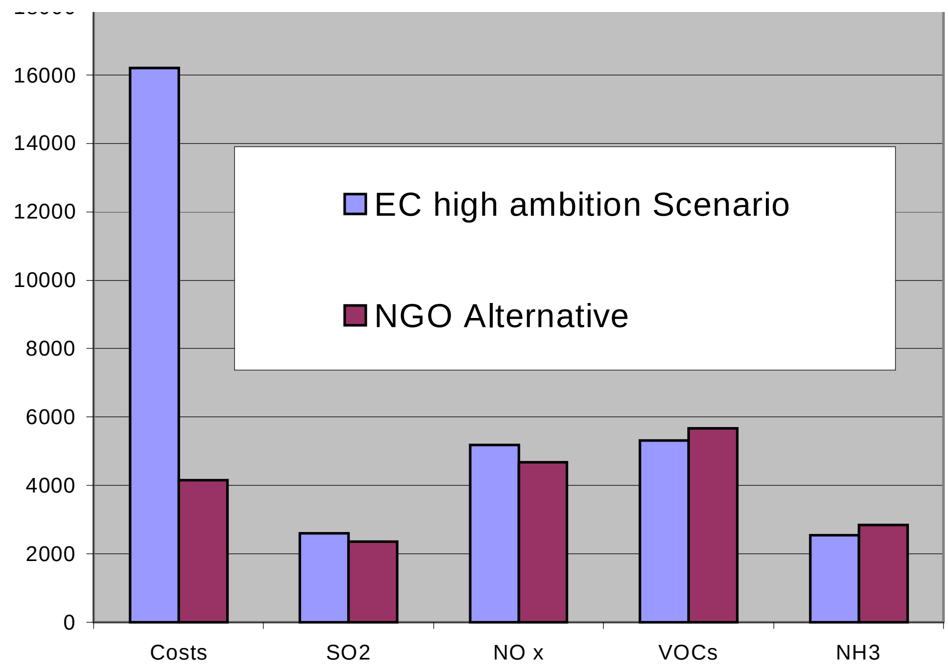
Getting more for less

An alternative assessment of the NEC directive



By Christer Ågren

Published by:

European Environmental Bureau (EEB)

The Swedish NGO Secretariat on Acid Rain

European Federation for Transport and Environment (T&E)

AIR POLLUTION AND CLIMATE SERIES NO. 13 /T&E REPORT 99/9

Getting more for less
- an alternative assessment of the NEC directive

Author: Christer Ågren

ISBN 91-973691-3-6
ISSN 1400-4909

Published by The Swedish NGO Secretariat on Acid Rain, The European Federation for Transport and Environment (T&E) and the European Environmental Bureau (EEB) – see presentations below.

Further copies can be obtained from any of the publishers.

The Swedish NGO Secretariat on Acid Rain
Box 7005, S-402 31 Göteborg, Sweden
Tel. +46 31 7114515.
Fax. +46 31 7114620.
E-mail: info@acidrain.org.
Internet: www.acidrain.org

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

The work of the secretariat is largely directed on the one hand towards eastern Europe, and on the other towards the European Union and its member countries. By emitting large amounts of sulphur and nitrogen compounds, all these countries add significantly to acid depositions over Sweden.

European Federation for Transport and Environment (T&E)
Boulevard de Waterloo 34,
B-1000 Brussels, Belgium
Tel. +32 2 5029909. Fax. +32 2 5029908.
E-mail: t+e@arcadis.be.

The European Federation for Transport and Environment (T&E) is Europe's primary non-governmental organisation campaigning on a Europe-wide level for an environmentally responsible approach to transport. The Federation was founded in 1989 as a European umbrella for organisations working in this field. At present T&E has 35 member organisations covering 21 countries.

T&E closely monitors developments in European transport policy and submits responses on all major papers and proposals from the European Commission.

T&E frequently publishes reports on important issues in the field of transport and the environment, and also carries out research projects.

European Environmental Bureau (EEB)
Boulevard de Waterloo 34,
B-1000 Brussels, Belgium
Tel. +32 2 2891090. Fax. +32 2 2891099.
E-mail: info@eeb.org.
Internet: www.eeb.org

The European Environmental Bureau is the largest environmental citizens organisation, comprised currently of 132 member organisations. Its main mission is to improve EU's environmental policies and promote sustainable development. Its priority areas include environmental policy integration, the environmental consequences of enlargement, pro-active industry policies (environmental liability, extended producer responsibility, eco-label, standardisation), agriculture, and policies on water, air and waste.

EEB is also coordinator of the Transatlantic Environmental Dialogue. It has a number of working groups and produces several publications a year, including a magazine called "Metamorphosis" (4 times a year).

Contents

1. Introduction

This report aims to support the development of more integrated strategies for environment policy, which in turn will generate smarter and more cost-effective emission abatement strategies. The three environmental organisations that have published this report have long been convinced that using policies to improve energy and transport efficiency, and to achieve fuel-switching and modal shifts in transport, will allow great pollution cuts at lower costs. This will realise the multiple benefits of improved economic efficiency, lower greenhouse-gas emissions, and lower pollution levels.

Critics of proposals for new environmental legislation and pollution abatement measures often focus on perceived "high" costs. Rarely do they look at the benefits with the same level of interest. Even more problematic is the fact that usually neither the legislators nor these "opponents" see, or try to realise, the opportunities presented by more integrated approaches.

Currently there are several EU programmes for controlling atmospheric pollution, aiming at, for instance:

- improving air quality;
- reducing air pollution from road traffic;
- combating acidification and ground-level ozone; and
- lowering greenhouse gas emissions.

Together these cover a range a range of pollutants, including sulphur dioxide, nitrogen oxides, volatile organic compounds, particulate matter, carbon monoxide, and carbon dioxide. To date these various programmes have largely been considered separately, despite the fact that there are strong linkages between them.

The proposed directive establishing national emission ceilings (NECs) for four ozone-forming, acidifying, and eutrophying air pollutants is an example of the great opportunities that can be provided by using a more integrated approach. Unfortunately, the current estimate of the costs for implementing this directive is based solely on technical "end-of-pipe" abatement measures. This means that measures aimed at improving energy and transport efficiency or fuel switching are not included, in spite of the fact that some of these measures can reduce emissions at zero or low net cost. Moreover, the energy scenario employed for making the analysis stands in total contradiction to the EU's commitments in the Kyoto protocol for reducing the emissions of the greenhouse gas carbon dioxide. This is of major importance since the energy scenario largely determines the levels of emissions of air pollutants such as sulphur dioxide and nitrogen oxides.

The lack of integration between the various programmes, and the focus on "end-of-pipe" measures, means that the estimated costs of meeting the separate objectives of individual programmes are generally to high. The scenario for energy conversion and use is a major determinant of the emissions of all the above mentioned pollutants. It is therefore a key input to the programmes, and its design presents an opportunity for investigating measures which bring emission abatement for all programmes, and reduce the total cost of meeting the different environmental objectives. By linking the development of abatement strategies for the four pollutants of the NEC directive with those needed for reducing emissions of the greenhouse gas carbon dioxide, costs can be substantially reduced.

When producing this report, the approach followed was to firstly develop low-carbon energy scenarios for the EU member states. These scenarios were then used to analyse the potential for cost savings in achieving the environmental goals of the EU's ozone and acidification strategies, i.e. the same interim environmental quality targets used by the Commission for developing the NEC-directive proposal. The cost for achieving a set of more ambitious environmental targets was also investigated.

