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# European environment outlook

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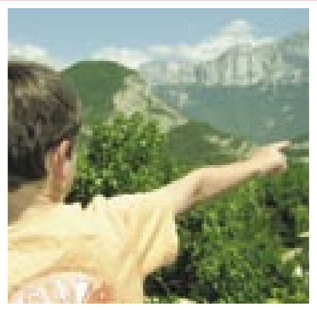

European Environment Agency

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# Contents

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# Foreword

Protecting our environment is a key element in ensuring sustainable livelihoods for today's and future generations.

Indeed, the most recent Eurobarometer surveys show that as Europeans we regard the protection of our environment to be one of the six key priorities for the European Union. Issues of particular concern are water and air pollution, man-made disasters, and climate change. In addition, new challenges arising from diffuse sources of pollution, changing consumption patterns, and the possibility of sudden extreme environmental changes all need to be addressed.

Europe is responding to these concerns through the policy arena. The sustainable development strategy, Lisbon agenda, and sixth environment action programme are all important in the balance between economic growth, a high quality of life and a healthy environment. And to arrive at further informed strategic decisions, we must anticipate what lies ahead, and grasp ongoing, emerging and latent developments.

Decision-makers, stakeholders and the public look to us, the EEA, to provide information on the future prospects of the state of Europe's environment. Whilst we cannot predict what changes the future will bring, we can, nevertheless, give a perspective of how current trends may unfold — based on our understanding of how environmental systems function and how they are shaped by socio-economic and technological developments.

This European environment outlook report addresses a range of environmental concerns and their common driving forces in an integrated way, and turns the spotlight on some of the more pressing issues. The report highlights the prospects for Europe's environment, exploring the consequences of our current expectations regarding socio-economic developments and, in some instances, points towards options for a more sustainable future.

With this EEA report dedicated solely to outlooks, we hope to inform the important discussions on how we can shape our common environmental future for the better.

Prof. Jacqueline McGlade
EEA Executive Director

# Executive summary

**The European environment outlook report of 2005** assesses the environmental consequences of key socio-economic developments in Europe, particularly with regard to climate change, air quality, water stress and water quality. The projected developments are discussed in the light of Europe's current policy targets as adopted in the European Union's sustainable development strategy and the sixth environment action programme. A number of key signals and headline messages emerge from this assessment:

**Changes in Europe's demographic patterns — ageing societies, rural depopulation and growing numbers of households** — are expected to increase some environmental pressures. The total population of Europe is expected to remain fairly stable over the next 30 years, but projections show a changing demographic structure with an increase in average age (with more than 20 % being more than 65 year old in 2030, compared with 15 % today). At the same time, the total number of households is expected to grow by more than 20 %. In general, more households mean more energy consumption and — until recently — water use, and more waste generation, resulting in more environmental pressures.

**The short-term European greenhouse gas emission targets are expected to be met, if all additional policies and measures planned are implemented.** With existing domestic policies and measures alone (as of mid-2004), emissions in the EU by 2008–2012 are expected to be less than 3 % below 1990 levels, compared with the Kyoto Protocol target of 8 %. However, taking into account the latest policy developments (e.g. emissions trading scheme with national allocation plans assessed and adopted by the European Commission in the second half of 2004), and provided that Member States implement all the additional policies, measures and third-country projects they are currently planning, and that several cut emissions by more than they have to, the EU is likely to be able to meet its Kyoto Protocol target.

**The long-term European greenhouse gas emission targets, set to prevent harmful climate change, are expected to be exceeded**. Projections indicate that, with existing domestic policies and measures alone, emissions are likely to fall short of the EU target of a reduction of an average of 1 % per year up to 2020. Also, unless deep emission reductions are achieved globally and in Europe, the overarching EU policy target of limiting increases in the global mean temperature to 2 °C above pre-industrial levels is expected to be exceeded in the second half of this century. This is likely to result in further changes in precipitation, rising sea levels and a change in the magnitude and frequency of some extreme weather events. Even sudden extreme changes, such as the collapse of the 'Gulf Stream' or the Arctic ecosystem, are not deemed entirely implausible.

**Air pollution and its impacts on health and ecosystems are expected to decline significantly.** On the basis of existing policies and measures, all emissions of land-based air pollutants (except ammonia) are expected to decline significantly (by more than 35 %) up to 2030. The EU as a whole is therefore expected to comply with the 2010 targets of the national emission ceilings directive. However, while a number of Member States are well below their binding upper national emission ceilings, others are not on track. As air quality in Europe is expected to improve significantly, impacts on human health and ecosystems may diminish substantially, although large differences across Europe are expected to prevail. In particular, negative impacts in highly populated areas of the EU are expected to remain significant.

**Water use is expected to decrease markedly in most of Europe; however, many Mediterranean river basins will continue to face water stress.** Total water abstraction in Europe is expected to decrease by more than 10 % by 2030. The sectoral profile of water use in most of Europe is changing: the manufacturing sector and households are replacing the electricity sector as the main abstractors. In southern Europe, irrigation continues to dominate (more than 40 % of the total), and expanding irrigated areas and likely climate changes are expected to increase vulnerability to droughts and other extreme climatic events.

**The urban waste water treatment (UWWT) directive is expected to lead to a significant reduction in the overall discharge of nutrients from point sources.** With implementation of the UWWT directive, emissions of nitrogen and phosphorus are expected to decrease significantly as a result of an increase in the proportion of the European population connected to wastewater treatment (to more than 75 %) and more use of tertiary treatment. However, nutrient discharges from rural populations not connected to wastewater treatment (about 30 % of the population in the 10 new Member States) and from other diffuse sources such as agriculture, are expected to remain a major water pollution problem. It is therefore vital, if water quality is to improve further, to continue to shift policy focus from point sources to diffuse sources, for example through the catchment area management approaches introduced in the water framework directive.

**The recent enlargement of the EU continues to provide both environmental opportunities and threats.** EU legislation has in many cases led to stronger environmental legislation in the 10 new Member States (New-10). At the same time, improved economic prospects and the associated higher levels of individual consumption are likely to increase the pressure on the environment. In contrast to the overall European trends, the use of water by households and mineral fertilisers in agriculture are expected to increase substantially in the New-10 (by more than 70 % and 35 % respectively, although these remain lower than in the EU-15 in absolute terms). Meanwhile, comparably low increases in future greenhouse gas emissions are expected to contribute significantly to limiting total EU emissions. Also, resource productivity in the New-10 is expected to remain relatively low (currently about four times lower than in the EU-15), providing ample opportunities for implementing cost-effective mechanisms or 'leapfrogging' towards the use of newer, more resource-efficient technologies.

**The EU's sixth environment action programme sets objectives and key environmental priorities.** The EU seems to be on track to meet the targets set for a number of issues, particularly for air pollution and nutrient emissions from point sources. Encouraging developments are also expected in other areas, for example a reduction in agricultural nutrient surpluses and water stress, and a relative decoupling of transport demand from economic growth. However, the EU continues to face significant challenges with respect to meeting the targets for greenhouse gas emission reductions and climate change, and achieving the goals for the use of alternative sources of energy for electricity generation, heat and transport.

**The current shift to more integrated approaches towards environmental policies provides further opportunities to improve the future state of Europe's environment.** For many environmental problems, past and current legislation has often successfully addressed the 'big polluters', but new concerns are likely to arise from individual consumption and diffuse sources of pollution. A shift in the nature of environmental pressures is expected: from production towards consumption, and from large point sources to more fragmented and diffuse sources (including households, agriculture and transport infrastructure). Successful responses may require policy-makers to give more consideration to the common drivers and sectoral developments (for example in transport and agriculture) behind many environmental pressures in Europe, and to address these in a coherent manner.

# 1. Looking ahead — setting the scene

## 1.1 Looking ahead: what for?

In striving to become more sustainable, we must seek to meet the needs of the present without compromising the ability of future generations to meet their own needs, in economic, social and environmental terms (1). In this context, Europe is aiming to become a more dynamic and competitive knowledge-based economy, capable of sustainable economic growth with more and better jobs and greater social cohesion (2).

In support of these goals, assessments of the state of the environment are only complete if they reflect the future prospects for the environment by discussing, in an 'outlook', how developments may unfold, together with a view of the wide range of uncertainties that the future may hold. This becomes particularly important where environmental systems display considerable time-lags between actions and their consequences.

## 1.2 The European environment outlook

The European Environment Agency's flagship report on the 'State of the environment and outlook' in 2005 addresses the main environmental concerns that Europe is facing (3), provides a state-of-the-art overview based on current scientific understanding, and addresses the policy dimensions of current and upcoming challenges (4).

The EEA's State of the environment and outlook report draws from a range of supporting sub-reports and technical documents (see Box 1.1). Within this framework, this report explores plausible future developments in more detail for Europe and its regions (5), and thus complements the overall assessment of the current state of the environment.

This report also describes plausible alternative scenarios, to help identify appropriate response options and assess whether Europe is on track to meeting its environmental objectives. It addresses a range of environmental concerns in a consistent and integrated manner, highlighting links between these issues and their common driving forces in the technical, social and economic realms (6).

The analysis extends to the 2020s and beyond, and brings together new quantitative information (where models and tools are available) and both quantitative and qualitative understanding derived from former EEA reports and other studies.

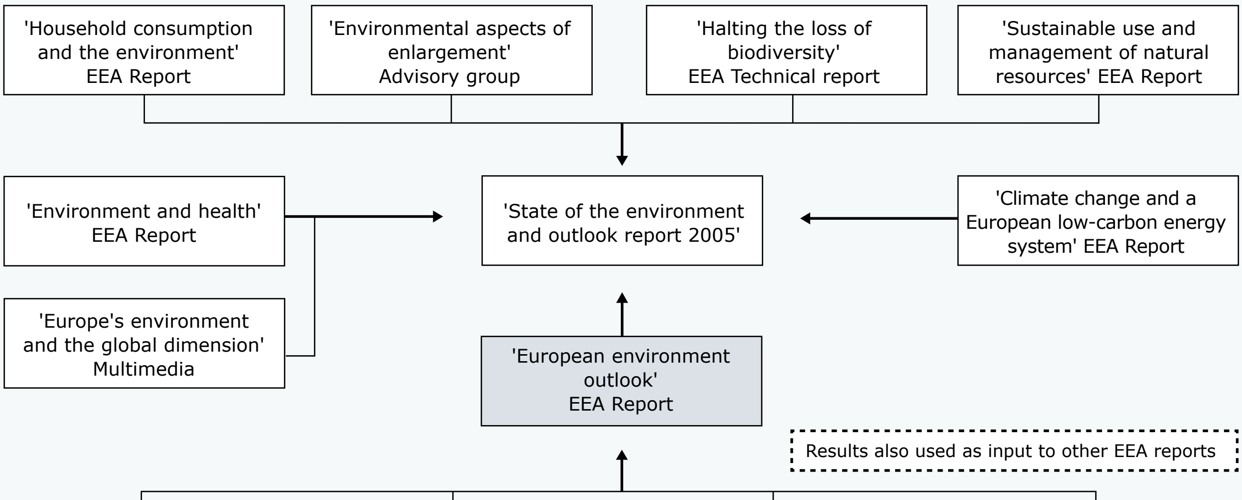
A short overview of the current understanding and the policy dimensions of environmental issues provides a natural starting point for analysing plausible future developments in Chapter 2. Today's prime concerns with regard to the state of Europe's environment include climate change and the quality of air, water stress and quality, soil degradation, and loss of biodiversity and natural capital, as well as changes in consumption patterns, the use of natural resources, waste, and greenhouse gas emissions. While all these issues are recognised as having their own distinct characteristics, they are also inter-connected through a range of common driving forces.

Developments in demography, macro-economy, sectors, technology and socio-cultural values are likely to continue to exert a decisive influence on the pressures on the environment and its state, as they do today. How they may unfold under a set of 'baseline' assumptions (7), and some of the immediate consequences, are presented in Chapter 3. The interplay between these driving forces and the environment will continue to change Europe, and the changes themselves will also induce feedbacks and cause additional changes. Chapter 4 spotlights important environmental changes likely under these baseline assumptions.

However, future developments are not cast in stone, but subject to considerable uncertainties, surprises, and to our own future actions. Indeed, one aim of providing an outlook is to identify looming undesirable developments and think through plausible alternative paths. Thus, Chapters 3 and 4 also highlight some key uncertainties in the projections, and explore the implications of a low greenhouse gas emission scenario and other alternatives in some detail (see Box 1.2).

### Box 1.1 State of the environment and outlook report 2005

The outlooks for the EEA's State of the environment and outlook 2005 report have been developed across a range of sectors and themes: greenhouse gas emissions, air pollution and climate change, agriculture, water stress and quality, and waste and material flows. An overview of their aims (and value-added to previous studies), models and outputs is given here. Annex 2 to this report describes the models used, while the exhaustive list of forward-looking indicators addressed can be found in the supporting background documents listed in Annex 3.



**Climate change and air pollution outlooks**

**Aim**

To provide (i) a detailed scenario of climate policy measures (sustainable emission pathway), including all GHGs and all sectors; (ii) an assessment of the co-benefits of climate policies for air quality issues as well as the benefits of associated measures; and (iii) a comprehensive environmental outlook for the 2020s and beyond, which builds on and ensures consistency with key European Commission projections developed for energy and transport (LREM project; DG TREN), and air pollution (Clean Air for Europe (CAFE); DG ENV).

**Models**

PRIMES (energy and transport)

POLES (energy and transport)

TIMER/FAIR (GHGs emissions)

RAINS (air pollution)

IMAGE (climate change)

Euromove (ecosystem composition)

**Output**

- Emissions (greenhouse gases, air pollutant)
- Environmental impacts (temperature and precipitation change, ecosystem composition, growing season)

**Agriculture outlooks**

**Aim**

To provide agricultural projections that (i) span beyond the 2020s and incorporate the mid-term review of the CAP; (ii) cover the EU-15 and the key (i.e. with regard to agriculture) new Member States; (iii) rely on a consistent modelling framework, which builds on the existing set of projections and an analysis of the characteristics of European driving forces and political issues; and (iv) represent an updated and expanded set, which is also used in the European Commission's air pollution outlooks within the CAFE programme.

**Models**

CAPSIM (sectoral model)

**Output**

- Livestock, cropping and fertiliser patterns
- Agriculture nutrient balances for N (nitrogen), P (phosphate), K (potassium)
- GHG emissions linked to fertilisers and livestock

**Water stress and water quality outlooks**

**Aim**

To provide (i) an integrated assessment of water use and availability, based on an analysis of the characteristics of European and national driving forces; (ii) an assessment of the impact of climate change policies in terms of water use and availability; and (iii) EU-25-wide projections of nutrient discharges after the implementation of the urban waste water treatment (UWWT) directive.

**Models**

WaterGAP (water use and availability)

A model on nutrients from UWWT plants

**Output**

- Water use (by domestic, industry, electricity and agriculture sectors), water availability and water stress projections (per 0.5 ° grid)
- Waste water quantities and treatment, and nutrient discharges (nitrogen and phosphorous) from urban wastewater treatment plants

**Waste and material flows outlooks**

**Aim**

To provide (i) projections based on a EU-wide macro-econometric model addressing material flows and significant waste streams; (ii) outlooks addressing coupling/decoupling issues (in particular with regard to economic and population growth); and (iii) an assessment of the impact of climate change policies in terms of material flows.

**Models**

A macro-econometric waste and material flows model

**Output**

- Waste: quantities of municipal, industrial, construction and demolition waste, paper and cardboard, glass, packaging, waste oil and used tyres from cars
- Material flows: domestic extraction and consumption of fossil fuels, metals, minerals, and biomass

Key signals and early warnings from this outlook are flagged (in Chapter 5 and the Executive summary), keeping in mind the uncertainties inherent in any discussion of future developments. Reflecting on the implications of the baseline and alternative scenarios, the key messages developed in this report aim to support well-informed policy decisions based on historical and current trends and also take into account the best available interpretation of possible future developments. Chapter 6 points to some important information gaps and uncertainties.

**Box 1.2 Baseline and alternative scenarios**

The EEA's baseline scenario follows a conventional definition and expands on current expectations regarding macro-economic, sectoral, technological and societal developments, as well as including those policies that have been implemented and/or adopted, which typically refer to pieces of legislation such as EU directives (e.g. on urban waste water treatment and on landfills) or political agreements (e.g. mid-term review of the common agriculture policy). The analysis presented here extends to the 2020s and beyond, with particular attention to long-term developments for climate change issues (up to 2100).

The EEA baseline assumptions expand on the socio-economic assumptions developed for the DG TREN baseline projections 'European energy and transport trends to 2030', which are also being used within the Clean Air for Europe (CAFE, DG ENV) programme. Additional assumptions have been made where appropriate and necessary to arrive at a broader environmental outlook, for example with regard to structural and technological changes (e.g. water sector), commodity prices or the implementation of EU policies (e.g. mid-term review of the CAP). The same set of baseline assumptions is used across the whole range of sectors and themes addressed, and in most cases constitute the key driving forces behind the projections (see Chapter 3 for more details).

A discussion of alternative scenarios, addressing key uncertainties around economic and technological issues as well as policy levers, complements the baseline scenario. The marginal or relative changes attributed to different assumptions often give sound insights into the comparative advantage of choosing one option vis-à-vis another (e.g. as analysed by contrasting baseline and policy variants), even where it is clear that the absolute values presented in this outlook carry significant uncertainty.

For key issues, alternative scenarios (i.e. assumptions) to the baseline scenario and policy variants have been analysed, including:

**Energy, transport and climate change**
- 'Low GHG emissions' scenario
- Economic and technological variants (e.g. low economic growth, accelerated penetration of renewables, accelerated decommissioning/adoption of nuclear)

**Air pollution**
- 'Maximum technically feasible reductions' scenario

**Agriculture**
- Best practices for fertiliser handling
- Liberalisation of animal product markets — extended CAP reform
- A stronger Euro

**Waste and material flows**
- 'Low GHG emissions' scenario (for fossil fuels only; see climate change outlooks)
- Low economic growth variant
- Impacts of the landfill directive for biodegradable municipal waste

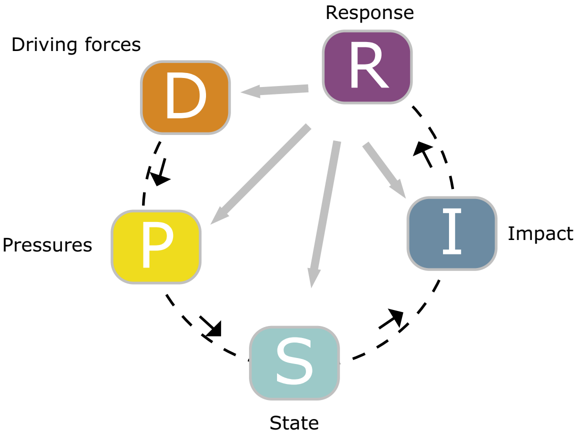
**Water stress**
- 'Low GHG emissions' scenario (see climate change outlooks)
- Low economic growth variant
- Non-convergence of per-capita water use in the New-10

# 2. Europe's environment — current concerns

Assessments that address the uncertainty of future states of the environment have played an important role both in the scientific discourse and in the policy debate since the 1970s. Early outlooks were triggered mainly by concerns regarding the sustainability of society's use of natural resources and in particular highlighted the limits to growth that the environment may put on populations and economic systems. Since then, a large number of studies have addressed the prospects for the environmental issues ([8]).

Most future-related environmental studies have focussed either on specific topics and issues of prime concern or on selected geographical regions. Also, many outlook exercises are based on thinking through the implications of a baseline projection; i.e. assuming that key driving forces largely continue to follow established trends and are not subject to sudden or drastic changes. However, in view of the uncertainties inherent in any futures assessment, projections benefit from being contrasted with a wide range of scenarios that aim to highlight viable alternatives. In particular, a range of alternative and contrasting scenarios have been developed in studies that aim to provide an integrated view of environmental change at the global or European scale, using comprehensive approaches with a systems-analysis orientation.

**Figure 2.1 The D-P-S-I-R scheme**



Some examples of such studies are shown in Box 2.1.

Past scenario and outlook studies have raised a number of common and overarching environmental concerns. Many of the outstanding European environmental issues have been addressed in past EEA assessments, and an updated and coherent discussion of an outlook on these concerns re-emerges in this report. This outlook is based on the so-called analytical DPSIR framework to address an array of driving forces, pressures, states and impacts of environmental change in an integrated manner to provide a basis for developing societal response options (see Figure 2.1).

This chapter summarises current understanding of environmental issues with regard to climate, air, water, biodiversity and soil. It highlights the most important driving forces behind environmental changes, and gives an indication of how the concerns are being tackled in the European policy context. Important pressures and other determinants that govern the state of the environment, such as greenhouse gas emissions, consumption patterns, resource use and waste generation, are addressed in subsequent chapters, together with a discussion on the way key driving forces unfold over the coming decades under a set of baseline assumptions.

## 2.1 Outstanding issues

### *Greenhouse gas emissions and climate change ([9])*

Human activity has resulted in a dramatic increase in the concentration of greenhouse gases in the atmosphere compared with pre-industrial levels — carbon dioxide alone has increased by more than 30 %. And it is generally accepted that greenhouse gas emissions lead to climate change, e.g. an increase in global average temperature, sea level rise and a change in the magnitude and frequency of some extreme weather events. Since 1900, European annual mean air temperatures have increased by 0.95 °C, and this trend is expected to continue. Even extreme sudden climate changes

### Box 2.1 Comprehensive global or European-scale environmental scenarios (examples)

**European Environment Agency** (EEA, 1999)

Focus: Europe's environment Horizon: 2010 and beyond
Scenarios: Outlook (thematic baseline projections)

**Global Scenarios Group, Stockholm Environment Institute** (SEI, 1997, 1998)

Focus: Environment, human values Horizon: 2050
Scenarios: Conventional world scenarios (incl. market forces variant; policy reform variant)
Barbarization scenarios (incl. breakdown variant; fortress world variant)
Great transitions scenarios (incl. eco-communalism variant; new sustainability variant)

**Intergovernmental Panel on Climate Change** (IPCC, 2000)

Focus: Climate, greenhouse gas emission Horizon: 2100
Scenarios: A1 scenario family (scenarios describing a globalised, economic-oriented world)
A2 scenario family (scenarios describing a regionalised, economic-oriented world)
B1 scenario family (scenarios describing a globalised, environmental-oriented world)
B2 scenario family (scenarios describing a regionalised, environmental-oriented world)

**Millennium Ecosystem Assessment** (MEA, 2005)

Focus: Biodiversity, ecosystems Horizon: 2050
Scenarios: Global orchestration scenario (globalised with economic growth and public goods)
Order from strength scenario (regionalised with emphasis on security and economic growth)
Adapting mosaic scenario (regionalised with emphasis on local adaptation/flexible governance)
TechnoGarden scenario (globalised with emphasis on green technology)

**OECD Environmental Outlook** (OECD, 2001)

Focus: Economy and environment Horizon: 2020
Scenarios: OECD Reference Outlook

**United Nations Environment Programme GEO-3** (UNEP, 2002)

Focus: Environment Horizon: 2030s
Scenarios: Markets first scenario
Policy first scenario
Security first scenario
Sustainability first Scenario

**World Business Council for Sustainable Development** (WBCSD, 1997)

Focus: Business and sustainability Horizon: 2050
Scenarios: FROG! scenario (market-driven growth and economic globalisation)
GEOPolity scenario (top-down approach to sustainability)
Jazz scenario (bottom-up approach to sustainability)

**World Water Vision** (WWV, 2000)

Focus: Water Horizon: 2025
Scenarios: Business-as-usual scenario
Technology, economics and private sector scenario
Values and lifestyles scenario

are not deemed entirely implausible, for example, those that would be associated with the sudden collapse of the north Atlantic thermohaline circulation (resulting in a sharp reduction in the moderating influence of the ocean on the climate of western Europe). Prompted by this growing concern with climate change, a multitude of greenhouse gas emission scenarios have been developed since the late 1980s.

Since the adoption of the United Nations Framework Convention on Climate Change by 189 countries following the Rio Earth Summit in 1992, climate change has been addressed as an important European policy issue. With the Kyoto Protocol (which entered into force on 16 February 2005) the EU and most other industrialised countries have subscribed to concrete targets to limit and curb greenhouse gas emissions. The EU is committed to reducing its greenhouse gas emissions by 8 % by 2008–2012 compared with emissions in a base year (1990 for most countries).

Between 1990 and 2002, emissions decreased by 2.9 % in the EU-15 and by 36 % in the 10 new Member States. Despite this limited achievement, European ambitions extend further, calling for efforts to ensure that the global mean annual temperature does not increase by more than 2 °C compared with pre-industrial levels ([10]). This would imply far more cuts in emissions worldwide than currently envisaged in the Kyoto Protocol.

### *Air quality and pollution ([11])*

The issue of air quality and pollution has been of prime concern in industrialised countries since the early 1950s. Air pollution from the energy and transport sectors still contribute substantially to the environmental problems of photochemical ozone (summer smog), high levels of fine particulate matter that damage human health, and excess deposition of eutrophying and acidifying substances on ecosystems. Emissions of sulphur dioxide ($SO_2$), coarse particulates and volatile organic compounds (VOCs) in most European countries have declined dramatically since the 1980s.

High concentrations of ground-level ozone (leading to summer smog) continue to be a problem, despite reductions in the emissions of their most significant precursors, nitrogen oxides ($NO_X$) and non-methane volatile organic compounds (NMVOCs), by 30 % (EU-15) and 43 % (New-10) between 1990 and 2001. Additionally, concerns about health risks and increased occurrences of cardiovascular and respiratory diseases associated with high concentrations of fine particulate matter persist, especially in urban areas ([12]).

Air quality is an area in which European policy has been particularly active in recent years. The issue of air pollution was first addressed multilaterally in the UNECE convention on long-range transboundary air pollution (CLTRAP) signed in Geneva 1979. The convention's protocols aim at reducing acidifying emissions, and concentrations of ozone, heavy metals, and persistent organic particles. Within the framework of the Clean Air for Europe process, the European Union aims to discuss the present limits, and eventually to tighten them further to reduce the risks to the environment and human health ([13]).

### *Water stress and water quality ([14])*

In Europe, on average about 21 % of the annually renewable freshwater resources are abstracted. In southern European countries, the pressure on water resources can be severe during summer when water abstraction to meet demands from the agricultural and tourist sectors is highest. Climate change and increasing water abstraction are expected to exert additional pressures on water resources, particularly in southern and eastern Europe.

Water pollution also continues to place a burden on water resources. Nitrate emissions, mainly from agriculture, decreased in many river basins between 1992 and 2002. However, in the same period about 15 % of river monitoring showed increasing nitrate concentrations, adding to eutrophication in coastal and marine waters and the pollution of drinking water. The number of heavily-polluted rivers has declined, due to reductions in organic matter discharges, the use of phosphate-free detergents and improved wastewater treatment. Nevertheless, around 20 % of all surface water in Europe is estimated to be seriously threatened by pollution.

Policy-makers worldwide have recognised the severity of water issues, and have explicitly agreed to aim to halve the proportion of the global population without sustainable access to safe drinking water and basic sanitation by 2015 as a UN Millennium Development Goal (2002).

The EU has also increased its efforts to address environmental issues in water management with its water framework directive (2000). Two of the EU targets are that all waters should meet 'good status' by 2015 and that sustainable water use is ensured throughout Europe. Other efforts to ensure clean water in Europe have been made with the adoption and implementation of the urban waste water treatment (1991) and nitrates (1991) directives.

***Nature and biodiversity* (15)**

The biodiversity of genes, species, ecosystems and habitats is under threat, both globally and in Europe. It has been estimated that about 32 000 plant species (800 of which occur in Europe), and about 4 000 vertebrate species (335 of which occur in Europe and Central Asia) are currently threatened.

In Europe, fragmentation of landscapes and suburbanisation of rural areas in particular continue to reduce areas available for fauna and flora. In addition, continuing acidification and eutrophication facilitates the expansion of robust generalist species at the expense of specialist species, which are particularly threatened by changing growing conditions under climate change.

Since the 1992 Rio conference, biodiversity loss has been globally recognised as an important policy priority. Global concern regarding biodiversity loss was re-emphasised at the Rio+10 conference in Johannesburg.

The EU has also made biodiversity a top priority in its 6th EAP and declared a key policy goal in its sustainable development strategy of halting the loss of biodiversity by 2010. Several other European-level policy initiatives support this, including the bird directive (1979) and habitat directive (1992). The habitat directive in particular sets up an ecological network of special protected areas known as the Natura 2000 network. The EU is also committed to a number of international conventions aimed at nature protection, including the Ramsar convention on the conservation of wetlands (1971) and the Bonn convention on migratory species (1979).

***Soil quality and degradation* (16)**

The main problems for soil in the EU are erosion, decline of organic matter, contamination, sealing, compaction, salinisation, loss of biodiversity, landslides and flooding. Soil degradation is bound to continue and be exacerbated by climate change, unsustainable land use and some other human activities.

While the need for soil conservation is internationally recognised, this has not as yet resulted in EU policy specifically targeted towards soil protection (17). Nevertheless, EU legislation addresses soil issues indirectly, including, for example, the directives on nitrates, sewage sludge and integrated pollution prevention and control (IPPC) and the common agricultural policy. From that perspective, existing measures mostly address soil degradation and contamination resulting from agricultural activities or local soil contamination resulting from industrial activities or waste disposal.

## 2.2 What drives changes in Europe's environment?

Environmental change, with regard to the state of the environment and associated impacts, is strongly linked to socio-economic driving forces. Key driving forces include a variety of demographic, economic, technical, societal, cultural and political developments; many of which are directly or indirectly linked to each other. A full review of each of the many drivers of environmental change is not included here; instead, in order to structure them, they are introduced here in clusters of related driving forces (18).

*Demographic drivers* include future developments in population numbers, ageing, migration and spatial distribution of population, mobility of people and immigration.

*Macro-economic drivers* include future developments in gross domestic product (GDP), trade agreements and commodity prices at European and global levels, incomes and price elasticities.

*Sectoral developments* in transport, energy and agriculture are of prime importance in the economic context. Long-term developments at the global level, such as globalisation versus regionalisation of national economies, also have significant impacts on Europe's environment.

*Technology drivers* include future technological progress both on the supply and demand side of European and global economies; this relates specifically to the pace of technology improvements (e.g. in efficiency) and the diffusion and adoption of new technologies (i.e. innovation). The technologies used, for example, in the power generation sector, the food industry, for waste treatment and for collective and individual transport are of prime relevance to the environmental impacts of economic development.

*Social and cultural drivers* include future developments in social values and preferences, consumption patterns, lifestyles, personal mobility, tourism, education and social mobility.

*Policy drivers/responses* include developments in the EU and EEA member countries, in national institutions and policies and in global agreements that either directly address environmental issues (e.g. climate regimes, such as the Kyoto Protocol) or have a large, even if indirect, effect on the state of the environment (e.g. World Trade Organisation negotiations and the issues around agricultural subventions).

Strong inter-linkages and feedbacks exist between the different drivers of environmental change, between sectoral activity and macro-economic driving forces, and across different environmental issues. For example, demographic developments strongly affect the economy and the labour market, which in turn are bound to impact social and cultural values, which themselves feed back into possible future population development.

While the relationships between driving forces and environmental change are sometimes more or less straightforward, the cause-effect relationship is often less direct: human activity and environmental impacts are linked via a complex system. And, in most systems, changes at one end of the system may feed back into changes at another. Changes in different realms of the environment also often have common or similar driving forces. For example, greenhouse gas emissions and summer smog development are both fuelled by transport. The transport sector itself is driven by a combination of demographic, economical, technological, and socio-cultural trends — and at the same time the environmental effects of transport are bound to feed back on sectoral policies. Thus, societal responses and policy approaches to reducing greenhouse gas emissions in the transport sector also indirectly address air pollution.

This understanding of environmental systems makes it important to address environmental change from an integrated perspective to complement spotlights cast on some of the most pressing concerns. Table 2.1 gives an indication of whether and how different clusters of driving forces affect the environmental concerns introduced above.

The table shows again the extent to which demographic development is central to the discussion of how human activity affects the environment. Put simply, a higher population size leads to more resource requirements and more pressure on the environment — unless technological progress or socio-cultural changes trigger more efficient or entirely different kinds of resource use. This becomes particularly evident where environmental impacts are closely coupled to per-capita resource usage, as with water use in households. As household water use per person has stabilised in most western European countries, and has even recently decreased somewhat in some, where and how much water is used in households depends on population size and its distribution (for more detail, see Section 4.3).

Similar relationships also exist elsewhere, for example between demography and waste generation. Here, in addition to the total number of people, the structure of households is of importance: as a rule of thumb, single households tend to be more resource-intensive than larger ones. The trend of a decreasing numbers of persons per household is expected to continue over the next 30 years (from an average 2.7 in 2000 to 2.4 in 2030). Combined with relatively stable total population numbers, this trend contributes, for example, to an expected increase in municipal waste generation (for more detail, see Chapter 3).

The relationship between economic activity and the state of the environment is of similar importance, but less clear-cut. In many cases an increase in economic activity is directly coupled — or at least has been in the past — to the intensity of both resource use and environmental impacts. For example, transport-related greenhouse gas emissions follow overall economic development. Indeed, 'decoupling' environmental pressures from economic growth is a key policy challenge. In other cases, the types and intensities of environmental pressures in an economy change with growing income levels.

Economic developments often affect the environment primarily through sectoral activity (we have therefore highlighted sectoral driving force clusters). The energy sector, for example, is closely linked to air quality and climate change, but also strongly affects water usage (thermal energy production needs water for cooling, and heats up the water). The transport sector is also directly linked to the emission of greenhouse gases, as well as air pollutants (e.g. particulate matter). Furthermore, transport infrastructures strongly affect land use and, as a result of fragmentation, can lead to biodiversity change and loss. And agricultural activity is directly linked to land-use change and biodiversity loss, in addition to the emission of greenhouse gases. Similarly, agriculture exerts pressures on water systems through emissions of nitrates and the use of other chemicals.

