Air Pollution in Europe 1997

Executive summary

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Main conclusions

Europe and in particular the European Union is making progress in reducing some air pollution and its impact on human health and ecosystems. The main improvements have been in acidification and urban air quality, due to the reduction of sulphur emissions from point sources and the introduction of unleaded petrol for passenger cars. However, even these improvements have not been sufficient to achieve acceptable levels of sulphur and lead in the environment in many parts of Europe. For other environmental problems related to air pollution (climate change and tropospheric ozone) there has been no improvement, or only stabilisation, in recent years. For all air related environmental problems, the policies and measures to abate emissions have been largely offset by an increase in the driving forces behind the pressures, particularly in the transport sector. Further substantial reductions of all atmospheric emissions are needed to reach target levels for air quality and for exceedances of critical loads on ecosystems.

According to the European Environment Agency Regulation (1210/90) the EEA is required to provide objective, reliable, and comparable information at the European level, in order to support policy making and increase public awareness. This report, "Air Pollution in Europe 1997", which is timed to support new EU policy initiatives in 1997/8, assesses several environmental problems in which air pollution plays a major role. The main focus of the report is on pressures, state and impacts, but information is also provided on the main driving forces that influence the state of the environment (see Figure 1). The report can be regarded as a building block for the production of an Annual Indicator Report and covers the following five environmental problems:

- climate change
- acidification;
- eutrophication (atmospheric deposition)
- urban air quality, and
- tropospheric ozone.

The report covers the 15 EU Member States (EU15), which are the main clients of the EEA. However, the report includes also information from other European countries and Parties to the UN-ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), since this convention plays a significant role in reducing transboundary air pollution in Europe.

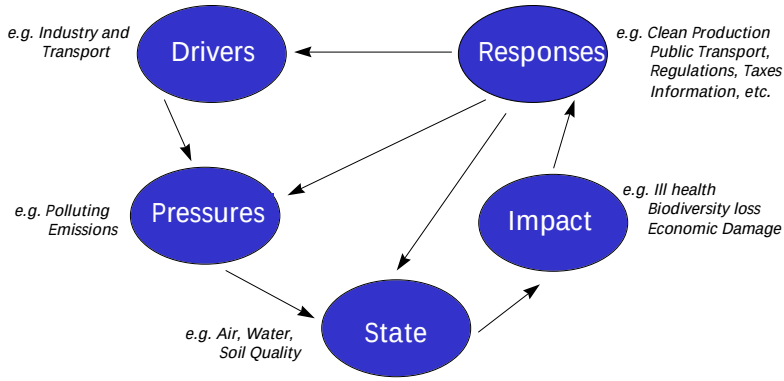

Figure 1 The DPSIR framework
Source : EEA

The main conclusions of the report are:

- only a relatively small number of pollutants released by human activities in the five economic sectors targeted in the EU fifth Environmental Action Programme (5EAP) contribute to five of the main environmental problems currently facing Europe;
- some improvements have emerged in recent years, particularly in those environmental problems which have been recognised for some time, where remedial measures are readily available, and where abatement measures and policy can be very specifically targeted, such as urban lead concentrations from leaded petrol, or acidification caused partly by sulphur emissions from large point sources, such as power plants;
- other problems such as climate change, urban air quality and tropospheric ozone, are more difficult to tackle, either due to increased economic activity or due to the large and increasing number of diffuse emission sources based on fossil fuels, for example vehicles.

However since the same pollutant in many cases is relevant for several of the environmental problems , reductions of emissions to improve one problem will also benefit others. For example, reductions of CO_2 emissions to address climate change will also reduce SO_2 , NO_x and CO emissions and hence improve acidification, tropospheric ozone and urban air quality.

