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Baltic Sea ENVIRONMENT PROGRAMME

European Bank for Reconstruction and Development

The Baltic Sea Environmental Programme

The Topical Area Study for Atmospheric Deposition of Pollutants

FINAL SYNTHESIS REPORT

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THE BALTIC SEA ENVIRONMENTAL PROGRAMME

THE TOPICAL AREA STUDY FOR ATMOSPHERIC DEPOSITION OF POLLUTANTS

SYNTHESIS REPORT

by

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1. INTRODUCTION

1.1 The Norwegian Institute for Air Research (NILU) has been contracted by the European Bank for Reconstruction and Development (EBRD) to provide information and consulting on the impact of air pollution on the contamination of the Baltic Sea.

1.2 The objectives of the study are to: 1) assess source-receptor relationships for air pollutants of concern in the Baltic Sea region with focus on pollution loading from the atmosphere, and 2) recommend reduction scenarios for atmospheric emissions of pollutants of concern and the means of investment in certain regions within the study area in order to meet the reduction goals.

1.3 The study focuses on inputs of nutrients, such as oxidized and reduced forms of nitrogen. Other pollutants of particular interest for the environmental quality of the Baltic Sea will also be studied. They include toxic trace metals, such as mercury, cadmium, copper, lead, zinc, and possibly arsenic, chromium and nickel, and persistent organic compounds, such as, polychlorinated biphenyls (PCBs), hexachlorocyclohexanes (HCHs), and hexachloro benzene (HCB).

1.4 The aim of this report is to provide the Bank with a concise review of current knowledge of emission and deposition fluxes of pollutants in the study area, and their future trends. Information on environmental legislation concerning emissions is enclosed as well as emission impact analysis. A review of national measures to reduce emissions is presented together with policy, legislation and regulating actions, and enforcement instruments. A list of priority actions concerning the major pollution regions is proposed. Finally, a review of previous and current studies and investment programmes of interest for the project is enclosed.

2. DESCRIPTION OF THE STUDY AREA

2.1 The study area is the Baltic Sea and source regions with emissions affecting the quality of the Baltic Sea water through the transport of pollutants with air masses and atmospheric deposition.

2.2 Information on deposition of oxidized and reduced nitrogen [1] (Table 1) and lead (Figure 1) suggests the study area to be parts of Eastern Europe (CSFR, Poland and Soviet Union) and Western Europe (Belgium, France, Germany, Netherlands and United Kingdom), as well as Northern Europe (Denmark, Finland, Norway, and Sweden).

3. ENVIRONMENTAL STATUS AND TRENDS IN THE STUDY AREA

3.1 Emissions

3.1.1 The Parties to the UN ECE Convention on Long-range Transboundary Air Pollution (LRTAP) report their emission of NO_x and the results for the study area are given in Table 2 [2]. Signatories to the 1988 Sofia Protocol expect their NO_x emissions to stabilize or decline by the year 1995. Some Parties are forecasting reductions by about 30 per cent or more. These countries include: Denmark, Germany, the Netherlands and Norway.

Contribution of NO_x from mobile sources to total NO_x emissions in the Western and Northern European countries in the study varies from 47 per cent in Finland to 84 per cent in Norway, while in the Eastern Europe countries does not exceed 35 per cent [3]. Concerning trends of NO_x emissions from mobile sources in the study area, only a few countries report their plans forecasting on average 25 per cent reduction of the 1985 emissions in the year 2000 [2].

A list of 10 major point sources of NO_x emissions in Poland and CSFR, as well as major point sources in Estonia, Latvia, Lithuania, Karelia and the St. Petersburg area is presented in Table 3 together with the emission amounts. Almost all major point sources of NO_x in the above countries are electric power plants, burning mainly coal. Interestingly, most of the NO_x emissions from point sources in Poland is released in the Silesia region and in Central Poland. The NO_x emissions from point sources in CSFR is concentrated in the western part of the country.

3.1.2 Denmark, Finland, Germany and the Netherlands report officially on their NH_3 emissions. These data together with estimates of Buijsman [4] for other countries in the study area are presented in Table 4. Emissions from livestock waste contribute about 80 per cent to the total NH_3 emissions in the study area. No major changes of NH_3 emissions in the study area are expected to occur in the near future. Decrease of these emissions during the period from the beginning of the 1980's to present time has been indicated due to decline in cattle breeding and for farming in some countries [5].

3.1.3 Major anthropogenic sources of Hg emissions in the study area include chlor-alkali plants, coal-fired power plants and waste incinerators. Emission quantities of gaseous and particle mercury in the study area are presented in Table 5 [6]. A list of 10 major point sources of mercury emissions in the study area is given in Table 6.

It is expected that the anthropogenic Hg emissions will be reduced in the near future mostly due to replacing the mercury cells with other methods to produce chlorine and alkali. For example, Contracting Parties to the Paris Convention for the Prevention of Marine Pollution from Land-based Sources agreed that existing mercury based chlor-alkali plants shall be required to meet by 31 December 1996 a standard of 2 g Hg/ton Cl_2 capacity for emissions to the atmosphere and recommended that these plants should be phased out as soon as practicable but not later than by year 2000.

3.1.4 Total emissions of arsenic, cadmium, copper, lead and zinc in countries in the study area are presented in Table 7 [7]. Production of non-ferrous metals in primary and secondary plants is the major source of atmospheric As, Cd, Cu and Zn, while combustion of gasoline is a dominating source of Pb emissions in the study area. A list of 10 major point sources of As, Cd, Cu, Pb and Zn in the study area is given in Table 8.

Emission trends for heavy metals in Europe have recently been studied [8] on the basis of information on control efficiency of the best available technology (BAT) and the use of unleaded gasoline. The BAT concept assumes the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting emissions. Prognosis of atmospheric emissions of As, Cd and Pb in whole Europe for the year 2000 is given in Table 9 assuming BAT in non-ferrous metal smelters and unleaded gasoline. The prognosis for countries within the study area is under preparation.

3.1.5 Emissions of polychlorinated biphenyls (PCBs), hexachlorocyclohexanes (HCHs), and hexachlorobenzene (HCB) in the study area are presented in Table 10. No information exists to discuss trends of these emissions in the near future. However, limited use of PCBs, HCHs, and HCB in Europe suggests no further increase of their emissions.

3.2 Emission standards

3.2.1 National legislation for environmental protection and for the abatement of air pollution in Europe has undergone continuouos revision by all Parties to the UN ECE LRTAP Convention since 1986.

Concerning the countries of interest for this study, comprehensive new environmental legislation, including revision of the Air Pollution Control Act is under preparation in CSFR. The emission limits originally set in 1967 for the 20 most important air pollutants are now under review. The Waste Disposal Act has been introduced in 1991.

3.2.2 The Danish Act on Emissions of Sulphur Dioxide and Nitrogen Oxides from Power Plants entered into force in October 1989. In a view of the increasing use of natural gas for electricity generation, nitrogen oxide emission limits of 650 mg/m^3 were set for gas engines and turbines in April 1989.

