

**Updating and upgrading the PHOXA emission  
data base to 1990**

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## **1 Introduction**

In 1984, the PHOXA emission data base with 1980 as the reference year was prepared for photo-oxidants and acid deposition model applications. It was the first data base of air pollutants that covered large parts of both West and East Europe. Since then, the OECD and the CEC established consistent inventories of their member countries with reference years 1980/1982 and 1985 respectively. In 1987 the PHOXA data base was extended to incorporate emissions of heavy metals and some non-volatile organic compounds. This extended PHOXA data base had 1982 as a reference year. In 1989 a variant of the PHOXA data base (LOTOS) was prepared, covering Europe to 60° longitude and serving the purpose of long-term ozone modelling. Its reference year also was 1985.

Cooperation between OECD, CEC and EMEP was established and presently the objective is to use one single system for all European Countries, i.e. the CEC's CORINAIR data base. CORINAIR 90 is in preparation and it is expected that all West European countries and some eastern countries will join this project.

Coping with the high ozone level episodes during summer 1990, observed in large parts of Europe, the German Umweltbundesamt decided to anticipate this development by upgrading and updating to 1990 the PHOXA 1980/82 data base. For this, it was decided to rely substantially on the knowledge acquired within CORINAIR and LOTOS and on the data contained in these data bases. Further, due to the recent political changes, exchange of information between Western and Eastern Europe can be used. In the past this was impossible.

This report briefly describes the preparation of the PHOXA 90 emission data base and the final results.

## **2 Description of the data base**

### **2.1 Area**

All European countries, except Albania, Greece, Spain and Portugal. The Soviet Union to 30° east longitude. The northern boundary is 66° latitude (See figure 1). The countries involved, their codes and numbers of inhabitants are given in table 1, in which all European countries are presented.

### **2.2 Grid**

30' longitude × 15' latitude (PHOXA).

### **2.3 Substances**

- SO<sub>2</sub>/SO<sub>4</sub>", NO<sub>2</sub>/NO, CO, VOC, (NH<sub>3</sub>).
- VOC-profiles according to chemical mechanisms of REGOM and ADOM/TADAP.
- Up to the present NH<sub>3</sub> is not treated within the update because of the intention to use the PHOXA 90 data base primarily for photo-oxidant modelling.

### **2.4 Point sources**

- Energy production: capacities > 100 MW<sub>e</sub> or >300 MW<sub>th</sub>.
- Petroleum refining.
- Chemical industry: ethene, LDPE, HDPE, VC, PVC, PS, PP, SBR, ABS. Primary iron- and steel industry.
- Pulp/paper.
- Cement.
- Vehicle manufacturing (VOC emissions from lacquer application).

### **2.5 Area Sources**

- Chemical industry.
- Primary iron and steel industry.
- Other industry.
- Energy production.
- Road transport: highway/other modes, ldv/hdv, gasoline/diesel, exhaust/evaporation, gasoline distribution.
- Non-industrial fuel consumption.
- Solvent use.
- Natural sources of VOC (vegetation).

## **2.6 Temporal distribution of emissions**

Identical to PHOXA 80.

### **3 Organization of the update**

#### **3.1 General**

As has been said in chapter 1 CORINAIR and LOTOS were the bases for the upgrading of PHOXA 90. No new research on emission estimating procedures was planned, instead, only available knowledge and data was to be used. In this respect reference should be made to new data that have become available since the completion of LOTOS.

Updating had to be done with changes in activity data in the time span 1985-1990 and with reported emission data for 1990 or for the nearest year.

#### **3.2 CEC member countries**

The commission's consent was obtained for the use of the CORINAIR 1985 data. These had to be processed to meet the demands of PHOXA 90 as detailed as possible.

#### **3.3 Other countries**

Of all countries, i.e. AT, BG, CH, CS, FI, HU, NO, PL, RO, SE, SU and YU, activity data and point source were to be retrieved from presently available data sources. The recent shift in the European political pattern and the increase of information resulting from it made it possible to draft inventories of the three Baltic States separately from the (now former) USSR. The part of this country comprised in PHOXA 90 consist of a very small part of Russia, a large part of Belorussia, the most western part of the Ukraine and Moldavia. St. Petersburg and the huge Ukrainian industrial zone are outside PHOXA 90.

#### **3.4 Ammonia emissions**

These can be taken from [K10].

#### **3.5 Point sources**

Initially it was planned to upgrade by inserting corrections and additions in the existing PHOXA 80/82 data base. The difference between available data and the contents of the data base, however, appeared to be so large that it was decided to perform a complete data reassessment, especially with respect to power and heat production. All relevant data were to be recorded or, if



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not available, to be reasonably estimated. Less important data, e.g. age of plants, were to be recorded only if readily contained in data sources. Plants, not being of primary importance for the PHOXA 90 objections, e.g. primary non-ferrous metal, chlorine and cement, were to be treated less systematically. These activities, however, are still kept within the data base, considering future use with respect to other pollutants.

The point source file of the PHOXA 80/82 data base contains some details that at the time of its design were considered to be useful either for direct or for future application. Since then, developments in the profession of emission inventorying demonstrated, that these would not contribute to the quality of estimated emission data. An example is the attempt to improve the estimation of combustion emissions in petroleum refineries by incorporating data of selected installations. This approach appeared to be deceptive.

### **3.6 Area sources**

The procedures for the spatial allocation of non-point source emissions, calculated from activity data and emission factors, have not fundamentally been changed since PHOXA 80/82 was designed. Surrogate parameters still are indispensable.

A remark on road transport should be made, however. The PHOXA 80/82 approach to estimate separately highway emissions and distribute them uniformly among mapped highways is considered to yield an improvement that is illusionary without – at least approximate – traffic intensity distributions. To this adds a still very incomplete knowledge about vehicle fleet characteristics and speed distributions in eastern European countries (the near-future cooperation in an UNECE/OECD/CEC framework will improve this situation). Based on an analysis of CORINAIR data it was shown that an estimation of nation-wide road transport emissions from fuel consumption data instead of one from activity data yields acceptable results in a situation where basic background data are scarce.

Road transport emissions in CEC member states have been calculated uniformly by the COPERT programme and have been distributed among territorial units by national experts with best possible means. CORINAIR data therefore can be used straightforwardly for PHOXA 90. Emissions from east European countries, on the other hand, were decided to be estimated from fuel consumption data and to be spatially distributed with population data. In EFTA countries, the additional problem of the effect of increasing use of catalytic control of exhaust made it necessary to use most recent national estimates. Spatial distribution in these countries could either be taken from reported data or prepared with population data.

Biogenic VOC emissions were to be based upon LOTOS data: vegetation data in the  $2^\circ \times 1^\circ$  grid, converted to biomass data and treated with – essentially – EPA emission factors. The larger resolution needed for PHOXA ( $0.5^\circ \times 0.25^\circ$ ) had to be made by forest coverage data from the PHOXA land use data base.

### **3.7 Work share-out and responsibilities**

The following distribution of work and allocation of responsibilities was agreed:

- a. Upgrading of point source data.  
Collection of most recent activity data (productions and consumptions).  
Emission factors (state-of-the-art).  
IMET-TNO (C. Veldt).
- b. Processing of CORINAIR data.  
IGG-TNO (J. Hulshoff).
- c. Update of CORINAIR data.  
Dornier GmbH (F. Axenfeld) and IMET-TNO (C. Veldt).
- d. Basic data for biogenic VOC emissions.  
Dornier GmbH (F. Axenfeld and B. Rauschelbach) and  
IMET-TNO (C. Veldt).
- e. Final generation of emission data base PHOXA 90.  
Dornier GmbH (F. Axenfeld).
- f. Prime Contractor to Federal Environmental Agency of Germany and overall  
project management.  
Dornier GmbH (H. Meinel and F. Axenfeld).



## 4 Upgrading of point source data

### 4.1 General

In the region outside the EC circa 200 energy conversion plants, circa 150 refineries and chemical industries and circa 200 other plants were described as a point source (table 2). The large number of data involved is not presented in this report. Instead, tables 3a and 3b give examples of the mode of data transfer.

#### Notes

- a. Coordinates are decimal.
- b. Installation, type  
E = electricity production.  
EH = electricity and heat production (fuel used to produce heat).  
H = heat production.
- c. Installation, number. Assignments were made when different fuels were used or because of different functions or differences in control. Only exceptionally assignments were the same as those locally in use for reasons of clarity (e.g. PL 4: 1,2,3).
- d. Year of commission. It was attempted to assess the age of plants by indicating the first year of utilization or the period of it. Data were entered only whenever readily available. Their operational value is questionable, at least because of possible intermediate reconstructions.
- e. Stack heights were taken from [U3] similarly as was done for PHOXA 80/82. Data are maximum heights, so probably many point sources will emit only a fraction of emissions at these heights.

Table 4 contains the references to the data sources used. Only the main sources will be discussed in this report.

### 4.2 Energy production

The IEA Coal Research (IEACR) compilation of coal fired power plants [M1], together with another IEACR report on the subject [C2] was the principal source of information. With the exception of the Soviet Union, all countries are considered into detail. For plants fueled with oil or gas, main references were J1, V4 and V5. Condensing power plants that deliver heat to networks were described as electricity producers. Plants, comprising separate heat generation were described as electricity and heat producers. In many cases no information was available about installed thermal capacity for heat production, making fuel allocation difficult there.

In some cases, data from different sources were in conflict so that choices had to be made. The point source data listing for PHOXA 90 is assumed to be the most probable one.

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Data on SO<sub>x</sub> emission control were taken from an IEACR compilation for coal fired plants [V1], those on NO<sub>x</sub> control were from a VGB-members compilation [K2]. Considering that in East European countries control is only exceptionally in use until now, coverage may be fairly complete.

**Miscellaneous comments per country****■ Austria**

For AT 11, [S2] was used.

**■ Bulgaria**

There was no information about heat generating capacities for individual sites. Data are estimated, based on population (circa 15% of residential heat is provided by CHPs [C2]).

**■ Czechoslovakia**

CS 1:1 and CS 5:1 cut their output by 50% [A9].

CS 9 = 583 MW<sub>e</sub> [V2] or  $2 \times 110 + 4 \times 55$  [C2].

A study by the DIW [B2] provided the location of CS 21, fuels for CS 19, 20, 21 and 47:1 as well as data for CS 14, 32:1, 50:1 and 52:1.

**■ Poland**

Capacities and fuels of PL 28-33 have been assumed.

**■ Romania**

Data on RO 3,7,8,14,21,22,49:1.2 were from [C5]. This is a report from 1980, which was used notwithstanding its age because of the scarcity of data from this country. RO 15 is more of a representation of CHPs in Bucharest.

**■ Soviet Union**

Power plants >2000 MW<sub>e</sub> are well recorded [E1, G1, M1]. The main data source for smaller plants is [G1] but this report dates back to 1982. Many locations are known but actual data are incomplete. Capacities at SU 1,2 and 11 are not known but are expected to be relatively small. Fuels used in SU 1,3,6,7,10 and 11 also are not known.

Installed electric capacity in the PHOXA area is covered for 88% (table 5).

**4.3 Other source categories**

These were taken from year books as the main source of information. The chemical industry in Scandinavia [C12] and cement plants [W2] are due for an update.

## 5 Fuel properties

In the past, only few data on sulphur contents of fuels used in East European countries were available. Some of these were conflicting and difficult to compare if not specified. With present available information – although far from complete – it was possible to record data on a common basis, i.e. 'as-mined'. Sulphur contents and heats of combustion of fuels used in point sources are in the point source file. For area sources, on the other hand, average values are needed. These had to be estimated or – in some cases – even be assumed. Only exceptionally they were reported.

Values of S and  $H_1$  are presented in table 6. Tables 7 and 8 contain additional fuel data that have been used for PHOXA 90.

Initially, it was attempted to also improve the data on sulphur retention in (brown)coal ash by correlating chosen characteristics of ash compositions with amounts of sulphur bound. The attempt failed, more because of poor correlations than because of scarcity of data. For brown coal ash an uniform value of 30% was therefore used for PHOXA, 5% for hard coal and 80% for oil shale [F2,H3].



## **6 Emission factors**

### **6.1 Stationary combustion**

Updated CORINAIR values were used. Surprisingly, the negative effect of tangential firing on NO<sub>x</sub> emissions is not reflected anymore in the reported data. Allegedly, large ranges of values prohibit distinctions between firing modes. In table 9 all relevant information is presented. Data on condensable organic compounds are given only as a reminder, hence they need not be considered as part of VOC yet.

### **6.2 Process emissions**

In table 10, factors for selected processes and substances are given. Factors for bulk monomer and bulk polymer production have still not been improved. It is very well possible that no improvement will turn out to be feasible, large differences in operating practice preventing factor development. Most of the factors are the same as proposed for CORINAIR. VOC factors for the primary iron and steel industry are from [V6]. For refinery emissions, see also [V6]. It appears that there is no significant difference in specific fuel consumptions of refineries in West and East Europe. This could be explained by considering that a less efficient fuel use is compensated by the lower average complexity of refining practice in eastern Europe. Combustion emission factors therefore are assumed to be equal.

### **6.3 Mobile sources**

As has been said in chapter 3.6 considerably more uncertainty can be expected to exist in the estimation of emissions from transportation in east European countries as compared to western Europe. In some of these countries statistical data are scarce, if available at all. This is both true for fuel consumption data and vehicle fleet characteristics. Further, emission factor development is hampered by parts of vehicle fleets that are aged and by the usage of two-stroke engines and gasoline-powered heavy duty vehicles in some countries. For the latter vehicle category information is incomplete. For two-stroke engines the same is true but, in comparison with the very roughly estimated factors used in PHOXA 80/82 and LOTOS, now at least some recently measured data are available.

A simple update of road transport emissions in West European countries is not possible because of the increasing use of catalytic control. For EC member countries use was made therefore of estimates made by COPERT.

For EFTA countries, reported data of road transport emissions were used as given in table 11. Actually, only data from Norway are complete. Those from Sweden can be used as a check because of separately reported emissions from gasoline and



diesel. Data from Austria and Switzerland are totals and thus are only limitedly useful.

Emissions from East European countries are estimated as follows.

