Environment in the European Union at the turn of the century

Summary

European Environment Agency

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Foreword

The Agency has previously reported that despite more than 25 years of Community Environmental Policy – which has been successful in its own terms – general environmental quality in the EU is not recovering significantly, and in some areas, it is worsening. This present report confirms both that situation and the fact that the unsustainable development of some economic sectors is the major barrier to improvement.

Up to now what has been missing has been an assessment of whether the actual economic, sectoral and environmental policies over the next decade or so will bring improvements, or whether there are trends and developments pushing us off target and seriously challenging substantial progress.

This report, 'Environment in the European Union at the turn of the century' is designed to address this issue and provide information on current state and future trends of direct use for deciding on sound and effective measures to really improve and protect the environment, and to move towards more sustainable development (Amsterdam Treaty, Articles 2 and 6).

What do we see?

In summary, most of the major challenges will continue over the next decade, namely significant societal developments (in GDP, population, consumption) and, despite some notable exceptions, a general failure to de-link these from environmental pressures; increasing environmental burdens from the growth of road and air transport, and general urbanisation and 'suburbanisation'; degradation of the rural environment; and increasingly significant risks to the valuable natural and biodiversity assets of central and eastern European countries, as well to those remaining in southern and Mediterranean countries and in northern and western Europe.

But also we see some still small but fast-growing positive signals that should be known about more widely, disseminated and encouraged: growth in wind energy; cycling taking higher percentages of some cities' traffic; pesticide-free areas or

municipalities being declared in many countries; a significant growth in organic agriculture; improving energy efficiency in many countries; some EU countries establishing indicators and even quantitative targets to master unsustainable development; and many municipalities and companies embracing sustainability as a feasible and profitable process developing their own local Agenda 21 programmes at local and business level.

What else do we need to identify and report on that could help in improving environmental quality and overcoming unsustainable trends?

As the Agency has struggled to build a seamless monitoring and reporting system, what has been missing is a more structured reference model with indicators and eventually targets for the main issues. In short, we have not had the instruments to make the socio-economic system accountable, in environmental and sustainability terms, to encourage and reward it to take a sustainable path.

The Agency will now move a further step forward by implementing the new obligation (Review of the 1210/1990 Council Regulation) to issue regular reports based on indicators. The first report to be published to provide a set of EU Environment Signals, by the end of 1999, will present an extended package of indicators to show progress and trends. From this a set of so-called 'headline indicators' will be identified. Together with GDP (Gross Domestic Product) and other key welfare indicators, attempts are being made to produce a so-called 'well-being index' beyond GDP, to better represent quality of life including environmental quality and progress with sustainability.

Since all this implies change, the political framework is also important. Environmental policy may have eased some problems, but economic and sectoral policies beyond the control of environmental policy have created new and bigger ones. The integration of environment into other policies is destined to face conflict. However, the 'Cardiff Initiative' (European Council of June 1998), has begun to operationalise this by calling upon the key economic and sectoral policies (Agriculture, Transport, Energy, Internal Market, Industry, Finance, Development) to be accountable in environmental and sustainability terms. The Helsinki Council in December 1999 should take stock of progress

and link these sectoral developments with a Global Assessment of the Fifth Environmental Action programme (to which this report is an input). A coordinated report on indicators (to which the EEA 1999 Environmental signals report is a main contribution) is also to be presented by the European Commission.

The present report is one step on the way to more effective reporting. The approach taken here is expected to allow for more successful partnerships tackling environment and sustainability issues; partnerships involving policy makers, users and consumers, the ordinary citizen, and not least of all, business and industry, which now understands that there will be no business if it is not sustainable business. Such developments are part of the move from 'environment as a burden' to 'environment and as an opportunity'. Forthcoming reports, and in particular our yearly 'EU Environmental signals' report based on indicators, should allow a more frequent monitoring of progress than our three or five-yearly report have hitherto allowed. These reports will also be the opportunity to identify, and perhaps even to focus upon, emerging positive experiences and trends, including indicators on encouraging issues or topics, disaggregated spatial (by Member States) or sectorally.

Both the reporting and accountability frameworks seem to be improving as do the political will, the readiness of the business sector and the public demands and expectations. We have two big challenges in front of us that could become increasing opportunities for ultimately testing our will and our capacities to improve the environment and quality of life quality and progress towards sustainable development: The climate change challenge or the reduction of greenhouse gases or rational use of fossil fuels (from climate change to a climate for change) and the enlargement of the EU (taking sustainability as a goal and compliance as a result). Let us do it.

Domingo Jiménez-Beltrán
Executive Director

Introduction

This summary is split into two main parts. The first (present booklet) analyses the situation and prospects for the environmental issues covered by the main report *Environment in the European Union at the turn of the century*. In doing so, links are made to performance now and in the future against agreed political targets at the EU level, to the wider impacts of environmental degradation on human health, biodiversity and sensitive landscapes and areas, and to how activities in key economic sectors contribute to environmental trends. Two important EU political considerations are also addressed – progress with the integration of environmental considerations in sectoral policies, and the situation and prospects for those countries expecting to join the EU under the Accession process. Good quality data and information are needed to underpin such analyses, hence an assessment is given on progress with plugging gaps and where further work needs to be given priority consideration.

The second booklet (Appendix) provides more detailed summary analysis of the environmental issues addressed by the main report.

1. Some progress, but a poor picture overall

What has been achieved, and in what areas – and what is the outlook?

From the summary table below, which shows the situation and prospects for both pressures and impacts for the main environmental problems, it appears that apart from significant and positive cuts in ozone-depleting substances, progress in reducing other pressures on the state of the environment has remained largely insufficient – in spite of positive trends in some areas such as reducing emissions contributing to acidification, or phosphorus discharges to rivers.

Pressures		Environmental Issues	State & Impact	
Present	Future		Present	Future
😐	☹	Greenhouse Gases and Climate Change	☹	☹
☺	😐	Ozone Depletion	☹	😐
😐	☹	Hazardous Substances	😐	?
😐	😐	Transboundary Air Pollution	😐	😐
😐	😐	Water Stress	😐	😐
☹	☹	Soil Degradation	☹	?
😐	☹	Waste	☹	☹
😐	?	Natural and Technological Hazards	😐	?
😐	?	Genetically Modified Organisms	?	—
☹	☹	Biodiversity	😐	?
😐	😐	Human Health	☹	?
😐	😐	Urban Areas	😐	😐
☹	☹	Coastal and Marine Areas	☹	?
☹	?	Rural Areas	☹	—
☹	?	Mountain Areas	☹	—

Legend:
☺ positive development
😐 some positive development but insufficient
☹ unfavourable development
— no quantitative data available
? uncertain (partial quantitative/expert analysis available)

Assessment of progress over the past 5-10 years and trends up to 2010 (2050 for Climate Change and Ozone Depleting Substances). The indications about the pressures show how factors, such as emissions of pollutants or land use, which give rise to the problems, are changing. The information about state and impacts indicate how these pressures are feeding through into changing environmental quality.

The outlook for most of the pressures is also not encouraging, in particular with future emissions increasing in problem areas that have appeared difficult to tackle: greenhouse gas emissions, chemicals and waste. These pressures feed through into an equally troubling story about the state of the environment. Here, no overall positive trends can be depicted within the scope of the outlooks. For most of the issues there has either been insufficient progress towards recovery of a healthy environment, or unfavourable underlying developments. Adverse developments are expected concerning impacts from climate change and waste generation. Some limited developments are nevertheless anticipated where impacts relate, for example, to transboundary air pollution, water pollution and air quality in cities, are expected to improve.

There remain, however, considerable uncertainties. Due either to a lack of data in some areas (such as in soil, biodiversity or pesticides in groundwater) or to uncertainties about future socio-economic developments, it is difficult to understand clearly the direction in which we are heading. It is particularly difficult to assess the prospects of important emerging issues, which are also of rising public concern such as human health issues, hazardous substances and genetically modified organisms.

Consequently, the state of the European Union's environment remains a serious concern. And while the evidence is that actions in some areas – e.g. acidification – to pre-empt and prevent environmental damage are improving, and yielding major dividends, it is clear that more needs to be done across a large front to improve environmental quality and ensure progress towards sustainability. In particular, environmental actions need to be integrated more closely into economic measures.

As Box 'Where are we now?' also shows, the overall picture is a very mixed one.

Box: Where are we now?