3.2.3 In the former German Democratic Republic, alignment on the major environmental laws and standards of the former Federal Republic of Germany, effective from July 1990, was one of the first steps in the process towards political and economical unification. A comprehensive system of emission standards corresponding to the best available technology has been implemented in the Federal Republic of Germany by various regulations dealing with large and small combustion sources including waste incineration. There is a specific legislation on heavy metal air pollution control in the former Federal Republic of Germany (No. 2.3 TA Luft and No. 3.1.4 TA Luft).

3.2.4 The Dutch standards for plants licensed under the Air Pollution Act are, at present, revised on the basis of the Dutch Acidification Abatement Plan. Emission standards have been set for waste incineration plants within the framework of the Waste Substances Act in 1989. There are guidelines to prevent an increase of ammonia emissions in areas near sensitive receptors.

3.2.5 In Poland, a decree on the protection of the atmosphere against pollution was enacted in February 1990. In the United Kingdom, an Environmental Protection Act received royal assent in 1990.

3.2.6 A summary of NO_x emission standards for power generation, industrial processes and vehicles in various countries in the study is given in Table 11.

Emission standards for atmospheric heavy metals have been recently reviewed by the ECE Task Force on Heavy Metal Emissions. Only three sets of standards have been reported from the study area, namely Germany, Sweden and the Soviet Union.

3.3 Atmospheric deposition to the Baltic Sea

3.3.1 Three methods have been used to assess the atmospheric deposition of nitrogen compounds and heavy metals to the Baltic Sea. Two methods are based on measurement data from the HELCOM/EGAP network. In the first method it is assumed that the precipitation recorded at coastal stations is representative for the open sea. In the second method the inputs are estimated on the basis of not only observed but also calculated precipitation amounts.

The following conclusions can be drawn from these estimates:

- the nitrogen flux decreases from about 1000 kg $N/km^2 \cdot year$ in the southern parts of the Baltic Sea to 700 kg $N/km^2 \cdot year$ in the north. This results in a total N wet deposition to the Baltic Sea of about 300 kt/year on average for 1987-1990, and
- the lead flux was about 2 $kg/km^2 \cdot year$ resulting in the wet deposition of this metal to be about 600 t/year on average for 1987-1989.

The third method estimates the deposition of nitrogen compounds and heavy metals on the basis of emission data [10]. As can be seen from Table 1, a total deposition of nitrogen to the Baltic Sea was about 300 kt/year during the period 1989-1990. Taking into account that wet deposition is by far more important than dry deposition for removing nitrogen compounds from the air [9], the model calculations agree very well with measurements of nitrogen deposition to the Baltic Sea.

The agreement for lead is also very good. The model calculated the wet deposition of this metal to be about 860 t in 1985 [11]. The total deposition of lead to the Baltic Sea was estimated about 1400 t in 1985.

3.3.2 Less information exists on deposition of other heavy metals to the Baltic Sea, because Cd, Cu, and Zn have become the minimum requirement pollutants measured within the HELCOM/EGAP monitoring programme only from 1990. A report from Poland [12] indicates wet fluxes of Cd, Cu, and Zn to be 0.47, 1.5, and 8.3 $kg/km^2 \cdot year$, resulting in the annual wet deposition of these metals to be about 140 t Cd, 450 t Cu and 2500 t Zn.

3.3.3 Concerning the deposition trends, the following can be concluded:

- the total nitrogen concentrations in precipitation (a sum of nitrate and ammonium) show a slightly increasing trend during the period from 1986 to 1990 mostly due to increasing concentrations of ammonium,
- the decreasing trend of Pb concentrations in precipitation stopped in 1988, being stable during the last couple of years, and
- there is a clear tendency for higher concentrations in the southern parts of the Baltic Sea than in the northern parts.

4. IMPACT ANALYSIS: SOURCE-RECEPTOR RELATIONSHIPS

4.1 Very good agreement between the HELCOM/EGAP measurements of deposition of pollutants to the Baltic Sea and model estimates proves a good quality of the input data into the model, including emission data. Combustion of fossil fuels in large combustion plants in Silesia and Central Poland, former German Democratic Republic, and in the Ruhr area together with combustion of gasoline and diesel oil have become the major source of oxidized nitrogen deposited to the Baltic Sea.

4.2 Emissions of ammonia are more evenly spread over the region adjacent to the Baltic Sea. Therefore, the origin of reduced nitrogen deposited to the Baltic Sea is more complicated. It can be concluded from the spatial distribution of ammonia emissions in Europe that NH_3 emissions in Poland, Latvia, Lithuania, Estonia, Ukraina, White Russia and Germany contribute much more to the receptor area than the emissions in Northern Europe.

4.3 Production of caustic soda and chlorine in V.E.B. Chemische Buna Verke in former German Democratic Republic has generated almost a half of atmospheric mercury in Europe in the late 1980's. This source together with other chemical plants in Poland and former Federal Republic of Germany, as well as coal-fired power plants, incinerators, and non-ferrous metal smelters, mostly in Germany, Poland and CSFR has contributed the most of 12 t of mercury deposited to the Baltic Sea annually as estimated by Petersen et al. [13].

4.4 Combustion of leaded gasoline, mainly in Eastern Europe has resulted in most of the lead deposited to the Baltic Sea. Concerning emissions from point sources, major part of lead, as well as arsenic, cadmium, copper, and zinc has been released from primary non-ferrous metal smelters located in Silesia, Central Germany, on Kola Peninsula and in Ukraina.

4.5 Strong increase of nutrient concentrations, mostly nitrogen and phosphorus in the Baltic Sea in the 1970s, resulted in the increasing biological production and its subsequent sedimentation followed by the microbial destruction of the biogenic organic material and deterioration of the oxygen conditions in the Baltic deep water. Present estimates of 300 kt nitrogen in atmospheric deposition indicate that this pathway accounts for one third of the total load of nitrogen to the Baltic Sea. This load has increased 4 times since the turn of the century. Therefore it can be concluded that the overall role of the atmosphere and long-range transport is important to any international pollution abatement strategy.

4.6 Mercury concentrations in biota of the Baltic Sea have not changed significantly from the beginning of the 1980s being at the levels measured in the North Sea and the North East Atlantic. Trends of increasing concentrations of Cd, Cu, and Zn in fish are observed in some regions of the Baltic Sea while decreasing tendences exist for lead in fish and shellfish from sampling locations in the Kattegat and the Belt Sea. Melvasalo and Rosemarin [17] concluded, that the load of Cd, Pb and Hg to the Baltic is five to seven times higher than the background levels, requiring these metals to receive urgent attention.

4.7 Concentrations of organochlorine residues in biota is decreasing following the ban in the use of some of these harmful substances as pesticides. However, the levels observed in fish from the Baltic Proper are still 3 to 10 times higher than in catches from around the Shetland Island.

