Assessment of the Effectiveness of European Air Quality Policies and Measures

B4-3040/2003/365967/MAR/C1

FINAL REPORT ON TASK 3.1 & 3.2 Databases

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1. EXECUTIVE SUMMARY OF THE TASK 3.1 & 3.2 DATABASES

The objective of Task 3.1 was to create a database summarising the main lessons to be learned from existing *ex-post* evaluations, while Task 3.2 required the establishment of a database which allows comparison of ambient air quality standards, emission limits and product standards (for motor vehicles and fuel quality) in various countries. These two databases have been created and are accessible on Internet page: http://www.dmu.dk/AtmosphericEnvironment/Expost.

The two databases are referred to as the "Studies database" (Task 3.1) and the "Standards database" (Task 3.2). They share a common interface so both databases are searched simultaneously. Both databases are intended to be tools for the Commission to continue to work with. The technical report provides an explanation of how both external users and administrators can use the database.

1.1. The Studies database

To create the content of the Studies database, the project team reviewed 44 existing studies. The team focused on existing studies which were of relevance for the case studies created under Task 3.2. The database is not strictly confined to studies with *ex-post* analyses. Various *ex-ante* studies and other studies were reviewed and included in the database, because they were considered to have a potential value for the case studies or the contract in general.

For each study the database contains a *summary* of the study and a note on the *findings and main lessons learnt*. The database allows a person interested in particular problems to find a few relevant studies through the search facility of the database, look at the reviews in the database, and eventually go to the full text of a particular study.

In general, air quality management programmes have been studied more intensively with *ex-ante* and *ex-post* studies in the US than in the EU. In the EU, it is noticeable that *ex-post* studies have not been conducted systematically, and only provide scattered information on various country-level programmes. **The team recommends more widespread use of *ex-ante* studies before new legislation is introduced, and of *ex-post* studies to follow up on the effect of such new legislation.**

Although pollution taxes or tradable permits are often presented as alternatives to direct regulation, they will in practice almost always be embedded in a mix of instruments, in which standards, voluntary agreements and/or other instruments may also be involved.

1.2. Standards database

The Standards database enables a user to compare air quality standards between various countries, and to retrieve certain other kinds of factual information, including:

- air quality standards in a range of countries;
- emission limit values within certain sectors and countries;
- standards related to vehicle emissions and fuel quality;
- emission targets (ceilings) for various pollutants in a range of countries;
- information on compliance in respect to EU directives;
- Internet links of relevance in respect to air pollution standards, air pollution *ex-post* studies, emission standards etc.

Concerning air quality standards, EU values are in all cases stricter than the corresponding US values (except that EU has not yet any limit value for $PM_{2.5}$). Switzerland has even stricter standards than the EU.

Concerning standards for vehicle emissions, standards have become progressively stricter over the past twenty years, both in EU and in the US. Generally, the US has taken the lead with the strictest standards.

One lesson to be learned from the Standards database is that it is difficult, sometimes impossible, to compare standards since frequently the reference conditions are dissimilar. For example, in the EU, emission limit values for particulate matter in the cement industry values are defined in terms of *pollutant mass per unit of exhaust gas* (mg/Nm^3), whereas in the US values are expressed as *pollutant mass per unit of raw material* (kg per ton of feed to the kiln).

2. INTRODUCTION

This technical report provides an overview of the databases developed during the project *Assessment of the effectiveness of European air quality policies and measures*. There are two databases (pertaining to task 3.1 and 3.2 as defined in the Terms of Reference), but because they share a common interface and are closely connected, we will to some extent discuss them together; often, we will simply refer to them as "the database".

The overview in the present report is structured in three main sections which consider the following aspects of the database:

- Contents of the databases; summary and findings;
- Use of the database by an external user;
- Use of the database by an information provider (administrator). The section gives an overview, while more details can be found in a guide: *How to enter content into the database with Studies and Standards,* included as an annex to the present report.

Anybody who wishes to retrieve information from the databases can find it on the Internet through the page: http://www.dmu.dk/AtmosphericEnvironment/Expost/.

More details on the use of the database are presented in Section 4.

3. OVERVIEW OF DATABASES: CONTENTS AND SUMMARY OF FINDINGS

There are two main parts of the database, one of them referred to as the "Studies database" (task 3.1), and the other as the "Standards database" (task 3.2).

3.1. The Studies database

The Studies database comprises information on existing *ex-post* studies and reports. The project team has reviewed 44 existing studies, and has made the information from the reviews available in the database.

The team has mainly focused on existing studies which were of relevance for the case studies conducted under task 3.2. The database has not been strictly confined to studies with *ex-post* analyses. Various *ex-ante* studies and other studies have also been reviewed and included in the database, because they were considered to have a potential value for the case studies or the subject of the contract in general. Information extracted during the reviews has been used in the case studies.

A list of all studies in the database is included as Annex IIa (a brief list) and Annex IIb (a version with summaries etc.).

The distribution of countries considered by the studies is shown in *Table 1* (a study may concern more than one country).

Table 1. Countries represented in the 44 studies.

Any	2
Europe	18
France	4
Germany	4
Japan	1
Other	1
Sweden	4
Switzerland	1
The Netherlands	3
UK	7
USA	22
Total	67

An example of the information in the database is depicted in ***Figure 1***. The figure shows all information concerning one particular study. Note that there is a section with *recommendations* from the study, a *summary* of the study, and a note on the *findings and main lessons learnt*. Annex IIb presents this information for all studies.

Countries:	USA
Pollutants:	Nitrogen oxides, VOC
Measures:	Any other measures
Sectors:	Transport

Study title	**Evaluating Vehicle Emissions Inspection and Maintenance Programs**
Web availability	http://books.nap.edu/books/0309074460/html/index.html
Publication year	2001
Authors	US National Research Council
Bibliographic information	
Commissioner	U.S. Environmental Protection Agency
Period	
Other countries	
Other pollutants	
Policies and measures	Vehicle Inspection and Maintenance
Criteria	Emissions reductions, cost-effectiveness, administrative ease.
Methodologies	Literature review
Economic analysis	From existing analysis
Recommendations	The Committee made the following recommendations: 1) the Environmental Protection Agency and States should expect lower emissions reduction benefits from I/M programs as currently configured; I/M programs should focus primarily on identification, diagnosis, and repair of the highest-emitting vehicles and verify those repairs; I/M programs that target NOx and PM might have to incorporate heavy-duty diesel vehicles to a greater extent; remote sensing should have an increased role in assessing motor vehicle emissions and I/M programs; and I/M programs can be improved by identifying ways to make them more cost-effective and more readily understood and by easing the testing burden for vehicle owners.
Summary	The U.S. National Research Council conducted a review of inspection and maintenance programs in the U.S. The review considered passenger-car and light-truck emissions, reviewed the effectiveness of these programs, and provided some initial recommendations for means to improve the programs effectiveness.
Findings	The Committee found that inspection and maintenance programs have generally achieved smaller emissions reductions than those estimated by models due to overestimation of the deterioration of vehicle-emissions performance, inadequate representation of the behavior of motorists and mechanics, overestimation of compliance with the program and effectiveness of repairs, overestimation of the ability to identify high-emitting vehicles, and incomplete implementation of some components of I/M programs. They found that a small fraction of the fleet contributes a substantial proportion of overall vehicle emissions—typically less than 10% of the fleet contributes more than 50% of emissions. They also found that many critical factors that have large effects on the emissions reduction benefits of I/M programs are still unknown. The Committee found that remote-sensing measurements are an excellent source of fleet-average CO and HC emissions data.

Figure 1 Example of an entry in the Studies database - a review of a study.

In the present report, we present some general observations and conclusions. Note however, that there is more information available in the database. Most of the studies contain detailed information pertaining to a particular context. The added value of the database is that it allows a person interested in particular problems to retrieve a few relevant studies using the search facility of the database, look at the reviews in the database, and eventually go the full text of a particular study if that seems warranted.

A difficulty in synthesizing the reviews is that the lessons to be learned often cannot easily be generalised; it is frequently the case that the studies reviewed concern the use of a certain mixture of instruments in a specific context, and often the outcome of a policy depends heavily on the details of its implementation and the context it is applied in.

In the following sections, we will highlight some lessons to be learned from the studies considered. Further, we will point to some central studies that deserve attention because they contain valuable reference information.

3.1.1. More ex-post studies are desirable

One overall conclusion from the process of establishing the Studies database concerns the amount and character of studies found. We found that air quality management programs have been studied more intensively with *ex-ante* and *ex-post* studies in the US than in the EU. For the EU it is very pronounced that *ex-post* studies have not been conducted systematically, but provide scattered information on various programs. The team has had particular difficulty in finding *ex-post* studies with information on the economic consequences of air quality policies and measures in Europe.

It would seem to be desirable with a more widespread use of *ex-ante* studies before new legislation is introduced, and with *ex-post* studies to follow up on the effect.

3.1.2. Central sources of comparative studies

Most of the studies that were reviewed are focused on either European or US conditions. There are some, however, which make comparisons across the Atlantic.

Very noteworthy in this context is a book edited by Harrington, Morgenstern and Sterner (2004) entitled *Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe.*

This book is so recent that it was not available physically at the time of writing, but the team has had access to drafts of chapters from the book. These chapters represent individual studies, some of which have been reviewed and included in the database.

The book contrasts the approach of direct regulation on one side of the Atlantic, versus incentive policy on the other. For example, Germany's direct regulation of SO_2 emissions is compared with an incentive approach in the United States (in a study by Wätzold – see below).

The book represents a valuable collection of experiences and analyses. It can be recommended for its excellent balanced discussions on economic incentives versus command-and-control policies. Even though the book attempts to present "clean" comparisons between distinct policies (economic incentives vs. command-and-control), it emphasises that policy instruments in the real world are complex and represent mixtures between the various categories of instruments.

Another central study with comparisons between countries is a study for DG Enterprise by Watkiss et al. (2004) - *A Comparison of EU Air Pollution Policies and Legislation with Other Countries. Review*

of the Implications for the Competitiveness of European Industry. This study concludes that there is very limited evidence for significant competitiveness effects resulting from EU air pollution legislation on a general level. The report further contains a range of interesting observations.

Another central comparative study is an article by Menz and Seip (2004). This paper considers how policies addressing acid rain in Europe and the United States have evolved over the past thirty years. The paper discusses also the emergence of acid rain as an environmental concern, scientific evidence about the effects of acidic deposition on natural ecosystems, US and European acid rain control policies, studies of the costs and benefits of reducing acid rain, and different policy contexts in Europe and the United States.

The critical load concept is used in Europe and not in the USA, where economic instruments have been used more extensively. It is envisaged that use of cost-benefit analysis to determine appropriate levels of reductions probably will increase, but not play a decisive role, since uncertainties in various steps will continue to be large in the foreseeable future and use of cost-benefit analysis to formulate pollution control targets remains controversial. The interaction between pollutants leading to more severe effects is important, and should be considered in scientific and economic assessments and in policy formation.

3.1.3. Ex-ante studies tend to overestimate costs

A common finding repeated in many studies is that the costs associated with environmental regulations are normally overestimated in *ex-ante* estimates before regulations are implemented. This is a major topic in one of the few European *ex-post* analyses that contains economic assessments, namely the study published by the Stockholm Environment Institute (1999). It also appears in several other studies such as a US study on sulphur emission trading by Carlson et al. (2000).

3.1.4. Market-based incentives versus command-and-control

Many of the US studies reviewed concern emissions trading. Generally, the US studies claim that this policy has been a success, especially in relation to monitoring of compliance, administrative feasibility and low administrative cost (e.g. Ellerman, 2003: *Are Cap-and-Trade Programs more Environmentally Effective than Conventional Regulation?*).

European studies sometimes consider that the command-and-control approach is more efficient. One instance of this is the German policy on SO_2 emissions as analysed by Wätzold (2004; in the book edited by Harrington et al., see above). Wätzold concludes that the German command-and-control instrument was most probably the best choice in terms of efficiency compared to other economic instruments. This was mainly because the policy aim was to reduce SO_2 emissions to a very high extent as soon as possible. Such an ambitious objective could be achieved only if all the sources reduced their emissions to the extent that was technologically feasible, leaving little room for differentiation.

Wätzold notes as a (possibly simplified) generalisation that economic instruments are to be preferred in terms of cost minimisation when the aim is to reduce emissions to a *medium* extent; otherwise – if either a very small or a very large emission reduction is required – command and control instruments are equal or even to be preferred.

He finally concludes that the case study on SO_2 policies in Germany contradicts some of the traditional economists' views on the efficency of environmental policy instruments. He sees the study as a reminder of the dangers of prejudiced generalisation when assessing environmental policy instruments, and of the need for a detailed analysis of each policy.

Overall, in the studies reviewed within the present project, there are many analyses of both command-and-control approaches, and of the effect of economic incentives.

There is no indication that one of these approaches should be abandoned in favour of the other. Both can be applied with success. Experiences with both types of instruments are mixed, and often the outcome of a policy depends heavily on the details of its implementation and the context it is applied in.

Thus, a relatively trivial recommendation coming from the work with studies is that a mixture of instruments should be applied.

3.1.5. Taxation as a supplement to command-and-control

Another very interesting study in the book edited by Harrington et al. is one by Millock and Sterner (2004).

Sweden and France have charges/taxes as supplementary instruments to command-and-control to control emissions of nitrogen oxides (NOx) from energy sector and industry boilers. The revenues from the Swedish charge are automatically recycled through payments to industry based on the energy produced. France has a tax applied to four different categories of air pollution, but at a much smaller level (about 1% of the Swedish) and with different criteria for refunding of the tax revenues.

Taxation generates funding, while trading with free allocation does not. Such funding can be used to compensate losers from taxation, and it can also be used to reinforce the effectiveness of the tax. The NO_X tax applied in Sweden is very high, and therefore has strong environmental effectiveness. Industry is willing to pay such a high rate of tax because the funds generated are recycled back to the industry which pays the tax, with those being most energy efficient getting the largest refunds. Where meeting a target is a high priority, then cap and trade emissions trading is preferable to taxation, because the polluter wishes to avoid the high losses expected if the target is missed. Conversely, if we are relatively indifferent about meeting a specific target, then taxation is likely to be more efficient.

A wide variation in abatement costs at the margin is important if emissions trading is to maximise its effectiveness. This means that emissions trading does not combine well with individual facility permit licensing, where every installation is required to install best available technology. Such a provision eliminates many of the potential gains from trade.

It is concluded in the paper that a charging/taxation system can be a useful supplement to command and control regulation. The level of charge/tax should be set in each case. It is important to ensure that the money will be returned to the most effective firms. Monitoring systems are important for fine-tuning of the plant operation and for documentation of the emissions.

3.1.6. Policy options

Notable studies with useful findings on policy options are the studies conducted in the framework of the research project IMPOL (*The implementation of EU environmental policy: Efficiency issues*) by Glachant et al. (two references in the database, both from 2000).

The central lesson of the IMPOL studies is that the implementation of EU legislation is not a top down process, but rather a piece in a complex dynamic of parallel policy processes. To efficiently cope with such pervasive interactions, implementation needs to be "adaptive". This adaptiveness means:

- To promote flexibility by avoiding to over-specify the means to the policy goals. This pleads for the use of economic instruments and 'bubble' approaches where firms are given maximal freedom regarding abatement choices.
- To promote integration with parallel environmental measures; here, the message is to think in terms of environmental policy mix in order to exploit the synergies, and to avoid contradictions between different policy components. Integration may also help to reduce policy uncertainty, which is a typical by-product of policy interactions. Uncertainty has a very detrimental effect on compliance leading to 'wait and see' behaviour due to the fact that compliance usually entails irreversible investments.

Information on economic incentives can be found in various papers. We would like to draw attention to a short, but useful guidance document associated with the Gothenburg protocol called *Guidance document on economic instruments to reduce nitrogen oxides, sulphur, volatile organic compounds and ammonia* (UNECE, 1999).

In the document, the experiences gained in the use of four economic instruments (tradable permits and quotas; emission and process taxes/charges; product charges and tax differentiation; subsidies and fiscal facilities) have been reviewed based on national expertise and scientific literature. These experiences have been condensed into tables in the guidance document. A central table shows the main features and aspects of the four categories of economic instruments that are likely to be the most relevant in a given context. The performance of each instrument is assessed against a number of criteria, and some important issues in the design of the instruments are outlined.

From the findings can be noted:

a) Economic instruments will have their optimal effect in cases where the market mechanism functions well. Therefore, it is necessary to check whether the actors who will be directly or indirectly affected by the instruments operate on (at least) reasonably competitive markets and have access to the information needed for their decision-making. It may be necessary to accompany (or precede) the introduction of an economic instrument with policies that improve the functioning of markets and the availability of information on emission reduction options and environmental benefits;

b) Although pollution taxes or tradable permits are often presented as alternatives to direct regulation, they will in practice almost always be embedded in a mix of instruments, in which also standards, voluntary agreements and/or other instruments may be involved. When introducing an economic instrument it should be checked that the various instruments will be mutually reinforcing rather than counteracting;

c) Taxes and charges can have an incentive function and/or a revenue-raising function. The incentive function can be realized directly by making abatement efforts profitable or indirectly through reaction in the market (due to the cost increase being passed on to consumers);

d) Preferably, economic instruments (especially taxes and charges), like other instruments, should be announced well in advance of their starting date and should involve consultations with stakeholders. This will enable producers and consumers to take account of the instrument in their investment decisions and to react optimally to the changed market conditions, thus improving overall efficiency. However, for some product taxes, the announcement may also lead to stockpiling.

A comprehensive US study on economic incentives is the report *The United States Experience with Economic Incentives for Protecting Environment* (National Center for Environmental Economics – NCEE, 2001). This study reviews a wide range of economic incentive programs. The report examines

cost effectiveness and overall efficacy of various incentive strategies including charges, fees and taxes, deposit refund systems, marketable permits, subsidies, liability, information disclosure and voluntary actions.

The report includes cost comparison of command-and-control approaches vs. incentive-based approaches for a number of different pollution types. Dozens of applications of economic incentives are discussed in the report but there are hundreds more.

The report concludes that there are four advantages to using economic incentives:

- They provide a unique contribution to environmental management. In many cases incentives generate benefits beyond what is possible with traditional regulations; sometimes they are applied where traditional regulations might not be possible;
- They can achieve reductions at a lower cost;
- They have wide applicability to a variety of different sources;
- They can promote technological development.

The report is designed to be utilised to help identify the best incentive-base policy approach to apply to a given problem.

3.1.7. Central reports on state and trends

In the process of assessing air pollution policy it is indispensable with good background information on the state and trends within air pollution. An excellent resource for such background information is the report published by the EEA *Air Pollution in Europe, 1990-2000* (Larssen et al., 2004).

This report provides an overview and analysis of the air pollution situation in Europe in the year 2000 and the preceding decade, based on indicators for underlying sectoral driving forces, emissions, air quality, deposition and the effectiveness of policies and measures. The report answers the following questions:

- How are driving forces of air pollutant emissions developing, and what progress has been made in reducing air pollutant emissions in Europe?
- What is the state of air quality in Europe in 2000? Is it developing in line with the decreasing pollutant emissions?
- How are policy measures affecting the air pollution problems?