**Table 2.1 The strongest links (between key driving forces and environmental issues)**

| | GHG emissions and climate change | Air quality and pollution | Water stress, flooding, droughts | Water quality and pollution | Nature and biodiversity loss | Soil quality and degradation |
|---|---|---|---|---|---|---|
| **Demographic developments** | | | | | | |
| Population | ●●● | ●●● | ●●● | ●●● | ●●● | ●● |
| Households (number, average size) | ●●● | ●●● | ●●● | ●●● | ●● | ● |
| Geographical distribution of population | ● | ●●● | ●●● | ●●● | ●●● | ●●● |
| **Socio-cultural developments** | | | | | | |
| Consumer preferences/individual choices | ●●● | ●● | ●● | ●● | ●● | ●● |
| Societal values/choices (e.g. willingness to pay) | ●●● | ●● | ●● | ●● | ●●● | ●● |
| **Macro-economic developments** | | | | | | |
| Gross domestic product (GDP | ●●● | ●● | ●●● | ●● | ●● | ●● |
| Income distribution | ●● | ●● | ●● | ● | ●● | ● |
| Fossil fuel prices | ●●● | ●●● | ● | ● | ●● | ● |
| Market liberalisation | ●●● | ● | ●● | ● | ●● | ●● |
| **Technological developments** | | | | | | |
| Technologies for production (e.g. energy, transport) | ●●● | ●●● | ●●● | ●●● | ●● | ●● |
| Resource use efficiency (e.g. water, energy, land) | ●●● | ●● | ●●● | ●●● | ●● | ●●● |
| **Sectoral developments** | | | | | | |
| **Energy and transport** | | | | | | |
| Primary energy supply | ●●● | ●●● | ●●● | ●● | ●● | ●● |
| Power generation | ●●● | ●●● | ●● | ● | ●● | ●● |
| Energy use in the transport sector | ●●● | ●●● | ● | ● | ●● | ● |
| Industrial energy use (e.g. steel, construction sector) | ●●● | ●●● | ●● | ●● | ●● | ● |
| Transport infrastructure | ●● | ●●● | ● | ● | ●●● | ●● |
| **Agriculture** | | | | | | |
| Crop and livestock production systems | ●●● | ●● | ●● | ●●● | ●●● | ●●● |
| Manure management and fertiliser use | ●● | ●●● | ● | ●●● | ●●● | ●●● |
| Pesticide use | ● | ● | ● | ●●● | ●●● | ●●● |
| Irrigation | ● | ● | ●●● | ●●● | ●● | ●●● |
| **Forestry** | | | | | | |
| Timber production/forestation | ●● | ● | ●● | ●● | ●●● | ●●● |
| **Households and service sector** | | | | | | |
| Energy use | ●●● | ●●● | ● | ●● | ●● | ● |
| Water use | ● | ● | ●●● | ●●● | ●● | ● |
| Tourism | ●●● | ●● | ●●● | ●● | ●●● | ●● |
| **Waste and material flows** | | | | | | |
| Waste management | ●● | ●● | ● | ●● | ●● | ●●● |
| Wastewater management | ● | ● | ● | ●●● | ●●● | ●● |

| | |
|---|---|
| ●●● | Strong links (direct effects) |
| ●● | Medium links (mostly indirect effects) |
| ● | Weak or no links |

Apart from the many direct and indirect links between driving forces and environmental impacts, changes in the environment also tend to interact with each other (and indeed to some degree also with the driving forces). For example, climate change, while an important issue in itself, also has a range of impacts on other environmental issues: by altering water availability it changes the level of water stress in different regions, by changing ambient conditions it puts biodiversity at risk and changes the marine environment, increasing temperatures may provide hazards to human health, and so on. At the same time, changing air quality may alter the scale of climate change (a well-documented example is the reduction of global warming by airborne sulphur particles). Table 2.2 summarises some of these interactions in an indicative way.

## 2.3 The policy dimension

Societal and policy responses to environmental pressures and impacts play an important role in shaping the future state of the environment, and have often resulted in dedicated environmental legislation. At the same time the determinants of future developments evolve and play out across a range of environmental issues. From this perspective, sectoral policies (e.g. for transport, water, or agriculture) provide an additional and necessary entry point for response options to environmental concerns, particularly since many sectoral developments share common driving forces.

The EU's sixth environment action programme (6th EAP) ([19]), which was adopted on 22 July 2002 and covers a period of ten years, promotes the integration of environmental concerns in all Community policies. In this it reaffirms the need for environmental integration strategies stressed in the 'Cardiff Process' ([20]), which calls for integration strategies for a range of sectors, including agriculture, transport, energy, industry, development, internal market, economic and financial affairs, general affairs and fisheries.

The 6th EAP also sets out key environmental objectives for environmental priorities to be met in four key areas: climate change, nature and biodiversity, environment and health and quality of life, and natural resources and wastes. In addition to establishing, where appropriate, targets and timetables, the 6th EAP provides the basis for the development of seven 'thematic strategies' to tackle priority environmental problems that require a broad approach (see Tables 2.3 and 2.4).

**Table 2.2 Important interactions between different environmental concerns**

| **How/affects** → ↓ | GHG emissions and climate change | Air quality and pollution | Water stress, flooding, droughts | Water quality and pollution | Nature and biodiversity loss | Soil quality and degradation |
|---|---|---|---|---|---|---|
| GHG emissions and climate change | | ●● | ●●● | ●● | ●●● | ●● |
| Air quality and pollution | ●● | | ● | ●●● | ●●● | ●● |
| Water stress, flooding, droughts | ● | ● | | ●●● | ●●● | ●●● |
| Water quality and pollution | ● | ● | ●● | | ●●● | ● |
| Nature and biodiversity loss | ● | ● | ●● | ●● | | ●● |
| Soil quality and degradation | ●● | ● | ●● | ●●● | ●●● | |

●●● Strong feedback
●● Medium or weak feedback
● Minor or no feedback

Similarly, the EU's sustainable development strategy provides a long-term perspective that involves combining a dynamic economy with social cohesion and high environmental standards. It specifically recognises that, in the long-term, economic growth, social cohesion and environmental protection need to go hand in hand. On the environmental side, the sustainable development strategy sets objectives to limit climate change and increase the use of clean energy, address threats to public health, manage natural resources more responsibly, and improve the transport system and land-use management. It also stresses the importance for the achievement of sustainable development of combating poverty and social exclusion and dealing with the economic and social implications of an ageing society.

Within the wider frame of the sustainable development strategy, the Lisbon agenda (21) sets a ten-year objective for the EU 'to become the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion'. With the Lisbon agenda, particular attention is given to preparing the transition to a knowledge-based economy and society — by better policies for the information society and research & development, stepping up the process of structural reform for competitiveness and innovation, and completing the internal market (22). Modernising the European social model and sustaining a healthy economy by applying an appropriate macro-economic policy mix are also central to the agenda.

The EU's Lisbon agenda, sustainable development strategy and environment action programmes complement other legally-binding directives that directly or indirectly affect the state of the environment in Europe. Examples of directives that address environmental concerns include the water framework directive (23), the nitrates directive (24), the habitats directive and the birds directive (25), the urban waster water directive (26), the air quality framework directive and the national emission ceiling directive (27) and a large number of directives aimed at reducing emissions of air pollutants from mobile and stationary sources.

While the above examples highlight the range of existing policies that address the state of the environment in Europe, an even stronger shift in policy-making from primarily issue-oriented policies to more integrated and consistent approaches may be warranted to better address the common drivers and many inter-linkages outlined here.

**Table 2.3 Thematic strategies defined in the sixth environment action programme**

| Action area | Thematic strategies defined in the 6th EAP |
|---|---|
| **Action on nature and biodiversity** | Thematic strategy on **soil protection** (Art. 6.2 (c)) (28)<br>Thematic strategy for the **protection and conservation of the marine environment** (Art. 6.2 (g)) (29) |
| **Action on environment and health and quality of life** | Thematic strategy on the **sustainable use of pesticides** (Art. 7 (c)) (30)<br>Thematic strategy to strengthen a coherent and integrated policy on **air pollution** (Art. 7 (f)) (31)<br>Thematic strategy […] improving the quality of **urban environment** (Art. 7 (h)) (32) |
| **Action on sustainable use and management of natural resources and wastes** | Thematic strategy on the **sustainable use and management of resources** (Art. 8.2 (i)) (33)<br>Thematic strategy on **waste recycling** (Art. 8.2 (iii)) (34) |

**Table 2.4 Sixth environment action programme objectives addressed in this outlook**

| Action area | Selected 6th EAP objectives |
|---|---|
| **Action on tackling climate change** | Kyoto Protocol commitment to an 8 % reduction in GHG emissions by 2008–2012 compared with 1990 levels for the EU as a whole (Art. 5.1) (35)<br>Long-term objective of a maximum global temperature increase of 2 °C over pre-industrial levels (Art. 2)<br>Use of renewable energy sources [… ] meeting the indicative target of 12 % of total energy use by 2010 (Art. 5.2 (ii (c))) (36)<br>Doubling the overall share of Combined Heat and Power to 18 % of total gross electricity production (Art. 5.2 (ii (d)))<br>In the transport sector promote the development and use of alternative fuels (Art. 5.2 (iii (f))) (37)<br>Decoupling economic growth and the demand for transport (Art. 5.2 (iii (h)) (38) |
| **Action on nature and biodiversity** | Halting biodiversity decline with the aim of reaching this objective by 2010 (Art. 6.1)<br>Protection and appropriate restoration of nature and biodiversity from damaging pollution (Art. 6.1)<br>Encouraging more environmentally-responsible farming, such as extensive, integrated, and organic farming (Art. 6.2 (f)) |
| **Action on environment and health and quality of life** | Ensure that the rates of extraction from water resources are sustainable over the long term (Art. 7.1) (39)<br>Achieve levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment (Art. 7.1) (40)<br>Sustainable use and high quality of water, ensuring a high level of protection of surface and groundwater, preventing pollution (Art. 7.2 (e)) (41) (42) |
| **Action on sustainable use and management of natural resources and wastes** | Indicative target to achieve 22 % of electricity production from renewable energies by 2010 (Art. 8.1) (43)<br>Significant overall reduction in the volumes of waste generated (Art. 8.1) (44)<br>Establish goals and targets for resource efficiency and the diminished use of resources (Art. 8.2 (i (c))) |

# 3. Societal drivers and pressures — a European baseline scenario

In order to provide an outlook of changes in Europe's environment, due attention has first to be paid to the drivers of change and how they may unfold in the future. Indeed, this focus is central, since the driving forces of environmental change are directly linked to technical, social and economic developments as well as to policy frameworks at the national and European levels, and are thus common to a range of environmental issues that the EU faces. In this sense, this chapter paves the way to an integrated view of the outlooks reported in Chapter 4.

While this chapter addresses some of the main driving forces of change in Europe's environment individually, it also pays particular attention to the inter-linkages across sectors and themes to a range of common drivers. Finally, from a methodological perspective, the assumptions made for driving forces determine the key variables in the models used for the outlooks and therefore govern their dynamics and end results (45).

## 3.1 The socio-economic context

The socio-economic context assumed for the baseline scenario is characterised by sustained moderate economic growth with a further predominance of the service sector, and by a European population which is stabilising and ageing. Technological progress is moderate but essential in key areas such as energy, agriculture and water, but there are no technological breakthroughs. The political sphere shows no marked shifts in terms of sectoral or environmental policies that target European production and consumption patterns. Social and cultural values and preferences adjust to reflect the ageing population and the service-oriented society that further develops, in particular in terms of education and social mobility.

Overall, the baseline scenario depicts developments that reflect current expectations in demographic, economic and technological terms, taking into account all implemented and adopted policies and measures only. In this framework, the targets set in directives and regulations are not assumed to be reached a priori. At the global level, trade agreements underpin economic growth, productivity gains (for physical and labour capital) and competitiveness, while environmental issues receive limited attention.

Given this socio-economic context, we focus in this report on driving forces of particular relevance to changes in some prominent environmental concerns, namely climate change, air pollution, water stress and quality, and waste and material flows. This implies paying special attention to developing common assumptions for the drivers that are central to changes in key economic sectors, e.g. energy, transport, agriculture and manufacturing.

As mentioned above, the EEA's outlooks across the various sectors and themes use a common reference set of assumptions for the key driving forces to ensure consistency across the board and facilitate cross-cutting analysis. This reference set builds mainly on the socio-economic assumptions developed though extensive stakeholder consultation for the DG TREN baseline projections 'European energy and transport trends to 2030' (46).

Within this framework, assumptions have been developed as a consistent set and cover the following key driving forces:

- population
- macro and meso-economic (i.e. sectoral) activity
- household expenditure
- number of households
- average household size
- energy flows.

These common assumptions for the driving forces constitute a reference set for all EEA outlooks. Consequently, being at the source of the assumption cascade, they play a crucial role in how we expect the future to develop, by adding both directly to environmental concerns and indirectly through sectoral environmental impacts. For example, assumptions on population, income and households directly affect water use and water stress and also govern the development of the energy and agricultural sectors, which then also affect water use and stress (through the number of thermal power plants or the amount of irrigation-intensive cropping). The inter-linkages between sectoral and thematic EEA outlooks are further discussed and presented in detail in Chapters 2 and 4 (47).

The same assumptions are used within the CAFE (Clean Air for Europe, DG ENV) programme (48), and this therefore ensures the consistency of the EEA outlooks, in terms of key driving forces and environmental results, with recent European Commission projections.

The next sections give an overview of the EEA reference set of assumptions and depict how, following these assumptions, the key driving forces and environmental pressures may unfold (49). Box 3.4 also introduces the 'low GHG emissions scenario' which is the main alternative to the baseline scenario, whose environmental assessments will be reported in Chapter 4.

## 3.2 Demography

***The European population is expected to stabilise, but gradually to become an ageing society.***

Population is a key to every socio-economic activity in Europe, and its impacts on the environment are therefore far-reaching, ranging from climate change, air pollution, water stress to soil degradation and biodiversity loss.

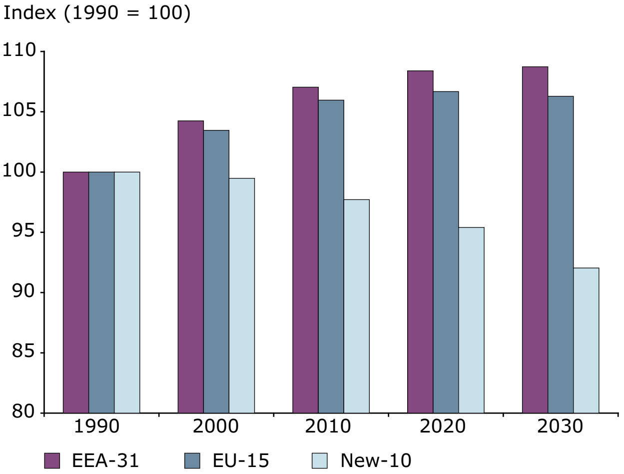
In 2004, the EU's population totalled more than 455 million (with 381 million in the EU-15 and 74 million in the New-10). While this is the highest recorded to date, the rate of growth has declined significantly over recent decades, from 0.88 % per year in the EU-25 in the 1960s to less than 0.3 % per year since the 1980s, and is continuing to decline (50). Migration has now become the largest contributor to population growth in the EU. In the New-10 however, population has been falling since the second half of the 1990s, due mainly to natural decrease.

**Table 3.1 Demography — population development 1990–2030**

| | Population (millions) | | | |
|---|---|---|---|---|
| | **EEA-31** | **EU-25** | **EU-15** | **New-10** |
| 1990 | 540 | 441 | 366 | 75 |
| 2000 | 563 | 453 | 379 | 75 |
| 2010 | 578 | 461 | 388 | 73 |
| 2020 | 586 | 462 | 390 | 72 |
| 2030 | 587 | 458 | 389 | 69 |
| | **Average annual growth rates (%)** | | | |
| 1990–2000 | 0.4 | 0.3 | 0.3 | − 0.1 |
| 1990–2030 | 0.2 | 0.1 | 0.2 | − 0.2 |

**Note**: Figures for the 1990–2000 period are observed data.

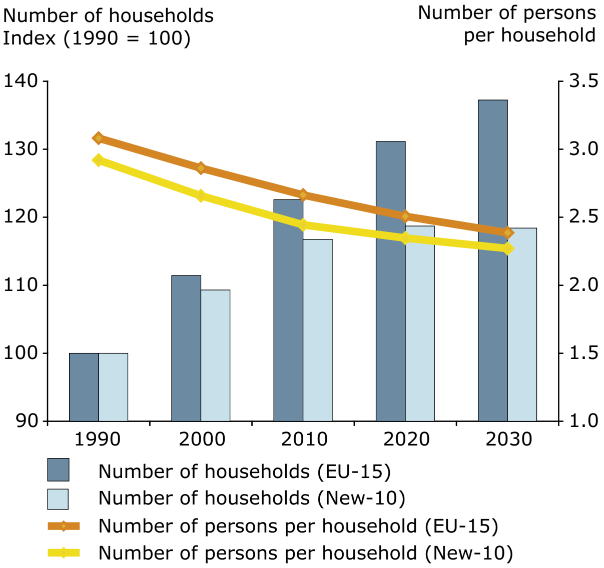
**Figure 3.1 Demography — population development 1990–2030**



**Note**: Figures for the 1990–2000 period are observed data.

The population of the EU-25 is expected to stay fairly constant until 2030, increasing by less than 1 % over today's level (see Figure 3.1 and Table 3.1). The slight increase in population in the EU-15 (1.5 % over today) contrasts sharply with the

**Figure 3.2 Households — population development 1990–2030**



situation in the New-10, where a dramatic decrease of 7 % is projected. It should be noted that Poland is a key driver of change in the New-10 demography as it now makes up about 50 % of the population and is expected to continue to do so. The total population of the 31 EEA member countries is expected to increase by 3 % since the continuing very fast population growth in Turkey (27 % over today's level by 2030) is only partially offset by the overall population decline in the other EU candidate countries (Bulgaria and Romania, a decline of 13 % in total).

Looking two to three generations into the future, global population is projected to grow from 6.3 billion in 2003 to about 9 billion in 2050, then potentially levelling off (51). For the EU, a sharp decrease in total population is expected between 2030 and 2050, with a net reduction of 27 million people.

The age distribution in the EU is a growing concern, particularly in connection with pension and health expenditure and working life-time. While the accession of the 10 new Member States in 2004 has somewhat rejuvenated the EU population, it failed to reverse the trend of increasing old age dependency from 30 % in the 1960s to 39 % today in the EU-25 (52).

This trend is expected to continue over the 2000–2030 period, with the share of people of 65 years and older in the total population increasing from 15 % to 25 % in the EU-15, and from 10 % to 22 % in the New-10. The ageing European society might conflict with the objectives of the Lisbon agenda, which aims at making the EU 'the world's most competitive and dynamic knowledge-driven economy by 2010'. Under this strategy, a stronger economy should drive job creation alongside social and environmental policies that ensure sustainable development and social inclusion.

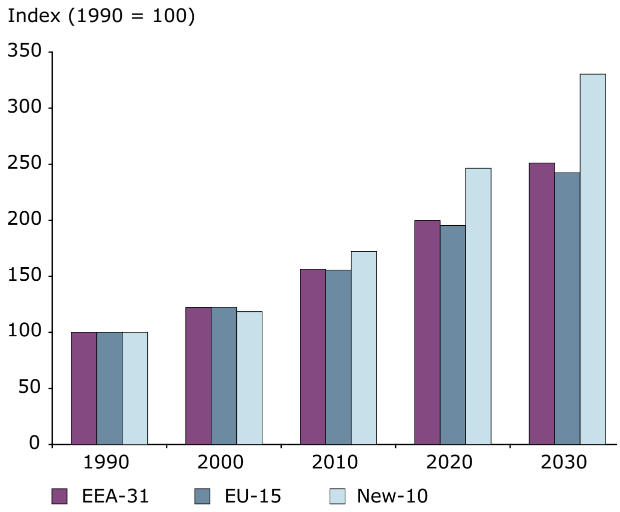
In the recent past, the average size of households has decreased, leaving the number of households in the EU growing much faster than the population (see EEA, 1999). This trend is expected to continue, both in the EU-15 and New-10, reducing the average household size to below 2.5 by 2030. Despite the expected stability of the EU population between 2000 and 2030, this leads to a marked increase in the number of households, which in turn is bound to increase average per-capita consumption and increase pressure on the environment (see Figure 3.2).

## 3.3 Macro-economy

***The macro-economic assumptions for Europe are moderately optimistic, and entail challenging trade-offs in light of achieving sustainable economic development.***

As a prime determinant of any socio-economic activity, macro-economic prospects impact the environment in many ways, with major contributions to climate change and water stress in particular.

**Figure 3.3 Income — gross domestic product (GDP) growth 1990–2030**



Between 2000 and 2030, average annual economic growth in the EU is expected to be 2.4 % (53) (see Table 3.2 and Figure 3.3) and gross domestic product (GDP) per capita almost to double in the EU-15 and triple in the New-10 (54). Although average annual growth rate in the New-10 is expected to be 3.5 %, their economic weight in Europe is expected to continue to be limited as their share of EU GDP increases only slightly, from 4.4 % in 2000 to 6 % in 2030. In the light of the economic growth experienced during the 1990s and the most recent economic developments, these macro-economic assumptions are considered as moderately optimistic.

## 3.4 Technological developments

***Technological progress is moderate but essential in key areas such as energy, agriculture and water, but no technological breakthroughs are assumed.***

This section reports the main technological assumptions at the sectoral level, which directly affect most of Europe's environmental concerns (55).

Technological learning effects generally results in a decreasing capital costs of technologies over time as increasing experience and knowledge are gained through their design (R and D), production (installed capacity) and use (generation). Typically, this affects new technologies to a much larger extent than mature ones for which opportunities for improvement fade away.

In the baseline scenario, technological learning rates have been assumed over the 2000–2030 period, in particular for the following power generation technologies: CHP (combined heat and power), CCGTs (combined cycle gas turbines), (coal-fired) supercritical power plants, PFBCs (pressurized fluidized bed combustion) and fuel cells. With regard to renewable energy sources, a decrease in capital costs, leading to enhanced competitiveness and further potential penetration, is accompanied by a decrease in subsidies over time. The following technologies are affected by 'net' learning effects in the baseline scenario: onshore wind, run of river (i.e. hydroelectricity), offshore wind and solar photovoltaic.

The baseline scenario assumes significant increases in crop yields in the European agriculture sector, in particular in the New-10 (see details below in the section on Agriculture). The main improvement in animal productivity has been assumed for milk yield, which increases in the EU by more than 25 % in 2020 over 2001 levels, i.e. to 7 200 kg on average per dairy cow annually. Slaughter or off-take weights are assumed to remain fairly constant over the period for cattle, pig, and poultry as well as yields for laying hens. In general, yield increases and technical improvements in agriculture have led to intensive land-use, which is harming the environment. The effect of significant improvements in production systems and applications efficiency has been assessed in the 'best practice' scenario, which is reported in Box 3.2.

A key factor in the efficiency of water use is the type of cooling systems in the electricity sector (once-through or tower cooling); power generating technologies based on once-through cooling withdraw 180 m$^3$/MWh compared with only 4.5 m$^3$/MWh for tower cooling. In the baseline scenario, it is assumed that any new power plant entering the market is based on tower cooling: this results in dramatic reductions in water withdrawals when they replace decommissioned plants based mainly on once-through cooling systems. If, in addition, an increase in electricity demand is met by building new plants, this will only marginally affect water withdrawal compared with what it used to be with once-through cooling systems. However, once-through cooling systems return virtually all the water inflow (only 0.5 % is evaporated) while tower-cooling systems only return about 70 % (30 % is evaporated). The implication of such a technological shift is that reducing water abstraction does not necessarily reduce water consumption; it will lead to additional water stress only at specific locations, particularly in connection with climate change impacts. In addition, from an environmental point of view, more tower-cooling systems would reduce the possible impacts of return flows on water quality, while more once-through cooling systems would reduce the possible impacts of evaporation on the micro-climate.

With regard to transport, no technological breakthroughs in infrastructure or mobility modes are assumed in the baseline scenario, i.e. no major technological alternatives to current liquid fuel-based vehicles, such as biofuels, electric/hybrid, hydrogen/fuel-cells or natural gas vehicles, penetrate the market significantly ([56]).

## 3.5 Sectoral developments

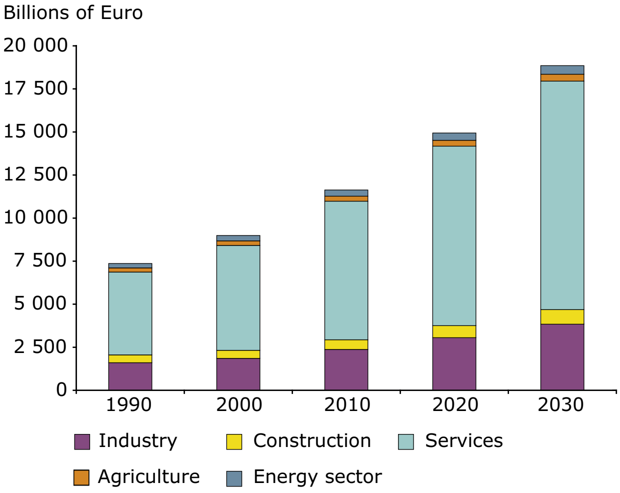
***The service sector is expected to retain its predominance in the European economy and be instrumental in sustaining economic growth.***

Economic growth in the EEA member countries is expected to be mainly in the service and industry

**Table 3.2 Income — GDP growth 2000–2030**

| | GDP per capita (1 000 Euro, year 2000) | | | | Average annual growth rates (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | EEA-31 | EU-25 | EU-15 | New-10 | | EEA-31 | EU-25 | EU-15 | New-10 |
| **2000** | 17.1 | 19.7 | 22.6 | 5.3 | **2000–2010** | 2.5 | 2.5 | 2.4 | 3.8 |
| **2010** | 21.3 | 24.8 | 28.0 | 7.8 | **2010–2020** | 2.5 | 2.4 | 2.3 | 3.6 |
| **2020** | 26.9 | 31.3 | 34.9 | 11.5 | **2020–2030** | 2.3 | 2.2 | 2.2 | 3.0 |
| **2030** | 33.7 | 39.3 | 43.5 | 15.9 | **2000–2030** | 2.4 | 2.4 | 2.3 | 3.5 |

**Figure 3.4 Gross value added by sectors 1990–2030**



sectors (See Figure 3.4). The service sector, with a current share of total gross value added (GVA) of about 70 %, is expected to grow at an average annual rate of 2.7 % and still to be the predominant sector in the European economy in 2020. The 'market services' and 'trade' branches are expected to be the most dynamic. Within industry, which has a fairly stable share of 20 % of total GVA from 2000 to 2020 and an average annual growth of 2.5 %, the 'pharmaceutical and cosmetics', 'engineering' and 'non-ferrous metals' branches are expected to be the most dynamic. In contrast, the construction, agriculture and energy sectors are expected to decrease their share of total GVA by 2020, representing respectively 4.7 % (10 % below the 2000 level), 2.3 % (21 % below) and 2.8 % (18 % below) of the total.

At the EU-15 and New-10 levels, more varied developments are projected. For example, the agriculture sector is expected to decrease its share of total GVA from 2.5 % in 2000 to 1.9 % in 2020 in the EU-15 (a reduction of 24 %), and from 5.7 % in 2000 to 3.6 % in 2020 in the New-10 (a reduction of 38 %). In the New-10, the service sector is expected to represent 62 % of total GVA in 2020 (9 % above the 2000 level) while the energy sector would represent only 2.9 % in 2020 (45 % below the 2000 level).

The income that each working person would have to generate in the future can be considered as a synthetic indicator and is a convenient way of looking at the combined implications of economic and population growth assumptions (see Figure 3.5). This indicator shows that the economic and population growth assumptions, which are considered reasonable when looked at separately, have challenging and far-reaching implications when looked at together: by 2030, each working person in the EU-15 would need to generate twice as much average income as in 2000; in the New-10 the average income to be generated would increase by a factor of three. This increasing requirement would have implications for the future development of labour participation rates and retirement ages.

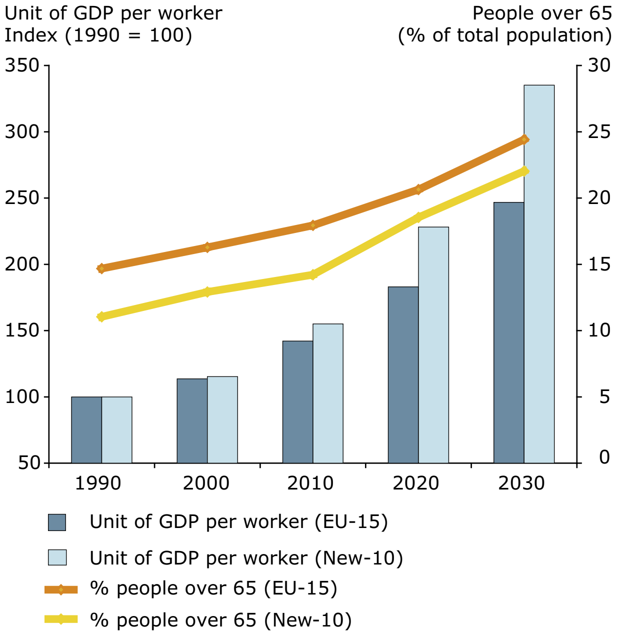
## 3.6 Consumption patterns

***The environmental pressures of consumption are generally lower than those of production, but are expected, as in the recent past, to grow significantly. This gradual shift of the environmental burden is of particular concern for the consumption of food and housing, and personal travel and tourism (57).***

***Settlement patterns have considerable impacts at specific locations on water resources, land use and natural capital, particularly in connection with shifts in lifestyles and societal preferences.***

Consumption patterns have many impacts on socio-economic activities and Europe's environment. The EEA has published a report on these issues entitled 'Household consumption and the environment' as an input to the 2005 State of the environment and outlook. It includes a review of past developments of consumption patterns and a horizon-scanning

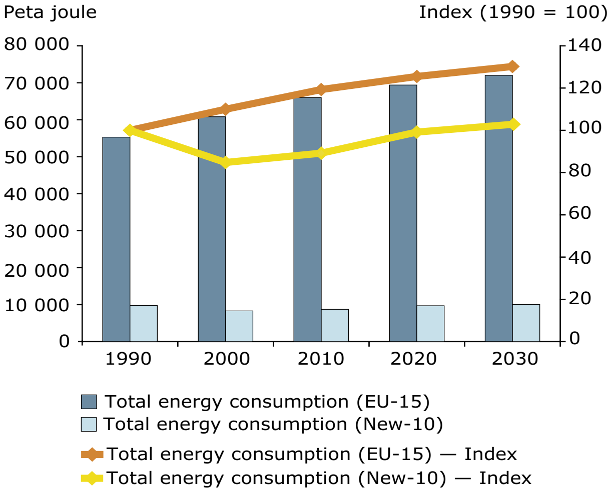
**Figure 3.5 Age — share of people over 65 in total population and requirement for income generation per working person**



exercise. The reader is referred to that report for further details.

Settlement patterns prove to be extremely important at specific locations, e.g. the Mediterranean and Atlantic coasts, where their impacts on water stress and biodiversity are particularly striking. These developments are linked to lifestyle patterns that result from demographic and economic developments. For example, an ageing population implies more people having a second home for holidays or moving permanently to mountain or coastal resorts, which are particularly vulnerable to environmental pressures. The south of the EU is such an example where water resources and land use are clearly impacted by shifts in lifestyles and societal values. Another example is people moving away from urban sprawls to improve their quality of life, with knock-on effects on land use and natural capital in the countryside.

**Figure 3.6 Total energy consumption 1990–2030**



## 3.7 Energy and transport

***Despite continuing increases, total energy consumption is expected to decouple significantly in relative terms from GDP over the coming decades, consolidating past improvements in energy intensity.***

***The indicative policy targets for renewable energy sources and combined heat and power are not expected to be met by the EU-25 as a whole.***

***Passenger and freight transport demands are expected to decouple relatively from economic growth over the next 30 years, in line with the policy target.***

***However, without technological breakthroughs, the transport sector is expected to continue to grow significantly in terms of energy requirements, and to crystallise environmental concerns due to ever-increasing $CO_2$ emissions to the air.***

The energy and transport sectors are prime contributors to environmental concerns such as climate change, air pollution and water stress. The projected development of energy supply and demand in these sectors is given below.

Under the baseline assumptions, a continuing increase in energy demand in Europe over the 2030 horizon is expected (see Figure 3.6 and Figure 3.7).

Total energy consumption in the EEA member countries is expected to increase by 20 % over today's level, with very similar annual growth rates in the EU-15 and the New-10 (about 0.6 % per year on average). Of particular interest is the dramatic relative decoupling expected to take place in the New-10 (see Box 3.1 for a definition of the concept of 'decoupling'). However, the New-10 represents only 12 % of EU energy consumption, so the final contribution is limited. Overall, a doubling of EU GDP between 2000 and 2030 is expected to be accompanied by a 19 % increase in energy requirements, which represents an important improvement in terms of energy intensity. This is due mainly to short-term gains on the demand side and to the penetration of efficient technologies in the power generation sector (see above the section on technological developments).

With regard to final energy demand, all sectors over the 2030 horizon are expected to decouple relatively from GDP. Significant energy intensity improvements are expected to occur in the New-10, particularly in industry where economic recovery may provide opportunities for efficiency gains and new technologies. The expected improvements are also explained by the increasing share of the services sector in the economy at the expense of traditional industries which are often energy-intensive (e.g. iron and steel, pulp and paper, textiles), and the energy sector itself. But further development of the service sector in the EU continues to be a key driver of final energy demand.

In the transport sector, EU final energy demand is expected to continue to increase, by about 35 % between 2000 and 2030, due to rapidly increasing passenger transport activity (53 % more in terms of km per capita), whereas freight transport per unit of GDP is expected to decrease slightly over the period (by 6.5 %). In the New-10, a total increase of 80 % from the 2000 level is expected, with the transport share of final energy demand increasing from 19 % in 2000 to 25 % in 2030. However, this means that passenger and freight transport demand are both expected to decouple relatively from economic growth over the next 30 years, in line with the policy target. From an environmental perspective, however, this means that without technological breakthroughs (in infrastructure or mobility modes) the transport sector is expected to continue to grow significantly in terms of related air emissions. Household final energy consumption is expected to increase by 20 % and 40 % in the EU-15 and the New-10 respectively. Overall, gas and electricity are expected to enhance their dominance as energy carriers in EU final energy demand (from about 20 % each in 2000 to 24 % each in 2030).

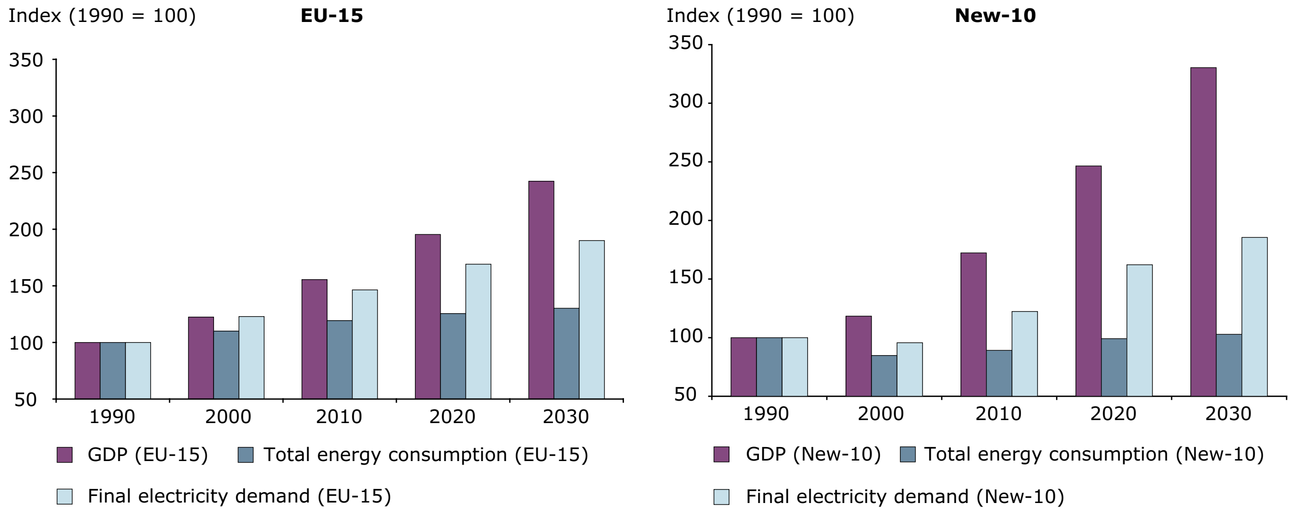
Final electricity demand (Figure 3.7) is also expected to decouple relatively from GDP, particularly in the New-10. However, reliance on electricity as the main energy carrier, particularly for services and the domestic sector, is expected to continue to grow at an average rate of 1.7 % per year between 2000 and 2030; electricity demand is therefore expected to increase by 50 % over this period.

With regard to power generation technologies, the most significant development expected in the next 30 years in the baseline scenario is further penetration of gas-fuelled technologies at the expense mainly of open-cycle units and nuclear plants (58): the shares of CCGTs (combined cycle gas turbines) and CHP (combined heat and power) in electricity production are expected to increase from 8.5 % and 12.5 % in 2000, to 35 % and 16.5 % in 2030 respectively, while the shares of open-cycle units and nuclear plants are expected to drop from 46 % and 32 % in 2000 to 13.5 % and 17.5 % by 2030 respectively. From 2015 onwards, he penetration of CCGTs is accompanied by rapid growth in (coal-fired) supercritical polyvalent units (16 % of electricity production in 2030) and wind technologies, which are expected to provide 7 % of EU electricity by 2030 and represent 12 % of generation capacity (59)(60).