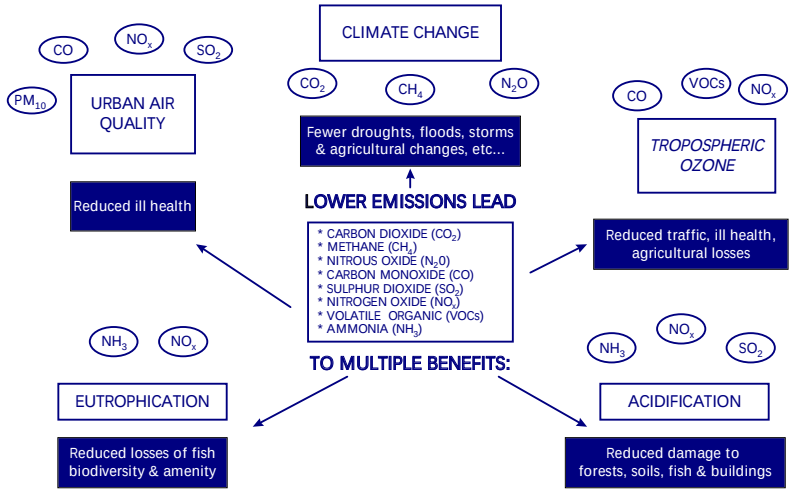

Figure 2 Multi-pollutant/multi-effect approach
Source : EEA

Finally, as shown by the example of tropospheric ozone, small reductions in precursor emissions can lead to an *increase* in local ozone concentrations (due to non-linear chemistry dependent on NO_x and NMVOC precursors). Hence it may be necessary to achieve large precursor emission reductions in order to reduce tropospheric ozone levels-but as we have seen ,this may be cost-effective because such reductions will also help reduce other problems such as acidification, eutrophication and air quality.

Environmental trends

The current status of the main (pressure) indicators is analysed in the chapters on environmental problems on air pollution and is summarised here in relation to the targets (in EU 5EAP and/or other relevant international targets and obligations). The focus in this summary is on EU15 (table 1).

Based on the summary in table 1 regarding EU15 pressure indicators, and additional information on state and impact indicators in the environmental problem chapters regarding the rest of Europe (in particular Parties to UNECE/CLRTAP), conclusions are presented for each of the four environmental problems covered in this report.

Table 1 **Assessment of environmental progress (pressure indicators) in achieving 2000 targets for EU15**

Problem (1990 = 100)	1985	1990	1994	2000 target	Remarks on targets in 2000
Climate change					
CO_2 emissions (fuelrelated)	99	100	97	100	EU and UNFCCC stabilisation of emissions in 2000 (related to 1990 levels)
Acidification/ eutrophication					
SO_2 emissions	120	100	72	60	• UNECE/CLRTAP emission reduction of 30 % (from 1980 levels) • EU emission reduction of 35 % (from 1985 levels) • EU and UNECE/CLRTAP "60 % gap closure" between existing deposition levels and critical loads or for EU as a whole 62% emission reduction (from 1980 levels)
NO_x emissions	94	100	93	70	EU and UNECE/CLRTAP target of 30 % emission reduction (from 1990 levels)
Tropospheric ozone					
NMVOC emissions		100	89	70	EU and UNECE/CLRTAP target of 30 % emission reduction (from 1990 levels)

Climate change

- the Second Assessment Report of IPCC (1995) concluded *inter alia* that "the balance of evidence suggests a discernible human influence on global climate", "the atmospheric concentrations of GHGs, *inter alia* CO_2, CH_4 and N_2O have grown significantly since pre-industrial times: by about 30 %, 145 % and 15 % respectively (values for 1992)", "global mean surface air temperature has increased by between about 0.3 and 0.6 °C since the late 19th century".
- from 1990 to 1994, CO_2 emissions of several EU Member States (Germany, United Kingdom, Italy) decreased, resulting for the EU15 in an emission reduction of approximately 2-3 %, mainly due to short-term factors like the temporary decrease of industrial and economic growth rates, the restructuring of industry in Germany, the closing of coal mines in the UK and the conversion of power plants to natural gas.
- the target of stabilisation of EU CO_2 emissions at 1990 levels by 2000 is being monitored by the European Commission. All Member States have submitted Annual Inventories for at least 1990 to 1994 and most also for 1995. They have also submitted first National Programmes in which they make projections for the future and describe the measures that are proposed to bring about reductions or stabilisation.
- there is uncertainty regarding the expected EU15 emission level in 2000 and whether the EU will achieve the target of stabilising the CO_2 emissions in 2000 (compared to 1990 levels). There is also uncertainty regarding the implementation of measures by Member States. Many measures will only have an impact after 2000.
- the EU Council of Environment Ministers has proposed that developed countries should reduce greenhouse gas emissions to 15% below 1990 levels by 2010. The target is based on the combined reduction of the main GHGs (CO_2, CH_4, N_2O), taking into account their global warming potential. Current commitments from Member States would enable the EU as a whole to reduce its emissions by 10% by 2010. Some EU Member States would be allowed to increase their emissions because this would be offset by decreases in other Member States. Further policies and measures will be

identified to enable EU countries to deliver an overall reduction of 15% by 2010, should developed countries agree to that target at the third Conference of Parties to the UN Framework Convention on Climate Change (UNFCCC) to be held in Kyoto (Japan) in December 1997.

