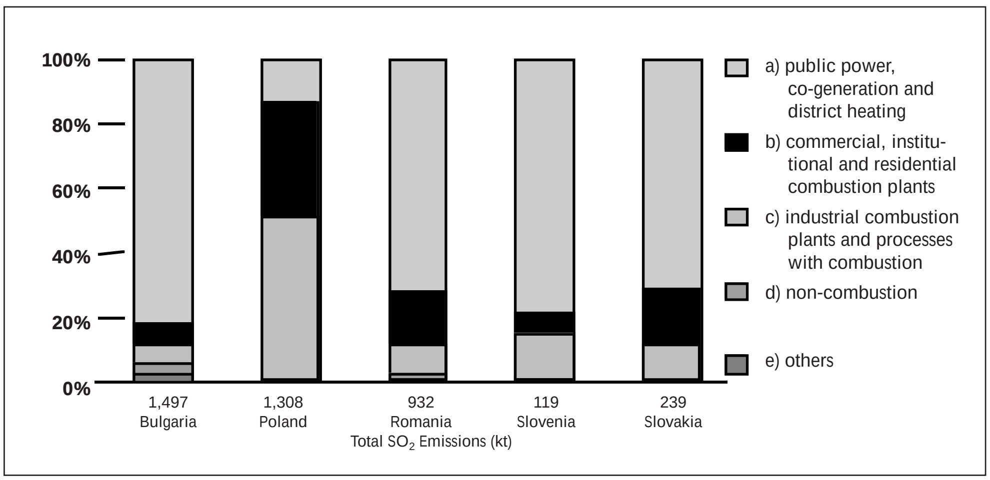


Figure 3.
SO_2 emissions by sector, 1995 [%]



3.1. SULFUR DIOXIDE

Decreasing Emissions

The data on SO_2 emissions obtained through the questionnaire survey and shown in Figure 1 clearly indicates a predominant downward trend in emission levels, as well as a number of fluctuations. For example, after an initial drop in SO_2 emissions for all countries during the 1990-1993 period, continuing decreases in Slovakia, Slovenia and Romania (until 1994), were offset by a slight upward trend in Bulgaria after 1993, with a later stabilizing of values. At the same time, the decreases in emission levels vary substantially from country to country. The drop is most explicit, for example, in Slovakia (some 41.62 percent in 1996 if 1990 values are set at 100 percent) and in the Czech Republic (50.43 percent in 1996 if 1990 values are set at 100 percent). Absolute values of SO_2 emissions are given in Table 3.

Main Sources

Based on questionnaire data, the main sources of SO_2 pollution have been identified as power generation and district heating plants, contributing in 1996 in Slovenia to as much as 87.2 percent of the total emissions. During the surveyed period, emissions from power, co-generation and district heating sources have actually increased as a percentage of the total SO_2 emission. In Slovakia, for example, 44.8 percent of SO_2 emissions in 1990 originated from such sources while by 1996 this share had grown to 68.6 percent. Generally, however, this source is most significant in Slovenia and Bulgaria where it tends to be responsible for more than 70-80 percent of the SO_2 emissions. In 1980, SO_2 emissions in Hungary were about 1,600 kt, having decreased to 660 kt by 1996. Of this figure, approximately 65 percent were emitted by public power plants.

Residential Sources

Figures 2 and 3 illustrate the emission sources and their respective share for two separate years (1990 and 1995) during the surveyed period. The share of commercial, institutional and residential combustion sources tends to remain relatively constant throughout the surveyed period for all countries. It can be noted that the share of emissions from

Figure 4.
SO_2 emissions per capita
[kg/capita]

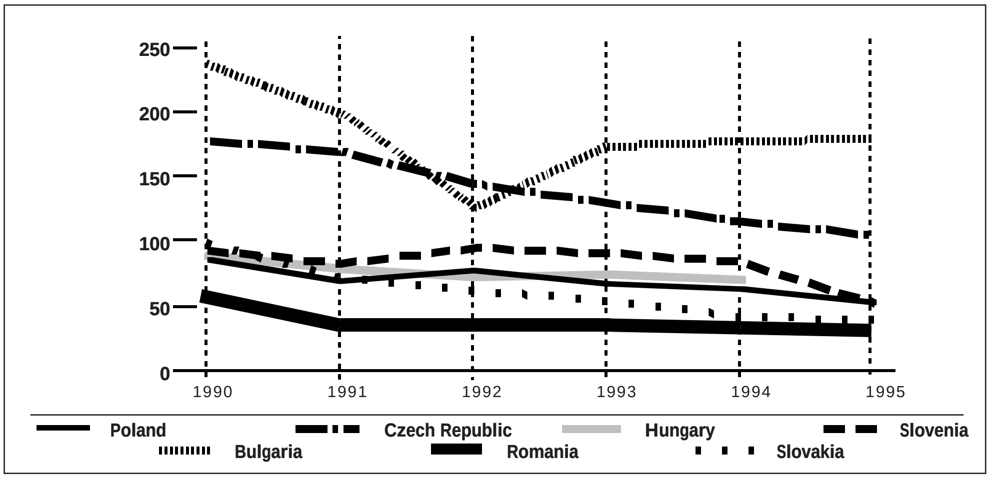
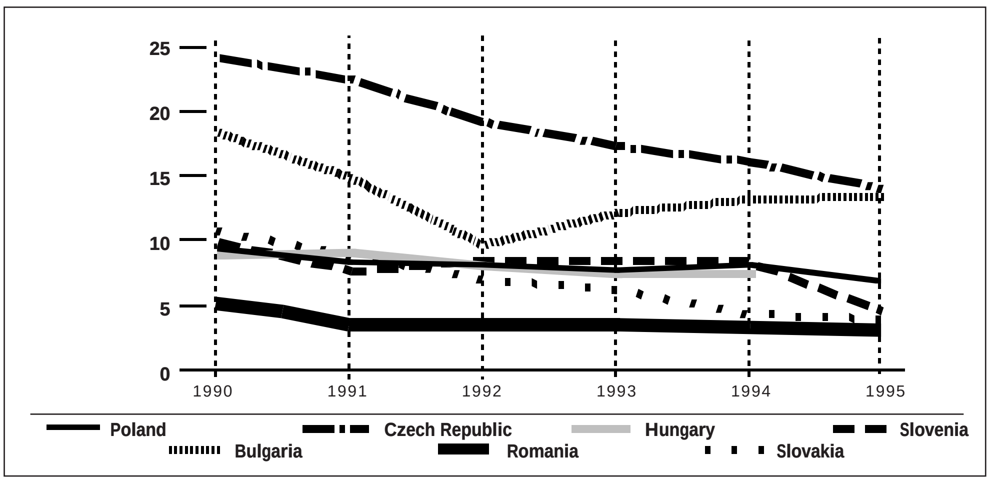


Figure 5.
Emissions per unit of area
[tons/km²]



these sources are much greater in Romania and Slovakia than in Bulgaria and Slovenia. In general, residential combustion tends to be the most serious small-scale source responsible for urban pollution.

Although incomplete, the above data also indicates the significant decrease in emissions from industrial combustion plants and processes, and this is particularly evident for Bulgaria. The tendency is typical of all countries in transition and can be explained by the reduction in industrial output and the more stringent environmental regulations adopted since 1990.

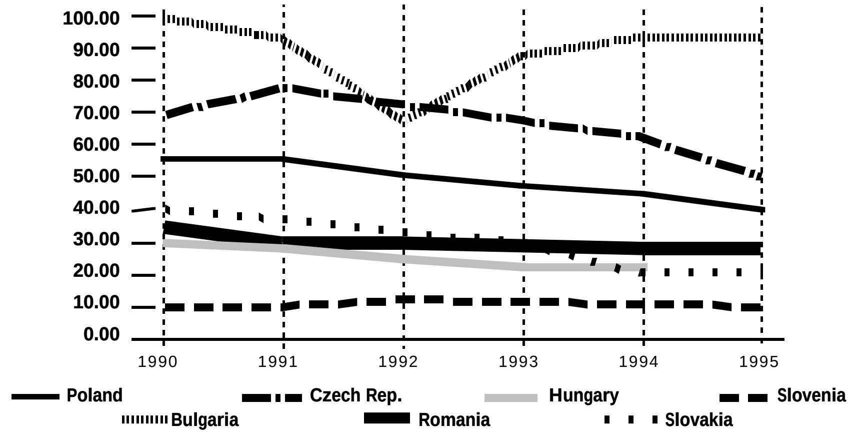
According to the data collected in the questionnaire survey, the *non-combustion* and *other* SO_2 sources have negligible shares in the total levels of emissions. The absolute figures and the precise share of these sources are doubtful, however, since the surveyed countries work with different categories and data is not easily comparable. Better specifications and a clear definition of each category is required in order to extract more reliable data.

While the data presented on the previous page shows the absolute levels of SO_2 emissions per country, with Bulgaria emerging the greatest producer, closely followed by Poland and the Czech Republic, more useful information on the levels of SO_2 emissions per capita and per area is given above. Figures 4 and 5 compare Bulgaria, the Czech Republic, Hungary, Romania, Slovakia and Slovenia during the period 1990-1995. Polish and Hungarian per capita emissions data is noticeably similar.

Emissions per Capita and Area

The results show that in respect to both per capita and per unit of area, emissions remain highest in Bulgaria and the Czech Republic. The values in terms of both these criteria were highest at the beginning of the surveyed period but are steadily decreasing. A steady decrease can also be observed in Slovakia, while in Bulgaria, an increase in emissions occurred after 1992. The remaining countries maintain relatively constant values with a sharp decrease having occurred in Slovenia between 1994 and 1995. Data also indicates that the SILAQ countries are identically ranked by both criteria. The decline in levels of

Figure 6.
SO_2 emissions per GDP
[kg/USD 1,000[1]]



[1] USD 1990 values
Source: World Bank, and IEA Statistics (CO2 Emissions from Fuel Combustion 1972-1995, 1997 Edition)

emissions is apparent for all SILAQ countries (with the exception of Bulgaria) and is the most explicit in the Czech Republic and Slovakia.

OECD Average

If the SO_2 emissions for 1993 in the SILAQ countries are compared with the OECD average of 52.6 kg SO_2/capita, one can see that Slovakia and Romania are well below this value while the Czech Republic and Bulgaria substantially exceed it.

Emissions per GDP

Comparisons might also be made based on emissions per unit of GDP. For Western countries SO_2 emission levels (per GDP) are less than 10 kg SO_2/USD 1,000 while for several CEE countries it is almost 10 times higher (see Figure 6). One reason could be the large dependency of the SILAQ countries on fossil fuels, particularly the low-heat, and high sulfur and ash-laden local lignites. In addition, these countries are characterized by industrialized economies where energy efficiency lags far behind that of OECD countries, due in many cases to the use of obsolete technologies. Due to the financial constraints, emission control devices available on the market have not been widely implemented.

Shift in Polluting Sectors

At the same time, owing to the overall economic recession, the so-called market transition, the modification and restructuring of aged industrial production systems, and the ceasing of the production of goods requiring high energy intensity, etc. GDP has significantly decreased over the last few years. However, restructuring and modernization of obsolete production systems, has resulted in a shift in the share of different sectors contributing to GDP. The energy intensive industrial sector for example has reduced its share and hence the structure of energy consumption has shifted resulting in significant improvement not only in terms of energy consumption but in environmental impact. All these factors lead to the indicated decrease in GDP, while the overall decrease in SO_2 emissions, both as an absolute value and as a ratio to the population levels, area and GDP are also due to the measures

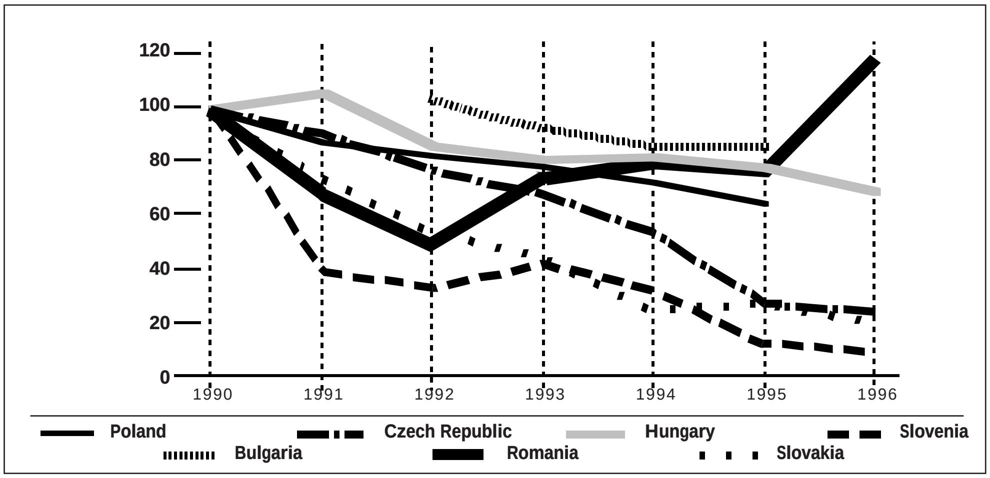
TABLE 4: Total Emissions of Particulate Matter [kt]

	1990	1991	1992	1993	1994	1995	1996
Bulgaria	–	–	423	382	353	358	306
Czech Republic	671	592	501	441	355	201	179
Hungary	134	139	111	107	107	102	89
Poland	1,950	1,680	1,580	1,495	1,395	1,308	—
Romania*	20	15	11	15	16	15	23
Slovakia	299	229	177	143	87	89	67
Slovenia**	26	11	10	12	9	4	3

*Romanian data only includes emissions from road traffic.

