EEA Technical report | No 8/2008

Catalogue of forward-looking indicators from selected sources

A contribution to the forward-looking component of a shared environmental information system (SEIS/Forward)

ISSN 1725-2237

European Environment Agency

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Cover design: EEA
Layout: Diadeis, EEA/Henriette Nilsson

Luxembourg: Office for Official Publications of the European Communities, 2008

ISBN 978-92-9167-373-5
EEA Technical report series: ISSN 1725-2237

DOI 10.2800/48407

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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Acknowledgements

This report has been designed and compiled by Elena Santer (UNEP/GRID-Arendal) with contributions of Anita Pirc Velkavrh (EEA).

Other contributors to the report include: Peter Saunders and Thomas Henrichs (NERI) for editing and commenting, Ybele Hoogeveen (EEA) for his contribution to the name which captures activities related to forward-looking information base.

Preparation and publishing of the report has been supported and guided by Teresa Ribeiro (EEA, Head of Scenarios and Forward Studies Group) and Jock Martin (EEA, Head of Programme Biodiversity, Spatial Analyses and Scenarios).

Anita Pirc Velkavrh (EEA) has been the project manager for this report.

Introduction

Wider context

Environmental policy-makers and others working with environmental issues are facing ever more demanding challenges. The situations they are grappling with are becoming more and more dynamic and complex. Rapid globalisation, for example, has increased the inter-dependencies of countries within Europe and with other global regions. These trends are expected to continue: emerging economies are growing quickly and new political alliances are being formed. Technological development, changes in consumption patterns and growing concerns about social inequity are also examples of areas where rapid and substantial changes are being driven by growing global inter-dependence and improved communication technologies. And while in the 1970s environmental issues barely made it into the public debate, today's discussions about the impacts of climate change and the use of natural resources are among the most prominent topics on political agendas.

Meanwhile this rapid rate of change — and the associated increase in complexity — is increasing the uncertainties related to possible future trends and about the effectiveness of policies. Recent projections of environmental trends, in particular, give great cause for concern: climate change, for example, is increasingly recognised as a major threat to our way of life; air pollution is expected to continue to pose significant threats to human health; the observed biodiversity decline and loss of ecosystem services is not expected to reverse unless new actions are introduced; and the unsustainable patterns of resource use and waste generation are expected to continue to increase.

These diverse issues — dynamic changes, complexity, uncertainty and unfavourable projections — occurring over a range of geographic scales, have triggered a growth in demand for forward-looking information and scenario-based assessments. According to an annual survey of management tools, more than 70 % of the companies surveyed used scenario planning in 2006, compared with only 40 % in 1999 (Hindle 2008). Scenario-based approaches are also increasingly being used in a policy context, albeit often in a more indirect form of support to decision making (such as stimulating the debate, framing a decision-making agenda) rather than as direct support (such as generating or appraising options for the future) (EEA forthcoming).

Nonetheless, well designed and sound forward-looking assessments and scenario-based approaches can effectively support different phases of the policy cycle. They can, for example, support policy making by providing a platform for reflecting on different options for the future, for identifying uncertainties, for framing policies by identifying priority and emerging issues, for checking whether and how targets can be met, for developing robust measures and precautionary actions, for analysing cause-effect relationships, for anticipating possible surprises, and for facilitating short and long-term thinking in a structured way. Furthermore, many approaches used to underpin forward-looking assessments are designed to be participatory and can thus help improve communication between stakeholders early in policy processes or facilitate discussion among different communities.

Forward-looking assessments can also help improve the information base and information relevance. We can develop more flexible information systems that can respond quickly and economically to different futures that may develop. To a large degree this can also support the strategic planning of monitoring systems in a cost-effective way.

Overall it is of crucial importance that forward-looking assessments are well designed, supported by appropriate information systems, and fit well into the existing policy-making processes, enhanced by stakeholder participation. It is also important that institutions at different levels develop their capacities to be able to manage these requirements in a coherent way. Recent EEA analyses (EEA 2007b) showed that there are many shortcomings in the current use of forward-looking tools in environmental assessments. There is a need to:

- develop more targeted and sound forward-looking integrated environmental assessments at appropriate geographic scales (integrating social, technological, environmental, economic and demographic issues)
- include future perspectives routinely in regular environment reporting activities and systems (adapting existing information systems to

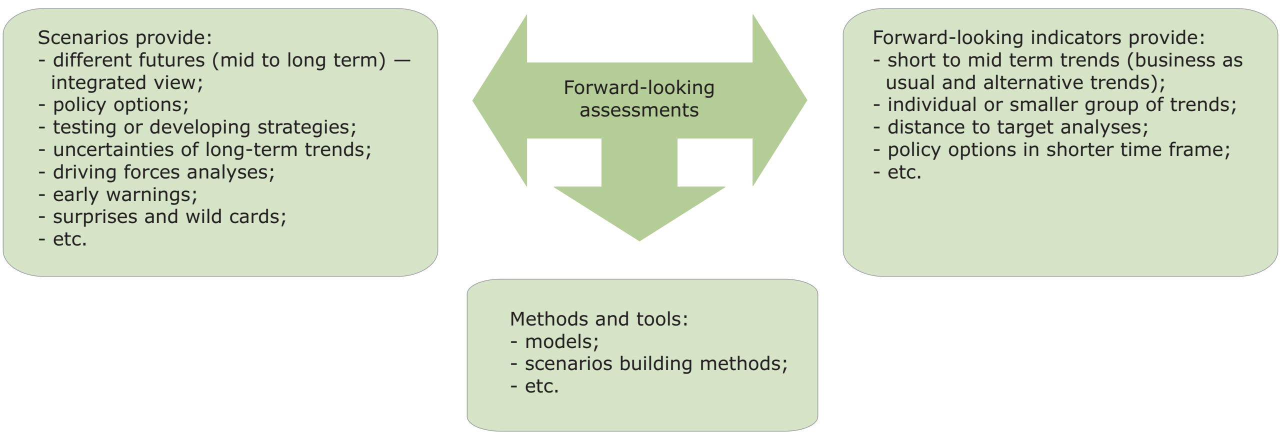
regularly capture data on future perspectives and emerging issues, and including more forward-looking perspectives in national environmental reporting products)
- strengthen national and regional leadership in producing forward-looking assessments to support policy processes (developing more forward-looking studies under the leadership of regional and national institutions)
- strengthen institutional capacity to perform forward-looking assessments at all levels (increasing expertise and resources to build and carry out forward-looking studies).

One of the basic requirements for the efficient use of forward-looking assessments is to improve and further develop forward-looking components of environmental information systems and integrate these into existing information systems. Here, the EEA is seeking to fill a gap in this area by developing forward-looking components of environment information systems that will ultimately contribute to a Shared Environmental Information System (SEIS) ([1]). Such forward-looking information systems should include both quantitative information (such as projections and other model-based data) and combinations of qualitative and qualitative information (such as environmental scenarios). The objective of this forward-looking information system is not to produce better data to reflect a reality that has not yet unfolded, but to produce information that provides deeper understanding and insights into possible future developments (see Figure 1).

A further requirement, in addition to improving the information base, is to ensure the consistency of assessments related to the past, present and future. There are many tools and approaches to support different types of assessment, but they may not provide coherent outputs if not selected and designed so as to complement each other. Such tools and approaches can be used with different effectiveness to deal with complexity and uncertainty and to cope with uncertainties that are increasing with time (Figure 2). While model-based projections might effectively support short-term decision processes where uncertainties are not too large, scenario development and scenario-based analyses (which are based on the exploration of uncertainties) become more important tools for longer-term assessments. If used and interpreted improperly they not only become ineffective, they may even be misleading.

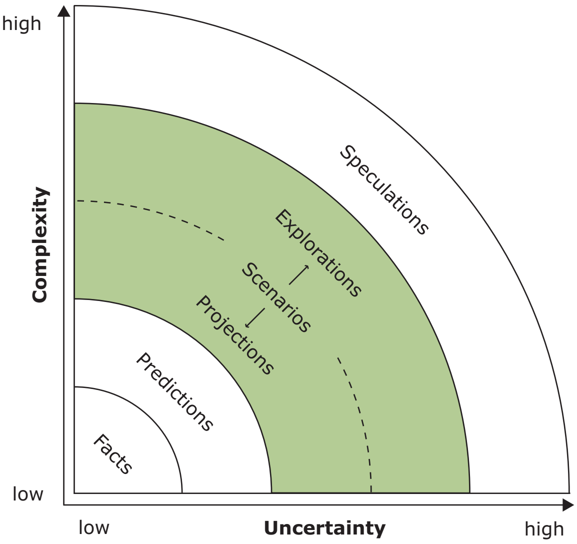
Projections and scenarios are not the only ways of exploring the future; the large number of forward-looking approaches and methods includes environmental scanning, mega-trend analysis, backcasting, road mapping, system dynamics, sensitivity analysis and probabilistic analysis. Some of these are statistical and economic forecasting tools, some are more qualitative in their approach, and others are based on probability theories (see also EEA, 2000 and EEA, 2001a and b). However, all of these approaches require not only knowledge and procedural understanding — there is an art in developing targeted methodological approaches

Figure 1 Forward-looking information building blocks of environmental information systems for the support of integrated assessments (including quantitative and qualitative information)



([1]) The Shared Environment Information System (SEIS) will be a distributed 'system of systems' for environmentally relevant information, in which current systems for managing information centrally are increasingly replaced by systems based on access, sharing and interoperability (COM(2008)46 final communication from the Commission to the Council, the European Parliament, the European and Social Committee and the Committee of the Regions/Towards a Shared Environmental Information System (SEIS) and EEA (2008) Shared Environment Information System Implementation Plan 2008 with Eionet).

Figure 2 Dealing with the uncertainty and complexity of underlying system dynamics in forward-looking assessments



Source: Zurek and Henrichs, 2007.

that use an appropriate selection of tools to deliver appropriate outcomes for our needs.

To further this, EEA activities in the last two years aimed at improving the information base of forward-looking assessment include (also see www.eea.europa.eu/themes/scenarios):

- cataloguing existing forward-looking indicators relevant for European environmental assessment (this report);
- establishing an inventory of models which support environment-related projections (this will be published later in 2008);
- cataloguing of scenarios and forward-looking studies in Europe (this overview will be published in 2009).

These three activities are being published in the form of a series of EEA technical reports labelled 'SEIS/Forward'. This series aims to reach as broad an audience as possible, and will also be made available on-line and updated regularly.

The report presented here is one part of this 'SEIS/Forward' series, and provides an overview of available forward-looking indicators. It includes selected forward-looking indicators, which have been published by EEA and other institutions and are relevant to European environment assessments. More detailed descriptions of the indicators presented here are available on-line in Indicator management service-outlooks (link: http://ims.eionet.europa.eu/IMS/ISpecs/sets#Outlook, will be publicly available by the end of 2008). For this report they are presented in a summarised form to improve their usability and raise awareness of their availability and potential for assessments. The latter will be assessed further in 2009, using specially developed criteria for quality assessment. However, there are already some challenges that can be identified on the basis of the material reviewed in this report: forward-looking indicators need to be more policy-relevant, inter-comparable, and allow for better spatial integration with data for the past.

About this report

Work on reviewing the availability of forward-looking indicators started in 2005, with the aim of enhancing their use in European environmental assessments. This work has resulted in an overview of the availability of forward-looking information (scenarios and indicators) across all themes and with various geographical coverage.

The literature review identified the forward-looking indicators available for the Pan-European region or parts of the region (reference list in Annexes 3 and 4). The set of indicators was selected for inclusion in the Indicator Management Service (IMS), an EEA tool normally used for the management of the EEA Core set of indicators (CSI) and other indicator sets related to past trends. The tool has now been adopted to also support the management of forward-looking indicators (Indicator management service-outlooks). This report presents a shorter version of the information available in the IMS and is just one step in the process of building a forward-looking information system.