Acidification

- for the EU the 5EAP target of 35 % reduction of SO_2 emissions (from 1985 levels) has already been reached in the year 1994, since the actual emission reduction between 1985 and 1994 was 40 %.
- for the whole of Europe the UNECE/CLRTAP target for 30 % reduction of SO_2 emissions (from 1980 levels) has also been reached in 1994, because the actual emission reduction between 1980 and 1994 was nearly 50 %.
- the reduction of SO_2 emissions in Europe between 1980 and 1994 was due to a number of reasons, including the possibility to target abatement measures on large point sources (low-sulphur coal and flue-gas desulphurisation) and emission reductions from indirect effects such as fuel switching with an increasing share of natural gas and a decreasing share of coal, renewal of power plants and the restructuring of the economies in Central and Eastern European countries.
- for EU and the rest of Europe achieving the aim of the second UNECE Sulphur Protocol by 2000 is uncertain. For EU15 as a whole the target is an emission reduction of 62 % (from the 1980 emission level). All Parties of the UNECE/LRTAP Convention are expected to reduce their emissions further, based on their emission reduction targets. As comparison, between 1980 and 1994 the SO_2-emissions in the EU were reduced by about 55%.
- new and more strict emission reduction targets for EU15 are currently being developed in connection with the two new EU strategies on acidification and ozone. The provisional EU15 emission ceiling by 2010 for SO2 is 2.7 million tonnes, or an 84 % reduction (from the 1990 level). These figures are provisional and they will be reviewed in the light of e.g. the forthcoming ozone strategy and further refinements to the scientific analysis.

- as a result of new initiatives at EU-level, such as the EU acidification strategy, the proposed new directive limiting the sulphur content of heavy fuel oil, the revision of the LCP Directive and the IPPC Directive, SO_2-emissions in the EU will continue to decrease after the year 2000.
- the target of the first NO_X Protocol of the LRTAP Convention of stabilising the emissions at the 1987 level by 1994, has been achieved on an overall European level, although not by all signatories to that Protocol. European emissions of NO_X were reduced by about 13% between 1987 and 1994. Reductions in CEEC are larger than in EU15 , probably partly due to the economic restructuring process in these countries.
- the target for EU, as given in the 5EAP, is a 30% reduction in NO_X emissions between 1990 and 2000. Although NO_X emissions have been reduced in recent years, it does not appear likely that this target will be met. There are several reasons for this, including the expected large growth in road traffic. Furthermore, the results of several measures taken to reduce emissions from motor vehicles, such as strengthened car emission standards, will not take full effect until after the year 2000, due to the rate of turnover of the vehicle fleet. Regarding stationary sources, emission reductions by 2000 are dependent on a number of factors, such as the level of energy use, the type of fuels used, and on how and how fast the provisions of relevant EU Directives (e.g. the LCP and the IPPC Directives) are implemented by the Member States.
- the relative importance of nitrogen as compared to sulphur in contributing to potentially acidifying depositions is currently increasing. The main reason for this is that over the last 10-15 years emissions of SO_2 have been reduced much more than those of NO_x and NH_3. Large parts of Europe are exposed to exceedance of the critical loads for eutrophying nitrogen.
- in order to reduce acidification, eutrophication, and tropospheric ozone, emissions of nitrogen oxides must be further reduced. In the EU strategies on acidification and ozone, and the forthcoming second NO_X Protocol (multi-pollutant, multi-effect) under the CLRTAP

Convention, establishing targets and measures for future NO_X reductions will most likely be integrated. This means the combined effects of the pollutants involved will be taken into account as well as the most cost-effective ways to minimise and eventually eliminate their harmful effects on the environment. The provisional emission reduction target for NO_X, as given in the EU acidification strategy, is 6 million tonnes by 2010, which means a reduction of 55% as compared to 1990.

- currently there are no international reduction targets for ammonia emissions, neither in the EU nor under the CLRTAP Convention. A small decrease in emissions took place between 1990 and 1994, probably due to reduced agricultural activity (livestock reductions). In the forthcoming directive as proposed in the EU acidification strategy, it is intended to include national emission ceilings for ammonia. The acidification strategy document lists a number of cost-effective emission abatement measures for ammonia. Moreover, ammonia is one of the pollutants, apart from NO_X and VOCs, that is covered in the ongoing negotiations for a new NO_X Protocol under the CLRTAP Convention.
- in accordance with the emission reductions of SO_2 mentioned, the total area in Europe with recorded exceedances of critical loads for sulphur (5 percentile) has been reduced by 50 % between 1980 and 1994. However widespread exceedance of critical loads still occurs. This can be explained from the remaining SO_2 emissions, but also because the emissions of NO_x and NH_3 have not been reduced as much as SO_2 emissions. Large parts of Europe are exposed to exceedance of the critical loads for eutrophying nitrogen.