**Slovenian data includes emission from the Sostanj Thermal power plant, Ljubljana co-generation plant and Trbovlje thermal power plant, as well as from the 23 biggest industrial objects, though this is still not representative of the entire country.

Figure 7.
Trends in particulate emissions [%]



already taken to address air pollution and to the changes in energy supply structure.

According to the Hungary Country Status Report, the sharp decrease in SO_2 emissions during the period 1985-1990 can be attributed to the installation of new nuclear reactor blocs in the Paks nuclear power plant. The changes in the subsequent period (1990-1996) resulted from the overall economic recession, restructured economic and production patterns, and a decline in fossil fuel consumption (through the implementation of natural gas programs with sharp decreases in household and industry coal consumption and decreases in the use of residential oil due to increased prices).

3.2. PARTICULATE MATTER

Table 4 provides data on the total emissions of particulate matter for the period 1990-1996 in the SILAQ countries. Due to incomplete data it is difficult to use this information for comparison but nevertheless, does help to indicate the trends within each country.

Decline in Emissions

In general, particulate emissions have decreased in each country during the surveyed period (see Figure 7). Although Romania appears to be the exception, this is explained by the fact that only emissions from road traffic are included. Transport emissions have increased in all the SILAQ countries due to the change in transport patterns and the shift towards increased vehicle use.

In analyzing the sources of particulate matter emissions (in Bulgaria for example), in contrast to Figures 2 and 3 (presenting SO2 emissions by sector), power plants cannot be considered main sources. This is due to the installation of high efficiency electric filters in all plants. The emissions from these sources have decreased between 1993 and 1995, from 140.1 kt to 88 kt. In terms of particulate emissions, residential combustion is the most significant source.

This situation is mirrored in Slovakia where the greatest share of particulate matter is discharged by residential and commercial combustion sources followed by emissions from industrial combustion processes. Data for emission sources is only available for 1990 and 1995-1996, however, there is a 3-4 fold drop in emission levels for each source during the given period. With the exception of Romania, no data was collected concerning emissions from mobile sources.

Source Shifts

Some source shifts have also been observed. While initially power plants in Hungary were found to be the main sources of particulate matter emissions (about 60 percent), more recently emissions from the residential sector have been found to play the most significant role (about 40 percent). From 370 kt in 1980, particulate emissions dropped to approximately 90 kt in 1996. About 82 percent of this figure is known to arise from solid fuel combustion processes.

3.3. MAIN SOURCES OF AIR POLLUTION IN THE SILAQ COUNTRIES

Although insufficient and fragmented data has made it difficult to draw conclusions concerning the present status, trends and specific problems in the SILAQ countries with regard to the main sources of air pollution, power plants, co-generation and district heating facilities remain among the main contributors to poor air quality.

BOX 3: Main Pollutant Emission Sources in Slovenia and Associated Reduction Measures

The main sources of pollutant emissions in Slovenia are power plants. In 1993, these contributed some 81 percent of the total SO_2 emissions. In addition, power stations are also an important source of particulate pollution in cities and towns. This is largely the result of the use of low-quality and high-sulfur content fuel. Among some of the initiatives taken to reduce the levels of emissions were:

- Use of additives in 1992 in all five blocks of the biggest Slovene coal electricity power plant Sostanj to reduce air pollution. The measure resulted in the reduction of SO_2 emission by 25 percent.
- Sludge disposal sites operated on the basis of a closed water cycle (where the water is returned into the working cycle).
- Dust dispersion is prevented by the simultaneous recultivation of the ash depot.
- Use of a flue gas desulfurization unit which reduced SO_2 emissions by more than 90 percent.
- Use of electric filters which reduce particulate levels below the accepted standard.
- The Trbovlje power plant, considered inappropriate for upgrading with cleaning devices, will be closed in 2004-2005. In the meantime, the plant will switch to the use of cleaner energy carriers. The ash depot is also well established which uses filtered water, and is simultaneously recultivated.
- A switch from local to low sulfur import coal at the coal electricity power plant heater in Ljubljana (TE-TO) has helped reduce its emissions some 50 percent.

Source: Program for the Abatement of Air Pollution in Slovenia, Environment for Europe, Oct 23-25, 1995. Sofia, Bulgaria

Dominating Plants

In reviewing power plants, the medium and large-scale plants using solid fuels tend to dominate the energy supply market. Although the process of privatization is at an advanced stage for all of the countries, most of the plants are still state owned and emit significant quantities of SO_2 to the atmosphere. Particulate emissions from power plants are also commonplace, however, among the SILAQ countries (Bulgaria, Slovakia and Hungary), discharges from residential and commercial combustion processes tend to be the major contributors of particulate emissions.

Emissions from power plants depend on the size of the plant and the type of the fuel used. In Bulgaria and Slovenia, it is the larger power plants with thermal capacity above 500 MW that dominate electricity production and air pollution in spite of a shift to imported solid and liquid fuels which are being used to replace solid fuels with medium and high sulfur contents (local lignites). In Slovenia, it is the use of local solid fuel with a high and medium sulfur content in power plants that contribute to air pollution. Romanian power plants tend to be of two types: small installations that run on liquid fuel, and medium-sized units that operate on local coal with a medium sulfur content. Generally the tendency is towards decreased consumption, however, the import of liquid fuel with high sulfur content is rising. Slovakia has provided detailed information on the type, quantity, and sulfur content of the fuels burnt during 1990 and 1996, and this has indicated a stable decrease in the sulfur content of the fuel mix.

Other Means to Reduce Emissions

In general, while fuel consumption for electricity production is decreasing, the import of liquid fuel with a high sulfur content is increasing, and thus power generation facilities remain a major source of SO_2 pollution. Progress in the field of implementing technical measures to deal with particulate and SO_2 emissions has also been slow and the potential to reduce emission levels by other means such as changing the fuel mix, reducing energy consumption and the installation of different pollution control devices are areas that should still be explored. The information provided here outlines the great opportunities that exist in the field, particularly if investments can be encouraged and more vigorous national policies would be pursued that would encourage investment in pollution-control and cleaner production technologies.

4. Legal Framework

The following sections of this Report provide a brief overview of the existing environmental, legislative and regulatory framework, the process of approximation within the associated EU Member States, and the related policies and measures to reduce pollutant emissions.

Key Issues

There are two key issues related to the problem of revising and improving the legislative and regulatory framework to effectively reduce air pollution. The first is the necessary improvement required in the institutional framework, and second the actual adoption of new and more stringent environmental legislation and standards. In principle, the regulations focus on ambient air quality, emission levels from specific sources, and the quality of fuels used.

4.1. INSTITUTIONAL FRAMEWORK

Concerning the institutional framework, it is worth mentioning that even under centrally planned economies, most of the SILAQ countries had rather well established institutional frameworks for environmental protection and particularly air pollution control. The most important components of this framework included the Ministry, which assumed responsibility for environmental protection at the governmental level; and the state environmental inspectorates, which acted at the regional level. The delegation of responsibilities today from central to local level bodies vary from country to country and currently those responsibilities are being reassessed given the recent changes in each of the countries' economies, and legislation, and the changing role of governments throughout the transition period, especially during the process of decentralization.

Division of Tasks

Broadly speaking, the central body (usually the Ministry of Environment) formulates, coordinates and implements environmental protection activities at the state level. It also controls the activities of the regional bodies and coordinates research and development in the field of environmental protection.

Regional bodies are responsible for guiding and enforcing environmental control at the local level, and for monitoring the quality of air, water and soil, while the responsibility and decisions for actions at the local level lie with different business entities and local authorities.

Capacity Problems

The need to strengthen institutional framework is recognized in all of the SILAQ countries. At the national level, the most often reported problems are the lack of personnel and funds available to ministries. At the regional level, in addition to these problems, there is a lack of administrative capacity and experience to deal with environmental problems. Local authorities are now overwhelmed with responsibility remain passive or unaware of environmental issues, particularly those problems inherited from the past.

4.2. ENVIRONMENTAL LEGISLATION

The process of adopting new environmental legislation, is regarded as an integral part of reform in the SILAQ countries. It is seen as a means for allowing the establishment of fundamental levels of environmental protection, and an opportunity to establish a framework that is consistent with the international commitments of these countries.

New Acts

New legislation, however, may fail to meet its objectives, (as often happened in the past), unless a broad mix of policy instruments are implemented alongside, including so-called economic instruments, regulations and guidelines. This report will later focus on these policy instruments and will examine the ways they have been implemented.

Since the political changes at the end of the last decade, many of the SILAQ countries have upgraded or adopted a new fundamental law, usually in the form of a Constitution. In it, a clear statement is made about the necessary environmental regulations and general policy requirements. It also establishes, for example in Bulgaria, Poland and Slovakia, the rights of citizens to a favorable environment, and to timely and complete information on the state of environment. Citizens enjoy the right to benefit from the values of the natural environment, but are also responsible for its protection.

Framework Laws

The principles and legislative instruments used to achieve the objectives of sustainable development and environmental protection are usually set forth by a single fundamental and comprehensive framework law, supported by other environmental, economic and energy laws and regulations. In the SILAQ countries, these include:

- In Bulgaria, the *Environmental Protection Act* was adopted in 1991 and amended in 1992. It partly revokes the *Act on Pollution and Protection of Air, Water and Soil*, adopted in 1975;
- In Poland, the *Act on Environment Protection and Shaping,* adopted in 1980 and amended in 1995;
- In the Czech and Slovak Republics the *Act on Environment*, adopted in 1992 and the

BOX 4: Air Quality Measurement and Control in Bulgaria

The monitoring of air pollution is carried out by the National System for Air Quality Control. It consists of 106 stationary points (92 undertaking manual sampling and 14 automatic stations) with a further six mobile stations. The stationary points are situated in 42 settlements. Air quality is controlled by monitoring emissions of dust, lead aerosols, SO_2, NO_2 and hydrogen sulfide, depending on the nature of pollution. The concentrations of particulates are monitored at 96 points, while SO_2 is monitored from 105 points.

With a view to reducing pollution, a *Regulation for the Upper Admissible Concentration of Harmful Substances in Settlements* was issued by the Ministry of Health in 1984. This regulation was updated in 1997 by the Ministry of Environment and Waters and by the Ministry of Health in relation to the introduction of the *Clean Ambient Air Act* (in June 1996).

In addition to the direct measurements, the Ministry of Environment and Waters and the National Statistical Institute undertook a joint annual inventory of the emissions of harmful substances into the atmosphere, which included quantities of SO_2 and dust. The inventory was carried out with the EU's methodology adopted under the CORINAIR Programme and adapted to local Bulgarian conditions. The inventory covers all human activities (including more than 2,600 industrial enterprises) with particulates being calculated according to a locally adapted methodology.

Source: National Report on the Reduction of SO_2 and Particulate Emissions in the Republic of Bulgaria

TABLE 5: Ambient Air Quality Standards [$\mu g/m^3$]

Item	Bulgaria	Czech Rep./ Slovakia[2]	Poland	Romania	Slovenia	EU[3]	USA[4]
SO_2 (with regard to health effects)							
a) Short term	500	500	600	750	—	—	—
b) Medium term	150	150	200	250	—	250	365
c) Long term	50	60	32	60	—	80	806
SO_2 (with regard to ecological effects)		Not yet adopted	Permitted concentrations for special protection areas	n/a			
a) Short-term	500	—	250	—	350	—	—
b) Medium-term	150	—	75	—	125	—	507
c) Long-term	50	—	11	—	50	—	—
Particulate Total Suspended Particulate (TSP) (with regard to health effects)							
a) Short-term	500	500	—	500	300	—	—
b) Medium-term	250	150	—	150	175	—	—
c) Long-term	150	50	—	75	70	—	—
Particulate PM10 (with regard to health effects)							
a) Short-term	—	—	—	n/a	200	—	—
b) Medium-term	—	—	120	n/a	125	—	150
c) Long-term	—	—	50	n/a	50	—	50
Particulates (with regard to ecological effects)			Permitted concentrations for special protection areas				
a) Short-term	500	—	—	n/a	0.350	—	—
b) Medium-term	250	—	60	n/a	0.125	—	—
c) Long-term	150	—	40	n/a	50	—	50
Combined SO_2 and Particulates (with regard to health effects)							
a) Short-term	—	—	—	n/a	—	—	—
b) Medium-term	—	250	—	n/a	—	—	—
c) Long-term	—	—	—	n/a	—	—	—

[2] Standards in the Czech and Slovak Republics are identical.