The IMS supports the management of indicators in the EEA's daily work, allows better inter-comparison of indicators, and will be used to assess the potential of indicators for use in responding to policy questions related to future developments. Quality appraisal of forward-looking indicators will be done in the next phases of the EEA's work (which are expected to finish in 2009) on the basis of selected quality criteria. One set of criteria will support the quality assessment of individual indicators; another will be used to assess their suitability for providing and contributing to the assessment of specific topics. The criteria will be manageable in number, outlook-specific and, as far as possible, consistent with the criteria for the EEA Core set of indicators. The outcome of this appraisal will support EEA's integrated assessment activities and the planning of possible regular updates and publishing of forward-looking indicators.

More than 45 international sources were reviewed in 2006 for the availability of forward-looking indicators which are relevant to environmental assessments and cover the pan-European region or parts of it. More than 150 indicators from 14 institutions based on 14 different models were identified (see the list of scanned studies and indicators in Annex 3). The most relevant forward-looking indicators, besides those already published in the EEA's most recent State of the Environment and Outlook (EEA, 2005a), were selected for further analysis and included in the EEA Indicator management service. The criteria for selection were:

- relevance to the EEA's Europe's environment: The fourth assessment (EEA, 2007a) (i.e. availability, and support to the report's priority topics);
- availability of data on past trends to complement the forward-looking indicators (i.e. taking into account the EEA CSI framework);
- expanded geographical coverage, from the EU-25 to Eastern Europe, Caucasus and Central Asia (EECCA) and South Eastern Europe (SEE) (i.e. taking into account the EECCA Core set of indicators framework).

Few of the forward-looking indicators published by other institutions are directly related to the EEA CSI. Examples of issues not covered or only weakly covered by forward-looking indicators with wider European coverage are: terrestrial indicators, fisheries, water quality, land and natural resource use, biodiversity, indicators related to environmental impacts, environmental management (response) and to integration with socio-economic issues.

Although the work on including forward-looking indicators in the IMS is still under way, some outcomes have already proved useful in substantiating information on current trends in the recent *Europe's environment — The fourth assessment* (EEA, 2007a) and in the forward-looking assessments in the report *The pan-European environment: glimpses into an uncertain future* (EEA, 2007b).

The structure of this report provides the reader with an overview of the available forward-looking indicators by topic, presented as the main metadata information and a short assessment (the graphs and assessments serve only as an illustration of the indicator assessment capacities and are mostly based on the 2006 status of data availability):

- Chapter 1 presents the list of forward-looking indicators in the Indicator Management Service-outlooks and the list of other important indicators published after 2006.
- Chapter 2 provides a mapping of the EEA Core set of indicators with the available forward-looking indicators.
- Chapter 3 provides selected summary information (from IMS-outlooks) for each forward-looking indicator: ownership, geographical coverage, temporal coverage, definition, policy question, illustrative graph and short assessment, policy context, model used for indicator calculation with references, data specifications and uncertainties (model-related uncertainties, data uncertainties and uncertainties related to the rationale of indicator calculation).
- Annexes 1 and 2 give examples of analyses made on the basis of the information collected:
    - Annex 1 presents the projected percentage change for 28 indicators by three European sub-regions: Western Europe (including EU-25), SEE and EECCA (source: *The pan-European environment: glimpses into an uncertain future*, EEA 2007b);
    - Annex 2 provides an overview of the availability of past and outlook information for Western Balkan countries by country and the possibility of provision of regional assessments on the basis of the available information (source: The environment in South Eastern Europe, Trends and future perspectives in selected priority issues: sustainable consumption, 2007 draft report, EEA forthcoming).
- Annexes 3 and 4 present the reference source information for the review of forward-looking indicators.

1 Available forward-looking indicators in EEA Indicator Management Service — outlooks

Web link: http://ims.eionet.europa.eu/IMS/ISpecs/sets#Outlook (will be publicly available by the end of 2008).

Theme	Code	Indicator title	Models used
Agriculture	AGRI_F01	Fertiliser consumption — outlook from FAO	FAO
	AGRI_F02	Use of fertiliser — outlook from EEA	CAPSIM
	AGRI_F03	Gross nutrient balance — outlook from EEA	CAPSIM
Air pollution	APE_F01	Emissions of acidifying substances — outlook from LRTAP	RAINS, EMEP
	APE_F02	Emissions of acidifying substances — outlook from WBCSD	IEA/SMP
	APE_F03	Emissions of ozone precursors — outlook from LRTAP	RAINS, EMEP
	APE_F04	Emissions of ozone precursors — outlook from WBCSD	IEA/SMP
	APE_F05	Emissions of primary particles — outlook from LRTAP	RAINS
	APE_F06	Emissions of primary particles — outlook from WBCSD	IEA/SMP
Biodiversity	BDIV_F01	Change in species diversity as a result of climate change — outlook from EEA	EUROMOVE
Climate change	CC_F01	Projections of GHG emissions — outlooks from National Communications under UNFCCC	N/A
	CC_F02	GHG emissions — outlook from IEA	WEM
	CC_F03	GHG emissions — outlook from IIASA	RAINS
	CC_F04	GHG emissions — outlook from WBCSD	IEA/SMP
	CC_F05	GHG emissions — outlook from MNP	IMAGE
	CC_F06	GHG emissions — outlook from EEA	PRIMES, IMAGE, WEM
	CC_F07	GHG Concentrations — outlook from EEA	IMAGE
	CC_F10	Global and European temperature — outlook from EEA	IMAGE
Energy	EE_F01	Final energy consumption — outlook from IEA	WEM
	EE_F02	Final energy consumption — outlook from EEA	PRIMES
	EE_F03	Total energy intensity — outlook from IEA	WEM
	EE_F04	Total energy intensity — outlook from EEA	PRIMES
	EE_F05	Total energy consumption — outlook from IEA	WEM
	EE_F06	Total energy consumption — outlook from EEA	PRIMES
	EE_F07	Total electricity consumption — outlook from IEA	WEM
	EE_F08	Total electricity consumption — outlook from EEA	PRIMES
	EE_F09	Renewable energy consumption — outlook from IEA	WEM
	EE_F11	Renewable energy consumption — outlook from EEA	PRIMES
	EE_F12	Renewable electricity — outlook from EEA	PRIMES
	EE_F13	Fuel prices — outlook from IEA	WEM
Terrestrial environment	TELC_F01	Land cover distribution and change — outlook from MNP	GLOBIO/IMAGE
	TELC_F02	Land cover, use of arable land — outlook from EEA	CAPSIM
Tourism	TOUR_F01	Tourist arrivals — outlook from WTO	WTO

Theme	Code	Indicator title	Models used
Transport	TERM_F01	Passenger transport demand — outlook from WBCSD	IEA/SMP
	TERM_F02	Passenger transport demand — outlook from OECD	MOVE II
	TERM_F03	Passenger transport demand — outlook from EEA	PRIMES
	TERM_F04	Freight transport demand — outlook from WBCSD	IEA/SMP
	TERM_F05	Freight transport demand — outlook from OECD	MOVE II
	TERM_F06	Freight transport demand — outlook from EEA	PRIMES
	TERM_F07	Car ownership — outlook from WBCSD	IEA/SMP
	TERM_F08	Use of cleaner and alternative fuels — outlook from WBCSD	IEA/SMP
Waste and material flows	WMF_F01	Municipal waste generation — outlooks from National Communications under UNFCCC	N/A
	WMF_F02	Municipal waste generation — outlook from OECD	JOBS, POLESTAR
	WMF_F03	Municipal waste generation — outlook from EEA	WMF
	WMF_F04	Generation and recycling of packaging waste — outlook from EEA	WMF
Water	WQ_F01	Use of freshwater resources — outlook from EEA	WaterGAP
	WQ_F02	Use of freshwater resources — outlook from UN SPECA	SPECA, SABAS
	WWEU_F01	Urban wastewater treatment — outlook from EEA	EEA/ETC Water
	WWND_F01	Floods and droughts — outlook from the University of Kassel	WaterGAP
Socio-economic	SE_F01	GDP — outlook from OECD	ENV linkages
	SE_F02	Total population — outlook from UNSTAT	UN population

Other indicators to be potentially included in IMS outlooks (screened in 2007 and 2008)

Theme	Indicator title	Models used
Agriculture	Fertiliser use — outlook from OECD	IMAGE
	Nitrogen balance — outlook from OECD	IMAGE
	Nutrient runoff to the Baltic Sea — outlook from HELCOM (Baltic Nest)	Baltic NEST Marine Model
Air pollution	Emissions of acidifying substances — outlook from OECD	FAIR, TIMER, IMAGE
	Emissions of ozone precursors — outlook from OECD	FAIR, TIMER, IMAGE
	Ozone concentrations at ground level — outlook from OECD	FAIR, TIMER, IMAGE
	Emissions of primary particles — outlook from OECD	FAIR, TIMER, IMAGE
	Exposure of the urban population to particulate matter — outlook from OECD	IMAGE (GUAM)
	Health impact due to particulate matter in urban agglomerations — outlook from OECD	IMAGE (GUAM)
	Health impact due to ozone in urban agglomerations — outlook from OECD	IMAGE (GUAM)
	Premature death due to exposure to particulate matter (PM_{10}) — outlook from OECD	IMAGE (GUAM)
	DALYs ([2]) due to particulate matter (PM_{10}) exposure in urban agglomerations — outlook from OECD	IMAGE (GUAM)
Biodiversity	Terrestrial biodiversity (mean species abundance) and also change by pressure factor — final output from OECD	IMAGE model (GLOBIO 3)
	Change in plant species — outlook based on Bakkeness *et. al.,* 2006 *	EuroMove
	Fish stock in the Baltic Sea — outlook from HELCOM	Baltic NEST Fish Model
	Impact of Climate change on the potential distribution of reptiles and amphibians in 2050 — outlook from MNP *	HadCM3 and CSIRO2
	Change of habitat suitability of 10 most dominant European Forest Categories — outlook from Institute for Environment and Sustainability, DG Joint research center, European Commission *	Ecological Niche Modeling, GARP
Climate change	Change in GHG emissions from land use changes — outlook from OECD	FAIR, TIMER, IMAGE
	Change in mean annual, summer and winter temperature over Europe — outlook from IPCC *	averaged over 21 models
	Number of tropical nights (i.e. minimum temperate > 20 °C) over Europe — outlook from PUDENCE *	HIRHAM4, HadCM3
	Precipitation — outlook from OECD	IMAGE (AOS)
	Precipitation change — outlook from IPCC	averaged over 21 models
	Precipitation of land average maximum 5-day precipitation sum — Max Planck Institute for Meteorology *	ECHAM5/MPI-OM simulations
	Precipitation time series of land average maximum number of consecutive dry days — Max Planck Institute for Meteorology *	ECHAM5/MPI-OM simulations
	Change in the height of extreme weather event due to changes in atmospheric storminess, an increase of sea level and vertical land movements — outlook from The Hadley Centre & University of Reading *	HadAM3H, POL, HadCM3
	Mean change in annual number of snow days — outlook Jylha, *et al.*(2008) *	GCM & seven RCM
	Retreat of the sea ice — outlook from Strove, *et al.*(2007) *	13 IPCC AR¤ climate models
	Global average sea level raise — outlook from IPCC *	AR4
Energy	Final energy consumption — outlook from OECD	IMAGE (TIMER)
	Primary energy intensity — outlook from OECD	IMAGE (TIMER)
	Total energy consumption — outlook from OECD	IMAGE (TIMER)
	Total electricity consumption — outlook from OECD	IMAGE (TIMER)
Terrestrial environment	Change in agricultural area — outlook from OECD	IMAGE (LCM)
	Change in land used for agriculture — outlook from OECD	IMAGE (LCM)
	Land sensitivity to water erosion — outlook from OECD	IMAGE

([2]) Disability-Adjusted Life Year.