The use of renewable energy sources is expected to increase over the 2000–2030 period. However, the indicative policy targets (as adopted before the enlargement of the EU) for renewable energy sources and combined heat and power (CHP) are not expected to be met by the EU-25 as a whole: by 2010, renewable energy sources are expected to provide only 7.5 % of total energy use or gross inland consumption (the indicative target is 12 %) and only 15 % of electricity production (the indicative target is 22 %). CHP is expected to provide 16.5 % of total gross electricity production by 2030 (the target is to double the overall share to 18 %, with no specific deadlines).

With regard to the modal split of transport, no major technological substitution is expected over the 2000–2030 horizon. The main development in passenger transport is in air travel, whose share of the total is expected to increase from 5.5 % to 10.5 %, while decreasing shares are expected for public road transport (from 9 % to 6.5 %) and to a limited extent private cars and motorcycles (from 78 % to 76 %). For freight transport, trucks are

**Figure 3.7 Total energy consumption, final electricity demand and GDP growth 1990–2030**

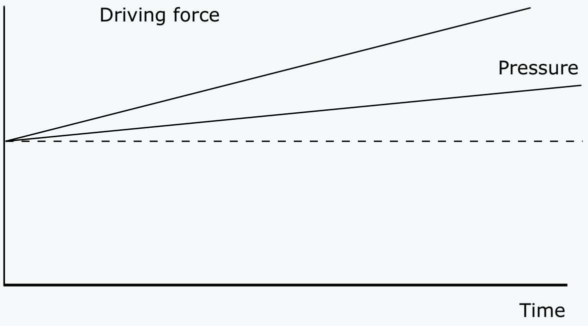


**Box 3.1 Defining the concept of 'decoupling'**

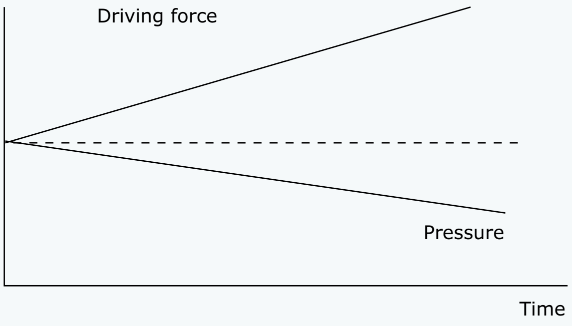
'Decoupling indicators describe the relationship between the first two components of the DPSIR framework, i.e. a change in environmental pressure as compared to a change in driving forces over the same time' (OECD, 2003).

Decoupling occurs if the growth rate of an environmental pressure (e.g. greenhouse gas emissions or waste amounts) is less than the growth rate of a given economic driving force (e.g. GDP) over a certain period of time. Relative decoupling occurs when an environmental pressure continues to grow, although at a slower rate than the underlying economic driver. Absolute decoupling is when an environmental pressure is decreasing in a period of economic growth.

**Relative decoupling**



**Absolute decoupling**



expected to further enhance their predominance (from 69 % to 77.5 % over the 2000–2030 period) at the expense of rail (from 17 % to 11 %) and inland navigation (from 14 % to 11.5 %) (61).

Biofuels (i.e. methanol and ethanol, including mixed with gasoline and diesel oil) are expected to represent about 1 %, 2 % and 4.5 % of transport final energy demand respectively by 2005, 2010 and 2030; the indicative targets (Biofuels Directive 2003/30/EC) of 2 % by 2005 and 5.75 % by 2010 for biofuels and other renewable fuels, calculated on the basis of energy content, of all petrol and diesel for transport purposes are therefore not expected to be met.

The use of domestic energy resources is expected to decrease further, leading to a surge in EU import dependency from 47 % in 2000 to 67 % by 2030, with net imports of natural gas and solids (e.g. hard coal and lignite) being expected to more than double. This development highlights the long-term trade-offs involved if Europe is to achieve energy independence, security of supply and limited environmental impacts associated with energy extraction.

Since the 1980s, the average gains in total energy intensity (62) in the EU-25 have been estimated at around 2 % per year (1.7 % per year between 1990 and 2000). This reflects to a large extent the shift within industry from energy-intensive to less energy-consuming activities, the sustained growth of the service sector and the improvements in technological efficiencies.

In the baseline scenario, energy intensity improves by 1.8 % per year (see also Table 4.1.2 below). On the supply side, the energy intensity improvements come mainly from the further penetration of CCGTs (combined cycle gas turbines) and CHP (combined heat and power) in the electricity production sector, i.e. from 8.5 % and 12.5 % in 2000 to 35 % and 16.5 % in 2030 respectively (63); the efficiency of thermal electricity and steam production (64) therefore increases from 49 % in 2000 to an expected value of 61 % in 2030. Final energy intensity per sector (65) is expected to decrease by 49 % in industry (1.7 % per year), 48 % in households (1.6 % per year), 42 % in services (1.3 % per year) and 33 % in transport (1 % per year), all compared with 1990 levels, by 2030. In the transport sector, improvements in energy intensity for passengers and freight (in terms of toe per km) are 27 % and 6 % respectively over the 2000–2030 period.

Finally, a continuation of the high prices and volatility of oil in the medium and long term (IPE Brent Crude lowest and highest oil prices in 2004 were USD 29 and USD 52/barrel) could significantly affect the development of the energy system over the coming decades. Futures and forward markets for energy commodities reflect developments that significantly affect the physical balance between supply and demand at the global level. In the case of oil, strong economic growth in China and India (see also the global steel market), geopolitical uncertainty in the Middle East and the fear of supply shortage in Russia and Venezuela are the main governing factors.

## 3.8 Agriculture

***Harvested land is expected to continue to be used mainly for fodder and the production of cereals (80 % of the total area). Yields increase is expected to be the main source of production growth in Europe over the next 20 years.***

***The shift in demand from beef to poultry is expected to continue.***

***Nutrient surpluses are expected to be moderately reduced in 2020.***

***Mineral fertiliser use is expected to increase considerably in the new Member States, but remains lower than in the EU-15 in absolute terms; this may lead to increases in associated environmental pressures.***

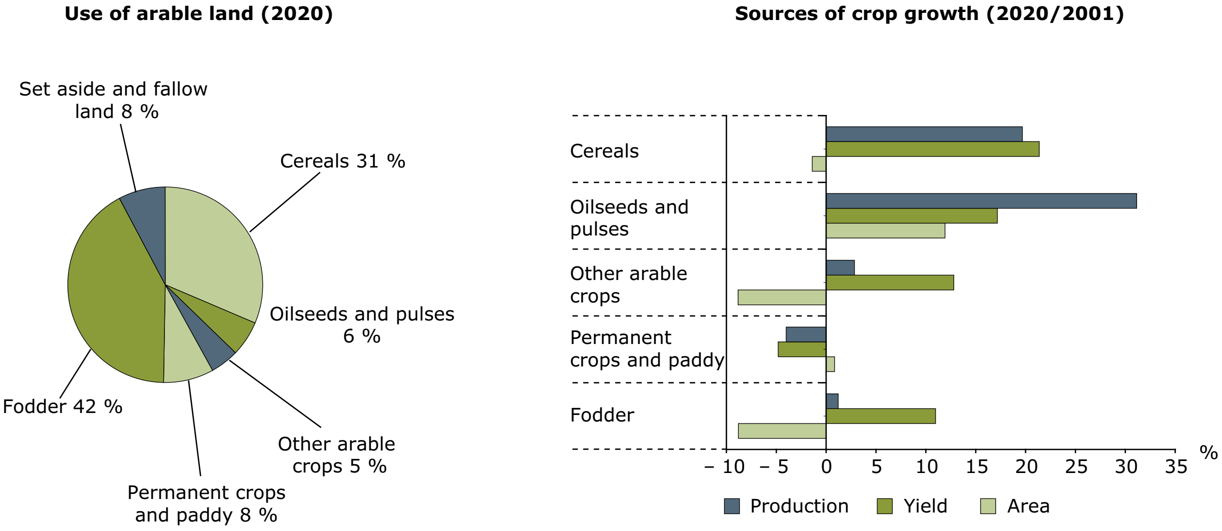
***Best practices for fertiliser handling could significantly reduce the environmental pressures.***

In view of the environmental impacts of fertiliser use, manure management and animal emissions on water and soil quality, biodiversity and climate change, particular attention is given to the agriculture variables in terms of cropping and livestock patterns over the 2020 horizon. The projections reported cover 23 EU Member States (i.e. the EU-15 and 8 new Member States, referred to as New-8; Cyprus and Malta are not included due to limited data) (66).

First, we consider the expected use of arable land (see Figure 3.8) (67). After an increase (5 %) in the EU-15 in the second half of the 1990s, the total area of cereals in the (enlarged) EU is expected to stay fairly stable over the period to reach 52 million ha by 2020, about 31 % of total arable land. The slight decrease in cereal area over the 2020 horizon mainly reflects the introduction of decoupling of payments associated with the mid-term review of the common agriculture policy (CAP) and the overall reduction in the level of support. Wheat production (soft and durum wheat), which is the main cereal in the EU, is expected to retain its predominance with about 23 million ha in 2020. Barley would see its area decrease slightly over the period.

Fodder areas, which represent the largest share of agricultural land by 2020 (42 %), are expected to experience a significant decrease over the period (about 9 %); this is due mainly to a reduction in fodder demand for ruminants, as both supply of beef meat and cow herds are expected to drop in the long term. Set-aside and fallow land

**Figure 3.8 Agriculture — arable land**



is expected to represent 13 million ha by 2020 (8 % of total agricultural land), increasing by about 13 % over 2001 levels; this is driven by the doubling expected in the New-8, where fallow land increases considerably (and cancels out the developments in the EU-15) and obligatory set-aside progresses as the *Grandes Cultures* areas shift in the long term from small farms, which are exempt from set-aside, to larger ones ([68]). The areas of permanent crops and paddy are expected to remain fairly stable, at about 8 % of agricultural land by 2020. In contrast, the areas of oilseeds ([69]) and pulses are expected to increase by about 12 % by 2020 to represent 6 % of arable land.

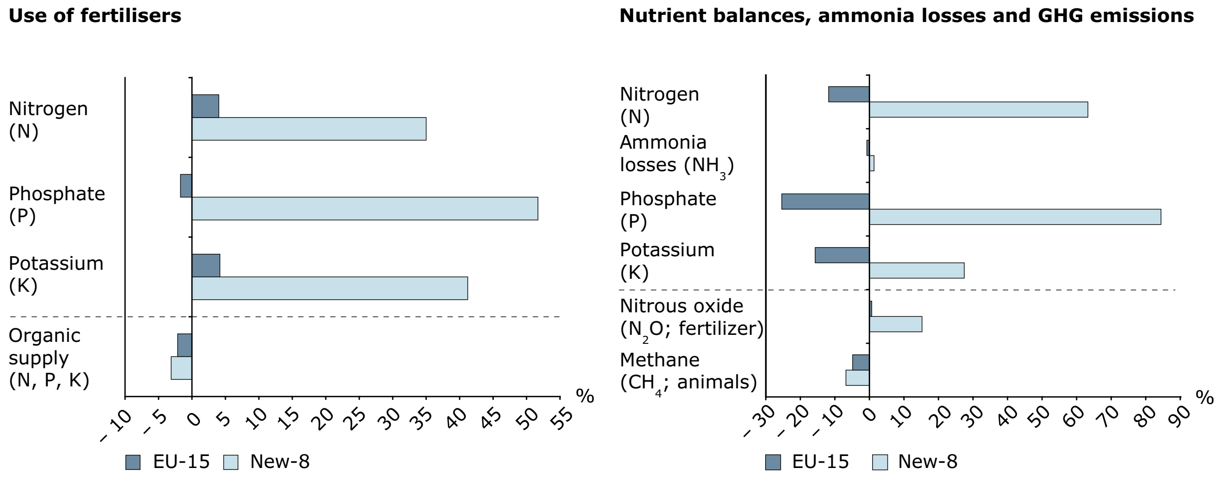
In sharp contrast to the relative stability of the area of arable and harvested land, yields are expected generally to increase significantly over the period and lead to an overall increase in production levels. This is certainly the case for cereals where an expected 21 % increase in yields offsets the effect of decreasing areas and leads to an expected 20 % increase inproduction. Similar patterns are expected for fodder and other arable crops where production levels in 2020 resemble those in 2001 as a result of yield increases. Oilseeds and pulses show the largest production increase (31 %) due to a yield increase of 17 %. Finally, the only activity where a decrease in production is expected is in permanent crops and paddy (by 4 %), since yields are expected to decrease.

However, the projected yield patterns vary considerably between the EU-15 and the New-8. For most of the activities reported above, the New-8 exhibit yield increases that are at least 50 % higher than in the EU-15 (cereals: 29 % compared with 18 %; other arable crops: 26 % compared with 8 %; fodder: 16 % compared with 10 %). This is of prime importance as this dramatically affects the use of fertilisers and therefore the environmental pressures. Oilseeds and pulses is the only activity where the yield increase in the New-8 is lower than that in the EU-15 (4 % compared with 20 %). Nevertheless, in absolute terms, yields in the EU-15 are far higher than in the New-8 (cereals and other arable crops 40 % higher, oilseeds and pulses 60 %, permanent crops and paddy 470 % and fodder 30 %).

In the meat sector, an increase of 20 % in poultry demand (to 12.2 millions tonnes by 2020) is expected, mainly at the expense of beef (down 6 % to 6.5 millions tonnes). This is reflected by herd sizes, which are expected to grow for poultry by 21 % to 6.6 millions heads by 2020, while fattened beef cattle and dairy cows decrease by 10 % and 20 % respectively (to 23 and 20 millions heads). After prominent increases in pork meat production in the 1970s and 1980s and a levelling-off in the past decade, demand is expected to increase only slightly to 20.2 millions t in 2020, still representing about 50 % of the EU market. Sheep and goat meat is expected to remain marginal in the meat sector (1.3 millions tonnes in 2020). The relative shares of the EU-15 and New-8 in the EU meat market in 2020 are expected to stay fairly stable, around 87 % and 13 % respectively.

These expected developments reflect ongoing changes in diets (i.e. domestic demands), resulting particularly in an increased demand for poultry, pork, vegetables and fish, at the expense of beef, potatoes and cereals. In addition, the consumption of pre-prepared and organic food is growing rapidly ([71]).

**Figure 3.9 Agriculture — environmental pressures (2020/2001)**



## Box 3.2 Agriculture projections — uncertainty analysis and alternative scenarios

The results of various alternatives to the baseline scenario are reported below, addressing particularly the issues of the liberalisation of animal product markets, best practices for fertilizers handling and the Euro/USD exchange rate (for further details see Witzke *et al.,* 2004).

Overall, only the best practice scenario leads to significant changes in environmental pressures. The 'end-of-pipe' technical improvements associated with this scenario have naturally stronger benefits for the environment than the other variants. Improved farming practices could reduce significantly the environmental pressures, particularly with regard to the new Member States.

**Extended CAP reform — liberalisation of animal product markets**
The current CAP, assumed to be continued to 2020 in the baseline scenario, increases prices for animal products, both by border protection and market interventions, beyond the level which would prevail in the absence of common market organisations. This scenario assesses the impact of an extended CAP reform on selected environmental indicators by assuming a continued liberalisation in the context of WTO negotiations for animal products markets. The quota regime for milk is assumed to be abolished at the end of the horizon (2025 in this case), and is accompanied by a gradual drop in administrative prices for butter and skimmed milk powder and tariffs for dairy products from 2011 onwards. Equally, market interventions for beef meat are eliminated, and tariffs for the different meats and eggs are removed. Consequently, EU market prices are assumed to be identical to border prices at the end of the time period.

Reducing administrative prices for dairy products and removing tariffs results in adjustments at both the farm and dairy level: lower prices for dairy products decrease demand for raw milk from the dairies, which results in lower milk prices (40 %) and lower dairy cow herds (9 %). Similarly, the lower prices of beef meat (36 %) compared with the baseline scenario reduce beef production (4 %). At the same time, market prices for pigs (+ 13 %) and poultry (+ 28 %) meat will line up with world markets, and herds adjust (– 5 % for pigs and – 11 % for poultry). The reduced herds lower the demand for fodder, and allow a reduction of fodder area (2 %), which in turn leads to an expansion of other crops (1 % for cereals).

The liberalisation of animal product markets leads to a limited change in the environmental indicators. The N, P, K surpluses decrease by 4 % to 5 %, smaller than might be expected. Gaseous emissions (ammonia losses, methane and nitrous oxide) are also reduced by 2 % to 5 % compared with the baseline scenario.

**Best practice scenario for fertiliser handling**
The effect of significant improvements in management practices for handling fertiliser has been assessed in this scenario, which therefore depicts a more environmental-friendly prospective for the European agriculture sector. Three sets of parameters have been changed from the base year onwards (70):
(1) Ammonia losses linked to organic nitrogen output from animals: in stables these are assumed to be cut by half, while fully covered storage facilities would also reduce storage losses sharply; better application techniques of manure reducing ammonia losses during application are also assumed;
(2) N, P and K from organic fertiliser available for crop application are increased respectively to 80 %, 95 % and 95 % of the nitrogen not lost as ammonia;
(3) The overall efficiency of farms when balancing crop nutrient needs and fertiliser applications: the over-fertilisation rate is decreased (5 %) and the New-8 converge towards EU-15 practices.

Overall, losses of P and K are cut compared with the baseline scenario by about 80 % to 95 % and by 50 % for N. Depending on the animal and country, ammonia losses have the potential to be reduced by up to 70 %.

In 2020, the N, P, K surpluses are expected to be reduced compared with the baseline scenario by 25 %, 70 %, and 57 % respectively. Gaseous emissions are also reduced (ammonia losses by 51 %, nitrous oxide naturally to a lesser extent (12 %), while methane emissions are left unchanged due to the definition of the scenario). The use of organic fertilisers increases sharply (between 60 % and 80 %) substituting for mineral fertilisers (reduction of 30 % to 60 %).

**A stronger Euro**
The exchange rate in the baseline scenario is fixed at 0.9 EUR/USD from 2001 onwards, in line with the latest European Commission assumptions ('Prospects for agricultural markets 2004–2011 — update for EU-25', DG AGRI, July 2004), thus the Euro is weaker than current market conditions. This scenario assesses the possible effects of a stronger Euro of 0.75 EUR/USD, close to levels observed during 2004. This would imply lower terms of trade for agricultural goods, but import tariffs and the level of administrative prices and quota regimes (milk) would dampen price transmissions between global and EU markets and stabilise prices. The results show therefore that the overall impact of a stronger Euro on cropping patterns, herd sizes and environmental pressures is estimated to be rather small in the short and medium terms. The same goes for the environmental indicators where many product-specific effects cancel each other out.

In terms of environmental pressures (see Figure 3.9), we focus on fertiliser use (72), nutrient balances and ammonia losses, and GHG emissions.

With regard to fertiliser use , considerable increases are projected for mineral fertiliser consumption in the New-8 over the next 20 years. The use of nitrogen (N) mineral fertilisers, which represents about 60 % of total mineral fertiliser use in 2020, is expected to increase by about 35 % over this period, while phosphate (P) and potassium (K) use increases by about 52 % and 41 % respectively. This contrasts sharply with the EU-15 situation where the use of mineral fertilisers is expected to stay fairly stable to 2020. This mainly reflects the differences between the EU-15 and the New-8 in terms of increases in application rates and yields (73) (74). The use of mineral fertilisers per ha is also expected to increase significantly by 2020 (38 %, 55 % and 44 % for N, P and K respectively); however, despite yield increases, it remains significantly lower in the New-8 than in the EU-15 in 2020 (13 % for N at 64.5 kg/ha, 10 % for P at 20.5 kg/ha and 23 % for K at 21 kg/ha). In contrast, the use of organic supply on crops is expected to decrease slightly over the period; in 2020, it represents about 36 % and 27 % of total fertiliser use in the EU-15 and New-8 respectively.

Calculations of expected nutrient balances/surpluses are also shown in Figure 3.9 (75). Overall, nutrient surpluses are expected to be moderately reduced in 2020 (by 6 %, 8 % and 12 % for N, P, K respectively). There are again striking differences between the EU-15 and the New-8 projections. Nutrient surpluses in the New-8 are expected to increase by 63 % for nitrogen (N), 84 % for phosphate (P) and 27 % for potassium (K) as a result of the expected sharp increase in the use of mineral fertilisers. In the EU-15, surpluses are expected to decrease (by 12 % for N, 25 % for P and 16 % for K) because of a stable use of fertilisers and an increase in exports in harvested material. The share of the New-8 in N, P, K surpluses in 2020 is expected to be 14 %, 14 % and 11 % respectively (these are 8 %, 6 % and 7 % in the base year). Finally, ammonia losses are not expected to change over the period.

Of the GHGs, nitrous oxide emissions are expected to increase significantly in the New-8 (by 15 %), in line with the related fertiliser projections. In contrast, methane emissions are expected to decrease by 5 % and 7 % in the EU-15 and New-8 respectively, as the total number of cattle decreases. With regard to gaseous emissions, the share of the New-8 in ammonia losses, methane and nitrous oxide is expected to stay fairly constant (15 %, 9 % and 13 % respectively in 2020).

The variants and alternative agriculture scenarios are reported in Box 3.2.

## 3.9 Waste and material flows

***In the EU-15, most waste streams are not expected to decouple significantly from GDP and none are expected to decouple absolutely. In the New-10, relative decoupling of waste from GDP is expected, particularly for municipal wastes.***

***As waste generation is expected to continue to grow across Europe, the policy target of absolute decoupling is not met. This might lead to an increase in environmental pressures and stretch the waste management capabilities of countries with less developed infrastructure.***

***In terms of material flows, significant relative decoupling is expected in the EU over the 2000–2020 period, particularly for fossil fuels and biomass ('burden shifting').***

***The economic situation in Europe has a significant impact on most waste streams and material flows.***

***Resource productivity is about four times lower in the New-10 than in the EU-15, but significant progress has been made over the past decade. This provides opportunities and scope for focused actions.***

Since the use of resources and generation of waste accompany any economic and social activity, their environmental pressures are far-reaching and range from climate change and water pollution to soil degradation and loss of biodiversity. As mentioned in the EU 6th environment action programme (76), decoupling resource use and waste generation from economic growth is a key issue to be addressed by the 'thematic strategy on sustainable use of natural resources'.

Recent decades have seen consistently growing waste volumes — more than 1.8 billion tonnes of waste are produced in the EU each year (i.e. 3.8 tonnes per person in 2000 in the EU-15 and 5 tonnes per person in central and eastern Europe) (77). Total waste generation in the EU-15 increased by nearly 13 % between 1990 and 2000. Half of this waste comes from manufacturing industry and construction/demolition activities. Recycling of glass and paper has been increasing but not sufficiently quickly to reduce the overall disposal volumes of these waste streams. Despite increasing recycling rates, landfilling remains the most common treatment for waste.

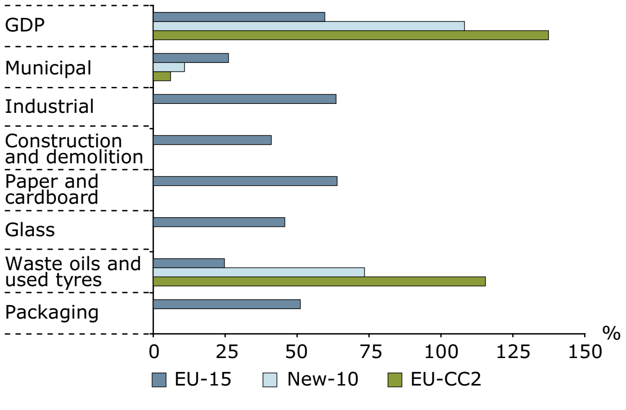
The EU 6th EAP identifies waste prevention and management as one of the top priorities, aiming at a significant overall reduction in the volumes of waste generated (i.e. absolute decoupling).

First we review the baseline waste projections, which address most of the significant waste streams (78) for the EU-15: municipal waste, industrial waste, waste from construction and demolition, paper and cardboard, glass, packaging, waste oils and used tyres from cars. Due to a lack of data, only municipal waste, waste oils and used tyres from cars are covered for the New-10 and two EU candidate countries (Bulgaria and Romania, EU-CC2).

The following developments are expected for waste quantities (see Figure 3.10) (79):

- In the EU-15, most waste streams are expected to decouple relatively from GDP by 2020. However, none are expected to decouple absolutely (80). Industrial waste and paper and cardboard show the largest increase (about 64 %), followed by packaging waste (50 %). Municipal waste (81) and waste oil and used tyres are expected to increase by only about 25 % over the period.
- In the New-10, relative decoupling from GDP is expected, particularly for municipal wastes, which are expected to increase by only 10 % by 2020. Similar developments are expected for Bulgaria and Romania (6 % increase). Although a promising relative decoupling from GDP is expected for waste oil and used tyres from cars, they are still expected to increase by about 70 %. This is due mainly to the strong economic growth and increase in household expenditure expected over the period, which are drivers both of the number of new registrations and end-of-life vehicles.
- Overall, the policy target of absolute decoupling is not expected to be met, as relative decoupling fails to counteract increases in waste generation.
- In absolute terms, the construction and demolition and industrial waste streams are expected to continue to be the most important contributors to waste quantities in the EU-15, with about 650 million tonnes per year by 2020. Municipal waste is expected to contribute 250 million tonnes per year.
- Spain appears as the EU-15 country with the highest level of municipal waste per household (about 2.2 tonnes in 2030), while the average for the other countries is about 1.3 tonnes. In the New-10, the average is around 1.2 tonnes per household.
- The paper and cardboard waste projections suggest that the use of paper in Europe in the long term is unlikely to be significantly reduced by the IT revolution (83).
- The impacts of the forthcoming implementation in the EU-15 of the landfill directive (84) for biodegradable municipal waste have been estimated in terms of environmental pressures (85). Under the assumption that the directive's targets are met (86), landfilling of biodegradable municipal waste is expected to be reduced by about 15 Mt in 2006, 28 Mt by 2009 and 41 Mt by 2016. This diversion towards other waste management options would reduce the related emissions of greenhouse gas (mainly nitrous oxide ($N_2O$) and methane ($CH_4$)) per year by about 31 Mt $CO_2$ eq. in 2006, 57 Mt in 2009 and 85 Mt in 2016; these savings represent 0.8 %, 1.4 % and 2 % respectively of total EU-15 GHG emissions in 2002 (87).

**Figure 3.10 Growths in waste quantities and GDP (2020/2000) (82)**



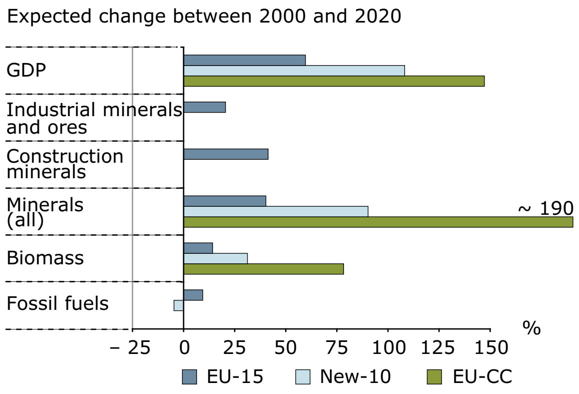
We review below the baseline projections for material flows, which cover industrial minerals and ores, construction minerals, biomass and fossil fuels for the EU-15 (88). Due to limited historic time series, all the minerals have been projected as one single aggregate (i.e. industrial and construction minerals and ores) for the New-10 and three EU candidate countries (Bulgaria, Romania and Turkey, EU-CC). The following projected features can be highlighted (see Figure 3.11):

- Significant relative decoupling from GDP is expected in the EU-15 and the New-10 over the natural resources being imported into the EU, which comes from the gradual depletion of domestic resources and economic competition from non-EU natural resources; these developments are known as 'burden shifting' ([89]).
- In absolute terms, construction minerals and biomass are expected to continue to be the largest contributors to material flow quantities in the EU-15, representing respectively 3.8 and 1.6 billion tonnes per year by 2020.
- Industrial and construction minerals and ores are expected to increase by about 190 % in Bulgaria, Romania and Turkey, as a result of strong economic growth (by 147 % between 2000 and 2020).
- Resource productivity (or material flow efficiency) is about four times lower in the New-10 than in the EU-15, but significant improvement of 2.6 % per year has been observed over the 1992–1999 period ([90]). Looking forward, resource productivity in the New-10 is expected to increase by about 50 % by 2020 (by 2 % on average per year, reaching 0.5 Euro of GDP per kg of resource used), with EU-15 resource productivity increasing by about 25 % (1.9 Euro of GDP per kg by 2020).

The 'low economic growth' variant for waste and material flows is reported in Box 3.3.

In view of these projections, several emerging challenges that are policy-relevant can be highlighted. The importance of policy actions that address both waste prevention and management is striking, since increasing waste quantities may challenge the limits of waste management options in the future, particularly at specific locations ([91]). With regard to material flows and resource productivity, the New-10 present considerable opportunities for benefiting from technology transfer (see 6th EAP Articles 2.5, 8.2 (i (e)), 8.2 (iii (c)) and 5.5) and realising their potential for improvements.

**Figure 3.11 Growths in quantities of material flow and GDP (2020/2000)**



Data on waste quantities are scarce, particularly for the New-10. The uncertainty surrounding the projections may therefore be significant and the results should be reviewed in the light of the methodological approach used and additional data available at the national level. There also seems to be a need for further development of waste and material flow outlooks, particularly with regard to environmental pressures and economic damage. A key issue is the extent to which policy/management and technological options available at the EU, national or local levels can reduce environmental pressures, particularly for the recycling, incineration and landfilling routes and the associated emissions.

In view of the key driving forces and pressures on Europe's environment that have been described above, and without anticipating the environmental impacts that are presented in Chapter 4, one should however highlight the likelihood of unsustainable environmental developments in the baseline scenario. Indeed, the analysis has pointed to a projected increase in economic growth and welfare, which, in the absence of breakthroughs in technology or sectoral and environmental policies that target production and consumption patterns, is likely to increase the pressures and impacts on Europe's environment.

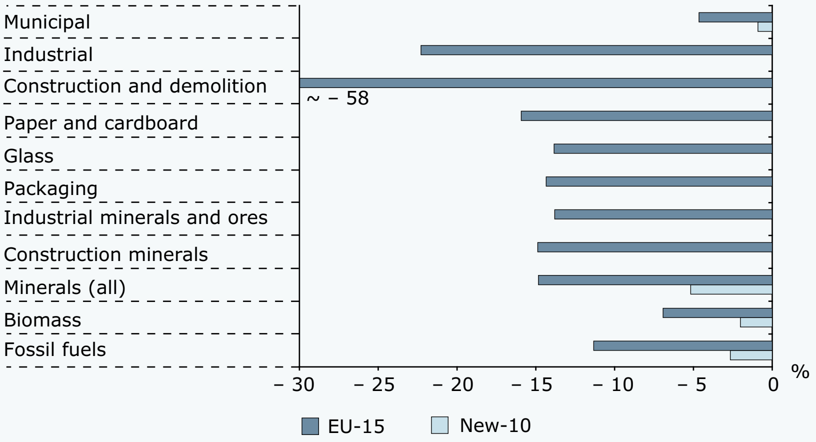
As stated in the introductory chapter, one of the objectives of this European environment outlook is to pay proper attention to the links between environmental issues, in terms of driving forces, impacts and policy responses. This chapter has discussed the key driving forces and pressures on Europe's environment, highlighting the inter-linkages between them and to the environment issues, and therefore paves the way for an integrated analysis of EEA's outlooks (Chapter 4).

## Box 3.3 Waste and material flows outlook — a 'low economic growth' variant

Since the waste generation and material flows outlook is based on a macro-economic model (see details in Annex 2), a 'low economic growth' variant to the baseline scenario has been developed to assess the (marginal) impact of the overall European economic situation on these environmental drivers. It has been estimated (92) that moderately pessimistic assumptions would lead to average annual growth rates of 1.6 % (EU-15) to 3.2 % (New-10) over 2000–2030 for different regions in Europe. In the baseline scenario, the growth assumptions range from 2.3 % (EU-15) to 3.5 % (New-10), which is considered to be moderately optimistic. In terms of GDP per capita in the EEA member countries, there is a reduction of 5.6 k Euro compared with the baseline scenario by 2030. See further details in Box 4.1.

The results of the variant suggest that the economic situation in Europe impacts significantly most of the waste streams and material flows, with a decrease on average of about 15 %. The industrial and construction and demolition wastes exhibit the highest sensitivity to GDP growth (– 58 % and – 22 % respectively), and this result appears reasonable. The effects in the New-10 are consistently estimated to be lower than in the EU-15 as their economic growth has been reduced by less than 10 % while the EU-15 are assumed to experience a drop of 30 %. The elasticity of waste and material flows to GDP growth would therefore be roughly estimated (i.e. on average) at 0.5 and 0.35 in the EU-15 and New-10 respectively.

**Waste generation and material flows — low economic growth scenario vs. baseline (2020)**



**Box 3.4 The low GHG emissions scenario** (also referred to as SEP (sustainable emission pathway) or LCEP (low-carbon energy pathway))

The key policy package that addresses European GHG emissions is the Kyoto Protocol adopted in December 1997 at the third Conference of the parties (COP3) to the United Nations framework convention on climate change (UNFCCC). It entered into force in February 2005 (93) and sets a binding reduction target for EU-15 GHG emissions of 8 % on average for the 2008–2012 period compared with 1990 levels, and 6.7 % for the eight new Member States having a Kyoto Protocol target (94); the 'combined' target for the EU is therefore to reduce its emissions by about 8 % on average for the 2008–2012 period compared with base year levels (usually 1990).

The EU-15 target has been negotiated with its Member States leading to a 'burden-sharing' agreement (European Council, 2002) which reflects differentiated levels of effort and contribution by countries. With regard to climate change impacts, the key EU policy package is the 6th environment action programme (6th EAP), which sets EU's long-term sustainable target: '*Thus a long term objective of a maximum global temperature increase of 2 °C over pre-industrial levels and a* $CO_2$ *concentration below 550 ppm shall guide the Programme. In the longer term this is likely to require a global reduction in emissions of greenhouse gases by 70 % as compared to 1990 as identified by the Intergovernmental Panel on Climate Change (IPCC)' (Article 2, paragraph 2)*'.

Recently, the EU Environment Council of 10 March 2005 reaffirmed the conclusions of the Environment Council of December 2004 (which confirmed the long-term global temperature target of not more than 2 °C above pre-industrial levels) and furthermore mentioned that (1) '*recent scientific research and work under the IPCC indicate that it is unlikely that stabilisation of concentrations above 550 ppmv* $CO_2$ *equivalent would be consistent with meeting the 2 °C objective and that in order to have a reasonable chance to limit global warming to no more than 2 °C, stabilisation of concentrations well below 550 ppmv* $CO_2$ *equivalent may be needed'* and (2) *'the EU looks forward to exploring with other Parties possible strategies for achieving necessary emission reductions and believes that, in this context, reduction pathways by the group of developed countries in the order of 15–30 % by 2020 and 60–80 % by 2050 compared to the baseline envisaged in the Kyoto Protocol should be considered*'.