[3] Directive 80/779/EEC

[4] National Ambient Air Quality Standards of US EPA

BOX 5: National Air Quality Monitoring Network in Hungary

In 1995, a strategy for a national air quality monitoring network was prepared consistent with European practices. It is expected to be implemented by the year 2000. Financial problems have hampered progress in the implementation of the monitoring networks which consist of two separate networks coordinated at the national level

The first includes the establishment and operation of an online network suitable for continuous air quality monitoring and feasible interventions in polluted settlements. Less polluted settlements would be controlled by sampling methods. The urban air quality control network will be composed of 87 control stations in 43 settlements.

Secondly, a network must be established to cover the areas outside settlements to ensure the measurement of background pollution away from existing pollution sources and which takes account of transboundary pollution. The air quality network operated outside settlements will consist of 15-20 monitoring stations (currently six stations are in operation).

Monitoring will help to ensure air quality control and provide appropriate information to the public. In that respect, it is necessary to establish and operate regional and national systems of administration and assessment with new units such as a national measurement center, network centers, and a Center for the Air Protection Information System. The measurements are to be coordinated by the Air Protection Reference Laboratory.

Tasks have been modified because of changes in economic and financial sources, as well as technological and scientific developments. The deadline for the project has been moved to 2005 and will likely be regularly revised. The harmonization of EU Directives (96/62 EC and 97/101/EC) has been taken into account when updating the plan.

Source: the Hungary Country Status Report

Act on Protection of the Air against Pollutants, adopted in 1991 (as federal laws of the former Czechoslovakia);

- In Slovenia, the *Law on Environmental Protection*, adopted in July 1993.

In most cases, these comprehensive laws introduce the “polluter pays” principle, specifies the administrative framework and responsibilities of authorities at the national and regional level and arranges financial mechanisms to support environmental projects, including national environmental funds and regional environmental funds. These laws also tend to promote the use of best-available technologies not entailing additional cost for new and retrofitted units, establish the rights of citizens to information on the environment, as well as to information on new projects which may have environmental impact. Where these issues are not covered by environmental legislation, they are addressed by the Constitution.

Related Regulations

Framework laws on the environment are usually supplemented by sets of other laws and subordinate regulations, including laws on air quality and protection that introduces air quality standards. In this regard, SILAQ countries traditionally have well elaborated regulations and standards. For example, in Bulgaria, 171 standards for maximum concentrations were adopted in 1984 and further updated in 1996 by the *Clean Air Act*.

Sulfur dioxide (SO_2), nitrogen dioxide (NO_3), ozone (O_3), carbon monoxide (CO), particulate matter and lead (Pb in aerosols) tend to be those air pollutants regulated in most of the SILAQ countries. The successful enforcement of regulations requires a well-designed and efficient institutional framework and monitoring system.

4.3. AIR QUALITY MONITORING

An important element in successful emission reduction is the construction of a consistent and reliable monitoring system (See Boxes 4 and 5).

All SILAQ countries have established monitoring networks but most require investments for construction of new stations and for the purchase and installation of new equipment.

4.4. AMBIENT AIR QUALITY STANDARDS

Some of the standards adopted by the SILAQ countries have already been mentioned in relation to the health impacts (see Section 2.2). These standards are part of a more general system of standards for SO_2 and particulate emissions adopted by the SILAQ countries which refer to air and fuel quality, and emissions from various sources. The basic compo-

BOX 6: WHO Air Quality Guidelines for Europe

WHO Air Quality Guidelines for Europe aim to protect public health. Ecologically based guidelines for the prevention of adverse effects to terrestrial vegetation and values for protection of vegetation from nitrogen, sulfur oxides and ozone have also been established.

In general, the guidelines address single pollutants, whereas in real-life, exposure to mixtures of chemicals occur, with additive, synergal or antagonistic effects. The guidelines are only tentative, although emissions should be reduced to the lowest achievable level.

Bearing in mind the new scientific data and advances in the field of air pollution toxicology and epidemiology, the Bilthoven Division of the WHO European Center for Environment and Health (in close cooperation with the International Program of Chemical Safety and the European Commission — DG XI) undertook a process of amending, updating and extending the Guidelines. In that respect, further studies on the effect of SO_2 on vegetation were developed in cooperation with the Working Group on Effects of the Convention of Transboundary Air Pollution of the UN ECE. Critical levels for various vegetation categories were established, for ozone, SO_2, nitrous oxides and ammonia. For SO_2, critical loads representing quantitative estimates of deposition were derived.

In 1994, the health risks of exposure to CO, O_3, NO_2, SO_2 and PM10 were evaluated. The effect of these pollutants were considered both individually and in combination. Thresholds for CO, NO_2, SO_2 and O_3 were established, while for PM_{10} dose-response information was provided, giving guidance to risk managers about the major health impacts for short and long term exposure to various levels of the pollutant.

The Final Consultation on the update and revision of the *WHO Air Quality Guidelines for Europe* took place on October 28-31, 1996. The aim of this Consultation was to critically evaluate the recommendations of the various working groups with a view to new emerging information, consistency and transparency in the derivation of the guidelines. The Consultation approved nearly all recommended guidelines and several amendments. The adopted values concerning SO_2 and particulate matter in the *WHO Air Quality Guidelines for Europe* are as follows:

SO_2	0.5 mg/m3 for 10 minutes
	0.125 mg/m3 for 24 hours
	0.05 mg/m3 for 1 year

SO_2	ecotoxic effects
critical level	0.01-0.03 mg/m^3 depending on the type of vegetation
critical load	0.25-1.5 eq/ha/yr depending on the type of soil and ecosystem

Particulate Matter
Based on exposure-response relationship

nents of this system are further discussed below in terms of the existing norms in the SILAQ countries, along with comparison with those standards adopted in other countries, and harmonization with EU standards.

Health-related Standards

The primary standards (related to health effects) for all pollutants are for short-term (less than 1 hour), medium-term (24-hour average) and long-term (annual averages). To protect populations from any adverse health effects originating from acute exposure to air pollution, short-term standards are introduced, while long-term standards are adopted to protect the population from chronic exposure to air pollution.

Secondary Standards

The secondary standards (those related to ecological effects) augment the primary regulations for all pollutants with only the exception of CO. They serve to protect public welfare, including vegetation, materials and visibility. For example, emissions of SO_2 can result in damage to the foliage of trees and crops, and is an integral component of acid rain, which results in the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility. The primary and secondary standards are the same for most of the criteria pollutants.

Air quality standards for the SILAQ countries, the EU and the USA are given in Table 5. Additional information about the WHO (World Health Organization) Air Quality Guidelines for Europe is provided in Box 6.

As shown in Table 5, ambient air quality standards for SO_2 and particulates have been adopted by all SILAQ countries. When related to health effects, the standards in Bulgaria are found to be the most stringent, but as already seen (Tables 1 and 2), are often violated. Romania applies weaker standards for short and medium-term exposure. With regard to standards concerning the ecological effects, the values in Slovenia are the most stringent in the short and medium-term. While the annual air quality standards are equal for Bulgaria and Slovenia, such standards have yet to be adopted in Slovakia. Regulations concerning critical sulfur levels for forests, natural vegetation and

TABLE 6: SO_2 Emission Limits for New Sources

Country	Thermal capacity [MW]	Solid fuels [mg/m³]	Oil-fired [mg/m³]	Gas-fired [mg/m³]
Czech Republic	0.2-5	2,500	<1% S in fuel	35
	5-50	2,500	1,700	35
	50-300	1,700	1,700	35
	>300	500	500	35
Romania	<100	2,000	1,700	35
	100-300	2,000	1,700	35
	300-500	400	400	35
	>500	400	400	35
Slovak Republic	0.2-2	2,500	—	35
	2-50	2,500	1700	35
	50-400	1,700-400 (140-400 MW)	1,700-400 (>300 MW)	35
	>400	400	1,700-400 (260-435 MW)	35
Slovenia	1-5	2,000		
	5-50	2,000	1,700	35
	50-100	2,000	1,700	35
	100-300	2,000-400 (100-500 MW)	1,700	35
	300-500	2000-400 (100-500 MW)	1,700-400 (300-500 MW)	35
	>500 MW	400	400	35

Limit value ranges are calculated on the base of linear decreasing.

agricultural crops are currently being prepared, as well as an annual critical load for the country of 1-2 g S/m².

With regard to total suspended particulates (TSP) and their effects on health, standards adopted by the Czech Republic and Slovakia are the same as those for SO_2 emissions. For Romania and Bulgaria, greater concentrations are permitted. Slovenia has adopted the strictest short-term standards. Values for the particulate, PM 10, are even more stringent with a separate air quality standard related to health effects. As for the air quality standards related to the ecological effects of particulate matter, the values in Slovenia mirror the values for SO_2, while those in Bulgaria mirror the standards related to the health effects of the TSP.

EU Values

In general, the adopted EU standard values are looser than those in the SILAQ countries, but they account for the combined effect of SO_2 and particulates. This is the reason two values appear for SO_2 depending on the concentration of the particulate matter. The synergetic effect of SO_2 and particulate matter on human health is only taken into account by the Czech and Slovak Republics among the SILAQ countries.

The US EPA has established National Ambient Air Quality Standards (NAAQS) for six pollutants (CO, Pb, NO_2, O_3, PM10, SO_2) for the protection of health and welfare. The values for SO_2 and PM10 air quality standards have been effective since 1995 (The National Air Quality and Emission Trends Report, 1995).

For particulates, the annual arithmetic mean standard is attained when the concentration is less than or equal to 0.05 mg/m³, while the 24-hour standard is attained when the expected number of days per year with concentrations >0.15 mg/m³ is $\leq$1. The 24-hour and 3-hour standards for SO_2 are not to be exceeded more than once a year.

In Japan, for example, an extensive regulation scheme exists for SO_2. This consists of an environmental quality standard that refers to: a desirable environmental quality that maintains human health and nature (1974); a so-called *K-value Regulation* which prescribes permissible SO_2 emission limits with regard to the height of stacks (1968); a *Total*

TABLE 7: Particulate Matter Limits for New Sources

Country	Thermal capacity [MW]	Solid fuels [mg/m³]	Oil-fired [mg/m³]	Gas-fired [mg/m³]
Czech Republic	0.2-5	250	100	10
	5-50	150	100	10
	50-300	100	50	10
	>300	100	50	10
Romania	<100	100	50	5
	100-300	100	50	5
	300-500	100	50	5
	>500	100	50	5
Slovak Republic	0.2-2	250	100	10
	2-50	150	100	10
	50-400	100	50	10
	>400	50	50	10
Slovenia	1-5	150		
	5-50	50	50	5
	50-100	50	50	5
	100-300	50	50	5
	300-500	50	50	5
	>500	50	50	5

TABLE 8: Emission Standards by Sources [mg/Nm³]

	Romania		**Slovakia**		**Slovenia**		**Bulgaria**	
Sources	SO_2	Particulates	SO_2	Particulates	SO_2	Particulates	SO_2	Particulates
Smelters	500 g/h 500 mg/m³	500 g/h	2,500 (1,500)	50	500- 1,500	50-150	800	20
Refineries	—	“50mg/m³ (part.<5 mm)	2,500	—	1,700	—	1000	—
Iron and steel plants	—	—	400	100	500	20-50 150	—	30
Cement plants	—	—	400	50	400	50 (150*)	750	80
Pulp mills	—	—	700	100	—	—	—	—

*If total emissions exceed 500 g/h — limit emission concentration is 50 mg/m³, otherwise it is 150 mg/m³.