Theme	Indicator title	Models used
Water	Load of nitrogen compounds on fresh water ecosystems — outlook from OECD	IMAGE
	Population with access to improved sanitation — outlook from OECD	IMAGE
	Average ocean surface pH values — outlook from Orr *et. al.* (2005) *	13 models of the ocean–carbon cycle
	Relative change in mean annual and seasonal river flow due to climate change– outlook from Institute for Environment and Sustainability, DG Joint Research Centre, European Commission *	HIRHAM, HAdAM3H/ HadCM3
	Change in surface water temperature due to the climate change- Uppsala University *	RCM

Note: * Indicators are published in EEA Report No 4/2008: *Impacts of Europe's changing climate — 2008 indicator-based assessment*. Joint EEA-JRC-WHO report (September 2008).

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2 Availability of complimentary forward-looking indicators from various sources in relation to EEA Core set of indicators

EEA Core set indicator ([3])	Forward-looking indicator for EECCA and SEE	Coverage for forward-looking indicators ([4])
Air		
Emissions of acidifying substances (CSI 001)	Emissions of acidifying substances — outlook from LRTAP	EU-25, EU + EFTA SEE, EECCA
	Emissions of acidifying substances — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
Emissions of ozone precursors (CSI 002)	Emissions of ozone precursors — outlook from LRTAP	EU-25 + EFTA SEE, EECCA
	Emissions of ozone precursors — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
Emissions of primary particles (CSI 003)	Emissions of primary particles – outlook from LRTAP	EU-25 + EFTA SEE, EECCA
	Emissions of primary particles — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
Biodiversity		
Species diversity (CSI 009)	Change in species diversity as a result of climate change — outlook from EEA	EU-25 + EFTA
Climate change		
a) GHG emissions trends (CSI 010) b) GHG emissions projections(CSI 011)	Projections of GHG emissions — outlooks from National Communications under UNFCCC	EU-15, EU-10 SEE, EECCA
	GHG emissions — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	GHG emissions — outlook from IIASA	EU-25 + EFTA SEE, EECCA
	GHG emissions — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
	GHG emissions — outlook from MNP	EU-25 + EFTA SEE, EECCA as part of the bigger region
	GHG emissions — outlook from EEA	EU-15, New EU-10
Atmospheric GHG Concentrations (CSI 013)	GHG Concentrations — outlook from EEA	Global
Global and European temperature (CSI 012)	Global and European temperature — outlook from EEA	Global, Europe
Terrestrial		
Land take (CSI 014)	Land cover distribution and change — outlook from MNP	Global, Europe
	Land cover change, arable land — outlook from EEA	EU-15, New EU-8
Waste		
Municipal waste generation (CSI 016)	Municipal waste generation — outlooks from National Communications under UNFCCC	EU-15, EU-10 SEE, EECCA
	Municipal waste generation — outlook from OECD	EU-15 + EFTA SEE, EECCA
	Municipal waste generation — outlook from EEA	EU-CC2, EU-15, EU-10
Municipal waste management — N/A	Municipal waste management — outlook from OECD	SEE, EECCA
Generation and recycling of packaging waste	Generation and recycling of packaging waste — outlook EEA	EU-15, EU-10

([3]) This table also includes a few non-core set indicators.

([4]) In most cases, in the last column 'Coverage' it is stated that the outlook is available for SEE and EECCA countries. The user should be aware that this is just general indication; countries covered are different for each specific outlook.

EEA Core set indicator (3)	Forward-looking indicator for EECCA and SEE	Coverage for forward-looking indicators (4)
Water		
Use of freshwater resources (CSI 018)	Use of freshwater resources — outlook from EEA	EU-27 + EFTA + Turkey SEE, EECCA
	Use of freshwater resources — outlook from UN SPECA	EECCA
Urban wastewater treatment (CSI 024)	Urban wastewater treatment — outlook from EEA/ETC	EU-15, EU-10
Floods and droughts (non-core set)	Floods and droughts — outlook from the University of Kassel	EU-27 + EFTA + Turkey SEE, EECCA
Agriculture		
Fertiliser consumption (non-core set)	Fertiliser consumption — outlook from FAO	EU, SEE, EECCA as part of bigger regions
	Use of fertiliser — outlook from EEA	EU-15, New EU-8
Gross nutrient balance (CSI 021)	Gross nutrient balance — outlook from EEA	EU-15, New EU-8
Energy		
Final energy consumption (SCI 027)	Final energy consumption — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	Final energy consumption — outlook from EEA	EU-15, EU-10
Total energy intensity (SCI 028)	Total energy intensity — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	Total energy intensity — outlook from EEA	EU-25
Primary Energy Consumption by fuel (CSI 029)	Total energy consumption — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	Total energy consumption — outlook from EEA	EU-15, New EU-10
Total electricity consumption (non-core set)	Total electricity consumption — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	Total electricity consumption — outlook from EEA	EU-15
Renewable energy consumption (SCI 30)	Renewable energy consumption — outlook from IEA	OECD Europe; Baltic States plus MT, CY; EECCA w/o Russia, Western Balkans + Bulgaria
	Renewable energy consumption — outlook from EEA	EU-25
Renewable electricity (CSI 031)	Renewable electricity — outlook from EEA	EU-25
Fuel prices (non-core set)	Fuel prices — outlook from IEA	Global
Transport		
Passenger transport demand (CSI 035)	Passenger transport demand — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
	Passenger transport demand — outlook from OECD	EU-15 + EFTA, SEE, EECCA
	Passenger transport demand — outlook from EEA	EU-25
Freight transport demand (CSI 036)	Freight transport demand — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
	Freight transport demand — outlook from OECD	EU-25 + EFTA SEE, EECCA
	Freight transport demand — outlook from EEA	EU-25
Car ownership (non-core set)	Car ownership — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
Use of cleaner and alternative fuels (CSI 037)	Use of cleaner and alternative fuels — outlook from WBCSD	EU-15 + EFTA SEE + 3, EECCA + 3
Tourism		
Tourist arrivals (non-core set)	Tourist arrivals — outlook from WTO	EU-15 + New EU-5 + EFTA SEE, EECCA + New EU-5
Socio-economic		
GDP (non-core set)	GDP — outlook from OECD	EECCA, EU-25 + EFTA, CEU
Total population (non-core set)	Total population — outlook from UNSTAT	EECCA, EU-25 + EFTA, SEE

3 Forward-looking indicators by topic

In this chapter are presented 51 forward-looking indicators which are currently available in the EEA IMS for outlooks (link: http://ims.eionet.europa.eu/IMS/ISpecs/sets#Outlook). IMS-outlooks will be publicly available by the end of 2008 and will be updated regularly. Indicators included are those reviewed from different sources (35 reports) and the set of forward-looking indicators that was computed for the purposes of the preparation of the EEA 2005 *State and outlook* report (16 indicators).

Some of these indicators were also published in 2007 in two EEA pan-European reports: *Europe's environment — The fourth assessment* and *The pan-European environment: glimpses into an uncertain future*.

Indicators are presented by their key metadata information, and with an example indicator assessment.

Agriculture

AGRI_F01	**Total fertiliser consumption — outlook from FAO**
AGRI_F02	**Total fertiliser consumption — outlook from EEA**
AGRI_F03	**Gross nutrient balance — outlook from EEA**

Theme: Agriculture
Indicators: AGRI_F01 — Total fertiliser consumption — outlook from FAO

Definition: Total fertiliser consumption refers to the total sum of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) used in agriculture. The time reference is generally the crop year (July through June).

Model used: FAO

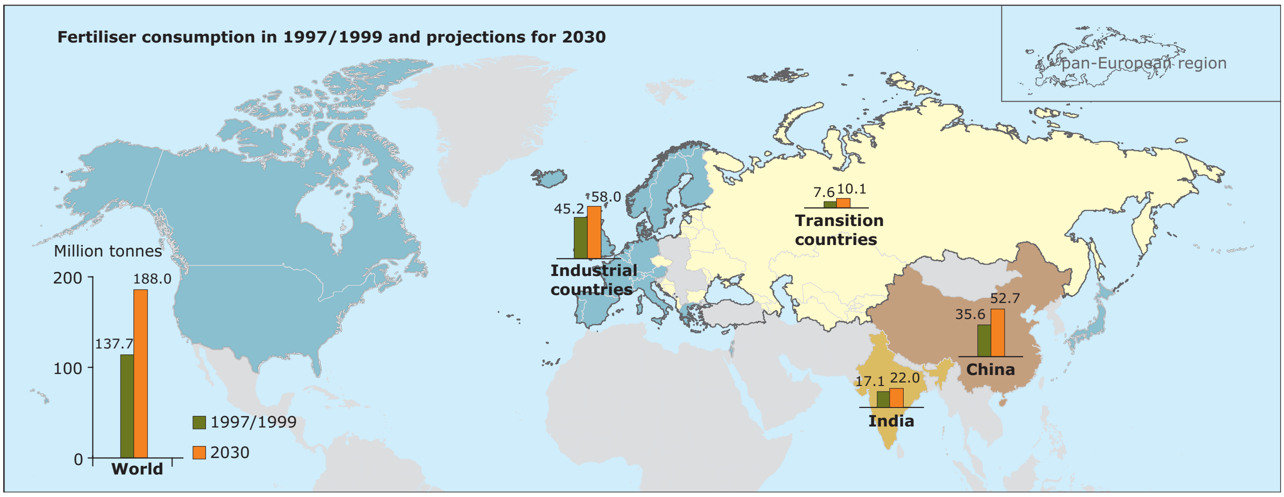
Ownership: Food and Agriculture Organzation of the United Nations (FAO)

Temporal coverage: 1997/99–2020

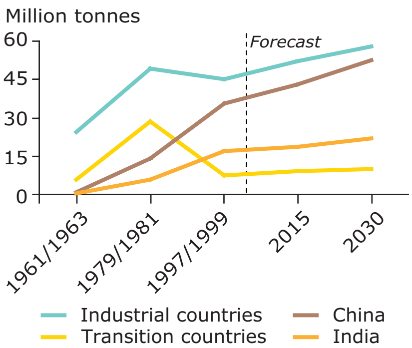
Geographical coverage: Sub-Saharah Africa, Latin America and the Caribbean, Near East/North Africa, South Asia, South Asia excl. India, East Asia, East Asia excl. China; industrialised countries; transition countries; world.

Policy question

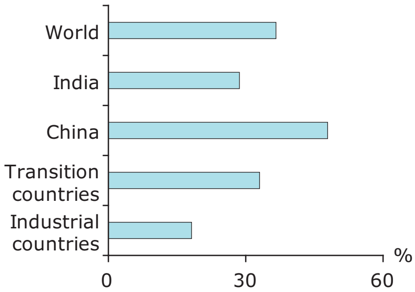
Are fertilisers being used in a more efficient/sustainable way?
Has the environmental impact of agriculture been reduced?



Projections of fertiliser consumption



Change in fertiliser consumption from 1997/1999 to 2030



Example assessment from 2003

The expected growth in populations and economies in all regions** implies increasing demand for crops and other agricultural products worldwide. If the current trends continue and if the efficiency of fertiliser use is improved*, this increasing demand will lead to a 1 % increase per year in global fertiliser use, from 138 million tonne in 1999 to 188 million in 2030 (37 % increase in total).

However, fertiliser use in many developing countries is very inefficient. Best practices for fertiliser handling could significantly reduce the environmental pressures associated with nutrient losses. Even modest increases in fertiliser application could cause problems when yield growth stagnates, leading to inefficient use of nutrients and severe pollution.

Note: The most recent assessment is available in OECD-FAO Agricultural Outlook 2008–2017, OECD-FAO 2008.