A somewhat similar resource of information, but for the US, is an EPA report - *National Air Quality and Emissions Trends Report* (EPA, 2003). The report provides a comprehensive collection of facts on trends of emissions and air quality. Also, a series of policy-relevant studies and exploratory analyses are summarized in this report.

Another central resource of information concerning US air quality is a National Research Council Report *Air Quality Management in the United States* (National Research Council, 2003). The report was prepared by the Committee on Air Quality Management. This committee was formed by the National Research Council to examine the role of science and technology in the implementation of the Clean Air Act, and to recommend ways in which the scientific and technical foundations for Air Quality Management in the United States can be enhanced. Over a 2-year period, the committee heard briefings from experts and stakeholders and examined the operation, successes, and limitations of the many components of the nation's air quality management system. The report presents an overview and evaluation of air quality management in the past, and provides recommendations on air quality management in the future.

3.1.8. Use the database!

The findings presented in the above sections do by no means cover everything in the database. The reader is advised to use the search facility of the database:
http://www.dmu.dk/AtmosphericEnvironment/Expost/ in order to make further use of the information contained in the database.

It should be noted that a backup copy of most of the external source material exists. The database refers to many reports located on the Web. In order to safeguard such material in case links are broken, a CD with backup is kept (see Section **5.2.1**).

3.2. Standards database

The second main part of the database is the so-called "Standards database", which is – i.a. – helpful when a user wishes to compare air quality standards between various countries.

More specifically, the database contains information of the following types:
- air quality standards in a range of countries;
- emission limit values within certain sectors and countries;
- standards related to vehicle emissions and fuel quality;
- emission targets (ceilings) for various pollutants in a range of countries;
- information on compliance in respect to EU directives;
- Internet links of relevance in respect to air pollution standards, air pollution *ex-post* studies, emission standards etc.

The database contains facts, figures and comparative tables as well as references to where the relevant information can be found. When it comes to analyses of how and why standards have developed over time etc., the reader is referred to the case studies – in particular to the Annexes of the case studies.

In the database, it has been attempted to the largest extent possible to provide tables that allow comparisons between standards in various countries. However, it must be understood that very often it is not feasible to produce such comparative tables. Often, differences in the definition of standards preclude a comparison. As an example, in the case of cement industry, emission limit values for particulate matter are defined in entirely different ways in the EU and in the USA. In the EU, values are defined in terms of *pollutant mass per unit of exhaust gas* (mg/Nm^3), whereas in the US values are expressed as *pollutant mass per unit of raw material* (kg per ton of feed to the kiln). Thus, in this case a comparison between EU and US is not feasible

As another difficulty, very often emission limit values or other standards are defined according to *different reference conditions*. E.g. for motor vehicle emissions, different test cycles are applied in US and in Europe. Furthermore, in the US a system of "bins" is used so that a car manufacturer can produce car models with quite different emission characteristics, while the emission limit value refers to an *average* value for each manufacturer. In such cases with different reference conditions, it may sometimes be possible to produce comparative tables, but they have to be interpreted with caution.

Difficulties such as these are well recognised in other attempts to provide comparisons of standards.

The way these difficulties have been handled in the database is to provide comparative tables wherever possible, but in any case – no matter whether a table can be produced – to provide central references, so that persons interested in pursuing specific questions can find relevant source material.

The database has a structure where the information – explanatory comments, comparison tables, references etc. – is contained in *reference documents*. These reference documents can be searched and retrieved through the Web interface of the database as described in Section 4.

In the following subsections, we will present and discuss some information extracted from the database, with particular focus on comparisons between countries. It should be recognised that the database covers a wider range of topics than those discussed in the following.

3.2.1. Air quality standards

The reference document *Air quality standards* compares air quality standards in the EU, USA, Switzerland, Japan, China and WHO guidance values. The document is included as Annex III. Many of the limit values are not directly comparable, because although the averaging time may be the same, the various countries allow a different number of exceedances. As an example we can consider the 24-hour average limit value for PM_{10}. In the EU, the value of this parameter is 50 $\mu g/m^3$; this value may be exceeded 35 times per year in 2005, but only 7 times per year in 2010. In the US, the limit value is 150 $\mu g/m^3$, and it may be exceeded *only once* per year.

In order to compare such limit values in a proper way, one will have to consider frequency distributions of observed concentrations. However, frequency distributions will have different characteristics depending on the characteristics of the sources. Are there many small sources (resulting in a relatively uniform time series of concentrations) or a few large point sources (resulting in a time series with significant peaks)? If we are in one location, a limit with 7 allowed exceedances might be the strictest, while the other limit may be strictest if we are in a different location.

Altogether, it is not possible to make a simple translation between a limit value with 7 allowed exceedances per year and a limit value with only one allowed exceedance. However, in the case at hand (the US value of 150 versus the EU value of 50), the difference in values between EU and the USA is very large. In view of the structure that characterises observed frequency distributions, in this case it can be safely stated that the EU limit value by 2010 is more strict than the current US value.

The concept of allowing exceedances instead of prescribing an absolute limit value is sound, but it does make comparisons difficult when various countries use differing definitions.

Another problem when comparing air quality limit values concerns measuring strategy: It makes a large difference whether compliance is required everywhere or just at, e.g., urban background monitoring stations.

In order to make comparisons between countries, *limit values for annual averages* are of obvious interest, because almost all countries have such limits. It appears from the table in the reference document that comparisons between other parameters are possible, but not for so many countries at one time.
The reference document on air quality standards displays a set of graphs where air quality standards for annual averages are compared among different countries. These are reproduced in *Figure 2*.

It is seen that the EU limits are stricter that US limits for all the parameters shown in *Figure 2* – except for $PM_{2.5}$, for which there is no EU limit value. An explanation for this may be that EU values were more recently updated.

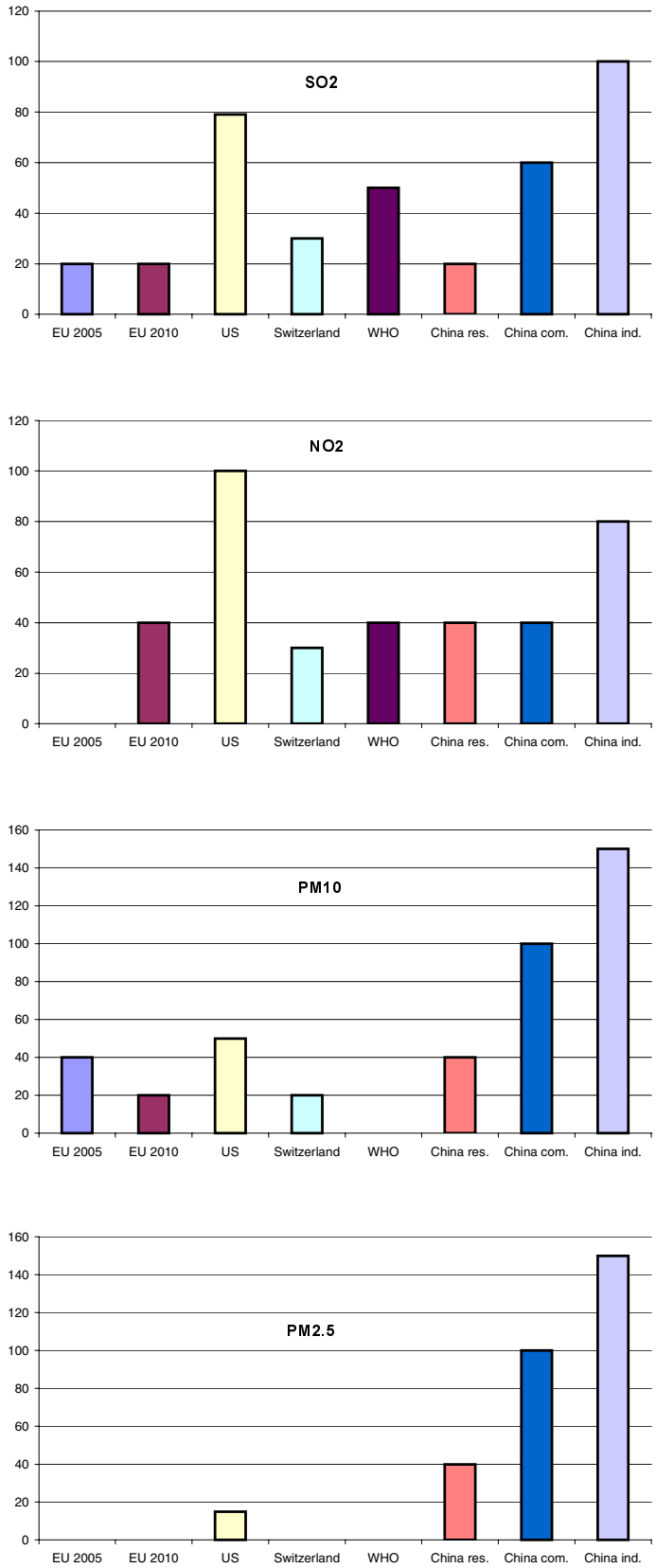


Figure 2 Comparison of air quality limit values for *annual averages* for various regions. Unit µg/m^3.

Swiss air quality values are even more strict than EU values. This is not the case for the annual average for SO_2, but for NO_2, as well as for the 24-hour average of SO_2 (Switzerland allows only one exceedance of the limit 100 µg/m^3, while EU allows 3 exceedances of 125 µg/m^3).

China makes a distinction between different areas (residential, commercial, industrial). In residential areas limits are similar to EU limit values, while much more pollution is allowed in Chinese industrial areas.

It appears from the tables in Annex III that that EU air quality limit values are generally stricter than US values – also for other parameters than annual averages.

A comparison of standards for ozone is displayed as *Figure 3*. Some countries have standards for 8-hour averages, and some for 1-hour averages. There are graphs for both of these parameters.

For the 8-hour-average, 120 µg/m^3 is a target value in the EU for 2010, to be understood in the following way: For each day, calculate the largest running 8-hour average during the day, and assign that value to the day. As an average over three years, there should be no more than 25 days per year with larger values that 120 µg/m^3. Further, as a long-term objective for 2020, this value of 120 µg/m^3 should be exceeded no more than 1 day per year.

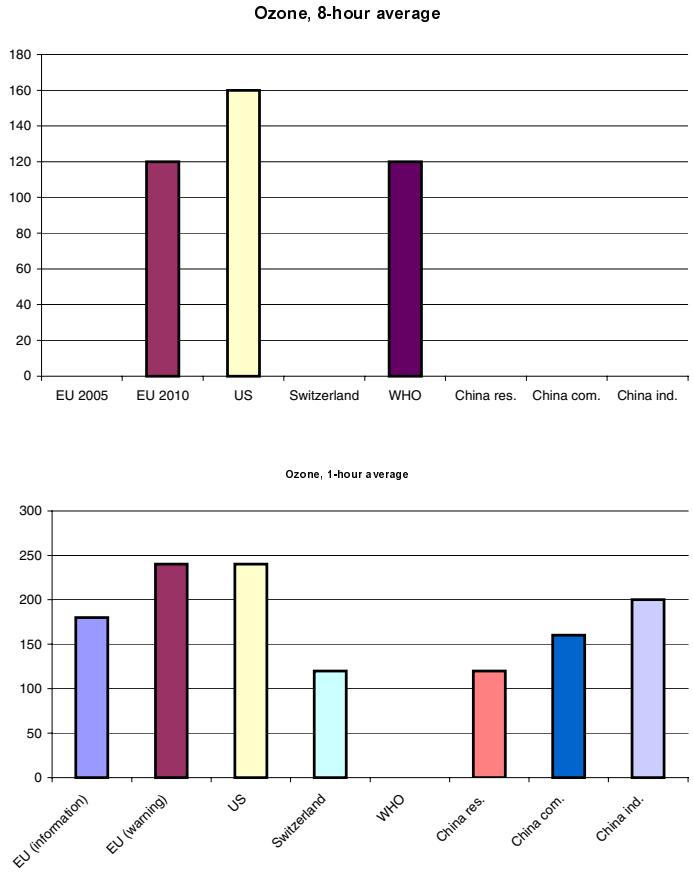


Figure 3 For ozone, there are no air quality standards concerning yearly averages, but there are limit values for several other parameters. This graph displays air quality standards/target values for 8-hour averages (on top) and for 1-hour averages (bottom). Unit µg/m^3. There is further explanation in the text.

The EU values concerning 1-hour averages are, respectively, an information threshold (180 $\mu g/m^3$) and a warning threshold (240 $\mu g/m^3$). For a warning to be issued, the value must be exceeded during three consecutive hours.

Switzerland has a standard of 120 $\mu g/m^3$ as a 1-hour average. This standard is much harder to comply with than the EU target value of 120 $\mu g/m^3$ as an 8-hour average. There are two reasons for this:

1. The Swiss value is a 1-hour average while the EU value is an 8-hour average. An 8-hour value (EU) will always be higher than the highest 1-hour average.
2. The EU value allows for 25 days with exceedances in 2010 and 1 day in 2020, while the Swiss value allows only one exceedance.

The Swiss value is not complied with at present.

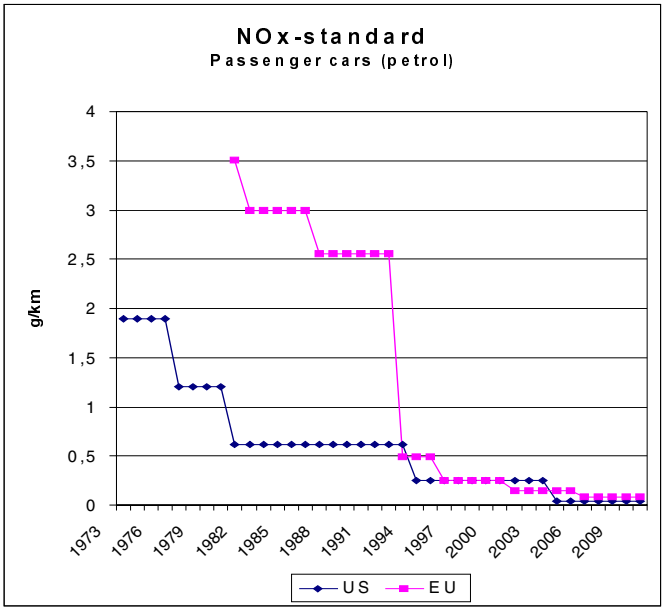
3.2.2. Emission limit values for vehicles

Graphical presentations of a few, selected emission standards for vehicles are shown below.
Vehicle emission standards is a very complicated issue. Comparisons are difficult, because an emission standard in two countries may be based on two different test cycles and may vary in other respects. Thus, the comparisons in the graphs should be taken with caution. For a full appreciation of the reference conditions etc., it is highly recommended to consult in the first place the reference document *"Vehicle emission standards: Values"* in the data base, and in the second place consult the references indicated in that document.

NO_X
In *Figure 4* emission limit values for NO_X are presented, for both petrol passenger cars and for diesel engines.

When comparing the standards it should be considered that the US standards for passenger cars uses a system of "bins" where the NOx value varies between 0.0 and 0.13 g/km. The system implies that a car manufacturer can produce car models with quite different emission characteristics, while the emission limit value refers to an *average* value for each manufacturer.

It is seen from *Figure 4* how the limit values are step-wise reduced over time, both in the EU and in the USA – normally with US taking the lead.



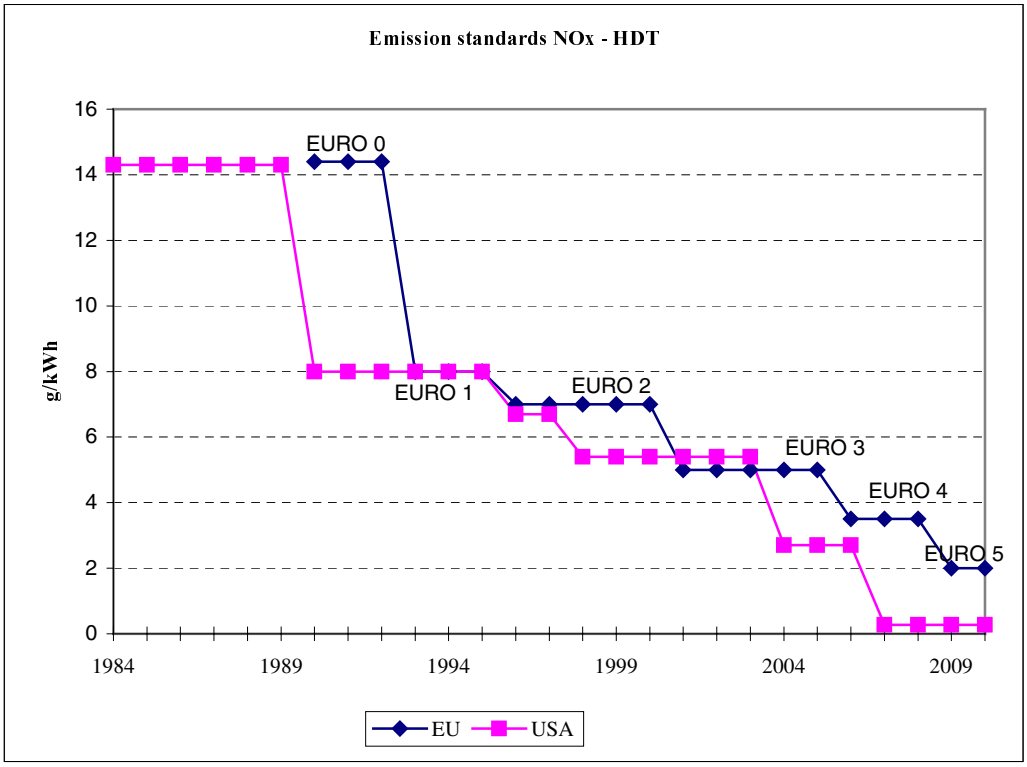
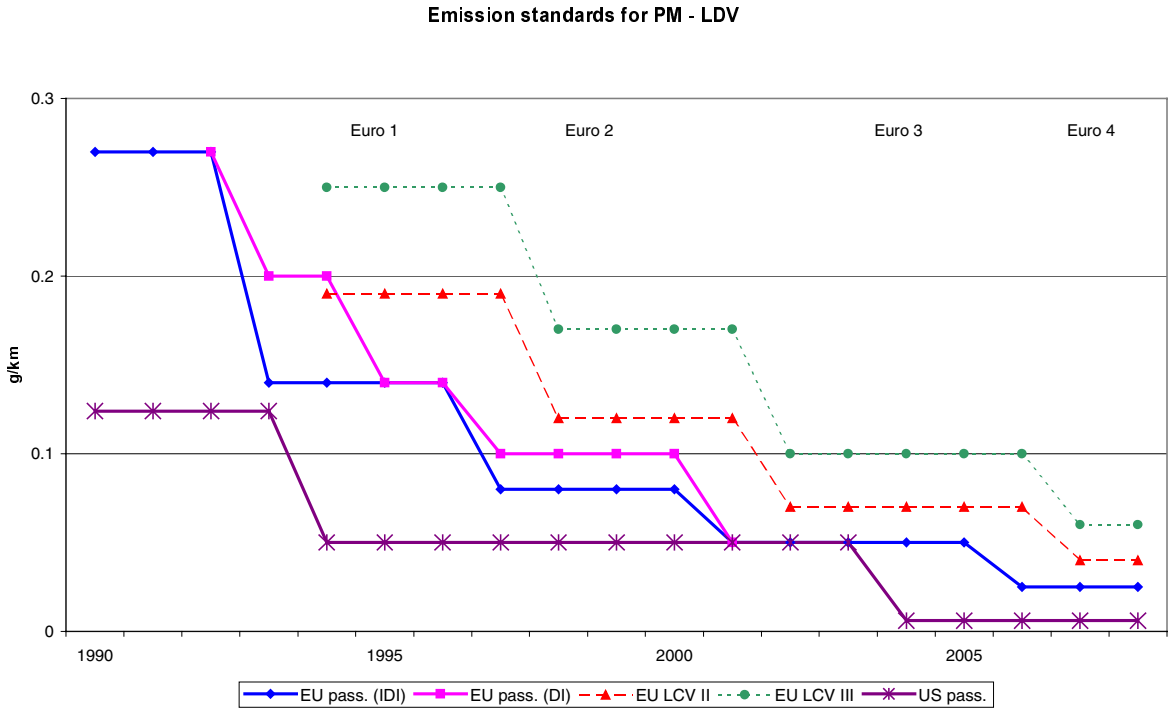


Figure 4 Emission limit values concerning NO_X in EU and in the USA.
Top: For passenger cars
Bottom: For Heavy-Duty diesel engines. *Note that the vertical axis has the unit g/kwh!*

Particulate matter
Figure 5 is a similar figure for particulate matter for diesel vehicles. Particulate matter is primarily of concern for diesel engines, not for petrol cars. The graph has two panels with different vertical scales: The top panel displays standards for passenger cars and light commercial vehicles, while the bottom panel displays standards for heavy duty diesel vehicles. Again, a stepwise reduction can be seen with the US in front.



