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RIJKSINSTITUUT VOOR VOLKSGEZONDHEID EN MILIEU
NATIONAL INSTITUTE OF PUBLIC HEALTH AND THE ENVIRONMENT

EUROPEAN ENVIRONMENTAL PRIORITIES: AN INTEGRATED ECONOMIC AND ENVIRONMENTAL ASSESSMENT

Report prepared by RIVM, EFTEC, NTUA and IIASA
In association with TME and TNO

Main Report

March 2001

This report has been prepared under a contract with the Environment Directorate-General of the European Commission (Contract no B4-3040/96/000777/MAR/B1). The findings, conclusions, recommendations and views expressed in this report represent those of the authors and do not necessarily coincide with those of the European Commission services.

RIVM report 481505010

Abstract

The economic assessment of priorities for a European environmental policy plan focuses on twelve identified prominent European environmental issues such as climate change, chemical risks and biodiversity. The study, commissioned by the European Commission (DG Environment) to a European consortium led by the RIVM, provides a basis for priority setting for European environmental policy planning in support of the sixth Environmental Action Programme. This programme follows up the current fifth Environmental Action Programme called 'Towards Sustainability'. The analysis is based on an examination of the cost of avoided damage, environmental expenditures, risk assessment, public opinion, social incidence and sustainability. The study incorporates information on targets, scenario results, and policy options and measures, including costs and benefits.

The following main conclusions emerged from the results. According to current trends, the European Union will be successful in reducing pressures on the environment if all existing policies are fully implemented and enforced. However, damage to human health and ecosystems can be substantially reduced with accelerated policies. The implementation costs of these additional policies will not exceed the environmental benefits and the impact on the economy will be manageable. This means that future policies will have to focus on least-cost solutions and follow an integrated approach. Nevertheless, these policies will not be adequate for achieving all policy objectives. The major problems remaining are the excess load of nitrogen in the ecosystem, exceedance of air quality guidelines (especially for particulate matter), noise nuisance and biodiversity loss.

Acknowledgements

The Environment Directorate General of the European Commission has launched this study that started in 1997. The scenario computations have been finalised in September 1999. The primary aim of the study was to provide, from a welfare-economic perspective, priorities for different policy targets and policy options in a new European Environmental Action programme (the sixth EAP). To succeed a complex and difficult project such as this, a consortium with economic and environmental expertise was created. The core team of this consortium included the following institutes and individuals:

- National Institute of Public Health and Environment (RIVM, the Netherlands): Prof. Jean-Paul Hettelingh (project manager in 1997 and 1998); Keimpe Wieringa (project manager from 1999); Bronno de Haan; Bart Strengers;
- Economics for the Environment (EFTEC, UK): Prof. David Pearce; Alexandra Howarth;
- National Technical University of Athens (E3Mlab of ICCS-NTUA, Greece): Prof. Pantelis Kapros and Leonidas Mantzos;
- International Institute for Applied Systems Analysis (IIASA, Austria): Janusz Cofala.

The study is the result of the efforts and contributions of many, both within and outside the consortium, including:

Markus Amann (IIASA), Bert Bannink (RIVM), Arthur Beusen (RIVM), Gert-Jan van den Born (RIVM), Ben ten Brink (RIVM), Floor Brouwer (LEI), Fiammetta Cocuzza (EFTEC), Hans Eerens (RIVM), Christian Fischer (EEA-ETC/Waste), Tannis Hett (EFTEC), Camiel Heunks (RIVM), Chris Heyes (IIASA), Kees Klein Goldewijk (RIVM), Guus de Hollander (RIVM), Jochem Jantzen (TME), Zbigniew Klimont (IIASA), Peter Kristensen (NERI), Conchi Lallana (WRi), Fred Langeweg (RIVM), Johan Lembrechts (RIVM), Ece Ozdemiroglu (EFTEC), Addo van Pul (RIVM), Tinus Pulles (TNO), Paul Rump, Coen Sedee (TME), Harry Slaper (RIVM), Rob Sluyter (RIVM), Winand Smeets (RIVM), Dan Varey (EFTEC), Guus Velders (RIVM), Antoon Visschedijk (TNO), Arnold van Vliet (RIVM), Detlef van Vuuren (RIVM), Mrs. Marianne Weismann (RIVM), Jaap van Woerden (RIVM), Mrs. Ruth de Wijs (RIVM).

A critical review of the results was performed throughout the study. The Peer Review group has met four times during the course of the project. This group consisted of Jose Carbajo (European Bank for Reconstruction and Development, UK), Frank Convery (University College Dublin, Ireland), Sylvie Faucheux (University of Versailles, France), Rui Ferreira dos Santos (DCEA, Portugal), Wim Hafkamp (Eramus University the Netherlands), Angela Köppl (Austrian Institute of Economic Research, Austria), Alberto Majocchi (University of Pavia, Italia), Thorvald Moe (OECD, France), Tomas Otterstrom (Ekono Energy, Finland), Domenico Siniscalo (Fondazione Eni Enrico Mattei, Italy), Mikael Skov Andersen (CESAM, Danmark), Rolf-Ulrich Sprenger (IFO, Germany), Thomas Sterner (Dept. of Economics and

commercial law, Sweden), Aviel Verbruggen (University of Antwerpen, Belgium), Tomasz Zylicz (Warsaw University, Poland).

The team worked closely together with the European Environment Agency (EEA) in order to exchange data and scenario results. Our liaison officer in Copenhagen was Mrs. Teresa Ribeiro. The second interim report of the study was delivered to the EEA in 1998 to provide scientific support to the 1999 report *Environment in the European Union at the turn of the century.*

The study was co-ordinated by the Environment Directorate-General of the European Commission. The Consortium benefited from the contacts and meetings with Marco Berti, Jos Delbeke, Rob Donkers, Kevin Flowers, Ger Klaassen, Matti Vainio and Marc Vanheukelen, all in the Environment DG.

CONTENTS

Technical Reports (published separately)

1. Stratospheric Ozone Depletion
2. Climate Change
3. Nuclear Accidents
4. Acidification, Eutrophication and Tropospheric Ozone
5. Chemicals, particulate matter and human health, air quality and noise
6. Water Quantity and Quality
7. Waste management
8. Soil Degradation
9. Biodiversity
10. Methodology Cost Benefit Analysis and Policy Responses
11. Socio-Economic Trends, Macro-Economic Impacts and Cost Interface
12. Enlargement

1 Summary and Conclusions

1.1 Main findings

Current trends show that if all existing policies are fully implemented and enforced, the European Union will be successful in reducing pressures on the environment. However, damage to human health and ecosystems can be substantially reduced with accelerated policies. The implementation costs of these additional policies will not exceed the environmental benefits and the impact on the economy is manageable. This requires future policies to focus on least-cost solutions and follow an integrated approach. Nevertheless, these policies will not be adequate for achieving all policy objectives. Remaining major problems are the excess load of nitrogen in the ecosystem, exceedance of air quality guidelines (especially particulate matter), noise nuisance and biodiversity loss. For climate change, the development of a policy strategy for the period after the year 2010 will become crucial, as further emission reductions are necessary and low-cost solutions will be exhausted. EU enlargement will alleviate some of the environmental problems and increase total benefits. However, enlargement may also add to environmental problems if, for example, perverse EU subsidy regimes are extended to Accession countries.

These main findings represent the major conclusions of an assessment of the current trends and future policy priorities in the European Union (EU) carried out by a Study Consortium in commission by the European Commission. The report represents a component in the preparation of a new Environmental Action Programme, the successor to the 1992 EC *Programme of Policy and Action in Relation to the Environment and Sustainable Development 'Towards Sustainability'*, the so-called Fifth Environmental Action Programme (5^{th} EAP). The 5^{th} EAP was built on the following:

- Environmental considerations were to become central to the formulation and implementation of both macroeconomic and sectoral policies (integration);
- To this end, new policy instruments for the achievement of convergence between economic and environmental objectives were to be utilised.

The current assessment acknowledges these themes and also relies on the next:

- The balance between economic and environmental considerations should be central to new environmental and sectoral policies;
- New policies should address the underlying causes of environmental problems such as market, institutional and information failures and
- Policy implementation costs should not exceed environmental benefits.

To support the preparation of the next EAP, an economic and environmental analysis was carried out on the future priorities of European environmental policies. This analysis looked at environmental trends, persistency of problems and their underlying causes, definition of new policy targets, robustness of policy responses, environmental expenditures, monetary damage, monetary benefits, efficiency, effectiveness, risk assessment and macro-economic impacts.

The study undertaken has addressed the following five key questions:
1. Are current policies adequate?
2. What can technology contribute to solving the policy gaps as identified?
3. Are the new targets chosen for this study achievable?
4. If so, are these targets economically reasonable?
5. What policy responses and instruments can be recommended?

1.1.1 Are current policies adequate?

A Baseline scenario has been constructed to assess the adequacy of current 5EAP policies and to identify remaining problems. This scenario has been derived in close co-operation with the European Environment Agency (EEA). The Baseline is, therefore, consistent with the EEA report*, Environment in the European Union at the turn of the century* (EEA, 1999). The Baseline scenario includes all existing and proposed EU policies in the pipeline as of August 1997, and shows the results of these policies, assuming that all are fully implemented. The following conclusions can be listed (see also *Table 1.1.1*).

- The EU will continue to reduce pressures on the environment during the forecasting period. Ensuring this progress requires full implementation and enforcement of current policies.
- Most of the key 5EAP targets have already been achieved and are only relevant for 2000. Current 5EAP policies (assuming full implementation) will be successful for the issues of stratospheric ozone depletion, nature conservation and water stress.
- Some policy gaps like climate change, waste and tropospheric ozone remain in the Baseline scenario. Additional policy initiatives are required if progress towards sustainability is to be achieved.
- In the case of chemicals, primary particulate matter (PM), water quality and air quality, the assessment reveals mixed success through enforcement of existing policies.
- With respect to stratospheric ozone depletion, the inherent time lags mean that positive recovery and impact trends will most probably not occur until after 2020.
- In a few areas, notably those pertaining to natural resources such as biodiversity, soil degradation and coastal zones, the lack of specific policy targets or sustainable levels inhibits the measurement of performance.
- Despite significant reduction of acidification, eutrophication, and ozone exposure, pressure will remain high on biodiversity in Europe's natural areas, which make approximately 50% of its territory. Pressure exerted by climate change is increasing and is expected to become a major factor in Northern Europe. The Bird's and Habitat Directive endorse the targets of the 5th Environmental Action Program. Their implementation will protect nature especially against increasing exploitation and habitat loss in about 10% of the EU territory. Given the ongoing high pressures, it is probable that the loss of biodiversity, which is currently observed in all European countries, will continue.
- From the Baseline scenario, it seems clear that transport will be the major driving force affecting environmental trends and target achievement during the outlook

period. Although the agricultural and industrial contributions will decrease, their overall contribution to environmental deterioration remains high.

- For this study, new policy targets for 2010 have been set. These targets are stricter than those in the 5EAP; current policies are not sufficient for these targets. Some of the targets have already been adopted (e.g., the Kyoto targets for the climate change issue) and for some adoption is in progress (e.g., targets for acidification). Not all environmental issues have new targets. The study restricts itself to those issues which require new initiatives, where benefits are expected to be up on costs, and where sufficient information is available.

Table 1.1.1: Summary of Baseline results per environmental issue in 2010

Environmental issue	Major current policy	Pressure trends	Impact trends	Distance to 5EAP targets
Ozone depletion	Montreal Protocol + amendments	+	-	+
Climate change	National policies	+/-	-	+/-
Nuclear accidents	Seveso Directive; nuclear safety standards	?	?	?
Biodiversity	Habitat and Birds Directive	-	-	+
Acidification	Second sulphur protocol	+	+	+/-
Chemicals and PM	National policies	+/-	+/-	+/-
Water quantity and quality	Nitrate directive, Urban wastewater directive	+	-	+
Waste management	National policies	+/-	+/-	-
Tropospheric ozone	VOC control protocol, NO_x protocol	+	+/-	+/-
Coastal zones	Bathing Water Directive	-	-	+/-
Air quality and noise	National policies	+/-	+/-	+/-
Soil degradation	National policies	-	-	NA

Legend:
+ , effective policy in reducing trends in EU or where a 'policy gap is no longer present'
- , policy not effective in reducing trends or where a 'policy gap is present'
+/- , more-or-less stabilising trends or where a 'policy target is almost achieved, but not completely'
NA, not available; the issue of soil degradation was not included in the 5EAP

1.1.2 What can technology contribute to closing the gap?

A second scenario has been developed to assess the maximum feasible reduction of environmental pressures using a set of measures based on the full application of available technology (mainly 'end-of-pipe' technologies), without regard to the costs. The following conclusions can be drawn from this scenario (see *Table 1.1.2*).

- Full application of available technological solutions ('end-of-pipe'), without regard to costs, might show considerable improvements for some environmental problems. Technological means can solve these problems, like nuclear risks, acidification, waste management and tropospheric ozone.

- However, there will be substantial costs. Estimates suggest that yearly environmental expenditures may rise to about € 50 billion over the expected costs under Baseline conditions. Acidification and tropospheric ozone abatement policies will take a lot of the direct costs. Welfare costs are significantly lower: about € 30 billion in 2010. With the implementation of all available technical abatement measures, the environmental expenditures as a percentage of gross domestic product (GDP) will slightly rise. It will only be 1% larger than in the Baseline scenario.

- The high costs of end-of-pipe technologies are caused partly by relatively expensive abatement measures. For instance, it will become increasingly expensive to reach an ever-higher abatement level. There will be a decreasing environmental return on additional environmental investment so that a greater proportion of GDP must be used for end-of-pipe abatement measures.
- For some environmental problems such as climate change, biodiversity and coastal zones, the end-of-pipe technologies available are limited. Without structural changes in consumption and production patterns, sustainable development remains therefore out of reach for solving these problems.
- Despite all the technical measures, some air pollution problems will not be completely solved: exceedances of air concentration targets for particulate matter still occur. Structural measures at the local level are crucial for meeting all air quality targets.

Table 1.1.2: Summary of environmental and economic effects of the Technology Driven scenario (see section 1.1.2) and the Accelerated Policies scenario (see section 1.1.3) as relative (%) change in comparison to the trend in the Baseline scenario by 2010.

	Indicator	Technology Driven	Accelerated Policies[1]	B/C test[4]
Environmental issue				
Climate change	GHG emissions	.	-14	+
Acidification	Ecosystem exposure	-57	-37	++
Trop. Ozone	Health exposure	-50	-43	++
	Ecosystem exposure	-34	-27	++
Waste	Landfill/incineration	-58[2]	-47	++
Chemicals and PM	Dioxin/Furan emissions	-63	-27	0
	HMs emissions	-34	-39	0
	Primary PM emissions	-59	-31	++
Human health and air quality	PM_{10} exposure above target level	-3	-3	++
	Noise nuisance	.	.	(++)
Biodiversity	Pressure on nature	.	-11	(++)
Stratospheric ozone	Ozone Depl. Sub.	.	.	(++)
Nuclear accidents	Unsafe reactors	-90	.	(+)
Water quantity and quality	-	.	.	(++)
Coastal zones	-	.	.	(?)
Soil degradation	-	.	.	(0)
Economy	Benefits[3]	€ 58 – 98 bln	€ 42 – 70 bln	
	Welfare costs	€ 30 bln	€ 16 bln	
	Benefit/cost ratio	1.9-3.3	2.7-4.5	

1 Full trade variant: welfare costs includes the costs of purchasing permits (€ 4.3 billion).
2 Maximum composting and recycling variant.
3 Total values assuming premature mortality are rated using VOLY and VOSL respectively.
4 Legend: 0 = benefit cost (B/C) ratio <1; + = B/C ratio >1; ++ = B/C ratio >2; B/C ratio in parentheses = expert judgement.

1.1.3 Are the new environmental policy targets achievable?

A third scenario has been developed to assess the achievability of the new targets as set down for this study. The scenario consists of structural and behavioural measures, mainly energy conservation and fuel switch. Structural measures in the transport sector are included in this scenario but are not substantial. Structural agricultural measures are almost absent, mainly as a consequence of the choice of problems for which new targets were selected (new targets were not set for issues where the agricultural sector is the main driving force). The following conclusions can be drawn from the scenario results (see also *Table 1.1.2*).

- Implementing additional policies based on least-cost solutions and considering specific policy targets for climate change, acidification, tropospheric ozone, waste management and human health and air quality (especially, particulate matter) might show considerable improvements to the environment, but to a lesser extent than applying all available ‘end-of- pipe’ technologies. Ecosystems and human health will benefit from this improvement. All the targets set for this study are achievable, with only one exception: the stringent target for particulate matter, which is almost unachievable due to high natural background concentrations.

- Besides the particulate matter problem, there are other environmental problems still remaining after implementation of the suggested additional policies; for example, the nitrogen load in the ecosystem (via air and water), noise nuisance and biodiversity loss. The transport and agricultural sectors are the main contributors to these remaining problems.

- Some policies have positive effects on other environmental problems without being purposely developed for solving them. Climate change policies have significant impact on acidification, tropospheric ozone, chemicals, primary particulate matter and air quality (see also *section 1.1.6*). Air quality and tropospheric ozone will also benefit from additional acidification policies. Climate change-related policies make policies required to reach acidification and ozone targets cheaper (by € 6 billion per year). Allowing flexible Kyoto mechanisms will lead to fewer cost savings for these problems (see *Fig. 3.3.3*), but is – overall - more cost-effective.

- Suggested additional policies are based on a search for least-cost solutions. Structural changes in our production and consumption patterns are almost absent for the target year 2010. Such changes will become crucial for future reductions. Implementing strategies as suggested in this study (mainly technological improvements and fuel switches) will result in additional time needed to prepare our economy for some of these structural changes and ‘to pave the way to sustainability’. However, long-term policy planning (beyond 2010) is therefore required.

- Some environmental problems have an irreversible character; i.e. impacts and risks such as stratospheric ozone depletion and nuclear accidents are found on a long-term scale. These problems, mainly transboundary, call for international co-ordination. The dilemma policy-makers are facing is the continuing large scientific uncertainty on the nature and causes of some of these problems, such as climate change, biodiversity and chemicals.

1.1.4 Are the new targets economically reasonable?

As previously stated, additional environmental policies will bring significant improvements to the environment in the EU. What are the economic impacts and benefits of such policies? Our study leads to the following conclusions:

- The overall impact of additional environmental policies on economic development is small. The total economic cost of these policies, measured as GDP losses, is considerably lower than the direct costs of investments and other expenditures. A large portion of this direct cost is recycled in the economy. The GDP losses range from € 16 to 30 billion in 2010 (which is from –0.15% to –0.3% of the EU GDP level in 2010).
- Although the overall impact is small, additional policies will influence the EU economy and will imply changes, like the electricity and energy-intensive sectors (due to more stringent climate change policies) and agriculture (mainly due to the low added value in this sector). These changes are important in distributional terms. Some sectors, such as those supplying environmental services and equipment, will profit from new environmental policies.
- For climate change, with particular reference to carbon dioxide, efficiency gains may be obtained by using emission permit-trading and joint implementation as a means of approaching a least-cost allocation of the emission reduction efforts among sectors and countries. An emission permit market for the power generation sector could be a first step. The macroeconomic costs for the EU are fairly manageable (while the beneficial spillover effects on other environmental areas of the EU are less, the overall effect is positive).
- Major monetary benefits can be expected for acidification, nuclear accident control, tropospheric ozone control and air quality improvements, suggesting that environmental policies, at least those focusing on human health, are beneficial.
- Total benefits of a scenario implementing all available technology are about 20% higher than a scenario with - more modest - accelerated policies[1]. However, the welfare costs of the technology scenario are considerably higher. The benefit/cost ratio is lower; in both cases benefits exceed costs.
- Allowing for the Kyoto flexible mechanisms will slightly reduce the total benefit estimates of the Accelerated Policies scenario for climate change, mainly due to lower secondary benefits. The assessment suggests substantial cost savings to EU from trading via the Kyoto flexibility mechanisms, i.e. the trade-off between secondary benefits within the EU versus the cost advantage of trading. Considering the cost-benefits, emission permit trading is more advantageous.
- For most of the environmental issues the policy implementation costs will not exceed the environmental benefits. Results also suggest some ranking (although uncertainties exist on how benefits and costs are estimated and attributed to the

[1] Total benefits of the maximum technology scenario are underestimated in this study due to exclusion of some PM_{10} benefits.

environmental issues, as there are many interlinkages and spillovers). EU policies focusing on climate change, acidification, waste management and (urban) air quality pay. Biodiversity and water stress might be added to this list, but there exist serious information gaps in these areas.

- Some major uncertainties are related to the method of benefit assessment. One of these is related to the question of how to monetise mortality, i.e., as 'death' or as 'life years lost'. In the summary tables, this uncertainty has been made explicit by showing both 'value of statistical life' (VOSL) and 'value of life years' (VOLY) benefit estimates. The analysis shows that the overall cost-benefit estimates are, however, hardly affected by this uncertainty. Only for one environmental problem - tropospheric ozone -, the uncertainty prevents a decision. If the lower estimate of avoided premature mortality is applied, abatement costs would exceed the benefits, while the higher estimate gives the opposite result.
- For some environmental problems the information on costs (acidification) is on firm grounds, whereas other environmental problems suffer from information weaknesses. Information on accelerated policies for water is observed to be too weak for an economic assessment of these policies. This applies also to policies for biodiversity.

1.1.5 What are the key policy responses?

Prior to the implementation of further environmental policy initiatives, it is imperative to secure the Baseline. A major effort should be directed towards two key issues:

- Firstly, if environmental policy incentives are to be effective, removing the disincentives is a priority. For example, the Baseline assumes the removal of all energy subsidies targeted at fossil fuels.
- Secondly, a major effort should be directed towards full compliance with all existing policies, especially the Bathing Water Directive, the Drinking Water Directive, the Habitats and Birds Directive, and the Directives on harmful substances.

We identified new policy actions in literature. A set of criteria are applied for selecting key policy actions (see *Table 1.1.3*), as it is very unlikely that any single criterion will be sufficient for this selection process. Rational criteria for selecting robust policy actions are:

- Causal (does the policy address the underlying economic failure?);
- Effectiveness (pressure reduction, multiple environmental effects);
- Efficiency (benefit–cost ratios, cost-effectiveness, benefits, public opinion),
- Macro-economic (macro-competitiveness, sectoral competitiveness, employment), and
- Jurisdictional (subsidiarity).

Table 1.1.3: Menu of key policy initiatives targeting environmental issues

Policy initiative	Environmental issue
Accelerated compliance by Annex 5 countries with Montreal Protocol and Amendments	Stratospheric Ozone Depletion
Energy-supply-side policies (carbon-trading energy sector)	Climate Change, Acidification, Human health and air quality
Energy-demand-side measures (energy standards; aviation tax; carbon / energy tax with negotiated agreement)	Climate Change, Acidification, Human health and air quality
Taxes on NO_x, SO_2 and VOC related to emissions from shipping, industrial processes, off-road vehicles, stationary combustion, and solvent paints	Acidification, Tropospheric Ozone, Human health and air quality
Accelerated substitution of nuclear facilities in Economies in Transition	Nuclear Accidents
Agricultural policy reform: i.e. increased use of agri-environmental schemes and mitigation banking	Biodiversity Loss, Coastal Zone Management
Transport package: i.e. parking charges, differential fuel tax, tradable efficiency permits for car manufacturers, etc.	Acidification, Tropospheric Ozone, Noise
Water pricing with 100% costs to society	Water management
Waste recycling credits	Waste management

Results suggest the conclusion that central policies for transboundary environmental issues have been exhausted or are less cost-effective: few additional policies (in terms of measures) need to be defined for the EU as a whole. An ‘emission ceiling directives’ approach, such as that adopted for acidification, could well serve the implementation of subsidiarity-based measures. Emission trading schemes within the EU forms another example of how cost-effectiveness of policies can be improved. All schemes should also require adequate reporting mechanisms.

1.1.6 Spillovers

Results of our study clearly show the benefits of an integrated approach policy (i.e. a policy considering spillover effects from one environmental issue to another). Significant cost reductions and increased benefits can be achieved. In other words, environmental targets can be realised easier. *Figure 1.1.1* shows the main spillovers between environmental issues. It illustrates that spillovers from climate change to other environmental issues are dominant, especially for acidification, chemicals (i.e. Heavy Metals, PAHs and dioxins/furans) and primary particulate matter (PM_{10} in *figure 1.1.1*). It is shown that CO_2 emission reduction of 15% compared to the Baseline results in emission reductions beyond 15% for many other substances. CO_2 emission reduction measures lead to emission reductions of 24% for SO_2, 8% for NO_x, 24% for PM_{10}, while SO_2, NO_x, and VOC control measures lead to auxiliary reduction of more than 7% PM_{10} emissions and significant reduction of the pressures on natural ecosystems. Measures to reduce the emission of PM_{10} reduce the emission of heavy metals to the same extend.

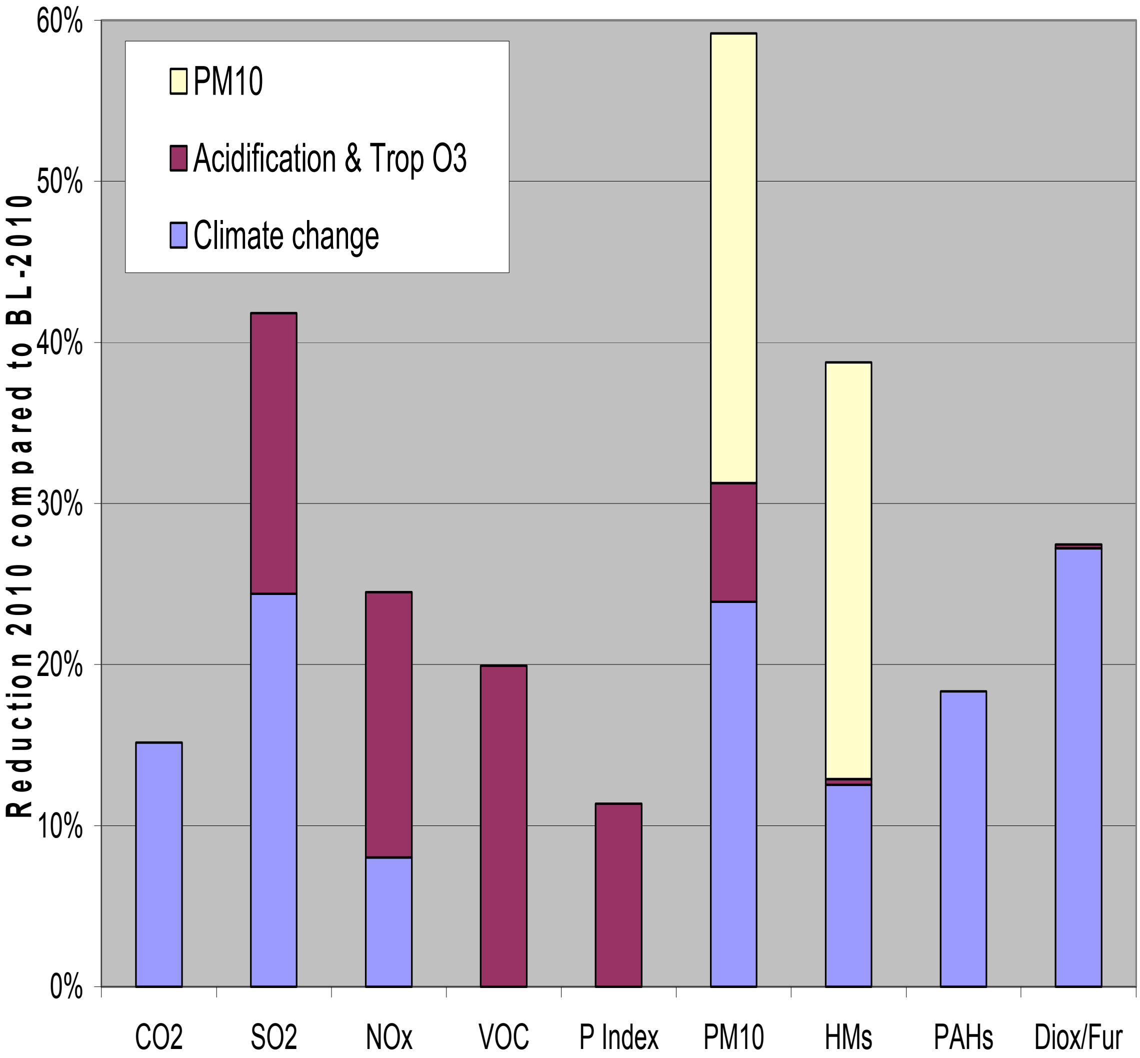

Figure 1.1.1 Spillover effects of climate change policies; acidification and tropospheric ozone policies and primary PM_{10} measures in the accelerated policy scenario (no-trade variant). P index is total pressure on biodiversity[2].

If, besides the Baseline policies, no climate-change policies were implemented at all, an additional investment in end-of-pipe measures of € 6 billion per year would be needed to reduce the acidifying emissions to a level that would ensure reaching the acidification targets. In terms of welfare loss, this would amount to nearly € 4 billion.

It should be noted that the interlinkages - as presented – depend on the formulation of the policy packages. In the accelerated policies scenario, developed in this study, one of the main measures is the switch from coal to gas. This measure dominates the spillover of climate change policies to other environmental issues. All policy packages have been defined and optimised for their own environmental problem. This means – at least in theory – that there is room for further optimising the spillover effects, and, thus, for improving the efficiency of accelerated policies package.

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[2] At European level, there is insufficient data to assess the status of biodiversity. The presented indicator was constructed to quantify as many as possible facets of the pressures on natural areas. Due to this data availability issue, air quality factors now dominate the indicator, while habitat destruction and habitat disruption lack.

1.1.7 EU Enlargement

Although the impact of EU enlargement on the environment was not fully appraised in this study, the following conclusions can be drawn from our findings:

- The EU enlargement can be expected to cause profound changes in the economies of the Accession countries. In countries that are advanced in the implementation of economic reforms (the 'first wave' of accession), energy consumption has dramatically decreased and the energy demand structure requires cleaner fuels. Energy intensities have also decreased.

- The EU enlargement will have a positive effect on the environmental situation in the Accession countries. Implementation of the Urban WasteWater Treatment Directive in combination with a large effort on sewerage development with tertiary treatment, i.e. nutrient removal, will improve river water quality considerably. Particularly water quality in the Baltic and Black Seas may benefit from this effort. Other environmental problems profiting from EU enlargement are waste management and air pollution.

- For transboundary problems the EU enlargement will have positive environmental effects within the Accession countries, but also within EU Member States. Approximation of emission control policies in Central and Eastern Europe to those of the European Union will make the achievement of environmental goals within the EU easier and cheaper.

- Additional benefits as a result of EU enlargement are expected if Accession countries fully comply with the Montreal Protocol; this will help to reduce the health risk associated with stratospheric ozone depletion worldwide. Closing or upgrading unsafe nuclear power plants in Accession countries brings about other benefits. Health risks associated with nuclear accidents will be reduced by almost 90% throughout Europe.

- In some economic sectors, the environmental performance is expected to improve, but the changes in the transport and agriculture sector may add to the deterioration of environmental quality. These sectors have, so far, not caused major problems in Eastern Europe. However, if, for example, current agricultural subsidy regimes remain unmodified, EU enlargement will lead to additional sectoral growth and, thus, to additional environmental problems, e.g. those of biodiversity loss. Integration of environmental considerations into economic sectors is therefore also crucial in the Accession countries.

- The approximation process will lead to high investment costs in the Accession countries, certainly in comparison with the available EU funds (e.g. PHARE, Cohesion funds). The effectiveness and efficiency of EU funding could improve if environmental impact assessment and cost/benefit analysis were applied.

1.2 Findings per Environmental Issue

1.2.1 Global Environmental Issues

Stratospheric Ozone Depletion

Anthropogenic emissions of chlorine and bromine compounds are the main cause of stratospheric ozone depletion. International agreements, supported by EU regulations, have been effective in reducing the production, use and emissions of ozone-depleting substances. However, the ozone layer is unlikely to recover before around 2050. Consequently, the adverse effects on human health and ecosystems are expected to continue throughout the 21st century.

It is generally agreed that in the EU the most effective measures for addressing ozone depletion are already in place. Future EU action, therefore, should support developing countries which have obligations under the Montreal Protocol to restrict their emissions. There are relatively high benefits (including for the EU) to be achieved against reasonable costs.

Climate Change

Increasing greenhouse gas concentrations may cause the climate to change. Ecosystems, but also the human society, may hardly find time to adapt to these changes such as temperature increase, sea-level rise, changes in rainfall and drought patterns, and the incidence of climatic extremes. Climate change may be irreversible, as there is a considerable time delay between the reduction of greenhouse gas emissions and the stabilisation of atmospheric concentrations. Climate change is addressed through the UN Framework Convention on Climate Change (FCCC), under which the EU committed itself to stabilise CO_2 emissions at 1990 levels by 2000. The EU is further committed to reduce the emissions of the main greenhouse gases by 8% in the period of 2008 to 2012 under the Kyoto Protocol.

Under the Baseline scenario, GHG emissions are expected to increase by 7% between 1990 and 2010 (see *Table 1.2.1*). All Member States, except Germany, would emit more CO_2; some, such as Portugal and Greece, by more than 50%. For CH_4 emissions, significant reductions are anticipated from the coal-mining industry and agriculture, while emissions from landfills will likely increase by 20%. The increase in N_2O emissions stems primarily from the transport sector. The most significant growth in the use of halogenated gases is expected in HFC application for refrigeration and foam blowing. It is clear from the Baseline assessment that additional policy measures will be required to meet the Kyoto reduction target. However, it must be stressed that technology improvement under Baseline conditions is of great significance.

Table 1.2.1 Main results for Climate Change in 2010

Climate Change	Unit	BL	AP-No trade	AP-Full trade
Emissions				
CO_2	1990=100	108	92	100[2)]
CH_4	1990=100	96	92	92
N_2O	1990=100	109	92	92
HFC, PFC, SF_6	1990=100	140	92	92
All GHGs	1990=100	107	92	98
Additional direct costs				
CO_2	billion €		92.0	36.3
Non-CO_2 GHGs	billion €		-0.4	-0.4
GDP loss (welfare costs)				
CO_2	billion €		17.1	9.2[3)]
Non-CO_2 GHGs	billion €		-0.2	-0.2
Primary + secondary benefits[1]	billion €		15 - 24	11 - 17
Benefit[1]*/Costs ratios*			0.9 - 1.4	1.2 - 1.9

[1] Total values assuming premature mortality are rated using VOLY and VOSL respectively. Secondary benefits include emission reductions of SO_2, NO_x, NH_3 (including secondary aerosols), and primary particulate matter.
[2] Results credited to the EU, excluding emission trading. If this is included, emissions will be 8% lower than Baseline results.
[3] Welfare costs include the costs of purchasing permits (€ 4.3 billion).

In this study, the EU target for climate change has been assessed for two 'accelerated policies' variants. In the first variant, 'no-trade', the Kyoto Protocol is implemented in all Member State countries according to their commitment, with no provision for emission trading. This assessment is likely to give an indication of the upper limit of the costs associated with achieving the targets. In this variant, CO_2 emissions are reduced by almost 15% or 500 Mtonnes compared to Baseline emissions by 2010. The electricity production sector realises about half of the reduction (46%), where the largest contribution comes from a change in fuel mix from oil and coal to natural gas, and non-fossil fuels. Technological improvements in especially aviation, electric appliances and equipment, space heating and cooling, and other heat uses contribute 30% to the total emission reduction. The largest reductions for methane (CH_4) are achieved through measures that promote mine gas and landfill methane recovery. For nitrous oxide (N_2O), almost 90% of all emission reductions can be achieved by technological improvements in fertiliser production. Technological improvements and the use of alternatives can lead to the largest reductions for halogenated gases.

In the second variant, 'full-trade', CO_2 emission trading is allowed among all Annex B countries. The assessment approaches a least-cost allocation of the combined EU effort to meet the Kyoto targets. This scenario implicitly includes the Joint Implementation and Clean Development Mechanism. Also in this variant, CO_2 emission reductions for each EU Member State are based on the Burden Sharing Agreement. However, least-cost considerations and emission trading will revise the obligations for each country. Total CO_2 emissions are reduced by 8% in 2010 within the EU compared to Baseline emissions. The remaining reduction obligation of 7% is obtained by buying emission rights from other Annex B countries - mainly the Ukraine and Russia - at a price of € 17.4 per tonne CO_2**.** This full trade provision will hardly shift the relative contributions of the economic sectors. The relative contribution from the electricity production sector is almost 10% higher since the emission reduction options in this sector are relatively cheap. Additional calculations suggest opportunities for a stepwise approach to implement a CO_2 emission permit trading system. For example, if the EU power generation sector sets out to establish an emission permit trading system, the permit price in that partial market would be close to the price mentioned above.

As shown in Table 1.2.1, CO_2-related measures strongly dominate total EU GDP losses in 2010. Although the variants were based on least-cost solutions, there is room for further cost reductions. CO_2 emission abatement measures could be replaced partly by (much) cheaper non-CO_2 GHG measures. However, uncertainties in both costs and emissions are large. Integrating climate change policies with waste management strategies can further reduce costs. This study shows that significant spillover effects in terms of CH_4 emissions from waste management to climate change are possible if landfilling of organic waste is reduced substantially.

CO_2 emission reductions cause emission reduction of many other pollutants as well. For example, measures that improve energy efficiency result in a lower use of fuels and therefore reduce the emissions of SO_2, NO_x, particulate matter, heavy metals, etc. Indeed, the monetary benefits of climate change are dominated by its secondary benefits as they cover 85-90% of the total benefits. If a lower premature mortality valuation were applied, the secondary benefits would still cover 75-80% of the total benefits.

In *Table 1.2.1* benefit-cost ratios vary between 0.9 and 1.9. This seems to justify the conclusion that a loss of economic growth due to climate change policies is offset by its benefits, where *secondary* benefits in the context of acidification and tropospheric ozone dominate. This conclusion even holds for a policy package that makes limited use of non-CO_2 emission reduction measures.

To achieve the target for climate change, a mix of regulatory and economic instruments must be implemented. Promising economic instruments are: tradable emission permits for GHGs (starting with CO_2 emission trading in the power generation sector), and/or a carbon/energy tax (about € 17.4 per tonne CO_2) and an aviation tax on kerosene (about € 0.2 per litre). Promising regulatory measures are: stricter standards on electrical appliances and other equipment, a market regulation for electricity (such as obligations to use renewables), stricter building codes both for houses and offices, incentives to use heat pumps and a continuation and reinforcement of energy conservation programmes for good housekeeping in energy use, heat/steam recovery, insulation etc.

Finally, a policy strategy for the period after 2010 becomes crucial. Massive nuclear decommissioning, anticipated to take place after 2010, will boost the demand for electricity produced by fossil fuel power plants putting the attained CO_2 emission reduction at risk. The development of structural changes in demand-side management and the use of renewable energy sources are expected to be small in 2010.

1.2.2 Continental Environmental Issues

Nuclear accidents

On a continental scale, three major types of accidents having significant adverse environmental implications are nuclear accidents, oil spills and chemical spills. This study focuses on the first one, nuclear accidents. Central and Eastern European Countries are responsible for at least 40 to 50% of the estimated human health risk due to radiation exposure in the EU; this is because the majority of the high-risk reactors are found in Central and Eastern Europe. Under current policies little change is expected in terms of mortality risks.

If most of the high-risk nuclear power plants are either closed or upgraded, risks will decrease by almost 90% for Europe as a whole. Costs of upgrading are estimated to be about € 100 million per year. However, these estimates are very uncertain. The upgrading is not justified in economic terms, as the benefits to the EU do not exceed the costs (based on avoided mortality). Yet, it is well known that people are more averse to accidents in which a considerable number of people die, or are injured, than to a series of smaller accidents, each of which produces a few fatalities, even though the total number of fatalities are the same. If this 'disaster aversion' is included in the benefits estimates, additional policies become economically efficient.

Acidification and Eutrophication

Sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3) react in the atmosphere to form clouds of acid rain. In many areas, dry and wet deposition of acid rain changes the chemical composition of soil and water threatening ecosystems. Also, it impairs human health and corrodes buildings and structures. Deposition of nitrogen compounds also causes eutrophication. The acidification has, since the 1980s, been effectively tackled by policy measures. The UN ECE Convention on Long-Range Transboundary Air Pollution (LRTAP) reached several international agreements to reduce emissions in a harmonised way. With respect to air pollution control, the EU has adopted emission and fuel-quality standards for its Member States. In addition, many European countries have adopted more stringent national standards and other types of regulations reflecting the seriousness of pollution and national environmental quality priorities.

Current policies form an important step towards achieving environmental sustainability for acidification and eutrophication (see *Table 1.2.2)*. Drastic improvements are probable for certain high-risk countries such as Germany (80% to 18%) and Belgium (58% to 23%). With respect to eutrophication, the protection levels are predicted to remain alarmingly low in some countries: below 10% in Belgium, Germany, Luxembourg and the Netherlands.

With the adoption of all feasible technical emission control measures, further reductions in emissions and improvements in ecosystem protection are possible. Under such a scenario, SO_2, NO_x and NH_3 emissions are likely to decrease markedly for the 1990 to 2010 period. Consequently, acid deposition exceeding critical loads is expected to affect only 2% of ecosystems in 2010. For eutrophication, the situation also improves, but exceedances remain high.

Table 1.2.2: Main results for Acidification and Eutrophication in 2010

	Unit	BL	TD	AP-nt	AP-ft
Emissions					
SO_2	1990=100	29	11	17	19
NO_x	1990=100	55	35	42	43
NH_3	1990=100	88	60	83	81
Target indicators					
Exceedance critical loads (acid)	%ecosyst	4.6	2.0	2.8	2.9
Exceedance critical loads (N)	%ecosyst	41	24	36	35
Accumulated acidity	10^9 acid eq	1.6	0.4	0.6	0.6
Additional direct costs					
SO_2	billion €		4.7	1.5	2.7
NO_x	billion €		15.7	1.4	1.9
NH_3	billion €		14.2	1.4	1.6
TOTAL	billion €		34.6	4.3	6.2
GDP loss	billion €		20.8	2.6	3.7
Primary + secondary benefits[1]	billion €		40-72	16 - 29	18 - 33
Benefit[1]*/Cost ratios*			1.9-3.4	6 - 11	5 - 9

[1] Total values assuming premature mortality are rated using VOLY and VOSL respectively.

For the accelerated policy scenario the target is set at the so-called ‘50% gap closure’. This means that the area of ecosystems not protected against acidification should be reduced *everywhere* by at least 50% compared to 1990. To achieve this target, exceedance of critical loads at EU level must be reduced to less than 3% in 2010. No targets have been specified for eutrophication. Improvements of eutrophication indicators result from policies needed to meet the acidification target. *Table 1.2.2* shows that emissions of SO_2 and NO_x must be reduced considerably to achieve the 50% gap closure target. Meeting this target hardly reduces the NH_3 emissions. This explains why the critical loads for eutrophication remain exceeded. Protection against eutrophication requires the definition of specific N deposition targets.

The welfare costs (or GDP loss) in the Technology Driven scenario are estimated to rise almost € 21 billion per year over the costs in the Baseline scenario. However, emission reductions would be large. Even larger than strictly needed to achieve the ‘50% gap closure’ target selected for the Accelerated Policy scenario. Spillovers from climate change policies and the less ambitious target make that the additional welfare costs of the accelerated policies scenario would reduce to between € 2.6 to € 3.7 billion per year.

Additional measures under the Accelerated Policy scenarios that are cost-efficient for at least one-third of EU member countries include: limiting the sulphur content of fuels and implementing NO_x control measures for national sea traffic; applying stricter controls on emissions from industrial processes other than energy combustion and further reduction of NO_x emissions from off-road vehicles through enforcement of standards similar to existing standards for road vehicles.

Independent of the approach to monetise premature mortality (VOLY or VOSL see section 1.1.4), the sum of primary and secondary benefits is (much) higher than welfare costs in all scenarios. This conclusion also holds for the technology driven scenario (TD), where no spillovers from climate change policies are considered (see Table 1.2.2). The results also show that acidification abatement will significantly benefit from climate change policies and this will reduce the costs.

Relevant policy instruments to achieve the acidification targets are: NO_x emission charges and a sulphur tax levied on the sulphur content of fossil fuels used for energy production. A comparison of costs and benefits suggests this would be economically efficient. For NH_3, the situation is complex. The best option probably is to establish a mineral accounting system. Any N-levy should be proportional to farm surpluses and all the main minerals involved.

Tropospheric Ozone

High tropospheric (ground-level) ozone concentrations are a major indicator of photochemical smog, which impairs vegetation and human health. Ozone is not emitted itself, but it is a product of reactions with (non-methane) volatile organic compounds (VOCs) and NO_x. Control of NO_x emissions has already been discussed in the context of acidification and eutrophication. In terms of environmental impact, AOT40 - the accumulated ozone exposure above the threshold value of 40 parts per billion (ppb) - is used to assess the potential damage to vegetation. AOT60 is used to define the critical threshold for human health. AOT60 values can also be used to estimate the exposure to peak ozone levels in cities. This will be discussed in the context of human health and air quality.

The transport sector is the most important source of NO_x emissions, while transport and solvent use in households and industry are the main sources of VOC emissions. The Fifth EAP established 30% reduction targets for NO_x (1990 to 2000) and VOC (1990 to 1999). Implementation of existing policies and policies in the pipeline is expected to reduce emission levels even further by 2010. (see Tables 1.2.2 and 1.2.3). These reductions will substantially reduce human and plant exposure to ozone.

Table 1.2.3: Main results for tropospheric ozone in 2010; VOC emissions only, for NO_x emission reductions see table 1.2.2.

	Unit	BL	TD	AP-nt	AP-ft
VOC emissions	1990=100	51	35	41	41
Target indicators					
AOT40	ppmh	4.1	2.7	3.0	3.0
AOT60	ppmh	1.4	0.7	0.8	0.8
Additional direct costs	billion €		8.8	3.2	4.2
GDP loss	billion €		5.3	1.9	2.5
Primary benefits[1]	billion €		1.2 – 9.1	0.7 – 5.6	0.7 – 5.7
Benefit/Cost ratios	billion €		0.2 – 1.7	0.4 – 3.0	0.3 – 2.3

[1] Benefits assume premature mortality is rated using VOLY and VOSL respectively.

The full application of existing technology could bring an 80% reduction in 2010 for the human-health related indicator (AOT60). For potential vegetation exposure the most significant improvements occur within large areas in France, Germany, Italy, Portugal and Spain. The additional welfare costs of applying existing technology to further reduce VOC emissions is estimated at € 5.3 billion per year, where it should be realised that these costs were made by non-transport sectors only. We considered VOC emission reductions in the transport sector itself to be a spillover of measures to reduce NO_x emissions. However, environmental expenditures in the transport sector can arbitrarily be assigned to NO_x control (acidification and eutrophication) or to VOC control (tropospheric ozone).

The targets in the accelerated policy scenarios have been taken from the proposal for the National Emission Ceilings Directive, which states that AOT60 (regarding health) should be reduced by two-thirds and AOT40 (regarding vegetation) by one-third until 2010, see the AP values in Table 1.2.3. Welfare costs in the Technology driven scenario rise to more than € 5 billion per year over the Baseline costs. In the accelerated policies scenario the additional costs are less than half of this amount. In all three scenarios, technical measures for controlling VOC emissions that are cost-efficient for at least one-third of the EU member countries are: further controls of VOC emissions from liquid-fuels processing and distribution; promotion of low-solvent paints in professional, industrial, and 'do-it-self' applications; and better controls of VOC emissions from 2-stroke engines.

The monetary benefits of tropospheric ozone abatement have been assessed, though these are difficult to quantify. The benefit range in *Table 1.2.3* reflects the uncertainty with respect to premature mortality. Inclusion of other uncertainties would result in an even broader range. Positive impacts of VOC emission reductions on other environmental issues (i.e. secondary benefits) are considered to be negligible. The benefit-cost ratios of the policy package show that the method of monetising premature mortality is crucial for passing the economic efficiency test. However, the benefit assessment had to disregard some important impacts. Therefore, the benefit estimates may be biased towards underestimation.

No additional end-of-pipe measures other than those already in place were found to be cost-efficient in all EU countries. Therefore, a VOC tax might be appropriate to stimulate the implementation of the most cost-efficient measures in each country.

Chemicals and particulate matter

The number of chemicals that enter the environment is large. Heavy metals (HMs) and persistent organic pollutants (POPs) represent two groups that are of particular importance due to their persistent, bio-accumulative and toxic characteristics. These substances cling to fine dust particles. Emission reductions of particulate matter (PM_{10}) are important to reduce its effect on human health, but also to limit the transport of many chemicals in the atmosphere. Human exposure to particulates (and other substances) is discussed in the context of human health and air quality.

Emission targets have been established for some HMs and POPs under the auspices of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Countries that signed the protocols on HMs and POPs are under the obligation to stabilise emissions of lead, cadmium, mercury, dioxins/furans and polycyclic aromatic hydrocarbons (PAHs) at 1990 levels. For PM_{10}, the target is set in terms of air concentrations only (i.e. 20 $\mu g/m^3$ annual average) as also discussed in the context of human health and air quality.

Under current policies, substantial emission reductions with respect to 1990 for PM_{10}, lead, dioxins/furans, and to a lesser degree for mercury, are expected by 2010 (see Table 1.2.3). The downward trend in PM_{10} emissions results primarily from lower transport and stationary combustion emissions due to stricter emission standards and reduced coal use, respectively. The phasing out of leaded petrol explains the reduction in lead emissions. The improvement in emission levels of dioxins/furans is explained by the application of efficient flue-gas cleaning technologies for waste incinerators. Reduced coal use and an abatement programme in the chloro-alkali industry are expected to lower mercury emissions by 2010. Small increases in the emissions of cadmium and PAHs are expected due to growth in road transport (for cadmium) and to higher use of wood fuel in households (for PAHs). Therefore, the achievement of stabilisation targets is not ensured for these gases under Baseline conditions.

The technology-driven scenario (TD) assumes full application of the most advanced end-of-pipe emission control technologies, such as high-efficiency electrostatic precipitators, fabric filters and highly efficiently wet scrubbers. This would significantly reduce emissions of all studied hazardous substances (see Table 1.2.4, Technology Driven scenario) and demonstrates the remaining technical potential for further control of emissions.

Under the Accelerated Policy scenario, spillover effects from climate change and acidification were analysed first. Climate change policies have the largest impact (about 75%). For HMs, estimated spillover effects are almost completely due to climate change action. The spillover reductions would achieve the emission stabilisation targets for all substances studied, including cadmium, copper and PAHs.

The Accelerated Policy scenario also includes full application of advanced abatement technologies for PM_{10}. The largest reduction of PM_{10} emissions can be achieved through further control of the emissions from major industrial production processes. However, the assessment demonstrates that still a large portion of the European population would be exposed to PM_{10} levels exceeding the target levels of 20 $\mu g/m^3$.

Total yearly direct costs and welfare costs compared to the Baseline are summarised in *Table 1.2.4,* where it should be noted that uncertainties are large: i.e., a factor of 2 to 4. Costs of measures to reduce PM_{10} emissions from transport are evaluated in the context of acidification.

Table 1.2.4: Main results for chemicals, primary particulate matter and human health and air quality.

	Unit	BL	TD	AP-nt
Emissions (Chemicals and PM)				
Primary PM_{10}	1990=100	60	30	25
Lead	1990=100	40	30	28
Copper	1990=100	101	77	74
Mercury	1990=100	91	53	47
Cadmium	1990=100	105	62	55
Dioxins/Furans	1990=100	69	26	50
PAHs	1990=100	105	43	86
Target indicators (Human health and air quality)				
Exposure above PM_{10} target	10^6 people	305	295	295
Exposure above Pb target	10^6 people	0	0	0
Exposure above NO_2 target	10^6 people	36	15	18
Exposure above SO_2 target	10^6 people	5	0	5
Exposure above B(a)P target	10^6 people	140	50	n.a.
Exposure above O_3 target	10^6 people	265	110	170
Additional direct costs				
Primary PM_{10}	billion €		1.8	1.6
Dioxins/Furans	billion €		0.4	0.0
GDP loss	*billion €*		*1.3*	*1.0*
Primary benefits[1] of PM_{10}	billion €		*n.a.*	*3.1 – 5.3*
Benefit[1]/Cost ratios of PM_{10}			*n.a.*	*3.1 – 5.3*

[1] The benefit assessment assumes that premature mortality is rated using VOLY and VOSL respectively. Benefit/cost ratio of PM10 is overestimated as it compares total benefits, including those of spillovers of climate change and acidification policies, with the direct costs of PM_{10} emission abatement

Economic instruments in the context of other environmental issues such as the carbon/energy tax, minimum excise duty, the aviation tax and nitrogen and sulphur taxes will also be beneficial in terms of PM_{10} reduction. With respect to regulations, an appropriate action could be to extend the Integrated Pollution Prevention and Control (IPPC) Directive with binding emission standards for major industrial production installations as they already exist for other major source categories. Such advanced measures for PM_{10} control will also reduce emissions of heavy metals, dioxins/furans and PAHs.

1.2.3 Regional and Local Environmental Issues

Water quantity and quality

Human use places severe pressure on Europe's water resources. Water quality is a major concern throughout Europe, while the level of abstraction represents a further stress in southern countries. Water withdrawals for irrigation can lower water tables and result in salt-water intrusion in coastal areas. Nitrogen pollution of groundwater restricts its use for drinking water, while eutrophication due to excessive nutrient load can lead to algae growth, oxygen deficiencies and fish kills. Coastal zones are areas of the highest biological and landscape diversity on Earth. In this assessment, the coastal zone issue is represented only through the analysis of nutrient loading. Other coastal issues, such as urbanisation, tourism and over-fishing are not taken into account.

Water demand seems to be stabilising and the implementation of measures for water quality is in progress. After full implementation of current policies (Nitrates and the Urban Waste Water Treatment Directives), the water quality will show steady improvement. The Biological Oxygen Demand in rivers is falling, though the nitrate load remains a problem**.** This also means that the biodiversity of marine ecosystems does not benefit from actions to limit excessive nitrogen releases to surface water.

Anticipating a need for further environmental improvements, the European Commission proposed the Water Framework Directive. At the moment, neither targets, action plans, nor environmental models are available to assess the impact of the new Directive.

The cost–benefit analysis of domestic water supply suggests the need for policy measures that do not focus on investments in new supply schemes, but on demand management and leakage control instead. The first step towards correct water pricing in agricultural water demand management is the removal of subsidies for agriculture and (irrigation) water.

There are only a few benefit-estimate studies in Europe on preventing water contamination. They are fairly consistent in suggesting that benefits to avoid contamination could be very high, reflecting the householder's concern about drinking water. Comparing costs and benefits for avoiding water contamination suggests the B/C ratios could be 1.5 - 15. For coastal zone management cost–benefit estimates are of limited availability and the existing studies do not provide a clear perspective.

Waste Management

In the EU, waste generation is increasing faster than economic growth. The volume of waste is an indicator of inefficient production processes, low durability of goods and unsustainable consumption patterns. In addition to the resource loss represented by waste quantities, waste management and disposal have significant impacts on the environment including air and water pollution. The accelerated policy (AP) scenario targets EU municipal waste disposal at 50% of composting and recycling. Industrial and hazardous waste has not been included in this study due to lack of harmonised data. However, future policies should focus on these waste streams.

Table 1.2.5. Overview of the environmental and economic results of the scenarios for municipal waste management

Municipal Waste Management	Unit	1993	2010	2010	2010
			BL	TD[2]	AP
Waste arisings[1]	1993=100	100	122	119	118
of which					
Composted and recycled	%	15	43	68	58
Incinerated[3]	%	22	19	13	12
Landfilled[1]	%	63	57	19	30
Additional treatment/Disposal costs	billion €			4.8	-0.8
GDP loss	billion €			2.9	-0.5
Primary + Secondary benefits	billion €			10.3	9.1
Benefit/Cost ratio				3.4	>>1

[1]Including landfilling of incineration waste
[2] Maximum composting and recycling
[3] Including energy recovery

Current targets controlling the amount of municipal solid waste are unachievable without additional policy responses. The annually generated amount of municipal waste per capita was 534 kg in 1993. This will increase by more than 20% by 2010 (while the target was stabilisation at the 1985 level). Due to the implementation of the Packaging Directive, landfill of waste will decrease, although it remains the dominant route for waste treatment. Recycling will double.

In a scenario that focuses on composting and recycling (TD), the share of landfill may decrease to almost 20%, while costs will increase by more than 35% (see *Table 1.2.5*). This strategy requires additional institutional structures for recycling and composting. Effective separation of waste streams at the source requires the setting up of kerbside collection and introducing systems for glass, paper, plastic, biodegradables and metal.

The Accelerated Policy scenario assumes preventive measures for reducing the amount of waste plastic and paper, and composting and recycling at a cost-optimal level. The increase of municipal solid waste occurrences will be limited to almost 5% over the 1993-2010 period. The share of landfill and composting/recycling will be 30% and 60%, respectively, in 2010 (this goes beyond the 50% target set for this scenario). Implementing these policies might lead to cost savings of more than 5% compared with unchanged strategies. Results also suggest that a strategy focusing on composting and recycling is more cost-effective than incineration and landfilling.

