EN06 Energy-related emissions of acidifying substances

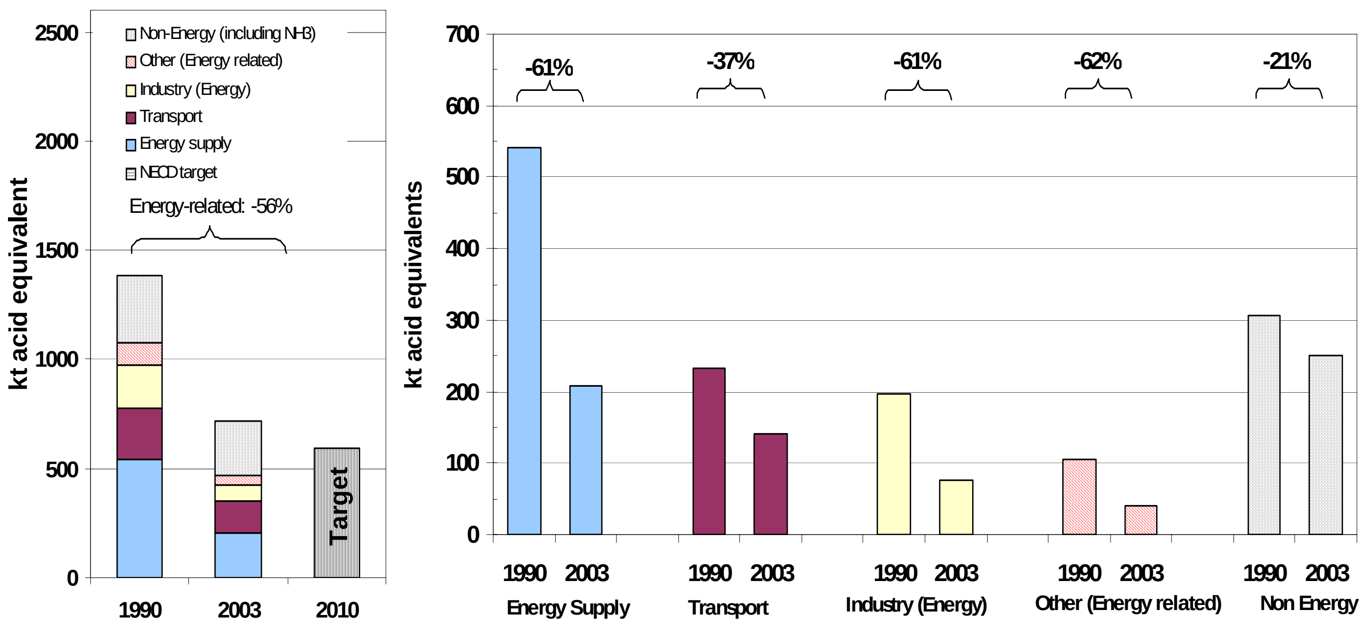
Key message

Emissions of energy-related acidifying pollutants decreased by 56 % in the EU-25 between 1990 and 2003. This was mainly due to abatement technologies, fuel switch and the uptake of low sulphur fuels together with improved energy efficiency and the closure of inefficient power plants. Further reductions in acidifying emissions from energy use are still needed to solve remaining local and transboundary air pollution issues.

Rationale

Energy-related emissions account for the majority of nitrogen oxides (NO_x) and sulphur dioxide (SO_2) emissions, while only a small fraction of ammonia (NH_3) emissions occur from energy production and use. These pollutants all contribute to acid deposition, leading to potential changes in soil and water quality and damage to forests, crops and other vegetation, and to adverse effects on aquatic ecosystems in rivers and lakes. Acidification also damages buildings and cultural monuments and because acidifying pollutants also contribute to the formation in the atmosphere of fine particulates it also indirectly contributes to human respiratory diseases. Other adverse health impacts can arise if acidification affects groundwater that is used for public water supply.