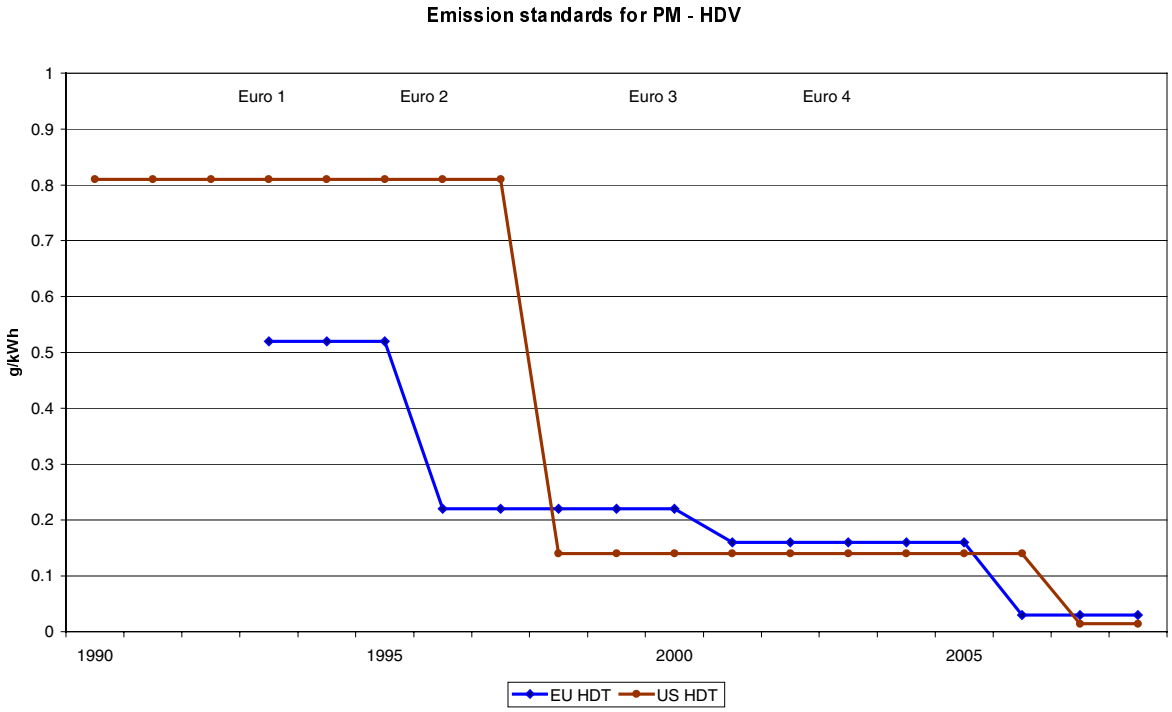


Figure 5 Emission standards for particulate matter for diesel vehicles in the EU and in the USA. *Top*: Light duty diesel vehicles. IDI refers to indirect injection, DI to direct. LCV II and III refer to vehicles heavier than, respectively, 1305 and 1760 kg. *Bottom*: Heavy duty diesel engines. *Note that the vertical axis has the unit g/kwh!*

3.2.3. Emission limit values for industry and combustion plants

In the database there are the following reference documents concerning emission limit values for combustion plants, cement industry and chemical industry:

- Emissions from stationary sources: Regulations
- Emission limit values: Combustion plants in EU and USA
- Emission limit values: Comparative tables for combustion plants, existing installations in the EU
- Emission limit values: Comparative tables for combustion plants, new or substantially changed installations in the EU
- Emission limit values: Cement industry in EU and USA
- Emission limit values: Comparative tables for cement industry, existing installations in the EU
- Emission limit values: Comparative tables for cement industry, new or substantially changed installations in the EU
- Emission limit values: Chemical industry in EU and USA
- Emission limit values: Comparative tables for basic chemicals, existing installations in the EU
- Emission limit values: Comparative tables for basic chemicals, new or substantially changed installations in the EU

In these reference documents, comparative tables can be found where emission limit values are compared between different industries in the various EU countries. A major source for this is the report *Analysis of Member States' first implementation reports on the IPPC Directive (EU-15),* June 2004 by LDK-ECO Environmental Consultants. The IPPC Directive 96/61/EC prescribes that member countries must report certain information on industrial activities to the European Commission. This information has been compiled from EU Member States through a questionnaire, and the results compiled in the report by LDK-ECO.

Some comments on the various sectors follow.

Combustion plants
For combustion plants, there are EU-wide regulations implemented in the "LCP directive", 2001/80/EC. Emissions limit values are defined for SO_2, NO_X and dust. As noted above, the database contains detailed tables of emission limit values for EU Member States. These tables are based on compulsory reports from the Member States to the Commission in the context of the IPPC Directive. For the USA, emission limit values related to combustion plants are given in Title 40 (Protection of Environment), Part 60 (Standards of Performance for New Stationary Sources) in various subparts, each pertaining to a particular class of combustion units. The standards refer to PM, SO_2 and NO_X and are given for the following classes of combustion plants:

- Fossil-Fuel-Fired Steam Generators for Which Construction is Commenced After August 17, 1971
- Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978
- Industrial-Commercial-Institutional Steam Generating Units
- Small Industrial-Commercial-Institutional Steam Generating Units.
- Stationary Gas Turbines.

When it comes to comparing standards for combustion plants between the EU and USA, a major difficulty – which precludes direct comparisons – should be noted. Standards are defined in entirely different ways in the EU and in the USA. In the EU, values are defined in terms of *pollutant mass per unit of exhaust gas* (mg/Nm^3), whereas in the US values are expressed as *pollutant mass per unit of energy input* (nanograms per joule heat input). Thus, a direct comparison between EU and US is not feasible.

Cement industry
For cement industry there are no EU-wide emission limit values, but cement industry in the EU must take into account an official BAT reference document on the best available techniques in the cement and lime industries. The database contains detailed tables of emission limit values for EU Member States concerning particles, NO_2 and SO_x plus several other pollutants. These tables are based on compulsory reports from the MS to the Commission in the context of the IPPC Directive.

When it comes to comparing standards for cement industry between the EU and USA, two difficulties – which preclude direct comparisons – should be noted. In the first place, in EU member states there are national emission limit values concerning particles, NO_X and SO_x plus several other pollutants, whereas in the USA there are standards concerning *only particulate matter*. Secondly, the standards for particulate matter are defined in entirely different ways in the EU and in the USA. In the EU, values are defined in terms of *pollutant mass per unit of exhaust gas* (mg/Nm^3), whereas in the US values are expressed as *pollutant mass per unit of raw material* (kg per ton of feed to the kiln). Thus, a comparison between EU and US is not feasible.

When comparing emission limit values between the EU member states, it can be noted that Finland and the Netherlands have low emission limit values for dust (10-15 mg/m^3 as opposed to a common level around 50 mg/Nm^3). For SO_2 and NO_X there are substantial differences between the countries; some of these differences can be attributed to diffences in processes (wet/dry) and in raw materials.
The limit values indicated in the tables reflect actual permits in the various countries.

Chemical industry
For chemical industry in the EU, emissions from industrial sources are regulated in a number of directives. Prominent among these is the IPPC Directive (96/61/EC) on Integrated Pollution Prevention and Control. The IPPC Directive to a large extent works through a mechanism with BAT Reference Documents.

Further, there are regulations relevant to chemical industry in the "VOC Directive" (1999/13/EC) *on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations*. Annex I of the Directive specifies emission limit values for VOC for a range of industrial activities, such as printing, surface cleaning, various types of coating, rubber conversion etc.

Except for VOC's, many standards concerning chemical industry in the EU is defined at a national level rather than a Community level, but with due respect to the BAT reference documents of the IPPC.

As noted above, the database contains detailed tables of emission limit values for EU Member States. These tables are based on compulsory reports from the Member States to the Commission in the context of the IPPC Directive.

There are tables concerning chemical installations for ten types of chemical industry, namely for the production of
- benzene
- ethylene oxide
- formaldehyde
- vinyl chlorine monomer
- ammonia
- nitric acid
- phosphoric acid
- sulphuric acid

- titanium dioxide
- chlor-alkali manufacture processes

In the USA, there are "Standards of Performance for New Stationary Sources" for various industries. There are standards for around 60 types of chemical industry.

When it comes to comparing standards for chemical industry between EU and the USA, the wide variety of industries and processes preclude a comparison with simple, general conclusions. For a comparison to be made, one must pick a particular process and in detail consider the reference conditions. Furthermore, in many cases we encounter the same problem as noted above in comparisons of combustion plants and cement industry: that for many substances, EU limit values refer to exhaust gas, while US limit values refer to raw material.

4. USE OF THE DATABASE BY AN EXTERNAL USER

An ordinary user can access the database on the Internet through the page http://www.dmu.dk/AtmosphericEnvironment/Expost/
Upon choosing the link "Search facility" he will meet the search form displayed as ***Figure 6***.

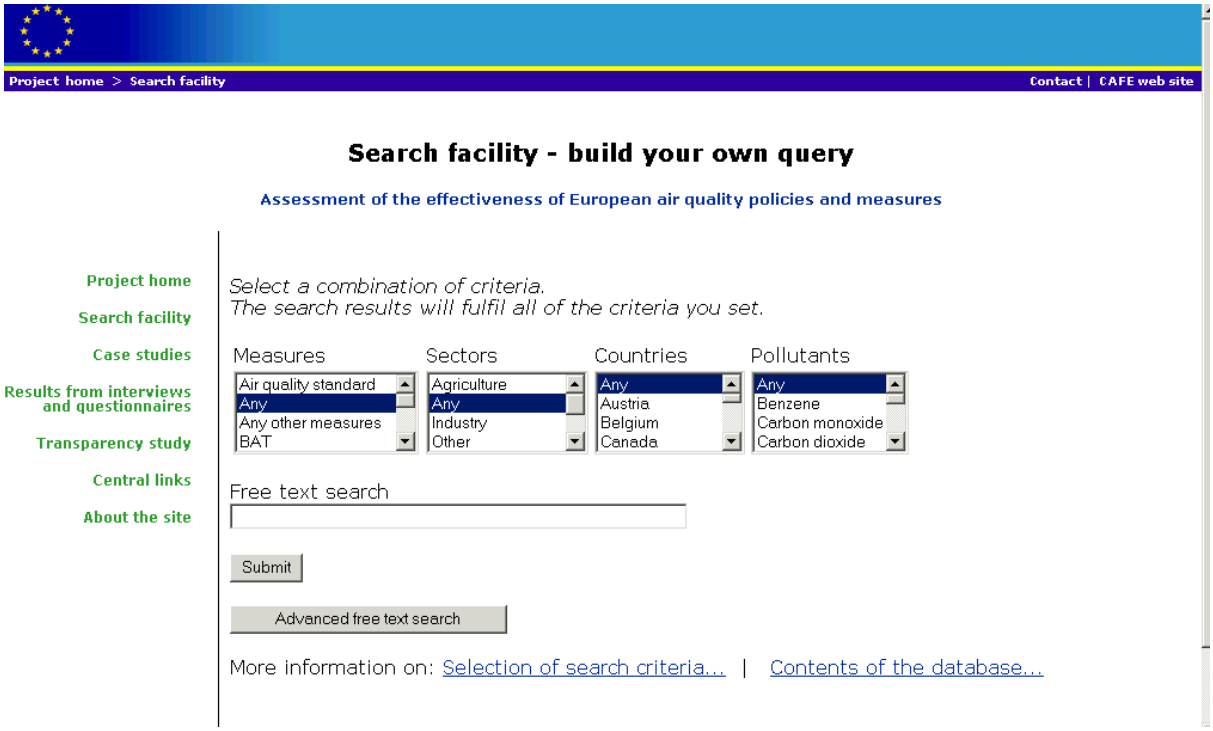


Figure 6 Main page of the search facility.

He or she can now search the entire database (both the *Studies* part and the *Standards* part) by specifying criteria. If he leaves the criteria at their default value ("Any") he will obtain access to all records in the database.

The "Free text search" provides a flexible means of searching the database, e.g. for an author name or for a specialised term.

A search will result in a page like the one displayed in ***Figure 7***, which provides an overview of search results. As it appears, there are four types of information. The first, "Expost studies" represents

the information in the Studies database, while the remaining three types all pertain to the Standards database.

Figure 7 The immediate result of a search

The user can now choose which type of information he is interested in, and then continue to inspect the details of the search result. If he chooses to inspect *ex-post* studies, he will find reviews like the one displayed in ***Figure 1***.

If he chooses to inspect "reference documents", he will first get an overview of the reference documents resulting from his search, like the overview depicted in
Figure 8. Such reference documents constitute the core of the Standards database. They contain information on:

- air quality standards in a range of countries;
- emission limit values within certain sectors and countries;
- standards related to vehicle emissions and fuel quality;
- emission targets (ceilings) for various pollutants in a range of countries;
- information on compliance in respect to EU directives.

It is also important to note that when using the database, a user will meet ample references to where more detailed information can be found. The references are contained in the various reference documents as well as in the information category: *Collections of Internet links* appearing in ***Figure 7***.


List of search results: Reference documents

Assessment of the effectiveness of European air quality policies and measures

Back to previous page...

Reference documents: Title and description

Typically, the documents are in PDF format. Many contain clickable links.

Air quality standards
Comparison table of air quality standards for a number of pollutants in various countries.

Compliance with Directives
For 12 EU directives related to air pollution, official information on compliance is summarised in the form of tables.

Emission limit values: Cement industry in EU and USA
Information about emission limit values for cement industry in EU and USA.

Emission limit values: Chemical industry in EU and USA
Information about emission limit values for chemical industry in EU and USA.

Figure 8 Example of search results within the category "Reference documents".

5. USE OF THE DATABASE BY AN INFORMATION PROVIDER (ADMINISTRATOR)

It must be understood that the database has two interfaces:

- an "administrative interface" for entering and updating information;
- a "dissemination interface" for retrieving the information. This interface consists of a set of Web pages, and its use has been described in the previous chapter: *Use of the database by a external user*

5.1. The administrative interface

Technically, the database has been designed in Microsoft Access. This means that the "administrative interface" can operate on any PC running Access 2000 (or higher).

The core of the database is the Access file MasterStudiesBasis.mdb. A person who wishes to update the database must have access to MasterStudiesBasis.mdb, either locally on his own PC or through a local network.

When he opens this file he will meet the main menu of the administrative interface, as depicted in ***Figure 9***. A separate guide – *How to enter content into the database with Studies and Standards* – explains the details of maintenance tasks. This guide is an Annex to the present report.

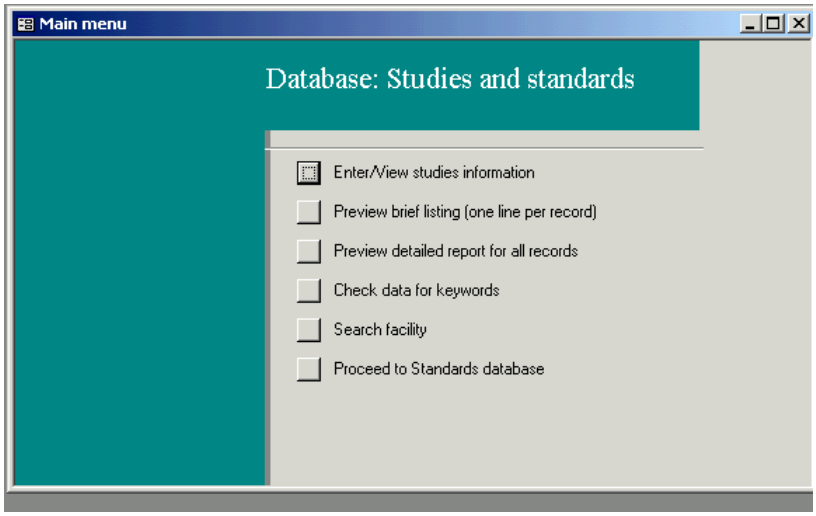


Figure 9 The main menu of the "administrative interface".

5.2. The dissemination interface

The use of the "dissemination interface" by external users was explained in a previous chapter. For an administrator, some further technical remarks are appropriate.

The dissemination interface consists of a set of Web pages in the ASP script language. These Web pages can be hosted on any Web server that supports ASP pages. The database will stay on the Web site of the National Environmental Research Institute (NERI) in Denmark after the end of the contract, unless the Commission prefers another arrangement.

Maintenance of the database primarily consists in modifying the Access database. For such modifications to have an effect on the appearance of the database on the Web, the modified Access database (MasterStudiesBasis.mdb) must be copied to the Web and replace the previous version. With the present arrangement, the Commission can just send an e-mail with the modified file and ask for a replacement of the old database.

Maintenance of the database can also involve the creation of new Web pages, which may be located on any server - e.g. the Europa server, or the server at NERI.

If the database in the future has to be transferred to another host, this can take place quite simply.

The details of all of these procedures are explained in the previously mentioned Guide (attached as an Annex).

5.2.1. Backup CD

All the necessary files for the database and for the Web site are provided on a backup CD.

The CD contains:

- A copy of the entire website of the project;
- Source material related to the Standards database. The Standards database makes use of reference documents in PDF format. The original version (source) of these reference documents is typically in MS Word or MS Excel.
- A backup copy of external source material. The database refers to many reports located on the Web. In order to safeguard such material in case links are broken, a backup copy is kept.