The AP scenario generates smaller benefit estimates (i.e. € 9.1 billion) than the TD scenario (i.e. € 10.3 billion). However, this is more than counterbalanced by lower costs in the AP scenario. In effect, the net efficiency of the AP scenario is the best. However, the TD policy strategy also passes the cost–benefit test. A strategy focusing on maximum incineration (including energy recovery) is economically inefficient.

Waste management policies can significantly contribute to climate change policies by reducing both methane emissions (CH_4) from landfills and carbon dioxide emissions (CO_2) as a result of (fossil) energy savings due to waste incineration with energy recovery. The AP scenario may generate considerable secondary benefits. The reduction of the amount of biodegradable waste disposed on landfills will reduce methane emissions from landfill sites, estimated at approximately 65 million tonnes of CO_2 eq. These benefits are valued at € 440 million.

The most promising policy responses in terms of environmental effectiveness and economic efficiency are virgin materials taxes and recycling credit schemes. The virgin materials tax reduces waste at source, whilst the recycling credit scheme addresses the current market failure in this area. In this way, both policies address main underlying causes of the waste management problem.

Soil Degradation

Soil degradation resulting from human practices reduces or destroys the land's long-term productivity and life-support function. Degradation of agricultural soils results in lower yields, persistent weed problems and an increasing need for artificial fertilisers. This assessment focuses on the erosion aspects of soil degradation and the threat to future agricultural productivity due to climate change.

Soil erosion accounts for about 60% of the degradation problem, which also encompasses such issues as land development, soil contamination and salinity encroachment. About 12% of Europe's land area is adversely affected by water erosion, while 4% suffers from wind erosion. These problems exist in most European countries, although the concentration of eroded lands is greatest in the Mediterranean region. There is no framework for European soil directives as soil problems are considered to be local and thus best handled at national or even regional level.

Current agri-environmental regulations at both the EU and Member State levels hold considerable promise for effectively preventing and mitigating soil erosion. Landowners are encouraged to adopt more extensive management practices such as organic farming, afforestation, pasture extension and benign crop production. Nevertheless, there is a need for policy makers and the public to intensify efforts to combat the pressures and risks to the soil resource. However, damage estimates suggest that soil conservation measures are likely to be cost-ineffective.

There is a significant association between soil degradation, and water management and climate change. Global warming and changing rainfall patterns will probably intensify degradation, which, without adequate responses, will magnify the problems of water pollution and clogged downstream watercourses, including reservoirs. Such changes could also result in the more intensive use of marginal soils to compensate for the loss of degraded land. Policy initiatives targeted at other environmental problems will help to alleviate the problem of soil degradation.

1.2.4 Cross-sectional Environmental Issues

Biodiversity loss

Diversity of ecosystems, species and genes is critical to the functioning of the ecosphere. At present, ecosystems are undergoing unprecedented degradation and loss of species due to the rapid increase in human use of natural resources. Biodiversity considerations are beginning to be integrated into sectoral policies. Despite this positive development, negative impacts will probably continue from such factors as agricultural intensification, mono-specific forestry, urban and transport development, climate change, pollution and the introduction of alien species. Various pressures on nature areas are not included in this study but are just as important, e.g. forestry, fisheries, hunting, extensive grazing, and fire and water management.

The implementation of the Bird and Habitat Directive is progressing. Currently, 5.3% and 10.7% of the EU area is protected under this Directive, which is about one-tenth and one-fifth of EU's nature areas, respectively. In the past, land-use change was the dominant process for biodiversity loss in the EU. This trend has stopped. Nature areas are projected to expand somewhat (from 49% to 51%) due to the 'setting aside' of agricultural land. The total environmental pressure on nature areas will decrease by 22% and 31% in the Baseline and the Accelerated Policy scenarios, respectively. This decrease is a spillover effect of the significant decrease in pressures from acidification, tropospheric ozone and eutrophication and, to a lesser extent, to de-fragmentation. Pressure from climate change will increase substantially in the 1990-2010 period.

There are no known 'willingness to pay' figures for a specific valuation of diversity. However, there is evidence to suggest benefit estimates could be large due to the 'willingness to pay' estimates for habitat and species conservation.

Further agricultural policy reform is required to take account of the impacts of or production from the agricultural sector and environmentally destructive technology on biodiversity. The limitations of land-use planning schemes and the earlier MacSharry reforms to the Common Agricultural Policy suggest that new policies will need to target specific issues, such as agri-environmental schemes.

Human health: air quality and noise

Human health and air quality problems are especially important in cities and large agglomeration. The number of people living in urban agglomerations is steadily increasing in the EU. This results in a greater potential effect on such environmental issues as air, noise, water pollution, concentrated waste levels and restricted amounts of open space. A common analytical framework for modelling such urban stresses is not currently available. This study focuses mainly on concentrations of selected air pollutants in cities and rural areas in the EU and noise nuisance.

Regarding noise, more than 30% of the EU population is currently exposed to road noise nuisance. In the future, it is likely that noise levels (both road and air traffic) will increase.

In general, air quality in Europe has improved in recent decades, although targets are still frequently exceeded for some specific pollutants, especially in cities, but also in rural areas. Existing policies and policies in the pipeline will reduce the exceedance of WHO air quality guidelines. By 2010, no more violations of the target exposure levels of SO_2, benzene and lead are expected (see *Table 1.2.4*). However, high levels of PM_{10}, exceeding the target level, remain a serious health problem. However, the prevailing 20 $\mu g/m^3$ target may need redefinition. On the hand, it should be realised that in many countries the natural background concentrations already exceed 20 $\mu g/m^3$. And, one the other hand, if it were applied to the *anthropogenic* contribution to PM_{10} concentrations only, there would be almost no problems left.

Under the Technology Driven scenario the situation improves significantly for ozone (O_3), B(a)P and NO_2. However, it remains serious for B(a)P and O_3. In most EU countries, population exposure exceeding the target level for PM_{10} is reduced only slightly and remains high.

Compared to the Baseline, the population exposure in the Accelerated Policy scenario is significantly lower for both NO_2 and O_3 in all EU countries. This is mainly due to spillover of acidification and tropospheric ozone abatement. Despite the introduction of acidification and PM10 abatement measures, still 50 million people will be exposed to air pollution exceeding PM10 health targets. Exceedances primarily occur in large agglomerations and cities. However, exceedances of PM_{10} occur *everywhere* and exposure to ozone also represents a problem in rural areas.

Climate change policies have only a limited impact on local air quality. Road transport, which is the major source of (urban) air pollutants, is expected to grow by more than 30%. There are several options to reduce PM_{10} and NO_x emissions beyond the emission levels of the AP scenario (especially within city boundaries), such as banning traffic in city-centres, improving traffic circulation plans, stimulating the switch from diesel- to petrol-driven cars, converting city buses' fuel system to natural gas, stimulating the use of electric cars and/or improving open fireplaces. Revenues from parking charges, fuel taxes, etc. could be used to (partly) finance the implementation of these measures. The subsidiarity principle says that city authorities can best take these measures. It should be noticed that in the Accelerated Policy scenarios none of these additional measures were evaluated, because detailed information to quantify environmental impacts and (welfare) costs was lacking.

Benefits of reducing air quality exceedances were already discussed in the context of acidification, tropospheric ozone and chemicals and particulate matter. With respect to noise nuisance, it is estimated that total damage costs due to current noise exposure is about € 13.2 billion per year. This suggests that policies to control exposure to noise levels from road, rail and transport (such as a noise tax on aircrafts) may yield large benefits. Costs of policies are not known, but the scale of the benefit estimates suggests that such measures could pass the cost–benefit test.

2 Introduction

2.1 Environmental Problems of Europe

In the 1990s, European environmental analysis and assessment has focused on a set of priority problems. The Dobriš Assessment and subsequent European state of the environment reports have been structured around these prominent issues (EEA, 1995; EEA, 1998; EEA, 1999), which are also clearly featured in the European Union's (EU) Fifth Environmental Action Programme (5th EAP). The problems were originally selected based on the following criteria: threats to sustainability; their long-term character; risk to human health; social, cultural, and economic impacts; and potential for ecological damage. In addition, global, transboundary, and European relevance were important considerations reflecting geographic scope.

These assessments show that progress to date in tackling the pressures and impacts associated with these problems has been mixed (see *Table 2.1.1*). Considerable progress, especially with respect to reducing emissions, has been made in some areas (for example: stratospheric ozone, acidification, certain chemicals and heavy metals, and the risk of nuclear accidents within the EU). For other issues, the magnitude of the problem continues to increase (for example: waste, biodiversity loss, and soil degradation); or progress has been limited and not totally effective (for example climate change, water stress, and urban areas).

Table 2.1.1 Summary of Current Progress under Existing Policies for the set of prominent environmental problems assessed in this study.

Prominent European Environmental Problem		Pressure Reduction	State & Impact Reduction
Global scale	Stratospheric Ozone	+	-
	Climate Change	+/-	-
Continental scale	Major Accidents	+/-	+/-
	Acidification	+	+/-
	Tropospheric Ozone	+/-	-
	Chemicals and Particulate Matter	+/-	+/-
Regional/local scale	Water Quantity and Quality	+/-	+/-
	Coastal Zones	-	-
	Waste	-	-
	Soil Degradation	-	-
Cross-sectional	Biodiversity	-	+/-
	Human health and air quality	+/-	+/-

\+ positive development
+/- some positive development but insufficient
\- unfavourable development

Source: Adapted from EEA, 1999

For these latter problems, there is a clear need for further policy measures to ensure that targets are met consistent with sustainable development and sustainable reference values are met. Nevertheless, it has to be recognised that the most obvious and cost-effective actions have already been taken. In the future, it will be necessary to focus on root causes emphasising an integrated and cost-benefit approach not only within issue areas, but also recognising the ecological and cost-benefit linkages between issues. Climate change, for example, accentuates acidification, eutrophication, tropospheric ozone, biodiversity loss, and soil degradation.

The problems listed in *Table 2.1.1* represent the starting point for this study. It could be argued that other issues warrant priority consideration. Considerable public attention is being focused on, for example, the impact of genetically modified organisms (GMOs), contaminated land, damage to cultural heritage, and the management of nuclear waste. However, such issues present difficulties especially if one wants to model or assess future developments. Furthermore, it should be pointed out that the depth of analysis possible varies among the selected problems. Only a superficial analysis of expected environmental quality in coastal zones is feasible due to the lack of comparable regional data on future infrastructure developments.

2.2 Study Objectives

The primary objective of this study is to provide an economic assessment of priorities for European environmental policy planning. In 1993, the Council and Member States adopted the general approach and strategy of the European Community Programme of policy and action in relation to environment and sustainable development (the 5th EAP), covering the period to the year 2000. The 5th EAP, 'Towards Sustainability', underscores the integration of environmental considerations into both macroeconomic and sectoral policies. The Commission has reviewed the Programme and concluded that the most important task is to set key priorities and translate further the Programme's strategy into a set of pragmatic and operational tools (COM(95)624 final). Furthermore, the Treaty of Amsterdam states that the elaboration of environmental policy should take account of the potential benefits and costs of action.

It is generally agreed that the next environmental action programme should be based on the following:

- balance between environmental and economic considerations should become central to the formulation and implementation of environmental and sectoral policies;
- new policy measures should address the underlying causes of environmental problems; and
- policy implementation costs should not exceed environmental benefits.

To support the preparation of the next EAP, this prospective analysis has been carried out to guide priority setting for European environmental policies. As far as possible, the analysis is based on an examination of the benefits of avoided damage, environmental expenditures, risk assessment, public opinion, social incidence and sustainability.

The following five questions are addressed by this study:

1. Are current policies adequate?
2. What can technology contribute to solve the policy gaps as identified?
3. Are the new targets, as chosen for this study, achievable?
4. If so, are these targets economic reasonable?
5. Which policy responses and instruments can be recommended?

Question 1: effectiveness current policies
For answering the first question, a 'Baseline' scenario (BL), using a 1990 to 2010 timeframe, is employed by the study. This scenario is based on projected changes to basic socio-economic parameters such as population and GDP growth and energy consumption; and continued implementation of existing and proposed EU policies as of August 1997. Thus, the Urban Waste Water Treatment Directive, issued in 1993, is reflected in the baseline scenario, while the provisions of the Kyoto Protocol are not. This scenario has been constructed in close co-operation with the European Environment Agency and is, therefore, largely consistent with the latest EU state of the environment report (EEA, 1999).

Question 2: technological contributions
A scenario has also been developed to assess the maximum feasible reduction of environmental pressures using a set of measures based on the full application of available technology ('end-of-pipe'), without regards for costs and not in relation to any target; the so-called 'Technology Driven' scenario (TD).

Question 3: achievability new targets
An 'Accelerated Policy' scenario (AP) has been constructed that uses new targets to assess a set of structural measures, which go beyond existing policies, but generally fall short of maximum technology. For this scenario, DG Environment selected a set of reasonably ambitious targets or objectives to be achieved by 2010, for instance, the Kyoto protocol to reduce greenhouse gases. The scenario aims to identify the least-cost actions (both technical and structural). It is best applied to issues which have well-defined impact indicators, and where credible economic values can be computed.

The Accelerated Policy scenario has been assessed by three variants in order to evaluate the dominance of climate change policies in relation to other environmental issues. These variants include the following climate change policies:
- full trading of greenhouse gas emissions;
- no trading of greenhouse gas emissions;
- complete absence of climate change policies (in order to fully understand the potential spillover effects from climate change policies).

Question 4: economic test
The results of the accelerated policy scenario and the selected targets has been tested on their economic consequences and compared, if applicable, with the results of technology driven scenario:
- Are the benefits exceeding the costs (cost-benefit analysis)?
- What are the macro-economic impacts of the suggested policies?

Question 5: policy responses
Finally, the most promising key policy responses have been identified according a number of criteria. These policy responses are necessary to ensure that producers and consumers take the necessary technical and structural actions as identified in the accelerated policy scenario.

EU Enlargement

In the coming years, the European Union will be enlarged by the accession to the Treaty of Central and Eastern European Countries, the so-called Accession countries[3]. In this study we have reviewed how the findings of the five questions might be affected by 'enlargement' or, in other words, how priorities for EU might alter. This review is not complete, as information on enlargement and state of environment in the countries concerned is only limited available. Therefore, the review is mainly qualitative.

Study limitations

The three principal scenarios have not been computed for all environmental issues, mainly due to the following reasons:

- Baseline results suggest that after full implementation some environmental issues are almost solved or policy targets are met; for these issues no additional policy actions are needed;
- Technical abatement or 'end-of-pipe' measures are not available; therefore no technology driven scenario has been analysed;
- Data, models, appropriate indicators and/or policy targets are missing.

Table 2.2.1 summarises the three scenarios as analysed in this study for the various environmental issues. It also identifies the analysed spillover effects between the issues. This means that actions in mitigating one environmental issue might have side effects to another (for example, energy conservation might contribute to the climate change issue, but also affects the acidification issue). These side effects might be positive or negative. In the framework of this study not all spillover effects and feedback mechanisms are taken into account. However, we do hope that the most prominent mechanisms and spillover effects have been assessed.

[3] Poland, Hungary, Czech Republic, Estonia, Slovakia, Lithuania, Latvia, Bulgaria and Romania are candidate Member States. In course of the study, Cyprus and Turkey have become candidate Member States as well. Specific consequences of the accession of these two countries have not been assessed.

Table 2.2.1 Overview of environmental issues and evaluated scenarios - baseline (BL), technology driven (TD) and accelerated policies (AP) - and their spillover effects in this study

	Environmental issue	Policy scenarios			Spillover effects
		BL	TD	AP	
Global scale	Stratospheric ozone	X			
	Climate change	X		X	X
Continental scale	Nuclear accidents	X	X		
	Acidification and eutrophication	X	X	X	X
	Tropospheric ozone	X	X	X	X
	Chemicals and particulate matter	X	X	X	X
Regional/local scale	Water stress	X			X
	Coastal zones	X			X
	Waste management	X	X	X	X
	Soil degradation	X			X
Cross-sectional issues	Human health and air quality	X			X
	Biodiversity loss	X			X

Other important limitations of the study are the following:

- Data and information presence is firm on air related issues and weak in issues related to natural resources. This means that the study was not able to fully appraise all environmental issues and related costs and benefits.
- Consequently, indicators and policy targets selected in this study are mainly focused on those issues where a solid information basis is present. This means that findings on the remaining issues are less robust.
- The time horizon of the scenario analysis is 2010. This prevails the assessment of longer-term issues and the consequences of policies that have societal time lags (due to, for instance, fleet-turnover rates).
- It is assumed that all measures and policy actions will be fully implemented and enforced. Implementation failures of actions (in place or identified) have not been assessed.
- The macroeconomic impacts of the benefits have not been appraised. This also counts for the distributional impacts of new policies on different socio-economic groups within the EU.
- The subsidiarity issue and the consequences of the EU enlargement have not been assessed in full detail.
- Although three scenarios and variants have been computed, time was too limited to fully quantify the sensitivities and uncertainties of the results.

Box 2.1: Definitions, scope and limitations

Base year	1990
Scenario period	1990 to 2010
BL scenario	Baseline scenario including socio-economic parameters and policies in place (as of Mid 1997) and in the pipeline
TD scenario	Technology Driven scenario including maximum feasible technical abatement measures
AP scenario	Accelerated Policy scenarios including assumptions on new environmental policy targets and a mix of structural and technical measures
AP-nt	AP scenario with no trading of greenhouse gas emissions
AP-ft	AP scenario with full trading of greenhouse gas emissions
New targets	Policy targets as assumed and determined by the commissioner of this study
Environmental issues	The environmental issues in this study follow the issues that have been selected by the European Environment Agency. The report does not cover natural hazards and genetically modified organisms and is limited in the areas of chemicals (non assessed chemicals and pesticides), technological hazards (oil and chemical spills, nuclear waste), noise, waste (chemical and industrial waste) and biodiversity.
Spillover effects	Positive or negative side-effect from mitigating one environmental issue to another
Geographical coverage	The report focuses on the 15 EU Member States. The EU Enlargement issue is only partially assessed.
Measure	Technical abatement measures, structural and/or behavioural change
Policy response	Policy instrument which give rise to behavioural change, including implementation of measures. Examples are regulation, levy, voluntary agreement
Costs	annualised costs in 2010 including operational and investment costs
Benefits	annualised value of avoided environmental damage in 2010
Discounting rate	4%
Currency	€ (Euro) of 1997

Structure of the report

This report focuses on the environmental and cost-benefit results of this scenario assessment. *Section 3* of the report examines the environmental results and the associated costs for each of the environmental issues. This section includes a brief assessment of the consequences of the new enlargement of the EU. The economic assessment (*section 4*) and an overview of policy opportunities (*section 5*) complement section 3. Section 5 considers the robustness of policies, whether they are best implemented at EU or Member State level. A brief overview of the methodology is presented in *section 6*. In addition to the scenarios and targets, this section discusses the indicators used, the cost-benefit approach, the organisational arrangements for the study, and a qualitative assessment of information gaps. These areas are fully documented in the various *Technical reports* that support this report. A background report is presented for each environmental issue giving an outline of the problem and its relationship to economic sectors and other issues; the benefits and the cost-benefit analysis; and the policy responses. Additional reports outline the benefits methodology, the EU enlargement issue and the macro-economic consequences of the scenarios.

3 Environmental Results

3.1 Socio-economic Developments

Main findings

- This study has been based on a socio-economic scenario that projects the average EU GDP to increase by 2.3% per year over the time interval 1990 to 2010. The service sector is likely to increase its prominence and industrial activity remains stable.
- The population of the EU is expected to increase slightly (0.5% per year).
- Energy demand is expected to continue to grow, although at a slower pace (20% between 1990 and 2010). Passenger and freight transport is expected to grow by 30% and 50% between 1995 and 2010, respectively.
- Total livestock will remain stable, although the number of dairy cows is expected to drop by 8% and poultry to rise by 8% during the period 1990 to 2010. The use of pesticides and artificial fertilisers is expected to decline.
- Economic growth in the Accession countries has been assumed to be slightly above the EU-15 average. Accession of countries to the EU is expected to accelerate growth in these countries. A consequence of EU Enlargement is that transport and agricultural production will be stimulated.

Assumptions

This section covers the socio-economic survey behind the Baseline scenario and describes the driving forces of the future development of environmental pressures, state and impacts. It provides a consistent framework for each of the EU Member States up to 2030. The Baseline scenario is founded on available macro-economic and sectoral projections for the short term (up to 2000), subsequently using aggregate world assumptions to extend the projections to 2030. The macro-economic and energy forecasts are taken from the DG Energy business-as-usual pre-Kyoto Protocol scenarios supplemented by transport and agricultural outlooks. For the non-EU countries, projections are based on data submitted by the governments to the UN/ECE. The principal assumptions behind the socio-economic scenarios are outlined in *Box 3.1.*

Box 3.1: The socio-economic scenario 1990-2010: main assumptions and EU policies

Rapid technological change in the world (industrial and agricultural production, transport and communication, environmental technology).

An increasingly open world economy (for example, complete removal of trade barriers is ultimately assumed, along with decreasing international transport and communication costs).

Favourable domestic political and economic developments, particularly in important countries such as China and Brazil, boosting the world economy and trade by 2010.

Europe benefits from a healthy world economy. Growth is further increased by monetary unification around 2000-2005, which will tend to eliminate fluctuations in interest and exchange rates in the EU and lead to a gradual convergence of prices.

A relatively stable population in size in Europe, with no employment market shortages.

EU Member States' economies continue to converge with each other.

Tight fiscal policies prevail over the next decade to reduce public deficits.

After 2005 the EU will gradually liberalise its Common Agricultural Policy (Agenda 2000 reforms are not included).

Implementation of the Trans-European Transport Network programmes (TEN).

EU's energy policy in response to the Kyoto agreement is not included in the Baseline scenario; further implementation of various energy programmes (e.g., SAVE II, ALTERNER, Combined Heat and Power strategy).

The liberalisation of electricity and gas markets goes into operation and further develops at the beginning of the new century.

The scenario did not include the socio-economic impacts of the forthcoming enlargement of the EU by the accession of Central and Eastern European Countries.

Socio-economic projections

In the Baseline scenario, average EU GDP growth is projected to increase by 2.4% per year from 2001 to 2010; slowing to 1.8% per year between 2011 and 2020, and 1.7% per year between 2020 and 2030. The population of the EU is expected to increase slightly during the first decade of the next millennium primarily due to immigration. After 2010, the rate of population growth falls and is expected to stabilise after 2020. Thus, the EU population is projected to be more than 386 million people by 2010; an increase of 21 million since 1990. With these expected increases, the average Member State GDP will increase from about € 18,500 per capita in 1990 to € 27,000 per capita in 2010. *Table 3.1.1* provides more specific projections from the Baseline socio-economic scenario for GDP, Private Consumption, the Consumer Price Index, and Population in the EU.

Table 3.1.1 Socio-economic scenario: observed (1985 to 1995) and projected (1995 to 2010) trends of some macro-economic indicators in the EU-15.

Macro-economic aggregates	*Observed*		*Projected*		
	1985-1990	*1990-1995*	*1995-2000*	*2000-2005*	*2005-2010*
%					
GDP Growth	3.2	1.4	2.6	2.5	2.3
Private Consumption	3.6	1.2	2.3	2.3	2.2
Consumer Price Index	4.9	3.6	2.3	2.1	2.0
Population	0.3	0.3	0.4	0.3	0.2

The assumption of gradual economic convergence implies higher growth rates for the cohesion countries (Greece, Ireland, Portugal, Spain), growth above the EU average for the UK, and lower growth for the affluent Scandinavian countries (Denmark, Sweden and Finland). This trend was already apparent in Ireland, Spain, and Portugal from 1985 to 1995. However, such convergence is likely to be far from complete even by 2030.

Sectoral projections

From a sectoral point of view, the Baseline scenario assumes a continuation of current trends, without extreme variations. Considerable differences are assumed in the evolution of the specific economies of Member States. However, certain general trends are common across the EU. Specialisation of countries is expected to continue, but not dramatically for most Member States. The service sector (which includes transport and tourism) is likely to increase its prominence, but not dominate national economies. Industrial activity is expected to be fairly stable following a period of re-structuring. New industrial activities with high value-added and lower material dependence are projected to emerge in most countries.

Under the Baseline scenario, energy intensity gains are projected, but energy demand is expected to continue to grow, although at a slower pace (20% between 1990 and 2010). Oil and natural gas use should continue to increase, while solid fuel consumption will decline. Minor increases in the energy demand for nuclear and renewable sources are also anticipated. Under baseline assumptions, new energy forms, such as hydrogen and methanol, do not make significant contributions. Despite efficiency gains, the primary growth in energy demand stems from the service and transportation sectors, although this will not result in any significant change in sectoral share by 2010. Rapid restructuring of power plants is expected to lead to the use of cleaner fuels and a significant increase in efficiency.

Energy prices are assumed to gradually increase, following a smooth ascending path from their present low levels. Oil prices are assumed to recover by 2000 to their 1995 level and then grow smoothly. Natural gas prices rise at lower rates in the first half of the period but then grow slightly faster than oil as a result of pressures from the supply side. Coal prices remain practically stable in real terms. Energy taxation policies are assumed to remain unchanged from the current situation in the EU Member States.

Passenger transport is expected to grow by 30% between 1995 and 2010. Similarly, freight transport is expected to increase by 50% between 1994 and 2010, mainly due to international freight movements. The overall split between transport modes will probably remain largely unchanged, although air travel is expected to almost double.

The existing provisions of the Common Agricultural Policy (CAP) aimed at integrating environmental considerations into agricultural policy are included in the Baseline scenario. According to Member State forecasts, the number of dairy cows is expected to decrease by 8%, the pig population to increase by 1%, and poultry to increase by 8% during the period 1990 to 2010[1].

The use of pesticides and artificial fertilisers is also expected to decline. The application of pesticides, for example, will probably decrease by about 30%. In addition, the application of less harmful agricultural products should contribute to reduced pressures on the environment.

Enlargement

After the deep economic recession at the beginning of the 1990s, growth rates in some of the accession countries are already higher than in the EU. In the Baseline scenario, i.e. without accession, we have assumed an economic growth rate of 3.4% per year between 1995 and 2010; this coming to slightly above the EU-15 average. It is generally expected that accession would accelerate economic growth in the accession countries. The OECD High-Growth scenario gives such an indication, as it assumes large increases in international trade and investments in efficient technology. Economic growth would then increase to an average of 5.5% per year, which is about 2% greater than the situation without accession (OECD, 1997).

The environmental impacts of increased economic growth are always ambiguous: pollution and energy use per unit of production usually decreases but total pollution and energy use increases as result of volume growth. Enlargement would stimulate efficiency improvement through fast adaptation of technologies, still standard in the EU. Nevertheless, energy demand is expected to grow. Replacement of old power plants and boilers in industry using solid fuels could result in a shift to natural gas, depending on its availability.

Obviously, an important consequence of EU Enlargement will be an increase of international trade and thus a sharp increase in freight transport between accession countries and the EU. Freight transport within the accession countries will also increase but at a (much) slower rate than GDP due to large efficiency gains. Passenger transport is expected to grow much faster than in the EU, eventually reaching levels that are currently common there.

There is some concern that during the period of transition to EU legislation, accession might lead to a shift of polluting production activities from the EU towards Accession countries. A first assessment of such effects, however, shows this effect to be as yet relatively small (IVM, 1997).

[1] The Environment in the European Union report (EEA, 1999) assumes other agricultural activity levels than the present Baseline (24% less cattle, 8% more pigs, 4% less nitrogen fertiliser use). This difference explains that the ammonia emissions in (EEA, 1999) were estimated 8% lower than in this report. According to a sensitivity study (compare Cofala and Klimont, 1999), this change in emissions has only marginal effects on environmental indicators. Thus, the conclusion of the present assessment is valid for both agricultural scenarios.

Inclusion of the Accession countries in the Common Agricultural Policy (CAP) Programme may lead to a shift of some agricultural production from the current EU Member States to Accession countries. However, the direction of this shift heavily depends on the new CAP Reform.

Accession may not only cause impacts in the Accession countries themselves, but also in the economic activity of the EU. In particular, enlargement of the liberated energy market may affect production capacity and levels in the EU as a result of import from Accession countries. Transport from the EU to Accession countries will increase as a result of larger trade volumes, while agricultural production of some products could decrease in the current EU Member States.

3.2 Global Environmental Issues

3.2.1 Stratospheric ozone depletion

Main findings

- Current policies reduce production and consumption of the major Ozone Depleting Substances (ODSs) to almost zero in 2010 in the EU-15.
- Nevertheless, full recovery of the ozone layer will take at least another 50 years.
- Also, (accelerated) compliance of Article 5 countries to the Montreal Protocol and its amendments should be ensured.

Context

Anthropogenic emissions of chlorine and bromine compounds are the main cause of stratospheric ozone depletion. This depletion leads to increases in the amount of UV radiation reaching the Earth's life zone. The effects of increased radiation on humans, plants and animals are likely to be complex and selective. Impacts on human beings include skin cancer, eye cataracts and a possible decreased function of the body's immune system. Many plants show reduced photosynthesis and growth under increased radiation exposure. Phytoplankton and zooplankton are probably the most susceptible to radiation damage due to their direct exposure to the sun.

International agreements, supported by EU regulations, have been effective in reducing the production, use and emissions of ozone-depleting substances. However, the ozone layer is unlikely to recover until around 2050. Consequently, the adverse effects on human health and ecosystems are expected to continue throughout the 21st century.

It is generally agreed that the most effective measures to address ozone depletion are already in place. Chlorofluorocarbon (CFC) production was effectively phased out in the EU in 1995. Future EU action, therefore, centres on support to developing countries (i.e., the so-called Article 5 countries) to ensure they meet their obligations under the Montreal Protocol (see also *section 5.1.2*), and prudence in tackling new potential threats to the ozone layer. Under these circumstances, no scenarios considering additional policy measures have been developed for the problem of stratospheric ozone depletion. Instead, an evaluation of existing policies is provided. This is accomplished by comparing estimates of UV radiation and human health implications under current international agreements with those assuming no intervention. The possible incidence of skin cancer is used as the impact indicator of human health.

There are no major connections to the other environmental issues of this assessment. However, with respect to climate change, an increase in carbon dioxide (CO_2) concentrations may delay the recovery of the ozone layer by several years due to an increase in clouds in the stratosphere. Inversely, increases in UV levels could adversely affect the absorption of CO_2 by the oceans through reduced growth, photosynthesis and reproduction of phytoplankton. In addition, UV radiation contributes to chemical processes related to methane and nitrogen oxides in the troposphere. It is thought that UV-B, for example, reduces tropospheric ozone in environments with low nitrogen oxide levels, but increases it in polluted areas where these levels are relatively high.

Assessment and trends

With the adoption of the Copenhagen Amendments to the Montreal Protocol, the annual increase in UV values over north-west Europe is expected to decline after the year 2000, when the ozone layer should start to recover. Full recovery will take at least another 50 years.

Under these circumstances of slow recovery, the number of excess skin cancer cases is estimated to be 1.25 per 100 million people per year in 2050. Without these measures, the rate of UV radiation would have continued to increase into the next century, with a projected skin cancer incidence of 3.40 per 100 million people per year. It can be deduced, therefore, that the implementation of the Copenhagen Amendment would probably avoid about 80,000 cases of skin cancer per year within the EU by 2050. Due to long time delays for the occurrence of skin cancer, these estimates would probably be 10 times higher for the year 2100.

Enlargement

All 10 Accession countries have ratified the Montreal Protocol and its amendments. In conformance with these agreements, consumption of CFCs in Accession countries decreased considerably after 1986, reaching a level of virtually zero in 1996. EU policies also limit the use and production of methyl bromide and HCFC. Compliance to EU legislation would accelerate the decrease of these ozone-depleting pollutant emissions in the Accession countries. Also, accession will accelerate the establishment of compliance control institutes. This trend will reduce the health risk due to UV radiation for both EU15 and Accession countries.

3.2.2 Climate change

Main findings

- Under the Baseline scenario, greenhouse gas emissions are expected to increase by more than 7% between 1990 and 2010, mainly due to the transport and service sectors.
- Nevertheless, meeting the 8% decrease of the Kyoto Protocol (i.e., the target in the accelerated policy scenarios) is feasible.
- The role of the power generation sector is crucial because of the existence of low-cost opportunities for emission reduction and because electrical technologies may enable efficiency gains in the demand side. The transport sector requires attention because of relatively high emission growth and high adjustment costs.
- The establishment of emission permit trading mechanisms will allow a least-cost allocation approach and will reduce the overall compliance cost. However, if the EU could bear higher costs so as to increase the emission reduction actions that will be undertaken within the EU territory, the environmental benefits in all areas would be substantially higher.
- Although uncertain, low cost measures to reduce emissions of non-CO_2 greenhouse gases are suggested as being able to substantially reduce emission reduction costs.

- A policy strategy for the period after the year 2010 becomes crucial. Massive nuclear decommissioning, anticipated to take place after 2010, will require extra conventional power generation. Up to 2010, contributions to CO_2 emission reduction from energy demand-side management and renewable energy sources are small.

Context

Climate change has wide implications brought about by temperature change, sea-level rise, changes in rainfall and drought patterns, and the incidence of climatic extremes. Such changes are likely to have significant impacts on ecosystems, human health and economic sectors such as agriculture and forestry.

Climate change is addressed through the UN Framework Convention on Climate Change (FCCC) under which the EU is committed to stabilise CO_2 emissions at 1990 levels by 2000. The EU is further committed to reduce the emissions of the main greenhouse gases (GHGs) by 8% in the period 2008 to 2012 under the Kyoto Protocol. This protocol introduced several new elements to assist countries to meet reduction targets. First of all, the protocol does not address carbon dioxide only, but a ‘bucket’ of six greenhouse gases, which allows reductions for gases with the lowest marginal costs. Secondly, the Protocol allows countries to include emission savings generated from landuse changes (such as reforestation) aimed at increasing carbon sink capacity. And finally, the protocol introduces three flexible instruments to meet reduction targets:
1) emissions trading among commitment countries (the Annex B countries[2]);
2) joint implementation among commitment countries and
3) co-operation under a ‘Clean Development Mechanism’ (CDM) between commitment countries and countries that have not taken up reduction targets.

The most important gases contributing to climate change (and included under the Kyoto Protocol) are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the halogenated compounds - hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The sectoral contributions to the emissions of these gases are summarised in *Table 3.2.1.*

[2] Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, The Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Ukraine, United Kingdom, United States of America.

Table 3.2.1 Major sources of greenhouse gas (GHG) emissions, 1995.

GHG	*Contribution to global warming (%)*	*Major sources and relative contribution*
CO_2	64	Energy sector (32%), transport (24%), industry (23%)
CH_4	20	Agriculture (42%), waste disposal and treatment (36%), energy industry (17%)
N_2O	6	Agriculture (46%), industry (26%)
HFCs		HCFC production, refrigeration
PFCs	10*	Aluminium production
SF_6		Electricity distribution

* Total for all halogenated compounds
Source: EEA, 1999

In this study, the provisions of the Kyoto Protocol have been applied in two variants of an accelerated policy scenario, both of which achieve the 8% GHG reduction target. The first alternative, a so-called ‘no-trade’ scenario, focuses on reduction of CO_2 emissions under the Burden Sharing Agreement to meet the Kyoto target. Thus the Kyoto Protocol would be implemented in each country’s territory according to the individual commitment, with no provision for GHG emissions trading either within the EU or internationally, or recognition of beneficial spillover effects from the management of other priority issues such as waste. However, the Accelerated Policy no-trade scenario assumes full trading within the borders of each separate EU member state. This means that the target is allocated to each sector in a cost-effective manner without any a priori allocation of emission reductions to any sector. This will likely give an indication of the upper cost limit associated with meeting the targets of the Protocol.

The second variant, a full trade scenario, assumes that CO_2 emission trading under the Kyoto Protocol will be allowed among all Annex B countries and uses this option to approach a least-cost allocation of the effort to meet the Kyoto target (also implicitly includes Joint Implementation and Clean Development Mechanism). In this case, emission reductions for each EU Member State are based on the Burden Sharing Agreement, but due to least-cost considerations and CO_2 emission trading, the actual emissions in each country will change, while the overall emission reduction in the EU will be less than in the no-trade scenario.

As it is difficult to model non-CO_2 greenhouse gases in a consistent and reliable manner and because uncertainties in both abatement costs and emissions are large, trading has been limited to CO_2 in this analysis.

Energy consumption is the main source of greenhouse gas emissions in the EU and the use of energy affects almost all sectors in its economy. Thus, through the energy system, climate change policies will have potentially important effects on many sectors and their emissions. For instance, if less coal is used due to climate change policies, then the other emissions related to coal use will also decrease. In particular, reductions of GHG emissions will also reduce emissions of SO_2, NO_x, primary particulate matter, heavy metals, PAKs, dioxins and furans. Methane emissions from landfill sites contribute to climate change, while incineration with energy recovery may reduce CO_2 emissions from fossil fuel combustion. Climate change has important long-term adverse implications for natural resources such as soil and biodiversity. Thus, implementation of policies for such issues as climate change, acidification, tropospheric ozone and waste management in an integrated way will most likely mean considerable environmental improvements in a more efficient manner.

Assessment and trends

Under the Baseline scenario, GHG emissions are expected to increase by 7% in the period 1990 to 2010. All of the contributing gases, except CH_4, are projected to have increased emissions by 2010 (see *Table 3.2.2*). In terms of CO_2 emissions, the transport and service sector contributions are projected to increase by 35 and 15% respectively, while industrial and energy sector CO_2 emissions should each decline by about 10%. All countries, except Germany, would probably experience increases in CO_2 emissions; some, such as Portugal and Greece, by more than 50%. For CH_4 emissions, significant reductions are anticipated from the coal mining industry and agriculture, while emissions from landfills will likely increase by 20%. The increase in N_2O emissions stems primarily from the transport sector. The most significant growth in the use of halogenated gases is expected in HFC application for refrigeration and foam blowing.

Table 3.2.2 EU-15 greenhouse gas (GHG) emissions for base year 1990 and the 2010 projections of Baseline (BL) scenario and two Accelerated Policy scenario variants 'no trade' (AP-NT) and 'full trade' (AP-FT) in comparison with the Kyoto emission reduction target: emission reduction of 8% by 2010 compared to 1990. All emissions have been normalised to CO_2 equivalents.

Greenhouse gas	*1990*	*BL 2010*		*AP-NT 2010*	*AP-FT 2010*	*target*
	Mt CO_2 eq	Mt CO_2 eq	% change	Mt CO_2 eq	Mt CO_2 eq	Mt CO_2 eq
CO_2*	3078	3322	+8	2822	3067	
CH_4	490	469	-4	451	451	
N_2O	313	342	+9	288	288	
HFCs, PFCs, SF_6**	58	81	+40	53	53	
Total GHG	3939	4214	+7	3614	3859	3624

* Excluding the emission of carbon dioxide by non-energy activities such as cement industry.

** Emissions for 1995.

Sources: Eurostat and PRIMES model for CO_2, AEAT (1998) for CH_4, Ecofys (1998) for N_2O, Ecofys (1999) for HFCs, PFCs and SF_6. Ecofys (2000) was not yet available at the time of writing.

It is clear from the baseline assessment that additional policy measures will be required to meet the Kyoto reduction target for GHG emissions. However, it must be stressed that technology improvement under baseline conditions is of great significance. A sensitivity analysis examined under the assumption of frozen technology, i.e., no progress in technology between 1995 and 2010, resulted in an increase in CO_2 emissions of 13% compared with 1990 levels. In other words, technology progress under baseline conditions contributes to a reduction in emissions of about 155 Mt of CO_2 compared to a frozen technology case. Under the no-trade variant of the Accelerated Policy scenario (AP-NT), where the Kyoto target is met internally within the EU, total greenhouse gas emissions would be expected to decline to the 3614 Mt CO_2 equivalent by 2010 (see *Table 3.2.2*). In the case of full-trade emissions (AP-FT), about half of the Kyoto commitment with respect to CO_2 would be achieved through emission reduction within the EU. The remainder would come from emissions trading with Annex B countries under the FCCC, especially The Ukraine and Russia.

Emission reductions

Carbon Dioxide (CO_2)

In the Accelerated Policy no-trade scenario, CO_2 emissions are reduced by almost 15% or 500 Mtonnes (Mt) in 2010, compared to Baseline emissions in the same year. The electricity production sector realises about 225 Mt (46%), excluding a demand effect accounting for 38 Mt (8%) and forming part of the emission reduction as reported below for the other sectors. The largest contribution in the electricity sector is through a change in fuel mix from oil and coal to natural gas (125 Mt). Since the size of the nuclear sector remains stable in the Accelerated Policy no-trade scenario compared to the Baseline, its share in electricity production rises, resulting in an emission reduction of 56 Mt (11.2%). The higher increase of hydropower in the no-trade scenario accounts for 20 Mt (4%) reduction in emissions of CO_2. The contribution of wind power and biomass is only 15 Mt (3%), which indicates these sectors will remain small despite their large relative growths of more than 20% per year.

The passenger and goods transport sector accounts for another 74 Mt (15%), where the highest reductions are achieved through technological improvements in aviation (29 Mt), structural changes and behavioural effects in the transport sector for goods (15 Mt). It should be noted here that the growth of CO_2 emissions in the Baseline scenario from transport is large (+35%, from 735 Mt in 1990 to 994 Mt in 2010); therefore there is still a large increase of emissions in the no-trade scenario (+32%).

The services sector is responsible for 65 Mt (13%) of the emission reduction, including a demand effect of 15 Mt. This 65 Mt reduction is mainly achieved through technological improvements in electrical appliances (13.5 Mt) and in space heating and cooling (25 Mt), as well as through better housekeeping and improvement of the thermal integrity of buildings (23 Mt).

Both households and industry contribute more than 50 Mt to the emission reduction in 2010; it should be noted here that they have already reduced their emissions in the Baseline scenario by 0.7 and 10%, respectively. More than half of these reductions are achieved through structural change (for example, electric arc processing in the iron and steel industry) and behavioural effects (for example, recycling). Technological improvements in space heating and cooling, and through the increased use of heat pumps in all industrial sectors, accounts for another 10 to 15 Mt.

In the Accelerated Policy full trade scenario, CO_2 emissions are reduced by 8% in 2010, compared to Baseline emissions in the same year: i.e., the remaining 7% is obtained through buying emissions from other Annex B countries - mainly from the Ukraine and Russia - at a price of € 17.4 per tonne CO_2 (or € 63.7 per tonne of carbon)[3]. This price is based on calculations with the POLES model[4], which are co-ordinated with the model runs of PRIMES as for Kyoto compliance under a regime of emission permits trading between Annex B countries. According to POLES, permit prices (Annex B countries to meet the Kyoto targets) have been found to be uniform at € 17.4 per tonne CO_2.

[3] One tonne of CO_2 emitted contains 12/44 tonnes of carbon. Therefore if the marginal abatement cost is one € per tonne of CO_2, the corresponding value per tonne of carbon is equal to € 44/12= € 3.67.
[4] The POLES model is a global sectoral model of the world energy system. Detailed results on emission trading can be found in JOULE III (1999). Other results were published in EC DG Energy (1999).

At the sectoral level the price results in a relative shift towards the electricity production sector, which is responsible now for 54% of the emission reduction, and 64% if the demand effect from other sectors is included. This result is what could be expected because the emission reduction options in the electricity sector - primarily fuel switch that contributes 37% in this scenario - are cheap compared to the other sectors. The distribution among the emission reduction options in the other sectors is comparable to the no-trade scenario. The only difference is the decrease in their relative contributions.

Table 3.2.3 Economic sectors' potential to realise emission reductions according to the Accelerated Policy scenario variants 'not allowing emission trading' (AP-NT) and 'allowing full emission trading' (AP-FT) respectively.

Emission reductions	*AP-NT*	*AP-FT*
	%[1)]	
Structural change and behavioural effects	21.2	18.4
a) Industrial sectors	*4.6*	*4.5*
b) Tertiary sector	*4.6*	*4.7*
c) Households	*5.3*	*4.1*
d) Transports (including modal shifts)	*5.8*	*4.8*
e) Agriculture and others	*0.9*	*0.4*
Technological improvement in 2010 on top of Baseline:	30.2	26.1
a) Space heating and cooling	*7.0*	*5.3*
b) Energy saving in other heating uses (water cooking, industry, etc.)	*4.5*	*3.4*
c) Electricity uses/appliances/equipment	*4.5*	*6.2*
d) Specific Industrial processes	*1.9*	*1.1*
e) Train transport	*0.9*	*0.7*
f) Aviation/Navigation	*5.8*	*3.5*
g) Road transport	*2.3*	*0.9*
h) Technological improvement of fossil fuel plants	*3.3*	*4.9*
Change of fuel mix	28.4	39.8
Production from non-fossil fuels:	20.2	15.4
TOTAL (%)	100	100
TOTAL (Mt CO_2 avoided in 2010 compared to 2010-BL)	499	254

[1)] Percentages indicate the contribution to TOTAL emission reduction in 2010 compared to 2010-BL.
Source: PRIMES model

Table 3.2.3 summarises the contribution of the emission reductions in the Accelerated Policy scenarios. It clearly shows the fuel switch to natural gas is more important in the full trade (AP-FT) scenario, which is almost completely related to the electricity production sector as described above.

As indicated earlier, major spillover effects are expected for emissions of SO_2, NO_x, particulate matter, heavy metals, PAHs, dioxins and furans which will be quantified in section 3.3.2 on acidification and section 3.3.4 on chemicals and particulate matter.
There is uncertainty about emission reduction targets beyond 2010. Analysis with the PRIMES model has shown that if Kyoto commitments for 2010 are met, keeping emissions at that level beyond 2010 would appear to be easier than meeting the 2010 target. This result is likely to reflect the fact that as a result of reaching the 2010 target, the energy system has become much less carbon intensive. Also, as one moves further into the future, technological improvements that are expected to take place in the longer run make emission reductions relatively easier than now achievable with present technologies. The time period 2015-2030 is particularly important because of massive nuclear decommissioning that is expected to take place. The choice of technology for

investment covering this period has to anticipate the likelihood of emission reduction targets prevailing for a period longer than the actual commitment period.

Methane (CH_4) and Nitrous Oxide (N_2O)

In the no-trade scenario, the largest reductions for CH_4 would be achieved through measures that reduce emissions from coal mining (i.e. 26% of the total reduction would be achieved through measures to recover and utilise mine gas), from the oil and gas industry (i.e. 17% through inspection and maintenance programmes, and the increase of gas utilisation offshore) and from landfills (i.e. 46% of the total reduction through improved landfill methane recovery).

It should be realised that large additional CH_4 emission reductions (i.e. additional to the emission reductions presented here) of about 65 Mt CO_2 equivalent or 1.7% of the *total* GHG emission in 1990 will be realised if organic and paper municipal waste targets are met (see *section 3.4*).

For N_2O, almost 90% of all emission reductions in the Accelerated Policy no-trade scenario can be achieved through the catalytic reduction to N_2 and O_2 in the production process of nitric and adipic acid. The largest reductions (60% of the total reduction) for halogenated gases can be achieved for HFCs through the incineration of flue gases in the production of HCFC-22 and the use of alternative blowing agents in foams. Reductions in SF_6 emissions contribute another 25% through leakage reduction modifications in high and mid-voltage switches and in double-glazing. The remainder (i.e. 15%) can be decreased by reducing PFC emissions in the aluminium production industry.

No full trade scenario has been explicitly determined for non-CO_2 GHGs, but it has been estimated what emission reductions would be achieved if all emission reduction measures cheaper than € 17.4 per tonne CO_2 equivalent are applied i.e. the permit price in the full trade scenario. It turns out that substantial additional reductions of about 73 Mt CO_2 equivalent (= almost 2% of *all* GHG emissions in 1990) can be achieved. This suggests that lower CO_2 emission reductions might be needed if emission trading is extended to CH_4 and N_2O. However, if CH_4 and N_2O are to be included in a trading regime, it would be necessary to reduce uncertainties in both emissions and cost curves to levels, which are comparable to uncertainties related to CO_2.

Costs

The direct costs of meeting the emission targets are estimated by the PRIMES model as the sum of all payments that the demand and supply sectors have to make in relation to energy-consuming equipment, energy savings, change of fuel mix, tariffs and fuel use. This total amount, stated as the total additional energy system cost, corresponds to the total additional funding that the energy consumers and suppliers need to deviate from other purposes in order to meet the emission targets. Clearly, these payments cannot be considered as a loss to the economy, because they are recycled in the economy in terms of additional demand for commodities and services.

The direct costs to meeting the Kyoto targets depend heavily on the policy choice and in particular on the magnitude of emissions of carbon dioxide that are avoided in the EU territory. In the no-trade case, in which the entire abatement takes place in the Member

States, the additional energy system costs in the EU are about € 92 billion per year. If a full trade mechanism is implemented, resulting in part of the abatement taking place outside the EU, the costs are considerably lower: € 32 billion. Most of the cost decreases are related to lower capital expenditures (less expensive/efficient technologies), the costs induced from stranded capital, and the lower fuel costs needed for fuel switching. Transaction costs, implementation failures and other side-effects that would increase the total compliance costs of the full trade scenario have not been included in this study. Similarly, the no-trading case assumes that the lowest cost is achieved individually in each country. From a policy implementation point of view this is also difficult and the costs could be higher due to failures and transaction costs.

Sensitivity analysis has provided an opportunity for a stepwise approach in implementing an emission permit trading system. If the EU starts to establish an emission permit market with, for example, the power generation sector, the equilibrium permit price in that partial market will be found close to the price that would prevail in a perfect and complete intra-EU trading system.

Meeting the Kyoto target under the no-trade scenario has significant implications at the Member State level, where the marginal costs differ substantially from country to country in the no-trade scenario. While the average cost of € 62.5 per tonne CO_2 would be avoided within the EU, it would range from € 28 in Germany to € 167 in the Netherlands. In the full trade scenario, the permit price of € 17.4 per tonne CO_2 would apply across the EU (and for the Annex B partners).

The above costs correspond to measures undertaken on EU territory. They do not include the costs for purchasing emission permits from outside the EU (Annex B countries) as in the case of the Accelerated Policy full trade scenario. Emission permits for 245 Mt of CO_2 at a permit price of € 17.4 per tonne CO_2 need to be purchased by EU member states, thus generating an additional € 4.3 billion per year.

The direct abatement costs for technical measures for CH_4 and N_2O in the no-trade scenario are estimated at € 425 million *lower* in 2010, in comparison to the Baseline. The reason is that measures for reducing methane and especially nitrous oxide are associated with negative costs.

As indicated earlier, no full trade scenario has been evaluated for non-CO_2 greenhouse gases, but direct costs to reduce the 73 Mt CO_2 equivalent, as mentioned above, would be limited to only € 80 million per year, mainly because it is assumed that low cost reductions of N_2O can be achieved in the chemical industry.

Enlargement

Enlargement of the EU can have some impact on the scenarios described above, in particular, on the full trade variant.

Under the Kyoto Protocol agreements, all Accession countries have committed themselves to reduction targets similar to that of EU-15 (mostly -8%, with the exception of Hungary and Poland, which have targets of -6%). In total this implies that emissions in Accession countries need to be reduced by about 70 Mt in 2008-2012 compared to 1990. Between 1990 and 1995 emissions in the Accession countries declined by approximately 150 Mt; this was associated with the decline in industrial production. In the Baseline scenario, however, emissions in 2010 are expected to recover, almost reaching the 1990 emissions level. This implies that additional measures are required in Accession countries to comply with the Kyoto targets.

Many studies indicate the Accession countries as providing scope for further emission reduction at significantly lower costs than within EU-15. Therefore, under the full trade variant - without assuming accession - it has been estimated that the Accession countries could trade about 50-100 Mt CO_2 emission permits with EU15. In total, the EU15 would achieve a reduction of about 240 Mt CO_2 by trading with Annex B countries, of which, by far, the largest share is expected to come from trading with Russia and the Ukraine.

The implications of accession for the Kyoto targets still depend on ongoing negotiations. It is expected, however, that targets of Accession countries cannot be included in the total EU group target (Oberthür and Ott, 1999). The most significant influence of accession could therefore be the expected increase in economic growth and related changes in energy efficiency and fossil fuel consumption. An IIASA scenario study (EEA, 1999) indicates that energy demand in 2010 might increase by about 10% compared to that demand in a 'no-accession' scenario. This would increase CO_2 emissions in Accession countries by about 100 Mt in 2010, limiting trade opportunities of Accession countries in an 'accession' scenario when compared with a 'no-accession' scenario.

Considered collectively, it is expected that accession will reduce the potential for emission trading between EU-15 and the Accession countries. The impacts for total emission reduction costs in the EU-15 are expected to be low, since the most important potential is already outside the Accession countries.

3.3 Continental Environmental Issues

3.3.1 Nuclear accidents

Main findings

- Central and Eastern European countries are responsible for at least 40 to 50% of the estimated human health risk due to radiation exposure in the EU-15 because the majority of the high-risk reactors are found in Central and Eastern Europe. Under current policies few changes are expected in terms of mortality risks.
- If most of the high-risk nuclear power plants are either closed or upgraded, risks will decrease by almost 90% in Europe on the whole. Costs of upgrading are estimated to be more then € 60 million. However, these estimates are very uncertain.
- Little is known about other risks, such as oil and chemical spills, and nuclear waste.

Context

In this study, ‘major accidents’, which was originally the scope of the environmental problem under concern, has been restricted to nuclear accidents and, to a limited extent, oil spills and chemical accidents. The assessment focuses on the risk of radiation exposure through inhalation, external exposure and ingestion of contaminated food products from equipment failure, design or operating errors, as well as unforeseen changes in environmental conditions at nuclear installations throughout the EU-15 and Central and Eastern Europe (referred to as ‘Europe’). Risks associated with transport and storage of nuclear waste have not been included in this study. A brief perspective on damage and clean-up costs for oil spills is provided in the Technical Report on Nuclear Accidents.

The risk of nuclear accidents is measured through an assessment of reactor safety at individual nuclear power plants. The majority of the high-risk reactors are found in Central and Eastern European Countries, so this issue is significant in the context of the accession process. The probability of nuclear accidents is used to estimate excess cancer mortality due to radiation exposure from accidental releases. The exposure is calculated for a lifetime follow-up period of 70 years and excess risks are expressed in terms of excess cancer mortality due to excess radiation doses received. Deaths in the short term in the direct vicinity of the power plants are *not* included.

The Technology Driven scenario assumes that all reactors over 35 years old will be closed by 2010 and that EU safety and equipment standards will be applied across Europe. No additional initiatives are suggested within an accelerated policy scenario.

The safety of nuclear power plants is an important issue related to future power generation in Europe. Promotion or reduction of nuclear power production influences the need for other energy sources. This has significant implications for the emissions of greenhouse gases and acidifying substances. It also influences the amount of nuclear waste requiring safe disposal.

Assessment and trends

A total of 213 reactors were operating in Europe in 1992. The nuclear reactors in Central and Eastern Europe are responsible for at least 40 to 50% of the estimated human health risk due to radiation exposure in the EU-15. In the Baseline scenario, the number of high and medium risk reactors is predicted to decrease by 2010: 25 to 21 for high risk and 146 to 134 for medium risk. This change is counterbalanced by expected EU population growth, resulting in a stable risk level for human health for the period 1990 to 2010.

Implementation of a maximum technology scenario would drastically reduce the number of high-risk nuclear sites from 25 in 1992 to 2 in 2010 through closure and upgrading to medium-risk reactors. The costs of making the necessary modifications will probably vary widely per NPP from tens to hundreds of millions €. Because almost no specific information is available at the NPP level, upgrading costs are based on the Probabilistic Safety Assessment (PSA) for the Ignalina NPPs, i.e. € 62.5 million per NPP.

No accelerated policy scenario has been defined because criteria (targets, which power plant should be upgraded, etc.) on the appearance of such a scenario are lacking. For this reason, this study is limited to a Technology Driven scenario, in which the mortality risk in the EU is expected to decline to 3.2 cancer deaths per 100 million people per year in 2010, compared to the 10.2 figure for 1990. These numbers are low but, as indicated above, it should be realised that deaths in the short term are excluded. Large variations exist throughout Europe too, with the largest reductions in cancer deaths found in Central and Eastern Europe. In fact, for all European countries combined, the risk is decreasing from 50 deaths per year per 100 million to 5.5; a difference of almost 90%.

Enlargement

Enlargement of the EU may lead to an acceleration of policies aimed at reducing risks, since the EU can demand safety measures to be implemented in Accession countries. Two high-risk reactors were supposed to be upgraded before 2000 (Bohunice-1 and Bohunice-2 in Slovakia) and four others (Kozloduy-3 and Kozloduy-4 in Bulgaria, Ignalina-1 and Ignalina-2 in Lithuania) by the year 2010. This upgrading will have a positive effect on risk reduction, both in the Accession countries and in the EU.