- a. Fuel-based emission factors were developed from CORINAIR factors. From a few data on age distribution of automobiles it was assumed that factors could be derived from those, valid for CEC-regulations 15-00 through 15-03 (1970-1978).
- b. The cold start emission correction procedure was simplified to  $1.3\% \cdot ^\circ\text{C}^{-1}$  for VOC and  $0.6\% \cdot ^\circ\text{C}^{-1}$  for VOC for gasoline-powered engines.
- c. Emission factors for two-stroke engines were derived from measured data [S7,S8]. Because of differences between emissions from Trabant and Wartburg, factors were calculated for an estimated  $2/3$  Trabant and  $1/3$  Wartburg contribution (based on data from DD and HU [S9]).
- d. Emission factors for inland navigation and rail transport were taken from EPA [E5] and Umweltbundesamt [U4].

Evaporative emissions have been estimated by COPERT from two measurement campaigns [C20,H8]. The effect of ambient temperature was only very roughly indicated. For LOTOS, an attempt was made to quantify this effect with data from [C20]. Much uncertainty still exists about estimating procedures and the value of  $45 \text{ g VOC} \cdot \text{vehicle}^{-1} \cdot \text{day}^{-1}$  at  $20^\circ\text{C}$  ambient temperature, which is an aggregation of hot soak, tank evaporative and running losses and was used for LOTOS should be considered as a first approximation only. Yet, this factor is proposed for PHOXA 90. The temperature effect is shown in figure 2.

Evaporative emissions from gasoline distribution outside refineries can be attributed to the transport source category but only the losses at filling stations can be realistically distributed with population data. The factor for depots is  $0.7 \text{ g VOC} \cdot \text{kg}^{-1}$  of gasoline, the overall factor for filling stations is  $2.8 \text{ g VOC} \cdot \text{kg}^{-1}$  of gasoline [C18]. In the Soviet Union the factor must be considerably higher [W6] but this does not mean that this is true also for other East European countries. An approximate value of  $5 \text{ g VOC} \cdot \text{kg}^{-1}$  could be used (for the USA circa  $4.5 \text{ g} \cdot \text{kg}^{-1}$  can be derived for the reference year 1980).

Transport emission factors are presented in table 12.

## 6.4 Solvent evaporation

In PHOXA 80/82, an uniform assumed value of  $5 \text{ kg} \cdot \text{cap}^{-1} \cdot \text{y}^{-1}$  was used to account for solvent losses in East European countries, in contrast with an estimated value of  $13 \text{ kg} \cdot \text{cap}^{-1} \cdot \text{y}^{-1}$  for West European countries. Pacyna [P5] estimate for East European countries  $3.3 \text{ kg}$  for non-industrial losses and half of this value for industrial losses and hence arrived at the same figure as used for PHOXA.

For LOTOS it was attempted to differentiate between countries by considering the effects of the main economic activities involved. Thus, for paint solvents it was assumed that the production in European COMECON countries was used in the same region, which was reasonably well confirmed by [F4]. For metal degreasing, printing and the chemical industry, production volumina and contributions to

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GNP were compared for metal products manufacturing, printing industry, printing paper consumption and the chemical industry. Results are presented in table 13. The estimation of losses from chemical cleaning and from consumer products is only a guess.

Neither of these approaches has a really sound basis. Unless consumption data, reliably estimated by national experts, become available, the contribution to total anthropogenic VOC emissions in eastern Europa will remain more or less a guess.

Data for EFTA countries are available from the OECD-MAP inventory for the reference year 1980 [O7]. EC members reported data to CORINAIR for 1985. Differences might be attributable to changes in consumption but also to revised emission estimation procedures (table 14). More recent data are provided by [Z3]. Generally, no substantial changes seem to have occurred, but at least part of this estimation is attributable to a lack of reliable data. Nevertheless, for PHOXA 90, these data could be used. Table 14 also gives the fraction of non-industrial emissions (including printing industry) for spatial allocation purposes.

## **6.5 Biogenic VOC emissions**

The first attempt to develop a methodology for the estimation of biogenic VOC emissions in Europe, as used in PHOXA, must be considered as obsolete now. Based on a thorough reinterpretation of measured data in the USA by Lamb et al [L11] a biogenic emissions inventory system (BEIS) now is in use by EPA [P6]. Measured data outside the USA in many cases appear to be different, however, but might give not enough support for a proposal to review the factors used in BEIS. Nevertheless a report, aiming at an intercontinental discussion, has been prepared [V7]. Topics are emission factors, leaf biomass factors and temperature – radiation – emission algorithms.

Anticipating this discussion, for PHOXA 90 the same factors as used for LOTOS are proposed, the only difference being the influence of ambient temperature on terpene emissions which, according to [V7] is less pronounced than as was described in LOTOS. Factors are given in table 15.



## 7 Composition of emissions

### 7.1 Acid oxides

Since the completion of the PHOXA 80 data base no research has been done to collect more information about  $\text{NO}_2$  and  $\text{SO}_4$  fractions. For the PHOXA 90 data base these fractions therefore will remain unchanged (table 15).

### 7.2 VOC-profiles

In terms of reliability, VOC profiles underwent no substantial change in the past years. Unavoidably applied as average data sets for modelling, as is done e.g. in PHOXA and LOTOS they clearly contribute to the overall error of emission inventories. The variability of some activities makes a better approach impracticable as in the case with stationary combustion, refineries and many chemical processes. Others can be improved if basic data are sufficiently available (gasoline vapour, solvents).

Some profiles that are used in PHOXA 90 are based on an up-to-date literature search (non-industrial combustion, refineries and coke ovens) [V6].

But this does not mean that their basis always is a sound one. The combustion of coal notably is a more default because there is hardly any information on this source type. Profiles for gasoline vapour and chemical processes were taken from CORINAIR [C18] and profiles for solvents and uncontrolled exhaust were from [V9]. It should be noted that these are planned to be subject to further research. It should also be noted that the overall composition of solvents, based on data from 1978-1982 are not conflicting with more recent data from European countries [V9] but still might not adequately reflect the present situation, drastic as measures in some countries are becoming now.

To make possible an adaptation of the gasoline exhaust profile to catalytic control, a profile for 3-way catalytically controlled exhaust has been included ([K7], profile no. 1203).

Exhaust from 2-stroke engines has a profile which differs from exhaust from 4-stroke engines because a considerable amount of unburned gasoline is emitted. No quantitative data being available, a profile for 2-stroke exhaust was used in PHOXA 80 and LOTOS composed of 10% 4-stroke exhaust and 90% gasoline vapour. This assumption was based on engineering judgement. At present, there are still no profile data available so the same assumption has to be made. However, measured data [S7,S8] suggest fractions of 20% 4-stroke exhaust and 80% of gasoline vapour.

Profiles are presented in table 17. Table 18 gives the same profiles but transformed to the ADOM chemical mechanism.

## 8 Activity data

### 8.1 Fuel consumption data

Consumption data for EFTA countries of the main fuels by source category were taken from statistical year books and from OECD statistics. Data for AT and SE were available for 1990, data for CH, FI and NO only for 1989. For BG, CS, H, PL and RO 1989 data were available from various data sources (table 3). Updating to 1990 was done with Plan Econ estimates [P4]. Plan Econ calculates apparent consumptions from production + import and export; these data are the most recent available. To facilitate data comparison with other sources, 1989 data for these countries were also recorded.

For the Baltic States, data were available from [F2] for 1988 (ET), 1985/1989 (LA) and – planned – data for 1990 (LI). No means were available for updating ET and LA. The same applies to YU, for which country only 1989 data were available.

The USSR is a special case. The small part inside the PHOXA 90 area of this huge country, not to mention large regional differences makes extrapolation impossible. An estimation, including some spatial allocation, was done with data from EMEP/MSCE [E4] and statistical data for the USSR [B3, P4b]. The following notes about the calculations will be made here (see also figure 3).

- For the area involved, data on SO<sub>x</sub> emissions from [B3] and [E4] are the same. NO<sub>x</sub> data differ because [B3] does not include non-industrial fuel combustion and other transport.
- In order to check whether Plan Econ data on contributions to national industrial performance from regions could be used together with estimated emission data, a comparison was made between LOTOS data (1985) and data from [B3] (1989). VOC and SO<sub>x</sub> data from LOTOS appeared to be 35% higher. NO<sub>x</sub> from all stationary sources – except the non-industrial ones – was 25% higher but NO<sub>x</sub> from road transport was 50% higher. Differences probably have to do with emission factors.
- It was therefore concluded that the methodology for inventorying stationary sources as used in the USSR does not significantly differ from the approach used for PHOXA and LOTOS (special reference is made here to emission factors). For the allocation of energy use as well for emissions the following data can be compared (percentages of national totals):

|                        | NO <sub>x</sub> -<br>emissions<br>stat.sources<br>[B3] | Inhabitants (x10 <sup>6</sup> ) |               | Industrial output<br>[P4b] |       |       | Electric<br>power<br>[P4b] |
|------------------------|--------------------------------------------------------|---------------------------------|---------------|----------------------------|-------|-------|----------------------------|
|                        |                                                        | Total                           | PHOXA<br>area | prim.<br>Fe                | chem. | other |                            |
| Ukraine,<br>South-west | 4.9                                                    | 7                               | 5             | 0.4                        | 6.0   | 7.5   | 7.9                        |
| Belorussia             | 2.6                                                    | 3.5                             | 3.4           | 0.4                        | 5.5   | 4.5   | 4.7                        |
| Moldavia               | 1.2                                                    | 1.4                             | 1.4           | 0.1                        | 0.4   | 1.5   | 2.0                        |



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To the NO<sub>x</sub> emissions the contribution from the non-industrial sector (LOTOS data) has been added. The share of electric power has been corrected for non-thermal generation.

- No gross deviations distort the pattern, so these data were used together with national fuel consumption data. Fuel consumption by point source power plants was separately estimated. Fuel consumption by industrial branches was allocated with per-branch shares of industrial output (5 to 10 branches) and fuel consumption by other source categories was allocated with population data. The unlikeliness of the assumption of homogeneity in fuel-use patterns throughout the whole USSR was, of course, recognized.

The small parts of the USSR, assigned LEN and ZAP (except Kaliningrad) west from 30° longitude could not be treated in this way. Simply assuming this region to be comparable to Latvia, its ca. 10<sup>6</sup> inhabitants are taken to consume 40% of the fuels, used in that country. For Kaliningrad, only data from [H3] were used.

Consumption data on fuel wood usually are not in official statistics. Existent data are not easily comparable because they may include various kinds of vegetational wastes and definitions are not always clear. What was found in data sources and used for this study is presented in table 19.

Fuel consumption data for road transport need differentiation if used for emission estimation because of the different emission factors involved. This is in the first place necessary for East European countries (see paragraph 6.3). Fuel splits between 2-stroke and 4-stroke engines and between gasoline powered ldv and hdv as well as the share of diesel consumption for mobile sources are not easy to estimate, hence data are of varying reliability (table 20).

## **8.2 Production data**

Main sources for production data were statistical year books, branch-specific UN statistics, CEDUCEE data and miscellaneous branch-specific data compilations.

Data of the non-CEC countries are given in table 21. The table is not complete. Reasons are: data are classified, further research needed or data are not suitable for a relation with emissions. In these cases, production may be estimated as an assumed fraction of capacity. National capacities may be assumed to be fully covered by point source capacities.

## 9 Update data for the CORINAIR inventory

With production and consumption data from national statistical year books and – for most fuel data – OECD statistics, update factors can be prepared. The application of these is a primitive approach, assuming a linear relationship between activity and emissions and neglecting various effects that can influence the latter.

Still better update factors can be obtained from shifts in fuel consumptions for an activity. This approach was used wherever possible. In the first place, however, reported emission data from CEC member countries were used. Results from fuel – based and production – based update factors have to be checked – and, if necessary – corrected with help of reported emission data.

For each SNAP code-emission combination, as part of national total emissions, an update factor was prepared. Bases for these factors were emission data (DK, FR: '90 (SO<sub>x</sub>, NO<sub>x</sub>); IT: '89 (SO<sub>x</sub>, NO<sub>x</sub>, VOC); NL: '90 (SO<sub>x</sub>, NO<sub>x</sub>, VOC); GB: '88 (SO<sub>x</sub>, NO<sub>x</sub>, VOC) and fuel/production data from '89. Extrapolations to '90 appeared to be illusory.

Road transport emissions for 1990 might be generated by COPERT. A tentative set of update factors was taken from graphs in [S18] (table 22).

Evidently, emission control must be taken into account. For power plants, relevant data are given in table 23.