ANNEX I

GUIDE ON HOW TO ENTER CONTENT INTO THE DATABASE FOR STUDIES (TASK 3.1) AND STANDARDS (TASK 3.2)

ANNEX I TO REPORT ON TASK 3.1 AND 3.2 DATABASES

GUIDE ON HOW TO ENTER CONTENT INTO THE DATABASE FOR STUDIES (TASK 3.1) AND STANDARDS (TASK 3.2)

1 Introduction

Overview of the guide

The present guide describes how the database with Studies and Standards can be maintained and updated. The guide can be used as a stand-alone document by persons maintaining the database. It is assumed that the reader has some general knowledge on the database, corresponding to the description provided in the chapter *Overview of databases: Contents and summary of findings* in the report on task 3.1 and 3.2 databases.

Chapter 2 in this guide describes how to get started, and how to enter content into the Studies part of the database. Chapter 3 describes how to enter content into the Standards part of the database. Chapter 4 describes how to update the Web site.

Computer requirements

The core of the database is the file MasterStudiesBasis.mdb. This is a file in Microsoft Access format. A person who wishes to update the database must have access to MasterStudiesBasis.mdb , either locally on his own PC or through a local network. Furthermore, it is required that MS Access 2000 (or higher) is installed on his PC.

2 The "Studies" part of the database

2.1 Getting started

Getting started

Use the database in the following way:
Double-click the file MasterStudiesBasis.mdb
Choose *Enter/View studies information*
You can browse through the entries by using the navigation buttons

at the bottom of the form.

Add new record

Add a new record with the button "Add new record".

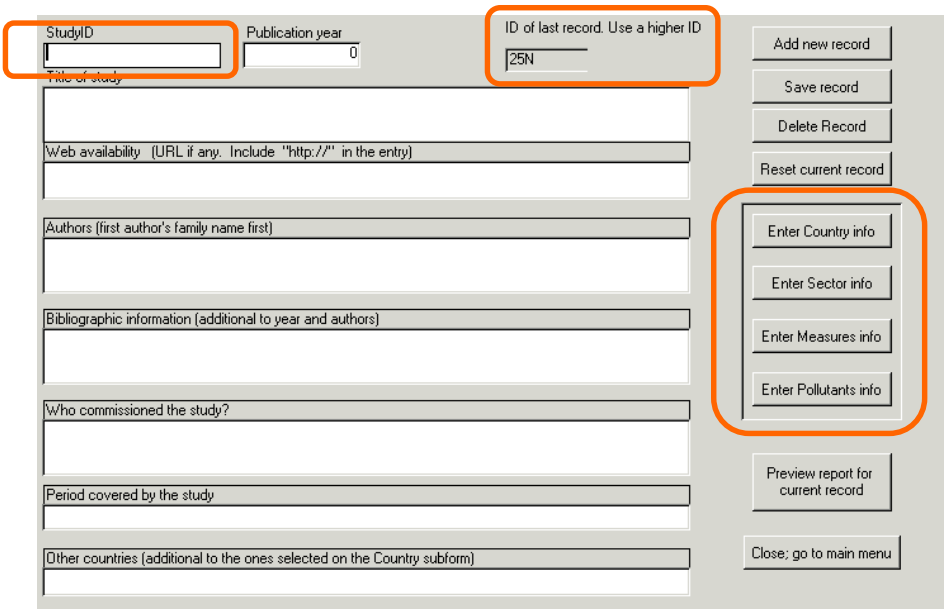


Figure 1 The items discussed immediately below are indicated in red.

About StudyID

First, you must fill in the field **StudyID**.
StudyID is a unique identification of each record. As of October 1, 2004, the records present in the database have ID's in two series:

"1C", "2C", "3C" etc (information supplied by CCAP)
"1N", "2N", "3N" etc. (information supplied by NERI).

Future StudyID's can be chosen freely (continue in one of these series or start a new). It is only required that each record has a StudyID, which is unique.
Note that the StudyID of the last record entered is displayed. This helps you to choose a different ID.

It is not crucial whether there are any "holes" in the consecutive numbering in the series of StudyID.

About the remaining fields

After having filled in StudyID you can tab through the remaining fields and enter information. Section 2.4 contains guidance concerning the individual fields.

The 4 buttons for entering keywords

It is important to be aware that in addition to the information in the visible fields, you must also supply information on four classes of compulsory keywords by using the 4 buttons "Enter ... info". See the next sections for details.

Free text fields
Add line breaks with Ctrl+Enter

A general note: Many of the fields can hold a lot of free text.
If you wish to create a new line in such a field, use Ctrl+Enter.

2.2 Introduction to the four types of compulsory keywords

For each study, it is compulsory that you appoint keywords of four types. The set of buttons which allow you to enter the keywords are shown in *Figure 2*.

*You **must** add keywords of all four types*

Note that before the database is transferred to the Web, you ***must*** have added keywords of all four types. Otherwise, the record won't show up when a user searches information.

You are free to enter this information at any time, as long as you end up having filled in all four types of keywords.

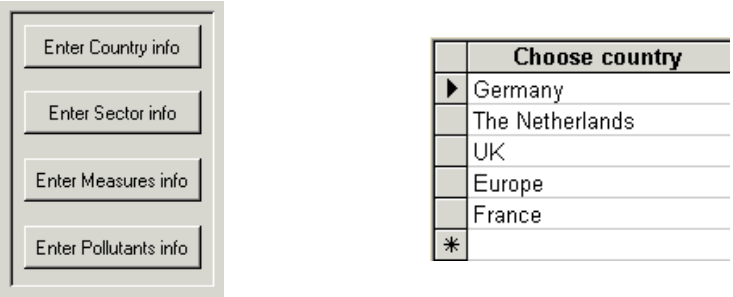


Figure 2 *Left*: Buttons which allow you to enter keywords
Right: You may select several keywords. Here, 5 keywords have been selected.

You can add several keywords, as the example in *Figure 2* shows.
The keywords are used when a user performs a search in the database.

The keyword "Any"

The keyword "Any" only has to be used if no other keyword can be naturally assigned to the record.

A tool that allows you to quickly check whether any records lack keywords - and to add keywords - is available from the main menu (*Figure 3*).

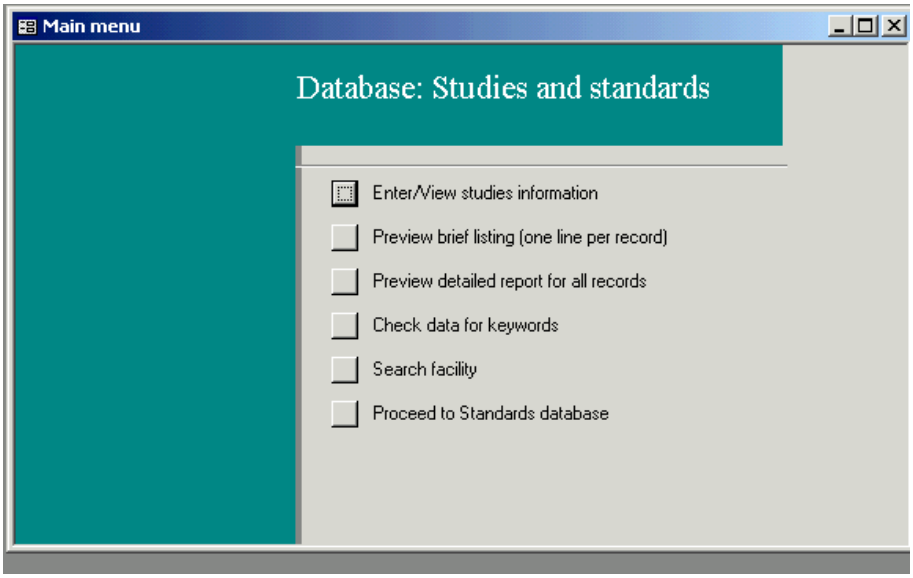


Figure 3 The fourth entry in the main menu - *Check data for keywords* - allows you to check whether all records have the compulsory keywords.

2.3 How a user retrieves data

You should be aware how a user searches the information in the database. This helps to ensure that the keywords work like they should.

A user retrieves information by filling in the form depicted in *Figure 4*

Figure 4 Form for search in the database.

Thus, he can specify values for the four types of compulsory keywords, but he may also choose another strategy and search for a text item, such as an author name. By default the keyword "Any" is selected for all four criteria. A search with default values will return all records in the database.

2.4 Guidelines on the contents to be entered in the database

2.4.1 The compulsory keywords - details

You can choose between the following keywords (the list of keywords for countries is longer than shown here). Note that you can assign several keywords of the same type to each study.

CountryName
Any
Austria
Belgium
Canada
Cyprus
Czech Republic
Denmark
Estonia
Europe
Finland
France
Germany
global
Greece
Hungary
Ireland

SectorName
Transport
Industry
Power plants
Waste incineration
Agriculture
Other
Any

Measure
Air quality standard
Emission limit values
BAT
Product standards
Emissions trading
Tax incentives
Charges
Subsidies
Consumer information
Any other measures
Any

PollutantSymbol
NOx
N
O3
SO2
S
Ben
Other
NH3
Dioxine
VOC
CO
CO2
Particles
Any
Pb

Figure 5 Keywords that can be assigned to a record (for countries, the list is longer than shown).

Country

If you are going to classify an item where a certain, named country plays a prominent role - like a case study for Germany - then use the keyword for the country, e.g. "Germany".
In that way it is ensured that a user who asks for information on Germany retrieves the study.

On the other hand, if you have information, which is common to many European countries, just classify it with the keyword "Europe".

Use of "Any" for country

Information, which is relevant for any country or a very large number of countries can be, assigned the keyword *Any* instead of a more specific keyword.

Sector

If it is irrelevant to assign a sector, then use the keyword "Any".

Measures

"Any other measure" could for instance be voluntary agreements.

Pollutants

Particles

A record, which refers to PM10, PM2.5, TSP or black soot, should be classified under the general keyword *Particles*

Nitrogen oxides

A record, which refers to NO2, should be classified under the keyword "Nitrogen oxides".

2.4.2 The individual fields in the main form

Remarks on some of the fields follow:

Authors

Author names may be entered either with initials or full name. Give the first author's family name first ("Jones, A.").
An institution may be author, but information such as affiliation should be entered in the field "Bibliographic information".

Users of the database must use free text search when they look for work by a particular author.

Bibliographic information

Bibliographic information should include the number of pages in the report.

Internal comments of reviewers

Reviewer's comments

There is a field for Reviewer's notes for internal use. This field is not displayed on the Internet.

3 The "Standards" part of the database

Reference documents

From an external user's point of view, the contents of the Standards database will to a large extent consist of "Reference documents". An example of a "Reference document" is a document with tables providing an overview of air quality standards in various countries.

The reference documents can be retrieved through the same interface (the Web pages) as the information from the "Studies database". From a technical point of view, each reference document is a file (e.g. a pdf file), while the database contains pointers to such files.

Update the reference documents and the database

Thus, when an information provider wishes to update the contents of the Standards database, there are two things to update

- A reference document, which may be a document in PDF format or a web page.
- An entry in an Access database (pretty similar to the entries in the Studies part of the database)

Depending on the situation, one or both of these tasks are relevant.

An example

Things are best explained by way of an example.

Create a reference document

Let us assume that the information provider - you - has created a new reference document in Word format. As the next step, you should generate a PDF file from the document (this task lies outside the scope of the present guide and is not described here). We assume that this file concerns air quality standards, and is called AQ_limit_values.pdf.

Update the database

The next step will be to create an entry in the Access database, pointing to this reference document.

This procedure resembles the one described in Chapter 2. Like before, you should start by double-clicking the file MasterStudiesBasis.mdb.

In the main menu (*Figure 3*) choose *Proceed to Standards database*, and then *Enter/view standards information.*

Now, add a new record and fill in the form more or less like the example in *Figure 6* shows. Some comments on the various fields are appropriate.

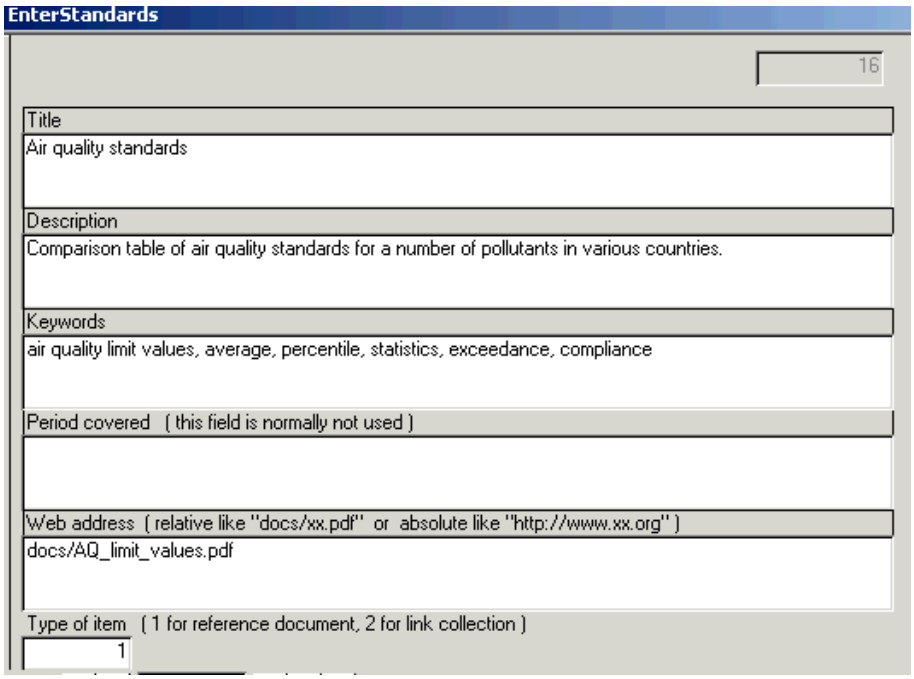


Figure 6 Menu for entering information in the "Standards" part of the database.

The title

The title is very important, because it is used to sort search results when an external user retrieves information from the database. The title should be precise, and it should indicate whether the reference document belongs to the same "family" as other reference documents. For instance, there are several reference documents, all entitled "Emission targets: ...".

Description

The description is displayed together with the title when an external user inspects search results, such as the example in *Figure 7* illustrates.

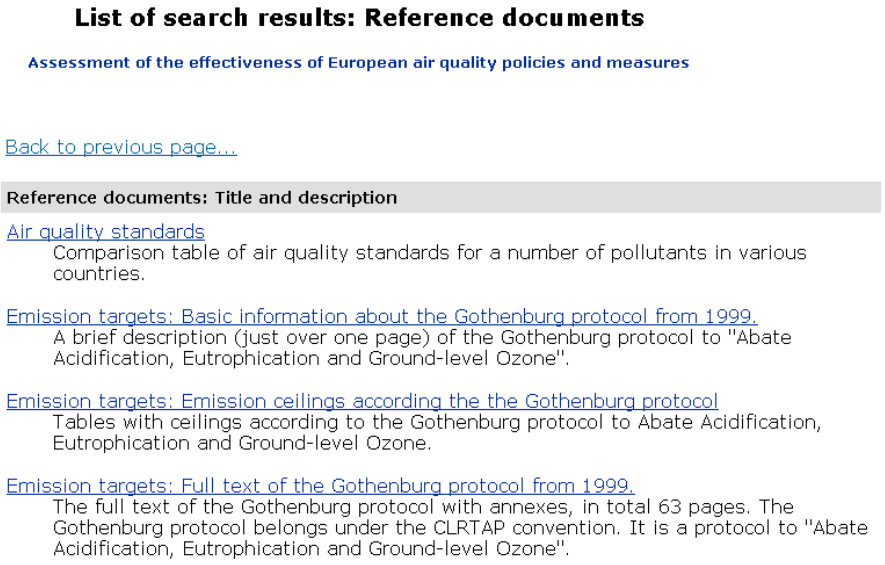


Figure 7 Example: This is the way an external user sees titles and descriptions of reference documents.

Keywords

The purpose of keywords is to ensure that an external user becomes aware of the document when he uses free text search. Free text search looks into all fields in the database, but not into the reference documents themselves. Therefore, it may be relevant to add some words from the reference documents as keywords. If a word or a phrase appears in the title or in the description, then there is no need to repeat it among the keywords.

Period covered

This field is normally not used.

Web address

The web address can be either an absolute address or a relative address. As an example, the reference document can be a document on the Europa server, and can be referred to as "http://europa.eu.int/comm/environment/air/xxx.pdf".

Alternatively, it can be a document on the same server as the database (presently at NERI in Denmark), and be referred to by a relative link like "docs/AQ_limit_values.pdf". Unless there is a reason to make an exception, reference documents are placed in the subfolder "docs" like the current example.

Type of item

There are three types of items, each characterised by a number:

- 1 for reference documents;
- 2 for collections of Internet links;
- 3 for the case studies conducted under the contract.

Compulsory keywords

In a similar way as for the Studies database, you have to provide compulsory keywords of four types (country, sector, measure, and pollutant) when you create an entry in the Standards database. Failure to do so will have the effect that the entry won't be visible to an external user.

4 Maintaining information on the web

MasterStudiesBasis.mdb must be copied to the Web

Above, we have described how to modify the Access database. For such modification to have an effect on the appearance of the database on the Web, the modified Access database (MasterStudiesBasis.mdb) must be copied to the Web and replace the previous version.

Send the file by e-mail

The procedure is - until something else has been decided - to email the file to hro@dmu.dk and ask for a replacement of the old database. If it is pertinent, new reference documents can also be sent by e-mail, and they will then be published on the web (in the subfolder "docs" unless something else is agreed). As explained in Chapter 3, reference documents can also be placed elsewhere, e.g. on the Europa server.

How to handle a change of host

If the database in future has to be transferred to another host, this can take place quite simply. It is a requirement that the new host supports pages in the ASP script language.

Backup CD

All the files needed for the Web site are provided on a backup CD. The contents of this CD should be copied to the new host. It may be necessary to make a slight change in a single or a few files, but the entire procedure is unproblematic. Some helpful hints are found in a Readme file on the backup CD.

ANNEX IIA

BIBLIOGRAPHY OF ENTRIES IN THE STUDIES DATABASE

ANNEX II TO REPORT ON TASK 3.1 AND 3.2 DATABASES

The list below includes all 44 entries in the Studies database. It is sorted by first author.
Use the database in order to retrieve full information about each study.

Bibliography of entries in the Studies database

AEA Technology; Holland, M.; Forster, D.; King, K.; Haworth, A., Watkiss, P. (1999): Economic evaluation of proposals for emission ceilings for atmospheric pollutants
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ANNEX IIB

EXTENDED VERSION OF ANNEX IIA INCLUDING SUMMARIES, FINDINGS AND RECOMMENDATIONS FOR EACH STUDY

ANNEX IIB TO REPORT ON TASK 3.1 AND 3.2 DATABASES

This document shows central information (summaries, findings and recommendations) extracted from the Studies database.
The entries are sorted by first author and year.

AEA Technology; Holland, M.; Forster, D.; King, K.; Haworth, A., Watkiss, P. (1999): **Economic evaluation of proposals for emission ceilings for atmospheric pollutants**

Summary:

AEA Technology, under sub-contract to IIASA, has conducted an economic evaluation of scenarios being explored in the development of further controls on acidification and ground-level ozone. The derivation of these scenarios is described in IIASA's Seventh Interim Report on Cost-effective Control of Acidification and Ground-level Ozone (January 1999). The analysis in the present report includes quantification of benefits and their comparison with the estimated costs of attaining these scenarios.