3.3.2 Acidification and eutrophication

Main findings

- Current policies will substantially improve the environment. The area of unprotected ecosystems affected by acidification decreases from 25% in 1990 to less than 5% in 2010. The eutrophication indicator shows the percentage of unprotected ecosystems improving from 55 to 41%.
- Accelerated policies reduce the ecosystem area not protected against acidification to less than 3%. 6% of ecosystems are additionally protected against eutrophication.
- The positive spillover effects of climate change policies on emissions of SO_2 and NO_x are between 35-70% of the total emission reductions. Consequently, costs of meeting the targets for acidification and ozone (on top of the Baseline) differ by up to 30% depending on the climate change policy adopted.

- Since the current EU-wide emission standards for acidification (and ozone) precursors are already quite strict, there are no additional add-on technical control measures that are cost-efficient in all EU member countries. Thus subsidiarity and market mechanisms will play an important role in designing national policies that meet environmental targets set by the Community.
- European enlargement is likely to have positive effects on acidification and eutrophication indicators in the current EU Member States. However, the investments necessary to comply with the EU legislation are high.

Context

The main sources of acidifying substances in the atmosphere are sulphur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3). These compounds undergo chemical conversion in the atmosphere into acid substances that can lead to changes in the chemical composition of soil and water, threatening ecosystems and material damage to buildings and structures. Deposition of nitrogen compounds also causes eutrophication and excessive plant growth. The formation and subsequent concentration of secondary aerosols or particulate matter from SO_2, NO_x and NH_3 are dealt with in section 3.5.2 on human health, air quality and noise.

The issues of acidification and eutrophication have been effectively tackled by policy measures in the EU since the 1980s. Several international agreements under the Convention on Long-Range Transboundary Air Pollution (LRTAP) have been reached to reduce emissions in a harmonised fashion. With respect to air pollution control, the EU has adopted emission and fuel quality standards for its Member States. In addition, many European countries have adopted national standards and other types of regulation reflecting the seriousness of pollution and national environmental quality priorities.

The emissions of SO_2 and NO_x originate principally in the energy sector (fuel combustion from power plants), industry, transport (road and off-road, international shipping), and the services sector. NH_3 emissions stem mainly from agricultural livestock. The impact indicators used in the scenarios relate to the proportion of ecosystems where ‘critical loads’ of acidity and eutrophication are exceeded, i.e. the maximum input to the ecosystem that is believed not to cause harmful effects. Within the accelerated policy scenario, the target of 50% gap closure is used, meaning that the area enclosing ecosystems not protected against acidification should be reduced *everywhere* by at least 50% compared to 1990 levels[5].

There are important linkages between acidification/eutrophication, climate change, tropospheric ozone, human health and air quality. Emissions and their control costs depend to a large extent on the development of national energy systems and strategies for the reduction of gases relevant to climate change. Emissions of NO_x also contribute to tropospheric ozone levels (see *section 3.3.3*); while measures to address acidification, eutrophication and ozone contribute to the mitigation of air pollution in both urban and rural areas (see *section 3.5.2*).

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[5] Details about the formulation of the targets are found in the Technical Report on Acidification, Eutrophication and Tropospheric Ozone. No targets have been specified for eutrophication. Improvements of eutrophication indicators result from policies needed to be implemented to meet the acidification target.

Assessment and trends

Implementation of existing policies and policies-in-the-pipeline is expected to decrease emission levels substantially in all sectors, and thereby improve ecosystem protection levels up to 2010. Expected emission level reductions in the EU for SO_2, NO_x, and NH_3 are shown in *figure 3.3.1*[6]. Despite significant increases in road transport, emission shares of this sector are projected to decrease. However, transport remains the principal source of NO_x emissions, while SO_2 emissions mainly stem from power generation and industry. Currently, there are no emission standards for ammonia emissions. Projected small reductions of NH_3 emissions are a result of decreasing agricultural production in some countries under the Baseline scenario.

Current policies form an important step towards achieving environmental sustainability; the share of ecosystems confronted with acid deposition above their critical loads is expected to decrease substantially (see *Table 3.3.1*). Drastic improvements are probable for certain high-risk countries such as Germany (80 to 18%) and Belgium (58 to 23%). With respect to eutrophication, the proportion of unprotected ecosystems is likely to decrease to a lesser extent, while the protection levels are predicted to remain seriously low in some countries: under 10% in Belgium, Germany, Luxembourg and the Netherlands.

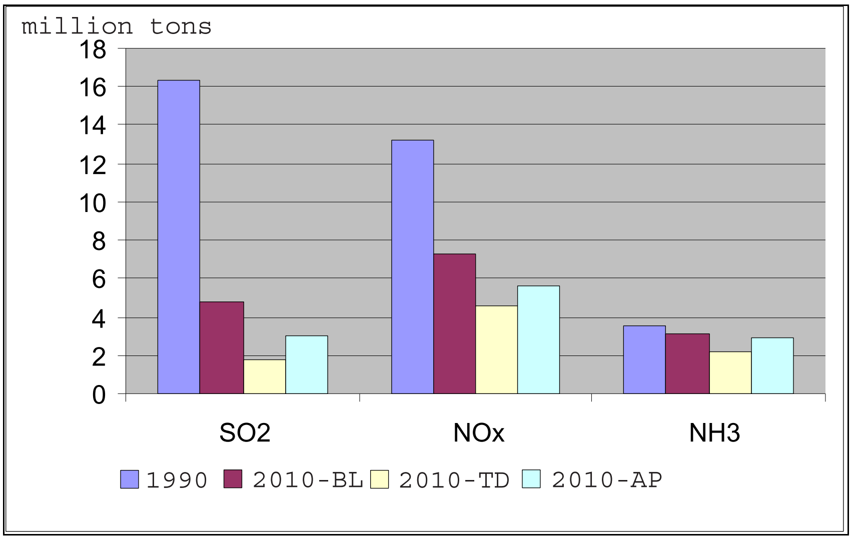


Figure 3.3.1 Acidification and eutrophication indicators. Emission reduction of SO_2,, NO_x and NH_3 in comparison to the base year (1990) under the Baseline (2010-BL), Technology Driven (2010-TD), and Accelerated Policy (2010-AP) scenarios (AP is full emission trading variant), 1990-2010.

[6] The Baseline policies include all emission and fuel standards that were in place or in the pipeline in 1997. For details about measures included in the Baseline and the references to the appropriate legal documents, see Technical Report on Acidification, Eutrophication and Tropospheric Ozone. In 1998 additional standards were proposed or adopted (post-2005 standards for road vehicles - EURO 4, stricter standards for new large combustion plants, revisied standards for gasoline and gas oil/diesel quality). All these standards were included as a starting point in looking for cost-optimal solutions in the 'Accelerated Policies' scenarios. Legislation adopted in 1998 should have decreased the Baseline emissions of SO_2, NO_x, (and VOC) by 3, 11 and 13%, respectively.

Table 3.3.1 Exceedance of ecosystem critical loads in base year (1990) in comparison with the Baseline (BL), Technology Driven (TD), and Accelerated Policy (AP-FT) scenarios, 1990-2010.

Acidification and eutrophication	*Unit*	*1990*	*BL*	*TD*	*AP-FT*[1)]
Exceed. Critical loads (acid)	% ecosystem	24.7	4.6	2.0	2.9
Exceed. Critical loads (eutrophication)	% ecosystem	55.3	41.3	24.0	35.2
Accumulated excess acidity	10^9 acid. eq.	23.9	1.6	0.4	0.6

[1)] The results for the AP-NT scenario are almost the same and therefore not shown.

With the adoption of all feasible technical emission control measures, further reductions in emissions and improvements in ecosystem protection are possible. Under such a scenario, SO_2, NO_x, and NH_3 emissions are likely to decrease markedly for the period 1990 to 2010 (see *figure 3.3.1*). Consequently, acid deposition above critical loads is expected to affect only 2% of ecosystems in 2010. For eutrophication, the situation also improves, but exceedances remain high.

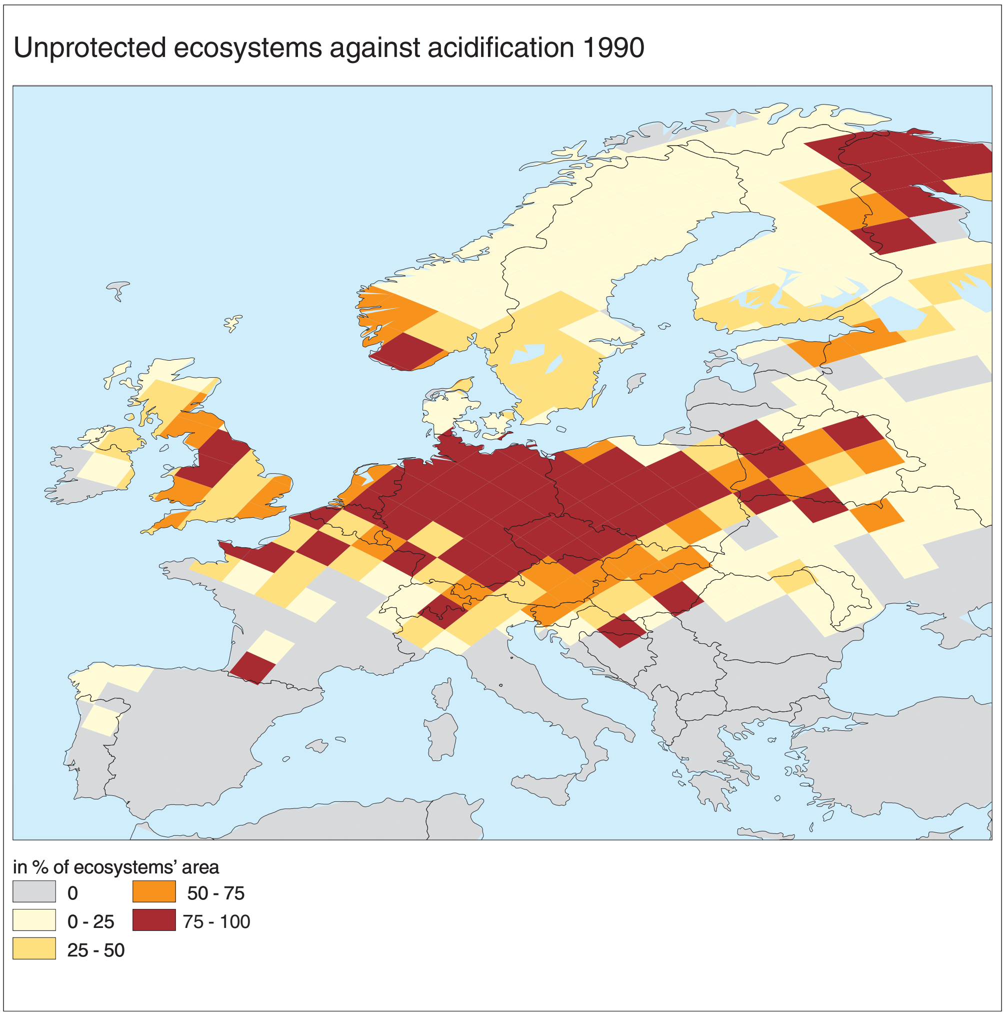
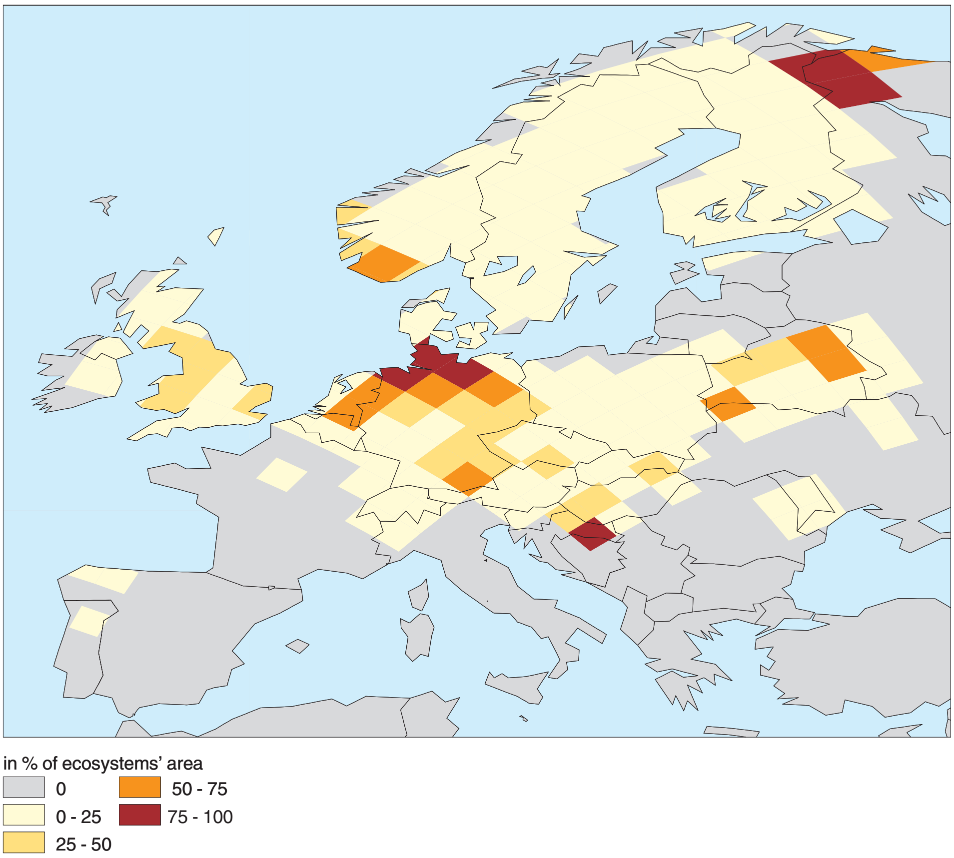
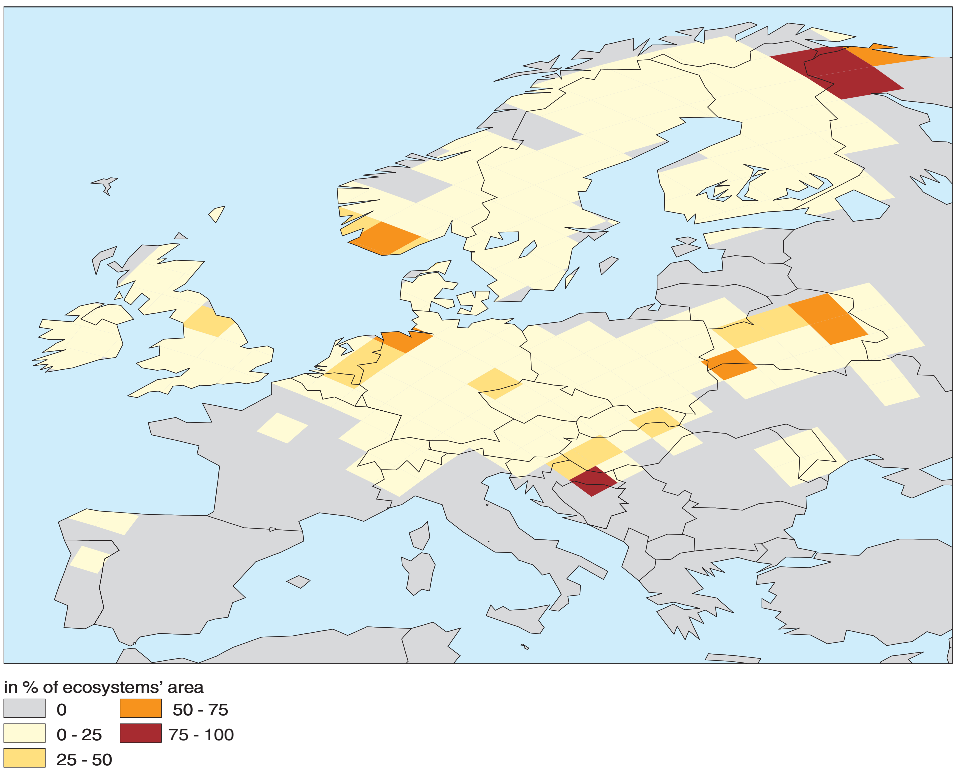


Figure 3.3.2 Ecosystems not protected against acidification in base year 1990 and as projected by 2010 under the Baseline and Accelerated Policy (AP) scenarios.

Unprotected ecosystems against acidification 2010 (Baseline)



Unprotected ecosystems against acidification 2010 (AP - No Trade)



Within the accelerated policy scenarios, the previously described target of 50% gap closure is used. To achieve this target, exceedance of critical loads for acidification at the EU-15-level must be reduced to less than 3% in 2010, while in, for example, Germany and Belgium the share of unprotected ecosystems will probably decrease to about 7% (see *figure 3.3.2*). Assuming full emissions trading among countries for climate change, emissions of SO_2, NO_x and NH_3 are expected to be about 37, 23 and 8% less, respectively, in 2010, compared to predicted emissions under the continuation of existing policies (see *figure 3.3.1*).

Since emissions of NH_3 are reduced to a limited extent, the area of ecosystems in the EU not protected against eutrophication remains rather high (36% in 2010). Although significant improvements for eutrophication are likely in Austria, Belgium, Denmark, Germany and Luxembourg (see *figure 3.3.2*) compared to the continuation of existing policies, this suggests specific targets for eutrophication are needed also.

Because of the same targets (50% gap closure for acidification), similar environmental improvements would also be expected if emissions trading does not take place among countries (the 'No-trade' or NT case) or if beneficial spillover effects from measures to cope with climate change under the Kyoto Protocol are not taken into account (the 'No climate policy' or NC case). However, it should be noticed that in the full trade scenario more than 40% of the SO_2 emission reduction in 2010 compared to the baseline emissions in the same year, is due to climate change policies and for NO_x this figure is almost 20%! In the no-trade case climate change policies are dominating even stronger: 60% and 35% for SO_2 and NO_x, respectively. For these reasons, direct costs will substantially differ to reach the acidification-targets (see *section on 'Measures and costs' below*).

Measures and costs

For acidification and eutrophication, the costs for reaching assumed emission standards or ceilings include costs related to the use of low sulphur fuels and the installation of additional pollution control equipment. In the transport sector, control measures reduce both NO_x and volatile organic compounds (VOC), thereby mitigating tropospheric ozone as well as acidification/eutrophication. Therefore it is not possible to allocate separate costs for these two issues in the transport sector. In the EU, the costs of implementing existing policies to 2010 are expected to be about € 67 billion per year. NO_x and VOC controls represent about 84% of this total, while SO_2 and NH_3 control costs represent a contribution of about 16 and 1%, respectively.

In comparison, the cost of applying best available technology within the EU is estimated at € 43 billion per year higher than expected costs under baseline conditions (of which almost € 9 billion is due to VOC measures in non-transport sectors, see *section 3.3.3*). Under this scenario, SO_2 and NO_x/VOC control costs would probably be about 44% higher; while those for NH_3 could increase by a factor of 36, primarily due to the current low level of application of emission controls within agriculture.

The application of accelerated policy targets for acidification and eutrophication would also increase costs. However, the results do not include the costs of implementation of climate change policies. These policies would help to reduce the costs. With the recognition of action on climate change, but with no emission trading between countries (i.e. variant AP-NT), EU costs will increase over the Baseline costs by almost € 8 billion per year (including about € 3.2 billion due to VOC measures in non-transport sectors) or 12% higher than Baseline. With emissions trading (i.e. variant AP-FT), these costs would be € 11 billion per year larger since spillover effects from climate change would be smaller. If this synergistic linkage is not taken into account at all, the additional cost of the accelerated policies scenario (i.e. variant AP-NC) is expected to be about € 14 billion per year, or about 20% higher than Baseline.

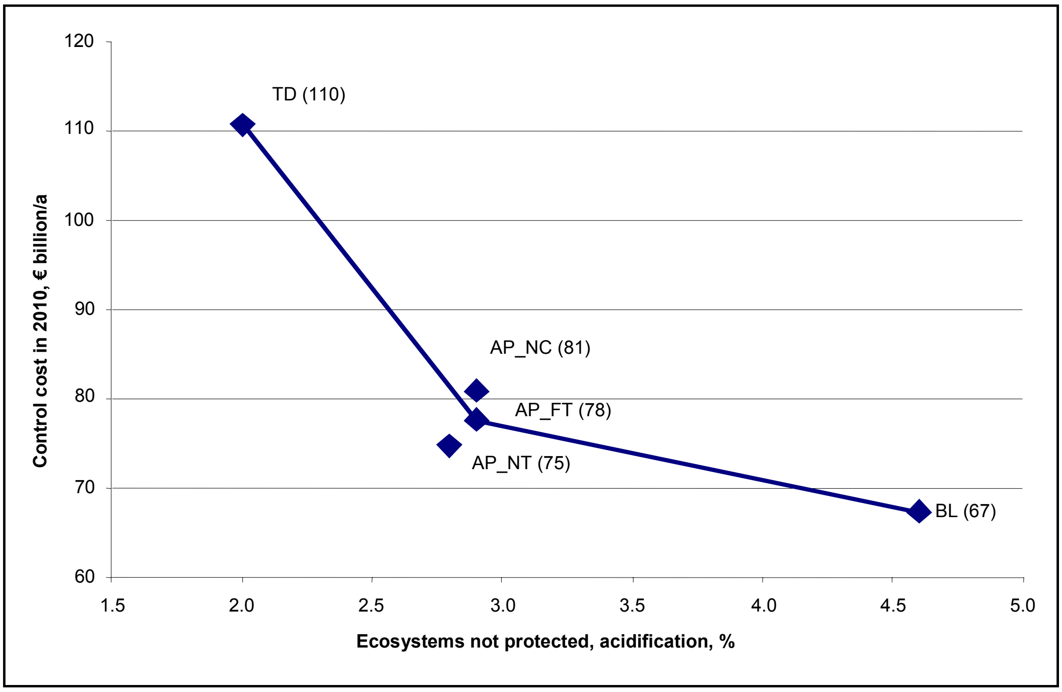


Figure 3.3.3 Comparison of the cost-effectiveness of the policy scenarios for ecosystem protection: Technology Driven (TD), Accelerated Policy with three variants: 'full trade' (AP_FT), 'no trade' (AP_NT), 'no climate policies' (AP_NC), and Baseline (BL); all costs were attributed to acidification, so costs include VOC control costs. See Table 3.6.1.

Figure 3.3.3 shows the relation between costs and environmental effects (acidification) in the Technology Driven and Accelerated Policy scenarios. The effects of assumptions about climate policies on costs are also shown (including VOC control costs in non-transport sectors). Differences in emission control costs demonstrate the important spillover effects of strategies aimed at reduction of climate relevant gases.

Since the emission reductions in the Accelerated Policy scenario are driven by environmental sensitivities in individual parts of Europe, marginal emission control costs for individual countries vary across Europe. For SO_2, marginal costs are found in the range of zero (i.e., no further measures on top of controls resulting from 'current legislation' necessary) for Greece, Italy, Portugal and Sweden to above € 5000 per tonne for Belgium, Germany and the Netherlands. For NO_x, the marginal costs vary from zero (i.e., for Denmark, Finland and the UK) to about € 13,000 per tonne for Belgium, France and Luxembourg.

Additional cost-efficient measures under the Accelerated Policy scenario for at least one-third of EU member countries include:

- Limiting the sulphur content of fuels and implementing NO_x control measures for national sea traffic;
- Stricter controls on emissions from industrial processes other than energy combustion;
- Further reduction of NO_x emissions from off-road vehicles through enforcement of similar standards that exist for road vehicles;
- Implementation of techniques that go beyond current national legislation to further control SO_2 and NO_x emissions from stationary combustion sources (this would be relevant to countries with a high ecosystem sensitivity to air pollution and/or high emission density of ozone precursors).

However, no additional common measures other than those already in place were found to be cost-efficient in all EU Member States. While setting the overall environmental policy objectives and ambition levels will remain a matter for Community action, the choice and implementation of specific measures will depend on national circumstances in the future. This means that subsidiarity and market mechanisms should play an important role in designing national policies on further control of precursor emissions.

Enlargement

In the period 1990-1996, emissions of SO_2 and NO_x decreased considerably in the Accession countries. The main reason for this decrease was the decline in industrial activities, but some of the reduction is a result of installing additional pollution abatement equipment as required in national policies and international agreements.

The consequences of enlargement on acidification and eutrophication could be a result of changes in the economy and the effects of various environmental directives. It is expected that enlargement could increase energy consumption and transport leading to higher environmental pressures. On the other hand, enlargement implies that Accession countries will comply with EU environmental directives. For acidification and eutrophication the implementation of the large combustion plants directive, the vehicles and fuel directives are the most relevant.

By applying the same environmental targets in the Accession countries as the targets from the ‘accelerated policies’ scenario, positive environmental effects are anticipated in Accession countries, but also in the current EU Member States.

Studies indicate that adoption of the EU standards combined with continuation of economic restructuring in Accession countries is likely to further decrease the emissions of SO_2 and NO_x by 70 and 60%, respectively, compared to the level of 1990. These lower emissions in the Accession Countries obviously will improve the environmental situation in Central Europe; according to Cofala *et al*. (1999), the number of ecosystems with acid deposition above their critical loads could decrease from 9.6 to 8.6%. In addition, this decrease will also bring environmental improvements in the neighbouring countries. In Germany and Austria, measures of Accession Countries will additionally protect up to 2% of the ecosystems against acidification.

Obviously, improvements are not without costs. Although in the period before 2000, considerable investments had already been made in certain Accession Countries to abate acidifying emissions, large additional efforts were and are required. It is estimated that compliance with the large combustion plants directive in the ten Accession Countries will generate an investment need of approximately € 10 billion, mainly in the power sector and heavy industries. Another € 10 billion will be needed for the adoption of the Vehicles Directives.

At the same time, lower emissions in the Accession countries also imply that the targets for the EU15 can be achieved at lower cost. The cost savings are up to 3% of total cost of controlling pollutants contributing to acidification and ground-level ozone. Cost savings in the EU15 are about 40% of extra expenditures in the Accession Countries necessary to achieve the EU standards and targets.

3.3.3 Tropospheric ozone

Main findings

- Full implementation of current policies will decrease photochemical ozone exposures in the EU. Health-related problems will reduce by 60% (compared to 1990) and vegetation-related problems by about 40%.
- Accelerated policies bring an additional 17% improvement of both indicators compared to 1990 values.
- Spill-over effects of climate change policies on tropospheric ozone are considerable.
- Measures that need to be implemented in each EU Member State to meet ozone targets depend on national circumstances.
- EU enlargement will have positive effects on troposheric ozone. However, as for acidification, the investments in the Accession countries necessary to comply with the EU legislation are high.

Context

Tropospheric (ground-level) ozone is a major contributor to the formation of photochemical smog, with resulting impacts on vegetation and human health. Despite considerable European efforts to reduce precursor emissions, health and crop protection threshold levels continue to be exceeded over large parts of Europe particularly in summer. Furthermore, although concentrations vary considerably from year to year, there is evidence that ozone levels are increasing on a global scale.

The primary contributors to tropospheric ozone levels are emissions of the non-methane volatile organic compounds (VOC) and NO_x (this second contributor is discussed in the previous section on acidification and eutrophication). In terms of environmental impact, two exceedance values are useful. The first, AOT40 (the accumulated ozone exposure above the threshold value of 40 ppb) is used to assess the potential damage to vegetation. The second, AOT60 is used to define the critical threshold for human health and relates to World Health Organization's Air Quality Guidelines for Europe. These impact indicators cannot be used to provide estimates of damage but are appropriate for scenario analysis. The Fifth Environmental Action Programme established 30% reduction targets for NO_x (1990 to 2000) and VOC (1990 to 1999). Under the accelerated policy scenario, the target follows the proposal for the National Emission Ceilings Directive to reduce the health-related ozone exposure by two-thirds and vegetation-related exposure by one-third up to 2010.

There are important linkages between tropospheric ozone and the issues of acidification/eutrophication, climate change and human health and air quality. Emissions and their control costs depend to a large extent on the development of national energy and transportation systems, and strategies for the reduction of gases relevant to climate change. Human health implications are further examined in section 3.5.2.

Assessment and trends

Implementation of existing policies in the EU is expected to significantly reduce emission levels by 2010. NO_x and VOC emissions are anticipated to decline by 45 and 49%, respectively (see *figure 3.3.4*). Transport represents the most important source of NO_x emissions, while transport and solvent use in households and industry are the main sources of VOC emissions.

These emission reductions are likely to substantially reduce human and plant exposure to damaging ozone levels (compare to *Table 3.3.2*). Using AOT60, the average human exposure is expected to decrease by 60% from 3.5 ppm.hours in 1990 to 1.4 ppm.hours in 2010. With the vegetation exposure index AOT40, a decline from 6.6 to 4.1 excess ppm.hours or 38% is anticipated for the EU as a whole. Changes in spatial distribution of those indicators are shown in *figure 3.3.5*.

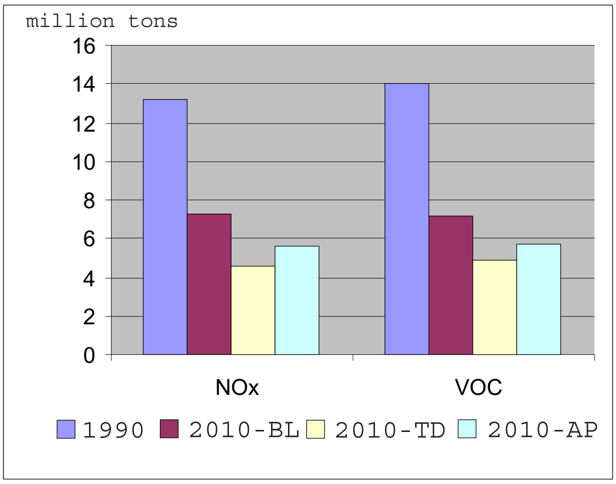


Figure 3.3.4 Tropospheric ozone precursors NO_X and VOC: Emissions in the base year (1990) and projected emissions under Baseline (2010-BL), Technology Driven (2010-TD) and Accelerated Policy (2010-AP) scenarios (full trade variant), 1990-2010.

Table 3.3.2 Ozone exposure indicators in the base year (1990) and projected for 2010 under the Baseline (BL), Technology Driven (TD) and Accelerated Policy (AP) scenarios, 1990-2010.

Ozone exposure index	*Unit*	*1990*	*BL*	*TD*	*AP*
Health-related (AOT60)	ppm.hours.	3.5	1.4	0.7	0.8
Vegetation-related (excess AOT40)[1]	excess ppm.hours	6.6	4.1	2.7	3.0

1 Excess over the threshold of 3 ppm.hours.

The maximum application of existing technology could bring further benefits from reduced emissions and lower ozone exposure. In this scenario, an 80% reduction to 0.7 ppm.hours in 2010 is anticipated for the human health-related index, with the greatest improvements likely in eastern France, Belgium, the Netherlands and Luxembourg. For potential vegetation exposure, a 60% reduction to 2.7 excess ppm.hours is possible, with the most significant benefits occurring within large areas in France, Germany, Italy, Portugal and Spain.

With new targets and an accelerated policy scenario, significant improvements in emission levels (due to lower energy consumption) are needed, but to a lesser extent than in the TD-scenario. Assuming emissions trading among countries, emissions of NO_x and VOC are expected to be 23 and 20% less in 2010 compared to predicted emissions under a continued regime of existing policies (see *figure 3.3.4*). As already indicated in section 3.3.2, 60% of this reduction in NO_x emissions is due to climate change policies. In the no trade case, it even rises to 70%. No spillover effects are expected for VOC.

In the full trade scenario, a 77% reduction to 0.8 ppm.hours is anticipated for the human health related index in 2010, while the vegetation exposure index is expected to be more than 50% lower at 3.0 excess ppm.hours. Figure 3.3.5 shows the spatial distribution of ozone indicators under accelerated policy conditions.

Measures and cost

Additional technical measures for controlling VOC emissions that are cost-efficient for at least one-third of the EU member countries:

- Further controls of VOC emissions from liquid fuel processing and distribution;
- Promotion of low solvent paints in professional, industrial and 'do it yourself' applications;
- Better controls of VOC emissions from 2-stroke engines.

Measures for controlling NO_x emissions are the same as for controlling acidification (see *section 3.3.2*).

As well, no additional common measures, other than those already in place, were found to be cost-efficient for precursor emissions of ground-level ozone in all EU Member States. As for acidification, control measures need to be identified for each Member State, with inclusion of subsidiarity and market mechanisms.

The costs to reduce emissions of NO_x and VOC are relatively high; this is largely due to strict and expensive controls on transport sources (these costs are also included in the total costs to mitigate acidification and eutrophication). In the EU, the cost of reducing NO_x and VOC emissions using existing policies is expected to be about € 56 billion per year in 2010.

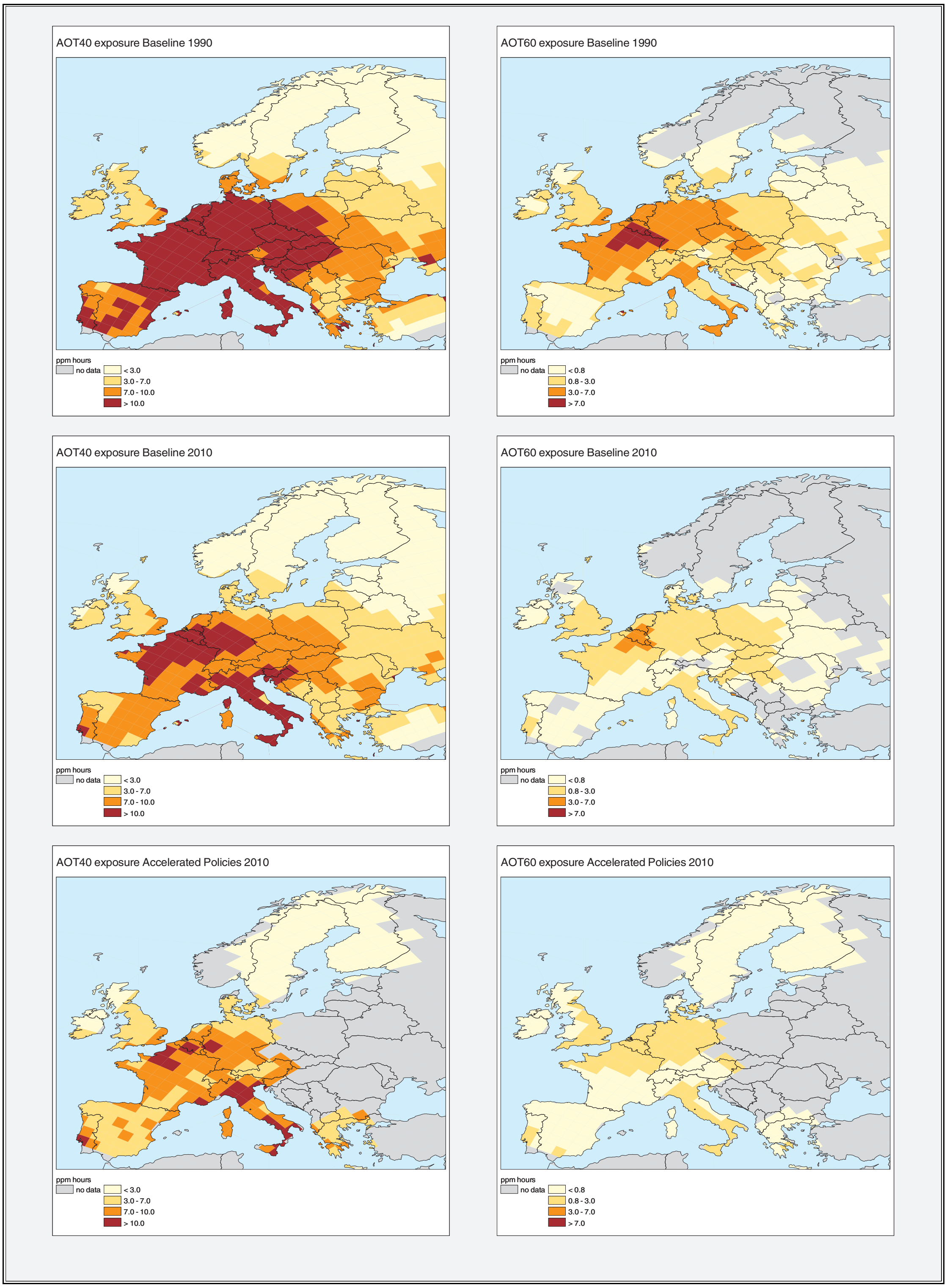


Figure 3.3.5 Ozone exposure AOT40 and AOT60 in 1990 and 2010 for the Baseline and Accelerated Policy scenarios.

The additional costs of applying best available technology to further reduce NO_x and VOC emissions is estimated at € 24.5 billion per year in 2010 (of which € 8.8 billion is due to VOC measures in the non-transport sectors). The application of new targets for tropospheric ozone will also increase costs, but to a lesser extent than the full application of all feasible technology measures. With action on climate change (lower energy consumption and changes in energy sources) and emissions trading between countries, additional EU costs are anticipated to be about € 6.1 billion per year (€ 4.2 billion for VOC measures in non-transport sectors). The costs are about € 1.5 billion per year lower in the no-trade case. Likewise, if no climate change actions are in place, the costs are € 1.1 billion per year higher.

Enlargement

In Accession countries it is anticipated that transport, one of the main sources contributing to the formation of tropospheric ozone, will increase much faster than in the EU-15. At the same time the adoption of the vehicles directives and other EU environmental legislation will lead to lower emission factors, foreseen in a scenario without accession. On balance, enlargement is expected to lead to lower emissions of NO_x and VOC, thus influencing levels of tropospheric ozone positively. This may positively affect ozone levels in EU15.

No cost estimates are available for the Accession countries in general. For part of the stationary VOC emissions - from oil storage and handling - total investment needs in the Accession countries is estimated to be about € 0.5 billion. Compliance with the Vehicles Directives would imply much larger investments: these are estimated at a total of € 11 billion. However, these investments cannot be attached solely to the issue of tropospheric ozone, as the policies also address the abatement of acidification.

3.3.4 Chemicals and particulate matter

Main findings

- Current policies achieve stabilisation targets for most Heavy Metals (HMs) and Persistent Organic Pollutants (POPs). Available information is too limited to include pesticides and many other chemicals in this study.
- More stringent targets are achievable with accelerated policies; however, particulate matter remains a problem.
- Emissions of primary particulate matter, heavy metals, PAHs and dioxins and furans are substantially reduced due to the implementation of climate change policies and policies in the context of acidification.
- Additional direct costs to reduce primary particulate matter emissions in the accelerated policy scenario are € 1.5 billion per year. The largest reductions can be obtained in major industrial processes but uncertainties of both reductions and costs are large: a factor of 2 to 4.
- Emission reductions for hazardous substances in the Accession countries will contribute to a significant improvement, not only in the environmental situation in these countries but also in the EU-15.

Context

The number of chemicals that enter the environment is large. Heavy metals (HMs) and persistent organic pollutants (POPs) represent two groups that are of particular importance due to their persistent, bio-accumulative and toxic characteristics. HMs and POPs are known to be a threat to human health (blood and organ disorders, carcinogenic effects, birth defects, intellectual development) and the environment (forest ecosystem stress, reproductive impairment). Clearly, there are tens of thousands of chemicals (including pesticides) that could be considered. This study focuses on emissions of heavy metals (HMs) and persistent organic pollutants (POPs) to air that are subject to EU, UN-ECE and other international agreements and for which a reasonable amount of data exists. The environmental issue on chemicals (or hazardous substances), is presented in detail in the state of environment reports by the EEA (EEA, 1998; 1999). The risk assessments of new and existing chemicals are dealt with in EU regulations (see *Box 3.2* below).

This section also considers emissions of primary particulate matter as many chemicals are transported in the atmosphere in association with particulates. Primary particulate matter consists of particles emitted from anthropogenic sources and natural sources such as sea-salt spray and suspended soil dust. Secondary particulate matter can be formed by conversion from SO_2, NO_x and NH_3, condensation of organic vapours emitted from various anthropogenic sources and photochemical reactions. Emissions of these gases are dealt with in the context of acidification and eutrophication (see *section 3.3.2*). Human exposure to particulates (both primary and secondary) is dealt with in section 3.5.2 on human health, air quality and noise.

Box 3.2: Assessment of chemicals

The world chemical industry output is almost € 1500 billion per year. With a share of about 30%, the EU is a major player on the global market. Within the EU sufficient regulatory legislation exists to adequately reduce risks associated with chemical substances. Although existing assessment procedures implied in current legislation could always be improved, these should not be regarded as a significant bottleneck in the proper handling of chemical risks. The efficacy of directives and international agreements in substantially reducing chemical risks varies largely. Where risks associated with the introduction of new chemicals could largely be avoided, the degree of manageability of risks associated with existing substances is not sufficient.

Adequate management of chemical risks implies targeted risk reduction measures that are based on risk assessments, when an apparent concern has been established for a given chemical. The EU started assessing the risks of the 100,000 existing chemicals in 1993, giving priority to the 2,500 so-called High Volume Production Chemicals (HVPCs; >1,000 tonnes per year). Since then the risks of some 30-40 chemicals have been assessed. For a few chemicals risks were sufficiently high to propose proper risk management programmes to be adopted by the Commission. At this pace it will take ages to assess adequately all the HVPCs. Assessment costs vary from € 100,000, for obtaining a basic set of toxicity data, to an estimated € 5 million for comprehensive toxicity testing of one substance.

Full risk assessment of more HVPCs suffers from inadequate toxicity information (for 75% of these HVPCs; minimal toxicity data for a preliminary assessment are lacking). In many cases where this information is available, limitations on or lack of information on emissions and exposure prevents further action.

To overcome these obstacles, a joint EU-wide professional organisation is needed to promote and monitor progress in producing adequate and free access (eco-)toxicity information on existing chemicals and substances that fall into special categories, such as biocides, pharmaceuticals, etc. A recent study recommended the following:
- improving the integration of the myriad of directives and regulations,
- clarifying definitions,
- providing clear guidance on the determination and weighing of advantages and implications of risk reduction measures and
- developing tools, including voluntary agreements, to speed up the slow chemical-by-chemical approach [Van Leeuwen *et al*., 1996].

Emission targets have been established for specific HMs and POPs under the auspices of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). According to the protocols on HMs and POPs, countries are obliged to reduce atmospheric emissions of lead (Pb), cadmium (Cd), mercury (Hg), dioxins/furans, and polycyclic aromatic hydrocarbons (PAHs) to below a reference year, most probably 1990 for the EU. Emissions of these substances, together with primary particulate matter (PM) and copper (Cu), which are not covered by the CLRTAP Protocols, are used as the main pressure indicators in this assessment. Future emissions of polychlorinated biphenyls (PCBs) and pentachlorophenol (PCP) are only briefly referenced due to the effective control on emissions by current EU regulations. Four agricultural pesticides (atrazine, endosulfan, lindane, pentachlorophenol (PCP)) have been considered in the Baseline scenario only. The sectoral contribution to emissions of the main HMs and POPs considered in this assessment is shown in *Table 3.3.3*.

Table 3.3.3 Major emission sources in the EU for fine particulates (primary PM_{10}), some heavy metals -Cadmium (Cd), Copper (Cu), Lead (Pb), Mercury (Hg)- and persistant organic pollutants in 1990.

Economic sectors as emission sources	*Primary PM_{10}*	*Cd*	*Cu*	*Pb*	*Hg*	*Dioxins Furans*	*PAH*
%							
Combustion in 'Public power, cogeneration and district heating' and 'industry'	33	25			31	26	
Energy and industry combustion			25				
Household and tertiary sector	18						26
Road transport	25	19	26	80			19
Other transport			22				
Waste incineration		8			17	41	
Industrial processes	18	40	22	12	47	21	12
Solvent use							40
Total	94	92	95	92	95	88	97

In the baseline scenario (BL) future trends in emissions under current legislation are assessed. The Technology Driven scenario (TD) assumes full penetration of advanced end-of-pipe emission control technologies, such as high efficiency electrostatic precipitators, fabric filters, and highly efficient wet scrubbers. The Accelerated Policy scenario (AP) projects emissions have taken into account the effects of policy action on climate change and acidification. High performance technologies to reduce PM_{10} emissions are considered also.

Technical Report on Chemicals and particulate matter briefly discusses deposition for some selected heavy metals (Cd, Cu, Pb), and persistent organic pollutants (dioxins/furans, atrazine, endosulfan, lindane, PCP). In addition, exceedances of critical loads for forest soils have been evaluated for cadmium, copper and lead[7]. The impacts of these substances on non-forest ecosystems and human health have not been assessed.

Assessment and trends

Under current policies, substantial emission reductions for PM_{10}, lead, dioxins/furans and, to a lesser degree, mercury over 1990 are expected by 2010 (see *table 3.3.4*). In addition, emissions of PCBs, PCP and lindane should be almost negligible due to current EU regulations[8]. With such reductions, the EU is likely to meet emission stabilisation targets for these HMs and POPs, as established under the UN ECE CLRTAP Protocols. However, the achievement of emission stabilisation targets for cadmium, copper and PAHs is not ensured under baseline conditions.

The projected downward trend in PM_{10} emissions under current legislation results primarily from lower transport and stationary combustion emissions due to stricter emission standards[9] and reduced coal use, respectively. The phasing out of leaded petrol explains the substantial reduction in lead emissions expected in 2010. The marked

[7] The critical load of a heavy metal equals the load causing a concentration in a compartment (soil, soil solution, groundwater, plant etc.) that does not exceed the critical limit set for that heavy metal.

[8] Emissions of atrazine and endosulfan are expected to stabilise.

[9] New post-2005 EURO-4 emission standards for freight and passenger road transport have not been taken into account in the Baseline scenario; these standards have been incorporated in the Technology Driven and Accelerated Policies scenarios.

improvement in emission levels of dioxins/furans is explained by the application of efficient flue gas cleaning technologies for waste incinerators[10]. Reduced coal use and reduced emissions from the chloro-alkali industry, which has adopted an emission abatement programme for emissions of mercury, are expected to lower mercury emissions by 2010. Under the Baseline scenario, small increases in the emissions of cadmium and PAHs are expected due to growth in road transport (for Cd) and higher use of wood fuel in households (for PAHs).

Table 3.3.4 EU-15 emission (1990) and emission reductions for various hazardous substances under the Baseline (BL), Technology Driven (TD) and Accelerated Policy (AP-NT) scenarios in % change in 2010 compared to 1990

Substance	*1990*	*BL*	*TD*	*AP-NT*	
	tonne	%	%	%	Spillover[1)] only
Primary PM_{10}	2.6×10^{6}	-40	-70	-75	*-59*
Lead (Pb)	16.4×10^{3}	-60	-70	-72	*-64*
Copper (Cu)	1.5×10^{3}	+1	-23	-26	*-11*
Mercury (Hg)	250	-9	-47	-53	*-21*
Cadmium (Cd)	200	+5	-38	-45	*-11*
Dioxins/Furans (I-Teq)	6.0×10^{-3}	-31	-74	-77	*-50*
PAHs	5.6×10^{3}	+5	-57	-54	*-14*

[1)] Spillover effects are due to policies abating of climate change and acidification.

With the reduced emission levels under the Baseline scenario, substantial decreases in lead and dioxins/furans depositions are anticipated in the EU. Nevertheless, critical loads for lead for forest soils are still likely to be exceeded over large parts of the EU in 2010. Despite the small increases in copper and cadmium emissions, no exceedance of critical loads for these HMs are foreseen in 2010. No assessment has been made of possible exceedances of critical loads for other substances due to a lack of data.

The full application of the most advanced end-of-pipe control technologies would significantly reduce emissions of all hazardous substances studied in comparison to baseline results (see *Table 3.3.4*). By 2010, emission levels of PM_{10}, lead and dioxins/furans would be reduced by about 70% compared to 1990, emissions for mercury and PAHs would be approximately cut in half while emissions for cadmium and copper would be reduced by 40 and 25%, respectively. These results clearly demonstrate the substantial remaining technical potential for the further control of emissions from hazardous substances.

Under the Accelerated Policy scenario, spillover effects from climate change and acidification were analysed first. Results demonstrate that emissions of all hazardous substances studied are significantly lowered due to these spillover effects (see ‘spillover’ column *Table 3.3.4*). Estimated spillover emission reductions for primary PM_{10} are about three-quarters due to climate change policies, especially the switch from coal to gas in the electricity sector; the balance being due to acidification measures. For HMs, estimated spillover effects are almost completely explained by climate action. With such reductions, emission stabilisation targets could be achieved for all studied substances, including cadmium, copper and PAHs, for which the achievement of targets was not ensured under baseline conditions.

[10] Under current policies an emission limit value of 0.1 ng I-TEQ/Nm^3 has been assumed for waste incineration.

The Accelerated Policy scenario shows the lower limit for future emissions, recognising spill-over effects from actions on climate change and acidification. Assessment of air concentration levels (see *section 3.5.2*) demonstrates that even with such far-reaching measures, stringent 2010-target concentration levels for PM_{10} of 20 $\mu g/m^3$ will still be exceeded in most countries.

Measures and costs

Technical measures to reduce emissions of PM_{10} and adsorbed HMs and POPs from stationary combustion sources that have been evaluated in the Technology and Accelerated Policy scenarios are highly efficient 4-field electrostatic precipitators (ESPs) for coal and biomass combustion in power plants and industry, ESPs for oil combustion in power plants and industry, and improved stoves for coal and biomass combustion in households. For industrial processes advanced dust cleaning methods have been assumed, such as fabric filters, high performance electrostatic precipitators and highly efficient wet scrubbers, all combined with waste gas collection systems.

Total PM_{10} reductions for advanced control technologies and their costs compared to the baseline are summarised in *Table 3.3.5,* where it should be noted that uncertainties are large: i.e., a factor 2 to 4. Costs of measures to reduce PM_{10} emissions from transport (i.e. EURO-4 emission standards) are evaluated in the context of acidification (see *section 3.3.2*).

The largest reduction of PM_{10} emissions can be achieved through further control of the emissions from major industrial production processes for which the existing Integrated Pollution Prevention and Control (IPPC) directive only contains a general requirement for using the Best Available Technologies. An appropriate action could be to extend the IPPC Directive with binding emission standards for major industrial production installations, as they already exist for other major source categories such as new large combustion plants (>50 MWh) in the energy sector and industry, waste incineration plants and mobile sources. The emission reduction for PM_{10} that could be achieved by upgrading industrial production sites with the most advanced control technology amounts to about 7% of 1990 emissions. Such advanced measures for PM_{10} control will also reduce emissions of heavy metals, dioxins/furans and PAHs. Compared to 1990 emission levels, substantial emission reductions are expected, ranging from about 7% for lead to 28% for cadmium.

Looking to cost effectiveness, further reduction of PM_{10} emissions may also be achieved in the sectors ‘Public power, cogeneration, and district heating’ and ‘Industrial combustion’. About 85% of the emission control potential mentioned in *Table 3.3.5* for these two sectors could be obtained by the replacement of dust arresters on coal and biomass-fired combustion installations with high performance arresters. The remaining 15% could be obtained by the installation of dust arresters on oil-fired installations, which currently do not have such technologies installed.

Table 3.3.5 Emission reductions for primary PM_{10} in the AP scenario due to spillover and due to application of PM_{10} emission control technologies, compared to Baseline scenario, including cost estimate and efectiveness.

Economic sector	*Spillover*	*Control technologies*		
	emissions (ktonne/yr)	*emissions* (ktonne/yr)	*direct costs* (M€/yr)	*Effectiveness* (M€/ktonne)
Public power, cogener., district heating	197	134	270	2.0
Residential, commerc., instit. Comb.	103	17	n.e.	n.e.
Industrial combustion	147	73	190	2.5
Industrial processes	0	186	1050	5.5
Transport	48[1)]	32[2)]	n.e.[3)]	n.e.[3)]
TOTAL	496	443	1510	3.4

[1)] Reduction includes effect of 50% penetration of EURO-4 emission standards compared to 100% penetration of EURO-3 emission standards as assumed under the Baseline.
[2)] Reduction refers to 100% penetration of EURO-4 emission standards, compared to 50% penetration of EURO-4 emission standards assumed under spillover.
[3)] n.e. = not estimated, costs of EURO-4 emission standards are part of acidification (see *section 3.3.2*).

Emission reductions for PM_{10} that may result from the installation of optimised burning systems in households are small. However, it should be noted that uncertainties in emissions from households are rather high due to large uncertainties in the quantity of wood burned and related emission factors. It should also be realised that these measures are important for reducing emissions at the local city level.

Total costs for further emission control in the context of the Accelerated Policy scenario are about 14% lower than total costs in the TD scenario due to the switch to less-polluting fuels in the Accelerated Policy scenario (coal to gas).

Enlargement

In general, emissions in Accession countries from stationary combustion sources are more important, and emissions from transport and waste incineration contribute less when compared to the EU-15. Under current policies substantial emission reductions for all substances studied are expected by 2010 compared to 1990, except for cadmium, for which a small increase in emissions is anticipated (see *Table 3.3.6*). Emission reductions for PM_{10}, lead, and mercury are similar to reductions expected for the EU; emissions of copper and PAHs will likely decrease more and emissions of dioxins/furans will decrease less. It should be noted that the Baseline scenario considers emission control requirements of the second UN/ECE sulphur protocol only; requirements of the UN-ECE protocols on HMs and POPs decided upon in 1998 have not been accounted for in the Baseline scenario.

The projected downward trend in emissions for PM_{10}, copper and mercury results primarily from lower combustion emissions due to reduced coal use and the implementation of the second UN/ECE Sulphur Protocol. The European wide elimination of the use of leaded gasoline explains the large reductions in lead emissions. For cadmium, positive effects of reduced coal use and S-protocol requirements on emissions will be reversed by the increase in the use of fuel oils in households. As a result a small increase in the emissions of cadmium is anticipated. The anticipated decline in emissions of PAHs and dioxins/furans is explained primarily by reduced coal use in households.

Table 3.3.6 Emissions (1990) and emission reductions for various hazardous substances for Accession countries under the Baseline (BL) and Technology Driven (TD) scenarios in % change in 2010 compared to 1990

Substance	*1990*	*BL*	*TD*
	tonne	%	%
Primary PM_{10}	1.95×10^{6}	-40	-80
Lead (Pb)	4.2×10^{3}	-58	-71
Copper (Cu)	1.0×10^{3}	-30	-58
Mercury (Hg)	77	-12	-49
Cadmium (Cd)	159	+4	-19
Dioxins/Furans (I-Teq)	2.5×10^{-3}	-9	-44
PAHs	1.5×10^{3}	-16	-40

No specific assessment has been made in this study of the consequences of enlargement on emissions and the associated costs. Enlargement could increase energy use and transport in Accession countries, leading to higher emissions of hazardous substances. On the other hand, enlargement implies that Accession countries have to comply with emission standards specified in EU directives, of which the large combustion plant directive, the vehicles directive, the waste incineration directives and fuel directives are the most important. Implementation will bring emission reductions between the results for the Baseline and the Technology Driven scenarios (see *Table 3.3.6*).

It is also important to note that current emission requirements of the UN/ECE protocols on HMs and POPs are as stringent as requirements of EU regulations, except for transport. Studies of the impact and costs of these HM and POP protocols (TNO, 1997;1998) indicate that total annual costs for upgrading industrial installations and waste incineration plants to emission standards for particulates and HM amount to about € 100 million per year (capital investment: € 1 billion). Similar cost estimates have been reported for smaller coal-fired combustion installations in the energy sector and industry[11]. In addition, costs for upgrading waste incineration plants to emission limit values for dioxins/furans are estimated at € 10 million per year (capital investment: € 100 million). Such cost figures are low compared to costs of acidification measures and costs of measures to reduce emissions from transport, both of which are evaluated in the context of acidification (see *section 3.3.2*).

Summarising, it can be concluded that due to reduced coal use and emission control requirements of the UN/ECE-protocols large emission reductions for hazardous substances may be expected for Accession countries. A major improvement of emission control technology may be expected for the near future in Accession countries for all relevant major source sectors. The reduced emission for hazardous substances in the Accession countries will contribute to significant improvement in the environmental situation in these countries, but also in the EU-15. Especially the particulate matter reductions are important in realising the EU policy objectives.

[11] It has been estimated that compliance with S-protocol requirements will also bring about compliance with HM-protocol requirements for about 80% of the coal-fired and 100% of the heavy fuel, oil-fired power generating capacity in the energy sector and industry (TNO, 1998). Costs of such S-protocol measures have not been included here.

3.4 Regional and Local Environmental Issues

3.4.1 Water Quantity and Quality

Main findings

- Water demand remains stable, though in southern European countries it is too high.
- Policies to improve water quality are in place (Nitrates Directive, Urban Wastewater Treatment Directive). Full implementation of current policies will lead to significant improvement of water quality. Contribution from agriculture remains high, despite the implementation of the Nitrate Directive. Nitrate concentrations in river basins will still be a problem in the future.
- To be effective, wastewater treatment policy in the Accession countries should combine a high effort on sewerage development with tertiary treatment, i.e. nutrient removal.

Context

Human use places severe pressure on Europe's water resources. Water quality is a major concern throughout Europe, while the level of abstraction represents a further stress in southern countries. Water withdrawals for irrigation can lower water tables and result in salt-water intrusion in coastal areas. Nitrogen pollution of groundwater mitigates its use for drinking water, while eutrophication due to excessive nutrient load can lead to algae growth, oxygen deficiencies, and fish kills. In the EU and its Member States, progress has been made in controlling point sources of pollution from industry and households through wastewater treatment. In addition, the demand for water is expected to only slowly increase, particularly where appropriate pricing policies are in effect. However, little improvement has been achieved to date for non-point sources of pollution from the agricultural sector (manure and the use of artificial fertilisers).