Greenhouse gases and climate change

- Carbon dioxide emissions fell about 1% between 1990 and 1996, with considerable variation between Member States. Methane emissions are decreasing.
- Global and European annual mean temperatures have increased by 0.3-0.6°C since 1900; 1998 was the warmest year on record.

Ozone-depleting substances

- The potential 'chlorine plus bromine' concentration (total potential depletion of the ozone layer) peaked in 1994 and is now decreasing.
- The use of ozone-depleting substances has decreased sharply, faster than required by the international measures, but atmospheric concentration of halons is still increasing against expectations.

Hazardous substances

- Various control measures have reduced chemical risk and some emissions, and environmental concentrations of persistent organic pollutants and heavy metals are declining.
- However, for 75% of the large volume chemicals on the market, there is insufficient analysis of toxicity and eco-toxicity available to support minimal risk assessment.

Transboundary air pollution

- In most countries, sulphur dioxide, volatile organic compounds and, to a lesser extent, nitrogen oxide emissions have declined. But success in abating emissions from stationary sources was almost counterbalanced by increased emissions due to rapid transport growth; emissions from international shipping are expanding their share.
- Harmful effects of transboundary air pollution on ecosystems have been reduced.
- All threshold values for summer smog set under the Ozone Directive have been exceeded since 1994.

Water stress

- There has been a significant decrease in the number of heavily polluted rivers due to reductions in point source discharges (such as phosphorus); organic matter discharges have fallen by 50 to 80% over the last 15 years.
- Nitrate concentrations in EU rivers have shown little change since 1980, contributing to eutrophication in coastal waters. Nutrient input from agriculture is still high.
- EU countries are yearly, on average, abstracting around 21% of their renewable freshwater resources, which is regarded as a sustainable position. Big water losses

occur in southern EU countries – around 18% of the resource is lost each year in irrigation, and overexploitation and salinisation of groundwaters in the coastal areas continue to be critical.

Soil degradation

- Damage is increasing and leads to irreversible losses due to growing water erosion, continuing local and diffuse contamination, and sealing of soil surfaces.

Waste

- The EU is generating and transporting more solid waste. EU Waste Strategy goals have not been reached: waste prevention measures have not stabilised production, and landfilling is still the most common treatment method despite significant progress in recovery and recycling.
- Recycling of glass and paper has been increasing but not sufficiently quickly to reduce overall generation for these waste streams.

Hazards

- Between 1990-96, economic losses due to floods and landslides were four times those in the whole of the preceding decade. As yet, there is no targeted policy to reduce natural hazards.
- Major industrial accidents continue to occur; over 300 accidents have been reported since 1984 in EU. There is indication that many of the often seemingly trivial 'lessons learned' from accidents have not yet been sufficiently evaluated and/or implemented in industry's practices and standards.
- The overall risk to the European environment from accidental releases of radionuclides, even if small, cannot be quantified.

Genetically modified organisms (GMOs)

- The issue of the genetically modified organisms remains beset by scientific uncertainty and political controversy.
- They have been released experimentally to the environment – as new crop plants – since 1985/86, and four commercial food crops have been approved.
- Under EU legislation which regulates their release – deliberate and accidental – and their safety in food, EU marketing consent for GMO products takes at least 1-2 years; and none has been approved unanimously so far.

Human health

- Traditional environmental health problems from unsafe drinking water, inadequate sanitation and poor housing have largely disappeared from the EU.

- According to the World Health Organisation, available evidence suggests that the environment has a limited (i.e. responsible for less than 5%) direct impact on public health. Particulate air pollutants possibly cause, per year, 40-150 000 deaths in adults in the EU cities, and a proportion of the rising skin cancer rates is caused by increased radiation through a thinning ozone layer.
- Low level exposure to a complex of pollutants in air, water, food, consumer products and buildings may be affecting overall quality of life or significantly contributing to asthma, allergies, food poisoning, some cancers, neuro-toxicity and immune-suppression.

Urban areas

- Ambient pollutant concentrations in cities have fallen over the last decade, contributing to some improvement in urban air quality. But the evidence on particulates is mixed – the general trend is down, but concentrations still exceed World Health Organization guidelines in a majority of cities.
- In terms of noise exposure, it is estimated that more than 30% of the EU population live in dwellings with significant exposure to road noise, in spite of significant reductions of noise limits from individual sources.

Coastal and marine areas

- Some 85% of the coasts, where about a third of EU population lives, are at high or moderate risk from different kinds of pressures while urbanisation, in general, has increased in most of the coastal areas.
- Among the 25 less favoured areas in EU in 1983, 23 were coastal areas; 19 remain so in 1996. The lack of economic growth curbs the conditions for environmental management.
- All EU seas are covered by Regional conventions, yet to be fully enforced; remaining poor water quality, coastal erosion and the lack of integrated coastal zone management are the main problems.

Nature and biodiversity

- Integrating biodiversity issues into other policies has started through agri-environment measures (on 20% of the agricultural land) and more targeted conservation approaches (management for multiple use, on-site and off-site conservation).
- Growing fragmentation (in particular the suburbanisation of rural areas), uniformity and simplification of landscapes continues to threaten biodiversity via severe reduction of areas available for fauna and flora. Natura 2000 has been implemented very slowly.
- Pollution (eutrophication, acidification) and introduction of species continue to facilitate the spreading of robust generalist species at the expense of specialist species.

The amount of business still unfinished sets a wide-ranging and formidable agenda for the coming years. What are the prospects for accomplishing this? The results of the baseline scenario, which assumes full implementation of policies in place or in the pipeline by August 1997, shows the extent of the challenges ahead. With a few exceptions such as production of ozone depleting substances, acidification and urban air quality, much ground has still to be made up to secure further across-the-board improvements to EU's environment.

Box: What's ahead for selected environmental issues?

- **Greenhouse gas** emissions are projected to increase in the EU by about 6% from 1990 to 2010. Atmospheric concentrations of carbon dioxide, methane and nitrous oxide could rise by as much as 45%, 80% and 20% respectively to 2050. Temperatures and sea levels are projected to keep on rising as well.

- The **ozone layer** is benefiting from the phasing out of ozone depleting substances, but it will only start to recover after the Mid-2030s, and is not expected to recover fully before 2050. Consequently, ultra-violet radiation levels and associated damaging effects, e.g. skin cancer rates, are expected to continue to increase.

- Chemical production and total **hazardous substances** emissions in the EU are predicted to increase, with significant regional differences. Important increases in emissions of mercury, cadmium and copper are expected by 2010, while emissions from some pesticides would only increase slightly. However, thanks to enforcement of existing and proposed policies, emissions, depositions and concentrations of lead, dioxins and polychlorinated biphenyl should all decrease, substantially in the case of lead.

- Emissions from all major gases contributing to **acidification** and **eutrophication** are expected to be reduced – leading to significant improvements to ecosystems threatened by these phenomena.

- The quality of the EU's **rivers and lakes** should improve – due to decreased input of nitrogen and phosphorus – because of measures to reduce water pollution from point sources; in particular urban waster treatment contributes to this improvement, but the quantity of contaminated sludge will increase accordingly. Rivers and lakes in intensively farmed regions will likely remain a problem unless there is also action to reduce the impact of phosphorus and nitrogen from agriculture. **Total water demand** is predicted to remain relatively stable or increase only slightly until 2010.

- **Recycling** has been highly successful in a number of EU Member States. In some areas of middle and northern Europe, the post-recycling residual waste is down to one-third, even less of the original amount of waste. However, despite policy initiatives at EU and national levels, the **volume of waste** – household, paper and cardboard and glass – is expected to increase.

- **Urban air quality** should continue to improve. The average exposure of cities' inhabitants to above recommended levels is expected to decrease for all substances but concentration levels of particulate matters, nitrogen dioxide, benzo(a)pyrene, and ozone are forecast to remain above air quality guidelines in most cities to 2010.