* *Projections are based on the Food and Agriculture Organisation vision concerning food, nutrients and agriculture. The vision takes into account current economic, social and industry trends as well as improved efficiency of fertiliser use.*

** *The European fertiliser manufacturers association make regular forecasts of fertiliser use in the European Union. These forecasts show a decline of all nutrients for 2012 compared with the base year average 1999–2001. It is based on criteria laid down in the current Common Agricultural Policy, but have not taken into account any of the new measures in the European Commission's Mid Term Review which could result in an even bigger decline. Source: Forecast of food, farming and fertiliser use in the European Union, 2002–2012, EFMA2007.*

Source:

FAO, 2003. World Agriculture: Towards 2015/2030. An FAO Perspective. Food and Agriculture Organisation, 2003: EEA, 2007. *Europe's environment – The fourth assessment*. European Environment Agency, Copenhagen.

Policy context

Pan-European policy context: The Helsinki Commission for the Protection of Marine Environment of the Baltic Sea (HELCOM) has developed recommendations for its Parties in this regard. (Helsinki declaration).

EU policy context: The fertiliser use is relevant to two EU Directives: the Nitrates Directive (91/676/EC) and the Water Framework Directive (2000/60/EC). The Nitrates Directive (Council of the European Communities, 1991) has the general purpose of 'reducing water pollution caused or induced by nitrates from agricultural sources and prevent further such pollution' (Art.1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the Directive limits applications of livestock manure to land to 170 kg N/ha/yr. The Water Framework Directive (Council of the European Communities, 2000) requires all inland and coastal waters to reach 'good status' by 2015. Good ecological status is defined in terms of the quality of the biological community, hydrological characteristics and chemical characteristics. The Sixth Environment Action Programme (European Commission, 2001), encourages the full implementation of both the Nitrates and Water Framework Directives, in order to achieve levels of water quality that do not give rise to unacceptable impacts on, and risks to, human health and the environment. (Council Directive (91/676/EEC). 12 December 1991, Water Framework Directive (WFD) 2000/60/EC).

EECCA policy context: No specific policy context directly related to the indicator is identified at the sub-regional level.

Model used for indicators calculation — FAO model

Projections for fertiliser consumption have been derived on the basis of the relationship between yields and fertiliser application rates that existed during 1995/97. It implicitly assumes that improvements in nutrient use efficiency will continue to occur as embodied in the relationship between yields and fertiliser application rates (fertiliser response coefficients) estimated for 1995/97.

In projecting the likely evolution of the key food and agricultural variables, a 'positive' approach has been followed, aiming at describing the future as it is likely to be (to the best of our knowledge at the time of carrying out this study), and not as it ought to be from a normative point of view. The study therefore does not attempt to spell out actions that need to be taken to reach a certain target (for example the World Food Summit target of halving the number of chronically undernourished persons by no later than 2015) or some other desirable outcome sometime in the future. The second overriding principle of the approach followed in this study was to draw to the maximum extent possible on FAO's in-house knowledge available in the various disciplines present in FAO, so as to make the study results represent FAO's 'collective wisdom' concerning the future of food, nutrition and agriculture.

References

FAO, 2003. Bruisnsma, J. (ed.). *World agriculture: towards 2015/2030 — An FAO perspective*. Earthscan, London and FAO, Rome. http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/004/y3557e/y3557e00.htm.

Alexandratos, N. (ed.), 1995. *World agriculture: towards 2010. An FAO study*. Chichester, United Kingdom, John Wiley and Rome, FAO.

Data specifications

Data set title	Source
Input for FAO model — fertiliser use by crop and fertiliser application rates — output from Harris, G., 1997	Fertiliser Institute, Washington DC
Input for FAO model — fertiliser use by crop and fertiliser application rates — output from FAO/IFA/IFDC, 1999	FAO/IFA/IFDC, 1999. Fertiliser use by crop, Fourth Edition, Food and Agriculture. Organization of the United Nations (FAO), International Fertiliser Industry Association (IFA) and International Fertiliser Development Center (IFDC), Rome, 52 pp.
Input for FAO model — fertiliser use efficiency rates, yields increase over time — output from IFA	International Fertiliser Industry Association
Output from FAO model — fertiliser consumption	Food and Agriculture Organization of the United Nations

Uncertainties

Uncertainty related to the model

The biggest problems related to the use of the FAO model is related to the data uncertainly (see below). Other most important uncertainties include *some problems with the exogenous assumptions* and *use of only one scenario*.

Some problems with the exogenous assumptions: As an example was mentioned the impossibility of foreseeing which countries may face extraordinary events leading to their being worse off in the future than at present.

One scenario: the model presentes only one possible outcome for the future based on a positive rather than normative assessment. Alternative scenarios have not been explored for a number of reasons, some conceptual, some practical, and usually a mix of both. Producing an alternative scenario is essentially a remake of the projections with a different set of assumptions. On the practical side, the major constraint is the time-consuming nature of estimating alternative scenarios with the methodology of expert-based inspection, evaluation and iterative adjustments of the projections. On the conceptual side, defining an alternative set of exogenous assumptions that are internally consistent represents a challenge of no easy resolution.

Data uncertainty

The significant commodity and country details underlying the analysis requires the handling of huge quantities of data. Inevitably, data problems that would remain hidden and go unnoticed in work conducted at the level of large country and commodity aggregates come to the fore all the time. Examples of typical data problems are given below.

Data reliability: When revised numbers become available in the successive rounds of updating and revision of the historical data, it is not uncommon to discover that some of the data were off the mark, sometimes by a very large margin. It may happen therefore that changes projected to occur in the future have already occurred in the past.

Unbalanced world trade: A second data problem relates to the large discrepancies often encountered in the trade statistics, i.e. world imports are not equal to world exports. Small discrepancies are inevitable and can be ignored but large ones pose serious problems since in the projections exporting countries must produce export surpluses equal to the net imports of other countries.

Uncertainty for indicators calculations

The total fertiliser consumption does not reflect the efficiency of fertiliser use per unit of crop or per unit of land. It also does not provide information regarding environmental impact and nutrient discharge. The actual environmental effects will depend on pollution abatement methods, soil and plant types, and meteorological conditions. Time series analysis of fertilisers consumption can however allow monitoring of its effect on the environment and enables preparation of strategies for mitigation of negative impacts of fertilisers on the environment.

Theme: Agriculture

Indicators: AGRI_F02 — Fertiliser consumption — outlook from EEA

Definition: The indicator 'use of fertilisers' is presented as total amount of mineral fertilisers used per unit of agricultural land. Total fertiliser consumption refers to the total sum of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) used in agriculture. The time reference is generally the crop year (July through June).

Model used: CAPSIM

Ownership: European Environment Agency (EEA)

Temporal coverage: 2001–2020

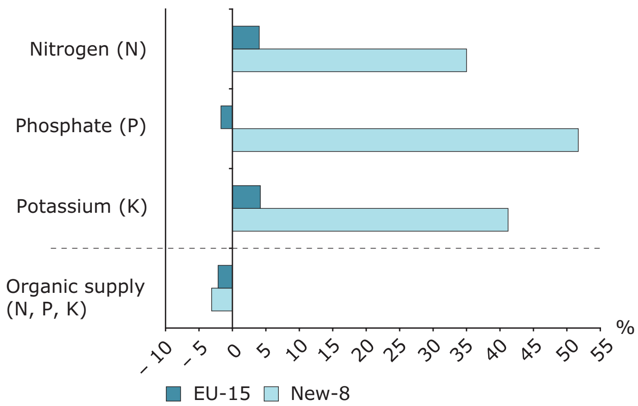
Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-8:** Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia.

Policy question

Are fertilisers used in more efficient/sustainable way?

Is the environmental impact of agriculture improving?

Use of fertilisers



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Mineral fertiliser use is expected to increase considerably in the new Member States although it may remain lower than in the EU-15 in absolute terms and may still lead to increases in associated environmental pressures. Best practices for fertiliser handling could significantly reduce the environmental pressures.

Considerable increases are projected for mineral fertiliser consumption in the New-8 over the next 20 years. The use of inorganic nitrogen (N) (mineral fertilisers), which will represent about 60% of total mineral fertiliser use by 2020, is expected to increase by about 35% , while phosphate (P) and potassium (K) use may increase by some 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.

Policy context

Pan-European policy context: The Helsinki Commission for the Protection of Marine Environment of the Baltic Sea (HELCOM) has developed recommendations for its Parties in this regard. (Helsinki declaration).

EU policy context: The fertiliser use is relevant to two EU Directives: the Nitrates Directive (91/676/EC) and the Water Framework Directive (2000/60/EC). The Nitrates Directive (Council of the European Communities, 1991) has the general purpose of 'reducing water pollution caused or induced by nitrates from agricultural sources and prevent further such pollution' (Art. 1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the Directive limits applications of livestock manure to land to 170 kg N/ha/yr. The Water Framework Directive (Council of the European Communities, 2000) requires all inland and coastal waters to reach 'good status' by 2015. Good ecological status is defined in terms of the quality of the biological community, hydrological characteristics and chemical characteristics. The Sixth Environment Action Programme (European Commission, 2001), encourages the full implementation of both the Nitrates and Water Framework Directives, in order to achieve levels of water quality that do not give rise to unacceptable impacts on, and risks to, human health and the environment. (Council Directive (91/676/EEC) 12 December 1991, Water Framework Directive (WFD) 2000/60/EC).

EECCA policy context: No specific policy context directly related to the indicator is identified at the subregional level. Indirectly EECCA Environmental Strategy emphasizes a need 'to implement practices for increase of nutrients levels' and 'to provide preconditions for facilitating production of environmentally clean food', which subsequently include amount of used fertilisers. (EECCA Environmental Strategy).

Model used for indicators calculation — CAPSIM model

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 combined with changes in exogenous inputs (e.g. population, prices or household expenditure) 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: European Commission (2004a); FAPRI, (2004); FAO (Bruinsma, 2003); and IFPRI (Rosenrant *et. al.,* 2001a and 2001b). CAPSIM is augmented by a calculation of nutrient balances (N,P,K) and gaseous emissions.

References

Witzke, H. P.; Zintl, A., 2005. CAPSIM. *Documentation of Model Structure and Implementation*. European Commission. Available online: http://www.uni-mannheim.de/edz/pdf/eurostat/05/KS-AZ-05-001-EN.pdf.

Data specifications

Data set title	Source
Input to CAPSIM model — population growth — output from Eurostat population data	Eurostat
Input to CAPSIM model — GDP growth — output from Eurostat	Eurostat
Input to CAPSIM model — household expenditure — output from Eurostat	Eurostat
Input to CAPSIM model — Euro/USD exchange rate — output from DG AGRI	European Commission, DG AGRI
Input to CAPSIM model — forecast assumptions for baseline scenario — output from DG AGRI	European Commission, DG AGRI
Input to CAPSIM model — forecast trends — output from FAPRI model	Food and Agricultural Policy Research Institute
Input to CAPSIM model — forecast trends — output from IFPRI model	International Food Policy Research Institute
Input to CAPSIM — forecast trends — output from FAO	Food and Agriculture organization of the United Nations
Output from CAPSIM — fertiliser use	Eurostat

Uncertainties

Methodology uncertainty

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.

The main limiting factor in developing a comprehensive environmental outlook has been the lack of data, information or models covering some environmental issues.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Agriculture
Indicators: AGRI_F03 — Gross nutrient balance — outlook from EEA

Definition: Gross nutrient balance estimates the potential surplus of nutrients such as nitrogen (N), phosphate (P) and potassium (K) on agricultural land. This is done by calculating the balance between a nutrient added to an agricultural system and the nutrient removed from the system per hectare of agricultural land. The indicator should account for all inputs to and outputs from the farm. The inputs consists of the amount of nutrient (N, P or K) applied via mineral fertilisers and animal manure as well as a nutrient fixation by legumes, deposition from the air, and some other minor sources. Nutrient output is contained in the harvested crops, or grass and crops eaten by livestock (escape of nutrients to the atmosphere, e.g. for nitrogen as N_2O, is difficult to estimate and therefore is usually not taken into account).