TABLE 9: Power Plant Emission Standards in Bulgaria [mg/Nm³]

Fuel type	Small power plants		Medium-sized power plants		Large power plants Built before 1992		Large power plants New plants	
	SO_2	**Dust**	**SO_2**	**Dust**	**SO_2**	**Dust**	**SO_2**	**Dust**
Solid Fuels	2,000	150	2,000	120	—	—	—	100
• Domestic coal	—	—	—	—	3,500	200	650	—
• Imported coal	—	—	—	—	2,000	150	650	80
Liquid fuels	1,000	80	1,000	50	1,700	50	650	50
Gaseous fuels	—	—	—	10	—	10	—	10

TABLE 10: Permitted Emissions[1] from Combustion Processes in Poland [g/Gj]

Fuel type	Furnace	Group A		Group B		Group C	
		SO_2	Dust	SO_2	Dust	SO_2	Dust
Hard coal	Fixed grate	990	1,850	720	1,370	650	1,370
	Mechanical grate	990	800	640	600	200	600
	Pulverized coal[1]	1,240	170	870	90	200	90
	Pulverized coal[2]	1,240	260	870	130	200	130
Brown coal	Pulverized coal[1]	1,540	140	1,070	70	200	70
	Pulverized coal[2]	1,540	195	1,070	95	200	95
Coke	Fixed grate	410	720	410	235	410	235
	Mechanical grate	500	310	250	235	250	235
Oil	Boilers <50 MW	1,720		1,250		125	
	Boilers >50 MW	1,720		170		170	

[1]With wet slag removal
[2]With dry slag removal

Rules for existing installations on the day the Ordinance detailing Permitted Emissions from Combustion Processes came into force:

- During the period to Dec. 31, 1997, must comply with the requirements for Group A;
- During the period after Dec. 31, 1997, must comply with the requirements for Group B;
- New installations put into operation after Dec. 31, 1994, should meet the requirements for Group C.

Note: Quantities given in Table 10 should be applied to installations of over 0.2 MW.

Mass Emission Control for SO_2 that details permissible amounts of total SO_2 emissions, and a *Regulation on the Sulfur Content of Fuel* set in 1971 and upgraded in 1976 to a S content within the range of 0.5-1.2 percent.

Most of the SILAQ countries revised their air emission standards during 1991 and 1995 and these standards were harmonized with international values. In Bulgaria in 1994, for example, emission standards were harmonized with International Standards Organization (ISO) and those of the World Health Organization.

4.5. SOURCE-SPECIFIC EMISSION STANDARDS

A further regulation concerning SO_2 and particulates are the emission standards applied for specific sources. These are listed in Tables 6 and 7. Table 8 lists those regulations applied for other sources besides power plants. The regulations for Bulgaria and Poland applied to power plants operating from natural gas, liquid and solid fuels depending on the unit size and the year the plant was built are given in Tables 10 and 11.

The emission standards given in Tables 6 and 7 will be applied to all new power plants once the legislation has been adopted. Meanwhile existing plants in the Czech Republic have to meet the emission standards applicable to new sources within a period of time individually determined for each plant but not later than December 31, 1998. Installation of control technologies is not directly required by the regulations, however, compliance with the standards is the responsibility of the plant operator. Most plants are expected to be retrofitted with flue gas desulfurization equipment.

Flexible Approach

The flexible approach adopted towards existing power plants is common for all SILAQ countries. Compliance with the standards established for new units are to be adhered to by existing plants on a case-by-case basis after so-called feasibility and environmental impact studies. In that transitional period (usually to the end of 1998) existing plants will have to install emission control devices, switch to alternative fuel mixes, etc. The deadlines for meeting the cited standards are within the first decade of the next century.

In addition, Bulgaria has established emission standards for the substitution of existing old plants as follows: the amount of SO_2 should be not higher than 650 mg/Nm^3, or the desulfurization efficiency may not be less than 90 percent in cases where fuel with a high sulfur content is used according to EU standards. As for NO_x, particulates and CO, the following standards must be met: NO_x — 600 mg/Nm^3; particulate — 100 mg/Nm^3; CO — 250 mg/Nm^3.

TABLE 11: SO_2 Emission Standards in the EU for New Plants Burning Solid Fuels

MW	Emission limit value — mg/Nm^3	Desulfurization rate (%)
50-100	2,000	-
100-500	2,000-400 (linear decrease)	40%: 100-167 MW 40-90%: linear increase 167-500 MW
>500	400	90

Note: Should the emission limit be exceeded with high-sulfur coal, the percentage reduction rates or maximum limit of 650 mg/Nm^3 should be applied

TABLE 12: SO_2 Emission Standards in the EU for New Plants Burning Gaseous Fuel

Fuel type	Limit value (mg/m^3)
Gaseous fuels in general	35
Liquefied gas	5
Low calorific gases from gasification of refinery residues, coke oven gas, blast-furnace gas	800

TABLE 13: Particulate Emission Standards in the EU for New Plants

Fuel type	MW	Limit value (mg/m^3)
Solid	>500 <500	50 100
Liquid	All plants	50
Gaseous	All plants	5 as a rule, but 10 for blast furnace gas and 50 for gases produced by steel industry which can be used elsewhere

Note: A limit value of 100 mg/Nm^3 may be applied to plants with a thermal capacity of less than 500 MW burning liquid fuel with an ash content of more than 0.06%.

Romania and Bulgaria apply different emission control standards to existing thermal power plants commissioned before 1992, and to those new power plants commissioned after. If the existing plant doesn't comply with the standards it can continue to operate by paying an environmental fine. If the standard is not met by a new plant, then it is forbidden to operate.

It is very important to note the comprehensive structure of Bulgarian and Slovenian standards that allows for specific cases to be dealt with in a flexible way. These take into account the economic situation of the country and allows for the smooth transition from existing towards more stringent regulations.

EU Harmonization

When comparing the emission standards for different sources, EU standards presented in Tables 11, 12 and 13 should be taken as the reference point. A comparison of the standards show that the values adopted in the SILAQ countries are comparable with EU standards and in some cases mirror them. But full harmonization requires a transition period that allows for a gradual shift towards the new standards without social, administrative or economic setbacks and restrictions.

4.6. FUEL QUALITY STANDARDS

Fuel quality standards regulate the sulfur content of fuels. Since 1994, Slovenia has introduced standards for light oil — 0.6 percent and for medium and heavy oil — 1 percent. In Slovakia, fuel quality standards exist only for sources smaller than 0.2 MW, in which the sulfur content has to be less than 1 percent for liquid fuels. Larger generation units are dealt with through specific emission limits. The standard for hard coal is 0.78 g S/MJ and 1.1 g S/MJ for lignites. These standards have been enforced since January 1, 1998.

In Romania, the standard values for sulfur content adopted are 0.5 percent for light oil,

TABLE 14: Conventional Air Cleaning Systems

Process type	Removal target: SO_2	SO_3	NO_x	By-products	Problems, Remarks
WET WORKING					
Lime-Limestone	YES	NO	NO	Gypsum, $CaSO_3/CaSO_4$	Demand for Gypsum
Magnesium Hydroxide	YES	NO	NO	$MgSO_4$, SO_2 , MgO	Availability of sorbent
Lime-Fly Ash	YES	NO	NO	$CaSO_3/CaSO_4$/Fly Ash	Demand for the by-product
Dual-alkali: primary — NaOH secondary — Lime and Limestone	YES	NO	NO	$CaSO_3$ / $CaSO_4$	Demand for the by-product
Sea water	YES	NO	NO	Wastewater	Availability of sea water
Wellman-Lord Na_2SO_3	YES	NO	NO	S, SO_2 , H_2SO_4	Cost of sorbent, corrosion
Ammonia scrubbing, GEESI Process	YES	YES	NO	$NH_4/_2SO_4$	Corrosion,wastewater
LINDE, $C_{10}H_{22}O_5$	YES	YES	NO	S, SO_2, H_2SO_4	Expensive sorbent
ispra-MARK 13A-Bromine	YES	YES	YES	H_2, H_2SO_4	Expensive sorbent
Hydrogen Peroxides	YES	YES	YES	HNO_3 and H_2SO_4	Expensive sorbent
Wet electrostatic precipitator	NO	YES	NO	Wastewater	Need for caustic and wastewater treatment
SPRAY DRYING					
FLAKT Lime injection	YES	YES	NO	$CaSO_3/CaSO_4$/Fly Ash	Demand for and utilization of the by-product
ROCKWELL, $Na2SO_3$	YES	YES	NO	Na_2 SO_3,/Na_2SO_4, Fly Ash	Utilization of the by-product
DRY WORKING					
UHDE/BPV Activated Carbon	YES	YES	YES	S, H_2SO_4, SO_2	Expensive sorbent
DAS/CDAS, Limestone, Lime and slacked Lime	YES	YES	NO	$CaSO_3/CaSO_4$ and Fly Ash	Utilization of by-product
Electron Beam	YES	YES	YES	$NH_4/2SO_4$ and NH_4NO_3	Energy consumption

≤2 percent for medium oil, 1-3.3 percent for heavy oil, 1-3.5 percent for hard coal and 0.8-2.4 percent for lignites.

In Bulgaria, the fuel quality standards for sulfur content are: <1 percent for low-sulfur content oil, a range of 1.1-2 percent for medium-sulfur content oil, and >2 percent for high-sulfur content oil. For solid fuels, standards for hard coal require a sulfur content in the range of 0.8-4.4 percent, while for lignites they are in the range of 0.7-6.5 percent.

Differences

Where air quality standards exist with relatively uniform values in the SILAQ countries, large deviations exist for fuel quality standards. For example, Slovenia adopts strict and comparatively stringent values for liquid fuels, while Slovakia has applied relatively stringent standards of 1 percent upper limits for all liquid fuels since January 1, 1998. At the same time, Romania and Bulgaria have set different standard values for light, medium and heavy fuel oils.

As for solid fuels, Romania and Bulgaria have set a range of values for sulfur content standards, that are less stringent in the case of Bulgaria, for example, allowing the sulfur content of lignites to vary within the range of 0.7 to 6.5 percent. Slovakia has adopted strict standards expressed in g S/MJ.

EU Directive

With regard to fuel standards, the EU Directive 93/12/EEC from March 23, 1993 for *the Sulfur Content of Certain Liquid Fuels* should be taken as a reference point for comparison. It sets forth the sulfur content of diesel fuel which must be less than 0.05 percent on weight basis, and the gas oil sulfur content which must be <0.2 percent. Fuels with a higher sulfur content cannot be traded within the EU. This has to be taken into account by all CEE countries and to be incorporated into their fuel quality standards.

TABLE 15: Sulfur Dioxide Content in the Flue Gases of Worldwide Thermal Power Stations

Country	*Location*	*Flow rate* Nm^3/h	*Content* SO_2 *ppm*
Bulgaria	Maritza East	1,500,000	5,500
Germany	Heilbrunn	1,225,000	1,125
Germany	Goldenberg	1,680,000	1,820
UK	Drax No. 1	1,680,000	1,546
USA	Georgia Power	2,534,000	1,800
Czech Republic	Prunenov No. 2	1,100,000	2,600
Poland	Polaniec No. 5	2,200,000	1,225
Croatia	Plomin PS	830,000	1,480
China	Luohuang	1,087,000	3,700
Japan	Matsuura	2,450,000	993

TABLE 16: Nominal Performance and Costs of Gas Reburning and Integrated Technologies

System type	**Emission control, %**		**Cost factors**		
	NO_x	SO_2	Capital cost (USD/kW)	Capital and operating costs (mills/kWh)	Pollutant removal (USD/ton)
Gas Reburning (GS)	60	18	30	2.8	254
Gas Reburning — Sorbent Injection (GR-SI)	60	50	90	8.0	388
Gas Reburning — Low-NO_x Burners (GR-LNB)	70	18	50	3.3	270

Based on 1 USD/10^6 Btu coal to gas differential
Source: Clean Coal Technology , NO_3, September 1993

5. Emission Reduction Measures

Successful measures used to reduce local air pollution in urban areas have included the regulation of fuel for domestic heating (e.g., low-sulfur oils and coals) introduction of natural gas instead of coal and oil, development of district heating, and restrictions to the use of cars in city centers. Furthermore, fly ash and dust removal installations in industrial sources and large boilers have resulted in major improvements, while cost-effective energy conservation measures and the substitution of fossil fuels for renewable energy sources offer further potential for the reduction of emissions.

These measures have been particularly successful in reducing SO_2 and particulate concentrations in the air. However, there has been little evidence of similar downward trends in No_x concentrations.

5.1. TECHNOLOGICAL MEASURES

Many countries have begun to pass more stringent air quality regulations which require improved efficiency in pollutant removal. Technologies that ensure the removal of these pollutants and develop by-products from them, besides dealing with the sludge produced, are likely to grow in importance.

Flue Gas Desulfurization

The technology most commonly used to remove SO_2 is known as flue gas desulfurization (FGD). Desulfurization of stack gas is commonplace in Japan, the US and Germany. In Japan, more than 1,800 such units operate alone. This is largely because of the strict the emission regulations whereby a tax is imposed on a factory that emits even below the SO_2 standard. As a result, FGD facilities have been installed even for small boilers. Fewer numbers of FGD units are used in the US owing to its less stringent air pollution standards.

Dust Removal

The most commonly used dust-cleaning systems are “dry types” — electrostatic precipitators and bag filters. Not only in the SILAQ countries but across the CEE region, these have most commonly been used in recent years in the metallurgical and energy sectors. The “wet-absorption type” systems are most commonly found in the chemical industries, where recycling of absorbent is possible or further technological treatment is applied to extract and/or use some of the components or by-products.