To complement the baseline scenario, the EEA has developed an alternative climate change scenario, which aims at identifying the implications of the EU's long-term sustainable objective as stated in the 6th EAP for future GHG patterns, sectoral developments and the costs of policies. This scenario, referred to as the 'low GHG emissions', therefore assumes a deep reduction in GHG emissions in Europe over this century. The scenario bears similarities with current initiatives, studies and political debate across the EU (95) for far-reaching climate change policies; a common characteristic of these initiatives is to assess post-2012 needs to reach the long-term sustainable targets.

It is essential to assess the technological feasibility of dramatic reductions in EU GHG emissions, and there are many possible implications; in that context, the low GHG emissions scenario aims to provide an assessment of the scale of the challenge and the main possible trade-offs for the EU. The EU GHG reduction targets have been derived on the assumption of per-capita emission contraction and convergence at the global level by 2075, in line with the long-term objective of a maximum global temperature increase of 2 °C over pre-industrial levels and a stabilisation of concentrations at 550 ppmv $CO_2$ equivalent. The milestones are a 20 % reduction compared with 1990 levels by 2020, 40 % by 2030 and 65 % by 2050.

The environmental impacts or knock-on effects of the low GHG emissions scenario in terms of water stress and material flows have been estimated and are reported in Chapter 4. These reflect the integration of the EEA outlooks that include assessment of upstream developments and feedback effects on the driving forces.

# 4. Changes in Europe's environment

## 4.1 Spotlight: GHG emissions and climate change

**Key messages**

With existing domestic policies and measures alone (as of mid-2004), emissions in the EU by 2008–2012 are expected to be less than 3 % below 1990 levels, compared with the Kyoto Protocol target of 8 %. However, taking into account the latest policy developments (e.g. emissions trading scheme with national allocation plans assessed and adopted by the European Commission in the second half of 2004), and provided that Member States implement all the additional policies, measures and third-country projects they are currently planning and that several cut emissions by more than they have to, the EU-15 is likely to be able to meet its Kyoto Protocol target (96).

Sensitivity and uncertainty analysis shows that reaching the Kyoto Protocol target in the EU depends significantly on the strength of the economy and on possible additional initiatives such as an enhanced diffusion of renewable energy sources. Additional uncertainty stems from the degree to which the Kyoto flexible mechanisms that allow countries to achieve their targets outside the EU are used.

By 2100, global temperature change is expected to be well above the long-term sustainable objective set in the 6th EAP (bearing in mind the inherent scientific and analytical uncertainty characterising the assessment of climate change impacts) (97).

A large enough reduction in greenhouse gas emissions to place the EU on track to achieve the long-term climate change objectives set in the 6th EAP is estimated to be technologically feasible but would require major sectoral shifts (e.g. in the energy system). While this assessment takes into account the sectors and activities that drive GHG emissions, analysis of the economic impacts has yet to be conducted with appropriate tools for addressing macro-economic and sectoral effects, the costs of inaction, the security of supply issue, and the socio-economic context as a whole.

This chapter reports the changes in GHG emissions and climate expected under the baseline and the 'low GHG emissions' scenarios, for key timeframes and deadlines such as 2008–2012, 2030 and 2100 (98)(99). By definition, the baseline scenario includes all (and only) implemented and current policies and measures as of mid-2004 (100), i.e. no assumptions are made on the development and implementation of additional measures and policies in the time horizon considered.

The most up-to-date energy projections at the EU level have been used, i.e. those reported in the DG TREN baseline projection 'European energy and transport trends to 2030' (101). By extending these projections to environmental impacts in terms of climate change and air pollution, the EEA has contributed to developing a full set of results within a baseline framework, also referred to as the long-range energy modelling — extended (LREM-E) scenario. This projection (rather than the inventory submissions made under the European Commission GHG monitoring mechanism and to the UNFCCC, and the Clean Air for Europe (CAFE) baseline (102) serves as the reference run to assess the progress of EU countries towards meeting their GHG emission targets under the Kyoto Protocol.

### *4.1.1 Baseline GHG emissions outlook* (103)

This section describes EU GHG emissions over the 2000–2030 period under the baseline scenario. It covers the six greenhouse gases addressed by the Kyoto Protocol: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorcarbons (HFCs), perfluorcarbons (PFCs) and sulphur hexafluoride ($SF_6$). The following developments are projected (see Figure 4.1 and Box 4.1 for further details on the uncertainty assessment of the baseline scenario) (104):

- The EU-15 Kyoto targets are unlikely to be met with existing domestic policies and measures alone, since increases in GHG emissions are expected from 2000 onwards (105). By 2008–2012, EU-15 GHG emissions are expected to be about 1.1 % above 1990 levels, reaching 4 107 Mt $CO_2$ eq. per year. These emissions are 10 % above the Kyoto target (i.e. non-compliance by 370 Mt $CO_2$ eq.). This is due mainly to the combination of sustained economic growth and a lack of incentives for technological shifts, in particular for the transport sector.

- In contrast, the New-10 are expected to largely meet their Kyoto target with existing domestic policies and measures. By 2008–2012, the New-10 GHG emissions (including Cyprus and Malta which, however, have no Kyoto Protocol targets) are expected to be about 18 % below 1990 levels, reaching about 725 Mt $CO_2$ eq. per year. These emissions are 11 % below the Kyoto target (i.e. over-compliance by 89 Mt $CO_2$ eq.). This results from the fact that the New-10 are not expected by then to have fully recovered from the economic breakdown of the 1990s.

- Hence, with existing domestic policies and measures alone, the EU-25 as a whole is not expected to meet its Kyoto target as GHG emission reductions by 2008–2012 are expected to be only 2.3 % below 1990 levels: this is 6 % above the target (106).

- By 2030, EU GHG emissions are expected to be 8.4 % above 1990 levels (12.1 % above for the EU-15 and 8.9 % below for the New-10), while the EEA member countries show GHG emissions 13.2 % above 1990 levels. In the EU, the share of energy-related $CO_2$ emissions is expected to increase further, from 76 % in 1990 (78 % in 2000) to 80 % in 2030. The other gases are expected to show only marginal changes. In addition, no striking differences in the split of GHG emissions between the EU-15 and the New-10 are expected.

- In terms of per-capita emissions in the EU-15 and the New-10, these developments would lead to a convergence towards about 11.7 t $CO_2$ eq. per year by 2030 (from 10.5 and 9.5 respectively in 2000).

### 4.1.2 *Baseline climate change outlook*

This section describes the environmental impacts (107) of the baseline scenario projection for climate change.

**Figure 4.1 Total GHG emissions in Europe 1990–2030 (baseline scenario)** (108)

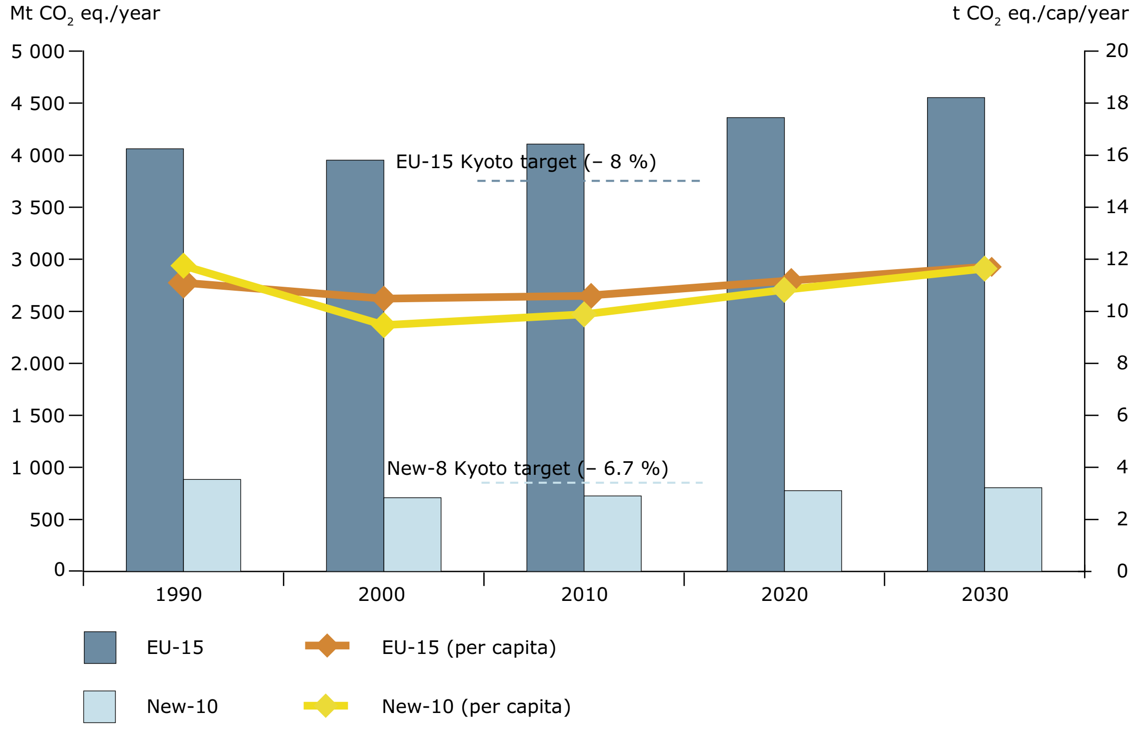
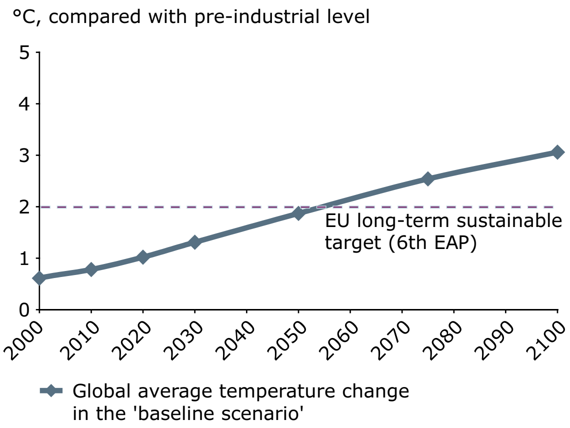


**Figure 4.2** **Global temperature change 2000–2100 (baseline scenario)**



- The projected increase in global temperature above the pre-industrial level between 2000 and 2100 is about 3.1 °C (see Figure 4.2). This is well above the long-term sustainable objective of a maximum of 2 °C set in the 6th EAP: this is, of course, due to both European GHG emissions and non-European emissions which, for example, represent more than 90 % of global emissions in 2050. Within Europe, the highest warming is expected for the southern and north-eastern parts.

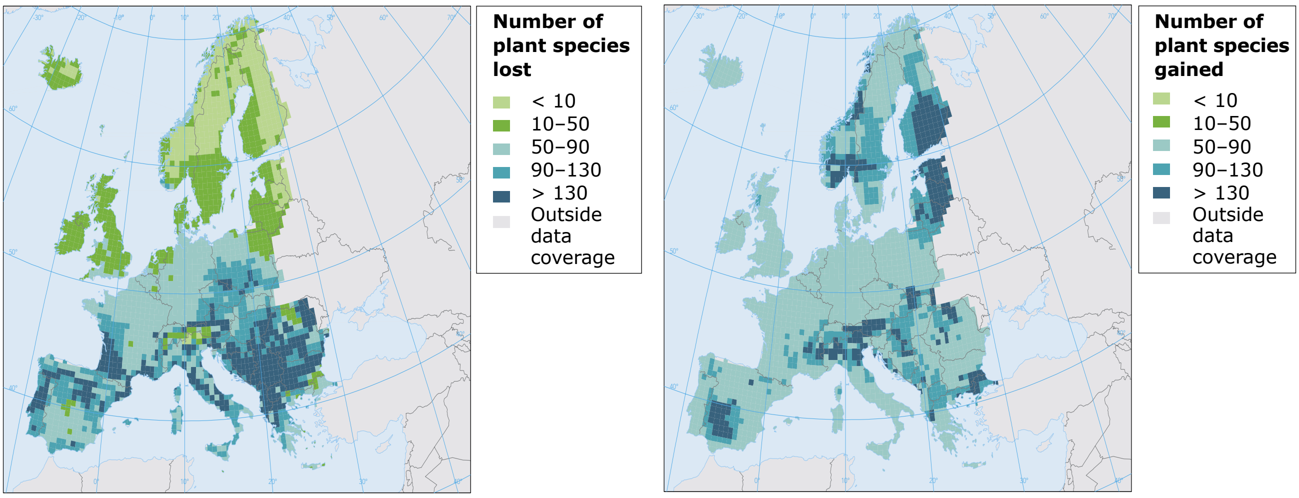
- Projections of extreme weather events (e.g. droughts, heat waves, floods, days of frost) are characterised by a high level of uncertainty. While the annual number of such events has increased in recent decades, the extent to which they are linked to changing climate, and what patterns might lead to them, is uncertain. However, by the end of this century, cold winters (i.e. the cold winters that occurred once every ten years between 1961 and 1990) are most likely to disappear, while almost every summer in many parts of Europe will be warmer than during recent one in ten hot summers.

- The effects on ecosystem composition are assessed in terms of the number of plant species (109) (see Map 4.1). Significant changes in the distribution of plant species in Europe are expected during this century, particularly in the south-east. Most European Member States are expected to lose more than 50 species by 2100 compared with the 1995 situation. The Scandinavian and Baltic countries are expected to gain significant numbers of new species, probably as a result of higher temperatures and precipitation resulting from climate change. However, the pattern of the number of species gained is not expected to clearly follow the geographical location of countries and associated climates.

- The length of the growing season and biomass production are bound to be affected by climate change. Most of Europe (about 85 %) is expected to experience an increase in the length of the growing season by 2100; a reduction in its length is expected to take place south of 40 degrees latitude and to lead to increasing drought stress.

The results of the baseline projection and its implications for Europe's environment show how important it is to establish what kind of policies would be needed to reach the long-term sustainable objective set in the 6th EAP, which highlights the need for a deep reduction in global GHG emissions in the

**Map 4.1** **Impact of climate change on number of plant species (in 2100 under the baseline scenario)**



### Box 4.1 Sensitivity and uncertainty analysis of the baseline scenario

It is vital to assess the uncertainties associated with climate change projections (from driving forces to environmental impacts). The assessments made for two sensitivities or variants around the baseline scenario are reported here: the first addresses a lower economic growth in Europe and the second considers an accelerated diffusion and adoption of renewables in the energy system.

For the 'low economic growth' scenario (low GDP growth), it has been estimated (110) that moderately pessimistic assumptions would lead to average annual growth rates of 1.6 % to 3.2 % over 2000–2030 for different regions in Europe. In the baseline scenario, the growth assumptions range from 2.3 % (EU-15) to 3.5 % (New-10), which is considered to be moderately optimistic. In terms of GDP per capita in the EEA member countries, there is a reduction of 5.6 k Euro compared with the baseline scenario by 2030. In the 'accelerated renewables' scenario (RES), the targets for the share of renewable energy in total energy consumption are 12 % in 2010, 16 % in 2020 and 20 % in 2030. For the power generation sector, subsidies are introduced to achieve the targets of 27 % electricity generation from renewables in 2020 and 35 % in 2030.

#### GDP assumptions in the 'low economic growth' scenario (2000–2030)

| | **GDP per capita (k Euro 2000)** | | | | | **Average annual GDP growth rates (%)** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | EEA-31 | EU-25 | EU-15 | New-10 | | EEA-31 | EU-25 | EU-15 | New-10 |
| **2000** | 17.1 | 19.7 | 22.6 | 5.3 | **2000–2010** | 1.8 | 1.7 | 1.6 | 3.4 |
| **2010** | 19.9 | 23.0 | 25.9 | 7.5 | **2010–2020** | 1.9 | 1.8 | 1.7 | 3.4 |
| **2020** | 23.7 | 27.4 | 30.5 | 10.7 | **2020–2030** | 1.8 | 1.7 | 1.6 | 2.7 |
| **2030** | 28.1 | 32.6 | 35.8 | 14.5 | **2000–2030** | 1.8 | 1.7 | 1.6 | 3.2 |

In the 'low GDP growth' variant, the main changes concern $CO_2$ emissions (see below). Over the 2008–2012 period, these are estimated to be 5.4 % lower than in the baseline projection, leading to a total reduction of GHGs of 7.4 % from 1990 levels (it is assumed that the non-$CO_2$ gases exhibit the same patterns as in the baseline).

In the 'accelerated renewables' variant, the main difference from the baseline projection also concerns $CO_2$ emissions. Over the 2008–2012 period, they are estimated to be 4.5 % lower than in the baseline, leading to a total reduction of GHGs of 6.5 % from 1990 levels (it is assumed that the non-$CO_2$ gases exhibit the same patterns as in the baseline).

#### $CO_2$ emissions in EU-25 (2000–2030)

**(Index 100 = 1990 and diff. vs. baseline)**

| | **Baseline** | **Low GDP growth** | **RES scenario** |
|---|---|---|---|
| **2000** | 97.2 | 97.2 (0.0 %) | 97.2 (0.0 %) |
| **2010** | 99.7 | 94.2 (– 5.4 %) | 95.2 (– 4.5 %) |
| **2020** | 107.2 | 96.8 (– 9.7 %) | 98.4 (– 8.2 %) |
| **2030** | 114.2 | 99.1 (– 13.2 %) | 99.2 (– 13.1 %) |

None of the variants have important enough changes in pressures to result in significant changes in terms of environmental impacts over the time period considered.

Comparing the low economic growth variant with the baseline projection highlights that reaching the Kyoto Protocol target in Europe depends significantly on the strength of the economy. In addition, the renewable variant highlights a significant potential for reducing $CO_2$ emissions. With regard to long-term developments, both variants point to significant potential for reducing $CO_2$ emissions.

longer term. This issue is addressed below with the low GHG emissions scenario.

### *4.1.3 The low GHG emissions scenario*

The main features of the low GHG emissions scenario (111) (See Figures 4.3, Table 4.1 and Table 4.2) are:

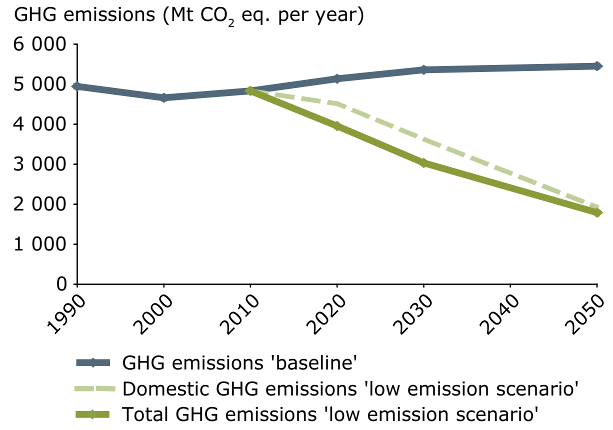
- Overall, EU GHG emissions are reduced to 20 % below 1990 levels by 2020, 40 % by 2030 and 65 % by 2050, with about 55 % of the reductions by 2020 resulting from the use of flexible mechanism, 32 % by 2030 and 8 % by 2050. The increasing reliance on domestic action reflects the gradual exhaustion of the cheapest options to curb GHG emissions, i.e. joint implementation and clean development mechanisms. The marginal abatement cost (MAC) associated with the targets of the scenario (i.e. the carbon price) is estimated at 30 Euro/tonne $CO_2$ eq. in 2020, 65 in 2030 and 115 in 2050.

- By 2030, EU domestic GHG emissions are expected to decrease by about 32 % compared with the baseline scenario, and by 27 % compared with 1990 levels. The main contribution to this reduction comes from methane (40 % below 1990 levels), nitrous oxide (26 % below) and carbon dioxide (11 % below). Sinks exhibit a significant increase, and reduce GHG emissions in 2030 by 2.2 %.

- With regard to the European energy system, Table 4.2 contrasts the key developments compared with the baseline scenario. Gross inland energy consumption and final energy demand are reduced by about 10 percentage points in 2030 compared with the baseline. The carbon constraint results in improved energy intensity but energy requirements are still rising in all sectors.

  One of the main shifts induced by the low GHG emissions scenario concerns the power generation sector in terms of fuel inputs. In particular, the share of solids is significantly reduced compared with the baseline scenario, and there is a greater deployment of renewables (112). The feedback effects on fossil fuel developments are discussed in Box 4.2. Overall, results show that at the margin, it is more difficult for the system to reduce overall energy demand than it is to change the mix of energy fuels, as GHG policies mainly affect the supply-side, which is characterised by greater flexibility and reactivity to price signals.

**Figure 4.3 EU GHG emissions 1990–2050**



- EU energy import dependency is reduced moderately by 2030 compared with the baseline projection, i.e. 62 % instead of 67 % (113); this is due to the overall reduction in energy requirements in the economy: gross inland consumption increases by only 10 % between 2000 and 2030, i.e. a reduction of 8 % in 2030 compared with the baseline. Natural gas imports almost triple between 2000 and 2030, while net imports of solids (e.g. hard coal and lignite) are reduced sharply (by about 55 %), and net imports of oil remain virtually constant.

- The additional supply-side energy costs associated with the low GHG emissions scenario compared with the baseline are estimated at about 63 billion EUR in 2030 (from 320 billion EUR in the baseline). In terms of EU GDP, which is projected to more than double between 2000 and 2030, this would represent 0.35 %, which in turn translates into an increase of more than 25 % of the average production cost (114).

- The additional demand-side energy costs associated with the low GHG emissions scenario compared with the baseline are estimated at 0.6 % of the EU GDP by 2030, to which the transport costs have yet to be added (115). Since this estimate reflects net costs, i.e. it takes into account the considerable savings due to lower energy demand, it represents a non-negligible cost. The add-on to the energy bill for households is estimated at 110–120 Euro per household by 2030 (from 3 700 EUR (2000) per household in the baseline).

- Analysis of the economic impacts of the scenario has yet to be conducted with appropriate tools for addressing macro-economic and sectoral effects, the costs of inaction, the security of supply issue, and the socio-economic context as a whole. The current assessment takes into account the sectors and activities that drive GHG emissions, but does not analyse the possibility of reaching win-win situations (116). Note that if the feedbacks of the climate change constraints on the macro-economic activity level had been considered, the energy costs reported above would be lower, as reducing overall economic activity would provide an additional flexibility or adaptation option alongside technological substitution.

The environmental impacts under the low GHG emissions scenario (see also Figure 4.4 and Map 4.2) are:

- Based on the definition of the scenario (the EU long-term sustainable objective of not more than 2 °C increase over pre-industrial levels, set in the 6th EAP) (117) global temperature over the 2000–2100 period is expected to reach 1.9 °C over the pre-industrial level. This is about 1.2 °C lower than in the baseline scenario. Within Europe, the avoided temperature increase is expected to be the largest in the south-west. In terms of global GHGs concentration, the scenario leads to a stabilisation at about 550 ppm $CO_2$ eq. by 2100 (see Box 3.4), which is about 40 % lower than in the baseline scenario.

- European average annual precipitation is expected to increase by about 2 % by 2100 over the 1961–1990 average, compared with about 3 % in the baseline scenario. The largest benefits in terms of reduced precipitation are projected for the Iberian Peninsula and south-east Europe (the Balkan countries and Turkey in particular).

- The loss of plant species by 2100 is expected to be significantly reduced compared with the baseline scenario, in particular in southern and central Europe. Most European countries also exhibit a significant reduction. The number of species gained is also expected to be significantly reduced compared with the baseline scenario, in particular in the south-eastern and Nordic parts of Europe.

- The increase in the length of the growing season (affecting about 85 % of the continent) by 2100 is expected to be about 50 % less than in the baseline scenario. A reduction in the length of the growing season is expected for south of 40 degrees, but not as much as in the baseline scenario.

The uncertainty associated with the low GHG emissions scenario has been addressed in more detail with the development of various economic and technological variants addressing (1) lower economic growth in Europe, (2) an accelerated diffusion of renewable energy sources and (3) accelerated decommissioning or adoption of nuclear.

The assumptions for the 'low economic growth' and 'accelerated renewable' variants are similar to those used for the sensitivity and uncertainty analysis of the baseline projection (see Box 4.1). In the 'nuclear phase out' scenario, it is assumed that existing nuclear plants are decommissioned on completion of their technical lifetime in addition to the stricter decommissioning policies that apply in certain Member States, and no further investment in nuclear power occurs. In the 'nuclear accelerated' scenario, it is assumed that new nuclear technologies become mature by 2010, leading to more Member States choosing the nuclear option (including re-evaluations of declared nuclear phase-out policies) (118).

Details of the results of these variants, particularly in terms of marginal abatement costs, can be found in the EEA Report 'Climate change and a European low-carbon energy system'. It also discusses the extent to which enhanced technological progress can help to achieve a considerable reduction of GHG emissions in Europe.

**Table 4.1 EU GHG reduction targets, domestic action and carbon price (2000–2050)**

| | EU reduction targets (from 1990 levels) | Domestic action (from 1990 levels) | Share of domestic action | EU carbon price (Euro/t $CO_2$ eq.) |
|---|---|---|---|---|
| **2020** | – 20 % | – 9 % | 45 % | 30 |
| **2030** | – 40 % | – 27 % | 68 % | 65 |
| **2050** | – 65 % | – 60 % | 92 % | 115 |

**Table 4.2 The European energy system (baseline and low GHG emissions scenarios)**

| | 1990 | 2000 | 2030 | |
|---|---|---|---|---|
| | | | Baseline | Low GHG emissions scenario |
| GDP (billion Euro 2000)<br>(index) | 7 315.2<br>(100) | 8 939.3<br>(122) | 18 020.3<br>(246) | 18 020.3<br>(246) |
| Population (million)<br>(index) | 441.1<br>(100) | 453.4<br>(103) | 458.2<br>(104) | 458.2<br>(104) |
| $CO_2$ emissions (Mt $CO_2$)<br>(index) | 3 769.5<br>(100) | 3 664.9<br>(97.2) | 4 303.6<br>(114.2) | 3 345.8<br>(88.8) |
| Gross inland energy consumption (GIEC, Mtoe)<br>(index) | 1 554.3<br>(100) | 1 650.7<br>(106) | 1 959.7<br>(126) | 1 810.8<br>(117) |
| Share of fuels in GIEC (%) | | | | |
| Solids | 27.7 | 18.4 | 15.3 | 4.9 |
| Oil | 38.4 | 38.5 | 34.4 | 34.7 |
| Gas | 16.7 | 22.8 | 32.1 | 35.1 |
| Nuclear | 12.7 | 14.4 | 9.5 | 12.0 |
| Renewables | 4.5 | 5.8 | 8.6 | 13.1 |
| Carbon intensity of GIEC (t $CO_2$/toe) (index) | 2.43<br>(100) | 2.22<br>(91) | 2.20<br>(91) | 1.85<br>(76) |
| Final energy demand (Mtoe)<br>(index) | 1 009.2<br>(100) | 1 074.4<br>(106) | 1 394.1<br>(138) | 1 291.7<br>(128) |
| Electricity demand (TWh) | | | | |
| Total<br>(index) | – | 2 509.1<br>(100) | 3 944.6<br>(157) | 3 795.1<br>(151) |
| Industry (including refineries) | – | 1 069.3 | 1 524.6 | 1 525.9 |
| Tertiary | – | 651.5 | 1 208.1 | 1 135.7 |
| Households | – | 694.7 | 1 114.4 | 1 041.6 |
| Transports | – | 68.8 | 75.7 | 70.1 |
| Energy sector (excl. auto–consumption) | – | 24.9 | 21.9 | 21.9 |
| Energy intensity index (1990 = 100) | | | | |
| Industry (energy on value added) | – | 82.7 | 51.3 | 48.7 |
| Residential (energy on private income) | – | 85.8 | 51.3 | 48.5 |
| Tertiary (energy on value added) | – | 86.8 | 58.2 | 52.4 |
| Transport (energy on GDP) | – | 99.3 | 66.5 | 61.7 |
| Carbon intensity indicators | | | | |
| Electricity and steam production (t of $CO_2$/MWh) | 0.44 | 0.37 | 0.30 | 0.18 |
| Final energy demand (t of $CO_2$/toe) | 2.26 | 2.12 | 1.83 | 1.77 |
| Industry | 2.18 | 1.96 | 1.42 | 1.29 |
| Residential | 1.94 | 1.66 | 1.44 | 1.39 |
| Tertiary | 1.83 | 1.54 | 1.17 | 1.09 |
| Transport | 2.90 | 2.91 | 2.80 | 2.80 |
| Efficiency of thermal power production (%) | – | 37.1 | 48.7 | 50.6 |
| Import dependency (%) | 44.8 | 47.2 | 67.3 | 62.4 |

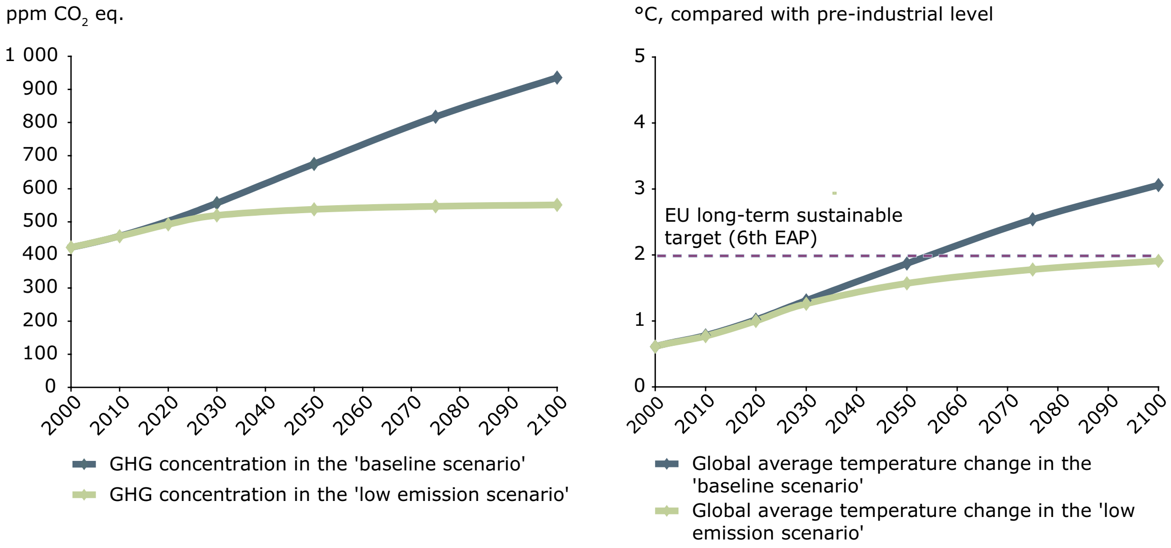
### *4.1.4 Emerging challenges*

With 137 signatories, the Kyoto Protocol constitutes the first international framework and attempt to curb anthropogenic emissions of GHGs; the overall reduction target (essentially for emissions from industrialised countries) is 5 % by 2008–2012 compared with base year levels (usually 1990). Without the commitment of the USA, China or India (representing about 40 % of global emissions in 1990), the final effect on global environment is, however, uncertain.

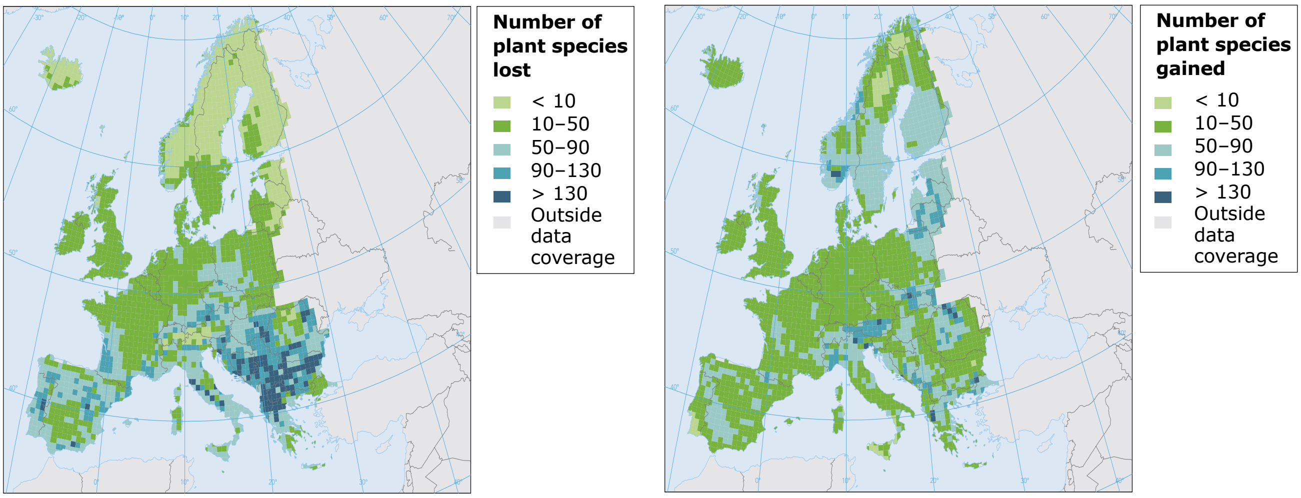
From that perspective, the Kyoto Protocol appears as only a first step in the right direction. If the 6th EAP objective is to be achieved, dramatic changes and shifts towards sustainable sectoral developments (e.g. in the energy system) and consumption in Europe appear to be needed. Future GHG emissions and climate change impacts and adaptation options will therefore depend essentially on the negotiations that will take place for a second commitment period and whether these lead to far-reaching targets.

Climate change may also result in a change in the magnitude and frequency of some extreme

**Figure 4.4 Global concentration and temperature change 2000–2100**



**Map 4.2 Impact of climate change on number of plant species (in 2100 under the low GHG emissions scenario)**

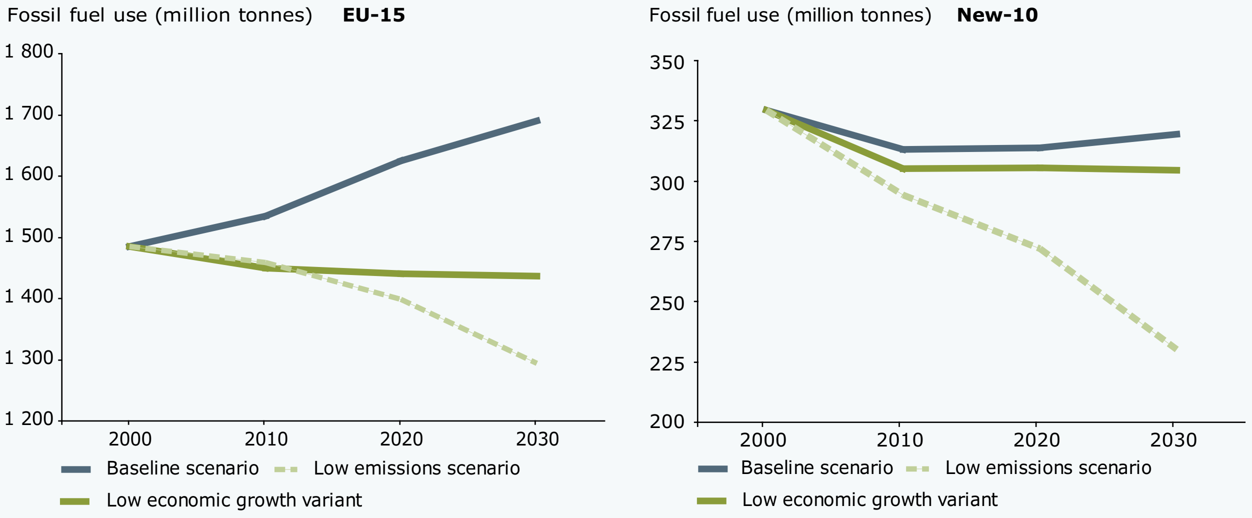


weather events. Even sudden extreme changes in the environment, such as collapse of the north Atlantic thermohaline circulation ('Gulf Stream') or the Arctic ecosystem, are not deemed entirely implausible and could have much larger impacts than the underlying driving force. The increase in temperature, for example, could be offset in Europe by cooling effects due to a collapse of the Gulf Stream.