Model used: CAPSIM

Ownership: European Environment Agency (EEA)

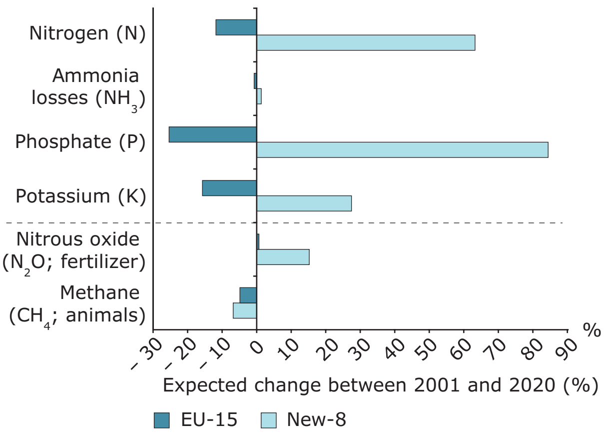
Temporal coverage: 2001–2020

Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-8:** Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia.

Policy question

Is the environmental impact of agriculture improving?

Projections of changes in gross nutrient balance — baseline scenario



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Baseline scenario: Overall, nutrient surpluses are expected to be moderately reduced in 2020 (by 6 %, 8 % and 12 % for N, P, K respectively). There are striking differences between the EU-15 and the New-8 countries. 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 export 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, 2000). The main reasons of the expectations are related to dependence amount of fertilisers and market's conditions with nutrient balances.

Alternative scenarios: The liberalization of animal product markets leads to a limited change in the environmental indicator. The N, P, K surpluses decrease by 4 % to 5 % (smaller than might be expected) (Liberalization of animal product markets scenario). In 2020, the N, P, K surpluses are expected to be reduced compared with the baseline scenario by 25 %, 70 %, and 57 % respectively (Best practice scenario for fertiliser handling).

Policy context

EU policy context: The gross nitrogen balance is relevant to two EU Directives: the Nitrates Directive (91/676/EC) and the Water Framework Directive (2000/60/EC). The Nitrates Directive (Council of the European Communities, 1991) has the general purpose of 'reducing water pollution caused or induced by nitrates from agricultural sources and prevent further such pollution' (Art.1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the Directive limits applications of livestock manure to land to 170 kg N/ha/yr. The Water Framework Directive (Council of the European Communities, 2000) requires all inland and coastal waters to reach 'good status' by 2015. Good ecological status is defined in terms of the quality of the biological community, hydrological characteristics and chemical characteristics. The Sixth Environment Action Programme (European Commission, 2001), encourages the full implementation of both the Nitrates and Water Framework Directives, in order to achieve levels of water quality that do not give rise to unacceptable impacts on, and risks to, human health and the environment. (Council Directive (91/676/EEC) 12 December 1991, Water Framework Directive (WFD) 2000/60/EC).

EECCA policy context: No specific policy context directly related to the indicator is identified. Indirectly EECCA Environmental strategy emphasizes a need 'to implement practices for increase of nutrients levels' and 'to provide preconditions for facilitating production of environmentally clean food', which subsequently include balanced use of fertilisers. (EECCA Environmental Strategy).

Model used for indicators calculation — CAPSIM model

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: European Commission (2004a); FAPRI, (2004); FAO (Bruinsma, 2003); and IFPRI (Rosenrant *et. al.,* 2001a and 2001b). CAPSIM is augmented by a calculation of nutrient balances (N, P, K) and gaseous emissions.

References

Witzke, H. P.; Zintl, A., 2005. CAPSIM. Documentation of Model Structure and Implementation. (2005) European Commission. Available online: http://www.uni-mannheim.de/edz/pdf/eurostat/05/KS-AZ-05-001-EN.pdf.

Data specifications

Data set title	Source
Input to CAPSIM model — population growth — output from Eurostat population data	Eurostat
Input to CAPSIM model — GDP growth — output from Eurostat	Eurostat
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Input to CAPSIM model — forecast assumptions for baseline scenario — output from DG AGRI	European Commission, DG AGRI
Input to CAPSIM model — forecast trends — output from FAPRI model	International Food Policy Research Institute
Input to CAPSIM model — forecast trends — output from IFPRI model	International Food Policy Research Institute
Input to CAPSIM — forecast trends — output from FAO	Food and Agriculture organization of the United Nations
Output from CAPSIM model — nutrient balances for N, P, K	Eurostat

Uncertainties

Uncertainty related to the model

N/A.

Data uncertainty

N/A.

Uncertainty for indicators calculations

N/A.

Air pollution

APE_F01	**Emissions of acidifying substances — outlook from LRTAP**
APE_F02	**Emissions of acidifying substances — outlook from WBCSD**
APE_F03	**Emissions of ozone precursors — outlook from LRTAP**
APE_F04	**Emissions of ozone precursors — outlook from WBCSD**
APE_F05	**Emissions of primary particles — outlook from LRTAP**
APE_F06	**Emissions of primary particles — outlook from WBCSD**

Theme: Air pollution

Indicators: APE_F01 — Emissions of acidifying substances — outlook from LRTAP

Definition: Emissions of acidifying pollutants tracks trends in anthropogenic emissions of acidifying substances such as nitrogen oxides, ammonia, and sulphur dioxide, each weighted by their acidifying potential. Outlook form RAINS&EMEP models provides information for nitrogen oxides, sulphur dioxide and ammonia. It is presented in total volumes of pollutants from all sources by sectors: power plants, process industry, domestic, road transport, off-road, and other.

Model used: RAINS, EMEP

Ownership: UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)

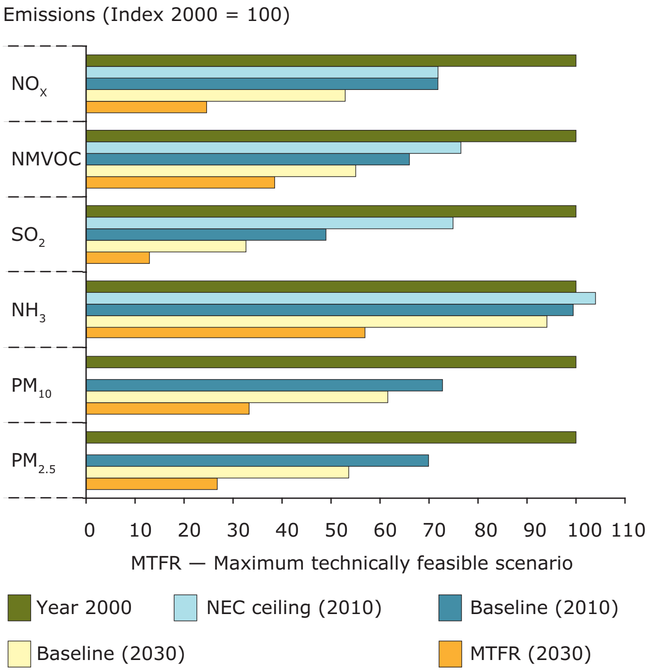
Temporal coverage: Emissions' trends: 2000–2003, projections: 2010, 2020

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **By country:** Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom.

Policy question

What are prospects in reducing emissions of acidifying pollutants across Europe?

Emissions of acidifying substances (Baseline and MTFR scenarios, index 100 in 2000)



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

On the basis of existing policies and measures, emissions of almost all acidifying substances (NO_x, NMVOC, SO_2) of land-based air pollutants are expected to decline significantly (by 47 % for NO_x emissions, by 45 % for NMVOCs, by 67 % for SO_2) up to 2030. In contrast, NH_3 emissions are expected to decline slightly (by 6 %).

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 the emissions.

Policy context

Pan-European policy context: At the Pan-European level this indicators is related to the implementation of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOCs and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. (1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone)

EU policy context: Emission ceiling targets for NO_x and SO_2 are specified in both the EU National Emission Ceilings Directive (NECD) and the Gothenburg protocol under the United Nations Convention on long-range transboundary air pollution (LRTAP Convention) (UNECE 1999). Emission reduction targets for the new EU-10 Member States have been specified in the Treaty of Accession to the European Union 2003 [1] in order that they can comply with the NECD. In addition, the Treaty of Accession also includes a new target for the EU-25 region as a whole. (Directive 2001/81/EC, national emission ceilings, UNECE Convention on Long-range Transboundary Air pollution)

EECCA policy context: Most of the EECCA countries ratified the 1979 Convention on Long-Range Transboundary Air pollution. These are A list of countries ratified the 1979 Convention: Armenia (1997), Azerbajan (2002), Belarus (1980), Georgia (1999), Kazakhstan (2001), Kyrgyzstan (2000), Republic of Moldova (1995), Russian Federation (1980), the Ukraine (1980). At the same time only two of them signed in the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone, notably Armenia (1999), Republic of Moldova (2000). (UNECE Convention on Long-range Transboundary Air pollution). Directive has been amended to include ceilings for the new Member States (Council Directive 2006/105/EC.

Model used for indicators calculation — RAINS and EMEP models

The projections of the acidifying pollutants for this outlook were obtained based on the Regional Air pollution Information and Simulation (RAINS) model. In RAINS emissions of pollutants are calculated as a product of activity level, uncontrolled emission factor, removal efficiency of control technology applied in a given sector, and implementation level of that technology in a given emission scenario. They are then combined with the European Monitoring and Evaluation Program (EMEP) model to obtain emissions' spatial distribution.

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 (TarrasoI *et al.,* 2004). Options and costs for controlling emissions are represented by several emission-reduction technologies.

EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air pollutants in Europe) is a programme that uses a suite of models to provide, on a regular basis, governments and other parties under the LRTAP convention on long range transboundary air pollution with scientific information. The unified EMEP model is an Eulerian model designed to simulate atmospheric transport and deposition of acidifying and eutrophying compounds as well as photo-oxidants and $PM_{2.5}$ and PM_{10} in Europe. This modelling system has been designed to provide a common core to different EMEP modelling activities, building upon one Eulerian model structure. In this system the only differences between say the acidification and oxidant versions lie in the chemical equations solved, and in the various inputs associated with this (for example, emissions and boundary conditions).

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).

References

Amann, M.; Cofala, J.; Heyes, C.; Klimont, Z.; Schopp, W., 1999. *The RAINS Model: A Tool for Assessing Regional Emission Control Strategies in Europe.* Pollution Atmospherique 4 (1999), Paris, France.

IIASA, 2005. Cofala, J.; Markus, A.; Mechler, R., 2005. *Scenarios of World Anthropogenic Emissions of Air Pollutants and Methane up to 2030*. International Institute for Applied Systems Analysis. Laxemburg, Austria.

Regional Air Pollution Information and Simulation

Simpson, D.; Fagerli, H.,; Jonson, J. E.; Tsyro, S.; and Wind, P., 2003. *Unified EMEP Model Description*. EMEP Report 1/2003, Oslo, Norway.

Simpson, D.; Fagerli, H.; Jonson, J. E.; Tsyro, S.; and Wind, P., 2003. *Transboundary Acidification and Eutrophication and Ground Level Ozone in Europe. Unified EMEP Model Description*. EMEP Status Report 1/2004, Oslo, Norway.

