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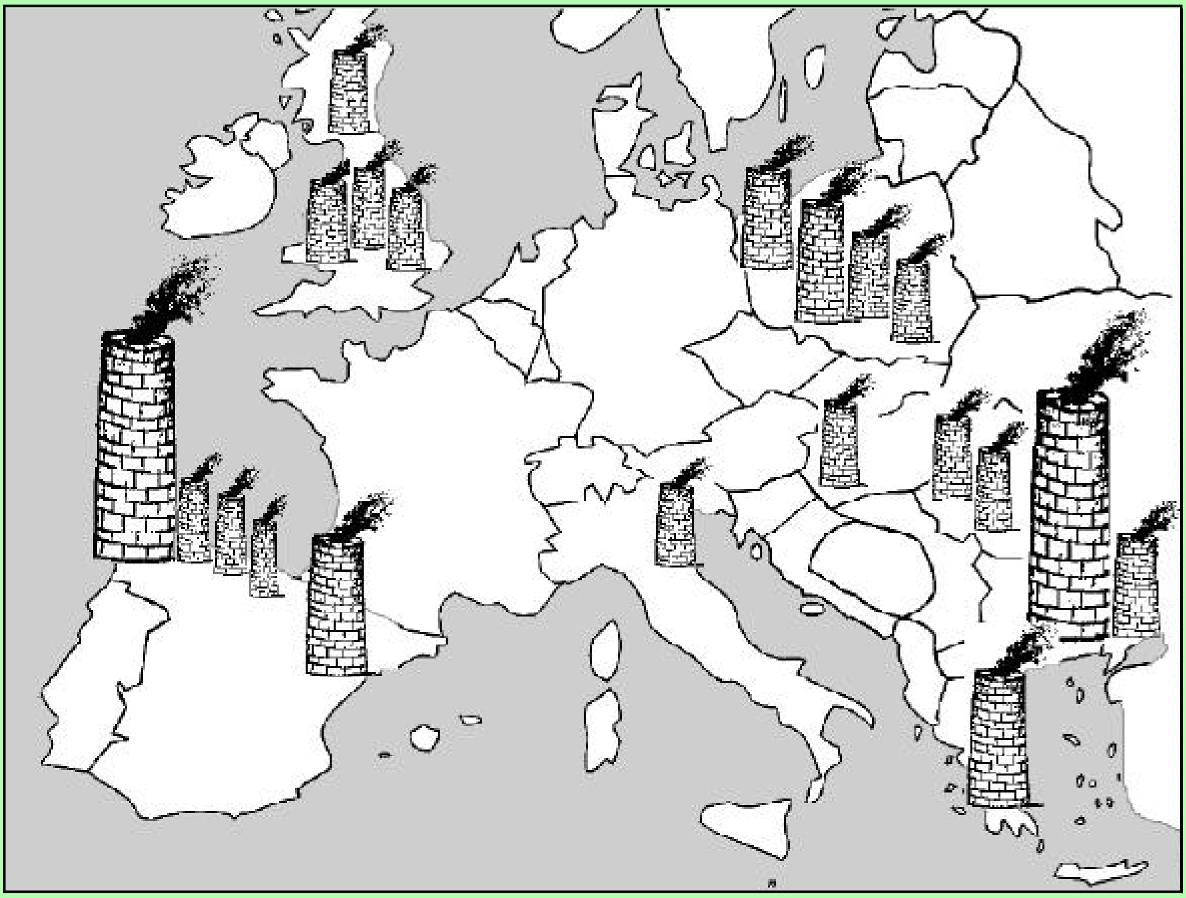
17

Atmospheric Emissions from Large Point Sources in Europe



By
Mark Barrett

THE SWEDISH
NGO SECRETARIAT
ON ACID RAIN

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AIR POLLUTION AND CLIMATE SERIES

Atmospheric Emissions from Large Point Sources in Europe

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Cover illustration: The 20 biggest point sources to SO_2 emissions in EU25 plus the two candidate countries Bulgaria and Romania. These are: Maritsa II, Bulgaria, 332 ktonnes; Puentes, Spain, 315 ktonnes; Megalopolis, Greece, 161 ktonnes; Andorra (Teruel), Spain, 152 ktonnes; Belchatow, Poland, 136 ktonnes; Adamow, Poland, 96 ktonnes; Maritsa I, Bulgaria, 96 ktonnes; Oroszlnany, Hungary, 81 ktonnes; Turow, Poland, 79 ktonnes; Craiova, Romania, 75 ktonnes; Porto Tolle , Italy, 73 ktonnes; Meirama, Spain, 71 ktonnes; Patnow, Poland, 71 ktonnes; Cottam, UK, 71 ktonnes; West Burton, UK, 69 ktonnes; Longannet, UK, 68 ktonnes; Compostilla, Spain, 62 ktonnes; Eggborough, UK, 60 ktonnes; Drobeta, Romania, 60 ktonnes; and La Robla, Spain, 57 ktonnes.

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SENCO would like to thank Christer Ågren (Director of the Swedish NGO Secretariat on Acid Rain) who wrote the summary and introduction to this study with the policy recommendations therein. This work was funded by the Swedish NGO Secretariat on Acid Rain. Mark Barrett of SENCO takes responsibility for any errors or misrepresentations in the report.

Summary

This report presents the "worst" and the "best" fossil-fuelled power plants in Europe, ranked according to their emissions of sulphur, although data on each plant's emissions of nitrogen oxides, particulate matter, and carbon dioxide, are also presented. The figures come from the latest survey of emissions from large point sources made by Mark Barrett of SENCO consultants at the instance of the Swedish NGO Secretariat on Acid Rain. This is an updated version of two previous surveys made in 1994 and 2000.

Topping the list of the greatest emitters of sulphur to the atmosphere in Europe are two large coal-fired power stations in Bulgaria and Spain, respectively. Together these two plants let out nearly 650 thousand tonnes of sulphur dioxide (SO_2) a year – as much as the combined total from all the following countries: Austria, Belgium, Denmark, Finland, Ireland, the Netherlands, Norway, Sweden, and Switzerland.

Although it is evident from comparison of the surveys that the emissions from large installations have declined markedly over the last decade, it is also clear that they are still far from negligible. According to the latest figures, the 100 largest emitters were still pouring out 7.1 million tonnes of SO_2 a year, corresponding to 43 per cent of the total of 16.7 million tonnes from all sources on land in Europe in 2001.

It may be noted that 89 of the 100 largest point sources of SO_2 are power stations, and that 70 of these are coal-fired. Eleven stations are fuelled with oil, and two – the Balti and Eesti plants in Estonia – burn oil shale. The remainder of the 100 largest are mainly refineries and metal production facilities.

An aspect that is of direct political importance is the age of the plants. It was found that around 90 per cent of the emissions of SO_2 from the largest coal-fired plants come from those that were commissioned before 1987. This is now relevant in view of the forthcoming review and revision of the EU directive for large combustion plants (LCP).

The present study includes an updating of the list of the "best" plants fired with fossil fuels. Here the plants are ranked according to their combined emissions of SO_2 and NOx in relation to their output of useful energy (electricity and/or heat). These new figures show that there are still a very large number of existing plants burning fossil fuel that easily meet the emission limit values set in the EU's LCP directive for new post-2003 installations. There can therefore be no doubt as to the possibility of achieving emission levels, by the use of conventional technology, that are considerably lower than the current EU standards for SO_2 and NOx emissions from large combustion plants.

The survey covers essentially the whole of Europe, including the "European regions" of Russia and Turkey. In total, SENCO's database includes some 7500 large point source emitters. These 7500 emit over 14 million tons of SO_2 a year, or about 88 per cent of all the emissions from land-based sources in Europe. In revising the list, use has been made of several databases from other institutions, including the European Environment Agency's European pollution emission register (EPER), and the International Energy Agency Coal Research's coal power station database. It is pointed out that differences in the age of the data, as well as operating changes, for instance, in the sulphur content of the fuel, and the number of operating hours per year, can make the ranking of the plants somewhat inexact.

1. Introduction: Motive and policy context

The European power plants that are fired with fossil fuels let out enormous amounts of air pollutants. It is mostly sulphur dioxide that they emit, but also nitrogen oxides, particles, and heavy metals, all making trouble for health and the natural environment. They all emit, too, large amounts of the greenhouse gas carbon dioxide.

The “worst”...

It is well known that a great part of the emissions of sulphur dioxide comes from a relatively small number of point sources, primarily coal-fired power stations. This was shown in earlier studies (1995 and 2000) made by Mark Barrett for the Swedish NGO Secretariat on Acid Rain, where it was estimated that between 75 and 90 per cent of the man-made emissions of sulphur in Europe came from a few thousand point sources, while the hundred worst ones were alone responsible for more than 40 per cent of the total. The new study confirms that this still is true.

Emissions from large point sources are regulated by EU legislation primarily by Directive 1996/61/EC on Integrated Pollution Prevention and Control (IPPC), and Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants (LCP). The latter sets emission limit values for sulphur dioxide, nitrogen oxides, and dust, and article 7 of this directive states that not later than 31 December 2004, the Commission shall submit a report to the European Parliament and the Council in which it shall assess among others the need for further measures, and the technical and economic feasibility of such measures, and that the report shall be accompanied by related proposals.

Consequently, proposals for the revision of the large combustion plants directive should be tabled before the end of this year. Any such proposals are however likely to be considered in the context of the EU s Clean Air For Europe (CAFE) programme. Based on work under this programme, by July 2005 the Commission is to deliver a communication to the Parliament and the Council, presenting its thematic strategy on air pollution.

Already ten years ago the Swedish NGO Secretariat on Acid Rain published a report showing that there were a number of plants in operation in Europe that were easily meeting the EU requirements for new installations. The plants surveyed were of various ages (built between 1961 and 1994), of greatly varying size (l00 to 5700 MW_{th}) and fired with a variety of fuels (hard coal, lignite, oil, gas, and biofuels).

... and the “best”

In connection with the present survey of the biggest sources of sulphur emissions in Europe, an updating of the list of the best plants fired with fossil fuels has also been made. Here the plants are ranked according to their combined emissions of SO_2 and NOx in relation to their output of useful energy (electricity and/or heat). Although this kind of assessment is somewhat unusual, it is better from the point of view of effects on the environment in that it rewards plants that use energy most effectively.

The best plants usually come in this order according to fuel type: those fired with natural gas (1), oil (2), and coal (3). Emission control techniques, such as flue-gas desulphurization or denitrification, may however change the order of ranking, which will also be affected if plants produce electricity only or heat as well. In combined heat-and-power plants the output of useful energy is typically 100 to 200 per cent higher, with a subsequent reduction of emissions per output.

Some of the coal-fired plants on the list have such low combined emissions of SO_2 and NOx as to be comparable with gas-fired ones. (If the emissions of the greenhouse gas carbon dioxide are also taken into consideration, coal-fired plants will of course be worse than gas-fired from the point of view of the environment.) All these coal-fired plants are producing both heat and power, and are equipped for desulphurization and denitrification of the flue gases. Most of the best coal-fired plants are located in Germany, but they can also be found in e.g. Austria, Denmark, and the Netherlands in other words, those countries with the strictest laws concerning measures to control emissions.

In the EU s LCP directive, as well as in many countries legislation, emissions are expressed as milligrams of pollutant per cubic metre of air (mg/m^3) in the flue gases, and this report also gives a list of the best plants with emissions denoted in this unit. In that list plant performances are also compared when estimated according to the emission limit values of the LCP directive.

It should be noted that the emission figures for the best plants have been calculated from the available official statistics. Since such plants quite frequently burn fuel of varying quality differing for instance in sulphur and energy content and sometimes even use different kinds of fuel, and be run at different load from one year to another, performance may vary considerably over the years.

Revision of the LCP directive

Be that as it may be, however, these new figures show that there are still a very large number of existing plants burning fossil fuel that easily meet the emission limit values set in the LCP directive for new post-2003 installations. There can therefore be no doubt as to the possibility of achieving emission levels, by the use of conventional technology, that are considerably lower than the current EU SO_2 and NOx standards for large combustion plants.

It is also a matter of interest, and of some concern, that the EU requirements for stationary plants are still being formulated in such a way as to be technology conserving. The emission limit values of the 2001 LCP directive, i.e. those that will apply to new plants for the next ten years or so, were being set so they could safely be met by using the same kind of commercially available techniques that was already in general use when the legislation was initially being drafted in the second half of the 1990s.

The requirements for road vehicles have on the other hand come to act as technology forcing , being set at levels that are considered possible of achievement within a few years. They are moreover being successively tightened up at much shorter intervals than those for stationary equipment.

This study of large point sources shows, too, that by far the greatest part of the emissions of SO_2 about 90 per cent comes from old plants (built before 1987). If the reductions that will be needed in the next five years for the fulfillment of the EU aims for air quality and acidification are to be achieved, something must obviously be done about the emissions from these plants.

Even though the list on the highest emitting large point sources shows their ranking in relation to sulphur emissions, the report contains data also on each plant s emissions of nitrogen oxides, carbon dioxide, and particulate matter. The information shows that many of the worst sulphur emitters are significant point sources for these pollutants as well. Consequently, there is a great potential for multiple benefits of smart emission abatement strategies, e.g. the introduction of strict technology forcing emission standards that are designed to promote both energy efficiency and a switching from the dirtiest fuels (e.g. coal) to cleaner, primarily renewable sources of energy.

The Swedish NGO Secretariat on Acid Rain argues that a simple way to protect both health and the environment, while at the same time ensuring level competition in a liberalised electricity market, would be to apply minimum environmental fiscal measures and standards; for example, taxes and charges on emissions and emission limit values. Each plant would, as a basic principle, have as far as possible to bear its own costs to the environment. The setting of strict mandatory emission limit values for existing plants would help ensure that the oldest, least efficient, and dirtiest plants would be shut down. And those that were to be kept going would either have to be retrofitted for modern flue-gas cleaning or fired with cleaner fuels, or both.

The foreseen review and revision of the LCP directive provides an opportunity to adjust and strengthen the emission limit values, and the results of this analysis should be taken into account when making policy for the future control of the emissions from large combustion plants in Europe.

September 2004

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The Swedish NGO Secretariat on Acid Rain

2. Background

This is the third version of this work on Large Point Sources (LPS) of pollution emission; previous reports were published in 1995 (Barrett & Protheroe 1995) and 2000 (Barrett 2000). This study is still confined to large stationary facilities, but it has been extended and improved.

First, estimates are made of the atmospheric emissions of particulate matter (PMa), as well as sulphur dioxide (SO_2), nitrogen oxides (NOx) and carbon dioxide (CO_2) as before. PMa is found in a range of particle sizes. In this text, PMa generally refers to particles less than 10 microns in diameter, PM_{10}.

Second, the geographical coverage has been extended notably to include more countries bordering the EU25. The region studied includes the current European Union (25 countries) and 16 countries inside it or bordering it. Point sources have been excluded if they are further east than 45º longitude East this exclusion mainly affects Russian sources. The study region contains 42 countries (excluding, in the lists, smaller states such as Monaco and Andorra) most of which emit significant quantities of atmospheric pollution. Table 1 (see Annex, p. 49) lists the larger countries covered. The three letter country codes (called CouISO3**)** are according to standard ISO 3166.

Third, in addition to SENCO s own data collated in previous studies, extensive use of more recent large facility databases from other institutions has been made. The databases, with their acronyms given first, are:

- ❑ **EPER**; the European Pollution Emission Register (EEA, 2004).
- ❑ **IEACR**; the International Energy Agency Coal Research coal power station database (IEACR, 2004).
- ❑ **Platts**; the Platts World Electric Power Plant database (Platts, 2000).
- ❑ **IEACO2**; a database assembled by the IEA Greenhouse Gas R&D Programme (IEA, 2002).

These databases have recent and comprehensive information. Large emitters of the pollutants in this study are generally covered well in these databases, and these constitute a large fraction of total emission of some pollutants, as is shown in section 6. Coverage of small power stations is good (Platts), but there is little information about other small facilities such as heat only boilers.

A standard framework for these databases has been developed and significant effort has gone into developing software which will combine these databases. Apart from the IEACO2 database, these databases are updated regularly and so they may be used with the software for future revisions, or for researching LPS in geographical regions other than Europe and western Asia.

The work carried out was divided into four phases:

i. Collection of basic data.

ii. Collation and estimation of emission for individual sources.

iii. Aggregation of point sources.

iv. Reporting including the presentation of tables and maps of largest emitters.

Further details of this study may be found at SENCO s web site, www.sencouk.co.uk.

3. LPS Databases

3.1 Data overview

There is no comprehensive database covering all types of emitter for the geographical region concerned, and so many disparate sources of data were utilised. Reconciling these different sources has caused problems. The sources will for example give inconsistent information about a particular emitter, and sometimes it is not clear which emitter the data refers to and there is the problem of potential double counting. The changing political boundaries and affiliations coupled with the large number of languages of the region have added to the problems.

The availability and consistency of data diminishes going from the EU15 to the EU25 to countries outside these regions, and emission standards generally follow the same trend. Therefore data available and used in this study are usually poorest for countries with high emission plants. Furthermore, the data-poor regions have typically manifested greater changes in their economies and political situations. Thus, even where good data exists for some past year, it may bear less relation to the current position than EU15 data.

The period between the data years (mostly 2000-2002) to the present (2004) has seen continued economic change in eastern Europe and Russia, and a further shift to gas and imported coal which have continued to bring major changes in emission patterns. In general SO_2 and NOx emissions from Large Point Sources (LPS) continue to decline because of these changes and tighter environmental standards.

The political reconfiguration means that a strict comparison is not possible between every database region and EMEP and ECE (Economic Commission for Europe) regions. In particular, some of the point sources in the databases have not yet been properly reallocated from the former Yugoslavia and former USSR to their new constituent countries. Also, for some states, notably Russia and Turkey, some of the ECE data relates only to the western European regions of these countries.

This version of the LPS study has utilised:

☐ Databases about LPS supplied by other institutions, these are called primary databases. These databases have reduced SENCO s data collection requirements hugely, and have the advantage that most of them are updated.

☐ A number of SENCO databases with supplementary LPS data, and databases which facilitate the standardisation and combination of all of the databases.

☐ Other databases with national emissions and energy data.

These databases are described in more detail below.

3.2 Primary data sources

The primary databases used are the EPER, IEACO2, IEACR and Platts databases. These databases partially overlap in terms of coverage as is shown in Figure 1.

Table 2 (see Annex, p. 49) summarises the primary databases. Important omissions from all of these databases are data on plant output (electricity generated, tonnes product, etc.) and the efficiency (e.g. electricity out/fuel in). More details of the primary databases are given below.

EPER emissions database

The EPER, which includes all reported data, is hosted by the European Environment Agency and reported at www.eper.cec.eu.int.

The EPER is described thus:

The European Pollutant Emission Register (EPER) was launched on the 23 February 2004 by the European Commission in the European Environment Agency in Copenhagen. EPER is the first Europe-wide register of emissions into air and water from large and medium-sized industrial facilities in Europe. The first EPER report includes data for the year 2001 from about 10,000 industrial facilities in the European Union and Norway.

Annex I of the IPPC Directive (96/61/EC) states: The threshold values given below generally refer to production capacities or outputs. Where one operator carries out several activities falling under the same subheading in the same installation or on the same site, the capacities of such activities are added together.

The EPER covers the EU15 and some sources in Norway and Hungary. It does not generally contain details of technology, fuel, and emission control.

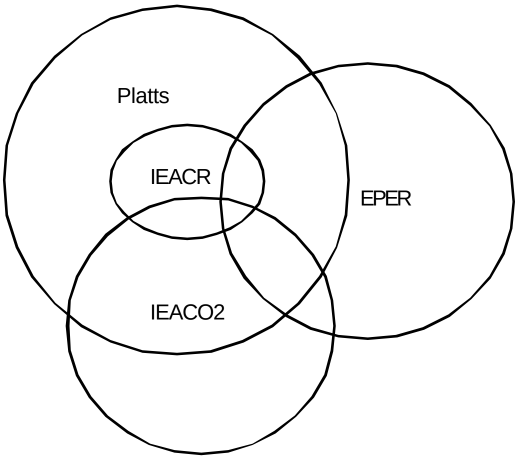
IEA CO2 database

The IEACO2 database was assembled for researching the potential for sequestering CO_2. This database was invaluable for complementing SENCO s data on non-power station LPS (refineries, iron and steel plant, etc.), especially for countries outside the EPER region. IEACO2 contains estimates of CO_2 emission and fuel types from which other emissions may be estimated.

3.2.1 Power station databases

The IEACR and Platts primary databases were the main sources of data for power stations. There are some discrepancies between these databases; most notably NOx and PMa emission control equipment may be recorded in one database, but not the other.

Figure 1. Primary database coverage.



IEACR Coal station database

The IEACR (UK) produces a database of power stations using coal, with or without other fuels (IEACR, 2004). The database covers stations greater than 50 MW_e which can burn coal (but also other alternative fuels) and so does not include stations fired only with oil or gas, or indeed nuclear units and stations using renewable energy resources. SENCO has used the 2004 version of this database (Coal Power 4), which contains data relating to the period up to 2000 or so.

The IEACR database gives information about the whole power station, and about the individual units making up that station. It includes information on:

- ☐ Electrical and thermal capacity in MW by unit; but not electrical or heat energy output (TWh/PJ), or efficiencies. CHP plant are identified and their heat outputs (MW) given.
- ☐ Type of boiler by unit.
- ☐ Coal consumption and coal quality (calorific value, sulphur, ash etc.), fraction of energy met with coal (if other fuels used) by station.
- ☐ Details of emission control for SO_2, NOx and PMa by unit.
- ☐ Utility or operator.

It should be noted that coal burn is given for the whole station, but not for each unit. Therefore when coal burn is less than maximum, there is a question as to which units the coal is burnt in. In general, given choice, the operator will use the coal in the units with lowest marginal cost and producing the least emissions. The approach taken here is to assume that coal is burnt equally in each power station unit pro rata to the electrical output. Similarly, the average emission control pollution removal fraction is calculated by a weighted fraction across all operating units.

The IEACR is generally preferred to Platts for coal stations because there are data on coal consumption and quality, and more detailed information about emission control application.

Platts power station database

This global database contains data on all types of power station (fossil, nuclear, renewable) at a unit level. It has similar data to IEACR, but no information on fuel quality or consumption.