- **Noise exposure** is forecast to worsen in certain situations, e.g. along ring roads and motorways, at regional airports, because of the growth in transportation, especially freight and air traffic

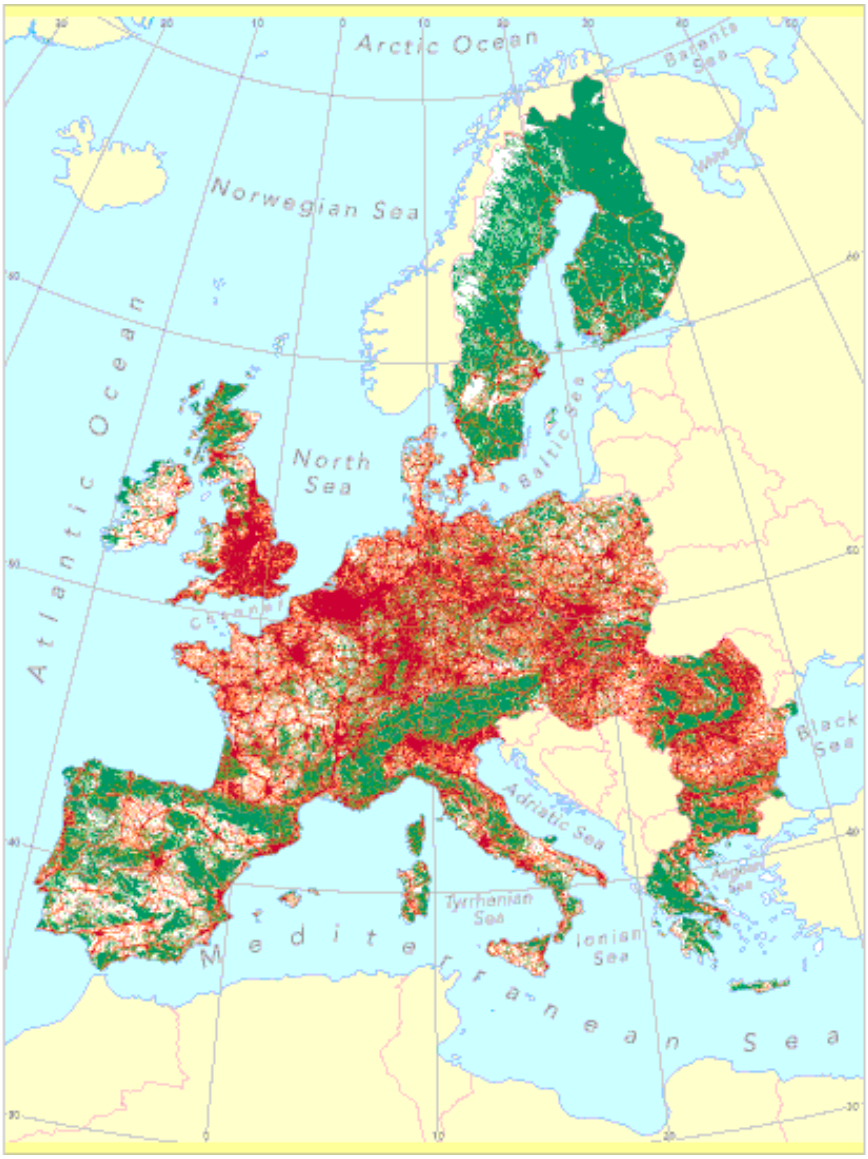
- The threat to **biodiversity** stems primarily from land use and changes in land use, from pollution and introduction of alien species. These factors are expected to remain significant for virtually the whole of Europe to 2010. During the period 1990 to 2050 increasing temperature will probably have impacts in arctic and mountaineous regions, while changing precipitation levels may have important effects in southern Europe: a significant change in species distribution may be the result.

- Air and water pollution, noise, chemical emissions, food contamination and ozone depletion will be the key environmental issues as far as **people's health** is concerned. Exceedances in the concentration levels of particulate matter, nitrogen dioxide, benzo(a)pyrene, and ozone in most cities to 2010 will have implications for life expectancy and mortality, and will push up asthma and respiratory allergy rates further. People face risks from nitrate and pesticide residues, and water pollution – particularly in areas relying on drinking supplies from shallow groundwater wells – while the expected growth in the production of certain manufactured chemicals known to cause adverse affects on humans, and increases in certain toxic wastes will accentuate future health impacts. More noise exposure in certain situations is expected – causing hearing problems, stress leading to hypertension and increasing the risk of cardiovascular disease. In addition, despite the planned reduction in ozone-depleting substances, skin cancer rates are projected to rise sharply, peaking around 2055.

These challenges are being exacerbated because people are leaving new 'footprints' on the environment. Dramatic changes in land use patterns are having a particular impact. Although more than 70% of Europeans live in urban areas, there has been a remarkable tendency since the 1950s for a dispersal and sprawling of urban settlements – by building

more roads and other infrastructures , converting land permanently from other uses, sealing soils, opening up areas to tourism – causing new 'hot-spots' to emerge .

Pressures on land resources and landscapes from urban areas and transport network



Source: EEA

Today, most of the EU countries have at least 80% of their territory given over to 'productive' uses like agriculture, forestry, urban centres, transport and industry, leaving limited margin for further uses; before the next 10 years is out, the length of motorways is proposed to be extended by more than 12 000 km. And a 5% increase in urban population will, according to present trends, require at least an equal increase in the take of urban land. This whole issue is an increasingly important one – the more so since existing EU, national and regional policies on land use tend to encourage these problems – and it needs more attention from policy-makers.

Box: Environmental hot-spots in Europe

- The good news is that the extent of areas with a very high concentration and combination of environmental pressures and impacts is decreasing. However, the spread of less intense 'hot-spots' grows as more space is taken up for energy generation, transport, industry and water supply and as these activities have an impact over wider areas.

- By 2010, the environmental quality of many of the traditional industrial 'hot-spots' should be greatly improved. In the Black Triangle area, for example, sulphur deposition is expected to fall sharply. But Germany and the Netherlands will still be affected by acidification, and Belgium, France, Germany, Denmark, Luxembourg, and the Netherlands by eutrophication – while the north-western part of Europe will also largely suffer most from hazardous substance emissions and deposition – cadmium, dioxins, bezno(a)pyrene, and polychlorinated biphenyl – and the Iberian Peninsula and Italy will suffer from the highest endosulphane emissions and depositions.

- Urban areas are expected to continue to suffer serious environmental pressures and impacts, for example from worsening traffic congestion and, in some areas, seasonal water shortages, as well as face the challenge of managing solid waste through incineration and recycling. And although air quality should improve, photochemical smog will probably intensify as an issue, especially in north-western Europe. In southern cities, seasonal water shortages are expected to intensify.

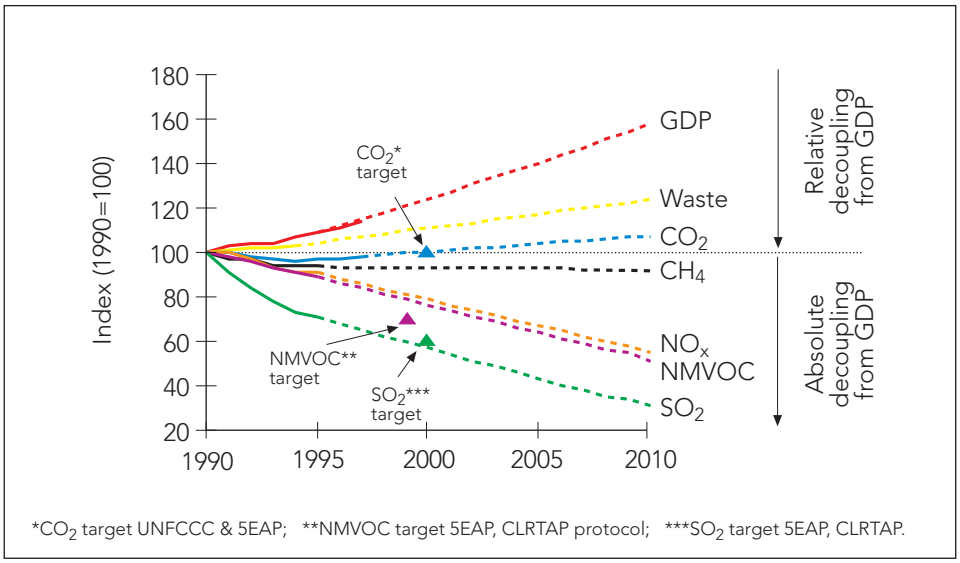
- Similarly, a major influx of tourists will impact on the Mediterranean areas, while agricultural adjustment could be particularly significant for other coastal areas, e.g. along the North Sea and Channel. The Alpine region faces increasing pressure from transport.

2. On target – on time?

A feature of many of today's major environmental issues is that they were only recognised after their causes had gone unchecked, activities and pressures increased further, and it was finally clear there were significant effects on health and the environment.