Data specifications

Data set title	Source
Input data for RAINS model — Emission factors for NO_x, SO_2 NH_3, NMVOC	IIASA — Atmospheric Pollution and Economic Development
Input data for RAINS model — Emission standards for Europe	Convention on Long-range Transboundary Air pollution
Input data for RAINS model — Emission standards other parts of the world	International Energy Egency
Input data for RAINS model — energy projections for EU countries from PRIMES model	DG-TREN
Input data for RAINS model — energy projections from national sources	National Sources (Austria, Denmark, France, Ireland, Italy, Latvia, Netherlands, Portugal, Slovenia, United Kingdom, Russia)
Input data for RAINS model — livestock projections for the EU countries	DG-AGRI
Input data for RAINS model — livestock projections for other countries from FAO	Food And Agriculture Organization of the United Nations
Input data for RAINS model — livestock projections from national projections	National Sources (France, Ireland, Italy, Latvia, the Netherlands, Portugal, Slovenia, United Kingdom)
Input data for RAINS model — transport activity from TREMOVE model	DG-TREN
Output data from RAINS model, total and by sector — NO_x emissions	IIASA — Atmospheric Pollution and Economic Development
Output data from RAINS model, total and by sector — SO_2 emissions	IIASA — Atmospheric Pollution and Economic Development
Output data from RAINS model, total and by sector — NH_3 emissions	IIASA — Atmospheric Pollution and Economic Development

Uncertainties

Uncertainty related to the model

RAINS model

A methodology has been developed to estimate uncertainties of emission calculations based on uncertainty estimates for the individual parameters of the calculation (Suutari *et al.,* 2001). It was found that uncertainties in modelled national emissions of SO_2 and NO_x in Europe typically lie in the range between 10 and 30 percent (Outlook from RAINS model). In general, the uncertainties are strongly dependent on the potential for error compensation. This compensation potential is larger (and uncertainties are smaller) if calculated emissions are composed of a larger number of similar-sized source categories, where the errors in input parameters are not correlated with each other. Thus, estimates of national total emissions are generally more certain than estimates of sectoral emissions. The uncertainty in input parameters showed that the actual uncertainties are critically influenced by the specific situation (pollutant, year, country). Generally, however, the emission factor is an important contributor to the uncertainty in estimates of historical emissions, while uncertainty in the activity data dominates the future estimates.
For more information see http://www.iiasa.ac.at/rains/review/suutari.pdf

EMEP models

Uncertainties in the model formulation itself give rise to uncertain deposition estimates. It has been shown that the EMEP model performance is rather homogeneous over the years (Fagerli *et al.* 2003b), but depend on geographical coverage and quality of the measurement data. The EMEP model has also been validated for nitrogen compounds in Simpson *et al.* (a) and for dry and wet deposition of sulphur, and wet depositions for nitrogen in Simpson *et al.* (b) with measurements outside the EMEP network.
For more information see http://www.emep.int/publ/reports/2006/status_report_1_2006_ch.pdf

Data uncertainty

National projections reflect national governmental expectations and probably in many cases also merely policy ambitions. Thus there is no guarantee for international consistency, e.g. in the volumes of exports and imports or in the underlying assumptions on the development of oil prices. However, the value of this set of projections is that it reflects bottom-up expectations on economic development as seen today by the individual countries.
Uncertainty in activities data. For more information see http://www.iiasa.ac.at/rains/review/suutari.pdf

Rationale uncertainty

N/A.

Theme: Air pollution

Indicators: APE_F02 — Emissions of acidifying substances — outlook from WBCSD

Definition: In general, the indicator 'emissions of acidifying pollutants' tracks trends in anthropogenic emissions of acidifying substances such as nitrogen oxides, ammonia, and sulphur dioxide, each weighted by their acidifying potential.

Outlook form IEA/SMP model provides information only for emissions of nitrogen oxides from transport sector.

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

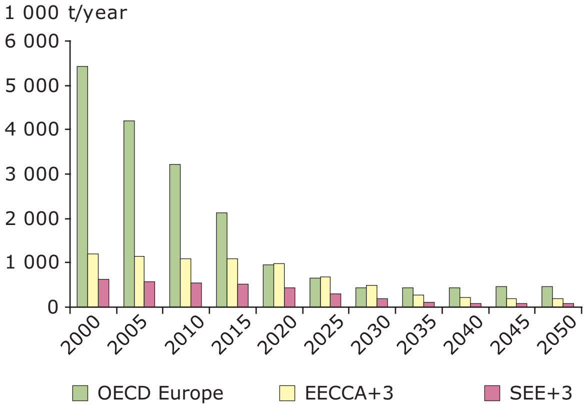
Temporal coverage: 1990–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China**.

Policy question

What are prospects in reducing emissions of acidifying pollutants across Europe?

Emissions of NO_x from road transport from 2000 to 2050



Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva.

Example assessment* from 2004

In developed countries efforts have been underway for decades to reduce acidifying substances (NO_x) and there has been progress in reducing total NO_x. Emissions per vehicle kilometer for light-duty vehicles have been substantially reduced. However, growth in transport activity and problems in controlling in-use emissions have tended to offset some of the anticipated improvements.

The situation regarding acidifying substances in transition countries (EECCA and SEE), especially their rapidly-growing urbanized areas, is different. Although NO_x is expected to be reduced, it is not expected to happen as easily or as quickly as desired.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Pan-European policy context: At the Pan-European level this indicators is related to the implementation of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOCs and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. (1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone).

EU policy context: Emission ceiling targets for NO_x and SO_2 are specified in both the EU National Emission Ceilings Directive (NECD) and the Gothenburg protocol under the United Nations Convention on long-range transboundary air pollution (LRTAP Convention) (UNECE 1999). Emission reduction targets for the new EU-10 Member States have been specified in the Treaty of Accession to the European Union 2003 [1] in order that they can comply with the NECD. In addition, the Treaty of Accession also includes a new target for the EU-25 region as a whole. (Directive 2001/81/EC, national emission ceilings, UNECE Convention on Long-range Transboundary Air pollution).

EECCA policy context: Most of the EECCA countries ratified the 1979 Convention on Long-Range Transboundary Air pollution. These are A list of countries ratified the 1979 Convention: Armenia (1997), Azerbaijan (2002), Belarus (1980), Georgia (1999), Kazakhstan (2001), Kyrgyzstan (2000), Republic of Moldova (1995), Russian Federation (1980), the Ukraine (1980). At the same time only two of them signed in the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone, notably Armenia (1999), Republic of Moldova (2000). (UNECE Convention on Long-range Transboundary Air pollution).

Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light-duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked. See table below.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection*. World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Sectors/modes	Vehicle technologies/fuels	Regions	Variables
-Light-duty vehicles (cars, minivans, SUVs) -Medium trucks -Heavy-duty (long-haul) trucks -Mini-buses ('paratransit') -Large buses -2-3 wheelers -Aviation (Domestic +Int'l) -Rail freight -Rail passenger -National waterborne (Inland plus coastal) -Int'l shipping	-Internal combustion engine: -Gasoline -Diesel -LPG-CNG -Ethanol-Biodiesel -Hybrid -Electric ICE (same fuels) -Fuel-cell vehicle -Hydrogen (With feedstockdifferentiation for biofuelsand hydrogen)	-OECD Europe -OECD North America -OECD Pacific (Japan, Korea, Australia, NZ) -Former Soviet Union (FSU) -Eastern Europe -Middle East -China -India -Other Asia -Latin America -Africa	Passenger kilometres of travel -Vehicle sales (LDVsonly) -Vehicle stocks -Average vehicle fuel efficiency -Vehicle travel -Fuel use-CO_2 emissions -Pollutant emissions (PM, NO_x, HC, CO,Pb) -Safety (road fatalities and injuries)

Data specifications

Data set title	Source
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data, Fulton, L., IEA/Eads, G., CRA (2004) p. 21
Input data to EIA/SMP model — GDP	International Energy Agency
Output from IEA/SMP model — emissions of acidifying substances	World Business Council on Sustainable Development
Input data to IEA/SMP model — Average Pollutant Emissions for Existing Vehicles in 2000 (g/km) — output from the report OECD Environment Directorate study, (part of the MOVE II project)	OECD Environment Directorate

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity. Not all technologies or variables are covered for all modes.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	Frt Rail	Pass Rail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	•	•	•	•	•	•	i	i	
New vehicle characteristics(sales, fuel consumption)	•								
Stock-average energy intensity	•	•	•	•	•	•	i	i	
Calculation of energy use and vehicle CO_2 emissions	•	•	•	•	•	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	•	i	•	•	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	•	i	•	•	i	i	i	•

Note: • = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf

Rationale uncertainty

The relevance of the balanced modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: Air pollution
Indicators: APE_F03 — Emissions of ozone precursors — outlook from LRTAP

Definition: Generally, the indicator 'emissions of ozone precursors' tracks trends in anthropogenic emissions of ozone precursors such as nitrogen oxides, carbon monoxide, methane and non methane volatile organic compounds, each weighted by their tropospheric ozone-forming potential. The outlook from RAINS&EMEP models provides information for only three ozone precursors, notably: nitrogen oxides (NO_X), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOCs). Each of the substances presented in total volume from all pollution sources and by sector: power plants, industry, domestic, road transport, off-road, and flaring and waste incineration.

Model used: RAINS, EMEP

Ownership: UNECE Convention on Long-range Transboudary Air Pollutants (LRTAP)

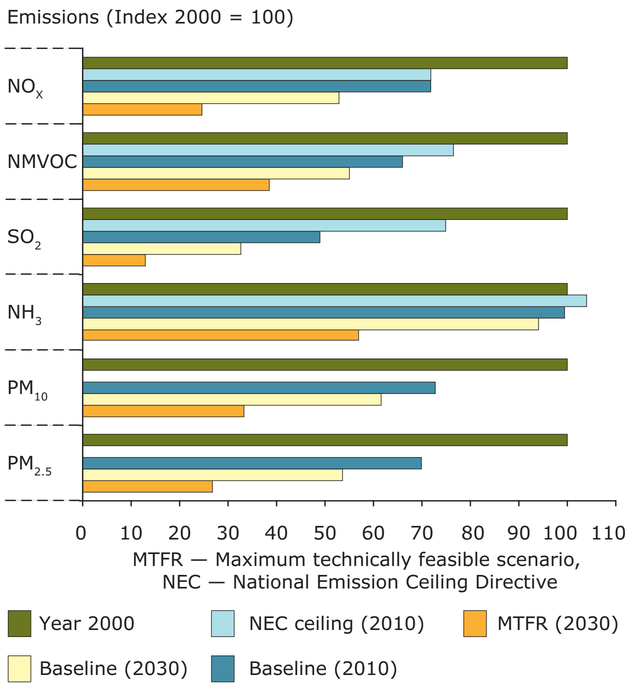
Temporal coverage: 2000, 2030

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **By country:** Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom.

Policy question

What are prospects in reducing emissions of ozone precursors across Europe?

Emissions of ozone precursors (Baseline and MTFR scenarios, index 100 in 2000)



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

On the basis of existing policies and measures, emissions of ozone precursors (NO_X) of land-based air pollutants are expected to decline significantly (by 47 % for NO_X emissions) 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 the emissions.

Policy context

Pan-European policy context: At the Pan-European level this indicators is related to the implementation of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_X, VOCs and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. **(The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone).**

EU policy context: Emission ceiling targets for NO_X and NMVOCs are specified in both the EU National Emission Ceilings Directive (NECD) and the Gothenburg protocol under the United Nations Convention on Long-Range Transboundary Air pollution (LRTAP Convention) (UNECE 1999). Emission reduction targets for the new EU-10 Member States have been specified in the Treaty of Accession to the European Union 2003 [1] in order that they can comply with the NECD. In addition, the Treaty of Accession also includes a new target for the EU-25 region as a whole. There are no specific EU emission targets set for either carbon monoxide (CO) or methane (CH_4). However, there are several Directives and Protocols that affect the emissions of CO and CH_4. For example, carbon monoxide is covered by the second daughter Directive under the Air Quality Directive. This gives a limit of 10 mg m-3 for ambient air quality to be met by 2005. Methane is included in the basket of six greenhouse gases under the Kyoto protocol (see CSI 10: Greenhouse gas emissions and removals). (Convention on Long-Range Transboundary Air pollution, Directive 2001/81/EC, national emission ceilings).