3.2.2 SENCO databases

The primary data were supplemented by data collected and collated separately by SENCO during the course of this and previous studies.

LPS Supplementary Database. This database has auxiliary and corrective information about LPS in the primary databases (e.g. latitude, longitude) and data on LPS not in the primary database (e.g. Russian smelters). It also has the data collated in previous studies which enables some cross-checking of the primary databases.

Field names database. Each primary database uses different field names for countries, technologies, fuel types, etc. A database was built in which the field names of each primary database were mapped onto standard names.

Code maps and data lookup tables. Each primary database uses different codes for plant names, countries, technologies, fuel types, emission control and so on. Unique standard codes were collated (or created as necessary) and the codes in each primary database mapped onto these standard codes. Most codes allow the access of data in lookup tables. For example, the fuel code S_CoaLig , denotes solid fuel-coal-lignite, and the fuels database will give typical values for calorific content, sulphur, etc. The following main code maps and lookup tables have been constructed.

- Country codes. All country names coded to ISO standard.
- Plant names: names in the primary database (constructed as necessary) are mapped to standard plant names.
- Economic classification: NACE/NOSE/SNAP, etc.
- Fuels: energy, carbon, sulphur contents, etc.
- Heat generators: boilers, internal combustion, etc.
- Technology types: gas turbine, steam turbine, etc.
- Emission factors (uncontrolled): for fuel/technology combinations.
- Emission abatement equipment types (SO_2, NOx, PMa): removal rates, costs.
- Operational status: planned, operating, retired, etc.

3.2.3 Other databases

A number of other databases have been used in a less systematic way, the principal ones are:

- EMEP. Data on the national emissions of a range of pollutants.
- CDIAC. The Carbon Dioxide Information Analysis Center. CO_2 emission data.
- USEIA. USA Energy Information. Data on energy flows and capacities.

3.2.4 Economic classification

NACE codes are generally used for economic classification in the EU. These codes are given numerically. For the work here it has been convenient to give these mnemonic hierarchic 3 letter codes (NACEm) which are easier to read and remember, and are useful for aggregation. The codes used devised by SENCO are tabulated in Table 3 (see Annex, pp. 50-52) in the order in which they appear in the top SO_2 emitters.

4. Data process

The data process is essentially to convert all of the primary and other databases into standard form, calculate emissions, aggregate to LPS, analyse and report. The following are the main steps:

1) Build code map and data lookup databases.
2) Standardise the primary databases.
   a) Put the databases into flat (non-relational) forms for simpler processing; this mainly applies to the EPER.
   b) Apply standard field names. The databases use different field names; these were converted to standard names.
   c) Code primary information with standard codes for all databases.
3) Estimate emissions for primary databases.
   a) Estimate emissions for each unit using emission factors, fuel quality, emission control, etc.

b) Aggregate units to LPS within each primary database; e.g. sum across units in a power station.

4) Collate LPS data from the primary databases to a single LPS database.

a) Build concordance map for plant names and type so that LPS in different databases can be matched up.

b) Combine information about each LPS from the different primary databases into a single record for each LPS. Account is taken of reliability ; for example EPER emission estimates are used in preference to SENCO estimates.

5) Supplement and adjust data with additional, corrective or recent information.

6) Analyse LPS data.

7) Output LPS data as tables, graphs and maps.

Computer implementation
The primary and other large databases are stored in Microsoft Access format; smaller databases are mainly in Microsoft Excel. The data manipulation process is programmed in Excel Visual Basic for Applications (VBA). Mapping has been carried out using the Manifold GIS programme and Excel.

4.1.1 Reconciling databases and aggregation

The various databases have to be reconciled as far as possible. There will always be problems of omissions, mistakes, inconsistencies (e.g. names) and different data periods of the databases; it is not possible to continuously update and perfectly cross-check large volumes of data. The priority in this study has been to check the data for the largest LPS. The two most important processes are matching plants across the databases, and handling discrepancies due to data being for different time periods.

Particularly important is reconciling the EPER with the other databases. For most large sources in the EU15 and Norway, there are EPER data. If not, there are a number of possible reasons, e.g. that a source was omitted from the EPER, perhaps because the plant did not operate that year, or because the data was not provided for collation. Alternatively, the other databases may record the plant as operational when it has been shut down.

Care has to be taken when correcting data, especially when removing or adding an LPS. For example, the output of a decommissioned electricity plant is usually replaced by the output of other plants, given that electricity demand increases in most countries, and these plants may not be in any of the databases. Removing such a decommissioned plant may therefore subtract an emission, without adding the emissions from the replacement plants.

Data period. Not all the data in the databases refer to the same time period, which may be a particular year defined with beginning and end dates. Even within a database version, data may not be for exactly the same period. The most significant problem here is that SENCO s version of the Platts database generally contains data for the year 2000 data, whereas the others generally refer to 2001.

A major part of this work has been to match a facility in one database to a facility in another. This is particularly difficult where there are many facilities clustered together, such as at Rotterdam or Teeside. Information used for this matching is, in approximate order of reliability and usefulness: country (always reliable), full address, plant name, economic classification (NACE code), capacity, fuel and plant type, town, company.

Plant names. The name of the plant is generally important for identification, but unfortunately different names are often used. A major part of the work has been to map alternative names used in the various databases. The Platts and IEACR databases use clear plant names. The EPER and IEACO2 are more difficult to use;

names are sometimes not given at all, or company names might be used. Furthermore, the rendition of the same name in the Roman alphabet is often inconsistent if the original language is accented (many languages) or uses non Roman letters (e.g. Cyrillic).

Economic and activity classification. Occasionally there is a problem allocating a NACE code to a facility. Sometimes a facility has more than one output: for example, different NACE codes are allocated to electricity production and the production and distribution of hot water, so which code should be allocated to a cogeneration plant? Should a generator in a refinery be given the NACE code for petroleum processing, or for electricity production? Apart from this, NACE codes are not always used consistently within a database: for example in the EPER database, what is (probably) electricity generation may be coded as EGW, EGW{Ele or EGW{Ele{Pro. Similar problems occur with NOSE and SNAP codes.

Address and spatial location. The physical locations of plants do not change, whereas plant name, fuel, technology, and ownership sometimes do. Furthermore, physical locations are defined by unique and unambiguous addresses in order for the postal system to work, and the names used rarely change. The address: country, city, street, number and particularly postal code, is therefore very useful in determining plant identity.

The latitude and longitude of a plant is also useful, but these coordinates may not be recorded or given to adequate precision. Often, in separate databases, national postal codes are mapped to approximate latitude and longitude. In many cases, the plant name is that of a nearby city or town, or some other geographical feature. (In SENCO s standard naming, these are used in preference for names as they change more slowly than other names used, such as company name.) A geographical feature usually enables the longitude and latitude to be at least approximately found.

The stages of estimating location were as follows:

- For most LPS, longitude and latitude are given in one of the primary databases (EPER, IEACO2) or previous SENCO work.
- SENCO has a database of cities and other geographical features, which has been used to look up the remaining longitudes and latitudes. The spatial error will typically be several kilometres because large point sources are rarely sited near the centre of towns. For some sources, the name is duplicated in the index or there are variants of the English spelling leading to confusion. This has doubtless led to errors.

4.1.2 Aggregation of sources

Data are given for each unit of a plant (IEACR, Platts), or for part or all of the plant (EPER, IEACO2). Most large plants are ensembles of technologies. For example, most electricity production sites have several units (boilers and turbogenerators) built over a period of years. These units and parts may be different in design, fuels used and the application of emission control technology such as flue-gas desulphurisation (FGD). One or more boilers may share a stack or chimney. Separately owned or operated refineries are often located close to each other. Many facilities have more than one owner. These units and parts must be aggregated to LPS.

First, there is the question of what is the minimum size of facility or unit to aggregate. The LCP directive defines minimum size in terms of heat input, and the EPER in terms of pollution emission. The SENCO LPS data has a lower limit than the LCP directive or EPER in that it includes the smaller units of the Platts database, but this only includes power stations.

A number of arbitrary definitions of an LPS can be proposed, using different combinations of physical parameters such as the a shared stack or flue, the process units (generator, boiler, kiln), inputs (fuel), outputs (electricity, heat, cement), siting or proximity (geography), and socioeconomic parameters such as legal responsibility (owner, operator).

Possible definitions of an LPS can include:

- Each stack or chimney is an LPS.
- Each heat generator boiler/electrical generator/industrial processor is an LPS.
- An aggregation at a site by input (e.g. fuels) or output (e.g. electricity, heat, cement) is an LPS.
- Each stack clustered within a certain area or distance may be aggregated to an LPS.
- The aggregate of sources at a site by owner or operator is an LPS.

All useful definitions are subject to ambiguities. Is a chimney with two flues counted as a single stack? Should emissions from catalytic cracking and power generation be added together at a refinery site? The best definition depends on what information is available, and how the definition of an LPS is to be used: e.g. for environmental impact studies, energy policy or for regulation. For the latter purpose the definition is particularly important.

For example, the definition of a plant subject to the LCP directive is not the same as that in the EPER. The LCP directive does not apply (at plant level) to combustion plant of less than 50 MW thermal input (MW_{th}). Consider a power station that has two coal boiler/generators each of 40 MW_{th} sharing a stack. Depending on the definition used, it would be possible to change the required LCP directive compliance of this station by measures such as building another stack, switching one boiler to gas, having two owners, using different fuel, etc.

Because of the importance of definition for environmental protection, government policy and the profitability of utility operations, there are extensive analyses and discussions of definitions.

When compiling lists of the biggest LPS, the aggregation procedure can obviously influence the overall size of the LPS and its ranking. Moscow city has twelve cogenerating power stations and over fifty district heating stations, plainly aggregating these to one LPS would rank Moscow high amongst the LPS.

In general, the databases used here do not contain the fine grain information required to reliably and accurately aggregate individual sources to LPS by stacks shared and spatial location. In this study, the emissions from individual sources are mostly aggregated by plant name, NACE code, and if available, fuel type. Where there are industrial complexes (e.g. Rotterdam, Grimsby/Immingham), plants are additionally differentiated by other parameters such as company.

If there are EPER data for an LPS, then this is used preferentially for emission estimates and an attempt is made to match the EPER data to each fuel. If there are no EPER data, then data is used, if available for an LPS, in the order of preference IEACR, Platts and then IEACO2. Because PMa control equipment may not be recorded, there is an option of selecting the lowest PMa emission between IEACR and Platts.

The process of aggregation is sufficient for concerns of long distance pollution transport since LPS are aggregates of sources within a few kilometres of each other. It is also generally useful for identifying the major LPS and policy implications. However it is not always adequate for local atmospheric pollution concerns, or for legislation, which might apply to single sources such as the LCP directive.

As an example of aggregation, Table 4 below shows information from each database and the emission estimates for the UK power station called Didcot . First, note the wide range in emissions estimates using the different databases. The PMa emission for coal using IEACR is over 500 times larger than the EPER estimate this is because, although installed, particulate control equipment is not recorded in IEACR, but it is in Platts. Also, it is surprising that the coal CO_2 emission estimated from IEACR coal burn is so much lower than the EPER figure, yet SO_2 is close.

The Didcot station has gas, oil and coal units and three aggregate LPS can be formed for Didcot, one each for gas, liquid and solid fuel. However, there are only two EPER records, which may be identified (in this case) as one for coal and one for gas by comparison with the emission estimates made with the other primary databases. Therefore Didcot is aggregated to two LPS, one for coal (41 kt SO_2), the other for gas.

Table 4. Aggregation example: Didcot, emission in kt.

Source	Fuel	CO_2	SO_2	NOx	PMa
EPER	Coal?	5550	41	16	0.62
EPER	Gas?	3020		2	
Platts	G_NatGas	3156	0	5	0.00
IEACO2	G_NatGas	2609	12	5	0.11
Platts	L_LigDis	36	0	0	0.00
IEACO2	L_Oil	73	0	0	0.00
IEACO2	S_Coa	6389	29	12	0.27
IEACR	S_CoaBit	3003	43	9	102.05
Platts	S_CoaBit	3945	35	26	0.20

5. Pollution emission estimation

This section summarises the essential combustion processes and then describes how pollution emission from facilities are estimated.

5.1.1 Combustion and flue gas concentrations

A combustible fuel is a complex mixture of chemical elements, occurring elementally or in compounds, most of which combine with oxygen when burnt thereby liberating heat. In conventional fuels, most of the heat comes from the oxidation of carbon and hydrogen, although other elements (such as sulphur) make, usually minor, contributions to heat output. Some elements are bound together in compounds such that in ordinary combustion conditions they are not available for combination with oxygen, this is usually called ash.

The chemical composition of fuels as supplied to consumers varies very widely as illustrated in Table 5 below. Note that oil and gas are processed before delivery to customers, and oil, particularly, shows a very wide range in composition across products such as heavy fuel oil, diesel and gasoline. The compositions of the fuels and their physical states (solid, liquid, gas) are prime determinants of pollution emission. As compared to gas, coal has more carbon, sulphur and ash. Furthermore, solids are more difficult to burn completely than gases.

Table 5. Fuel mass fractions (as supplied).

	Coal	Oil	Natural gas
Carbon	85-95%	85-90%	75%
Hydrogen	2-4%	10-15%	25%
Sulphur	0.1-4%	0.01-4%	negligible
Ash	1-35%	0-0.1%	negligible

Elements combine with oxygen in one or more fixed ratios according to chemical reactions. The dominant reactions are shown in Table 6.

The elements in the fuel combine with oxygen in all of these reactions, but in an efficient combustor most elements will be fully oxidized (i.e. combine with the maximum number of oxygen atoms) because that results in the maximum release of heat. Thus most carbon is oxidized to CO_2, but some will be partially oxidized to CO, and some will be unoxidised, and left as elemental carbon (soot).

By using these chemical equations and the atomic weights of the elements, it is possible to work out what mass of oxygen is required to combine with each element for each equation. By assuming the fraction of element reacting according to each equation, then the mass of oxygen required to burn a kilogramme of fuel may be calculated given that the fraction of each element in the fuel available for combustion is known.

Table 6. Dominant combustion reactions.

Carbon	$C + O_2 \quad CO_2$	
	$2C + O_2 \quad 2CO$	Incomplete oxidation
Hydrogen	$4H + O_2 \quad 2H_2O$	
Sulphur	$S + O_2 \quad SO_2$	
	$2S + 3O_2 \quad 2SO_3$	
Nitrogen	$4N + O_2 \quad 2N_2O$	Incomplete oxidation
	$2N + O_2 \quad 2NO$	
	$N + O_2 \quad NO_2$	

Oxygen constitutes about 21% of air by mass, and this varies slightly with conditions (humidity, etc.) The minimum mass of air required to burn the fuel may be calculated, and this ratio is called the stoichiometric air:fuel ratio. In order to reduce the amount of incompletely burnt fuel to an acceptable degree, more than the minimum volume of air (oxygen) required for complete combustion is used, and this is called excess air. In a typical boiler the excess might range from 5% to 30% for gaseous and liquid fuels, and up to 50% for solid fuels. If the exhaust gases are used to drive a gas turbine, then the excess air fraction is much larger.

In addition to the chemical reactions involving the elements in the fuel, chemical reactions can also occur between the constituents of the air. For example, during combustion, some of the atmospheric nitrogen combines with atmospheric oxygen to form a mixture of N_2O, NO and NO_2, collectively called thermal NOx. The extent of these reactions is dependent on combustion conditions (pressure, temperature, oxygen excess, etc.), and the nature of the fuel.

Using data for fuel composition and combustion reactions, the total mass of each combustion product (from the fuel, and the air) can be calculated. The volume of the remaining air and the gaseous combustion products may also be calculated and summed to give the total volume of exhaust gases. This volume is usually given at standard or Normal conditions of temperature (273 ºK) and pressure (101.3 kPa) after correction for the water vapour content. The units are called Nm^3 normal cubic metres.

The concentration of each product in the flue gas is then found by dividing the mass of each product by the total volume. SENCO has developed a preliminary computer programme to carry out this calculation.

5.1.2 Emission limit values

The Large Combustion Plant directive (2001/80/EC, updating 88/609/EEC), or LCP directive, specifies emission limits for plant which use combustible fuels to generate heat, and have a maximum heat input greater than 50 MW.

One measure of the environmental performance of a plant is the concentration of pollutants in the flue or exhaust gases resulting from combustion. (Arguably, a better measure is the amount of pollution per unit output of the plant.) Part of the LCP directive sets Emission Limit Values (ELVs) for SO_2, NOx and PMa for plants expressed as maximum concentrations of pollutants in the exhaust gases in mg/Nm^3. (Note that the term Emission Limit Value has a different meaning in other contexts.)

Increasing excess air lowers the concentrations of flue gas pollutants, but not the total mass of emission. In order to prevent meeting ELVs being met by adding excess air/oxygen, maximum concentrations of oxygen in the exhaust gas may be specified. The LCP directive assumes an oxygen content by volume in the waste gas of 3 % in the case of liquid and gaseous fuels, 6 % in the case of solid fuels and 15 % in the case of gas turbines.

The 2001 LCP directive sets ELVs for both new and existing plants. New plants are defined as those that are either licenced before 27 November 2002 or put into operation after 27 November 2003. The ELVs that apply to these new plants are presented in Table 7a, below.

Table 7a. Emission limit values for SO_2 and NOx from plants to be built after 2003 (mg/m^3).

	Sulphur dioxide			Nitrogen oxides		
Plant size (MW$_{th}$)	**50-100**	**100-300**	**>300**	**50-100**	**100-300**	**>300**
Solid fuels[1]	850	200	200	400	200	200
Liquid fuels	850	400-200 (linear decrease)	200	400	200	200
Biomass	200	200	200	400	300	200
Natural gas[2]	35	35	35	150	150	100

[1] Where the emission limit values for SO_2 cannot be met due to the characteristics of the fuel, installations smaller than 300 MW$_{th}$ shall achieve either 300 mg/m^3 SO_2 or a rate of desulphurisation of at least 92%. Larger plants must achieve rate of desulphurisation of at least or 95% and maximum 400 mgSO_2/m^3.

[2] Specifically for gas turbines using natural gas, the limit value in most cases being 50 mg NOx/m^3.

In the 2001 LCP directive, existing plants are separated into two categories: those built before 1988 (i.e. the ones that were called existing in the 88/609/EEC directive), and those built from 1988 up to 2003 (i.e. the ones that were called new in the 88/609/EEC directive). For the latter the ELVs in directive 88/609/EEC have applied since 1988. The new directive will not only mean a tightening-up of the requirements for post-1988 plants, but also the introduction of ELVs for pre-1988 ones. See Table 7b.

Table 7b. Emission limit values to be applied from 1 January 2008 for SO_2 and NOx from existing (built before 2003) plants (mg/m^3).

	Sulphur dioxide			Nitrogen oxides	
Plant size (MW_{th})	**50-100**	**100-500**	**>500**	**50-500**	**>500**
Solid fuels	2000[1]	2000-400[1] (linear decrease)	400[1]	600	500[2]
Plant size (MW_{th})	**50-300**	**300-500**	**>500**	**50-500**	**>500**
Liquid fuels	1700	1700-400 (linear decrease)	400	450	400
Plant size (MW_{th})	**>50**			**50-500**	**>500**
Natural gas	35			300	200

[1] Where the emission limits for SO_2 cannot be met due to the characteristics of the fuel, various rates of desulphurisation (from 60 to 94%, with the highest rate applicable for plants greater than 500 MW_{th}) shall be achieved.

[2] From 1 January 2016 the emission limit value is 200 mgNOx/m^3.

5.2 Emissions estimates

The preceding section outlined the basis whereby the emission of pollution (in tonnes) is estimated. The sources of estimates and the process of estimation are now described.

Where possible, SENCO has utilised the EPER emissions data for the EU15 and Norway as they are public and amenable to scrutiny. Of course, the EPER data are themselves estimates made by people from industry and government using various methods and assumptions, and some may be no more accurate than calculations done by SENCO or others. The author has found no comprehensive quantitative comparison between emission estimates as arrived at by the different methods, and emissions derived from physical monitoring (e.g. of flue gas concentrations), though an analysis by Suutari et al (2001) is helpful.

The EPER guidance document (at www.eper.cec.eu.int/eper) states:

> Standardised reporting formats, agreed estimation techniques and the use of accepted methodologies and emission factors, as for in-stance has been described for air in the second edition of the Atmospheric Emission Inventory Guidebook (2000) or the IPCC Guidelines (1997), will improve the comparability of the reported emission data.

The EPER estimates will differ from actual emissions for the same reasons discussed below. It is, however, to be expected that the EPER emission estimates will be more precise for the big emitters, which dominate total emissions.

There are limited data detailing historical emissions from individual sources outside of the EPER region; and simple calculations have been extensively used to estimate emissions. It has not been possible to use the most sophisticated modelling techniques given the resources allocated to this study, although the detail and quality of information about plants is often not adequate for sophisticated modelling in any case.

Because of uncertainties the estimates of emissions as described below may be quite inaccurate for a certain plant in a particular year: the estimated emission may be considerably greater or smaller than estimated. In the available historic emission data for particular plant very significant changes in emission are seen. The accuracy of emission estimation by calculation varies according to pollutants with the author s *indicative* range of uncertainty for a power station with a known fuel burn as follows: CO_2 (± 2%), SO_2 (± 10%), NO_x (± 30%), and PMa (± 95%).

The emission of a source is dependent on these factors:

☐ **Operational conditions**. Emission will vary according to operational conditions such as plant loading and temperature; for example, power station emissions on cold start up or at a fractional and varying load are very different from when operating at design temperature and maximum steady load.

☐ **Production/output.** For different reasons the production from any particular source can vary between zero and maximum capacity from one year to the next. The plant might be closed down or out of operation for some other reason such as maintenance. Alternatively plant not used one year might be required in the next. This may be because other plants are not available: for example, drought and nuclear power problems in France may decrease hydro and nuclear output, and fossil power stations have to be used more extensively. Alternatively, product demand may fluctuate because of economic activity. Outputs of plant are often estimated from capacities and annual utilisation factors.

☐ **Fuel and other inputs.** The characteristics of the fuels or feedstocks for a plant might change. For example, coal sulphur content per energy can range by a factor of six: from over 3000 t/PJ (tonnes per Peta Joule; 1 PJ = 10^{15} Joules of fuel energy) for some Spanish coal to imported coal with sulphur content nearer to 500 t/PJ.