Fig. 1: Total and sectoral energy-related emissions of acidifying pollutants, EU-25 (weighted by acidification potential factors)

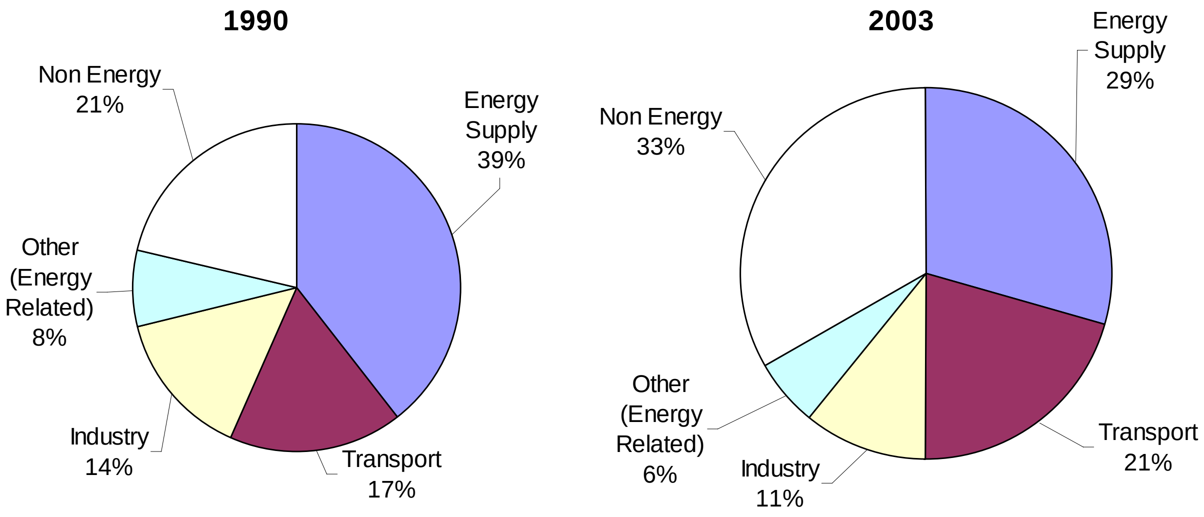


Source: ETC-ACC 2005

Notes: The figure shows the emissions of acidifying pollutants (sulphur dioxide SO_2, nitrogen oxides NOx and ammonia NH_3) each weighted by an acid equivalency factor prior to aggregation to represent their respective acidification potentials. The acid equivalency factors are given by: w(SO_2) = 2/64 acid eq/g = 31.25 acid eq/kg, w(NOx) = 1/46 acid eq/g = 21.74 acid eq/kg and w(NH_3) = 1/17 acid eq/g = 58.82 acid eq/kg. Data for Malta not available.

The target indicated is the 2010 National Emissions Ceiling Directive (NECD) (2001/81/EC) target for the combined acidifying pollutants NOx, SO2 and NH3 including energy- and non-energy related emissions. Targets for the new Member States are temporary and are without prejudice to the review of the NEC Directive which is to be completed in 2005-2006. The energy supply sector includes public electricity and heat production, oil refining, production of solid fuels and fugitive emissions from fuels. The transport sector includes emissions from road and off-road sources (e.g. railways and vehicles used for agriculture and forestry). Industry (Energy) relates to emissions from combustion processes used in the manufacturing industry including boilers, gas turbines and stationary engines. ‘Other (energy-related)’ covers energy use mainly in the services and household sectors.

Fig. 2: Sectoral shares of acidifying pollutants (SO_2, NOx, NH_3; energy and non-energy



components) in total emissions, EU-25

Source: EEA ETC-ACC 2005.

1. Indicator assessment

EU-25 energy-related acidifying emissions are responsible for over 66 % of the total acidifying emissions in 2003, underlining the large contribution that energy use makes to both local and transboundary air pollution. In the case of NO_x and SO_2, the share of energy-related emissions is even higher with more than over 95 % of total acidifying emissions for each of these respective pollutants.

Energy-related acidifying emissions decreased by 56 % over the period 1990-2003, more than from other sources. In the EU-15 this has mainly been due to improved abatement technology and increased rates of implementation of these technologies, switching from coal and heavy fuel oil to natural gas, the increased share of low sulphur fuels, and improved energy efficiency. In the new Member States, the main reasons for the decrease in emissions include the combined effect of economic restructuring, reduced energy consumption, closing of inefficient plants, reduced use of sulphurous fuels and the increased market penetration of pollution abatement technologies such as flue gas desulphurisation.