Levels of organochlorines remain very high in grey and ringed seals. The population of seals in the Baltic Sea has decreased dramatically since the turn of the century, one reason being organochlorine pollution.

5. NATIONAL MEASURES TO REDUCE EMISSIONS, INCLUDING POLICY, LEGISLATION, REGULATORY ACTIONS AND ENFORCEMENT INSTRUMENTS.

5.1 The measures taken by countries in the study area to carry out national strategies and policies to reduce emissions include legislation and regulatory actions, economic incentives and disincentives, and control technology requirements. Some aspects of legislation and regulatory actions have already been dealt with in p.3.2 when describing emission standards.

5.2 A somewhat complicated situation exists in the Baltic States, where the environmental legislation and norms prepared by the Ministries of the Environment of the Soviet Union and the Russian Federation at the unionlevel ministry are not effective until they are ratified by the governments of the States. The above mentioned legislation and norms often need reform to adapt towards the application of a market economy.

5.3 Major economic incentives and disincentives include subsides, fuel tax measures, emission charges and fines, and emission credits and quotas.

5.3.1 The following subsidies have been introduced in the study area recently [2]:

- in Denmark, new cars meeting stricter emission standards have since 1989 been subject to lower registration taxes,
- in Finland, tax exemptions have been introduced until the end of 1991 for the purchase of cars meeting new emission standards,
- in Germany, tax exemptions or even cash settlements have been introduced in January 1990 for the purchase of low-pollution private cars,
- in the Netherlands, not only tax reductions to new cars meeting more stringent emission standards are available but also subsidies for the demonstration of new technology, for investment in alternative energy sources and for energy conservation in existing buildings,
- in Poland, subsidies for pollution abatment investments are available, and
- in Sweden, subsidies are limited to the development, testing and demonstration of new technology.

5.3.2 The following fuel tax measures have been undertaken in the study area [2]:

- high fossil-fuel taxation in France to discourage pollutant emissions,
- increase of lead-free petrol in Germany up to 65 per cent of market share by 1989,

- phasing-out leaded petrol in the Netherlands through fiscal measures affecting petrol prices, and
- higher taxes on leaded than lead-free petrol in Norway.

5.3.3 A system of emission charges and fines is in operation in all countries in the study area with the rates charged proportionate to the estimated cost of the environmental damage caused by the emissions.

5.3.4 In some countries, emission credits and quotas have been introduced. For example, in Denmark, a four-year emission quotas for th electricity sector as a whole are laid down, while in the Netherlands common ceilings for SO_2 and NO_x emissions from power plants by the year 2000 have been agreed in addition to compliance with emission standards for combustion installations.

5.4 Technology performance forms a basis for setting emission standards. Several countries, including Germany and the Netherlands, introduce BAT or "best practicable technology"-BPT in their environmental policies through emission standards set on the basis of technical performance. In this view control technology requirements are set for stationary and mobile sources, separately. Concerning the stationary sources, low-NO_x combustion technologies to meet NO_x emission standards are required for new and existing plants in the Netherlands.

A number of regulations are in force concerning the emissions of pollutants by motor vehicle engines. They are based on the international standards laid down in the 1958 ECE Agreement. The details are available from [2].

6. EVALUATION OF PROPOSED ACTIONS.

The actions are proposed in order to reduce atmospheric emissions and further deposition to the Baltic Sea of nitrogen compounds, heavy metals and persistent organic compounds emitted from point and area sources in Poland, CSFR, Latvia, Lithuania, Estonia, Leningrad Region, Kaliningrad Region and Karelia, called further in this report as the proposed action area.

6.1 Point sources of emission

The following industrial sectors are prioritized for actions to be taken:

- production of electricity and heat, because of emissions of NO_x and heavy metals and particularly mercury,
- non-ferrous metal industry, because of emissions of heavy metals, and particularly arsenic, cadmium, copper, lead and zinc, and
- chemical industry, and particularly production of caustic soda and chlorine, because of emissions of mercury.

6.1.1 Production of heat and eletricity.

Generally, the NO_x emission reduction can be obtained either through primary measures related to combustion modifications or secondary measures related to exhaust gas treatment. None of the measures is in operation in the heat and electricity plants in the proposed action area. Recently the UN ECE NO_x Task Force has reviewed technologies for controlling NO_x emissions from stationary sources [14]. The following can be concluded:

Depending on site specific parameters, NO_x reductions of up to 20 per cent can sometimes be achieved by minor modifications of the combustion process such as operating at lower excess air or by adjusting the fuel/air ratio at selected burners. However, the main area of interest for combustion modifications for NO_x control lies in the use of:

- low NO_x burner (LNB),
- off stoichiometric combustion (overfire air) (OSC),
- flue gas recirculation (FGR),

all of which can be used either separately or in conjunction with each other. Major changes are sometimes required to implement these latter technologies as retrofits although all are applicable to new units.

LNBs are available for burning coal, oil and gas. For new facilities the NO_x reduction attributable to LNB is about 30-60 per cent.

OSC technique is applicable at new and retrofit systems of all boiler types. Extents of NO_x reduction range from about 10 to 40 per cent depending on fuel and boiler type. A possible negative side effect can be boiler corrosion by reducing atmospheres which might limit retrofittability.

FGR is applicable for new and retrofit installations burning gas and oil, as well as for high temperature coal combustion. NO_x reduction of about 20 per cent for coal, 20-40 per cent for oil, and up to 50 per cent for gas can be achieved.

For existing utility boilers the following emission values have been demonstrated for retrofitting low NO_x combustion systems:

(i) pulverized coal firing (6% O_2)
- wet bottom boiler: 1 000 - 1 400 mg/m^3 (350-490 g/GJ)
- dry bottom boiler: 600 - 800 mg/m^3 (tangential) (210-280 g/GJ)
  600 - 1 100 mg/m^3 (wall-fired)(210-380 g/GJ)

(ii) oil firing (3% O_2): 200 - 400 mg/m^3 (60-120 g/GJ)

(iii) gas firing (3% O_2): 100 - 300 mg/m^3 (30-90 g/GJ)

At new facilities in many cases the emissions may be lower than the smaller value of the above mentioned emission ranges.

Concerning secondary measures to reduce NO_x emissions from heat and electric power plants, some technologies are currently offered commercially in the ECE region for flue gas denitrification. The most highly developed process has been Selective Catalytic Reduction (SCR), achieving up to 80 per cent NO_x reduction. For all types of fuels this process uses ammonia to reduce NO_x, resulting in fugitive emissions of ammonia and N_2O.

Investment costs for primary measures are fairly low compared with those for secondary flue gas treatment systems. These costs may be negligable for new plants and can range from 5 to 15 ECU/kW_{el} for retrofit. Additional operating costs are low in the majority of reported cases.