John Hontelez
Director
EEB

Beatrice Schell
Director
T&E

Christer Ågren
Director
Swedish NGO Secretariat on Acid Rain

2. Overview

The preparation of the proposed national emission ceilings directive by the European Commission followed an exhaustive technical analysis of the most cost-effective strategy to reduce emissions of four air pollutants in order to achieve environmental objectives by the target year 2010. Despite the exhaustive nature of this exercise, some of the assumptions that underpinned the analysis neglected another important environmental objective – that of combating climate change. It was therefore decided to replicate some the exhaustive technical process undertaken to define the Commission proposal, but with assumed changes to energy use that would deliver greenhouse gas reductions necessary to combat climate change.

A comparison of the two processes is outlined below:

Stage of process	European Commission	NGO alternative
Defining scenarios of future energy use	Member state predictions or Commission estimates – no linkage to climate change objectives. Emissions of CO_2 increase by 9% between 1990 and 2010.	Alternative energy scenarios developed by SENCO. By demand management, energy efficiency and fuel switch, CO_2 emissions come down by 15% between 1990 and 2010.
Reference scenario generation	Use of Commission and member states energy scenarios in the RAINS computer model to establish reference scenario – also able to estimate the costs of these already agreed measures.	Use of the alternative Carbon15 energy scenario in the RAINS model to establish reference scenario – also able to estimate the costs of these already agreed measures.
Estimating the costs of achieving environmental targets	RAINS modelling to define the most cost-effective options of emission reductions for achieving environmental targets.	RAINS modelling to define the most cost-effective options of emission reductions for achieving environmental targets.
Documentation	Amann, et al, 1999	SENCO, 1999

This report is a description of the results of this alternative analysis and a comparison with the proposal of the Commission.

3. Summary and conclusions

For a number of reasons the methodology applied so far both in the EU and by the Convention on Long-Range Transboundary Air Pollution results in a systematic overestimate of the costs for initiatives aimed at reducing emissions of air pollutants. The proposed directive establishing national emission ceilings (NECs) for four ozone-forming, acidifying, and eutrophying air pollutants is an example of this. The estimate of the costs for implementing this directive is based solely on technical "end-of-pipe" abatement measures. This means that measures aimed at improving energy and transport efficiency or fuel switching are not included, in spite of the fact that some of these measures can reduce emissions at zero or low net cost. Moreover, the energy scenario employed for making the analysis stands in total contradiction to the EU's commitment in the Kyoto protocol for reducing the emissions of the main greenhouse gas carbon dioxide.

Assumptions on future energy use are key inputs for the projection of air pollutant emissions. Consequently, the expected use of energy will be decisive for the outcome of the analysis of emission abatement strategies. This concerns both the total amount of energy used and its attribution to various sources – coal, oil, nuclear, etc. If the total energy used – and especially the part generated from fossil fuels – is overestimated, the estimated cost of reducing emissions to a certain level will also be exaggerated. An overestimation of future energy use will also result in an underestimation of the possibilities of reducing the emissions of air pollutants, thus weakening the setting of interim environmental quality targets. Moreover, inflated cost estimates are likely to lower the political acceptance of the initiatives concerned.

For the purpose of this study, as a first step low-carbon energy scenarios for the EU member states were developed. These energy scenarios were then used to analyse the potential for cost savings in achieving the environmental goals of the EU's ozone and acidification strategies, i.e. the same interim environmental quality targets used by the Commission for developing the NEC-directive proposal. The cost for achieving a set of more ambitious environmental targets was also investigated.

By using an alternative low-CO_2 energy scenario (Carbon15), which is described in this report, the estimated annual costs for achieving the interim environmental quality targets of the NEC directive can be reduced by nearly two thirds, from €7.5 to €2.7 billion. This result confirms those of earlier analyses made by the Commission when investigating the impacts of low-CO_2 energy scenarios, which showed estimated costs falling by 40-60 per cent.

The Carbon15 energy scenario was also used to investigate some other emission scenarios. The estimated annual costs of achieving already adopted legislation - the reference scenario - fell by more than 30 per cent. Moreover, even the environmental targets of the Commission's so-called "high ambition" scenario could be achieved at a cost significantly lower than that estimated for the NEC directive proposal. Here the estimated costs dropped by nearly three quarters, from €16.2 billion to €4.2 billion.

This study demonstrates that by linking the development of abatement strategies for the four air pollutants (SO_2, NOx, VOCs, and NH_3) with those needed for reducing emissions of the greenhouse gas carbon dioxide, estimated abatement costs can be substantially reduced. It is suggested that those cost savings should be used for further improving the protection of human health and the environment from the damaging impacts of air pollution. This would mean aiming for a higher level of environmental ambition, as compared to one being proposed by the Commission in the NEC directive.

To base the analysis of the NEC directive proposal on an energy scenario that is more sound politically as well as environmentally not only results in more accurate cost estimates, but also in a strategy that provides the *double benefits* of reducing local, regional and European air pollution and related environmental problems, while at the same time also reducing the emissions of the prime greenhouse gas carbon dioxide.

4. The proposed NEC directive

On June 9, 1999, the Commission passed its proposal for a new directive on national emission ceilings (NECs) for four ozone-forming, acidifying and eutrophying air pollutants (CEC, 1999). These are sulphur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOCs), and ammonia (NH_3). At the same time also a proposal for a new daughter directive on ground-level ozone was passed (CEC, 1999).

If implemented, the proposed NEC directive will by 2010 markedly reduce the damage caused by air pollution in the EU. For instance, health-related ozone exposure will be lowered by 36 per cent, vegetation-related ozone by 20 per cent, the area of sensitive ecosystems unprotected against acidification will be reduced by 32 per cent, and the area unprotected against soil eutrophication will come down by 13 per cent. Moreover, the levels of health-damaging small particles (PM_{10}), part of which is formed in the atmosphere from emissions of SO_2 and NOx, will also come down.

These estimated improvements are in comparison to the expected situation in 2010 without the implementation of the NEC directive (i.e. with the emission levels of the so-called reference scenario). If compared to the situation in 1990, the improvements will be significantly larger – health-related ozone exposure will come down by 76 per cent and vegetation-related ozone exposure by 53 per cent, and the areas where critical loads for acidification and eutrophication are exceeded will fall by respectively 88 and 37 per cent.

The proposed NEC directive should be seen as a first step towards the achievement of the long-term objectives of the EU's Fifth Environmental Action Programme. In regard to acidification and eutrophication, the long-term aim is that there should be no exceeding ever of the critical loads. The aim for air quality is that all people should be effectively protected against recognised health risks from air pollution.

Following a careful analysis of various scenarios, the Commission agreed on so-called interim environmental quality targets that it wishes to see achieved by 2010. The International Institute for Applied Systems Analysis (IIASA), which has been the Commission's main consultant, used its RAINS computer model to carry out a joint optimisation in order to find the most cost-effective way, for EU as a whole, for achieving these environmental aims. The approach (methodology and modelling techniques) used for the NEC directive is fully consistent with that used for many years in the Convention on Long-Range Transboundary Air Pollution (CLRTAP). It was for instance used for the new CLRTAP protocol to abate acidification, eutrophication and ground-level ozone, which was signed by 27 countries on 1 December 1999 (UN ECE, 1999).