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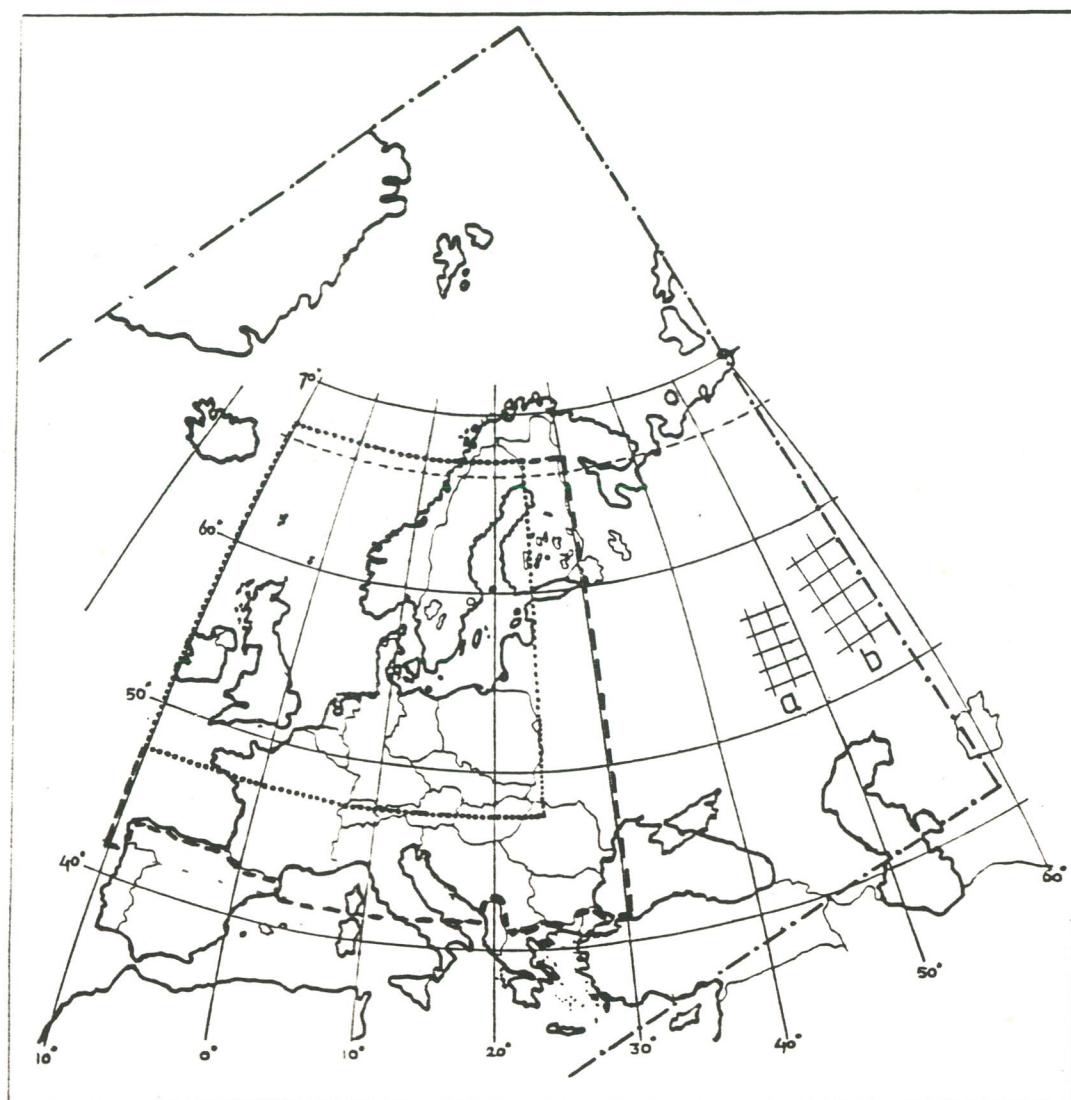


Figure 1 Europe in geographic and EMEP grids.

EMEP area: - . - . - .

PHOXA 80 area: . . . . .

PHOXA 90 area: - . - . - .

Grid cells shown: a = geographical grid, b = EMEP grid





## Updating and upgrading the PHOXA emission data base to 1990

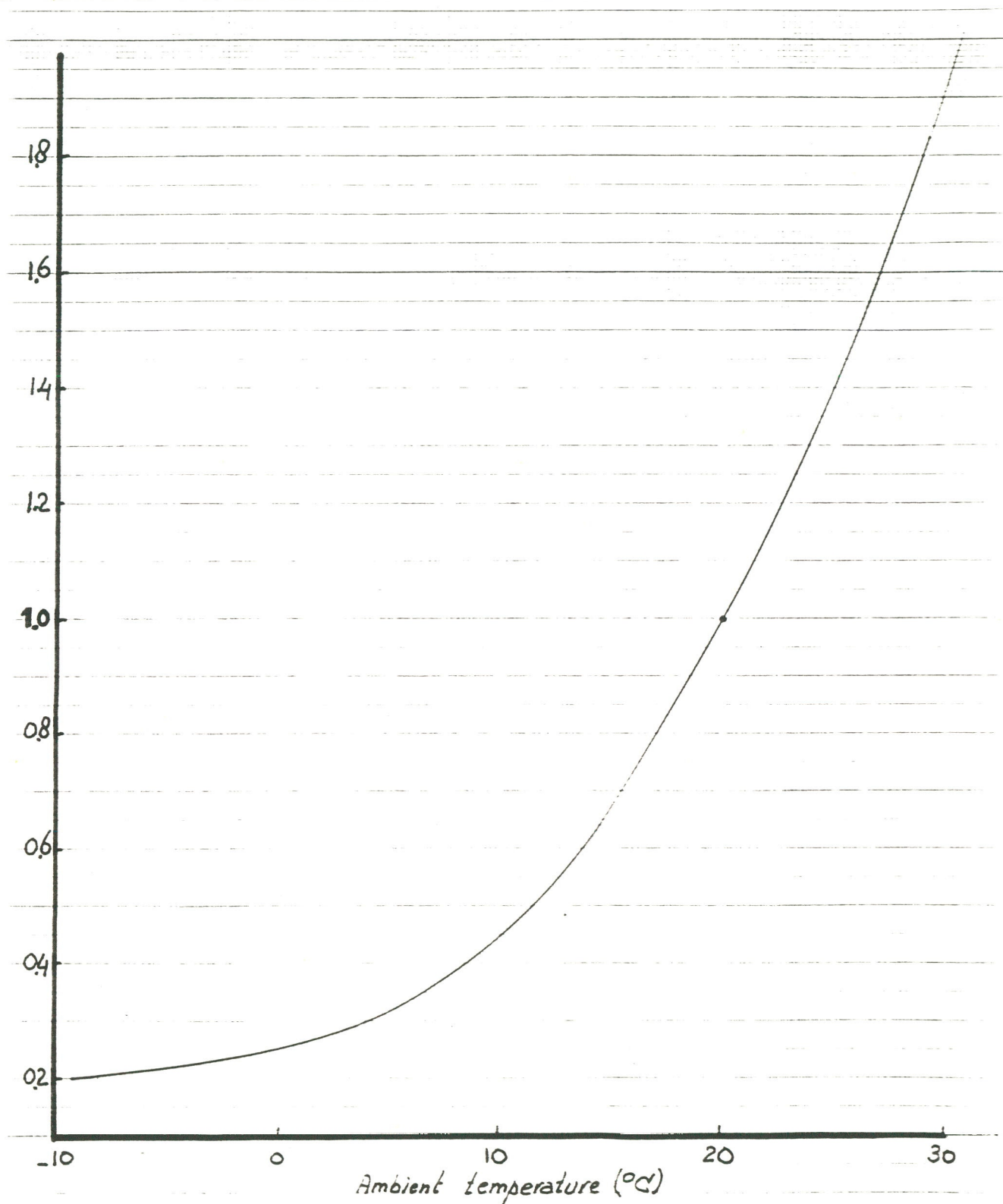


Figure 2 Evaporative VOC emissions from gasoline-powered vehicles as a function of temperature



## Updating and upgrading the PHOXA emission data base to 1990

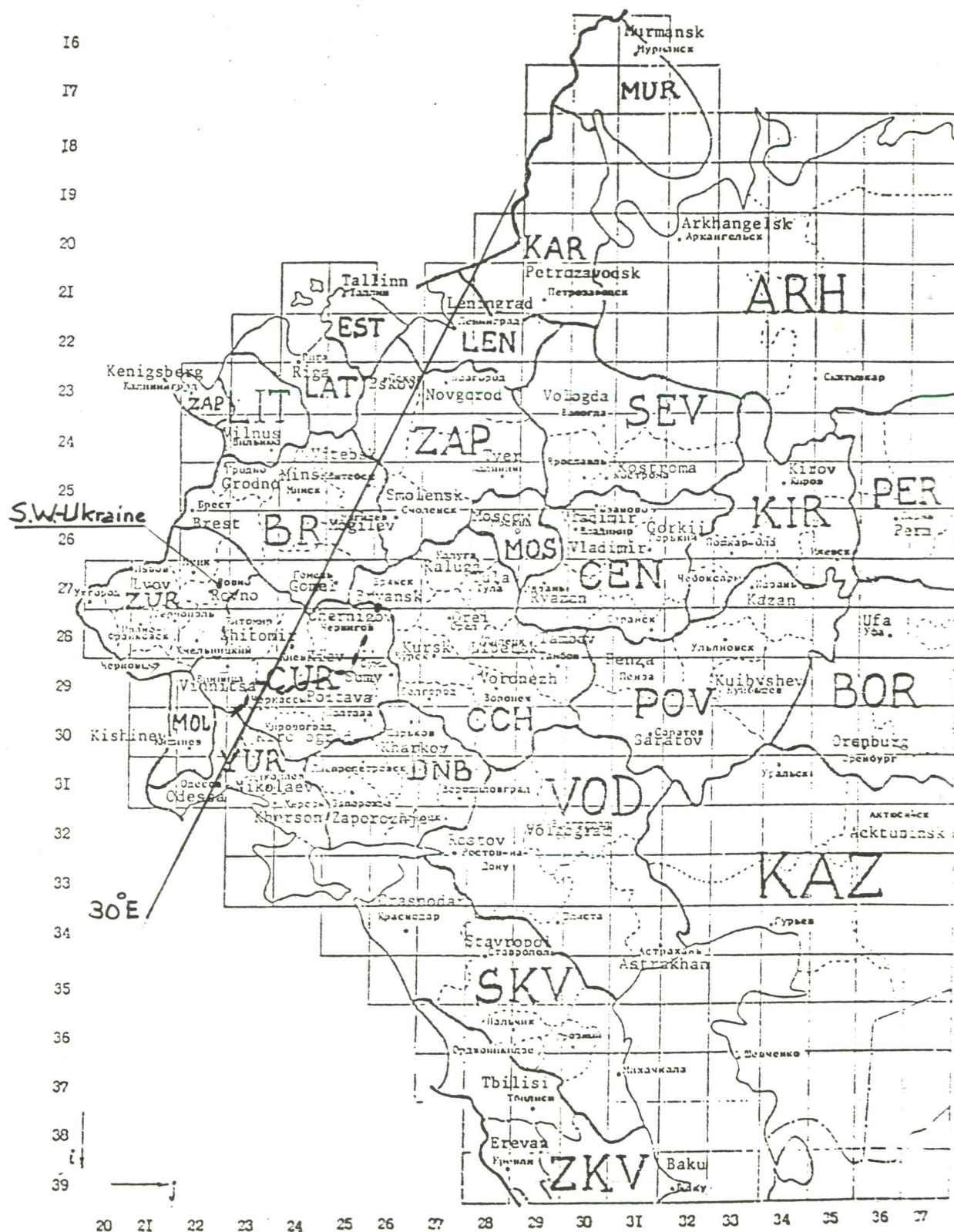


Figure 3 USSR territory division (MSC-E EMEP)





## Updating and upgrading the PHOXA emission data base to 1990

Table 1 Inhabitants of European Countries

| Country          | Code | Inhabitants ( $\times 10^3$ ) |                      |                    |
|------------------|------|-------------------------------|----------------------|--------------------|
|                  |      | 1980                          | 1985                 | 1990               |
| Albania          | AL   | 2671                          | 3000                 | 3278               |
| Austria          | AT   | 7549                          | 7552                 | 7614               |
| Belgium          | BE   | 9859                          | 9859                 | 9881               |
| Bulgaria         | BG   | 8862                          | 8979                 | 8995               |
| Switzerland      | CH   | 6385                          |                      | 6724               |
| Czechoslovakia   | CS   | 15265                         | 15509                | 15664              |
| Germany-East     | DD   | 16737                         | 16703                | 16598              |
| Germany-West     | DE   | 61566                         | 60940                | 61156              |
| Denmark          | DK   | 5123                          | 5109                 | 5141               |
| Spain            | ES   | 37424                         | 38765                | 39322              |
| Estonia          | ET   |                               |                      | 1573 <sup>1)</sup> |
| Finland          | FI   | 4780                          | 4910                 | 4971               |
| France           | FR   | 53880                         | 55191                | 56342              |
| United Kingdom   | GB   | 56330                         | 56518                | 57376              |
| Greece           | GR   | 9643                          | 9976                 | 10141              |
| Hungary          | HU   | 10708                         | 10645                | 10563              |
| Ireland          | IE   | 3415                          | 3614                 | 3509               |
| Italy            | IT   | 56434                         | 57079                | 57461              |
| Iceland          | IS   | 228                           | 243                  | 255                |
| Latvia           | LA   |                               |                      | 2681 <sup>1)</sup> |
| Lithuania        | LI   |                               |                      | 3690 <sup>1)</sup> |
| Luxembourg       | LU   | 364                           | 366                  | 377                |
| The Netherlands  | NL   | 14150                         | 14472                | 14927              |
| Norway           | NO   | 4086                          | 4157                 | 4245               |
| Poland           | PL   | 35578                         | 37160                | 38064              |
| Portugal         | PT   | 9766                          | 10151                | 10434              |
| Romania          | RO   | 22201                         | 22715                | 23278              |
| Sweden           | SE   | 8310                          | 8345                 | 8523               |
| Soviet Union-Eur | SU   |                               | 200100 <sup>2)</sup> |                    |
| Soviet Union     | SU   | 265542                        | 277500               | 290417             |
| Yugoslavia       | YU   | 23304                         | 23235                | 23861              |

<sup>1)</sup> [F2]<sup>2)</sup> SU < 60° longitude (LOTOS estimation)

Source: Britannica World Data 1986, 1990, Encyclopaedia Britannica Inc.