Focus of this evaluation is on existing plants. The actions required or recommended are:

a) installation of at least low NO_x burners in major power plants (over 1000 MW_{el} and district heating boilers (over 200 GJ/h capacity) in the proposed action area,

b) examination of the possibility to install a combined system of primary and secondary measures to reduce NO_x emissions in power plants mentioned in Table 3,

c) control of all electric power plants larger than 200 MW_{el} and heat boilers with capacity over 100 GJ/h in the area, with respect to NO_x emissions, and

d) introduction of fluidized bed combustion (FBC) when planning new electric power plants. In FBC the flue gas emissions can be maintained at significantly lower levels than in conventional combustion techniques.

Another advantage of installation of low NO_x technologies is reduction of heavy metal emissions in the flue gases due to the lower operating temperatures. However, more heavy metals are removed from flue gases by flue gas desulphurization (FGD) systems. Various types of FGD systems remove between 20 and 60 per cent of gaseous mercury from flue gases, which means 20 to 60 per cent of total mercury in coal introduced to the burners [15]. Significant reductions have also been measured for other volatile heavy metals including Cd, Pb, and Zn.

It is recommended to:

a) examine the possibility to equip major existing coal-fired power plants (over 1000 MW_{el}) in the proposed action area with a FGD system.

Of course, the major advantage of the above action will be a substantial removal of sulphur from flue gases, but the action is very expensive.

Major part of heavy metals from electric power plants is emitted on fine particles with diameter lower than 2 μm. At present, electrostatic precipitators (ESP) are mainly used in large electric power plants to remove particles from flue gases. Removal efficiency of ESP's installed in the area is about 96 per cent on average for various size particles, with even lower efficiency of about 90 per cent for fine particles carrying As, Cd, Cu, Pb, and Zn among other trace elements [16].

It is recommended to install high efficiency ESPs in major coal-fired power plants (over 1000 MW_{el}) in the proposed action area in order to achieve the total concentration of As, Cd, Pb, Cr, Ni, and Co in flue gases lower than 1.5 mg/Nm^3 as recommended by German regulations for existing plants.

6.1.2 Non-ferrous metal industry.

Reduction of heavy metal emissions from both primary and secondary non-ferrous industries can be obtained by installation of proper control systems removing efficiently particles from flue gases.

Using the concept of BAT, the following action is recommended:

a) installation of ESPs or fabric filters in all non-ferrous metal smelters in the proposed action area in order to achieve a dust content in flue gases lower than 10 mg/Nm^3. In most cases of lead, copper and zinc production, all gases can be cleaned in ESPs and fabric filters to levels lower than 5 mg/Nm^3. Both types of fabric filters: baghouses and membrane-type can be considered for installation, taking into account their limitations. Common limitation for both types of fabric filters is temperature of the gases, which should not exceed 280^0C depending on cloth or membrane material. In addition, membrane-type of fabric filters are not suitable for cleaning the oil-containing dust; and

b) installation of ESPs or fabric filters in secondary non-ferrous smelters in the proposed action area in order to reduce the dust emissions below 10 mg/nm^3. Lead, copper and zinc smelters shall be given priority in this action, as they generate considerable amounts of atmospheric As, Cd, Cu, Pb and Zn.

6.1.3 Chlor-alkali industry.

In the chlor-alkali industry, chlorine and caustic soda are mostly produced either in the mercury process or the diaphragm process, both resulting in atmospheric emissions of mercury. The third method, the membrane process is not commonly used. The membrane process is considered as BAT. A conversion of existing chloralkali plants (mercury or diaphragm process) to membrane cell operation is possible utilizing some of the existing equipment.

The following action is recommended:

a) introduction of control steps to existing chlor-alkali plants in order to comply with the PARCOM/HELCOM recommendations, requesting the emissions to be lower than 2 g Hg/t Cl_2 capacity by the end of 1996 and phasing-out existing mercury cell chlor-alkali plants by the year 2000, and

b) examination of the possibility to convert existing chlor-alkali plants using mercury or diaphragm process to membrane cell operation for the existing plants in the proposed action area.

6.2 Area sources of emission

Major area sources of emissions for actions to be undertaken include mobile sources, heat production in commercial and residential burners, and livestock farming.

6.2.1 Mobile sources.

Several ways to control NO_x emissions from gasoline - and diesel-fuelled engines have been considered. Considering the gasoline engines, two major groups of technologies are available, namely methods related to engine modifications and installation of exhaust after-treatment devices, such as catalytic convertors.

The engine modifications to reduce NO_x emissions include the following methods: air/fuel ratio and mixture preparation, delayed ignition timing, increased compression ratio, combustion chamber design, intake charge dilution by exhaust gas recirculation (EGR), and electronic control of ignition timing.

The most common control method for NO_x emissions from diesel-fuelled engines is exhaust gas recirculation (EGR). Reductions of NO_x emissions of up to 50 per cent are achievable for both passenger cars and heavy -duty trucks.

The following action is recommended:

a) examination of the possibility to introduce three-way catalysts in the proposed action area as suggested in national plans in Poland, CSFR, Estonia, Latvia and Lithuania. As a result, three-way management systems (hydrocarbons, CO and NO_x) will foster the improved air/fuel management systems, such as advanced carburettors and throttle body fuel injection systems, as well as closed-loop electronic controls of fuel metering. A three-way catalyst combined with a closed-loop system operates at stoichiometric air/fuel ratio to effectively reduce pollutants. Three-way catalyst systems are also sensitive to the use of leaded gasoline.

Application of closed-loop three-way catalysts will improve vehicle performance and driveability, reduce maintenance, and is consistent with improved fuel economy. Controls of evaporative emissions are also readily available and cost effective; and

b) introduction of EGR technique to diesel-fuelled cars in the proposed action area, and at least in large cities.

Concerning the use of leaded gasoline in the area, it is recommended to reduce the present lead content of 0.4 g/l to 0.15 g/l and wider use of unleaded gasoline. This action should be taken simultaneously with the introduction of three-way catalysts. Based on the European market trends for unleaded gasoline (25 per cent of the Western Europe market by the end of 1989) it is suggested to phase out gasoline containing 0.4 g Pb/l by the year 2000 and achieve 25 per cent of the market in the proposed action area for unleaded gasoline.

6.2.2 Heat production in small commercial and residential burners.

The heating sector has a huge potential for energy savings and reduction of atmospheric emissions of various compounds including NO_x and heavy metals.

The following actions are recommended:

a) introduction of district heating replacing the production of heat in small commercial and residential burners. The high percentage of district heating creates possibilities for a high degree of decentralized heat and power plants in the energy system. In general, the size of a power plant should be so that the heat produced is not greater than needed for a given district, mostly in towns, and

b) increased use of natural gas networks already existing in the area, e.g. in small decentralized gas-motor heat and power units in small towns and villages.

6.2.3 Livestock farming.

Methods reducing ammonia emissions should be implemented in feeding, in the construction and use of cattle barns, in the storage and treatment of manure, and in the spreading of manure in the fields. Immidiate mixing with top soil is the best method for manure spreading.