In this assessment, water abstraction relative to net precipitation and groundwater recharge, and nitrogen and phosphorus loading from agricultural land represent the primary pressure indicators, while concentrations of nitrates and phosphorus are used to measure the state of the water resource. The level of wastewater treatment under the Urban Wastewater Treatment Directive (UWWTD) and the application of the Nitrate Directive represent the principal societal responses under the Baseline scenario. The UWWTD requires full compliance by 2003. Consequently, the Baseline scenario will assume full implementation in 2010. Under the Nitrate Directive, the maximum use of organic fertilisers (manure) is set at 170 kgN/ha. No other scenarios were developed for water management due to the lack of regionally consistent data.

There is some inter-linkage between the issues of acidification and eutrophication and water management. Enhanced nutrient loading distorts the balance of aquatic ecosystems and adversely affects water quality. Biodiversity, especially marine ecosystems, would greatly benefit from actions to limit excessive nitrogen releases to surface waters. Finally, soil degradation is often associated with the overexploitation of groundwater resources.

Assessment and trends

Future water abstraction in the EU is likely to remain relatively constant, since the demand from most sectors will probably decline and national water conservation policies improve the efficiency of water use. In southern countries, the extent of irrigated land and the quantity of water used per hectare will probably decline, although these semi-arid areas will likely remain susceptible to the effects of desertification.

Under full implementation of the UWWTD, sewage treatment will be upgraded, while 95% of the EU population will be connected to sewers. The improved efficiency in wastewater treatment should translate into significant reductions of nutrients to surface water. Organic matter, for example, is expected to be reduced by 65% by 2010, while phosphorus and nitrogen discharges should decrease by about 31 and 21%, respectively. Thus, full compliance is expected to eliminate most of the problems associated with surface water pollution from wastewater. The cost of implementing the UWWTD in the EU is expected to increase from € 41 per capita in 1995 to € 48 per capita in 2010.

Under the Baseline scenario, it is assumed that animal numbers will drop by about 2% to 2010 (see *section 3.1*). Member States provided the information for the scenario. It is not clear whether the scenario reflects the impact of the Nitrate Directive. However, reductions are most pronounced in those Member States with intensive animal husbandry (see *Technical Report on Water Quantity and Quality*). Nevertheless, additional policy responses will be necessary to significantly reduce agricultural impacts on water quality. This response could be achieved, for example, through further technical measures to address agricultural emissions contributing to acidification and eutrophication or through a radical reduction in livestock numbers.

Figure 3.4.1 presents the change in nitrate concentration at the river mouth. Agriculture is the main emitter of nitrates. Except for the hot spots of animal husbandry, nutrient emissions hardly change. Figure 3.4.1 also presents the change in phosphate concentration at the river mouth. Phosphate concentration decreases mainly due to the use of detergents without phosphates in some EU Member States. Despite the population and welfare growth - both factors amplifying emissions - the nutrient concentrations are shown to decrease in all European rivers.

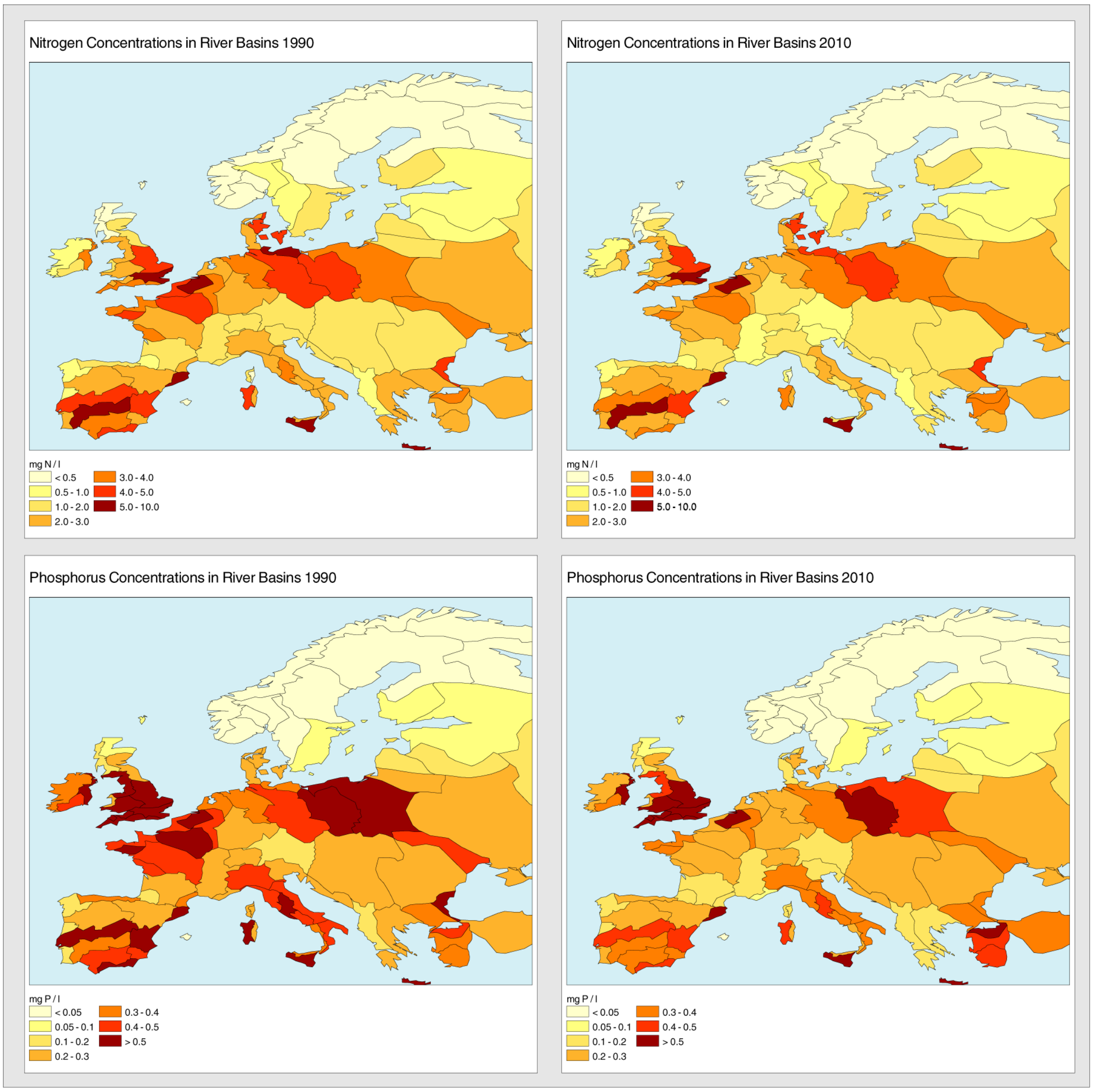


*Figure 3.4.1 Nitrogen and phosphorus concentrations in river basins by 1990 and 2010, as projected for the river mouth for the Baseline scenario. In the EU, the agricultural sector is the main supplier of nitrates. The introduction of new household detergents has/will have a marked effect on the phosphate load. For the Central and Eastern European countries, the Baseline scenario projects show convergence to EU standards, implying an enhancement of sewerage system connections and sewage treatment (*see *section on enlargement, scenario A).*

Enlargement

In the last decade pressure on (ground)water resources has in general decreased in Accession countries, mainly as a result of the decreased use of fertiliser in agriculture, but also of the completion of new wastewater treatment facilities. The nutrient loads in the Accession countries decreased by 5% for nitrogen and 11% for phosphorus. In the EU much larger reductions are projected. Accession might likewise enable reductions by the adoption of the urban wastewater Treatment Directive (UWWT).

Study results suggest that implementation of the UWWT Directive in the 10 Accession countries will require considerable investments. (Lack, 1999; EEA, 1999). The study considered the environmental benefits and potential costs that may accrue from implementing the UWWT Directive in the 10 Accession countries under three different scenarios:

A. moderate development of sewage and wastewater treatment as a requirement for normal areas (secondary treatment);
B. large effort on sewerage system development and wastewater treatment as a requirement for normal areas;
C. large effort on sewerage system development and wastewater treatment as a requirement for sensitive areas (secondary treatment plus nutrient removal).

The construction and upgrading of wastewater treatment plants will result in marked reductions in the amount of organic matter and nutrients being discharged from urban wastewater treatment plants. The increase in Scenarios A and B by 59 and 67%, respectively, of the waste water treated in biological treatment plants will result in a reduction of the organic waste being discharged from a current value of 1.1 Mt to around 0.45 Mt; this is equal to a 60% reduction in the load of organic matter (*Table 3.4.1*). Scenario C will result in a small further reduction in the amount of organic matter being discharged to around one-third of the current discharges. There will only be small changes in the amount of nutrients being discharged in the two first scenarios: a reduction of 12 and 10% for phosphorus and nitrogen, respectively. In scenario C, with half the wastewater being treated in wastewater treatment plants with nutrient removal, there will be a 50% reduction in the phosphorus discharge and a 40% reduction in the nitrogen discharge compared to the current discharges.

The cost effectiveness of Scenario B is clearly less than that of Scenario A. This suggests that a large effort on sewerage system development should be accompanied by tertiary treatment, i.e. nutrient removal.

Table 3.4.1 Discharge of organic matter and nutrients from urban wastewater treatment plants and associated operation and investment costs.

	1990 to 1995	*2010*		
		Scenario A	*Scenario B*	*Scenario C*
BOD_5 index	100	42	39	32
P_{TOT} index	100	87	88	51
N_{TOT} index	100	89	91	62
Annual operating costs (€ billion)		0.7	0.9	1.4
Capital investments (€ billion)		5.3	6.9	9.0

Source: Lack, 1999; EEA, 1999.

The cost figures presented in *Table 3.4.1* should be handled with care. Another recent study, PHARE/DISAE, estimates that considerably higher investments (+ 50%, if compared to scenario C) would be needed to comply with the UWWT directive:

- for the construction of new sewerage, an investment of € 10.6 billion;
- for upgrading treatment plants and extension of treatment capacity, an investment of € 4.6 billion.

The PHARE/DISAE estimates are based on detailed country-specific studies, see *Technical Report on Enlargement* for details. Annual operational costs have been estimated in a few cases only. The PHARE/DISAE program did not make a systematic assessment of the environmental benefits of the implementation of the UWWT directive. In the few cases that this assessment was made, the results are quite comparable with those presented in Table 3.4.1.

3.4.2 Coastal zones

Main findings

- In Southern Europe coastal zone management is primarily concerned with the rapid urbanisation of the coastal zone and is related to landuse and biodiversity changes.
- In North Europe coastal zone management is primarily concerned with the eutrophication of the seas by supply of nitrates and phosphates released by agriculture and is related to water stress.
- The Baltic and Black Seas may benefit from the EU enlargement if the Accession countries adopt the urban wastewater treatment directive while combining a large effort on sewerage system development with wastewater treatment (secondary treatment plus nutrient removal).

Context

Coastal zones are areas of the highest biological and landscape diversity on Earth. The coastline of the European Union is no exception. These rich coastal ecosystems are under threat. Construction of roads, pipelines, utilities, cities and ports need conversion of natural areas and wastewater, and agriculture is polluting coastal waters. In southern Europe, coastal zone management is primarily concerned with the rapid urbanisation of the coastal zone and relates to landuse and biodiversity changes. In northern Europe, coastal zone management is primarily concerned with the eutrophication of the seas by supply of nitrates and phosphates released by agriculture and wastewater, and is related to the issue of water stress. In this assessment, coastal zone issues are only represented through the analysis of nutrient loading. Other coastal issues, such as urbanisation, tourism and over-fishing are not taken into account.

In many coastal areas, poor water quality and distorted marine ecosystems are attributed to excess nitrogen, particularly along the margins of enclosed seas with relatively little connection to the open ocean. Water quality is generally well covered by existing EU directives, including the Bathing Water Directive and the UWWT Directive. However, full implementation has yet to be achieved. The most appropriate indicator to measure the impact on bathing water quality is agricultural nitrate load, which reflects the largest pollution source for coastal seas. However, generic policy targets for this area have not been established.

In the context of this study, there is a close linkage to water management. The biodiversity of marine ecosystems benefits from actions to limit excessive nitrogen releases to surface water.

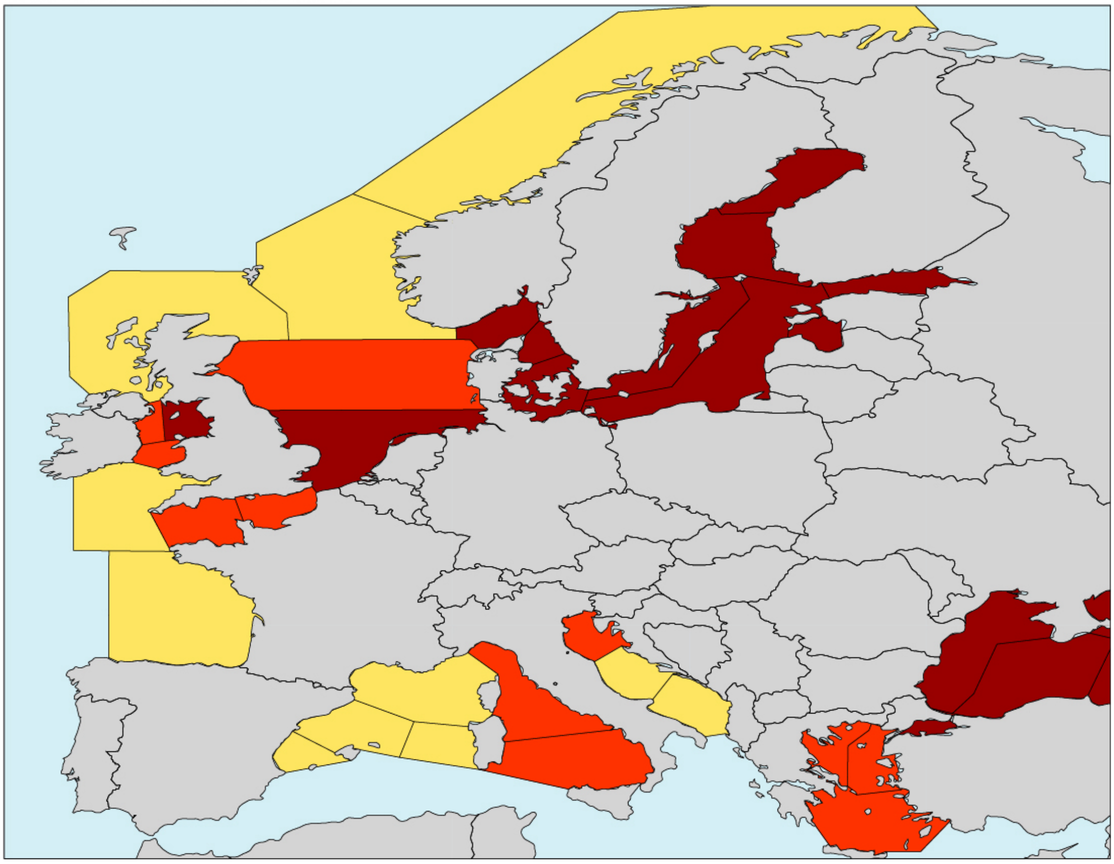
Assessment and trends

The agricultural intensification since 1950 has brought about an increase in the amounts of excess nutrients entering the surface waters and the coastal seas. Figure 3.4.2 presents the nitrogen enrichment in coastal zones. The indicator is potential nitrate concentration. The index is labelled *potential* and represents all nutrient inputs to the seas, including air deposition, oceanic influx and exchanges. The index does not account for removal processes in the seas themselves.

In general, there will be little change in the location or degree of enrichment between 1990 and 2010 under the continuation of existing policies (EEA, 1998). This can be considered as a positive result of these policies as the impact of population and welfare growth - both factors amplifying emissions - have been mitigated. The enrichment trend, which started since 1950, has come to a halt. To reverse the trend, additional policies are required.

The Nitrate Directive has some positive impact on coastal zone eutrophication, but has not been designed for coastal zone management. The Nitrate Directive refers to manure and not to artificial fertiliser, which contributes to some 50% of the total agricultural N input. Hence, overall reductions due to the Nitrate Directive are small. Trends for surface fresh water are provided in section 3.4.1.

Nitrate concentration 1990



Nitrite/nitrate in surface water (μmol/l)

- good (< 6.5)
- fair (6.5 - 9.0)
- poor (9.0 - 16.0)
- bad (> 16.0)

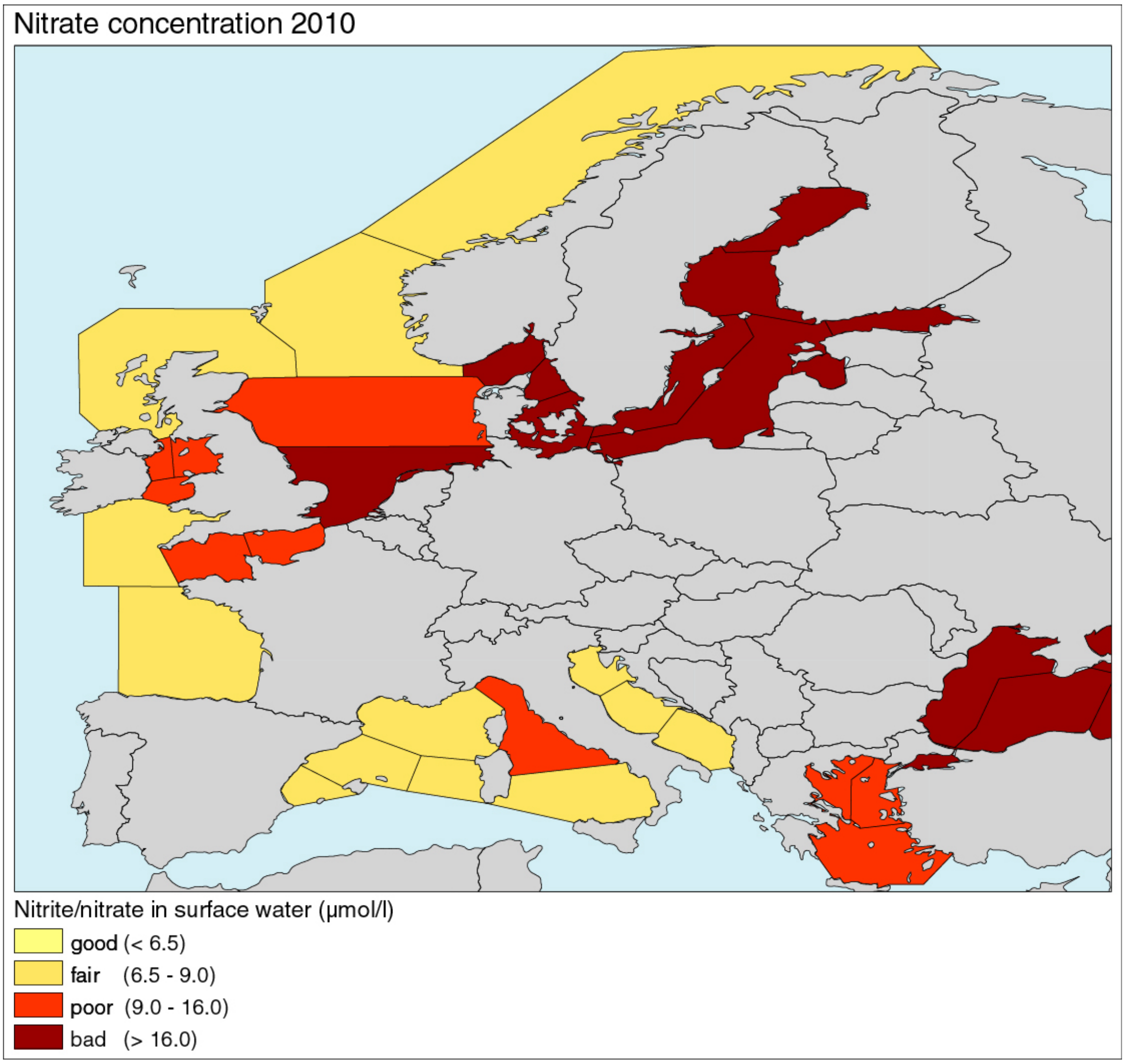


Figure 3.4.2 Baseline projection of potential nitrate concentration by 1990 and in 2010. CARMEN model calculations, which account for riverine and atmospheric input, and mixing with neighbouring waters, provide so-called potential nitrate concentration for coastal zones. Due to limited mixing with fresh ocean water, the Baltic Sea and the Black Sea are sensitive to nutrient enrichment. N.B. No marine denitrification processes have been modelled.

Enlargement

Discharges of nutrients and hazardous substances in Accession countries have declined during the last decade, both as a result of the economic decline and implementation of international agreements (for example, HELCOM for the Baltic Sea). A further decline may be anticipated with the implementation of water management policies (as discussed under water management) and EU environmental legislation in Accession countries. Therefore, enlargement of the EU with the Accession countries will have a positive effect on the water quality of coastal zones.

The implementation of the UWWT Directive in the 10 Accession Countries would lead to an increase in the quantity of waste water fed to the treatment plants and thus an increase in the nitrogen loads, on the condition that this load remains untreated. The scenarios A, B and C, defined in previous section, have been evaluated to assess the impact of increasing treatment of the loads to the coastal seas. *Table 3.4.2* lists the potential reductions in discharge of nitrogen due to wastewater treatment changes to the marine environment. In the Baltic and Black Seas the nitrogen load can be reduced by more than 50%, while in the North Sea the potential is less than 10% (Lack, 1999; EEA, 1999).

Table 3.4.2 Potential reductions in discharges of nitrogen from wastewater treatment plants to marine waters according to the Scenarios A, B and C.

	1990 to 1995	*2010*		
	index	*Scenario A*	*Scenario B*	*Scenario C*
North Sea	100	98	98	92
Baltic Sea	100	77	80	43
Black Sea	100	92	93	48

Source: Lack, 1999.

Scenario B combines a high incidence of connection to sewage systems with low nutrient removal levels. Nutrient emissions to the surface waters are added in this scenario, giving it the lowest environmental performance.

3.4.3 Waste management

Main findings

- Without additional policy responses current targets controlling the amount of municipal solid waste are unachievable. The annually generated amount of municipal waste per capita was 534 kg in 1993. This will increase by more than 15% by 2010 (target is stabilisation at the 1985 level).
- Due to the implementation of the Packaging Directive, waste landfill will decrease from 63 to 57% over the period 1993-2010, keeping landfill the dominant treatment route for waste. Recycling will be almost doubled (from 10 to 18%).
- If additional policies are more focused on incineration, the share of landfill can be reduced to about 15% in 2010. In this case, waste treatment and disposal costs increase by 55% compared with the baseline. An alternative policy option is to maximise composting and recycling; the share of landfill is then almost 20% and costs will increase by more than 35%.
- Under the Accelerated policy scenario (assuming preventive measures and optimal costs for composting and recycling) the increase in municipal solid waste occurrences will be limited to about 10% over the period 1993-2010. The share of landfill and composting/recycling will be 30 and 60%, respectively, in 2010. Implementing these policies might lead to cost savings of more than 5% compared with unchanged policies. A strategy focusing on composting and recycling is more cost-effective than incineration and landfilling. This strategy requires additional institutional structures for recycling.
- Industrial waste and hazardous waste have not been included in this study due to lack of harmonised data. However, future policies should focus on these waste streams.
- Waste management policies can contribute significantly to climate change policies by reducing of methane emissions (CH_4) from landfills and reducing carbon dioxide emissions (CO_2) as result of (fossil) energy savings due to waste incineration with energy recovery.

Context

Waste generation is increasing in the EU faster than economic growth. The volume of waste is an indicator of inefficient production processes, low durability of goods and unsustainable consumption patterns (EEA, 1999). In addition to the resource loss represented by waste quantities, waste management and disposal have significant impacts on environment pollution, including air and water pollution.

Currently, about half of the waste generated in the EU comes from the manufacturing and construction/demolition sectors, with about 15% municipal solid waste (EEA, 1999). Nevertheless, this assessment is limited to the consideration of municipal solid waste due to the general paucity of systematic and consistent data. Under the EU Waste Management Strategy, approaches to waste are ranked according to potential environmental impacts and the need to minimise the use of materials. Thus, prevention is recognised as the most favoured option, followed by recycling and reuse, incineration with energy recovery, and incineration without energy recovery. The EU Fifth Environmental Action Programme discourages landfill disposal, the most prevalent current approach, while encouraging recycling. To date, recycling efforts have been partially successful, but have not arrested the trend in increasing waste disposals. Preventive measures, needed to achieve the Action Programme's objective of stabilising municipal waste levels, are currently not concrete enough and have failed to reduce amounts of waste generated.

In the Baseline and Technology-driven scenarios, the indicators used relate to the targets of the Fifth Environmental Action Programme by referring to five categories for solid waste treatment and disposal; namely composting, recycling, incineration with energy recovery, incineration and landfill disposal. As these targets will not be achieved under existing policy, the new Landfill Directive, optimal recycling, and a waste prevention measure are considered within an accelerated policy scenario. This scenario considers the following targets for 2010: waste occurrences should not exceed the 1990 level; and recycling and composting should accommodate at least 50% of all disposable waste.

Increasing consumption has implications for the extraction of virgin materials and the use of energy. The management of solid waste increases, in turn, the probability of air emissions and leaching to water; solid waste also occupies land, creates secondary waste streams, and adversely affects ecosystems and urban areas. Leaching from landfills can, for example, lead to nutrient enrichment, and heavy metal and toxic contamination of the aquatic environment. In addition, the landfill of organic waste contributes to climate change through increased methane emissions, while incineration with energy recovery may reduce CO_2 emissions from fossil fuel combustion. Incineration, however, results in increased SO_2, NO_x and particulate emissions, with adverse implications to acidification/eutrophication and urban areas. In addition, the generation of large volumes of waste acerbates transportation growth leading to further environmental impacts.

Assessment and trends

With the continuation of existing policies, the total amount of municipal solid waste is expected to rise from 534 kg per capita per year in 1993 to 622 kg per capita per year in 2010 - an increase in total waste of about 22% (see *Table 3.4.3*). In this scenario, the proportion of waste diverted to each treatment or disposal method is not expected to change radically. The share of waste going to landfill would marginally decline, while recycling would increase to 18% due to the implementation of the Packaging Directive. Landfill disposal would remain the predominant method of waste management, while the share of incineration with energy recovery would remain static. Thus, a continuation of existing policies will not effectively reduce waste levels or significantly move waste management to more environmentally friendly treatment methods. The total annual treatment and disposal costs for solid wastes in the EU are likely to increase by about 10%, to € 13.3 billion per year by 2010.

Table 3.4.3 Waste arisings, waste treatment, and cost estimate in the base year (1993) and projections for 2010 under the Baseline (2010 BL), Technology Driven (2010 TD), and Accelerated Policy (2010 AP) scenarios[12].

Amount of waste		*1993*	*2010*			
			BL	*TD-WTE*	*TD-C&R*	*AP*
Total arisings	Mt/yr	186	228	228	228	222
Total arisings[1)]	Mt/yr	197	240	271	236	232
Arisings per capita[1)]	Kg/yr	534	622	701	611	600
Energy potential	PJ/yr	25	29	154	17	26
Composted	%	5	5	5	27	25
Recycled	%	10	18	16	41	33
Incineration + WTE	%	14	13	63	8	12
Incineration	%	8	6	0	5	0
Landfill[1)]	%	63	57	16	19	30
MSW treatment or disposal costs	€ billion/yr	12.1	13.3	21.0	18.3	12.5

[1)] Including landfilling of incinerated waste.
WTE = incineration with energy recovery (Waste To Energy).
C&R = composting and recycling.

Under a Technology Driven scenario, waste levels would still increase by at least 20%, but the treatment proportions would change to encourage greater compliance with the EU Waste Management Strategy to reduce landfill disposal. Two options are suggested. The first would focus on incineration with energy recovery, and the second on composting and recycling (see *Table 3.4.3*). If the first option were pursued, incineration with energy recovery would probably increase to about 63% by 2010, while landfill disposal would decline to 16%. This represents the only scenario where the sustainable energy potential of waste is maximised (about 5 times more than other scenarios). With the focus on reuse, recycling and composting, these management categories could potentially increase so to handle about 68% of solid wastes, with only about 19% going to landfills. The reduction in landfilling would have a significant effect in reducing CH_4 emissions from this source.

[12] Scenario 2010-BL includes the Packaging Directive.
Scenario 2010 TD-WTE focuses on maximum incineration with energy recovery.
Scenario 2010 TD-C&R focuses on maximum composting and maximum recycling.
Scenario 2010 AP includes a paper and plastic tax to prevent MSW rises, the Landfill Directive, and an optimal mix of the 'bring and collect' system for composting and recycling.

Costs and measures

Three factors that affect disposal costs can be distinguished: (i) waste occurrences per capita, (ii) the shift from landfilling to composting, incineration or to (limited) options like prevention, and (iii) recycling rates of paper, glass, plastic and metal. Obviously, increasing waste arisings will tend to increase disposal costs. The second factor increases disposal costs because landfilling is considered to be cheaper than composting, incineration or prevention. Low costs are involved for the third factor if paper, glass, metals etc. are collected through bring systems. However, to achieve recycling rates of more than 75%, expensive curbside collection is necessary, which is up to 10 times more expensive than bring systems.

Based on these observations, the disposal costs in *Table 3.4.3* can be interpreted as follows. First of all, total waste occurrences (and thus disposal costs) go up in all scenarios because population grows by 8%. On top of that there is a slight increase in disposal costs in the Baseline due to increasing waste occurrences per capita and a decrease in costs due to a (limited) shift from landfilling to cheap recycling options. In the Accelerated Policy scenario, the same factors are operating but at a different intensity, resulting in a slight decrease in disposal costs. In the Technolgy-driven WTE scenario there is a large increase in waste occurrences, also due to a large increase in incineration ashes, and a large shift from landfilling to incineration with energy recovery, which is relatively expensive. The second variant of the Technology Driven scenario, which shows a large shift from landfilling to composting and recycling (including curbside collection), results in disposal costs which are high, but lower than the WTE variant. These lower costs show that incineration (even with energy recovery) is more expensive than composting and full recycling, partly due to the fact that incineration ashes have to be landfilled.

In general, it can be stated that additional policy measures will be needed to stave off the increase in the amount of waste generated. A ‘virgin materials’ tax, aimed at reducing the amount of packaging waste by 8.5% between 2000 and 2010, is suggested. With the consideration of this preventive policy measure and encouraging cost-optimal composting and recycling under the accelerated policy scenario, the total amount of solid is expected to fall by about 3% by 2010, while the amounts recycled and composted, would more than double compared to baseline projections. The amount of waste diverted to landfill sites would be significantly decreased, though not as much as in the Technology Driven scenarios. However, even with these measures, it is unlikely that the objective of stabilising waste levels at 1990 levels will be achieved.

Spillover effects of waste management to climate change

All incineration would include energy recovery. The energy potential of incinerating waste is quite substantial. The sustainable potential of the various scenarios amounts to as much as 154 PJ per year for the Technology Driven ‘waste-to-energy’ scenario. The cost-optimal accelerated policy scenario leads to much less incineration; the revenue falls back to the level of 1993.

The reduction in the amounts of organic and paper waste to landfill has a direct influence on methane emissions. This reduction results in a decrease of about 3 Mt CH_4 per year

(65 Mt CO_2 equivalent per year) by 2010. This would mean, for example, that this reduction represents a cheap option to reduce CH_4 emissions as a contribution to achieving climate change targets.

Enlargement

Municipal waste generation per capita in Accession countries is currently much lower (-35%) than the EU average. Accession is, however, expected to imply that waste quantities will increase to EU levels as a result of enhanced economic growth and adoption of ‘western’ lifestyles. Accession will not impact the EU-15, as waste management is a regional or local issue.

Recycling rates in Accession countries are currently at levels similar to those of the EU-15. It should be noted that the expected increase in waste generated in Accession countries requires a considerable increase of recycling capacity in these countries.

To comply with the landfill and packaging directive, Accession countries will have to change their waste management systems considerably. Currently, the waste collection infrastructure in Accession countries is poor and mainly directed towards landfill. Setting up separate collection and waste processing facilities (composting, recycling) will demand considerable investments. Also the closure of and care for existing landfills will require considerable investments, not in the least because in Accession countries many unofficial landfill sites exist.

A partial assessment of these investment needs (excluding industrial waste, but also including management of hazardous waste) shows that about € 14 billion is needed to comply with the EU directives. About one-third of this amount is needed to take care of existing landfills, some € 8 billion is needed to construct sanitary landfills, composting and recycling facilities. About € 0.5 billion is needed to create an adequate infrastructure for the management of hazardous waste.

3.4.4 Soil degradation

Main findings

- There is no framework for European soil directives as soil problems are considered to be local problems that can best be handled at national or even regional level. There is also an information gap for assessing soil degradation on a European scale.
- Climate change will accelerate soil erosion and degrade the possibilities for maize cultivation.

Context

Soil degradation, resulting from human practices, reduces or destroys the land’s long-term productivity and life support function. Degradation of agricultural soils results in lower yields, persistent weed problems, and an increasing need for artificial fertilisers. This assessment focuses on the erosion aspects of soil degradation and the threat to future agricultural productivity due to climate change. The primary indicators used are water erosion risk and its impact on the productivity of maize.

Soil erosion accounts for about 60% of the degradation problem that also encompasses such issues as land development, soil contamination and salinity encroachment. About 12% of Europe's land area is adversely affected by water erosion, while 4% suffers from wind erosion (EEA, 1998). These problems exist in most European countries, although the concentration of eroded lands is greatest in the Mediterranean region. Intensification of agricultural land use, land abandonment, deforestation and urban development are the primary factors contributing to soil erosion risk.

Current agri-environmental regulations at both the EU and Member State level hold considerable promise for effectively preventing and mitigating soil erosion. Landowners are encouraged to use more extensive management practices such as organic farming, afforestation, pasture extension and benign crop production. Nevertheless, there is a need for policy makers and the public to intensify efforts to combat the pressures and risks to the soil resource.

There is a significant association between soil degradation, and water management and climate change. Global warming and higher rainfall will probably intensify degradation; which, without adequate responses, will magnify the problems of water pollution and clogged downstream watercourses, including reservoirs. Such changes could also result in the more intensive use of marginal soils to compensate for the loss of degraded land.

Assessment and trends

In 1990, high to very high, water erosion risk areas occurred over about one-third of Europe, primarily on the agricultural lands of the southern and central regions. Under the continuation of existing policies, water erosion risk is expected to increase over about 80% of agricultural land in the EU by 2050. While the area of high erosion risk will probably triple, the area of moderate risk will probably decrease by half. Countries significantly affected by this overall increase in risk level include Germany, Italy, Spain, Greece, Ireland and Austria.

Water erosion will probably adversely affect the productivity of maize cultivation in Europe by 2050. In the EU, both a decrease in the area suitable for maize production and a tendency towards lower yields are likely to occur.

Enlargement

Natural circumstances, continental climate and soil characteristics make most Central and Eastern European countries - in particular Slovenia, the Czech and Slovak Republics, Romania, Bulgaria and the south of Poland - prone to water erosion. These fragile soil conditions require good land use practices for a sustainable agriculture. Monitoring and control of the soil problems through the introduction of preventive measures and education programmes could be harmonised for the benefit of both EU-15 and the Accession countries concerned.

3.5 Cross-sectional Environmental Issues

3.5.1 Biodiversity

Main findings

From this study, the following general conclusions can be drawn:

- Through literature surveys it was shown that the citizens of the EU place a high value on nature, e.g. in the form of valuing (rare) species, beautiful landscape and recreation possibilities. While these values do not reflect attitudes towards biodiversity *per se*, there is evidence that people are willing to contribute to halt the deterioration of biodiversity.
- In the EU, about half of all land cover is still considered to be natural area. This share is not projected to change due to large-scale conversion in agricultural or built area. Neither is re-conversion into nature projected to occur to large extent by 2010.
- From the natural area, only a minor part is protected under the Habitat or Birds Directives, i.e. 10% and 20% respectively.
- The natural area is suffering from acidification, eutrofication, tropospheric ozone, climate change as well as from fragmentation of natural area. In addition, natural areas are effected pressures related to population density and production/consumption. These will contribute towards small-scale habitat destruction, habitat disruption, over-exploitation of natural resources and contamination with heavy metals and organic pollutants.
- An indicator was constructed to quantify some facets of these pressures. The indicator predicts a decrease of these pressures by 22% to 31%, but this probably due to the fact that the air quality related indicators dominate the index.
- Even with the decrease in the indicator the pressure remains high, exceeding several critical loads. Thus, biodiversity loss is expected to continue, though at a slightly lower rate.
- The effect of small-scale conversion[13] has not been studied, but this might well be a serious threat to biodiversity. Biodiversity loss may be accelerated if small-scale habitat loss and fragmentation increase and other major pressures such as forestry, water extraction, fires and extensive cattle grazing, expand in the years to come.
- In sum, evidence exists to demonstrate that biodiversity in the EU has deteriorated and that this negative trend is not likely to reverse. This evidence should be seriously concerned.

However, at European level, data are not yet sufficiently available to quantitatively assess the status of biodiversity, let alone to make reliable projections. Much data and knowledge already exists, but this is scattered all over Europe. If the data were pooled together, it would be possible to carry out a European-wide quantitative assessment. Such an assessment would pave the way for better understanding of the state of biodiversity in Europe. A general assessment framework, such as the Natural Capital Index framework as developed under the Convention on Biological Diversity, could be

[13] 'Small-scale conversion' is the term indicating the conversion of an area with small-scales in its landscape like ponds, hedgerows, brooks into a homogeneous area for a more efficient agriculture or transport.

applied in such analysis. In the study, systematic monitoring and targeted research into baseline information and pressure-effect relationships would have to be established in order to track changes over time, give significance to data as such, and prioritising abatement measures.

Context

Diversity of ecosystems, species, and genes is critical to the functioning of the ecosphere. At present, ecosystems are undergoing unprecedented degradation and loss of species due to the rapid increase in human consumption of natural resources.

Biodiversity considerations are beginning to be integrated into sectoral policies. However, negative impacts will probably continue from such factors as agricultural intensification, mono-specific forestry, urban and transport development, climate change, pollution and the introduction of alien species (EEA, 1999).

Various instruments exist to support biodiversity conservation strategies (EEA, 1998). The Convention on Biological Biodiversity, which the CEC has ratified, provides a global framework for countries to prepare biodiversity strategies and action plans. A biodiversity indicator framework has also been proposed to assess whether or not progress is made. This Natural Capital Index (NCI) framework has been applied in this study.
Other relevant international conventions include the Bonn Convention (migratory species), the World Heritage Convention (natural heritage), the Bern Convention (wildlife and natural habitats), CITES (trade in endangered species) and the Ramsar Convention (wetlands). In the EU, a Biodiversity Strategy was developed in 1998; the Birds and Habitats Directives support the development of the NATURA 2000 Network of nature conservation sites.

In this study biodiversity change is measured using the -adapted- Natural Capital Index (NCI) framework as developed under the Convention on Biological Diversity. The NCI framework takes into account the remaining ecosystem size (ecosystem quantity) and its quality as two complementary indicators describing natural capital.

This study focuses on the effects of the Baseline and Accelerated Policy scenarios on natural areas. Ecosystem quantity is measured as the percentage natural area of the country's total area of the EU-15 total area. Due to the lack of data, ecosystem quality could not be assessed on state indicators. Instead, pressure indicators have been used as a substitute. It has been assumed that the higher the pressure, the lower the chance on quality.

The pressures used are: climate change, human population density, production & consumption rate (GDP per km^2), isolation/fragmentation, acidification, eutrophication, and tropospheric ozone concentration. Each pressure is preliminarily graded on a linear scale from 0 (no pressure) to 1000 (very high pressure). Pressure 1000 indicates a high chance of extremely poor biodiversity compared with the baseline state. European geographical explicit data are available on these pressures for the year 1990 as well as for the year 2010 in the Baseline and Accelerated Policy scenarios. The Accelerated Policy scenario for biodiversity assumes that environmental targets used in the preparation of the Emission Ceilings Directive are met in each EU Member State in a cost-effective way.

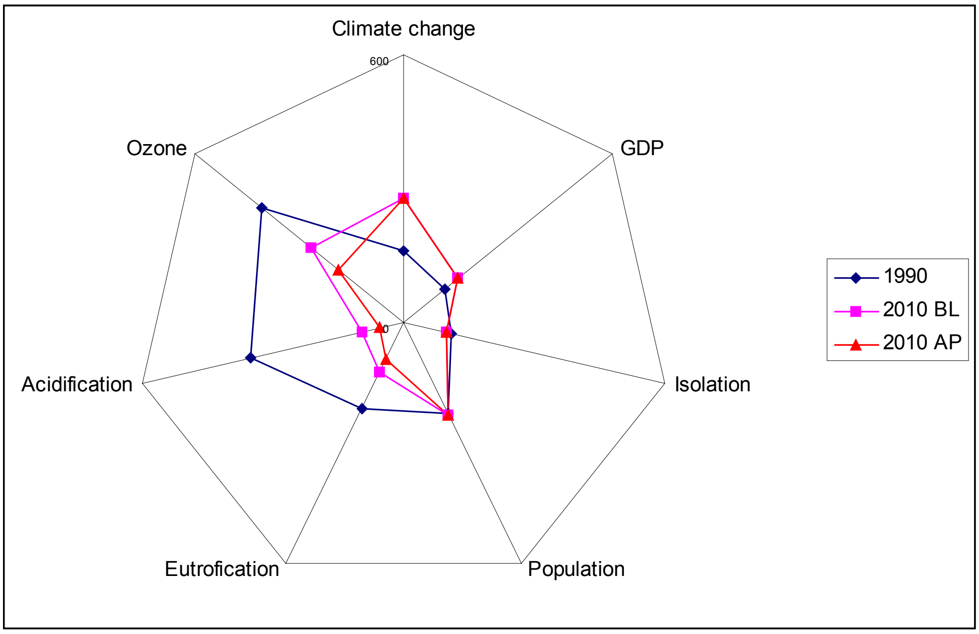
This study represents a preliminary estimation of the size of effects of various environmental policy scenarios on biodiversity, the relative contributions of single pressures and how they are distributed geographically over Europe.

Assessment and trends

Assuming a continuation of existing policies in the EU (Baseline scenario), the proportion of nature areas in the EU is expected to change from 49% in 1990 to 51% in 2010. Most countries should experience a slight increase in nature area, although a decrease is likely to occur in Ireland, Italy, Portugal and Spain.

With respect to ecosystem quality the total pressure will be reduced by about 22% compared to 1990. Nevertheless, the absolute total pressure on biodiversity is expected to remain high for many natural areas: from pressure 1596 in 1990 to pressure 1249 in 2010 on a pressure scale of 0 - 2500[14]. The pressure from tropospheric ozone, acidification and eutrophication is expected to decrease significantly, while the pressure from climate change (temperature increase) and production rate will increase (see *figure 3.5.1*).

Figure 3.5.1 Overview of 7 individual mean pressuresin the base year (1990) and projections for 2010 under the Baseline (2010 BL) and Accelerated Policy (2010 AP) scenarios. Eutrophication, tropospheric ozone and acidification pressures are reduced, while climate change (by year 2050) and other, production-related, pressures (GDP/km^2) increase. Isolation and human population density pressures remain more or less stable.



Note: individual pressures per grid cell seized 1 km^2 are scaled from 0 (no pressure) to 1000 (extremely high pressure with a low chance of high ecosystem quality). To obtain mean pressures these grid cell values have been aggregated for the EU. To get a better perspective on the changes in this figure, see the outside figure at pressure 600.

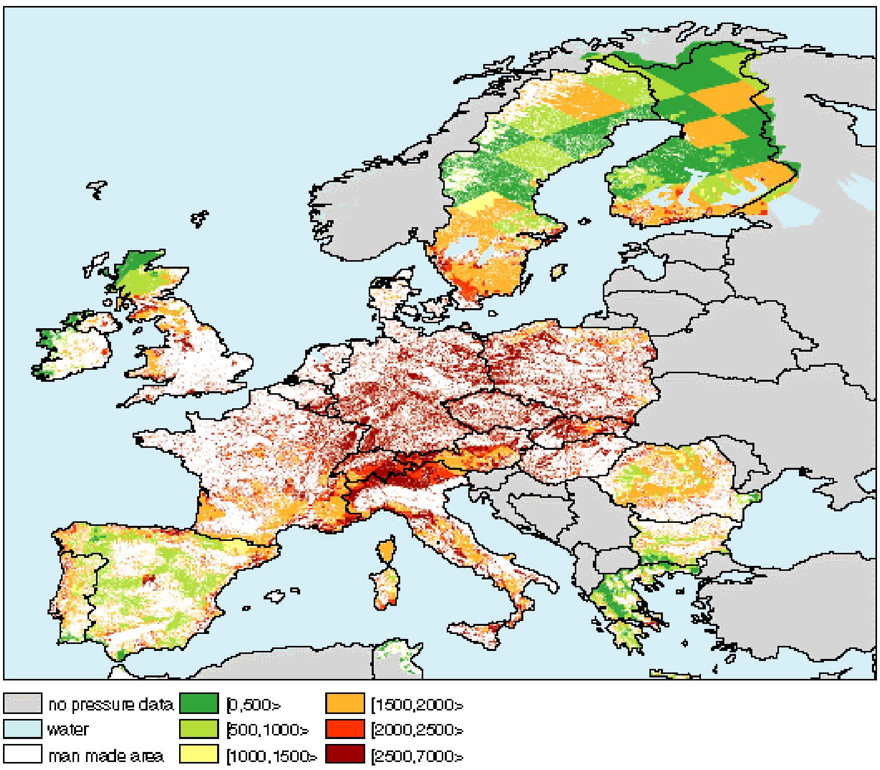
[14] Pressure 0 means no pressure on ecosystems. Pressure 2500 means very high pressure, probably leading to a severe ecosystem deterioration and consequently low ecosystem quality (< 10%).

The Accelerated Policy scenario does not include specific, biodiversity targeted measures additional to the Baseline scenario. Therefore, similar to the Baseline scenario, the proportion of nature areas in the EU is expected to change from 49% in 1990 to 51% in 2010. Most countries should experience a slight increase in nature areas, although a decrease is likely to occur in Ireland, Italy, Portugal and Spain.

With respect to ecosystem quality the total pressure will be reduced by about 31% compared to 1990, and not the 22% in the Baseline scenario, due to a further decrease of tropospheric ozone, acidification and eutrophication. The pressure from climate change (temperature increase) and production rate increases similarly (see *figure 3.5.1*). There are no additional measures included on defragmentation.

Although the total pressure of the above seven pressures are expected to decrease, the absolute pressure to biodiversity remains high: from pressure 1596 in 1990 to pressure 1107 in 2010 on a pressure scale of 0-2500[14]. Because ecosystem effects lag considerably behind the changes in pressures, the deterioration of biodiversity currently observed in all European countries will probably continue. Geographically, pressures would probably remain at a crucial level in Belgium/Luxembourg, Germany and the Netherlands. The lowest pressures are expected in Finland, Sweden, Greece, Ireland and Spain (see *figure 3.5.2*).

Pressure index in remaining self-regenerating land (1990)



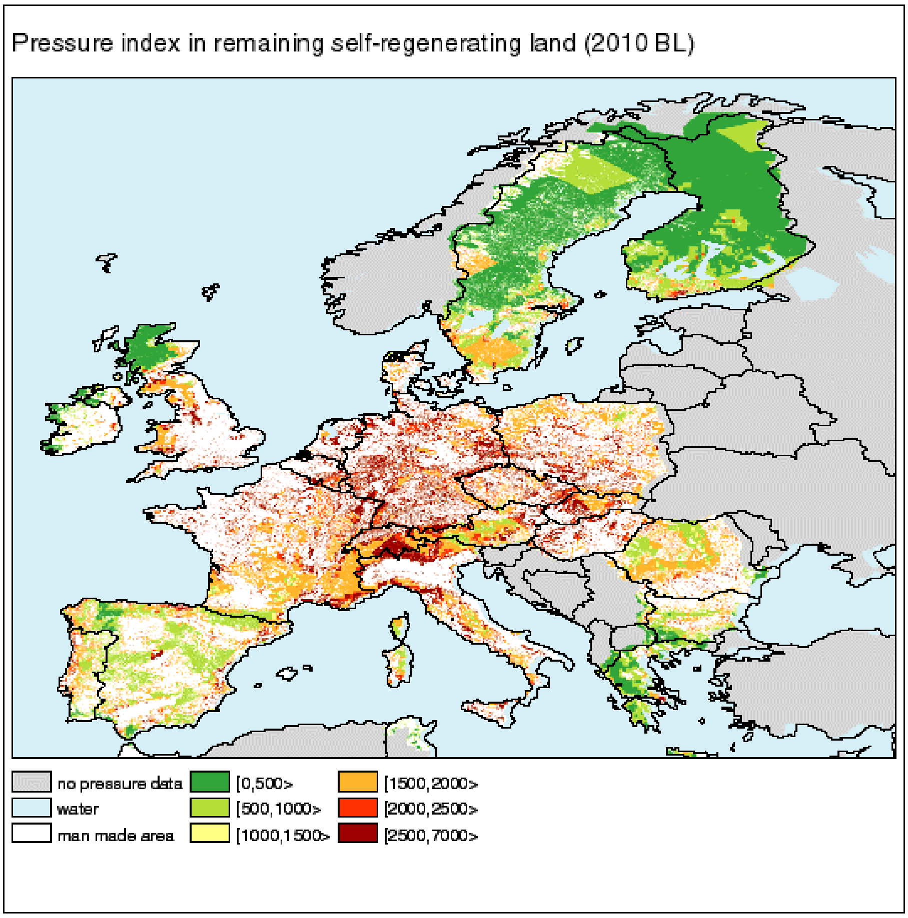


Figure 3.5.2 Pressure index in remaining natural area in 1990 and in 2010 according to the Baseline and Accelerated Policy scenarios.

Enlargement

Agricultural land use exerts a strong pressure on biodiversity. In the Accession Countries, this pressure is currently small in comparison to the one in the EU-15. The Common Agricultural Policy (CAP) stimulates intensive land use and pesticide and fertiliser use in the EU-15 are high. If enlargement implies that CAP subsidy regulations would also apply to the Accession Countries, a negative impact on the agro-biodiversity may be expected.

Enlargement is likely to reduce the emission and transboundary transport of air pollutants. This will contribute to a significant reduction of the pressures on biodiversity both in the Accession Countries and in the EU-15.

3.5.2 Human health, air quality and noise

Main findings

- Current policies eliminate exceedances of target levels for SO_2, benzene and lead.
- Accelerated policies reduce exceedances of target levels for NO_2 and O_3 by 50 and 35%, respectively, but especially O_3 remains a problem.

- Although significant emission reductions result from measures taken in the context of climate change, acidification, tropospheric ozone and primary particulate matter, the PM_{10} concentration target is far from achieved in all scenarios due to the fact that natural background concentrations already exceed the target level in many places.
- To reduce PM_{10} (and NO_x) concentrations any further, transport measures inside cities should be implemented.
- Due to data-limitations, problems related to urban areas have not been covered in this study. Noise has been covered to a limited extent only.

Context

Human health, air quality and noise problems are especially important in cities and large agglomeration. Since the number of people living in urban agglomerations is steadily increasing in the EU, this results in greater potential for this issue, also with respect to issues such as noise and water pollution, concentrated waste levels, and restricted open space. However, a common analytical framework for modelling such (urban) stresses is not currently available.

An approach on prioritising environmental exposures in relation to public health loss is presented in the text box 3.3 below. This assessment, however, is limited to focusing on the following situations: a) Concentrations of selected air pollutants in 24 cities in the EU-15 and 10 cities in the Accession countries, from which concentrations have been extrapolated for large agglomerations having more than 750,000 inhabitants, cities between 100,000 and 750,000 inhabitants and for the remaining area; and b) Human exposure above target levels derived from EU legislation and World Health Organisation Air Quality Guidelines (WHO AQG). Specific hot-spot exceedances (e.g. busy streets) have not been calculated in this study. The pollutants and their health-related target levels - used in the AP scenario - are shown in *Table 3.5.1.* Notice that tropospheric ozone is also included in this table, the reason being that in section 3.3.3, the tropospheric ozone issue was not evaluated in terms of concentrations at the detailed city level. Instead, it was limited to a coarse grid in terms of AOT60 and AOT40. In this section, AOT results have been translated to peak levels, based on measurements from AIRBASE between 1978 and 1998.

Table 3.5.1 Urban air pollutants and their respective targets for the accelerated policies scenario.

Pollutant	*Target*
NO_2	40 µg/m^3 annual average
SO_2	24 µg/m^3 annual average[1)]
PM_{10}	40 µg/m^3 annual average (2005 target)
PM_{10}	*20 µg/m^3 annual average (2010 target[2)])*
O_3	120 µg/m^3 for 8 hours < 20 days[3)]
Pb	0.5 µg/m^3
Benzene	5 µg/m^3 annual average[4)]
B(a)P	1 ng/m^3 annual average

[1)] This annual average is a reflection of the maximum daily average target value of 125 µg/m^3.
[2)] Directive 1999/30/EG; note that this target will be re-evaluated in 2003.
[3)] See proposal for the Ozone Directive (COM(1999)125) as currently in discussion by the European Community.
[4)] See proposal for Benzene and Carbon monoxide Directive (COM(1998)591).

In general, air quality in European cities and rural areas has improved in recent decades, although targets are still frequently exceeded for specific pollutants. This is especially the case with the photochemical pollutants (NO_x, VOC, CO, and O_3). Road transportation is the main source of this type of pollution especially in urban areas. The main sources of SO_2 and particulates have been industry and energy production, where adoption of more efficient combustion technologies and the increasing dependence on cleaner fuels have significantly improved emission and concentration levels. Furthermore, lead concentrations have been effectively lowered through the use of unleaded fuel so that no urban area exceeded long-term WHO AQGs for this substance in 1995 (EEA, 1999).

Assessment and trends

Despite reductions in vehicle noise limits by 85% for cars and 90% for lorries since 1970, EEA (1999) estimates that about 32% of the EU population (120 million people) is exposed to road noise levels above 55 dB(A) on house facades. It is unlikely that noise levels will diminish in the future, which is valid for road transport (mainly due to growth in freight transport) as well as aircraft noise (especially at European regional airports). AP scenarios could not be defined due to a lack of harmonised indices, methodologies (i.e. calculation and measurement) and limit values at the European level. In chapter 4 noise related costs and benefits will be discussed.

With respect to air quality, existing policies and policies in the pipe line are expected to improve the exceedance ratio, and human exposure levels in by 2010. Exceedances of target levels would be virtually eliminated for SO_2, benzene, lead and for the 2005 target for PM_{10}. Only in large agglomerations in Greece and to a lesser extent in Italy and Austria do exceedances remain for these substances. The most significant exceedances in 2010 are likely to be for NO_2 in Italy, Greece, Finland, France, Germany and Spain; for O_3 in Belgium, Luxembourg, Germany, the Netherlands, France and Portugal, and to a lesser extent Italy, Spain and Austria. For benzo(a)pyrene, exceedances do exist (B(a)P) in all but four countries: Denmark, France, Portugal and Sweden. However, it should be indicated that computed B(a)P concentration tend to be too high if compared with measurements. Also, the target level itself is subject to discussion.

And finally, if the stringent 2010 PM_{10} target is applied, all but two countries (Sweden and the UK) face serious problems in the Baseline scenario. In general, it should be realised that the 20 $\mu g/m^3$ target is very difficult to achieve because in many countries the natural background concentrations already exceed this level. In fact, if the 20 $\mu g/m^3$ were to be applied to the *anthropogenic* contribution to PM_{10} concentrations only, there would be no problem, except for large agglomerations in Greece. Therefore, it can be expected that in 2003, when an evaluation will take place, the target level might change. The target level will be raised to a higher concnetration-level, and/or a distinction will be made between the natural and the anthropogenic contribution. Note that anthropogenic sources mainly concern smaller particles ($PM_{2.5}$), which are usually considered to be more harmful to human health than the larger ones.

Table 3.5.2 Exceedances of the targets in the base year (1990) and projections under the Baseline (BL), Technology Driven (TD), and Accelerated Policy (AP NT) scenarios, 1990 to 2010.

Indicator	*1990*		*BL*		*TD*		*AP NT*	
	Tot[1)]	*Agg*[2)]	*Tot*	*Agg*	*Tot*	*Agg*	*Tot*	*Agg*
Million inhabitants								
Exposure above NO_2 target	120	92	36	33	15	15	18	18
Exposure above SO_2 target	170	96	5	5	0	0	5	5
Exposure above PM_{10} 2005-target	160	67	15	9	5	3	n.c.	n.c.
Exposure above PM_{10} 2010-target	350	102	305	87	295	84	295	84
Exposure above O_3 target	330	80	265	55	110	1	170	3
Exposure above Pb target	46	36	0	0	0	0	n.c.	n.c.
Exposure above benzene target	85	66	8	8	2	2	n.c.	n.c.
Exposure above B(a)P target	190	97	140	55	50	25	n.c.	n.c.