☐ **Technology.** This generally changes slowly, but the refurbishment and replacement of components such as boilers will affect emissions.

☐ **Emission control.** The application of emission control such as flue gas treatment typically reduces emissions of SO_2 or NOx by 50-95% and PMa by about 99%. The emissions from a plant will correspondingly be reduced when such controls are installed; or increased if the controls are not functioning because of maintenance or breakdown.

5.3 Emissions from non-power facilities

This section summarise information about emissions from energy facilities other than power stations. The principal data sources used were the SENCO and IEACO2 databases. As explained above, emission factors depend in complex ways on LPS parameters such as technology and fuel. The available databases contain little or no information about these parameters except for power stations. Therefore two approaches are taken:

The first is to use obtain emission estimates as reported by other sources, such as for Russian smelters.

The second is to use CO_2 estimates from IEACO2 and multiply these by ratios for CO_2 emission to the emission of other pollutants. These ratios were found by summing the emissions given in EPER for each NACE class (see Table 3, pp. 50-52, for NACE codes) and calculating the ratios of CO_2 emission to other pollutants; these are shown in Table 8. Note first, that the IEACO2 CO_2 emission estimates are often obtained from capacity factors, not directly from recorded fuel burn. The EPER covers the EU15 and Norway, and in general facilities in this region are likely to have lower emissions per unit output than in eastern Europe and west Asia because of the development of tighter emission regulations historically in western and northern Europe; however, in this study, the resources and data were not available to support this contention. Therefore the use of these EPER ratios is likely to underestimate emissions outside the EPER region.

An obvious drawback of this approach is that if, for the particular NACE, CO_2 emission is estimated as zero, or the ratio of CO_2 to other pollutant is zero, then so will be the emissions of other pollutants. This problem can only be resolved by using reported emissions, or by using emission factors applied to some output, such as kg of SO_2 per tonne of zinc produced. The assembling of data on the outputs of non-energy plants and their emission factors is beyond the scope of this study.

Table 8. Emission ratios (tonne/tonne) derived from EPER.

EconNACEm	CO_2 To SO_2 Ratio	CO_2 To NOx Ratio	CO_2 To PMa Ratio
Com{SeR	0.014%	0.270%	0.0041%
EGW{Gas	0.000%	0.460%	0.0000%
Man{Che	0.008%	0.164%	0.0118%
Man{Che{Bas	0.041%	0.089%	0.0000%
Man{CPN{Cok	0.727%	0.234%	0.0180%
Man{CPN{ReP	0.498%	0.132%	0.0083%
Man{Met{Iro	0.180%	0.143%	0.0272%
Man{Met{PNF{Alu	0.806%	0.086%	0.0404%
Man{NoM	0.048%	0.441%	0.0586%
Man{NoM{Bri	1.227%	0.195%	0.1794%
Man{NoM{CLP{Cem	0.058%	0.261%	0.0084%
Man{NoM{Gla{Hol	1.095%	2.261%	0.0794%
Man{PuP{PPP	0.261%	0.368%	0.0510%
MiQ{Ene{Ext{PGa	0.074%	0.355%	0.0000%
MiQ{NEn{Oth{Sal	0.000%	0.119%	0.0000%

5.4 Power station emissions

For power stations, the IEACR and Platts databases contain data defining parameters such as fuels and emission control as applied to each unit of a power station; therefore emissions may be estimated by calculation, unlike for other LPS.

Fuel consumption

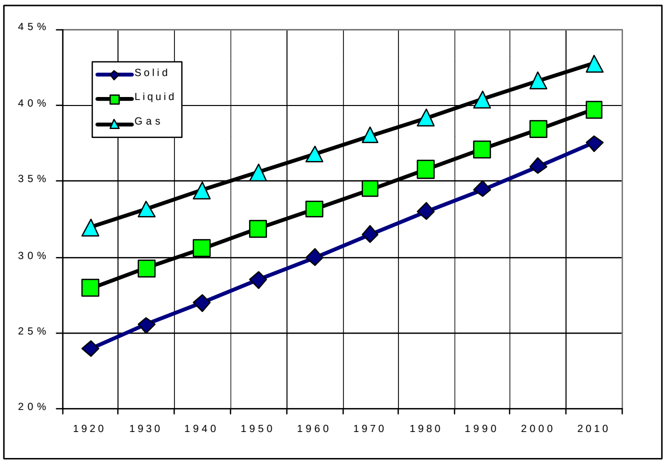
Emissions are primarily determined by fuel consumption. The IEACR database gives figures for coal burn in Mt and the thermal content of coal (GJ/tonne). Multiplying these together give the fuel input in PJ.

For non-coal stations, default values are used for plant load factor and efficiency. Fuel consumption is then simply calculated by dividing annual generation (PJ) by efficiency, to give PJ, and then by the fuel calorific value (GJ/tonne) to give tonnes of fuel.

Default load factors for non-coal plant have been estimated from energy statistics for the year 2000 using Platts capacity and generation data from a range of sources. This gives average national load factors for plant by fuel type.

Efficiencies vary, *inter alia*, according to the design, which has improved over the past decades, and fuel type. The average efficiencies of power stations are assumed to change by commissioning year as shown in Figure 2.

Figure 2. Generalized efficiency of power plants by commissioning year.



In actuality, the efficiencies and load factors for a fuel and plant type will vary widely according to the size and efficiency of the plant, the specific nature and cost of the fuel, emission control, and other factors such as whether it is a cogeneration or peak-load plant. Typically, older plant will be used less than more modern plant. In this study average load factors have been used, which may lead to emission overestimation. This error could be reduced by acquiring more data, e.g. on annual electrical output and fuel input, and efficiency. Alternatively, some of this could be estimated with an electricity model.

Fuel characteristics

The IEACR database gives figures for coal burn in Mt, the thermal content of coal (GJ/tonne), and coal sulphur content. The Platts data for the technical and fuel characteristics of non-coal stations are less detailed than the IEACR data.

A large proportion of fossil plant can utilise several different fuels; with stations capable of using both oil and gas being common. In such cases, it has been assumed that only the fuel first listed in the database is used. Coal and heavy fuel oil both produce significant emissions of sulphur per kWh generated and so the error in emission estimate arising from an inappropriate choice of coal or oil may not be too great. But natural gas typically has a low sulphur content and so assuming gas rather than coal or oil will introduce a very large error if gas is not actually used.

Non-coal fuels (oil, gas, etc.) can vary widely in between sectors, countries and locations, not least because there are often local regulations limiting parameters such as sulphur content. In the EU several directives apply to liquid fuels such that their sulphur contents have increasingly stringent limits over the period 2000 to 2008. The detailing of how non-coal parameters such as fuel sulphur contents vary by sector, country and year is beyond the scope of this study. Table 9 gives the codes and default values for the principal fuels, but note that specific coal data are used from IEACR.

Table 9. Default fuel characteristics.

FuelID	Description	GJ/t	Sulphur %
G_NatGas	Natural gas	55	0.0%
L_Die	Gas/Diesel oil	43	0.3%
L_FueOil	Fuel oil	43	1.2%
L_Oil	Oil	43	1.0%
S_Bio	Biomass	10	0.1%
S_Coa	Coal	27	1.1%
S_CoaAnt	Anthracite	29	0.7%
S_CoaBit	Bituminous coal	27	1.1%
S_CoaLig	Brown coal/lignite	20	1.5%
S_Cok	Coke	28	0.1%
S_OilSha	Oil shale	9	3.0%
S_Pea	Peat	10	1.5%

Carbon dioxide emission

Carbon emission is estimated using standard International Energy Agency (IEA) coefficients as applied to energy inputs to plants (see Table 10).

Sulphur dioxide emission

The percentage of sulphur in the fuel emitted depends on how much is retained by the fuel ash (coal, oil shale), and how much is removed by emission control equipment. Emission control equipment types are described in section 5.5.

Table 10. Carbon dioxide emission factors.

Fuel	kgCarbon / GJ
Coal	25
Oil	19
Gas	14

Sulphur emission is calculated as follows:

Emission= (fuel burn tonnes) x (% sulphur in fuel)
x (1- % sulphur retained in ash)
x (1- % sulphur removed by emission control) tonnes sulphur

Incombustible minerals in fuels combine with sulphur during combustion to form solid residues and so reduce atmospheric sulphur emission. The proportion of sulphur so removed depends both on the nature of the ash (e.g. its alkali content) and on combustion conditions. The retention factors used are summarised in Table 11, and are taken from a range of sources. These factors can vary very widely. For other fuels, mainly oil and gas, it is assumed that retention factors are zero.

Table 11. Sulphur ash retention factors.

Country	Boiler type	Fuel	Retention
	DBB	Hard coal	5%
	DBB	Brown coal	30%
	WBB	Hard coal	1%
EST		Oil shale	80%

Note: Dry Bottom Boiler (DBB), Wet Bottom Boiler (WBB)

5.4.1 Other emission factors

The emission of other pollutants is calculated from the energy content of the fuel consumed, an uncontrolled emission factor, and emission control, as follows:

Emission = (fuel burn GJ) x (uncontrolled emission factor kg/GJ)
x (1- % pollutant removed by emission control) kg emitted

For power stations, the uncontrolled emission factor is required since there are data on emission control, the effects of which are calculated as for sulphur.

The uncontrolled emissions of NOx and PMa depend on complex processes.

❑ **Nitrogen oxides emission.** During combustion, nitrogen oxides are formed from nitrogen compounds in the fuel (fuel NOx) and from the combination of atmospheric oxygen and nitrogen (thermal NOx). Thermal NOx formation depends on conditions such as temperature, pressure, and residence time. Thus NOx depends both on fuel characteristics and on combustion conditions, and these latter vary with operational regime.

❑ **Particulates emission.** As for SO_2 and NOx, particulate formation depends on the chemical and physical properties of fuels, combustor technology and combustion conditions. There is the additional complexity that health impact is dependent on particle size, and therefore PMa emission is usually specified by size range, typically >10 microns, <10 microns (PM_{10}), 2.5-10 microns, and <2.5 microns ($PM_{2.5}$). A further complication for PMa emission is the formation of secondary particles some time after combustion.

There is a wide range of information on emission factors for these and other pollutants from many sources including CORINAIR, the NAEI (National Atmospheric

Emissions Inventory, UK), the IIASA (International Institute for Applied Systems Analysis, Austria), and the USEPA (US Environmental Protection Agency). Unfortunately these are not all on a consistent basis. Most sources give factors assuming typical levels of emission control (such as low-NOx burners) found in that country at present, while some give factors for uncontrolled emissions. Where uncontrolled factors are given, there may be a different baseline technology assumed for example new power stations generally have lower NOx burners then older stations. PMa control equipment has been standard in most western European countries for many years, which is perhaps why it is sometimes not recorded in the power station databases even when it present. The emission factors for a given fuel-technology combination can vary widely, often by more than a factor of two, because of specified differences, such as boiler type, or other undefined differences.

It is beyond this study s scope to comprehensively collate and appraise the emission factors from all the available sources. There are data which would allow more sophisticated emission calculations; for example, IEACR gives the ash content of coals, a dominant contributor to primary particulate formation.

Table 12 summarises the emission factors assumed for uncontrolled emissions from power stations the factors are in grammes of pollutant emitted per GJ of fuel consumed.

Table 12. Power station emission factors.

Fuel	Combustor	NOx g/GJ fuel	PM$_{10}$ g/GJ fuel
Gas		80	0.1
Natural gas	Combined cycle	30	0.1
Natural gas	Boiler	130	0.1
Liquid		200	13.2
Fuel oil	Boiler	200	13.2
Light distillate oil	Boiler	350	1.1
Solid		481	945
Coal - hard	Boiler	538	804
Coal - hard	Dry bottom	481	945
Coal - hard	Wet bottom	596	662
Coal - hard	Fluidised bed	86	2860
Coal - brown		483	945
Coal - brown	Dry bottom	483	945

5.5 Emission control technologies

There are a number of processes used for the removal of SO_2, NOx and PMa separately. Those processes present in the databases are tabulated below with descriptions and acronyms. The descriptions are taken from the IEACR and Platts databases. Some of these processes may be combined, some are mutually exclusive. It is fairly common for combinations to be used to control NOx: a primary process, such as boiler firing modification, may be combined with flue gas treatment. Most processes will affect the emissions of more than one pollutant; for example, FGD will reduce NOx and PMa. Most emission control increases CO_2 per station output because energy is required to run emission control equipment or there are other efficiency losses. These losses are not modelled here.

Table 13 (see Annex, pp. 53-54) sets out the basic emission control systems and combinations as found in the Platts and IEACR databases. Before the underscore in the acronym are given the pollutants primarily controlled by the technology (N NOx, S SO_2, P PMa).

The last columns give percentage reductions in emissions brought about by each process if it is applied to all of the combustion and combustion products in a station. It is emphasised that there is a great variation in these reduction figures in actual systems because of the specific details of plant design, fuel characteristics, etc. Note that particulate control equipment typically reduces PMa emission by over 99%. A small error in this fraction will result in a very large error in emission. Furthermore the reduction will vary with particle characteristics (size, physical and chemical properties).

Only the IEACR and Platts primary databases give information about emission control equipment, and the data relate to each unit of a power station. The IEACR power station database gives specific reductions for many emission control installations that are different from the typical figures. Where such specific data are not provided, the default data in Table 13 are assumed.

6. Results

The collation of LPS data from each of the primary databases results in about 12000 records for the geographical region. Many of these records refer to the same LPS, and when LPS data for the same individual facilities from each primary database are reconciled, about 7500 LPS result.

This section presents the estimated emissions of sulphur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PMa) and carbon dioxide (CO_2) from LPS in various ways, as:

- ☐ A fraction of total emissions from each country.
- ☐ A list of the 200 largest SO_2 emitters in Europe, and the 100 largest SO_2 emitters in EU25.
- ☐ Maps of the largest emitters of SO_2, CO_2, and NOx.
- ☐ SO_2 emissions by age of power station.
- ☐ Listing of best facilities emitting the least pollution per useful output.

6.1 Large point sources and regional emission

Table 14 summarises emission data for the regions and for all the point sources in the geographical region recorded in the databases. Each pollutant has three columns: the first is the total emission from LPS, the second is the country total; the third is the percentage of country emissions accounted for by the LPS. Country CO_2 emission are from the Carbon Dioxide Information Analysis Center (CDIAC, 2004); other emission data are taken from the EMEP programme (*the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe*); data are as given at the EMEP website in June 2004 (EMEP, 2004).

Table 14 is meant to illustrate the importance of LPS with regard to total pollution emission, but there are too many LPS to thoroughly check the data for the smaller emitters. In some instances especially as regards PMa the sum of all LPS emissions in the database is more than the country total this is marked with emboldened text. The first three rows give the totals for the whole region, for the EU25, and for the EU15.

Overall the results are as expected: LPS account for a large fraction of national SO_2, but a smaller fraction of NOx. The LPS database gives large excesses of SO_2 for Russia and the Ukraine as compared to EMEP. It is not known why this is, but it may be due to EMEP dividing some countries into sub-regions.

Table 14. Summary of LPS and country emission.

	kt SO_2			kt NOx			kt PMa			Mt CO_2		
Cou	**LPS**	**Tot**	**LPS%**	**LPS**	**Tot**	**LPS%**	**LPS**	**Tot**	**LPS%**	**LPS**	**Tot**	**LPS%**
All	14650	16675	88%	8084	16681	48%	4227	5002	85%	3307	5996	55%
EU25	6539	8759	75%	4242	11595	37%	1148	2368	48%	2038	3644	56%
EU15	5082	6072	84%	3073	9940	31%	935	1813	52%	1736	3076	56%
ALB	6.4	58	11%	2.7	29	9%	0.2	7.7	3%	1.3	2.9	47%
ARM	27	8.4	**326%**	14	10.0	**136%**	0.7	7.3	9%	7.0	3.5	**199%**
AUT	33	38	86%	32	196	17%	19	47	40%	30	61	49%
BEL	134	165	81%	116	329	35%	18	65	27%	67	102	65%
BGR	605	982	62%	127	184	69%	24	132	19%	31	42	73%
BIH	4.9	419	1%	3.8	55	7%	0.6	46	1%	2.7	19	14%
BLR	111	143	78%	60	135	45%	2.6	62	4%	30	59	51%
CHE	15	19	79%	18	95	19%	5.2	26	20%	6.8	39	17%
CYP	11	50	23%	7.8	23	34%	0.3	3.5	10%	2.9	6.4	44%
CZE	129	265	49%	239	321	74%	147	104	**141%**	59	119	50%
DEU	497	638	78%	460	1584	29%	414	239	**173%**	480	786	61%
DNK	21	27	77%	55	207	26%	28	20	**139%**	31	45	69%
ESP	1312	1484	88%	484	1335	36%	102	209	49%	169	283	60%
EST	85	95	89%	42	41	**103%**	41	37	**110%**	7.7	16	48%
FIN	79	73	**108%**	78	236	33%	121	48	**252%**	41	53	76%
FRA	457	659	69%	269	1432	19%	31	545	6%	120	363	33%
GBR	1007	1188	85%	616	1737	35%	18	178	10%	275	568	48%
GEO	16	9.0	**179%**	7.2	30	24%	0.4	12	4%	3.7	6.2	60%
GRC	435	483	90%	134	320	42%	31	57	54%	75	90	83%
HRV	40	58	69%	22	77	28%	0.8	25	3%	9.8	20	50%
HUN	240	486	49%	84	185	45%	8.6	47	18%	27	54	51%
IRL	113	131	86%	54	125	43%	7.8	14	57%	25	42	59%
ITA	680	758	90%	394	1372	29%	40	213	19%	247	428	58%
LTU	46	43	**107%**	24	47	51%	1.3	14	9%	11	12	91%
LUX	3.0	3.1	97%	4.8	17	28%	0.5	3.7	12%	1.5	8.5	17%
LVA	2.8	17	17%	3.7	35	11%	0.3	11	2%	2.0	6.0	34%
MDA	12	12	**102%**	9.9	17	59%	0.1	28	0%	4.9		
MKD	5.4	105	5%	2.8	30	9%	0.1	20	0%	1.1	11	10%
NLD	71	91	77%	115	413	28%	9.1	62	15%	94	139	68%
NOR	19	27	71%	20	224	9%	0.5	66	1%	15	50	31%
POL	848	1511	56%	715	838	85%	10	282	4%	171	302	57%
PRT	198	274	72%	208	385	54%	33	44	75%	56	60	94%
ROM	407	912	45%	123	319	39%	31	187	17%	53	86	62%
RUS	4299	1996	**215%**	2080	2350	89%	1730	1129	**153%**	729	1436	51%
SVK	70	124	57%	42	106	40%	2.0	44	5%	18	35	50%
SVN	17	96	18%	6.3	58	11%	2.4	13	19%	1.9	15	13%
SWE	42	58	72%	49	252	20%	63	66	95%	26	47	56%
TUR	448	2112	21%	319	942	34%	25	420	6%	101	222	46%
UKR	2038	1029	**198%**	998	561	**178%**	1242	463	**268%**	258	343	75%

Possible reasons for discrepancies between the LPS data, and the emissions reported for the region, are:

- Emission calculations can be inaccurate, as is discussed in section 5. This especially so for PMa emissions, which are often overestimated in the LPS database because PMa control equipment is not recorded for some plants.
- Due to the problems of aggregation (see section 4.1.2), some LPS may be counted more than once leading to emission overestimation (probably the more prevalent error), and others may be aggregated when they are different plant, leading to underestimation.
- For Balkan countries (i.e. former Yugoslavia), the data are not all realigned to account for the political changes.
- Different years for the historic LPS data and EMEP emissions data. For the countries with small emissions (e.g. Finland, Ireland), large proportionate discrepancies can be caused by errors in a small number of point sources for example, by one major plant closing and being replaced with a lower emission plant, or having emission control fitted.

6.2 Largest sulphur dioxide emitters

This section lists the LPS which are the largest SO_2 emitters. Note, as discussed in the section 4.1.2, that the definition used for aggregation determines the size of some of the individual LPS.

Figure 3 shows the size distribution of the 200 largest SO_2 sources in the whole region, along with the cumulative fraction of total emission from LPS. It illustrates the dominance of the largest sources: the top 10 constitute 19% of total; the top 20, 30% of total; the top 50, 45%; the top 100, 60%, and the top 200, 73%.

Figure 3. The 200 largest sulphur dioxide emitters – whole region.

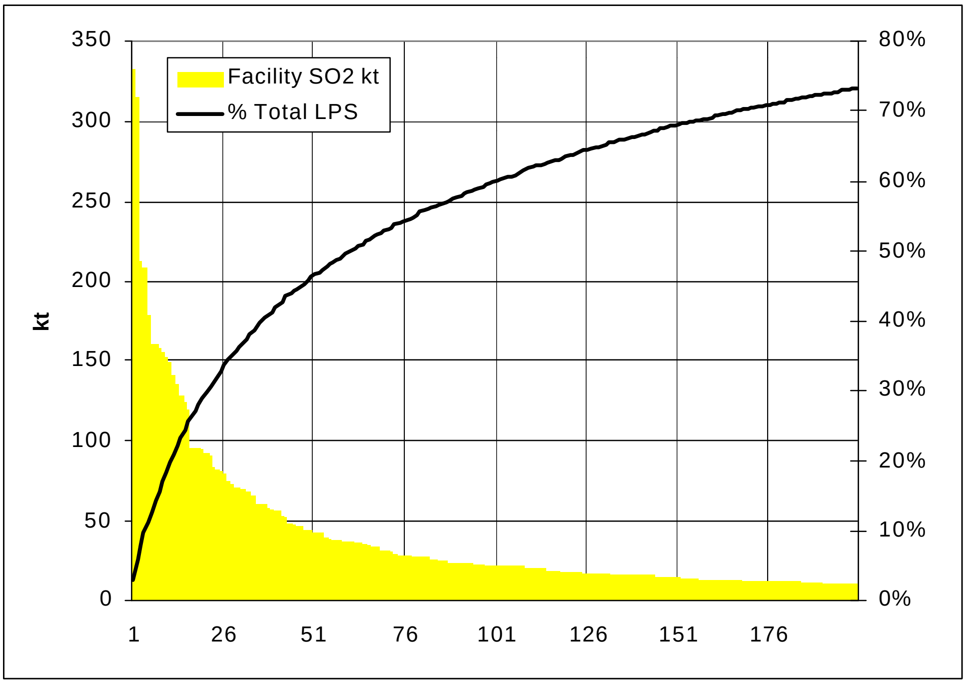


Table 15 summarises the fractions of LPS emissions by the ten most important NACE categories (source types) for the whole region, and for the EU25.