Tropospheric ozone

- for the EU and the rest of Europe the emissions of NMVOCs have been reduced. Emissions of NMVOCs have been reduced by 14 % overall in Europe and 9 % in EU15 between 1990 and 1994. Reductions in CEEC are larger than in EU15 , probably partly due to the economic restructuring process in these countries.
- due to the fact that the several important Directives for EU Member States (for example the Solvent Directive, emission limits for passenger cars resulting from Auto Oil I, the Stage I Directive on storage and distribution of petrol, the IPPC Directive) will not have full effect before 2000, meeting the target of 30 % emission reduction of NMVOCs (from 1990 levels) in 2000 remains uncertain.
- the EU ozone threshold value for the protection of human health (110 $\mu g/m^3$, 8h average) is exceeded substantially. Based on measurements at urban stations it can be concluded that 80 % of the EU urban population is exposed to these exceedances at least one day per year during summer smog episodes. On average the EU urban population is exposed to concentrations above the threshold during 1-2 consecutive days per year. Maximum episode lengths of 5-8 days were reported in 1995.
- based on model calculations, it can be concluded that 66% of the non-EU-Europeans may be exposed, at least once per year, to exceedances of the WHO and EU thresholds for the protection of human health.
- the threshold value for providing information to the public (180 µg/m3, 1h average) has been exceeded in almost all Member States during a limited number of days both in 1995 and 1996. This concerned about 31 million Europeans (46% of the urban population living in cities with operational monitors). Exceedance of the threshold value for warning the public (360 µg/m3) has been reported from one site in 1995 and three stations during 1996.

- in 1995 the threshold value for daily average concentrations set for the protection of vegetation (65 μg/m³) was exceeded substantially (by up to a factor of 3), in all reporting EU15 countries and frequently. Exceedances during more than 150 days are estimated for more than 27% of the area.

Air quality

- for SO_2 about 70% of the total population of all the European cities with monitoring stations (population of about 37 million) is exposed to levels above the lower EU Guide value (100 μg/m^3, max. 24-h mean). Maximum 24-hour concentrations regionally may reach 100-150 μg/m^3 in several areas in Europe (Central/east Europe and UK). This is actually as high as the EU (and WHO) Guide value, indicating that during episodic "winter smog" situations in Central and North-western Europe, a large part of the population is exposed to SO_2 concentrations which pose a certain health risk.
- for NO_2 a number of cities with about 40% of the population (population of about 27 million) have an average level above the EU Guide values (50 μg/m^3, P50). Maximum 24-hour concentrations regionally may reach 60-70 μg/m^3 in most of central Europe, well below the WHO Guideline of 150 μg/m^3. Thus, episodes of regionally high NO_2 concentrations do not pose a health risk to the population outside urban areas.
- trend data for SO_2 and NO_2 levels in recent years is only available on a consistent reporting basis for a limited number of cities in Europe. Over the period 1988-1993 a rather consistent downward trend in SO_2 concentrations occurs with an average reduction in SO_2 (annual mean) in these cities of 30%. There is a similar trend in NO_2 concentrations, with an average reduction in annual mean of 16%. These trends are the result of several factors, including past and current abatement policies like the UNECE/CLRTAP sulphur protocol and introduction of 3-way catalysts for passenger cars, but also indirect effects like the restructuring of economies in CEEC.

- for particulate matter measurement data is not complete enough to present a representative map on the European scale. TSP and BS exceeds EU Limit values to some extent at a few places, and EU Guide and WHO Guideline values at several places;
- the small-sized particulate matter (PM_{10}, 98-percentile) exceeds the UK recommended guideline of 50 $\mu g/m^3$ extensively in most of the cities for which data are available.
- regional PM_{10} concentrations can reach 25 $\mu g/m^3$ as annual average in certain parts of Central/North-western Europe. The additional urban contribution is most often smaller than this regional component. To control long-term average PM_{10}, abatement of the regional scale contributions is thus very important. For maximum short-term (24 hour) episodes, the urban contribution is more important;
- although lead concentrations have been decreasing in recent years, lead still may represent a pollution problem near roads with intense traffic in the countries which still have a relatively high lead content in gasoline.
- the EU has not yet established Guide values for benzene. UK, the Netherlands, Italy and Germany have recommended guidelines within the range of 3-16 $\mu g/m^3$, as annual average. City background levels are presently in the same range as the range of these recommended guidelines
- the current ongoing introduction of three-way catalysts on gasoline-powered vehicles, current legislation for diesel-powered vehicles, and further vehicle technology and fuel improvements resulting from the Auto-Oil I programme will have a further significant effect on urban air quality as regards NO_2, CO, benzene and to a smaller extent PM_{10}.