[1] The Treaty of Accession 2003 of the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia. AA2003/ACT/ Annex II/en 2072.

EECCA policy context: Most of the EECCA countries ratified the 1979 Convention on Long-Range Transboundary Air pollution. These are A list of countries ratified the 1979 Convention: Armenia (1997), Azerbaijan (2002), Belarus (1980), Georgia (1999), Kazakhstan (2001), Kyrgyzstan (2000), Republic of Moldova (1995), Russian Federation (1980), the Ukraine (1980).

At the same time only two of them signed in the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone, notably Armenia (1999), Republic of Moldova (2000). (Convention on Long-Range Transboundary Air pollution, The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone).

Model used for indicators calculation — RAINS and EMEP models

The projections of the ozone precursors were obtained based on the Regional Air pollution Information and Simulation (RAINS) model. In RAINS emissions of pollutants are calculated as a product of activity level, uncontrolled emission factor, removal efficiency of control technology applied in a given sector, and implementation level of that technology in a given emission scenario. They are then combined with the European Monitoring and Evaluation Program (EMEP) model to obtain emissions' spatial distribution.

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 (TarrasoI>*et al.,* 2004). Options and costs for controlling emissions are represented by several emission-reduction technologies.

EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air pollutants in Europe) is a programme that uses a suite of models to provide, on a regular basis, governments and other parties under the LRTAP convention on long range transboundary air pollution with scientific information. The unified EMEP model is an Eulerian model designed to simulate atmospheric transport and deposition of acidifying and eutrophying compounds as well as photo-oxidants and $PM_{2.5}$ and PM_{10} in Europe. This modelling system has been designed to provide a common core to different EMEP modelling activities, building upon one Eulerian model structure. In this system the only differences between say the acidification and oxidant versions lie in the chemical equations solved, and in the various inputs associated with this (for example, emissions and boundary conditions).

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).

References

Amann, M.; Cofala, J.; Heyes, C.; Klimont, Z.; Schopp, W., 1999. *The RAINS Model: A Tool for Assessing Regional Emission Control Strategies in Europe.* Pollution Atmospherique 4 (1999), Paris, France.

IIASA, 2005. Cofala, J.; Markus, A.; Mechler, R., 2005. *Scenarios of World Anthropogenic Emissions of Air Pollutants and Methane up to 2030*. International Institute for Applied Systems Analysis. Laxemburg, Austria.

Regional Air pollution Information and Simulation.

Simpson, D.; Fagerli, H.; Jonson, J. E.; Tsyro, S.; and Wind, P., 2003. Unified EMEP Model Description. EMEP Report 1/2003, Oslo, Norway.

Simpson, D.; Fagerli, H.; Jonson, J. E.; Tsyro, S.; and Wind, P., 2003. Transboundary Acidification and Eutrophication and Ground Level Ozone in Europe. Unified EMEP Model Description. EMEP Status Report 1/2004, Oslo, Norway.

Data specifications

Data set title	Source
Input data for RAINS model — Emission standards for Europe	Convention on Long-range Transboundary Air pollution
Input data for RAINS model — livestock projectionist for the EU countries	DG-AGRI
Input data for RAINS model — transport activity from TREMOVE model	DG-TREN Energy
Input data for RAINS model — livestock projections for other countries from FAO	Food And Agriculture Organization of the United Nations
Input data for RAINS model — Emission factors for NO_x, SO_2	IIASA — Atmospheric Pollution and Economic Development
Input data for RAINS model — Emission factors CO	The Intergovernmental Panel on Climate Change (IPCC)
Input data for RAINS model — Emission standards other parts of the world	International Energy Agency
Input data for RAINS model — energy projections from national sources	National Sources (Austria, Denmark, France, Ireland, Italy, Latvia, Netherlands, Portugal, Slovenia, United Kingdom, Russia)
Input data for RAINS model — livestock projections from national projections	National Sources (France, Ireland, Italy, Latvia, the Netherlands, Portugal, Slovenia, United Kingdom)(External source)
Output data from RAINS, EMEP models, total and by sector CO emissions	IIASA — Atmospheric Pollution and Economic Development
Output data from RAINS, EMEP models, total and by sector — non -methane VOCs Emissions	IIASA — Atmospheric Pollution and Economic Development
Output data from RAINS, EMEP models, total and by sector — NO_x emissions	IIASA — Atmospheric Pollution and Economic Development

Uncertainties

Uncertainty related to the model

RAINS model

A methodology has been developed to estimate uncertainties of emission calculations based on uncertainty estimates for the individual parameters of the calculation (Suutari *et al.,* 2001). It was found that uncertainties in modelled national emissions of SO_2 and NO_x in Europe typically lie in the range between 10 and 30 percent (Outlook from RAINS model). In general, the uncertainties are strongly dependent on the potential for error compensation. This compensation potential is larger (and uncertainties are smaller) if calculated emissions are composed of a larger number of similar-sized source categories, where the errors in input parameters are not correlated with each other. Thus, estimates of national total emissions are generally more certain than estimates of sectoral emissions. The uncertainty in input parameters showed that the actual uncertainties are critically influenced by the specific situation (pollutant, year, country). Generally, however, the emission factor is an important contributor to the uncertainty in estimates of historical emissions, while uncertainty in the activity data dominates the future estimates.
For more information see http://www.iiasa.ac.at/rains/review/suutari.pdf.

EMEP models

Uncertainties in the model formulation itself give rise to uncertain deposition estimates. It has been shown that the EMEP model performance is rather homogeneous over the years (Fagerli *et al.* 2003b), but depend on geographical coverage and quality of the measurement data. The EMEP model has also been validated for nitrogen compounds in Simpson *et al.* (a) and for dry and wet deposition of sulphur, and wet depositions for nitrogen in Simpson *et al.* (b) with measurements outside the EMEP network.
For more information see http://www.emep.int/publ/reports/2006/status_report_1_2006_ch.pdf.

Data uncertainty

National projections reflect national governmental expectations and probably in many cases also merely policy ambitions. Thus there is no guarantee for international consistency, e.g. in the volumes of exports and imports or in the underlying assumptions on the development of oil prices. However, the value of this set of projections is that it reflects bottom-up expectations on economic development as seen today by the individual countries.
Uncertainty in activities data.

Rationale uncertainty

N/A.

Theme: Air pollution

Indicators: APE_F04 — Emissions of ozone precursors — outlook from WBCSD

Definition: Generally the indicator 'emissions of ozone precursors' tracks trends in anthropogenic emissions of ozone precursors: nitrogen oxides, carbon monoxide, methane and non methane volatile organic compounds, each weighted by their tropospheric ozone-forming potential.

The outlook form IEA/SMP model provides information only for nitrogen oxides and carbon monoxide in transport sector.

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

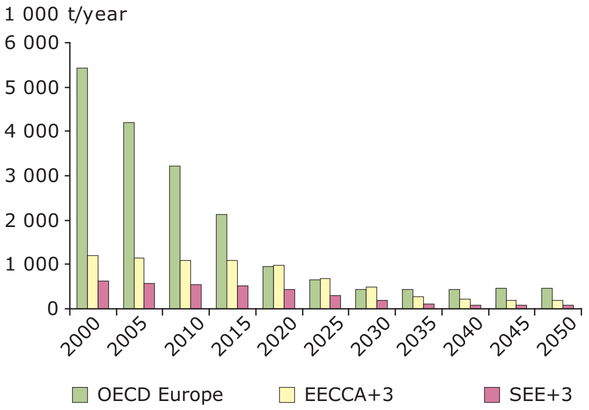
Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China**.

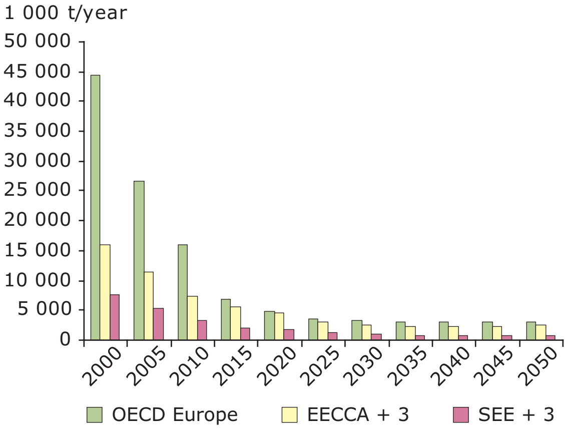
Policy question

What are prospects in reducing emissions of ozone precursors across Europe?

Emissions of NO_x from road transport from 2000 to 2050



Emissions of CO from road transport from 2000 to 2050



Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability*. World Business Council for Sustainable Development, Geneva.

Example assessment * from 2004

In developed countries efforts have been underway for decades to reduce ozone precursors (NOx, CO). There has been progress in reducing total NO_x and CO emissions from transport. Emissions per vehicle kilometer for light-duty vehicles have been substantially reduced. But growth in transport activity and problems in controlling emissions have tended to offset some of the hoped-for improvements.

The situation regarding acidifying substances in the transition countries (EECCA and SEE), especially their rapidly-growing urbanized areas, is somewhat different. Although NO_x and CO emissions are expected to be reduced, it is not expected to happen as easily or as quickly as desired.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Pan-European policy context: At the Pan-European level this indicators is related to the implementation of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_X, VOCs and ammonia. These ceilings were negotiated on the basis of scientific assessments of pollution effects and abatement options. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. (The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone).

EU policy context: Emission ceiling targets for NO_x and NMVOCs are specified in both the EU National Emission Ceilings Directive (NECD) and the Gothenburg protocol under the United Nations Convention on Long-Range Transboundary Air pollution (LRTAP Convention) (UNECE 1999). Emission reduction targets for the new EU-10 Member States have been specified in the Treaty of Accession to the European Union 2003 [1] in order that they can comply with the NECD. In addition, the Treaty of Accession also includes a new target for the EU-25 region as a whole. There are no specific EU emission targets set for either carbon monoxide (CO) or methane (CH_4). However, there are several Directives and Protocols that affect the emissions of CO and CH_4. For example, carbon monoxide is covered by the second daughter Directive under the Air Quality Directive. This gives a limit of 10 mg m-3 for ambient air quality to be met by 2005. Methane is included in the basket of six greenhouse gases under the Kyoto protocol (see CSI 10: Greenhouse gas emissions and removals). (Convention on Long-Range Transboundary Air pollution, Directive 2001/81/EC, national emission ceilings).

[1] The Treaty of Accession 2003 of the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia. AA2003/ACT/Annex II/en 2072.

EECCA policy context: Most of the EECCA countries ratified the 1979 Convention on Long-Range Transboundary Air pollution. These are A list of countries ratified the 1979 Convention: Armenia (1997), Azerbaijan (2002), Belarus (1980), Georgia (1999), Kazakhstan (2001), Kyrgyzstan (2000), Republic of Moldova (1995), Russian Federation (1980), the Ukraine (1980). At the same time only two of them signed in the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone, notably Armenia (1999), Republic of Moldova (2000). (Convention on Long-range Transboundary Air pollution, The Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone).

Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_X, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light-duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked. See table below.