Table 15. Largest SO_2 emitters by NACE category.

Whole region	**All LPS**					**Top 200**				
NACEm	**N**	**SO_2 kt**	**NO_x kt**	**CO_2 kt**	**PM kt**	**N**	**SO_2 kt**	**NO_x kt**	**CO_2 kt**	**PM kt**
Total	**7180**	**99%**	**91%**	**90%**	**99%**	**200**	**73%**	**44%**	**29%**	**64%**
EGW{Ele	5429	77%	69%	59%	94%	164	65%	41%	25%	63%
Man{CPN{ReP	183	8%	4%	7%	0%	23	3%	1%	2%	0%
Man{Met	262	6%	4%	8%	2%	9	3%	1%	2%	0%
Man{Che	353	2%	2%	4%	0%	2	0%	0%	0%	0%
Man{Foo	116	1%	0%	0%	0%	1	0%	0%	0%	0%
EGW{StW{Dis	150	1%	1%	1%	1%	1	1%	0%	0%	0%
MiQ{Ene	87	0%	1%	1%	0%	0	0%	0%	0%	0%
Man{NoM	591	5%	11%	9%	1%	0	0%	0%	0%	0%
EGW{Wat{CPD	3	0%	0%	0%	0%	0	0%	0%	0%	0%
Man{CPN{Cok	6	0%	0%	0%	0%	0	0%	0%	0%	0%
EU25	**All LPS**					**Top 200**				
NACEm	**N**	**SO_2 kt**	**NO_x kt**	**CO_2 Mt**	**PM kt**	**N**	**SO_2 kt**	**NO_x kt**	**CO_2 Mt**	**PM kt**
Total	**6404**	**99%**	**89%**	**89%**	**97%**	**200**	**72%**	**42%**	**33%**	**24%**
EGW{Ele	4921	71%	63%	58%	87%	141	59%	37%	27%	22%
Man{CPN{ReP	138	10%	4%	6%	1%	39	8%	2%	4%	0%
Man{Met	207	5%	4%	7%	4%	9	2%	1%	1%	1%
Man{Che	298	3%	2%	5%	0%	4	1%	0%	0%	0%
Man{Foo	116	1%	0%	0%	0%	1	0%	0%	0%	0%
EGW{StW{Dis	150	2%	1%	2%	3%	1	1%	1%	0%	0%
MiQ{Ene	86	0%	1%	1%	0%	1	0%	0%	0%	0%
Man{NoM	479	6%	12%	9%	2%	2	0%	0%	0%	0%
EGW{Wat{CPD	3	0%	0%	0%	0%	1	0%	0%	0%	0%
Man{CPN{Cok	6	0%	0%	0%	0%	1	0%	0%	0%	0%

6.2.1 The 200 largest SO_2 emitters – whole region

Table 16 (see Annex, pp. 55-58) shows the 200 largest SO_2 emitters in the whole region. The type of plant is given along with the emission estimate for a given year. The principal fuel is given. Fuel codes may be found in Table 9; X denotes unknown fuel or fuels. Countries in the EU25 are shown emboldened. If an LPS is in the EU15, but the emission data are not from EPER, the country is italicised. Section 4.1.1 discusses possible reasons for discrepancies.

These 200 sources make up 73% of the total SO_2 emission from all LPS in the region. In total, the top 200 SO_2 emitters are estimated to emit some 900 Mt of CO_2 (million tonnes of carbon dioxide), about 30% of the total from all LPS. Of the largest 200 sources as shown in Table 16, 174 are power stations and 128 of these are fuelled with coal. The five largest sources, Maritsa II (BGR), Puentes (ESP), Krivoy Rog (UKR), Burshytn (UKR) and Lodyzhinsk (UKR) are coal fired power stations and they make up about 14% of total SO_2 from the top 200.

1.2.2 The 100 largest SO_2 emitters – EU25

Table 17 shows the 100 largest SO_2 emitters in the EU25. Of the largest 100 sources of SO_2 emissions in EU25, 82 are power stations and 64 of these are fuelled with coal. The five largest sources, Puentes (ESP), Megalopolis (GRC), Andorra (Teruel, ESP), Belchatow (POL), and Adamov (POL) are coal fired power stations and these five jointly are responsible for annual emissions of about 860 kt of SO_2, 205 kt of NOx, and 52 Mt of CO_2.

Table 17. 100 largest SO_2 emitters – EU25.

N	Source	Cou	Plant	NACEm	Fuel	SO_2 kt	NO_x kt	CO_2 Mt	PM kt
1	EPER	ESP	Puentes	EGW{Ele	S_Coa	315	20	10	0.4
2	EPER	GRC	Megalopolis	EGW{Ele	S_Coa	161	4	5	0.1
3	EPER	ESP	Andorra (Teruel)	EGW{Ele	S_Coa	152	20	5	0.3
4	IEACR	POL	Belchatow	EGW{Ele	S_CoaLig	136	144	29	0.5
5	IEACR	POL	Adamow	EGW{Ele	S_CoaLig	96	16	3	0.1
6	IEACR	HUN	Oroszlnany	EGW{Ele	S_CoaSub	81	10	2	0.0
7	IEACR	POL	Turow	EGW{Ele	S_CoaLig	79	68	14	0.3
8	EPER	ITA	Porto Tolle	EGW{Ele	L	73	10	8	0.0
9	EPER	ESP	Meirama	EGW{Ele	S_Coa	71	9	4	2.7
10	IEACR	POL	Patnow	EGW{Ele	S_CoaLig	71	40	8	0.1
11	EPER	GBR	Cottam	EGW{Ele	S_Coa	71	18	7	0.0
12	EPER	GBR	West Burton	EGW{Ele	S_Coa	69	16	7	0.2
13	EPER	GBR	Longannet	EGW{StW{Dis	S_Coa	68	24	10	0.4
14	EPER	ESP	Compostilla	EGW{Ele	S_CoaAnt	62	35	7	5.9
15	EPER	GBR	Eggborough	EGW{Ele	S_Coa	60	14	6	0.2
16	EPER	ESP	La Robla	EGW{Ele	S_CoaBit	57	23	4	1.6
17	EPER	PRT	Setubal	EGW{Ele	L	57	14	4	0.4
18	EPER	GBR	Belfast West	EGW{Ele	S_Coa	53	2	1	0.4
19	EPER	GBR	Ferrybridge	EGW{Ele	S_Coa	48	16	7	0.2
20	EPER	ESP	Puertollano/ Ref	Man{CPN{ReP	X	44	0	3	0.0
21	IEACR	POL	Pomorzany	EGW{Ele	S_CoaBit	44	34	6	0.0
22	IEACR	POL	Krakow	EGW{Ele	S_CoaBit	44	22	5	2.0
23	IEACR	HUN	Matra	EGW{Ele	S_CoaLig	43	26	5	0.1
24	EPER	GBR	Didcot	EGW{Ele	S_Coa	41	16	6	0.0
25	Platts	EST	Eesti	EGW{Ele	S_OilSha	40	19	3	0.0
26	EPER	PRT	Sines	EGW{Ele	S_Coa	39	21	9	0.3
27	Platts	EST	Balti	EGW{Ele	S_OilSha	39	19	3	37.2
28	EPER	ITA	Taranto	Man{Met{Iro	X	38	25	8	2.5
29	IEACR	SVK	Novaky	EGW{Ele	S_CoaLig	38	13	3	0.3
30	EPER	ESP	Alberto	Man{Che{Bas{Ino	X	36		1	0.4
31	EPER	GBR	Drax	EGW{Ele	S_Coa	35	50	16	0.2
32	EPER	GBR	Rugeley	EGW{Ele	S_Coa	34	15	4	0.1
33	EPER	GBR	High Marnham	EGW{Ele	S_Coa	33	6	3	0.1
34	EPER	GBR	Kingsnorth	EGW{Ele	S_Coa	33	17	7	0.2
35	EPER	GBR	Grain	EGW{Ele	L	33	1	2	0.8
36	EPER	IRL	Moneypoint	EGW{Ele	S_Coa	32	22	6	0.2
37	IEACR	POL	Rybnik	EGW{Ele	S_CoaBit	32	26	8	0.2
38	EPER	GBR	Ironbridge	EGW{Ele	S_Coa	32	11	4	0.1
39	EPER	GBR	Aberthaw	EGW{Ele	S_Coa	31	23	6	0.2
40	EPER	GBR	Lynemouth	EGW{Ele	S_Coa	28	8	3	0.1
41	EPER	GBR	Fiddlers Ferry	EGW{Ele	S_Coa	28	10	5	0.2
42	EPER	ESP	Escucha	Man{Foo{Mea{Pre	X	28	2	1	0.4
43	EPER	GRC	Megalopolis	EGW{Ele	X	28	4	3	0.1
44	EPER	GRC	Opountion	Man{Met{Iro	X	27	3	1	0.7
45	IEACR	CZE	Ledvice	EGW{Ele	S_CoaLig	27	14	3	26.9
46	EPER	ITA	San Filippo	EGW{Ele	L	27	6	5	0.4
47	EPER	ESP	Escatron	EGW{Ele	S_Coa	26	0	0	0.1
48	EPER	GRC	Lavrio	EGW{Ele	G_Nat	26	7	3	0.0
49	IEACR	HUN	Borsod	EGW{Ele	S_CoaSub	25	6	1	3.0
50	EPER	ESP	Gibraltar	Man{CPN{ReP	X	24	2	2	0.4

Table 17. 100 largest SO_2 emitters – EU25 (continued).

N	Source	Cou	Plant	NACEm	Fuel	SO_2 kt	NO_x kt	CO_2 Mt	PM kt
51	EPER	GRC	Amyntaio	EGW{Ele	S_Coa	24	6	5	13.1
52	IEACR	POL	Lodz	EGW{Ele	S_CoaBit	24	15	3	0.1
53	EPER	ESP	San Martin	Man{CPN{ReP	X	24	5	2	
54	EPER	GRC	Thessaloniki/ Dimitrios	EGW{Ele	S_Coa	24	20	14	0.2
55	EPER	ESP	Soto De Ribera	EGW{Ele	S_Coa	24	9	3	1.0
56	EPER	FRA	Gravenchon	Man{CPN{ReP	X	24	5	3	0.1
57	IEACR	POL	Ostroleka	EGW{Ele	S_CoaBit	23	10	3	0.1
58	Platts	LTU	Elektrenai	EGW{Ele	L_FuOHea	23	8	3	0.5
59	EPER	IRL	Tarbert	EGW{Ele	L	23	5	2	0.1
60	EPER	GBR	Drakelow	EGW{Ele	S_Coa	23	5	2	0.1
61	EPER	ESP	Almeria	EGW{Ele	S_Coa	23	15	7	0.2
62	EPER	DEU	Schwedt	Man{CPN{ReP	X	22	4	4	0.2
63	EPER	ITA	Gela/ Ref	Man{CPN{ReP	X	22	4	4	0.1
64	*IEACR*	*ESP*	Guardo	EGW{Ele	S_CoaBit	22	12	2	0.1
65	Platts	HUN	Dunamenti	EGW{Ele	L_FuOHea	22	8	3	0.0
66	EPER	ESP	Anllares	EGW{Ele	S_Coa	22	15	0	0.1
67	IEACR	CZE	Tisova	EGW{Ele	S_CoaLig	22	9	2	12.3
68	EPER	ESP	Abono	EGW{Ele	S_Coa	22	17	8	0.2
69	IEACR	POL	Zeran	EGW{Ele	S_CoaBit	22	15	3	0.0
70	EPER	PRT	Carregado	EGW{Ele	L	20	5	2	0.3
71	EPER	ITA	Priolo Gargallo Nord	Man{CPN{ReP	X	20	4	3	0.2
72	IEACR	POL	Skawina	EGW{Ele	S_CoaBit	20	14	2	0.1
73	EPER	GBR	Cockenzie	EGW{Ele	S_Coa	20	11	3	0.1
74	EPER	FRA	Gonfreville/ Ref	Man{CPN{ReP	X	20	3	2	0.3
75	EPER	GRC	Tamynion	EGW{Ele	X	19	2	1	
76	IEACR	POL	Siersza	EGW{Ele	S_CoaBit	19	16	3	0.1
77	IEACR	HUN	Banhida	EGW{Ele	S_CoaSub	19	4	1	0.0
78	IEACR	HUN	Pecs	EGW{Ele	S_CoaSub	19	6	1	4.0
79	EPER	DEU	Jänschwalde	EGW{Ele	S_Coa	18	17	25	0.3
80	IEACR	POL	Krakow Leg	EGW{Ele	S_CoaBit	18	11	2	0.0
81	EPER	ITA	La Casella	EGW{Ele	L	18	3	2	0.4
82	EPER	GBR	Fort Dunlop	EGW{Ele	G_Nat	18	0	0	0.0
83	EPER	GBR	Kilroot	EGW{Ele	S_Coa	17	8	3	0.3
84	EPER	GRC	Kardia	EGW{Ele	S_Coa	17	16	10	0.1
85	EPER	GBR	Tilbury	EGW{Ele	S_Coa	17	19	5	0.2
86	*Platts*	*ITA*	Sicilia	EGW{Ele	L_LigDis	17	7	3	0.4
87	EPER	GBR	Fawley/ Ref	Man{CPN{ReP	X	17	5	2	0.0
88	EPER	NLD	Rotterdam/ Pernis/Shell	Man{CPN{ReP	X	17	5	6	0.3
89	*IEACR*	*PRT*	Pego	EGW{Ele	S_CoaBit	17	13	3	28.2
90	EPER	ESP	Los Barrios	EGW{Ele	S_Coa	17	11	4	0.1
91	EPER	ITA	Piombino	EGW{Ele	L	17	5	3	0.0
92	EPER	DEU	Lippendorf	EGW{Ele	S_Coa	16	7	10	0.2
93	*IEACR*	*ESP*	Cercs	EGW{Ele	S_CoaBit	16	4	1	6.2
94	*Platts*	*IRL*	Rhode	EGW{Ele	S_PeaMil	16	3	0	5.3
95	EPER	GBR	Ratcliffe	EGW{Ele	S_Coa	16	23	9	0.1
96	EPER	GRC	Nikolaos	Man{Met{PNF{Alu	X	16	1	1	
97	EPER	IRL	Aughinish	Man{Che{Bas{Ino	X	16	2	1	0.1
98	EPER	PRT	Porto Ref	Man{CPN{ReP	X	15	2	1	0.1
99	IEACR	CZE	Prunerov	EGW{Ele	S_CoaLig	15	40	8	0.4
100	IEACR	SVK	Vojany	EGW{Ele	S_CoaHar	15	11	3	0.0

6.3 Maps of largest emitters

The latitude and longitude of most of the largest LPS have been recorded in the database (about 45% of the 7500 LPS have spatial coordinates). The LPS database has been input to a Geographical Information System (GIS) in order to map out the spatial distribution of the largest sources. The plotted area of the LPS symbols is proportionate to the emission of the LPS. The largest LPS are labelled. The LPS are plotted in order of decreasing size so that the smaller overlay the larger where they are close together.

Figure 4, 5 and 6 depict the LPS emissions of SO_2 for the whole study area, and western and eastern Europe respectively. Figure 7 and 8 show the LPS emissions of NOx and CO_2 for the whole study area.

Figure 4. 200 Largest SO_2 emitters – whole region.

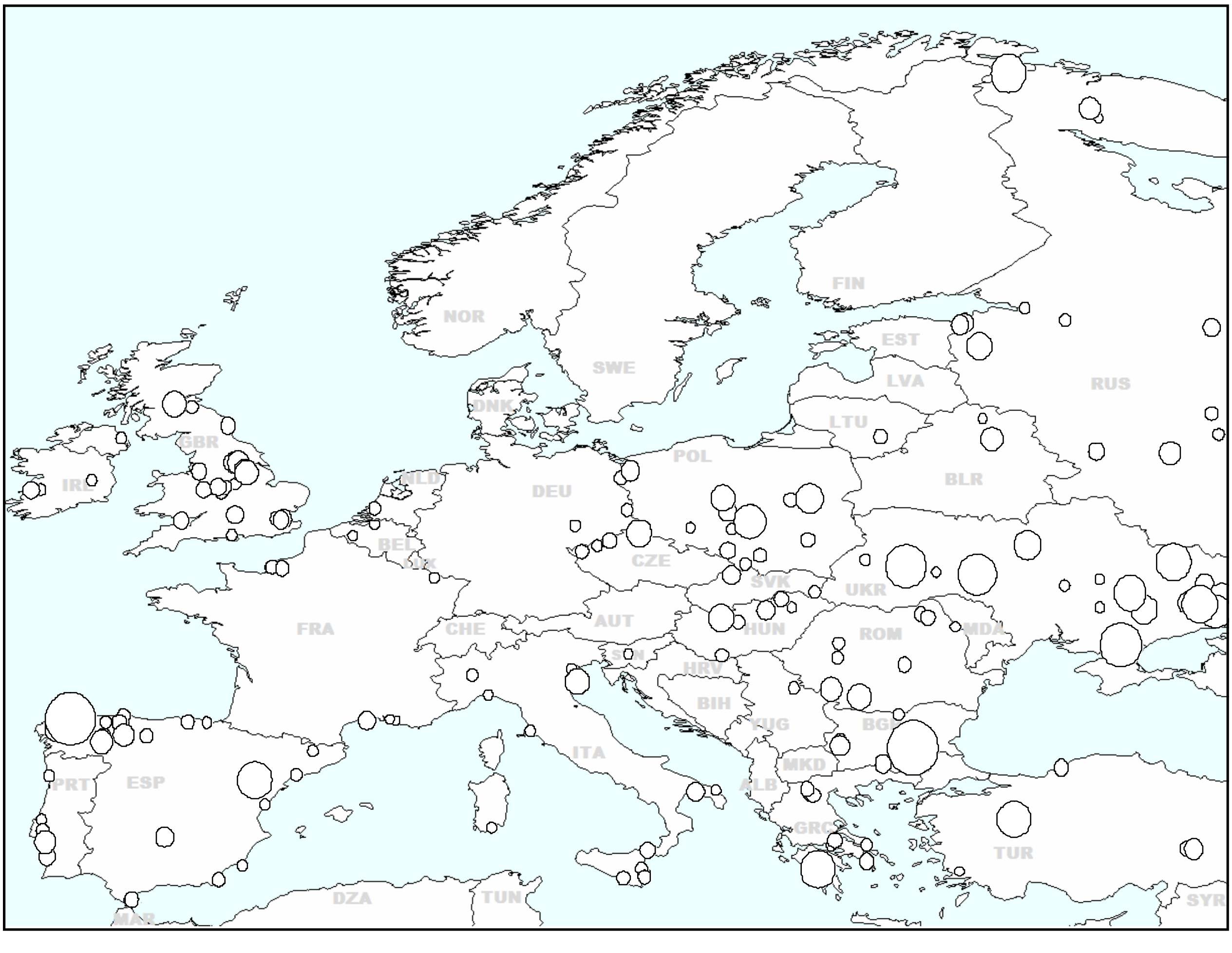


Figure 5. 500 Largest SO_2 emitters – western Europe.

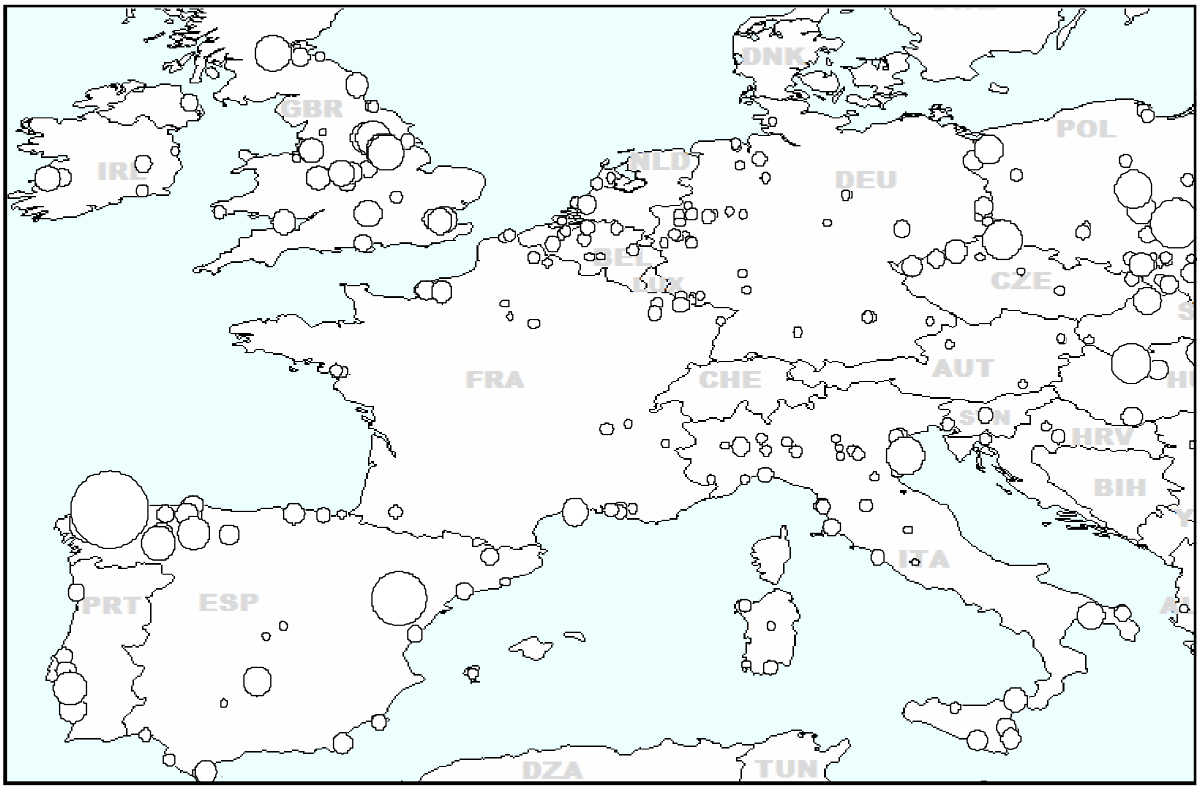


Figure 6. 500 Largest SO_2 emitters – eastern Europe.