The resulting emission ceilings for individual member states, as well as the associated extra costs for achieving the ceilings, are set forth in Table 1, below. For the EU as a whole, the NEC directive would ensure that, compared with 1990 levels, SO_2 emissions are reduced by 78 per cent, NOx emissions by 55 per cent, VOC emissions by 60 per cent, and NH_3 emissions by 21 per cent. These emission reductions can be compared with those that are already likely both as a result of current national and international commitments and of existing and impending EU legislation, which are described in the so-called reference scenario. According to this, between 1990 and 2010 emissions would come down by 71, 48, 49, and 12 per cent respectively.

Table 1: The Commission's proposed national emission ceilings for 2010 and the estimated additional costs for achieving them (CEC, 1999).

	Emissions (thousand tons)				**Costs (€ million)**
	SO_2	**NOx**	**VOCs**	**NH_3**	
Austria	40	91	129	67	119
Belgium	76	127	102	57	1053
Denmark	77	127	85	71	6
Finland	116	152	110	31	0
France	218	679	932	718	916
Germany	463	1051	924	413	2147
Greece	546	264	173	74	338
Ireland	28	59	55	123	44
Italy	566	869	962	430	403
Lux.	3	8	6	7	4
NL	50	238	156	104	971
Portugal	141	144	102	67	57
Spain	746	781	662	353	22
Sweden	67	152	219	48	87
UK	497	1181	964	264	1348
EU15	**3637**	**5922**	**5581**	**2826**	**7514**

It is estimated by the Commission that the total extra cost of reducing emissions in line with the NEC directive proposal will be €7.5 billion a year in 2010. (The cost for the emission reductions of the reference scenario is estimated to €58 billion a year in 2010.) Although €7.5 billion may seem a lot of money, it only amounts to €20 per individual in the EU. Moreover, for a number of reasons it is obvious that this figure is a gross overestimate.

Firstly, the estimates have been based on a reduction of the emissions solely through the application of technical "end-of-pipe" measures – thus ignoring the fact that a lot of non-technical methods are possible and often relatively inexpensive. Secondly, the figures reflect current technology and costs – no account is taken of technical developments and improvements. Finally there is the fact that the energy scenario employed for making the analysis stands in total contradiction to the EU's commitments to reducing the emissions of the greenhouse gas carbon dioxide. If the EU should really carry out the climate policy to which it is committed, and there should be no stop to technical developments, the real cost of the NEC directive would be significantly lower, perhaps no more than half the supposed figure.

The Commission engaged another consultant, AEA Technology, to make an analysis of the quantifiable gains in terms of money that could be expected from the extra emission reductions proposed in the directive (AEA Technology, 1999). Account was taken chiefly to the effects on human health (morbidity and mortality), on farm crops, and on modern buildings and materials. Their calculations showed the annual quantifiable gains to amount to €17-32 billion for the year 2010.

It should however be noted that a number of gains have not been included, primarily since they cannot currently be satisfactorily quantified in economic terms. They include less acidification of soil and water, less eutrophication, fewer effects on biological diversity, less long-term risk for lowered forest productivity, reduced direct health effects of NO_2 and VOCs, and less damage to historical buildings and monuments. In conclusion: While only some of the benefits can be assessed in terms of money, those that are so quantifiable can be accounted as worth as much as four times the supposed, overestimated, costs.

5. The role of energy scenarios

Assumptions on future energy use are key inputs for the projection of air pollutant emissions. Consequently, the expected use of energy will be decisive for the outcome of the analysis of emission abatement strategies. This concerns both the total amount of energy used and its attribution to various sources – coal, oil, nuclear, etc. If the total energy used – and especially the part generated from fossil fuels – is overestimated, the estimated cost of reducing emissions to a certain level will also be exaggerated. Moreover, as a result of the methodology used in the analysis, an overestimation of future energy use will result in an underestimation of the possibilities of reducing the emissions of air pollutants, thus weakening the setting of interim environmental quality targets.

The energy scenarios that have been used when developing the proposed NEC directive as well as in the negotiations within the Convention on Long-Range

Transboundary Air Pollution (CLRTAP), are illustrative of this problem. In both cases the same so-called “baseline” energy scenario was used to provide information on the expected energy use for each EU member state up to the year 2010 (Amann, et al, 1999). Here the scenarios for ten of the fifteen countries have been produced by the countries themselves. The remaining five - for France, Italy, Luxembourg, Portugal, and Spain - were worked out by the Commission’s energy directorate some years ago, but approved by the countries concerned.

As a result the use of energy in the EU as a whole is calculated to rise by almost 20 per cent between 1990 and 2010 (Amann, et al, 1998). An increase of 100 per cent is forecast for Greece, 71 per cent for Ireland, 59 per cent for Portugal, 45 per cent for Spain, 36 per cent for the Netherlands, and 30 per cent for Finland. Coal use is foreseen to decrease by 30 per cent, while the use of natural gas is expected to increase by more than 70 per cent. Also the use of other energy sources (renewables and nuclear) is projected to increase, in this case by 24 per cent. Continued growth is expected also for the transport sector, resulting in a 32 per cent increase in the demand for transport fuels.

According to these same scenarios, between 1990 and 2010, the total EU emissions of the greenhouse gas carbon dioxide (CO_2) will rise by about 9 per cent – in contradiction to the commitments of the EU and its member countries under the Kyoto protocol, which requires them to reduce emissions by 8 per cent. In June 1998 it was decided, too, by the Council of Ministers how that 8 per cent reduction was to be distributed among the member countries – so-called burden sharing (Council, 1998).

As part of the Commission’s preparations for the NEC directive, a so-called illustrative low-CO_2 scenario was investigated – in an attempt to show how a more realistic energy scenario (at least as regards international commitments) could affect the outcome of the analysis. In this scenario the increase in total energy use was restricted to 8 per cent, as compared to 19 per cent in the baseline energy scenario. The emissions of CO_2 in the EU were reduced by 7 per cent, relative to 1990. It was found that by using this scenario, the environmental aims of the NEC directive – the so-called interim environmental quality targets – could be attained at more than 40 per cent less cost (Amann, et al, 1998).

Similarly, when developing the Community strategy to combat acidification in 1996/97, the impacts of assuming an alternative low-CO_2 energy scenario was analysed by the Commission (CEC, 1997a). In this alternative scenario, the increase in final energy demand was restricted, energy efficiency improved, and the share of renewable sources of energy increased. As a result, CO_2 emissions were reduced by 10 per cent between 1990 and 2010, and moreover, the emissions of SO_2 and NOx were also reduced. For these reasons, less abatement measures were needed to meet the interim target for acidification. Consequently, the estimated cost of meeting that target fell by nearly 60 per cent, as compared to the main scenario.

It is also worth recalling that before the Kyoto meeting of December 1997, the Commission presented a cost-effective strategy which could have reduced the emissions of carbon dioxide by 15 per cent (CEC, 1997b). Moreover, the European Parliament has repeatedly spoken in favour of a target of a 15 per cent CO_2 reduction from 1990 to 2010 for the EU (Parliament, 1999).