A good example is the damage to the ozone layer: while the use of ozone-depleting substances has now been curbed drastically, the ozone layer is not expected to recover fully until the middle of the next century. A similar case will happen with greenhouse gases; there is a considerable time delay between a reduction of emissions of greenhouse gases and stabilisation of the atmospheric concentration. For example to reach a potentially sustainable carbon dioxide (CO_2) concentration by 2100, that is stabilised at the 1990 level, would involve a reduction of global annual CO_2 emissions by 50 to 70%. Finally, acidification was only brought down to current levels after three decades of increasingly stringent legislation.

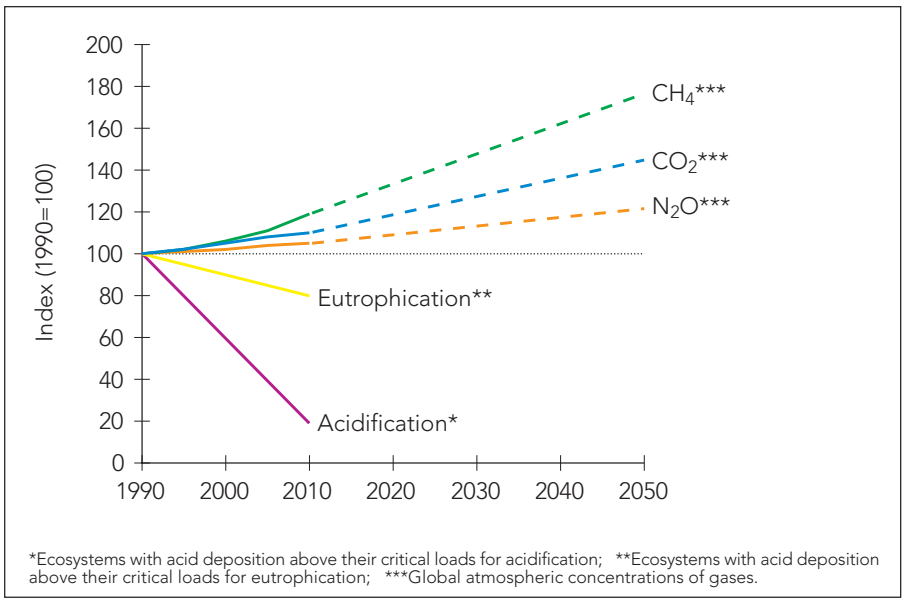
Economic developments and trends in pressures in EU (1990-2010) in relation to environmental targets



*CO_2 target UNFCCC & 5EAP; **NMVOC target 5EAP, CLRTAP protocol; ***SO_2 target 5EAP, CLRTAP.

Source: Compiled from multiple sources

Selected trends in the state of the environment (1990-2010-2050)



*Ecosystems with acid deposition above their critical loads for acidification; **Ecosystems with acid deposition above their critical loads for eutrophication; ***Global atmospheric concentrations of gases.

Source: Compiled from multiple sources

The delay between identifying problems and devising and implementing policy measures to tackle them needs to be reduced. In the past, policies have either been introduced too late, or they have not been on the scale needed to deal with issues, or they have been neutralised by negative pressures caused by the unsustainable growth in other areas (e.g. transport). Good information on environmental trends can help shorten this time lag by providing a vital link between scientific research and policy making, and enabling policy makers to anticipate future problems, and to plan to address them. The public also has responsibility in that context, both in terms of effective participation in the decision making process and through changes in behaviour and consumption patterns.

Setting clear targets, and introducing policies to meet them is crucial to achieving further environmental progress, faster. The EU has set, and will continue to fix targets for the key areas, but while it has hit and is expected to achieve some of them, it is likely to miss others, namely:

- For CO_2 the EU aims initially to stabilise emissions by 2000 at the 1990 level. The EU agreed in Kyoto to reduce **greenhouse gas** emissions, measured as CO_2 equivalents, by 8% between 1990 and 2008-2012. The baseline scenario indicates a 6% increase of total greenhouse gas emissions, while CO_2 emissions initially decreased about 1% in 1996 from 1990 level.

- The use of **stratospheric ozone-depleting substances** decreased in all countries of the EU at a more rapid rate than required to meet European targets. Although in 1996 the chlorofluorocarbon (CFC) production was a little higher than in 1995, the expectation is that future EU emissions will continue to decrease, so that future targets should be met. The Commission has proposed to phase out consumption of hydrochlorofluorocarbons (HCFCs) by 2015.

- Significant reductions in **air pollution emissions** are expected by 2010 – but not enough to meet proposed EU targets for 2010 and agreed ones for 2000. The targets are from the proposed Acidification Strategy of the Commission and the Convention on Long-Range Transboundary Air Pollution protocol of the United Nations – Economic Commission for Europe (UNECE).

- A significant gap is likely to remain on **eliminating all hazardous discharges**. Existing EU action will probably achieve new UNECE targets for reducing lead, dioxins, furans and hexachlorobenzene emissions, but not those for cadmium or mercury – polycyclic aromatic hydrocarbon emissions are expected to rise due to significant increases in road transport.

- Most cities are expected to make good progress towards **EU urban air quality** targets for sulphur dioxide (SO_2), particulate matters, benzene and benzo(a)pyrene, but less progress for ozone and nitrogen dioxide (NO_2) concentrations.

- New initiatives – requiring a comprehensive life cycle approach emphasising preventative measures and re-use – will be needed to stem predicted increases in most **waste streams**. Data comparability is a major problem.

- EU targets are not available for groundwater quality but only for water intended for human consumption, for which information on trends is far too limited to allow any analysis of performance. The use of pesticides is expected to decrease further, but pesticides will continue to be found in groundwater and in some cases remain a problem. Nitrate in groundwater will probably remain stable.

Progress in achieving key EU Environmental targets (Index 1990 = 100)

	1985 level	1990 level	1995 level	expected level in target year	target	progress?
Greenhouse gases (GHG) and c limate change						
basket GHG emissions	-	100	98	106	92 in 2008-2012	☹
CO_2 emissions	96	100	97	98-102	100 in 2000	😐
Ozone Depleting Substances						
CFC production	160	100	11	appr.0	0 in 1995	☺
HCFCs production	-	100	108	appr.0	0in2025	☺
Acidification						
SO_2 emissions	119	100	65	53* 29	60 in 2000 16 in 2010**	☺ ☹
NO_x emissions	95	100	89	81* 55	70 in2000 45 in2010	☹ ☹
non-methane volatile organic compounds (NMVOC)emissions	98	100	89	81*	70 in 1999	☹
Regional scale problems						
Municipal waste (per capita)	79	100	103	109	79 in 2000	☹

* based on Current Reduction Plans of Member States

** proposed targets which may be reviewed in the framework of the combined ozone/acidification strategy

Performance in some areas – natural resources such as biodiversity, soil degradation, and coastal zones – is difficult to appraise since there are no quantitative targets, nor the necessary data.

One of the reasons why progress towards targets is slow is because problems are dealt with separately so that the inter-connections between environmental problems and their causes are not fully addressed. More comprehensive, or integrated, approaches to their management and assessment are therefore required. For example, the EU Acidification Strategy, under discussion, is based on a multi-pollutant/ effect approach which recognises the multiple role that sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds play in causing four interconnected environmental problems: acidification, eutrophication, tropospheric ozone and climate change. An integrated approach to these different environmental impacts increases cost effectiveness and political support. Similarly, an integrated approach to climate change recognises the multiple benefits to both health and ecosystems, of improvements in fossil fuel efficiency and use of renewable energy supplies or, in general, of reducing the burning of fossil rare materials.

Monitoring progress towards such 'systems integration' in the management of environmental problems is difficult, but some indicators of progress are the EU Framework Directives for Air and Water, the Integrated Pollution Prevention and Control Directive for large industrial enterprises, and the Auto-Oil programme on air pollutants from vehicles. More comprehensive approaches towards the more efficient use of energy and materials to minimise environmental impacts (so called eco-efficiency approaches) are being developed by the World Business Council for Sustainable Development and the Organization for Economic Co-operation and Development.