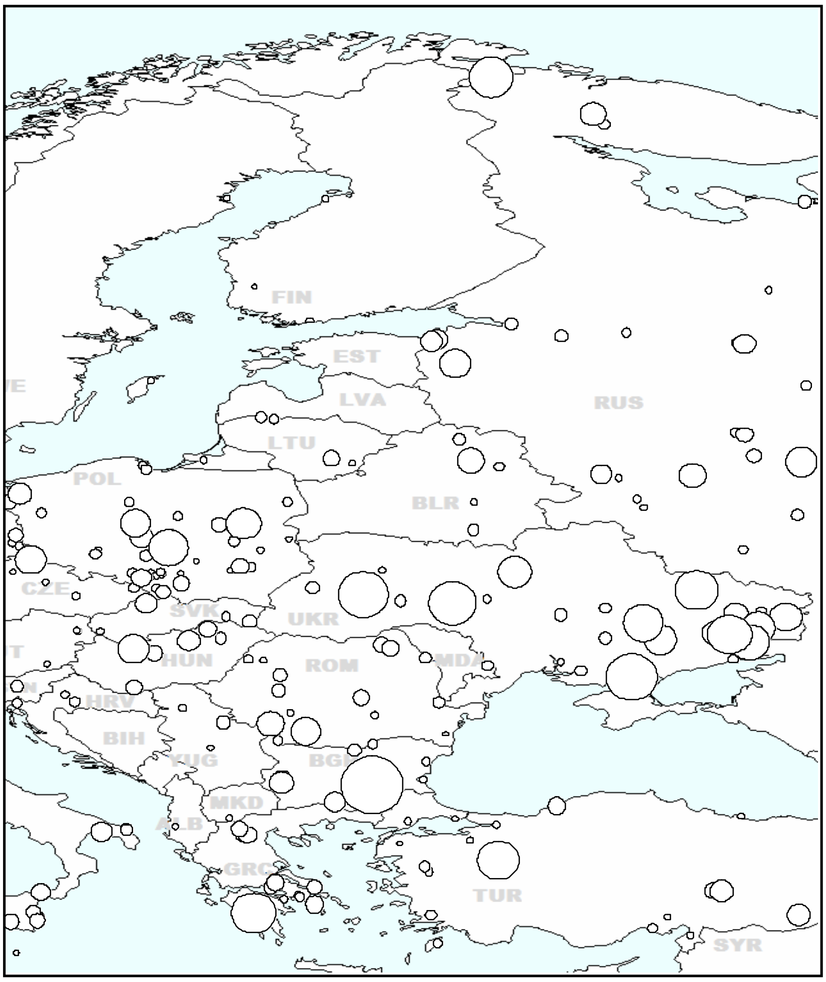


Figure 7. 200 Largest NOx emitters – whole region.

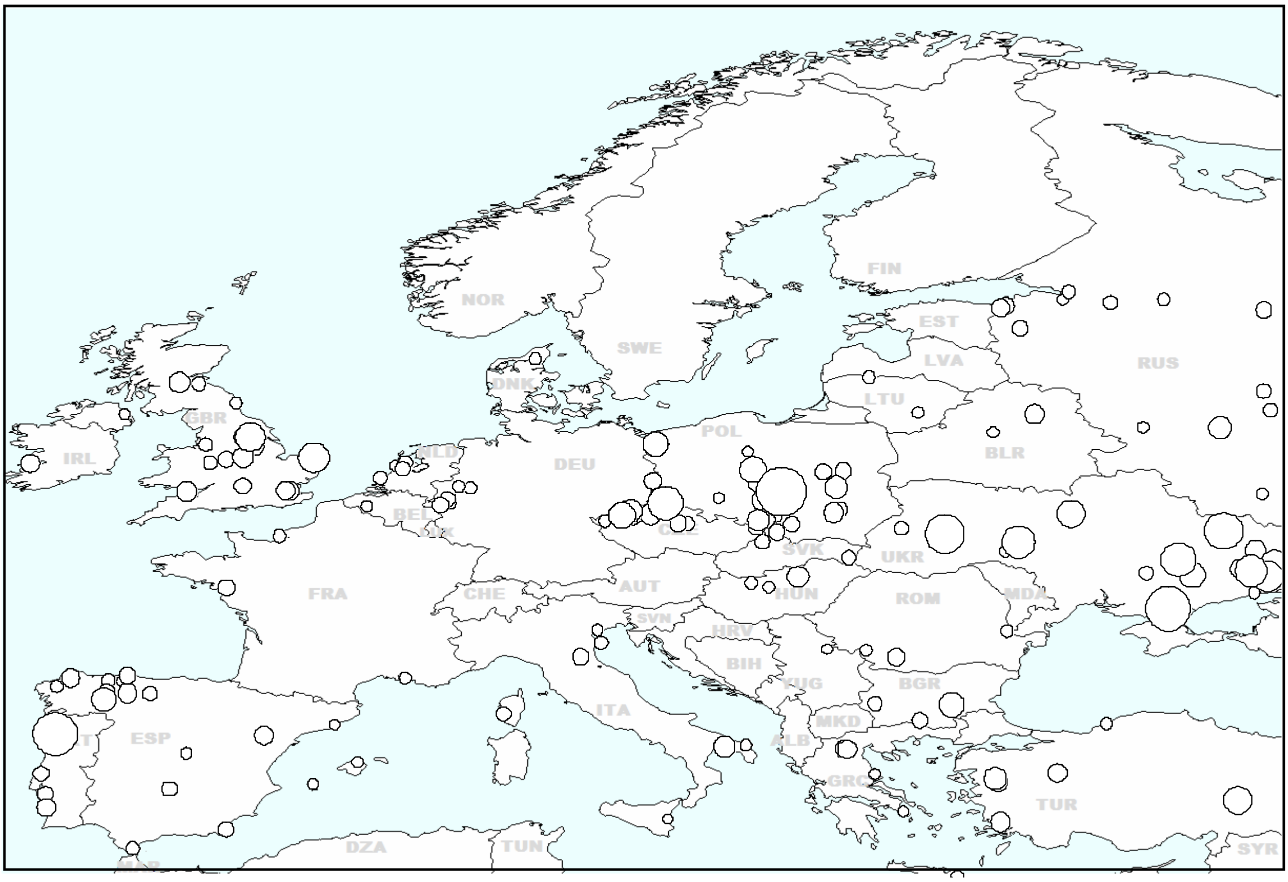
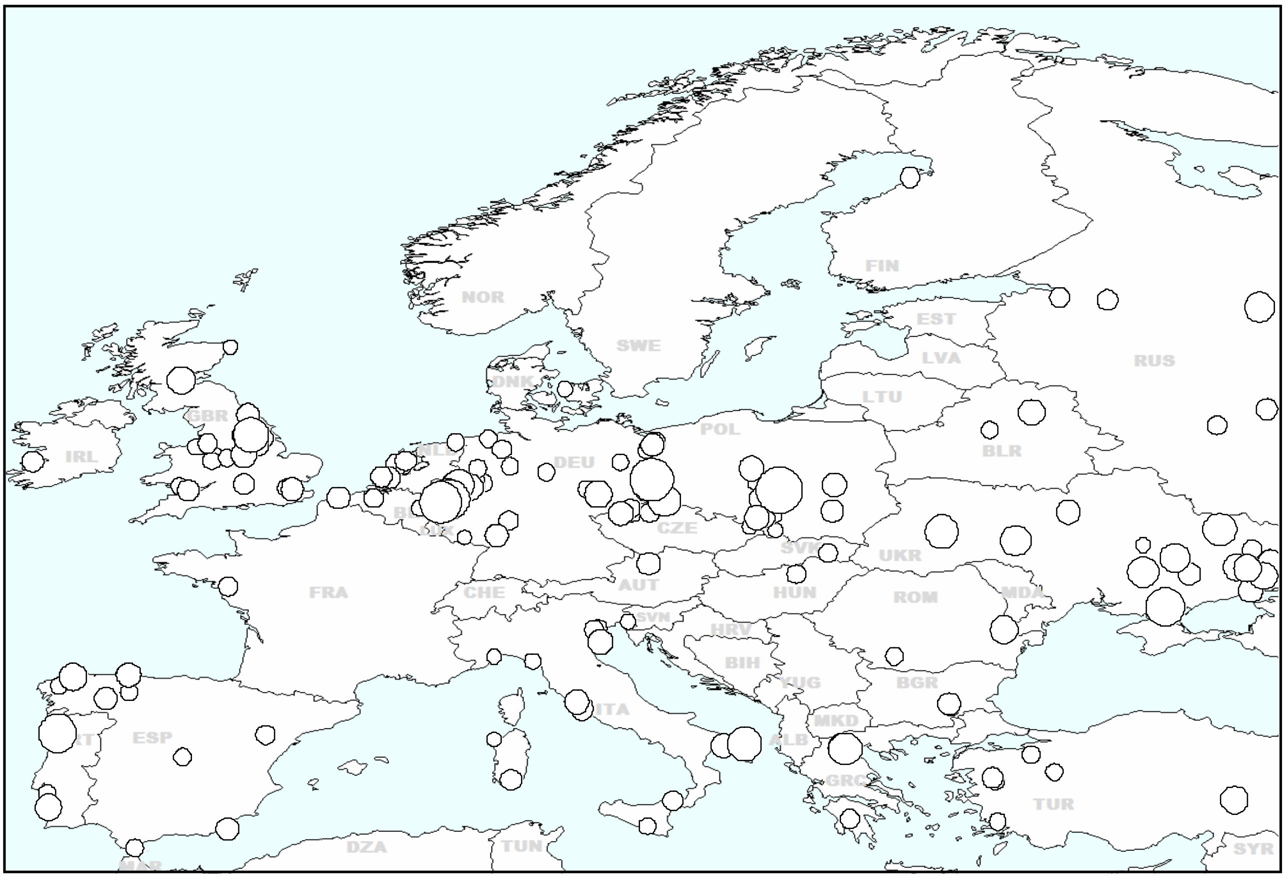


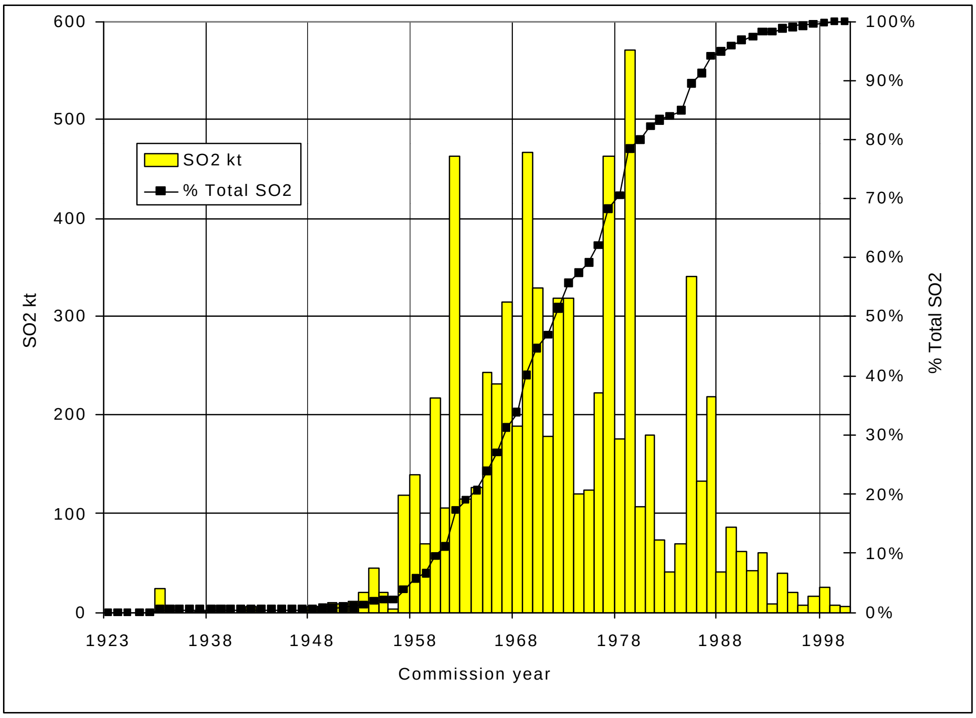
Figure 8. 200 Largest CO_2 emitters – whole region.



6.4 Emissions and age of power plant

The IEACR and Platts power station databases give commissioning dates for most units. The following analysis applies only to those plants for which there are commissioning year data these plants produce about 85% of total SO_2 emission from power plants. Figure 9 below shows the SO_2 emission for each commissioning year, and the cumulative fraction of emission. Over 90% of SO_2 emission comes from plant commissioned before 1987.

Figure 9. SO_2 emission and commissioning year of power plants.



6.5 Best facilities

The best facilities may be defined in terms of pollution produced per output of useful energy. The data so far collated are only adequate to attempt to define pollution produced per useful output for power stations and CHP plants using combustible fuels. It would be possible to compare pollution per output for other facilities: e.g. pollution per tonne of product such as oil, iron, or paper but more data are required.

Even for power stations and CHP plants, there are significant uncertainties in emission (discussed elsewhere). Table 18 gives estimates of CHP capacity for selected countries, and the approximate fraction of capacity using combustible fossil, waste and renewable fuels this represents. IEACR explicitly identifies which coal plants are CHP or cogenerating and gives the useful heat power output in MW. This is not so for non-coal plants in the Platts database, and SENCO does not currently have access to more detailed statistics on non-coal CHP plants. Currently, a non-coal plant is assumed to be CHP where heat recovery is specified in the Platts technology description. As a consequence of the above, in the listing of best plants, many CHP are omitted.

Because of the lack of data, the ranking given below is adequate only to give trends for different plant types, rather than for the comparison of individual plants.

If more than one pollutant is to be aggregated to give total pollution then the question arises as to how to give weights to the different pollutants. These should be allocated with respect to some damage function relating the emission of the

Table 18. CHP capacity (MWe) of selected countries in 2000.

Country	MWe	% fossil capacity	Country	MWe	% fossil capacity
DNK	7984	57%	BGR	1264	17%
SVA	1268	54%	DEU	18751	15%
AUT	3690	51%	FRA	5556	15%
CHE	459	48%	ITA	10665	15%
SWE	3131	40%	HUN	1226	13%
ROM	6715	38%	EST	434	12%
LTA	831	33%	ESP	4546	12%
FIN	4040	31%	PRT	903	12%
NLD	7873	30%	BEL	1341	11%
CZE	2741	23%	GBR	4632	4%
SLV	337	22%	GRC	316	3%
POL	7021	19%	NOR	16	2%
LUX	71	17%	IRL	117	2%

Sources: COGEN Europe (http://www.cogen.org/), Platts.

pollutants to an environmental cost such as critical load exceedance, human health impact, or economic loss. These damage functions are complex, and result in weights which vary with parameters such as geographical location and time of day or year. This complexity is beyond the scope of this study; total pollution is simply defined here as the sum of SO_2 and NOx emissions in kt.

Output is the sum of total electricity (E) and useful heat (H) output in PJ. The index, PO, is pollution divided by output, i.e. kt/PJ. It is emphasised that these results are subject to the uncertainties discussed in section 5. Because of default assumptions for some parameters, many stations have exactly the same PO index.

Four factors principally affect PO:

- ☐ Fuel characteristics (e.g. sulphur content). The order of fuels from best to worst is natural gas, oil and coal.
- ☐ Output. If a plant is CHP or cogenerating and produces useful heat as well as electricity, then useful energy output is typically increased by 100% to 200%, depending on the heat to electricity ratio, and the emissions per output are reduced accordingly.
- ☐ Plant technology. Pollution production (particularly thermal NOx) and efficiency vary with technology (e.g. combined cycle, steam cycle, turbine, reciprocating).
- ☐ Emission control.

Generally, plants with the lowest PO are gas fired combined cycle cogeneration plants, while electricity only coal steam cycle plants have the highest PO. If emission control were applied equally to all fuel types (i.e. with the same degree of basic emission reduction), then the order would not change appreciably. There would be exceptions: for example plants using very low sulphur coal or oil, or with high sulphur retention in coal ash, might be cleaner than plants using dirty oil.

Table 19 lists the 200 best fossil fuelled power stations with an electrical output greater than 20 MW_e (typically rated at 50-60 MW_{th}) ordered by increasing pollution (SO_2+NOx) per useful output. There are a large number of gas CHP plants smaller then 20 MW_e with a very low PO index and if these were included, they would displace virtually all other plants from the list. The acronyms for emission control equipment are shown in Table 13 (see Annex, pp. 53-54).

If CO_2 and PMa emissions were also considered then the ordering of the best plants would not change significantly. In fact, the advantage of natural gas would be even more marked because it produces little PMa, has a low carbon per energy content, and gas fired combined cycle plant are significantly more efficient than steam cycle coal and oil plant.

It should be noted that emission control technologies can increase carbon emission per useful output. Applying FGD to a coal plant will reduce SO_2 emission, but increase CO_2.

A programme to calculate flue gas concentration has been written. It is in preliminary form in that it does not account for certain details of fuel characteristics and emission control. Table 20 (p.43) gives preliminary estimates of the flue gas concentrations of SO_2 and NOx for the first 30 of the best stations. These are compared with the strictest ELVs of the LCP directive (2001/80/EC), i.e. those applying to new post-2003 plants. Table 20 shows that a number of existing plants many of them built in the 1970s and the 1980s have emission concentrations considerably lower than the strictest ELVs for new plants. If compared to the ELVs that are or will become mandatory for these plants according to the LCP directive, the gap is even bigger. The methodology requires further development, but it does indicate how the implications of reduced ELVs for pollution emission might be analysed in some detail.

6.6 Conclusions

The integration of databases has constituted an advance on previous work, although there are still inconsistencies to be removed.

Emission calculation has been extended to include PMa which is potentially useful, but the frequent omission of recorded PMa emission control equipment has led to the overestimation of emissions for some LPS. Emissions from facilities other than power stations have been estimated using simple emission ratios, which do not give great accuracy.

Large polluting facilities have lifetimes typically of 20-40 years and so the patterns of emission change fairly slowly. Nonetheless, there has been a further reduction in SO_2 and NOx emissions from LPS since the previous study. In western Europe, this is mainly because of the application of flue gas treatment and the switch to lower sulphur fuels. Further east these changes have also occurred, but to a smaller degree and further economic restructuring has also been an important factor in changing emission.

A large fraction of the emissions of air pollutants as well as the greenhouse gas carbon dioxide are emitted by a relatively small number of installations. Old coal-fired power stations still dominate emissions from LPS, and those commissioned before 1987, are responsible for more than 90% of total European SO_2 emissions from power stations.

The analysis of the best facilities demonstrates the advantage of producing useful heat from cogeneration plant, and underlines the role of such plant in an energy efficient, low-emission future.

The superior qualities of natural gas are again made prominent by this work, but Europe faces a future in which its own gas production will decline, and it will be competing with other countries like China for the remaining reserves such as in Siberia.

The maps illustrate the importance of LPS in eastern European countries for emissions of air pollutants, and the control of air pollution damage in the EU25 will need further policies in these countries.

Table 19. 200 best fossil fuelled power stations.

N	Cou	Plant	Year	Fuel	MWe	Out	PO	SO2 ConID	NOx ConID
1	ITA	Malpensa Airport	1997	G_Nat	21	EH	0.0		LNB_Solonox
2	GBR	Charterhouse St.	1994	G_Nat	32	EH	0.0		FGT_SCR
3	DEU	Brandenberg	1997	G_Nat	37	E	0.1		FGT_SCR_Wal
4	DEU	Nord Rhein Neckar H.		G_Nat	41	E	0.1	SNP_FBC_Atm	
5	AUT	Mellach	1986	S_Coa	246	EH	0.1	S_FGD_Wet_Lst	
6	DEU	Schwandorf	1972	S_Coa	314	EH	0.1	S_FGD_Wet_Lst	
7	DEU	Rostock	1994	S_Coa	509	EH	0.1	S_FGD_Wet_CaC	FGT_SCR
8	DEU	Hamburg/Hafen	1981	S_CoaBit	70	EH	0.1	S_FGD_Wet_Lst	FGT_SCR
9	DNK	Avedore	1990	S_Coa	250	EH	0.1	S_FGD_Wet_Lst	LNB_SCR
10	DEU	Berlin/Reuter West	1984	S_Coa	600	EH	0.1	S_FGD_Wet_Lst	FGT_SCR
11	DNK	Vendsyssel	1980	S_Coa	727	EH	0.1	SN_FGT_SNOx	FGT_SCR
12	DEU	Cuno Herdecke		S_CoaBit	94	EH	0.1		
13	SWE	Nyköping	1995	S_BioWoo	35	E	0.1	SNP_FBC_Bub	FGT_SCR
14	ITA	Pietrafitta	1979	G_Nat	176	E	0.1	SNP_FBC_Atm	
15	DEU	Zolling	1985	S_Coa	450	EH	0.1	S_FGD_Wet_Lst	
16	HUN	Kelenfold	1995	G_Nat	136	EH	0.1		ISt
17	TUR	Bursa Bisas	1993	G_Nat	34	EH	0.1		ISt
18	FIN	Sahanmaki	1991	G_Nat	47	EH	0.1		ISt
19	DEU	Altbach	1991	S_Coa	817	EH	0.2	S_FGD_Wet_Lst	FGT_SCR
20	ITA	Sarmato	1998	G_Nat	180	E	0.2		LNB
21	ITA	Magenta Sondel	1998	G_Nat	85	E	0.2		LNB
22	GBR	Kings Lynn/Wissingt	1998	G_Nat	41	E	0.2		LNB
23	GBR	Connahs Quay	1996	G_Nat	1400	E	0.2		LNB
24	DEU	Friedrichstrasse	1996	G_Nat	25	E	0.2		LNB
25	BEL	Zeebrugge Distrigas	1996	G_Nat	38	E	0.2		LNB
26	NLD	Eindhoven Phillips	1995	G_Nat	41	E	0.2		LNB
27	DEU	Berlin/Reuter		S_Coa	232	EH	0.2		
28	DEU	Neckar		S_CoaBit	713	EH	0.2		
29	SWE	Völund	1991	G_Nat	22	E	0.2		LNB
30	DEU	Nord Brunswick	1990	G_Nat	26	E	0.2		LNB
31	SWE	Stjärnvik		G_Nat	60	E	0.2		LNB
32	ESP	Truchas Del Cinca Pl.	1998	G_Nat	24	EH	0.2		
33	ITA	Celano	1998	G_Nat	123	EH	0.2		
34	FRA	Mulhouse	1998	G_Nat	21	EH	0.2		
35	DNK	Viborg	1996	G_Nat	38	EH	0.2		
36	DNK	Bronderslev	1995	G_Nat	21	EH	0.2		
37	GBR	Dalry	1995	G_Nat	22	EH	0.2		
38	DEU	München Sud	1975	G_Nat	582	E	0.2		FGT_SCR
39	DNK	Elsinore	1994	G_Nat	38	EH	0.2		
40	SWE	Brista	1997	S_BioWoo	44	E	0.2	SNP_FBC_Atm	
41	ESP	Miranda De Ebro	1994	G_Nat	38	EH	0.2		
42	ESP	Granada Grelva	1994	G_Nat	33	EH	0.2		
43	DEU	Kaiserstuhl	1993	G_Nat	25	EH	0.2		
44	NLD	Westland Sewage Pl	1992	G_Nat	52	EH	0.2		
45	SWE	Västhamnsverket	1993	G_Nat	125	E	0.2		LNB_OFA
46	DEU	Hannover	1989	S_Coa	264	EH	0.2		
47	NLD	Moerdijk Shell	1985	G_Nat	37	EH	0.2		
48	DEU	Heilbronn	1972	S_Coa	1010	EH	0.2	S_FGD_Wet_Lst	
49	SWE	Sandviksverket	1995	S_BioWoo	65	E	0.2	SNP_FBC_Atm	
50	NLD	Parenco Paper Mill	1978	G_Nat	24	EH	0.2		

Table 19. 200 best fossil fuelled power stations (continued).