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*Updating and upgrading the PHOXA emission data base to 1990*
**Table 2**    *Numbers of point sources in European countries, outside the EC*

| Country code     | Electricity/heat production | Refineries chem.ind. | Prim. Fe | Prim. non-Fe | Cement | Pulp/paper | Auto-mobiles | Total |
|------------------|-----------------------------|----------------------|----------|--------------|--------|------------|--------------|-------|
| AT               | 13                          | 5                    | 3        | 4            | 8      |            |              | 33    |
| BG               | 9                           | 7                    | 2        | 4            | 4      |            |              | 26    |
| CH               | 1                           | 4                    | 3        | 2            | 6      |            |              | 16    |
| CS               | 30                          | 17                   | 6        | 2            | 9      |            | 1            | 65    |
| ET <sup>1)</sup> | 5                           | 1                    |          |              | 1      |            |              | 7     |
| FI               | 16                          | 9                    | 4        | 2            | 4      | 5          |              | 40    |
| HU               | 10                          | 8                    | 5        | 3            | 4      |            | 3            | 33    |
| LA <sup>2)</sup> | 2                           |                      | 1        |              | 2      |            |              | 5     |
| LI <sup>3)</sup> | 10                          | 3                    |          |              | 1      |            |              | 14    |
| NO               |                             | 10                   | 2        | 9            | 3      | 1          |              | 25    |
| PL               | 33                          | 17                   | 15       | 5            | 13     | 2          | 7            | 92    |
| RO               | 22                          | 23                   | 5        | 5            |        |            |              | 55    |
| SE               | 18                          | 22                   | 8        | 2            | 3      | 3          |              | 56    |
| SU               | 11                          | 9                    | 1        |              | 4      | 4          |              | 29    |
| YU               | 27                          | 20                   | 8        | 8            | 11     |            |              | 74    |
|                  | 207                         | 155                  | 63       | 46           | 73     | 15         | 11           | 570   |

<sup>1)</sup> Estonia

<sup>2)</sup> Latvia

<sup>3)</sup> Lithuania



92-118/112322-23155

| PHOXA POINT SOURCES    |                                     |                                       |                 |                             |                                                               |            |                             |                  |              |                                               |                                                                                        |            |                                     |                                                                                               |  |                                                                                  |  |  |
|------------------------|-------------------------------------|---------------------------------------|-----------------|-----------------------------|---------------------------------------------------------------|------------|-----------------------------|------------------|--------------|-----------------------------------------------|----------------------------------------------------------------------------------------|------------|-------------------------------------|-----------------------------------------------------------------------------------------------|--|----------------------------------------------------------------------------------|--|--|
| Country <i>Hungary</i> |                                     |                                       |                 |                             |                                                               |            |                             |                  |              |                                               |                                                                                        |            |                                     |                                                                                               |  |                                                                                  |  |  |
| Site nr.               | Name/location                       | Coord.<br>(decimal)<br><br>long, lat. | Inst type       | InstYear<br>nr. of<br>comm. | Installed<br>capacity<br><br>MW <sub>e</sub> MW <sub>th</sub> |            | Max.<br>ntack<br>ht.<br>(m) | Type             | S<br><br>(%) | H <sub>1</sub><br><br>(M)<br>kg <sup>-1</sup> | Fuel<br>Emission<br>factor<br>(g.GJ <sup>-1</sup> )<br>SO <sub>x</sub> NO <sub>x</sub> |            | Consumpt.<br><br>year/<br>acc. (PJ) | Control<br>SO <sub>x</sub> NO <sub>x</sub><br>year % year %<br>of contr of contr<br>comm comm |  | Emission<br>(Gg.y <sup>-1</sup> )<br>(scs)<br>SO <sub>x</sub> NO <sub>x</sub> CO |  |  |
| 1                      | <i>Dunamenti,<br/>Szazhalmatlan</i> | <i>18.92 47.33</i>                    | <i>EH</i>       |                             | <i>3x150<br/>6x215<br/>1740 (900)</i>                         | <i>195</i> | <i>0</i>                    | <i>3</i>         |              |                                               | <i>1470</i>                                                                            | <i>260</i> |                                     |                                                                                               |  |                                                                                  |  |  |
| 2                      | <i>Tisza,<br/>Leninvaros</i>        | <i>21.08 47.92</i>                    | <i>EH<br/>E</i> | <i>1<br/>2</i>              | <i>4x130<br/>3x55<br/>235 (380)<br/>1100<br/>1335</i>         | <i>250</i> | <i>B<br/>G</i>              | <i>1.7<br/>-</i> | <i>10</i>    | <i>2400</i>                                   | <i>150</i>                                                                             | <i>170</i> |                                     |                                                                                               |  |                                                                                  |  |  |
| 3                      | <i>Gagarin,<br/>Gyongyos</i>        | <i>20.07 47.48</i>                    | <i>E</i>        |                             | <i>2x100<br/>3x200<br/>800</i>                                | <i>205</i> | <i>B</i>                    | <i>0.85</i>      | <i>6.7</i>   | <i>1800</i>                                   | <i>260</i>                                                                             |            |                                     |                                                                                               |  |                                                                                  |  |  |
| 4                      | <i>Oroszlany</i>                    | <i>18.28 47.50</i>                    | <i>E</i>        |                             | <i>3x60<br/>1x55<br/>235</i>                                  | <i>120</i> | <i>B</i>                    | <i>2.4</i>       | <i>13.7</i>  | <i>2450</i>                                   | <i>260</i>                                                                             |            |                                     |                                                                                               |  |                                                                                  |  |  |
| 5                      | <i>Pecs</i>                         | <i>18.27 46.07</i>                    | <i>EH</i>       |                             | <i>20<br/>3x30<br/>2x60<br/>230 (500)</i>                     | <i>115</i> | <i>B</i>                    |                  |              | <i>(2000)</i>                                 | <i>200</i>                                                                             |            |                                     |                                                                                               |  |                                                                                  |  |  |
| 6                      | <i>Borsod</i>                       | <i>20.37 48.07</i>                    | <i>EH</i>       |                             | <i>9x130<br/>170 (650)</i>                                    | <i>90</i>  | <i>B</i>                    | <i>1.7</i>       | <i>10</i>    | <i>2400</i>                                   | <i>150</i>                                                                             |            |                                     |                                                                                               |  |                                                                                  |  |  |



Table 3.b Example of point source input data sheet (industry)

| PHOXA POINT SOURCES |                                            |                           |                       |                     |                                                                |                                     |                          |      |                                      |                                          |        |    |
|---------------------|--------------------------------------------|---------------------------|-----------------------|---------------------|----------------------------------------------------------------|-------------------------------------|--------------------------|------|--------------------------------------|------------------------------------------|--------|----|
| Country: Romania    |                                            |                           |                       |                     |                                                                |                                     |                          |      |                                      |                                          |        |    |
| Site nr.            | Name/location                              | Coordinates<br>long. lat. | Inst.<br>nr.          | Year<br>of<br>comm. | Product                                                        | Capacity<br>(Gg.y <sup>-1</sup> )   | Max.<br>stack<br>ht. (m) | type | Fuel<br>consumption<br>year scs (PJ) | Emissions<br>(Gg.y <sup>-1</sup> ) (scs) |        |    |
|                     |                                            |                           |                       |                     |                                                                |                                     |                          |      |                                      | SO                                       | NO     | CO |
| 23                  | Brazi, Ploiesti                            | 26°00 44.88               | 1<br>2<br>3           | (65)                | petr<br>eth<br>LDPE                                            | 4500<br>40<br>90                    | 170                      |      |                                      |                                          |        |    |
| 24                  | Pitesti                                    | 25°03 44.78               | 1<br>2<br>3<br>4<br>5 | '74                 | petr<br>eth<br>LDPE<br>HDPE<br>PS                              | 4000<br>300<br>60<br>30<br>(20)     | 110                      |      |                                      |                                          |        |    |
| 25                  | Borzesti, Bucuresti                        | 26°08 44.33               | 1<br>2<br>3<br>4<br>5 | 80                  | petr<br>PVC<br>PS<br>SBR<br>Cl <sub>2</sub>                    | 11000<br>(20)<br>(20)<br>150<br>270 | 75                       |      |                                      |                                          |        |    |
| 26                  | Teleajen, Ploiesti                         | 26°08 44.95               | 1<br>2<br>3<br>4      | 80<br>'81           | petr<br>eth<br>HDPE<br>PS                                      | 12000<br>220<br>60<br>25            | 155                      |      |                                      |                                          |        |    |
| 27                  | Midia (formerly<br>Navodari),<br>Constanta | 28°65 44.34               | 1<br>2<br>3<br>4<br>5 | '79<br>'83          | petr.<br>eth<br>LDPE<br>HDPE<br>H <sub>2</sub> SO <sub>4</sub> | 3500<br>220<br>60<br>120<br>300     | 185                      |      |                                      |                                          |        |    |
| 28                  | Bacau                                      | 26°95 46.52               | 1<br>2                |                     | petr.<br>PVC                                                   | 250<br>25                           | 70                       |      |                                      |                                          |        |    |
|                     |                                            |                           |                       |                     |                                                                |                                     |                          |      |                                      |                                          | pyrite |    |
|                     |                                            |                           |                       |                     |                                                                |                                     |                          |      |                                      |                                          | emu/s. |    |

3 plants with diaphr. (225)  
1 plant with Hg (45)





Table 4 Data sources for data base and inventory data

|                                          | Main                                             | AT                       | BG                | CH      | CS                                      | FI                | HU                           | NO            | PL                                                  | RO                   | SE             | SU                | YU                            |
|------------------------------------------|--------------------------------------------------|--------------------------|-------------------|---------|-----------------------------------------|-------------------|------------------------------|---------------|-----------------------------------------------------|----------------------|----------------|-------------------|-------------------------------|
| Energy prod.                             | C2, M1                                           | J1, S2,<br>V4, V5,<br>O4 | B1, K1,<br>T1, T2 | J1, V4  | A9, B2,<br>B7, C4,<br>F3, M3,<br>S4, V2 | A2, A3,<br>J1, O4 | A1, E1,<br>H1, L7            |               | A8, C15,<br>G2, G3,<br>L9, M5,<br>P1, R2,<br>W1, Z2 | C5, E1               | A4, J1<br>O1   | G1, H3,<br>L2, L3 | A11, D2,<br>J1, L1,<br>S1, V4 |
| SO <sub>x</sub> /NO <sub>x</sub> control | K2, V1                                           | L4, O4                   |                   |         |                                         |                   |                              |               |                                                     |                      |                |                   |                               |
| Petr. refineries                         | I2                                               |                          | L6                |         |                                         |                   |                              |               | C17, V3                                             |                      |                |                   |                               |
| Chem. industry                           | A10,<br>F1, P2                                   | A6, B4,<br>O2            | L6                |         |                                         | C12               |                              | C12           |                                                     |                      | C12            |                   |                               |
| Prim. iron & steel                       | A12, I1,<br>U2                                   |                          |                   |         | H5                                      |                   | H4                           |               | B8, C6,<br>V3, W1<br>M6, W3                         |                      |                |                   |                               |
| Prim. non-ferrous                        | M9, N1                                           |                          |                   |         |                                         |                   |                              |               |                                                     |                      |                |                   |                               |
| Cement                                   | W2                                               |                          |                   |         |                                         |                   |                              |               |                                                     |                      |                |                   |                               |
| Pulp/paper                               | I3                                               |                          |                   |         |                                         |                   |                              |               |                                                     |                      |                |                   |                               |
| Vehicle manuf.                           | A7                                               |                          |                   |         |                                         |                   |                              |               |                                                     |                      |                |                   |                               |
| Fuel properties                          | C1, C2,<br>M1                                    | B4, S2                   | D1, T1,<br>T2     |         | S3, V2                                  | A2, J2            | M2, R1                       |               | C11,<br>C13,<br>C14,<br>C16,<br>C19, D1             | C5, P3               | H3             | D1, H3,<br>N2     | A5, L1                        |
| Fuel consumption                         | C2, F3,<br>H6, L6,<br>P4, U1                     | O5, S6,<br>O2            | T1, T2,<br>T3, P5 | O5, S10 | K3, P5,<br>W5                           | O5, Y1,<br>F3     | H1, K4,<br>L8, M7,<br>P5, W5 | O5, Y1,<br>K6 | C15, H2,<br>K2, L9,<br>O6, P5                       | P5                   | O5, S11,<br>Y1 | O6, T5,<br>S13    | E3, O6,<br>W5, S15            |
| Reported emissions                       |                                                  | U6                       | T1                | B10     | V2, Z1                                  | A19               |                              | K6            | H2, O3,<br>R4, R5,<br>R6, V3                        |                      |                | B3, E4,<br>H3, F2 |                               |
| Activity data                            | A16,<br>C10, E3,<br>M9, O8,<br>P4, U1,<br>U5, W4 | S6                       | T4                |         | B6, H5                                  |                   | H9                           |               | B5, D3,<br>V3                                       | L5, L12 <sub>c</sub> |                | C7-9,<br>E2, S14  | L12a,<br>S14,<br>S15          |

## Updating and upgrading the PHOXA emission data base to 1990

Table 5 Percentages of energy production capacities covered by point sources in European countries outside the EC (except USSR)

| Country code | Public                                              |                                                     |                  | Industrial electricity                               |
|--------------|-----------------------------------------------------|-----------------------------------------------------|------------------|------------------------------------------------------|
|              | Electricity incl. CHPs                              | Heat                                                |                  |                                                      |
|              |                                                     | CHPs                                                | Heating stations |                                                      |
| AT           | 96                                                  | 34                                                  | 0                | 41                                                   |
| BG           | 99                                                  | 25                                                  | 0                | 54                                                   |
| CH           | 51                                                  | 0                                                   | 0                | 0                                                    |
| CS           | 100 <sup>1)</sup>                                   | 16                                                  | 6                | 47                                                   |
| ET           | 99                                                  | 70                                                  | 11               | 0                                                    |
| FI           | 83                                                  | 32                                                  | 0                | 46                                                   |
| H            | 100 <sup>2)</sup>                                   | 92                                                  | 0                | 0                                                    |
| LA           | 86                                                  | 0                                                   | 0                | 0                                                    |
| LI           | 98                                                  | 72                                                  | 0                | 0                                                    |
| NO           | 0                                                   | 0                                                   | 0                | 0                                                    |
| PL           | 94                                                  | 35                                                  | 18               | 28                                                   |
| RO           | 81                                                  | 0                                                   | 0                | 0                                                    |
| SE           | 88                                                  | 54                                                  | 0                | 28                                                   |
| YU           | 98                                                  | 0                                                   | 0                | 0                                                    |
| Total        | 94 <sup>3)</sup><br>(93.1 of 99.2 Gw <sub>e</sub> ) | 18 <sup>4)</sup><br>(38.7 of 221 Gw <sub>th</sub> ) |                  | 31 <sup>3) 4)</sup><br>3.6 of 11.6 Gw <sub>e</sub> ) |

1) s.a. A9

2) apparently industrial capacity included

3) Total capacity for electricity: 87% (96.6 of 110.9 GW<sub>e</sub>)

4) except Ro

N.B. In the Soviet Union <30%/at, except the Baltic States, 9.77 GW<sub>e</sub> has been recorded. Capacities of 3 plants are unknown but expected to be relatively small. Total coverage in the PHOXA area may be 88%.