### Box 4.2 The low GHG emissions scenario — feedback effects on fossil fuel developments

This box reports the expected feedback effects of the low GHG emissions scenario on fossil fuel developments, which involve considerable environmental impacts. As the energy requirements are reduced in the low GHG emissions scenario compared with the baseline scenario, the need for fossil fuels is also expected to be reduced (see figure below).

**Fossils fuels developments (2000–2030, baseline, low economic growth and low GHG emissions scenarios)**



In the low GHG emissions scenario, fossil fuel use in 2030 is expected to decrease by about 13 % in the EU-15 and 30 % in the New-10 from 2000 levels; this is about 23 % and 28 % less than in the baseline scenario, respectively. Compared with the low economic growth variant, this represents a decrease of 10 % and 25 %. The drop is due mainly to a significant decrease in both domestic extraction (35 % compared with the baseline scenario by 2030) and net trade (20 %) across Europe. Also note the significant relative effect on fossil fuel developments in the EU-15 of the low economic growth variant compared with the low GHG emissions scenario.

## 4.2 Spotlight: air quality

**Key messages**

On the basis of existing policies and measures, all emissions of land-based air pollutants (except ammonia) are expected to decline significantly (by more than 35 %) up to 2030. Hence, the EU as a whole is expected to comply with the 2010 targets of the national emission ceilings directive. However, while a number of Member States are well below their binding upper national emission ceilings, others are not on track.

The implementation of all feasible technical measures (best available technologies) is estimated to offer a considerable potential for further reductions in air emissions.

As air quality in Europe is expected to improve significantly, impacts on human health and ecosystems diminish substantially, although large differences across Europe are expected to prevail. Negative impacts in highly populated areas of the EU are however expected to remain significant, requiring further efforts to reach long-term objectives.

This section reports the expected changes in air pollutant emissions and impacts on health and ecosystems in the baseline ([119]) and the Maximum Technically Feasible Reductions (MTFR) ([120]) scenarios by 2030. These scenarios are fully consistent with those developed within the Clean Air for Europe programme (CAFE) of the European Commission ([121]).

Air pollution is a trans-boundary, multi-pollutant, multi-effect environmental problem. It arises from atmospheric deposition of pollutants (e.g. ecosystem acidification and eutrophication) or direct exposure to ambient concentrations of pollutants (e.g. exposure to ground-level (tropospheric) ozone, particulate matter) ([122]). Although the last two decades have seen a reduction in emissions, air pollution in Europe continues to pose risks and have adverse effects on human health and on natural and man-made environments.

The main policy framework in which air pollution issues are addressed in Europe is the National emission ceilings directive (Directive 2001/81/EC), which sets emission ceilings for sulphur dioxide ($SO_2$), nitrogen oxides ($NO_X$), ammonia ($NH_3$) and volatile organic compounds (VOCs) by 2010. These ceilings correspond to interim targets towards a long-term aim of non-exceedance of critical thresholds for ecosystem and human health regarding acidification, eutrophication and ground-level ozone. In addition, EU sectoral emission legislation sets emission standards for specific source categories ([123]) as well as air quality (air quality framework directive and the three daughter directives).

National emission ceilings for EU and non-EU countries have been agreed under the CLRTAP (United Nations Economic Commission for Europe convention on long-range transboundary air pollution) Gothenburg Protocol. The Gothenburg Protocol ceilings are higher than the ones in the NEC directive.

### *4.2.1 Emissions of air pollutants*

This section describes the European air pollutant emissions expected over the 2000–2030 period for the baseline and the maximum technically feasible reductions scenarios (see Figure 4.5 and Table 4.2). It covers the following anthropogenic air pollutants: nitrogen oxides ($NO_X$), non-methane volatile organic compounds (NMVOC), sulphur dioxide ($SO_2$), ammonia ($NH_3$) and primary particulate matter ($PM_{10}$ and $PM_{2.5}$, fine particulates with particle diameter less than 10 and 2.5 µm respectively). The following developments are expected:

- In the baseline scenario, emissions of NOx are expected to decrease by 47 % in 2030 compared with 2000. Baseline emissions aggregated at the EU level are expected to comply with the 2010 NECD ceilings by a thin margin, although compliance may vary between individual Member States. Under the MTFR scenario, emissions are expected to be reduced in 2030 by half to 2.8 million tonnes. The largest contributor to $NO_X$ emissions in 2000 was road transport (46 %), followed by the power plant and other fuel conversions sector (26 %). The non-road sector contributed 15 % and manufacturing industry and production processes another 13 %.

In the MTFR scenario, the importance of road transport emissions is reduced due to the introduction of best available technology (38 %); the power plant and other fuel conversions sector becomes responsible for 29 % of the emissions, non-road transport for 17 % and manufacturing industry and production processes for 16 %.

- In the baseline scenario, emissions of NMVOCs are expected to decrease by 45 % in 2030 (to 5.9 million tonnes). In 2000, the largest contributor was road transport (45 %), followed by the solvent use sector (28 %). Due to implementation of stringent controls required by the legislation on mobile sources, emissions from road transport are expected to be reduced by about 90 %, representing about 12 % in 2030, while the share of emissions from the solvent use and process sectors increase to 40 % and 18 %, respectively. Baseline emissions aggregated at the EU level are expected to comply with the 2010 NECD ceilings, although compliance may vary between individual Member States. Implementation of best available control technology in the MTFR scenario reduces the emissions by a further one third (to 4.1 million tonnes).

- Substantial reductions are projected for emissions of $SO_2$ by 2030. In the baseline scenario, emissions are expected to decrease by 67 % (to 2.9 million tonnes). This is due mainly to stringent controls in the energy sector, which will decrease its share from 65 % in 2000 to 32 % in 2030. Baseline emissions aggregated at the EU level are expected to comply with the 2010 NECD ceilings, although compliance may vary between individual Member States.

  The MTFR scenario indicates that despite the very high reductions achieved in the baseline scenario, there is still a high potential to reduce emissions through implementation of best available technology. Thus in the MTFR scenario emissions are reduced by another 45 % (to 1.1 million tonnes). While the sectoral composition of $SO_2$ emissions in 2000 showed that combustion in energy industries (power plants) was responsible for about 65 % of emissions, followed by combustion in manufacturing industry (15 %), non-industrial combustion plants (8 %) and production processes (7 %), in the MTFR scenario in 2030 the share of emissions from power plants are expected to decrease to 32 %, with a simultaneous increase of the shares of manufacturing industries and production processes (to 25 % and 29 % respectively).

- In contrast, $NH_3$ emissions (responsible for eutrophication and acidification) are projected to decrease only slightly (6 %) to 3.6 million tonnes in 2030 in the baseline scenario. Emissions from the EU-15 decrease while those from the New-10 increase slightly; however, the EU-15 still represents about 82 % of EU emissions in 2030. Baseline emissions aggregated at the EU level are expected to comply with the 2010 NECD emission ceilings by a thin margin.

  The MTFR scenario indicates that the potential to reduce $NH_3$ emissions is substantial and corresponds to a 40 % reduction compared with baseline emissions. The share of the agricultural sector in ammonia emissions remains at about 90 % over the period, 82 % of which originates from livestock farming. The remaining emissions stem mainly from the waste treatment sector.

- The baseline scenario projects future emissions of $PM_{10}$ and $PM_{2.5}$ to decrease further, although much more slowly than in the last decade ([124]). By 2030, $PM_{10}$ and $PM_{2.5}$ emissions are projected to be reduced by 38 % and 46 % respectively compared with 2000 levels. The EU-15 represents slightly more than 80 % of the total $PM_{10}$ and $PM_{2.5}$ emissions.

  The MTFR scenario suggests that the potential for reduction in 2030 is about 46 % for $PM_{10}$ and 50 % for $PM_{2.5}$ compared with the baseline. In 2000, 70 % of EU emissions of $PM_{10}$ originated from four sectors: non-industrial combustion plants (28 %), road transport (16 %), production processes (15 %), and combustion in energy industries (11 %); 73 % of EU emissions of $PM_{2.5}$ in 2000 stemmed from the following sectors: non-industrial combustion plants (35 %), road transport (18 %), non-road mobile sources (11 %), production processes (10 %), and combustion in energy industries (9 %). In the MTFR scenario, the shares of non-industrial combustion and energy industries in $PM_{10}$ emissions by 2030 are expected to decrease to 12 % and 3 % respectively. With regard to $PM_{2.5}$, non-road mobile sources and non-industrial combustion plants are expected to represent 21 % and 4 % respectively. Although strict standards have been imposed on exhaust PM emissions from transport sources, total emissions from transport will not decrease proportionally to the stringency of the standards. This is because non-exhaust emissions (tyre and brake wear, which remain uncontrolled) will increase proportionally to traffic volume.

- International emissions from shipping (125) are expected to increase considerably in the baseline scenario: in 2030 $NO_X$ emissions increase by 87 % compared with 2000 and $SO_2$ emissions by 82 %. Emissions of NMVOC, $PM_{10}$ and $PM_{2.5}$ are projected to more than double. In 2030, shipping emissions are expected to exceed land-based emissions of $NO_X$ and $SO_2$, while $PM_{10}$ and $PM_{2.5}$ emissions would represent 30 % and 45 % respectively. The MTFR scenario indicates that the scope for reducing emissions through best available technology is very large for $NO_X$ and $SO_2$ (88 % and 78 % respectively in 2030).

### 4.2.2 *Impacts on health and ecosystems*

This section reports the expected impacts of air pollutant emissions on a range of health and environmental indicators (126).

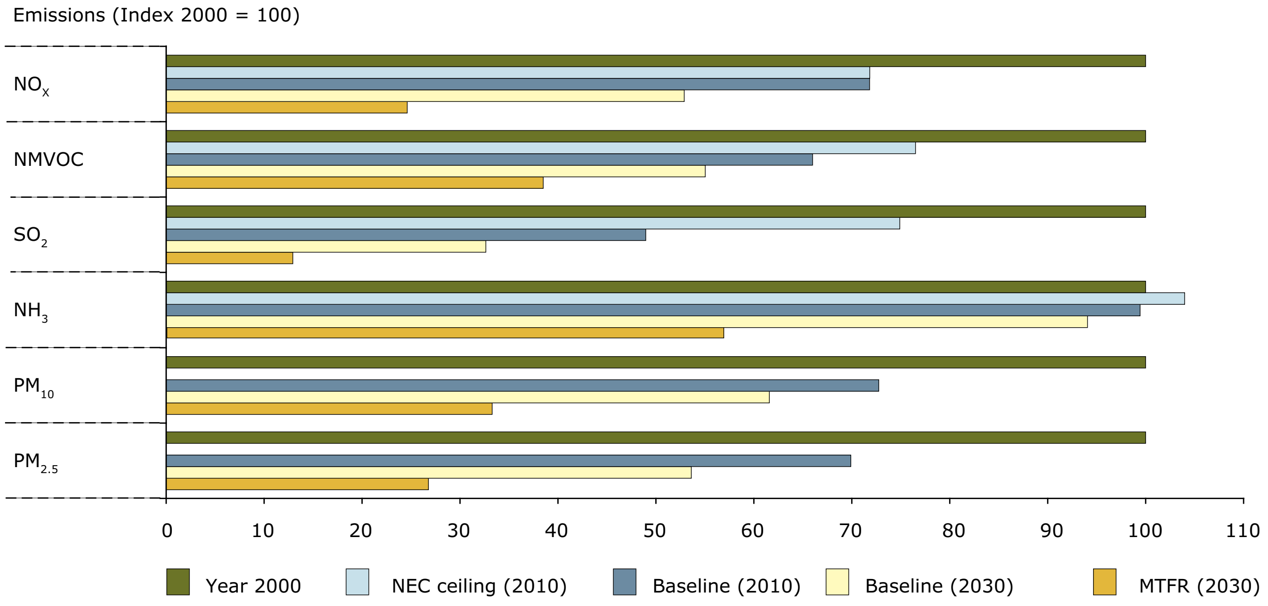
- The loss of statistical life expectancy in the EU attributable to the identified anthropogenic contributions of $PM_{2.5}$ is estimated in 2000 at approximately 9 months. Spatial analysis suggests that there are several hot-spots in central Europe where the statistical loss of life expectancy in 2000 was particularly high. The MTFR scenario suggests that by 2030 the expected loss in life expectancy could be reduced to about 2 months, as dramatic decreases of losses throughout Europe would be observed.

- The premature deaths attributable to exposure to ground-level ozone, estimated at about 49 cases per million inhabitants on average in 2000 in the EEA region, are expected to be about 26 cases per million inhabitants by 2030 in the MTFR scenario. The MTFR scenario therefore indicates that there is a large scope for reducing exposures if best available technology is introduced on a large scale. Exposure parameters (such as the SOMO35 used to assess health damage) are generally highest for southern countries (Italy, Spain, Greece, Bulgaria).

The assessment of ecosystem impacts includes damage of vegetation by ground-level ozone, acid deposition on forest and semi-natural ecosystems and freshwater bodies, and the excess of nitrogen deposition.

- Excess ozone, which is considered harmful to forest trees, has been calculated for 2000 for large parts of the EU, specially in the central and southern parts. In the MTFR scenario, the area affected by 2030 would be limited to a number of hot spots, mainly in Italy.

**Figure 4.5 Emissions of air pollutants (baseline and MTFR scenarios)**



- About 18 % of forests in the EU-15 countries received acid deposition above critical loads in 2004 (central Europe, UK and Scandinavia are generally the areas with most exceedance). The corresponding figure for the New-10 was 35 %. The MTFR scenario indicates dramatic decreases by 2030 in the area of exceedances, with less than 5 % of the forest area in the EU-15 at risk of acidification (only some parts of Germany and Benelux have heavy exceedances) while virtually no forest has exceedances in the New-10.

- In the five EU countries that have provided estimates of critical loads for semi-natural ecosystems (127), about 25 % of the area was receiving acid deposition above critical loads in 2000 (Italy is estimated not to have any area with exceedances). The MTFR scenario indicates dramatic decreases by 2030 in the area of exceedances, with less than 2 % of the area at risk of acidification.

- In the five European countries which have estimated critical loads for the catchments areas of freshwater bodies (lakes and streams) (128), about 23 % of the area were receiving acid deposition above their critical loads in 2000. The MTFR scenario indicates dramatic decreases by 2030 in the area of exceedances, with less than 6 % of the area at risk of acidification. However, one has to note that recovery from acidification requires acid deposition to stay below the critical loads for some time.

**Table 4.3 Emissions of air pollutants (baseline and MTFR scenarios, 1 000 tonnes)**

| | | 2000* | NEC ceiling 2010 | Baseline 2010 (index) | Baseline 2030 (index) | MTFR 2030 (index) |
|---|---|---|---|---|---|---|
| | | | **Land-based** | | | |
| **$NO_x$** | **EU-25** | 11 581 | 8 319 | 8 316 *(72)* | 6 125 *(53)* | 2 849 *(25)* |
| | **EU-15** | 9 911 | 6 519 | 7 145 *(72)* | 5 348 *(54)* | 2 532 *(26)* |
| | **New-10** | 1 670 | 1 800 | 1 171 *(70)* | 777 *(47)* | 317 *(19)* |
| **NMVOC** | **EU-25** | 10 654 | 8 150 | 7 031 *(66)* | 5 863 *(55)* | 4 101 *(38)* |
| | **EU-15** | 9 344 | 6 510 | 6 129 *(66)* | 5 156 *(55)* | 3 698 *(40)* |
| | **New-10** | 1 310 | 1 640 | 902 *(69)* | 707 *(54)* | 403 *(31)* |
| **$SO_2$** | **EU-25** | 8 736 | 6 543 | 4 278 *(49)* | 2 851 *(33)* | 1 130 *(13)* |
| | **EU-15** | 6 040 | 3 850 | 2 656 *(44)* | 2 187 *(36)* | 978 *(16)* |
| | **New-10** | 2 696 | 2 693 | 1 622 *(60)* | 664 *(25)* | 152 *(6)* |
| **$NH_3$** | **EU-25** | 3 824 | 3 976 | 3 802 *(99)* | 3 597 *(94)* | 2 174 *(57)* |
| | **EU-15** | 3 234 | 3 110 | 3 184 *(98)* | 2 952 *(91)* | 1 866 *(58)* |
| | **New-10** | 590 | 866 | 618 *(105)* | 645 *(109)* | 308 *(52)* |
| **$PM_{10}$** | **EU-25** | 2 455 | n.a. | 1 786 *(73)* | 1 512 *(62)* | 817 *(33)* |
| | **EU-15** | 1 830 | n.a. | 1 403 *(77)* | 1 234 *(67)* | 699 *(38)* |
| | **New-10** | 625 | n.a. | 383 *(61)* | 278 *(44)* | 118 *(19)* |
| **$PM_{2.5}$** | **EU-25** | 1 748 | n.a. | 1 222 *(70)* | 937 *(54)* | 468 *(27)* |
| | **EU-15** | 1 323 | n.a. | 955 *(72)* | 761 *(58)* | 405 *(31)* |
| | **New-10** | 425 | n.a. | 267 *(63)* | 176 *(41)* | 63 *(15)* |
| | | | **Shipping** (129) | | | |
| **$NO_x$** | | 3 501 | n.a. | 4 265 *(122)* | 6 530 *(187)* | 769 *(22)* |
| **NMVOC** | | 131 | n.a. | 170 *(130)* | 284 *(217)* | 284 *(217)* |
| **$SO_2$** | | 2 418 | n.a. | 2 652 *(110)* | 4 406 *(182)* | 972 *(40)* |
| **$PM_{10}$** | | 222 | n.a. | 270 *(122)* | 450 *(203)* | 385 *(173)* |
| **$PM_{2.5}$** | | 210 | n.a. | 255 *(121)* | 426 *(203)* | 364 *(173)* |

* Index 100 = 2000

**Note**: For details about the 2020 CAFE results, see the final report 'Baseline scenarios for the Clean Air for Europe (CAFE) programme' available at: http://europa.eu.int/comm/environment/air/cafe/general/pdf/cafe_lot1.pdf.

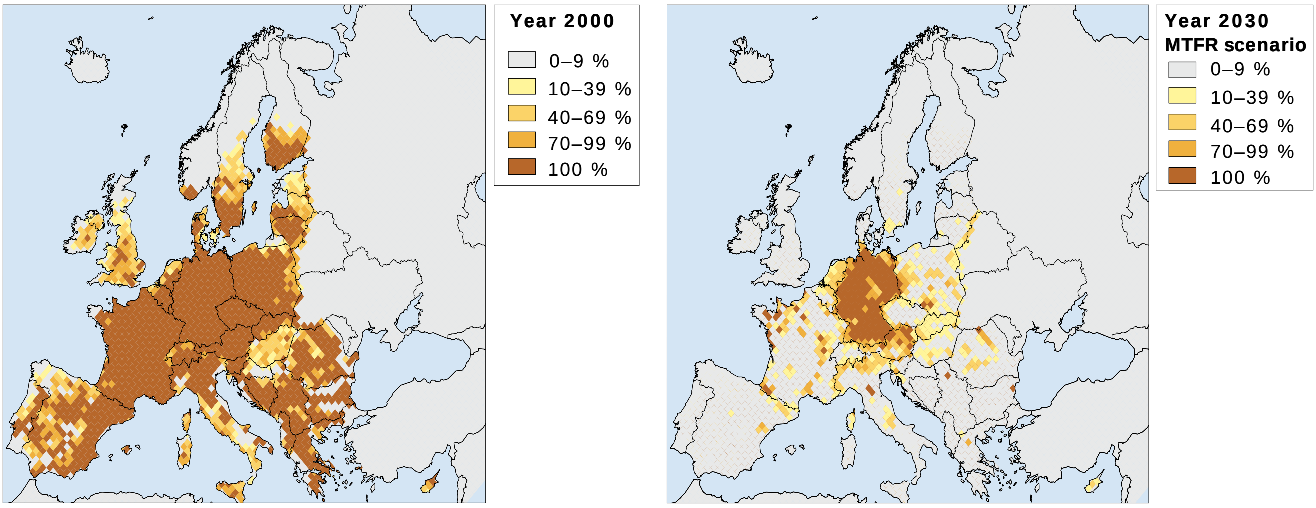
- In 2000, more than 55 % of ecosystems were endangered by eutrophication (54 % for EU-15, 71 % for the New-10). Spatial analysis suggests that virtually all countries were subject to high exceedances of nitrogen in 2000 (see Map 4.3). The MTFR scenario suggests that the ecosystem area with exceedances could be reduced to about 10 % across the EU in 2030, hence reducing the eutrophication problem, which otherwise in the baseline scenario remains a major concern over the entire period (due to limited reduction in $NH_3$ and despite significant reduction in $NO_X$). Most ecosystems in European countries therefore are not expected to receive nitrogen deposition above critical loads, except those in Germany which are expected to remain largely affected.

### 4.2.3 *Emerging challenges*

The projections suggest that the relevance of different pollution sources will change in the future. Traditionally large polluting sectors are expected to reduce their shares of total emissions dramatically, because of the enforcement of stringent control measures. In turn, other sources, which have received less attention in the past, are expected to become dominating contributors. In 2030, the major contributions to land-based $SO_2$ emissions are expected to come from industrial combustion and process sources. $NO_X$ emissions originate mainly from heavy-duty diesel vehicles and off-road machinery. Solvents become the major source of VOC emissions, and wood burning and industrial processes are responsible for the majority of emissions of fine particulate matter. Risk to ecosystems from acidification and eutrophication is expected to be dominated by ammonia emissions from the agricultural sector.

Although current legislation results in substantial improvement of impact indicators, it does not assure sustainable conditions. The scenario with the best available emission controls is much closer to sustainability targets, but even in this scenario environmental damage, in terms of impacts on human health and ecosystems, is likely to occur at least in some parts of Europe. In addition, assessed impacts differ substantially between regions in Europe.

**Map 4.3 Excess of nitrogen deposition**



**Note**: Percentage of total ecosystems area receiving nitrogen deposition above the critical loads (data base of 2004). Note that calculations are reported only for EEA member countries (except Iceland and Turkey).

## 4.3 Spotlight: water stress

**Key messages**

Total water abstraction in Europe is expected to decrease by more than 10 % between 2000 and 2030 with pronounced decreases in western Europe.

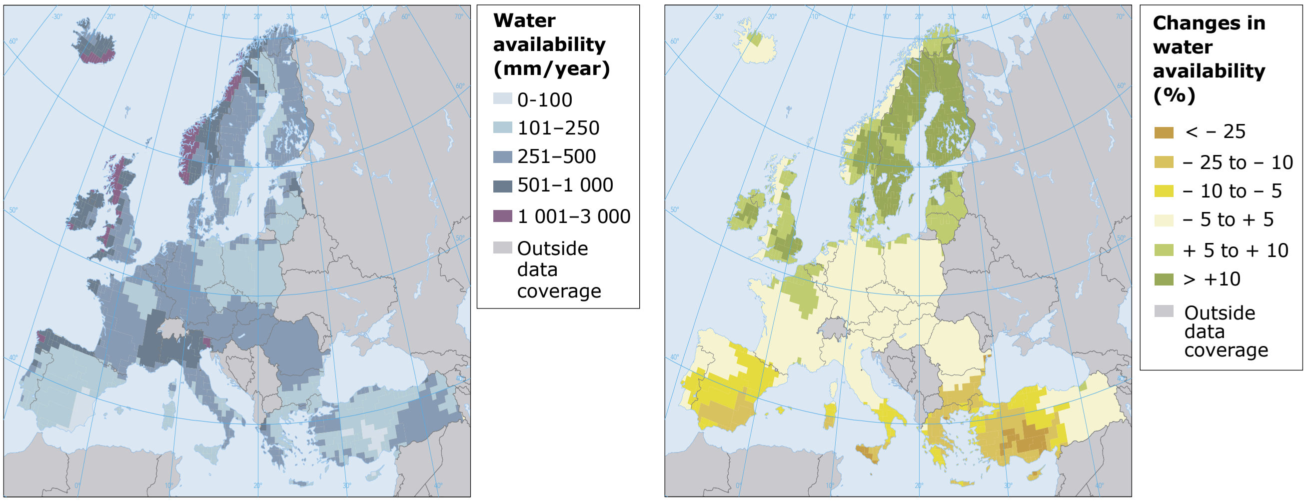
Climate change is expected to reduce water availability and increase irrigation withdrawals in Mediterranean river basins. Under mid-range assumptions on temperature and precipitation changes, water availability is expected to decline in southern and south-eastern Europe (by 10 % or more in some river basins by 2030).

The sectoral profile of water abstraction is expected to change: withdrawals for the electricity sector are projected to decrease dramatically over the next 30 years as a result of continuing substitution of once-through cooling by less water-intensive cooling tower systems. Water use in the manufacturing sector is likely to continue to grow. In eastern Europe, water use in the domestic sector may grow significantly. Agriculture is expected to remain the largest water user in the Mediterranean countries, with more irrigation and warmer and drier growing seasons resulting from climate change.

Across Europe, about 300 $km^3$ (i.e. 300 billion $m^3$) of water is currently withdrawn every year — about equal to the combined annual water discharge at the mouths of three major European rivers: Danube, Rhine and Loire. This amounts to roughly a tenth of Europe's annually available freshwater resources. Most of this water is used in agriculture (37 %) and the energy sector (32 %); households (24 %) and the manufacturing (13 %) complete the picture. Some of this water is cleaned and returned after use, particularly that withdrawn for cooling in electricity generation. Nevertheless, a considerable fraction is 'consumed' or evaporates once withdrawn (130). Large water abstraction generally affects the status of water bodies with regard to their quantitative amount, ecological integrity or chemical composition.

The EU's water framework directive (issued in October 2000) and the 6th environment action programme set a goal of achieving a 'good status' (ecological, chemical and quantitative) for all Community water bodies by 2015. Both programmes stress the need for close international cooperation at the river-basin level, and call for individual river-basin management plans for all European waters. Further key EU policy objectives include the promotion of sustainable water use, improved protection of aquatic ecosystems, reduced pollution of surface and groundwaters,

**Map 4.4 Water availability**



Current water availability in European river basins

Changes in average annual water availability under the LREM-E scenario by 2030 and the mitigation of the effects of floods and droughts (131).

The 1990s saw a general decrease in total water abstraction. However, trends differ considerably between regions and sectors, and leave several outstanding problems (including a continuing increase in water demand for irrigation in southern Europe) and geographical 'hot-spots' (with severe over-abstraction around several large cities and along the Mediterranean coast and islands).

The water availability and water use outlook presented here is based mainly on the baseline assumptions for the key driving forces (see Chapter 3), and the climate change-related temperature and precipitation changes that follow from these (see Section 4.1) (132). Important additional assumptions relevant to a 20–30 year outlook include the rate of technological change (improved efficiency of water-use appliances), the changes in water use in electricity production (mainly substitution of once-through cooling with other cooling systems in thermal power plants), the expansion and utilisation of irrigated areas, and the average use of water in households.

### *4.3.1 Water availability outlook*

The Intergovernmental Panel on Climate Change has repeatedly warned that climate change could further decrease water availability in many already water-scarce areas. The changes in river-flow and groundwater recharge are expected to vary between regions, and to depend critically on the degree and types of climate change.

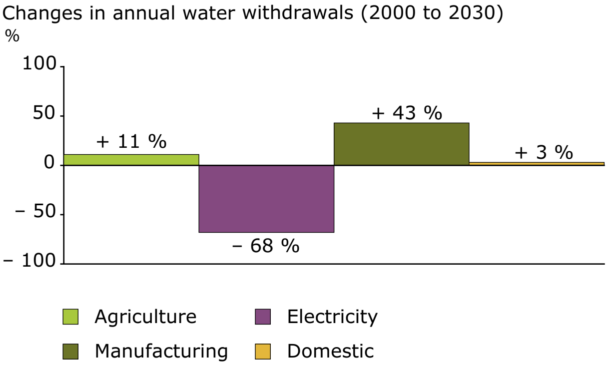
Under the climate change assumptions outlined above (i.e. an increase in global average temperature over pre-industrial levels of 1.3 °C by 2030 and 3.1 °C by 2100), changes in average water availability in most European river basins are estimated to be relatively small over the next 30 years. Increases in annual run-off are expected for several river basins in northern Europe as average precipitation increases.

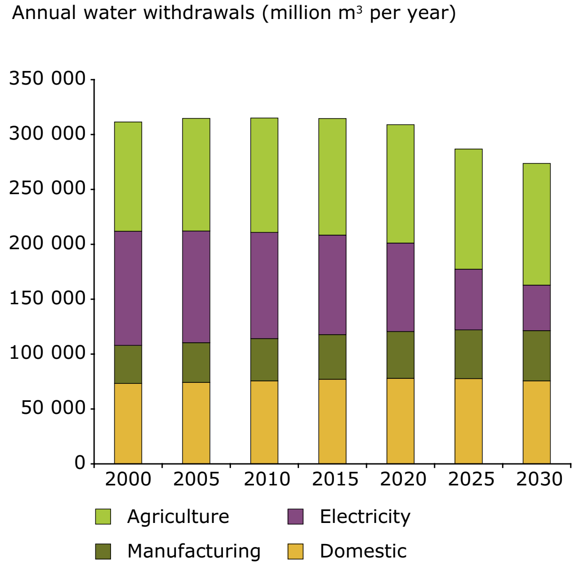
In contrast, average run-off in southern European rivers is projected to decrease with increasing temperature and decreasing precipitation. In particular, some river basins in the Mediterranean region, which often already face water stress, may see decreases of 10 % or more below today's levels by 2030 (see Map 4.4). In the longer term, changes in water availability are likely to develop more noticeably, making the general developments expected above more pronounced.

While the changes in average annual water availability over the next 30 years may be relatively small in most parts of Europe, possible changes in intra-annual climatic variability are likely to be followed closely by changes in intra-annual water availability. Changing temperature and precipitation patterns, accompanied by increased water abstraction in some regions, may also change the frequency and intensity of droughts, particularly in southern and parts of central Europe. Similarly, changes in extreme

**Figure 4.6 Water abstraction in Europe (EEA-31 without data for Iceland)**

| Sector | Withdrawals in 2000 |
|---|---|
| Agriculture | 99.6 km³ (32 %) |
| Electricity | 95.0 km³ (31 %) |
| Manufacturing | 39.8 km³ (13 %) |
| Domestic | 73.2 km³ (24 %) |


Changes in annual water withdrawals (2000 to 2030)


Annual water withdrawals (million m³ per year)

flood events are also expected to follow changing climate patterns.

Under a low greenhouse gas emissions scenario (as introduced in Chapter 3, in Box 3.3), temperature increases and precipitation changes are expected to occur at a slower rate than under the baseline scenario. Thus, the general pattern of change in water availability in a low emission scenario is expected to be nearly identical to the baseline pattern, but marginally smaller (the changes by 2030 differ by roughly 10 % or less from those shown in the right-hand map in Map 4.4). Thus, the expected impacts of different climate policies on annual river run-off are relatively small in the short and mid-term, mainly because of the enormous inertia of the global climate system. However, in the longer term, initiatives and policies that effectively mitigate severe climate change should also mitigate associated changes in water availability.

### 4.3.2 *Water use outlook*

Under the baseline scenario assumptions, water withdrawal across Europe is expected to decrease by about 11 %, to less than 275 km$^3$ per year by 2030 (from about 300 km$^3$ in 2000 — see Figure 4.6). While large decreases are expected in water withdrawals for cooling purposes in electricity production across Europe, there is considerable variation in the water use outlook of different regions and sectors (i.e. households and domestic purposes, manufacturing, cooling for electricity production, and agriculture and irrigation).

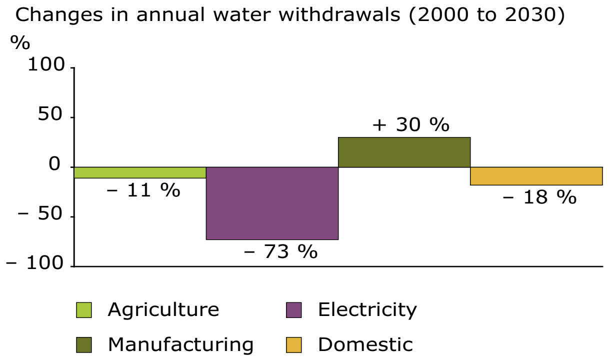
Agriculture accounts for about one-third of the total water abstraction in Europe, used mostly for irrigation. The amount of irrigation water needed per crop and hectare depends mainly on soil and climate conditions, and on the efficiency of the irrigation systems. Estimates of future water abstraction for agriculture are closely correlated to estimates of the future area under irrigation (133). Under baseline assumptions, this is expected to increase by 20 % or more by 2030 in southern Europe, the EU candidate countries, and in Hungary, Malta, and Cyprus, while remaining more or less at current levels in other European countries.

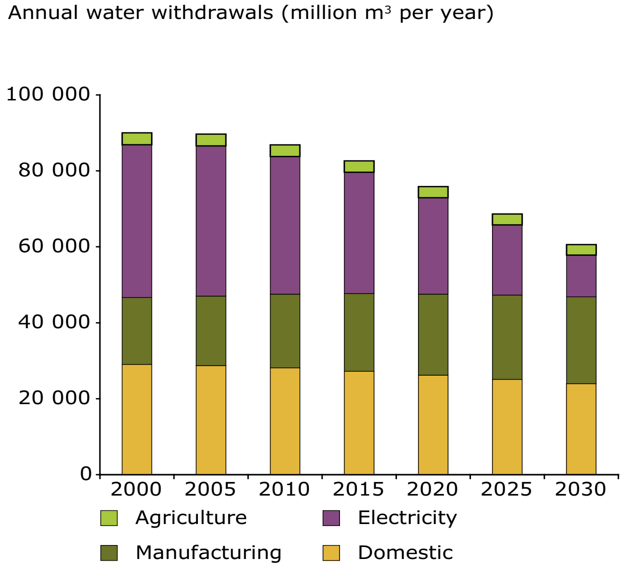
Large decreases in water withdrawal for electricity production are likely. Many older power stations rely on once-through cooling systems, and newer plants are expected to replace many of these over the next 30 years. The newer plants usually operate with tower cooling systems (134), which should result in substantial reductions, of 50 % or more, in water withdrawal, despite an expected near doubling of thermal electricity production in Europe between 1990 and 2030 (see Chapter 3).

Under the low greenhouse gas emissions scenario (Box 3.3), reductions in water withdrawal would be even more pronounced (by up to 10 %), as fossil fuel power is replaced by renewable energy sources that are not cooling-intensive. However, water consumed (the part of the withdrawal that is not returned to the river) is projected to increase somewhat under both the baseline and the low emissions scenario, since evaporation is about twice as high in newer

**Figure 4.7 Water abstraction in northern Europe**

| Sector | Withdrawals in 2000 |
|---|---|
| Agriculture | 3.1 km$^3$ ( 3 %) |
| Electricity | 40.3 km$^3$ (45 %) |
| Manufacturing | 17.6 km$^3$ (20 %) |
| Domestic | 29.1 km$^3$ (32 %) |


Changes in annual water withdrawals (2000 to 2030)


Annual water withdrawals (million m$^3$ per year)

tower-cooling plants than in once-through cooling systems (135).

The development of water use in households varies considerably across Europe. On average a quarter of European water abstraction is for use in the 'domestic sector', which includes households and small businesses. The future water demand of this sector is highly uncertain and will depend on a wide range of factors, including the incomes and sizes of households (water use per person usually increases with income and with fewer people per household), the age distribution of the population (water use varies considerably between different age groups), tourism and water pricing (high water prices reduce the demand for water in households, but the relationship between prices and use is highly variable ) (136). Another important factor is technological change, which generally increases the water-use efficiency of household appliances, and thus reduces total water withdrawals (137).