The following is recommended:

a) introduction of conservative application techniques, also called low N-applications (LNA) as a method to reduce NH_3 emissions;

b) examination of the possibilities to introduce LNA together with stable adaptations systems;

c) information and advising services, as cattle breeders in particular can limit the evaporation of ammonia from cattle manure and promote the use of manure as a fertilizer. Agricultural advisory centres can be organized;

d) construction of new cattle barns and the renovation of old ones with focus on air pollution controls; and

e) financial support for the acquisition of manure spreaders and top soil fertilizing equipment, as well as for investments in the introduction of turf for use as bedding in animal shelters.

7. CAPITAL COST OF IMPLEMENTATION OF THE PROPOSED ACTION PROGRAMME

For practical reasons it was assumed that 1 European Currency Unit (ECU) equals 1.2 US$ or 2 DM.

7.1 Discussion on cost estimates for various control techniques and cost-benefits has been presented in the technical report. It has been reported how much would it cost to abate 1 tonne of nitrogen or 1 kg of heavy metals using various methods. This information is used here to estimate the cost of implementation of the proposed action. The estimates are given in Table 12 and 13 for point sources and area sources, respectively.

7.2 As much as $1.3 \cdot 10^6$ t NO_x from stationary sources and $0.5 \cdot 10^6$ t NO_x from mobile sources can be abated at a cost between $450 \cdot 10^6$ and $750 \cdot 10^6$ ECU annually. This accounts for reduction of up to 80 per cent of current NO_x emissions in the proposed action area. This reduction is somewhat higher than the maximum feasible reduction for whole Europe as estimated at IIASA [18]. However, it should be born in mind that no controls are currently in use in the proposed action area, while some measures are already applied in Western Europe. Therefore, the reduction potential in the proposed action area is larger than in other parts of Europe.

Investment cost shall be added to the above mentioned operating and maintenance costs. However, the investment is very small, as already indicated (below 10 per cent of the operating and maintenance costs).

The above mentioned emission reduction cost for NO_x has been estimated assuming installation of low NO_x burners in major electric power plants (over 1000 MW_{el}) and heat plants (above 200 GJ/h capacity), replacement of small residential and commercial burners by district heating equipped with low NO_x burners, introduction of three way catalysts for gasoline cars, and flue gas recirculation (FGR) to diesel fuelled cars.

Other methods can be proposed, such as flue gas desulphurization, which not only removes NO_x but also mercury, other volatile heavy metals and of course SO_2. A cost of this method is between 3.75 and $8.0 \cdot 10^9$ ECU annually, thus several times higher than for application of low NO_x burners.

7.3 A reduction of 80 per cent of current lead emissions in the proposed action are requires about $110 \cdot 10^6$ ECU including $28 \cdot 10^6$ ECU for ESPs in major power plants and smelters.

In contrary to no controls for NO_x in the proposed action area at present, several electric power plants and smelters is equipped with ESP's. The cost in Tables 12 and 13 is requested to improve the efficiency of the existing ESP's or fabric filters and/or installation of new ESP's.

7.4 An amount of $28 \cdot 10^6$ ECU per year is needed to obtain reduction of heavy metal emissions, including lead from major electric power plants and heat plants, smelters, and iron and steel plants in the proposed action area. It is very difficult to assess the cost of replacement of chlor-alkali plants using mercury or diaphragm process by membrane cell operation.

7.5 It was calculated that about 60 per cent of NH_3 emissions to the air in the proposed action area can be achieved by conservative application techniques at a cost of up to $80 \cdot 10^6$ ECU per year. Other methods are much more expensive.

7.6 Implementation of the proposed action programme in the project will cost at least between 4 and $8.5 \cdot 10^9$ ECU with major contribution from cost of NO_x emission reduction.

8. BENEFITS OF THE PROPOSED ACTION PROGRAMME

8.1 There are several benefits which will be obtained through implementation of the proposed actions in the area of interest. These benefits are for local environment, e.g. around a certain point source of emission, in a given geographical region, or even in a whole country within the proposed action area. The benefits could also be measured on regional or global scale, e.g. the whole study area, or Northern Europe.

8.2 Local benefits include environmental, health, economic, and social benefits.

Major environmental benefit of the proposed action programme is due to improvement of the quality of environment through the reduction of atmospheric deposition of the pollutants of interest. The reduction of atmospheric deposition will decrease the uptake of pollutants by surface waters, soils, and plants in the vicinity of major point sources of emissions, and limit migration of these pollutants through various environmental media.

Not only the emissions of the pollutants of interest will be reduced through the installation of control equipment as recommended in the programme but also emissions of other compounds, such as SO_2, VOC and several trace metals from stationary sources, and VOC and CO from mobile sources.

Installation of ESPs or fabric filters, or improvement of their performance will contribute to improvement of air visibility in the proposed action area.

Reduction of atmospheric emissions of heavy metals will result in lowering their intake to human body mostly due to reducing their ingestion in the proposed action area. This intake has already exceeded the WHO/FAO maximum permissible values in some locations within the proposed action area.

8.3 Combustion modifications to limit NO_x emissions will result in fuel savings in large point sources recommended for action in the project. Application of closed-loop three way catalysts will not only improve vehicle performance and driveability, and reduce maintenance but also is consistent with improved fuel economy.

8.4 Implementation of the proposed action programme will be a substantial step towards improving chemical and to some extent biological recovery of the environment in the proposed action area. As a result, an increase of fish population, an important factor of local economy in the area, can be expected.

8.5 Reduction of emissions as recommended in the programme will diminish the risk of relocation of certain groups of people or whole settlements from highly polluted regions in the proposed action area.

8.6 Major part of pollutants emitted in the proposed action area is deposited outside the emission region and therefore limitation of emissions in the proposed action area will have benefits measured on regional and global scale. It is expected that emission reductions as recommended in the programme will result in 40 to 50 per cent decrease of atmospheric deposition in Scandinavia.

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Table 1: Deposition of oxidized and reduced nitrogen to the Baltic Sea in the period 1985-1990 as calculated by EMEP [1] (in: 100 t N).

Major emitter country	1985			1987			1988			1989			1990 (provisional)		
	Oxidized	Reduced	Total	Oxidized	Reduced	Total	Oxidized	Reduced	Total	Oxidized	Reduced	Total	Oxidized	Reduced	Total
Belgium	28	13	41	21	10	31	29	11	40	29	12	41	34	13	47
Czechoslovakia	83	25	108	56	18	74	66	20	86	59	17	76	45	11	56
Denmark	79	152	231	81	150	231	75	131	206	86	141	227	89	149	238
Finland	60	30	90	62	31	93	58	27	85	48	22	70	57	26	83
France	65	40	105	47	27	74	69	33	102	75	32	107	84	40	124
German Dem. Rep.	123	104	227	134	100	234	143	96	239	138	92	230	133	94	227
Fed.Rep. of Germany	324	99	423	275	86	361	332	95	427	306	86	392	347	101	448
Netherlands	68	55	123	54	44	98	68	51	119	67	47	114	84	60	144
Norway	18	7	25	21	6	27	18	6	24	22	7	29	22	7	29
Poland	157	163	320	164	161	325	188	155	343	156	138	294	127	110	237
Sweden	111	67	178	101	63	164	104	61	165	112	65	177	115	64	179
Soviet Union	129	267	396	155	286	441	128	257	385	67	169	236	83	162	245
United Kingdom	158	42	200	145	37	182	171	38	209	176	37	213	250	53	303
Others	248	193	441	236	174	410	244	180	424	234	172	406	262	181	443
TOTAL	1651	1257	2908	1552	1193	2745	1693	1161	2854	1575	1037	2612	1732	1071	2803

Table 2: Total NO_x emissions in the study area during the period 1985-2005 as reported to the ECE [2] (in: 1000 t NO_2).