N	Cou	Plant	Year	Fuel	MWe	Out	PO	SO2 ConID	NOx ConID
51	POL	Gorzow	1999	G_Nat	53	E	0.2		LNB_EV
52	DEU	Alsdorf	1973	G_Nat	66	EH	0.2		
53	SWE	Gällivare	1982	S_BioWoo	20	E	0.2	SNP_FBC_Atm	
54	FIN	Pietersaari	1982	S_BioWoo	25	E	0.2	SNP_FBC_Bub	
55	NLD	Nijmegen Mill	1990	G_Nat	76	EH	0.2		
56	DEU	Gutleutstrasse	1995	G_Nat	100	E	0.2		LNB_EV
57	NLD	Den Bosch Heineken	1994	G_Nat	34	E	0.2		LNB_EV
58	NLD	Hunzestroom Edon	1994	G_Nat	25	E	0.2		LNB_EV
59	HUN	Dunamenti	1996	G_Nat	396	E	0.2		LNB
60	DEU	Sterkrade	1992	X/_	25	E	0.2		
61	DEU	Werne/Gerstein	1968	S_Coa	765	EH	0.2	S_FGD_Wet_Lim	FGT_SCR
62	DNK	Aabenraa/Silkeborg	1995	G_Nat	109	E	0.2		LNB
63	DEU	Heyden	1987	S_Coa	840	E	0.2	S_FGD_Wet_Lst	LNB_SCR
64	DEU	Nossener Bruecke	1995	G_Nat	283	E	0.2		LNB
65	SWE	Åkeslundsverket	1991	G_Nat	28	E	0.2		LNB
66	DEU	Emsland	1982	G_Nat	97	EH	0.2		
67	ITA	Trino	1996	G_Nat	691	E	0.2		LNB
68	TUR	Marmara	1999	G_Nat	480	E	0.2		LNB
69	CHE	Pierre De Plan	1994	G_Nat	26	E	0.2		LNB_EV
70	NLD	Klazinaveen Egd	1996	G_Nat	70	E	0.2		LNB_EV
71	NLD	Delesto	1989	G_Nat	533	E	0.2		LNB
72	DNK	Aabenraa/Mariager	1998	G_Nat	30	E	0.2		LNB_EV
73	GBR	Didcot	1996	G_Nat	1372	E	0.2		LNB
74	GBR	Runcorn	1998	G_Nat	740	E	0.2		
75	GBR	Keadby	1996	G_Nat	717	E	0.2		LNB
76	GBR	Grimsby/Killingh. N	1993	G_Nat	671	E	0.2		LNB
77	GBR	Sutton Bridge	1999	G_Nat	756	E	0.2		LNB
78	FIN	Jarvenpaa	1991	G_Nat	37	EH	0.2		FGT_SCR
79	GBR	Little Barford	1996	G_Nat	674	E	0.2		LNB
80	DEU	Neubrandenburg	1996	G_Nat	77	E	0.2		LNB
81	NLD	Erica	1996	G_Nat	77	E	0.2		LNB_EV
82	GBR	Grimsby/Killingh. S	1992	G_Nat	912	E	0.2		LNB
83	GBR	Cottam	1999	G_Nat	350	E	0.2		LNB_Hyb
84	PRT	Tapada/ G	1998	G_Nat	1005	E	0.2		LNB_Hyb
85	GBR	Kings Lynn	1997	G_Nat	347	E	0.2		LNB_Hyb
86	GRC	Herakleio/Georgios	1969	G_Nat	360	E	0.2		LNB_OFA
87	TUR	Ambarli	1989	G_Nat	1349	E	0.2		LNB
88	DEU	Berlin/Mitte	1997	G_Nat	386	E	0.2		LNB_EV
89	DEU	Mider Ref	1996	L_ResOil	101	E	0.2	S_FGD_Wet_Lst	FGT_SCR
90	BEL	Drogenbos	1981	G_Nat	512	E	0.2		
91	FIN	Lielahti	1988	G_Nat	130	E	0.2		LNB
92	DEU	Frankfurt		S_CoaBit	170	E	0.2		
93	DEU	Wedel	1972	S_Coa	235	EH	0.2	S_FGD	FGT_SCR
94	GBR	Deeside	1994	G_Nat	508	E	0.2		LNB_EV
95	DEU	Bremen/Hafen		S_Coa	440	E	0.2		
96	DEU	Offleben	1972	S_Coa	325	EH	0.2	S_FGD_WeL	FGT_SNR
97	AUT	Theiss	1975	G_Nat	302	E	0.2		LNB
98	ESP	Tirmadrid	1992	S_MunRef	30	E	0.2	S_FGD_Wet_Lim	
99	DEU	Staudinger	1972	S_Coa	1110	EH	0.2	S_FGD_Wet_Lst	
100	FRA	Fos Sur Mer Lyondell	1999	G_Nat	40	E	0.3		IWa

Table 19. 200 best fossil fuelled power stations (continued).

N	Cou	Plant	Year	Fuel	MWe	Out	PO	SO2 ConID	NOx ConID
101	FIN	Vaasa Pilot	1998	L_FuOHea	34	E	0.3	S_FGD_Wet_Lim	FGT_SCR
102	GBR	Chickerell	1998	G_Nat	45	E	0.3		IWa
103	GBR	Burghfield	1998	G_Nat	45	E	0.3		IWa
104	BEL	Brugge/ Herdersbrug	1998	G_Nat	464	E	0.3		LNB_Hyb
105	GBR	Seabank	1998	G_Nat	760	E	0.3		LNB_Hyb
106	NLD	Merwedekanaal	1982	G_Nat	434	E	0.3		
107	DNK	Sonderborg	1996	G_Nat	40	E	0.3		IWa
108	DEU	Frankfurt Hoechst	1958	S_Coa	88	EH	0.3	S_FGD_Wet_Lim	FGT_SCR
109	UKR	Simpheropol	1984	G_Nat	255	EH	0.3		
110	BEL	Antwerp Wkk	1993	G_Nat	36	E	0.3		ISt
111	IRL	Dublin/ North Wall	1982	G_Nat	270	E	0.3		
112	FRA	Bassens	1998	G_Nat	48	E	0.3		LNB
113	BEL	Seraing	1993	G_Nat	465	E	0.3		LNB_Hyb
114	FIN	Kouvola	1987	G_Nat	47	E	0.3		ISt
115	ESP	Castilla La Mancha	1997	X/G_CoaG	190	E	0.3		ISt
116	GBR	Weston Salt Union	1996	G_Nat	46	E	0.3		ISt
117	GBR	Iggesund Mill	1997	G_Nat	50	E	0.3		IWa
118	ITA	Livorno Agip	1992	G_Nat	176	E	0.3		ISt
119	FRA	Clermont Ferrand	1989	G_Nat	65	E	0.3		IWa
120	DEU	Russelsheim	1999	G_Nat	100	E	0.3		Com
121	NLD	Helmond	1985	G_Nat	48	E	0.3		ISt
122	GBR	Teesside/ Middlesborough/ Seal/ Innogy	1997	G_Nat	64	E	0.3		ISt
123	GBR	Teesside	1993	G_Nat	1854	E	0.3		ISt
124	BEL	Antwerp Indaver	1997	S_MunRef	21	E	0.3		FGT_SCR
125	DEU	Berlin/ Rudow		S_Coa	176	E	0.3		
126	FRA	Chambiere	1991	G_Nat	55	E	0.3		ISt
127	GBR	Roosecote	1991	G_Nat	229	E	0.3		ISt
128	DEU	Lankow	1994	G_Nat	24	E	0.3		IWa
129	DEU	Bremen/ Hastedt	1989	S_Coa	130	E	0.3		
130	SVK	Vojany	1973	G_Nat	660	E	0.3		LNB
131	NLD	Lage Weide	1985	G_Nat	573	E	0.3		LNB
132	GBR	Kent Grovehurst	1995	G_Nat	81	E	0.3		ISt
133	DEU	Kobra	1997	X/G_CoaG	219	E	0.3		
134	ITA	Taranto Agip	1994	X/G_RefO	38	E	0.3		
135	ESP	San Roque Cepsa	1995	X/G_RefO	117	E	0.3		
136	NLD	Buggenum	1994	X/G_CoaG	156	E	0.3		
137	ESP	Somorrostro Ref	1993	X/G_RefO	38	E	0.3		
138	DEU	Veltheim	1966	S_Coa	515	E	0.3	S_FGD_Wet_Lst	FGT_SCR
139	ESP	La Coruna/ Ref	1991	X/G_RefO	38	E	0.3		
140	ITA	Brindisi Sud		S_Coa	2640	E	0.3		
141	GRC	Aspropyrgos	1990	X/G_RefO	44	E	0.3		
142	DEU	Werdohl	1976	S_Coa	521	E	0.3	S_FGD_Wet_Lst	FGT_SCR
143	ITA	Sannazzaro	1989	X/G_RefO	54	E	0.3		
144	AUT	Voitsberg	1983	S_Coa	330	E	0.3	S_FGD_Wet_Lst	FGT_SCR
145	GBR	Saltend	2000	G_Nat	400	E	0.3		
146	POL	Nowa Sarzyna	2000	G_Nat	116	E	0.3		
147	AUT	Wien/ Simmering	1985	G_Nat	985	E	0.3		LNB
148	DEU	Walheim	1965	S_Coa	256	E	0.3	S_FGD_SpD	FGT_SCR
149	GRC	Corinth Ref	1984	X/G_RefO	28	E	0.3		
150	CZE	Kyjov Chp	1999	G_Nat	23	E	0.3		

Table 19. 200 best fossil fuelled power stations (continued).

N	Cou	Plant	Year	Fuel	MWe	Out	PO	SO2 ConID	NOx ConID
151	TUR	Trakya	1999	G_Nat	495	E	0.3		
152	GBR	Fawley	1999	G_Nat	135	E	0.3		
153	GBR	Sandbach Hays	1999	G_Nat	70	E	0.3		
154	CZE	Kladno	1999	G_Nat	68	E	0.3		
155	POL	Glogow	1999	G_Nat	38	E	0.3		
156	BEL	Baudour	1999	G_Nat	360	E	0.3		
157	TUR	Bilkent University Ext	1999	G_Nat	36	E	0.3		
158	TUR	Bursa	1999	G_Nat	1400	E	0.3		
159	FRA	Nancy La Madeleine Nc	1999	G_Nat	80	E	0.3		
160	NLD	Swentibold	1999	G_Nat	246	E	0.3		
161	TUR	Esenyurt Doga	1999	G_Nat	194	E	0.3		
162	TUR	Hereke Cement Works	1999	G_Nat	39	E	0.3		
163	ESP	La Coruna	1999	S_RefRDF	49	E	0.3	S_FGD_SpD_Lim	
164	TUR	Bursa Entek	1998	G_Nat	100	E	0.3		
165	TUR	Kentsa Industrial Park	1998	G_Nat	38	E	0.3		
166	SWE	Mörrum Mill		X/_	40	E	0.3		
167	SWE	Mönsterås Mill	1995	X/_	33	E	0.3		
168	DNK	Tech University Denm.	1998	G_Nat	38	E	0.3		
169	HUN	Liter	1998	G_Nat	123	E	0.3		
170	GBR	Fife Energy Park	1998	G_Nat	75	E	0.3		
171	HUN	Sajoszoged	1998	G_Nat	123	E	0.3		
172	GBR	Smurfit Townsend Mill	1998	G_Nat	52	E	0.3		
173	CZE	Cerveny Mlyn	1998	G_Nat	98	E	0.3		
174	NLD	Rotterdam Eastman	1998	G_Nat	23	E	0.3		
175	GBR	Barry	1998	G_Nat	240	E	0.3		
176	GBR	Newcastle Upon Tyne	1998	G_Nat	52	E	0.3		
177	CZE	Usti Nad Labem	1998	G_Nat	38	E	0.3		
178	BEL	Gent/Ringvaart	1998	G_Nat	359	E	0.3		
179	MLT	Delimara	1998	G_Nat	37	E	0.3		
180	ESP	Huelva Intecsa	1998	G_Nat	28	E	0.3		
181	ITA	Ravenna	1998	G_Nat	110	E	0.3		
182	ITA	Pomigliano Serene	1998	G_Nat	96	E	0.3		
183	ITA	Rivalta Serene	1998	G_Nat	48	E	0.3		
184	TUR	Eskisehir Factory	1998	G_Nat	36	E	0.3		
185	ITA	Cassino	1998	G_Nat	96	E	0.3		
186	ITA	Sulmona Serene	1998	G_Nat	48	E	0.3		
187	GBR	Fort Dunlop	1998	G_Nat	100	E	0.3		
188	ITA	Torrente Tone	1998	G_Nat	22	E	0.3		
189	DEU	Bonn Chp	1998	G_Nat	26	E	0.3		
190	HRV	Zagreb	1998	G_Nat	52	E	0.3		
191	ITA	Teverola	1998	G_Nat	124	E	0.3		
192	BLR	Orsha	1998	G_Nat	70	E	0.3		
193	TUR	Brode Boya Textile	1997	G_Nat	108	E	0.3		
194	NLD	Moerdijk	1997	G_Nat	360	E	0.3		
195	TUR	Luleburgaz	1997	G_Nat	32	E	0.3		
196	TUR	Bozuyuk Ak	1997	G_Nat	127	E	0.3		
197	TUR	Erdemir	1997	G_Nat	77	E	0.3		
198	GBR	Thornhill	1997	G_Nat	50	E	0.3		
199	ITA	Porto Viro	1997	G_Nat	140	E	0.3		
200	DEU	Kobra	1997	G_Nat	155	E	0.3		

Table 20. The 30 best power stations – flue gas concentrations.

N	Cou	Plant	Com	Fuel	MWe	SO_2 ConID	NOx ConID	SO_2 mg/m³	SO_2 ELV mg/m³	NO_x mg/m³	NO_x ELV mg/m³
1	ITA	Malpensa Airport	1997	G_Nat	21		N_LNB_Solonox	1	35	52	150
2	GBR	Charterhouse St.	1994	G_Nat	32		N_FGT_SCR	1	35	69	150
3	DEU	Brandenberg	1997	G_Nat	37		N_FGT_SCR_Wal	0	35	69	150
4	DEU	Nord Rhein Neckar HKW		G_Nat	41	SNP_FBC_Atm		0	35	74	150
5	AUT	Mellach	1986	S_Coa	246	S_FGD_Wet_Lst		44	200	92	200
6	DEU	Schwandorf	1972	S_Coa	314	S_FGD_Wet_Lst		110	200	139	200
7	DEU	Rostock	1994	S_Coa	509	S_FGD_Wet_CaC	N_FGT_SCR	57	200	92	200
8	DEU	Hamburg/ Hafen	1981	S_CoaBit	70	S_FGD_Wet_Lst	N_FGT_SCR	57	200	92	200
9	DNK	Avedore	1990	S_Coa	250	S_FGD_Wet_Lst	N_LNB_SCR	65	200	92	200
10	DEU	Berlin/ Reuter West	1984	S_Coa	600	S_FGD_Wet_Lst	N_FGT_SCR	82	200	92	200
11	DNK	Vendsyssel	1980	S_Coa	727	SN_FGT_SNOx	N_FGT_SCR	59	200	130	200
12	DEU	Cuno Herdecke		S_CoaBit	94			105	200	92	200
13	SWE	Nyköping	1995	S_BioWoo	35	SNP_FBC_Bub	N_FGT_SCR	48	200	29	300
14	ITA	Pietrafitta	1979	G_Nat	176	SNP_FBC_Atm		0	35	138	100
15	DEU	Zolling	1985	S_Coa	450	S_FGD_Wet_Lst		123	200	92	200
16	HUN	Kelenfold	1995	G_Nat	136		N_ISt	1	35	276	100
17	TUR	Bursa Bisas	1993	G_Nat	34		N_ISt	1	35	276	150
18	FIN	Sahanmaki	1991	G_Nat	47		N_ISt	1	35	276	150
19	DEU	Altbach	1991	S_Coa	817	S_FGD_Wet_Lst	N_FGT_SCR	98	200	149	200
20	ITA	Sarmato	1998	G_Nat	180		N_LNB	1	35	172	100
21	ITA	Magenta Sondel	1998	G_Nat	85		N_LNB	1	35	172	150
22	GBR	Kings Lynn/ Wissington	1998	G_Nat	41		N_LNB	1	35	172	150
23	GBR	Connahs Quay	1996	G_Nat	1400		N_LNB	1	35	172	100
24	DEU	Friedrichstrasse	1996	G_Nat	25		N_LNB	1	35	172	150
25	BEL	Zeebrugge Distrigas	1996	G_Nat	38		N_LNB	1	35	172	150
26	NLD	Eindhoven Phillips	1995	G_Nat	41		N_LNB	1	35	172	150
27	DEU	Berlin/Reuter		S_Coa	232			82	200	92	200
28	DEU	Neckar		S_CoaBit	713			140	200	106	200
29	SWE	Völund	1991	G_Nat	22		N_LNB	1	35	172	150
30	DEU	Nord Brunswick	1990	G_Nat	26		N_LNB	0	35	172	150

7. Further development and application

Further development of the LPS work could include further database integration, improvements to emission calculation, extension to other pollutants, and general enhancements to the databases.

7.1 Database development

Integration

Maintaining and updating databases involves large amounts of tedious work. The work described here has focused on integrating other pre-existing databases as far as has been possible. There are many databases which have been used in this study but have not been standardised. These include emission and energy databases held by the IEA, EEA, EMEP, UNFCC, and the USEIA. There are also databases not used here, such as databases of facilities other than power stations (refineries, iron and steel plants, etc.) collected by commercial and other organisations. These could be integrated into the same framework used in this study.

In all the primary databases used, there are internal inconsistencies and omissions in the coding of information, and little usage of standard codes between the databases. The main effort involved has been to develop standard database frameworks with standard field names and information codes. Such standardisation facilitates combination and comparison of information about LPS in different databases. Then, for example, a search on the name Drax in the field PlantNameID will display the information in the field SO2Emit_kt as recorded in the EPER, IEACR, Platts and IEACO2 databases. This standardisation will facilitate the removal of inconsistencies.

Therefore a major objective of work in this area should be to promote standards and conventions. At present there is a great wastage of time because data collection is duplicated. Coordination would enable more time to be spent on using the databases for policy work.

Enrichment

There is a broad scope for enriching the databases. The following would be useful additions:

❑ Details of plant fuel consumption (and other inputs), efficiency and plant output.

❑ Specification of which non-coal plant are CHP, and details such as useful heat output.

❑ Greater detail for non-power facilities; fuel, emission control, annual production, etc.

❑ Aggregating units or parts of plant according to different definitions would be made easier with richer data. For example, in power stations, coding systems for individual boilers, generators and stacks could be utilised so that their actual or potential connectivity could be determined.

7.2 Improved and extended calculation

Production. If a facility s production or fuel consumption is not recorded, then it has been estimated in this work with default capacity factors. It would be better to utilise a system model for that commodity (e.g. an electricity system model) to better estimate production.

The accuracy of emission estimation could be improved. The first step is to compare emissions calculations from primary data sources with EPER data and other data, particularly if it is empirical data such as arises from flue gas monitoring. Large discrepancies in the emission estimates indicate errors in data recording or emission calculation methods and data assumptions. This comparison should be made first for the big emitters, i.e. the coal-fired power stations.

Pollutants covered. Many of the LPS are significant sources of atmospheric pollutants other than SO_2, NOx, CO_2, and PMa. These include toxic metals and other chemicals; carbon monoxide, nitrous oxide and volatile organic compounds including methane.

7.3 Application of LPS data

Emissions from LPS constitute a large fraction of the total emissions of pollutants which raise local pollution concentrations above air quality limits as well as contributing to long-range pollution and global warming.

In the EU, large reductions in the emissions of several pollutants (CO_2, SO_2, NOx, PMa) have been achieved through switching from coal to gas, particularly for electricity generation. However, as European gas production reaches a plateau, and as demand grows within Europe and in countries outside Europe, the availability of gas will decline and its relative price will increase. This will raise the pressure to use fuels other than gas within the European Union, and this could mean increases in pollution emission. Coal and nuclear fuels are two alternatives to gas, both of which are problematic, because of environmental impact, risk and economic cost. Alternatively, there is the possibility of importing electricity from non-EU countries such as Ukraine which has surplus generating capacity. This has the problem that global and regional pollution emission may increase, and it faces EU producers with unfair competition against dirty producers.