[1)] Tot: total million people exposed to pollution levels higher than the target value, compare with a EU population of 365 million in 1990 and 387 million in 2010.
[2)] Agg: the contribution of large agglomerations' population.
n.c. = not computed; exposures would be even closer to 0 than in the BL scenario.

Under the Technology Driven scenario - which is the result of emission reduction measures as described in the sections on climate change, acidification, tropospheric ozone, and chemicals and particulate matter - exposures above target levels decrease for O_3 by more than 150 million people but remain high, especially in Belgium, Luxembourg and the Netherlands. However, two remarks should be made here. Firstly, the methodology to estimate health impacts of ozone is still under development; therefore results should be interpreted with care. Secondly, exposures would significantly decrease if a slightly lower target value were used (for example, 19 days instead of 20).

Also, the situation for NO_2 improves significantly in the TD scenario: problems remain primarily for large agglomerations in Italy. Exposures above the target level for B(a)P are reduced, but remain high, especially in Belgium, the Netherlands, Austria, United Kingdom and Germany. Exposure to the stringent target level of PM_{10} is reduced only slightly and remains high in all the countries already mentioned with respect to the BL scenario.

Compared to the Baseline scenario, the population exposure in the AP scenario is significantly lower for both NO_2 and O_3 in 2010 in all countries involved. For PM_{10}, the reduction in exceedances, compared to 1990, applies to about 50 million people. Nevertheless, total exceedances remain high.

As indicated in *Table 3.5.2*, the impact of accelerated policy on the PM_{10} 2005 target, lead, benzene and B(a)P have not been quantified, either because concentrations were already very low in the Baseline scenario or because very low health effects were expected (which holds for B(a)P).

From *Table 3.5.2* it is clear that exceedances are primarily related to large agglomerations, except for particulate matter and especially ozone. The reason for PM_{10} simply is that exceedances occur *everywhere*. For ozone, the problem is generally smaller in cities and agglomerations because NO from traffic reacts with O_3, resulting in NO_2 and O_2. The effects of the full-trade variant have not been modelled, but these effects can be stated to be primarily the result of measures taken within the context of acidification (see *section 3.3.2*). Climate change policies will have a limited impact on air quality because transport, which is the major source of (urban) air pollutants, increases by more than 30% in all scenarios, including the full-trade variant of the scenario. Therefore, if concentrations were computed for full-trade, the results would be comparable to the no-trade case.

Measures and costs

Particulate Matter

PM_{10} concentrations can be lowered by reducing either primary PM_{10} emissions or the emissions of SO_2, NO_x and NH_3 in order to reduce the formation of secondary PM_{10}. Obviously, natural sources of primary PM_{10} cannot be tackled. Measures to reduce SO_2, NO_x and NH_3 are discussed in section 3.3.2. Next, in section 3.3.4, it was indicated what could be done to reduce emissions from primary sources outside cities. Within city boundaries, traffic and households are the most important sources. For traffic it should be noted that emissions of particles from diesel traffic are already reduced substantially in the context of acidification: in the AP scenarios the EURO IV emission standards are applied to all new cars dating from 2005, resulting in a situation in 2010 where 50% of all cars comply with these standards. Full compliance with the standard would, at least, take another 10 years and would result in additional primary PM_{10} emission reductions of about 25Kton (= 2.5% of total emissions in 2010 APNT). Currently *no* techniques are available to reduce these emissions from traffic either further and/or faster. To reduce PM_{10} (and NO_x) emissions within cities any further (i.e., below the emission levels of the AP no trade scenario) one could do the following:

1) Limit traffic in city-centres and improve on traffic circulation plans (see, for example, Daly, 1997).
2) Stimulate the switch from diesel to petrol cars, especially passenger cars. A disadvantage would be that CO_2 emissions and emissions of petrol-car-related substances would increase.
3) Convert city bus fuel to natural gas.
4) Stimulate the use of electric cars.
5) Reduce the emissions from open fireplaces.

Although these measures will not contribute much to the reduction of emissions as compared to total emissions, their contribution to concentration levels in especially urban areas could be relatively high because they will be implemented inside the city boundaries. Revenues from parking charges, fuel taxes, etc. could be used to (partly) finance the implementation of these measures, as will be discussed in section 5.1.1.

Tropospheric ozone

Measures at the local-city level to reduce O_3 concentrations are difficult. In fact, O_3 levels generally go up when the concentration of NO goes down; this is due to acidification-related policies. To reduce O_3 levels any further, additional measures as described in the context of ‘tropospheric ozone’ will have to be implemented (see *section 3.3.3*).

Box 3.3: Public health burden due to environmental exposure

A tentative effort is made here to assess the disease burden in EU-15 associated with a set of environmental exposures for 1990 and 2010. To describe and compare the disease burden associated with environmental exposures, and, eventually, to perform cost effectiveness analysis of options for environmental policy obviously some sort of 'public health currency' is required. Considering the fact that annual mortality or even loss of life expectancy does not fully represent the environmental health loss, we tentatively applied an approach largely based on the 'burden of disease' measure that was developed by Murray and Lopez and which has been applied by WHO and World Bank. To assess the global disease burden, and consequently the health policy priorities in different regions in the world, they employed 'disability adjusted life years' (DALYs). This health impact measure combines years of life lost and years lived with disease or a disability that are standardised by means of severity weights. Thus, public health loss is defined as time spent with reduced quality of life, aggregated over the population involved. Provisional calculations for the Netherlands indicated that the contribution of environment exposures to the total disease burden would probably not exceed 3%, which is roughly equivalent to the burden caused by car accidents.

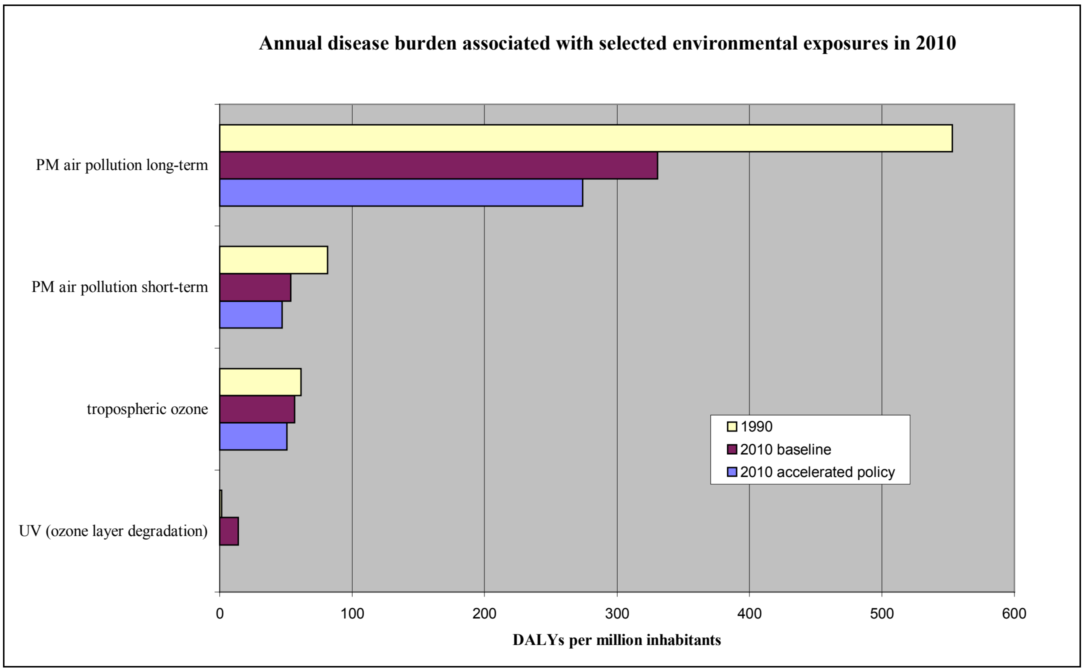


Figure 3.5.3 Disability-Adjusted Life Years (DALYs) lost annually per million inhabitants to exposure to particulate air pollution, tropospheric ozone and UV radiation.

In the framework of the study adequate data and projections were only available for particulate matter, tropospheric ozone and UV. Figure 3.5.3 shows the disease burden per 1 million inhabitants in the EU-15 total for 1990 and the Baseline and Accelerated Policy scenarios that can be attributed to exposure to particulate air pollution, photochemical air pollution (ozone) and UV due to ozone layer degradation. The disease burden associated with these exposures appears to be dominated by the long-term effects of particulates; the contribution of UV radiation is minor (however, attributive disease burden will rapidly increase until after 2050 due to a large time lag). Especially Germany, Italy, Greece and Belgium currently face a relative high environmental disease burden. However, it has to be noted that the estimates for long-term health effects are based on the results of a limited number of North-American cohort studies; the internal and external validity of which still needs to be verified, preferably in well-designed European epidemiological studies.

As is evident from these estimates, the disease burden associated with air pollution is still substantial and the current policies yield a fair public health benefit for 2010, especially with respect to particulates. In EU-15 the burden will be reduced by one third. According to the Baseline, Belgium, Greece and Italy remain as the countries with the highest disease burden from environmental exposures. Accelerated policies will further improve the situation in all countries.

In this study only three environmental exposures have been assessed, more information being available for the Dutch situation. The ranking found for EU-15 is the same as in the Netherlands (particulate matter shows the highest disease burden and UV radiation the lowest). The Dutch results also suggest a substantial disease burden associated with noise pollution; the mental and cognitive responses to noise pollution are, in general, very mild but the number of people involved is very high. The disease burden caused by chemicals (PAHs and benzene) is relatively minor, with the exception of lead in drinking water.

It is important to note that attributable disease burden is only one of the many aspects that characterise environmental risk. Other aspects that determine the social acceptability of environmental risk are the voluntariness of exposure, equity of the distribution of risks and benefits, trust in risk managers and government and perceived controllability. Catastrophic potential is another important attribute: several studies have shown that accidents that victimise a large number of people at the same time, such as aeroplane or nuclear accidents, are much less accepted than accidents that kill people one at the time, e.g. traffic accidents. The social disruption that takes place in response to large accidents may justify putting more weight on potential victims of nuclear accidents than on the faceless victims of air pollution or UV radiation.

Enlargement

For various pollutants the situation in Accession countries is worse than in the EU. This applies especially to SO_2, NO_x, and PM_{10}. In the 1995-2010 period, policies already in place in Accession countries will abate pollution levels, leading to improved air quality.

As a result of enlargement, Accession countries will have to implement EU environmental legislation, which could further abate emissions. The exact impact is unknown, but there are indications that especially emissions of PM_{10} (–55%), NO_x (-15%) and VOC (-20%) will be reduced as well.

Marginal costs of reduction measures in Accession countries are, in general, lower than in the EU.

3.6 Summarising the Results

The study examined twelve prominent European environmental problems. The Baseline scenario was developed to see whether current and planned policy measures would meet the targets. The Baseline builds on a consistent socio-economic trend evaluated for all Member States and economic sectors. The following division could be made according to the results of the baseline assessment:

1. Issues which are mainly solved after implementation of current policies or where major information gaps are present, viz. stratospheric ozone, nuclear accidents, water stress, soil degradation, coastal zone management and biodiversity loss.
2. Issues for which new targets are proposed, viz. climate change, acidification, eutrophication, tropospheric ozone, waste management, and to some extent, chemicals and particulate matter and human health and air quality.

Scenario results

The baseline assessment showed that some issues will be largely resolved provided the policy measures are properly implemented. For others, the lack of adequate data obstruct further assessment. For these issues there were - for various reasons - no incentives to define new policies. These issues have been listed in category 1 (see *Table 3.6.1*); main findings follow:

- The Montreal Protocol and its amendments have set targets for the emission reduction of ozone depleting pollutants to reduce stratospheric ozone depletion. According to the Baseline scenario, the EU-15 will meet these targets.
- The need for reducing the risk of nuclear accidents has been found not to lie within the EU, but in the Central and Eastern European countries. Costs for upgrading the unsafest nuclear plants are roughly estimated at € 94 million per year.
- Water demand has stabilised, with the implementation of measures for water quality in progress, viz. the Nitrates Directive and the Urban Waste Water Treatment Directive are expected to be implemented by 2003 and 2005, respectively. The Baseline scenario projects a steady improvement of water quality. In the rivers, Biological Oxygen Demand is falling, though nitrate load remains high. Anticipating a need for further environmental improvements, the Commission proposed the Water Framework Directive in 1997. This directive requires the Member States to collect data on the status of, and pressures on, rivers, lakes and groundwater, and to develop targets and action programmes to restore water quality according to the local circumstances related to nature. At the moment neither targets, action plans, nor environmental models are available to assess the impact of the new Directive.
- The issues of coastal zone management and soil degradation are strongly related to the water stress issue. As no targets have been set, no policies have been evaluated. Both issues may gain significance due to impacts of climate change: sea-level rise and advancing erosion.
- The pressure on biodiversity has been assessed in terms of the level of air pollution, the rate of climate change and socio-economic developments. Due to spillover, the sum of pressures weighed on biodiversity is expected to decrease by 31% in the AP scenario. However, the pressures exerted upon biodiversity remain high, and it is expected that biodiversity will continue to decline in the EU. It should also be

mentioned that the most important pressure on biodiversity, i.e. land use change, could not be quantified in this study.

Table 3.6.1 Main environmental results in the year 2010, including spill-over effects and direct costs for the baseline (BL), technology driven (TD), and accelerated policies (AP) scenarios. Climate change policy dominates the costs. The integrated assessment indicates that a climate change policy 'allowing full emission trading' (AP-FT) may only cost half of a policy 'not allowing emission trading' (AP-NT).

Issue	*Indicator*	*Relative to 1990 (1990 = 100)*			*Costs over BL-2010 € billion per year in 2010*		
		BL	*TD*	*AP*	*TD*	*AP-NT*	*AP-FT*
Category 1							
Stratosph. O_3	Emission of O_3 depleting subst.	0					
Nuclear risks	High risk nuclear power plants	84	8		0.1		
Water quality	River load phosphorus	37					
	River load nitrogen	85					
Biodiversity	Pressure Index	78		69			
Category 2							
Climate change	CO_2 emissions	108		92[1]		92[2]	36.3[2]
	Non-CO_2 emissions (in CO_2 eq.)	104		92		-0.4	-0.4
Acidification	SO_2 emissions	29	11	17	4.7	1.5	2.7
	NO_x emissions [3]	55	35	42	15.7	1.4	1.9
	NH_3 emissions	88	60	83	14.2	1.4	1.6
	Exceedance critical loads (acid.)	19	8	11			
	Exceedance critical loads (eutr.)	74	43	65			
Chemicals and particulate matt	Primary PM_{10} emissions	60	30	25	1.8	1.6	1.6
	Dioxins/Furans emissions	69	26	50	0.35		
Human Health and air quality	Exposure above PM_{10} target	87	84	74			
	Exposure above NO_2 target	30	13	15			
	Exposure above ozone target	42	6	8			
Tropospheric ozone	VOC emissions [3]	51	35	41	8.8	3.2	4.2
	Excess of AOT40	62	41	45			
	Excess of AOT60	40	20	23			
Waste management	Fraction landfilled or incinerated	89	38	48	4.8	-0.8	-0.8
TOTAL					50.4	99.9	47.0

[1] Including permit trading, if applicable (i.e., in the AP full trade scenario).
[2] All payments for equipment using energy, energy savings, change of fuel mix, tariffs and fuel use.
[3] Direct costs for NO_x also contain VOC costs for transport because these cannot be separated; direct costs for VOC refer to non-transport sectors only.

In category 2 environmental issues have been grouped for which the defined targets require an acceleration of the current and planned policies. This policy scenario is called Accelerated Policies (AP). The Technology Driven scenario (TD) provides a 'marker' of these targets by comparing them to what could be achieved if available technology, irrespective of costs, had been applied. The main conclusions are as follows:

- Under the Baseline scenario, greenhouse gas emissions (in $CO_{2\ eq.}$) are expected to increase by more than 7% between 1990 and 2010, mainly due to the transport and service transport. Meeting the minus 8% in the AP scenarios is feasible where the role of the power generation sector is crucial. The transport sector needs to be focused on because of relatively high emission growth and high adjustment costs. The establishment of emission-permit trading mechanisms would allow consideration of a least-cost allocation and will reduce the overall compliance cost.

Although uncertain, it is suggested that low cost measures to reduce emissions of non-CO_2 greenhouse gases could reduce emission reduction costs substantially.
- The targets of the 5th EAP for acidification and eutrophication have been met in the Baseline scenario. Accelerated policies reduce the area of ecosystems not protected against acidification to less than 3%. Six per cent of ecosystems are additionally protected against eutrophication.
- For tropospheric ozone, current policies bring about a 60% improvement in the EU-wide health-related ozone indicator (AOT60) and a 38% improvement in the vegetation-related indicator (AOT40). Accelerated policies bring an additional 17% improvement in both indicators compared to 1990 values. Measures that need to be implemented in each EU Member country to meet ozone targets depend on national circumstances.
- Costs of achieving the targets for acidification and ozone (on top of the Baseline) can be higher or lower by up to 30%, depending on the climate change policies adopted. Implementation of technological abatement measures (TD) could reduce the critical loads exceedance even beyond this target, however at very high costs.
- The targets set by the 5th EAP were not met for waste management; AP targets require 50% of the total municipal waste occurrences to be composted or recycled. The costs of this policy are estimated to be lower than the baseline costs at € 800 million; this is due to prevention and recycling benefits.
- In this study the issue of ‘Chemicals and particulate matter’ has been limited to a small number of airborne substances; this is because available information is too limited to include pesticides and many other chemicals. In the BL scenario, current policies achieve stabilisation targets for most Heavy Metals (HMs) and Persistent Organic Pollutants (POPs). Accelerated policies meet all targets, but PM_{10} remains a problem. Targets for PM_{10} are not met in the AP scenarios in spite of significant PM_{10} emission reductions through accelerated policies for climate change and acidification (see *section 3.6.2*) and despite the fact that all known additional end-of-pipe measures are assumed to be implemented. The direct costs for implementing these end-of-pipe measures are € 1.6 billion per year, but uncertainties are large (factor of 2 to 4).
- Human health and air quality have improved due to the accelerated policies to a level where exceedances of target levels for SO_2, benzene and lead are almost eliminated. Accelerated policies reduce exceedances of targeted levels for NO_2 and O_3 by 50 and 35%, respectively, but especially O_3 remains a problem. As indicated above, the PM_{10} target of 20 $\mu g/m^3$ (directive 1999/30/EG) is far from achieved in all scenarios due to the fact that natural background co concentrations already exceed the target level in many places. Even in the Technology Driven scenario more than 75% of the EU population would be exposed to too high levels of fine particles in 2010, mainly due to the high level of natural background PM_{10} in most Member States. To reduce PM_{10} (and NO_X) concentrations any further, transport measures at the city level should be implemented.

The additional costs of the accelerated policy scenario over the baseline in 2010 depend on the variant chosen for climate change policy. If trade in CO_2 emission permits is not allowed, additional direct costs for measures other than related to CO_2 would add up to almost € 8 billion per year (99.9 minus 92). Allowing for full trade would raise these costs by almost € 3 billion because spillovers would be less while the same environmental targets have to be met. However, reductions in additional energy system costs are much higher (about € 60 billion). And at the macro-economic level, the full trade scenario is superior too, as will be discussed in chapter 4.

Spillover effects

If the emissions of CO_2 are reduced due to climate change policies, emissions of many other pollutants are reduced as well. For example, measures that improve energy efficiency result in lower use of fuels and therefore reduce the emissions of SO_2, NO_x, particulate matter (PM), heavy metals (HMs), etc. Obviously, these measures can also be interpreted as measures to combat acidification and the presence of a spillover effect from acidification on climate change could be argued. However, in this study one of the key questions is to what extent climate change policies are dominant, and were, for this reason, chosen as the starting point from where spillovers are taken into consideration. Figure 3.6.1 summarises the spillover effects of the No-Trade variant of the accelerated policy scenario. This variant is presented here because spillover effects are maximal.

The CO_2 emission reduction of 15% compared to the baseline level in 2010 is shown to result in emission reductions beyond 15% for several other substances. This ‘amplifying’ effect occurs mainly because the most cost-effective way to reduce CO_2 emissions is the switch from coal to gas, especially in the electricity sector (see *section 3.2.2*), where each part of CO_2 reduction (in %) results in larger reductions for other substances, especially SO_2, PM_{10}, and dioxins/furans.

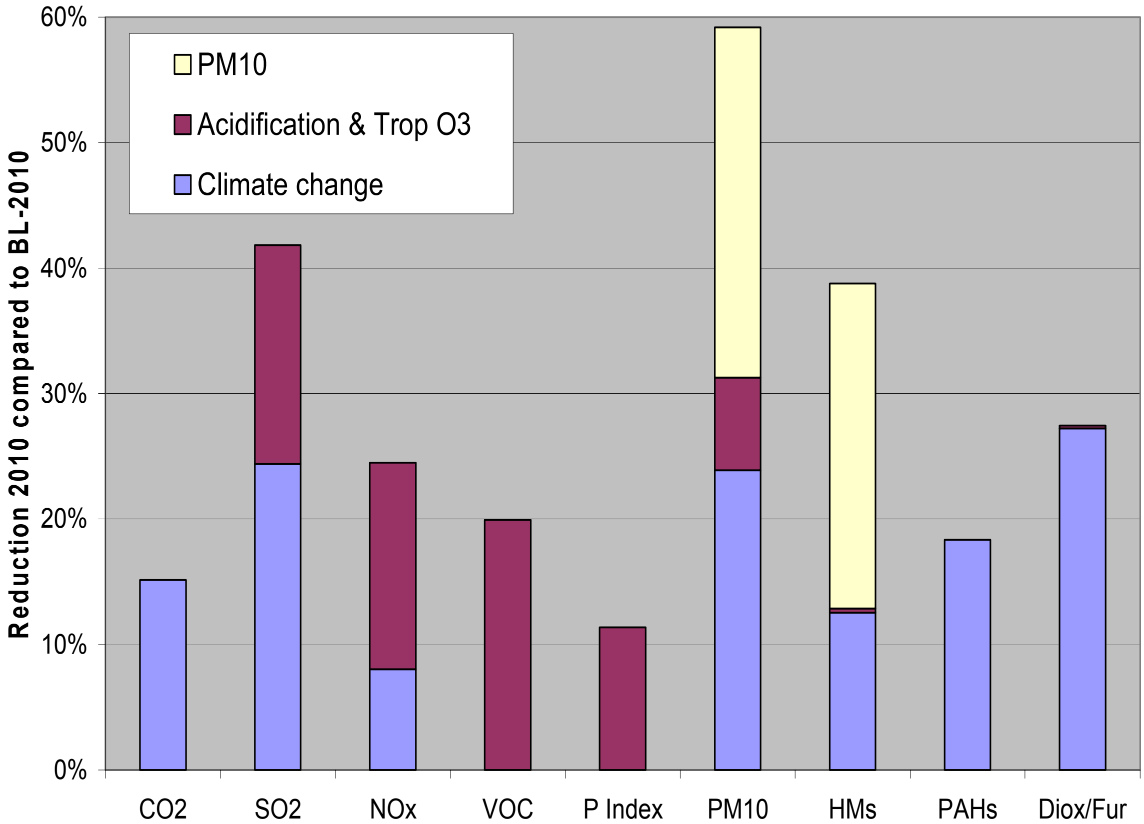


Figure 3.6.1 Spillover effects in the variant ‘not allowing CO_2 emission trading’ of the accelerated policies (AP-NT) scenario.

Acidification-related measures reduce PM_{10} emissions by more than 7%, but have a very limited effect on emissions of heavy metals. This is because the reduction of SO_2 in the AP-NT scenario is mainly through flue gas desulphurisation in coal-fired plants, while heavy metals are related to oil.

The reduction in the value of the Pressure Index (PI) for biodiversity is related to a decrease in the exceedance of critical loads for acidification and also in AOT40. Other components in the pressure index do not change in the AP-NT scenario.

Finally, there is a significant spill-over effect due to end-of-pipe measures that reduce emissions of primary PM_{10} on HMs, PAHs, dioxins and furans, which are partly attached to these particles. The spillover effect on HMs has been quantified only. For PAHs, dioxins and furans there is also a spill-over effect, but this effect has not been explicitly quantified.

4. Economic Appraisal

Section 4.1 evaluates the total, direct and indirect, costs incurring because the European Union sectors and households undertake environment-improving actions in order to meet environmental targets set for 2010. Since under baseline conditions these targets are not met, the sectors have to undertake additional actions and incur economic losses because they deviate from their baseline economic equilibrium. The total costs estimated in this section are compared with the benefits obtained because the environmental actions avoid some of the damages caused by environmental degradation (*section 4.2*). This comparison, also stated as cost-benefit analysis, is further used to set the policy priorities (*section 4.3*).

4.1 Macroeconomic assessment

Main findings

- The Technology Driven scenario (TD) involving investment on end-of-pipe technologies that improve the environment in all areas (climate change is omitted) has significant macroeconomic costs with rather noticeable implications on some sectors, like agriculture, electricity and energy-intensive industry and on some EU cohesion countries.
- The Accelerated Policies scenarios, involving climate change policy for Kyoto and beneficial spillover effects on other environmental areas, will influence the EU economy and the changes are found to be important in distributional terms, since carbon intensive sectors and commodities are displaced.
- The total economic cost of these policies, measured as GDP losses, is considerable lower than the direct costs that took the form of investments and other expenditures. A large part of this direct cost is recycled in the economy. The GDP losses range from € 10 to 30 billion in 2010 (or from -0.1% to -0.3% of the EU GDP level in 2010).
- Regarding climate change, and in particular carbon dioxide, efficiency gains may be obtained by using emission permit trading as a means of approaching a least-cost allocation of the emission reduction efforts to sectors and countries. The macroeconomic costs for the EU are then quite manageable, but the beneficial spillover effects on other environmental areas of the EU are smaller.
- The macroeconomic assessment analysis reveals that in general the changes and adjustments needed at the level of some sectors are probably more difficult to manage and higher in magnitude than the overall macroeconomic impacts. The areas of agriculture, energy supply and energy intensive industries are sensitive in this respect. The analysis also showed that the cost impacts on households are rather higher than for the firms.

4.1.1 Macroeconomic Implications of the Technology Driven scenario

Assumptions

The Technology Driven scenario involves direct costs associated to the purchasing of end-of-pipe equipment that protect the environment. The micro-scale studies estimated a total direct cost of about € 50 billion in annualised terms additional to expenditures that might have been undertaken in the baseline scenario (see *section 3.6*). This corresponds to about 0.5% of the EU GDP in 2010. Firms (sectors) incur two third of these costs and households one third. The costs are unequally distributed across the member-states; some are affected more than others, as for example is the case of Portugal, Ireland, Greece and Spain. Also the sectors are unequally affected. In relative terms, electricity production, and agriculture and to a lesser extend energy-intensive manufacturing sectors bear higher costs.

Results

The direct environment-improving expenditures oblige the sectors and the households to pay more without getting back higher volumes that could magnify their production capacity or their well being. Ceteris paribus they have to reduce other expenditures, like purchasing production factors or buying consumer goods, which have a higher economic multiplier effect than the environmental expenditures. This is why net economic losses, in terms of GDP or total welfare, are observed. The indirect positive economic effects of the environmental expenditures, for example through the additional commodities that are necessary to build the environment-improving capital, are not enough to compensate the losses. However, this explains why the GDP or welfare losses are found to be lower (in absolute terms) than the total direct costs.

In production sectors unit production costs increase since firms bear additional charges for the environment without obtaining higher productivity or production capacity. Higher unit production costs cause domestic prices to rise. This implies further losses because the competitiveness of the sector is weakened vis-à-vis other sectors and countries that might have incurring lower environmental costs.

For households, the extra charges for the environment cause a reduction of the part of total disposable income that is allocated to the purchase of goods and services that relate to the household's total utility. They have to spend more on certain consumption categories (like housing, heating and electric appliances and cars) to improve their environmental quality without getting higher volume of these goods and without getting higher economic welfare. So the households are worse-off and also bear the negative effects due to higher prices in the supply of commodities. They see their real income diminished.

The goods and services needed to build the environmental improving technologies is addressed as additional demand to the domestic sectors and to imports. This additional demand partly compensates the drop of demand that is due to higher prices. They help keeping up demand, and the net effect on total domestic demand is uncertain in sign. However, the additional demand is addressed to sectors that may substantially differ from the sectors that were receiving the displaced demand. This effect in conjunction with the competitiveness effects explains why the sectors and countries are differentially influenced by the environment-improving actions. This is stated as distributional impact of the policy.

The rising of domestic prices implies a loss of competitiveness of domestic supply leading to higher imports and lower exports. The European Union having established a large single market bears moderate consequences from this loss of competitiveness, in condition that all environmental investments are uniformly undertaken in all the EU member-states. However, as mentioned above the situation of the environment being different in the members-states, the imposition of a uniform target leads to unevenly distributed costs to member-states. Through differentiated effects on competitiveness the country implications significantly vary. Regarding the effects on countries, the results show a clear correlation between the relative magnitude of the environmental expenditures, for example considered as percent ratio to GDP, and the amplitude of GDP losses. For example Greece, Ireland and Portugal facing high environmental expenditures as percentage of their GDP also bear high consequences in terms of GDP losses and price increases.

There are, however, factors related to the structure of trade that also influence the country-level implications. The trade structure combines with the sectoral changes effected by the environmental expenditures as for example for the equipment goods industry, which is generally favoured. Therefore countries like Germany having a strong position in trade for the goods of this sector obtain gains and partly compensate the other negative effects. Similar are the cases of Italy, UK, Sweden and Austria.

The sectors face different changes of the demand for their goods. Some sectors, as for example the equipment goods industry, face a drop of demand because of loss of competitiveness but also a rise of demand because of the additional needs of environment investments. The net effect is positive, except for transport equipment due to the reduction of car purchasing by households. Sectors that bear relatively higher environmental charges, like agriculture and energy-intensive manufacturing, are negatively affected, except if they face higher demand due to goods and services used in the environmental investment (for example the net effect on chemicals is found positive). Finally, the effects on other sectors are almost negligible, as for example for consumer goods and services. The distributional effects of the TD scenario are mostly significant, rather than it's overall impact.

This general conclusion, about the importance of distributional effects on some sectors and countries, may call upon accompanying policies. For example the case of the agriculture sector and the cohesion countries may require compensations to come along the policy involved in the TD scenario.

In aggregate macroeconomic terms the changes in the TD scenario induce a loss in GDP at the national and EU level. The results of the model show that mainly because of a general rise of the level of prices (by 0.50% for the consumers and by 0.16% for GDP at the level of the EU), all countries suffer from losses in GDP both in 2010 and in longer term. The loss at the level of the EU reaches 0.29 of one percent point, representing about € 30 billion per year. This is less than the direct environmental expenditures, which is about € 51 billion per year in annualised payment terms, indicating that not all of this amount is a loss for the economy, since additional goods and services have to be produced.

Private consumption (of households) is more affected than GDP, dropping by 0.50% at the EU level. The reasons relate to the drop of real wages rather than to the direct environmental expenses of households. Workers face higher consumption prices, because of the general rise of domestic prices as explained above, and do not see higher demand for labour because domestic production is under threat because of loss of competitiveness. They do decrease labour supply but this is not enough to reverse the downward pressure on their real salaries.

Despite the drop of private consumption, total domestic demand for goods increases (by 0.17% for the EU), because of the additional demand for goods required for the environment protection. Firms face lower business perspectives because of loss of competitiveness, but also are optimistic in some sectors as they see domestic demand rising. These effects compensate each other, resulting into a small decrease of total productive investments (-0.08% for the EU). Similarly total employment is found almost unaffected and even positively affected in some cases.

The effects of price increases are significant for foreign trade. Exports drop (in average by 0.27%) and imports increase (0.35%) leading to a deterioration of the current account and of course an improvement in the terms of trade, as export prices (driven by domestic production costs) increase more than average import prices. The effect on foreign trade is certainly moderated by the fact that most of the trade is taking place in the EU single market in which all EU trade partners are more or less equally affected by the environmental policy and the consequent price increases. The net losses are brought about mostly through trading with the rest of the World.

4.1.2 Macroeconomic Implications of the Accelerated Policy scenarios

Assumptions

The Accelerated Policies scenarios involve small direct environmental expenditures, related to the environmental areas other than carbon dioxide emissions, amounting at around € 8 to 10 billion in annualised terms or 0.1% of EU GDP (see *section 3.6*). This is mostly due to ancillary benefits (spillover effects) from climate change policy. The macroeconomic impacts of the direct costs associated to all areas other than carbon dioxide are small, since the direct costs are also small. The macroeconomic mechanisms and the explanations about the effects are similar to the TD case, but as mentioned they are significantly smaller in magnitude.

The macroeconomic implications of the Accelerated Policies scenarios are largely dominated by the effects of the actions undertaken in order to reduce carbon dioxide emissions from energy combustion, as compared with the baseline scenario.

The AP-No-Trade case imposing CO_2 emission reduction targets separately to each EU country and imposing all possible measures to take place in the EU territory naturally involves higher macroeconomic impacts that the AP-Full-Trade case. In the latter, the EU countries trade emission permits to each other and with the rest of Annex B countries in order to obtain least-cost and equalised marginal abatement costs. Consequently fewer emissions are reduced in the EU territory under the AP-Full-Trade case. A general finding from the GEM-E3 and PRIMES analyses is that the costs, both direct and indirect, grow non-linearly with the magnitude of emission reduction taking place in a country's frontiers. In all cases the countries, either collectively or individually, see an emission reduction constraint. The modelling approach corresponds to the assumption that each country is able to allocate the emission reduction effort at least cost to the sectors, including the households. This is of course idealised, compared to real world. Therefore possible policy implementation failures and transaction costs could lead to higher compliance costs than those estimated in this study.

It is also assumed that CO_2 emission reduction continues beyond 2010 so as to stabilise emissions at the level of 1990, continuously up to 2030. This implies that the agents cannot recover, after 2010, to their production or consumption structure as it was in the baseline scenario.

Results

The direct effect of the constraint on carbon dioxide emissions (or the restrictions on the distribution of emission permits) is through substituting away from fossil energy and in general improving the productivity of energy or the marginal utility from energy. This acts in favour of other production factors including labour[1], capital and non-energy intermediate consumption. It also acts in favour of consuming non-energy goods and services, as also in the case of households. In general low or zero carbon-intensive commodities and factors are favoured.

The substitutions cannot be perfect given the technical production possibilities and the preferences of the consumer. Therefore the firms bear higher costs, domestic prices rise and the consumers are obliged to consume less at given level of income. Compare to the baseline economic equilibrium, the implied loss of efficiency in production and loss of welfare in consumption explain why the emission restriction cause a global GDP loss to the economy. The effects are differentiated by sectors and country because the substitutions that favour low or zero carbon-intensive commodities are unevenly distributed and have non-uniform implications. This explains why the distributional effects (who gains and who loses) of the emission restriction are very important.

Despite trading and restructuring within the EU, caused as a result of the substitutions triggered by the emission restrictions, a general rise of domestic prices cannot be avoided. The resulting increase of domestic prices is far below 1% except for electricity (more than 3%). Energy intensive industries are more affected than other sectors; for example the industry of metals face costs higher by 1.5% and other energy intensive industries faces increases of 0.5%. The costs of using energy increases for all sectors, ranging from 5% (manufacturing) to more than 20% in the industry of metals. This undermines the commercial competitiveness of the EU with the rest of the World, at least in relation to those trade partners that do not undertake emission reduction (non Annex B) or might need lower effort to meet their targets (part of Annex B). Consequently, imports of non-energy commodities from the rest of the World tend to increase and exports to the rest of the World diminish. In reality this might reflect partly relocation of some of the energy-intensive industries from the EU to other countries (e.g. non Annex B).

The general implication of the above is a drop of domestic production and GDP in the EU. The results of the model indicate that in the case of AP-full-trade the GDP loss for

[1] Other exercises with GEM-E3 have shown that accompanying measures such as lowering the social security costs of employers would lead to higher substitutions in favour of labour and to higher demand for labour.

the EU as a whole is 0.11 of one percent (€ 11.6 billion, in 2010). The same loss continues beyond 2010 as a consequence of continued emission reduction effort. Both domestic demand and exports drop (by 0.22%) as a consequence of competitiveness weakening. The effects on domestic demand are also due to the decrease of private consumption because real salaries fall, as workers in the labour market cannot fully recover the losses from the eroding real wages resulting from the general rise of domestic prices.

Under the AP-full-trade case, the EU is purchasing emission permits from the rest of Annex B countries, mainly from Russia and Ukraine. The value of this purchasing is about € 4.3 billion which is considered as an additional loss of wealth for the EU. So the total welfare loss in 2010 is € 15.9 billion. However, the payments for the permits are not necessarily a loss for the EU: some of the sellers of the permits will use the earnings to buy commodities partly supplied by the EU and so some of the payments will be recycled in the EU economy. This effect is ignored in the analysis.

Imports obtain a higher market share in domestic economies, due the effects of domestic prices on competitiveness. However this occurs for the non-energy commodities. Energy imports decrease considerably because fossil fuels are substituted; hence demand for fossil fuel drops. Due to different carbon contents, the reduction of imports is substantially higher for coal than for gas and oil. The latter is less affected because of its almost exclusive use in transports. Beside the political consequences of lower dependence on imported fuels, resulted from climate change policies; there are benefits on the current account[2] and the balance of trade, compensating the losses in the area of tradable non-energy commodities.

The net effect on non-energy imports is uncertain in sign. On one hand the loss of competitiveness tend imports to increase, on the other hand the decrease of private consumption hence domestic demand imply lower import needs. Imports and domestic production are also affected by structural changes in the sectoral composition of economic growth, for example because of lower needs for energy intensive commodities and higher needs for equipment goods.

Investment is by far less affected than domestic production. The results show insignificant changes on total productive investment, even positive effects (higher investment) in non-energy sectors and electricity generation. On the contrary high negative effects are observed for the sectors producing fossil fuels, as these sectors see their market shrinking. The increase of productive investment is due to the substitution effects in favour of capital, as energy becomes more expensive. This enables higher accumulation of capital and acts as a moderator for the rise of costs and prices.

On the contrary, the purchase of durable goods by households is decreasing in volume, as a result of higher costs of using the durable goods (due to energy), the substitution effects in the structure of consumption by purpose (for example less cars as shifting towards public transports) and the general compression of real income.
Sectors that produce equipment and construct capital assets face higher demand for their products because of higher private investment but also face lower demand because of the reduction of demand for durable goods. As a consequence, manufacturers of transport

[2] If the payments for the permits are also added at the level of the current account then the changes from baseline become negative.

equipment see their activity shrinking, but manufacturers of other equipment see their business expanding.

The sectoral analysis shows that in all countries electricity and some of the energy intensive industries have a rather high potential for emission reduction, relatively to other sectors, so they are potential seller of permits if such a market was established. Less emission intensive industries (like services and consumer good industries) are less affected and even expand their market shares. Households however are among those that are mostly affected in economic terms. This relates to the reduction of income and private consumption as mentioned. In policy terms these results would be even more pronounced if the analysis could distinguish social classes: poorer classes would be significantly more affected than richer ones. This result calls upon accompanying policies to alleviate the social implications of the emission reduction policy.

The AP-No-Trade case is generally considerably less efficient than the trading case because, as mentioned, the marginal cost of emission abatement grows non-linearly with the magnitude of emissions abated. Although AP-No-Trade case undertakes emission reduction within the EU territory that is double than the AP-Full-Trade case, the macroeconomic implications are in rough terms higher than double.

The model results indicate that in the AP-No-Trade case the loss of GDP is up to 0.23% in 2010. Costs induced by substitution away from carbon intensive fuels lead to a general rise of prices (0.11% for GDP deflator and 0.62% for consumer price index). The cost of domestic production increases by about 0.4% in the non-energy intensive sectors, by 1 to 3% in energy intensive sectors and by 8 to 10% in power generation. Households face shrinking of their real income so they consume less, leading to a fall of private consumption by -0.6%. As also domestic production drops, domestic demand is found lowered by -0.55%.

The domestic economies weaken in competitiveness so they lose some of their market shares. Exports fall by -0.5%. On the contrary, imports of non-energy goods tend to increase but because of the drop of domestic demand, the net result is slightly negative (-0.1 to -0.2%). Imports of energy considerably decrease as for example for coal (-35%), oil (-7%) and even for gas (-4%) despite substitution in favour of gas (because total energy needs reduce as well). Total energy consumption decreases by about -8% in 2010 from baseline.

The above changes in foreign trade, mainly because energy imports decrease, lead to positive effects on current accounts and the terms of trade.

Induced by the substitution effects, private investments are maintained almost at their baseline level (-0.04%). This is beneficial for some of the equipment goods sectors selling goods for building capital.

The macroeconomic assessment shows different implications for the EU member-states. Part of this is due to the particular allocation of the emission reduction effort as decided in the EU Burden Sharing Agreement. Of course the evaluation is based on how the model estimates both the baseline developments and the marginal abatement cost curves. These estimates do not necessarily coincide with the perceptions the member-states had when concluding the Burden Sharing Agreement. The differences are also due to the energy structures, since some member-states have been in 1990 far more carbon-intensive than others.

The analysis shows that mainly the Netherlands (-1.14% loss of GDP), Belgium and secondarily Denmark, Sweden and UK bear losses that are higher than the EU average. The other countries are better off, in particular Spain, Italy and France. The mechanism is complex and the country results should not be attributed only to the Burden Sharing Agreement. The indirect effects of sectoral changes through intra-EU trade are significant. This explains why, despite bearing higher domestic costs, some countries like Italy and Spain even reach gains in terms of GDP, which are due to the new allocation of non-energy intra-EU trade. The sectoral and trade changes are such that these countries reinforce their market position in the sectors of consumer goods, market services and agriculture. Through the expansion in these sectors they overcompensate the losses in other sectors.

4.1.3 Summarising the results

The Technology Driven Scenario conveys significant environmental charges to the economic sectors. These lead to higher prices and a fall of domestic activities, hence a GDP loss. The substitution effects are rather small; however there are some gains for some sectors, as for example the equipment good industries. The costs are rather high and accompanying policies, for example for the agriculture sector, might be necessary to alleviate some of the impacts.

The Accelerated Policies Scenarios are fully dominated by the compliance to CO_2 emission reduction targets of Kyoto. The sectors also bear higher costs, prices rise and again competitiveness losses are experienced. However, in this case substitution effects are dominating having complex effects on the distribution of wealth between sectors and countries. In general, imported energy fuels are substituted for domestically produced commodities, in particular in favour of equipment goods. This partly compensates the negative effects on domestic activities, keeping up employment, investment and the terms of trade.

The analysis has shown clear benefits from trading CO_2 emission permits in the case of Accelerated Policies Scenario, in particular among the Annex B countries but also within the European Union. The macro economic consequences are considerably moderated and the GDP losses are rather small when full trading is established. However, this conclusion does not takes into account the possible costs of a real-world permit trading system, as for example transaction costs, impossibility to involve all sectors, failures and possible oligopolistic situations. The costs are lower in case of full trading because fewer carbon dioxide emissions are abated in the EU territory and because the allocation within the EU is more efficient. However abating fewer emissions in the EU implies lower spillover effects, hence lower benefits, in the environmental areas other than climate change.

The tables below summarise the main findings:

Table 4.1.1 Summary of Macroeconomic Aggregate Effects in % change from baseline in 2010.

Macroeconomic indicator	AP-No-Trade	AP-Full-Trade	TD Scenario
GDP in 2010	-0.23	-0.11	-0.29
GDP long term	-0.23	-0.12	-0.21
Employment (diff. In '000 persons)	140	50	47
Private Investment	-0.04	-0.02	-0.08
Private Consumption	-0.58	-0.23	-0.50
Domestic Demand	-0.55	-0.22	0.17
Exports in volume	-0.48	-0.22	-0.27
Imports in volume	-1.11	-0.43	0.35
Energy consumption in volume	-7.89	-3.60	-0.61
Consumers' price index	0.62	0.25	0.50
GDP deflator in factor prices	0.11	0.07	0.16
Nominal Wage rate	0.22	0.08	-0.73
Real wage rate	-0.40	-0.17	-1.23
Current account as % of GDP (diff.)	0.17	0.06	-0.13
Terms of Trade	0.18	0.11	0.28

Within the limitations of the study, there is clear evidence that AP-Full-Trade case is manageable in macroeconomic terms. There are however effects that might be still of concern, regarding sectors using energy intensively, like heavy industry and power generation.

Table 4.1.2 Summary of Macroeconomic Sectoral Effects in % change of Domestic Production in 2010 from baseline.

Sectors	AP-No-Trade	AP-Full-Trade	TD Scenario
Agriculture	-0.13	-0.14	-1.29
Coal	-21.57	-13.38	-0.90
Crude oil and oil products	-5.24	-2.07	-0.47
Natural gas	-5.57	-2.11	-0.82
Electricity	-1.85	-0.74	-1.11
Ferrous, non-ferrous ore and metals	-0.40	-0.24	-0.77
Chemical products	-0.24	-0.14	0.34
Other energy intensive industries	-0.13	-0.11	-0.20
Electrical goods	-0.10	-0.01	0.82
Transport equipment	-0.20	-0.16	-0.39
Other equipment goods industries	0.26	0.31	2.63
Consumer goods industries	-0.23	-0.15	-0.34
Building and construction	-0.05	-0.01	0.06
Telecommunication services	-0.10	-0.04	-0.04
Transports	-0.68	-0.13	-0.10
Credit and insurance	-0.11	0.00	0.72
Other market services	-0.17	-0.07	-0.11
Non market services	-0.13	-0.05	-0.03

Table 4.1.3 shows the GDP losses for each environmental issue[3]. These results will be used as input for the cost-benefit analysis of Section 4.3. Table 3.6.1 provides comparable information on direct costs.

Table 4.1.3 Macroeconomic effect on GDP per environmental issue in 2010, expressed in billion €$_{97}$ per year compared to the Baseline in 2010.

Environmental issue	AP-No-Trade	AP-Full-Trade	TD Scenario
Climate Change (CO_2)	-17.1	-9.2	n.a.
Climate Change (non CO_2 GHGs)	+0.2	+0.2	n.a.
Nuclear Risks	n.a.	n.a.	-0.6
Acidification (SO_2)	-0.9	-1.6	-2.8
Acidification (NH_3)	-0.8	-0.9	-8.5
Tropospheric Ozone (NO_x + VOC)	-2.7	-3.6	-14.6
Chemicals (PAH, Dioxins)	n.a.	n.a.	-0.2
Primary particulate matter	-1.0	-1.0	-1.1
Municipal Waste Management	+0.5	+0.5	-2.9
TOTAL	**-22**	**-16**	**-30**

[3] Only the TD scenario has been assessed completely by running the GEM-E3 model separately for each environmental issue. The macroeconomic assessment of the AP variants was limited to the impact of all issues together and of CO_2 policies only. Main reason was that the costs of CO_2 policies dominate the macroeconomic impacts in the AP scenarios. In order to estimate the GDP loss of new policies in the other areas, a simple relation has been derived from the TD results (i.e., GDP loss = 0.6×direct costs). This factor has been applied for the AP variants (except for CO_2 policies).

4.2 Benefits

Main findings

- Total benefit estimates of the No Trade and Full Trade variants of the Accelerated Policy scenario are roughly the same. Inclusion of secondary benefits raises the benefit estimates for No Trade and Full Trade variants from € 45 and 49 billion respectively, to € 73 and 70 billion respectively;
- emission trading of greenhouse gasses lowers the total primary and secondary benefit estimate (about € 3 billion);
- total benefits of a scenario where all available technology is implemented are about 40%higher than a scenario with - more modest - accelerated policies;
- major monetary benefits can be expected for acidification, nuclear accident control, human health and air quality and tropospheric ozone, and
- premature mortality valuation remains a controversial area of valuation. This study uses both the VOSL and VOLY approach to premature mortality. Benefits estimates using the VOSL approach are about 65% higher than estimates using VOLY. The overall conclusions with respect to benefits estimates (i.e. ranking of the scenarios and variants) are <u>not</u> affected by the estimates used for premature mortality.

4.2.1 Accelerated policy scenario

Climate change

Primary benefit estimates
There are two variants of the AP scenario for climate change: 'No Trade' (NT) and 'Full Trade'(FT). It is important to recall that both variants achieve the same global, greenhouse gas emissions reduction target. Thus, given that the climate change impact of greenhouse gases is not affected by the location they are emitted from, the primary benefits to the world of the 'No Trade' and 'Full Trade' variants are the same. By subtracting the 'No Trade' 2010 damages from the Baseline, the primary benefit to the world of the AP scenario is given at some € 3.7 billion, with a range of € 1.2 - 8.5 billion.

The primary benefit estimates are based on reduced environmental impacts due to reductions in emissions of CH_4, N_2O and CO_2 only. They are calculated using the mean monetary unit damage values estimated by Fankhauser (1995), which include damage to drylands, wetlands, ecosystems, agriculture, forestry, energy, water sector, amenity, human health and coastal regions.

Secondary benefit estimates
Meeting the Accelerated Policy scenario targets will generate large secondary benefits, mainly due to reductions in emissions of SO_2, NO_x (and thus reductions in concentrations of secondary aerosols) and primary particulate matter. There may also be reductions in heavy metals, dioxins, furans and polyaromatic hydrocarbons.

Table 4.2.1 presents the 'No Trade' and 'Full Trade' secondary benefit estimates to acidification, tropospheric ozone and particulate matter. As would be expected the secondary benefits to the EU decline as the carbon trading with non-EU countries increases. For example, 'No Trade' secondary benefits are higher at € 23.7 billion than the secondary benefits due to 'Full Trade' scenario, given at € 16.6 billion, (both values assume premature mortality is valued with VOSL, assuming VOLY gives secondary benefits for NT/FT scenario as € 11.9, 7.9 billion respectively). The evidence suggests that cost savings to EU-15 from trading via the Kyoto flexibility mechanisms are substantial, at some € 7.9 billion[4] in 2010 alone. Thus, there is a trade-off between secondary benefits within the EU versus the cost advantage of trading.

The secondary benefit estimates are found by the following procedure:

i) estimate positive secondary benefits to acidification from SO_x and NO_x emissions reductions and negative secondary benefits to acidification from NH_3 emissions increase, i.e. the changes in emissions are valued with unit pollutant damage values established for acidification (see *Technical Report on Acidification, Eutrophication and Tropospheric Ozone);*
ii) estimate secondary benefits to tropospheric ozone, i.e. NO_x emissions reduction due to climate control are valued with average NO_x damage values established for tropospheric ozone (see *Technical Report on Acidification, Eutrophication and Tropospheric Ozone);*
iii) estimate secondary benefits due to primary PM_{10} and secondary aerosols reduction from climate change related measures. Here, benefits are measured as avoided cases of premature mortality and morbidity incidences, valued with the relevant value per incidence (VOSL-age adjusted, VOLY and values for morbidity effects). The secondary benefits due to measures that reduce secondary aerosols, however, are provided as an indication of their size only. This is because these values are already subsumed in the secondary benefits to acidification (see estimate i) above)[5].
iv) sum the secondary benefit estimates.

The lower and upper secondary benefit estimates for climate change presented in *Table 4.2.1* assume premature mortality is valued with VOLY and VOSL respectively.

Uncertainty and bias in the benefit estimates for climate change
The extent of uncertainty for climate change primary benefit estimates is large. The main areas of uncertainty are climatological i.e. the expected changes in global mean temperature and changes in temperature dependent factors such as sea level, precipitation, evaporation etc. The uncertainty continues in the estimation of the impacts to ecosystems, agricultural yields and human health. The reliability of the Fankhauser (1995) marginal damage values is measured by using the 90% confidence interval, this provides low and high marginal damage values around the mid value. The results given in *Table 4.2.1* show that AP scenario benefit estimates for climate change can be estimated to within a factor of roughly 2. Overall, the benefit estimates can be interpreted as an assessment of the order of magnitude only. As a cross-check for the reliability of these unit damage values, the benefit estimates are also calculated using the mean marginal damage values taken from Eyre et al.(1997), the results of which are shown as the upper values of the mid benefit estimates presented in *Table 4.2.1*.

[4] Cost savings from trading via the Kyoto flexibility mechanism are estimated as: 'No Trade' AP scenario welfare costs less 'Full Trade' AP scenario welfare costs, i.e. € 17.1 billion - € 9.2 billion , (see *table 4.1.3).*
[5] The SO_x and NO_x emissions data used in this study are reasonably consistent with the data used in AEA Technology (1999) study. This suggests the secondary benefit estimates to acidification could be justified.

Table 4.2.1 AP scenario benefits for each environmental problem.

Problem		*Primary benefit of AP scenario* $D_{BL} - D_{AP}$ *€ billion per year*			*Secondary benefit* SB_{AP} *€ billion per year*
		Low	*Mid*	*High*	
Climate change					
VOSL	NT	*1.2*	*3.7*	*8.5*	*20.5*
	FT	*1.2*	*3.7*	*8.5*	*13.4*
VOLY	NT				*11.5*
	FT				*7.5*
Acidification					
VOSL	NT	*5.6*	*21.7*	*83.1*	*7.1*
	FT	*6.5*	*25.2*	*96.6*	*7.8*
VOLY	NT	*3.6*	*14.0*	*53.8*	*1.6*
	FT	*4.2*	*16.3*	*62.5*	*1.7*
Tropospheric ozone					
VOSL	NT	-	*5.6*	-	-
	FT	-	*5.7*	-	-
VOLY	NT	-	*0.7*	-	-
	FT	-	*0.7*	-	-
Waste management					
AP 1 (with source reduction of waste)			*8.7*	-	*0.4*
AP 2 (w/o source reduction of waste)			*7.2*	-	*0.4*
Chemicals and particulate matter					
VOSL	AP	-	5.3	19.0	-
VOLY	AP	-	3.1	13.9	-
TOTAL Primary Benefit*				**TOTAL Primary and Secondary Benefit****	
VOLY/VOSL	NT		30.2 / 45.0	VOLY/VOSL NT	43.6 / 73.0
	FT		32.5 / 48.6	FT	42.1 / 70.1

Where: '-' = not available, VOLY = value of life year; VOSL = value of statistical life, NT = 'No Trade' and FT = 'Full Trade' variants of the Accelerated Policy scenario.

Note: primary benefits for climate change are due to the control of CO_2, CH_4 and N_20 only. For acidification, primary benefits are due to control of SO_x, NH_3 and NO_x, for tropospheric ozone primary benefit estimates are due to the direct control of VOCs only and for chemicals and particulate matter, primary benefits relate to the end-of-pipe measures (e.g. filters), which reduce concentrations of primary PM_{10}.

Secondary benefits for climate change are due to reductions in acidification, tropospheric ozone and particulate matter (through the reduction of primary PM_{10} and secondary aerosols). The acidification secondary benefit estimates are due to reductions in tropospheric ozone and particulate matter (due to reduction of primary PM_{10} only, this is because the benefits of reduced secondary aerosols are already subsumed in the overall primary benefits estimate for acidification). The secondary benefits of waste management are to climate change only.

* Total primary benefit estimates, NT/FT values assume Waste management AP with source reduction.
** Total primary and secondary benefit estimates assume total primary benefits plus secondary benefits of strategies to control climate change, acidification and waste management.
Lower / upper total benefit estimates assume premature mortality is value with VOLY, VOSL respectively.

The primary benefit estimates may be biased downwards due to the omission of avoided damage to other sectors dependent on climate, such as tourism, transport, construction and insurance. But they may be overstated due to the omission of adaptation strategies (Mendelsohn and Neuman, 1999).

The secondary benefit estimates to acidification, tropospheric ozone and particulate matter follow the primary benefit assessment procedures for these issues described in the relevant sections below. Areas of uncertainty and potential bias associated with the component parts of the climate change secondary benefits estimates are also discussed there. Where possible, we present the ranges for the component parts of the secondary benefit estimates, in this section. Secondary benefits due to acidification only for the NT variant are € 13.1 billion with a range of € 3.4 - 50.3 billion, where premature mortality is valued with VOSL, whilst for FT variant secondary benefit estimates are, € 7.3 billion with a range of € 1.9 - 28.1, where premature mortality is valued with VOSL. Assuming VOLY reduces the secondary benefit estimates to acidification only to, NT € 8.5 billion (€ 2.2 - 32.7 billion) and for the FT variant, € 4.7 billion (€ 1.2 - 18.2 billion).

Secondary benefit estimates to tropospheric ozone only are, for the NT variant € 2.8 billion and for the FT variant, € 1.5 billion, where premature mortality is valued with VOSL. Assuming VOLY reduces the secondary benefit estimates to tropospheric ozone to, NT € 0.4 billion and FT € 0.2 billion. Unfortunately, due to information limitations, it is not possible to test the reliability of the secondary benefit estimates for tropospheric ozone by the usual method of confidence intervals. As an alternative, the results are tested by cross-checking with other studies estimating benefits due to reduced tropospheric ozone (see tropospheric ozone below).