In the context of both integration and potential cost-savings, it is also worthwhile noting the interaction with developments related to agricultural activities. An illustrative "low NH_3" scenario, assuming 10 per cent lower livestock number as compared to the reference scenario, was investigated (Amann, et al, 1999). The lower remaining ammonia emissions of this scenario relieve some of the demand for SO_2 and NOx control. Consequently, the cost of SO_2 abatement was decreased by 27 per cent, while overall costs fell by 19 per cent, as compared to the €7.5 billion estimated for the NEC directive proposal. Estimates of the potential and cost for abating agricultural ammonia emissions are acknowledged to be complex and relatively uncertain. Nevertheless it is possible to conclude that integrated approaches to agricultural policy would have spin off effects on decreasing costs of wider Community pollution abatement strategies.

A further sector that could deliver large reductions in emissions at low costs is the maritime sector. To date there has been little or no technical efforts to reduce the emissions from shipping. Improving fuel quality and engine design - including catalytic after-treatment of the exhaust gas – is therefore up to 8 times more cost-effective than additional measures on land based emission sources (Kågeson, 1999). The Commission's analyses for the acidification strategy and the NEC directive have shown that including measures to reduce SO_2 and NOx emissions from shipping could reduce the costs of achieving the interim environmental quality targets by between 11 and 25 per cent (CEC, 1997a; Amann, et al, 1999). The reason few technical measures have been taken in shipping thus far is due to the character of the sector's international regulatory framework. However, as demonstrated by recent experience in Sweden, innovative fiscal instruments could be utilised to overcome this hurdle.

As described above, the Commission has estimated the annual additional cost - i.e. the cost above that for implementing existing legislation and commitments according to the reference scenario – of the proposed NEC directive to €7.5 billion for the target year 2010. However, it is pointed out by the Commission that for a number of reasons this is to be regarded as a worst case estimate. In the Commission's own words:

> *"It is important to be aware that the measures considered in the model calculations are "end of pipe" – i.e. technological solutions. The model does not consider changes in energy supply or other structural measures. In reality, structural changes may result from other developments and policies other than environmental policy. They may also figure largely in policies to comply with the emission ceilings addressed here, as well as climate policy, and involve costs which may in some cases be significantly lower than those of the technical control options.*

Furthermore, the use of economic instruments to initiate emission reductions may lead to cheaper solutions than "command-and-control" instruments. Options that may be introduced at the local level, such as road pricing schemes or the introduction of LPG/CNG buses, are also excluded from the current format.

For these reasons it is very likely that the RAINS model has provided an upper estimate of the cost of implementing the national emission ceilings. Real costs are expected to be less than the €7.5 billion per year projected by RAINS." (CEC, 1999, page 33)

The opposition to the proposed NEC directive has so far come mainly from some industry groups, primarily those with direct or indirect links to fossil fuel use, such as the oil, coal and electricity industries, and UNICE, the Union of Industrial and Employers' Confederations of Europe (UNICE, 1999). Voices of concern have also been raised by some member states, especially those in the southern parts of Europe. A common focus for the criticism relates to the high estimated costs of implementing the proposed NEC directive. However, very rarely, if ever, do these industry groups or member states recognise the fact that the costs are highly overestimated.

It is a major shortcoming that the Commission was not able to develop and use a more appropriate energy scenario, i.e. one that would better reflect the EU's and the member states' commitments in regard to the Kyoto protocol of the United Nations Framework Convention on Climate Change. (At the time of writing this report (January, 2000), the Commission had still not come up with a more realistic energy scenario that had been used to improve the analysis of the proposed NEC directive.)

Against this background a group of three environmental organisations agreed to jointly fund a consultant to develop an alternative energy scenario for the 15 EU member states, and to use the RAINS model to investigate the impacts on costs as well as on the environment.

6. The Carbon15 energy scenario

The objective given to SENCO (Sustainable Environment Consultants Ltd) was to produce scenarios in which the total emissions of CO_2 from the EU are reduced by 15 per cent between 1990 and 2010. This 15 per cent reduction target was selected because it is widely recognised to be both practically achievable and politically acceptable. As mentioned above, the Commission has presented a cost-effective strategy aimed at reducing the emissions of CO_2 by 15 per cent, and the European Parliament has repeatedly spoken in favour of such a target for the EU.

The main strategy to achieve this CO_2 reduction should include measures such as demand management (energy savings), improved energy efficiency, and increased use of energy sources emitting little or no CO_2. Moreover, it was assumed that the total output of nuclear power declines at a rate of five per cent per year as from 2005. The full results of the study are presented in SENCO (1999).

It should be noted that any extra CO_2 abatement measures analysed in this study, are being introduced earliest as from the year 2000, and would therefore have ten years at the most to take effect. Judgement as to which measures to introduce was based on technical feasibility, cost-effectiveness, and speed of introduction. Examples of key measures include:

- Increased efficiency of electricity use;
- More energy efficient cars; and,
- Energy conservation in buildings.

The process for the development of the country-by-country scenarios started by extracting national energy data for 1990-96 from the International Energy Agency (IEA). Based on that data, projections for 1997-99 were made, assuming no change in measures. Projections for energy use and resulting CO_2 emissions for the period 2000 to 2020 were then carried out with assumed programmes of measures. By using SENCO's energy model ScenaGen, expected impacts in energy use resulting from factors such as economic and population growth in the various countries were taken into account. Average economic and population growth rates from the period 1990-96 were assumed to continue to 2020.

In the scenarios, the policy measures of demand management, energy efficiency, and fuel switch were implemented to varying degrees in the different countries according to:

- What is required in order for each country to meet its Kyoto commitment;
- The degree to which the measures have already been applied; and,
- The potential for further application.

The ScenaGen model was run for 1990-2020 for all member countries. For reasons of comparison, five different scenarios were investigated: No measures; Business-as-usual; Kyoto; Carbon15; and, Maximum reduction. The principal scenario of the study, Carbon15, achieves the aim of a 15 per cent reduction in CO_2 emissions by 2010. It is worthwhile noting that the CO_2 emissions of this scenario continue to fall also after 2010. The fact that this reduction is maintained, and with some margin of safety as well, also up to 2020, illustrates that the scenario is quite robust. By comparison, the Maximum reduction scenario results in CO_2 reductions of more than 30 per cent by 2010.

In most countries the measures are not implemented to the maximum degree possible. Therefore, if the assumed maxima are approximately correct, the scenarios should be technically feasible. No estimates were made of the costs of the assumed measures, but energy efficiency measures are judged to be cost-effective against conventional supply costs.

The changes in CO_2 emissions country-by-country of the Carbon15 scenario and of the Baseline scenario used by the Commission for its NEC directive proposal, are shown in Table 2. For comparison also the Council decision of 1998 on the agreed "burden sharing" between the member countries are presented. It should be noted that the Kyoto protocol, as well as the Council decision, refers to reductions in the emissions of a basket of greenhouse gases (not solely CO_2), and that those reductions are to be achieved by 2008-2012.

Table 2: Changes in CO_2 emissions between 1990 and 2010 according to the Carbon15 and the Baseline scenarios, and the burden sharing agreed by the Council in 1998. (per cent)

	Carbon15 scenario	**Baseline scenario**	**EU burden sharing**
Austria	0	-2	-13
Belgium	-3	+22	-7.5
Denmark	+15	-7	-21
Finland	-23	+33	0
France	0	+26	0
Germany	-27	-11	-21
Greece	-19	+24	+25
Ireland	+18	+63	+13
Italy	-17	+16	-6.5
Luxembourg	+26	-8	-28
Netherlands	+1	+22	-6
Portugal	+1	+47	+27
Spain	-10	+31	+15
Sweden	+2	+24	+4
UK	-22	+5	-12.5
EU15	**-15**	**+9**	**-8.6**

There are significant differences between the Carbon15 scenario and other energy scenarios. This is in part accounted for by different assumptions on economic growth rates and nuclear phase out.