There are two general approaches to assessment of benefits that are subject to significant uncertainty. The first is conservative, quantifying only those effects for which it is felt that associated uncertainty will be small. The second, which was followed here, is to quantify more widely, and then to consider the potential errors involved. Backed up by an appropriate level of uncertainty and sensitivity analysis a reasonably robust and complete perspective can be obtained.

Based on extensive review of the potential for error in the analysis, the key sensitivities in the analysis were found to be:
a) Issues relating to the assessment of mortality generally
b) Prediction of changes in ozone exposure using the EMEP model
c) Influence of meteorological and other factors on estimates of changes in crop yield.
d) Omission of effects on ecosystems, possible chronic effects of ozone exposure on morbidity, indirect economic effects arising from reduced agricultural yield, altruistic effects related to health impacts etc.
Other sensitivities were explored, but found to be less significant.

Findings:

The authors conclude that benefits are likely to exceed the costs of implementing the scenarios considered in this study. This conclusion needs to be considered against other information presented in the report. Most notable are the level of confidence associated with estimated benefits, and the weighting that should be given to effects that remain unquantified. The limitations of other inputs to the work, notably the cost estimates made at IIASA and the results of the EMEP ozone model also need to be considered.

Combining different assumptions on the individual elements in the list of uncertainties, it is possible to generate total benefits estimates that are smaller than the costs for the scenarios considered. Based on a discussion of sensitivities, the authors nevertheless consider the conclusion above reasonably robust

Ando, A., McConnell, V., Harrington, W. (1999): **Costs, Emissions Reductions, and Vehicle Repair: Evidence from Arizona**

Summary:

The study considered information from the Arizona I/M program by analyzing emissions test data before and after repair, costs of repair, test failure rates by model year, and identify the elements of successful repairs.

Findings:

The analysis found that the cost of emission repairs for the Arizona I/M program was $123 per repaired vehicle and $199 per repaired vehicle when tamper-related repairs are excluded. The average emissions reductions from these repairs was 0.82 g/mile for HC, 12.35 g/mile for CO, and 0.92 g/mile for NOx.

The study also found that there are large differences in repair costs across vehicles with the higher cost repairs more likely falling on low income vehicle-owners. In addition, about 22 percent of vehicles failing the initial test do not show a passing test. These vehicles may be sold outside the region, scrapped, or in process of completing the I/M cycle.

Recommendations:

The study concludes that more work needs to be done to track non-passing vehicles. The results also indicate that it is critical to consider costs and cost-effectiveness in the design of the program since there is wide variation in vehicle repair costs. Therefore, costs could be reduced if there was better targeting of which vehicles to test and repair.

Burtraw, D. & Evans, D.A. (2003): **The Evolution of Nox Control Policy for Coal-Fired Power Plants in the United States.**

Summary:

Emissions of nitrogen oxides (NOx) contribute to formation of particulate matter and ozone, and also to acidification of the environment. The electricity sector is responsible for about 20% of NOx emissions in the United States, and the sector has been the target of both prescriptive (command-and-control) and flexible (cap-and-trade) approaches to regulation. We summarize the major NOx control policies affecting this sector, and provide some perspectives as to their effectiveness. While both prescriptive and flexible approaches continue to play an important role, significant new proposals have wholly embraced a cap-and-trade approach.

Findings:

Policy controlling NOx emissions from coal-fired power plants in the US has evolved from prescriptive approaches to more flexible cap-and-trade approaches. Prescriptive approaches including NSPS and Title IV have led to emissions reductions despite the criticism that undermined the effectiveness of the program because there is no cap to limit aggregate emissions. The cap-and-trade program has been more flexible and cost-effective while reducing significant emission reductions. Both approaches are important today, but an expanded role for the use of cap-and-trade is expected in the future.

Recommendations:

NOx trading should be extended spatially and thoughout the year; How emissions allowances are distributed should be reevaluated. .

Burtraw, D. & Mansur, E. (1999): **Environmental Effects of SO2 Trading and Banking.**

Summary:

The widely acknowledged innovation of Title IV of the 1990 Clean Air Act Amendments is sulfur dioxide allowance trading, which is designed to encourage the electricity industry to minimize the cost of reducing emissions. Few studies have examined the environmental effects of trading, and none have explored the effects of banking. We used an integrated assessment computer model, the Tracking and Analysis Framework, to evaluate changes in emissions of SO2, atmospheric concentrations of sulfates and deposition of sulfur, and public health benefits from reduced exposure to SO2 and particulate matter. We assessed geographic

and temporal changes at the state level that result from trading and banking and compared them with estimated cost savings. Our findings are not consistent with the fears of the program's critics. In the East and Northeast including New York State, an area of particular concern, we found that health benefits increase and sulfur deposition decrease slightly as a result of trading. Nationally, trading results in health-related benefits in addition to significant cost savings. Banking changes the timing of emissions, but the geographic consequence of banking is varied.

Findings:

Benefits from Trading: emission and deposition will decrease significantly in NE and SE regions, while it may increase in the midwestern region. Net health-related benefits is total $124 millon (1995 dollars, no discounting) in 2005. Benefits from Banking: intertemporal change - decrease in emissions and deposition in 1995 followed by increase in 2005. Similar pattern appears in health benefits in that greater benefits in 1995 where as less benefits in 2005. Flexibility offered by trading and banking led to significant decreasese in cost (37% decrease: from $1.44 biilon with no trading to $905 million in the baseline in 2005).

Burtraw, D.; Palmer, K. (2003): **The Paparazzi Take a Look at a Living Legend: The SO2 Cap-and-Trade Program for Power Plants in the United States**

Summary:

For years economists have urged policymakers to use market-based approaches such as cap-and-trade programs or emission taxes to control pollution. The SO2 allowance market created by Title IV of the 1990 U.S. Clean Air Act Amendments (CAAA) presents the first real test of the wisdom of economists' advice. This paper provides an overview of the origins, design, and performance of the U.S. acid rain program, and an analysis of its specific features and its adaptability as a model for addressing other pollution problems, such as control of NOx or CO2 emissions. The program also has resulted in innovation through changes in organizational technology, in the organization of markets, and through experimentation at individual boilers, much of which arguably would not have occurred under a more prescriptive approach to regulation. There is ample evidence that allowance trading has achieved substantial cost savings, and there are lessons that can guide the design of future policies.

Findings:

The SO2 trading program has achieved its environmental objectives at a much lower cost than originally predicted. Approximately a ten million ton reduction in electric utilities' SO2 emissions from 1980 levels has been achieved with no instances of emissions "hot-spots." Costs of the program were predicted in 1990 to be around $400 per ton and actual prices have typically been below $200. Trading activity increased over time as participants became more familiar with the new policy paradigm. Rather than trading in the early years, participants banked allowances for compliance in future years. Compliance has been perfect except for a recent case where a participant fell short by eleven allowances due to an accounting error. The trading program led to innovations in related markets, such as control technologies (e.g., scrubbers), that further reduced compliance costs. The program could have reduced costs further by auctioning allowances and using the revenue to offset other market-distorting taxes.

Bush, T.; C Brand, J Stedman and T Murrells. AEA Technology (2001): **Policy Evaluation: measures to reduce air pollution from road traffic**

Summary:

The report provides an analysis of the impacts of policy measures to reduce NOx, PM10 and CO emissions from road traffic. The objectives were to evaluate which instruments would

probably have been the most important of them in terms of urban air quality, namely the measures taken to reduce emissions from road vehicles. It has been shown that policy measures have reduced concentrations of NO2, PM10 and CO from 1990 to 1999, 2005 and 2010 relative to estimates of concentrations had abatement policies not been introduced.

Findings:

The single largest contributor to reductions in NOx emission from road transport was the introduction of three-way catalysts for petrol vehicles under Euro I. The policies measures up to and including the introduction of the Euro IV standard are unlikely to be sufficient to reduce concentrations at all roadsides to below the EU Daughter Directive Limit Value of 40 µgm-3 by 2010.

Carlson, C., Burtraw, D., Cropper, M. & Palmer, K. L. (2000): **Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?**

Summary:

Title IV of the 1990 Clean Air Act Amendments (CAAA) established a market for transferable sulfur dioxide (SO2) emission allowances among electric utilities. This market offers firms facing high marginal abatement costs the opportunity to purchase the right to emit SO2 from firms with lower costs, and this is expected to yield cost savings compared to a command-and-control approach to environmental regulation. This paper uses economically estimated marginal abatement cost functions for power plans affected by Title IV of the CAAA to evaluate the performance of the SO2 allowance market. Specifically, we investigate whether the much-heralded fall in the cost of abating SO2, compared to original estimates, can be attributed to allowance trading. We demonstrate that, for plants that use low-sulfur coal to reduce SO2 emissions, technical change and the fall in prices of low-sulfur coal have lowered marginal abatement cost curves by over 50 percent since 1985. The flexibility to take advantage of these changes is the main source of cost reductions, rather than trading per se. In the long run, allowance trading may achieve cost savings of $700-$800 million per year compared to an "enlightened" command-and-control program characterized by a uniform emission rate standard. The cost savings would be twice as great if the alternative to trading were forced scrubbing. However, a comparison of potential cost savings in 1995 and 1997 which modeled costs of actual emissions suggests that most trading gains were unrealized in the first two years of the program.

Findings:

Marginal abatement costs for SO2 emissions have fallen considerably since 1990. Improvements such as the ability to burn low-sulfur coal and increases in overall generator efficiency lowered the typical unit's marginal abatement cost by almost $50 per ton in the decade preceding 1995. The decline in fuel costs lowered marginal abatement costs by about $200 per ton.

Marginal abatement costs were much higher for Phase II units than for Phase I units due to the lower emission rates of the former. Marginal abatement costs have fallen over time for both categories due to a fall in the price of coal and technical progress in abating emissions.

Under the least-cost efficient trading solution developed and analyzed in the study, the marginal cost of reducing emissions is $291 per ton in 2010.

In comparison with a command and control, uniform emission rate regulatory program, emissions trading (least-cost solution) is estimated to produce annual cost savings of $250 million in Phase I and $784 million in Phase II. These cost savings are lower than original government estimates due to the drop in the price of low-sulfur coal and technical improvements that facilitated fuel switching.

In 1995, the actual compliance costs of the SO2 program were $280 million higher than the least-cost trading solution estimated in the study, indicating that the allowance market failed to capture the full gains from trade. This difference increased to $339 million in 1996. This may be due to the fact that the study does not account for short-term adjustment costs faced by firms in the first two years, and that little trading occurred during this period.

Recommendations:

Future ex ante attempts to estimate costs of emission control programs may overestimate due to difficulties in forecasting future trends in technological change and other factors.

The design of allowance markets should consider the source of trading gains and how these may change over time. In the potential carbon market, conversion from coal to natural gas will produce large gains initially, but these will decline over time.

Allowance markets need to be given time to mature for the potential gains from trade to be realized.

Catalyze, Larry Phillips and Adrian Stock (2003): **Use of Multi-Criteria Analysis in Air Quality Policy**

Summary:

The difference between multi-criteria decision analysis (MCDA) and cost-benefit analysis (CBA) is the valuations of costs and benefits are expressed: monetary units for CBA, non-monetary units for MCDA. To use non-monetary units in MCDA requires judgements of value functions, which translate objective performance measures into values, and assessments of criterion weights, which express the trade-offs between values on the various criteria.

Findings:

Multi-criteria decision analysis (MCDA) can extend cost-benefit analysis (CBA) by effectively incorporating criteria that are difficult or impossible to monetise using CBA techniques. As applied to air quality policy options, MCDA can be used for appraisal against any set of important criteria, for constructing portfolios "top-down" of policy options across different areas, and for constructing portfolios of "bottom-up" abatement measures.

Cofala, J.; Amann, M. (2001): **Emission Reductions from Existing Large Combustion Plants Resulting from the Amendment of the Large Combustion Plants Directive**

Summary:

The study considers a proposed amendment to Directive 88/609/EEC on large combustion plants, and estimates the effects in 2010. The amendment concerns emission limit values for existing sources as proposed in the Common Position 1998/0225 (COD) from October 2000 for sulfur dioxide and nitrogen oxides.

The analysis is limited to the existing sources in the power plant sector. The analysis was carried out for the EU-15 and for accession countries.

The analysis clearly shows that existing (pre 1987) large combustion plants will remain important sources of SO2 and NOx emissions in the year 2010. Without the provisions of the revised large combustion plant directive, this group of plants is likely to be responsible for about 44 percent of total EU- 15 emissions of SO2 and 12 percent of emissions of NOx. Their shares are even higher in the accession countries, where they are expected to contribute 58 percent of total SO2 and 18 percent of NOx emissions.

If the proposed emission limit values were implemented to the full extent to all existing (pre-1987) plants in the EU-15, SO2 emissions from these sources would be cut by almost 70 percent and NOx emissions by about nine percent. In accession countries SO2 emissions from existing LCPs would be 86 percent lower and NOx emissions would be cut by eight percent.

These emission reductions will significantly contribute to the achievement of the national emission ceilings. This holds particularly for SO2 emissions, while the contribution to the necessary reductions in NOx emissions is less significant.

Findings:

[The summary explains the context of the statements below]

If the proposed emission limit values were implemented to the full extent to all existing (pre-1987) plants in the EU-15, SO2 emissions from these sources would be cut by almost 70 percent and NOx emissions by about nine percent. In accession countries SO2 emissions from existing LCPs would be 86 percent lower and NOx emissions would be cut by eight percent.

Commission of the European Communities (2003): **Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. On the Road to Sustainable Production.**

Summary:

The paper reports on progress and problems encountered with the implementation of the IPPC directive so far. The Commission wishes to launch a broad European consultation on the current state of play, and possible developments in those areas of environment policy which address impacts of large industrial point sources. The Commission is interested in the views of all stakeholders and encourages them to play an active role in the debate on implementation issues as well as future developments. To that effect, seven key questions are raised in the paper, and a consultation web site has been launched (http://www.europa.eu.int/comm/environment/ippc/ippc_consultation.htm). The Commission will report to the EU Institutions on the results of this consultation and on Member States' official replies in the general implementation survey in the first half of 2004.

Findings:

The IPPC Directive represents a challenge for European industry, but also an opportunity. A large number of IPPC plants have demonstrated that strong environmental performance goes hand-in-hand with strong economic performance. The exchange of information on best available techniques between Member States and stakeholders represents a key instrument.

In the opinion of the Commission, a large number of Member States need to accelerate progress towards a high level of environmental protection, given the final deadline for full implementation. Furthermore, the majority of the Acceding Countries must continue to significantly enhance their efforts, as agreed in the accession negotiations.

Recommendations:

The Commission wishes to send a clear message to Member States and Candidate Countries: a high level of protection of the environment, which is the overriding objective of the IPPC Directive, can only be achieved if the authorities in charge of implementation make the efforts necessary for correct implementation and engage in constructive interaction with plant operators and other stakeholders. A large number of Member States need to accelerate progress towards this objective and the majority of the Acceding Countries must continue to significantly enhance their efforts, as agreed in the accession negotiations. The final deadline for existing installations to apply the best available techniques and meet all other requirements is October 2007.

Commission of the European Communities (2002): **Report from the Commission. On the state of implementation of the ambient air quality Directives 80/779/EEC, 82/884/EEC and 85/203/EEC in the period 1997-1999.**

Summary:

The report is very brief, because information on air pollution levels is now (as opposed to previously) available from EEA's European Topic Centre on Air and Climate Change (ETC/ACC) through yearly reports and the Airbase information system. There is no need to duplicate that information.

The three directives considered concern SO2, black soot/TSP, NO2 and lead.

Exceedances were reported for eight (of 15) EU countries for at least one of these substances and for at least one of the three years considered.

Findings:

There were problems with the implementation of the ambient air quality directives under consideration (80/779/EEC, 82/884/EEC and 85/203/EEC). Thus, there were substantial differences in the way Member States measured their air quality and reported the results to the Commission.

This has made it difficult to compare the situation in different Member States and to follow progress with the measures and procedures being implemented.

These implementation problems are more effectively addressed withe the reporting obligations set up under the new air quality directives.

Recommendations:

Better reporting procedures as implemented under the new directives.

Commission of the European Communities (2002): **Fourth Annual Survey on the implementation and enforcement of Community environmental law.**

Summary:

The report provides provides for the year 2002 an overview concerning the implementation of Community Environmental Law in the Member States. It includes details on transposing measures for certain directives, as well as statistics concerning the number of cases of non-communication, non-conformity and "horisontal bad application".

Furthermore, the report includes a Fourth Annual Survey on the activities of the IMPEL network IMPEL is the informal EU network for the Implementation of Environmental Law consisting of the Commission and the Member States.

Commission of the European Communities (2000): **Report from the Commission to the Council and the European Parliament. On the experiences gained in the application of council Directive 90/313/EEC of 7 June 1990, on freedom of access to information on the environment.**

Summary:

Experiences with the Directive 90/313/EEC on freedom of access to information on the environment are reviewed. The information is drawn from compulsory national reports by Member States, as well as from reports by NGO's. Also, in 1998 there was an IMPEL workshop on the implementation and application of the Directive.

The first draft of the Aarhus Convention was inspired by the Directive, but the Commission considers that the final text of the Aarhus Convention represents a clear advance on the provisions of the Directive.

According to the national reports the Directive has brought positive results. However, a number of difficulties have been identified, and this has led to proposals for improvements in the directive (see Recommendations).

Findings:

See Recommendations.

Recommendations:

The Commission considers it desirable to replace the Directive with a new Directive, and a proposal has been prepared. The new Directive shall correct the shortcomings identified, and it also also serves the purpose of aligning Community legislation with the Aarhus Convention.

Commission of the European Communities (2000): **Communication from the Commission to the Council and the European Parliament. Implementing the Community Strategy to reduce CO2 emissions from cars. First annual report on the effectiveness of the strategy.**

Summary:

The Community's strategy to reduce CO2 emissions from passenger cars and improve fuel economy1 was endorsed by the Council in 1996. It is based on three main pillars:

1. Commitments of the automobile industry on fuel economy improvements, aiming at achieving an average CO2 emission figure for new passenger cars of 140 g CO2/km by 2008/2009.
2. Fuel-economy labelling of cars3.
3. The promotion of car fuel efficiency by fiscal measures.

The two first pillars are in place, while intensive work on the third (fiscal measures) is underway.

The present - first - report covers progress made so far; it only addresses the first pillar: commitments made by the automobile industry.

The first set of "Joint Reports" shows that the ACEA (European manufacturers) and JAMA (Japan manufacturers) are on the way to match the interim targets. KAMA (Korean Manufacturers) has to increase its efforts significantly. The Commission has no particular reason to believe that any of the associations would not live up to its commitment.

Recommendations:

To achieve the Community strategy target of 120g CO2/km by 2010, it is important that the Community continues its work in developing and implementing the two pillars for consumer information and fiscality.

Commission of the European Communities (2000): **Communication from the Commission. A review of the Auto-Oil II Programme**

Summary:

Auto-Oil II was a technical programme of work undertaken jointly by several Commission services and a wide range of stakeholders, in order to assess policy options for achieving air quality objectives with a particular focus on reducing road transport emissions. Auto-Oil II was based on the principles of cost-effectiveness, sound science and transparency.