## Updating and upgrading the PHOXA emission data base to 1990

Table 6 Lower heat values ( $H_I$ ,  $Mj.kg^{-1}$ ) and sulphur contents ( $S$ , %ww) of fuels used in European countries, outside the EC

| Country code | Industrial sources      |                          |            |      | Non-industrial sources |      |                          |                        | All sources                   |           |
|--------------|-------------------------|--------------------------|------------|------|------------------------|------|--------------------------|------------------------|-------------------------------|-----------|
|              | Hardcoal                |                          | Brown coal |      | Hard coal              |      | Brown coal               |                        | Res. oil                      | Dist. oil |
|              | $H_I$                   | $S$                      | $H_I$      | $S$  | $H_I$                  | $S$  | $H_I$                    | $S$                    | $S$                           | $S$       |
| AT           | 28                      | 1.2                      | 10.9       | 1    | 28                     | 0.9  | 10.9<br>20 <sup>1)</sup> | 1<br>0.2 <sup>1)</sup> | (2)                           | (0.2)     |
| BG           | 25                      | 2.5                      | n.a.       | n.a. | 25                     | 2.5  | 20 <sup>1)</sup>         | 4 <sup>1)</sup>        | (2.5)                         | (0.5)     |
| CH           | 25                      | (1)                      | n.a.       | n.a. | 25                     | (1)  | (20) <sup>1)</sup>       | (0.2)<br>1)            | 2 <sup>2)</sup> [B9]          | 0.2 [B9]  |
| CS           | 19                      | 1                        | 12.5       | 1.3  | 24.2                   | 0.8  | 15.3                     | 1.3                    | 2.5 [V2]                      | 1.5 [V2]  |
| ET           | 8.7 <sup>3)</sup><br>28 | 1.5 <sup>3)</sup><br>0.9 | n.a.       | n.a. | n.a.                   | n.a. | n.a.                     | n.a.                   | (2.5)                         | (0.5)     |
| FI           | 25                      | 1.2                      | n.a.       | n.a. | 2.5                    | 1.2  | n.a.                     | n.a.                   | (1)                           | (0.2)     |
| HU           | n.a.                    | n.a.                     | 12         | 2    | n.a.                   | n.a. | 12<br>21 <sup>1)</sup>   | 2<br>3 <sup>1)</sup>   | 3 [M2]                        | (0.5)     |
| LA           | 25                      | 0.8                      | n.a.       | n.a. | 25                     | 0.8  | n.a.                     | n.a.                   | 2 <sup>4)</sup> [F2]<br>(2.5) | (0.5)     |
| LI           | 25                      | 2.5                      | n.a.       | n.a. | 25                     | 2.5  | n.a.                     | n.a.                   | 3 <sup>4)</sup> [H3]<br>(2.5) | (0.5)     |
| NO           | (25)                    | (1)                      | n.a.       | n.a. | n.a.                   | n.a. | n.a.                     | n.a.                   | (1)                           | (0.2)     |
| PL           | 22                      | 1.3                      | 9          | 0.8  | 25                     | 1    | n.a.                     | n.a.                   | 2.5 [C19]                     | (0.5)     |
| RO           | n.a.                    | n.a.                     | 6.5        | 0.85 | 24                     | (1)  | (20) <sup>1)</sup>       | (2) <sup>1)</sup>      | 3-4 [C5]<br>(3.5)             | (0.5)     |
| SE           | 25                      | 0.8                      | n.a.       | n.a. | 25                     | 0.8  | n.a.                     | n.a.                   | <1 [H3]<br>(0.8)              | (0.2)     |
| SU           | 24                      | 2                        | 10.6       | 1.3  | 24                     | 2    | 10.6                     | 1.3                    | 2.5 [H3]                      | 0.5 [H3]  |
| YU           | 24                      | (1)                      | 9          | 0.2  | n.a.                   | n.a. | 9                        | 0.2                    | (2)                           | (0.5)     |

1) brown coal briquettes

2) average of medium (1.35%) and heavy (2.5%)

3) oil shale

4) since LA and LI use oil from the USSR, 2.5% is considered to be a best estimate

## Notes

- Data for solid fuels are from detailed fuel properties data sheets, used for power plants. Also from import data
- Values in parentheses are assumptions
- For peat and briquettes uniform data are used.  
Peat:  $H_I = 9$ ,  $S = 0.5$ ; briquette :  $H_I = 15$ ,  $S = 0.5$

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 Updating and upgrading the PHOXA emission data base to 1990

Table 7 Lower heat values of liquid and gaseous fuels

| Fuel              | MJ.kg <sup>-1</sup> | MJ.m <sup>-3</sup> <sub>0</sub> |
|-------------------|---------------------|---------------------------------|
| Residual oil      | 41                  |                                 |
| Distillate oil    | 42                  |                                 |
| Gasolene, kersone | 43                  |                                 |
| LPG               | 45                  |                                 |
| Natural gas       |                     | 34                              |
| Coke oven gas     |                     | 17                              |
| Blast furnace gas |                     | 3.5                             |

Table 8 Volume factors for fuels ( $m_o^3 \cdot GJ^{-1}$ )

| Fuel              | Power plants | Industrial sources district heating |
|-------------------|--------------|-------------------------------------|
| Hard coal         | 350          | 450                                 |
| Brown coal        | 450          | 400                                 |
| Residual oil      | 300          |                                     |
| Distillate oil    | 300          |                                     |
| Natural gas       | 300          | 400                                 |
| Coke oven gas     |              | 400                                 |
| Blast furnace gas |              | 450                                 |
| Oil shale         | 900          |                                     |

Sources: H7, V2, H3 (oil shale)



Table 9 Emission factors for stationary combustion sources (g.GJ<sup>-1</sup>)

| Fuel, firing mode                    | Large units                           |        |         |      |                   | SOx <sup>1)</sup>   | Small units     |                  |                               |                     |                            |
|--------------------------------------|---------------------------------------|--------|---------|------|-------------------|---------------------|-----------------|------------------|-------------------------------|---------------------|----------------------------|
|                                      | NO <sub>x</sub><br>power (MWth input) |        |         |      |                   |                     | NO <sub>x</sub> | CO <sup>2)</sup> | CH <sub>4</sub> <sup>3)</sup> | NMVOC <sup>3)</sup> | cond.<br>org <sup>3)</sup> |
|                                      | <50                                   | 50-100 | 100-300 | >300 | all<br>values     |                     |                 |                  |                               |                     |                            |
| Hard coal and -briq.-, small units   |                                       |        |         |      |                   | 19000 S/H           | 50              | 5000             | 200                           | 200                 | 80                         |
| Hard coal, wall and tan. firing      | 180                                   | 250    | 310     | 380  |                   | 19000 S/H           |                 |                  |                               |                     |                            |
| Hard coal, grate firing              | 150                                   | 150    |         |      |                   | 19000 S/H           |                 |                  |                               |                     |                            |
| Brown coal and - briq.-, small units |                                       |        |         |      |                   | 14000 S/H           | 100             | 5000             | 200                           | 200                 | 80                         |
| Brown coal, pulverised               |                                       |        | 260     | 260  |                   | 14000 S/H           |                 |                  |                               |                     |                            |
| Brown coal, grate firing             | 150                                   | 150    |         |      |                   | 14000 S/H           |                 |                  |                               |                     |                            |
| Peat, small units                    |                                       |        |         |      |                   | 14000 S/H           | 100             |                  | 200                           | 200                 |                            |
| Peat, pulverised                     | 280                                   | 300    | 300     | 300  |                   | 14000 S/H           |                 |                  |                               |                     |                            |
| Peat, grate firing                   | 230                                   | 230    | 230     |      |                   | 14000 S/H           |                 |                  |                               |                     |                            |
| Coke                                 |                                       |        |         |      | 150 *             | 550                 | 100 *           | 2000             | —                             | —                   | —                          |
| Oil shale                            |                                       |        |         |      | 100 <sup>4)</sup> | 4000 SH             |                 |                  |                               |                     |                            |
| Wood                                 | 200                                   | 200    |         |      |                   | —                   | 80              | 7000             | 400                           | 600                 | 400                        |
| Resid. oil, small units              |                                       |        |         |      |                   | 490 S               | 180 *           |                  |                               |                     |                            |
| Resid. oil, wall or bottom firing    | 180                                   | 190    | 210     | 260  |                   | 490 S               |                 |                  |                               |                     |                            |
| Resid. oil, tan. firing              | 140                                   | 150    | 170     | 210  |                   | 490 S               |                 |                  |                               |                     |                            |
| Dist. oils, kerosene                 | 80                                    | 100    | 100     |      |                   | 470 S               | 50              | 60               | —                             | —                   | —                          |
| Dist. oils, gas turbines             |                                       |        |         |      | 400 <sup>5)</sup> | 470 S               |                 |                  |                               |                     |                            |
| LPG                                  |                                       |        |         |      |                   | —                   | 50              | 30               | —                             | —                   | —                          |
| Nat. gas                             | 100                                   | 125    | 150     | 170  |                   | —                   | 50              | 100              | —                             | —                   | —                          |
| Nat. gas, gas turbines               |                                       |        |         |      | 400 <sup>5)</sup> | —                   |                 |                  |                               |                     |                            |
| Coke oven gas, manufactured gas      | 90                                    | 110    | 130     | 150  |                   | 500 S <sup>6)</sup> |                 |                  |                               |                     |                            |
| Blast furnace gas                    | 55                                    | 65     | 80      | 95   |                   | —                   |                 |                  |                               |                     |                            |
| Sulph. liquor                        |                                       |        |         |      | 50 <sup>7)</sup>  | 2000 <sup>8)</sup>  |                 |                  |                               |                     |                            |

<sup>1)</sup> Assumed fraction retained in ash: brown coal, peat: 30%; hard coal: 5%; oil shale: 80%

<sup>2)</sup> Averages of different reported figures

<sup>3)</sup> s.a. [V.6]

<sup>4)</sup> Estimated from emission data [F2]

<sup>5)</sup> Broad range of values reported, average is assumed

<sup>6)</sup> for small units: 550

<sup>7)</sup> [L10]

<sup>8)</sup> [U4]

Sources:

CORINAIR [C18], except figures, marked with an asterisk. CO and VOC from large units are neglected; from small units, only coal, peat and wood are inventoried

## Updating and upgrading the PHOXA emission data base to 1990

Table 10 Emission factors for process emissions (kg.Mg<sup>-1</sup> of product)

|                                               | NO <sub>x</sub> | SO <sub>x</sub> | CH <sub>4</sub>               | NMVOC                     | CO |
|-----------------------------------------------|-----------------|-----------------|-------------------------------|---------------------------|----|
| Petroleum refining <sup>1)</sup>              | 0.35 (0.2-0.6)  | 2.5             | 0.06 (0.02-0.2) <sup>2)</sup> | 0.5 (0.2-2) <sup>2)</sup> |    |
| Ethylene                                      |                 |                 | 0.3-1                         | 2-5                       |    |
| LD polythene                                  |                 |                 |                               | 1.5-10                    |    |
| HD polythene                                  |                 |                 |                               | 6                         |    |
| Vinylchloride                                 |                 |                 |                               | 2.5 (1-10)                |    |
| PVC, emulsion polymerization                  |                 |                 |                               | 3                         |    |
| PVC, suspension polymerization                |                 |                 |                               | 1.5                       |    |
| Polystyrene                                   |                 |                 |                               | 1                         |    |
| Polypropene                                   |                 |                 |                               | 8 (5-12)                  |    |
| SBR rubber                                    |                 |                 |                               | 5 (1-10)                  |    |
| SBR latex                                     |                 |                 |                               | 10 (3-15)                 |    |
| ABS                                           |                 |                 |                               | 5 (1-10)                  |    |
| Sulphuric acid, single absorption             |                 | 14 (10-25)      |                               |                           |    |
| Sulphuric acid, dual absorption               |                 | 3 (1-5)         |                               |                           |    |
| Nitric acid                                   | 7 (3-15)        |                 |                               |                           |    |
| Ammonia                                       | 2-6             |                 |                               |                           |    |
| Coke <sup>1)</sup>                            | 1.0             | 0.65            | 0.5 (0.2 - 2.5)               | 0.5 (0.2-2.5)             |    |
| Sinter                                        | 1.5             |                 | 0.5                           | 0.05                      | 30 |
| Blast furnace                                 |                 |                 | 0.9                           | 0.05                      | 10 |
| Steel, BOF                                    | 0.05            |                 |                               | 0.01                      | 10 |
| Steel, EAF                                    | 0.2             |                 |                               | 0.1                       | 10 |
| Steel, OHF                                    |                 |                 |                               | 0.05                      |    |
| Hot rolling                                   |                 |                 |                               | 0.02                      |    |
| Cold rolling                                  |                 |                 |                               | 0.15                      |    |
| integrated iron and steel plant <sup>3)</sup> | 5 <sup>1)</sup> |                 | 1.5                           | 0.15                      | 60 |
| Bread                                         |                 |                 |                               | 3                         |    |
| Wine, white                                   |                 |                 |                               | 0.35                      |    |
| red                                           |                 |                 |                               | 0.8                       |    |
| Automobiles <sup>4)</sup>                     |                 |                 |                               | 5-20                      |    |
| hdv, buses <sup>4)</sup>                      |                 |                 |                               | 10-30                     |    |

<sup>1)</sup> Process emissions and combustion emissions

<sup>2)</sup> USSR: CH<sub>4</sub>; 1; NMVOC = 11

<sup>3)</sup> kg.Mg<sup>-1</sup> of crude steel; without coke and EAF; rough, average values

<sup>4)</sup> kg. vehicle<sup>-1</sup>

### Note

Factors are presented in different ways:

- single factor: no data available for differentiation.
- range: lower value for modern plants, higher value for old plants.
- factor plus range: factor is default value, range, differentiation between modern and old plants.