It has been shown that the efficiency of electrostatic precipitators in the SILAQ countries is relatively high with a cleaning rate in the range of 97-98 percent. When bag filters are used as alternatives to electrical precipitators, the dust content far exceeds EU standards and is usually it is within the range of 5-10 mg/m^3 . The wet dust type cleaning systems can give better results, but problems with secondary pollution and the use of by-products can result in the need for further treatment.

The selection of an air filtering system should therefore consider a number of separate issues, the most important of which include:

- Selection of dry or wet type cleaning systems (sorbent or chemosorbent type), and in particular the cleaning rate, cost, selectivity, capacity, heat balance, availability of sorbent, etc;
- Selection on the basis of implications from possible secondary pollution such as waste-water discharges, waste suspension or solid wastes;
- Selection on the basis of the by-products released and the possibility for their direct use, recycling, and other means for utilization, disposal costs, environmental and human risks;
- Selection of a total universal cleaning system that offers opportunity for the removal of most or all harmful components from waste gases — SO_2, NO_x, dust etc.

Preventive Measures

Besides "end-of-pipe" technologies there are also other ways to reduce the air pollution caused by combustion processes. Such examples include:

- Changing the fuel mix, and using additives;
- Increasing the conversion efficiency;
- Introducing low emission combustion or conversion processes;
- Fuel cleaning.

Flue gas cleaning systems have been implemented world-wide and such systems have been introduced more recently in the SILAQ countries. The feasibility studies performed and national environmental action plans all target considerable investment in the coming years for such systems. A list of the conventional air cleaning systems are given in Table 14.

The performance targets of flue gas cleaning systems vary considerably, while different kinds of plants and the requirements regarding SO_2 removal efficiency will also have a bearing on the results of such processes. The type and composition of the fuels are further factors that can affect performance. Table 15 summarizes the various levels of SO_2 found in the flue gases of different kinds of thermal power stations. Among other issues to be considered when selecting an FGD unit are the operational costs, environmental and health benefits, and whether any other similar actions have already taken place.

Such variations in flue gas concentrations are related not only to SO_2 content, but also to water vapor, SO_3, NO_x and other pollutants. Being aware of the level of such contents is essential for optimizing the performance of the cleaning systems, and therefore feasibility studies are of great importance for successful project implementation

SILAQ Practice

Within the SILAQ countries, different cleaning systems are operated or are in the process of being implemented. Wet working lime-limestone systems tend to be more commonplace, however, dry cleaning systems tend to offer a number of clear advantages, indicating interest in these systems in the near future will grow. They do, for example, meet those standards otherwise achieved through "clean technologies" and are consistent with the goals of sustainable development.

Further studies concerning the efficiency of newly implemented installations in the SILAQ countries and others in the coming years may help to show new trends and indicate the values of certain cleaning systems over others. For example, while common in the US, gas reburning and sorbent injection methods, either separate or combined, are not widely used in the SILAQ countries. While they might be advantageous, the application of gas-reburning and integrated technologies would require modification to existing power plant equipment and the related capital and operating costs would have to depend on a number of site-specific factors. Some data related to the performance and cost of such systems is given in Table 16.

BOX 7: Investing in Pollution Control in Central and Eastern Europe

In 1990, the energy intensity of economies in Central and Eastern Europe was estimated to be some 3 times higher than that of Western Europe; emissions of NO_x and SO_2 were estimated to be more than 4 times higher; while particulate matter was considerably higher per unit of GDP. Within the framework of the *Environmental Action Plan for Central and Eastern Europe*, a joint study was conducted by the World Bank, RIVM, and Resources for the Future, on the likely impacts of different levels of cleaner production technologies on atmospheric pollutant levels in the CEE region. Four scenarios were studied as follows:

- Base case — only new installations are equipped with current Western European technologies;
- Accelerated substitution — old as well as new installations are equipped with current Western European technologies by 2010 and fuel is switched from coal to gas;
- BAT policy — old and new installations are equipped with the best available technologies (BAT). Only gas and non-fossil fuels are used.
- Worst case — old equipment remains operational and no switch is made from coal to gas.

The results for SO_2 and particulate matter emissions are given below:

Percentage reduction from 1990 to 2010

	Base case	Accelerated substitution	BAT policy	Worst case
SO_2	60	95	98	30
Particulate matter	55	97	99	35

The analysis shows that the retrofitting of old installations could reduce emissions to a level that is sufficient to meet most environmental quality goals and standards such as the WHO standard for particulate and sulfur or the acidification targets within the framework of UN ECE.

In the base case scenario, investments are assumed to be USD 175 billion per year. Accelerated substitution would bring sulfur dioxide emissions down to acceptable levels and would require an additional USD 50 billion per year, raising the total to USD 225 billion (60 percent in Eastern Europe, 15 percent in Central Europe and 25 percent in the Balkan region). However, the worst case pollution scenario from a human health point of view can be improved by addressing local sources of SO_2, with about 10 percent of the additional investment level (i.e. USD 5 billion per year). This would be an obvious starting point.

Source: RIVM, 1993. Scenarios for Economy and Environment in Central and Eastern Europe. Document prepared for the World Bank within the framework of the Environmental Action Plan for Central and Eastern Europe. National Institute of Public Health and the Environment (RIVM). Bilthoven, the Netherlands.

Capital Requirements

It is obvious that feasibility studies should be made on a case-by-case basis since the economic efficiencies of all the available technologies may vary widely. This could be the focus of future SILAQ studies.

5.2. AIR POLLUTION REDUCTION TARGETS

Workshop/Study

Questionnaire data was not extensive enough to provide specific information on the existing installations and the nature of flue gases in use in CEE. Evaluating the current status and defining targets for air pollution reduction is therefore somewhat difficult. Box 7 however, provides an overview of a separate study which examined the possible impacts of different cleaner production technologies on atmospheric pollution levels in the CEE region. In response, a more extensive assessment of those cleaning systems implemented in the SILAQ countries, which might include many more indicators and criteria such as a cost-benefit analysis is suggested. A study and workshop assessing flue gas cleaning systems could also be useful for authorities, decisionmaking experts and officials in evaluating the various options available for meeting future pollution reduction targets based on this assessment. Case studies for selected areas concerning the health status of individuals and environmental losses may give additional information, and contribute to establishing targets and means for pollution reduction.

BOX 8: National Environmental Policy in Bulgaria

Most regulations implementing the Clean Ambient Air Quality Act (adopted in 1996) are currently being drafted and are closely linked to SO_2 and dust reduction. They provide a regulatory basis for reduction targets and among those already passed include:

- Regulation on upper admissible concentration levels for harmful substances in the ambient air of human settlements;
- Regulation on admissible levels (concentrations in waste gases) for harmful substances emitted to ambient air by stationary sources;
- Methodology for calculating the height of discharging facilities, the dispersion, and the expected concentrations of polluting substances in the lowest layer;
- Bulgarian State Standards (BSS) for standardized methods of automated monitoring of emissions of dust, SO_2, CO, NO_x, O_3 and CnHm;
- Regulation on threshold concentrations of harmful substances in ambient air for SO_2, NO_x, CO, O_3;
- Regulation on issuing permits for operation of sites and facilities.

The preparation of all regulations is in accordance with corresponding EU Directives and is performed with the support and assistance of the EU.

BOX 9: National Environmental Policy in Poland

In 1991, the Polish Parliament approved the *National Environmental Policy*. Among its medium-term objectives (to 2000) related to SO_2 and particulate matter are the limitation of SO_2 emissions to 2.9 million tons; limiting emissions of particulates by 50 percent compared to 1990 levels; and increasing the mean efficiency of dust removal to 96 percent . Within the long-term objectives (to 2010), stated measures include the total elimination of individual coal-fired burners in urban agglomerations and spa areas; the introduction of catalytic converters to all cars manufactured and in use; reduction in emissions of SO_2 and other gases to levels agreed at international fora. The medium-term objectives for SO_2 was achieved by 1992. In 1995, an *Executive Program to the National Environmental Policy for 1994-2000* was discussed.

In 1996, the Parliament approved the *Assumptions Underlying Poland's Energy Policy to the Year 2010* which takes consideration of the environmental issues.

Pursuant to the Parliament's decisions several ministers agreed upon the need to draw up a *National Program for Reducing Emissions of SO_2 by the Year 2010*. This should help Poland meet its commitments arising under the Second Sulfur Protocol. One element of this is the *Program for the Reduction of Emissions of SO_2 in the Power Supply Industry*, approved in 1996. This anticipates the reduction of SO_2 emissions from the sector to 700,000 tons by 2010.

5.3. POLICY MEASURES

Among the driving forces behind reducing SO_2 and particulate emissions in the SILAQ countries are the UN Conventions related to air pollution. Learning from Western experiences, most of the countries' main efforts have been concentrated in the following directions:

- Development and introduction of new legislation, harmonized with the standards of the European Union;
- Development of national action plans and strategies;
- Improvements in monitoring and control systems;
- Introduction of new economic instruments;
- Implementation of new cleaning systems and new combustion technologies.

EU Harmonization

Over the last three years, the SILAQ countries have harmonized almost all their principle domestic legal acts with those of the EU. New air pollutant limits introduced across the region are very close or even identical to their EU counterparts, while in other countries, new regulations are now being drafted.

Country Targets

As part of the transition process, most SILAQ countries tend to include their emission reduction targets within the wider context of national policies, including national programs, regulations and economic instruments. The examples given in Boxes 8-11 help to illustrate the actions currently taking place.

Slovenia, for example, has set itself ambitious SO_2 reduction targets and its program incorporates a list of actions to be undertaken by different stakeholders at different levels while at the same time employing a variety of different instruments.

National programs are therefore able to take advantage of numerous reduction

BOX 10: Air Pollution Abatement in Slovenia

Based on the *Slovenian Law on Environmental Protection* (Official Gazette 32/93), and the program for the preparation of by-laws, a number of acts were adopted in the area of air protection. Some acts were adopted as Decisions of the government and some were termed Decrees of the Ministry of the Environment. Amongst the most important are the Decisions in the area of liquid fuels adopted at the beginning of 1995 that prescribe standards, and determine the upper levels for sulfur in gasoline and in heavier oils.

Power plants are the biggest source of air pollution in Slovenia. In 1993, they contributed some 81 percent or 139,435t to the total SO_2 emissions in Slovenia. Despite the substantial investments needed, the upgrading of power plants has been successfully achieved to a level in which it is possible to reach the emission levels set by the law. Significant results have been achieved also in terms of the reduction of emissions from industrial sources through the closure of polluting industries and the introduction of new technologies.

An important part of the overall framework are local measures. Local authorities have undertaken various actions both in the regulatory area (Decisions, Measures), and in the area of improved gas supply to households and heating networks of cities. Thus Maribor (the second largest Slovenian city), succeeded in reducing SO_2 emissions by half during the period 1990-1993 due to more active and strict regulation and gasification and heating network.

Also of considerable importance are the inspections and institutional efforts undertaken in reorganizing air protection responsibilities among local public services (Official Gazette 32/93). On a national level, a short-term action program to reduce air pollution and switch to cleaner fuel has been organized by the Ministry of Environment and Physical Planning and has been running since 1992. The Ecological Development Fund, meanwhile, in cooperation with the World Bank, provides loans to consumers encouraging their switch to environmentally friendly fuels.

options, considered to be the most suitable for the circumstances of a particular country.

Economic Instruments

Regulation, or the use of 'economic instruments' is an approach that has grown in importance in recent years and is used successfully as the driving force in all SILAQ countries for reducing emissions. Among the most popular instruments, charges, fines and taxes are used to regulate polluters. These revenues generated by these measures are collected in "Eco-funds" and play an important role in the financing of actual control systems and in the implementation of policy measures.

There are, however, drawbacks in the use of direct regulations, including their lack of flexibility, their increasing costs and their complexity. Nevertheless, where market mechanisms are starting to take root in the SILAQ countries, the regulations in the short run will remain the best and most significant option in properly addressing environmental issues and in particular air pollution.

Expected Emission Increases

Nevertheless, growth in industrial activity and total energy consumption in the SILAQ countries consistent with economic recovery, is expected to lead to a rise in SO_2 and particulate emissions, particularly in those countries where measures like those above have yet to be taken. The question then is not just whether the levels of emissions will increase proportional to the total energy demand and production growth rates, but whether they will rise proportional with the growth in demand for individual fuels, the efficiency of the technologies applied, and according to the extent and enforcement of new environmental policies, legislation and regulations.

Emission Controls

In terms of actual emission controls, Hungary, the Czech Republic, Poland, Slovenia and Slovakia have already introduced a number of cleaning systems, with the main installations at industrial plants in Slovenia completed, and those in the Czech Republic, Hungary and Slovakia due for completion this year. Installations in Poland will be completed next year. Bulgaria and Romania are still at an earlier stage of development. As mentioned earlier, the efficiency of new cleaning systems could be a topic of further study in the coming years, and could help each country understand the costs and benefits from the actions taken. The progress achieved in the adjustment of the monitoring and control systems to the requirements of US EPA would be a good pre-condition for such an assessment.