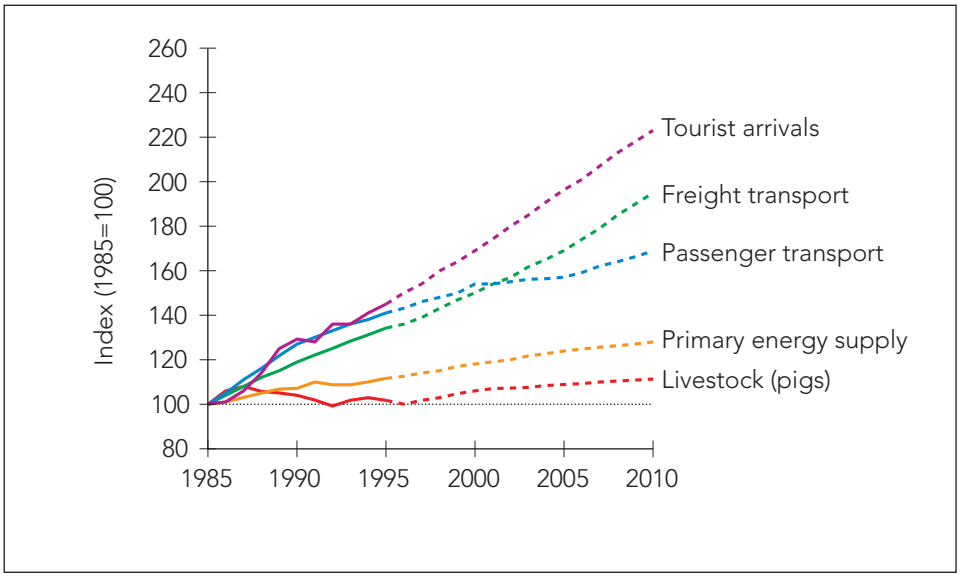
Some barriers to further progress with systems integration are the lack of scientific understanding and information about the links between environmental problems, the lack of targets to measure policy performance, and the separation of the scientific disciplines and political institutions that deal with different environmental impacts.

3. Where the pressures are coming from?

The European Union environment will for the foreseeable future remain under serious pressure from a range of activities – economic, industrial, leisure and even personal – many of which are forecast to expand, and which, because they are interconnected, will have a knock-on effect on each other.

The economies of the EU Member States have been creating more material welfare for their inhabitants in the last decade. But economic growth is so large that production and consumption will in general demand more natural resources and generate more pollution than before. The end use of consumer goods and services not only requires the materials and energy incorporated in the product or services itself, but also the materials and energy used in earlier stages of the production process (the 'ecological rucksack'). Under the baseline scenario, a 45% increase in economic growth is expected to 2010. This will have environmental impacts, and it is likely to erode gains from environmental policy initiatives and increase the difficulty in achieving sustainability. As it is, materials intensity in the leading EU economies fell in the 1980s, but this trend has not continued into the 1990s.

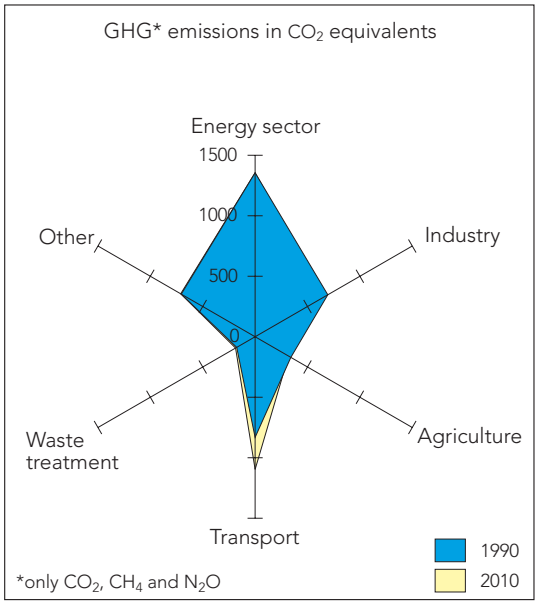
Primary energy supply and major driving forces trends in EU (1985-2010)



Source: EEA

Total primary energy supply is also showing an upward trend and the curves of the major driving forces in the economy are even steeper.

EU economies generally have recently been less *energy intensive*, but this trend still implies a growing demand for energy in absolute terms. Falling world energy prices threaten further reductions in energy intensity. The increasing use of energy is inducing more emissions of carbon dioxide, a main component of greenhouse gases. The shares of the various economic sectors in the generation of greenhouse gases develop differently through time.



Sectoral contribution to greenhouse gas emissions in the EU (1990-2010)

Source: Compiled from multiple sources

Transport and mobility is jeopardising the EU's ability to achieve many of its environmental policy targets. Big increases in both passenger and freight vehicle use are putting a strain on climate change, transboundary and urban air pollution goals. The transport infrastructure, constantly in expansion, is used beyond its capacity and congestion causes significant economic losses. In passenger transport, improvements in energy efficiency of engines is not sufficient to offset the upward pressure on energy

consumption from three developments: the increased number of passenger kilometres, the tendency to use bigger cars, and a shift to car and air travelling. A similar development can be seen in freight transport, as, in spite of policy programmes to support these modes (e.g. the Trans-European Network policy), rail and inland shipping continue to loose ground to road transport.

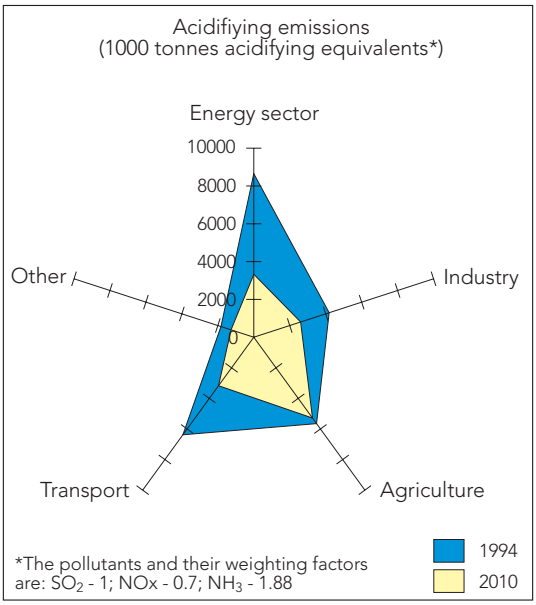
On present forecasts, households, *industry and the services* sector will also use more energy. The chemicals, pulp and paper and building materials industries are set for major expansion, but the services sector is the fastest growing area, which will have serious implications for transportation and energy use. A shift from solid fuels and oil to natural gas is expected which represents a positive change for environmental quality. The current share of renewables is modest with about 6% and it could increase up to 8% by 2010. The EU objective aims for a 12% share by 2010; however, given the present energy market conditions, strong measures would have to be put in place if this target is to be achieved. Although further energy efficiency gains are predicted in economic sectors, the projected overall growth of sector activities will more than offset the benefits from energy technology improvements.

While the EU's population is remaining relatively stable, rising incomes and more and smaller *households* will lead to a projected 50% rise in final consumption between 1995 and 2010, and add more pressure on environmental services and natural resources. Domestic energy use has outstripped efficiency improvements because households are getting smaller hence they grow in number.

Tourism, which benefits from the increasing economic welfare, more leisure time and attractive prices (not internalising the environmental costs), is expected to grow significantly. The development of tourism activities will challenge sensitive areas such as coastal and mountain zones, and also further fuel the growth in transport.

About 40% of EU land is agricultural – much of it on or next to important sites for biodiversity. Despite reforms of

the Common Agricultural Policy introducing certain environmental measures, there remains a prospect of agricultural polarisation: a combination of intensive farming and land marginalisation – both impacting on the environment. The composition of livestock is expected to shift from cattle to pigs and poultry. The use of fertilisers is on a declining trend, while the use of pesticides is fluctuating: it declined, but since 1994 has tended to rise. Future developments are unsure, but a decrease in the volume of active ingredients in pesticides is not unlikely. *Agriculture* causes acidifying emissions (ammonia) and the development in livestock will bring this sector to the very top of the contributors to acidification over the next decade, as it is hardly able to reduce the emissions, in contrast to the other sectors.



Sectoral contribution to emissions of acidifying substances in EU (1994-2010)

Source: Compiled from multiple sources

4. Are we making progress towards integration?

Progress with *sectoral integration* has been slow since its importance has been identified in the Fifth Environmental Action programme in 1992 (5EAP). However, the Cardiff European Council in June 1998 invited the Agriculture, Energy and Transport Councils to report on their strategies on environmental integration and sustainable development, and the Vienna Council in December 1998 extended this to Internal market development and Industry. That is a significant step towards the *institutional integration* required if the 'driving forces' of sectoral economic activity are to incorporate environmental considerations into their objectives and programmes.