Energy supply was responsible for the largest decrease in emissions of energy-related acidifying pollutants in the EU-25 between 1990 and 2003 in absolute terms as well as in relative terms (-61 %), together with the ‘services and household’ sectors. In the latter sectors, this was mainly due to a decrease of SO_2 emissions caused by use of less sulphurous fuels (including fuel switching etc). In the electricity production sector, combustion modification and flue-gas treatment have been used to reduce NO_x emissions (see EN09 for details). One of the most common forms of combustion modification is to use low NO_x burners, which typically can reduce NO_x emissions by up to 40 %. Flue gas treatment can also be used to remove NO_x from the flue gases. Transport emissions across the EU-25 have also decreased significantly by 37 % between 1990 and 2003, due to the introduction of catalytic converters on new cars since the early 1990s. Across Europe there is an increasing awareness of the contribution made to acidifying pollutant emissions by ship traffic. (A detailed discussion of this issue is contained in TERM indicator fact sheet TERM03 - Transport emissions of air pollutants.) Many of these actions were implemented as a result of various European policies and measures, including the IPPC Directive, the Large Combustion Plant Directive and vehicle EURO standards (see section 2.2).

The majority of EU-25 Member States have contributed to the reduction in overall emissions of acidifying substances. In particular, many of the EU-10 Member States have already met or exceeded their indicative targets under the National Emission Ceilings Directive (NECD) due to structural changes in their economies, such as the decline in heavy industry and the closure of older inefficient power plants. This has led to a decline of over 50 % in many cases, even though total per capita emissions often still remain high. However, some EU-15 Member States are currently not well on track to meet their 2010 emissions targets under the NECD.

2. Indicator rationale

2.1 Environmental context

Acidification is caused by emissions of sulphur dioxide, nitrogen dioxide and ammonia into the atmosphere, and their subsequent chemical reactions and deposition on ecosystems and materials. Deposition of acidifying substances causes damage to ecosystems, buildings and materials (corrosion). The adverse effect associated with each individual pollutant depends on its potential to acidify and the individual properties of the ecosystems and materials. The deposition of acidifying substance still often exceeds the critical loads[1] of the ecosystems across Europe. Efforts to reduce the effects of acidification are therefore focused on reducing the emissions of acidifying substances. NO_x and SO_2 can also have direct or indirect impacts on human health and can transform into small-diameter particulate matter (see EN07 for more information about energy-related particulate emissions) which when inhaled, can cause harmful effects to human health such as respiratory problems. NO_x is also a tropospheric ozone precursor that reacts in the atmosphere in the presence of sunlight to form ozone which, in high concentrations, can lead to significant health impacts and damage to crops and other vegetation. Furthermore, an excessive input of nutrients from atmospheric deposition leads to eutrophication.

2.2 Policy context

Several EU-wide emissions limits and targets exist for the reduction of SO_2, NO_x and NH_3, including the National Emissions Ceiling Directive (NECD; 2001/81/EC) and the UNECE CLRTAP Gothenburg Protocol under UNECE CLRTAP (UNECE 1999). This indicator provides relevant information for assessing the achievement of these targets and also for analyses performed within the European Commission's Clean Air For Europe programme (CAFE). This thematic strategy on air quality was released in September 2005.

The NEC Directive includes emission reduction targets that are slightly stricter than the targets set in the Gothenburg Protocol and requires the introduction of national emission ceilings for emissions of SO_2, NO_x and NH_3 (and also NMVOCs) in each Member State, as well as setting interim environmental objectives for reducing the exposure of ecosystems and human populations to damaging levels of the acid pollutants. Targets for the new Member States are temporary and are without prejudice to the review of the NEC Directive which is to be completed in 2005-2006.

In terms of the energy sector, the most relevant NEC Directive targets for the EU-25 as a whole are:

- SO_2: emissions reduction of 74 % by 2010 from 1990 levels;
- NO_x: emissions reduction of 53 % by 2010 from 1990 levels.