The paper reviews the approach taken and the work carried out within the Auto-Oil II programme, and reports on the key results in terms of
- emissions and air quality predictions,
- development of modelling tools for assessing policy options
- conclusions on the cost-effectiveness of the policy options studied.

Findings:

Auto-Oil II has been especially innovative in a number of ways.

- Auto-Oil II has been characterised by the involvement of a wide range of stakeholders.
- Auto-Oil II has been an integrated approach in that it has looked at a wide range of potential measures, both technical and non-technical, in order to meet a number of air quality targets.
- Through the intensive stakeholder dialogue and involvement of dedicated experts, the Auto-Oil II structure has ensured that its findings are based on the best available scientific information.

Auto-Oil II has provided an important learning experience for all involved. One particularly important lesson concerns the way in which the founding principles of cost-effectiveness, sound science and transparency should be applied. It is essential that programmes such as Auto-Oil are sufficiently flexible to keep up with technological, political and market developments.

Two further lessons relevant for the development of future air quality policy are the following.
- There is a need for improved scientific knowledge on the links between emission targets and air quality requirements.
- A really cost-effective policy package will require an integrated approach across sources, pollutants and measures. One of the key conclusions from Auto-Oil II is that an exclusive focus on road transport and specific sources does not guarantee a cost-effective outcome.

Recommendations:

Auto-Oil II has yielded some useful results concerning the cost-effectiveness of a range of technical and non-technical measures. Some of the key conclusions in this respect are listed in th paper. One is that fiscal measures provide a win-win solution for both environment and the economy. Well-targeted differentiated taxes are considered to be an effective tool to influence consumers behaviour.

While the analysis has led to some useful results concerning measures to be taken in the transport sector, it also strongly suggests that increased attention will need to be paid to other emission sources if further improvements in air quality are to be achieved. With this in mind the CAFE programme is being launched.

Corburn, J. (2001): **Emissions trading and environmental justice: distributive fairness and the USA's Acid Rain Programme. 2.**

Summary:

As emissions trading regimes become increasingly popular mechanisms for environmental pollution control around the world, environmentalists are asking whether market-based programmes meet their promise of both efficient and equitable pollution reductions. The emissions trading regime of the USA's Acid Rain Programme (ARP) is investigated in order to determine whether the programme has concentrated sulphur dioxide (SO2) pollution disproportionately for the poor and people of colour. While the USA emissions trading regime has been hailed as a success for cost-efficiently reducing pollution in the aggregate, critics contend that the programme is insufficiently attentive to the localized concentrations of harmful SO2 that trading can create. Further, advocates of environmental justice question whether emissions trading might exacerbate the disproportionate pollution burdens already facing the poor and people of colour. Stack emissions and pollution allowance holdings for all 110 power plants participating in Phase I of the trading programme are correlated with income and racial demographic characteristics of the people living around each plant to determine whether the ARP might raise distributive environmental justice concerns. Using USA Census data at the tract level, income and racial demographics around plants that increased and decreased their emissions as well as plants that were net purchasers and sellers of pollution allowances over the first three years of the programme are compared. For the first few years of the ARP, the emissions trading regime does not appear to have been concentrating SO2 pollution disproportionately for the poor and racial minority populations.

Findings:

The 110 Phase I power plants are located in areas with moderate to low household incomes and predominantly white populations. The mean median household income and percentage in poverty for all radial zones does not significantly differ from the aggregate state or county averages (i.e. the average across all states and counties with Phase I plants), and the percentage African-American and Hispanic populations in the power plant radial zones is lower than in the states and counties.

The income and racial demographics in radial zones that increased emissions (on an absolute tonnage basis) were not significantly different from those that decreased emissions. In one radial zone, the plants that experienced the largest percentage reductions in emissions had the lowest median incomes and the lowest percentage of African-Americans. There appears to be no relationship between the concentration of low-income populations and increases in Phase I power plant emissions.

There is no consistent relationship between allowance transfers (purchases or sales) and the percentage of the population in poverty or African-American. In comparison with the national means and the means for states and counties with Phase I plants, the median household incomes and the proportions in poverty are slightly lower for both sellers and purchasers of allowances. In addition, the percentage of whites is higher and that of African-Americans and Hispanics is significantly lower than the national means in both cases.

When plant radial zone characteristics are compared to the respective state averages rather than the national average or the averages across all states with Phase I plants, the results do not contradict the conclusion of the study that poor and minority communities are not being disproportionately affected by pollution increases under the Acid Rain Program.

Recommendations:

Due to data and other restrictions, the study included only the 110 primary Phase I units. The inclusion of the more than 150 so-called substitution and compensating units would produce a more definitive analysis. The analysis could also be improved by expanding the time period to cover the years following 1997.

Analyze the factors that influenced the original location of power plants, such as property values and employment characteristics.

Expand the scope of analysis to include questions of procedural justice (e.g., unfairness in participation in program design or allowance allocation).

Dixon, L. & Garber, S. (2001): **Fighting Air Pollution in Southern California by Scrapping Old Vehicles**

Summary:

This report examined the effects of a potential "voluntary accelerated vehicle retirement" program in California's South Coast region. The program would aim to retire 75,000 vehicles per year in California's South Coast by 2010. They analyzed the impact of this program on fleet turnover, emissions reductions, spillover effects into other regions of California, and cost-effectiveness.

Findings:

This analysis found that the program is estimated to lead to reduction in the number of vehicles 15 years or older by 147,000 and an increase in the number of vehicles less than 15 years old by 87,000 in the South Coast of California. The program is estimated to reduce emissions in the South Coast by 13 tons per day (tpd) in 2010—a decrease of about 4 percent. The program will also have an impact on the surrounding regions by reducing the number of vehicles 15 years or older by 40,000 and vehicles less than 15 years old by 43,000, which will

result in emissions reductions in the surrounding area of 3 tons per day—less than 1 percent. This analysis also found that the program would lead to an in-migration of vehicles into the South Coast region due to the increase in vehicle prices in the region.

The study also estimated the costs and cost-effectiveness of the program. They assumed that the cost per vehicle would range between $500 and $1500. As a result, the cost-effectiveness of the program was estimated at $3,700 – 33,300 per ton.

Recommendations:

None

Ellerman, A. D. (2003): **Are Cap-and-Trade Programs more Environmentally Effective than Conventional Regulation?**

Summary:

This paper considers the evidence and possible reasons that cap-and-trade programs are more effective in meeting environmental objectives than conventional prescriptive regulation. The evidence is based mostly, but not entirely, on the SO2 provisions of the Acid Rain Program and it consists of quicker implementation, accelerated emission reductions, absence of exemptions, and the lack of "hot spots." The paper also notes the trend, evident in the Northeastern NOx Budget Program and the RECLAIM programs, for cap-and-trade regulation to supplant conventional prescriptive regulation even when regulators have ample legal authority to impose the latter. This trend and the better environmental performance of these programs are attributed to the advantages that cap-and-trade programs offer to both pragmatic regulators and regulated entities.

Findings:

Title IV achieved large reductions within a quick time frame, incentivized ealier reductions, with relatively easy compliance (indicated by 100% compliance rate), without the feared pollution hot-spots. The NOx Budget Program and the RECLAIM programs also achieved similar results. This proven effectiveness combined with the difficulties associated with designing and implementing command and control policies suggest policy makers should consider market-based intruments as a leading policy option.

Ellerman, A. D. & Dubroeucq, F. (2004): **The Sources of Emission Reductions: Evidence from U.S. SO2 Emissions from 1985 through 2002.**

Summary:

An enduring issue in environmental regulation is whether to clean up existing "old" plants or in some manner to bring in new “clean” plants to replace the old. In this paper, a unit-level data base of emissions by nearly 2000 electric generating units from 1985 through 2002 is used to analyze the contribution of these two factors in accomplishing the significant reduction of sulfur dioxide emissions from these sources in the United States. The effect on SO2 emissions of the new natural-gas-fired, combined-cycle capacity that has been introduced since 1998 is also examined. The results indicate that cleaning up the old plants has made by far the greatest contribution to reducing SO2 emissions, and that this contribution has been especially large since the introduction of the SO2 cap-and-trade program in 1995. The new natural-gas-fired, combined cycle units have displaced conventional generation that would have emitted about 800,000 tons of SO2; however, the effect has not been to reduce total SO2 emissions since the 9.0 million ton cap is unchanged, but to reduce the quantity of abatement required of other units in meeting the cap and thereby the cost of doing so.

Findings:

Emission reductions in the US since 1985 mainly due to reductions at existing units. Reductions due to new units displacing older units has had important but secondary effect.

Ellerman, A.D. (2003): **Ex Post Evaluation of Tradable Permits: The U.S. SO2 Cap-and-Trade Program.**

Summary:

The U.S. SO2 cap-and-trade program was established as a result of the enactment of the 1990 Clean Air Act Amendments (1990 CAAA) under the authority granted by Title IV, which included several measures to reduce precursor emissions of acid deposition.2 The SO2 component consisted of a two-phase, cap-and-trade program for reducing SO2 emissions from fossil-fuel burning power plants located in the continental forty-eight states of the United States. During Phase I, lasting from 1995 through 1999, electric generating units larger than 100 MWe in generating capacity with an annual average emission rate in 1985 greater than 2.5 pounds of SO2 per million Btu of heat input in 1985 (hereafter, #SO2/mmBtu) were required to reduce emissions to a level that would be, on average, no greater than 2.5 #SO2/mmBtu. In Phase II, beginning in 2000 and continuing indefinitely, the program was expanded to include fossil-fuel electricity generating units greater than 25 MWe, or virtually all fossil-fuel power plants in the United States. Emissions from these affected units are limited, after accounting for any allowances banked from Phase I, to an annual cap of 8.9 million tons, or about half of total electric utility SO2 emissions in the early 1980s. The Phase II cap is equivalent to an Ex Post Evaluation: US SO2 Program 2 average emission rate of 1.2 #SO2/mmBtu, when divided by the mid-1980s level of heat input at fossil-fuel burning power plants.

Findings:

Market-based incentive systems achieve pollution reductions as well or better than command-and-control systems at considerably less cost.

Recommendations:

Market-based approaches should and will play an increasing role in the regulation of air emissions.

Ellerman, A.D. & Montero, J-P. (2002): **The Temporal Efficiency of SO2 Emissions Trading.**

Summary:

This paper provides an empirical evaluation of the temporal efficiency of the U.S. Acid Rain Program, which implemented a nationwide market for trading and banking sulfur dioxide (SO2) emission allowances. We first develop a model of efficient banking and select appropriate parameter values. Then, we use aggregate data from the first seven years of the Acid Rain Program, to assess the temporal efficiency of the observed banking behavior. We find that banking has been surprisingly efficient and we discuss why this finding disagrees with the common perception of excessive banking in this program.

Findings:

Despite popular notion excess banking of permits, especially in the early years of the acid rain trading program, analysis indicates that market participants were optimally participating in the banking program.

Glachant, M. (2000): **How can the Implementation of EU Environmental Policy be more Effective and Efficient? Lessons from Implementation Studies**

Summary:

The paper is the synthesis final research report of the project IMPOL ("The implementation of EU environmental policy: efficiency issues"). It is written for an academic audience. For research users (policy makers, private decision-makers, NGOs), a policy oriented report is

also available ("The implementation of EU environmental policies -the need for adaptability"; http://www.cerna.ensmp.fr/Progeuropeens/IMPOL/IMPOL_policy_brief.pdf).

The core of the project is made of three case studies of European environmental Directives or Council Regulations, which assess and compare the performances of their implementation in France, Germany, The Netherlands and United Kingdom. The three pieces of legislation are the Directive 89/429 regulating atmospheric emissions by domestic waste incinerators, the Directive 88/609 dealing with SO2 and NOx emissions by large combustion plants and the Council regulation 1836/93 concerning the voluntary participation of industrial companies in an EU Eco-Management and Audit scheme (EMAS).

The three case studies are presented elsewhere in three separate reports (Bültmann and Wätzold, 2000; Eames, 2000; Lulofs, 2000); the goal of the present report is to draw some general lessons from this available material.

The main striking general result is the pervasive and often-tremendous impact of non-anticipated parallel policy measures on the environmental outcomes. In order to cope efficiently with such policy interactions, implementation needs to be adaptive (see Findings)

Findings:

The central lesson of the paper is that the implementation of EU legislation is not a top down process but rather a piece in a complex dynamic of parallel policy processes. To efficiently cope with such pervasive interactions, implementation needs to be adaptive. This means:

To promote flexibility by avoiding to over-specify the means through which the regulated agents will attain the policy goals. This pleads for the use of economic instruments and 'bubble' approaches where firms are given maximal freedom regarding abatement choices.

To promote integration with parallel environmental measures; here, the message is to think in terms of environmental policy mix in order to exploit the synergies or to avoid contradictions between different policy components. Integration may also help to reduce policy uncertainty at the regulated agent level; uncertainty is a typical by-product of policy interactions. Uncertainty has a very detrimental effect on compliance leading to 'wait and see' behaviour due to the fact that compliance usually entails irreversible investments.

To promote de-centralisation and "horizontal co-ordination" between different policy branches.

Recommendations:

See findings.

Glachant, M. (2000): **The Implementation of EU Environmental Policies -The Need for Adaptability**

Summary:

The short report (15 pages) is a "research policy brief" on the outcome of the IMPOL project. IMPOL is the short name for The Implementation of EU Environmental Policies: Efficiency Issues. A more detailed report is also available ("How can the Implementation of EU Environmental Policy be more Effective and Efficient? Lessons from Implementation Studies").

The core of the IMPOL project consists in the ex post evaluation of the implementation outcomes of selected pieces of EU legislation in four countries (France, Germany, the Netherlands and the United Kingdom). Three cases were evaluated: the directive regulating emissions from existing domestic waste incinerators (89/429); the directive on emissions of

SO2 and NOx from Large Combustion Plants (88/609), and the council regulation on the Eco-Management and Audit Scheme (1863/93).

Findings:

To put in practice in Malmö and in Porto an environmental policy adopted in Brussels is clearly a challenge. Based on evaluation's results of a sample of EU policies implemented in the nineties, the current report argues that one key aspect is related to policy interactions. The impacts of other environmental or non-environmental policies made and implemented in parallel have huge impacts, either negative or positive, on the environmental outcomes of particular Directives. In this regard, the implementation of environmental directives is not a top down process, but a piece in a patchwork of policy processes arising at different levels (European, national, local) and in different areas (environmental and non-environmental).
Given that the impacts of such policy interactions are, by nature, difficult to anticipate, policy and its implementation needs to be adaptive. Adaptive policy means to promote:
- Flexibility through the use of economic instruments, which leaves the polluters free to choose how to adapt to unanticipated changes.
- Decentralisation and subsidiarity. Decentralised political systems are more likely to easily adjust when unanticipated changes occur. For the EU level, it means policies to develop policies focussing on environmental objectives rather than on the precise means necessary to reach them.
- Integration of parallel policy measures in policy mix. Here, the rationale is to promote the synergies and to limit the inconsistencies between the different policy components. At the EU level, this militates for broadening the scope of individual directives.
- Policy learning through cautious monitoring, ex post evaluation and revision mechanisms.

Harrington, Winston; Richard Morgenstern, and Thomas Sterner (Eds.) (2004): **Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe**

Summary:

This book includes a number of studies.
This book is so recent that it has not available physically to the reviewing team, who has had access to drafts of some chapters.

For two studies in the book there are individual reviews, namely:

"SO2 Emissions in Germany: Regulations to Fight Waldsterben" by Frank Wätzold

"NOx Emissions in France and Sweden: Markets Go Where Regulation Can't" by Katrin Millock and Thomas Sterner

The entire list of studies in the book is as follows:

Overview: Comparing Instrument Choices
Winston Harrington, Richard D. Morgenstern and Thomas Sterner

1. SO2 Emissions in Germany: Regulations to Fight Waldsterben
Frank Wätzold

2 SO2 Cap-and-Trade Program in the United States: A "Living Legend" of Market Effectiveness
Dallas Burtraw and Karen Palmer

3. Industrial Water Pollution in the United States: Direct Regulation or Market Incentive?
Winston Harrington

4. Industrial Water Pollution in the Netherlands: A Fee-Based Approach
Hans Th. A Bressers and Kris R.D. Lulofs

5. NOx Emissions in France and Sweden: Markets Go Where Regulation Can't
Katrin Millock and Thomas Sterner

6. NOx Emissions in the United States: A Potpourri of Policies
Dallas Burtraw and David A. Evans

7. CFCs: A Look Across Two Continents
James K. Hammitt

8. Leaded Gasoline in the United States: The Breakthrough of Permit Trading
Richard Newell and Kristian Rogers

9. Leaded Gasoline in Europe: Differences in Timing and Taxes
Henrik Hammar and Åsa Löfgren

10. Trichloroethylene in Europe: Ban vs. Tax
Thomas Sterner

11. Trichloroethylene in the United States: Embracing Market-Based Approaches?
Miranda Loh and Richard D. Morgenstern

Lessons from the Case Studies

Findings:

See individual studies

Recommendations:

See individual studies

Hordijk, L. (1998): **The lessons of transboundary air pollution in Europe**

Summary:

The paper is a 2-page summary for an OECD workshop. It discusses experiences from the implementation of the LRTAP convention and its 5 (until 1998) protocols.
The summary highlights:
Points of success
Obstacles
Prospects
Lessons

Findings:

- Interaction between scientists and policy advisors was crucial; in climate change terms: IPCC and FCCC were closely linked.
- The IAMs were developed in close collaboration with the negotiators; in climate change, most models (MAGE, ICAM, etc.) were developed by scientists and brought to policy advisors in a later stage.
- Although the intra-Europe negotiations were quite successful, the United States did not sign the second sulphur protocol; a regional approach (excluding North America) would have been better.
- The sometimes very large emission reductions percentages require a better compliance monitoring mechanism than currently in place.

Hutchinson, Emma J. and Peter J. G. Pearson (2004): **An Evaluation of the Environmental and Health Effects of Vehicle Exhaust Catalysts in the United Kingdom**

Summary:

The effect of three-way catalysts on emissions and the resulting ambient air concentration, human exposure and health effects was evaluated. The biggest benefit was obtained for PM10. The estimates of benefit was uncertain due to difficulties with cost estimates of the adverse health effects, but the net benefit was positive for the three different values of statistical life (VOSL) from the literature.

Findings:

No attempt was made to assess whether the mandating of three-way catalysts was necessarily the best policy option; alternative policies or actions might conceivably have led to larger benefits or a reduction in cost. The paper emphasises the value of undertaking ex ante evaluations of sets of alternative environmental policy interventions, to assist in the development of effective, appropriate pollution control policy strategies, as well as ex post appraisals of the net benefits realised from the chosen instrument(s).

Johnstone, N. (2003): **Efficient and Effective Use of Tradeable Permits in Combination with other Policy Instruments**

Summary:

This short paper (11 pages) was prepared for the OECD Global Forum on Sustainable Development: Emissions Trading and Concerted Action on Tradeable Emissions Permits (CATEP) Country Forum, held at the OECD Headquarters in Paris on 17-18 March 2003. The use of environmental policy mixes has been advocated by the OECD Environment Directorate (and others) for many years. However, surprisingly little work has been done on the conditions under which the use of multiple environmental policy instruments is likely to be preferable to the application of a single policy instrument. Moreover, little work has been done on examining the combinations of policy instruments which are likely to serve as effective and efficient complements.