Shift Needed

While some of options such as the installation of desulfurization devices, electrical filters or the enforcement of taxes and charges can help in the short-term, "end-of-pipe"

BOX 11: Strategies and Policies in Air Protection in the Slovak Republic

The protection and regulation of the environment is managed by the Ministry of Environment and is implemented through its three inspectorates and through the Offices of the Environment (technically under the Ministry of Interior). The Ministry of Economy is responsible for energy issues. The energy sector has been partly privatized.

The *National Environmental Action Program (NEAP)* was adopted under Government Resolution No. 350 on May 14, 1996, and was first among the CEE countries. A document presenting the "Strategies, Principles and Priorities of the Governmental Environmental Policy" (NEP) was adopted by the parliament on November 18, 1993. Air quality protection is among the priorities established under the NEP combined with a list of short, medium and long-term objectives and overall priorities and principles.

The measures and objectives coincide partly with the goals of the *Act of the Ministry of Environment 208/1996 on Emission Reduction Programs* and obliges individual sources of air pollution to initiate their own reduction programs and to pass disclose details of these to the responsible local authority that supervises and regularly evaluates it.

Among the legal framework, the following acts and regulations apply:

Legislative Framework

- Law 309/1991 on air protection
- Law 134/1992 on state management of air pollution
- Law 311/1992 on penalties for air pollution
- Act of the Ministry of Environment No. 111/1993 on issuing expert opinions the matters of air protection, appointing persons authorized to give such opinions and verification of their professional abilities
- Act of the Ministry of Environment No. 2/1993 on specifying areas requiring special air protection and on operation of smog warning and regulatory systems
- Government regulation No. 92/1996 regarding emission standards, categorization of pollution sources and list of the polluting substances
- Act of the Ministry of Environment No. 299/1995 on conditions for appointing persons authorized to carry out emission and ambient air quality measurements
- Act of the Ministry of Environment No. 208/1996 on reduction programs
- Act of the Ministry of Environment No. 41/1997 on emission measurement
- Act of the Ministry of Environment No. 268/1997 on fuel quality requirements

Regulatory Measures

- Ambient air quality standards
- Fuel quality standards
- Emission standards

Economic Instruments

- Emission charges, taxes and fines
- Subsidies

measures are no substitute for the preventive approach which perhaps has to be the more serious long-term policy measure. A clear shift from technical based measures towards government and policy related options is being noted in the SILAQ countries, as the benefits of other measures like the decommissioning of old coal-fired power plants, switching to natural gas, the use of renewable energy, and implementation of new state-of-the-art technologies are realized (see Box 12).

Economic incentives, changes in fuel mixes (e.g., increasing the share of renewable energies), energy conservation, demand-side management, enhanced penetration of new technologies, and promotion of energy efficiency can be considered some of the other preventive measures available. Public information, however, should also be provided and improved public awareness (see Box 13) should give rise to greater knowledge, understanding and public participation.

BOX 12: Anticipated Results of the Decin Project in the Czech Republic

This project was initiated primarily to address the urgent ecological and health problems in the city of Decin related to sulfur dioxide (SO_2) emissions and violation of the WHO health limits. The project envisages a fuel switch from coal to natural gas, the installation of a co-generation facility, and the improvement of efficiency in the heat distribution network. The implementation of the project will result in the reduction of carbon dioxide (CO_2) emissions by 6,000 tons/annually, sulfur dioxide (SO_2) by 95 tons/annually, and particulate matter by 3,190 tons/annually.

Source: Billharz, 1996

BOX 13: Public Awareness

The results of a survey conducted in the summer of 1995 indicates that 82 percent of Europeans consider protecting the environment an "immediate and urgent problem", while 72 percent consider it necessary to protect the environment while ensuring economic development. This feeling of urgency and environmental awareness has yet to become a common belief among the SILAQ countries. The experiences of the EU, US and other countries should be used in raising public awareness to environmental issues and encouraging public participation with regard to air quality issues. Improved awareness can help to increase acceptance of "green taxes" and encourage the backing of initiatives like the "Public Participation" Convention. Interestingly, most Europeans see the introduction of "green taxes" as an effective instrument contributing to environmental protection and are willing to support their introduction.

BOX 14: Economic Instruments Available to Environmental Managers in the Field of Air Quality Improvement

- **Charge Systems** — (pollution charges, user charges, betterment charges, impact fees, road tolls, etc.)
- **Fiscal Instruments** — (pollution taxes, input taxes, product taxes, export taxes, import tariffs, tax differentiation, investment tax credits, accelerated depreciation, subsidies)
- **Financial Instruments** — (subsidies, soft loans, grants, location incentives, subsidized interest, revolving funds, sectoral funds, eco-funds, green funds)
- **Property Rights** — (ownership, use and development rights)
- **Market Creation** — (e.g. tradable emission permits)
- **Liability Systems** — (legal liability — non-compliance charges; joint and several liabilities, liability insurance, enforcement incentives)
- **Bonds and Deposit Refund Systems** — (environment performance bonds, deposit refund systems/shares)

BOX 15: Environmental Standards, Pollution Charges and the Environmental Protection Fund of the Czech Republic

Environmental protection in the Czech Republic is based on the application of both emission standards and pollution charges. Operators who pollute the air from 1998 are required to comply with emission standards that are comparable to those western levels of 1986. Polluters who do not comply with the standards pay an additional charge which is over and above the fixed charge. A differentiation is made between new and existing facilities so as to minimize social costs and maximize the ability of managers at older facilities to make the necessary investments in abatement technologies during the transition period.

Revenue raised from emission charges are collected by the State Environmental Protection Fund and channeled into air pollution projects co-financed by municipalities and private entities. An Air Pollution Fund has also been established by utilizing a percentage of the revenues from the first wave of privatization, and is used for investments in gasification projects in heavily polluted communities. The suspension of pollution charges during the period of installation of new technologies is an example of an economic incentive applied. The evaluation of possible tradable emission permits is currently underway.

Source: An Overview of the Czech Republic's Experience with Economic Instruments in Attaining Improvements in Environmental Protection

5.4. ECONOMIC INSTRUMENTS

During the course of transition to a free market economy, economic instruments are playing an increasingly important role in the SILAQ countries in environmental policy. Compared with most West European countries, the rule of law as a fundamental principle of society is less well established, and as a consequence poor enforcement of environmental legislation results. At the same time, however, the majority of private and business entities in the SILAQ countries are becoming more responsive to monetary signals such as fees and fines and financial incentives (e.g. tax exemptions), that are proving economic instruments to be more and more efficient in achieving emission reductions.

In this situation, economic instruments complement command and control mechanisms and, allow for environmental problems to be addressed more quickly, more effectively and/or in a more cost-efficient manner. If the rates of economic instruments are set high enough, both a reduction in the level of pollution and the prevention of the over-exploitation of natural resources can be achieved.

Environmental Benefits

When further discussing the role of economic instruments in the SILAQ countries, it should be noted that the OECD definition will be used in the analysis. This stipulates that economic instruments are "instruments that affect costs and benefits of alternative actions open to economic agents, with the effect of influencing behavior in a way that is favorable to the environment." A list of selected economic instruments is provided in Box 14.

The following pages will focus only on those economic instruments that have been used or plan to be implemented in the SILAQ countries.

Economic instruments have been in use in the region for several years. Today a mixture of new instruments are being introduced, while older instruments are being revised. Examples of these instruments include: pollution charges and taxes (air, water, waste); non-compliance charges ("environmental fines"); product charges (e.g., on gasoline); deposit refund systems; import tariffs (e.g., for old cars); and tax differentiation or exemption (e.g., lower taxes for unleaded gasoline/petrol and tax relief for environmental equipment or investment). Some countries are now considering the introduction of tradable pollution permits.

Environmental Costs

In most of the SILAQ countries, prices for resources (water and energy) have increased, but still remain well below the detrimental cost to the environment. Product charges have not been widely adopted, although one exception is the product charges on fuel in Bulgaria and Hungary. Energy taxation has been discussed in several of the transition countries, in Poland and the Czech Republic for instance, but it is not likely these taxes will be introduced in the near future.

Several examples are given below of the successful use of different economic instruments.

Fines

Environmental fines for non-compliance with emission standards are used in most of the transition countries. In the Czech Republic, Poland and Slovakia they are used in addition to emission charges. In Bulgaria, Hungary and Romania environmental fines are charged only for non-compliance with emission standards. Environmental fines are found to be the highest in Poland, some 10 times greater than the emission charge.

Levels of *emission charges* are typically low in the SILAQ countries, but are now being revised in the process of legal approximation with the EU. The number of pollutants regulated and the levels of emission charges still vary substantially from country to country. In the Czech and Slovak Republics, 80 pollutants are subject to charge, while in Poland 60 are listed. With regard to the levels of charges made across the region, rates in Poland in 1993 for sulfur dioxide (SO_2) and nitrogen oxides (NO_x) were found to be several times higher than those in the Czech and Slovak Republics (Klarer, 1996).

Charges

Environmental charges for the use or pollution of air, water and waste, together with pollution fines and fuel taxes are common revenue raising tools for national and regional environmental funds in all the SILAQ countries except Romania where no fund has yet been established (see Box 17). Financing is provided for a number of priority areas including support for national environmental programs, the implementation of new environmental legislation and regulations through investments in end-of-pipe pollution abatement technologies.

Debt Swaps

In Bulgaria and Poland, funds have been used to support 'debt-for-nature' swaps. This scheme frees up funds for investments in environmental protection that would otherwise be committed to clearing international debts. These new fundraising and investment mechanisms will facilitate the efforts of SILAQ countries in meeting more stringent envi-

BOX 16: Use of Economic Instruments in Poland

The environmental charges and fines adopted in Poland are among the highest in the world when expressed in USD per metric ton of pollutant. Facilities which operate without a valid permit are liable to pay twice the normal charge for each unit of emission.

In addition to the environmental charge, there is a system of non-compliance fines for all discharges above legally or administratively set limits. In contrast to the regular charges — which are treated as a production cost — non-compliance fines are payable from the after-tax income. Being 10 times the regular charge, their effect tends to be somewhat more substantial. In cases of serious non-compliance, which can result after 3 years for non-payment of fines, fine rates are doubled. Provisions do exist which allow for payment to be deferred or even full forgiveness of fines in cases where the polluter undertakes environmental investments which bring facilities into compliance.

Other economic measures in use are income tax allowances in the form of deductions from environmental investments, the lower excise tax on liquid fuels with low sulfur content, and tariff exemption on the import of environmental protection equipment.

Environmental funds play a further crucial role in national environmental policy, providing different loans and grants for environmental investments.

In addition to the traditional economic instruments and in compliance with the market mechanisms, a pilot project for the trading of SO_2 emissions is under development. Tradable emission permits provide an opportunity for the successful achievement of emission reduction programs in the energy sector by 2040, and provide a strategy for minimizing the social costs of achieving reduction targets.

The high level of environmental charges and fines adopted in Poland together with other environmental and energy, economic and regulatory instruments have had a very positive impact on pollutant emission trends in recent years.

Source: Economic instruments in the environmental management in Poland

ronmental regulations and will assist them in pursuing their commitments to European Union accession. However, even with additional European Union finance and support, further schemes for generating new sources for domestic environmental finance (or re-designing existing methods) remains very important.

6. Implementation Strategies

Most of the SO_2 and particulate emission reductions which have taken place in Western Europe since the nineteen-eighties were due to a switch from coal to oil and gas, the increased use of nuclear energy, and technological improvements in desulfurization and dust removal installations.

In CEE, significant pollution reduction can be achieved by switching to gas and low-sulfur coal, more widespread use of district heating, the fitting of end-of-pipe equipment including flue-gas desulfurization, the application of energy saving measures, and the implementation of energy-efficient installations and advanced combustion technologies.

Much of the needed progress will be achieved by CEE countries as a result of obligations stipulated in various international conventions, and due to the harmonization of domestic regulations with those of the European Union.

6.1. EU APPROXIMATION AND INTERNATIONAL PROTOCOLS

During the course of EU accession in the SILAQ countries, it is worth emphasizing the process of harmonizing domestic environmental strategies, legislation and regulations. Although this section focuses mainly on the SILAQ countries, it refers in general terms to all ten countries in Central and Eastern Europe that have signed the Europe Agreement, including Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia. Besides assigning some preferential trade treatment, the Europe Agreement also calls for the harmonization of environmental regulations and legislation (Simeonova and Missfield, 1997).