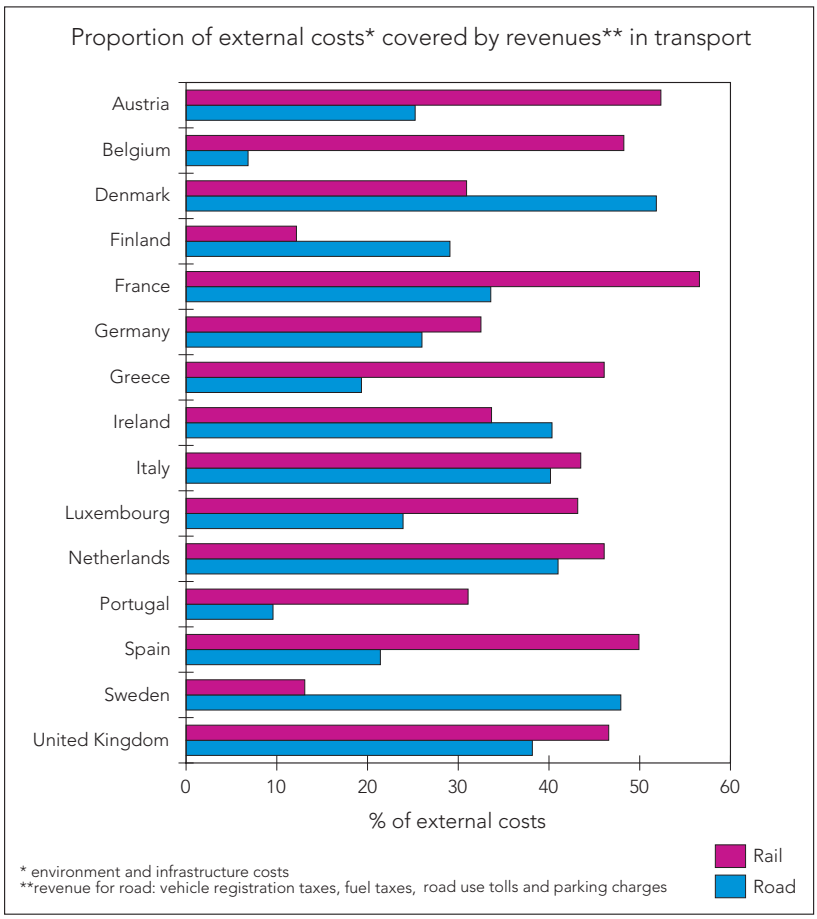
At present, integrated strategies that include the environment in a sector's objectives remain rare, being absent from the Common Agricultural Policy treaty objectives, and absent from the EU common transport policy objectives. However, at least five countries (Austria, Denmark, the Netherlands, Sweden and the UK) have produced transport strategies that incorporate environmental objectives. The more heterogeneous industry and energy sectors are less amenable to overall integrated programmes, but climate change is now encouraging overall energy sector plans, turning the challenge of climate change into an opportunity, or 'a climate for change'.

Evaluating progress towards sectoral integration is not easy without agreement on how it is to be operationalised and monitored. In its report, *Europe's Environment: The Second Assessment*, the European Environment Agency proposed some initial sectoral integration criteria, based on the 5EAP and the United Nations Rio Declaration (on Environment and Development). They focus on the important role of prices, taxes and subsidies in encouraging particular kinds of sectoral economic activity (*market integration*), and on the use of environmental impact assessments, management systems and product policies to anticipate and minimise environmental impacts (*management integration*). Monitoring progress against these criteria has only just begun.

Some initial results on progress with the internalisation of transport *externalities* (including infrastructure costs) into

prices, via taxes, in Member States are available. These are tentative conclusions which do not cover all environmental impacts of transport, but they represent an initial step in trying to achieve 'fair and efficient' market prices for transport. Without such internalisation of external costs, transport receives a significant 'subsidy' (estimated at around 4% of EU gross domestic product) which encourages mobility beyond the optimum for society, especially for freight transport, which may sometimes be cross-subsidised by private car transport. Comparable data for aviation and shipping is not available, but the absence of aviation fuel tax, and aircraft contributions to air pollution, means that air transport externalities are also far from being internalised into market prices.

Transport externalities in EU countries



Source: IWW/INFRAS, ECMT

Environmentally damaging *subsidies*, which are another example of failure to integrate environmental cost into market prices**,** are difficult to estimate. They are in general declining, though still large in agriculture, industry and the energy sectors (particularly for coal); in total they still amount to some tens of billions of euros. Tax concessions for car use and parking in some countries are another subsidy to private mobility.

A broadening of the range of *policy instruments* has slowly occurred since 1992 with a greater use of taxes, environmental agreements and information, in addition to legislative measures such as directives. Concerning economic instruments, more environmental taxes and other economic instruments are in practice (especially in energy and transport) – less than 100 economic instruments in use in EU countries in 1987, compared to 134 in 1997. However, revenues from 'green' taxes are still less than 7% of total EU taxes (including energy taxes), and such taxes are in force mainly in Scandinavian countries, Belgium and the Netherlands, with few taxes being used in southern countries. There has been little progress in ecological tax reform, where labour taxes are reduced with revenue from environmental taxes.

There has been a more dramatic increase in the use of *environmental agreements* over the last 10 years: a survey by the European Commission found that by 1986 a total of 44 agreements recognised by Member States had been concluded in the EU, while 10 years later (by mid 1996) 304 agreements were known to be in force. However, most of these agreements do not have the monitoring and implementation procedures required to enforce and assess their environmental effectiveness.

The *use of information* has also increased but mainly in northern countries, and in the agricultural and industrial sectors where eco-labels are beginning to have an impact. Pesticides residue labelling and food quality assurance, including the organic origins of agricultural products, is becoming increasingly important in consumer choice. The possibility of choosing 'green' electricity, or locally supplied food products, is just beginning. Belgium (Flemish region),

the Netherlands and Sweden have developed 'pollutant emission registers' that are consistent with the Community statistical classification of economic activities (NACE), hence allowing for cross-country analyses and linkage with economic variables. Other emission inventories (notably in Belgium, France, Germany and the UK) have been set up in response to various national and international reporting requirements.

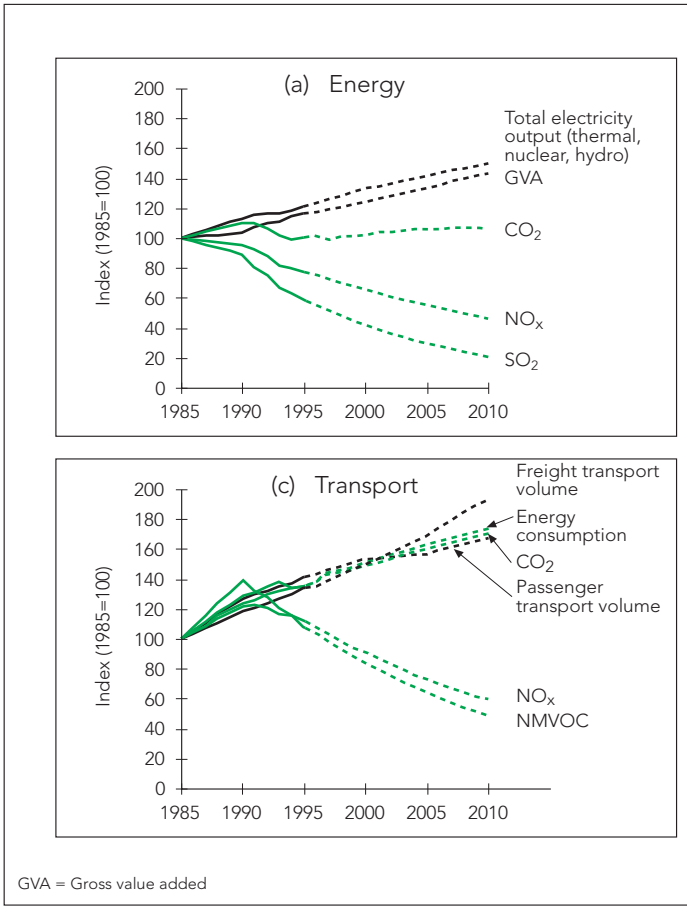
The anticipation and reduction of environmental impacts by the prior assessment of projects and policies has made some progress, encouraged by EU activity. Most Member States and some sectors have produced guidance and other support in the use of *Environmental Impact Assessments* (EIA), which is seen as an important influence on project planning. However, most of these assessments have only lead to limited adjustments to projects, often because they were executed at rather a late stage in project design. Although the Strategic Environmental Assessment Directive is still only under discussion – several Member States (Belgium, Denmark, Finland, Italy, Netherlands and Spain) and the European Commission have developed procedures and initiatives for SEA.