	1985	1986	1987	1988a	1989a	1990b	1993b	1995b	2000b	2005b
Belgium	281	292	297			300		250		
Byelorussian SSR c/	220	258	287	262	263	271	269	251	187	159
Czechoslovakia	1127	1060	965	950						
Denmark	258	266	262	249		254		224	177	
Finland d/	251	256	270	276				321	226	193
France	1615	1618	1630	1615	1772					
German Dem. Rep.			701	708	705					
Germany Fed. Rep. e/	2930	2990	2940	2860					1980	
Netherlands f/	544	559	559	562	552			422	268	
Norway	203	222	232	227	226				155	
Poland	1500	1590	1590	1550	1480				1345	
Sweden h/	394			390		373		343	341	347
Ukrainian SSR c/	1059	1112	1095	1090	1065	1099	1096	1056	930	885
USSR i/	3369	3330	4218	4201	4418					
United Kingdom	2278	2350	2429	2480		2573	2471	2300	1822	1718

a/ Preliminary data
b/ Projected estimates
c/ Also included under USSR
d/ 2005 = 2010 estimats; 2000 and 2010 projections by Nitrogen Oxide Commission
e/ 2000 = 1998 estimates
f/ 1995 = 1994 estimates; 2000 estimates; according to national environmental policy plan
h/ Projections based on current environmental regulations
i/ European part of USSR within EMEP

Table 3: Major point sources of NO_x emissions in the eastern part of the study area and their emission amounts (in 1000 t/year).

	Poland		CSFR		Estonia		Latvia *1		Lithuania		Karelia		St. Petersburg area	
	Point source	Emission (1989)	Point source	Emission (1987)	Point source	Emission (1989)	Point source	Emission (1988)	Point source	Emission	Point source	Emission	Point source	Emission (1989)
1	El.Belchatow	93.3	El.Pocerady	64.0	El.Estonian	9.0	Riga	2.2	Vilnius		El.Petro-zavodsk		8 power plants in St.Peters-burg	21.8
2	El.Rybnik	33.2	El.Prunerov II	55.0	El.Baltic	6.6	Liepaja	2.5	Kaunas		Iron & steel -Kostamuksha		Aluminium pl. Volkhov	0.3
3	El.Patnow	32.3	El.Melnik	53.0	El.Tallin	0.4	Dangavpils	0.5	Mazeikiai					
4	El.Kozienice	32.1	El.Novaky	35.0	El.Iru	0.4	Jurmala	0.4	Siauliai					
5	El.Polaniec	28.8	El.Tusimice I	33.0	Chem. plant Kohtha-Järve	0.2	Ventspils	0.4						
6	El.Dolna Odra	24.0	El.Tisova	27.0										
7	El.Jaworzno II	23.7	Litvinov	29.0	El.Kohtla-Järve	0.1	Jelgava	0.3						
8	El.Turow	20.2	El.Tusimice II	28.0	El.Ahtme	0.1	Rezekne	0.2						
9	El.Laziska	18.3	El.Chvaletice	27.0										
10	El.Konin	17.7	El.Prunerov I	26.0										

*1 Emission from cities.

Table 4: Emissions of ammonia in the study area as calculated by EMEP [1] in 1000 t NH_3).

	1988	1989	1990
Belgium	94	94	94
Czechoslovakia	200	200	200
Denmark*1	129	125	125
Finland*1	43	43	43
France	841	841	841
German Dem. Rep.	242	242	242
Fed.Rep. of Germany*1	380	380	380
Netherlands*1	254	254	254
Norway	41	41	41
Poland	478	478	478
Sweden	62	62	62
Soviet Union	3180	3180	3180
United Kingdom	478	478	478

*1 data provided by country.

Table 5: Anthropogenic mercury emissions in the study area. Total Hg-emission and emission of Hg species (in t).

Country	No. Sources	Hg (total)	Hg^0 (gas)	Hg^{++} (gas)	Hg (particles)
Belgium	21	8.9	5.3	2.2	1.4
Czechoslovakia	31	15.0	7.8	4.5	2.7
Denmark	21	4.8	2.1	1.9	0.8
Finland	33	4.1	3.1	0.8	0.3
France	59	29.9	15.3	9.0	5.6
German Dem. Rep.	23	330.0	203.0	99.0	28.0
Fed.Rep. of Germany	225	65.0	38.0	20.0	7.0
Netherlands	39	8.2	3.0	3.8	1.4
Norway	9	2.0	1.4	0.4	0.2
Poland	42	44.7	23.3	13.1	8.3
Sweden	34	7.5	5.6	1.4	0.5
Soviet Union	50	87.7	45.0	25.7	17.0
United Kingdom	127	40.0	21.0	14.0	5.0

Table 6: A list of 10 major point sources of mercury emissions in the study area in 1985.

No	Name	Source category	Country
1	V.E.B. Chemische Buna Verke	Chemical industry	German Dem. Rep.
2	Zaklady Oswiecim	Chemical industry	Poland
3	El. Turow	Electric power plant	Poland
4	Inc. Hamburg	Waste incineration	Fed.Rep. of Germany
5	Dow Chemical GmbH Stade	Chemical industry	Fed.Rep. of Germany
6	Preussag AG Metall - Harlingerode	Non-ferrous metal production	Fed.Rep. of Germany
7	El. Jaworzno	Electric power plant	Poland
8	El. Pocerady	Electric power plant	CSFR
9	El. St. Petersburg	Electric power plant	Soviet Union
10	Societe Miniere et Metallurgique de Penarroya	Non-ferrous metal production	France

Table 7: Total emissions of As, Cd, Cu, Pb, and Zn from anthropogenic sources the study area in 1982 (in t/y).

Country	As	Cd	Cu*1	Pb	Zn
Belgium	85	12.1	613	2 097	695
Czechoslovakia	94	21.6	323	1 151	756
Denmark	9	6.3	38	653	129
Finland	106	8.0	246	1 123	217
France	144	31.8	450	8 683	3 637
German Dem.Rep.	95	37.1	376	1 750	819
German Fed.Rep.	351	81.1	1 552	5 562	3 699
Netherlands	34	5.5	105	2 206	294
Norway	41	2.1	40	727	117
Poland	591	180.4	1 161	2 956	4 040
Sweden	181	16.4	36	1 035	426
United Kingdom	119	30.7	130	8 615	2 299
USSR (European part)	2 094	308.6	631	30 924	13 160

*1 Data for 1979/1980.