In the present report, the links between tradeable permits and other policy instruments is explored.

Findings:

As a general principle it is unlikely to be economically efficient and environmentally effective to "kill one bird with two stones"., i.e. use a mixture of environmental policy instruments. In many instances it is likely to be administratively costly, economically inefficient, and/or environmentally ineffective. However, there are conditions under which it may be necessary to use two instruments, and this report has discussed four such cases. Indeed, there are certainly other cases as well, indicating that efficient environmental policy is often likely to involve the use of mixes of instruments, even when targeting the same environmental damage arising from the same source. However, in all cases the objective of each instrument must be clearly defined, and the relationship between the two instruments must be properly understood. Thus in order for the use of an additional policy instrument to be increase efficiency and effectiveness in the presence of a tradeable permit system, the "complementary" instrument must:

- meet a legitimate policy objective which can not be met more efficiently through the tradeable permit system itself;
- be the best instrument available to the regulatory authority if it is to meet that policy objective;
- preserve the benefits of the tradeable permit system (i.e. abatement cost reduction, dynamic incentives, environmental certainty) to the greatest extent possible; and,

- be administratively feasible at reasonable cost.

These conditions are by no means easy to fulfill. As such, designing an efficient and effective combination of environmental policy instruments is one of the great challenges facing policy makers today.

Larssen, S. (Ed.); M. L. Adams, K.J. Barrett, M.vh. Bolscher, F. de Leeuw and T. Pulles (2004): **Air Pollution in Europe,1990-2000**

Summary:

This report provides an overview and analysis of the air pollution situation in Europe, in the year 2000 and the preceding decade, based on indicators for underlying sectoral driving forces, emissions, air quality, deposition and the effectiveness of policies and measures.

The report answers the following questions:

1. How are driving forces of air pollutant emissions developing, and what progress has been made in reducing air pollutant emissions in Europe?
2. What is the state of air quality in Europe in 2000? Is it developing in line with the decreasing pollutant emissions?
3. How are policy measures affecting the air pollution problems?

Findings:

The major contribution to the decreased emissions in Europe is due to the successful abatement of sulphur dioxide emissions, by the UNECE LRTAP Convention and the European Union's Large Combustion Plant directives. These directives also decreased the emissions of NOx. Further reduction in emissions of this pollutant has been achieved by the introduction of catalysts in gasoline fuelled passenger cars as a response to the successive road vehicle related EU Directives. This technology also resulted in simultaneous reductions in the emissions of NMVOCs and CO.

Ambient air quality has followed largely the reductions in emissions, for PM10, NO2 and SO2, while for tropospheric ozone, the reductions in precursor emissions are not reflected in the atmospheric measurements

The emission reductions have resulted in notable decreases of the air pollution problems in the field of particulate matter and acidification.

Recommendations:

The two major contributions to the improvements in the air quality as achieved: the successful reduction of sulphur dioxide emissions throughout Europe and the introduction of catalysts in passenger cars can be characterised as the 'low hanging fruits', which now have been almost completely picked. Further reductions of air pollution will be more difficult and costly. This applies to the reduction of emissions of nitrogen oxides, ammonia and NMVOC as required under the NEC Directive and as relevant for eutrophication and ground level ozone. Further reduction of the emission of these pollutants is also needed in order to bring concentrations of fine particulate matter below the limit values.

Ozone and PM10/PM2.5 are now generally seen as the priority pollutants with continued non-attainment of limit values and major implications for human health.

In view of the costs involved, optimisation of cost-effective reduction strategies for these two priority pollutants in integrated assessment is essential. Such integrated assessment modelling is the core activity in the Commissions Clean Air for Europe (CAFE) programme.

Many measures to reduce emissions of greenhouse gases reduce air pollutants as well. Implementation of the Kyoto Protocol is expected to result in lower cost of air pollution abatement in Europe. Considering greenhouse gas emissions and air pollutant emissions in a common framework is therefore recommended.

Laxen, Duncan; Penny Wilson
(Air Quality Consultants Ltd., UK)

Clare Beattie, Dr Tim Chatterton, Professor Jim Longhurst
(Air Quality Management Resource Centre,University of West of England, Bristol, UK) (2002): **Evaluation of the first round of the Local Air Quality Management Process**

Recommendations:

A key recommendation is to carry out the next round in two steps
1. an Updating and Screening Assessment;
2. a Detailed Assessment of those pollutants and/or locations identified as requiring further work

The Updating and Screening Assessment should start when the Guidance is published and be completed within 3 months. The Detailed Assessment should be finished within 12 months of the start of the next round. The aim should be to have guidance ready by the end of 2002 to allow the next round to be completed by the end of 2003.

Menz, F.C. & Seip, H.M (2004): **Acid Rain in Europe and the United States: An Update**

Summary:

This paper considers how issues linked to and policies addressing acid rain in Europe and the United States have evolved over the past thirty years. The paper discusses also the emergence of acid rain as an environmental concern, scientific evidence about the effects of acidic deposition on natural ecosystems, US and European acid rain control policies, studies of the costs and benefits of reducing acid rain, and different policy contexts in Europe and the United States.

Findings:

The relationship between science and policy is more pronounced in Europe than in the USA. The reductions obtained in Europe are larger than in the USA. While there has been progress regarding dose-response functions for health effects of pollutants, the effects of acid deposition on forests can still not be quantified. On the other hand, use of economic models to analyze the effectiveness of various pollution control strategies is likely to increase, particularly given the success of the acid rain program in the United States.

Recommendations:

The critical load concept is used in Europe and not in the USA, where economic instruments were used more extensively. Use of cost-benefit analysis to determine appropriate levels of reductions will probably increase, but not play a decisive role, since uncertainties in various steps will continue to be large in the foreseeable future and its use to formulate pollution control targets remains controversial. Interaction of various types of air pollution is important to take into account. The interaction between pollutant leading to more severe effects is also important. These factors should be considered in scientific and economic assessments and in policy formation.

Millock, K. and Sterner, T. (2004): **NOx Emissions in France and Sweden: Markets Go Where Regulation Can't**

Summary:

Sweden and France have charges/taxes as supplementary instruments to command and control to control emissions of nitrogen oxides (NOx) from energy sector and industry boilers. The revenues from the Swedish charge are automatically recycled through payments to industry based on their energy produced. France has a tax applied to four different categories of air pollution, but at a much smaller level and with different criteria for refunding of the tax revenues.

No ex-ante analysis were performed in Sweden or in France. The Swedish charge is automatically refunded to tax payers according to their energy production, the French tax revenues were recycled through subsidies for abatement measures. The French tax, though, was only about 1% of the Swedish one.

Findings:

Taxation generates funding, while trading with free allocation does not. Such funding can be used to compensate losers from taxation, and it can also be used to reinforce the effectiveness of the tax. The NOx tax applied in Sweden is very high, and therefore has strong environmental effectiveness; industry is willing to pay such a high rate because the funds generated are recycled back to the industry which pays the tax, with those being most energy efficient are getting the largest refunds, see below. Where meeting a target is a high priority, then cap and trade emissions trading is preferable to taxation, because the polluter wishes to avoid the high losses expected if the target is missed. Conversely, if we are relatively indifferent about meeting a specific target, then taxation is likely to be more efficient. A wide variation in abatement costs at the margin is important if emissions trading is to maximise its ef-fectiveness. This means that it does not combine well with individual facility permit licensing, where every installation is required to install best available technology. Such a provision eliminates many of the potential gains from trade.

Recommendations:

A charging/taxation system can be a useful supplement to command and control regulation. The level of charge/tax should be set in each case. It is important to ensure that the money will be returned to the most effective firms. Monitoring systems are important for fine-tuning of the plant operation and for documentation of the emissions.

National Expert Group on Transboundary Air Pollution (NEGTAP) at CEH Edinburgh (2001): **Transboundary Air Pollution: Acidification, Eutrophication and Ground-level Ozone in the UK**

Summary:

The report provides a description of the current status of the problems of acid deposition, eutrophication and ground-level ozone in the UK, including emissions, atmospheric concentrations and deposition of major pollutants, and impact on soils, vegetation and freshwater. A summary of impact throughout Europe is included to provide a perspective for the assessment. The emissions of SO2 and NOx declined significantly The deposition of sulphur declined significantly and oxidised nitrogen the same. The reduced nitrogen dominates in many European countries. The average ozone concentration showed upward trend, probably due to emissions of precursors in Eastern Europe and Asia. The peak concentrations of ozone declined. Signs of recovery of ecosystems have been observed, but recoverey will take very long time.

Findings:

Emissions of SO2 and NOx in 1999 have declined by 80% in the UK. Emissions of NH3 have changed little since the peak emissions in the mid 1980s, but a decline of 12% relative to 1990 is expected by 2010;

Emissions of sulphur in Europe declined by 41% between 1990 and 1998. During the same period, emissions of NOx declined by 21%, NH3 by 14%, NMVOC by 24%. European policy to decrease emissions was much more successful than that of the US.

The deposition of S and NOx in the UK has declined since the peak in emissions by 50% for S and 16% for N. However, substantial non-linearities in relationships between emission and deposition have been detected.

The acidity of UK rainfall more than halved over large areas of the UK between 1985 and 1999;

A substantial decrease in S deposition and rainfall acidity has been recorded throughout Europe;

Nitrogen deposition in Europe has changed little over the last two decades;

Scenarios show that by 2010 the Gothenburg protocol will lead to a substantial reduction of the exceedance of critical loads of acidity in Europe. For nutrient nitrogen, however, critical load exceedances are unlikely to change very much;

Ground-level ozone concentrations regularly exceed the threshold for effects on vegetation and human health throughout the UK, but the peak concentrations declined by 30% between 1986 and 1999;

Ground-level ozone continues to exceed thresholds for effects on vegetation ad human health. The peak concentrations have declined during the last decade but mean ozone concentrations show signs of an upward trend;

The assessment of future pollutant concentrations and deposition rely heavily on numerical models;

Particulate matter has become an issue of increasing concern over Europe and North America and is considered to be the most important driving force for future control of the substances under the Gothenburg Protocol and the NECD.

Most EU and PHARE countries need substantial further reductions to meet NOx targets for 2010.

Recommendations:

Maintain and improve spatially disaggregated emission inventories, reduce uncertainty of emission inventories (especially for NH3).
More sophisticated methods of ecological risk assessment is needed. The long term operated monitoring is vital for demonstration of compliance and scientific assessment of the state.
Extensive recommendations regarding monitoring improvements of depositions;
Further develop long range transport models to quantify the fate of major air pollutants; etc.

National Research Council (2004): **Air Quality Management in the United States**

Summary:

The reports presents an overview and evaluation of air quality management in the past, and provides recommendations on air quality management in the future.
Over the past three decades, the US has devoted substantial efforts and resources to protect and improve air quality through implementation of the Clean Air Act (CAA). The US EPA estimates that the direct costs of CAA has been as high as $20-30 billion/year. The CAA has played an important role in lowering emissions of pollutants and cost-benefit analyses have shown that the economic value of the benefits to public health and welfare have equaled or exceeded the costs of implementation.

Despite substantial progress in improving air quality, the problems posed by pollutant emissions in the US are by no means solved. Additional effort is needed to deal with future economic population expansions and concomitant increased needs (i.e. electricity and transportation).

Findings:

The CAA has substantially decreased emissions of several pollutants, mostly due to regulations for transport, stationary sources. However, most of the reductions have been

accomplished through regulations on new facilities, while many older, often higher-emitting facilities can be a substantial source of emissions. Emission trading program provided a mechanism for achieving emission reductions at reduced costs. Air quality monitoring networks have confirmed that ambient pollutant concentrations, especially in urban areas, have decreased over the past three decades, and monitoring has documented a reduction in sulfate deposition in the eastern United States. Economic assessments of the overall costs and benefits of AQM in the United States indicate, despite uncertainties, that implementation of the CAA has had and will probably continue to have substantial net economic benefits.

Challenges ahead are:
Meeting new standards for ozone, particulate matter, and regional haze.
Understanding and addressing the human health risks from exposure to air toxics.
Responding to the evidence that, for some pollutants, there may be no identifiable threshold exposure below which harmful effects cease to occur.
Mitigating pollution effects that might disproportionately occur in minority and low-income communities in densely populated urban areas.
Enhancing understanding and protection of ecosystems affected by air pollution.
Understanding and addressing multistate and international transport of pollutants.
Adapting the AQM system to a changing (and most likely warmer) climate.

Recommendations:

US Air Quality Management should:
• Strive to identify and assess more clearly the most significant exposures, risks, and uncertainties.
• Strive to take an integrated multipollutant approach to controlling emissions of pollutants posing the most significant risks.
• Strive to take an airshed2-based approach by assessing and controlling emissions of important pollutants arising from local, multistate, national, and international sources.
• Strive to emphasize results over process, create accountability for the results, and dynamically adjust and correct the system as data on progress are assessed.

NCEE (National Center for Environmental Economics) (2001): **The United States Experience with Economic Incentives for Protecting Environment**

Summary:

Comprehensive review of economic incentive programs. Four advantages to using economic incentives: 1) Achieve larger emissions reductions; 2) Achieve reductions at a lower cost; 3) Able to cover a variety of different sources; 4) Promote technological development. Report examines cost effectiveness and overall efficacy of various incentive strategies including: Charges, fees and taxes, deposit refund systems, marketable permits, subsidies, liability, information disclosure and voluntary actions. Report includes cost comparison of command-and-control approaches vs. incentive-based approaches for a number of different pollution types.

Findings:

Increasing diversity of economic incentives used by EPA--Although historically EPA has relied on regulations to reduce pollution and improve the environment, it has begun to use a wide variety of economic incentive mechanisms in recent years.

Increasing application at other levels of government–Dozens of such applications are discussed in the report but there are hundreds more. Both the number of applications and their diversity is growing rapidly at the state and local level. Incentives are particularly useful in controlling pollution that has not already been subjected to traditional forms of regulation.

Recommendations:

The report was designed to be utilized to help identify the best incentive-base policy approach to apply to a given problem.

Parliamentary Committee on Agriculture and the Environment (1999): **Natural Acidification Only, Sweden**

Summary:

The report summarises the driving forces, the emissions and depositions and the state in relation to SO2 and NOx and acidification in Sweden since early 1990ies and predictions up to 2010. The actions taken and planned are summarised and targets are set up. Conflicting goals: Increased harvesting of forest-based fuels is beneficial from a climate point of view, but may come into conflict with the objective Natural Acidification Only. Liming of wetlands, on the other hand, which is a means of reducing the acidification of surface waters, may also have adverse effects on wetland vegetation and could thus conflict with the environmental quality objective Thriving Wetlands.

Findings:

The CLRTAP, NEC and other directives provide the main measures for the European action on acidification.

Recommendations:

Monitoring is important

Popp, D. (2001): **Pollution control Innovations and the Clean Air Act of 1990**

Summary:

See Findings...

Findings:

It is found that requiring plants constructed before 1990 to install scrubbers created incentives for innovation that would lower the costs of operating scrubbers. There is little evidence that the new patents created before 1990 improved the ability of scrubbers to more effectively control pollution. However, patents granted during the 1990s, when market-based mechanisms were in place, do serve to improve the removal efficiency of scrubbers.

Recommendations:

N/A

RIVM (2003): **The Netherlands contribution to the EMEP air quality assessment report. Acidification and air quality in the past decades and policy targets for 2010**

Summary:

The EU legislation is implemented in the Netherlands, and has lead to substantial improvements for most of the pollutants. The nitrogen compounds are now the dominating pollutants in relation to acidification and eutrophication. The measures have been less effective on PM and NO2, and the NO2 limit values are exceeded at many locations (many people are still exposed to levels above the limit values). NO2/NOx and PM are regional problems too. The Netherlands have set lower targets for deposition of nitrogen compounds and potential acid than corresponding to the NEC directive.

Stockholm Environment Institute. Research undertaken by Gary Haq, John Forrester, Johan Kuylenstierna, Gerry Leach and Peter Bailey (1999): **Costs and Strategies presented by Industry during the Negotiation of Environmental Regulations**

Summary:

On the basis of five case studies selected from Europe, the United States, and globally (Montreal protocol), the following question is discussed: When negotiating environmental regulations, does the industry provide a correct estimate of the costs associated with the implementation?

It is documented that in general, industry tended towards over-estimation of predicted compliance costs and in certain cases based its substantive opposition to regulations on such cost estimates.

The study is based on the following five case studies:
1. UNECE Protocols on Acidification and the EC Directive on Air Emissions from Large Combustion Plants
2. EC Directive 91/441/EEC on Vehicle Emission Standards (Euro I Standards and Catalytic Converter on Cars)
3. The European Auto-Oil Programme
4. The United States Clean Air Act
The Montreal Protocol on Substances that Deplete the Ozone Layer

When debating regulations, there is a much wider range of arguments used by industry representatives than fiscal costs alone. It is discussed how the industry may be opposed to new environmental regulations with the following arguments
1. The proposed policy will fail to yield the anticipated environmental benefits; the environmental goal may be valid, but the proposed instrument is economically inefficient because it imposes unnecessary costs.
2. The proposed instrument will make particular sections of industry less competitive or disadvantage industry as a whole compared with other countries or regions.
3. Employment opportunities will be adversely affected.
4. There is a lack of high quality scientific evidence linking cause and effect and hence the action demanded will be unlikely to yield the desired result.
5. There is an unresolved conflict between society's desire for higher environmental standards and a company's goal of adding to shareholder value.

A discussion of the concept of cost is given, and the problem with accurate cost estimates highlighted.

Some regulatory approaches to environmental improvement may impose a burden on companies, which industry will tend to oppose. However, parts of industry has also come to recognise that properly designed regulation need not increase costs, and that good regulation has often enhanced competitiveness in well-run companies.

The report includes a chapter with conclusions (3 pages).

Findings:

On the basis of five case studies selected from Europe, the United States, and globally (Montreal protocol), the following question is discussed: When negotiating environmental regulations, does the industry provide a correct estimate of the costs associated with the implementation?

It is documented that in general, industry tended towards over-estimation of predicted compliance costs and in certain cases based its substantive opposition to regulations on such cost estimates.

Another finding is that the costs of compliance are hard to compare in a meaningful way. The term cost has many different meanings in everyday language and within technical discussions.

The before and after compliance costs are not directly comparable as they refer only to unit costs and exclude other important costs such as those relevant to installation. Another issue is that the unit cost of production is typically high but, as production increases, costs fall.

When debating regulations, there is a much wider range of arguments used by industry representatives than fiscal costs alone. These arguments are discussed. Some regulatory approaches to environmental improvement may impose a burden on companies, which industry will tend to oppose. However, parts of industry has also come to recognise that properly designed regulation need not increase costs, and that good regulation has often enhanced competitiveness in well-run companies.