The data and analysis system developed in this work is a resource for improving the analysis of how the available energy and environment policy options would impact on different LPS power stations, refineries, cement factories, etc. Some possibilities are summarised:

A detailed analysis of emission control. This could include an assessment of the further potential application to facilities with less effective or without emission control, the costs of application, and the penalty in terms of increased CO_2 emission because of efficiency loss. It is emphasised that emission control is not generally the best option for the first tranche of emission reduction. For example: FGD as compared to energy efficiency is expensive and has its own environmental impacts such as limestone mining and waste dumping.

Emission standards. An appraisal of the impact of tighter ELVs, or the use of new standards such as environmental performance. If the physical outputs of the LPS (electricity, heat, steel, cement, etc.) were known then the plants with accurate emission estimates could be ranked in terms of emission per output, as is attempted here with power stations.

Changing production pattern. There is a potential for reducing total emissions by concentrating production in the least polluting plants. This may be facilitated by emission trading. The LPS data would allow a better analysis of this.

CHP or cogeneration is a key technology for reducing pollution per unit of useful energy. The database would aid an appraisal of what the further CHP potential might be by identifying which large heat demands are not supplied by CHP, and which power plants are near heat demands. The effect of increased CHP on emissions could be ascertained.

Spatial distribution of emission. The LPS data allow an accurate spatial distribution of emission to be constructed. (If an electricity model were utilised, then the variation of emission with time from each station could be estimated. For example: most output from coal stations in the UK would occur in the winter.) This distribution of emission could be used in long range pollution transport modelling (e.g. IIASA, EMEP). Overlaying the spatial distributions of emission and population could aid the assessment of health impacts.

The LPS data could be used in more integrated energy and environment planning approaches using electricity and energy models. In general, integrated approaches utilising demand management and end use energy efficiency as well as options such as cogeneration, fuel switching and emission control equipment, lead to superior energy and environment plans. Costs are lower for meeting environmental objectives such as National Emission Ceilings. Energy supply security and fuel mix flexibility are enhanced because overall energy consumption is lower. [A separate study for the Swedish NGO Secretariat on Acid Rain (SNGOSAR/EFTE/EEB, 2000) showed that measures to control CO_2, including energy efficiency and switching to gas, would significantly reduce the total cost of SO_2 and NOx emission control so as to meet emission ceilings. The energy scenario for this, including the power sector, *An Alternative Energy Scenario for the European Union*, was developed by SENCO. The scenario incorporated significant changes to electricity consumption because of end use efficiency.]

The LPS data can facilitate a more accurate analysis of the impact of energy scenarios. For example, the LPS data would give more precision to the marginal electricity generating plant displaced by demand management, new generators or trading.

8. References

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Annex

Table 1. Countries included in study.

EU25			Other		
Entity	**CouISO3**	**UN Region**	**Entity**	**CouISO3**	**UN Region**
Austria	AUT	EuWe	Albania	ALB	EuSo
Belgium	BEL	EuWe	Armenia	ARM	AsWe
Cyprus	CYP	AsWe	Belarus	BLR	AsWe
Czech Republic	CZE	EuEa	Bosnia and Herzegovina	BIH	EuSo
Denmark	DNK	EuNo	Bulgaria	BGR	EuEa
Estonia	EST	EuEa	Croatia	HRV	EuSo
Finland	FIN	EuNo	Georgia	GEO	AsWe
France	FRA	EuWe	Macedonia	MKD	EuSo
Germany	DEU	EuWe	Moldova	MDA	EuEa
Greece	GRC	EuSo	Norway	NOR	EuNo
Hungary	HUN	EuEa	Romania	ROM	EuEa
Ireland	IRL	EuNo	Russia	RUS	AsWe
Italy	ITA	EuSo	Switzerland	CHE	EuWe
Latvia	LVA	EuEa	Turkey	TUR	AsWe
Lithuania	LTU	EuEa	Ukraine	UKR	EuEa
Luxembourg	LUX	EuWe	Yugoslavia	YUG	EuWe
Malta	MLT	EuSo			
Netherlands	NLD	EuWe			
Poland	POL	EuEa			
Portugal	PRT	EuSo			
Slovakia	SVK	EuNo			
Slovenia	SVN	EuSo			
Spain	ESP	EuWe			
Sweden	SWE	EuNo			
United Kingdom	GBR	EuSo			

Table 2. Summary of primary databases.

	EPER	IEACO2	IEACR	Platts
Records	9300	15000	6000	96000
Data year	2001	2001	2001	2000
Geography	EU15 +Norway	Global	Global	Global
Type	Large emitters	Large CO_2 emitters	Coal power stations	All power stations
Pollutant emission	Multi pollutant official report	CO_2 estimate		
Plant naming		patchy	consistent	consistent
Output				
Efficiency				
Latitude/Longitude	x	x		
Economic sector	x	x	x	x
Technology (e.g. turbine type)		x	x	x
Combustion technology (e.g. boiler type)			x	x
Capacity (e.g. MW)		x	x	x
Fuel types		x	x	x
Fuel consumption			x	
Fuel quality			x	
Emission control			x	x

Table 3. NACE Codes.

NACE	NACEm	DESCRIPTION
40.1	EGW{Ele	Production and distribution of electricity
DJ	Man{Met	Manufacture of basic metals and fabricated metal products
40.3	EGW{StW{Dis	Steam and hot water supply
DF	Man{CPN{ReP	Manufacture of coke, refined petroleum products and nuclear fuel
27.1	Man{Met{Iro	Manufacture of basic iron and steel and of ferro-alloys
24.13	Man{Che{Bas{Ino	Manufacture of other inorganic basic chemicals
15.12	Man{Foo{Mea{Pre	Production and preserving of poultrymeat
27.42	Man{Met{PNF{Alu	Aluminium production
11.1	MiQ{Ene{Ext{PGa	Extraction of crude petroleum and natural gas
41	EGW{Wat{CPD	Collection, purification and distribution of water
24.14	Man{Che{Bas{Org	Manufacture of other organic basic chemicals
27.43	Man{Met{PNF{PZS	Lead, zinc and tin production
23.1	Man{CPN{Cok	Manufacture of coke oven products
26.51	Man{NoM{CLP{Cem	Manufacture of cement
26.4	Man{NoM{Bri	Manufacture of bricks, tiles and construction products, in baked clay
27.52	Man{Met{Cas{Ste	Casting of steel
24.16	Man{Che{Bas{Pla	Manufacture of plastics in primary forms
27.44	Man{Met{PNF{Cop	Copper production
11.2	MiQ{Ene{Ext{OGs	Service activities incidental to oil and gas extraction, excl. surveying
51.1	Ret{Who{Fee	Wholesale on a fee or contract basis
E	EGW	Electricity, gas and water supply
26.8	Man{NoM{Oth	Manufacture of other non-metallic mineral products
26.11	Man{NoM{Gla{Fla	Manufacture of flat glass
26.5	Man{NoM{CLP	Manufacture of cement, lime and plaster
24.7	Man{Che{Fib	Manufacture of man-made fibres
40.13	EGW{Ele{Dis	Distribution and trade of electricity
24.66	Man{Che{Oth{Oth	Manufacture of other chemical products n.e.c.
15.83	Man{Foo{Oth{sug	Manufacture of sugar
26.52	Man{NoM{CLP{Lim	Manufacture of lime
21	Man{PuP{PPP	Manufacture of pulp, paper and paper products
10.2	MiQ{Ene{Min{Lig	Mining and agglomeration of lignite
24.15	Man{Che{Bas{Fer	Manufacture of fertilizers and nitrogen compounds
26.23	Man{NoM{Cer{Ins	Manufacture of ceramic insulators and insulating fittings
24.12	Man{Che{Bas{Dye	Manufacture of dyes and pigments
24.17	Man{Che{Bas{Rub	Manufacture of synthetic rubber in primary forms
26.12	Man{NoM{Gla{Sha	Shaping and processing of flat glass

Table 3. NACE Codes (continued).

NACE	NACEm	DESCRIPTION
DA	Man{Foo	Manufacture of food products, beverages and tobacco
27.4	Man{Met{PNF	Manufacture of basic precious and non-ferrous metals
27.45	Man{Met{PNF{ONF	Other non-ferrous metal production
13.1	MiQ{NEn{MMe{Iro	Mining of iron ores
27.51	Man{Met{Cas{Iro	Casting of iron
23.3	Man{CPN{Nuc	Processing of nuclear fuel
31	Man{ElO{Ele	Manufacture of electrical machinery and apparatus n.e.c.
27.3	Man{Met{Pro	Other first processing of iron and steel
15.62	Man{Foo{Gra{Sta	Manufacture of starches and starch products
26.13	Man{NoM{Gla{Hol	Manufacture of hollow glass
29.5	Man{McE{Oth{Spe	Manufacture of other special purpose machinery
15.89	Man{Foo{Oth{Oth	Manufacture of other food products n.e.c.
DI	Man{NoM	Manufacture of other non-metallic mineral products
10.1	MiQ{Ene{Min{Coa	Mining and agglomeration of hard coal
34.1	Man{Tra{VeT{Veh	Manufacture of motor vehicles
27.53	Man{Met{Cas{LMe	Casting of light metals
20.2	Man{Woo{Ply	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards
15.41	Man{Foo{Oil{CoF	Manufacture of crude oils and fats
24.1	Man{Che{Bas	Manufacture of basic chemicals
25.24	Man{RuP{Pla{Oth	Manufacture of other plastic products
24.42	Man{Che{Med{PhP	Manufacture of pharmaceutical preparations
90	Com{SeR	Sewage and refuse disposal, sanitation and similar activities
28.4	Man{MeF{For	Forging, pressing, stamping and roll forming of metal; metallurgy
17.22	Man{Tex{Wea{Woo	Woollen-type weaving
17.5	Man{Tex{Oth	Manufacture of other textiles
45.11	Con{Sit{Dem	Demolition and wrecking of buildings; earth moving
27.22	Man{Met{Tub{Ste	Manufacture of steel tubes
26.1	Man{NoM{Gla	Manufacture of glass and glass products
24.2	Man{Che{Pes	Manufacture of pesticides and other agro-chemical products
24.11	Man{Che{Bas{IGa	Manufacture of industrial gases
24.41	Man{Che{Med{Pha	Manufacture of basic pharmaceutical products
15.42	Man{Foo{Oil{RoF	Manufacture of refined oils and fats
50.3	Ret{VPa	Sale of motor vehicle parts and accessories
85.11	Hea{Hos	Hospital activities
15.51	Man{Foo{Dai{Che	Operation of dairies and cheese making
15.96	Man{Foo{Bev{Bee	Manufacture of beer
14.12	MiQ{NEn{Oth{Lim	Quarrying of limestone, gypsum and chalk
17.3	Man{Tex{Fin	Finishing of textiles
26.26	Man{NoM{Cer{Ref	Manufacture of refractory ceramic products
DG	Man{Che	Manufacture of chemicals, chemical products and man-made fibres
29.31	Man{McE{Agr{Tra	Manufacture of agricultural tractors
40.12	EGW{Ele{Tra	Transmission of electricity
31.6	Man{ElO{Ele{Equ	Manufacture of electrical equipment n.e.c.
15.71	Man{Foo{AnF{Far	Manufacture of prepared feeds for farm animals
17.2	Man{Tex{Wea	Textile weaving
26.14	Man{NoM{Gla{Fib	Manufacture of glass fibres
17.6	Man{Tex{KnF	Manufacture of knitted and crocheted fabrics

Table 3. NACE Codes (continued).

NACE	NACEm	DESCRIPTION
25.1	Man{RuP{Rub	Manufacture of rubber products
25.21	Man{RuP{Pla{PlS	Manufacture of plastic plates, sheets, tubes and profiles
15.5	Man{Foo{Dai	Manufacture of dairy products
24.62	Man{Che{Oth{Glu	Manufacture of glues and gelatines
15.88	Man{Foo{Oth{Hom	Manufacture of homogenized food preparations and dietetic food
14.5	MiQ{NEn{Oth{Oth	Other mining and quarrying n.e.c.
15.33	Man{Foo{Veg{Pro	Processing and preserving of fruit and vegetables n.e.c.
15.31	Man{Foo{Veg{Pot	Processing and preserving of potatoes
24.51	Man{Che{SCP{Soa	Manufacture of soap and detergents, cleaning and polishing preparations
75.22	Pub{Adm{Def	Defence activities
26.62	Man{NoM{CPC{Pla	Manufacture of plaster products for construction purposes
15.81	Man{Foo{Oth{Bre	Manufacture of bread; manufacture of fresh pastry goods and cakes
1.41	AGF{AgH{Ser{Lan	Agricultural service activities; landscape gardening
14.22	MiQ{NEn{Oth{Cla	Mining of clays and kaolin
15.85	Man{Foo{Oth{pas	Manufacture of macaroni, noodles, couscous and similar farinaceous products
15.92	Man{Foo{Bev{Eth	Production of ethyl alcohol from fermented materials
26.24	Man{NoM{Cer{Tec	Manufacture of other technical ceramic products
40.2	EGW{Gas	Manufacture of gas; distribution of gaseous fuels through mains
26.15	Man{NoM{Gla{Oth	Manufacture and processing of other glass, including technical glassware
14.1	MiQ{NEn{Oth{Sto	Quarrying of stone
27.32	Man{Met{Pro{Rol	Cold rolling of narrow strip
15.6	Man{Foo{Gra	Manufacture of grain mill products, starches and starch products
14.3	MiQ{NEn{Oth{Che	Mining of chemical and fertilizer minerals
74.7	OBu{Cle	Industrial cleaning
74.1	OBu{Con	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy; holdings
22.22	Man{PuP{Pri{nec	Printing n.e.c.
27.54	Man{Met{Cas{NFM	Casting of other non-ferrous metals
26.64	Man{NoM{CPC{Mor	Manufacture of mortars
28.51	Man{MeF{TCo{TCo	Treatment and coating of metals
60.3	TrC{TrL{Pip	Transport via pipelines
14.21	MiQ{NEn{Oth{Gra	Operation of gravel and sand pits
40.21	EGW{Gas{Man	Manufacture of gas
40.22	EGW{Gas{Dis	Distribution and trade of gaseous fuels through mains
63.2	TrC{Aux{Oth	Other supporting transport activities
34.3	Man{Tra{VeT{Par	Manufacture of parts and accessories for motor vehicles and their engines
70	Est{Act	Real estate activities
15.72	Man{Foo{AnF{Pet	Manufacture of prepared pet foods
14.4	MiQ{NEn{Oth{Sal	Production of salt
11	MiQ{Ene{Ext{PGs	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
73.1	ReD{ScE	Research and experimental development on natural sciences and engineering

Table 13. Emission control systems.

Acronym	Description	NOx Rem	SO_2 Rem	PMa Rem
N_BOO	burners out of service [BOOS]	20%		
N_BOO_FGR	burners out of service [BOOS]; flue gas recirculation [FGR]	20%		
N_BOO_OFA	burners out of service [BOOS]; overfire air [OFA]	20%		
N_Com	Unspecified combustion modifications for dry low NOX operation	20%		
N_Con	boiler controls tuning	45%		
N_FGR	flue gas recirculation [FGR]	30%		
N_FGR_UrI	Flue gas recirculation and urea injection	50%		
N_FGT	COS hydrolysis and MDEA scrubber	85%		
N_FGT_AcC	Activated-coke filter	85%		
N_FGT_MDE	COS hydrolysis and MDEA scrubber	85%		
N_FGT_SCR	selective catalytic reduction [SCR]	80%		
N_FGT_SCR_Oxi	OXI catalyst (NOX control)	80%		
N_FGT_SCR_SNR	SCR/selective non-catalytic reduction	80%		
N_FGT_SCR_WaI	Selective catalytic reduction/water injection	80%		
N_FGT_SNR	selective non-catalytic reduction [SNCR]	50%		
N_FGT_SNR_OFA	Selective non-catalytic reduction/overfire air	60%		
N_FGT_SNR_Reb	SNCR/gas reburn	60%		
N_FGT_SOLONOX	SoLoNox nox control methodology	20%		
N_Inj_Amm	Ammonia injection	90%		
N_ISt	steam injection	20%		
N_ISt_SCR	Steam injection and SCR	70%		
N_IWa	Water injection	20%		
N_IWa_SCR	Water injection plus SCR	70%		
N_LNB	Dry low NOX burners	50%		
N_LNB_DLE	DLE low-NOX combustor	40%		
N_LNB_EV	Advanced environmental votex burners	40%		
N_LNB_EV_SCR	EV low-NOX burners plus SCR	40%		
N_LNB_FGR	Flue gas recirculation and low Nox burners	30%		
N_LNB_FGR_OFA	flue gas recirculation [FGR]; low NOx burners [LNB]; overfire air [OFA]	30%		
N_LNB_FGR_StC	flue gas recirculation [FGR]; low NOx burners [LNB]; two stage combustion [SC]	30%		
N_LNB_Hyb	Hybrid low-NOX burners	30%		
N_LNB_IWa	Low-NOX burners/water injection	30%		
N_LNB_Lea	LeaNOx combustion control system	30%		
N_LNB_OFA	Close-coupled overfire air	42%		
N_LNB_OFA_Cmo	Overfire air/combustion modifications	50%		
N_LNB_OFA_FGR	flue gas recirculation [FGR]; overfire air [OFA]	50%		
N_LNB_OFA_Reb	low-NOx cell burners; natural gas reburning; overfire air [OFA]	50%		

Table 13. Emission control systems (continued).

Acronym	Description	NOx Rem	SO_2 Rem	PMa Rem
N_LNB_OFA_Sta	lowNOx burner; staged combustion [SC]; overfire air [OFA]	50%		
N_LNB_Ope	operational optimization	50%		
N_LNB_Reb	low NOx burners [LNB]; reburning [natural gas]	50%		
N_LNB_SCR	Dry low NOX combustors plus SCR	85%		
N_LNB_Solonox	SoLoNox lean pre-mixed combustion	85%		
N_LNB_St2	Two-stage combustion/lo-NOX burners	30%		
N_LNB_StC	Low Nox burners/staged combustion	30%		
N_St2	Two-stage combustion	30%		
N_St2_FGR	Two-stage combustion/flue-gas recirculation	40%		
N_StC	staged combustion [SC]	30%		
N_StC_OFA	staged combustion [SC]; overfire air [OFA]	40%		
N_StC_SCR	Staged combustion/SCR	85%		
N_StC_SNR	Staged combustion/SNCR	85%		
N_The	Thermal DeNox system	40%		
N_Unsp	Unspecified NOX removal equipment	40%		
N_Xon	Xonon catalytic combustion system	40%		
P_Bag	fabric filter [baghouse]			99.5%
P_Bag_Ven_Cyc	fabric filter [baghouse]; wet particulate scrubber [venturi]; mechanical collector [cyclone]			99.5%
P_Cyc	mechanical collector [cyclone]			99.5%
P_Cyc_Bag	fabric filter [baghouse]; mechanical collector [cyclone]			99.5%
P_Cyc_Fil	mechanical collector [cyclone]; ceramic filter			99.5%
P_ESP	Cold side ESP			99.5%
P_ESP_Bag	Baghouse/hot-side ESP			99.5%
P_ESP_Cyc	Combination particulate control (usually ESP preceded by multiclones or cyclone collector)			99.5%
P_ESP_Scb	ESP/scrubber			99.5%
P_ESP_Ven	electrostatic precipitator [ESP]; wet particulate scrubber [venturi]			99.5%
P_FGT	Semi-wet flue-gas cleaning			99.5%
P_Fil	hot gas filter			99.5%
P_Fil_Cer	ceramic filter			99.5%
P_Mec	Mechanical particulate control device			99.5%
P_N/A	Not applicable			
P_None	None			
P_Scb	Particulate scrubber			99.5%
P_Ven	Venturi particulate scrubber			99.5%
P_Ven_Fil	ceramic candle filters and Venturi scrubber			99.5%
S_FGD	system unknown		85%	
S_FGD_Alk	Double alkali FGD scrubber		85%	
S_FGD_Amm	Ammonia FGD scrubber		85%	

Table 16. 200 largest SO_2 emitters – whole region.