## Updating and upgrading the PHOXA emission data base to 1990

Table 11 Reported road transport emissions in EFTA countries (Gg)

## Norway (1988)

|                   | NO <sub>x</sub> | VOC  | CO    | SO <sub>x</sub> |
|-------------------|-----------------|------|-------|-----------------|
| <b>Road</b>       |                 |      |       |                 |
| ldv gasoline      | 44.4            | 35.9 | 348.7 | 1.1             |
| ldv diesel        | 2.4             | 1.7  | 3.4   | 0.6             |
| hdv gasoline      | 4.2             | 2.8  | 27.2  | 0.1             |
| hdv diesel        | 33.3            | 3.7  | 7.5   | 2.7             |
|                   | 84.3            | 44.1 | 386.8 | 4.5             |
| <b>Off-road</b>   |                 |      |       |                 |
| gasoline          | 0.2             | 23.2 | 58.9  | 0.1             |
| diesel            | 13.1            | 2.2  | 8.0   | 0.9             |
|                   | 13.3            | 25.4 | 66.9  | 1.0             |
| <b>Rail</b>       | 0.5             | 0.1  | 0.2   | 0.1             |
| <b>Aerial</b>     | 4.0             | 2.2  | 10.5  | 0.2             |
| <b>Navigation</b> |                 |      |       |                 |
| coastal           | 48.8            | 1.7  | 3.5   | 8.1             |
| fishery           | 32.8            | 1.2  | 2.3   | 2.0             |
| off-shore         | 6.2             | 0.2  | 0.4   | 0.4             |
|                   | 87.8            | 3.1  | 6.2   | 10.5            |
| <b>Total</b>      |                 |      |       |                 |
| 1988              | 189.9           | 74.8 | 470.6 | 16.1            |
| 1989              | 186             | 70   | 428   | 14              |
| 1990              | 177             | 66   | 393   | 14              |

Source [K6]

Sweden, NO<sub>x</sub> (1989)

|             | gasoline | diesel |
|-------------|----------|--------|
| <b>Road</b> |          |        |
| automobiles | 99       | 1.8    |
| other ldv   | 9.6      | 1.0    |
| hdv         | } 0.3    | 65     |
| buses       |          | 12     |
|             | 108.9    | 78.8   |

Source: [A20]

NB: fraction of automobiles with controlled exhaust per 31-12-'89 is ca. 0.20

## Austria (1988), traffic

|                 |     |
|-----------------|-----|
| NO <sub>x</sub> | 148 |
| VOC             | 140 |
| CO              | 532 |
| SO <sub>x</sub> | 5   |

Source: [U6]

N.B. fraction of automobiles with controlled exhaust in 1988: 0.10, in 1990: 0.23 [S6]

## Switzerland (1988) traffic

|                 |      |
|-----------------|------|
| NO <sub>x</sub> | 136  |
| VOC             | 72.8 |
| SO <sub>x</sub> | 4.9  |

Table 12 Emission factors for mobile sources (g.GJ<sup>-1</sup>)

## A. Exhaust emissions

| Vehicle/fuel type                  | NO <sub>x</sub> |           |         | CH <sub>4</sub> |           |         | NMVOC |           |         | CO    |           |         | SO <sub>x</sub> |
|------------------------------------|-----------------|-----------|---------|-----------------|-----------|---------|-------|-----------|---------|-------|-----------|---------|-----------------|
|                                    | urban           | non-urban | overall | urban           | non-urban | overall | urban | non-urban | overall | urban | non-urban | overall |                 |
| <b>Light duty vehicles</b>         |                 |           |         |                 |           |         |       |           |         |       |           |         |                 |
| gasoline, 4-stroke <sup>1)</sup>   | 450             | 1200      | 800     | 65              | 45        | 55      | 750   | 530       | 640     | 5800  | 4600      | 5200    | 24              |
| gasoline, 2-stroke                 | 100             | 350       | 220     | 70              | 40        | 50      | 4000  | 2500      | 3200    | 6500  | 4000      | 5000    | 24              |
| diesel                             | 290             | 330       | 310     | 3               | 8         | 6       | 60    | 190       | 150     | 420   | 460       | 440     | 240             |
| <b>Heavy duty vehicles, buses</b>  |                 |           |         |                 |           |         |       |           |         |       |           |         |                 |
| gasoline                           | 470             | 1100      | 1000    | 60              | 40        | 45      | 670   | 450       | 500     | 7000  | 7000      | 7000    | 24              |
| diesel                             | 1300            | 1600      | 1550    | 12              | 5         | 6       | 300   | 120       | 150     | 650   | 320       | 350     | 240             |
| <b>Motorcycles, mopeds</b>         |                 |           | 80      |                 |           | 150     |       |           | 9000    |       |           | 15000   | 24              |
| <b>Rail and waterway transport</b> |                 |           |         |                 |           |         |       |           |         |       |           |         |                 |
| diesel                             |                 |           | 1550    |                 |           | 6       |       |           | 150     |       |           |         | 240             |

<sup>1)</sup> at 20 °C ambient temperature; incl. cold start

Sources: calculated from COPERT data; 2-stroke Idv: [S7], 2/3 Trabant and 1/3 Wartburg assumed. [S9], SO<sub>x</sub> factors are default values (0.5% S in diesel and 0.05% S in gasoline assumed)

## B. Evaporative emissions

Vehicles: 45 g VOC.vehicle<sup>-1</sup>.day<sup>-1</sup> at 20 °C ambient temperature (relation with temperature in fig. 2).

Gasoline distribution: 3.5 g VOC.kg<sup>-1</sup> of gasoline (80 g: GJ<sup>-1</sup>).



## Updating and upgrading the PHOXA emission data base to 1990

Table 13 Estimated solvent losses in East European countries ( $\text{kg.cap.}^{-1}.\text{y}^{-1}$ )

| Country code     | Paint        |          | Metal degreasing | Printing | Chem. industry | Chem. cleaning | Consumer products | Total    |              |
|------------------|--------------|----------|------------------|----------|----------------|----------------|-------------------|----------|--------------|
|                  | non-industr. | industr. |                  |          |                |                |                   | industr. | non-industr. |
| BG               | 2            | 1.5      | 1                | 0.5      | 2              | 0.2            | 0.5               | 5        | 2.7          |
| CS               | 2.5          | 2        | 1.5              | 0.5      | 2              | 0.3            | 0.5               | 6        | 3.3          |
| H                | 2            | 1        | 0.5              | 0.5      | 1              | 0.2            | 0.5               | 3        | 2.7          |
| PL               | 2            | 1        | 0.8              | 0.5      | 1              | 0.2            | 0.5               | 3.3      | 2.7          |
| R                | 1.5          | 1.5      | 1.5              | 0.3      | 2              | 0.2            | 0.3               | 5.3      | 2.0          |
| SU <sup>1)</sup> | 2.5          | 2        | 1.5              | 0.5      | 1.5            | 0.2            | 0.5               | 5.5      | 3.2          |
| YU               | 1.5          | 1        | 0.5              | 0.5      | 0.5            | 0.2            | 0.5               | 2.5      | 2.2          |

<sup>1)</sup> For the Baltic States, totals are assumed to be 3 both for industrial and non-industrial losses.

## Updating and upgrading the PHOXA emission data base to 1990

Table 14 Reported solvent losses in West European countries

|    | OECD-MAP<br>(1980)  |                      | CORINAIR<br>(1985) |                      | 1985<br>—<br>1980 | [Z3]<br>member<br>state<br>estimates | %<br>non<br>industrial<br>[Z3] |
|----|---------------------|----------------------|--------------------|----------------------|-------------------|--------------------------------------|--------------------------------|
|    | Gg                  | kg.cap <sup>-1</sup> | Gg                 | kg.cap <sup>-1</sup> |                   |                                      |                                |
| AT | 130 <sup>1)</sup>   | 17.2                 |                    |                      |                   |                                      |                                |
| BE | 128                 | 13.0                 | 82.4               | 8.36                 | 0.64              | 82.4 ('85)                           | 59                             |
| CH | 165 <sup>2)</sup>   | 25.8                 |                    |                      |                   |                                      |                                |
| DE | 915                 | 14.9                 | 1119.7             | 18.4                 | 1.23              | 1050 ('90)                           | 31                             |
| DK | 53.7                | 10.5                 | 58.5               | 11.5                 | 1.10              | 58 ('89)                             | 52                             |
| ES | 536                 | 14.3                 | 327.1              | 8.45                 | 0.59              | 327 ('85)                            | 64                             |
| FI | 67.9                | 14.2                 |                    |                      |                   |                                      |                                |
| FR | 464.5               | 8.62                 | 437.6              | 7.93                 | 0.92              | 438 ('90)                            | 49                             |
| GB | 630                 | 11.2                 | 668                | 11.8                 | 1.05              | 662 ('89)                            | 47                             |
| GR | 37.1                | 3.85                 | 27.9               | 2.80                 | 0.73              | 27.9 ('85)                           | 62                             |
| IE | 34.1                | 10.0                 | 21.2               | 5.87                 | 0.59              | 25 ('90)                             | 68                             |
| IT | 640                 | 11.3                 | 396.6              | 6.95                 | 0.62              | 519 ('89)                            | 39                             |
| LU | 3.50                | 9.62                 | 2.64               | 7.21                 | 0.75              | 2.6 ('85)                            | 67                             |
| NL | 145.4               | 10.3                 | 163.7              | 11.3                 | 1.10              | 164 ('85)                            | 58                             |
| NO | 50 <sup>1)</sup>    | 12.2                 |                    |                      |                   |                                      |                                |
| PT | 75                  | 7.68                 | 52.1               | 5.13                 | 0.67              | 66.5 ('90)                           | 53                             |
| SE | 110.5 <sup>3)</sup> | 13.3                 |                    |                      |                   |                                      |                                |

<sup>1)</sup> reported data for 1988 are the same

<sup>2)</sup> reported for 1988: 184.5 (27.7)

<sup>3)</sup> reported for 1990?: 95

## Updating and upgrading the PHOXA emission data base to 1990

Table 15 Emission factors for biogenic VOC emissions from vegetation

| Vegetation    |                                              | Leaf biomass factor <sup>1)</sup><br>(Mg.km <sup>-2</sup> ) | Emission factor at 30 °C <sup>2)</sup> |                                        | Composition <sup>2) 3)</sup> |                  |                  |
|---------------|----------------------------------------------|-------------------------------------------------------------|----------------------------------------|----------------------------------------|------------------------------|------------------|------------------|
| category      | representative                               |                                                             | (µg.g <sup>-1</sup> .h <sup>-1</sup> ) | (µg.m <sup>-2</sup> .h <sup>-1</sup> ) | I                            | T                | U                |
| High isoprene | all oak species                              | 320                                                         | day: 14.3<br>night: 3.5                |                                        | 75                           |                  | 25<br>100        |
| Non-isoprene  | all other broad-leaved deciduous ssp.        | 300                                                         | 2                                      |                                        |                              | 5                | 95               |
| Coniferous    | All conifer species                          | 500-1600 <sup>4)</sup>                                      | 3.8                                    |                                        |                              | 65               | 35               |
| Crops         | all crops                                    | n.a.                                                        |                                        | 40                                     | 20                           | 50               | 30               |
| Grassland     | pastures, grassland range lands, stepps etc. | n.a.                                                        |                                        | 100                                    |                              | 20 <sup>5)</sup> | 80 <sup>5)</sup> |

1) from [V8]

2) from [P6]

3) I = Isoprene, T = terpenes, U = unidentified

4)

|                  | >60° lat. | 55°-60° lat. | <55° lat. |
|------------------|-----------|--------------|-----------|
| Pinus sylvestris | 500       | 700          | 700       |
| Picea abies      | 800       | 1400         | 1600      |
| Other conifers   | 1400      | 1400         | 1400      |

5) different from [P6], use was made also of [S12]

Influence of ambient temperature:

$$E_t = E_{30} \exp [a (t-30)]$$

|              | a     |
|--------------|-------|
| Isoprene     | 0.24  |
| Terpenes     | 0.10  |
| Unidentified | 0.072 |



## Updating and upgrading the PHOXA emission data base to 1990

Table 16  $\text{INO}_2$  and  $\text{SO}_4''$  fractions in  $\text{NO}_x$  and  $\text{SO}_x$  emissions (% ww)

|                                      | Solid fuels   |                 | Residual oil  |                 | Other liquid fuels |               | Gaseous fuels   |                 |
|--------------------------------------|---------------|-----------------|---------------|-----------------|--------------------|---------------|-----------------|-----------------|
|                                      | $\text{NO}_2$ | $\text{SO}_4''$ | $\text{NO}_2$ | $\text{SO}_4''$ | $\text{NO}_2$      | $\text{NO}_2$ | $\text{SO}_4''$ | $\text{SO}_4''$ |
| <b>Stationary combustion sources</b> |               |                 |               |                 |                    |               |                 |                 |
| point sources, boilers               | 4             | 1               | 2             | 3               | n.a.               | 3             | 1.5             | —               |
| point sources, gas turbines          | —             | —               | —             | —               | 15                 | —             | 15              | —               |
| area sources, industrial             | 2             | 2               | 1.5           | 5               | 4                  | 3.5           | 3               | —               |
| area sources, non-industrial         | 2             | 2               | 1             | 4               | 5                  | 3.5           | 5               | —               |
| <b>Processes</b>                     |               |                 |               |                 |                    |               |                 |                 |
| Sulphuric acid, single contact       |               | 3               |               |                 |                    |               |                 |                 |
| Sulphuric acid, double contact       |               | 6               |               |                 |                    |               |                 |                 |
| Nitric acid                          | 40            |                 |               |                 |                    |               |                 |                 |
| Ammonia                              | 40            |                 |               |                 |                    |               |                 |                 |
| <b>Mobile sources</b>                |               |                 |               |                 |                    |               |                 |                 |
| Gasoline, highways                   |               |                 |               |                 | 1                  | 1             |                 |                 |
| Gasoline, other modes                |               |                 |               |                 | 3                  | 1             |                 |                 |
| Gasoline, overall                    |               |                 |               |                 | 2.5                | 1             |                 |                 |
| Diesel fuel                          |               |                 |               |                 | 8                  | 2             |                 |                 |