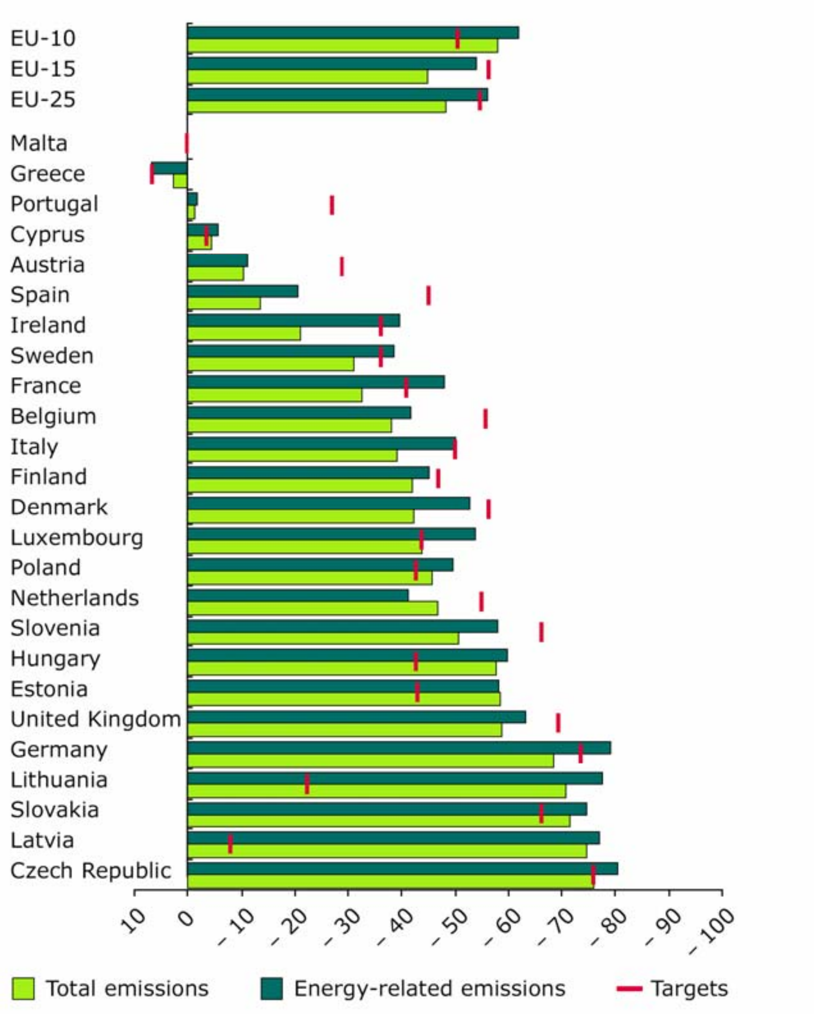
NH_3 emissions are also an important source of acid deposition and have an emissions target under NEC (emissions reduction of 13 % by 2010 from 1990 levels), but energy-related emissions of ammonia are insignificant, accounting for only 2.8 % of total EU-25 ammonia emissions in 2003. Agriculture is by far the largest contributing sector to EU ammonia emissions.

Other key policies that have contributed to the reduction of acidifying emissions across Europe include:

- The Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC), which entered into force in 1999. It aims to prevent or minimise pollution of water, air and soil by industrial effluent and other waste from industrial installations, including energy industries, by defining basic obligations for operating licences or permits and by introducing targets, or benchmarks, for energy efficiency. It will also require the application of Best Available Techniques in new installations from now on (and for existing plants over 10 years, according to national legislation).
- The Large Combustion Plant Directive (2001/80/EC) is important in reducing emissions of SO_2, NO_x and dust from combustion plants with a thermal capacity greater than 50 MW. The Directive sets emission limits for licensing of new plants and requires Member States to establish programmes for reducing total emissions. Emissions limits for all plants will be revised in 2007 under the IPPC Directive.

[1] Critical load: the ability of the eco-systems to bear an environmental load (i.e. acidifying depositions) without significant damage.

Fig. 3: Overall change in emissions of acidifying substances by country, 1990-2003



Note: The graph shows the emissions of acidifying pollutants (SO2, NOx and NH3) each weighted by an acid equivalency factor prior to aggregation to represent their respective acidification potentials. The acid equivalency factors are given by: w(SO2) = 2/64 acid eq/g = 31.25 acid eq/kg, w(NOx) = 1/46 acid eq/g = 21.74 acid eq/kg and w(NH3) = 1/17 acid eq/g = 58.82 acid eq/kg. The target indicated is the aggregate 2010 National Emissions Ceiling Directive target for the combined acidifying pollutants NOx, SO2 and NH3. They are based on absolute emission levels. Targets for the new Member States are temporary and are without prejudice to the review of the NEC Directive. Data for Malta are not available.

Source: ETC-ACC 2005.