Increases in water abstraction for manufacturing (138) are also expected with continuing growth in economic activity and output. Although future water-use estimates for different industries entail considerable uncertainty, the increases are expected to be significant (more than 20 % in most countries); in the faster-growing economies of the EU candidate countries, where current abstraction for manufacturing is relatively low, water use may even double. The large uncertainties in this estimate relate to the uptake of new less water-intensive technologies such as electronics, the future of existing water-intensive industries, and the possible emergence of more water-intensive manufacturing processes.

### Northern Europe

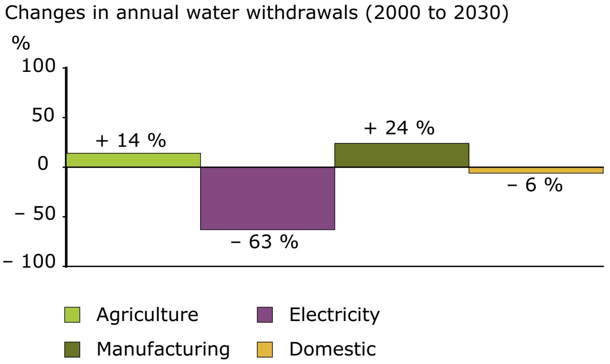
Water withdrawal in northern Europe (139) is dominated by electricity production, and its share is expected to decrease substantially (see above). In contrast, withdrawal for manufacturing is likely to play a much larger role, despite increased water-use efficiency with technological change. And technological improvements in water-use efficiency are expected to lead to a further decrease or at least a stabilisation of average water use by households. Agricultural water withdrawal is relatively small, and may even decrease further with changing climate conditions, technologically-improved irrigation systems and a more or less constant area under irrigation (see Figure 4.7).

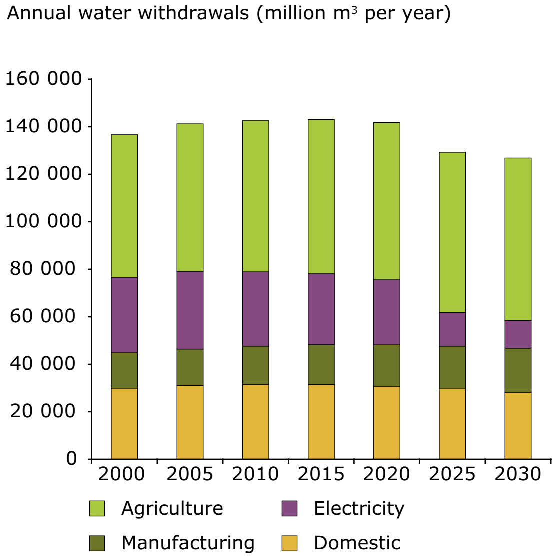
### Southern Europe

Water withdrawal for irrigation is the largest share of overall water abstraction in southern Europe (140) and will be in future. Continuously improving efficiency in irrigation water use decreases water withdrawal per unit irrigated, but the savings are offset by an increase in the utilised irrigated area, leading to an increase of more than 15 % in withdrawals for agriculture (utilized irrigated area is assumed to expand by more than 20 % by 2030). However, even if the area under irrigation remains constant over the next 30 years, changing climate conditions alone are estimated to increase irrigation requirements by around 5 %.

**Figure 4.8 Water abstraction in southern Europe**

| Sector | Withdrawals in 2000 |
|---|---|
| Agriculture | 60.0 km³ (44 %) |
| Electricity | 31.8 km³ (23 %) |
| Manufacturing | 14.9 km³ (11 %) |
| Domestic | 29.9 km³ (22 %) |


Changes in annual water withdrawals (2000 to 2030)


Annual water withdrawals (million m³ per year)

In the other main water-use sectors (electricity, manufacturing and domestic) the dynamics in southern Europe are expected to be similar to those in northern Europe, i.e. large decreases in withdrawals for electricity production and some increase for manufacturing (see Figure 4.8).

### New EU Member States

A major uncertainty in the new EU Member States (141) is future domestic water use. Water use per capita in households decreased markedly during the 1990s in all the countries expect Malta and Cyprus. Assuming that water use per person rises gradually to the level of other EU countries by 2030, total water abstraction by households may increase substantially (by as much as 74 %) despite decreasing populations and more water-efficient household appliances (average water use in these countries in 2000 ranged from about 40 $m^3$ per person per year (Baltic countries) to more than 100 $m^3$ per person per year (Cyprus) compared with the EU average of about 125 $m^3$ per person per year).

If water use per capita were to remain at 2000 levels instead of rising to the current EU average, domestic withdrawals would be only about half of the values projected for 2030 (i.e. total domestic water use would actually be less than today). This range (i.e. small decreases to major increase) highlights the large uncertainty in water-use projections, but also suggests avenues for future water savings in this and other regions.

Water use in electricity production in the new EU Member States is likely to follow a similar dynamic to that in northern and southern Europe, i.e. marked decreases as power plants that rely on once-through cooling systems are replaced. As in other European regions, water use in the manufacturing sector is expected to increase with increasing economic activity. Agricultural water use is expected to remain more or less constant, as the adverse effects of climate change in this region are estimated to be of the same order of magnitude as the water savings expected from more efficient irrigation systems (see Figure 4.9).

### EU candidate countries

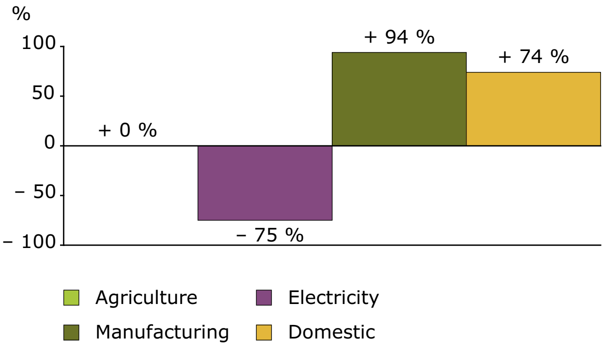
Changes in water use in the EU candidate countries (142) are very dynamic; while total abstraction is expected to decline in most of Europe, they are expected to increase significantly in these countries (primarily in Turkey).

The trend for withdrawals for manufacturing is expected to be similar to that in the rest of Europe, but somewhat more pronounced as economic activity is assumed to grow more quickly (in relative terms). In the domestic sector, Turkey is expected to experience marked increases because of continuing population growth (23.5 million more people by 2030, see Chapter 3) and increased per-capita water use (current per-capita use in households is about half the EU average). Water withdrawals may also increase somewhat in the agricultural sector, due to drier and warmer climate conditions and an expected rise in the area irrigated of around 20 % (143). Combined with the use of more water-efficient irrigation systems, overall water withdrawal increases for irrigation are estimated to be about 10 % (see Figure 4.10).

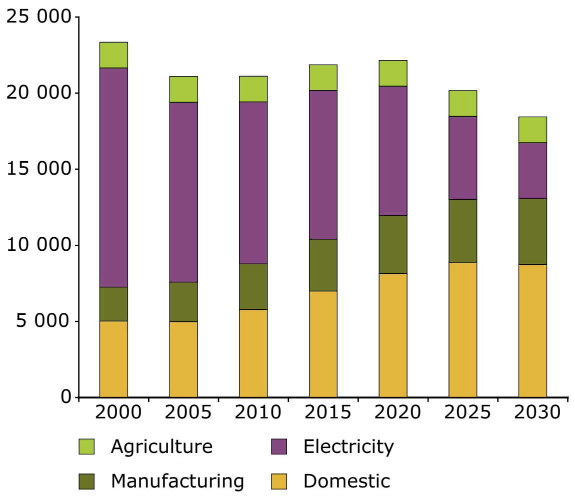
**Figure 4.9 Water abstraction in new EU Member States**

| Sector | Withdrawals in 2000 |
|---|---|
| Agriculture | 1.7 $km^3$ ( 7 %) |
| Electricity | 14.4 $km^3$ (61 %) |
| Manufacturing | 2.2 $km^3$ (10 %) |
| Domestic | 5.0 $km^3$ (22 %) |

Changes in annual water withdrawals (2000–2030)



Annual water withdrawals (million $m^3$ per year)



Since the outlook for total water use varies considerably across Europe and sectors, strategies aimed at reducing water abstraction need to take a multi-sectoral approach and be targeted by region or individual river basin. In this respect, the mechanism laid out in the EU's water framework directive, which calls for regionally-targeted approaches to river basin management, provides an ample framework for further reductions in water use.

### *4.3.3 Water stress outlook*

Water stress is a measure of the pressures that water abstraction (144) places on water resources and aquatic ecosystems. Map 4.5 (left) provides an overview of river basins that currently face high levels of water stress: these are mainly the dry and irrigation-intensive river basins in southern Europe and hot-spots around urban centres. Large parts of central Europe also have relatively high levels of water withdrawal compared with availability, but these often include large withdrawals for electricity production, i.e. water that is used but returned to the river system more or less unpolluted.

If water withdrawal for electricity production plummets as assumed, water stress, particularly in the central European river basins (Rhine, Elbe), is expected to decrease significantly over the next 20 to 30 years. Indeed most large European river basins are likely to see decreasing levels of water stress over the next 30 years (see Figure 4.11). The situation is different in river basins in the Mediterranean countries, where the interplay between decreasing water availability as a result of changing climate conditions and increasing water withdrawals for irrigation and manufacturing (and, in Turkey, for domestic use) is expected to lead to higher level of water stress (prominent examples are the Spanish rivers of Guadalquivir and Guadiana, and the Kizil Irmak in Turkey).

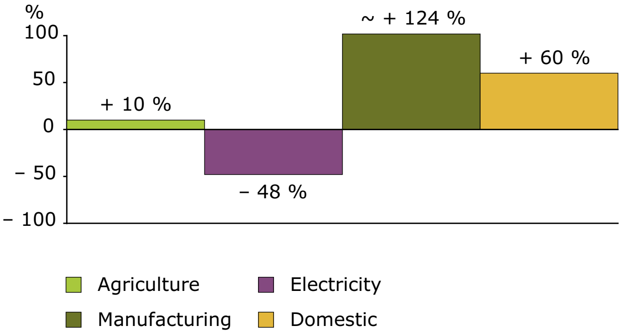
A possible increase in water stress in general would also pose an increased risk on food production in drought-prone regions. Expanding irrigated areas in already water-stressed regions may deteriorate the ecological and chemical status of freshwater bodies in these areas in two ways: increased water abstraction may increase water stress levels, and agricultural return-flows (145) may have a higher pollution load which could further decrease water quality. This underlines the indirect yet close linkages between water quality/quantity issues and agricultural policies.

Another important dimension to water stress is the changes in intra-annual variability of water availability and abstraction, which may result in changes in the frequency of droughts and floods. Recent extreme weather events have been seen as a harbinger of future conditions, but research so far has fallen short of providing proof of a causal link to climate change. Nevertheless it has been argued (146) that increases in precipitation and changing snow-melt patterns are likely to increase flood risk in northern Europe, and that continuing high water abstraction paired with the expected reduction in rainfall may lead to more frequent hydrological droughts in southern Europe.

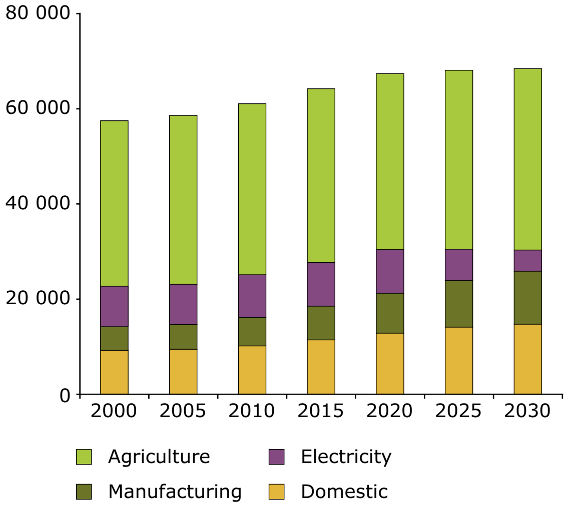
**Figure 4.10 Water abstraction in EU candidate countries**

| Sector | Withdrawals in 2000 |
|---|---|
| Agriculture | 34.8 km³ (60 %) |
| Electricity | 8.5 km³ (15 %) |
| Manufacturing | 5.0 km³ ( 9 %) |
| Domestic | 9.2 km³ (16 %) |

Changes in annual water withdrawals (2000 to 2030)



Annual water withdrawals (million m³ per year)



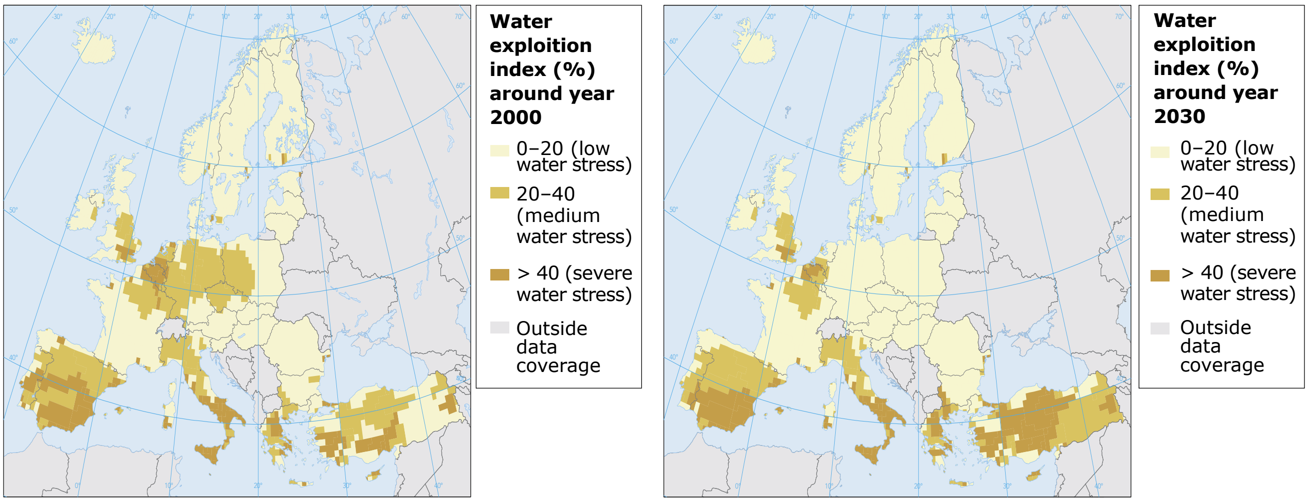
### *4.3.4 Emerging challenges*

The complexity of the prospects and associated uncertainties of this outlook for water availability and water use in different European sectors and regions highlights the need for integrated and multi-sectoral approaches to promote sustainable use of water resources.

With this perspective the European water framework directive addresses the overall need for such approaches, but regional policy and legal measures need to address the issues specific to individual river basins. Such endeavours for further reductions, implementation of appropriate legal instruments, technological shifts and new consumption patterns aiming at water efficiency are important in river basins with severe water stress and seemingly water-abundant areas alike. The driving forces that are key to current and future water stress are also at the heart of other environmental concerns (see Chapter 2). Thus water policies indirectly also address a wider range of environmental concerns — and vice versa (e.g. renewable electricity production is usually also less cooling-intensive).

An example of a policy measure to control or reduce water demand by different users is water pricing. Indeed, most European countries either have already moved or are moving towards implementing water-pricing systems. However, quantifying the effects of water prices at the European level, particularly in an outlook exercise, is complex. In general, increasing water prices have been accompanied by reduced water use in households. But it has been argued that water charges only represent a very small percentage of household income, and the exact correlation is unclear. It should be highlighted that the agricultural sector pays much lower prices than other sectors, particularly in southern Europe where water use for irrigation is high and commonly not metered. Increased prices are more likely to have a marked effect on water use where withdrawals are metered, water prices are high in relation to income, and water abstraction is high.

**Map 4.5 Water stress in Europe**



Current water stress in European river basins

Water stress in European river basins under the LREM-E scenario by 2030

**Box 4.3 Water stress defined**

Water stress occurs when there is an excessive abstraction of water in relation to the resources available in a particular area.

Water stress can be approximated by the *water exploitation index*, the ratio of annual water abstraction to average annual availability. If annual abstraction in a river basin exceeds 20 % of average annual availability, a river basin is characterised as being under 'water stress', if it exceeds 40 %, as under 'severe water stress'. Note that these thresholds are empirical average values, and that regions with a water exploitation index below 40 % may experience severe water stress during droughts or low river-flow periods.

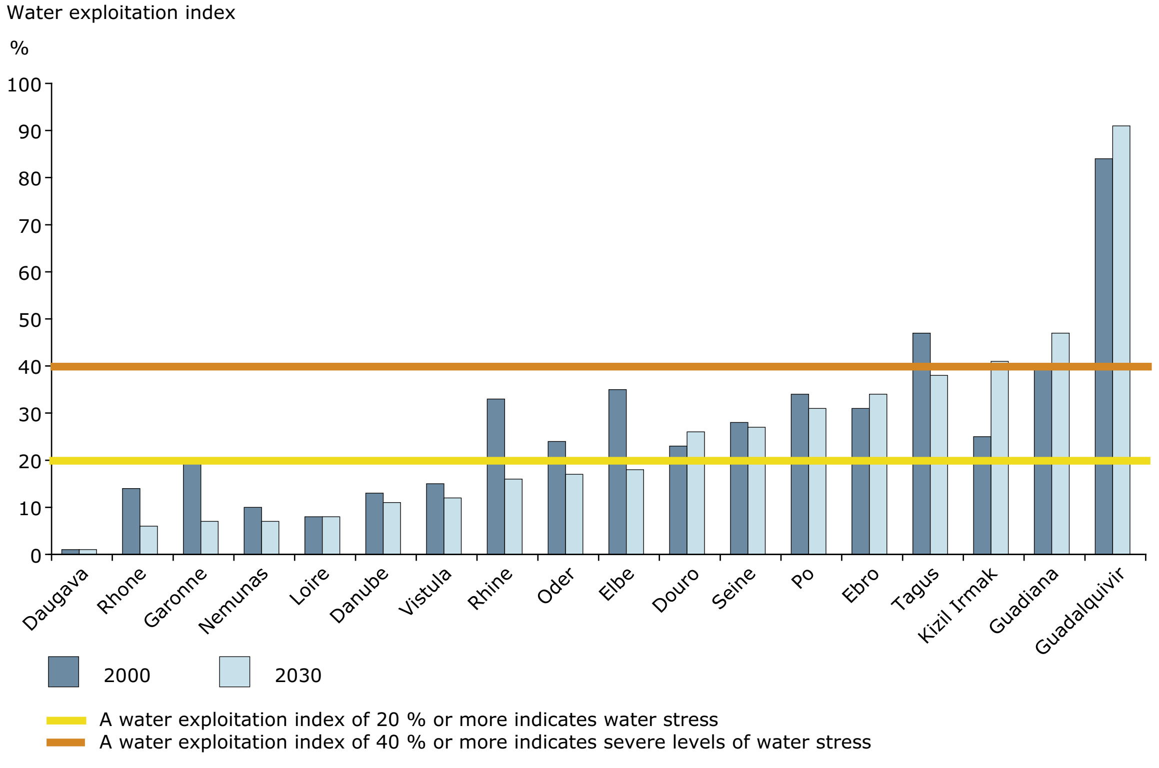
Generally speaking, high levels of water stress indicate imbalances in the quantitative and/or ecological status of water bodies. Water stress usually results in major competition between water users, possibly with limitations to downstream water use in low-flow periods. Minimum water requirements of aquatic ecosystems may also be threatened under severe water stress conditions, posing particular risks to the ecological health of downstream wetlands and river deltas.

Different ways of measuring water stress have been proposed and used in other studies:

*Water consumption index*, i.e. total consumption divided by average annual availability. The average water consumption index in Europe is around 3 %. In most Mediterranean countries this index is reported to be above 10 % (even above 20 % in Spain, Cyprus and Malta).

*Water availability index*, i.e. average annual water availability per person. A region is considered to have low levels of water availability if this index is below 5 000 $m^3$ per person per year, and to be 'water scarce' if it drops below 1 000 $m^3$ per person per year. In Europe, particularly in river basins in the south and in densely populated areas with moderate rainfall in the west, this index is reported to be low.

**Figure 4.11 Water stress in large European river basins, 2000 and 2030**



## 4.4 Spotlight: water quality

**Key messages**

By increasing the connection rate of the European population and the use of tertiary treatment, implementation of the UWWT directive is expected to make it possible to increase the amount of wastewater treated while reducing total discharges of nutrients.

The diverse situation in European countries regarding wastewater treatment systems is a challenge to the implementation of EU directives.

Diffuse sources of nutrients (e.g. agriculture) are expected to become prime issues to address as implementation of directives targeted at point sources results in significant reductions in their environmental impact (e.g. eutrophication).

This section reviews the baseline water quality projection, which specifically addresses the issue of nutrient discharges from urban wastewater treatment plants in Europe. The methodology used consists of a simple techno-economic model, which links discharges of nutrients to population growth in areas connected to sewers and to developments in treatment technologies. The outlook covers most of the EU member countries and intends to reflect the level of nutrient discharges (i.e. nitrogen (N) and phosphorous (P)) after the urban waste water treatment directive (UWWT, 91/271/EEC) is fully implemented ([147]).

Industrial production and household consumption increased at a rapid rate during the last century, producing larger amounts of wastewater. The extent to which this is discharged into surface waters depends on the sewage collection and treatment facilities available, as well as on the content of the items produced or consumed (e.g. phosphorus in detergents). In Europe most phosphorus loading of surface waters is attributable to discharges from point sources (in particular municipal sewage and industrial effluents), while nitrogen loading comes mainly from the use of nitrogen fertilisers and manure in agriculture. For an overview of past developments in wastewater treatment, see Box 4.4.

The central piece of legislation for this outlook is the Urban Waste Water Treatment Directive (91/271/EEC) ([148]). It is a key EU water policy, which aims at protecting the environment from the adverse effects of urban wastewater discharges. The directive sets minimum standards for the collection, treatment and disposal of wastewater that depend on the size of the agglomeration, and the type and sensitivity of the receiving waters. In general terms, the directive has to be fully implemented in the EU-15 countries by the end of 2005 and in the New-10 in the 2008–2015 period; the majority of the urban population will then be connected to tertiary or secondary treatment.

Since many EU-15 countries have delayed implementing the UWWT directive, and the New-10 have diverse transition periods, this outlook reports the expected discharges of nutrients *after* the implementation of the directive rather than by a specific date. There are many requirements and deadlines for implementation of the directive, and there is significant uncertainty regarding its final implementation.

Implementation of the UWWT directive is expected to lead to the following developments (see Figures 4.12 and 4.13) ([149]):

- A dramatic shift towards tertiary treatment is expected in the New-5 (Estonia, Czech Republic, Poland, Hungary and Slovenia) and Belgium and Luxembourg (Group 2), at the expense of primary and secondary treatment and significant levels of discharge without treatment. In the New-5, these improvements are expected to be accompanied by an increase in the connection of the population to wastewater treatment plants from 57 % to 70 %.

  For the Group 3 countries and the United Kingdom, in all of which a relatively low proportion of the territory is designated as sensitive area, the future development of wastewater treatment is expected to be characterised by an increasing connection rate (from 67 % to 80 %) and an enhanced diffusion of secondary treatment.

  Finally, only minor changes in the level and type of wastewater treatment are expected in Group 1 countries, since they already almost comply with the directive's requirements (i.e. in terms of level and type of wastewater treatment) and have a very limited amount treated only in primary facilities or discharged without treatment.

- Considerable reductions in nutrient discharges are expected in countries that experience a dramatic increase in tertiary treatment. Belgium and Luxembourg are projected to reduce their total discharges of nitrogen and phosphorous by 40 % and 80 % respectively. In the New-5, discharges are projected to decrease from 3 to 2.3 kg N/person/year (a 24 % reduction), and 0.4 to 0.15 kg P (62 %).

  In contrast, total discharges in Group 3 countries are expected to increase since the percentage of the population connected to UWWT plants will increase significantly while tertiary treatment will remain limited: nitrogen and phosphorous discharges are projected to increase by about 14 %, which, compared with a 29 % increase in the connected population, leads to a slight decrease of nutrient discharges per capita.

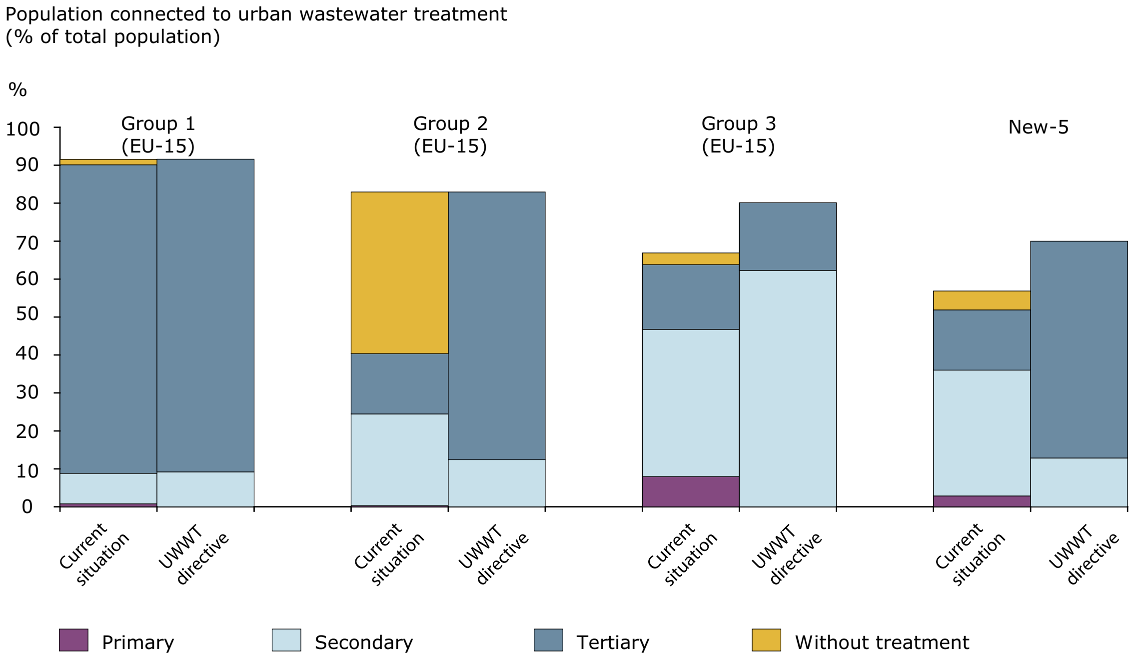
  Finally, discharges are expected to remain nearly unchanged in countries that have already almost achieved the directive's requirements (Group 1).

- Overall nitrogen and phosphorus discharges in countries with high levels of tertiary treatment are expected to be about 2.3 kg N/person/yr and 0.1 kg P. Countries that plan to rely essentially on secondary treatment are expected to have significantly higher discharges, in particular for phosphorous, by an estimated factor of three.

- At the country level, data and information on wastewater treatment and population distribution in terms of size of agglomeration are limited and heterogeneous, hence very difficult to compile into a European overview. There is also some uncertainty about the detailed national implementation of the UWWT directive (150). As a consequence, the projections reported here are subject to some uncertainty, and might conflict with national assessments.

By increasing the connection rate of the European population, the UWWT directive would in principle increase discharges of nutrients from UWWT plants; however, the increasing use of tertiary treatment that should result would make it possible to increase the amount of wastewater treated and achieve an overall decrease in discharges of nutrients. The net benefit to the environment, in terms of reduced discharges leading to less eutrophication, is therefore considerable since wastewater is expected to be more systematically treated in future and in a more efficient way (151).

**Figure 4.12 Current and projected levels of wastewater treatment in Europe**

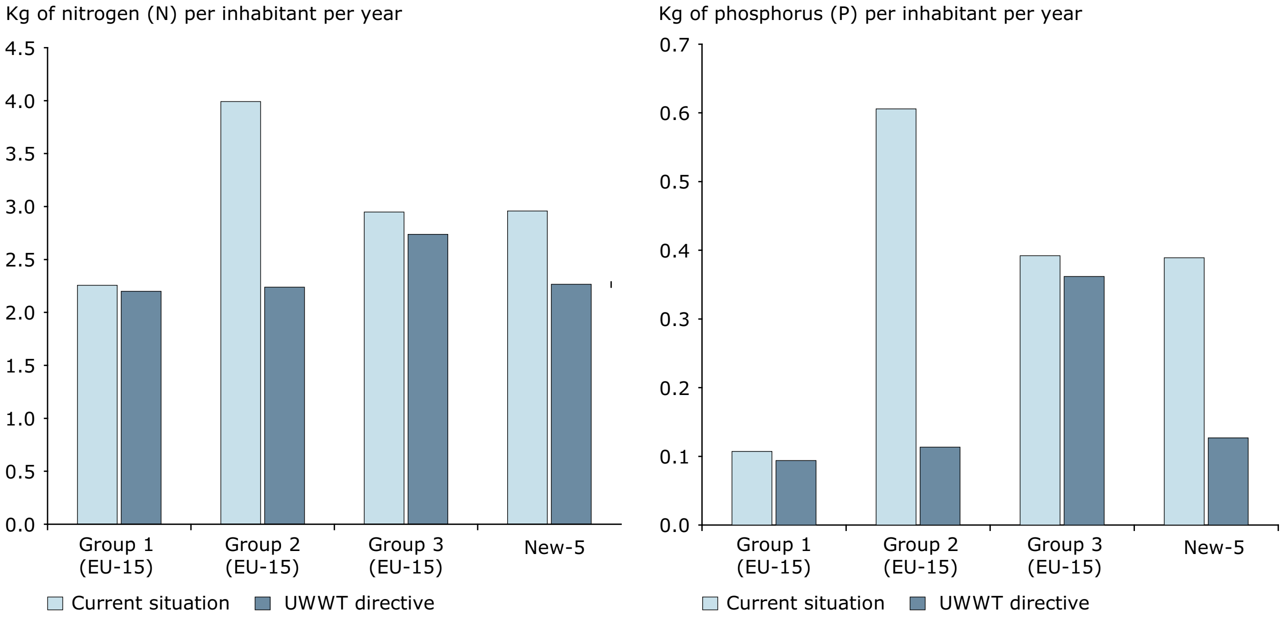


However, nutrient discharges from rural populations, usually not connected to collecting systems, are not accounted for or reported here; some of these pollutants may be retained in soil and wetlands before discharge to water. This issue is particularly important in the New-10 where about one third of the population lives in rural areas. With further economic development, a movement of people from rural areas to cities is expected in these countries.

The outlook has addressed the future development of nutrient discharges from UWWT plants, i.e. point sources. In this context, the urban waste water treatment directive appears very successful in improving wastewater treatment and reducing nutrient discharges.

However, diffuse sources remain of prime importance (about 50 % of total nutrient pollution), in particular because of their multiple environmental impacts over long time periods; it has been estimated, for example, that it takes about 20 years for nitrogen discharges to diffuse fully into water. Controlling discharges from diffuse sources is therefore bound to become the key issue, particularly in connection with agricultural practices and the implementation of the nitrates directive. In this perspective, agricultural outlooks are reported in Chapter 3, including an alternative scenario that highlights the potential environmental benefits of best practices for fertiliser handling; the indicators include the future use of fertilisers, N-P-K (nitrogen-phosphorous-potassium) nutrient balances, and GHG emissions.

**Figure 4.13 Discharges of nitrogen and phosphorous from wastewater treatment plants**



**Box 4.4 Overview of past developments in wastewater treatment**

Over the past twenty years, there has been a marked increase in the proportion of the EU population connected to sewers and wastewater treatment facilities. The majority of the population is now connected to sewers and urban wastewater treatment plants, but there are some regional differences: more than 90 % of the population in the north-western EU-15 countries are generally connected, between 50 % and 80 % in the southern EU-15 countries and fewer than 60 % in the New-10. In most EU countries nearly all wastewater from sewers is treated in wastewater treatment plants before being discharged. In addition, most industries in Europe discharge to sewers (this represents between 25 % and 60 % of the total discharges, depending on the country) and have their wastewater treated in their own urban treatment plants.

Over the past two decades, the most marked change in the nutrient content of wastewater has resulted from reductions in the phosphate content of household detergents, as a result of laws or voluntary agreements in many European countries. Decreases of more than 50 % in phosphate consumption have commonly been observed (e.g. Germany, UK) and, despite an increased use of dishwasher detergents with phosphate in recent years, phosphate-free detergents make the bulk of sales nowadays. The marked reduction in the phosphorus content of detergents significantly changed the nutrient loads to wastewater treatment plants: phosphorus produced per person was reduced from around 1.2–1.6 kg P/year in the 1980s to current levels of 0.9–1 kg P/year. In contrast, only minor changes have occurred in the nitrogen loads and resulting water pollutants (current typical values are 5–6 kg N/person/year), as human food intake in terms of protein per person has not changed significantly. There has also been significant improvement in wastewater treatment technology. Although the situation varies considerably between European countries, there has been a trend towards increasing treatment of collected wastewater and more reliance on tertiary treatment which has a much higher nutrient retention rate (about 60 % for nitrogen and 90 % for phosphorous).

# 5. Key signals and early warnings

This chapter brings together the main messages of the EEA's 2005 European environment outlook report and benchmarks projected developments against Europe's current policy objectives. The report assesses the environmental consequences of the unfolding of key driving forces in Europe under a set of baseline assumptions (based mainly on the European Commission's baseline projection reported in DG TREN's publication 'European energy and transport trends to 2030', which is also used in DG ENV's Clean Air for Europe (CAFE) programme) and alternative scenarios.

While this bases the outlook firmly within an authoritative and legitimate view of plausible future developments, the assumptions carry some degree of uncertainty, which is greater in some areas (e.g. macro-economic prospects, future oil prices) than in others (e.g. population, technological progress). Particularly, the assumptions made do not necessarily reflect the short-term situation and movements of markets. Should future developments in the key driving forces turn out to be significantly different, the outcome of this assessment may be affected.

## Headline messages

**Changes in Europe's demographic patterns — ageing societies, rural depopulation and growing numbers of households — are expected to increase some environmental pressures**. The total population of the EU-25 is expected to remain fairly stable over the next 30 years, at about 460 million. However, average household size is expected to decrease to below 2.5 persons, leading the total number of households to grow by more than 20 %. More households mean more energy consumption and — until recently — water use, and more waste generation, all of which results in more environmental pressures. At the same time, the average age of the population is expected to increase (with more than 20 % being more than 65 year old in 2030, compared with 15 % today), and old age dependency to increase sharply over the next 20 years. Possible implications for the environment include increased pressures from an increase in the number of second homes (and therefore of energy and water use and waste generation), in tourism (with more retired and affluent elderly people), in the need for social and medical services, and possible changes in behaviour with regard to environmental issues.

**The short-term European greenhouse gas emission targets are expected to be met, if all additional policies and measures currently planned are implemented.** With existing domestic policies and measures alone (as of mid-2004), emissions in the EU by 2008–2012 are expected to be less than 3 % below 1990 levels, compared with the Kyoto Protocol target of 8 %. The 10 new Member States are expected to contribute significantly to limiting EU GHG emissions, as they are expected to over-comply with their targets and reduce emissions by 18 % below 1990 levels. However, taking into account the latest policy developments (e.g. emissions trading scheme with national allocation plans assessed and adopted by the European Commission in the second half of 2004), and provided that Member States implement all the additional policies, measures and third-country projects they are currently planning and that several cut emissions by more than they have to, the EU-15 is likely to be able to meet its Kyoto Protocol target.