## Updating and upgrading the PHOXA emission data base to 1990

Table 17. NMVOC profiles (% ww, substances)

| Non-industr. comb. |      | Refineries | Gasoline vapour | Coke ovens | Chem. process | Solvents       | Transport          |             |        |           |      |             |     |
|--------------------|------|------------|-----------------|------------|---------------|----------------|--------------------|-------------|--------|-----------|------|-------------|-----|
| Solid fuels        | Wood |            |                 |            |               |                | Gasoline, 4-stroke |             | Diesel |           |      |             |     |
|                    |      |            |                 |            |               |                | uncontrolled       | controlled  |        |           |      |             |     |
| C2                 | 15   | C2         | 10              | C2         | 20            | Etylene:       | C4 <sup>+</sup>    | C2          | 1      | C2        | 2    | C2          | 0.5 |
| C3                 | 10   | C3         | 1.5             | C3         | 1             | C3             | T                  | C3          | 0.2    | C3        | 0    | C13         | 52  |
| C4+                | 5    | nC4        | 0.4             | C2 =       | 60            | C2 =           | oX                 | nC4         | 2.5    | nC4       | 4.3  | C2 =        | 12  |
| C2 =               | 30   | iC4        | 0.1             | C2 =       | 2             | C4 =           | 12                 | iC4         | 0.5    | iC4       | 0.7  | C2 =        | 3   |
| C2 =               | 5    | C5+        | 3               | C3 =       | 5             | B              | 5                  | nC5         | 2      | nC5       | 1.8  | C3 =        | 3.5 |
| C3 =               | 5    | iC5        | 30              | C6         | 20            | T              | 1                  | iC5         | 5.5    | iC5       | 3.9  | C4 =        | 1.5 |
| C4+ =              | 5    | C2 =       | 10              | C7+        | 5             | LDPE:          |                    | C6          | 9      | C6        | 7.1  | C5 =        | 0.5 |
| B                  | 5    | C2 =       | 6               | B =        | 10            |                |                    | C7+         | 17     | C7+       | 15.6 | C13 =       | 2   |
| T                  | 1    | C3 =       | 0.5             | T =        | 1             | C2 =           | 100                | ipa         | 5      | C2 =      | 9.4  | B           | 2.5 |
| X                  | 1    | C3 =       | 0.5             | C5 =       | 5             | HDPE:          |                    | cellosolves | 7      | C2 =      | 2.5  | arC12       | 8.5 |
| oxyg.              | 18   | C2 =       | 2               | C6+ =      | 3             | C3             | 85                 | acetone     | 5      | C2 =      | 3.2  | form        | 6.5 |
|                    |      | C3 =       | 15              | B          | 1             | C2 =           | 15                 | MEK         | 4      | C3 =      | 0.2  | sataldC4    | 4   |
|                    |      | C4 =       | 5               | T          | 1.5           | VC:            |                    | MIBK        | 2      | C3 =      | 0.15 | unsatldC3   | 0.5 |
|                    |      | B          | 5               | X          | 0.5           | C2 =           | 20                 | esters      | 7      | C3 =      | 1.8  | acetone     | 2   |
|                    |      | oX         | 0.5             |            |               | dce            | 45                 | ethers      | 2      | 1C4 =     | 0.5  | org.acidsC2 | 1   |
|                    |      | mpX        | 1.5             |            |               | VC             | 20                 | CIHC        | 16     | 2C4 =     | 0.5  |             |     |
|                    |      | EB         | 0.5             |            |               | CIHC           | 15                 |             |        | 1.3C4 =   | 0.5  |             |     |
|                    |      | form       | 2               |            |               | PVC:           |                    |             |        | 1C5 =     | 1.4  |             |     |
|                    |      | acald      | 1               |            |               | VC             | 100                |             |        | 2C5 =     | 0.55 |             |     |
|                    |      | satald C4  | 3               |            |               | PS:            |                    |             |        | 1C6 =     | 0.6  |             |     |
|                    |      | unsatld C4 | 2               |            |               | ST             | 100                |             |        | 2.3C6 =   | 0.2  |             |     |
|                    |      | ket        | 1.5             |            |               | PP:            |                    |             |        | C7+ =     | 1.8  |             |     |
|                    |      | furans     | 4               |            |               | C4             | 95                 |             |        | B         | 6.4  |             |     |
|                    |      |            |                 |            |               | C3 =           | 5                  |             |        | T         | 2.0  |             |     |
|                    |      |            |                 |            |               | SBR rubber:    |                    |             |        | oX        | 3.2  |             |     |
|                    |      |            |                 |            |               | 1.3C4 =        | 5                  |             |        | mpX       | 0    |             |     |
|                    |      |            |                 |            |               | ST             | 95                 |             |        | EB        | 1.0  |             |     |
|                    |      |            |                 |            |               | SBR latex:     |                    |             |        | ST        | 3.3  |             |     |
|                    |      |            |                 |            |               | 1.3 C4 =       | 25                 |             |        | 124 TMB   | 2.5  |             |     |
|                    |      |            |                 |            |               | ST             | 75                 |             |        | 135 TMB   | 0.9  |             |     |
|                    |      |            |                 |            |               | ABS:           |                    |             |        | 123 TMB   | 2.9  |             |     |
|                    |      |            |                 |            |               | 1.3 C4 =       | 20                 |             |        | oth.ar C9 | 6.3  |             |     |
|                    |      |            |                 |            |               | ST             | 40                 |             |        | ar C10    | 1.6  |             |     |
|                    |      |            |                 |            |               | acrylo-nitrile |                    |             |        | form      | 0.55 |             |     |
|                    |      |            |                 |            |               | 40             |                    |             |        | acald     | 0.55 |             |     |
|                    |      |            |                 |            |               |                |                    |             |        | oth.oxyg. | 10.6 |             |     |



Table 18 NMVOC profiles, ADOM chemical mechanism (% ww)

|                          | Non-industrial combustion |                  | Refineries | Gasoline vapour | Coke ovens | Solvents         | Transport |        |        |
|--------------------------|---------------------------|------------------|------------|-----------------|------------|------------------|-----------|--------|--------|
|                          | Solid fuels               | Wood             |            |                 |            |                  | Gasoline  |        | Diesel |
|                          |                           |                  |            |                 |            |                  | Uncontr.  | Contr. |        |
| non reactive             | 25                        | 40 <sup>1)</sup> | 7          | 1               | 32         | 21               | 11.8      | 6.5    | 9      |
| propane                  | 10                        | 1.5              | 20         | 1               | 1          | -                | 0.2       | 0      | -      |
| C4+ alkanes              | 5                         | 3.5              | 65         | 85              | -          | 27               | 36.5      | 40     | 52     |
| ethene                   | 30                        | 30               | 1          | -               | 60         | -                | 7         | 9.4    | 12     |
| higher alkenes           | 10                        | 9                | 1.5        | 11              | 6          | -                | 10.5      | 9.0    | 7.5    |
| mono-alkylbenzenes       | 1                         | 5.5              | 3.5        | 1.5             | 1          | 6                | 12.8      | 7.4    | } 8.5  |
| di- and trialkylbenzenes | 1                         | 2                | 2          | 0.5             |            | 10               | 19.2      | 25     |        |
| formaldehyde             | } 18                      | 2                | -          | -               |            | -                | 1         | 1.6    | 6.5    |
| higher aldehydes         |                           | 6                | -          | -               |            | -                | } 1       | } 1.1  | 4.5    |
| higher ketones           |                           | 0.5              | -          | -               |            | 36 <sup>2)</sup> |           |        | -      |
| % CH <sub>4</sub> in VOC | 50                        | 40               | 11         | 0               | 50         | 0                | 8         | 11     | 4      |

<sup>1)</sup> incl. furans<sup>2)</sup> incl. alcohols, esters and ethers



## Updating and upgrading the PHOXA emission data base to 1990

Table 19 Fuel wood consumption (small units)

|    | [O6] (OECD)<br>1989<br>Vegetal fuels (PJ) | [H6]                       |                                      | Miscellaneous             | This work <sup>1)</sup> |                      |
|----|-------------------------------------------|----------------------------|--------------------------------------|---------------------------|-------------------------|----------------------|
|    |                                           | FAO, 1988<br>Fuelwood (PJ) | Various '88<br>(89?)<br>Biomass (PJ) |                           | PJ                      | GJ.cap <sup>-1</sup> |
| AL | 15.7                                      | 17                         |                                      |                           | 17                      | 5.2                  |
| AT |                                           | 15                         |                                      | 65 <sup>2)</sup>          | 65                      | 8.6                  |
| BE |                                           | 6                          |                                      |                           | 6                       | 0.6                  |
| BG | 16.5                                      | 19                         | 17                                   |                           | 17                      | 1.9                  |
| CH |                                           | 9                          |                                      | 12.1 <sup>3)</sup>        | 12                      | 1.8                  |
| CS | 44.8                                      | 16                         | 20                                   |                           | (30)                    | (1.9)                |
| DD | 37.0                                      | }                          | }                                    |                           | 40                      | 2.4                  |
| DE |                                           |                            |                                      | 42 <sup>4)</sup>          | 40                      | 0.65                 |
| DK |                                           |                            |                                      | 17 <sup>5)6)</sup>        | 4                       | 0.8                  |
| ES |                                           | 36                         | 38                                   |                           | 38                      | 1.0                  |
| ET |                                           |                            |                                      | 7 <sup>7)</sup>           | 7                       | 4.5                  |
| FI |                                           | 32                         | 150                                  | 158 <sup>5)</sup> (30)    | 30                      | 6.1                  |
| FR |                                           | 112                        | 336                                  |                           | 112                     | 2.0                  |
| GB |                                           | 2                          | 50                                   |                           | 50                      | 0.9                  |
| GR |                                           | 22                         | 42                                   |                           | 42                      | 4.1                  |
| HU | 16.2                                      | 32                         | 34                                   | 15 <sup>8)</sup>          | 15                      | 1.4                  |
| IE |                                           | 0                          | 46                                   | 0 <sup>9)</sup>           | 0                       | 0                    |
| IT |                                           | 48                         | 162                                  | 60 <sup>10)</sup>         | (60)                    | 1.0                  |
| IS |                                           | 0                          |                                      | 0 <sup>5)</sup>           | 0                       | 0                    |
| LA |                                           |                            |                                      | 38 <sup>11)</sup>         | 35                      | 13                   |
| LI |                                           |                            |                                      | 15 <sup>12)</sup>         | 15                      | 4.1                  |
| LU |                                           |                            |                                      |                           | 0.2 <sup>13)</sup>      | 0.6                  |
| NL |                                           | 1                          |                                      | 17 <sup>14)</sup>         | 17                      | 1.1                  |
| NO |                                           | 10                         | 32                                   | 34 <sup>5)</sup> (18.6)   | 19                      | 4.4                  |
| PL | 66.5                                      | 40                         | 82                                   |                           | (70)                    | (1.8)                |
| PT |                                           | 6                          | 34                                   |                           | 34                      | 3.3                  |
| RO | 46.0                                      | 49                         | 45                                   |                           | 46                      | 2.0                  |
| SE |                                           | 48                         | 234                                  | 235 <sup>5)15)</sup> (35) | 35                      | 4.1                  |
| SU | 1037                                      | 930                        | 1617                                 | <sup>16)</sup>            | 1000                    | 3.4                  |
| YU |                                           | 48                         | 30                                   |                           | 160                     | 7 <sup>17)</sup>     |

<sup>1)</sup> Figures in parenthesis: estimated (generally by comparison)

<sup>2)</sup> [O2], [O11]

<sup>3)</sup> 1990 (20% industr. ?) [S10]

<sup>4)</sup> 2.8 Tg in 1986 [A14]

<sup>5)</sup> Wood, peat, sulphate and sulphite lyes, garbage [Y1, S11]

<sup>6)</sup> Incl. straw

<sup>7)</sup> 1988 [F2]

<sup>8)</sup>  $2.4 \times 10^6 \text{ m}^3$  (1986) [K4]; 0.98 Tg (resid.); 0.13 Tg (agric., forestry) 0.06 Tg (ind.) [H9]

<sup>9)</sup> Peat only (CORINAIR)

<sup>10)</sup> Source unknown

<sup>11)</sup> 1985: 46; 1989: 35 (estimation) [F2]

<sup>12)</sup> 6 PJ Wood, 9 PJ other (agr. waste?) [F2]

<sup>13)</sup> Assumed to be proportional to BE

<sup>14)</sup> [O10] 980 Gg

<sup>15)</sup> Energy conversion: 46; Industry: 154 [S11]

<sup>16)</sup> For heat from < 20 MW<sub>th</sub> inst.: 440 [S13].