Influencing supply chains through *environmental purchasing* is another means of integrating environmental considerations into management policies, and initial progress is evident in several Member States (Denmark, Finland, Germany, the Netherlands and the UK). The use of environmental management systems, encouraged by European Environmental Management and Audit Schemes (EMAS) and International Standardisation Organization (standard ISO 14000), is spreading slowly, but unevenly, with most registered EMAS sites being in Germany.

The success of the sectoral integration tools described above can be measured by the extent to which sectors decouple their economic activity from their environmental impacts, with associated increases in their 'eco-efficiency'. At the EU level, only air polluting emissions have shown a significant decoupling from GDP since 1990. By contrast, there has been only a relatively small decoupling of carbon dioxide and waste, and these trends continue to 2010.

Within the sectors polluting emissions have declined significantly in energy, transport and industry sectors, and less so in agriculture, but energy use and carbon dioxide have either continued in step with output (transport and agriculture) or have decoupled only slightly, and there is no indication of significant eco-efficiency gains in these two critical environmental impacts up to 2010.

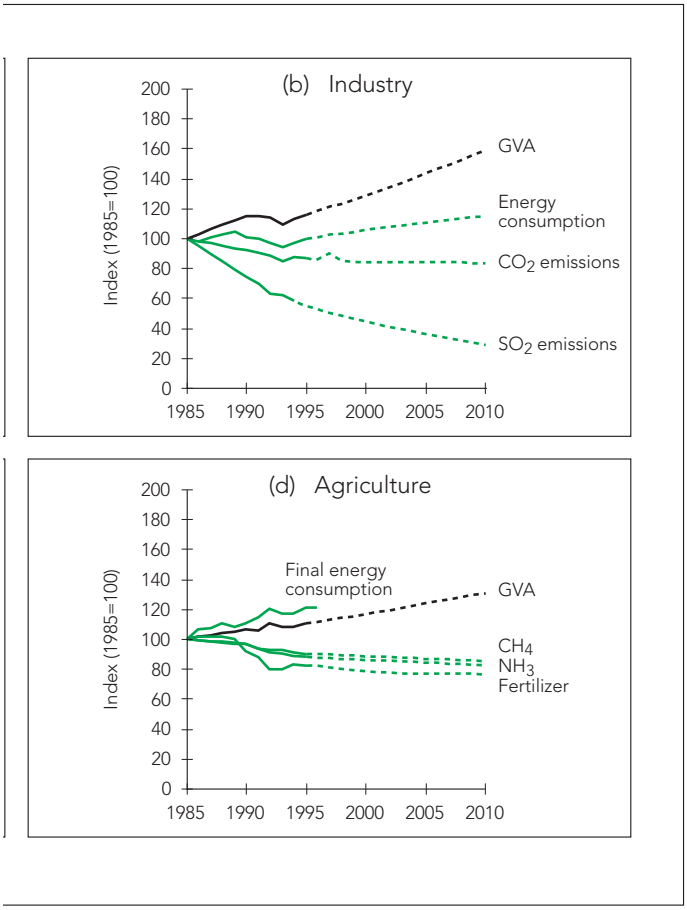
Eco-efficiency on sector level



GVA = Gross value added

Source: Compiled from multiple sources

Eco-efficiency gains may not be sufficient to achieve sustainability as there sometimes needs to be an absolute reduction in the total load on the environment (and not just relatively less eco-impact per unit of output from eco-efficiency gains), as with greenhouse gas emissions and acidification. In addition, global environmental impacts can increase if eco-efficiency gains in the EU arise from polluting industries relocating abroad.



5. Challenge and opportunities of EU enlargement

While the 'Accession Countries' (on course for EU membership early in the next century) share many similar problems to the EU, the state of their environment also shows some differences. In the more industrial areas particularly, there is an inheritance of environmental damage, e.g. from sulphur emissions and heavy metal contamination,and water quality is poor in some areas, especially where supplies are drawn from groundwater contaminated by nitrates. There are also still potential environmental hazards associated with Soviet-era nuclear plants and military bases, for which remediation works are being undertaken.

Some Accession Countries have more environmentally sustainable economic activities, and also more extensive areas of natural habitats (the natural asset). Notwithstanding the social implications, the significant decline in gross domestic product levels in the early years of the transition process actually helped in a sense their environment – through lower waste generation, energy consumption, and use of agricultural chemicals – reducing pollution and environmental health risks. In addition, land use is not as high as in many EU countries, which is positive for biodiversity, landscape diversity and maintaining ecological processes.

However, in the transition to EU membership, there is a danger that their environment will suffer if they follow the same development path of the EU15.

When convergence with the present EU implies accelerated economic growth in the Accession Countries, their challenge is to ensure that they do not repeat the two decades of environmental neglect that occurred in western Europe – which eventually, in the 1970s, prompted a crash programme of remedial action at European and national level. It is perhaps more realistic and useful to consider that both the EU15 and the Accession Countries are in transition – transition to more sustainable development. Both have some way to go but, with different starting points, their transition paths will be different.

Box: Developments in the environment of the Accession Countries

Central and eastern Europe Accession countries:

- With expanding economies, **consumption and production** increases could be greater than in EU countries. In particular, private car use could increase by about 60% by 2010. The expected economic growth could well exacerbate, for example, municipal waste levels, and traffic congestion and pollution.
- With measures likely to be applied under the convergence process, **energy consumption and intensity** will probably dramatically decrease. Energy intensity in industry, especially, could improve by 35% by 2010. The energy restructuring process could result in significant declines of sulphur dioxide and carbon dioxide emissions at relatively low cost. With lower depositions, ecosystems adversely affected by acidification would probably be reduced from 44% in 1990 to 6% in 2010; ecosystems in the EU will also benefit from reduced emissions in Accession Countries; more modest gains can be expected for eutrophication. Improvements in energy efficiency and other baseline scenario assumptions would lead to a decrease in CO_2 emissions by about 8% between 1990 and 2010 for the Accession Countries.
- Currently, the **transportation systems** have less adverse implications for the environment than those in the EU. The rail network in most Accession Countries is well developed, although modernisation is required. At the same time, the road infrastructure and private transportation is less developed. This situation provides the basis for developing an efficient transportation system which is relatively harmless from an environmental perspective.
- Recent increasing yields and production occurred in **agriculture**, accompanied by lower use of pesticides and fertiliser. But the potential for increasing the use of fertilisers and the spread of manure represents an important threat to water quality. The land tenure changes already instituted in Accession Countries have significant implications for land use and increased agricultural output. Nevertheless, the opportunity exists to protect ecosystem assets through agricultural-environment integration under the proposed reforms of the Common Agricultural Policy. This could have major benefits for rural economies through the enhancement of low-impact agriculture and development of eco-tourism, while at the same time maintaining biodiversity.
- The implementation of the **urban waste water** treatment Directive in the Accession Countries could result, with high effort on sewerage development and waste water treatment with nutrient removal, in a two-thirds reduction in organic matter load and a 40-50% reduction of nutrients input. This would potentially reduce the nitrate and phosphorus loading to both the Baltic and Black Seas by around 15-30%. However, such measures are expected to originate a very serious sludge problem, due to a drastic increase of the amounts produced. Furthermore the costs estimated for building up the necessary sewage treatment plants (excluding

connections) could be of the order of 9 billion euros.

- Major reductions in the emissions of certain **hazardous substances** could be achieved with the application of EU policy within Accession Countries. Over the next decade, considerable reductions could be expected, mostly for lead, copper and mercury. EU policy could also reduce the amount of cadmium emissions although growth in traffic would largely counter this potential improvement. Large increases in the emissions of all the studied pesticides are anticipated due to growth in agricultural production, while the increase in hexachlorocyclohexane (HCB) emissions stems from the expected growth in the volume of incinerated waste.
- As regards **transboundary air pollution**, sulphur dioxide and nitrogen oxide emissions are expected to be reduced by approximately 40-50%. Deposition of these pollutants will subsequently decrease but nonetheless two-thirds of ecosystems areas will still be affected by acidification and mainly eutrophication.
- **Urban air pollution**: around 90% of the population lives in cities where exposure exceeds threshold values. For all air pollutants an improvement is expected, mainly for benzene. Nevertheless, Benzo(a)pyrene, nitrogen oxides and, to a lesser extent, sulphur dioxide and particulate matters (especially PM10) will remain serious problems.
- The existing **hazardous waste** sites and nuclear plants in the area pose significant health risks and represent an environmental liability. Indeed, the severe environmental and health impacts include lower life expectancy, higher incidences of certain diseases, and greater impacts on ecosystems.