5th Environmental Action Program

All existing environmental policy and legislation in the SILAQ countries is now being revised according to the goals of the EU's Fifth Environmental Action Program "Towards Sustainable Development." Within this framework the major areas concentrated upon include: climate change; ozone-depleting substances; acidification and air quality; water

BOX 17: Air Quality Control in Hungary

A financial scheme established as part of the Intersectoral Air Quality Control Action Program allocates resources to local governments and business circles for investments related to the improvement of air quality in Hungary. Further assistance is provided by the Central Environmental Protection Fund managed by the Ministry of Environment, which acts as a repository for pollution fines and environment product charges, as well as foreign assistance schemes. Local governments are entitled to receive up to 60% assistance from the CEPF to implement the AQQAP program. Funds are provided in the form of credit (with 30% disbursed as a grant and 30% as a loan, subject to reimbursement). The loan, available both to local governments and companies, is offered either interest free or as part of a soft-interest scheme.

quality; urban environment and waste management. A parallel objective in this process is to incorporate the fundamental principles of EU environmental policy and legislation into national legislation. The process of approximation is to a large extent, based on the EU Directive on Integrated Pollution Prevention and Control (IPPC) and sectoral legislation, for example in the field of air pollution, energy, agriculture, forestry and waste.

EU Assistance

Various instruments are used by the EU to facilitate the SILAQ countries' accession, including the Environmental Approximation Facility, the Environmental Pre-Accession Strategy, the PHARE Programme (Poland and Hungary, Action for Reconstruction of Economy), and the Technical Assistance Information Exchange Office to the PHARE program. Associated EU Member States have acknowledged the role of the EU's approximation instruments in addressing the most important issues related to achieving overall environmental improvement. Some of the areas concentrated upon have included the development and harmonization of legislation in the field of environment and energy legislation, institutional reform and capacity building.

International Commitment

Of paramount importance to the process of shaping national environmental policies in the SILAQ countries are those international environmental laws and conventions which have been signed over the course of the last ten years. This includes the Convention on Long-Range Transboundary Air Pollution and its Sulfur Protocol, the Vienna Convention for the Protection of Stratospheric Ozone and Montreal Protocol, and the UN Framework Convention on Climate Change (UN FCCC).

FCCC

As a result of the drastic decreases in industrial output during the transition process and new national environmental legislation and regulations, all the SILAQ countries are likely to meet their commitments to international conventions and laws. Under the UN FCCC, all countries expect to return greenhouse gas emissions to their 1990 levels by the year 2000. In some countries, such as Bulgaria and Poland, ensuring compliance with the requirements of the Montreal Protocol will remain problematic. Given the economic difficulties in all SILAQ countries, further implementation of their respective commitments will depend strongly on the availability of financial resources to implement specific projects. Among the donors of these sources is the Global Environmental Facility (GEF). GEF was created as a follow-up to the UN conference on Sustainable Development held in Rio for the financing of projects related to climate and the phase-out of ozone depleting substances.

CLRTAP

With regard to SO_2 emissions, SILAQ countries are also implementing measures for their reduction as signatories of the Convention on Long-Range Transboundary Air Pollution. The Convention was supplemented in 1994 by the Protocol on the Further Reduction of Sulfur Emissions which set different targets and timetables based on the critical load concept. The EU's Member State commitments under the Sulfur Protocol led to a consolidated overall 55 percent reduction target in SO_2 emissions in the EU by the year 2000 as compared with 1985 levels. All SILAQ countries signed the *Second Sulfur Protocol to the Convention on Long-Range Transboundary Air Pollution* on June 14, 1994 in Oslo. The targets agreed for Bulgaria, for example, require the total reduction of SO_2 emissions reduction by 33 percent, 40 percent and 45 percent by the years 2000, 2005 and 2010 respectively in comparison with 1980 levels (2,050 kt). In Slovenia and Hungary, the reduction targets for the same years are 45 percent, 60 percent and 70 percent, while in Romania the aim is a 20 percent reduction by the year 2000. Slovakia has also signed the Second Sulfur Protocol and is now preparing to ratify it. According to national projections, SO_2 emissions by the year 2010 in Slovakia should be between 121 and 161 thousand tons (kt), depending on GDP growth.

BOX 18: Intersectoral Program to Improve Ambient Air Quality in Hungary

In December 1993, the Hungarian government adopted a proposal submitted by the Ministry of Environment and Regional Policy aimed at launching an intersectoral program to improve ambient air quality. The preparation of the 5 year program involved the participation of the Ministry of Environment and Regional Policy, the Ministry of Transport, Telecommunications and Water Management, the Ministry of Welfare, the Ministry of Industry and Trade, the Ministry of the Interior, and the Ministry of Finance. The implementation of the program required the participation not only of the above listed Ministries but also of regional and local environmental, health and other authorities, local governments and business. The objective in terms of SO_2 output is a reduction of 13-18 percent by 1998, compared with 1991 levels (from 902 kt/yr to 120-160 kt/yr). The program is supported by a detailed workplan which lists responsibilities, deadlines, and addresses financial aspects. The costs of the program are to be covered by the central funds (e.g., the Regional Development Fund, and the Central Environmental Protection Fund) as well as local communities, with both parties benefiting from further resources made available through international assistance schemes.

Source: Intersectoral Air Quality Control Action Program in Hungary— report to the Ministerial Conference, Environment for Europe, Sofia, Bulgaria Oct. 23-25 , 1995

6.2. NATIONAL POLICY ISSUES

While only a few elements of the overall reform process in the SILAQ countries have been highlighted in this Report, the changes in political, economic and social systems and their impact on the environment has been a far-reaching process.

The removal of subsidies and the respective increases in energy prices to realistic market values is one such example. In most of the transition countries this policy is now at an advanced stage, especially in the Czech Republic, Poland and some of the Baltic states. While this policy creates incentives to promote energy efficiency in all sectors of the economy, even in these countries there has been serious concern for the increasing social problems for the average household resulting from rising energy prices. Nevertheless, the policy helps to decrease the energy intensity of the national economy and industrial production, increases the penetration of renewable energy technologies, and results in substantially lower levels of emissions from combustion processes.

Privatization

Another element of reform is the change in ownership and property rights through privatization. In the past environmental regulation failed to meet its objectives because enforcement was poor, even meaningless, since the state was the regulator and the regulated. With privatization, both enterprises and land have become the property of individuals and firms, ensuring that the owners have to be responsive to market conditions and incentives, thus creating a fundamental mechanism for the rational use of energy and other resources. Privatized enterprises are now forced to ensure compliance with emission standards.

Decentralization

Decentralization of political power and the delegation of limited rights and responsibilities to local governments is another element of reform with impact on environmental issues. In this way, infrastructure decisions, waste treatment policies and trade-offs for various environmental controls can be made at the local level with the necessary knowledge and local understanding missing from government decisionmakers at the central level.

Another characteristic of transition countries is their integration into international economic markets, which combined with internal processes, is leading to the decline of heavy industry and on increasing light industry and service-sector activities. In this regard the economic make-up of transition countries is approaching those levels of OECD countries. More importantly, however, new high-tech and less polluting technologies are rapidly penetrating the market. For example, the food processing, furniture and apparel industries in Poland have been growing by some 10-20 percent a year since 1990.

Nevertheless, there are still many other barriers to overcome on the path to reform and, therefore, further improvements to be made in terms of the environment and air quality. Transition countries are recognizing that the shift to a new political system, which includes a restructuring of the economy and privatization, is not only painful, but also slower than expected. Even in those countries that lead in reform, such as Poland and

BOX 19: Case Studies of Projects Supported by the Danish Environmental Support Fund

The Dolna Odra power plant complex in Poland comprises of eight 200 MW coal-fired units. Initially two electronic precipitators and two additional precipitators were financed followed by the implementation of a flue gas monitoring and computer control system to minimize the energy consumption of the four-filter systems, and the installation of low NO_x burners were also supported, resulting in annual reductions of 35 kt of particulates and decreased heavy metal pollution. The resulting costs of the reduction are estimated to be around USD 280 per ton of emissions.

Coke oven desulfurization also took place in four plants in Ukraine. Coke oven gas is captured and converted into sulfuric acid resulting in an annual reduction of 117 kt of SO_2 emissions. The cost-effectiveness is around 180-280 USD per ton.

Hungary, the share of state-owned enterprises is still substantial, delaying those foreign direct investments that bring in modern pollution control technologies and which support the development of less polluting sectors of light industry. In addition, those transition countries which have lost access to their traditional markets under the Council for Mutual Economic Assistance, struggle to gain access to international markets, thus hindering much needed economic development.

6.3. VARIOUS STAKEHOLDER GROUPS

The transition process has also seen the development of new environmental stakeholder groups that brings about responsibility for the environment among all sectors of the economy and society. For example, economic reform and the approximation of EU legislation has delegated greater responsibility to local authorities by broadening their rights and abilities, both in pollution control and for promoting investments and measures for pollution abatement. Private companies are also now expected to mobilize funds for investment in cleaner technologies and production, in order to remain competitive on the international market. The private sector is now not only a polluter but also a source of solutions, a key source of financing and a strategic partner.

Meanwhile, the government is now responsible for setting realistic environmental targets, and regulations; allowing time for compliance; enforcing regulations; and balancing external incentives (such as prices and taxes). And as harmonization with the EU encourages greater consideration for environmental issues in all sectors of the economy, so cooperation increases among governmental bodies. Box 18 gives one such example of improved cooperation.

The general public now also enjoy broader responsibility, including the right to participate in the decisionmaking process and to determine the quality of the environment in which they live. The considerable effects of SO_2 and PM on health is one area that can add impetus to calls for a right to live in a healthy environment.

6.4. AIR POLLUTION CONTROL — CASE STUDIES

External Assistance

Considerable progress was achieved in the field of air pollution control following the Lucerne Ministerial Conference in 1993. During the Sofia Environment Ministers Conference (1995), the results from case studies concerning the reduction of lead-based aerosols were presented. These studies were financed by different institutions including The World Bank, European Bank for Reconstruction and Development, and the US and Japanese Development Agencies. Funded usually on a bilateral basis, these included not only case studies, but also pre-feasibility and feasibility studies, and the development of national programs and strategies in SILAQ and other CEE countries. Examples of some of the projects supported by the Danish Environmental Support Fund are provided in box 19 below. Following the successes of the Sofia Conference, a number of other investment projects have been implemented related to dust cleaning and desulfurization systems in the metallurgical and energy sectors. Dust precipitation systems, for example, have been implemented or are in the process of being implemented in the metallurgical plants of Bulgaria (namely the Lead-Zinc companies of Kurdjali and Plovdiv, and the steel-making companies of Pernik), while in Poland, Slovakia, Slovenia and Romania, dust cleaning systems have been introduced predominantly in the energy sector (in thermal power plants).

BOX 20: Modernization and Desulfurization of the CEZ Coal Plants

In order to achieve the production of electricity without detrimental effect to the environment (a stated goal of the CEZ power generator industry), the first step was to ensure compliance with the requirements of Czech environmental legislation. Existing legislation establishes emission limits for solid pollutants, sulfur dioxide, nitrogen oxides and carbon oxides and offers a final deadline for compliance with these emission limits of December 31, 1998. Among the goals of the environment program were:

- The desulfurization of 5,930 MW of capacity throughout its 32 fossil fuel plant units by means of flue gas limestone washing (5,710 MW through wet limestone washing, and 220 MW through semi-dry washing),
- To construct 7 fluidized bed boilers in one of the power plants,
- To increase the efficiency of the fly ash separators,
- To decrease NO_x and CO emissions.
- The decommission the oldest generation facilities.

Through these measures, a total capacity of 2,020 MW will be gradually phased out.

Before CEZ's modernization and desulfurization program was initiated, the overall capacity for electricity generation was 8,447 MW.

Between 1994 and 1995, desulfurization equipment was successfully installed at the Pocerady power plant (2x200 MW) and the Prunerov power plant (4x110 MW). The equipment, based on wet limestone washing methods, operates with a minimum efficiency of 92 percent. The first fluidized-bed boiler in the Czech Republic commenced a test run at the Tisova power plant in 1995. Its output is 350 t/steam/hour.

The replacement of electric fly ash separators was completed at Ledvice, Chvaletice, Melnik, Pocerady and Prunerov power plants. New filters were fitted to the fluidized boilers in the Tisova power plant and to the equipment in the Nachod and Dvur Kralove nad Labem plants. A total capacity of 1,115 MW in 12 power plants has been already phased out.

The overall installed capacity of Czech coal plants as of May 30, 1997 was 7,367 MW with 50 percent of these already supplied with emission control installations. 3,510 MW in Northern Bohemia are now desulfurized and fluidized-bed combustion technology is applied to 222 MW units. According to existing plans, an additional 1,300 MW will have been supplied with desulfurization units by the end of 1997. Guaranteeing the further installation of FGD equipment, the country's leading manufacturer has just signed contracts for the entire desulfurization program.