7. Introducing Carbon15 into the RAINS model

In order to assess the likely environmental situation in the year 2010 resulting from current emission control strategies, the Commission uses a so-called reference scenario (REF). This scenario takes into account national as well as international legislation and commitments, including already adopted but not yet (fully) implemented EU legislation, and commitments undertaken by countries in protocols under the Convention on Long-Range Transboundary Air Pollution. The reference scenario acts in practice as a starting point for any optimisations performed with computer models for integrated assessment (such as the RAINS model), i.e. it is assumed that by 2010 all countries as a minimum achieve the emission reductions of the reference scenario.

With the assistance of IIASA, the Carbon15 energy scenario was introduced into the RAINS computer model. As a result of the changed assumptions on energy use for the different countries, the estimated emissions of the reference scenario will also change. The improved energy efficiency, energy conservation and fuel switch of the Carbon15 scenario means that the use of fossil fuels (i.a. coal, heavy fuel oil, petrol, and diesel) in the various sectors is lower, as compared to the situation in the Baseline scenario.

Not surprisingly, the reference scenario emissions of SO_2, NOx, and VOCs in 2010 will be lower when using the Carbon15 scenario as compared to those resulting from the Baseline scenario. This is shown in Table 3. For the EU as a whole, the emissions of SO_2 are reduced by 31 per cent, those of NOx by 27 per cent, and VOCs by 8 per cent, as compared to those resulting from using the Baseline scenario. The ammonia emissions, which originate primarily from agricultural activities, remain unchanged. As a result of lower initial emissions, the “new” reference scenario is 31 per cent less costly, as compared to the “old” reference scenario, i.e the estimated costs drop from €58 billion to €40 billion.

Table 3: Emissions and control costs of the “new” reference scenario (REF_{new}) resulting from applying the Carbon15 energy scenario, and the “old” reference scenario (REF_{old}). The latter is the one used for the Commission’s analysis (CEC, 1999). Emissions are given in kilotons, and costs in € million per year in 2010.

	SO_2		**NOx**		**VOCs**		**NH_3**		**Costs**	
	REF new	REF old	REF new	REF old	REF new	REF old	REF new	REF old	REF new	REF old
Aus	43	40	71	103	173	205	67	67	816	1093
Bel	174	193	169	191	176	193	96	96	1138	1704
Den	90	90	116	128	84	85	72	72	572	623
Fin	113	116	82	152	129	110	31	31	480	889
Fra	321	448	642	858	1245	1223	777	777	5790	8659
Ger	419	581	952	1184	1137	1137	571	571	10104	13813
Gre	252	546	212	344	175	267	74	74	657	1482
Ire	36	66	42	70	40	55	126	126	376	618
Ita	312	567	647	1130	905	1159	432	432	6559	9644
Lux	4	4	9	10	7	7	7	7	103	98
Net	98	73	202	280	203	233	136	136	1617	2267
Por	91	141	112	177	127	144	67	67	1089	1530
Spa	439	774	663	847	650	669	353	353	4312	6495
Swe	57	67	91	190	181	290	48	48	982	1554
UK	778	980	998	1186	1351	1351	297	297	5458	7964
EU15	**3226**	**4687**	**5007**	**6849**	**6582**	**7128**	**3154**	**3154**	**40055**	**58433**

For the purpose of the Commission’s analysis, a further scenario has been constructed to illustrate the potential of a full application of current emission control technologies. This is called the Maximum technically Feasible Reductions (MFR) scenario, and serves two purposes. Firstly it gives an indication to what extent achievement of the long-term environmental and health objectives is possible by 2010, assuming the application of technological abatement measures only. Secondly, it provides an upper limit for the country-by-country emission reductions that can be assessed in the computer model optimisations.

By using the Carbon15 instead of the Baseline energy scenario, the potential for emission reductions in the MFR scenario increases. Emissions of SO_2 and NOx comes down by another 25-30 per cent, and those of VOCs by about 10 per cent extra. For the same reasons as above, the ammonia emissions remain at the same level. In spite of the fact that the MFR scenario based on the Carbon15 energy scenario results in lower levels of emissions, the cost for its attainment is also lower.

8. Environmental targets can be achieved at much less cost

The impacts of using the Carbon15 energy scenario while achieving the same interim environmental quality targets as was used by the Commission for developing the NEC directive was also investigated. If comparing with the Commission's analysis, this alternative scenario should be compared to the so-called H1 scenario of the IIASA's Seventh Interim Report (Amann, et al, 1999). This H1 scenario was the one selected by the Commission to set the national emission ceilings that are proposed in the NEC directive.

As to be expected, the modified input assumptions as regards energy use result in a somewhat changed allocation of emission control measures. For the EU as a whole this new H1 scenario ($H1_{new}$) results in lower emissions of SO_2 and NOx, as compared to the proposed directive NECs. Despite the higher reductions, there is a substantial fall in the costs for SO_2 and NOx control. The emissions of VOCs and NH_3 of the new H1 scenario are, on the other hand, slightly higher (see Table 4). This is due to the fact that the environmental goals can be attained at lower costs by reducing the two other pollutants. Overall, the annual extra costs for the new H1 scenario are estimated at €2.7 billion for the year 2010. This should be compared with the €7.5 billion, estimated to be the cost for implementing the NEC-directive. Consequently, the structural changes assumed in the Carbon15 energy scenario could, if implemented, reduce the (estimated) cost of meeting the interim environmental quality targets by €4.8 billion per year, or by 64 per cent.

For most of the countries and pollutants, the application of the Carbon15 energy scenario in the optimisation results in equal or lower emission ceiling levels. The cases where emission ceilings are significantly below those of the NEC directive proposal, can usually be explained by the fact that emissions in the new reference scenario are lower than those in the reference scenario resulting from using the Baseline energy scenario. There are also cases where the ceilings of the new H1 scenario are higher, as compared to those of the NEC directive proposal. This applies for instance to the VOC and NH_3 emissions of quite some countries. Also this can largely be explained by the initially lower SO_2 and NOx emissions of the new reference scenario, which relaxes the demand for further, relatively expensive, control measures for VOCs and NH_3.

Whatever the starting point, the RAINS computer model is programmed to achieve the set environmental quality targets at the lowest cost for the EU as a whole. The interim environmental quality targets set by the Commission for 2010 are achieved by the ceilings given in the proposed NEC directive. They are however also achieved, and with quite a margin of safety as well, with the ceilings given in the new H1 scenario. In fact the latter scenario yields up to 10 per cent better environmental results, both for ground-level ozone exposure and acidification, as compared to the emission ceilings of the NEC directive proposal.

The main purpose of this exercise is not to suggest alternatives to the national emission ceilings put forward in the Commission's proposal, but to illustrate the huge cost savings that could follow from adopting a smarter approach to solve inter-related environmental problems. From the above it is obvious that if the EU and its member countries take action that is necessary to reduce emissions of the main greenhouse gas carbon dioxide, the costs for reducing emissions of ozone-forming, acidifying and eutrophying air pollutants will be significantly lower than is currently anticipated.

Table 4: Emissions and control costs of the "new" H1 scenario ($H1_{new}$) resulting from applying the Carbon15 energy scenario, and the "old" H1 scenario (NEC). The latter is the one selected by the Commission for setting the proposed national emission ceilings (CEC, 1999). Emissions are given in kilotons, and costs in € million per year in 2010.