Table 8: A list of 10 major point sources of arsenic, cadmium, copper, lead and zinc in the study area in 1982.

No	Name	Source category	Country
1	Huta Glogow I & II	Non-ferrous metal production	Poland
2	Huta Legnica	Non-ferrous metal production	Poland
3	Ukrzinc-Konstantinovka	Non-ferrous metal production	Soviet Union
4	Nikel complex - Kola Penisuela	Non-ferrous metal production	Soviet Union
5	Huta Szopienice	Non-ferrous metal production	Poland
6	Krompachy Copper works	Non-ferrous metal production	CSFR
7	Societe Miniere et Metallurgique de Penarroya	Non-ferrous metal production	France
8	Preussag AG Metall	Non-ferrous metal production	Fed.Rep. of Germany
9	Berzelius Metallhütten GmbH-Duisburg	Non-ferrous metal production	Fed.Rep. of Germany
10	V.E.B. Bergbau u.Hütten Kombinat	Non-ferrous metal production	German Dem.Rep.

Table 9: Prognosis of atmospheric emissions of As, Cd and Pb in Europe for the year 2000 (in t unless as indicated) assuming BAT in non-ferrous metal smelters and unleaded gasoline.

Source category	As	Cd	Pb x 10^3		
	BAT	BAT	BAT	Unleaded gasoline	BAT + unleaded
1 Power plants	324	149	1.7	1.7	1.7
2 Chemical industry	-	1	-	-	-
3 Steel & iron manufacturing	219	53	3.9	3.9	3.9
4 Non-ferrous metal production	182	365	1.6	13.0	1.6
5 Other industries (incl. cement and metal application)	340	20	0.7	0.7	0.7
6 Industrial, commercial and residential boilers	408	171	2.1	2.1	2.1
7 Gasoline combustion	-	-	68.3	-	-
TOTAL	1473	759	78.3	21.4	10.0
Total / 1982 emissions	0.3	0.5	0.9	0.25	0.1

Table 10: Emissions of PCBs, HCHs, and HCB in the study area in the mid 1980's

Country	PCBs in 1000 t	γ-HCH in t	HCB in kg
Belgium	20	1.6	470
Czechoslovakia	31	4.3	950
Denmark	10	1.5	340
Finland	10	0.2	310
France	110	12.8	4 000
German Dem.Rep.	34	6.6	950
Fed.Rep. of Germany	122	36.0	3 300
Netherlands	29	3.1	420
Norway	8	0.5	150
Poland	74	14.5	2 000
Sweden	17	0.4	510
Soviet Union*1	350	217.5	23 600
United Kingdom	113	26.7	2 400

*1 the European part of the country

Table 11: NO_x emission standards in the study area.

Emission standards	CSFR	Denmark	Finland	France	Fed Rep of Germany	Netherlands	Norway	Sweden	EEC
(i) Power generation (g/Nm^3) - Small plants - Medium-sized plants - Large plants	In preparation	0.4	Hard coal N: 70-150 mg/MJ E: 150-230 mg/MJ Peat N: 150 E: 150-180 Natural gas N: 50-100 E: 80-100 Oil: N: 80-150 E: 120-150		New and existing solid fuels >300 MW 0.2 50-300 MW 0.4 liquid fuels >300 MW 0.15 50-300 MW 0.3 gaseous fuels >300 MW 0.1 10-300 MW 0.2 Waste incineration: 0.2	Coal / Oil / Gas N E / N E / N E 0.5 / 0.3 0.7 / 0.2 0.5 0.5 / 0.3 0.7 / 0.2 0.5 0.4 1 / 0.3 0.7 / 0.2 0.5		N 1990 gNO_x/MJ Coal fired: 0.05 oth.>300tNOx/y 0.05-0.1 oth.>10 MW: 0.1-0.2 E 1995 gNO_x/MJ >600 tNOx/Y 0.05-0.1 >150<600 tNOx/y 0.1-0.2	Solid fuels, in general: 0.65 Solid fuels, special: 1.3 Liquid fuels: 0.45 Gaseous fuels: 0.35
(ii) Industrial processes (g/Nm^3) - Nitric acid plants - Fertilizer plants		0.5 0.5			Industrial processes: 0.5	N: 0.41 E: 1.13	Typical licence emission limits: No general requirements, BAT No general requriements		Industrial processes major sectors, new and existing plants: SO_2, NO_x, VOC, heavy metals, Cl, F: BATNEEC (best available technology not entailing excessive cost)
(iii) Vehicle (g/km) - Petrol-fuelled, light-duty vehicles - Petrol-fuelled, heavy-duty vehicles - Diesel-fuelled, light-duty vehicles - Diesel-fuelled, heavy-duty vehicles	New standards in preparation 1990: 14.4 g/kWh 1993: 12.6 g/kWh 1995: 10.7 g/kWh Two stroke engines (1991): <15 g/kWh > 6 g/kWh		New passenger: reduction of emissions by 80-90% (for all new 1.1.1990) Heavy duty: R.49 R.24, by 1995 50% of present levels of emissions	88/76/EEC, 88/77/EEC, 89/458/EEC		In conformity with EC regulations.	Petrol, diesel-fuelled: Passenger cars and light-duty trucks <3500 kg, max load <750 kg: 0.62 g/km urban driv., 0.76 g/km highway. Light-duty trucks <3500 kg, max load >760 kg: 1.1 g/km urban driv., 1.4 g/km highway. Heavy duty >3500 kg: 7 g/kWh	Loading capacity <690kg <690 kg after 1988: NO_x 0.62-0.76 evaporation: 2 Loading capacity <690kg after 1991: NO_x 1.1-1.4 evaporation: 2 Heavy duty, after 1992 NO_x: 9	Passanger cars: Type approv. / Prod. CO 2.72 / 3.16 HC + NO_x 0.97 / 1.13 Particles 0.19 / 0.24 Heavy diesel(88/77): CO 11.2 / 12.3 HC 2.4 / 2.6 NO_x 14.4 / 15.8

N = new sources
E = existing sources

Table 12: Cost of implementation of the proposed action programme for point sources of emission.