Flue gas desulfurization has been introduced in Slovenia, Poland, the Czech Republic (see Box 20), and Hungary, and these experiences could be benefitted from for projects in Bulgaria, Romania and other countries. In Bulgaria, three desulfurization systems are currently being implemented — two of them in the metallurgical sector (in Plovdiv and Eliseina), and one in the Maritza-East 2 thermal power plant.

In the Czech republic, a flue gas desulfurization (FGD) project financed by the World Bank was carried out at the Prunerov-2 lignite-fired power plant located in northern Bohemia (see Box 21). The FGD plant has a capacity of 5.5 million Nm^3/h and a removal efficiency of 96.3 percent.

FGD units are also expected to have been installed in Poland, some 100 by 1999. Poland has also been chosen for the installation of a demonstration pilot project for desulfurization by electron beam processing. The total capital investment required for the project amounts to USD 19.95 million. Part of this amount will be provided by the Government of Poland (USD 11.69 million), while the remainder will be provided by the Japanese International Cooperation Agency, the Japanese Stabilization Fund for Poland (USD 5.01 million), and by the International Atomic Energy Agency (USD 2.25 million in the form of equipment, experts and training).

Electron Beam Processing

Electron beam processing is a dry scrubbing process that simultaneously removes both SO_2 and NO_x. The flue-gas is cleaned of fly ash and cooled in a spray cooler as it passes through a process vessel, where it is irradiated by beams of high energy electrons in the presence of stoichoiometric amounts of ammonia. The by-product is a useful fertilizer. Japanese, German, United States and Polish demonstration plants have shown that the total efficiency for SO_2 removal using the electron beam process normally exceeds 95 per-

BOX 21: Dust Emissions Reduction from Old Power Plants in Germany

VEAG (Vereigte Enegiewerke AG) was established in 1990 to supply power to the former German Democratic Republic (GDR), and inherited the two GDR lignite-fired power plants and interconnecting networks.

The electrostatic precipitators installed in the old plants were characterized by a low separation rate and a poor state of repair. This resulted in low efficiency. As a result, an emergency program was initiated in 1990 aimed at rapidly and efficiently reducing dust emissions from those plants. The reasons behind the inadequate performance of the ash-removal unit and dust separators were analyzed and remedial actions were planned. Attention was given to measures that could be carried out by the repair personnel at the site. This essentially helped to cut costs.

The most important steps included:

- Improving/balancing the flue-gas flow in the electrostatic precipitator;
- Repairing the perforated plates, and the use of new materials;
- Repairing the spraying and precipitation systems;
- Restructuring the rapping gear in order to improve efficiency and operating safety;
- Sealing the jacket of the electrostatic precipitator;
- Modernizing the control unit of the rapping gear, etc.

The end result was that the emissions were lower than the established standards set for the dust burden of cleaned gas, despite the fact that the equipment had been in operation for twenty years. VEAG is ready to share its experience in upgrading electrostatic precipitators and ash removal installations to all interested parties and to assist power plant operators in implementing such programs.

Cooperating closely with the supply industry, VEAG developed the concept for an 800 MW unit. This type of unit was established at Schwarze Pumpe for the first time, making the new power plant the most advanced, efficient and environmentally compatible lignite-fired power plant in the world with an energy efficiency rate of 40.6 percent and specific CO_2 emissions less than 1.0 kg CO_2/kWh_{net}. The power plant operates from state-of-the-art pollution control equipment. The design of the electrostatic precipitators ensure that the dust burden of cleaned gas does not exceed 50 mg/m^3 n, dry, 6 percent O_2. Under normal operating conditions, values of between 5 and 15 mg/m^3 have been obtained. The actual particulate emissions are as low as 1-3 mg/m^3, since a second stage of dust precipitation takes place in the wet flue gas desulfurization (FGD) unit.

Wet FGD is based on a two circuit process, using limestone as a sorbent. With 98 percent or 99 percent of the sulfur removed under operating conditions, the design separation rate of 95 percent is clearly surpassed. The output gypsum is scrubbed and dehydrated at the power plant and processed at the gypsum factory adjacent to the power plant or transported to other gypsum factories (six building material factories process the FGD gypsum).

Within the FGD unit, the SO_2 concentrations of 2,500- 5,000 mg/m^3 in the raw gas are reduced to quantities of 30-60 mg/m^3. Thus the limit value of 400 mg/m^3 is surpassed.

cent and reaches 80-85 percent for NO_x removal. That level of efficiency meets the most stringent regulatory requirements.

The economics of the process have been studied and show that the system will be available for around USD 200/kW. Thus, the electron beam process is competitive with existing SO_2 removal systems with no need for additional selective catalytic reduction (SCR) removal systems for NO_x. The Polish pilot-project shows that costs are reduced by 20 percent compared with conventional installations. The system has been proven efficient for fuels with high-sulfur content which is important to all the SILAQ countries.

These examples show that when choosing an emission control installation, many criteria have to be considered in the SILAQ countries. Thus, while FGD is less expensive and more widely used, it requires large quantities of lime resources with all the associated problems related to its extraction, processing, transportation. Gypsum by-products must also be considered along with the auxiliary energy uses in the process.

Box 22 gives information on those successful measures undertaken by VEAG to reduce dust emissions from old power plants in Germany.

7. Conclusions

The CEE countries have already made significant progress in reducing pollutant emissions. This is clearly the result of the implementation of new environmental policies and regulations, and the changes in the level and main focus of economic activities. Further pollution reductions are possible by converting to gas and low-sulfur coal, the more widescale use of district heating systems, use of flue-gas desulfurization, energy saving equipment, and implementation of energy-efficient installations, and the use of advanced combustion technologies.

Economic incentives, the increased use of renewable energies, demand-side management, enhanced penetration of new technologies and the promotion of energy efficiency can be considered some of the other preventive measures available. Public awareness and understanding of the problems should also be increased.

The country studies and data presented above provide a significant resource for future knowledge transfer, not only among the countries of Central and Eastern Europe but conceivably also for the Newly Independent States and international cooperative projects, such as the work of the SILAQ group, can facilitate this progress in the coming years.

7.1. SUGGESTIONS FOR FURTHER STUDIES AND ASSISTANCE

Filling the information gaps, both in terms of quantitative data and supplementary qualitative information should be the key target of future studies. Special attention should be given to those regions heavily affected by emissions from the industry and energy sectors. For example, in Bulgaria more then 50 percent of SO_2 emissions alone are produced by the thermal power stations in the Maritza-East region, and a similar situation with respect to concentrated industrial pollution occurs in northern Bohemia in the Czech Republic, and in the Silesia region of Poland.

A multi-national project assessing of the various cleaning systems available for different flue gases in the SILAQ countries could be particularly useful. Further assessments, however, require bi-lateral and multi-lateral agreements and commitments.

Based on the experiences gained from the implementation of the various programs for the reduction of air pollution, the following measures could be undertaken in order to facilitate further progress in the SILAQ countries:

- Public awareness raising measures, including the preparation of a "status report" for official and public use;
- The development of a set of key case studies demonstrating the adverse impacts on human health and the environment losses arising in selected "hot spots";
- Improved air quality monitoring, especially with regard to small-size particulate matter;
- Short-term monitoring projects and data assessment related to specific local air quality problems;
- Experience-sharing in the field of innovative regulatory approaches and implementation instruments;
- Experience sharing in harmonizing environmental legislation, and with regard to monitoring and control systems in use within the EU, including the difficulties, impacts, and lessons learned;
- Workshops focusing on experiences in the application of economic incentives in air quality management;
- Experience sharing concerning the effective mobilizing and use of financial resources, including information on potential sources of external assistance;
- Study-tours and workshops on SO_2 and particulate matter reduction, as well as on local air quality management (including East-East experience transfer);
- Improving the understanding of the impact of emission sources on ambient air quality;
- Developing case studies to assess the role of various pollution sources, and dissemination of the outcome of these studies;
- The development of indicators and criteria for the assessment of the effectiveness and constraints of various flue gas desulfurization systems;

BOX 22: World Bank Instruments Used to Address Urban Air Quality Issues

Environmental Studies and Technical Assistance

- Environmental strategies and action programs;
- Risk assessment and health studies;
- Integrated urban air quality management studies and cross-sectoral discussions;
- Least-cost approaches and feasibility studies.

Pollution Abatement Projects

- Sectoral projects with pollution abatement components;
- Donor coordination.

- Preparing feasibility studies addressing options for SO_2 and particulate matter emission reduction;
- Implementation of industrial-scale installations;
- Feasibility studies and demonstration projects on fuel cleaning (i.e., sulfur removal);
- Demonstration projects on the use of clean technologies in coal fired units burning coal with a high sulfur content;
- Dissemination of information on low-cost measures for local air quality management;
- Promotion of energy efficiency measures and other “win-win” approaches.

For the individual environmental “hot spot” areas identified, the following activities might also be undertaken:

- Preparation of integrated air quality management plans and action programs that include industry, power generation, traffic, and households;
- Identification of least-cost approaches;
- Preparation of feasibility studies;
- Developing financing plans and funding applications;
- Demonstration projects for low-cost measures, cleaner technologies, energy efficiency, and other win-win approaches integrating the efforts of responsible national authorities;
- Assessment of the operational efficiency of pollution abatement technologies and management approaches;
- Dissemination of the results of project implementation.

However, such programs and measures can only take place with the specific financial support of donors and expert assistance from different countries and institutions. The Regional Environmental Center for Central and Eastern Europe with its network spanning 15 countries and expert relations could play a coordinating role in such a multinational program.

Boxes 22 and 23 present a sample of activities and forms of assistance available from international organizations or individual governments whose efforts in these areas should be acknowledged and which could once again be utilized. For country-specific projects, the main activities could be financially supported from national resources, or on the basis of bi-lateral and multi-lateral agreements.

7.2. ROLE FOR FUTURE EXCHANGE OF EXPERIENCE

As stated at the beginning of this Report, one of the main objectives of the SILAQ Initiative has been to identify valuable information on local air pollution control strategies and their implementation, and to facilitate the exchange of this information. The data collected for this report has helped to compare the steps taken by the different countries in harmonizing policies, standards and regulations among themselves, and with regard to international practices and approximation to the EU. The information exchanged among the participating countries has been a valuable activity, particularly during the workshop in Bratislava in January 1998, and during discussions on the drafting of this Synthesis Report. It is clear that the parties involved have gained from one anothers’ experiences, and have benefited from this knowledge in improving local air quality.

BOX 23: Danish Environmental Support Fund

The Danish Environmental Support Fund (DESF) was established according to the *Law on Support for Environmental Activities in Central and Eastern Europe.* To date it has funded 380 environmental projects and in the period 1991-1995, 76 of these were related to air quality, 47 among them devoted to emission reduction, i.e. 21 percent.

The majority of funds have been allocated to energy projects in the form of technical assistance. 28 projects have addressed SO_2 emissions, and the expected SO_2 reduction per year is 132 kt which is still 62 percent of Danish emissions at 1990 levels. There were 27 particulate matter related projects, with the reduction level around 29 kt.

Denmark has a competitive advantage in the field of emission control including large ESP, baghouses, FGD, De-NO_x, vapor recovery, and catalytic incineration facilities. Among the suggested future target areas is the improvement of existing coal fired power plants in populated areas (through improvement of combustion efficiency and operational control, and the installation of particulate and SO_2 emission control technology). Cleaner technologies, energy conservation, fuel changes and emission control systems to reduce PM and toxic gas emissions at industrial plants in populated areas should also be considered as well as transportation policy development, public transport and monitoring.

It can be said that the policy measures and experience of Western partners have had a catalytic effect on the SILAQ countries. The information related to economic instruments, flue gas cleaning systems, and the availability of clean technologies as reported by those experts of the World Bank, the US EPA, Denmark and Germany during the workshop in Bratislava can be seen as guidelines for future activities. It is clear that the use of incentive-based policies can lead to improved community health.

A further recommendation might be the establishment of a database that could help in the further development and implementation of national and local strategies for the least-cost reduction of SO_2 and particulate matter. The information could be used to serve both decisionmakers and the public. It is clear that further dissemination of the information collected on the impacts of SO_2 and particulate emissions and the related mitigation measures is required, and participation of the public in this process is encouraged.

In summarizing, the actions thus far taken, such as the approximation of legislation, the projects implemented, and the workshops and regular meetings, seem to indicate a good basis for future activities. It can also be said these have firmly contributed to the overall European integration process and the Environment for Europe process. Furthermore, the experience could in turn be used to the benefit of other CEE and NIS countries not yet well advanced in the process.

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The REC was established in 1990 by the United States, the European Commission and Hungary. Today, the REC is legally based on a Charter signed by the governments of twenty-six countries and the European Commission, and on an International Agreement with the Government of Hungary. The REC has its headquarters in Szentendre, Hungary and Local Offices in each of its 15 beneficiary CEE countries which are: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, FYR Macedonia, Poland, Romania, Slovakia, Slovenia and Yugoslavia.

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Reduction of SO_2 and Particulate Emissions