References

de Leeuw F. A. A. M. (2002). 'A set of emission indicators for long-range transboundary air pollution', *Environmental Science & Policy*, 5, pp. 135–145. (http://www.sciencedirect.com/science/article/B6VP6-44HYMJ7-1/1/d6e469ff7969874250c6d0f656a8c76b)

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Fig. 4 Energy-related emissions of acidifying substances 1990-2003 (acidifying potential units; ktonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	% Change 1990-2003
Austria	7	7	6	6	6	6	6	6	6	5	5	6	6	6	-11%
Belgium	17	16	16	16	14	15	14	13	13	11	11	10	10	10	-42%
Bulgaria	67	56	39	48	49	50	48	46	43	33	34	33	34	34	-50%
Cyprus	2	1	2	2	2	2	2	2	2	2	2	2	2	2	-6%
Czech Republic	73	69	62	55	48	43	39	31	23	17	17	15	14	14	-80%
Denmark	11	14	12	11	11	10	12	9	7	6	5	5	5	5	-53%
Estonia	10	9	7	6	6	5	5	5	5	4	4	4	4	4	-58%
Finland	13	11	9	9	9	8	8	8	8	7	7	7	7	7	-45%
France	78	83	77	70	67	64	63	57	57	52	47	44	42	41	-48%
Germany	224	178	152	139	121	101	80	69	61	57	52	51	48	47	-79%
Greece	21	23	23	23	22	23	23	23	23	24	22	23	23	23	7%
Hungary	36	33	30	27	27	26	25	25	23	23	19	16	15	15	-60%
Iceland	2	2	2	2	2	2	1	1	1	1	1	1	1	1	-12%
Ireland	8	8	8	8	8	8	7	8	8	8	7	7	6	5	-40%
Italy	93	91	88	83	79	76	73	70	63	59	53	51	47	47	-50%
Latvia	5	4	3	3	3	2	3	2	2	2	1	1	1	1	-77%
Liechtenstein	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-39%
Lithuania	10	11	6	6	5	4	4	4	4	3	2	3	2	2	-78%
Luxembourg	1	1	1	1	1	1	1	1	0	0	0	0	0	0	-54%
Netherlands	17	17	17	16	15	14	14	13	13	13	11	10	10	10	-41%
Norway	5	5	5	5	5	5	5	5	5	5	5	5	5	5	-6%
Poland	130	119	112	108	105	97	98	91	80	74	64	65	65	65	-50%
Portugal	15	15	18	16	15	16	14	15	16	17	16	15	15	15	-2%
Romania	51	41	36	35	34	34	33	32	32	26	28	33	33	33	-35%
Slovakia	22	18	16	14	11	11	10	9	8	8	6	7	6	5	-75%
Slovenia	8	7	7	7	7	5	5	5	5	5	4	3	3	3	-58%
Spain	93	94	94	89	88	84	76	83	78	80	77	75	80	74	-20%
Sweden	9	9	9	8	8	8	7	7	7	6	6	6	6	6	-39%
Switzerland	4	5	5	4	4	3	3	3	3	2	2	2	2	2	-47%
Turkey	63	66	65	65	72	72	78	80	84	85	85	85	78	71	12%
United Kingdom	176	167	163	149	134	121	109	95	92	77	75	71	66	65	-63%
EU-10	294	271	244	228	214	196	191	174	152	137	121	116	113	112	-62%
EU-15	785	734	693	643	597	554	508	473	453	423	394	381	370	360	-54%
EU-25	1079	1006	938	871	811	750	699	647	605	561	515	497	482	472	-56%
EEA	1271	1180	1089	1030	977	915	868	815	773	714	671	657	635	619	-51%

Note: Data not available for Malta
Source: ETC-ACC 2005.

Meta data

Technical information

1. Data source: Officially reported national total and sectoral emissions to UNECE/EMEP (United Nations Economic Commission for Europe/Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe) Convention on Long-range Transboundary Air Pollution (CLRTAP), submission 2004. Base data are available on the EMEP web site (http://webdab.emep.int/). Emissions of acidifying substances is one of the European Environment Agency's core-set indicators. More information can be found at http://themes.eea.eu.int/IMS/CSI
Gross inland energy consumption data from EUROSTAT (download August 2005) http://europa.eu.int/comm/eurostat/

2. Description of data: Emissions of combined SO2 and NOx (also NH_3 where applicable) in 1000 tonnes acid equivalents. Gaps filled by ETC/ACC where necessary using simple interpolation techniques (see 6).

3. Geographical coverage: EU-25 for comparison with EU National Emission Ceilings Directive. Other analyses include data for EFTA 4 (Iceland, Liechtenstein, Switzerland and Norway) and Bulgaria, Romania, Croatia and Turkey. The EEA country grouping includes EU-25, EFTA4 and Bulgaria, Romania and Turkey.