Source category	Control method proposed	Compared to be abated	Maximum control efficiency in %	Amount of compounds to be abated	Cost of 1 tonne (or 1 kg) abated in ECU	Total cost in 10^6 ECU
Production of heat and electricity	Installation of low NO_x burners in major electric power plants and co-generation plants*1 (over 1000 MW_e or 200 GJ/h capacity)	NO_x	90	850 000 t (electric power plants) 470 000 t (heat production) Σ1320 000 t	100-200 ECU/t 100-200 ECU/t	85-170 47-94 Σ 232-264
	Combined systems of primary and secondary measures to reduce NO_x emissions in electric power plants as given in Table 3 of this report	NO_x	90	670 000 t	600-1000 ECU/t	402-670
	Flue gas desulphurization in major electric power plants and co-generation plants (over 1000 MW_{el} or 200 GJ/h capacity)	NO_x	90	1320 000 t	3000-6000 ECU/t	3960-7920
						or
		Hg (gas)	80	16 t	240000-480000 ECU/t	3840-7680
	Installation of ESPs in major electric power plants	Heavy metals	95	15 t Cd	1650 ECU/kg	25
Non-ferrous metal industry (smelters)	Installation of ESPs or fabric filters	Heavy metals	95	150 t Cd	16.5 ECU/kg	2.5
Iron & steel industry	Installation of ESPs or fabric filters	Heavy metals	95	4 t Cd	150 ECU/kg	0.6

*1 It was assumed that 70 per cent of heat is produced in these plants.

Table 13: Cost of implementation of the proposed action programme for area sources of emission.

Source category	Control method proposed	Compared to be abated	Maximum control efficiency in %	Amount of compounds to be abated	Cost of 1 tonne (or 1 kg) abated in ECU	Total cost in 10^6 ECU
Combustion of gasoline	1) Introduction of unleaded gasoline (25% of the market)	Pb		$2.00 \cdot 10^6$ t gasoline	15 ECU/tonne gasoline	30
	2) Reduction of Pb in gasoline from 0.4 g/l to 0.15 g/l (75% of the market)	Pb		$5.80 \cdot 10^6$ t gasoline	10 ECU/tonne gasoline	58
	3) Introduction of three way catalysts	NO_x	80	200 000	350-650	70-130
	4) Introduction of flue gas recirculation (FGR) to diesel fuelled cars	NO_x	40	80 000	2800-4050	225-325
Production of heat	Introduction of district heating replacing small commercial and residential burners - installation of low NO_x burners in new district heating plans	NO_x	90	200 000	100-200	20-40
Livestock wastes	1) Introduction of conservative application techniques (LNA)	NH_3	65 (?)	320 000	5-250	1.6-80
	2) Introduction of LNA together with stable adaptations	NH_3	65	320 000	1000-7250	320-2320

*1 It was assumed that the population in the previous Soviet Union territory of the proposed action area is 10 mln. The assessment of NO_x, NH_3, and Pb emissions from area sources in this region was made on the basis of emission in the European Soviet Union and according to the population ratio. The same has been applied when estimating the amounts of these pollutants to be abated.

*2 unless as specified.

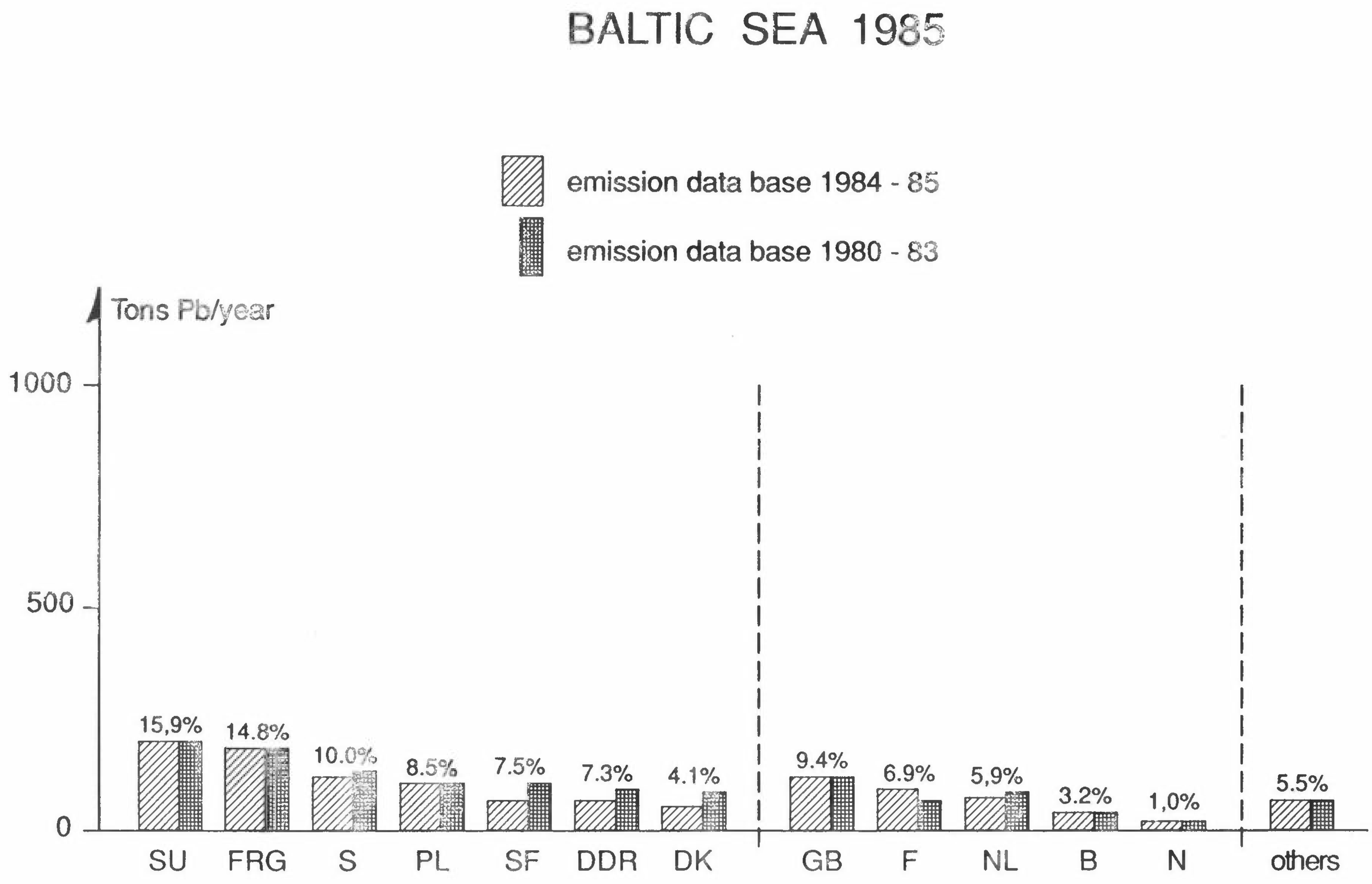

Figure 1: Deposition of lead to the Baltic Sea in 1985.

APPENDIX A

The following persons have collaborated with the author when preparing this report:

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TITLE
The topical area study for atmospheric deposition of pollutants

ABSTRACT
A concise review of current knowledge of emission and deposition fluxes of pollutants in the Baltic Sea region is presented together with future trends. Information on environmental legislation concerning emissions is enclosed as well as emission impact analysis. A review of national measures to reduce emissions is presented together with policy, legislation and regulating actions, and enforcement instruments. A list of priority actions is proposed.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C