**The long-term European greenhouse gas emission targets, set to prevent harmful climate change, are expected not to be met.** Projections indicate that, with existing domestic policies and measures alone, emissions are likely to fall short of the EU target of a reduction of an average of 1 % per year up to 2020 (as set in the sustainable development strategy — in March 2005 the Environment Council reaffirmed an indicative target of 15 % to 30 %). Instead, greenhouse emissions in the EU are expected to increase to 4 % above 1990 levels by 2020. Also, unless deep emission reductions are achieved globally and in Europe, the overarching EU climate policy target of limiting increases in the global mean temperature to 2 °C, is expected to be exceeded in the second half of this century (the target set in the EU sixth environment action programme and affirmed by European Council conclusions in March 2005). Following a baseline projection, the increase in global average temperature by 2100 is expected to be even above 3 °C. This is likely to result in further changes in precipitation, rising sea levels and a change in the magnitude and frequency of some extreme weather events. Even sudden extreme changes, such as the collapse of the 'Gulf Stream' or the Arctic ecosystem, are not deemed entirely implausible.

**However, there is potential for a massive reduction in EU greenhouse gas emissions in the long term (to 40 % below 1990 levels in the next 30 years).** While this may be technologically feasible, it would depend on the implementation of far-reaching climate policies. Such a dramatic reduction is one of several possible ways of getting the EU on track to achieving the long-term climate change goals set in the sixth environment action programme. The key to achieving large reductions in emissions is a major shift in the EU energy system to alternative energy sources and an increased uptake of environment-friendly technologies. The analysis indicates that reductions of GHG emissions within the EU would represent an increasing share of the total effort (about 50 % in 2020 and 70 % in 2030), with the rest being covered by the use of flexible mechanisms (as defined by the Kyoto Protocol).

**Air pollution and its impacts on health and ecosystems are expected to decline significantly.** On the basis of existing policies and measures, all emissions of land-based air pollutants (except ammonia) are expected to decline significantly (by more than 35 %) up to 2030. Hence, the EU as a whole is expected to comply with the 2010 targets of the national emission ceilings directive. However, while a number of Member States are well below their binding upper national emission ceilings, others are not on track. In contrast, the international shipping emissions are expected to increase considerably by 2030 (by more than 80 %). The implementation of all feasible technical measures (best available technologies) is estimated to offer a considerable potential for further reducing air emissions. As overall air quality in Europe is expected to improve significantly, impacts on human health and ecosystems may diminish substantially, although large differences across Europe are expected to prevail. In particular, negative impacts in highly populated areas of the EU are expected to remain significant, thus requiring further efforts to reach long-term objectives.

**Water use is expected to decrease markedly in most of Europe; however, many Mediterranean river basins will continue to face water stress.** Total water withdrawals in Europe are expected to decrease by more than 10 % between 2000 and 2030. In northern and eastern Europe, the sectoral profile of water use is changing, with the main withdrawals shifting from the electricity sector (reductions of 70 % or more) to the manufacturing sector (increases of more than 30 %) and households (decreases in the north and west of Europe, increases in the east). Indeed, water withdrawals for cooling purposes in the power generation process per unit of electricity produced are expected to decrease sharply (by more than 95 %) following a shift from once-through to tower-cooling technologies (but while this reduces water withdrawal considerably, water consumption increases slightly due to evaporation). In southern Europe, withdrawals for agriculture continue to dominate water use (more than 40 % of the total). With expanding irrigated areas and reduced precipitation due to a changing climate, irrigation is expected to increase by more than 10 % in this region, making it particularly vulnerable to extreme climatic events. River basins considered under stress today, such as the Guadalquivir and Guadiana on the Iberian Peninsula as well as most of southern Italy, Greece and Turkey, are expected to experience continuing or even increased water stress.

**The urban waste water treatment (UWWT) directive is expected to lead to a significant reduction in the overall discharge of nutrients from point sources.** With implementation of the UWWT directive, the connection rate to wastewater treatment of the European population is expected to increase to more than 80 % in the EU-15 and 70 % in the five new Member States analysed in this report. This, combined with a larger use of tertiary treatment, is expected to reduce emissions of nitrogen (N) and phosphorus (P) considerably (e.g. by 40 % (N) and 80 % (P) in Belgium; and by 24 % (N) and 62 % (P) in the five new Member States). In the countries that increase their population's connection to wastewater treatment while continuing to rely mostly on secondary treatment, overall emissions are expected to go up slightly (14 %) but per-capita nutrient discharges to be reduced. However, nutrient discharges from rural populations not connected to wastewater treatment (about 30 % of the total population in the new Member States) and from other diffuse sources such as agricultural (for example from the expected increase in fertiliser use in the new Member States), are expected to remain a major water pollution problem. It is therefore vital, if water quality is to improve further, to continue to shift policy focus from point sources to diffuse sources, for example through the catchment area management approaches introduced in the the water framework directive. This will facilitate addressing water quality issues in groundwater, rivers and seas, despite the environmental complexity of diffuse pollution.

**The recent enlargement of the EU continues to provide both environmental opportunities and threats.** EU legislation has in many cases led to stronger environmental legislation in the 10 new Member States, but improved economic prospects and the associated higher level of individual consumption are likely to increase the burden on the environment. Important developments expected in the new Member States include:

- **Mineral fertiliser use is expected to soar, increasing agriculture-related environmental pressures considerably.** By 2020, the use of nitrogen fertiliser is expected to increase by 35 %, and phosphate and potassium by up to 50 % (while fertiliser use in the EU-15 is expected to remain fairly stable). This reflects the expectation that growth in agricultural production in the new Member States will come mainly from a considerable increase in application rates and yields. However, despite yield improvements, the use of mineral fertilisers remains significantly lower in the new Member States than in the EU-15.

- **Water withdrawal for household use is expected to increase significantly as water use per person approaches the EU-15 average.** Total water withdrawal is expected to increase by up to 75 % as water use in the new Member States (40–100 m$^3$/person/year) is assumed to rise gradually to the EU-15 average (125 m$^3$).

- **Waste generation is expected to decouple significantly (in relative terms) from GDP, particularly at the municipal level.** This reflects the weaker link between waste generation and GDP in the new Member States in the past decade than in the EU-15. Economic recovery and convergence also provides opportunities for adopting better and more up-to-date technologies. This contrasts with the EU-15, where the quantities of most wastes are not expected to decouple significantly from GDP.

- **Without additional measures, resource productivity is expected to remain about four times lower than in the EU-15.** Although significant progress has been made over the past decade, resource productivity in the new Member States is not expected to improve vis-à-vis the EU-15 without additional measures. There are significant opportunities and scope for action which could greatly improve the situation both in the new Member States and in the EU as a whole. At the European level, this also provides an opportunity to implement cost-effective mechanisms (such as the Joint Implementation and clean development mechanisms that provide market-based instruments for reducing GHG emissions) or 'leapfrog' towards the use of newer, more resource-efficient technologies.

- **The 10 new Member States are expected to contribute significantly to limiting EU GHG emissions, as they are expected to reduce emissions by 18 % below 1990 levels by 2008–2012** (see above).

**The current shift to more integrated approaches to environmental policies provides further opportunities to improve the future state of Europe's environment.** For many environmental problems, past and current legislation has often successfully addressed the 'big polluters', but new concerns are likely to arise from individual consumption and diffuse sources of pollution. For example, while significant progress has been made with respect to greenhouse gas emissions from industry and primary energy consumption, projections show ever-growing increases from the transport sector. Policies are reducing nutrient discharges from point sources, but seldom address diffuse sources. A shift in the nature of environmental pressures is expected from production (where improvements in terms of increased eco-efficiency and end-of-pipe solutions have taken place) towards consumption, and from large point sources towards more fragmented and diffuse sources (including households, agriculture and transport infrastructure). A shift of policy focus from large point sources to fragmented diffuse sources is not straight-forward and calls for new approaches. This may require policy-makers to give more consideration to the common drivers of change behind most of the environmental concerns in Europe. Areas such as transport and agriculture provide a logical and natural entry point to such discussions, since they share key driving forces (population and economic growth, individual preferences and consumption patterns) and have wide impacts on the environment. The fit and misfit of European policies also needs attention since policies sometimes conflict with each other with regard to environmental issues (e.g. transport policy and emission reduction strategies). The consistency and effectiveness of EU policies could be significantly improved by relying more on integrated policy approaches that bring together sectoral and environmental issues from the outset.

## Sixth environment action programme — Are we on track?

### Action on tackling climate change

| Target | Outlook | Region |
|---|---|---|
| Kyoto Protocol commitment of an 8 % reduction in GHG emissions in the EU as a whole by 2008–2012 compared with 1990 levels (Art. 5.1) | -> With existing domestic policies and measures alone (as of mid-2004), a reduction in emissions of less than 3 % is expected in the EU | EU-25 |
| | -> However, taking into account the latest policy developments (152) and all the additional policies, measures and third-country projects planned so far, the EU-15 is likely to meet its target (153) | EU-15 |
| Long-term objective of a maximum global temperature increase of 2 °C over pre-industrial levels (Art. 2) (154) | -> Global temperature to increase by more than 3 °C by 2100 | EU-25 |
| | -> Potential to reach target by a long-term deep reductions of global and EU GHG emissions | EU-25 |
| Use of renewable energy sources [… ] meeting the indicative target of 12 % of total energy use by 2010 (Art. 5.2 (ii (c))) (155) | -> Renewable energy sources in total energy use expected to be about 7.5 % by 2010 | EU-25 |
| Doubling the overall share of combined heat and power to 18 % of total gross electricity production (Art. 5.2 (ii (d))) | -> Combined Heat and Power in total gross electricity production is expected to be about 16 % by 2030 | EU-25 |
| Promote the development and use of alternative fuels in the transport sector (Art. 5.2 (iii (f))) (156) | -> Biofuels in transport final energy demand are expected to be 1 %, 2 % and 4.5 % by 2005, 2010 and 2030 | EU-25 |
| Decoupling economic growth and the demand for transport (Art. 5.2 (iii (h))) (157) | -> Relative decoupling from GDP is expected over the next 30 years for both passenger and freight transport demand | EU-25 |

### Action on nature and biodiversity

| Target | Outlook | Region |
|---|---|---|
| Halting biodiversity decline with the aim of reaching this objective by 2010 (Art. 6.1) | -> Losses in the number of plant species are expected as a consequence of climate change in some European countries | EU-25 |
| Protection and appropriate restoration of nature and biodiversity from damaging pollution (Art. 6.1) | -> On the basis of existing policies and measures, air pollution and its impacts on health and ecosystems are expected to decline significantly up to 2030 | EU-25 |
| Encouraging more environmentally-responsible farming, such as extensive, integrated, and organic farming (Art. 6.2 (f)) | -> Moderate expansion of good farming practices expected | EU-25 |

### Action on environment and health and quality of life

| Target | Outlook | Region |
|---|---|---|
| Ensure that the rates of extraction from water resources are sustainable over the long term (Art. 7.1) (158) | -> Total water withdrawals are expected to decrease by 2030, but water stress may remain in southern Europe | EU-25 |
| Achieve levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment (Art. 7.1) (159) | -> On the basis of existing policies and measures, all emissions of land-based air pollutants (except ammonia) are expected to decline significantly up to 2030 | EU-25 |
| | -> The EU as a whole is expected to comply with the 2010 targets of the NEC directive | EU-25 |
| | -> Impacts on human health and ecosystems are expected to diminish substantially, although large differences across Europe persist | EU-25 |
| Sustainable use and high quality of water, ensuring a high level of protection of surface and groundwater, preventing pollution (Art. 7.2 (e)) (160) (161) | -> The urban waste water directive is expected to significantly reduce the overall discharge of nutrients | EU-25 |
| | -> Agricultural nutrient surpluses are expected to be moderately reduced in 2020 | EU-15 |
| | -> Pressures are expected to increase significantly in the New-10, due to mineral fertiliser use | New-10 |

### Action on the sustainable use and management of natural resources and waste

| Target | Outlook | Region |
|---|---|---|
| Indicative target to achieve 22 % of electricity production from renewable energies by 2010 (Art. 8.1) (162) | -> Electricity production from renewable energy expected to be about 15 % in 2010 | EU-25 |
| Significant overall reduction in the volumes of waste generated (Art. 8.1) (163) | -> Waste generation continues to grow across Europe. In the New-10 relative decoupling from GDP growth is expected (but not in the EU-15) | EU-25 |
| Establishment of goals and targets for resource efficiency and the diminished use of resources (Art. 8.2 (i (c))) | -> Resource productivity in the New-10 is expected to remain about 4 times lower than in the EU-15 | EU-25 |

# 6. Uncertainties and information gaps

Any outlook exercise involves a number of uncertainties and shortcomings, related for example to the methodological approaches used or the scope of the study. These information gaps and limitations are inherent in any assessment of possible futures, and this outlook would certainly have benefited from additional information covering some issues that are discussed below (164).

The main limiting factor in developing a comprehensive environmental outlook has been the lack of data, information or models covering some environmental issues. In many ways, these gaps reflect the fact that some environmental issues have only emerged as priority areas in recent years or that scientific knowledge and environmental monitoring schemes do not yet allow the development of outlooks with sufficient confidence. This is particularly true with regard to developing an outlook on European biodiversity. Settlement patterns, natural hazards, diffuse sources of pollution and the links between chemicals and health are also scientific areas that seem to fall under this category. Although indicators are increasingly becoming available to help understand some of these environmental issues (for example the natural capital index), models that allow sound future assessments are still under development or review.

This outlook exercise has relied largely on quantitative models — and is thus subject to their limitations in terms of methodological choices, data gaps, spatial coverage and embedded uncertainties. Spatially explicit analysis has been limited to the issues of the impacts of climate change and water stress.

A further shortcoming is that some feedback effects have not been formally quantified in this exercise, for example the feedback links between climate change impacts and water availability onto agricultural activities. Also, although sinks were considered in the climate change analysis, there was no quantitative analysis of the forestry issue.

In addition, a number of environmental issues involve particularly large uncertainties or even lack of sufficient understanding of the underlying dynamics, making analytical focus on an agreed baseline scenario difficult. These issues require a wider approach in which a range of contrasting and equally plausible scenarios is discussed. In these cases, modelling tools alone are not necessarily the best way of developing long-term views of the future, since they usually overlook the possible society-wide paradigm shifts (e.g. cultural, behavioural, technological) that surround any sectoral issues, or shocks and surprises. The futures of urban and rural environments, land cover and land use, quality of life and the issue of sudden extreme changes in the environment are examples of this (165). Nevertheless, the findings of this outlook — combined with results from other exercises — can provide a starting point to explore further issues not addressed directly by this report.

# Footnotes

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(1) This concept of 'sustainable development' is derived from the 'Brundtland-Report', see WCED (1987).

(2) The European Union laid out these goals in March 2000 in its 'Lisbon strategy for economic, social and environmental renewal', see http://europa.eu.int/comm/lisbon_strategy/index_en.html.

(3) The European Environment Agency regulation requires it to 'publish a report on the state of, trends in and prospects for the environment every five years, supplemented by indicator reports focusing upon specific issues' (EEA Council Regulation (EEC) No 1210/90 Article 2 (vi)).

(4) One of the aims of the EEA's State of the environment and outlook report of 2005 is to support the European Commission in the mid-term review of its sixth environment action programme. This programme focuses on four priority areas: climate change, nature and biodiversity, sustainable resource use and waste, and environment and health. The issues addressed also relate to the EU's sustainable development strategy.

(5) See Annex 1 for an overview of the geographical coverage and country groupings used in this report.

(6) The methodological approach to the development of this outlook follows the call of the EEA Council Regulation (EEC) No 1210/90 Article 2 (vii)) 'to stimulate the development and application of environmental forecasting techniques so that adequate preventive measures can be taken in good time'.

(7) The set of assumptions reflects a baseline projection, and thus plays the role of a benchmark or reference scenario. It includes all implemented and adopted policies, and reflects current expectations in terms of macro-economic, sectoral, technological and societal developments. In this framework, the targets set in directives and regulations are not assumed to be reached a priori. Strictly speaking it differs from a 'business-as-usual' scenario, which usually implies that all assumptions, for example on
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these differ considerably from past trends (e.g. new technologies, commodity prices changes).

(8) For an overview, see EEA, 2000. Annex 4 provides a glossary of terms used in the context of scenarios and outlook exercises. For more details, see EEA 2001a, 2001b.

(9) For references and a more detailed discussion of greenhouse gas emissions and climate change, see, for example, EEA 2004b, EEA, 2004c, EEA, 2005a; and various publications by the Intergovernmental Panel on Climate Change (e.g. IPCC 1990, 1992, 2000).

(10) The European Union's aim to limit increase in the global average temperature to less than 2 °C compared with pre-industrial levels is documented in the sixth environment action programme, and was reaffirmed by the European Council in spring 2005.

(11) For references and a more detailed discussion of air quality and air pollution, see, for example, EEA, 2004a.

(12) Fine particulate matter is an air pollutant consisting of mixture of particulates which vary in size, composition and origin. These include $PM_{10}$ and $PM_{2.5}$ (with particle sizes below 10 μm and 2.5 μm, respectively). Between 1996 and 2001, 25–45 % of the urban population in the EU was exposed to particulate concentrations in excess of the EU limit value (EEA, 2004a).

(13) The Clean Air for Europe (CAFE) process supports the development of an thematic strategy to strengthen a coherent and integrated policy on air pollution called for in the EU's sixth environment action programme — for more details see Section 2.3.

(14) For references and a more detailed discussion of water stress and water quality, see, for example, EEA, 2004a; Lehner *et al.,* 2000; and Henrichs *et al.* 2002.

(15) For references and a more detailed discussion of nature and biodiversity, see, for example, EEA, 1999.

(16) For references and a more detailed discussion of soil quality and degradation, see, for example, EEA, 1999.

(17) In response to soil degradation concerns, the EU is aiming to implement a thematic strategy on soil protection as part of the sixth environment action programme.

(18) Note that such comprehensive and exhaustive reviews already exist, e.g. MEA, 2005; OECD, 2001; IPCC, 2000 and SEI, 1998.

(19) Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002: 6th EAP, sixth community environment action programme; see also European Commission Communication 'On the sixth environment action programme of the European Community — Environment 2010: Our future, our choice ' (COM (2001) 29).

(20) This is the name given to the process launched by European heads of state and government (the European Council) at their meeting in Cardiff, in June 1998, requiring different Council formations to integrate environmental considerations into their respective activities, putting article 6 of the EC Treaty into practice.

(21) Launched in March 2000 in Lisbon, see http://europa.eu.int/growthandjobs/index_en.htm.

(22) See also the European Commission proposal for the EU's new research framework programme 2007–2013 (FP7), http://europa.eu.int/comm/research/future/index_en.cfm.

(23) Decision No 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for the Community action field of water policy: EU Water Framework Directive (published in OJ L 327 of 22 December 2000).

(24) Council Directive 91/676/EEC of 12 December 1991 concerning the protection of water against pollution caused by nitrates from agricultural sources: nitrates directive.

(25) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora: habitats directive and Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds: birds directive.

(26) Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment: urban waste water directive.

(27) Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management: air quality framework directive; Council Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for cetain atmospheric pollutants: national emission ceiling directive.

(28) See also COM (2002) 179, and EC DG ENV information at http://europa.eu.int/comm/environment/soil/index.htm.

(29) See also Communication from the Commission to the Council and the European Parliament COM (2002) 539.

(30) See also COM (2002) 349, and EC DG ENV information at http://europa.eu.int/comm/environment/ppps/home.htm.

(31) Also referred to as the 'Clean Air for Europe (CAFE) programme'; see also COM (2001) 245, and EC DG ENV information at http://europa.eu.int/comm/environment/air/cafe.

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(32) See also COM (2004) 60, and EC DG ENV information at http://europa.eu.int/comm/environment/urban/thematic_strategy.htm.

(33) See also COM (2003) 572, and EC DG ENV information at http://europa.eu.int/comm/environment/natres/index.htm.

(34) See also COM (2003) 301, and EC DG ENV information at http://europa.eu.int/comm/environment/waste/strategy.htm.

(35) The EU's sustainable development strategy gives a target of reducing emissions by 1 % per year compared with 1990 levels until 2020. The baseline projection presented here indicates that EU-25 emissions by 2020 are expected to have increased by 4 % over 1990 levels.

(36) See also 'Energy for the future: renewable sources of energy — white paper for a community strategy and action plan' (COM (97) 599 final).

(37) See also the indicative targets of 2 % by 2005 and 5.75 % by 2010 for biofuels and other renewable fuels, calculated on the basis of energy content, of all petrol and diesel for transport purposes (EU directive on the promotion of the use of biofuels or other renewable fuels for transport, Directive 2003/30/EC).

(38) The sustainable development strategy calls for a 'significant decoupling of transport growth from growth in gross domestic product' and for a 'shift in transport use so that the share of road transport in 2010 is no greater than in 1998'.

(39) See also the water framework directive's target calling for 'by 2015 all EU waters to meet 'good status' (ecological, chemical, quantitative status) and sustainable water use'.

(40) See also the national emissions ceilings directive for certain atmospheric pollutants (Directive 2001/81/EC).

(41) The urban waste water treatment directive's target is to ensure that 'collecting and treatment system must be provided in all agglomerations larger than 2 000 inhabitants' by 2005 (EU-15) and 2015 (New-10).

(42) See also the nitrates directive's target 'to reduce water pollution caused or induced by nitrates from agricultural sources and preventing further pollution'.

(43) See also the EU directive on the promotion of electricity from renewable energy sources in the internal market (Directive 2001/77/EC).

(44) The EU sustainable development strategy sets the target to 'decouple the use of resources and generation of waste from the rate of economic growth.'

(45) The theoretical frameworks and structures of the models, together with their internal settings and parameters, also play a key role in developing projections, but these will not be addressed in detail here (see Annex 2 for further details).

(46) The LREM (long-range energy modelling) project has been undertaken by the National Technical University of Athens using the PRIMES model. For more information, see European Commission (2003a) and Annex 2.

(47) The integration of the outlooks is undertaken in terms of both driving forces and environmental impacts. When a baseline assumption is changed for a sensitivity run or a variant, it is used across sectors and themes where appropriate. For example, the EEA assumptions for a low growth scenario are used for the energy, transport, waste and water outlooks.

(48) Details on the CAFE (Clean Air for Europe, DG ENV) programme and the associated thematic strategy on air pollution under the sixth environment action programme can be accessed at http://europa.eu.int/comm/environment/air/cafe/. The International Institute for Applied Systems Analysis (IIASA) and the National Technical University of Athens (NTUA) undertake the project using the RAINS and PRIMES models.

(49) For further details on projections for energy, transport, climate change and air pollution, see the EEA Report 'Climate change and a European low-carbon energy system', EEA (2005a). As far as consumption patterns are concerned, further details are given in the EEA Report 'Household consumption and the environment', EEA (2005b).

(50) Includes numbers and figures from 'Population statistics — Data 1960–2003', Eurostat (2004).

(51) See UN (2003, 2004). The UN stresses that the realisation of this projection is contingent on ensuring access to family planning and that efforts to arrest the current spread of the HIV/AIDS epidemic are successful.

(52) Data based on Eurostat (2004). Note that the old age dependency ratio describes the number of people aged 60 or over, as percentage of the population aged 20 to 59 (i.e. the working population).

(53) For comparison: EU-25 economic growth was 1.8 % in 2001, 1.1 % in 2002, 1.0 % in 2003 and 2.4 % in 2004.

(54) A more detailed description of the economic growth assumptions is given in 'European energy and transport trends to 2030' (European Commission, 2003a). Sections 3.4 through 3.9 of this outlook describe the associated sectoral development assumptions.

(55) Determining potentials for and diffusion of new technologies is a challenging exercise in any projection, as it depends on many factors. Energy projections from the 1970s, for example, generally under-estimated the penetration of wind technologies (although their potential was recognised) as the possibility of high subsidies as provided nowadays was not considered. In this EEA outlook, technological progress is through technology substitution rather than technological breakthroughs (such as hydrogen, fuel cells and desalination technologies or carbon sequestration). See European Commission (2003a) and also EEA (2004d) for more details on energy subsidies and renewables.

(56) Consequently, the implications on the development of energy crops and biomass have not been specifically addressed here.

(57) For example, see World Tourism Organisation (2001).

(58) Over the 2000–2030 period, the prices of coal, oil and gas are here assumed to rise respectively from USD 8 to USD 10 (1999)/barrel, from USD 21 to USD 30 (1999)/barrel and from USD 15 to USD 22 (1999)/barrel. By 2050, coal, oil and gas prices are assumed to be USD 13, 40 and 25 (1999)/barrel. In this context, natural gas has significant advantages over the other fossil fuels as it has the lowest carbon content and the related power generation technologies are the most efficient. Higher oil prices would certainly lead to a further penetration of competing technologies for power production both in terms of carbon content and dependency on oil prices (e.g. gas). Assumptions on oil prices are considered to be on the low side.

(59) In the baseline projection, fuel cells are not expected to penetrate the power generation or the transport sector.

(60) See the forthcoming uncertainty analysis of the EEA energy and climate change scenarios (undertaken with the Prometheus model, see Annex 2), which addresses the assumptions on key driving forces, the main environmental pressures and compares those with other prominent studies (e.g. 'World energy outlook' (IEA, 2004), OECD oil projections).

(61) Short sea shipping, as an alternative to road transport for freight activities, is not considered in detail here.

(62) Defined as the gross inland energy consumption (GIEC) per unit of GDP.

(63) Simultaneously, CHP plants are expected to increase their share of steam production from 54 % in 2000 to about 64.5 % in 2030.

(64) Calculated as the ratio of net electricity and steam production from thermal plants to their total energy consumption.

(65) Calculated as the final energy consumption per unit of GDP, value added or private consumption.

(66) This section reports the results of the agricultural outlook (see Witzke *et al.* (2004) for further details) that updates former studies in three ways: in terms of (1) timeframe, as this outlook covers the next 20 years while agricultural projections usually cover only short and medium terms, (2) spatial coverage, as this is the first time to our knowledge that eight of the new Member States of the EU are covered in a prospective study in a systematic and consistent way, and (3) policy context, as this outlook takes into account the Luxembourg Compromise (Council of the European Union, 2003) on the mid-term review of the common agriculture policy (CAP), in particular in terms of decoupling payments and supports. The agriculture projections are based on the CAPSIM model for which further details are given in Annex 2. The exchange rate used in the baseline projection has been fixed at 1.1 USD/Euro from 2001 onwards, in line with the latest European Commission assumptions 'Prospects for agricultural markets 2004–2011 — Update for EU-25', European Commission (2004a). Note that the EEA agricultural outlooks are useful in their own right for the reasons given above, and are not the basis for the air quality and climate change assessments reported in Chapter 4.

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(67) The crop categories are defined as follows:
Cereals: soft wheat, durum wheat, rye and meslin, barley, oats, grain maize, other cereals
Oilseeds and pulses: rape, sunflower, soya, other oils, pulses
Other arable crops: potatoes, sugar beet (A, B, C), textile and industrial crops, vegetables
Permanent crops and paddy: fruits, olives for oil, wine, paddy rice, other crops
Fodder: fodder maize, other fodder on arable, grass and grazings
Set aside and fallow land: set-aside obligatory, set-aside voluntary, non food on set-aside, fallow land.

(68) The future developments of fallow land and set-aside in the New-8 is considered to be characterised by significant uncertainty. In addition, the increasing interest in biofuels may also change the picture to some extent.

(69) Oilseeds include the area dedicated to bioenergy, which is not explicitly covered here.

(70) An important caveat in the best practice scenario should be kept in mind: the improvements in management practice are simply assumed to happen, without considering their cost, particularly on agricultural income.

(71) See also the EEA Report 'Household consumption and the environment' (EEA, 2005b) and Bruinsma (2003). This will also have specific consequences on the development of organic farming, genetically modified organisms, livestock and feeds, none of which have been addressed here.

(72) See also the latest projections from the European Fertilizer Manufacturers Association (EFMA, 2004).

(73) Yield is an indicator directly linked to environmental pressures and impacts. However, since higher yields could also result from decreasing the total harvested area, the final net effect of yield changes on the environment has to be worked out taking account of changes in agricultural areas.

(74) There is over-fertilisation when the total fertilizer supply exceeds the net exports in harvested material. This characterises the behaviour of farmers in terms of good practices and is one component of the calculation of nutrient balances. In the case of the new Member States, the fertilisation rate dropped dramatically in the early 1990s (under-fertilisation) and this explains to some extent the rapid increase expected over the next decade.

(75) Calculations of nutrient balances take into account the various stages of the nutrients cycle: production by animals, organic supply to crop production, mineral fertiliser purchases, bio-fixation and atmospheric deposition (for N only), ammonia losses (for N only) and net exports in harvested material.

(76) The sixth environment action programme identifies four priority areas, one of which is 'natural resources and waste'. Within this priority area it states that the development of a 'thematic strategy on sustainable use of natural resources' should aim at '…ensuring that the consumption of resources and their associated impacts do not exceed the carrying capacity of the environment and breaking the linkages between economic growth and resource use'. The thematic strategy sets the target to 'decouple the use of resources and generation of waste from the rate of economic growth (Article 8.1).

(77) See Eurostat 2000.

(78) As identified in COM(96)0399, i.e. used tyres, end-of-life vehicles (ELV), healthcare waste, waste from construction and demolition (C and D) and waste electrical and electronic equipment (WEEE). Priority waste streams are wastes that are important to achieving the associated objectives, and have been identified as priorities on account of one or more of the following: their volume, hazardous nature, potential for recycling or potential to create an economic benefit.

(79) The waste and material flows outlooks (see Skovgaard *et al.* (2004) for further details) are based on a macro-econometric model developed by the EEA European Topic Centre on Waste and Material Flows (ETC/WMF) in collaboration with Risø National Laboratory. The methodology used implies that the projections are a function of the development of the economy, population and households. Projections for the environmental impacts of end-of-life vehicles (ELVs) and sewage sludge management (not reported here) have been derived from two technical models specific to each waste stream (also developed by the ETC/WMF). It is believed that the models complement each other as they bring together top-down macroeconomic and bottom-up technical approaches. This methodological choice is considered as a key element of the integrated assessment of EEA's waste and material flows outlooks. See Annex 2 for further details on the modelling tools.

(80) Given the macro-econometric nature of the model used, i.e. the links between GDP or the number of households with waste quantities are coefficients giving the level of 'coupling', projections reflect past trends to a large extent (the amount of waste is also greatly influenced by the efficiency of the collection system, which has improved substantially in the recent past). Coupling or decoupling in excess of what happened in the past would be an assumption fed into the model rather than a result of it. In addition, the pieces of legislation in the baseline projection (e.g. landfill directive) are not explicitly included in macro-economic models. Note that the same applies to the material flows outlooks reported here.

(81) The elasticity per inhabitant of domestic waste generation (i.e. a sub-set of the municipal waste stream) to private consumption in Denmark, for example has been estimated to be about 0.4.

(82) The figures for the EU-15 are estimated as a sum of the projections for the countries where projections are available. For example no projections for Luxembourg are available for municipal waste, paper & board, glass, packaging and waste oil.

(83) Similarly, the economic research community has extensively discussed the lack of empirical evidence on the effects of the introduction of IT equipment on productivity levels. The question of whether this is due to indicators not being properly defined and measured or to a genuine lack of productivity improvement is still under debate.

(84) The landfill directive (Council Directive 1999/31/EC) sets progressive targets over the 2006–2016 period for the diversion of biodegradable municipal waste away from landfill. The final target is to reduce the landfilling of biodegradable municipal waste by 65 %.

(85) This constitutes a first estimate only. Due to limited data on the share of biodegradable waste in total municipal waste or emission figures for landfill gas, simplified assumptions have been made. In addition, some uncertainties surround future management practices in the baseline projection, i.e. without the directive's implementation.

(86) Several EU countries and regions (e.g. Austria, Belgium (Flanders), Denmark, Germany (Baden-Württemberg) and the Netherlands) already fulfil the targets of the directive as they landfill less than 35 % of their biodegradable municipal waste. Other countries currently landfill more than 80 % of their biodegradable municipal waste (e.g. Ireland and the UK).

(87) Separating the biodegradable fraction from municipal solid waste could also mean that more biomass to produce bioenergy is available.

(88) The domestic material consumption (DMC) indicator is reported for fossil fuels (i.e. domestic extraction + net trade (imports-exports)), while domestic extraction is estimated only for minerals and biomass. Fossil fuel projections are estimated directly from the PRIMES model using country-specific coefficients for transforming ktoe to tonnes, see Annex 2.

(89) The substitution of domestic resources or products by imports concerns the goods themselves but also the embodied inputs necessary for their extraction or production (e.g. the energy content of imported products).

(90) As well as being a signal of lower resource efficiency, this also reflects differences in economic profiles, since the share of heavy industries in the New-10 is much higher than in the EU-15. Further development and economic convergence accompanied by additional policy measures might improve overall resource productivity.

(91) See EEA (2001d) and EEA (2005d, 2005e) for related effectiveness analysis.

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(92) Using the stochastic model Prometheus. See Annex 2 for further details.

(93) After the Russian Federation endorsed ratification of the Kyoto Protocol and deposited the formal instrument of ratification with the Secretary-General of the United Nations on 18 November 2004, so that the signatories of the Protocol that have ratified represent not less than 55 parties to the Convention (137 signatories in total), and the Annex I parties that have ratified represent in total at least 55 % of the total carbon dioxide emissions for 1990 from that group.

(94) Most of the New-10 have a target of an 8% reduction for 2008–2012 compared with base year levels under the Kyoto Protocol (Hungary and Poland aim at reducing their emissions by 6 %; Cyprus and Malta have no targets), and belong within the UNFCCC to the group of countries undergoing a process of transition towards a market economy. Most other EEA member countries also have a target of an 8 % reduction.

(95) See, for example, DEFRA (2003) for the UK, WBGU (2003a, b) for Germany, and Criqui and Kitous (2004) for France.

(96) See EEA (2004b, 2004e) based on national emission inventory schemes and projections.

(97) An uncertainty analysis of the energy and climate change outlooks with the stochastic model Prometheus is currently being undertaken to complement the analytical results reported here, see Annex 2.

(98) For further details, see the EEA Report 'Climate change and a European low-carbon energy system' and Isoard and Wiesenthal (2005).

(99) The baseline projection has been developed by using various models: PRIMES (energy, European), POLES (energy, global), CAPSIM (agriculture, European), FAIR and IMAGE (climate change, global). See Annex 2 for further details on these models.

(100) Not including the emissions trading scheme (ETS, implemented in January 2005) whose National Allocation Plans began to be assessed and adopted by the European Commission in the second half of 2004.

(101) The LREM (long-range energy modelling) project has been undertaken by the National Technical University of Athens using the PRIMES model. For more information, see European Commission (2003).

(102) The CAFE baseline scenario, which considers the full implementation of the Kyoto Protocol, assumes that the EU target will be reached, relying on an EU-wide emissions trading regime (whose permit price ranges from 12 Euro (2000) per tonne of $CO_2$ in 2010 to 16 Euro in 2015 and 20 Euro in 2020–2030) and the use of flexible mechanisms.

(103) In the baseline projection, the assumptions made with regard to nuclear are as follows. The European countries which have announced and adopted a decommissioning policy (i.e. Germany, Belgium and Sweden) implement it fully according to published time schedules. The countries which currently have nuclear plants in operation do not face any kind of limitation on the extension or reduction of their nuclear plants; on economic, technical and environmental grounds, nuclear technology can be expanded or abandoned, just like any other technology. Finally, the countries which currently do not have any nuclear plants do not opt for nuclear in the future.

(104) See Chapter 3 for agriculture-related GHG emissions such as nitrous oxide (fertilisers) and methane (animals).

(105) Between 1990 and 2002, the EU-15 countries reduced their GHG emissions by 2.9 %.

(106) For more detailed information on projections of greenhouse gas emissions and the use of Kyoto mechanisms based on national inventories and projections, see EEA, 2004b; EEA, 2004e.