	SO_2		**NOx**		**VOCs**		**NH_3**		**Costs**	
	H1 new	NEC	H1 new	NEC	H1 new	NEC	H1 new	NEC	H1 new	NEC
Aus	43	40	71	91	173	129	67	67	0	119
Bel	76	76	122	127	96	102	69	57	507	1053
Den	90	77	116	127	84	85	71	72	0	6
Fin	113	116	82	152	129	110	31	31	0	0
Fra	170	218	555	679	969	932	725	718	331	916
Ger	358	463	923	1051	1008	924	473	413	608	2147
Gre	252	546	212	264	175	173	74	74	0	338
Ire	33	28	40	59	40	55	126	123	2	44
Ita	312	566	647	869	905	962	432	430	0	403
Lux	4	3	8	8	6	6	7	7	1	4
Net	63	50	202	238	142	156	105	104	716	971
Por	91	141	99	144	127	102	67	67	3	57
Spa	439	746	660	781	650	662	353	353	0	22
Swe	57	67	91	152	181	219	48	48	0	87
UK	433	497	994	1181	1036	964	274	264	557	1348
EU15	**2532**	**3637**	**4822**	**5922**	**5721**	**5581**	**2920**	**2826**	**2724**	**7514**

9. More environmental protection – still lower costs

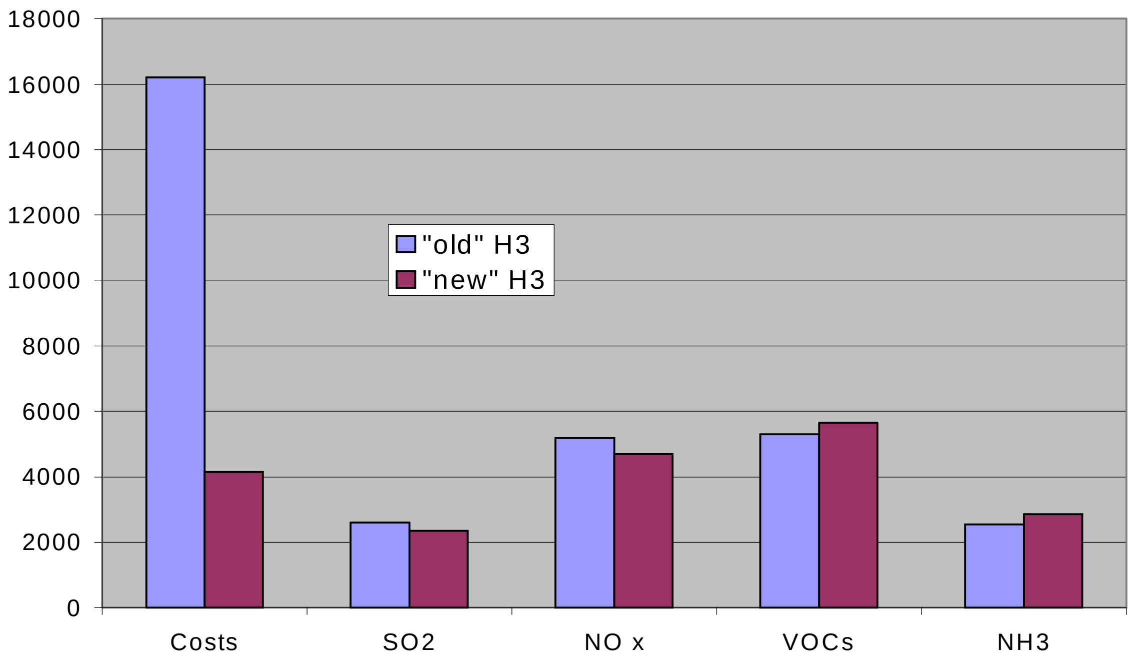
In its preparations for the NEC directive, the Commission also investigated scenarios with higher and lower levels of environmental ambition (Amann, et al, 1999). The so-called high ambition case (scenario H3) aimed at higher levels of gap closure percentages both for health- and vegetation-related ozone, and acidification. It also aimed at achieving lower exposure ceiling targets for health- and vegetation-related ozone.

Due primarily to the high estimated costs of achieving these more ambitious interim environmental quality targets – the costs of the H3 scenario were estimated to amount to €16.2 billion per year in 2010 – this scenario was not selected by the Commission as the basis for the NEC directive.

When repeating the computer model optimisation with the more ambitious environmental objectives of the H3 scenario, but instead using the Carbon15 energy scenario, the estimated costs dropped by nearly three quarters, down to €4.2 billion. The reasons for this dramatic fall are principally the same as those given in section 8, above.

Comparing the "old" and the "new" H3 scenarios shows that the emissions of SO_2 and NOx of the "new" H3 scenario are about 10 per cent lower, while those of VOCs and NH_3 are respectively 7 and 12 per cent higher. Concerning ozone exposure, the "new" H3 scenario results in a higher level of environmental protection, while the acidification and eutrophication situation is somewhat worsened. For all four environmental quality areas, the results are markedly better than those expected to result from the NEC directive proposal as shown in Figure 1.

Figure 1 Costs and Emissions from the EC "high ambition" (H3) scenario and a similar "high ambition" (H3) scenario using the Carbon 15 energy scenario. (costs in € 100, 000 emissions in Kilo tonnes.



10. Conclusions and recommendations

This study demonstrates the importance of using a more integrated approach to environmental policy, and especially the key role played by scenarios over future energy use for the assessment of the potential and costs of further reductions of air pollutant emissions. This is illustrated by the proposal for a directive on national emission ceilings (NECs).

The main purpose of this exercise is not to suggest alternatives to the national emission ceilings put forward in the Commission's proposal, but to illustrate the huge cost savings that could follow from adopting a smarter approach to solve inter-related environmental problems. This study demonstrates that if the EU and its member countries take action that is necessary to reduce emissions of the main greenhouse gas carbon dioxide, the costs for reducing emissions of ozone-forming, acidifying and eutrophying air pollutants will be significantly lower than is currently anticipated.

The use of an alternative low-CO_2 energy scenario (Carbon15), which is described in this report, shows that the estimated annual costs for achieving the interim environmental quality targets of the NEC directive can be reduced by €4.8 billion, from €7.5 to €2.7 billion, i.e. by 64 per cent. This result confirms those of earlier analyses made by the Commission when investigating the impacts of low-CO_2 energy scenarios, which showed estimated costs falling by 40-60 per cent.

The Carbon15 energy scenario was also used to investigate some other emission scenarios. The estimated annual costs of achieving already adopted legislation - the reference scenario - fell by more than 30 per cent. Moreover, even the environmental targets of the Commission's so-called "high ambition" scenario could be achieved at a cost significantly lower than that estimated for the NEC directive proposal. Here the estimated costs dropped by nearly three quarters, from €16.2 billion to €4.2 billion.

To base the analysis of the NEC directive proposal on an energy scenario that is more sound politically as well as environmentally not only results in more accurate cost estimates, but also in a strategy that provides the *double benefits* of reducing local, regional and European air pollution and related environmental problems, while at the same time also reducing the emissions of the prime greenhouse gas carbon dioxide.