Societal trends and target sectors

Societal trends

In this report a description and (limited) analysis has been made of societal developments, or "driving forces" (following the DPSIR framework) in the past years (1980-1994), based on indicators that 'explain' environmental pressure mainly in the EU.
One of the key strategies of the 5EAP (EU) is to integrate environmental considerations into other policy areas, focusing on five target sectors, i.e. industry, energy, transport, agriculture and tourism. These sectors are also major sources of air pollution. The aim is to initiate changes in current practices and trends which are the causal factors (driving forces) behind environmental pressures. Progress in integration has been slow and the main driving forces producing the pressures have not changed or lessened. Growth has meant increasing energy consumption and emissions, especially for transport. The main trends relevant for air pollution problems are (for EU15):

- population increase;
- fast growth in transport (road and air);
- continuous growth in tourism (only addressed indirectly in this report in the section on air transport development);
- continuous increase in energy consumption (improvements in energy efficiency in industry is counterbalanced by the increased consumption in the transport target sector);
- mixed picture regarding agriculture (some livestock increase, some decrease, changes in fertiliser use).

Target sectors

This section presents a summary of the contribution of the target sectors, as defined in the 5EAP (EU), to each of the environmental problems. The conclusions mentioned here are related to EU15 only.

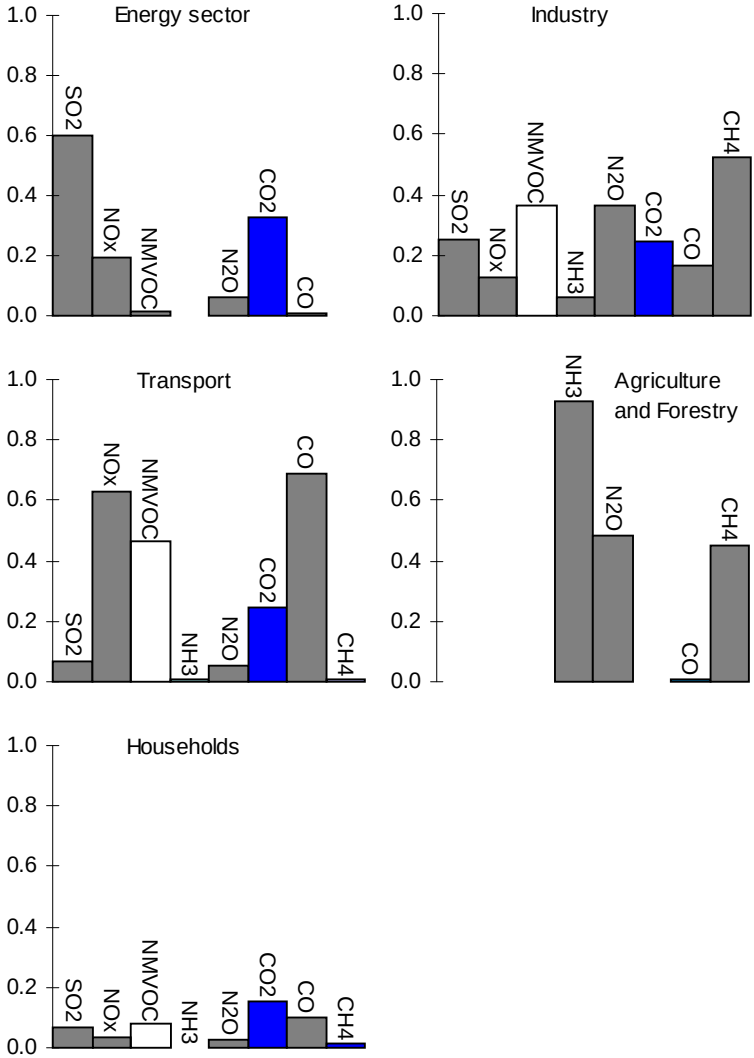

Figure 3 **Contribution of the 5 target sectors (5EAP) to the total EU15 emissions (1994) (ETC/AE)**