The secondary benefits due to reductions in primary PM_{10} are, € 4.6 billion, assuming premature mortality is valued with VOSL and € 2.6 billion assuming VOLY. The secondary benefits due to reductions in secondary aerosols are € 9.8 billion, where premature mortality is valued with VOSL and € 5.7 billion assuming VOLY, recall that these values are reported as an indication of their size only as they are already subsumed in the secondary benefits to acidification.

It is not possible to test the reliability of the secondary benefit estimates to particulate matter by the usual method of confidence intervals. As an alternative we test the reliability of the secondary benefits to particulate matter, by re-estimating the secondary benefits using the PM_{10} / health relationships of ExternE, European Commission, (1995b, 1998) and presented in AEA Technology (1999), combined with the VOSL / VOLY and values for morbidity effects based on work by Markandya (European Commission, 1998). The results are, i) benefits due to reduced primary PM_{10} are € 16.4 billion (VOSL) or € 12.0 billion (VOLY), and ii) benefits due to reduced secondary aerosols are € 35.3 billion (VOSL) or € 25.7 billion (VOLY). These estimates are roughly four times greater than the main secondary benefit estimates to particulate matter presented earlier. This may be explained by greater incidences of premature mortality and morbidity, both of which are valued more highly than our main estimates.

Total secondary benefit estimates due to climate change measures may be an underestimate due to the omission of some important effects, such as benefits due to reductions in $PM_{2.5}$, heavy metals, furans, dioxins and polyaromatic hydrocarbons.

There are two important issues to consider with the secondary and primary benefits of climate change measures. Firstly the time horizon, this is important because the secondary benefits will take place closer to the present, more or less in parallel with the costs of mitigation rather than decades or centuries into the future as with the primary benefits. The second issue is that since most secondary pollutants of greenhouse gas control policies (i.e. SO_x, NO_x) are subject to independent policies, emissions are expected to fall over time, this means that climate change policies will secure further but smaller secondary benefits in the future.

In response to the overall uncertainty associated with the secondary benefit estimates, for purposes of cost benefit analysis, we compare welfare costs with, i) primary benefits only, and ii) primary and secondary benefits.

Acidification

Benefit estimates

The 'No Trade' (NT) and 'Full Trade' (FT) emission reduction targets are achieved through the direct control of the acidifying pollutants and the measures targeted at the climate change problem. The primary benefit estimates reflect the benefits due to the direct control of SO_x, NO_x and NH_3 only. As expected, the primary benefit estimates are greater for the FT scenario than the NT scenario due to greater direct control of acidifying pollutants in order to meet the same acidifying targets as the NT scenario.

The direct control of acidifying pollutants gives secondary benefits to tropospheric ozone (due to reduction of precursor pollutant NO_x) and particulates (due to reduction of i) primary PM_{10} and ii) reduction of NO_x and SO_x emissions which consequently give reductions in secondary aerosols). The secondary benefits to tropospheric ozone due to the direct control of NO_x emissions are found by valuing NO_x emissions reduction with the unit damage values relevant for tropospheric ozone. The secondary benefits to particulates are calculated by estimating the number of premature mortality and morbidity incidences avoided and valuing each with the relevant value for premature mortality and morbidity effects.

The primary benefit estimates are based on the average unit pollutant damage values drawn from the AEA Technology (1999) study of pan-European benefits from reductions in acidifying emissions. The study used is judged to be the best available. The benefit estimates for acidification include: avoided damage to human health (acute mortality and morbidity due to NO_3 and SO_4 aerosols, SO_2)[6], avoided damage to materials (due to SO_2) and the loss of fertilisation impact to agriculture (due to SO_2 and N).

Uncertainty and bias in the benefit estimates

The main areas of uncertainty associated with the primary benefit estimates are identified as follows:

- the approach to premature mortality valuation;
- use of UNECE average unit damage values estimated from AEA Technology (1999). UNECE values will be lower than EU unit damage values since UNECE includes EU and poorer economies in transition;
- comission of impacts on ecosystems, cultural assets (within materials damage) and visibility impacts. The impacts of NH_3 emissions relate only to health and agriculture, i.e. impacts to ecosystems through eutrophication are excluded. The positive dampening effect of SO_2 on global warming is also omitted, and
- use of average unit pollutant damage values rather than the relevant marginal damage values.

[6] It is important to note that the AP scenario benefit estimates for acidification include the avoided impacts to health due to reduced secondary aerosol emissions.

The omission of impacts with potentially large benefits from the control of acidifying pollutants (e.g. ecosystems) and the use of UNECE unit damage values suggests that the overall direction of error in the benefit estimates is biased towards underestimation. On the other hand, benefits to health dominate the results. In response to the fact that one of the main areas of uncertainty is due to the treatment of premature mortality valuation, benefit estimates are calculated using both the ‘value of life-year’ (VOLY) and the ‘value of statistical life’ (VOSL) approach. However, the VOLY estimates are themselves subject to unknown error due to the fact that they are not founded in sound economic theory. The relevant unit pollutant damage values for this study are marginal values, unfortunately these values are not known. The second best values are average unit pollutant damage values. But, we do not know whether the average values are greater or less than the relevant marginal values. Thus the direction of bias in the benefit estimates due to this type of uncertainty is unknown.

The reliability of the average damage values for the different pollutants is measured by using the 68% confidence limits around the mean values[7]. Low, mid and high benefit estimates are presented in *Table 4.2.1*, they suggest that the benefit estimates for acidification can be estimated to within a factor of roughly 4. Thus the results should be interpreted with caution and considered as an assessment of the order of magnitude only.

Table 4.2.1 presents the secondary benefits to i) tropospheric ozone and ii) particulate matter. The secondary benefits to particulate matter are due to reductions in primary PM_{10} emissions only. The secondary benefits from acidification related measures that reduce secondary aerosols are already subsumed in the primary benefit estimates for acidification presented in *Table 4.2.1*, due to the nature of the unit damage values used. In order to avoid double counting, the secondary benefits due to reduced secondary aerosols are therefore omitted from the total secondary benefits estimates.

The secondary benefits to tropospheric ozone only (due to the control of NO_x and VOCs) for the NT scenario are € 5.6 billion (VOSL) and € 0.7 billion (VOLY), and for the FT are € 6.3 billion or € 0.8 billion. The secondary benefits to particulate matter due to primary PM_{10} reduction only are € 1.5 billion (VOSL) and € 0.9 billion (VOLY). The reliability of these secondary benefits to particulate matter is tested by re-calculating the secondary benefits using the PM_{10} / health relationships of ExternE, European Commission, (1995b, 1998) presented in AEA Technology (1999), combined with the VOSL / VOLY and values for morbidity effects based on work by Markandya (European Commission, 1998). The secondary benefits due to reductions in primary PM_{10} become € 5.5 billion (VOSL) and € 4.0 billion (VOLY). These results are roughly four times greater than the main results used in *Table 4.2.1*.

The SO_2 and NO_x emissions data used in this study are reasonably similar to the data used in the AEA Technology (1999) study. Consistent SO_2 and NO_x emissions data indicate that the secondary benefits of reduced secondary aerosols subsumed in the overall primary benefit estimates for acidification could be justified. We indicate the size of the secondary benefits for reduced secondary aerosols as € 5.3 billion (VOSL) and € 3.1 billion (VOLY). Based on the same exposure response functions and premature mortality / morbidity valuations, the values become € 19.0 billion (VOSL) and € 13.9 billion (VOLY).

[7] 90% confidence intervals are not reported. The range of benefit estimates based on the 90% confidence interval is so large that it is questionable if a meaningful interpretation can be made from the results.

Total secondary benefits due to acidification related measures may be biased downwards due to the omission of benefits from reduced $PM_{2.5}$, heavy metals, furans and dioxins.

The areas of uncertainty and potential biases associated with the secondary benefit estimates to tropospheric ozone and particulate matter are identified below in the relevant sections.

Tropospheric ozone

Benefit estimates
The 'No Trade' and 'Full Trade' emission reduction targets for tropospheric ozone, are achieved through the direct control of VOCs and the climate change and acidification related measures that reduce NO_x, the precursor pollutants for tropospheric ozone.

The benefits of the AP scenario are measured in terms of avoided damage to crops and human health due to the control of NO_x and VOCs. Impacts omitted from the benefit estimates include damages to materials, forests, ecosystems, non-crop vegetation and biodiversity. The method is based on a modified extension of the Rabl and Eyre (1997) analysis and it makes use of average monetary damage values per tonne of NO_x and VOCs.

The primary benefit estimates for the 'No Trade' and 'Full Trade' variants of the AP scenario are due to the direct control of the precursor pollutant VOCs only. The secondary benefits from climate change are estimated for the NT and FT scenarios as € 2.8 and 1.5 billion respectively, while the secondary benefits due to the control of NO_x in acidification control are € 5.6 and 6.3 billion, for the NT and FT scenarios respectively. In other words, the total secondary benefits from climate change and acidification to tropospheric ozone are: NT € 8.4 billion (from € 2.8 + 5.6 billion) and FT: € 7.8 billion (from € 1.5 + 6.3 billion).

Uncertainty and bias in the benefit estimates for tropospheric ozone
The main areas of uncertainty are identified as follows:

- the treatment of premature mortality valuation;
- the epidemiological uncertainty for the statistical relationship between ozone and mortality. The approach taken in this study makes use of the APHEA (1996) Barcelona study. This selection can be disputed;
- omission of impacts to materials, forests, ecosystems, non-crop vegetation, biodiversity, and
- use of average damage values per tonne of NO_x and VOCs rather than the relevant marginal damage values.

In response to the first area of uncertainty, benefit estimates are calculated using both the 'value of life-year' (VOLY) and the 'value of statistical life' (VOSL) approach to premature valuation. As noted above, the VOLY estimates are themselves subject to unknown error due to the fact that they are not founded in sound economic theory.

On the basis that the statistical relationship between tropospheric ozone and mortality is too uncertain, when the benefit estimates for the AP scenario are calculated, excluding acute mortality, the results become: primary benefit estimates: NT and FT : € 0.6 - 0.6 billion, total secondary benefits from climate change and acidification: NT and FT variants: € 0.8 - 0.8 billion.

The omission of some important impacts suggests that the final benefit estimates may be biased towards underestimation.

Due to the absence of information, it has not been possible to measure the reliability of the benefit estimates in the usual fashion, i.e. through the use of confidence intervals to establish the low and high benefit estimates. As an alternative, in order to check the robustness of the total primary benefits plus the secondary benefits of climate and acidification control, they are cross checked according to:

i) yield loss estimates based on dose-response functions for crop damage. This approach estimates EU15 crop damage, in 1990, at € 5.7 billion, whilst the modified Rabl-Eyre approach suggests crop damages in 1990 were € 4.9 billion.
ii) AEA Technology (1998) analyses avoided crop damage for the control of nitrogen and nitrogen-related compounds. Their results for avoided damages to crops in the EU15 are greater than those estimated by the modified Rabl-Eyre approach, by a factor of roughly 3.
iii) IIASA et al (1998) give a more detailed analysis of the economic costs and benefits of air quality targets for ozone. Based on their analysis of the 12/2 scenario, which secures a 65% gap closure on AOT 60 and a 35% gap closure on AOT 40 (the scenario adopted by UNECE) the unit damage values for NO_x are greater by a factor of 3. This may be explained by the inclusion of a greater number of impacts such as materials, any N-fertilisation effects, additional impacts to human health, crops and forests.

The comparison of the modified Rabl-Eyre (1997) benefit estimates for avoided crop damage with the initial cross-check suggest that there is broad consistency across the results for damage to crops due to low level ozone. However, based on the other two cross-checks we conclude that total benefit estimates presented in *Table 4.2.1* may be underestimated by a factor of roughly 3.

Waste management

Primary benefit estimates
The primary benefit estimates for the AP scenario are measured as the avoided environmental damage of waste going to different disposal routes. Benefit estimates are calculated using average damage values per tonne of waste going to different disposal routes, adapted from EC (1996).

Benefit estimates for the AP scenario with source reduction of waste are greater than the AP scenario without source reduction of waste because it includes the benefits of avoided waste disposal and the benefits of avoided virgin materials production. Interestingly, the AP scenario with source reduction of waste benefit estimates are less than for the Technology Driven scenario with maximum composting and recycling, estimated to be € 10.3 billion. This can be explained by the distribution of waste assumed for the different scenarios, where more waste is sent to incineration and less waste is sent to recycling in the AP scenario with source reduction of waste than the Technology Driven scenario with maximum compost and recycling. This means fewer tonnes of waste go to the disposal method which gives environmental benefits (rather than costs) per tonne, i.e. recycling.

Secondary benefits

The AP scenario for waste management generates considerable secondary benefits in terms of reduced greenhouse gas emissions. The reduction of biodegradable waste to landfill will reduce methane emissions from landfill sites, estimated to be approximately 65 million tonnes of CO_2 equivalent emission reduction. The secondary benefits to climate change from reduced methane emissions at landfill sites in 2010, are valued at € 440 million, with a range of € 140 - 1020 million.

Uncertainties and bias in the benefit estimates for waste management
The main uncertainties in the primary benefit estimates relate to:

- waste arisings and the distribution of waste over the different disposal routes, and
- the average monetary damage values per tonne of waste to the different disposal routes. Due to insufficient information it is not possible to check the reliability of the benefit estimates in the usual manner using confidence intervals around the mean values. However, it is held that the EC (1996) study is the best available.

The direction of bias in the benefit estimates, due to both types of uncertainty is unknown.

Chemicals and particulate matter

For a discussion on the economic analysis of chemicals see *Section 4.3.2*. This section considers particulate matter only.

Benefit estimates for particulate matter
The concentration reduction targets for the scenarios are achieved through i) the direct control of primary PM_{10}, ii) climate change and acidification related measures that reduce primary PM_{10} and iii) climate change and acidification related measures that reduce emissions of SO_x and NO_x which reduce the concentration of secondary aerosols. The benefit estimates for reduced PM_{10} levels are measured in terms of avoided human health impacts, including both premature mortality and morbidity.

The primary benefit estimates for PM_{10} are due to the direct control of primary PM_{10} i.e. end-of-pipe measures such as filters. The benefits of reduced primary PM_{10} and secondary aerosols from climate change and acidification related measures are added to the secondary benefits of climate change and acidification respectively. The distribution of benefits due to primary PM_{10} reduction between these two sources is based on the emission reduction of primary PM_{10}, i.e. 75% to climate change and 25% to acidification. The distribution of the benefits due to reduced secondary aerosols between the two sources is based on the emission reduction of NO_x and SO_x, i.e. 65% to climate change and 35% to acidification.

Uncertainties and bias in the benefit estimates for particulate matter
The main areas of uncertainty in the primary benefit estimates for reduced PM_{10} levels are:

- the relationships between exposure to PM_{10} and premature mortality and morbidity;
- relationships between exposures to $PM_{2.5}$ and premature mortality and morbidity;
- the treatment of premature mortality valuation;

- morbidity valuation estimates, and
- omission of impacts to visibility.

As a check for the number of morbidity incidences due to PM_{10} exposure, two sets of PM_{10} / health relationships (exposure response functions) are used. The results presented in *Table 4.2.1* are based on functions derived by Maddison et al (1997) in his meta-analysis of several epidemiological studies from North America, South America and Europe. However, the benefit estimates are also calculated in the style of AEA Technology (1999), they make use of exposure response relationships given in the ExternE Project (European Commission, 1998). The results are greater than those in *Table 4.2.1* at € 13.9 - 19.0 billion, where the low values assume VOLY and the high values assume VOSL (unadjusted for age). The estimates are greater because they include greater incidences of premature mortality and chronic bronchitis and premature mortality is valued more highly.

24% of the anthropogenic PM_{10} emissions reductions used in this study are due to particles smaller than 2.5μg/m^3, i.e. reductions in $PM_{2.5}$. Although it is widely believed that smaller particles are more harmful than bigger ones, the exposure response functions showing the relationship between exposure to $PM_{2.5}$ and premature mortality and morbidity are not clearly defined. Thus we do not estimate the benefits of avoided premature mortality and morbidity due to reductions in $PM_{2.5}$. We assume the 24% is PM_{10}.

In response to the third area of uncertainty, benefit estimates are provided using both the VOLY and VOSL (adjusted for age[8]) approach to premature mortality. With regard to the uncertainty of the valuation of morbidity incidences, two sets of morbidity values are used, the main results are based on values presented in Pearce et al (1996) adjusted for European values, however, we also make use of morbidity values presented in AEA Technology (1999) based on the work by Markandya (European Commission 1998). For example, for the AP scenario, primary benefit estimates given in *Table 4.2.1* are € 5.3 billion (VOSL adjusted for age) and € 3.1 billion (VOLY). Primary benefit estimates based on AEA Technology (1999) are, € 19.0 billion (VOSL) or € 13.9 billion (VOLY). These estimates are roughly four times greater and can be explained due to greater incidences of mortality and chronic bronchitis.

The omission of PM_{10} impacts to visibility and the benefits of reduced $PM_{2.5}$ suggests the benefit estimates are biased towards underestimation.

4.2.2 Technology driven scenario

Table 4.2.2 gives the benefits of achieving the Technology Driven scenario targets for acidification, tropospheric ozone, waste management, particulate matter and nuclear accidents. Benefits are measured as the difference between the value of the damage in the baseline for the target year 2010, less the value of the damage in the TD scenario.

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[8] Maddison et al (1997) suggest that pollution-related mortality affects largely the elderly (over 85% of premature deaths are in the over 65 group). We assume values of risk aversion are lower for this age group at around 70% of the prevailing risk values. This reduces the VOSL to € 2.32 million (1997 prices).

Table 4.2.2 TD scenario benefits for each environmental problem.

Problem	*Primary benefit of TD scenario* $D_{BL} - D_{TD}$ € *billion*			*Secondary benefit* SB_{TD} € *billion*
	Low	*Mid*	*High*	
Acidification				
VOSL	*15.2*	*58.9*	*226.0*	*12.6**
VOLY	*9.9*	*38.1*	*146.0*	*1.7**
Tropospheric ozone				
VOSL	-	*9.1*	-	-
VOLY	-	*1.2*	-	-
Waste management				
Maximum compost and recycling		*10.3*	-	-
Maximum incineration		*-2.8*	-	-
Particulate matter				
VOSL	-	*(24.2)*	-	-
VOLY	-	*(14.0)*	-	-
Nuclear risks				
VOSL	-	*6.8*	-	-
TOTAL Primary benefit (VOSL)			**TOTAL Primary and secondary benefit (VOSL)**	
TD (with max compost and recycling)		*85.1*	TD (with max compost and recycling)	97.7
TD (with max incineration)		72.0	TD (with max incineration)	84.6

Where '-' = not available, VOLY = value of life year, VOSL = value of statistical life, TD = Technology Driven scenario, D_{BL} = damage in baseline, D_{TD} = damage in TD scenario.

Note: Total benefit estimates assume premature mortality is valued with VOSL only. Total benefit estimates are the sum of benefits from acidification, tropospheric ozone, waste management and nuclear accidents only. Particulate matter is excluded to avoid double counting the benefits of reduced secondary aerosols (recall that primary benefit estimates for acidification includes the benefits of reduced secondary aerosols). This suggests total TD benefits may be underestimated due to exclusion of benefits of i) direct control of primary PM_{10} (due to the nature of the benefit estimation for the TD scenario it is not possible to estimate benefits of primary PM10 and secondary aerosols separately), and ii) acidification related measures that reduce primary PM_{10}.

Waste management benefit estimates for TD with maximum incineration are negative. This suggests that achieving such targets could be a cost to the environment (for further discussion see *section 4.2.1* on waste management). Nuclear risks procedure described in *section 4.3.2* on nuclear risks.

*Secondary benefits of acidification are to tropospheric ozone only. Due to data limitations it is not possible to estimate the secondary benefits to human health and air quality.

Acidification benefit estimates for the Technology Driven scenario are far greater than the Accelerated Policy scenario: at € 10 - 38 - 146 billion (low-medium-high estimates) when premature mortality is valued with VOLY and € 15 - 59 - 226 billion when premature mortality is valued with VOSL (see *Table 4.2.2*).

For tropospheric ozone the overall benefit estimates for the Technology Driven scenario are € 21.7 billion, where premature mortality is valued with VOSL, or € 2.8 billion (assuming VOLY. These values are a combination of acidification related measures that reduce NO_x, estimated to be € billion 12.6 (VOSL) or € 1.7 billion (VOLY) and direct measures that reduce VOCs, € 9.1 billion (VOSL) or € 1.2 billion (VOLY).

As discussed earlier the benefits of the waste management Technology Driven scenario with maximum compost and recycling are € 10.3 billion. Moving from the Baseline to the Technology Driven scenario with maximum incineration yields negative benefits at € -2.8 billion, i.e. it is a cost to the environment to move to this scenario. This apparently counter-intuitive result is explained by the distribution of waste over the different disposal routes in the two scenarios. For example, it is assumed that all waste to landfill in the Baseline is re-directed to incineration in the TD scenario with maximum incineration.

This means over five times as much waste is incinerated in the TD scenario with maximum incineration, compared to the Baseline. The unit damage value for a tonne of MSW to incineration is almost double the unit damage value of a tonne of MSW to landfill. Thus, the total environmental damage in 2010 for the TD (maximum incineration) scenario is greater than for the Baseline. Thus, moving to the TD (maximum incineration) scenario from the Baseline yields damages (i.e. costs) rather than avoided damages (i.e. benefits).

4.2.3 Total benefit estimates

The benefit estimates for the AP scenarios across the environmental problems are summed. Total mid primary benefit estimate for the 'No Trade' variant of the AP scenario is € 45.0 billion (using VOSL based benefit estimates this is equivalent to, 3.7 + 21.7 + 5.6 + 8.7+ 5.3). Total mid primary benefit estimate for the 'Full Trade' variant is € 48.6 billion (using VOSL based benefit estimates this is found by: 3.7 + 25.2 + 5.7 + 8.7+ 5.3). Note that both values assume an AP scenario with source reduction of waste for waste management. Total mid primary benefit estimates for the Technology Driven scenario are based on the sum of benefits from acidification, tropospheric ozone, waste management and nuclear accidents[9], they are roughly € 72.0 - 85.1 billion (i.e. 58.9 + 9.1- 2.8 + 6.8, or 58.9 + 9.1 + 10.3 + 6.8).

Total primary and secondary benefit estimates for the 'No Trade' variant are some € 73.0 billion and for the 'Full Trade' variant some € 70.1 billion. Both estimates assume primary benefits plus secondary benefits from climate change control, acidification and waste management, and assume premature mortality is valued with VOSL. For the TD scenario we assume the primary benefits plus the secondary benefits for acidification, this gives roughly € billion 84.6 - 97.7, where the low/high estimates assume for waste management, maximum incineration benefits/maximum compost and recycling benefits, respectively.

[9] To avoid double counting the benefits of reduced secondary aerosols, the TD scenario benefits for particulate matter are not included in the overall TD total. This suggests TD total benefits may be underestimated due to exclusion of benefits from, i) the direct control of primary PM_{10} reduction and ii) acidification related measures that reduce primary PM_{10}.

4.3 Cost benefit assessment

Main findings

- 'No Trade', 'Full Trade' variants of the AP scenario and the Technology Driven scenario all pass the cost benefit test even when only primary benefits are compared to costs. The benefit cost (B/C) ratios increase if the secondary benefits are included;
- the 'Full Trade' variant increases the total B/C ratio due to substantial resource cost savings. The Kyoto policy is far more likely to pass a benefit cost test with trading or use of the flexibility mechanism than without;
- the controversy about the approach to valuation of premature mortality has no effect on the cost benefit test. Total B/C ratios remain above unity for No Trade, Full Trade and the Technology Driven scenarios with VOSL or VOLY, and
- many environmental issues cannot be adapted easily to scenario analysis and cost benefit analysis, such as biodiversity loss, coastal zones, water management, chemicals, soil degradation and noise nuisance. There are however potentially significant benefits from the control of these problems. Further research is required in these areas.

4.3.1 Benefit cost ratios

This section compares the benefits with the costs of environmental control for each problem. For reasons of clarity we present benefit cost ratios based on the welfare costs only. Welfare cost is the combined loss of producer and consumer surplus from meeting scenario targets and it is measured as GDP loss. Welfare costs are presented in *Table 4.1.3*. The direct costs (otherwise known as the technology-based costs) of moving from the Baseline to the AP and TD scenarios are reported in *Table 3.6.1*. Direct costs tend to provide an upper limit on costs since, typically, behavioural changes can be made which avoid full adoption of 'end of pipe' abatement technology. Consequently a comparison of benefits with direct costs tends to be a 'worst case scenario', where possible, B/C ratios based on direct costs are presented in the *Technical Reports*.

Table 4.3.1 assembles the B/C ratios for the transition from Baseline to Accelerated Policy scenarios. The ratios offer some guidance on priorities, although there is no suggestion that issues with lower B/C ratios are not deserving of further policy attention (provided the ratio exceeds unity).

B/C ratios are based on a comparison of: i) primary benefits with welfare costs and ii) primary and secondary benefits with welfare costs. The B/C ratios presented in *Table 4.3.1* assume benefits are based on the 'value of statistical life' (VOSL) approach to premature mortality, where relevant. B/C ratios that assume VOLY are discussed in the text. All costs and benefits are annual and relate to the year 2010.

Table 4.3.1 B/C ratios for the AP scenarios based on 'value of statistical life' (VOSL) approach to premature mortality.

Problem/scenario	benefits / welfare costs $B_{AP - BL} / C_{AP - BL}$ in 2010		
	Low	Mid	High
Climate change			
NT: PB	0.1	0.2	0.5
NT: PB and SB to EU15	-	1.4	-
FT: PB	0.1	0.4	0.9
FT: PB and SB to EU15	-	1.9	-
Acidification only			
NT: PB	2.2	8.3	31.9
NT: PB and SB to EU15		11.1	
FT: PB	1.8	6.8	26.1`
FT: PB and SB to EU15		8.9	
Tropospheric ozone			
NT: PB (VOCs only)	-	3.0	-
FT: PB (VOCs only)	-	2.3	-
Acidification and Tropospheric ozone			
NT: PB and SB	-	7.6	-
FT: PB and SB	-	6.2	-
Waste management			
AP with source reduction	-	-c	-
AP without source reduction	-	-c	-
Human health and air quality			
AP		5.3	19.0
TOTAL			
NT: PB	-	2.1	-
FT: PB	-	3.1	-
NT: PB and SB	-	3.3	-
FT: PB and SB	-	4.5	-

NT = No Trade variant of AP scenario, FT = Full Trade variant of AP scenario, AP = Accelerated Policy scenario, PB = primary benefits, SB = secondary benefits, '-' = missing ratios due to missing benefit estimates, '-c' = missing ratios due to negative costs.

Note: B/C ratios > 1 indicate recommended action is cost effective, whilst B/C ratios < 1 indicate costs outweigh benefits, the suggested action therefore does not pass the cost benefit test.

The caveats associated with the B/C ratios are as follows:

- not all benefits are estimated;
- there is uncertainty about the ranges of values;
- costs are difficult to estimate without detailed analysis of various policy packages (see below), and
- considerations other than economic efficiency are relevant to policy decisions and are not incorporated in B/C ratios.

Note, however, that the existence of uncertainty in the benefit and cost estimates does not make the exercise of limited value. Unless an alternative measure of 'output' or 'effectiveness' is defined and calculated, the environmental problems cannot be compared in the absence of money measures. In other words, failure to monetise benefits creates another, very different uncertainty, that arises when environmental issues cannot be compared at all.

Climate change

The No Trade and Full Trade variants of the AP scenario both pass the cost benefit test when primary and secondary benefits are compared with welfare costs. Despite the loss of some secondary benefits (since less emissions reduction takes place within the EU), emissions trading raises the benefit cost ratio due to substantial resource cost savings. This suggests, the Kyoto policy is more likely to pass a benefit-cost test with trading (or use of the flexibility mechanisms) than without trading.

Due to the uncertainty associated with the secondary benefit estimates, *Table 4.3.1* also presents B/C ratios based only on primary benefits. In both cases, the No Trade and Full Trade variants fail the cost benefit test. Assuming premature mortality is valued with VOLY the B/C ratios based on primary and secondary benefits are reduced and become 0.9 and 1.3 for the No Trade and Full Trade variants respectively.

Acidification

The B/C ratios reported for acidification are based on i) primary benefit estimates of reduced SO_x, NO_x and NH_3, and ii) primary benefits and secondary benefits to tropospheric ozone and particulate matter. The costs relate to costs of control for SO_x, NO_x and NH_3.

GHG emissions trading lowers the benefit cost ratio for acidification due to the increase in costs associated with the necessarily greater levels of direct control for the acidifying pollutants. Where B/C ratios assume welfare costs comparisons with i) primary benefits only and ii) primary and secondary benefits, mid B/C ratios for the No Trade and Full Trade variants of the AP scenario are 8.3 - 11.1 and 6.8 - 8.9, respectively. Even when benefits are compared to direct costs both variants pass the cost benefit test, for example mid B/C ratios for the No Trade and Full Trade variants are: 5.0 - 6.6 and 4.1 - 5.3, respectively.

Assuming premature mortality is valued with VOLY, B/C ratios fall only slightly, for example, mid B/C ratios for No Trade and Full Trade variants are between 65.4 - 6.0 and 4.4 - 4.9, respectively. When we assume benefits (based on VOLY) are compared to direct costs, the B/C ratios are further reduced but in both cases the scenarios pass the cost benefit test, for example, mid B/C ratios for the No Trade / Full Trade variants are, 3.2 - 3.6 and 2.6 - 2.9, respectively.

B/C ratios based on i) primary and ii) primary and secondary benefits compared to welfare costs for the TD scenario are 2.8 - 3.4. B/C ratios based on direct costs are reduced and become 1.7 - 2.1. Assuming VOLY, the B/C ratios based on welfare costs become, 1.8 - 1.9, whilst B/C ratios based on direct costs are 1.1 - 1.1.

Box 4.1: Benefits of the National Emission Ceilings Directive

The issue

The Baseline scenario used in this study assumes a continued implementation of existing and proposed EU policies as of August 1997. Thus, the 1999 National Emission Ceilings Directive (NEC) objectives for acidification and tropospheric ozone are not included in the Baseline scenario, but instead in the Accelerated Policy (AP) scenario. The assessment of the AP scenario assumes a specific ordering of policy implementation. In particular, it assumes that policies for climate change control are implemented first, followed by policies for other environmental problems. This is here referred to as policy order 1. This section considers the effects of changing the policy order, such that acidification control takes place first followed by policies for climate change control. This is defined as policy order 2. We expect the change in policy order to have the greatest effect on the magnitude of the secondary benefits from climate change to acidification.

When considering policy order 2, the implementation of the NEC Directive precedes implementation of the Kyoto protocol. The Kyoto policies will have a spillover effect that will continue reducing emissions leading to acidification. Most likely, the spillover effects will mean the acidification targets are exceeded, which is known as target overshoot.

The primary benefits of policy order 2 are estimated as € 28 billion (VOSL); *see figure below*. These benefits are € 6.5 billion higher than those of policy order 1. As expected, there is a decrease of € 4 billion in the secondary benefits from climate change control to acidification from € 13 to 9 billion. In policy order 2 the costs of acidification are increased by roughly € 7 billion, as its measures cut deeper since the spillovers of climate change policies are not yet taken into account. Overall, the benefits of implementing acidification policies (regardless of climate change policies) still exceed the costs.

Conclusions

Assumptions regarding the order of policy implementation are clearly important. As the results show, policy order 2 means secondary benefits of climate change control decrease, whilst primary benefits from acidification control increase, resulting in higher total benefits. While for both orders benefits exceed costs, net benefits of policy order 2 are less than the net benefits associated with policy order 1.

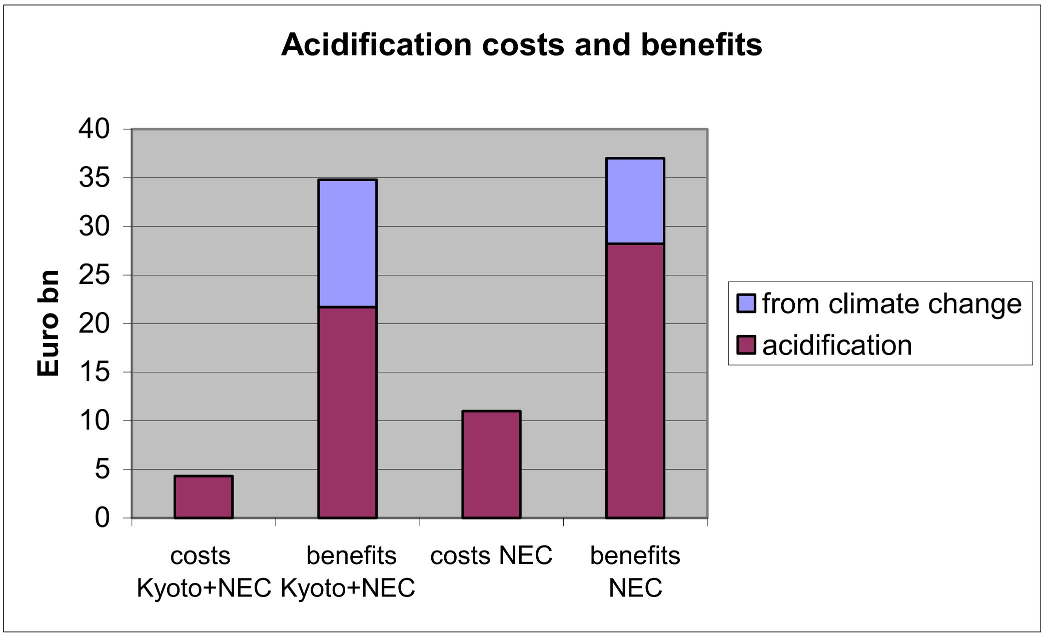

Figure: Costs and benefits of acidification in comparison with the baseline in 2010 (in € billion referring to VOSL-mid values). It considers the no-trade variant of the accelerated policy scenario (Kyoto) for climate change and the National Emission Ceilings Directive (NEC) for acidification. The figure presents the cost benefit evaluation of two policy implementation options. On the left, where climate change policy is implemented prior to acidification control, and the right, where acidification control is implemented independently from climate change, two opposing implementation orders are shown. The second ordering - NEC first - will lead to an overshoot of the acidification policy target, while the net benefits decrease.

Tropospheric ozone

Costs of NO_x and VOC are combined and any allocation of costs to NO_x and VOC emission control separately would be arbitrary. Despite this shortfall, we assume the costs of control for VOCs are, € 1.9 billion, 2.5 billion and 5.3 billion for the No Trade and Full Trade variants of the AP scenario and the TD scenarios respectively. B/C ratios for tropospheric ozone based on the primary benefits for VOCs control compared to the welfare costs of control for VOCs only are greater than unity for all scenarios. The Full Trade variant lowers the benefit cost ratio for tropospheric ozone due to the increase in costs associated with greater levels of VOC control. The B/C ratio for the TD scenario is estimated to be 1.7.

A key issue relating to the B/C ratios for the control of the tropospheric ozone precursor pollutant, VOCs, is the approach to premature mortality valuation. Assuming VOLY means all scenarios fail the cost benefit test, i.e. B/C ratios are below unity. For example, B/C ratios based on primary benefits of VOC control compared to welfare costs of VOC control, for the No Trade, Full Trade and Technology Driven scenario become, 0.4, 0.3 and 0.2 respectively.

If we compare total benefits to tropospheric ozone i.e. primary benefits of VOC control plus secondary benefits to tropospheric ozone from the acidification strategy, to the combined welfare costs of NO_x and VOCs, the B/C ratios for the No Trade, Full Trade and Technology Driven scenarios are 4.9, 2.7 and 1.5 respectively. These B/C ratios may be an underestimation due to the omission of the primary benefits of NOx control (recall these benefits are included in the B/C ratios for acidification). VOLY also has a significant effect on the B/C ratios based on total benefits to tropospheric ozone. For example, B/C ratios for the No Trade, Full Trade and Technology Driven scenarios are, 1.6, 0.9 and 0.2 respectively.

Acidification and Tropospheric ozone

In this section we discuss B/C ratios based on the sum of i) primary benefits to acidification, ii) secondary benefits from acidification to tropospheric ozone and particulate matter (i.e. through the reduction on primary PM_{10})[10] and iii) primary benefits to tropospheric ozone, compared to the welfare costs of SO_x, NH_3, NO_x and VOC control. B/C ratios for the No Trade, Full Trade and Technology Driven scenarios are, 7.6, 6.2 and 3.1 respectively. Assuming direct costs, the B/C ratios for the No Trade, Full Trade and Technology Driven scenarios become, 3.6, 3.0 and 1.9 respectively.

If VOLY is preferred, the B/C ratios based on welfare costs become, 4.6, 3.7 and 1.6 for the No Trade, Full Trade and Technology Driven scenarios respectively, whilst B/C ratios based on direct costs are, 2.2, 1.8 and 0.9. These results suggest that in all cases (i.e. assuming welfare or direct costs, assuming VOSL or VOLY) the No Trade, Full Trade and Technology Driven scenarios pass the cost benefit test. The NT scenario has highest B/C ratios due to lower levels of domestic control of the acidifying pollutants necessary in order to reach the same targets as the FT scenario.

[10] Secondary benefits due to reductions in SO_x and NO_x emissions and hence reductions in secondary aerosols are already subsumed in the primary benefits estimate for acidification.

Waste management

B/C ratios are not calculated for waste management Accelerated Policy scenarios, because both the welfare and direct costs are negative. In other words, it is a benefit to move to the AP scenarios. This suggests that the AP scenario targets are economically efficient for waste management.

The Technology Driven scenario with maximum compost and recycling is also justified in economic terms, the ratio of benefits to costs is estimated to be between 2.1 - 3.6, where low/high ratios assume direct costs, welfare costs respectively. However, the Technology Driven scenario with maximum incineration is economically inefficient due to the negative benefit estimates. This implies it is a cost to the environment to move to the TD with maximum incineration scenario, which effectively reduces the B/C ratio to zero.

Particulate matter and chemicals

B/C ratios based on the primary benefits of end-of-pipe measures to reduce primary PM_{10} and welfare costs are, 5.3 - 19.0 assuming premature mortality is valued with VOSL. Assuming VOLY gives B/C ratios of 3.1 - 13.9. B/C ratios based on direct costs are, 3.3 - 11.9 (VOSL) or 1.9 - 8.7 (VOLY). The control of primary PM_{10} by end-of-pipe measures clearly passes the cost benefit test.

Total monetised benefits and costs

Overall, when total costs are compared to total benefits the Full Trade, No Trade and Technology Driven scenarios pass the cost benefit test. Emissions trading raises the benefit cost ratio. For example, assuming the primary benefits of climate change, acidification, tropospheric ozone, waste management and particulate matter only are compared to the welfare costs, the B/C ratio for the No Trade variant is 2.1 (from 45.0/21.9), for the Full Trade variant the B/C ratio is, 3.1 (from 48.6/15.7).

Benefit cost ratios increase when the secondary benefits of climate control, acidification and waste management are included. For example, assuming primary benefits as above, plus the secondary benefits of climate control, acidification and waste management are compared to total welfare costs, the B/C ratio for the No Trade variant is, 3.3 (from 73.0/21.9) and ratio for the Full Trade variant is, 4.5 (from 70.2/15.7).

Interestingly, the TD scenario also passes the cost benefit test and in some cases the B/C ratios are greater than the B/C ratios for the No Trade scenario. For example, when primary benefits of acidification, tropospheric ozone and waste management (with maximum incineration or maximum compost and recycling) and nuclear accidents are compared to welfare costs, B/C ratios are, 2.4 / 2.8 (from 72.0/30.5 and 85.1/30.5). When secondary benefits are included, the B/C ratios become, 2.8 / 3.2 (from 84.6/30.5 and 97.7/30.5)

The No Trade, Full Trade and Technology Driven scenarios pass the cost benefit test even assuming VOLY. For example, primary benefits compared to welfare costs give the following B/C ratios for the No Trade and Full Trade variants respectively, 1.4 and 2.1. The B/C ratios are raised if the secondary benefits are included. For TD[11] scenario

[11] VOLY based B/C ratios for the TD scenario exclude benefits and costs due to nuclear accidents due to benefit estimates not estimated with VOLY.

(assuming waste management with maximum incineration/maximum composting and recycling) the B/C ratio is, 1.2 / 1.7.

4.3.2 Environmental issues recommended for further control

For the remaining environmental problems that do not have Accelerated Policy scenarios, we can only indicate the potential benefits from the control of these problems. The benefit estimates are based on the analysis devoted to each environmental issue throughout this study. *Table 4.3.2* highlights those environmental issues most likely to benefit greatly from the introduction of targets and objectives.

Stratospheric ozone depletion

Measures addressing stratospheric ozone depletion are already in place through the London and Copenhagen Amendments to the Montreal Protocol. The EU15 currently over-complies with the Montreal Protocol thus scenarios are not developed for this issue. Instead, an evaluation of existing policy (the Montreal Protocol) and a recommended objective (accelerated compliance of Article 5 countries to the Montreal Protocol) is provided. The results are presented in *Table 4.3.2*.

The benefits of the Montreal Protocol are found by comparing the damages experienced under the Montreal Protocol with the damages that would have arisen in a 'No Restrictions' situation, i.e. it is a measure of the damages that would have happened if the Montreal Protocol were not put in place. The benefits relate to the avoided fatal and non-fatal skin cancer incidences in NW Europe only, between 1990 and 2050[12]. The main uncertainties are due to the computation of skin cancer incidences and the treatment of premature mortality valuation, in this case we use VOSL. The result may be biased towards underestimation due to the non-quantification of all ecosystem effects and other health effects.

Benefit estimates to the <u>world</u> from EU15 action towards the accelerated compliance of Article 5 countries to the Montreal Protocol are based on ARC (1997). The benefit estimate includes quantification of effects to fisheries, agriculture, materials and health. The cost to EU15 as a share of world costs is also estimated.

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[12] The time horizon for stratospheric ozone depletion differs from the analysis of the other environmental problems because the impacts of the policies in place are not readily discernible much before 2020. Accordingly we take 2050 as a benchmarks.

Table 4.3.2 Environmental problems recommended for control.

Problem	*Objective*	*Benefit estimate € billion*	*Costs € billion*	*B/C ratio*
Stratospheric ozone depletion				
The Montreal Protocol	To EU 15	12	-	-
Accelerated compliance of Article 5 countries to Montreal Protocol	to world	79	24	3.3
Biodiversity				
Agricultural policy reform, through the re-direction of subsidies in the form of price support mechanisms to agri-environmental schemes		potentially large	-	-
Nuclear risks				
Technology Driven scenario; i.e. the phase out of highest risk nuclear reactors in central and Eastern Europe	Mortality Without DAF with DAF	 0.1 – 0.4 6.8 - 18.1	 0.94	 0.2 - 0.4 7.2 - 19.3
	Mortality & morbidity Without DAF with DAF	 0.2 – 0.6 11.3 - 30.2		 0.2 - 0.6 12.0 - 32.1
Human health, air quality and noise				
Measures to control exposures to noise from rail, road and air.		13.2	-	Potentially >1

B/C ratios > 1 indicates recommend action is cost effective, whilst B/C ratios < 1 indicates costs outweigh benefits, the suggested action therefore does not pass the cost benefit test.
Where, DAF is 'disaster aversion factor'. It is well known that people are more averse to accidents in which a significant number of people die, or are injured, compared to a series of accidents each of which has a few fatalities but where the total fatalities are the same. This is known as disaster aversion. It is less obvious how this aversion should be accounted for. We suggest a DAF of 50, based on the current literature.

Biodiversity loss

This study does not thoroughly investigate the problem of biodiversity loss for two main reasons. Firstly, information on the key indicator 'land use change' is not available and secondly, at the time of writing, there are no known willingness to pay figures for the value of diversity specifically. However, there is evidence to suggest benefit estimates could be large due to the willingness to pay estimates for habitat and species conservation.

Nuclear risks

The Technology Driven scenario assumes there is a gradual reduction in the number of high risk category reactors (10^{-3}) from 25 to 2 between 1990 and 2010, while over the same period it assumes there is an increase in the number of mid risk category reactors (10^{-4}) from 146 to 153. The benefit estimate for the reduced probability of a nuclear accident is measured as the avoided excess cancer mortality due to radiation exposure from accidental releases. Direct deaths, which occur where the unsafe reactors are, i.e. Eastern Europe, are *not* taken into account.

The main areas of uncertainty are as follows:

- the approach to premature mortality valuation, (VOSL assumed);
- estimates of mortality cases arising in the period after a nuclear accident;
- inclusion of a 'disaster aversion factor';
- omission of direct deaths, and
- omission of non-health effects.

In response to the second area of uncertainty, a range of benefit estimates are presented, based on the mean and the upper 95% fraction for mortality cases due to a nuclear accident. Mortality cases are estimated by the Centre D'Etude sur L'Evaluation de la Protection dans le Domaine Nucleaire (CEPN, 1992).

It is well known that people are more averse to accidents in which a significant number of people die, or are injured, compared to a series of accidents each of which has a few fatalities but where the total fatalities are the same. The issue of how to account for this 'disaster aversion' is unresolved in the literature. We adopt the conservative disaster aversion multiplier, 50, based on the review of the current literature. However, estimates are also provided excluding the disaster aversion factor. *Table 4.3.2* demonstrates that the issue of 'disaster aversion' is of key importance to the analysis of nuclear risks. If included, the Technology Driven scenario targets are shown to be economically efficient, but if omitted than the B/C ratios fall below unity suggesting that stringent targets of the Technology Driven scenario are not justified in economic terms.

However, it should be noted that the benefit estimates are biased towards underestimation due to the focus on EU15 countries and un-quantified non-health effects. Benefits would be much higher (both with and without 'disaster aversion') if the health effects in Eastern Europe were also taken into account.

Human health, air quality and noise

Health related benefits due to air quality improvements are dealt with in the context of other issues, such as 'chemicals and particulate matter' and 'tropospheric ozone'. In this section we consider noise only.

A noise exposure scenario is not provided in this study, however we estimate damage costs due to current noise exposure at € billion 13.2 (1997 prices). This suggests policies to control exposure to noise levels from road, rail and transport may yield potentially large benefits. Costs of policies are not known, but the scale of the benefit estimates suggests such measures would pass the cost benefit test.

The main areas of uncertainty for the noise nuisance damage costs are:

- population exposure to noise nuisance by dB bands;
- value of housing stock:
- noise sensitivity depreciation index (NSDI) for housing, i.e. percentage depreciation in house price for each decibel of noise above the threshold level. Below the threshold noise exposure level, NSDI is zero, and
- noise threshold.

The estimates for noise nuisance damage costs may be biased towards underestimation because of the use of lower bound estimate for EU15 house price data, calculations based on household exposure rather than numbers of people exposed to noise and the noise threshold, assumed to be 55dB(A). Estimates for noise nuisance could be biased upwards due to assumptions regarding the NSDI assumed to be 0.67%, recent studies suggest that NSDI could be lower at 0.2%-0.4%.

4.3.3 The remaining environmental problems

The economic analysis of the remaining environmental problems is restricted because information on the relevant indicators is not available. The environmental problems include water availability and quality, soil degradation, coastal zones and chemicals. Despite the limited available information we conclude the following:

Water management

Water availability

In 2010, it is estimated that roughly 14% of the EU15 population, equivalent to some 54 million people will suffer from poor water availability. The preliminary cost-benefit analysis indicates that WTP to avoid limited water availability in the domestic sector is greater than only the least cost supply options, such as new groundwater schemes and re-use schemes. This suggests the need for policy measures that do not focus on large investments in supply, but focus on leakage control and demand management.

Water quality

There are only a few WTP to avoid water contamination studies in Europe. They are fairly consistent in suggesting that WTP to avoid contamination could be very high, reflecting household’s concern over drinking water. The two European studies, Hanley (1989) for England and Press (1998) for Italy, suggest a range of valuations of one order of magnitude. Costs of decontamination for a clean up programme in Italy are some € 31 per household per annum (Soderqvist 1998). Comparing costs and benefits of avoided water contamination, suggests the B/C ratios could be 1.5 - 15. The B/C ratios may be underestimated due to the omission of important benefits to bathing water.

Soil degradation

Damage to arable land due to soil degradation indicated by lost crop output is estimated to be roughly 0.5 - 2.2% of value added by agriculture in 1990. The damage estimation therefore suggests that major soil conservation measures are not needed and are likely to be cost ineffective.

Coastal zone management

For coastal zone management cost–benefit estimates are of limited availability and the existing studies do not provide a clear perspective. However, there are some indications that coastal zone management might be cost effective, see, for example, the programme to alleviate the eutrophication of the Baltic Sea.

The cost benefit analysis of a 50% nutrient (nitrates and phosphates) load reduction to the Baltic Sea shows benefits exceed costs with a B/C ratio of 2.2.

Chemicals

There is a vast array of chemical and heavy metal related risks. In practice, little is known about emissions for many of these pollutants and even less about the impacts to human health and ecosystems. Accordingly, we focus on airborne emissions of lead, cadmium, dioxins and pesticides, where some reasonably reliable information is available. However, caution needs to be exercised when interpreting the benefit figures since even where information is available and thought to be reliable, considerable uncertainties remain. The analysis of the Technology Driven scenarios for chemicals suggest the following:

- benefit estimates of further cadmium control appear to be modest at € 3 million;
- likewise for dioxins, despite their notoriety as serious pollutants, available dose response functions suggest the benefits of further control of dioxins is moderate at € 58 million;

The issue of thresholds is fundamental to the benefit analysis of lead emissions reduction. This issue is not resolved in the literature. Assuming WHO thresholds reduces the benefits of further lead control to zero. However, assuming no thresholds suggests the benefits of further control of lead could be substantial at € 0.5 - 2.7 billion.

5 Policy Responses

Main findings

- Secure the Baseline through the removal of subsidies to fossil fuels and improve compliance with current policies;
- the Kyoto target is achievable with emissions trading or possibly the use of the flexibility mechanisms (i.e. joint implementation with Annex 1 countries (mainly Eastern Europe), or the clean development mechanism in non Annex 1 countries (mainly developing countries);
- target climate change policies on the electricity production sector;
- policy action in the transport sector provides one of the clearest opportunities to secure synergistic benefits to climate change, acidification, tropospheric ozone and human health and air quality, and
- further agricultural policy reform with particular attention on agri-environmental schemes. These can be used to effectively target land use and farming practices in order to alleviate problems of biodiversity loss, soil degradation and coastal zone management.

5.1 Policies

Chapter 4 showed the benefit and cost estimates for the movement from the Baseline to the Accelerated Policy scenarios. However, the actual process of meeting AP scenario targets is dependent on policy packages, i.e. the combination of instruments which give rise to behavioural change, including the adoption of the technologies implicit in the cost estimates of reaching the AP scenarios.

Nature of policy instruments

A critical goal of environmental policy is cost-effectiveness: the achievement of the policy goal at least cost. In welfare economics terms, 'least cost' means least loss of economic well being[1]. A narrower goal would be to measure costs solely in terms of the costs borne by the regulated agent in complying with the policy.

Policy instruments are broadly grouped into economic instruments (EIs) and command and control regulation (CAC)[2]. Definitions of economic instruments are not easy to provide. All forms of regulation impose a cost on the regulated agent, so that the presence of a financial incentive is not peculiar to economic instruments. It is widely argued that EIs leave the regulated agent with more flexibility on how to respond to policy. Thus, traditional 'command and control' (CAC) regulation might be regarded as setting target (what to achieve) and mechanism (how to achieve it), whereas EIs leave the regulated agent with the choice of what to achieve and how to achieve it, provided the overall policy goal is met in the aggregate. Thus, an individual regulated agent can

[1] Which, ideally, would be measured by the change in the sum of producers' and consumers' surpluses. In practice, this measure is only available in some cases.

[2] Hybrid agreements, i.e. voluntary agreements are also a policy instrument. Currently there is not enough evidence on their performance, for this reason they are not included in the policy package discussion.

emit pollution up to any level provided it pays the necessary environmental tax or holds the necessary permit to emit. The choice of the mix of abatement measures and tax payments /permit holdings is up to the regulated agent. But policy will have set an aggregate goal - a total level of emissions say - that must be met and permits will be issued equal to this aggregate goal, or an estimate will have been made of the emission reduction effect of taxes so as to achieve the goal.

There are general reasons for supposing that EIs are best suited to achieving the least cost goal. However, the presumption that EIs are more cost effective than CAC is not always the case. In general, quite specific conditions have to be present for EIs to perform better than CAC. These factors need to be taken into account in deciding the match of policy instruments to environmental problems.

Criteria for selecting policy instruments

Fundamental to this study is the use of 'welfare economics', it is therefore appropriate that the criteria for selecting 'desirable' policy instruments should be based on social cost benefit analysis. However, it is important to assess policy instruments against other considerations, such as distributional concerns (i.e. impacts to socio-economic class and region), macroeconomic issues (competition and employment effects), administrative feasibility[3] and subsidiarity (i.e. the 'optimal jurisdiction' issue, in other words, whether policy is most effectively located at the EU or individual Member State level). Subjecting policy instruments to many criteria for acceptability risks making almost all policy instruments fail. Similarly, we have no clear criteria (meta-criteria) for deciding which criteria are the most important. In order to identify rational policy instruments to meet AP scenario targets, we suggest that there are five groups of criteria for choosing a policy instrument, these are set out below:

- causal;
- efficiency;
- equity;
- macroeconomic, and
- jurisdictional.

The causal criterion answers the basic question: 'does the policy instrument address the underlying economic failure'? If policy does not address the real causes of environmental degradation, it will have a high risk of failure. It is important to note that real causes do not equate with 'pressures' in the DPSR paradigm, nor what is popularly understood by 'driving forces'. The underlying causes are i) market failures (i.e. not well defined property rights, missing markets and lack of information ii) intervention failure (i.e. counter-effective subsidies and inconsistent policies iii) implementation failures, i.e. if legislation exists, but is not fully implemented by Member States iv) growth of real income and v) population change (i.e. natural growth, migration and social change). Overall policy measures are targeted at the first three underlying causes only.

The economic efficiency criterion includes: i) benefit cost ratios, ii) cost-effectiveness, iii) benefits, and iv) public opinion for each policy instrument. The least-cost action is

[3] Note that, 'political feasibility' is not explicitly considered, since the research team's concern is to define a potential menu of policies. The extent to which such policies are politically feasible is not for the research team to judge.

embodied in the cost-benefit and cost effectiveness approaches. Public opinion is included in efficiency because public opinion indicates public preferences, which in turn underlie the notion of willingness to pay. In turn, willingness-to-pay is the building block of the benefits assessment.

The equity or distributional criterion considers: i) intra-generational equity (impacts to current socio-economic class, economic sector and region) and ii) inter-generational equity (distributional impacts between generations).

The macro-economic criterion is discussed earlier in section 4.1.

The jurisdictional criterion concentrates on the issue of subsidiarity, i.e. where is policy most effectively located, such as, EU, national or local level. There are three main criteria upon which the level of subsidiarity can be assessed: i) gains from co-operation, ii) gains from harmonisation and co-operation and iii) gains in sustainable implementation.

5.2 Environmental issues with AP scenarios: policy package

Potential policy packages for climate change, acidification, tropospheric ozone, particulate matter and waste management are presented in *Table 5.2.1.* this table sets out the policy packages with their associated achievements in terms of ‘distance to goal’ (i.e. amount of target reduction achieved). Where possible, the costs and benefits of each policy and the policy B/C ratio are also reported.

There is a substantial variety of policy instruments, which could be introduced, and many of them could be combined to produce ‘hybrid instruments’. In an ideal world all policies would be costed, alone and in combination, and the least cost set of measures would be adopted so that the Accelerated Policy scenario is achieved. In practice such a procedure is impossible because:

- costs of many policy packages are not known, and
- many of the packages have uncertain benefits, i.e. it is not possible to say with any accuracy whether policies will achieve what they set out to achieve.

Assuming perfect enforcement, packages can be ranked according to their likelihood of being environmentally efficient (i.e. achieving their targets) as follows: i) standard setting, ii) tradable permits and iii) taxes.

But standard setting may not be perfectly enforced due to ‘regulatory capture’; tradable quotas can result in aggregate targets being met but with ‘regional hotspots’ and taxes may be hit and miss affairs unless they can be modified frequently. All policy impacts are therefore uncertain. Moreover, while standard setting may be environmentally efficient, it is economically inefficient, because it is unlikely to minimise costs. Without very detailed knowledge of policy effectiveness and costs, it is not possible to find a ‘least cost’ package that guarantees the achievement of the AP scenarios. Procedure had therefore to be more ad hoc. The packages selected are primarily EIs because of the judgement that these may be considerably less costly than the alternatives. These cost savings are thought to outweigh any environmental inefficiency.

Table 5.2.1 Environmental and economic efficiency of potential policy packages for climate change, acidification, low level ozone, human health and air quality and waste management.