In the context of both integration and potential cost-savings, it is also worthwhile noting the interaction with developments related to agricultural activities. An illustrative "low NH_3" scenario, assuming 10 per cent lower livestock number as compared to the reference scenario, would decrease overall costs by 19 per cent. Consequently, structural changes in the agriculture sector could contribute to decreasing costs of wider EU pollution abatement strategies.

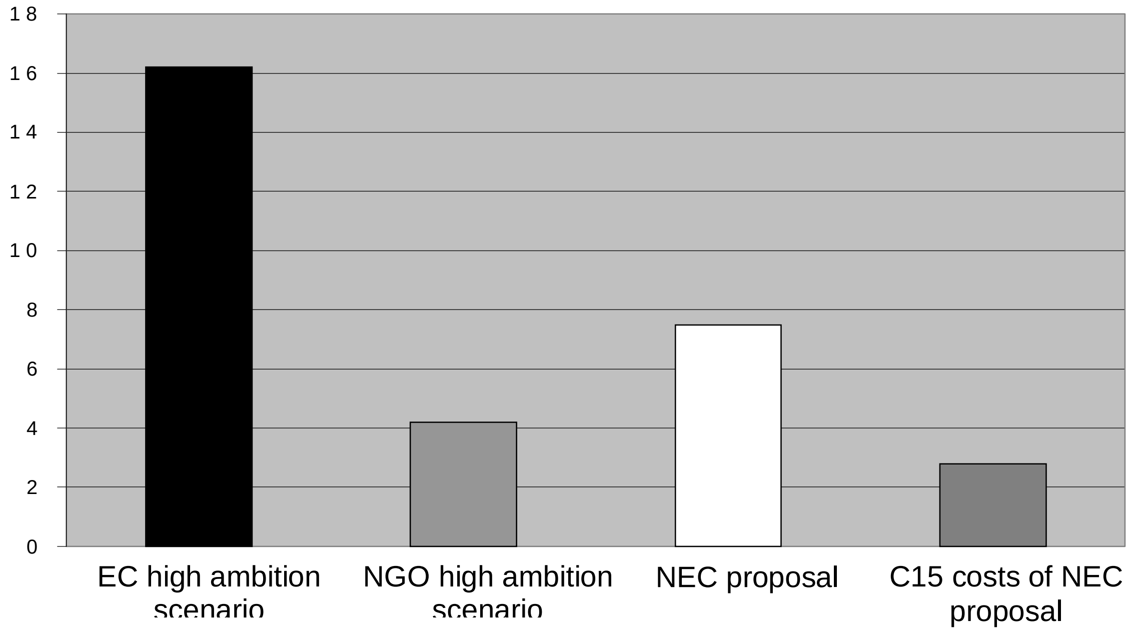
A further sector that could deliver large reductions in emissions at low costs is the maritime sector. Measures such as improving fuel quality and engine design are much more cost-effective than many additional abatement measures on land based emission sources The Commission's analyses for the acidification strategy and the NEC directive have shown that including measures to reduce SO_2 and NOx emissions from shipping could reduce the costs of achieving the interim environmental quality targets by between 11 and 25 per cent.

The three organisations that have published this report support the Commission's proposal for a NEC directive, but want to stress that the proposed figures for national emission ceilings must be seen as minimum targets. In light of the reductions necessary to achieve long-term environmental quality objectives, and the substantial benefits to society (human health, environment, nature, cultural objects), at least the amount of money suggested by the Commission, i.e. €7.5 billion, should be spent on this first step. Whilst the overall figure of €7.5 billion appears large it still only represents on the average some euro 20 per person. This report shows that with a reasonable and realistic energy policy, a higher level of environmental protection - and thus also even higher benefits - than those estimated by the Commission, could be achieved for that amount of money.

In summary, using a more integrated approach that cost-effectively reduces the emissions of CO_2 by a rational energy policy would:

- reduce the estimated costs of achieving legislation already adopted (the reference scenario) by about 30 per cent;
- reduce costs estimated for achieving the Commission's interim environmental quality targets of the NEC directive proposal by more than 60 per cent (or €4.8 billion)
- enable achievement of the environmental targets of the so-called "high ambition scenario" (the H3 scenario) at a cost of €4.2 billion, i.e. significantly lower even than the Commission's estimate of €7.5 billion for the proposed NEC directive.

Figure 2. Comparison of the estimated costs for achieving two different sets of environmental quality targets. (Commission estimates are based on the so-called Baseline energy scenario, while NGO estimates are based on an alternative low-CO_2 energy scenario).



References

AEA Technology (1999). Economic evaluation of proposals for emission ceilings for atmospheric pollutants. Interim report for DGXI of the European Commission. AEA Technology, Culham, UK.

Amann, M., Bertok, I., Cofala, J., Gyarfas, F., Heyes, C., Klimont, Z., Makowski, M., Schöpp, W. & Syri, S. (1998). Cost-effective control of acidification and ground-level ozone. Sixth interim report to the European Commission, October 1998. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Amann, M., Bertok, I., Cofala, J., Gyarfas, F., Heyes, C., Klimont, Z., Makowski, M., Schöpp, W. & Syri, S. (1999). Cost-effective control of acidification and ground-level ozone. Seventh interim report to the European Commission, January 1999. International Institute for Applied Systems Analysis, Laxenburg, Austria.

CEC (1997a). Communication to the Council and the European Parliament on a Community strategy to combat acidification. COM(97)88 final.

CEC (1997b). Climate change – The EU approach for Kyoto. COM(97)481.

CEC (1999). Proposal for a directive of the European Parliament and of the Council on national emission ceilings for certain atmospheric pollutants; and, Proposal for a directive of the European Parliament and of the Council relating to ozone in ambient air. (COM(1999)125 final).

Council (1998). Council Document 09402/98, Luxembourg, 16 June, 1998.

Kågeson (1999) Economic Instruments for reducing Emissions from Sea Transport. The Swedish NGO Secretariat on Acid Rain, the European Environmental Bureau, and the European Federation for Transport and Environment. Brussels/Göteborg.

Parliament (1999). European Parliament resolution on climate change: Follow-up to the fifth conference of the parties to the UNFCCC. Document B5-0314/1999. 15 December, 1999.

SENCO (1999). An alternative energy scenario for the European Union. The Swedish NGO Secretariat on Acid Rain, the European Environmental Bureau, and the European Federation for Transport and Environment. Brussels/Göteborg.

UN ECE (1999). Draft protocol to the 1979 Convention on long-range transboundary air pollution to abate acidification, eutrophication and ground-level ozone. EB.AIR/1999/1 and 2. UN ECE, Geneva, Switzerland.

UNICE (1999). Proposed ozone air quality and national emission ceilings directives – UNICE position. 1 December, 1999.

Annex: Country-by-country figures on emissions and costs resulting from computer model analysis of different scenarios, all based on the Carbon15 energy scenario.