(107) For further details, see the EEA Report 'Impacts of Europe's changing climate' (EEA, 2004c). The potential benefits of climate change (such as extension of crop production or access to huge oil reserves under the Artic icecap) are not assessed here.

(108) See also EEA (2004b, 2004e) for assessments based on national emission inventory schemes and projections.

(109) The calculations used the EuroMove model, which includes about 1 400 species in total; each EU country usually exhibits more that 250 species (see Annex 2 for further details).

(110) Using the stochastic model Prometheus. See Annex 2 for further details.

(111) For details on the low GHG emissions scenario see Box 3.4 in Chapter 3. Also see Chapter 3 for the alternative agriculture scenarios to the baseline projection.

(112) A continuation of the current high oil prices and volatility in the medium and long term would provide additional incentives for the further penetration of carbon-free technologies.

(113) Security of supply, which in essence differs from the dependence issue, is not addressed here.

(114) The investment costs are the net result of two off-setting effects: lower investments due to a lower overall electricity demand growth, and higher (substitution) investments to comply with the GHG emissions targets. The considerable increase in fuel costs directly reflects the introduction of carbon permit prices (rising to 65 EUR/t $CO_2$ in 2030 and 115 EUR/t $CO_2$ by 2050).

(115) Note that supply-side and demand-side energy costs cannot be added since the former are partly passed on to end-users, and that the costs of inaction (i.e. costs of climate change impacts) are not accounted for here.

(116) Also referred to as 'double dividend' situations, i.e. when policy measures for protecting the environment also lead to economic benefits, for example in terms of employment, trade or innovations.

(117) As the sixth environment action programme does not mention any dates for the long-term climate change target, it has been assumed in the low GHG emissions scenario that global temperature increase stabilises at 2 °C between 2100 and 2150.

(118) Note that this analysis represents one element of a full chain analysis of the nuclear option, which should take into account the issues related to decommissioning and waste management (e.g. costs, environment and health impacts).

(119) The baseline scenario includes emission control policies according to current legislation in each country; all known policies that have been implemented (or are in the pipeline) until the end of 2003 are included. The assumption about penetration of emission control measures for individual countries has been verified by national experts during bilateral stakeholder consultations carried out within the CAFE Programme. Further detail on the air quality scenarios can be found in Eerens *et al*., 2005.

(120) MTFR denotes the combined air pollution and climate change 'low emissions' scenario. With regard to climate change, the MTFR scenario relies on the low GHG emissions assumptions presented above (see Box 3.4 in Chapter 3 and Chapter 4.1). As far as air pollution is concerned, the MTFR scenario assumes the implementation of the most advanced technical emission control measures in each economic sector in order to give an indication of the potential to meet long-term environmental and health objectives. In many cases technology available depends on the age (vintage) of the capital stock in a given sector. Only measures that do not require premature retirement of existing equipment before the end of its technical life time are included.

(121) The longer time frame of the EEA scenarios (2030 rather than 2020) results generally in additional structural changes in European energy supply and consumption and higher penetration of control measures compared with the CAFE scenarios.

(122) The issues of stratospheric ozone depletion and dispersion of chemicals such as organic compounds or heavy metals are not addressed in this report.

(123) See, for example, directives for vehicles (Council Directive 2000/53/EC), large combustion plants (Council Directive 2001/80/EC) and industry (VOC directives (Council Directive 94/63/EC and Council Directive 1999/13/EC) and the integrated pollution prevention and control directive (Council Directive 96/61/EC)).

(124) Emissions of $PM_{10}$ and $PM_{2.5}$ in the EU decreased by approximately 50 % between 1990 and 2000. The most important drivers were (1) economic restructuring in central and eastern Europe (New-10) and in eastern Germany, which has caused a dramatic decrease of emissions from the power plant, industry and process sectors, (2) a switch from coal to other fuels in the household sector, (3) implementation of more efficient control technologies, especially on large combustion sources, and (4) enforcement of stringent standards on exhaust emissions from road transport sources.

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(125) As with the land-based emissions, two scenarios have been developed under the CAFE programme: a baseline scenario and the maximum technically feasible reductions; the former includes measures already decided, as well as measures that are the state of the art technology for newly built ships, while the latter assumes full implementation of the best available emission control technology on all existing and new ships.

(126) The calculations have been performed with the RAINS and EMEP models. The analysis was carried out for the meteorological conditions of a single year (1997). Eerens *et al*. (2005) discusses in detail the method and intrinsic difficulties of performing these types of assessment and further results in terms of spatial analysis.

(127) France, Germany, Italy, The Netherlands and the United Kingdom.

(128) Finland, Norway, Sweden, Switzerland and the United Kingdom.

(129) This represents international shipping for the European sea region, i.e. Atlantic Ocean, Baltic Sea, Black Sea, Mediterranean Sea and North Sea.

(130) The fraction of water consumed and not returned to the water body after withdrawal is about 80 % for agriculture, 20 % for households and manufacturing, and 5 % for electricity generation.

(131) The figures in this outlook do not include the possible effects of improved water management regimes and water pricing systems.

(132) See Flörke and Alcamo (2004) for further details.

(133) The extent of this area can be considerably lower than the area equipped for irrigation due to economic and/or climatic reasons — in Romania, for example, less than 10 % of the area equipped for irrigation is actually irrigated.

(134) Current estimates show that on average about 4.5 $m^3$ of water are required per MWh produced in a tower cooling system, and 180 $m^3$ for a once-through flow cooling system (see Chapter 3).

(135) Flörke and Alcamo (2004) assumes that on average about 1.33 $m^3$ are required per MWh produced with tower cooling and 0.65 $m^3$ with once-through cooling.

(136) See EEA report 'Household consumption and the environment' (EEA, 2005b).

(137) The figures on water use for households are based on a model which relates future water withdrawals to income via a sigmoid curve and to continuously improving water-use efficiency of household appliances. See Annex 2 for further details.

(138) Manufacturing includes water use in the iron & steel, non-ferrous metals, chemicals, non-metallic minerals, paper & pulp, food & drink, engineering, and textile sectors — water withdrawals in these sectors combine to more than 80 % of total withdrawals for manufacturing purposes.

(139) For explanation of country grouping see Annex 1.

(140) For explanation of country grouping see Annex 1.

(141) For explanation of country grouping see Annex 1.

(142) For explanation of country grouping see Annex 1.

(143) Only part of the area equipped for irrigation in some European countries is actually irrigated on a regular basis (e.g. 5 % (Romania), 6 % (Bulgaria) and 60 % (Turkey)). Thus assumptions of an expansion of irrigated area do not necessarily imply setting up new large-scale irrigation projects, but also refers to an enhanced 'exploitation' of current irrigation by bringing systems into use or installing newer systems.

(144) Water stress is calculated on the basis of water withdrawals. Particularly when used for cooling purposes, much of the water is returned directly to the river basin, and not actually consumed.

(145) Return-flow is the amount of irrigation water minus evapo-transpiration.

(146) See Lehner *et al.* (2000) and EEA (2005c).

(147) Details of this study, undertaken by EEA's European Topic Centre for Water, can be found in Kristensen *et al.* (2004). Annex 2 gives a short description of the techno-economic model developed.

(148) See EEA (2001d) and EEA (2005d, 2005e) for related effectiveness analysis.

(149) Four groups of European countries have been used for reporting the outlook results:
Group 1 (EU-15) countries: EU-15 countries that already have a high level of tertiary treatment (the Netherlands, Germany, Austria, Denmark, Sweden, and Finland).
Group 2 (EU-15) countries: EU-15 countries that currently have secondary treatment or discharges without treatment, and will have tertiary treatment when the UWWT directive is implemented (Belgium and Luxembourg).
Group 3 (EU-15) countries: EU-15 countries that will have the majority of their population connected to secondary treatment when the UWWT directive is implemented (France, Ireland, Italy, Greece, Portugal, and Spain).
New-5 countries: Five new Member States of the EU (Estonia, Czech Republic, Poland, Hungary and Slovenia). Insufficient information on current wastewater treatment is available for the remaining new Member States of the EU.

(150) For example, the urban waste water treatment directive imposes 'at least secondary treatment' on agglomerations greater than 2 000 person-equivalent that do not discharge into sensitive areas; the present outlook, due to a lack of sufficient information, does not take into account that some countries may decide to do better than the directive's mininmum requirements.

(151) An analysis of the economic costs of compliance with the directive appears desirable in order to complement the results of this outlook exercise.

(152) For example, the emissions trading scheme (ETS, implemented in January 2005) with national allocation plans assessed and adopted by the European Commission in the second half of 2004.

(153) See EEA (2004b, 2004e) based on national emission inventory schemes and projections.

(154) The sustainable development strategy sets a target of reducing emissions by an average of 1 % per year up to 2020. The baseline projection indicates that EU-25 emissions by 2020 are expected to have increased by 4 % over 1990 levels.

(155) See also 'Energy for the future: renewable sources of energy — white paper for a community strategy and action plan' (COM (97) 599).

(156) See also the indicative targets of 2 % by 2005 and 5.75 % by 2010 for biofuels and other renewable fuels, calculated on the basis of energy content, of all petrol and diesel for transport purposes (Council Directive 2003/30/EC).

(157) The sustainable development strategy targets call for a 'significant decoupling of transport growth from growth in gross domestic product' and for a 'shift in transport use so that the share of road transport in 2010 is no greater than in 1998'

(158) See also the water framework directive target calling for 'by 2015 all EU waters to meet 'good status' (ecological, chemical, quantitative status) and sustainable water use'.

(159) See also the national emissions ceilings directive for certain atmospheric pollutants (Directive 2001/81/EC).

(160) The urban waste water treatment directive target is to ensure that 'collecting and treatment system must be provided in all agglomerations larger than 2000 inhabitants' by 2005 and 2015 respectively for the EU-15 and the New-10.

(161) See also the nitrates directive target 'to reduce water pollution caused or induced by nitrates from agricultural sources and preventing further pollution'.

(162) See also the EU directive on the promotion of electricity from renewable energy sources in the internal market (2001/77/EC).

(163) The sustainable development strategy sets the target to 'decouple the use of resources and generation of waste from the rate of economic growth'.

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(164) EEA's outlooks have been subjected to quality assurance and consultation processes. This included a series of review from the members of the advisory group, the contributors who worked on the background information of this report and the EEA staff. In addition, two official consultations with the EEA's Management Board, Scientific Committee and Eionet network (national focal points (NFPs) and national reference centres (NRCs)) were undertaken. This included the European Commission and the European Parliament, which sit on EEA's Management Board. A document listing all the comments received during the 2005 consultation processes, and indicating for each of them how they have been taken into consideration and addressed in the final version of the report, has been developed and is available from EEA Environmental Scenarios Information Web Portal (http://scenarios.ewindows.eu.org).

(165) In this context, the EEA's Prelude project (Prospective environmental analysis of land use development in Europe) developed and analysed five land-use changes scenarios for Europe.

# Annex 1 Country groupings/ acronyms and abbreviations

### Country groupings used in this report

**EEA-31** (also: EEA member countries): Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Italy, Latvia, Lithuania, Liechtenstein, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Turkey, United Kingdom.

**EU-25**: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom. (Note: EU-25 comprises both EU-15 and New-10 country groupings below).

**EU-15:** Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom.

**New-10** (also: EU 10 new Member States): Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia.

**EU-CC** (also: EU candidate countries): Bulgaria, Romania, Turkey.

***Specific country groupings referred to only in Chapter 3***

**New-8:** EU new Member States except Cyprus and Malta: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia.

**EU-CC2:** Bulgaria, Romania.

***Specific country groupings referred to only in Section 4.3.***

**Northern Europe:** Austria, Belgium, Denmark Finland, Germany, Ireland, Luxembourg, Netherlands, Sweden, United Kingdom, Norway, Switzerland.

**Southern Europe:** France, Greece, Italy, Portugal, Spain.

***Specific country groupings referred to only in Section 4.4***

**Group 1 (EU-15)** countries: the Netherlands, Germany, Austria, Denmark, Sweden, Finland.

**Group 2 (EU-15)** countries: Belgium and Luxembourg.

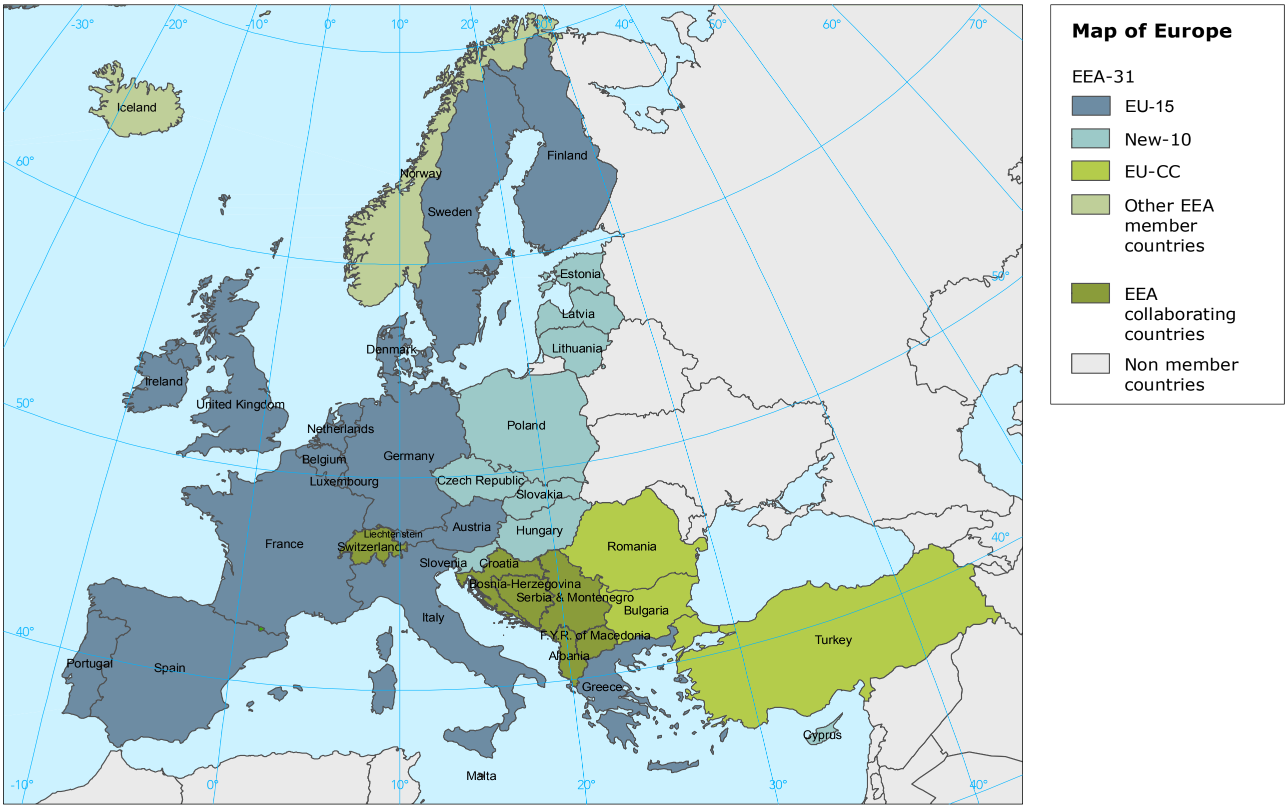
**Group 3 (EU-15)** countries: France, Ireland, Italy, Greece, Portugal, Spain.

**New-5 countries:** Estonia, Czech Republic, Poland, Hungary and Slovenia.

## Acronyms and abbreviations

| | |
|---|---|
| CAFE | Clean Air for Europe programme |
| $CH_4$ | Methane |
| $CO_2$ | Carbon dioxide |
| DG AGRI | Directorate-General for Agriculture and Rural Development |
| DG ENV | Directorate-General for Environment |
| DG TREN | Directorate-General for Energy and Transport |
| EEA | European Environment Agency |
| EU | European Union |
| GEO | Global Environment Outlook (UNEP) |
| GHG | Greenhouse gases ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$) |
| HFCs | Hydrofluorcarbons |
| IPCC | Intergovernmental Panel on Climate Change |
| K | Potassium |
| MEA | Millennium Ecosystem Assessment |
| N | Nitrogen |
| $N_2O$ | Nitrous oxide |
| P | Phosphate |
| PFCs | Perfluorcarbons |
| $SF_6$ | Sulphur hexafluoride |
| SoEOR2005 | 2005 State of the environment and outlook report |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |

## Country groupings



# Annex 2 Concise description of the modelling tools used

## Energy

### *PRIMES model*

PRIMES is a partial equilibrium model for the European Union energy system developed by, and maintained at, the National Technical University of Athens, E3M-Laboratory. The most recent version of the model used in this study covers each of the EU Member States, EU candidate countries and Neighbouring countries, uses Eurostat as the main data source, and is updated with 2000 as the base year. The PRIMES model is the result of collaborative research under a series of projects supported by the Joule programme of the Directorate General for Research of the European Commission.

The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply match the quantity consumers wish to use. The equilibrium is static (within each time period) but repeated in a time-forward path, under dynamic relationships. The model is behavioural but also represents in an explicit and detailed way the available energy demand and supply technologies and pollution abatement technologies. It reflects considerations about market economics, industry structure, energy/environmental policies and regulation. These are conceived so as to influence the market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision-making among agents that decide individually about their supply, demand, combined supply and demand, and prices. Then the market-integrating part of PRIMES simulates market clearing. PRIMES is a general purpose model. It is conceived for forecasting, scenario construction and policy impact analysis. It covers a medium to long-term horizon. It is modular and allows either for a unified model use or for partial use of modules to support specific energy studies.

For more information see: http://www.e3mlab.ntua.gr/manuals/PRIMESld.pdf and http://www.e3mlab.ntua.gr/.

### *POLES model*

The POLES model, developed and used under different EC programmes since 1994, allows elaboration of long-term energy supply and demand projections for the different regions of the world under a set of consistent assumptions concerning, in particular, economic growth, population and hydrocarbon resources.

The model structure corresponds to a hierarchical system of inter-connected modules and involves three levels of analysis:

- international energy markets;
- regional energy balances;
- national models of energy demand, new technologies and renewable energy, power generation, primary energy supply and $CO_2$ emissions. The POLES model distinguishes thirty-eight world regions or countries.

The dynamics of the model are based on a recursive simulation process, in which energy demand and supply in each national or regional module respond with different lag structures to international price variations in the preceding periods. In each module, behavioural equations take into account the combination of price effects, techno-economic constraints and trends. There are fifteen final energy demand sectors (covering the main industrial branches, transport modes, the residential and service sectors), twelve large-scale power generation technologies and twelve new and renewable energy technologies.

Oil and gas supply profiles in the largest world producing countries are dealt with in a discovery process model in which oil and gas production depends on the dynamics of the drilling activity and discovery of new reserves, given existing resources and cumulative production. Coal supply is essentially demand-driven.

For more information see: www.upmf-grenoble.fr/iepe/textes/POLES8p_01.pdf and http://web.upmf-grenoble.fr/iepe/Recherche/Recha5.html.

### *Prometheus model*

Prometheus is a tool for the generation of stochastic information for key energy, environment and technology variables. It is developed by, and maintained at, the National Technical University of Athens, E3M-Laboratory. Prometheus is a self-contained energy model consisting of a set of stochastic equations. It contains relations and/or exogenous variables for all the main quantities. These include demographic and economic activity indicators, energy consumption by main fuel, fuel resources and prices, $CO_2$ emissions, technology uptake and two factor learning curves. All exogenous variables, parameters and error terms in the model are stochastic with explicit representation of their distribution including in many cases terms of co-variance. It follows that all endogenous variables are also stochastic.

The basic output of Prometheus is a data set of Monte Carlo simulations containing values for all the variables in the model. This set can subsequently be used in its own right, as strategically or analytically important information on risks and probabilities regarding the variables incorporated in it or any pre-determined function involving them. Major applications are in security of supply assessment, environmental risk assessment and investment risk analysis.

For more information see: http://www.e3mlab.ntua.gr/.

### *TIMER model*

The energy system model, TIMER (targets image energy regional model), has been developed to simulate long-term energy baseline and mitigation scenarios and explore the long-term dynamics of the energy system. The model describes the investments in, and the use of, different types of energy options influenced by technology development (learning-by-doing) and depletion. Inputs to the model are macro-economic scenarios and assumptions on technology development, preference levels and fuel trade. The output of the model demonstrates how energy intensity, fuel costs and competing non-fossil supply technologies develop over time. The model recognises 17 world regions, 5 different end-use sectors, several different energy-producing sectors and about 10 energy carriers. The electricity generation sub-model includes production options based on hydropower, nuclear energy, renewables and different fossil fuels. The model is linked to an emission module that relates energy use to emissions of various greenhouse gases. TIMER is incorporated into the IMAGE integrated assessment framework to study global change. Implementation of $CO_2$ mitigation is generally modelled on the basis of price signals. A tax on carbon dioxide (carbon tax) is applied to bring down carbon emissions from the energy system. It should be noted that TIMER does not account for any feedback from the energy system to economic drivers.

For more information see: http://arch.rivm.nl/ieweb/ieweb/index.html?tools/timer.html.

## Agriculture

### *CAPSIM model*

The EEA agricultural outlooks are based on the CAPSIM model developed by EuroCARE GBmv (Bonn, Germany, see Witzke *et al.* (2004) for further details). CAPSIM is a European partial equilibrium modelling tool with behavioural functions for activity levels, input demand, consumer demand and processing. It is designed for policy-relevant analysis of the CAP and consequently covers the whole of agriculture of EU Member States in the concepts of the Economic Accounts (EAA) at a high level of disaggregation, both in the list of included items (cropping and livestock patterns and animal products per country) and in policy coverage. Technological, structural and preference changes combine with changes in exogenous inputs (e.g. population, prices or household expenditure) to determine the future development of agriculture.

The model allows combining different projections, for example from modelling tools, expert panels or trends forecasts, and finds a compromise between these under a set of economic (e.g. market balances), spatial (e.g. used vs. available areas) and technical (e.g. balancing of feed contents and animal requirements) constraints. The projections from the following organisations have been taken into account in the EEA agricultural outlooks: European Commission (2004a); FAPRI, (2004); FAO (Bruinsma, 2003); and IFPRI (Rosegrant *et al.,* 2001a and 2001b).

CAPSIM is augmented by a calculation of selected environmental indicators, namely: nutrient balances (N, P, K) and gaseous emissions ($NH_3$, $N_2O$, $CH_4$). Without additional assumptions and informed reasoning it is impossible to draw conclusions for biodiversity, landscape characteristics and erosion, to mention the most important omissions. Furthermore the database does not permit the identification of irrigated areas, organic farming, biofuels or energy crops and environmental programmes. It should finally be mentioned that all indicators have been calculated per ha of agricultural area used, that is net of fallow land or set aside.

For more information see: http://www.eurocare-bonn.de/profrec/capsim/capsim_e.htm.

## Waste and material flows

### *Waste and material flows model*

The EEA's European Topic Centre on Waste and Material Flows, in collaboration with the Risø National Laboratory, has developed a macro-econometric model that projects the generation of waste and materials flows at the national level (see Skovgaard *et al.* (2004) for further details). The theoretical approach is rooted in macro-econometrics as the quantities of waste and material flows are projected as a function of future developments in the number of households, the size of population, or economic activity in the relevant sectors (e.g. production, gross value-added or private final consumption). Projections for waste oil and used tyres are based on the 'car stock and end-of-life vehicles' vintage model developed by the Risø national laboratory. Fossil fuel projections are based on the results of the PRIMES model using country-specific coefficients for transforming ktoe to tonnes. The domestic material consumption (DMC) indicator is reported for fossil fuels (i.e. domestic extraction + net trade (imports — exports)), while the domestic extraction only is estimated for minerals and biomass.

The calibration of the model over past data reflects the level of 'coupling' between the explanatory variables and waste and materials flows. Coupling or decoupling in excess of what happened in the past are an assumption fed into the model rather than a result of it. In addition, time trends that represent (autonomous) technological change are progressively phased-out over the projection period (at different rates depending on the waste stream and the country), leaving the dynamics of the model governed by the socio-economic explanatory variables. Finally, one has to note that the pieces of legislation are only implicitly included in macro-economic models.

For more information see: http://waste.eionet.eu.int/publications/wpl_2005.

## GHG emissions and climate change

### *IMAGE model*

IMAGE 2 (Integrated Model to Assess the Global Environment) is a so-called 'Integrated Assessment Model (IAM)'. IAMs are in general developed to assess human impacts on the environment and earth system. IMAGE 2 is a multi-disciplinary IAM, designed to simulate the dynamics of the global society-biosphere-climate system. The objectives of the model are both science- and policy-related.

Scientific goals of the model are:

- to simulate future trends of greenhouse gas emissions.
- to investigate linkages and feedbacks in the society-biosphere-climate system.
- to assess the most important sources of uncertainty in such society-biosphere-climate linked system.
- to help identify gaps in knowledge about the system in order to help set the agenda for global change research.

Policy-related goals of IMAGE 2 are:

- to support decision-making by linking important scientific and policy aspects of global change.
- to provide a dynamic and long-term (30–100 years) perspective of the consequences of global change.
- to evaluate the consequences of different policy options, and economic and technological scenarios, including costs and benefits.
- to provide insights on cross-linkages of various policy measures.

IMAGE 2 consists of three systems of models (II-3): The energy model TIMER, terrestrial environment system (TES), and atmosphere ocean system (AOS). Interactions and several feedbacks between these systems and underlying model are modelled explicitly.

TIMER uses information on economic and demographic trends in the 18 regions to compute human activities, energy-related variables (e.g.

consumption, efficiency improvement, supply and trade of fossil fuel and renewables), industrial production, and emissions of greenhouse gases, ozone precursors and sulphur. Furthermore, although IMAGE 2 is global in application, calculations range from a 0.5 °longitude x 0.5 °latitude grid (for terrestrial issue) to the world region level, depending on the type of calculation.

TES consists of various models computing food, fodder and wood demand, crop and animal production, trading of food and timber, the distribution of natural ecosystem, greenhouse gas emissions from land-use change, natural ecosystems and agricultural production systems, and the carbon storage pools within the terrestrial biosphere and exchange between biosphere and atmosphere.

Models in the AOS compute changes in atmospheric composition by employing the emissions from TIMER and TES and by taking the oceanic and terrestrial $CO_2$ uptake and atmospheric chemistry into consideration. Subsequently, changes in climatic properties are computed by resolving oceanic heat transport and the changes in radiative forcing by GHGs and aerosols. Finally, IMAGE 2 contains specific impact models for sea-level rise and land degradation risk.

For more information see: http://arch.rivm.nl/ieweb/Image/index.html?home.html.

### *Euromove model*

Euromove is a species-based model using logistic regression equations to calculate occurrence probabilities for almost 1 400 European vascular plant species. The equations are based on six climatic variables from IMAGE (including climatic temperature data) and species data from the Atlas Flora Europaeae (AFE) (Jalas and Suominen 1989; Ascroft 1994). In the Euromove model (Bakkenes *et al.*, 2002) a threshold probability value for each species have been determined to transform calculated probabilities into absent-present states.

For more information see: http://arch.rivm.nl/ieweb/ieweb/index.html?tools/euromove.html.

### *FAIR model*

The policy decision-support tool FAIR (framework to assess international regimes for the differentiation of commitments) aims to support policy-makers in assessing the environmental and economic implications of international climate regimes for differentiation of future commitments beyond 2012 compatible with the climate change convention objective of stabilising the atmospheric concentrations of greenhouse gases (Article 2) (den Elzen and Lucas, 2003). Other objectives are to evaluate the Kyoto Protocol after the Bonn and Marrakesh agreements in terms of environmental effectiveness and economic costs, and to support the dialogue between scientists and policy makers. The FAIR 2.0 model represents an integration of three sub-models: 1. A climate model for evaluating the climate impacts of global emission profiles and calculating the regional contributions to climate change. 2. An emissions allocation model to explore and evaluate the emission allowances for differentiation of future commitments for ten climate regimes of the world regions (e.g. the Brazilian proposal, and multistage, contraction & convergence, emission intensity target, triptych). 3. A mitigation-cost and emission-trading model to distribute the emission reduction objective over the different regions, gases and sectors following a least-cost approach, to calculate the international permit price and determine the buyers and sellers on the international trading market, and to calculate the regional mitigation costs and emission reductions.

For more information see: http://www.rivm.nl/fair/.

## Air quality

### *RAINS model*

The regional air pollution information and simulation (RAINS) model provides a tool for analysis of reduction strategies for air pollutants (Amann *et al.*, 1999). The model considers emissions of sulphur dioxide ($SO_2$), nitrogen oxides ($NO_X$), ammonia ($NH_3$), non-methane volatile organic compounds (NMVOC) and particulate matter (PM). RAINS consists of several modules, which contain information on:

- economic activities that cause emissions (energy production and consumption, passenger and freight transport, industrial and agricultural production, solvent use etc.);
- emission control options and costs;
- atmospheric dispersion of pollutants;
- sensitivities of ecosystems and humans to air pollution.

It simultaneously addresses impacts on health and ecosystems of particulate pollution, acidification, eutrophication and tropospheric ozone. Thus it creates a consistent framework for multi-pollutant, multi-effect air pollution management. Historic emissions of air pollutants are estimated for each country in Europe based on information collected by international emission inventories (EEA, 2005c) and national information (Tarrasón *et al.*, 2004). Options and costs for controlling emissions are represented by several emission-reduction technologies. Atmospheric dispersion processes over Europe for all pollutants are modelled on the basis of results of the European EMEP model developed at the Norwegian Meteorological Institute (Simpson *et al.*, 2003).

The model covers almost all European countries, including the European part of Russia. RAINS incorporates data on energy consumption for 42 regions in Europe, distinguishing about 24 categories of fuel use in 6 major economic sectors. The RAINS database also covers scenarios of non-energy economic activities responsible for air pollution (agricultural production, industrial processes, solvent use, etc.). Activity scenarios are an exogenous input to the model.

RAINS calculates emission reductions for control strategies reflecting current pollution control legislation in Europe. Emission reductions are assumed to be achieved exclusively by technical measures; any feedback of emission controls on economic and energy systems is not included. Options and costs for controlling emissions for the various substances are represented in the model by reflecting characteristic technical and economic features of the most important emission control technologies. The model covers several hundred technologies.

For more information see: http://www.iiasa.ac.at/rains/Rains-online.html?sb=8.

### *EMEP model*

The unified EMEP model is a Eulerian model that has been developed at EMEP/MSC-W (Meteorological Synthesizing Centre — West) for simulating atmospheric transport and deposition of acidifying and eutrophying compounds as well as photo-oxidants and $PM_{2.5}$ and $PM_{10}$ in Europe. The latest model version has been documented in the EMEP Status report I, Part I (Simpson *et. al*., 2003) and the EMEP Status report 2004 (Tarrasón *et al.*, 2004) where a few updates are described.

The model domain covers Europe and the Atlantic Ocean. The model grid has a horizontal resolution of 50 km at 60 °N, which is consistent with the resolution of emission data reported to CLRTAP. In the vertical, the model has 20 sigma layers reaching up to 100 hPa. The unified model uses 3-hourly resolution meteorological data from the PARLAM-PS model, a dedicated version of the HIRLAM (high resolution limited area model) numerical weather prediction model.

The emissions consist of gridded annual national emissions of sulphur dioxide, nitrogen oxides, ammonia, non-methane volatile organic compounds and carbon monoxide. They are available in each cell of the $50 \times 50$ km$^2$ model grid and distributed temporally according to monthly and daily factors derived from data provided by the University of Stuttgart (IER). Concentrations of 71 species are computed in the latest version of the Unified EMEP model (56 are advected and 15 are short-lived and not advected). Four secondary and two primary PM compounds are included in the model. The sulphur and nitrogen chemistry is coupled to the photo-chemistry, which allows a more sophisticated description of e.g. the oxidation of sulphur dioxide to sulphate, also including oxidant limitations.

Dry deposition is calculated using the resistance analogy and is a function of the pollutant type, meteorological conditions and surface properties. Parametrisation of wet deposition processes includes both in-cloud and sub-cloud scavenging of gases and particles using scavenging coefficients.

For more information see: http://www.emep.int

## Water stress

### *WaterGAP model*

WaterGAP (Water: global assessment and prognosis; version 2.1) is the first global model that computes both water availability and water use on the river basin scale (Alcamo *et al.,* 2003a; 2003b). The model, developed at the University of Kassel, Germany, has two main components: A global hydrology model and a global water use model.

WaterGAP's global hydrology model simulates the characteristic macro-scale behaviour of the terrestrial water cycle to estimate water availability. The global water use model consists of four main sub-models that compute water use for the domestic, manufacturing, energy, and agriculture sectors. All computations cover the entire land surface on a 0.5 x 0.5 °latitude-longitude grid.

A drainage direction map then allows the analysis of the water resources situation in all large drainage basins.

For more information see: http://www.usf.uni-kassel.de/usf/forschung/projekte/watergap.en.htm

## Water quality

### *Nutrients discharges from UWWT plants model*

The EEA's European Topic Centre for Water developed a simple techno-economic model that projects at the national level nutrient discharges from urban waste water treatment plants. Nutrient discharges are projected as a function of future developments in the population connected to sewers and the level and retention characteristics of wastewater treatments. For calibration purposes, the model builds on the following information:

- past and current data on the level of nutrients produced per capita;
- past and current data on connection rate to sewers, the level of wastewater treatment and the different technologies used in the EU countries. This is based on information collected by the joint Eurostat/OECD questionnaire of 2002 (see also Eurostat 2003; and OECD, 2003);
- national information on the retention of organic matter and nutrients in waste water treatment plants.

For more information see Kristensen *et al.*, (2004).

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# Annex 4 Glossary on environment outlooks

An **outlook** depicts future developments, usually highlighting the relationship and interactions between key driving forces and their possible implications.

A **scenario** is a plausible description of how the future may unfold based on 'if-then' propositions. A typical environmental scenario includes a representation of the initial situation and a storyline that describes the key driving forces and the changes that lead to an image of the future. Note that scenarios are neither predictions nor forecasts.

**Baseline scenarios** (also referred to as 'reference scenarios' or 'benchmark scenarios') are scenarios in which no new policies or measures are implemented apart from those already adopted or agreed upon.

**Alternative scenarios** (also referred to as 'policy scenarios') are scenarios, which take into account new policies or measures additional to those already adopted or agreed upon and/or assumptions on key driving forces that diverge from those depicted in a baseline scenario.

**Exploratory scenarios** start with an initial situation and a set of assumptions on policies, measures and key driving forces to explore plausible future developments.

**Anticipatory scenarios** (sometime also referred to as 'normative scenarios') start with a prescribed vision of the future and then works backwards to visualise how this future could emerge.

**Qualitative scenarios** are narrative descriptions of future developments (presented as storylines, diagrams, images, etc).

**Quantitative scenarios** are numerical estimates of future developments (presented as tables, graphs, maps, etc), usually based on available data, past trends and/or mathematical models.

**Projection** — see quantitative scenarios.

A **sensitivity analysis** is an investigation of how outputs vary with changes in individual key assumptions/input variables of projections. The aim is to identify the relative (marginal) effect of an individual assumption/input variable on the projection outcomes and isolate its chain of effects. Stress testing is a specific form of sensitivity analysis in which the effects of extreme values are investigated. The aim is to study under which conditions the boundary conditions (for example dramatic unsustainable patterns) would be reached.

An **uncertainty analysis** is an assessment of the degree to which a value (e.g. describing a future development or state) is unknown, in which the consequences of uncertainties in assumptions and/or model inputs/equations on the outputs are analysed. In model-based assessments the input variables for the uncertainty analysis usually range within values investigated by sensitivity analyses — common techniques include, for example, Monte Carlo approaches and the calculation of confidence intervals. Uncertainty can also be represented by qualitative statements, for example reflecting expert judgment.

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