N	Source	Cou	Plant	NACEm	Fuel	SO_2 kt	NO_x kt	CO_2 Mt	PM kt
1	IEACR	BGR	Maritsa II	EGW{Ele	S_CoaLig	332	35	7	0.2
2	**EPER**	**ESP**	Puentes	EGW{Ele	S_Coa	315	20	10	0.4
3	IEACR	UKR	Krivoy Rog	EGW{Ele	S_CoaBit	213	115	20	120.8
4	IEACR	UKR	Burshytn	EGW{Ele	S_CoaBit	208	87	15	0.0
5	IEACR	UKR	Lodyzhinsk	EGW{Ele	S_CoaBit	179	62	12	606.9
6	**EPER**	**GRC**	Megalopolis	EGW{Ele	S_Coa	161	4	5	0.1
7	SENCO	RUS	Nikel	Man{Met		161			
8	IEACR	UKR	Zmiyev	EGW{Ele	S_CoaBit	158	84	15	0.5
9	IEACR	UKR	Kurakhovka	EGW{Ele	S_CoaBit	155	58	10	0.3
10	**EPER**	**ESP**	Andorra (Teruel)	EGW{Ele	S_Coa	152	20	5	0.3
11	IEACR	TUR	Seyitomer	EGW{Ele	S_CoaLig	149	20	4	0.1
12	IEACR	RUS	Troitsk	EGW{Ele	S_CoaSub	141	45	8	95.3
13	**IEACR**	**POL**	Belchatow	EGW{Ele	S_CoaLig	136	144	29	0.5
14	IEACR	UKR	Pridneprovsk	EGW{Ele	S_CoaBit	129	71	12	71.5
15	IEACR	UKR	Zuev	EGW{Ele	S_CoaBit	124	46	8	90.0
16	IEACR	UKR	Starobeshev	EGW{Ele	S_CoaBit	120	55	10	0.7
17	IEACR	BGR	Maritsa I	EGW{Ele	S_CoaLig	96	9	2	0.0
18	**IEACR**	**POL**	Adamow	EGW{Ele	S_CoaLig	96	16	3	0.1
19	IEACR	UKR	Uglegorsk	EGW{Ele	S_CoaBit	95	46	8	0.0
20	IEACR	UKR	Kiev	EGW{Ele	S_CoaBit	93	44	8	0.7
21	IEACR	UKR	Zaporozhye	EGW{Ele	S_CoaBit	91	38	7	227.2
22	IEACR	UKR	Lugansk	EGW{Ele	S_CoaBit	84	38	7	83.0
23	Platts	RUS	Kostroma	EGW{Ele	S_Pea	82	14	2	0.0
24	IEACR	RUS	Ryazan	EGW{Ele	S_CoaSub	82	19	3	0.0
25	Platts	RUS	Pskov	EGW{Ele	S_Pea	81	14	2	0.0
26	**IEACR**	**HUN**	Oroszlnany	EGW{Ele	S_CoaSub	81	10	2	0.0
27	**IEACR**	**POL**	Turow	EGW{Ele	S_CoaLig	79	68	14	0.3
28	IEACR	ROM	Craiova	EGW{Ele	S_CoaLig	75	9	2	0.2
29	**EPER**	**ITA**	Porto Tolle	EGW{Ele	L	73	10	8	0.0
30	**EPER**	**ESP**	Meirama	EGW{Ele	S_Coa	71	9	4	2.7
31	**IEACR**	**POL**	Patnow	EGW{Ele	S_CoaLig	71	40	8	0.1
32	**EPER**	**GBR**	Cottam	EGW{Ele	S_Coa	71	18	7	0.0
33	Platts	RUS	Ryazan	EGW{Ele	L_FuOHea	69	25	10	0.0
34	**EPER**	**GBR**	West Burton	EGW{Ele	S_Coa	69	16	7	0.2
35	**EPER**	**GBR**	Longannet	EGW{StW{Dis	S_Coa	68	24	10	0.4
36	IEACR	RUS	Novocherkassk	EGW{Ele	S_CoaAnt	67	61	11	0.0
37	**EPER**	**ESP**	Compostilla	EGW{Ele	S_CoaAnt	62	35	7	5.9
38	Platts	UKR	Uglegorsk	EGW{Ele	L_FueOil	60	22	9	0.0
39	IEACR	ROM	Drobeta	EGW{Ele	S_CoaLig	60	8	2	0.0
40	Platts	UKR	Zaporizhzhya	EGW{Ele	L_FueOil	60	21	9	0.0
41	**EPER**	**GBR**	Eggborough	EGW{Ele	S_Coa	60	14	6	0.2
42	Platts	BLR	Lukoml	EGW{Ele	L_FuOHea	59	21	9	1.4
43	IEACR	RUS	Cherepetsk	EGW{Ele	S_CoaBit	58	31	5	60.2
44	SENCO	RUS	Monchegorsk	Man{Met		57			
45	**EPER**	**ESP**	La Robla	EGW{Ele	S_CoaBit	57	23	4	1.6
46	**EPER**	**PRT**	Setubal	EGW{Ele	L	57	14	4	0.4
47	**EPER**	**GBR**	Belfast West	EGW{Ele	S_Coa	53	2	1	0.4
48	IEACR	ROM	Turceni	EGW{Ele	S_CoaLig	52	18	4	0.3
49	**EPER**	**GBR**	Ferrybridge	EGW{Ele	S_Coa	48	16	7	0.2
50	IEACR	BGR	Bobovdol	EGW{Ele	S_CoaLig	47	12	2	0.1

Table 16. 200 largest SO_2 emitters – whole region (continued).

N	Source	Cou	Plant	NACEm	Fuel	SO_2 kt	NO_x kt	CO_2 Mt	PM kt
51	IEACR	UKR	Slavyansk	EGW{Ele	S_CoaBit	46	25	4	0.0
52	IEACR	TUR	Kangal	EGW{Ele	S_CoaLig	46	7	1	0.0
53	**EPER**	**ESP**	Puertollano/Ref	Man{CPN{ReP	X	44	0	3	0.0
54	**IEACR**	**POL**	Pomorzany	EGW{Ele	S_CoaBit	44	34	6	0.0
55	**IEACR**	**POL**	Krakow	EGW{Ele	S_CoaBit	44	22	5	2.0
56	IEACR	TUR	Tuncbilek	EGW{Ele	S_CoaLig	43	8	2	10.1
57	**IEACR**	**HUN**	Matra	EGW{Ele	S_CoaLig	43	26	5	0.1
58	**EPER**	**GBR**	Didcot	EGW{Ele	S_Coa	41	16	6	0.0
59	**Platts**	**EST**	Eesti	EGW{Ele	S_OilSha	40	19	3	0.0
60	**EPER**	**PRT**	Sines	EGW{Ele	S_Coa	39	21	9	0.3
61	**Platts**	**EST**	Balti	EGW{Ele	S_OilSha	39	19	3	37.2
62	**EPER**	**ITA**	Taranto	Man{Met{Iro	X	38	25	8	2.5
63	**IEACR**	**SVK**	Novaky	EGW{Ele	S_CoaLig	38	13	3	0.3
64	IEACR	BGR	Varna	EGW{Ele	S_CoaAnt	37	15	3	0.1
65	Platts	RUS	Chero/ Sever	EGW{Ele	X/G_BlaF	36	1	1	0.0
66	IEACR	RUS	Cherepovets	EGW{Ele	S_CoaBit	36	16	3	0.0
67	**EPER**	**ESP**	Alberto	Man{Che{Bas{Ino	X	36		1	0.4
68	IEACR	RUS	Smolensk	EGW{Ele	X	35	8	1	0.0
69	**EPER**	**GBR**	Drax	EGW{Ele	S_Coa	35	50	16	0.2
70	**EPER**	**GBR**	Rugeley	EGW{Ele	S_Coa	34	15	4	0.1
71	**EPER**	**GBR**	High Marnham	EGW{Ele	S_Coa	33	6	3	0.1
72	**EPER**	**GBR**	Kingsnorth	EGW{Ele	S_Coa	33	17	7	0.2
73	**EPER**	**GBR**	Grain	EGW{Ele	L	33	1	2	0.8
74	**EPER**	**IRL**	Moneypoint	EGW{Ele	S_Coa	32	22	6	0.2
75	**IEACR**	**POL**	Rybnik	EGW{Ele	S_CoaBit	32	26	8	0.2
76	**EPER**	**GBR**	Ironbridge	EGW{Ele	S_Coa	32	11	4	0.1
77	Platts	UKR	Starobeshev	EGW{Ele	L_FuOHea	31	11	5	0.7
78	**EPER**	**GBR**	Aberthaw	EGW{Ele	S_Coa	31	23	6	0.2
79	Platts	UKR	Kiev	EGW{Ele	L_FuOHea	30	11	4	0.7
80	IEACR	TUR	Catalagzi	EGW{Ele	S_Coa	29	8	1	5.5
81	**EPER**	**GBR**	Lynemouth	EGW{Ele	S_Coa	28	8	3	0.1
82	**EPER**	**GBR**	Fiddlers Ferry	EGW{Ele	S_Coa	28	10	5	0.2
83	**EPER**	**ESP**	Escucha	Man{Foo{Mea{Pre	X	28	2	1	0.4
84	**EPER**	**GRC**	Megalopolis	EGW{Ele	X	28	4	3	0.1
85	Platts	ARM	Hrazdan	EGW{Ele	L_FueOil	27	10	4	0.7
86	**EPER**	**GRC**	Opountion	Man{Met{Iro	X	27	3	1	0.7
87	**IEACR**	**CZE**	Ledvice	EGW{Ele	S_CoaLig	27	14	3	26.9
88	**EPER**	**ITA**	San Filippo	EGW{Ele	L	27	6	5	0.4
89	IEACR	ROM	Govora	EGW{Ele	S_CoaLig	27	3	1	0.0
90	**EPER**	**ESP**	Escatron	EGW{Ele	S_Coa	26	0	0	0.1
91	**EPER**	**GRC**	Lavrio	EGW{Ele	G_Nat	26	7	3	0.0
92	IEACR	TUR	Afsin Elbistan	EGW{Ele	S_CoaLig	25	48	10	0.0
93	IEACR	ROM	Brasov	EGW{Ele	S_CoaLig	25	3	1	0.0
94	**IEACR**	**HUN**	Borsod	EGW{Ele	S_CoaSub	25	6	1	3.0
95	**EPER**	**ESP**	Gibraltar	Man{CPN{ReP	X	24	2	2	0.4
96	**EPER**	**GRC**	Amyntaio	EGW{Ele	S_Coa	24	6	5	13.1
97	**IEACR**	**POL**	Lodz	EGW{Ele	S_CoaBit	24	15	3	0.1
98	**EPER**	**ESP**	San Martin	Man{CPN{ReP	X	24	5	2	
99	**EPER**	**GRC**	Thessaloniki/ Dimitrios	EGW{Ele	S_Coa	24	20	14	0.2
100	**EPER**	**FRA**	Gravenchon	Man{CPN{ReP	X	24	5	3	0.1

Table 16. 200 largest SO_2 emitters – whole region (continued).

N	**Source**	**Cou**	**Plant**	**NACEm**	**Fuel**	**SO_2 kt**	**NO_x kt**	**CO_2 Mt**	**PM kt**
101	**EPER**	**ESP**	Soto De Ribera	EGW{Ele	S_Coa	24	9	3	1.0
102	**IEACR**	**POL**	Ostroleka	EGW{Ele	S_CoaBit	23	10	3	0.1
103	**Platts**	**LTU**	Elektrenai	EGW{Ele	L_FuOHea	23	8	3	0.5
104	**EPER**	**IRL**	Tarbert	EGW{Ele	L	23	5	2	0.1
105	**EPER**	**GBR**	Drakelow	EGW{Ele	S_Coa	23	5	2	0.1
106	**EPER**	**ESP**	Almeria	EGW{Ele	S_Coa	23	15	7	0.2
107	**EPER**	**DEU**	Schwedt	Man{CPN{ReP	X	22	4	4	0.2
108	**EPER**	**ITA**	Gela/ Ref	Man{CPN{ReP	X	22	4	4	0.1
109	***IEACR***	***ESP***	Guardo	EGW{Ele	S_CoaBit	22	12	2	0.1
110	**Platts**	**HUN**	Dunamenti	EGW{Ele	L_FuOHea	22	8	3	0.0
111	IEACR	BGR	Maritsa III	EGW{Ele	S_CoaLig	22	20	4	4.5
112	**EPER**	**ESP**	Anllares	EGW{Ele	S_Coa	22	15	0	0.1
113	**IEACR**	**CZE**	Tisova	EGW{Ele	S_CoaLig	22	9	2	12.3
114	**EPER**	**ESP**	Abono	EGW{Ele	S_Coa	22	17	8	0.2
115	**IEACR**	**POL**	Zeran	EGW{Ele	S_CoaBit	22	15	3	0.0
116	IEACR	ROM	Suceava	EGW{Ele	S_CoaLig	22	0	0	0.0
117	**EPER**	**PRT**	Carregado	EGW{Ele	L	20	5	2	0.3
118	**EPER**	**ITA**	Priolo Gargallo N.	Man{CPN{ReP	X	20	4	3	0.2
119	IEACR	RUS	Moscow/22	EGW{Ele	S_CoaBit	20	12	2	52.8
120	**IEACR**	**POL**	Skawina	EGW{Ele	S_CoaBit	20	14	2	0.1
121	**EPER**	**GBR**	Cockenzie	EGW{Ele	S_Coa	20	11	3	0.1
122	**EPER**	**FRA**	Gonfreville/Ref	Man{CPN{ReP	X	20	3	2	0.3
123	**EPER**	**GRC**	Tamynion	EGW{Ele	X	19	2	1	
124	**IEACR**	**POL**	Siersza	EGW{Ele	S_CoaBit	19	16	3	0.1
125	**IEACR**	**HUN**	Banhida	EGW{Ele	S_CoaSub	19	4	1	0.0
126	**IEACR**	**HUN**	Pecs	EGW{Ele	S_CoaSub	19	6	1	4.0
127	**EPER**	**DEU**	Jänschwalde	EGW{Ele	S_Coa	18	17	25	0.3
128	IEACR	BGR	Republica I	EGW{Ele	S_Coa	18	3	1	3.8
129	**IEACR**	**POL**	Krakow Leg	EGW{Ele	S_CoaBit	18	11	2	0.0
130	**EPER**	**ITA**	La Casella	EGW{Ele	L	18	3	2	0.4
131	**EPER**	**GBR**	Fort Dunlop	EGW{Ele	G_Nat	18	0	0	0.0
132	IEACR	ROM	Giurgiu	EGW{Ele	S_CoaLig	18	1	0	0.0
133	**EPER**	**GBR**	Kilroot	EGW{Ele	S_Coa	17	8	3	0.3
134	**EPER**	**GRC**	Kardia	EGW{Ele	S_Coa	17	16	10	0.1
135	**EPER**	**GBR**	Tilbury	EGW{Ele	S_Coa	17	19	5	0.2
136	IEACR	RUS	Moscow/Kashira	EGW{Ele	S_CoaBit	17	11	2	0.0
137	***Platts***	***ITA***	Sicilia	EGW{Ele	L_LigDis	17	7	3	0.4
138	**EPER**	**NLD**	Rotterdam/ Pernis/Shell	Man{CPN{ReP	X	17	5	6	0.3
139	**EPER**	**GBR**	Fawley/Ref	Man{CPN{ReP	X	17	5	2	0.0
140	***IEACR***	***PRT***	Pego	EGW{Ele	S_CoaBit	17	13	3	28.2
141	**EPER**	**ESP**	Los Barrios	EGW{Ele	S_Coa	17	11	4	0.1
142	**EPER**	**ITA**	Piombino	EGW{Ele	L	17	5	3	0.0
143	**EPER**	**DEU**	Lippendorf	EGW{Ele	S_Coa	16	7	10	0.2
144	***IEACR***	***ESP***	Cercs	EGW{Ele	S_CoaBit	16	4	1	6.2
145	Platts	YUG	Kostolac	EGW{Ele	X/_	16	7	1	13.8
146	IEACR	ROM	Paroseni	EGW{Ele	S_Coa	16	4	1	0.0
147	***Platts***	***IRL***	Rhode	EGW{Ele	S_PeaMil	16	3	0	5.3
148	**EPER**	**GBR**	Ratcliffe	EGW{Ele	S_Coa	16	23	9	0.1
149	**EPER**	**GRC**	Nikolaos	Man{Met{PNF{Alu	X	16	1	1	
150	IEACR	RUS	Pervomoisk	EGW{Ele	S_CoaBit	16	10	2	71.8

Table 16. 200 largest SO$_2$ emitters – whole region (continued).

N	Source	Cou	Plant	NACEm	Fuel	SO$_2$ kt	NO$_x$ kt	CO$_2$ Mt	PM kt
151	IEACR	RUS	Severodvinsk	EGW{Ele	S_CoaBit	16	7	1	0.2
152	**EPER**	**IRL**	Aughinish	Man{Che{Bas{Ino	X	16	2	1	0.1
153	**EPER**	**PRT**	Porto Ref	Man{CPN{ReP	X	15	2	1	0.1
154	**IEACR**	**CZE**	Prunerov	EGW{Ele	S_CoaLig	15	40	8	0.4
155	Platts	UKR	Trypilya	EGW{Ele	L_FuOHea	15	5	2	0.4
156	**IEACR**	**SVK**	Vojany	EGW{Ele	S_CoaHar	15	11	3	0.0
157	IEACR	UKR	Dobrotvorsk	EGW{Ele	S_CoaBit	15	12	2	0.0
158	**EPER**	**ESP**	Tarragona Repsol	Man{CPN{ReP	X	15	5	3	0.2
159	**EPER**	**ESP**	Narcea	EGW{Ele	S_Coa	15	12	3	1.9
160	IEACR	BGR	Svishtov	EGW{Ele	S_CoaBit	15	4	1	2.8
161	**EPER**	**ESP**	Castellon/ Ref	Man{CPN{ReP	L	14	1	1	0.3
162	IEACO2	RUS	Kstovo	Man{CPN{ReP	X	14	6	4	0.4
163	**EPER**	**GRC**	Herakleio/Linoperamato	EGW{Ele	L	14	4	1	0.0
164	IEACO2	RUS	Cherepovets	Man{Met{Iro	X	14	11	12	3.0
165	Platts	BLR	Polotsk	EGW{Ele	L_FuOHea	13	5	2	0.3
166	**IEACR**	**SVN**	Ljubljana	EGW{Ele	S_CoaLig	13	3	1	2.2
167	IEACO2	UKR	Krivoi Rog	Man{Met{Iro	X	13	11	12	2.9
168	**EPER**	**ITA**	Brindisi/ Federico	EGW{Ele	X	13	8	15	
169	**IEACR**	**POL**	Jaworzno	EGW{Ele	S_CoaBit	13	25	7	0.2
170	IEACR	UKR	Kramatorsk	EGW{Ele	S_CoaBit	13	8	1	11.3
171	**EPER**	**ESP**	Lada	EGW{Ele	S_Coa	13	6	2	18.2
172	**EPER**	**FRA**	Emile Huchet	EGW{Ele	S_Coa	13	5	2	7.7
173	**EPER**	**ITA**	Augusta	Man{CPN{ReP	X	13	3	2	0.1
174	**EPER**	**PRT**	Sines	Man{CPN{ReP	X	13	4	1	0.2
175	IEACR	RUS	Vladimir	EGW{Ele	S_CoaBit	13	7	1	0.0
176	**EPER**	**ITA**	Milazzo	EGW{Ele	S_Coa	13	0	1	12.8
177	IEACO2	RUS	Kirishi	Man{CPN{ReP	X	13	6	4	0.0
178	IEACR	ROM	Iasi	EGW{Ele	S_CoaLig	12	3	1	0.0
179	***Platts***	***ESP***	Santurce	EGW{Ele	L_FuOHea	12	4	2	0.3
180	IEACO2	RUS	Novo Lipetsk	Man{Met{Iro	X	12	10	11	2.7
181	**EPER**	**FRA**	Le Havre	EGW{Ele	S_Coa	12	10	3	0.1
182	**EPER**	**ITA**	Genova	EGW{Ele	S_Coa	12	5	2	0.8
183	**IEACR**	**POL**	Konin	EGW{Ele	S_CoaLig	12	26	4	0.1
184	IEACR	TUR	Kemerkoy	EGW{Ele	S_CoaLig	12	22	4	0.8
185	IEACR	ROM	Borzesti	EGW{Ele	S_CoaLig	12	1	0	0.0
186	**EPER**	**BEL**	Ruien	EGW{Ele	S_Coa	12	8	3	0.1
187	IEACR	RUS	Apatity	EGW{Ele	S_CoaBit	12	6	1	47.0
188	***Platts***	***ESP***	Cartagena/Escombreras	EGW{Ele	L_FuOHea	12	4	2	0.3
189	**EPER**	**ITA**	Sarroch	Man{CPN{ReP	X	12	5	6	0.2
190	**EPER**	**FRA**	Fos Sur Mer/Iron	Man{Met{Iro	X	12	8	2	1.3
191	**Platts**	**HUN**	Tisza	EGW{Ele	L_FuOHea	12	4	2	0.3
192	IEACO2	UKR	Kremenchug	Man{CPN{ReP	X	12	5	3	0.3
193	IEACO2	RUS	Ryazan	Man{CPN{ReP	X	12	5	3	0.0
194	**EPER**	**ITA**	Venezia/ Mal	EGW{Ele	X	12	7	5	
195	**IEACR**	**POL**	Wroclaw	EGW{Ele	S_CoaBit	11	7	2	0.1
196	Platts	RUS	Dzerzhinsk	EGW{Ele	L_FuOHea	11	4	2	0.3
197	Platts	GEO	Gardabani	EGW{Ele	L_FuOHea	11	4	2	0.3
198	**EPER**	**BEL**	Antwerp/Esso	Man{CPN{ReP	X	11	3	2	0.2
199	**EPER**	**FRA**	La Mede	Man{CPN{ReP	X	11	2	1	0.1
200	**EPER**	**FRA**	Petit Couronne	Man{CPN{ReP	X	11	1	1	0.1

It is well known that a great part of the emissions of acidifying air pollutants comes from a relatively small number of point sources, primarily coal-fired power stations. In this study it is estimated that the hundred largest sources alone emit more than seven million tons of sulphur dioxide, which is about 43 per cent of the total European emissions in 2001.

Of the hundred largest sulphur emitters, eighty-nine are power stations, and seventy of these are coal-fired. Moreover, it is demonstrated that around ninety per cent of the sulphur emissions from power plants come from those commissioned before 1987.

When ranking the power stations by increasing emissions of sulphur and nitrogen oxides per useful output, it is shown that a large number of plants already in operation have flue-gas pollutant concentrations that are much lower than the limit values set for new post-2003 installations in the EU large combustion plants directive.

This study has been commissioned by the Swedish NGO Secretariat on Acid Rain as a contribution to the debate on the forthcoming review and revision of the EU directive on emissions of air pollutants from large combustion plants.

The Swedish NGO Secretariat on Acid Rain

The essential aim of the Swedish NGO Secretariat on Acid Rain is to promote awareness of the problems associated with air pollution, and thus, in part as a result of public pressure, to bring about the needed reductions in the emissions of air pollutants. The aim is to have those emissions eventually brought down to levels – the so-called critical loads – that the environment can tolerate without suffering damage.

In furtherance of these aims, the secretariat

❑ Keeps up observation of political trends and scientific developments.

❑ Acts as an information centre, primarily for European environmentalist organizations, but also for the media, authorities, and researchers.

❑ Produces information material.

❑ Supports environmentalist bodies in other countries in their work towards common ends.

❑ Participates in the lobbying and campaigning activities of European environmentalist organizations concerning European policy relating to air quality and climate change, as well as in meetings of the Convention on Long-range Transboundary Air Pollution and the UN Framework Convention on Climate Change.

The work of the secretariat is largely directed on the one hand towards eastern Europe, especially Poland, the Baltic States, Russia, and the Czech Republic, and on the other towards the European Union and its member countries.

As regards the eastern European countries, activity mostly takes the form of supporting and cooperating with the local environmentalist movements. Since 1988, for instance, financial support has been given towards maintaining information centres on energy, transport, and air pollution. All are run by local environmentalist organizations.

The Secretariat has a board consisting of one representative from each of the following organizations: Friends of the Earth Sweden, the Swedish Anglers' National Association, the Swedish Society for Nature Conservation, the Swedish Youth Association for Environmental Studies and Conservation, and the World Wide Fund for Nature Sweden.

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