Source: EEA-ETC/AE

The *energy sect33or* is responsible for a large contribution to the emissions of CO_2 (33 %), NO_x (20%) and SO_2 (60%) and furthermore contributes to a large extent to the emissions of particulates (40-55 %). The emissions are mainly caused by power plants and refineries. These emissions contribute in particular to the environmental problems of climate change, acidification and urban air quality. The energy sector is expected to make a major contribution to meeting objectives for these problems. EU15 emissions of all pollutants emitted by the energy sector have been significantly reduced between 1980 and 1994. For SO_2 it appears targets have been met relatively easily by fuel switching (which will also contribute to NO_x and CO_2 targets), by the use of low sulphur coal and by retrofitting flue gas desulphurisation to power plants (LCP Directive). Achievement of the targets for CO_2 emissions is more uncertain and depends on the improvement of energy efficiency, introduction of renewable energy and the level of further switching of fuel to natural gas and perhaps to nuclear power.

The emissions of *industry* are significant for the following pollutants : CO_2 (24 %), N_2O (37 %), NO_x (13 %), SO_2 (25%), NMVOC (37 %), CH_4 (52 %, due to the inclusion of waste treatment in the sector industry) and particulates (15-30 %) and are therefore contributing significantly to the environmental problems of climate change, acidification, tropospheric ozone and urban air quality. The industry sector is expected to make a major contribution to meeting objectives for these problems. EU15 emissions of most pollutants emitted by industry have been significantly reduced between 1980 and 1994. For SO_2 and CO_2 the same is valid to a large extent as for the energy sector, mentioned above. In general, industrial point sources have been well targeted in the past by regulations (LCP Directive), which often have resulted in the development of new end-of-pipe technologies. However diffuse sources have been less effectively tackled and it is expected that some new and/or proposed

Directives will stimulate reduction of emissions from these diffuse sources (e.g. the IPPC and Solvent Directives). Voluntary mechanisms and self-regulation are becoming increasingly important in the industrial sector (see the EEA report on voluntary agreements, to be published in 1997).

Transport (both road and off-road) is responsible for a large contribution to the emissions of CO (69 %), CO_2 (24 %), NO_x (63 %), NMVOC (47 %) and particulates (10-25 %) and is therefore contributing significantly to the environmental problems of climate change, acidification, tropospheric ozone and urban air quality. Emissions from transport will have to be significantly reduced in order to meet the overall 5EAP emission reduction targets. However mainly due to increased mobility the emissions of all pollutants emitted by mobile sources increased between 1980 and 1990. Based on the information presented in this report there are indications that emissions of NO_x and NMVOC have decreased slightly between 1990 and 1994, mainly due to the introduction of catalytic converters. Due to the large scale introduction of unleaded petrol, atmospheric lead concentrations have been reduced in recent years. However some issues remain to be addressed, like the cold start problem of catalytic converters and the emissions of particulates from diesel engines. The EU Auto Oil II Programme will look into further cost-effective emission reductions in road transport taking into account contributions from other sectors (e.g. industry, energy sector, households) and both technical and non-technical (transport management) measures. Finally, a large part of the reduction of NO_x and NMVOC emissions has been offset and might be further offset in the future by rising traffic levels and mobility.

The emissions of *agriculture* are significant for the following pollutants : N_2O (48 %), CH_4 (45 %) and NH_3 (97%) and are therefore contributing significantly to the environmental problems of climate change, acidification and eutrophication. The agricultural sector is expected to make a major contribution to meeting objectives for these problems. EU15 emissions of all pollutants emitted by agriculture have been more or less stable between 1980 and 1994, because the emissions are mainly related to the number of livestock and decreases of cattle have been offset by increases of pigs and poultry. At present, there are no EU targets for emissions of the greenhouse gases N_2O and CH_4, or the acidifying gas, NH_3. However, such targets might be developed in the future in the framework of the UN-FCCC negotiations and the EU acidification strategy.

Households (although not explicitly identified as a specific target sector in 5EAP) are responsible for a significant contribution to the emissions of CO_2 (15 %), CO (10 %) and to a lesser extent NMVOC (8%) and are therefore contributing significantly to the environmental problems of climate change and tropospheric ozone. The household sector, which excludes transport, can make a significant contribution to meeting the 5EAP targets in several ways, for example improvement of energy efficiency (housing) and increased awareness about particular products (for example high-NMVOC containing products and high-energy-consuming products).