Swiss Federal Council (1999): **Report on pollution abatement action by Swiss federal and cantonal authorities of 23rd June 1999**

Summary:

The Swiss strategy has been to reduce the emissions as much as possible, e.g. the NOx and VOC emissions to1960 level and SO2 to 1950 level. Many different measures were applied. These reductions were only sufficient for SO2, and many new measures are planned or decided. The measures treated in the report are assessed to be capable of bringing about a sustainable improvement in air quality. For example, considerable technical potential remains to be exploited to reduce emissions. Incentives to promote environmentally sensitive behaviour in terms of mobility, consumption patterns and production may also assist in improving air quality. The key concepts here are environmental tax reform, agricultural reform and ensuring that the traffic pays the external costs of its share of air pollution. Switzerland can also support further air pollution control measures at the international level.

Findings:

An emission reduction of SO2 has been a success. NO2 was a limited success, mainly due to traffic emissions and the influence of O3. O3 requires international co-operation.

Recommendations:

A long list of future and planned measures is given on heating plants and buildings, industry, transport, agriculture and others

U.S. EPA (2003): **National Air Quality and Emissions Trends Report**

Summary:

Air quality programs have been effective in reducing levels of criteria pollutants, however 146 million Americans still live in areas designated as non-attainment areas for at least one pollutant. Progress has been the slowest on ground-level ozone reductions. Emission estimation methodologies are described and changes from previous years are noted. Also, a series of policy-relevant studies and exploratory analyses are summarized in this report. These studies address analysis of PM concentrations, carbon monoxide trends, the number of days above AQI levels of 100 for the ozone NAAQS, the spatial variation of air pollutants, and a proposed new reporting technique for air quality data.

Findings:

Emissions levels of the six criteria pollutants have dropped since 1970 despite large increases in GDP, energy use and VMT.

UNECE (2000): **Guidance document on economic instruments to reduce nitrogen oxides, sulphur, volatile organic compounds and ammonia**

Summary:

The experience gained in the use of economic instruments to reduce emissions of nitrogen oxides (NOx), sulphur, volatile organic compounds (VOCs) and ammonia has been reviewed in a background document based on national expertise and scientific literature. This has been condensed into three tables in the present, very short guidance document..

The first of the three tables shows the main features and aspects of the four categories of economic instruments that are likely to be the most relevant in the present context (tradable permits and quotas; emission and process taxes/charges; product charges and tax differentiation; subsidies and fiscal facilities). Their performance is assessed against a number of criteria and some important issues in the design of the instruments are mentioned. The second table illustrates the applicability and actual application (in the years until 1998) of the four instrument categories to various source categories and the third table presents a (non-exhaustive) list of provisions needed for the actual implementation of economic instruments

Findings:

The experiences concerning 4 economic instruments (tradable permits and quotas; emission and process taxes/charges; product charges and tax differentiation; subsidies and fiscal facilities) are reproduced in a very condensed form in a few tables.

Recommendations:

The tables present information specific to individual instruments. In addition, the following general considerations and recommendations should be taken into account:

(a) Economic instruments will have their optimal effect in cases where the market mechanism functions well. Therefore, it is necessary to check whether the actors who will be directly or indirectly affected by the instruments operate on (at least) reasonably competitive markets and have access to the information needed for their decision-making. It may be necessary to accompany (or precede) the introduction of an economic instrument with policies that improve the functioning of markets and the availability of information on emission reduction options and environmental benefits;

(b) Although pollution taxes or tradable permits are often presented as alternatives to direct regulation, they will in practice almost always be embedded in a mix of instruments, in which also standards, voluntary agreements and/or other instruments may be involved. When introducing an economic instrument it should be checked that the various instruments will be mutually reinforcing rather than counteracting;

(c) Taxes and charges can have an incentive function and/or a revenue-raising function. The incentive function can be realized directly by making abatement efforts profitable or indirectly through reaction in the market (due to the cost increase being passed on to consumers);

(d) Preferably, economic instruments (especially taxes and charges), like other instruments, should be announced well in advance of their starting date and should involve consultations with stakeholders. This will enable producers and consumers to take account of the instrument in their investment decisions and to react optimally to the changed market conditions, thus improving overall efficiency. However, for some product taxes, the announcement may also lead to stockpiling.

US National Research Council (2001): **Evaluating Vehicle Emissions Inspection and Maintenance Programs**

Summary:

The U.S. National Research Council conducted a review of inspection and maintenance programs in the U.S. The review considered passenger-car and light-truck emissions, reviewed the effectiveness of these programs, and provided some initial recommendations for means to improve the programs effectiveness.

Findings:

The Committee found that inspection and maintenance programs have generally achieved smaller emissions reductions than those estimated by models due to overestimation of the deterioration of vehicle-emissions performance, inadequate representation of the behavior of motorists and mechanics, overestimation of compliance with the program and effectiveness of repairs, overestimation of the ability to identify high-emitting vehicles, and incomplete implementation of some components of I/M programs.

They found that a small fraction of the fleet contributes a substantial proportion of overall vehicle emissions—typically less than 10% of the fleet contributes more than 50% of emissions. They also found that many critical factors that have large effects on the emissions reduction benefits of I/M programs are still unknown.

The Committee found that remote-sensing measurements are an excellent source of fleet-average CO and HC emissions data.

Recommendations:

The Committee made the following recommendations: 1) the Environmental Protection Agency and States should expect lower emissions reduction benefits from I/M programs as currently configured; I/M programs should focus primarily on identification, diagnosis, and repair of the highest-emitting vehicles and verify those repairs; I/M programs that target NOx and PM might have to incorporate heavy-duty diesel vehicles to a greater extent; remote sensing should have an increased role in assessing motor vehicle emissions and I/M programs; and I/M programs can be improved by identifying ways to make them more cost-effective and more readily understood and by easing the testing burden for vehicle owners.

Watkiss, P., Forster, D., Hunt, A., Smith, A. and Taylor, T. (2004): **A Comparison of EU Air Quality Policies and Legislation with Other Countries.**

Summary:

To date there is very limited evidence that there are significant competitiveness effects resulting from air pollution legislation on a general level and it has not been possible to disaggregate between the impacts on different sectors. The main reasons cited in the literature to explain why air pollution regulations generally do not appear to have a major impact on competitiveness are improved technology, relatively low air pollution expenditures compared to GVA, labour cost and stability and access to market is more important than environmental cost, cost of compliance often overestimated (ex-ante) and some important legislation is not fully implemented.

Findings:

It is extremely difficult to assess the impacts of air pollution legislation on relocation from the other factors that determine location decisions, though it is clear that labour costs and access to market are much more important than environmental legislation.

The industrial relocation for reasons of different environmental standards is not found to be significant from OECD countries to non-OECD countries.

Recommendations:

Given the status of the planned EU and US programmes (e.g. the Thematic Strategy on Air Pollution, Clear Skies) it is currently impossible to predict whether future policy will create a different competitive environment in Europe.

Based on historical trends, it would be expected that, relative to major EU competitors, future air pollution legislation in Europe would not be so significant as to have a major effect on international competitiveness. Note however, that a number of important directives have not yet been fully implemented (for example the IPPC directive, the National Emissions Ceiling Directive, Air Quality Framework daughter directives, the amended Large Combustion Plant

Directive, and the Greenhouse Gas Emissions Directive), and the cumulative effects of this legislation could still have economic implications.
However, the US is likely to implement future improvements through market-based instruments, which may offer a lower cost approach for US industry.
Air pollution policy in other competing regions, including China, is likely to increase markedly in future years, which may help reduce the gap between Europe and non-OECD countries.

Wätzold, Frank, UFZ-Centre for Environmental Research, Department of Economics, Sociology and Law, Germany (2004): **SO2 Emissions in Germany: Regulations to Fight Waldsterben**

Summary:

The report gives 1) a summary of the "forest death" and the electricity industry in Germany, 2) a description of the political evolution and the main content of the Ordinance on Large Combustion Plants (GFA-VO), 3) a short description of the voluntary agreement in North Rhine-Westphalia, 4) evaluation of the efficiency of GFA-VO and the Emission Reduction Plan (EMP) in North Rhine-Westphalia, and 5) a discussion of the German SO2 policy.
A "command and control" instrument was used in Germany. The most striking feature of the German SO2 policy was the great success in terms of emission reductions. The requirements were not only fulfilled, but a high degree of over-compliance was observed. The potential for over-compliance was used due to enormous public pressure to stop "forest death" and the monopolies of the electricity suppliers to shift the cost to the consumers.

Findings:

The German "command and control" instrument was most likely the best choice in terms of efficiency compared to economic instruments. This was mainly because the policy aim was to reduce the SO2 emission to a very high extent as soon as possible. With such an ambitious objective, there are little potential for differentiation left, which could be used under economic instruments.

Recommendations:

An effective monitoring and enforcement system was a precondition for the success of the type of policy applied in Germany.

ANNEX III

EXAMPLE OF DATABASE CONTENT

The reference document
Air quality standards

Air quality standards (limit values, target values etc.)

Pollutant & averaging	EU 2005	EU 2010	US	Japan	WHO[1]	China I[2]	China II[2]	China III[2]	Switzerland
SO_2 ($\mu g/m^3$)									
1 hour average *Statistics*	350 *24 per year*			262		150	500	700	100 *½-hour ave., 95 percentile*
3 hour average *Statistics*			1310 *1 per year*						
24 hour average *Statistics*	125 *3 per year*		365 *1 per year*	104	125	50	150	250	100 *1 per year*
Annual average *Statistics*	20 *Annual and winter ave.*		79		50	20	60	100	30
NO_2 ($\mu g/m^3$)									
1 hour average *Statistics*		200 *18 per year*			200	120	120	240	100 *½-hour ave., 95 percentile*
24 hour average *Statistics*				75-113		80	80	120	80 *1 per year*
Annual average *Statistics*		40	100		40	40	40	80	30
PM_{10} ($\mu g/m^3$)									
1 hour average *Statistics*				200					
24 hour average *Statistics*	50 *35 per year*	50 *7 per year*	150 *1 per year*	100[3]		50	150	250	50 *1 per year*
Annual average *Statistics*	40	20	50			40	100	150	20
$PM_{2.5}$ ($\mu g/m^3$)									
24 hour average *Statistics*			65 *98 percentile*			50	150	250	
Annual average			15			40	100	150	

[1] WHO values are guideline values.
[2] China: Zone 1: residential areas; Zone 2: commercial areas; Zone 3: industrial areas
[3] Suspended particulate matter

Pollutant & averaging	EU 2005	EU 2010	US	Japan	WHO[1]	China I[2]	China II[2]	China III[2]	Switzerland
CO (μg/m³)									
1 hour average *Statistics*			40000 *1 per year*		30000	10000	10000	10000	
8 hour average *Statistics*	10000		10000 *1 per year*	22900	10000				
24 hour average *Statistics*				11500		4000	4000	4000	8000 *1 per year*
Ozone (μg/m³)									
1 hour average *Statistics*	180/240[4]		240			120	160	200	120[5] *1 per year*
8 hour average *Statistics*		120 25 days/year[6]	160		120				
24 hour average *Statistics*									
AOT40[7] *Statistics*		18000[7] May-July							
Benzene									
Annual average *Statistics*		5		3					

[4] There is an information threshold of 180 μg/m³, and a warning threshold of 240 μg/m³. For a warning to be issued, the value must be exceeded during three consecutive hours.

[5] Switzerland has also a limit for ½-hourly values: For each month, 98% of halfhourly values should be below 100 μg/m³.

[6] 120 μg/m³ is a target value for 2010, to be understood in the following way: For each day, calculate the largest running 8-hour average during the day, and assign that value to the day. As an average over three years, there should be no more than 25 days per year with larger values that 120 μg/m³. Further, as a long-term objective for 2020, this value of 120 μg/m³ should be exceeded no more than 1 day per year.

[7] AOT40 is defined as the sum of the differences between hourly ozone concentration and 40 ppb for each hour when the concentration exceeds 40 ppb during a relevant growing season, e.g. for forest and crops. The limit value here is given in the units μg/m³*hours. The EU has set a target value of 18,000 μg/m³*hour for 2010, and a long-term objective of 6,000 μg/m³*hour for 2020.

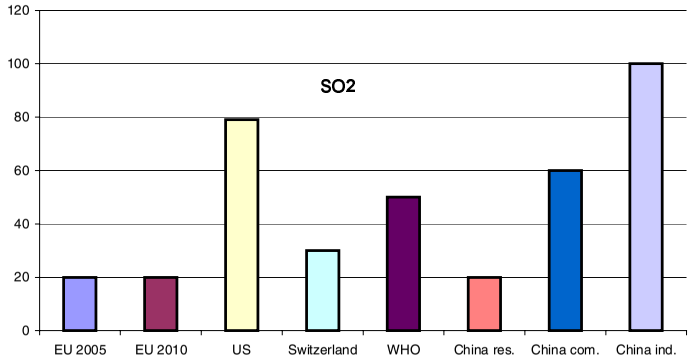
Pollutant & averaging	EU 2005	EU 2010	US	Japan	WHO[1]	China I[2]	China II[2]	China III[2]	Switzerland
Lead									
Annual average *Statistics*	0.5		1.5 *Quaterly ave.*		0.5	1	1	1	0.5
Benz(a)pyrene									
Annual average *Statistics*		(0.001) Proposal				0.010	0.010	0.010	

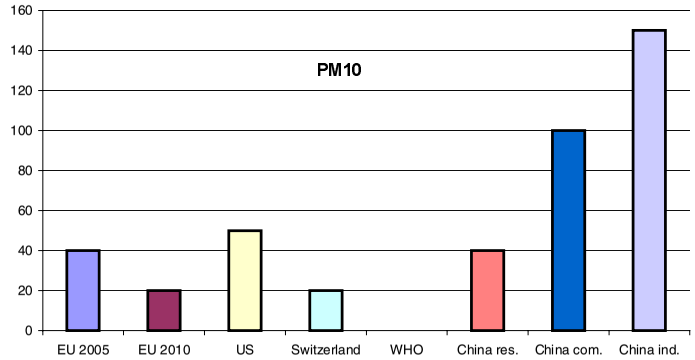
Notes

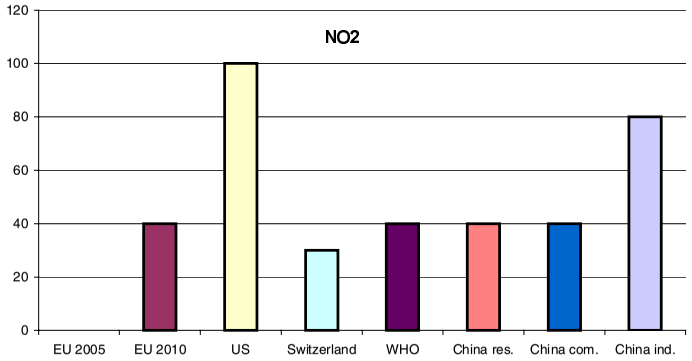
- In the "Statistics" line, e.g. "24 per year" means that 24 exceedances per year are permitted
- Some values have been converted from an official value given in ppm. This may result in slight inaccuracies. For information on conversion factors, see the reference document "Conversion between ppb and other units" (part of the data base, you may search for the text "conversion").

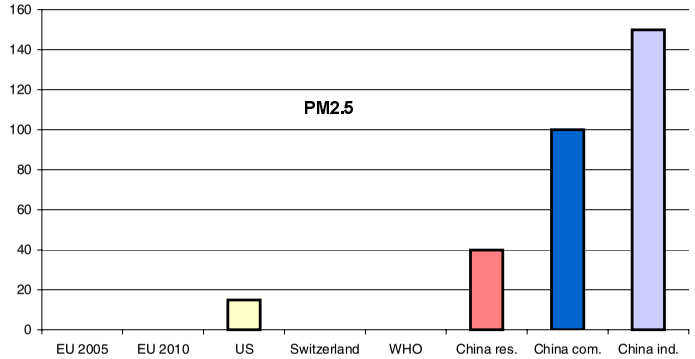
References

- US: http://www.epa.gov/ttn/naaqs/
  National Ambient Air Quality Standards (NAAQS)
- EU: A description of the very important "Air Quality Framework Directive" (EC 96/62/EC) and its Daughter Directives can be found on the page http://europa.eu.int/comm/environment/air/ambient.htm (there are links to the directives from that page). There is a an overview of other directives related to air pollution on the page http://europa.eu.int/comm/environment/air/legis.htm
- Switzerland: http://www.umwelt-schweiz.ch/imperia/md/content/luft/fachgebiet/d/stab/Immissionsgrenzwerte.pdf
- Japan: http://www.env.go.jp/en/lar/regulation/aq.html
- China http://www.vecc-sepa.org.cn/eng/news/news_detail.jsp?newsid=e00397
  SEPA, Vehicle Emission Control Center
- WHO Air Quality Guidelines for Europe: http://www.who.dk/InformationSources/Publications/Catalogue/20010910_6
- Other countries: The World Bank has a list, but it is not up to date: http://www.worldbank.org/html/fpd/em/power/standards/airqstd.stm
- In the Annexes of the case studies conducted under the current project on *Assessment of the effectiveness of European air quality policies and measures*, there are sections entitled "Legislation and Measures Implemented". These sections describe how and why standards have developed in EU, US, and to some extent Canada and Japan.

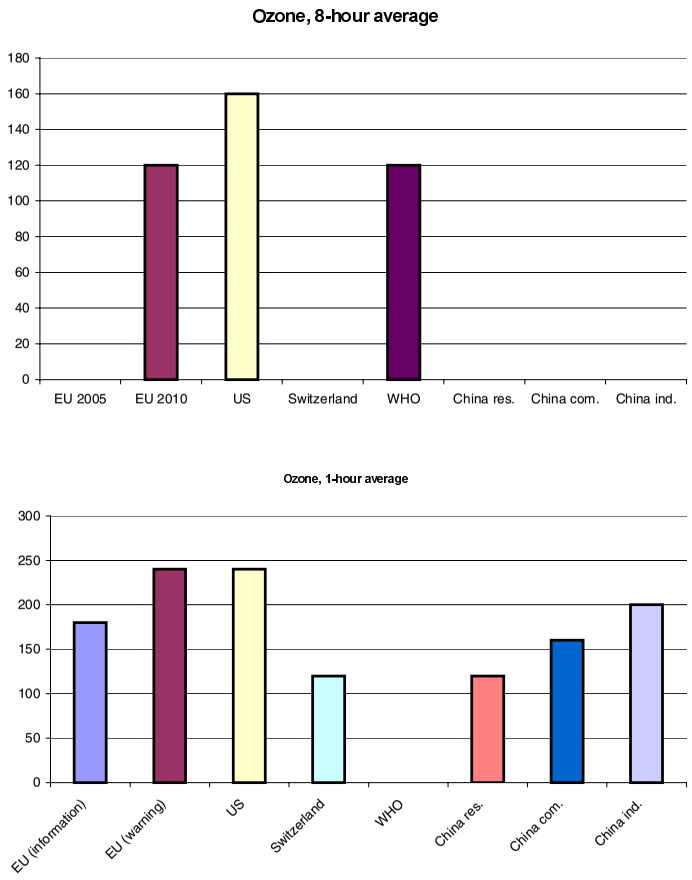








Comparison of air quality limit values for *annual averages* for various regions. Unit $\mu g/m^3$.



Comparison of air quality limit values for ozone. This graph displays air quality standards/target values for 8-hour averages (on top) and for 1-hour averages (bottom). The table and the footnotes to it explain how the limit values should be understood..