Policy package		*Achieved distance to AP scenario target %*		*Costs, benefits and B/C ratios € million*		
				Direct costs	*Benefits*	*B/C ratio*
Climate Change						
Minimum excise duty		10		low	420 – 840	~
Carbon / energy tax		70		-	2800 – 5700	~
Tradable quotas for GHGs		40		4300	8300 – 10300	2.0 - 2.4
Aviation tax		6		-	250 – 500	~
Substitution and energy saving for halogenated gases		1 – 3		1.5 - 5	30-100, 60-200	6-67, 12-133[1]
Methane tax (livestock)		-		-	-	~
Car manufacturers emission trading		-		-	-	~
Transport policies						
Acidification						
		NT	FT			
NO_x tax for stationary sources	NOx	42	38	625	3980 – 6140	6.4 - 9.8
Sulphur tax for stationary sources	SOx	50	40	240 - 360	1030 – 1580	7.2 - 16.5
Transport policies	All	-	-	-	-	~
Tropospheric ozone						
NOx control: see Acidification Transport policies		-		-	-	~
VOC control: VOC tax		16%		<2272	1025 – 7533	> 1
Chemicals and particulate matter						
Transport policies		-		-	-	-
Waste management						
Recycling credits		high		low	high	High
Virgin materials tax		≤100		-800	2441	High

Where: '-' = not known, and '~' = not estimated due to missing policy cost and/or benefit information.
[1] Lower range for UK only, higher range for the EU assuming other Member States adapt the same measures.

Climate change

A number of policy measures are recommended for the EU to achieve the Kyoto target. It is important to note that it is the research team's concern to define a potential menu of policies, the extent to which such policies are politically feasible is not for the research team to judge.

The main underlying causes of the climate change problem are market failures, population growth, and growth of real income. The following policies typically address the first underlying cause.

It is our judgement that the EU is unlikely to achieve the Kyoto target without either an energy / carbon tax or EU tradable permits or Kyoto flexible mechanisms[4]. For 2010, tradable permits may not be in place quickly enough despite numerous sectoral initiatives (e.g. British Petroleum and Shell), whilst the feasibility of a centralised EU carbon tax is low. Despite this, many member states including; Sweden, Denmark, Netherlands, Finland, and the UK (Climate Change Levy, for 2001) already have or plan to introduce carbon / energy initiatives. Overall there needs to be a mix of regulatory and economic instruments. The main ones are:

- minimum excise duties;
- carbon / energy tax;
- tradable emission permits for greenhouse gases;
- aviation tax on kerosene;
- substitution and energy savings for halogenated gases, and
- tradable efficiency permits for car manufacturers.

However, other important supply side and demand side actions to consider are:

- market regulation for electricity;
  - non fossil fuel obligations;
  - priorities for renewables and co-generation of heat and power, and
  - transparency on fuel costs (to effectively obtain removal of subsidies);
- incentives for higher recycling of materials (see waste management);
- stricter standards on electrical appliances and other equipment such as household appliances, motor drives, air conditioning, etc;
- incentives for greater use of heat pumps;
- continuation and reinforcement of energy conservation programmes for good housekeeping in energy use, heat / steam recovery, insulation etc, and
- stricter building codes both for tertiary and household buildings.

Prior to the introduction of further policies to control GHG emissions, a key issue for the achievement of the Kyoto targets is to ensure that the removal of subsidies assumed in the Baseline takes place.

It is not possible to evaluate separately the effects of each of the above measures. Chapter 4 compares the costs against the benefits for the package in the two variants of the AP scenario, whilst *Table 5.2.1* assesses the environmental and economic efficiency of the main policy initiatives required to secure the Kyoto targets.

Minimum excise duty: The effects of full implementation of the proposed EC minimum excise duty COM (97) 30, are likely to be small for three reasons: i) the proposal relates to minimum taxes only, in some cases, such as coal and lignite, the tax rate maybe zero ii) Member states already tax some energy products at levels exceeding the proposed minimum tax rate, such as petrol, gas oil, heavy fuel oil (see Ekins and Speck 1998), and iii) fuels used for power generation and natural gas is exempt as long as the market share of natural gas in national energy markets is below 10%. The estimated 'distance to goal' for the minimum excise duty measure is roughly 10%, this is based on the assumption

[4] Kyoto flexible mechanisms refer to i) joint implementation with Annex 1 countries, (mainly Eastern Europe) and ii) clean development mechanism in non-annex 1 countries (mainly developing countries).

that 2010 carbon emissions fall by 1.5%, i.e. 17 Mt C. Although the costs of this measure are not known with certainty they are expected to be low for the above reasons. Benefits are estimated to be around € 400 - 800 million, suggesting that this policy is economically efficient.

Carbon / energy tax: as an illustration of the size of the carbon tax needed to reduce emissions by 8% 1990 levels in 2010, we turn to earlier estimates of carbon taxes and experience. Gregory (1992) estimates that a $10 bbl oil tax (the original EC tax proposal, with 50% of the tax on energy and 50% on carbon) would reduce baseline demand by a maximum of 10%, depending on the 'mix' of the tax on energy and on carbon. This seems broadly consistent with the work of DRI (1994) which showed that the $10 bbl tax eventually leads to a 11% reduction in primary energy demand in the EU relative to their 'reference' (BAU) scenario. The illustrative $10bbl tax on energy is equivalent to $75 per tonne C (€ 63 per tonne C). Assuming the tax achieves the expected reduction in carbon emissions (i.e. $0.1 \times 1149 = 115$ Mt C, equivalent to 70% of the emission reduction target), we can say the cost of the tax will be less than € 7.2 billion. Benefit estimates for the carbon tax range from € 2.8 – 5.7 billion. It seems likely that the carbon tax is justified in cost benefit terms, particularly if the secondary benefits are included. COHERENCE et al (1997) suggest the illustrative tax given above could achieve a 7% reduction in SO_2 emissions, a 3% reduction in NO_x and a 4% increase in NH_3 emissions.

Tradable permits for greenhouse gases: The use of tradable quotas can curb CO_2 emissions and not raise the tax burden or change the existing tax structure, yet give emitters greater flexibility to reduce emissions compared to direct regulation of fuel or carbon use. At the time of writing there are no operational tradable carbon permits in Europe, beyond within corporation schemes, such as BP / Amoco etc. Tradable quota systems can offer a known effect on emissions but quota prices are initially uncertain, thus the distributional effects through quota trade are also uncertain. The chances of 'carbon leakage' are less if a large number of countries are involved in the quota system. This is one of the reasons why a tradable quota system for the whole of the EU will be more effective than a system introduced in only one country. The costs and benefits of trading presented in *Table 5.2.1* are based on the following: The 'Full Trade' AP scenario assumes that Europe meets about 40% of the 2010 target through trading, this gives a reduction of almost 70 Mtonnes C. The trading price for carbon is taken as € 63 per tC, (see *section 3.2.2*), thus the direct cost of trading is € 4.3 billion. Including the welfare loss for the 'Full Trade' AP scenario will increase costs by a further € 4.6 billion (i.e. welfare loss due to CO_2 plus non-CO_2: $4.9 + -0.3 = 4.6$). The benefits from trading are the cost savings from trading rather than by cutting emissions nationally. CSERGE (1998) estimates the ratio of domestic costs to costs in economies in transition and less developed countries at 3, i.e. if the EU pays € 4.3 billion in trading, it would have cost three times this at € 12.9 billion if emissions were cut nationally. Hence the benefit is € 8.6 billion, less any transaction costs from trading. The upper benefit estimates include both the cost savings from trading and the benefits of avoided primary damage due to reduced GHG emissions (i.e. cost saving + primary benefit = $8.6 + (70 \times 0.025) =$ € 10.3 billion). The B/C ratios for trading indicate that trading is an economically efficient measure.

It is important to recall that where there is carbon trading there is a trade-off between reduced costs of carbon control and reduced secondary benefits to EU-15. Secondary benefits are large in 2010, estimated at: € 16.1 billion for the 'No Trade' scenario and € 9 billion for the 'Full Trade' scenario (see Chapter 4, Section 4.2 on Benefits). Thus we see, as more of the carbon reduction takes place outside the EU15, less secondary benefits to the EU15 will occur.

Aviation tax; aircraft contribute to environmental pollution and nuisance in several ways: global pollution through CO_2 emissions and high level NO_x emissions, regional air pollution via NO_x and VOC emissions, local air pollution, and noise pollution. Pearce and Pearce (1999) show how a tax can be devised which varies by aircraft type and airport characteristics, thus approximating a 'true' externality tax. The economic value of air pollutants is taken from established studies on the willingness to pay to avoid pollution, and a new estimate is derived for high level NO_x emissions based on recent IPCC estimates of the relative contributions of aircraft NO_x and CO_2 to global warming. The tax on carbon dioxide emissions is given as roughly 40% - 60% of the air pollution component of the aviation tax. Centre for Energy Conservation and Environmental Technology (1998) show that an aviation tax set at roughly \$0.2 per litre of fuel would lower aircraft CO_2 emissions by roughly 10 Mt C in 2010, this is about 6% of the reduction target for the AP scenario.

Substitution and energy saving measures for HFC, PFC, SF_6; March Consulting (1999), suggests that some reductions can be obtained cheaply relative to the marginal social costs of damages. A number of the reduction measures, the report suggests, pass the CBA test (when benefits are the avoided marginal damage cost). The total reduction that can be achieved by these measures (namely, energy efficiency measures in refrigeration, HFC23 emissions from manufacture and extruded polystyrene product emissions) is around 1.2 Mt C equivalent. Assuming that the other EU Member States would implement the same measures with the same percentage reduction effect, the upper bound of savings from this action would be about 4 Mt C equivalent. The ratio of benefits to costs reported in *Table 5.2.1* suggests that these types of measures are highly efficient.

Tradable efficiency permits for car manufacturers: They are simply an extension of the tradable permits scheme. This policy is described in the transport policy package discussed below.

Finally with regard to climate change, there are secondary benefits from other policy initiatives targeted at different environmental issues, such as: transport policies, recycling credits recommended for waste management and all policies that reduce the quantity of biodegradable waste to landfill sites and hence reduce methane emissions. The AP scenarios for waste management estimate that the carbon equivalent of methane emissions fall by 17 Mt C. Such policies are most probably cost efficient as costs will be low and the benefits range for € 142 - 1000 million, with a mid value of € 440 million.

Acidification

The underlying causes of the acidification problem are identified as market failure, intervention failure, growth in real income and growth in population. The following policies typically address the first two underlying causes.

Policy measures to alleviate the problem of acidification need to be targeted at both the mobile and stationary emission sources. Relevant policies include:

- policies targeted at the transport sector (discussed below);
- carbon / energy tax. COHERENCE et al. (1997) estimate that a carbon tax that leads to a 10% reduction in CO_2 emissions across the EU will also result in 7% reduction in SO_2 emissions, 3% reduction in NO_x emissions and a 4% increase in NH_3 emissions), and
- emissions taxes such as an NO_x emission tax on stationary sources and SO_x taxes on the sulphur content of fuels.

NOx: direct NO_x emission charges can only be levied on stationary sources where measurement equipment is in place. An NO_x charge can only be levied on large or medium sized plants where the cost of measuring emissions is fairly proportional to the saving the plant can make by cutting emissions and thus reducing the environmental tax payable. Based on the Swedish experience, the recommended European NO_x tax could be set according to the ratio 4:1 tax to costs of abatement. The effectiveness of the recommended NO_x tax for stationary sources is estimated to be a reduction of roughly 0.5mt NO_x emissions in EU15. Valued with the average damage values for NO_x, € 7950 - 12280 / t $NO_{x,}$ the benefit estimates for this policy range from € 4 to 6 billion. Costs are reported at € 0.6 billion, which suggests this policy passes the cost benefit test.

SOx: tradable permits in sulphur have long been established in the USA. Policy simulations show that substantial cost savings can be obtained through trading. However, the European context may be such that emissions trading will be of limited feasibility. First, trading would only 'fine tune' the measures undertaken through the Second Sulphur Protocol, i.e. unlike the USA, trades would not be the main instrument of control, but rather a means of accommodating residual inefficiencies in the Second Sulphur Protocol. The plant-specific measures under IPCC are not consistent with trading, so that trades are likely to be comparatively few. This is borne out by available simulations (Klaassen 1997, and Sorrell 1998). Second, whereas the US trades are based on a 'one-to-one' exchange rate (i.e. one tonne of S increase can be traded for one tonne of S decrease), one-to-one trades in Europe may infringe the ecosystem integrity of third parties. The Second Sulphur Protocol essentially restricts trades so as to avoid significant impacts of this kind. Accordingly, while sulphur trading has many attractions it is not likely to be a dominant policy instrument in the European context.

The greatest part of SO_2 emissions in Europe emanates from power generation, in particular from coal fired power plants. In countries with a low share of coal in power generation such as Sweden, the Netherlands, Luxembourg, Finland and Austria, industrial processes and mobile sources are the main emitters. Based on the experience in Sweden, an EU sulphur tax levied on the sulphur content of fossil fuels used for energy production, set according to ratio 3:1 tax to abatement costs, is estimated to reduce EU sulphur emissions by 0.4mt SO_2. The benefits of this policy are given at € 1.0 - 1.6 billion, i.e. emissions reduction multiplied by average damage value for SOx € 2575 - 3950 /tSO_2 . Derived from Swedish experience, costs are roughly € 200 - 350. A comparison of costs to benefits suggests a sulphur tax may be economically efficient.

NH_3: The major source of NH_3 emissions in Europe is agriculture, and within that source, most emissions are relating to animal manure, the rest to the use of fertilisers.

NH_3 emissions are implicated in acidification and, because of the potassium, nitrogen and phosphorus in the manure, also in eutrophication. The 'divorce' between mineral inputs and outputs at the farm level in modern agriculture means that mineral surpluses are generated and these find their way to the environment as opposed to being 'embodied' in food output. Policy therefore needs to aim for a better balance between mineral inputs and outputs.

Unfortunately, the issue of how best to control NH_3 is extremely complicated. Mineral losses are determined by the number of animals, the type of animal, the nature of the farming operation (intensive, extensive), storage facilities, uses of the manure (e.g. plough-back), the nature of the crops grown on land treated with manure, the nature of the soil, climate variables, and so on. No single policy measure is therefore likely to achieve the desired change in concentrations.

Overall, then, while NH_3 control is obviously complex, there is a need for a policy instrument, which is targeted at the damage done. The concept of a mineral surplus, i.e. the excess of any output of minerals over any input to an ecosystem, provides a suitable proxy for damage. There is therefore a need for an accounting system, which at least approximately measures mineral surpluses. Any levy should then be proportional to the surpluses and should account for all the main minerals involved.

Tropospheric ozone

The control of the precursor pollutants to tropospheric ozone will mostly take place through the implementation of the policies recommended for other environmental issues, such as, the transport sector, acidification, and climate change.

However, in order to reduce VOC emissions specifically, a tax on VOCs could be levied. The proposed VOC tax in Switzerland, set at € 1260 per tonne VOCs is expected to give a 16% reduction in VOC emissions. A crude estimate of the effectiveness of an EU VOC tax, based on the tax proposed in Switzerland, is given at 16% of 1990 emissions, i.e. 2.2mt VOCs. Where VOC reduction is valued with the average damage values for VOC (€ 466 - 3424 / t VOC), the benefits of this policy are estimated at € 1.0 - 7.5 billion. Costs will be less than € 2.3 billion (i.e. expected reduction multiplied by marginal abatement costs), this suggests that the VOC tax could be economically efficient at the EU level.

The above policies can address the main underlying causes of tropospheric ozone, market failure and transport growth.

Chemicals and particulate matter

For a discussion on suitable policies for chemicals control see Section 'remaining environmental problems'.

Particulate matter

The suggested policies address the main underlying causes, market failure, intervention failure and implementation failure. Other causes of this environmental problem include, population / transport growth and the growth in real income.

This issue is controlled mainly through policy initiatives recommended for the transport sector as discussed below. All policies designed to reduce vehicle use will be beneficial in terms of PM_{10} emission reductions and noise reductions.

Policies implemented to reduce other environmental issues such as the carbon / energy tax, minimum excise duty, the aviation tax and the nitrogen and sulphur taxes will also be beneficial in terms of PM_{10} reduction.

Waste management

Some of the many waste management policy options are: recycling credits, landfill tax, incineration tax, collection charges, deposit refund schemes for returnable containers and batteries, tradable recycling quotas and producer responsibility agreements. However it is our judgement that the most promising in terms of environmental effectiveness and economic efficiency are; i) virgin materials taxes and ii) recycling credit schemes. The virgin materials tax reduces waste at source, whilst the recycling credit scheme addresses the current market failure in this area, thus both policies address the main underlying causes of the waste management problem.

In general, waste management policy is directed at waste once it has been generated, rather than at source reduction per se. This runs counter to the waste hierarchy as espoused in most countries and particularly by the European Commission. Innovative policy on waste should therefore be directed at source reduction, i.e. at preventing waste from arising in the first place. This suggests a focus on making waste generation expensive. While, in principle, this is achieved by taxes on emissions or products, there are strong arguments in favour of material or input charges and taxes. Particularly relevant are the monitoring and administrative costs of charges aimed at emissions to the environment. Inputs tend to be more easily measurable. In some contexts, e.g. packaging, environmental impacts tend to be associated with the material input rather than the specific product or emission. Virgin materials taxes should encourage source reduction and the use of secondary materials (recycling). Also, waste taxes have an in-built incentive for evasion through fly tipping (which has been one of the results of the UK landfill tax). Thus materials taxes have several attractions. Despite these attractions, there appear to be few examples of virgin material taxes in the EU.

The AP scenario with source reduction of waste assumes a virgin materials tax based on Bruvoll (1998). Bruvoll simulates a hypothetical tax on virgin paper and plastics for Norway. The analysis for Norway suggests that serious consideration should be given to a virgin materials tax as a substitute for landfill and other disposal taxes. A crude elasticity estimate suggests that a 1% charge on virgin materials would lead to a 0.5% decline in packaging waste over 10 years, and a 0.25% decline in the use of the taxed material (paper and plastics) over the same period. Thus, the elasticities for overall packaging waste and for paper and plastics in specific are -0.5 and -0.25 respectively. Assuming the virgin materials tax secures the full 6778 ktonne reduction in waste, costs are estimated as negative at € -800 million (see *Chapter 3*, note negative costs indicate a benefit) and the benefits of not producing waste are roughly € 2.4 billion. This suggests the virgin materials tax is economically efficient.

The recycling credit system is unusual in that it consists of a transfer of funds between different agents in the waste sector. There are no revenues to or expenditures by government. Essentially, those who collect or dispose of waste, transfer the cost of avoided disposal to those who engage in incremental recycling. Thus, if a collection or disposal authority would have spent € 20 per tonne disposing of waste, and that tonne is recycled instead of going to disposal, the saved € 20 become available as a credit to recyclers. Since the marginal (private) costs of disposal can be high, the credits have the potential to transform the economics of recycling. At this stage, it is not possible to estimate the effectiveness of recycling credits across the EU, however, we expect that recycling credits could have a major role to play in achieving this goal.

Transport policies

Policy action in the transport sector provides one of the clearest opportunities to secure synergistic benefits. The main policy options are summarised as:

- congestion tolls, parking charges, workplace parking charge;
- differential fuel taxes;
- vehicle taxes;
- tradable efficiency permits for car manufacturers, and
- accelerated phase-out of older vehicles.

Other policy measures include:

- incentives to retire old vehicles in favour of new, lower emission vehicles;
- incentives to maintain vehicles in proper order;
- general fuel tax in order to reduce demand for vehicle use;
- tax on emissions from vehicles;
- standards for emissions per vehicle;
- manage traffic flow (park and ride, traffic calming, etc.), and
- subsidise public transport.

The relative merits of the various instruments have been discussed extensively in other studies. The following summarises the key issues for the main policy measures.

Congestion tolls, parking charges, removing commuter subsidies: These policies aim to raise the price of vehicle use, especially where emissions are likely to be highest per km travelled, e.g. congested towns. Road pricing involves charging vehicles for entry to a given area, say a congested urban area, or a motorway. Motorway charges are common in the EU, but road pricing in urban areas is uncommon. Research suggests that road pricing may be a very cost-effective way of reducing traffic. Currently many parking spaces are provided by employers, thus effectively subsidising car travel into towns. Workplace parking charges are currently under consideration in the UK. Road and parking charges are generally unpopular, but Goodwin (1992) suggests that greater public acceptance can be secured by hypothecating some of the revenues to investment in transport infrastructure and public transport.

In principle, road pricing merits careful attention as the most likely way forward for the future of road transport in the EU.

Differential fuel taxes are already in place in the EU. All Member states differentiate between leaded and unleaded gasoline, for example. In principle, the same approach can be used for other fuels, however there needs to be a strong substitution effect between fuels. Price differentials for leaded / unleaded fuels helped encourage the switch to unleaded fuel, although the dominant effect on vehicle lead emissions had at least as much to do with the reduction in the lead content of leaded fuels.

Environmental damage caused by emissions from transport depends strongly upon location and it is not possible to differentiate fuel taxes between locations. Eyre et al (1997) show that urban fuel should be taxed in the ratio 1: 2.8: 7.2 for natural gas vehicles, gasoline and diesel respectively. In rural areas the ratios are 1: 2.4: 3.4. The diesel-to-gasoline ratio is very much higher for urban areas. Thus if a tax is based on ‘urban’ externality, rural car drivers will be ‘overtaxed’ by a system, which increases the price of fuel on which they are dependent through an absence of public transport alternatives. However, It would be difficult to differentiate any fuel tax by region because vehicle owners would simply engage in arbitrage. The regressive effects can be countered by using tax proceeds to increase transfers to low-income households and to improve the provision of public and non-motorised transport.

Vehicle taxes are applied as an annual fixed fee on the ownership of a vehicle with intent to use. It does not relate to actual emissions since ownership is divorced from actual use. However, as a long term measure to gradually change the emissions profile of the vehicle stock, differentiated vehicle ownership taxes are recommended. For example, low engine capacity vehicles could be taxed less than higher engine capacity vehicles. A further possibility is to differentiate by the fuel used in the vehicle since this is almost invariably a design feature of the vehicle that cannot easily be changed. This would account in part for the need to differentiate taxes by fuel type.

Tradable efficiency permits for car manufacturers are as yet untested in the EU. They are simply an extension of the tradable permits scheme. Manufacturers are given fuel efficiency targets, which rise over time. Manufacturers over achieving the standard receive credits equal to the difference between the average kms / litre fuel achieved and the standard. Those failing to achieve the standard would have to buy credits, thus creating a market for fuel efficiency permits. Such schemes avoid many of the political problems of taxes, devolving the actions on to the manufacturers and avoided transfers of funds (unless the initial permits are auctioned).

Accelerated phase-out of older vehicles. A subsidy on scrapping older vehicles could be introduced. However, the subsidy could become a liability on state revenues unless vehicle manufacturers are encouraged to share the cost of the subsidy. The analogy would be the subsidy provided by governments to energy efficient schemes in the domestic sector where the householder pays most but not all the increased cost of the efficiency measure.

There is considerable scope for the adoption of economic instruments in the transport sector, which will tackle the synergistic issues arising in that sector. The most likely package to be cost effective is; i) escalating fuel charges differentiated by fuel type and ascending in the following order: natural gas, gasoline and diesel; ii) road pricing for entry into towns, combined with workplace parking charges; iii) tradable vehicle emission credits for vehicle manufacturers, and iv) removal of the remaining subsidies to using private vehicles.

5.3 Remaining environmental issues

This section discusses potential policy packages for those environmental issues without AP scenarios: stratospheric ozone, nuclear accidents, biodiversity loss, water management, coastal zone management, chemicals and particulate matter and soil degradation. *Table 5.3.1* sets out the suggested policies and where possible, policy environmental effectiveness, i.e. 'distance to target', costs, benefits and B/C ratios are provided.

Table 5.3.1 Environmental and economic efficiency of potential policy packages for the remaining environmental issues.

Policy Package	*Achieved distance target %*	*Costs, benefits and B/C ratios € million*		
		direct costs	*Benefits*	*B/C ratio*
Stratospheric ozone depletion				
Accelerated compliance by Article 5 countries with the Montreal Protocol	≤100	24,000	79,000	3.3
Nuclear accidents				
Accelerated substitution of nuclear facilities	≤100	874	135 - 362 225 - 603 6750 - 18,100 11,250 - 30,150	0.1 - 0.4 0.3 - 0.7 7.7 - 20.7 12.8 - 34.5
Biodiversity loss				
Agricultural policy reform	-	-	-	~
Mitigation banking (development of natural area to be offset by the creation of a 'like' site.	≤100	-	0.015 - 0.03 per hectare	~
Water management				
Water availability				
Water pricing at full social cost	-		-	-
Water quality				
Fertiliser tax with payments to farmers to switch organic crops	-		-	~
Groundwater contamination clean up	-		-	1.5 – 15[1]
Coastal zone management				
Land use planning Tradable development rights Fishing quotas Owner liability and performance bonds	-	-	-	~
Eutrophication				
Ammonia control:				
B/C ratio for 50% nutrient load reduction in the Baltic Sea: policy option not provided.	50% (Baltic Sea only)	3484	7773	2.2
NH_3: 0.87 million tonne reduction (AEA Technology (1999)): policy option not provided.	-	3770	5670 - 6800	1.5 - 1.8
Chemicals				
Pesticides tax	-	-	-	~
Noise				
Noise tax on aircraft	-	-	-	-

[1] Benefits are underestimated because clean up of water will also have major effects on the improvement of bathing water, thus B/C ratios for groundwater contamination clean up are expected to be greater.

Stratospheric ozone depletion

Due to the current state of over-compliance by the EU15 with the Montreal Protocol, no further internal policy is necessary. However, further policy outside of the EU15 is recommended by ensuring the accelerated compliance of Article 5 countries with the Montreal Protocol. The current procedure for dealing with the developing countries is via the Multilateral Fund, which meets the incremental costs of ozone depleting substances (ODS) substitution on a project-by-project basis. This policy passes the cost benefit test: the B/C ratio is greater than unity at 3.3. Desai and Mathur (1996), however, suggest that this approach is too slow and costly for accelerated progress. They recommend establishing competitive bid auctions for the Fund's grants and that developing countries set firm targets for ODSs and also consider introducing market-based instruments to comply with the Montreal Protocol.

Nuclear accidents

The highest risk of a nuclear accident in Europe is from the Central and Eastern European reactors. The recommended policy initiative is therefore, the substitution of nuclear technology in order to reduce the probability of nuclear accidents occurring in these countries. The countries of Central and Eastern Europe in question are unlikely to be able to meet (at least not fully) the costs of reducing nuclear risks. Therefore, the polluter-pays principle has to be rejected in favour of a partial *victim pays principle*, where the potential sufferers of the damage pay for risk reduction. Despite the polluter pays principle being embodied in the Treaty of Union, this is very much how the European Union approaches the issue, with the EC TACIS and PHARE Programmes contributing to a broader fund aimed at improved safety in Central and East European States. To a considerable extent, therefore, the appropriate policy instrument is already in place. The outstanding issue is whether the finance going into such funds reflects the scale of the problem. From the analysis of the likely costs of decommissioning and other serious risk reduction measures, it seems contributions may need to increase considerably.

The underlying cause of a nuclear accident is mainly implementation failure, however, growth in real income and population growth also have a role. Since the policy initiative is targeted specifically at the highest risk reactors this policy addresses the main underlying cause.

Biodiversity loss

Further agricultural policy reform is required in order to take account of the impacts of over production in the agricultural sector and environmentally destructive technology on biodiversity. The limitations of land use planning schemes and the earlier MacSharry reforms to the CAP suggest that policy needs to be targeted at specific issues.

In order for biodiversity incentives to be effective, the removal and / or reduction of subsidies damaging to the environment is a priority. In Sweden, for example, subsidisation of forest land drainage to increase timber production has led to the loss of over 30,000 ha of wetlands annually (OECD, 1996). In France, the higher tax on undeveloped land, and agricultural market distortions, provide incentives to drain wetlands for other purposes: it is estimated that the annual rate of wetland loss is 10,000-80,000 ha.

A potential policy package to alleviate biodiversity loss is mainly a combination of various *agri-environmental schemes*, many of which are already in place in many Member States. Focus is centred on agri-environmental schemes because they can be used effectively to target land use and farming practices for the benefit of biodiversity. Some of the most promising agri-environmental schemes recently introduced in the UK in order to implement the Environmentally Sensitive Farming Regulation 2078/92 are:

- Environmentally Sensitive Areas (ESA) scheme;
- Countryside access scheme;
- Countryside Stewardship Scheme;
- Arable Stewardship Scheme;
- Farm Woodland Premium Scheme and Woodland Grant Scheme;
- Habitat Scheme;
- Moorland Scheme;
- Organic Farming Scheme;
- Management agreements;
- Nitrate Sensitive Areas (NSAs), and
- Set-aside schemes.

Each policy targets a specific agri-environmental issue. We propose the continued use of agri-environmental schemes and the introduction of mitigation banking schemes, which offer potential for conserving threatened land areas and especially wetlands.

Agri-environmental schemes are voluntary and offer payments to farmers who agree to manage their land for the positive benefit of biodiversity, landscape amenity, natural resource protection, historical / cultural heritage or public access. The schemes involve a legally binding contract for a set period of time under which the landowner agrees to undertake, or refrain from, certain activities in return for reimbursement for the cost of the service provided to society, rather than as a compensation to lost value. The payments are based on the agricultural income which farmers forego by participating in the schemes and are partly funded by the European Union.

Ideally, the schemes should be set for a very long period of time otherwise many biodiversity benefits will be lost. Some of the advantages of the agreements are the fact that they are easily targeted, flexible, and help to clarify property rights. Agri-environmental schemes are considered to be cost-effective as they involve only a redirection of existing subsidies to farmers.

Mitigation banking (MB) can complement the agri-environmental measures. The achievement of biodiversity conservation is essentially an offset procedure such that conversion of a natural area to some developmental use has to be compensated for, in advance of conversion, by the creation of a ‘like’ area. The new area thus ‘offsets’ the converted area, resulting in, as far as possible, a ‘no net loss’ situation. By varying the requirements for the ‘exchange rate’, it is also possible to expand the area under conservation, e.g. by requiring that compensation take place on a basis of, say, 2 km^2 per km^2 lost.

The issue is whether MB could be used for wetlands (and other ecosystems) in the EU. The Habitats Directive can be interpreted as having a no-net-loss policy for the Natura 2000 sites, i.e. sites listed as Special Protection Areas (SPAs) under the Birds Directive, and Special Areas of Conservation (SACs) under the Habitats Directive. Articles 6(3) and 6(4) explicitly require compensatory measures to be undertaken where conversion is unavoidable. In principle, therefore, MB could be used to implement the Directives and to extend the area under conservation.

Assessing the costs and benefits of a mitigation banking system is complex. Based on the literature review of WTP for natural capital, conducted for this study, WTP for habitat conservation is assumed to be € 20 per person per annum. This is equivalent to € 4.5 billion for 150 million households multiplied by 1.5 adults per household. Assuming that those expressing WTP are aware of the rates of land conversion from natural to ‘developed’ sites, then € 4.5 billion can be considered as an aggregate valuation for the marginal change in land use per annum. Taking the figures for the conversion of agricultural land to ‘built’ uses between 1960 - 1990 for France, UK, Germany and the Netherlands, we estimate the that the benefits of a mitigation banking policy that prevented the conversion of this land could result in benefits of € 15,000 - 30,000 per hectare. Costs of mitigation are not known with certainty. James and Green (1998) report typical EU budgets for protected areas as high at, € 30,000 per km^2 in the Netherlands or € 300 per ha. Mitigation would, of course, involve potentially major capital works compared to protection expenditures, but it seems unlikely that they would exceed the magnitudes for benefits.

The underlying causes of biodiversity loss include: i) intervention failure, ii) market failure, iii) implementation failure, iv) population growth and v) growth in real income. The above policies typically address the first two underlying causes.

Finally, the issue of biodiversity loss will benefit from policy initiatives targeted at specific issues for; i) coastal zones protection, ii) water availability; iii) water quality, and iv) chemicals and particulate matter.

Water management

Policy initiatives are required to target the two main issues concerning water management: water availability and water quality.

Water availability

In 2010, roughly 14% of EU15 population, some 54 million people, will suffer from reduced water availability. The cost-benefit analysis indicates that WTP to avoid reduced water availability in the domestic sector is greater than only the least cost supply options, such as new groundwater and re-use schemes. This suggests the need for policy measures to initially focus on further demand management and leakage control. Demand management could be particularly relevant in the tourist sector in order to control water use.

Economic pricing of water: Demand for water will, most effectively, be controlled through pricing of water at long run marginal cost (LRMC) as part of a longer run commitment to full social cost pricing. The correct pricing of water must account for the (i) long run extraction and distribution costs; (ii) the environmental costs of low flow regimes, and (iii) the opportunity costs of water use.

The first step towards correct water pricing is the removal of subsidies. Where cross-subsidisation of low-income consumers is required this can be achieved by 'lifeline' tariffs, i.e. charging low prices for low consumption and higher prices for higher consumption. An additional instrument for the control of water demand is tradable water rights for the agricultural sector (irrigation water); see for further details *Technical Report on Water Quantity and Quality.*

Water quality
Groundwater contamination can be caused by various pollutants including; pesticides and fertilisers. When groundwater is known to be contaminated, there are a number of well-defined technological options available to clean the water, although there may be some instances where the issue cannot be resolved. A nitrates or pesticides tax cannot reduce existing pollution but revenues could be hypothecated towards clean-up programmes. However, when groundwater is known to be under threat from contamination, it may be possible to regulate by means of a tax. In order to do so a good monitoring system to identify the cause of contamination must be put in place in those areas where the threat of contamination is greatest.

If the contaminant is nitrate run-off, the preferred policy option is a fertiliser tax with payments to organic crops. Due to the inelasticity of demand for fertilisers, it is likely that a fertiliser tax will not change the quantity of fertiliser used significantly. Therefore the high revenues from fertiliser tax could be hypothecated to clean up the water. To reduce the tax burden to farmers, payments to farmers to switch crops are recommended, e.g. to provide incentives to increase organic produce.

The main underlying causes of the water management problem are intervention failure and market failure. The correct pricing of water and tradable water rights schemes address the former underlying cause, whilst a fertiliser tax (or pesticide tax) may address the second.

Coastal zones

Potential polices for coastal zone management target the following key issues: land use, fisheries, oil spills and eutrophication. Although, beach quality is generally covered by existing Directives (i.e. Urban Waste Water, Bathing Water), the issue of *implementation* is outstanding.

Land use planning which contains regulations on what type of activity or structures can and cannot take place has been thought of as the principle mechanism for coastal zone management. Land use planning exists in most EU countries, however, implementation differs between different sites and in connection with other related policies. The recent report on the EC's Integrated Coastal Zone Management (ICZM) project remarks that land use planning alone is not a sufficient vehicle for ICZM (EC, 1999).

In order to guarantee adequate coastal zone management other mechanisms are required. The policy package most likely to be cost effective is (see for details *Technical Report on Water Quantity and Quality*):

- transferable development rights;
- tradable fishing quotas;
- owner liability and performance bonds against oil spills, and
- measures to reduce eutrophication.

The underlying causes of coastal zone management include, i) market failure ii) implementation failure iii) population growth and iv) real growth in income. The suggested policies address the first two underlying causes.

Chemicals and particulate matter

The issue of airborne chemicals and particulate matter will be partially controlled through policy initiatives targeted at other environmental problems, such as the transport sector and all policies designed to reduce energy demand derived from fossil fuels.

Chemicals
Targeting high toxicity pesticides by means of a pesticide tax will only be successful if the tax is differentiated according to the toxicity of chemicals. Otherwise the impact on pesticide use will be very low due inelastic demand for pesticides. Bailey and Rapsomanikis (1999) show that although the 'own' price elasticity of demand for pesticides in the aggregate is low, the cross-price elasticities are greater, suggesting that farmers might switch between types of pesticide. This means that while a tax would not have a significant overall effect on pesticide use it could lead to switches between pesticides, such that the overall toxicity of pesticide use will be lowered. However, there are some doubts about whether a tax would always result in the 'right' substitution of low toxic pesticides for high toxic ones. Revenues raised could be used for clean up of cumulative pesticide contamination in groundwater, if hypothecation of taxes is accepted, as is increasingly the case within EU-15.

This policy can address the two main underlying causes for the chemicals problem, market failure and intervention failure.

Soil degradation

Policy initiatives targeted at other environmental problems will help to alleviate the problem of soil degradation. These policies include: i) agricultural policy reform (see Biodiversity loss) ii) ammonia tax based on a system of mineral accounting targeted at the issue acidification; iii) pesticides tax directed as described above, and iv) fertiliser tax designed to ameliorate water quality issues.

Human health, air quality and noise

Air quality policies are dealt with in the context of other issues, i.e. acidification, transport, chemicals and particulate matter and climate change. In this section we consider policies relevant for noise only.

Noise-specific measures include noise tax on aircraft. The aviation tax suggested in climate change, based on Pearce and Pearce (1999), includes a noise tax set at marginal environmental damage from aircraft at London Heathrow airport.

The economic value of noise nuisance is derived from a meta-analysis of hedonic house price studies, producing an index which links house price depreciation to a unit of noise. The resulting economic values therefore vary with the level of house prices, and housing density in the surrounding noise 'footprint'

5.4 Distributional impact

Unfortunately resources do not permit a full analysis of the distributional incidence for each potential policy. *Table 5.4.1* indicates the sectoral impact of the various policy options, whilst below we provide a rough guide to key socio-economic and regional distribution concerns. Note that impacts are judgmental i.e. we have not attempted to estimate the costs of policy packages to these sectors.

Climate change

The distributional impacts of a carbon / energy tax across income groups may be regressive. However, some social payments from tax revenues could be made to alleviate this effect. Tradable quota systems can offer a known effect on emissions but the quota prices are uncertain, thus the distributional effects through the quota are uncertain. The distribution of the carbon energy tax by spatial unit in the EU15 is addressed by the EU burden sharing agreement. The change in welfare in each Member State is discussed in Chapter 4 on Macroeconomic impacts.

Global warming is a future orientated problem. Assuming future generations are richer than current generations, this in effect means we are transferring monies from poor to rich. The justification for this transferral are as follows; (a) future generations have a limited ‘vote’ due to limited cross-generational markets and (b) the possibility that global warming may in fact reduce their well-being, i.e. there is the risk that they won’t be richer than the current generation (Schelling, 1999).

Acidification

In general, emissions taxes that lead to higher energy prices are likely to be regressive across different income groups. These effects can be reduced by side payments from the tax revenues to those harmed by the tax. The distribution of emission taxes by region in the EU15 are not known with certainty as it depends on many factors, such as climatic conditions, dispersion of emissions, sensitivity of the receiving ecosystem and population density, as well as the degree of dependence a nation has on fossil fuel power generation.

Waste management

Virgin material tax costs are most likely borne by producers, who may pass them on to consumers. We would expect this not to be regressive across incomes. The distributional impacts of recycling credits are expected to be negligible. They can in fact benefit local groups such as charities and youth clubs to collect waste suitable for recycling.

Stratospheric ozone

The accelerated compliance of Article 5 countries with the Montreal Protocol meets the equity criterion since these countries do not pay for the incremental costs and hence are no worse off than they would be without action. These countries also get improved health and ecosystem benefits and the probable transfer of technology benefits.

Table 5.4.1 Sectoral impacts of policy measures.

Environmental issue	*Policy option*	*Sector*					
		Ind	*Agri*	*Wat*	*Hh*	*Tran*	*Gov*
Climate[1] Change	minimum excise duty	x			x	**X**	
	carbon / energy tax	**X**[2]			**X**[3]	**X**	
	aviation tax				x		
	tradable permits for GHGs	**X**			x	**X**[4]	
	substitution of other GHGs	x				**X**	
	transport policy				x	**X**	
Acidification	NO_x tax	**X**			x		
	SO_x tax				x		
	NH_3 tax	**X**	**X**				
	transport policies				x	**X**	
Tropospheric ozone	VOC tax	x					
	transport policies				x	**X**	
Waste management	recycling credits						
	virgin materials tax	x			x		
Chemicals and particulate matter	pesticide tax	**X**[5]	x		x		
	transport policies				x	**X**	
Stratospheric Ozone	accelerated compliance by Annex 5 countries						**X**
Nuclear Accidents	transition fund						**X**
Biodiversity loss	agricultural policy reform		x		x		**X**
	mitigation banking	x					
Water management	pricing water at full social cost	x	**X**	x	**X**		
	fertiliser tax with subsidies to switch crops	x	x				x
	groundwater contamination cleanup	x		x			
Coastal Zone management	land use planning						
	tradable development rights / mitigation banking	x					
	fishing quotas		x				
	owner liability / performance bonds	x					
	nutrient load reduction to coastal waters to alleviate eutrophication	x	x				
Soil degradation	See Biodiversity		x		x		

'**X**' denotes significant impact and 'x' denotes small impact, Ind = industry, Agri = agriculture, Wat = water, Hh = households, Tran = transport, Gov = government.

[1] The mix of regulatory and economic instruments targeted at climate change necessarily focus as a priority on the electricity production sectors

[2] Energy intensive industries, electricity.

[3] Unless exempted.

[4] Aviation sector only.

[5] Chemical industry.

Nuclear accidents

Policy initiatives to reduce high-risk nuclear reactors in Central and Eastern Europe meet the equity criterion. Nuclear damage affects all socio-economic groups thus the benefits are neutrally distributed. The costs are small but taxes may be used to finance the reduction in nuclear risk. Thus, the distributional incidence of the clean up program is fair. However, damage could well be distributed unequally spatially, it is the Accession countries and their neighbours that are more at risk.

Biodiversity loss

Current policies of price support have regressive impacts for households, which may be substantial. Re-directing subsidies towards agri-environmental schemes can achieve the same distributional goals for farmers, while reducing the regressive impact on households, through the overall reduction in subsidies paid out, i.e. reduced expenditures on the disposal of surpluses.

Chemicals and particulate matter

The distributional incidence of the pesticide tax is not known with certainty, however, the occupational group will be affected (i.e. agricultural sector). In the long run the pesticide tax will affect the price of food, but this as a proportion of individuals' income is expected to be negligible.

Water management

Experience with water pricing suggests that the 'poor' need not suffer as water costs may decline as more efficient use is practised. If distributional problems arise, 'lifeline' pricing can be practised whereby a rising tariff for high consumers is used to subsidise low volume (users paying a below marginal cost tariff). The distributional incidence of the fertiliser tax is uncertain although the occupational group will be affected (i.e. agricultural sector). In the long run the fertiliser tax will affect the price of food, but this as a proportion of individuals' income is expected to be negligible.

Coastal zone management

Transferable development rights schemes have the potential to operate in an equitable manner if a mature market exists for the land with development rights, such that, compensated land owners have the option to sell their rights at a profit.

Tradable fishing quotas automatically compensate the marginal producers removed from the fleet. But experience has shown that quota systems can exclude small-scale and independent fishers from fisheries, which fall increasingly under the control of large corporations. Schemes for conflict resolution between fishermen and wildlife could be based on capturing some of the WTP for wildlife.

Owner liability will only have a distributional incidence once a company has been found responsible for an oil spill. Until this occurs, the distributional incidence of owner liability is zero. When an accident occurs and companies are required to pay the 'expected price' of damage, these costs have the potential of being passed on to the consumer. However, due to the diversity of oil based products and products that require oil as an input it is not possible to determine the degree of distributional incidence. Oil spills affect all socio-economic groups, thus the benefits of avoided oil spills are neutrally distributed.

5.5 Subsidiarity

An economic interpretation of the issue of EU subsidiarity gives three main criteria upon which the level of subsidarity can be assessed. These are:

- gains from co-operation;
- gains from harmonisation and co-operation, and
- gains in sustainable implementation (credibility).

Gains from co-operation. The gains from the co-operation principle relate directly to environmental issues that are transboundary externalities. It is usually, but not necessarily, true that a co-operative solution to a transboundary problem will be to the benefit of each individual Member State compared to a non-co-operative solution. This outcome arises from the fact that the benefits of pollution control accrue nationally but the costs accrue internationally. The ‘joint optimum’ that arises from co-operation is to be preferred to the non-co-operation (the prisoners’ dilemma) in which each Member State would be worse off. Where the ‘publicness’ of the externality is localised within a Member State, there is no role, perhaps beyond a ‘framework information’ role, for the Commission.

Gains from harmonisation and co-ordination. In some circumstances it will be optimal to transfer functions such as co-ordinating standards to the Commission. This will be so if it can be shown that the ‘federal’ solution exploits economies of scale that would be unrealised by individual Member State policy. Also, for cases where Member States will have incentives to overstate the cost of regulation, this incentive is reduced if the EC undertakes the co-ordinating activity.

Gains in sustainable implementation (credibility). Once agreed, it is important that agreements are kept. But there are always incentives for any one Member State to break an agreement, even at the risk of retaliation by other Member States. A ‘federal’ solution has greater credibility than loose agreements between Member States where the incentive to cheat remains because regulation is costly and the benefits of regulation are distributed between the parties to the agreement. This holds provided the EC has the power to secure compliance (and uses it).

In *Table 5.5.1*, the environmental problems are assessed according to the subsidiarity criteria above. Many of the environmental problems considered in this study could be alleviated through the implementation of policies targeted at the transport sector. In general, urban transport issues are a localised and thus not a central issue. However there may need to be co-ordination between countries with respect to differentiated fuel taxes as vehicle owners may engage in arbitration. Tradable efficiency permits would also require central control.

Table 5.5.1 Environmental problems and the issue of subsidiarity.

Environmental issue	*'Publicness'*	*Harmonisation*	*Credibility of centralisation*
Stratospheric ozone depletion	Global	Economies of scale in bargaining: benefits of internal trade in CFCs,	Very high
Climate change	Global	Economies of scale in bargaining. Benefits of internal trade in CO_2 permits. Centralised tax minimises compliance costs	Very high
Nuclear accidents	Regional	Economies of scale in bargaining with E Europe. Pooling of costs of reducing risks	Very high
Chemical / oil spills	Transboundary (i.e. Seveso) but in general local (i.e. most oil spills)	Potential cost economies in action plans	High when co-ordinated actions plans are needed
Biodiversity loss	Transboundary: i.e. migratory species, 'joined-up habitat' National, Non-use values are regional and could be global	Not clear	Significant
Acidification	Transboundary	Economies of co-ordination	Low relative to UNECE
Chemicals and particulate matter	Transboundary, national and local	Economies of co-ordination	High
Water management	Local	No gains	Low
Waste management MSW	Local	Low to zero	Low
Waste management Hazardous waste	Transboundary	Economies of co-ordination	High
Tropospheric ozone	Transboundary	Economies of co-ordination may be possible. Member States negotiate in UNECE	Low relative to UNECE
Coastal zone management	Transboundary (i.e. biodiversity) but mostly local	Some gains may be possible	Medium. Member States may not act on their own
Particulate matter	Predominantly local	Some gains possible	Low / medium
Noise	Local	No gains	Low
Soil degradation	Local	No gains	Low
Forests	Local, however, non-use value is nation-wide	Low	Low

5.6 Menu of key policy initiatives

Prior to the implementation of further environmental policy initiatives, it is imperative to secure the Baseline. A major effort should be directed towards two key issues:

- firstly, in order for environmental policy incentives to be effective, it is a priority to remove the disincentives. For example, the Baseline assumes all energy subsidies targeted at fossil fuels are removed. Thus attention should be given to the removal of these subsidies before any new energy policy is put in place;

- secondly, a major effort should be directed towards full compliance with all existing policies. In 1998, the latest round of infringement proceedings showed that the Commission was targeting the majority of EU Member States for non-compliance with at least twelve EU environmental directives (EEA, 1999). Particular attention should be given to: the Bathing Water Directive, the Drinking Water Directive, the Habitats and Birds Directive, Directives on harmful substances.

Assuming the Baseline is achieved, *Table 5.6.1* presents some key environmental policies recommended to achieve the AP scenario targets. The key policy instruments are selected based on the five criteria discussed in Section 5.1.2, i.e. causal, efficiency, equity, jurisdictional and macro-economic criteria. The overall assessments of policies against the first four criteria are presented in Sections 5.2, 5.3 and 5.4. The last criterion is discussed in Section 4.1. Subjecting policy measures to many criteria for acceptability risks making almost all policy instruments fail. Unfortunately, it is not possible to determine which criterion is the most important. Thus the final choice of policy instruments is made on the authors' best judgement informed through this study and other studies we have been able to draw upon. It is important to note that it is the research team's concern to define a potential menu of policies, the extent to which such policies are politically feasible is not for the research team to judge.

Many policies targeted at one environmental problem will benefit other environmental problems, to such a degree that further control of the secondary environmental problem may not be necessary. This could be the case for tropospheric ozone, chemicals and particulate matter, soil degradation and noise. For example, tropospheric ozone benefits from policies targeted at acidification, climate change control and the transport sector, whilst chemicals and particulate matter can be reduced through the transport policies and an aviation tax (targeted at climate change control). Noise levels could be reduced by introducing the aviation tax coupled for air pollution and climate change impacts with a noise component. Specific policies are not suggested for soil degradation because the agricultural policy reform recommended for biodiversity loss could be sufficient.

Overall the key policy initiatives represent a mix of economic instruments and regulation.

Table 5.6.1 Menu of key policy initiatives.

Environmental issues	*Policy initiative*
Stratospheric ozone depletion	• accelerated compliance by Article 5 countries with Montreal Protocol and Amendments
Climate Change	*Supply side*: • incentives to use gas • market regulation for electricity, with i) non fossil fuel obligation; ii) emissions trading; iii) support of renewable energy sources, and iv) transparency on fuel costs (to assist removal of hidden subsidies) *Demand side*: • standards for electrical appliances and other household equipment, motor drives, air conditioning etc; • incentives for greater use of heat pumps; • building codes; • tradable emissions permits for car manufacturers • aviation tax on kerosene; • carbon / energy tax with negotiated agreement / minimum excise duties; • substitution of other greenhouse gases (SF_6, PFCs, HFCs) • measures to reduce CH_4 from landfill and N_2O from fertiliser production.
Nuclear Accidents	• accelerated substitution of nuclear facilities in Economies in transition
Biodiversity loss	• agricultural policy reform: i.e. increased use of agri-environmental schemes; and
Water management	• water pricing at full social cost.
Waste management	• recycling credits.
Chemicals and particulate matter	• pesticide tax; • bans on high toxicity pesticides; • secondary benefit from climate change and transport policies.
Acidification	• NO_x, SO_x, NH_3 emissions taxes; • secondary benefit from climate change and transport policies.
Tropospheric ozone	• secondary benefit from acidification and climate change policies.
Coastal zone management	• transferable development rights; • tradable fishing quotas, and • measures to reduce eutrophication. • secondary benefits from biodiversity loss policies.
Soil degradation	• secondary benefits from biodiversity loss policies .
Transport Sector	• congestion, parking and workplace parking charges (removal of tax benefits to commuters on private vehicle use); • differential fuel tax; • vehicle taxes; • accelerated phase-out of older vehicles; • tradable efficiency permits for car manufacturers, and • subsidies to public transport.

6 Methodology and Approach

The first section presents the methodology of integrated environmental assessment applying the DPSIR chain and demonstrates the use of scenarios. The methodology is built up of three coherent parts: the socio-economic scenario, the policy scenario and the environmental projection. There are three scenarios: the baseline (the yardstick for the other scenarios); the technology driven scenario (assessing the scope of 'end of pipe' techniques) and the accelerated policy scenario (a mix of 'end of pipe' techniques and structural measures). The targets used for the accelerated policy scenario were provided by the Directorate General for Environment. After describing scenarios, targets and projections, we will consider the comparison of direct costs with monetised benefits of the scenarios in the section on economic appraisal. The two final sections describe the Consortium expertise and role in the study, followed by a discussion on information gaps and uncertainties.

6.1 Driving forces-Pressure-State-Impact-Response analysis

The study is based on a chain analysis of socio-economic and environmental processes geared towards the selection of environmental issues, and focuses on the economic efficiency and increased environmental effectiveness of policy actions to abate environmental damage. This kind of analysis, generally known among environmental modellers as Integrated Environmental Assessment, has been widely documented in the scientific literature. Within OECD and EEA (1995) the concept has been tailored to a so-called *Driving forces-Pressure-State-Impact-Response* (DPSIR) analysis, as outlined below:

D: *Driving forces* or *underlying causes* describe the ultimate factors causing environmental change; these include change in real income, population change, behavioural and social change, and failures at market, policy and information levels.

P: Driving forces lead to *pressure*s on the environment exerted by *proximate causes* (e.g. use of natural and biological resources, and of emissions).

S: Pressures affect the *state* of the various environmental compartments (air, water and soil) in relation to their functions.

I: Changes in the state of compartments may have *impact*s on ecosystems, humans, materials and amenities and resources.

R: Appraisal of different policy options as a *response* to environmental problems.

In general, Integrated Environmental Assessment focuses on the analysis of environmental impacts. However, *this study does not only focus on environmental impacts*, but also on the *cost effectiveness and priorities* of (additional) policy responses to *alleviate or reduce* <u>all</u> environmental impacts of relevance in the EU, i.e. listed as environmental issues. The study combines a cost-benefit analysis and integrated environmental assessment by means of repeated model simulations describing the DPSIR chain for a selection of policy packages, with the aim of identifying the most cost-effective set of policy responses. However, in addition to cost, other considerations are important for the assessing and ranking policy responses. These include the comparison of distance-to-targets of scenario outcomes and the extent to which policy responses affect more than one environmental issue.

Figure 6.1 shows a schematic representation of DPSIR tailored to this study. Policy response can be assigned to any of the five kinds of actions (macro-economic policy, sector-specific, source-oriented, effect-oriented and curative). In some cases, the underlying causes may not be amenable to policy influence, e.g. population change. Policy actions will be sought that remove or ameliorate the underlying causes of the environmental problems. As an example, the use of water for irrigation can be uneconomic if groundwater property rights are missing. The underlying cause of groundwater overexploitation then is market failure i.e. the failure of resource allocation systems to reflect the true 'opportunity' cost of water . Correct water pricing would be the preferred mechanism for bringing supply and demand into balance. Other underlying causes are missing markets e.g. the fact that there may be no market for environmental services performed by water resources, information gaps, policy inconsistency (subsidies), and implementation failure.

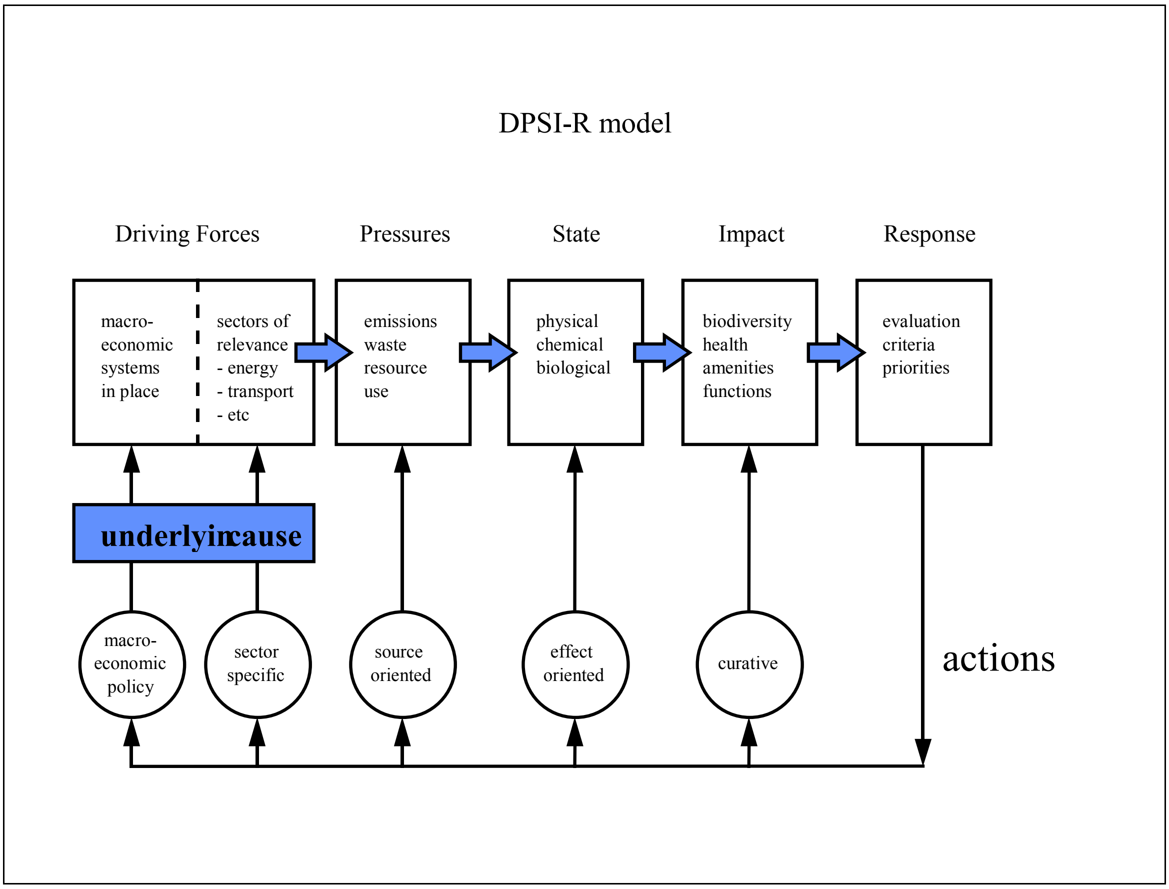

Figure 6.1 The Driving Forces-Pressure-State-Impact-Response (DPSIR) scheme. Underlying causes can be: a) market failure, b) government failure and c) information failure.