Cyprus:

- Despite its partial degradation, the quality of the environment remains quite good on the whole. However, urbanisation, which rose from about 44% in 1974 to 68% in 1992, has mostly concentrated along the coast. This increase, combined with the fact that 93% of tourist bed capacity is also located along the coast, has led to heavy pressures exacerbated by infrastructure development and, to a lesser extent, by agricultural and industrial development. Moreover, as water resources are scarce, the demands for water are causing concern, as are pressures on its quality in some areas due to effluent and use of agrochemicals. In the coastal plain aquifers, nitrate concentrations in some areas have increased. The principal groundwater quality problem is salinity due to overpumping. The annual per capita production of solid waste, estimated at 470 kg/year for residential areas and 670 kg/year for tourist areas has given rise to the generation of a variety of associated problems. In the agricultural sector, soil erosion, use of weed killers and agrochemicals and the losses of prime agricultural land to other uses, are some of the most important concerns, though the quality of the soils is good.

  Undoubtedly, the protection of the coastal zone and the prudent management of water resources are the two most critical and urgent issues requiring a core programme of immediate – mostly corrective – tasks.

The Accession Countries have already started to tackle this task through the establishment of framework environmental and environmental health action plans, and the integration of EU environmental standards in national legislation. Under future convergence, appropriate policy intervention and implementation has the potential for beneficial effects in both the Accession Countries and the EU at substantially lower costs through the application of tested approaches.

In this context, a significant time-lag can be expected before full compliance is achieved with EU environmental policies and standards which themselves are evolving. In addition, environmentally damaging activities not adequately covered by EU legislation also need to be addressed in Accession Countries. This requires in particular larger consideration of the 'integration issue' (e.g. in transport, energy and agriculture). This would directly contribute to a more sustainable enlargement process, something that would certainly go beyond specific environmental legislation. And taking sustainable development as the reference, in particular for the sectors mentioned above, a broader compliance can be achieved.

6. Closing the information gaps

The chairman of the 'Bridging the Gap' Conference (June 1998) on new needs and perspectives for environmental information concluded that:

'At present some of the systems for monitoring and gathering information about the environment in European countries are inefficient and wasteful. They generate excessive amounts of data on subjects which do not need it; and they fail to provide timely and relevant information on other subjects where there is an urgent policy need for better focused information, and for consistent environmental assessment and reporting.'

he also recognised the need for a concerted pan-European movement:

- to streamline environmental monitoring and practices,
- to focus information gathering on key issues, and
- to develop indicators, which would need to be widely agreed, illuminating the significance of environmental change and the progress of sustainability.

The European Environment Agency (EEA) report in 1995 *Europe's Environment: The Dobris Assessment*, included an overview of strengths and weaknesses in environmental and related information. There has been some progress since the 1995 review but much remains to be done to achieve the EEA mandate and the goals of the 'Bridging the Gap' Conference. Nevertheless, as shown in the present report, in *Europe's Environment: The Second Assessment*, and in the OECD (Organization for Economic Co-operation and Development) and UNECE (United Nations Economic Commission for Europe) country environmental performance reviews, more use is being made of the information currently available to highlight the state of knowledge and the remaining gaps and inconsistencies.

Box: Progress towards better information

- EU Directive (96/62/EC) on **ambient air quality** assessment and management and the third EU Decision (97/101/EEC) on exchange of air quality information have been adopted. EEA has established EuroAirNet and AIRBASE to complement and support this legislation and, in co-operation with the Commission, EEA member countries and the EMEP Programme (under the Convention on Long Range Transboundary Air Pollution), improve the quality, consistency and timeliness of air quality data and information available at the European level. However, there has been little progress in detailed monitoring of volatile organic compounds.

- There have been improvements in the detail, comparability and timeliness of **atmospheric emission inventories** through continuing co-operation between the EEA, European Commission (EU Monitoring Mechanism for greenhouse gases), EMEP, International Panel for Climate Change (IPCC – providing technical support to UN Framework Climate Change Convention) and member countries. However, there has been little progress in direct emission measurements or in compiling at the European level emissions into water bodies on the catchment scale or releases into, or onto, land.

- Data on toxicity, ecotoxicity and environmental fate for manufactured **chemicals** is still not satisfactory but it is now recognised that new approaches focusing on persistence and bio-accumulation are required.

- There has been little progress in the quality of **waste information**; the Commission in early 1999 adopted a proposal for a regulation on waste statistics that will take some time for adoption and implementation and there has been some progress co-ordinated by the EEA and Eurostat on improving the quality and consistency of household waste statistics.

- There is an improved culture with regard to **industrial accident** reporting and sharing the lessons learnt. The European Commission accident database MARS, only for EU countries, is now complemented by SPIRS (Seveso Plants Information Retrieval Systems) which will cover the contents of the safety report of each 'Seveso plant' in the EU.

- An enormous amount of accident monitoring and environmental **radioactivity** data is now being collected across Europe which now needs to be better linked and used.

- Information about environmental impacts of **natural hazards** and

interactions with human activities is not widely available.

- Information on regional **water** resources and on water abstractions has improved. An initial report presenting available information on groundwater quality and quantity has been made by the EEA. In collaboration with member countries and several Accession Countries, EEA is also developing EuroWaterNet/Waterbase to help improve data comparability and provide the information relevant to the proposed water framework Directive. However, there is still little data on small rivers and lakes, organic micropollutants and metals.

- Apart from major soil types, basic data, such as detailed European **soil** maps, are still unavailable for assessment and there has been no progress in the quality and comparability of data available at the European level. There is no European-wide monitoring network for soil, although some progress has been made, for example in monitoring of forest soils. A European inventory of contaminated sites is still lacking but requirements are being developed. Nevertheless, the importance of the soil medium and the need for European comparable data are being recognised.

- Initial assessments of methodologies and needs for **landscape** description and information have been made but comparable information at the European level is still lacking.

- There has been progress in accessibility to data on **ecosystems, habitats and species** in most countries: best data still concern vertebrates and vascular plants, but several invertebrate groups such as butterflies and lower plants are emerging. Red lists for the same species groups now exist in most countries. Forest maps are now available but need harmonisation.

- There has been progress in compiling information on flora, fauna, species and habitats for Natura 2000 (the Birds and the Habitats Directives) for the EU countries and for non-EU European countries in the related Emerald Network of the Bern Convention. Data are being used by EEA through the European Nature Information System (EUNIS) in co-operation with the Commission, the Council of Europe and international nature conservation organisations.

- On **urban environment**, there has been little progress in providing comparable information on noise. The Community Noise Strategy which will consider requirements and methodologies for such information was only established in September 1998. There are several European urban

environment and **planning** initiatives but these have not yet produced much comparable information on cities across Europe.

- Information on Europe's seas remains limited but the EEA has brought together the various **marine** conventions and programmes in an Interregional Marine Forum to help improve the comparability and timeliness of information for future assessment and reporting. Information necessary for an integrated approach on European **coastal zones** and their management is still missing or poorly co-ordinated.

- There has been little progress in the collection of **geo-referenced environmental data** for spatial and territorial analysis at the European level. Consistent information on land cover for most of the EU and Accession Countries is now for the first time available. Also some progress, though limited, on specific geographical patterns or areas such as coastal strip, watersheds, natural sites. However, much more needs to be done to improve the required quality, consistency and coverage of geo-referenced environmental data for improved integrated assessments.

Public information and participation

'While surveys show a high and increasing level of environmental awareness among the general public, the public is considerably lacking in essential information' (EU Fifth Environmental Action programme).

The Directive on Freedom of Access to Environmental Information, 1990, which establishes the right of the public to access environmental information held by public authorities, has unquestionably unleashed a process of change in attitude and behaviour on the part of public authorities in many member states in improving the flow of information to the public. However, there have been numerous complaints over the implementation of the Directive, with problems over how it is being interpreted, the wide scope for refusing access, and also slow responses and differences in charging for information. The Directive is likely to be strengthened: it is currently under review, and the EU and Member States' commitment to implement

the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, and a new article in the Amsterdam Treaty establishing the right of access to documents held by EU institutions, will all aid improvement if implemented effectively.

Information to the public (via eco-labels, pollutant emission registers, environmental impact analyses and relevant indicators) is an increasingly important policy tool required to help change behaviour towards more sustainable production and consumption activities, such as demand-side management, the 'products to services' shift, and life-cycle impact reduction.

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