Ca. 1400 wood and 110 peat [T5]

<sup>17)</sup> [S16] Slovenia (1983): 21.6 GJ per household

→ 6.8 GJ.cap<sup>-1</sup> (Slovenia: 8.4% of inh.);

Urban = 0.45 of rural

## Updating and upgrading the PHOXA emission data base to 1990

Table 20 Transport, fuel consumption (PJ)

| Country | Road, gasoline |          |      |        |       | Road, diesel |     |       | Other, diesel |       |              |      | Total diesel |
|---------|----------------|----------|------|--------|-------|--------------|-----|-------|---------------|-------|--------------|------|--------------|
|         | ldv            |          | hdv  | mc, mp | total | ldv          | hdv | total | rail          | water | rail & water |      |              |
|         | 4-stroke       | 2-stroke |      |        |       |              |     |       |               |       |              |      |              |
|         |                |          |      |        |       |              |     |       |               |       |              |      |              |
| AT      |                | -        | -    |        | 110   |              |     | 83    |               |       |              | 87   |              |
| BG      | 10             | -        | 27   | 3      | 40    | 2            | 35  | 37    | 7.5           | 1.5   | 4.2          | 46   |              |
| CH (89) |                | -        | -    |        | 150   |              |     | 34    | 0.4           | 0.4   | 0.8          | 35   |              |
| CS      | 57             | 7        | -    | 7      | 71    | 3            | 60  | 63    | 19            | 1.5   | 21           | 84   |              |
| ET (88) |                | -        |      |        | 20    |              |     | 5     |               |       | 15           | 20   |              |
| FI (89) |                | -        | -    |        | 83    |              |     | 64    | 3             | 2     | 5            | 69   |              |
| HU      | 32             | 13       | 5    | 3      | 53    | 10           | 24  | 34    | 10            | 3     | 13           | 47   |              |
| LA (89) |                | -        |      |        | 3     |              |     | 2.5   |               |       | 1            | 3.5  |              |
| LI      |                | -        |      |        | 15    |              |     | 18    | 7             | 17    | 24           | 42   |              |
| NO (89) |                | -        | -    |        | 76    |              |     | 29    | 1.2           | 25    | 27           | 56   |              |
| PL      | 84             | 11       | 8    | 7      | 110   | 7            | 90  | 97    | 21            | 1.5   | 23           | 120  |              |
| RO      | 83             | -        | -    | 5      | 88    | 8            | 135 | 143   | 71            | 3     | 74           | 217  |              |
| SE      |                | -        | -    |        | 185   |              |     | 70    | 2.5           | 4     | 6.5          | 77   |              |
| SU      | 625            | -        | 1350 | 75     | 2050  | 130          | 320 | 450   | 580           | 420   | 1000         | 1450 |              |
| YU      | 95             | -        | -    | 5      | 100   | 10           | 124 | 134   | 19            | 3     | 22           | 156  |              |



Table 21 Production data of non-CEC countries (Gg; vehicles:  $\times 10^3$ )

|                                | AT                 | BG                 | CH                 | CS                  | FI                 | HU            | NO                  | PL                 | RO                  | SE                  | YU                 | SU                 | ET     | LA            | LI                 | MO     | BR                 |
|--------------------------------|--------------------|--------------------|--------------------|---------------------|--------------------|---------------|---------------------|--------------------|---------------------|---------------------|--------------------|--------------------|--------|---------------|--------------------|--------|--------------------|
| Refinery throughput            | 8800 <sup>1)</sup> | 11086              | 3054               | 15100               | 9240 <sup>1)</sup> | 7938          | 10000 <sup>1)</sup> | 13304              | 23948               | 16000 <sup>1)</sup> | 15769              | 466600             | -      | -             | 12000              | -      | 32000              |
| Coke                           | 1771 <sup>1)</sup> | 1375               | -                  | 9743                | -                  | 1027          | -                   | 13720              | 4080                | 1174 <sup>2)</sup>  | 2350               | 77200              | -      | -             | -                  | -      | -                  |
| Pig iron                       | 3823 <sup>1)</sup> | 1442 <sup>2)</sup> | -                  | 9670                | 2284               | 1697          | 240 <sup>1)</sup>   | 8500               | (8280)              | 2638 <sup>1)</sup>  | 2460               | 110000             | -      | -             | -                  | -      | -                  |
| Crude steel, BOF               | 4334 <sup>1)</sup> | (1600)             | -                  | (6900)              | (2380)             | 1424          | (130)               | 6000               | (4650)              | (2450)              | (1450)             | (51000)            | -      | -             | -                  | -      | <sup>3)</sup>      |
| Crude steel, EAF               | 384 <sup>1)</sup>  | (1000)             | 1050 <sup>1)</sup> | (2500)              | (470)              | 358           | (246)               | 2200               | (2300)              | (1950)              | (1150)             | (22000)            | -      | <sup>3)</sup> | -                  | 600    | <sup>3)</sup>      |
| Crude steel, OHF               | -                  | (300)              | -                  | (5500)              | -                  | 1180          | -                   | 5400               | (2750)              | -                   | (1100)             | (81000)            | -      | <sup>3)</sup> | -                  | -      | <sup>3)</sup>      |
| Crude steel, total             | 4291               | 2900 <sup>1)</sup> | 1050 <sup>1)</sup> | 14900               | 2850               | 2963          | 376                 | 13600              | 9690                | 4400                | 3690               | 154000             | -      | (600)         | -                  | (600)  | 1100 <sup>1)</sup> |
| Rolled products                | <sup>3)</sup>      | <sup>3)</sup>      | -                  | <sup>3)</sup>       | -                  | 2176          | -                   | 9850               | 10600               | <sup>3)</sup>       | <sup>3)</sup>      | 112000             | -      | (800)         | -                  | (450)  | (700)              |
| H <sub>2</sub> SO <sub>4</sub> | <sup>3)</sup>      | 846 <sup>1)</sup>  | -                  | 1242 <sup>1)</sup>  | 1179 <sup>2)</sup> | 244           | 796 <sup>2)</sup>   | 3160 <sup>2)</sup> | 1825 <sup>2)</sup>  | 1000 <sup>2)</sup>  | 1384               | 27300              | (500)  | -             | -                  | -      | <sup>3)</sup>      |
| HNO <sub>3</sub>               | <sup>3)</sup>      | <sup>3)</sup>      | -                  | <sup>3)</sup>       | 544 <sup>2)</sup>  | (630)         | <sup>3)</sup>       | 2187 <sup>2)</sup> | <sup>3)</sup>       | <sup>3)</sup>       | 858 <sup>2)</sup>  | -                  | (100)  | -             | -                  | -      | <sup>3)</sup>      |
| NH <sub>3</sub>                | <sup>3)</sup>      | 1326 <sup>1)</sup> | <sup>3)</sup>      | 969 <sup>1)</sup>   | 3 <sup>2)</sup>    | 540           | <sup>3)</sup>       | 2338 <sup>2)</sup> | 3385 <sup>4)</sup>  | <sup>3)</sup>       | 858 <sup>2)</sup>  | 22460              | (200)  | -             | -                  | -      | <sup>3)</sup>      |
| Ethylene                       | <sup>3)</sup>      | 217 <sup>1)</sup>  | <sup>3)</sup>      | 641 <sup>1)</sup>   | <sup>3)</sup>      | 234           | <sup>3)</sup>       | 166 <sup>2)</sup>  | 319 <sup>4)</sup>   | 304 <sup>1)</sup>   | 242 <sup>2)</sup>  | 3175 <sup>2)</sup> | -      | -             | -                  | -      | <sup>3)</sup>      |
| Vinylchloride                  | -                  | <sup>3)</sup>      | -                  | <sup>3)</sup>       | <sup>3)</sup>      | <sup>3)</sup> | <sup>3)</sup>       | <sup>3)</sup>      | <sup>3)</sup>       | <sup>3)</sup>       | <sup>3)</sup>      | -                  | -      | -             | -                  | -      | -                  |
| PVC                            | (30)               | 31 <sup>1)</sup>   | <sup>3)</sup>      | 213 <sup>1)</sup>   | <sup>3)</sup>      | 185           | <sup>3)</sup>       | 208                | 208 <sup>4)</sup>   | <sup>3)</sup>       | 182 <sup>2)</sup>  | (800)              | -      | -             | -                  | -      | -                  |
| LDPE                           | (130)              | (80)               | -                  | (100)               | <sup>3)</sup>      | 221           | <sup>3)</sup>       | 166 <sup>2)</sup>  | (65)                | (160)               | (130)              | -                  | -      | -             | -                  | -      | <sup>3)</sup>      |
| HDPE                           | (80)               | (30)               | -                  | (70)                | -                  | -             | <sup>3)</sup>       | -                  | (85)                | (67)                | (100)              | -                  | -      | -             | -                  | -      | -                  |
| PE                             | (210)              | 111 <sup>1)</sup>  | -                  | 172 <sup>1)</sup>   | <sup>3)</sup>      | 221           | <sup>3)</sup>       | 166 <sup>2)</sup>  | 150 <sup>4)</sup>   | 227 <sup>1)</sup>   | 234 <sup>2)</sup>  | (1500)             | -      | -             | -                  | -      | -                  |
| PP                             | (200)              | 59 <sup>1)</sup>   | -                  | 192 <sup>1)</sup>   | -                  | 156           | <sup>3)</sup>       | 81 <sup>2)</sup>   | -                   | <sup>3)</sup>       | 29 <sup>2)</sup>   | (200)              | -      | -             | -                  | -      | -                  |
| PS                             | -                  | 29 <sup>1)</sup>   | -                  | 77 <sup>1)</sup>    | <sup>3)</sup>      | -             | -                   | 23 <sup>2)</sup>   | 33 <sup>4)</sup>    | <sup>3)</sup>       | 43 <sup>2)</sup>   | (600)              | -      | -             | -                  | -      | -                  |
| SBR                            | -                  | 25 <sup>1)</sup>   | -                  | 76 <sup>1)</sup>    | <sup>3)</sup>      | -             | -                   | 127 <sup>2)</sup>  | <sup>3)</sup>       | <sup>3)</sup>       | <sup>3)</sup>      | <sup>3)</sup>      | -      | -             | -                  | -      | -                  |
| Cement                         | 4903               | 4680               | 4944 <sup>1)</sup> | 10970 <sup>2)</sup> | 1667               | 3933          | 1261                | 12564              | 13260 <sup>1)</sup> | 2400                | 8100               | 137000             | (1100) | (830)         | 3500 <sup>1)</sup> | (2200) | (2200)             |
| Pulp                           | <sup>3)</sup>      | 173 <sup>1)</sup>  | <sup>3)</sup>      | <sup>3)</sup>       | <sup>3)</sup>      | 61            | 1940 <sup>2)</sup>  | 678 <sup>2)</sup>  | <sup>3)</sup>       | 2374 <sup>1)</sup>  | 656                | (10800)            | (150)  | (240)         | (200)              | -      | (340)              |
| Bread                          | 71                 | (650)              | (60)               | (1000)              | 177 <sup>2)</sup>  | 673           | (130)               | (2700)             | (1500)              | 225 <sup>1)</sup>   | 1225 <sup>2)</sup> | 32500              | (230)  | (400)         | (550)              | (400)  | 1503 <sup>2)</sup> |
| Automobiles, ldv               | 6.64 <sup>1)</sup> | 14.2 <sup>1)</sup> | -                  | 189 <sup>1)</sup>   | 36 <sup>1)</sup>   | -             | -                   | 286 <sup>1)</sup>  | 144 <sup>1)</sup>   | 235 <sup>1)</sup>   | 285                | 1300               | -      | -             | -                  | -      | -                  |
| hdv, buses                     | 4.98 <sup>1)</sup> | 10 <sup>1)</sup>   | -                  | 50.5 <sup>2)</sup>  | 0.8 <sup>1)</sup>  | 8.0           | -                   | 5.3 <sup>1)</sup>  | 3.9 <sup>1)</sup>   | 30 <sup>1)</sup>    | 29 <sup>1)</sup>   | 1068 <sup>2)</sup> | -      | -             | -                  | -      | -                  |

<sup>1)</sup> 1989<sup>2)</sup> 1988<sup>3)</sup> data absent<sup>4)</sup> 1987

data in parenthesis: estimate



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*Updating and upgrading the PHOXA emission data base to 1990*
*Table 22 Update factors for road transport emissions in CEC countries 1990/1985*

|                |                           | BE   | DE   | DK   | FR   | GB   | IE   | IT   | LU   | NL   |
|----------------|---------------------------|------|------|------|------|------|------|------|------|------|
| 6010+6050+6070 | NO <sub>x</sub>           | 1.02 | 0.96 | 1.22 | 1.08 | 1.11 | 1.15 | 1.12 | 1.11 | 1.12 |
|                | CO                        | 0.77 | 0.67 | 0.85 | 0.87 | 0.86 | 0.85 | 0.90 | 0.85 | 0.75 |
|                | VOC                       | 0.96 | 0.81 | 1.08 | 1.03 | 1.06 | 1.08 | 1.05 | 1.03 | 0.90 |
| 6020+6060      | NO <sub>x</sub> , CO, VOC | 1.10 | 1.10 | 1.04 | 1.13 | 1.05 | 1.16 | 1.28 | 1.04 | 1.10 |
|                | SO <sub>x</sub>           | 0.72 | 0.67 | 0.42 | 1.13 | 1.02 | 0.98 | 0.87 | 0.67 | 0.73 |
| 6030+6040      |                           | 1.0  | 1.0  | 1.0  | 1.0  | 1.0  | 1.0  | 1.0  | 1.0  | 1.0  |
| 6080+6090      | VOC                       | 1.09 | 1.17 | 1.06 | 1.03 | 1.19 | 1.03 | 1.29 | 1.35 | 1.02 |

Source: [S18]

## Updating and upgrading the PHOXA emission data base to 1990

Table 23 SO<sub>x</sub> abatement installations at power plants in CEC countries

| Country/plant name          | Unit | Capacity (MW <sub>e</sub> ) | Year | %SO <sub>x</sub> removal |
|-----------------------------|------|-----------------------------|------|--------------------------|
| <b>Denmark</b>              |      |                             |      |                          |
| Amagerværket KK             | 3    | 250                         | 89   | 90                       |
| Avedøreværket <sup>1)</sup> | 1    | 250                         | 90   | 90                       |
| Studstrupværket             | 3    | 350                         | 89   | 92                       |
| <b>France</b>               |      |                             |      |                          |
| Gardanne                    | 5    | 600                         | 85   | 60                       |
| <b>Italy</b>                |      |                             |      |                          |
| Brindisi Sud                | 1    | 660                         | 90   |                          |
| Brindisi Sud                | 2    | 660                         | 90   |                          |
| Brindisi Sud                | 3    | 660                         | 90   |                          |
| Brindisi Sud                | 4    | 660                         | 90   |                          |
| Brindisi Nord               | 1    | 320                         | 90   |                          |
| Brindisi Nord               | 2    | 320                         | 90   |                          |
| <b>Netherlands</b>          |      |                             |      |                          |
| Amer                        | 8    | 645                         | 88   | 88                       |
| Borssele                    | 11   | 200                         | 87   | 93                       |
| Borssele                    | 12   | 200                         | 87   | 93                       |
| Nijmegen                    | 13.1 | 325                         | 85   | 90                       |
| Nijmegen                    | 13.2 | 300                         | 89   | 90                       |
| Maasvlakte (R'dam)          | 1    | 540                         | 87   | 88                       |
| Maasvlakte (R'dam)          | 2    | 540                         | 88   | 88                       |

<sup>1)</sup> New power plant; also NO<sub>x</sub> control

Source: [V1]  
Installations in use ≤ 1990 only.