4. Temporal coverage: 1990-2003

5. Methodology and frequency of data collection: Annual country data submissions to UNECE/CLRTAP/EMEP. Combination of emission measurements and emission estimates based on volume of activities and emission factors. Recommended methodologies for emission data collection are compiled in the Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook 3rd edition, EEA, Copenhagen EEA (2004).

6. Methodology of data manipulation, including making 'early estimates': ETC-ACC gap-filling methodology. To allow trend analysis where countries have not reported data for one or several years, data has been interpolated to derive annual emissions. If the reported data is missing either at the beginning or at the end of the time series period, the emission value has been considered to equal the first (or last) reported emission value. It is recognised that the use of gap-filling can potentially lead to artificial trends, but it is considered unavoidable if a comprehensive and comparable set of emissions data for European countries is required for policy analysis purposes. The gap-filled air emissions spreadsheet is available on http://dataservice.eea.eu.int/dataservice/metadetails.asp?id=818 .
   Acid Equivalents: Weighting factors (w) are used for SO_2, NOx and NH_3, which are multiplied with the emissions (Em, Gg) and the resulting acid equiv. emissions are added (de Leeuw 2002).
   Thus, total acid equivalent emission = $w(SO_2)*Em(SO_2) + w(NOx)*Em(NOx) + w(NH_3)*Em(NH_3)$ where weight factors are given by:
   - $w(SO_2)$ = 2/64 acid eq/g = 31.25 acid eq/kg
   - w(NOx) = 1/46 acid eq/g = 21.74 acid eq/kg
   - $w(NH_3)$ = 1/17 acid eq/g = 58.82 acid eq/kg

   These factors are assumed to be representative for Europe as a whole; on the (very) local scale different factors might be estimated; see de Leeuw (2002) for a more extensive discussion on the uncertainties in these factors. Due to the variation in potential TOFP factors that might be determined on a local scale, the use of such factors does not always have wide support or recognition in EU Member States.
   The energy supply sector includes public electricity and heat production, oil refining, production of solid fuels and fugitive emissions from fuels. The transport sector includes emissions from road and off-road sources (e.g. railways and vehicles used for agriculture and forestry). Industry (Energy) relates to emissions from combustion processes used in the manufacturing industry including boilers, gas turbines and stationary engines. 'Other (energy-related)' covers energy use principally in the services and household sectors.

Quality information

7. Strengths and weaknesses (at data level): Strength: officially reported data following agreed procedures and Emission Inventory Guidebook (EEA 2001), e.g. regarding source sector split. Weakness: The incomplete reporting and resultant extrapolation may obscure some trends.

8. Reliability, accuracy, robustness, uncertainty (at data level):
   The uncertainties of sulphur dioxide emission estimates in Europe are relatively low, as the sulphur emitted comes from the fuel burnt and therefore can be accurately estimated. However, because of the need for interpolation to account for missing data the complete dataset used here will have higher uncertainty. EMEP has compared modelled (which include emission data as one of the model parameters) and measured concentrations throughout Europe (EMEP 2005). From these studies the uncertainties associated with the modelled annual averages for a specific point in time have been estimated in the order of ± 30 %. This is consistent with an inventory uncertainty of ±10 % (with additional uncertainties arising from the other model parameters, modelling methodologies, and the air quality measurement data etc).
   In contrast, NOx emission estimates in Europe are thought to have higher uncertainty, as the NOx emitted comes both from the fuel burnt and the combustion air and so cannot be estimated accurately from fuel nitrogen alone. EMEP has compared modelled and measured concentrations throughout Europe (EMEP 2005). From these studies differences for individual monitoring stations of more than a factor of two have been found. This is consistent with an inventory of national annual emissions having an uncertainty of ±30% or greater (there are also uncertainties in the air quality measurements and especially the modelling).
   For some countries, reported time-series emissions data may be inconsistent. This may occur where for example different inventory reporting definitions have been used in different years and/or where changes made to estimation methodologies have not been applied back to 1990. For all emissions the trend is likely to be much more accurate than individual absolute annual values - the annual values are not independent of each other.

9. Overall scoring (1 = no major problems, 3 = major reservations):
   - Relevance: 1
   - Accuracy: 2 (acidifying coefficients not agreed and used in all EU Member States)
   - Comparability over time: 2
   - Comparability over space: 2