6.2 Scenarios, targets and projections

Scenarios

Three environmental policy scenarios have been evaluated:

- Baseline (BL), which consists of policies in place or in the pipeline (PIPP).
- Technology Driven (TD), which abates proximate cause, i.e. emissions, by requiring that all available 'proven' technology to abate emissions be implemented.
- Accelerated Policy (AP) is related to new targets (set by DG ENV) and mixes technology implementation with structural measures, where TD tends to fail the cost-benefit test.

In the first instance a baseline has been established, consisting of three connected parts: the socio-economic trend, the set of policy measures that are in place or in the pipeline, and the resulting projection for the selected environmental issues. Policies in place or in the pipeline have been defined by a cut-off date of August 1997. The baseline (BL) was used by the European Environment Agency for its second State of the Environment Report (EEA, 1999). Free exchange of information and agreement on the BL scenario make the EEA reporting consistent with this report on policy response priorities.

In this study we assessed only one socio-economic scenario, as detailed in section 3.1. However, enlargement of the EU after accession of Central and Eastern European countries may have considerable impacts. To assess these, enlargement is discussed in the related environmental sections; however, is not based on a consistent socio-economic scenario.

The assessment of new policy measures has been carried out in three consecutive steps. Firstly, the BL scenario discussed above has been established. The BL scenario is the yardstick for testing the other policy scenarios discussed below.

Secondly, to set an 'upper limit' on environmental policy measures, we analysed the environmental projections for an environmental policy response consisting of technology driven solutions (TD). This response was not restricted by considering its cost effectiveness: all proven 'add on' technology was considered applicable. Particularly, the abatement of air pollution viz. the environmental issues of acidification, eutrophication, chemicals and particulate matter, ozone and human health and air quality benefited from this scenario. Obviously, unrestricted technology application may lead to costs of avoided environmental damage being higher than benefits.

The third environmental policy scenario results from a choice of technology and incentive measures. As incentive measures require the definition of targets to set the level of implementation, DG Environment set environmental targets where appropriate. For climate change, the target is identical to the greenhouse gas emission reduction set out during the 1998 Conference of Parties, also known as the Kyoto agreement. This Accelerated Policies (AP) scenario provides new insight into the abatement of climate change, air pollution and the spillovers to biodiversity.

We tested the robustness of the AP scenario appraisal by varying the policy options of the Kyoto agreement. The implementation of the Kyoto agreement has been shown to have a large impact on the policies required for other environmental issues as it changes the overall energy use. While the required reduction emissions were decided in the Kyoto agreement, the detailed scope of the mechanisms open to the Parties to bring this reduction about has not. However, these options do have a strong impact at the level of spill-over to other environmental issues. As an example of this spillover, reducing power demand contributes directly to greenhouse gas emission reductions and indirectly to SO_2 and NO_x emission reductions. This impact has been assessed by exploring the three variants below**.**

Kyoto mechanisms: full trade, no trade, no climate variants in the AP scenario

In the ‘no trade’ variant we assessed the impact of meeting the Kyoto reduction agreement without emission trading of any kind. Parties - Member States - have to meet their targets through measures within their boundaries. This variant leads to large differences in cost-effectiveness of the measures. It appears that the Netherlands will have to spend the most to prevent greenhouse gases emission, while Germany and the UK will need to spend considerably less. Another variant is the ‘full trade’ option, allowing for emission trading with third parties like Russia and The Ukraine. Effectively, the EU15 will reduce both its own and the emissions of third parties’, though its own emissions will be reduced to a much lower extent than in the ‘no trade’ scenario. Anticipating an emission trading price of €17 per tonne $CO_{2\ eq}$, the ‘full trade’ variant will create less welfare loss. A third variant, ‘no climate’, assumes the spillover effects of climate change policies to other policies to be absent. Hence policies such as acidification control, cost more due to the hypothesised absence of spillover from climate change policy. This will be the high cost option. Without the structural measures adopted for the greenhouse gas emission reduction, the AP targets in acidification and other environmental issues will require expansive measures to be taken.

Targets

For each environmental issue an effort has been made to identify indicators that describe the performance of the policy scenarios. Special attention has been paid to getting the indicators linked with existing or potential policy targets and with the indicators used in the benefit assessment. However, there are two reasons for not making EU15-wide assessments. First, data and models are lacking or limited and often inconsistent, particularly for issues with a local character, like water stress and soil degradation. Second, policies will not be made at EHS level but at regional level, e.g. water-basin level. *Table 6.1* gives an overview of the AP scenario targets.

Table 6.1 Environmental targets in the Accelerated Policy (AP) scenario

Environmental problem	*AP target (2010 compared to 1990)*	*Comment*
Stratospheric ozone depletion	Not applicable	
Climate change	Reduce emissions of GHGs by 8%	Based on Kyoto protocol
Nuclear accidents	Not applicable	
Biodiversity loss	Not applicable	
Acidification	Reduce ecosystems not protected against acidification by 50%	The general target of the EU acidification strategy
Eutrophication	Not target defined	
Chemicals and particulate matter	Stabilise emissions of heavy metals and POPs	Based on the UN ECE CLRTAP on HMs and POPs
Water stress	Not applicable	
Municipal waste management	Restrict the sum of landfill and incineration to 50%	
Tropospheric ozone	Reduce the excess AOT40 by one-third	Indicator for vegetation
	Limit the highest excess AOT40 to 10 ppm.hours	Should be combined with the previous target
	Reduce the excess AOT60 by two-thirds	Surrogate indicator for health-related excess ozone exposure
	Limit the largest excess AOT60 to 2.9 ppm.hours	Should be combined with the previous target
Coastal zones	Not applicable	
Human health and air quality	Air quality targets for SO_2, NO_x, PM_{10}, B(a)P, lead, benzene and O_3.	Based on EUlegislation in preparation and WHO-AQGs (see *Table 3.5.1).*
Soil degradation	Not applicable	

6.3 Economic appraisal

In general, the basic methodology for meeting the objectives of the study can best be described as making use of economic assessment of costs and benefits of potential policy responses. Costs and benefits will be measured as far as possible in monetary terms using welfare economic criteria (see *figure 6.2*).

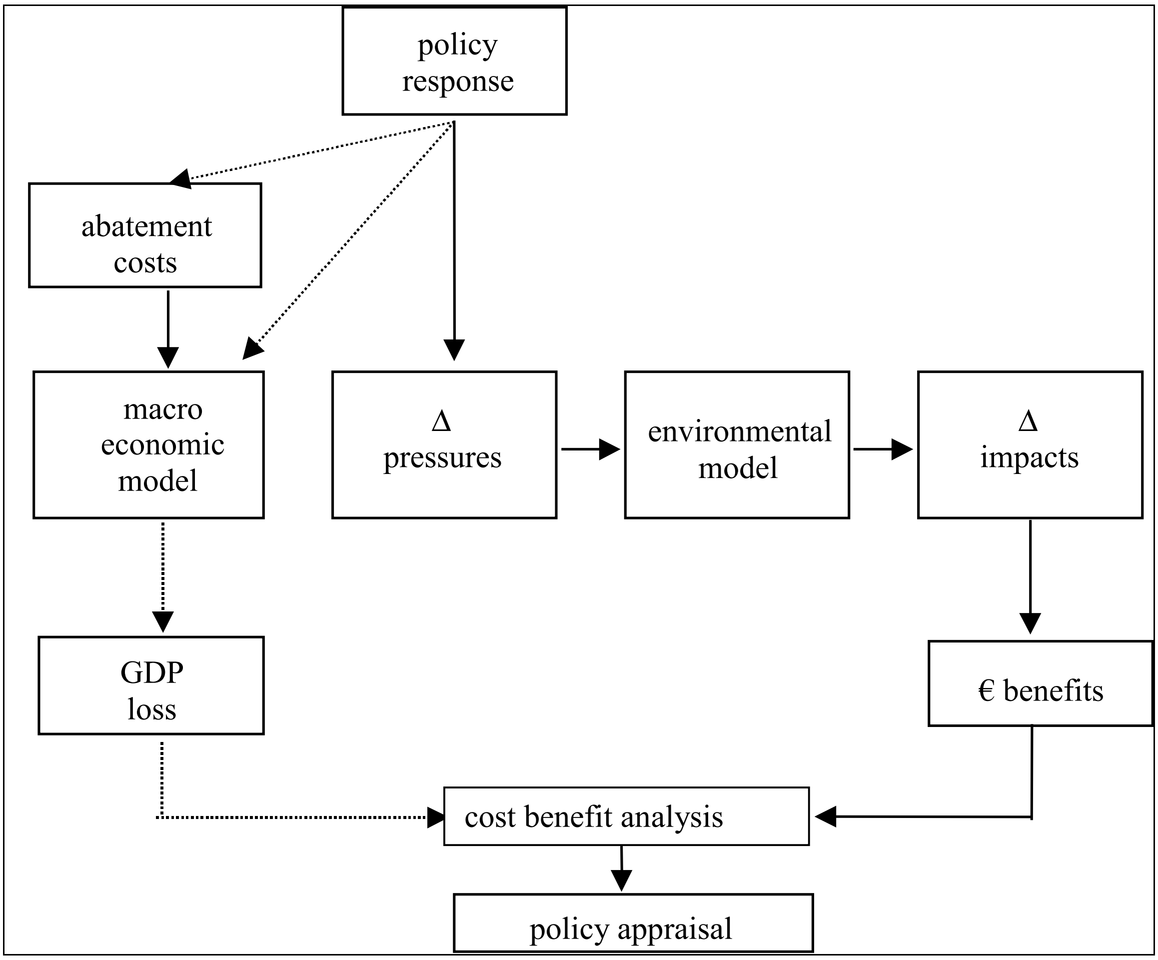

Figure 6.2 Appraisal of policy responses.

The effectiveness of policy responses is evaluated in terms of reducing pressures (Δ pressures) and ecological/health impacts (Δ impacts). For an economic appraisal, the change in impacts is also expressed in monetary terms (€ benefits) (see *chapter 4 - Benefit assessment*). The economic impacts will be either expressed in direct costs (abatement costs) or in changes in the parameters (e.g. taxes) of the macroeconomic model to compute the changes of macroeconomic variables (GDP loss) for the economic sectors. The cost-benefit analysis compares this GDP loss with monetised benefits (€ benefits) and is input to an overall appraisal of the policy response (policy appraisal).

The economic appraisal uses the same models as in the baseline assessment, though in another sequence. In the baseline assessment, the macroeconomic model provides input for the environmental model to compute the state of the environment (impact). In the economic appraisal, the proposed policy response prescribes the changes of the inputs both to the macroeconomic model and the environmental model in order to compare the macroeconomic changes and the monetary impacts.

When costs and benefits are measured in monetary terms, the economic assessment will be a *cost-benefit analysis*. When costs are expressed in monetary terms but benefits only in physical terms, the assessment is equivalent to a *cost-effectiveness analysis*. Other costs and benefits will tend to be more judgmental in nature. The *distributional impacts* of policy packages, for example, could be expressed as an indicator of distributional incidence, e.g. the proportion of benefits accruing to low income groups, to different parts of the EU or to future populations. Similarly, the extent to which actions contribute to *sustainable development* could, as far as possible, be expressed by indicators based on quantitative measures of sustainability but will otherwise be judgmental in nature.

Benefit assessment methodology

Many least cost actions (both technical and structural) have been applied in order to meet the Accelerated Policy (AP) targets by 2010. However, it is beyond the scope of this study to evaluate the effects of each action separately. The benefit estimates therefore represent the 'package' of actions used to achieve the AP scenario targets. Benefits are measured as the difference between the value of the damage in the baseline (D_{BL}) for the target year 2010 minus the value of the damage in AP (D_{AP}), i.e., benefits are assumed to be equal to avoided damage. The benefits of the Technology Driven scenarios are also provided, where applicable.

Essentially, the magnitude D_{BL} - D_{AP} is the benefit of the AP scenario, assuming that policies of some kind guarantee that AP targets are met. The full benefits of moving from Baseline to the AP scenario will, however, be partially policy dependent. This is because the magnitude of secondary effects will partly depend on which policies are put in place. Thus, a climate change policy directed at the transport sector will secure secondary benefits in the form of reduced noise, acidifying pollutants, PM_{10} and low level ozone. A climate policy directed at electricity generation will secure benefits in the form of reduced acidifying pollutants, PM_{10} etc. Thus, the full benefits of going from the Baseline to the AP scenario can be expressed as:

$$B_{AP/BL} = (D_{BL} - D_{AP}) + SB_{AP}(\text{policy})$$

Macroeconomic assessment

The macroeconomic assessment provides insight into the expected welfare loss in the EU due to implementation of the policy scenarios. In the study the general equilibrium macroeconomic model GEM-E3 was used to carry out the evaluation of macroeconomic implications of adopting environmental targets higher than in a reference situation: this was described in a baseline scenario. The macroeconomic implications are effected through direct and indirect costs incurred as a consequence of meeting these targets. Through further micro-level analysis, the study determined the direct expenditure incurred within each policy scenario. Either through least-cost allocation, or by applying a polluter-pay principle, the expenditures in the study were attributed to economic agents represented as companies/firms in economic sectors, government and households.

The role of the GEM-E3 model was then to assess the changes implied by these expenditures for economic growth, production, employment, foreign trade and prices. These changes, conceived as deviations from a baseline growth pace, entailing losses and gains for the economic agents, signify the overall costs of meeting the environmental targets. The analysis with GEM-E3 covers the individual European Union Member States, linked together under the EU Single Market, and their relationships with the rest of the world, which is also considered as a single trade partner.

Cost benefit test

The costs and benefits of the environmental projections associated with the BL, TD and AP policy scenarios have been assessed as far as the technical and economic information allows. This assessment has led to the appraisal of policy response to the selected environmental issues. Company costs and benefits provide the acid test for the proposed policy scenarios. If the benefits of the avoided damage are larger that the cost associated with policies, these policies will stand the economic test. The integrated assessment and consequent interaction of pressure (emission) and state (deposition) trends between environmental issues makes way for a consistent appraisal of the secondary benefits (spill-over) of policies designed for interaction between environmental issues.

6.4 Consortium expertise and role

The project was awarded with a Consortium consisting of RIVM, NTUA, IIASA and EFTEC. This Consortium, headed by RIVM, formed a multi-disciplinary and geographically balanced research team. Collaboration was set up with the EEA on data collection and the Baseline scenario. The Consortium interacted with a group of peer experts nominated by the co-ordinator of DG ENV. During the project, experts from TME on costs of technology, TNO on chemicals and primary particulate matter, ETC-IW on water demand and ETC-Waste on waste management joined the research team. The Consortium used the historical data collected by the EEA as much as possible.

The Consortium developed and applied an integrated environmental assessment methodology based on three dimensions:
- a list of European Environmental issues, as indicated in the Dobrice Assessment (EEA, 1996), including a set of environmental targets and policy objectives and goals;
- a list of economic subsectors spanning the driving forces of the selected environmental issues, including projections for each country of the study domain;
- a list of policy responses and criteria for choosing policy options, including cost-effectiveness and robustness, and reflecting subsidiarity, compliance and other policy elements as appropriate.

A schematic overview of Consortium involvement and division of tasks, based on the methodology of the three dimensions, is provided in figure 6.3. Displayed are the three dimensions - environmental problems, economic subsectors and policy options - as well as the benefits of scenarios of policy alternatives. The Baseline assessment, characterised by policies in the ‘pipeline’, appeared in EEA’s State of the Environment Report issued in 1999. The Consortium strives for consistency between the scenarios.

The integrated assessment methodology has combined economic models, energy use models, emission data sets and models, environmental effect models, economic benefit models, and databases on the costs and efficiency of policy measures. This enables the scenario evaluation of Europe’s environment and the identification of policy priorities cq. policy alternatives.

<table>
<tr><th rowspan="2">Socio economic scenario</th><th colspan="2">Environmental projections</th><th rowspan="2">costs</th><th rowspan="2">benefits</th></tr>
<tr><th>emissions</th><th>Issues</th></tr>
<tr><td rowspan="3">NTUA
households
energy
industry</td><td>NTUA/RIVM</td><td>Global warming</td><td>NTUA/RIVM</td><td rowspan="4">EFTEC</td></tr>
<tr><td>IIASA</td><td>Acidification
tropospheric ozone</td><td>IIASA</td></tr>
<tr><td>RIVM</td><td>biodiversity
soil degradation
stratospheric ozone
nuclear accidents
urban stress</td><td>no data</td></tr>
<tr><td>IIASA
agriculture
transport</td><td>EEA/TME
EEA/RIVM
EEA/RIVM</td><td>waste management
chemical stress
water stress
coastal zones</td><td>TME
EEA
TME</td></tr>
</table>

Figure 6.3 Consortium involvement in the Integrated Environmental Assessment methodology
•NTUA was responsible for the socioeconomic scenario and the global warming issue,
•IIASA was responsible for the issues of acidification, eutrophication and tropospheric ozone.
•EFTEC was responsible for the benefit and new policies assessment of all issues,
•TME was responsible for the waste issue and provided costs for several issues
•EEA co-operated on several issues and used the entire baseline assessment
•RIVM coordinated the study and was responsible for the issues of biodiversity, soil degradation, stratospheric ozone depletion, nuclear accidents, urban stress, water stress and coastal management

Application of the methodology will result in two final products:

- an environmental baseline for all selected environmental issues after implementation of all 'policies in place and in the pipeline' for use in the State of the Environment Report issued by the EEA and as a yardstick for TD and AP policy-response scenarios.
- identification of the most cost-effective and robust new policy actions in the TD and AP scenarios.

Environment DG was the coordinator for the European Commission (EC), thus forming the link to reaching services within the EC. A peer review group consisting of experts from each Member State was established. This group has met three times in Brussels to assess and record the progress of the Consortium carrying out the assignment. DG ENV has also supported the co-operation and information exchange with other research teams - e.g. within EEA, OECD, EUROSTAT and other DGs.

6.5 Information gaps and uncertainties

The European Environment Agency (EEA) report in the *1999 Environment in the European Union at the turn of the century* included an overview of needs and gaps in environmental and related information. This overview will not be repeated in this section. Based on the experience in our study we found the following strengths and weaknesses (see *Table 6.3*). Some of these findings are partly related to the Consortium's own expertise.

Table 6.3 Expert judgement of information gaps and uncertainties found for environmental problems assessed in this study

Environmental issue	*Pressure*	*Impact*	*Costs*	*Benefits*
Stratospheric Ozone Depletion	++	++	++	++
Climate change: CO_2	++	+	++	+
Climate change: other GHGs	+	+	+	0
Nuclear accidents	++	++	+	+
Oil spills and chemical accidents	0	0	0	0
Acidification and eutrophication	++	++	++	++
Tropospheric Ozone	++	+	++	++
Chemicals and particulate matter	+	+	+	0
Water quantity and quality	+	+	+	0
Coastal zones	0	0	0	0
Waste: municipal solid waste	+	+	+	+
Waste: other	0	0	0	0
Soil degradation	0	0	0	0
Biodiversity	+	0	0	0
Human health, air quality and noise	+	+	+	+
Noise	+	0	0	0

Legend	*Relative range of uncertainty or information gaps*
++	Most certain; well defined
+	Intermediate
0	Uncertain; many information gaps

We are fairly confident on most of the air-related issues. Some of the others, such as water stress, coastal zones, soil degradation and biodiversity, are not well defined. Indicators are missing, data is lacking and policy objectives are not clear. All this hampers the development of assessment models. Specific findings are given below.

Transport and agricultural trends and policy responses: Although transport and agricultural trends are included in this study and the models applied, projections (and scenarios) can be improved. The organisational set-up of the Consortium is the main cause of this weakness. We believe that sufficient expertise is present at the EU level, but research linking this expertise with integrated assessment communities could be enhanced.

Enlargement of the EU: Additional information on the accession process has been collected for this study. Most models do not include the Accession countries. The consequences of the accession process (market, production and consumption changes) are also poorly understood. There is a clear need for strengthening this area.

Distributional incidence of gains and losses from environmental policy: Little is known about the cost of policies and who bears the cost. There may be more known about the incidence of benefits if questionnaires are used, since these can be examined for the ratio of WTP to income and hence the 'income elasticity of WTP'. However, little has been done on this.

Biodiversity: Biodiversity loss is very much a function of (a) landuse change, including temporal change to any existing land use (e.g. summer to winter crops); (b) pollution of watercourses and (c) climate change. Of these, the first is likely to be the most important. Future scenarios of landuse change need to be traced out to assess their impact on biodiversity, allowing for the likely implementation of NATURA 2000 and changes in Accession countries. Future landuse change needs to account for (a) natural and migratory human population change, (b) economic development, especially housing, roads and tourism, and (c) changes in farming practice resulting from 'reform' of the CAP. The links between the CAP and biodiversity require special emphasis. Feasible policy measures to counteract negative impacts on biodiversity need to be assessed. Changes in key biodiversity indicators; e.g. birds, should be highlighted.

Climate change: The costs and benefits of controlling the main GHGs are reasonably well understood, but there is a need to extend the cost benefit analysis to HFCs, PFCs and SF_6. Wide variation in control costs have been reported, depending on the extent to which energy conservation measures are feasible (HFCs, PFCs) and on the difficulties of substituting SF_6 in electrical transmission uses. The few existing studies ignore, for example, trade-offs in SF_6 substitution, since substitutes raise issues of safety and storage. Data problems also abound since the exact quantities of the gases are not known in detail. Such a project would require close co-operation with the relevant industries. Costs and benefits research activities of carbon trading should be extended.

Coastal zones: There is a major need for a 'landuse' study (see recommendations under Biodiversity), where special attention should be paid to (a) leisure and tourism developments, (b) changes in sewage outfall due to existing/planned policies, and (c) transport developments (ports etc.).

Water stress: The water stress problem requires local conditions to be taken into account. The proposed Water Framework Directive does this as it refers to local ecological targets and abatement action plans. The introduction of a monitoring system - EUROWATERNET - should alleviate the data problem in the near future. There is still an urgent need for a European water policy assessment model to play a role similar to the RAINS model for acidification.

Acidification, eutrophication and tropospheric ozone: As every assessment based on modeling, the results are burdened with uncertainties resulting *inter alia*, from simplifications and aggregations necessary to make the models manageable. Depositions and/or concentrations of precursor pollutants are calculated on a rather crude spatial resolution (EMEP grid - 150x150 km). In addition, the health-related ozone exposure index is calculated from concentrations characteristic for rural areas. The indicator is computed using total population per grid. Since the concentrations of air pollution in cities are different, this causes inaccuracies for the grids covering major urban areas. Nevertheless, according to current knowledge, the accuracy with which the pressures, impacts, and mitigation costs are calculated is regarded as being detailed enough for integrated assessment on a European scale. More in-depth, local studies are necessary to develop policies for hot spots, e.g., large cities.

There are important gaps in the valuation of benefits of policies in the area of acidification and tropospheric ozone. In particular, economic studies are needed for: (a) ecosystem valuation and (b) visibility. There are few studies on ecosystem valuation. Although these few do suggest potentially very large economic values, the studies in question are open to methodological challenge. While the paradox is that the LRTAP Protocols are 'driven' by ecosystem change concepts, economic analysis has focused on impacts of health and buildings. Economic analysis of ecosystem change is complex since it involves valuing a 'holistic' object and sets of interrelated activities and nature aspects. The benefits of pollution control in terms of visibility improvement form an integral feature of US air quality policy. Yet no study on visibility in the EU exists. Whether the issue can be perceived as being important in the EU or not still has to be determined.

Chemicals: Surprisingly, very little activity on costs-benefits in population exposure (as opposed to occupational exposure) to or concern about chemicals has been undertaken in Europe.

PM_{10}: emissions, concentrations, and health effects: Results from a Dutch research program on particulates show that computed concentrations of PM_{10} in the Netherlands explain only 50 to 75% of the measured concentrations. This problem is mainly caused by uncertainties related to primary PM_{10}, where the contribution of unknown (mainly natural) sources is dominant. In this study emissions from unknown sources were set to a fixed level during the simulation period. The uncertainty for distinct source categories of primary PM_{10} is also considerable (about factor 2), partly due to the fact that German emission factors have been applied to all the other countries. In general, future research on emissions from known (transport, industry, wood combustion in households) as well as unknown sources (nature, accidental emissions industry, agriculture) is needed.

Next, it should be mentioned that annual average concentrations of PM_{10} have been modelled only. Daily maximum values are directly computed from these annual averages using a fixed relationship, based on measurements. The current relationship implies that if the annual average target of 20 $\mu g/m^3$ is met, the daily maximum target of 50 $\mu g/m^3$ will be met also. However, when certain components of PM_{10} emissions will be reduced more than others, it is uncertain whether the relationship remains valid.

Although there is a clear correlation between concentrations and health effects, the underlying causal principles are still largely unknown. For example, very little is known concerning the question what component of PM_{10} - which consists of particles of many different sizes and different chemical compositions - is responsible for the eventual health effect. Having this information policies could be aimed at those components of PM_{10} that cause the largest health effects.

Valuing health effects: A common feature of many environmental issues is the impact of policy change on human health; examples are stratospheric ozone, climate change, chemicals, accidents, air pollution and bathing water quality (coastal zones). In turn, health impacts may be decomposed into morbidity and premature mortality. Morbidity impacts in Europe are better understood (in the context of air quality) because of the APHEA (see *Box* in *Section 3.5.2*) programme and their economic valuation has improved. Nevertheless, debate on valuing premature mortality continues. Other concepts, such as the DALY approach, are in development (see *Box* in *Section 3.5.2*). This approach should be extended with other health-related environmental issues.

Acronyms and abbreviations

Acronym	Full wording of the acronym
5EAP	Fifth Environmental Action Programme (EU)
AOT40/AOT60	Accumulated Ozone concentration over Threshold of 40 resp 60 ppb.
AP	Accelerated Policy scenario
AP-nt	AP scenario with no trade of greenhouse gas emissions
AP-ft	AP scenario with full trade of greenhouse gas emissions
AQG	Air Quality Guidelines (e.g. by World Health Organisation)
B(a)P	Benzo(a)Pyrene
BL	Baseline scenario
CAC	Command and control measures
CAP	Common Agricultural Policy (EU)
CBA	Cost Benefit Analysis
CDM	Clean Development Mechanism
CEC	Commission of the European Communities
CEECs	Central and Eastern European Countries
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CSERGE	Centre for Social and Economic Research on the Global Environment
DG	Directorate General of the CEC
Dobrice^{+3}	Environment report to be issued by the EEA in 1998
DPSIR	Driving Force, Pressure, State, Impact, and Response model to assess the coherence between cause and effects of environmental problems
DTV	Dutch Target Values
EAP	Environmental Action Programme, the 5th EAP is currently operative
EEA	European Environment Agency based in Copenhagen, Denmark
EFTEC	Economics For The Environment Consultancy Ltd, England, UK
EIZ	Economics Instruments
ESP	Eloctrostatic Precipitator
EU-15	The 15 Member States of the EU
GDP	Gross Domestic Product
GEO2	UNEP’s second Global Environment Outlook
GHG	Green House Gas (CO_2, CH_4, etc)
HM	Heavy Metals, e.g. copper, cadmium, lead etc.
IAEP	Integrated Assessment of Environmental Priority Problems
IEA	Integrated Environmental Assessment
IIASA	International Institute for Applied Systems Analysis based in Laxenburg, Austria
LNG	Liquid Natural gas
LRTAP	Convention on Long Range Transboundary Air Pollution of the UN ECE
MBI	Market Based Instruments
NIC	New Industrial Country
NMVOC	Non Methane Volatile Organic Compound
NPP	Nuclear Power Plant
NTUA	National Technical University of Athens, Greece
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substance
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCP	Pentachlorophenol
POP	Persistent Organic Pollutants
PEEP	Prominent European Environmental Problem
PM_{10}	Particle matter sized smaller than 10 μm
PSA	Probabilistic Safety Assessment
RIVM	National Institute of Public Health and the Environment based in Bilthoven, the Netherlands

SCR/SNCR	Selective Catalytic Reductions
TD	Technology Driven scenario
TEN	EU policy plan to prepare Trans European Networks and infrastructure for the next century
UN ECE	United Nations Economic Commission for Europe
UWWTD	Urban Waste Water Treatment Directive
VA	Voluntary Agreement
VOC	Volatile Organic Compound
WHO	World Health Organisation
WTP	Willingness To Pay

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Appendix A: Overview scenario results and targets

The indicators in the table below have been selected by the following criteria:
1. Existence of targets (to be used in the AP scenarios)
2. Utility in the Cost Benefit Analysis (indicators in *italics*)
3. Availability of data and models to compute future values.

Table: Indicators, Targets and EU15-results

P #	Indicator	Unit	Status 1990	BL 2010	TD 2010	AP-NT 2010	AP-FT 2010	Target
1	**Stratospheric ozone depletion**							
	Consumption of major ODSs[i]	ODP-kt	253	≈ 0[j]	na	na	na	na
	Consumption of methyl bromide	ODP-kt	11	≈ 0[j]	na	na	na	na
	Consumption of HCFCs	ODP-kt	2	-95% ct '89	na	na	na	na
	Production of major ODSs[i]	ODP-kt	376	≈ 0[j]	na	na	na	na
	Production of methyl bromide	ODP-kt	10	≈ 0[j]	na	na	na	na
	Production of HCFCs	ODP-kt	4	-65% ct '97	na	na	na	na
	Avoided skin cancer incidences in 2050[h)]	*non-fatal*	*0*	*77000*	*na*	*na*	*na*	na
	compared to the No Restrictions scenario	*deaths*	*0*	*850*	*na*	*na*	*na*	na
2	**Climate change**							
	CO_2 emissions (excl. non-energy sectors[a])	Mt	3078	3322	na	2819	3066	(2832)
	CH_4 emissions	$MtCO_2$ eq.	490	469	na	451	451	(451)
	N_2O emissions	$MtCO_2$ eq.	313	342	na	288	288	(288)
	SF_6, HFCs and PFCs	$MtCO_2$ eq.	58	81	na	53	53	(53)
	GHG emissions (excl. non-energy sectors[a])	*$MtCO_2$ eq.*	*3939*	*4213*	*na*	*3612*	*3895*	*3624*
3	**Nuclear Accidents**							
	No. of 'unsafe' reactors	units	25	21	2	na	na	na
	No. of deaths due to NPPs	*# per 10^8*	*50*	*nc*	*6*	*na*	na	na
4	**Biodiversity loss**							
	Natural Capital Index	0-7000	1596	1249	nc	1107	na	na
	NATURA2000 SPA area (birds)	% of area	2[b]	nd[c]	na	na	na	na
	NATURA2000 SAC area (habitat)	% of area	3[b]	≈12[c]	na	na	na	na
5	**Acidification and eutrophication**							
	SO_2 emissions	*Mt*	*16.3*	*4.8*	*1.8*	*2.8*	*3.4*	*na*
	NO_x emissions	*Mt*	*13.2*	*7.3*	*4.6*	*5.5*	5.9	*na*
	NH_3 emissions	*Mt*	*3.6*	*3.1*	*2.2*	*3.0*	*2.9*	*na*
	Exceed. critical loads (acidification)	% ecosyst.	24.7	4.6	2.0	2.8	2.8	2.9[d]
	Exceed. critical loads (N)	% ecosyst.	55.3	41.3	24.0	35.2	35.9	na
	Accumulated excess acidity	10^9 acid. eq.	23.9	1.6	0.4	0.6	0.6	0.6[d]
6	**Chemicals and PM**							
	Primary PM_{10} emissions	Mt	2.6	1.6	0.8	0.6	na	na
	Lead emissions	*kt*	*16.4*	*6.6*	*4.9*	*4.5*	*na*	16.4[k]
	Cadmium emissions	kt	0.20	0.21	0.12	0.11	na	0.20[k]
	Copper emissions	kt	1.5	1.5	1.12	1.07	na	1.5[k]
	Mercury emissions	kt	0.25	0.23	0.13	0.12	na	0.25[k]
	PAH emissions	kt	5.6	5.9	2.4	2.6	na	5.6[k]
	Emissions of 4 pesticides	kt	4.0	4.0	0	0	na	0
	Emissions dioxins and furans	*Kg I-teq*	*6.0*	*4.1*	*1.6*	*1.4*	*na*	*6.0[k]*

7	**Water Quality**							
	P-load to rivers	%	100	78	na	na	na	na
	N-load to rivers	%	100	85	na	na	na	na
8	**Waste Management**							
	Industrial waste: recycling + composting	%	nd	nd	nd	nd	nd	70
	Domestic waste: prevention	*%*	*0*	*0*	*0*	*na*	*na*	*na*
	Domestic waste: recycling + composting	*%*	*16*	*25*	*70*	*60*	*na*	*50*
	Domestic waste: Waste To Energy (WTE)	*%*	*15*	*14*	8	*13*	*na*	*na*
9	**Tropospheric Ozone**							
	VOC emissions	*Mt*	*14.0*	*7.2*	*4.9*	*5.7*	*5.6*	*na*
	Emissions NO_x	See (P5)						
	AOT 40 (vegetation, background), excess over threshold of 3 ppm.hours.	ppm×hours	6.6	4.1	2.7	3.0	3.0	3.1[e]
	AOT 60 (health, background)	ppm×hours	3.5	1.4	0.7	0.8	0.8	0.8[f]
10	**Coastal Zones**							
	No indicators, No targets							
11	**Human Health and air quality**							
	Average concentration of benzene	$\mu g/m^3$	5.0	1.7	1.4	na	na	na
	Average concentration of B(a)P	ng/m^3	1.6	1.2	0.6	na	na	na
	Average concentration of NO_2	$\mu g/m^3$	36	24	19	19	na	na
	Maximum daily average concentration of SO_2	$\mu g/m^3$	129	42	21	22	na	na
	Average concentration. of PM_{10}	$\mu g/m^3$	*39*	*28*	*24*	*25*	na	na
	Average conentration of $PM_{2.5}$	$\mu g/m^3$	*21*	*9.5*	*6.0*	*6.5*	na	na
	Average conentration of secondary aerosols	$\mu g/m^3$	*15*	*6.3*	*3.6*	*4.0*	na	na
	Average concentration of lead	$\mu g/m^3$	0.24	na	na	na	na	na
	Average concentration of O_3 (120 µg/m3 8h <20d)	$\mu g/m^3$	43	24	16	19	na	na
	Exposure above benzene target (5 $\mu g/m^3$ aa)	10^6 people	85	8	2	na	na	0
	Exposure above B(a)P target (1 ng/m^3 aa)	10^6 people	188	143	51	na	na	0
	Exposure above NO_2 target (40 $\mu g/m^3$ aa)	10^6 people	123	36	15	18	na	0
	Exposure above SO_2 target (125 $\mu g/m^3$ 24h)	10^6 people	171	5	0	5	na	0
	Exposure above PM_{10} target (40 $\mu g/m^3$ aa)	10^6 people	160	15	5	nd	na	0
	Exposure above PM_{10} target (20 $\mu g/m^3$ aa)	10^6 people	351	305	294	302	na	0
	Exposure above $PM_{2.5}$ target (20 $\mu g/m^3$ aa)	10^6 people	175	9	1	2	na	na
	Exposure above Pb target (0.5 $\mu g/m^3$ aa)	10^6 people	46	0	0	0	na	0
	Exposure above O_3 target (120 $\mu g/m^3$ 8h <20 d)	10^6 people	328	265	107	182	na	0
	Total Population in EU15	10^6 people	365	387	387	387	387	na
12	**Soil Degradation**			.				
	See comments below							

nd = no data available, na = not applicable for this study, aa = annual average

8h <20 d = 8 hours average for less than 20 days in a year (3 out of 5 years)

24h = maximum 24 hours a year

[a] The non-energy sector (such as cement-production) cover about 5% of total CO_2 emissions.

[b] Data are for 1996 in stead of 1990. The NATURA2000 Directive reports in 1999 5% for SPA (birds) and 10% for SAC (habitat).

[c] The target is around 12% in 2004 for SAC area; for SPA there is no quantitative area target defined yet.

[d] The interim target in the EU Acidification strategy is to reduce in the year 2010 the area of ecosystems not protected against acidification everywhere in the Community by at least 50 percent compared to 1990. This is equivalent to the 95 percent gap closure of accumulated excess acidity. Accumulated excess acidity is defined as acid deposition in excess of the critical loads, accumulated for all ecosystems in a grid cell. Column ‘target’ specifies values of indicators for the whole area of the EU-15 calculated with national emissions from the proposal for the National Emission Ceilings Directive. The European Community programme of Policy and action in relation to the environment and sustainable development (the Fifth Environmental Action Programme) sets the objective of no exceedance of critical loads and levels for acidification in the Community (no time-frame is set).

[e] The interim objective is to reduce the excess AOT40 by one third between 1990 and 2010. In addition, the highest excess AOT40 in the EU15 is limited to an absolute ceiling of 10.0 ppm.hours. Long-term target of AOT40=3ppm.hours, but no time frame has been set. Column ‘target’ specifies average value for the whole area of the EU-15 calculated with national emissions from the proposal for the National Emission Ceilings Directive.

[f] The interim objective is a relative reduction of the AOT60 by two thirds between 1990 and 2010. In addition, highest excess ozone in the EU15 is addressed by introducing an absolute ceiling on the AOT60 of 2.9 ppm.hours. Long-term target AOT60=0 (120 $\mu g/m^3$), but no time frame has been set. Column 'target' specifies average value for the whole area of the EU-15 calculated with national emissions from the proposal for the National Emission Ceilings Directive.

[h] Data are for 2050 instead of 2010 due to long delays.

[i] Major ODSs are: CFCs (Groups I and II), halons (Group III), carbon tetrachloride (Group IV), and 1,1,1-trichloroethane (Group V).

[j] Production and consumption of so called 'essential uses' are still allowed. Also, the production of major ODSs is allowed for the use developing countries.

[k] In the UNECE HM- and POP-protocols it is stated that the EU15 should stabilise its emissions to the level of a reference year between '85 and '95. In consultation with DG Env, it was decided that 1990 should be used as the year of reference.

Appendix B: Overview EU-Environmental legislation: Policies in Place and in the Pipeline

The next pages present a list of environmental regulations, proposals, amendements and decisions as adopted or proposed by the Comission before September 1997.

Legend:

Convention,..	Name of the convention, directive etc, grouped per PEEP	
Year:	Year of adoption	
Document:	Year/number of the reference document (EC reference system), or name of the reference document/institute	
Substances:	**List I substances**	Hexachlorocyclohexane (lindane)
		pentachlorophenol (PCP)
		DDT
		aldrin
		dieldrin
		endrin
		isodrin
		hexachlorobenzene (HCB)
List II substances		polychlorinated chloroethyl sulphonamido diphenylethers (PCSD)
		cyfluthin
		sulcofuron
		flucofuron
		permethrin
		tributyltin
		tryphenyltin
In Bl?	flag for inclusion on Baseline scenario	

Convention/Directive/Decision/Regulation/Target	Year	Document	Substances	In BL?
STRATOSPHERIC OZONE				
On the conclusion of the Montreal Protocol on Substances that Deplete the Ozone Layer	1988	88/540	ODSs	Yes
London Amendments to the Montreal Protocol	1990	n.a.	ODSs	Yes
Copenhagen Amendments to the Montreal Protocol	1992	n.a.	Halons, CFCs, Methyls, CTC, HCFC's	Yes
Regulation on Substances that Deplete the Ozone Layer	1994	3093/94	CFCs, Halons, 1,1,1-tri-chloro-ethane, CCl4, HCFC's	Yes
The allocation of quotas for methyl bromide	1995	95/107	Methyl bromide	No
The allocation of quotas for HCFCs	1996	96/511	HCFCs	No
CLIMATE CHANGE				
FCCC - Framework Climate Change Convention	1992	n.a.	GHGs	Almost
Energy standards for traded products	1992	92/42	GHGs	Yes
Energy labelling	1992	92/75	CO_2	Partly
Energy efficiency programme - SAVE	1993	93/76	CO_2	Partly
Monitoring and limiting GHG's	1993	93/389	GHGs	No
Renewable energy - ALTENER	1993	93/500	CO_2	Partly
Renewable energy program - JOULE			CO_2	Partly
Proposal on carbon/energy tax	1995	COM(95)172	CO_2	No
Energy labels for washing machines and driers.	1995	COM(95)...	CO_2	Partly
Energy efficiency requirements for refrigerators and freezers.	1996	96/57	CO_2	Partly
Energy efficiency programme - SAVE II	1996	93/76	CO_2	Partly
Modification of Monitoring and limiting GHG's	1996	COM(96)369	GHGs	No
Methane emissions	1996	COM(96)557	CH_4	No
Landfill of waste	1997	COM(97)105	(Hazardous) waste, CH4	No
Restructuring the Community Framework for the taxation of energy products	1997	COM(97)30	CO_2	No
NUCLEAR ACCIDENTS (& other major accidents)				
Basic Safety Standards (BSS)	1982	80/836	n.a.	No
Convention on Transboundary Effects of Industrial Accidents	1992	n.a.	n.a.	No
Major-accident hazards of certain industrial activities.	1982	82/501	Dangerous subst.	Partly
Regulation on existing chemicals	1993	93/67	Chemicals	No
Minimum requirements for vessels carrying dangerous or polluting goods	1993	93/75	Dangerous goods	No
Shipment of radioactive substances between Member States.	1993	1493/93	Radioactive subst.	No
Proposal to review Seveso Directive	1994	COM(94)4	n.a.	No
BIODIVERSITY				
Nature Protection and Wildlife Preservation in the Western Hemisphere	1940	n.a.	n.a.	No
International Plant Protection Convention	1951	n.a.	n.a.	No
International Plant Protection Convention	1979	n.a.	n.a.	No
The Protection of the World Cultural and Natural Heritage (the Paris Convention)	1972	n.a.	n.a.	No
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1973	n.a.	n.a.	No
Bonn Amendment on CITES	1979	n.a.	n.a.	No

Bern Convention on the Conservation of European Wildlife and Natural Habitats	1979	n.a.	n.a.	No
Conventions on the marine environment	n.a.	n.a.	n.a.	No
World Charter for Nature	1982	n.a.	n.a.	No
Birds and their habitats	1979	79/409	n.a.	No
Trade in endangered species	1982	3626/82	n.a.	No
Environmentally sensitive farming	1991	2328/91	n.a.	No
Environmentally sensitive farming	1992	2078/92	n.a.	No
LIFE - finance	1992	1973/92	n.a.	No
Habitats and species conservation	1992	92/43	n.a.	No
United Nations Convention on Biological Diversity	1992	n.a.	n.a.	No
Protection of birds	1994	COM(94)39	n.a.	No
LIFE II - finance	1996	1404/96	n.a.	No
Environmentally sensitive farming	1996	746/96	n.a.	No
Protection of species of wild fauna and the trade therein	1997	338/97	n.a.	No
ACIDIFICATION and EUTROPHICATION				
Motor vehicles (positive-ignition)	1970	70/220	NO_x etc.	Yes
Motor vehicles (diesel)	1972	72/306	PM	Yes
Motor vehicles	1974	74/290		Yes
Sulphur content of certain liquid fuels	1975	75/716	SO_2	Yes
Motor vehicles	1977	77/102		Yes
Diesel engines for use in wheeled agricultural or forestry tractors	1977	77/537	NO_x	Yes
Motor vehicles (which?)	1978	78/665		Yes
On the conclusion of the Convention on Long-Range Transboundary Air Pollution	1981	81/462	NO_x NH_3	Yes
Diesel engines for use in tractors	1982	82/890	NO_x	Yes
Smoke and sulphur dioxide	1980	80/779	SO2 and particulates	Yes
Smoke and sulphur dioxide	1981	81/857	SO2 and particulates	Yes
Motor vehicles	1983	83/351		Yes
Emissions from industrial plants	1984	84/360	SO_2	Yes
Reduction of Sulfur Emissions or their Transboundary fluxes	1985		SO_2	Yes
Air Quality Standards for Nitrogen Dioxide	1985	85/203	NO_2	Yes
Air Quality Standards for Nitrogen Dioxide	1985	85/580	NO_2	Yes
Sulphur content of Liquid Fuels	1987	87/219	SO_2	Yes
Motor vehicles	1988	88/76		Yes
Motor vehicles	1988	88/436		Yes
Commercial vehicles	1988	88/77	NO_x	Yes
Large combustion plants	1988	88/609	SO_2, NO_x	Yes
Motor vehicles	1989	89/458		Yes
Smoke and sulphur dioxide	1989	89/427	SO2 and particulates	Yes
Motor vehicles	1989	89/491		Yes
Motor vehicles	1991	91/441		Yes
Commercial vehicles	1991	91/542	NO_x	Yes
Vehicle emission tests	1992	92/55	NO_x,	No
Light commercial vehicles emissions	1993	93/59	NO_x	Yes
Sulphur contents of Diesel	1993	93/12	SO_2	Yes
Long-range transboundary air pollution concerning the control of emissions of nitrogen oxides or their transboundary fluxes	1993	93/621	NO_x	Yes
	1993	93/361	NO_x	
Large combustion plants	1994	94/66	SO_2, NO_x	Yes
Emissions from vehicles	1994	94/12	NO_x	Yes
Emissions from engines in non-road mobile machinery	1995	COM(95)350	NO_x	No
Emissions from vehicles	1996	96/44	NO_x	Yes

Fuel Quality (Auto Oil)	1996	COM(96)248 COM(97)271	aromatics (Human Health and Air Q.) Benzene, SO_2	No
Integrated Pollution Prevention and Control	1996	96/61		No
Reduction of air pollution from motor veheicles (Auto Oil)	1997	COM(97)255 COM(97)77	CO, HCs, NO_x, PM	No
Emissions from light commercial vehicles (LCVs) (has been adopted in a more stringent form!)	1997	COM(97)61	$NO_{x,}$,	No
Sulphur content of Liquid Fuels	1997	COM(97)88	SO_2	No
CHEMICALS				
Data collection of existing chemicals	1967	67/584	About 100.000 chemicals	No
Restrictions on marketing and use of dangerous substances	1976	76/769	Dangerous subst.	No
Dangerous substances in water	1976	76/464	See Water Stress	No
Inland water quality	1983	83/513	Cd	No
Limit values and quality objectives for discharges of certain dangerous substances	1986	86/280	Dangerous subst.	No
Probition of the disposal of certain substances resulting from exploration and exploitation in the Mediterranean	1987	87/217	See Coastal Zones	No
Batteries and accumulators containing hazardous substances	1991	91/157	Cd e.o.	Yes
Cadmium	1991	91/338	Cd	Yes
Batteries and accumulators containing hazardous substances	1993	93/86	Cd e.a.	Partly
Testing of chemicals on the market before 18.9.81	1993	93/793	Chemicals	No
Restrictions on marketing and use of dangerous substances	1994	94/27	Dangerous subst.	No
Restrictions on marketing and use of dangerous substances	1994	94/48	Dangerous subst.	No
Restrictions on marketing and use of dangerous substances	1994	94/60	Dangerous subst.	No
Transport of dangerous goods by road	1994	94/55	Dangerous goods	No
1994 Protocol for the Protection of the Mediterranean Sea	1994	-	See Coastal Zones	No
Integrated Pollution Prevention and Control	1996	96/61	See Acidification	No
The marketing and use of certain dangerous substances and preparations ('The 17th amendment)	1996	COM(96)513	About 800 Substances	No
Persistent Organic Pollutants	1997	EB.AIR/WG.5 /R.72/Rev.1	Pesticides, see Comments	Partly
Heavy Metals	1997	EB.AIR/WG.5 /R.81	Pb, Cd, Hg	Partly
Chemical and hzardous waste management	n.a.	n.a	Waste	n.a.
2nd and 3rd North Sea conference Targets	1995	Rev5EAP	Cd, Hg, Pb	
2nd and 3rd North Sea conference Targets	1995	Rev5EAP	Ag,Cu,Zn,As,Cr,Ni	
MANAGEMENT of WATER RESOURCES				
Inland Waters resources: quality	1975	75/440	114 categories, e.g. Hg, Se, Pb, Cd, As, Zn, etc	No
Bathing Water	1976	76/160	Various	No
Dangerous Substances	1976	76/464	LIST I and II substances	Partly
Surface Water for Drinking	1979	79/869		No
Fresh water fish	1978	78/659		No
Shellfish Waters	1979	79/923	Various	No
Groundwater	1980	80/68		No
Drinking Water	1980	80/778	heavy metals, pesticides, fertilizers	No
			Pb, NO_3, pesticides	No
Surface water for drinking	1981	81/855		No
Inland water quality	1983	83/513	Cd	No
Surface Water for Drinking	1984	84/491	hexachlorocyclohexane	No

Limit values and quality objectives for discharges of certain dangerous substances included in List 1 of the Annex to Directive 76/464	1986	86/280	Various	No
Limit values and quality objectives for discharges of certain dangerous substances	1988	88/347		No
Limit values and quality objectives for discharges of certain dangerous substances	1990	90/415		No
Urban Waste Water Treatment	1991	91/271	BOD, COD, TSS	Yes
Urban Waste- and Waste Water Treatment	1993	93/481		Yes
Nitrates from Agricultural Sources	1991	91/676	NO_3	Yes
Ecological Quality of surface water	1993	COM(93)680		No
Quality of Bathing Waters	1994	COM(94)036	See 76/160	No
Integrated Pollution Prevention and Control	1996	96/61	See Acidification	No
Protection and management of groundwater	1996	COM(96)315	NO_3, Pesticides	No
Biocides	1997	COM(97)331	Biocides	No
Drinking Water	1997	COM(97)228	Pesticides, Boron, Cu	No
Community water resources	1997	COM(97)49		No
Persistent Organic Pollutants	1997		See Chemicals	Partly
WASTE MANAGEMENT				
International Agreements				
Convention on the Prevention of Marine Pollution by Dumping Waste and Other Matter	1972	n.a	Waste	No
Barcelona Convention for the Mediterranean	1976	n.a	(hazardous) waste, oils, waste	No
Basel Convention on the control of transboundary movements of hazardous wastes and their disposal	1993	93A216(02)	Hazardous waste	Partly
EC PIPPS				
Framework				
Waste - Framework Directive	1975	75/442	Waste	Partly
Waste	1991	91/156	Waste	Partly
Hazardous Waste				
Directive on Toxic Waste	1978	78/319	Toxic waste	No
Hazardous and Toxic Wastes	1991	91/689	Hazardous waste	No
Hazardous and Toxic Wastes	1994	94/31	Hazardous and Toxic waste	No
Hazardous Waste Database	1994	94/904	Hazardous waste	n.a.
Format of Information about Hazardous waste	1996	96/302	Hazardous waste	n.a.
Shipment of hazardous + Ordinary Waste				
Shipment of all waste within, into and out of the Community	1993	259/93	All waste in FD 75/442	No
Shipment of certain types of waste to non-OECD countries	1994	94/575	Hazardous + ordinary waste	No
Modification of green, amber and red waste lists	1994	94/721	Hazardous + ordinary waste	No
Standard Consignment Note	1994	94/774	Hazardous + ordinary waste	No
Shipment of non-hazardous waste to third countries	1995	COM(95)143 COM(96)62	'green list' waste	No
PCBs + PCTs				
Disposal of PCB / PCTs	1976	76/403	PCBs + PCTs	No
Disposal of PCB/ PCTs	1996	96/59	PCBs + PCTs	No
Waste Oils				
Disposal of waste oils	1975	75/439	Cd,Ni,Cr,Cl, Vanadium, Furans	No
Disposal of waste oils	1987	87/101	same as above	No
Incineration				

Municipal waste incinerators	1989	89/869	dust,Hcl,Pb,Cr,Cl,Mn,Ni,As,Cd,Hg,SO 2,HF,HMs,CO,VOCs	No
Municipal waste incinerators	1989	89/429	dust	No
Hazardous waste incinerators	1994	94/67	dust, HCl, HF, SO2	No
Landfill				
landfill of waste	1997	COM(97)105	hazardous, municipal, inert waste	No
			Bio-degradable waste	No
			Liquid, explosice, flammable, medical waste	No
End of Life Vehicles				
End of life vehicles	1997	COM(97)358		No
Packaging				
Packaging and packaging waste	1994	94/62	Pb,Hg,Cd,Hexa-valent chromium by weight	Yes
Titanium Dioxide				
Waste from theTitanium Dioxide Industry	1978	78/176	Waste from the Titanium Dioxide Industry	No
Titanium Dioxide Industry	1983	83/29	Titanium Dioxide	No
Titanium Dioxide Industry	1982	82/883	Titanium Dioxide	No
Titanium Dioxide Industry	1989	89/428	Titanium Dioxide	No
Titanium Dioxide Industry	1992	92/112	Titanium Dioxide	No
TROPOSPHERIC OZONE				
Control of Emissions of VOC or their Transboundary Fluxes	1991	-	VOCs	Yes
Protocol to the 1979 Convention on LRTP on control of Volatile Organic Compounds - Geneva 1991	1991	-	VOCs	Yes
	1991	91/441	VOCs	Yes
Air pollution by ozone (related to health and vegetation)	1992	92/72	O_3	Partly
VOC from storage and distribution of petrol, Stage I	1994	94/63	VOCs	Partly
VOC-emissions during petrol refuelling, Stage II			VOCs	No
Emissions of organic solvents from solvent-using industry (VOCs)	1996	COM(96)538	VOCs	Yes
COASTAL ZONES				
International Convention for the Prevention of Pollution of the Sea by Oil	1954	n.a.	Oil	No
Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat	1971	n.a.	n.a.	No
Convention on the Prevention of Marine Pollution by Dumping Waste and Other Matter	1972	n.a.	Waste	No
Convention on the Protection of the Marine Environment of the Baltic Sea	1974	n.a	n.a.	No
Convention for the Prevention of Marine pollution form Land-Based sources.	1974	n.a.		No
Barcelona Convention for the Mediterranean	1976	n.a.	(hazardous) subst., oils, waste	No
Bathing Water	1976	76/160	see Water stress	No
Shellfish Waters	1979	79/923	see Water stress	No
Amendment to the Ramsar Convention	1982	n.a.	n.a.	No
Amendment to the Ramsar Convention	1987	n.a.	n.a.	No
Environmental Impact Assessment	1985	85/337	n.a.	No
Probition of the disposal of certain substances resulting from exploration and exploitation in the Mediterranean	1987	87/217	asbestos, crocidolite, actinolite, anthophyllitye, chrysotile, amosite, tremolite	No

Urban Waste- and Waste Water Treatment	1991	91/271		Yes
1994 Protocol for the Protection of the Mediterranean Sea Against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil	1994	-	plastics, sewage, heavy metals, oil, organoph., persis. synthetics, carcinogenic	No
Bathing Water	1994	COM(94)36		No
Integrated management of coastal zones.	1995	COM(95)511	n.a.	No
HUMAN HEALTH , AIR QUALITY AND NOISE				
Noise from cars, busses and lorries.	1970	70/157	Noise	No
Noise from cars, busses and lorries.	1978	78/1051	Noise	No
limitation of noise emissions from subsonic aircraft	1980	80/51	Noise	No
Smoke and sulphur dioxide	1980	80/779	Smoke, SO_2	Yes
Lead in air	1982	82/884	Pb	Yes
NO_x, SO_2 and Ozone	n.a.	n.a	NO_x	Yes
Noise from compressors	1984	84/533	Noise	No
Noise from power generators	1984	84/534	Noise	No
Lead in petrol	1985	85/210	Pb	Yes
Air quality standards for nitrogen dioxide	1985	85/203	NOx	Yes
Limitation of noise emitted by hydraulic excavators, rope-operated excavators, dozers, loaders and excavator-loaders	1986	86/662	Noise	No
Lead in petrol	1987	87/416	Pb	Yes
Limitation of noise emissions from subsonic aircraft	1989	89/629	Noise	No
Urban Waste- and Waste Water Treatment	1991	91/271		Yes
Gas/particulate emissions from diesel vehicles.	1991	91/542	Gas, PM10	Yes
The limitation of the operations of aeroplanes.	1992	92/14	Noise	No
Vehicle emission tests	1992	92/55		No
Permissible sound level and exhaust system of motor vehicles	1992	92/97	Noise	No
Noise from machinery, air crafts and on work.	1993	COM(93)154	noise	No
Assessment and management of air quality	1994	COM(94)109		No
Emissions from engines in non-road mobile machinery	1995	COM(95)350	NO_x	No
			HCs	No
			PM	No
Air quality objectives, Commission Auto Oil Programme	1996	Europe Environment no 480	PM10, O3, CO, VOC, oxides of carbon	No
Air Quality assessment and management	1996	96/62	13 substances<year 2000	No
Quality of petrol and diesel	1996	COM(96)248 COM(97)271	See Acidification	No
Emissions from light commercial vehicles (LCVs)	1997	COM(97)61	NO_x, HC, CO, PM	No
Green Paper on future policy in relation to noise.	1997	COM(96)540	Noise	No
Measures against the emissions form diesel vehicles	1997	97/20		No
Emissions from non-mobile machinery	1997	COM(97)354		No
Heavy Metals	1997	See Chemicals	Pb, Cd, Hg	Partly
SOIL DEGRADATION				
European Soil Charter	1977	UNECE	n.a.	No
Sewage Sludge; limitations for concentrations of heavy metals	1986	86/278	Heavy metals	No