Annex Table 1:
Emissions and control costs for the “new” reference scenario (REF_{new})

	Emissions, kt				Costs, € million per year			
	NO_x	VOC	NH_3	SO_2	NO_x/ VOC	NH_3	SO_2	Total
Austria	71	173	67	43	637	0	179	816
Belgium	169	176	96	174	810	0	328	1138
Denmark	116	84	72	90	419	0	153	572
Finland	82	129	31	113	350	0	129	480
France	642	1245	777	321	4826	0	964	5790
Germany	952	1137	571	419	7734	0	2370	10104
Greece	212	175	74	252	457	0	201	657
Ireland	42	40	126	36	285	9	82	376
Italy	647	905	432	312	5480	0	1079	6559
Luxembourg	9	7	7	4	75	15	14	103
Netherlands	202	203	136	98	1143	196	277	1617
Portugal	112	127	67	91	936	0	153	1089
Spain	663	650	353	439	3651	28	633	4312
Sweden	91	181	48	57	586	113	284	982
UK	998	1351	297	778	4604	0	854	5458
EU-15	**5007**	**6582**	**3154**	**3226**	**31994**	**361**	**7699**	**40055**

Annex Table 2: Emissions and costs above REF for the “new” H1 scenario

	Emissions, kt				Costs above REF, € Million per year			
	NO_x	VOC	NH_3	SO_2	NO_x/ VOC	NH_3	SO_2	Total
Austria	71	173	67	43	0	0	0	0
Belgium	122	96	69	76	271	147	89	507
Denmark	116	84	71	90	0	0	0	0
Finland	82	129	31	113	0	0	0	0
France	555	969	725	170	234	33	64	331
Germany	923	1008	473	358	194	313	101	608
Greece	212	175	74	252	0	0	0	0
Ireland	40	40	126	33	0	0	1	2
Italy	647	905	432	312	0	0	0	0
Lux.	8	6	7	4	1	0	0	1
NL	202	142	105	63	55	633	27	716
Portugal	99	127	67	91	3	0	0	3
Spain	660	650	353	439	0	0	0	0
Sweden	91	181	48	57	0	0	0	0
UK	994	1036	274	433	403	12	142	557
EU-15	**4822**	**5721**	**2920**	**2532**	**1161**	**1139**	**424**	**2724**

Annex Table 3: Emissions and costs above REF for the "new" H3 scenario

	Emissions, kt				Costs above REF, M.EURO per year			
	NO_x	VOC	NH_3	SO_2	NO_x/VOC	NH_3	SO_2	Total
Austria	71	173	67	43	0	0	0	0
Belgium	121	93	75	76	295	82	89	466
Denmark	114	84	71	87	0	0	1	1
Finland	82	129	31	113	0	0	0	0
France	530	961	718	145	372	41	100	513
Germany	895	963	416	327	393	1061	237	1691
Greece	212	175	74	252	0	0	0	0
Ireland	38	40	126	20	1	0	7	7
Italy	647	905	430	312	0	0	0	0
Lux	6	6	7	3	12	0	0	13
NL	196	137	105	63	88	665	27	781
Portugal	98	124	67	91	4	0	0	4
Spain	636	650	353	397	6	0	4	10
Sweden	91	181	48	57	0	0	0	0
UK	945	1036	264	370	413	23	232	668
EU-15	**4682**	**5658**	**2851**	**2357**	**1585**	**1872**	**698**	**4155**

Annex Table 4:
Ecosystems with acid deposition above their critical loads for acidification

	1000 hectares			Per cent of ecosystems		
	new REF	new H1	new H3	new REF	new H1	new H3
Austria	122	92	78	2.4	1.8	1.6
Belgium	118	52	49	16.8	7.4	7.0
Denmark	7	6	5	1.9	1.4	1.3
Finland	1122	1108	1100	4.1	4.1	4.0
France	112	85	82	0.4	0.3	0.3
Germany	1176	674	553	11.5	6.6	5.4
Greece	0	0	0	0.0	0.0	0.0
Ireland	9	9	8	1.0	1.0	0.9
Italy	56	53	52	0.5	0.5	0.5
Luxembourg	4	1	1	4.5	0.8	0.7
Netherlands	173	76	68	54.0	23.6	21.1
Portugal	1	1	1	0.0	0.0	0.0
Spain	6	6	0	0.1	0.1	0.0
Sweden	1437	1333	1289	3.7	3.4	3.3
UK	932	562	432	9.7	5.9	4.5
EU-15	**5276**	**4055**	**3717**	**3.5**	**2.7**	**2.5**

Annex Table 5: Ozone population exposure indices

	Cumulative population exposure index (million.persons.ppm.h)			Average population exposure index (ppm.h)		
	new REF	new H1	new H3	new REF	new H1	new H3
Austria	2	2	2	0.3	0.2	0.2
Belgium	30	22	21	2.7	2.0	1.9
Denmark	2	1	1	0.4	0.3	0.3
Finland	0	0	0	0.0	0.0	0.0
France	68	46	42	1.2	0.8	0.8
Germany	116	92	87	1.5	1.2	1.1
Greece	2	2	2	0.2	0.2	0.2
Ireland	1	0	0	0.2	0.1	0.1
Italy	27	25	24	0.5	0.4	0.4
Luxembourg	1	1	1	2.4	1.8	1.7
Netherlands	35	26	25	2.3	1.8	1.7
Portugal	6	5	5	0.6	0.5	0.5
Spain	3	2	2	0.1	0.1	0.0
Sweden	0	0	0	0.0	0.0	0.0
UK	73	48	46	1.3	0.8	0.8
EU-15	**366**	**273**	**259**	**1.0**	**0.8**	**0.7**

Annex Table 6: Ozone vegetation exposure indices

	Cumulative vegetation exposure index (1000 $km^2 \cdot$ppm.h)			Average vegetation exposure index (ppm.h)		
	new REF	new H1	new H3	new REF	new H1	new H3
Austria	210	194	191	4.1	3.8	3.7
Belgium	136	115	113	8.8	7.4	7.3
Denmark	42	32	31	1.4	1.1	1.0
Finland	0	0	0	0.0	0.0	0.0
France	1973	1634	1575	6.1	5.1	4.9
Germany	1066	910	880	5.0	4.3	4.1
Greece	123	121	121	2.3	2.2	2.2
Ireland	5	3	3	0.2	0.1	0.1
Italy	918	880	873	5.8	5.6	5.5
Luxembourg	12	10	10	8.3	6.9	6.6
Netherlands	78	66	65	6.0	5.0	5.0
Portugal	217	201	197	3.7	3.5	3.4
Spain	979	913	878	3.2	3.0	2.9
Sweden	9	7	6	0.0	0.0	0.0
UK	156	109	108	1.9	1.3	1.3
EU-15	**5925**	**5196**	**5050**	**3.2**	**2.8**	**2.7**

Annex Table 7:
Ecosystems with nitrogen deposition above their critical loads for eutrophication

	1000 hectares			Per cent of ecosystems		
	new REF	new H1	new H3	new REF	new H1	new H3
Austria	3095	2716	2581	51.9	45.5	43.2
Belgium	656	596	592	93.5	84.9	84.4
Denmark	96	85	82	30.4	27.1	26.1
Finland	1641	1571	1532	10.0	9.5	9.3
France	23629	22259	22191	74.4	70.1	69.9
Germany	8701	7667	6954	84.8	74.7	67.8
Greece	115	114	114	4.7	4.7	4.7
Ireland	55	54	53	6.0	5.9	5.9
Italy	3376	3233	3060	28.2	27.0	25.5
Luxembourg	77	66	64	87.3	74.7	72.9
Netherlands	287	277	276	89.5	86.6	86.1
Portugal	618	610	608	21.9	21.6	21.5
Spain	781	734	711	9.2	8.6	8.3
Sweden	701	651	595	3.7	3.5	3.2
UK	92	60	55	1.0	0.7	0.6
EU-15	**43920**	**40692**	**39468**	**36.4**	**33.7**	**32.7**