Sectors/modes	Vehicle technologies/fuels	Regions	Variables
-Light-duty vehicles (cars, minivans, SUVs) -Medium trucks -Heavy-duty (long-haul) trucks -Mini-buses ('paratransit') -Large buses -2-3 wheelers -Aviation (Domestic +Int'l) -Rail freight -Rail passenger -National waterborne (Inland plus coastal) -Int'l shipping	-Internal combustion engine: -Gasoline -Diesel -LPG-CNG -Ethanol-Biodiesel -Hybrid -Electric ICE (same fuels) -Fuel-cell vehicle -Hydrogen (With feedstock differentiation for biofuelsand hydrogen)	-OECD Europe -OECD North America -OECD Pacific (Japan, Korea, Australia, NZ) -Former Soviet Union (FSU) -Eastern Europe -Middle East -China -India -Other Asia -Latin America -Africa	Passenger kilometres of travel -Vehicle sales (LDVs only) -Vehicle stocks -Average vehicle fuel efficiency -Vehicle travel -Fuel use-CO_2 emissions -Pollutant emissions (PM, NO_X, HC, CO, Pb) -Safety (road fatalities and injuries)

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection*. World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Data specifications

Data set title	Source
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data, Fulton, L., IEA/Eads, G., CRA (2004) p. 21
Input data to EIA/SMP model — GDP	International Energy Agency
Output from IEA/SMP model — emissions of ozone precursors	World Business Council on Sustainable Development
Input data to IEA/SMP model — Average Pollutant Emissions for Existing Vehicles in 2000 (g/km) — output from the report OECD Environment Directorate study, (part of the MOVE II project)	OECD Environment Directorate

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.

Not all technologies or variables are covered for all modes

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	Frt Rail	Pass Rail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	•	•	•	•	•	•	i	i	
New vehicle characteristics(sales, fuel consumption)	•								
Stock-average energy intensity	•	•	•	•	•	•	i	i	
Calculation of energy use and vehicle CO_2 emissions	•	•	•	•	•	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	•	i	•	•	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	•	i	•	•	i	i	i	•

Note: • = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Rationale uncertainty

The relevance of the balanced modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

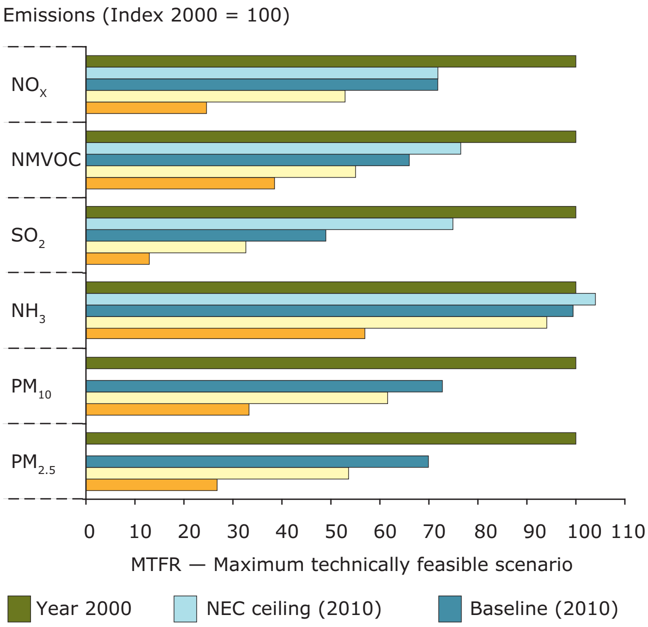
Theme: Air pollution
Indicators: APE_F05 — Emissions of primary particles — outlook from LRTAP

Definition: This indicator tracks trends in emissions of primary particulate PM_{10} and $PM_{2.5}$.
'PM_{10}' means particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 10 μm aerodynamic diameter;
'$PM_{2.5}$' means particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 2.5 μm aerodynamic diameter.
Model used: RAINS, EMEP
Ownership: UNECE Convention on Long-range Transboudary Air Pollutants (LRTAP)
Temporal coverage: 2000, 2030
Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **By country:** Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom.

Policy question

What are prospects in reducing emissions of PM across Europe?

Emissions of acidifying substances (Baseline and MTFR scenarios, index 100 in 2000)



Source:
EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

On the basis of existing policies and measures, emissions of PM and secondary particulate precursors (PM_{10} and $PM_{2.5}$) of land-based air pollutants are expected to decline significantly (by 38 % for PM_{10} and by 46 % for $PM_{2.5}$) 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 the emissions.

Policy context

Pan-European policy context: (UNECE Convention on Long-range Transboundary Air pollution).

EU policy context: There are no specific EU related emission targets set for primary PM_{10} and $PM_{2.5}$. However, there are several Directives and Protocols that affect the emissions of primary PM_{10} and $PM_{2.5}$, including air quality standards for PM in the First Daughter Directive to the Framework Directive on Ambient Air Quality and emission standards for specific mobile and stationary sources for primary PM precursor emissions. (Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air)

EECCA policy context: However EECCA Environmental strategy does not explicitly put emphasis on the particulate mater, it highlights a need for '..optimisation of standards, accounting for environmental and combined health impacts (based on WHO4 criteria)'.

Model used — 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 (Tarrason *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.

The model can be operated in the 'scenario analysis' mode, i.e., following the pathways of the emissions from their sources to their impacts (see descriptions of scenarios at the link). In this case the model provides estimates of regional costs and environmental benefits of alternative emission control strategies. 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. An 'optimization mode' is under development to identify cost-optimal allocations of emission reductions in order to achieve specified deposition and concentration targets. The current version of the model can be used for viewing activity levels and emission control strategies, as well as calculating emissions and control costs for those strategies.

References

Amann, M.; Cofala, J.; Heyes, C.; Klimont, Z.; Schopp, W., 1999. *The RAINS Model: A Tool for Assessing Regional Emission Control Strategies in Europe.* Pollution Atmospherique 4 (1999), Paris, France.

Data specifications

Data set title	Source
Input data for RAINS model — Heat values of fuels	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Ash content of solid fuels	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Fuel-sector combinations	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Ash retention in boilers	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Shares of PM in TSP	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Removal efficiencies	IIASA — Atmospheric Pollution and Economic
Input data for RAINS model — Emission factors	IIASA — Atmospheric Pollution and Economic
Output data from RAINS model Emissions of PM_{10}, $PM_{2.5}$	IIASA — Atmospheric Pollution and Economic

Uncertainties

Methodology uncertainty

A methodology has been developed to estimate uncertainties of emission calculations based on uncertainty estimates for the individual parameters of the calculation (Suutari *et al.,* 2001). It was found that uncertainties in modeled national emissions of SO_2 and NO_X in Europe typically lie in the range between 10 and 30 percent (Outlook from RAINS model). In general, the uncertainties are strongly dependent on the potential for error compensation. This compensation potential is larger (and uncertainties are smaller) if calculated emissions are composed of a larger number of similar-sized source categories, where the errors in input parameters are not correlated with each other. Thus, estimates of national total emissions are generally more certain than estimates of sectoral emissions.
For more information see http://www.iiasa.ac.at/rains/review/suutari.pdf

Data uncertainty

The uncertainty in input parameters showed that the actual uncertainties are critically influenced by the specific situation (pollutant, year, country). Generally, however, the emission factor is an important contributor to the uncertainty in estimates of historical emissions, while uncertainty in the activity data dominates the future estimates.

These preliminary estimates are still associated with considerable uncertainties, and more work, involving national experts, will be necessary to obtain a verified and generally accepted European data base to estimate the potential for further reductions of fine particles in Europe.

Rationale uncertainty

Emission reductions are assumed to be achieved exclusively by technical measures; any feedback of emission controls on economic and energy systems is not included.

Theme: Air pollution

Indicators: APE_F06- Emissions of primary particles — outlook from WBCSD

Definition: Generally, the indicator 'Emissions of primary particles include PM_{10} and $PM_{2.5}$. 'PM_{10}' means particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 10 μm aerodynamic diameter; '$PM_{2.5}$' means particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 2.5 μm aerodynamic diameter.

The outlook from IEA/SMP model provides information about PM_{10} from the transport sector.

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

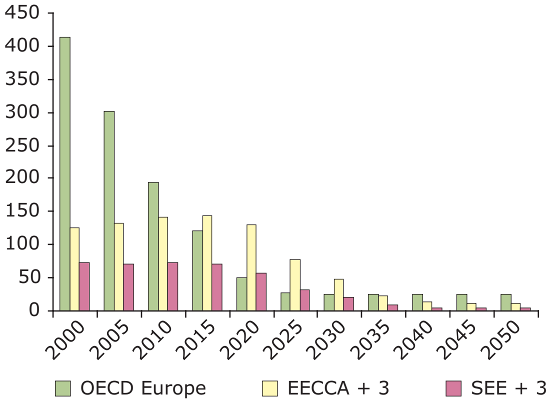
Temporal coverage: 1990–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China**.

Policy question

What are prospects in reducing emissions of PM across Europe?

Emissions of particulate matter from road transport from 2000 to 2050



Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva.

Example assessment* from 2004

In OECD-Europe countries efforts have been underway for decades to reduce particles (PM_{10}). Progress in reducing total PM_{10} has been slower. Emissions per vehicle kilometer for light-duty vehicles have been substantially reduced. But growth in transport activity and problems in controlling in-use emissions have tended to offset some of the hoped-for improvements.

The situation regarding primary particles in the countries of EECCA and SEE (especially its rapidly-growing urbanized areas) is different. PM are not expected to be reduced as easily or as quickly. Total PM emissions are expected to increase for the next few decades and perhaps longer, before eventually declining.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Pan-European policy context: (UNECE Convention on Long-range Transboundary Air pollution).

EU policy context: There are no specific EU related emission targets set for primary PM_{10} and $PM_{2.5}$. However, there are several Directives and Protocols that affect the emissions of primary PM_{10} and $PM_{2.5}$, including air quality standards for PM in the First Daughter Directive to the Framework Directive on Ambient Air Quality and emission standards for specific mobile and stationary sources for primary PM precursor emissions. (Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air).

EECCA policy context: However EECCA Environmental strategy does not explicitly put emphasis on the particulate mater, it highlights a need for '..optimisation of standards, accounting for environmental and combined health impacts (based on WHO4 criteria)'. (EECCA Environmental Strategy).

Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light-duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked. See table below.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection.* World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Sectors/modes	Vehicle technologies/fuels	Regions	Variables
-Light-duty vehicles (cars, minivans, SUVs) -Medium trucks -Heavy-duty (long-haul) trucks -Mini-buses ('paratransit') -Large buses -2-3 wheelers -Aviation (Domestic + Int'l) -Rail freight -Rail passenger -National waterborne (Inland plus coastal) -Int'l shipping	-Internal combustion engine: -Gasoline -Diesel -LPG-CNG -Ethanol-Biodiesel -Hybrid -Electric ICE (same fuels) -Fuel-cell vehicle -Hydrogen (With feedstock differentiation for biofuels and hydrogen)	-OECD Europe -OECD North America -OECD Pacific (Japan, Korea, Australia, NZ) -Former Soviet Union (FSU) -Eastern Europe -Middle East -China -India -Other Asia -Latin America -Africa	Passenger kilometres of travel -Vehicle sales (LDVs only) -Vehicle stocks -Average vehicle fuel efficiency -Vehicle travel -Fuel use-CO_2 emissions -Pollutant emissions (PM, NO_x, HC, CO, Pb) -Safety (road fatalities and injuries)

Data specifications

Data set title	Source
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data, Fulton, L., IEA/Eads, G., CRA (2004) p. 21
Input data to EIA/SMP model — GDP	International Energy Agency
Output from IEA/SMP model — emissions of primary particles	World Business Council on Sustainable Development
Input data to IEA/SMP model — Average Pollutant Emissions for Existing Vehicles in 2000 (g/km) — output from the report OECD Environment Directorate study, (part of the MOVE II project)	OECD Environment Directorate

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.Not all technologies or variables are covered for all modes.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	Frt Rail	Pass Rail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	●	●	●	●	●	●	i	i	
New vehicle characteristics (sales, fuel consumption)	●								
Stock-average energy intensity	●	●	●	●	●	●	i	i	
Calculation of energy use and vehicle CO_2 emissions	●	●	●	●	●	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	●	i	●	●	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	●	i	●	●	i	i	i	●

Note: ● = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Rationale uncertainty

The relevance of the balanced modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Biodiversity

BDIV_F01 **Change in species diversity as a result of climate change — outlook from EEA**

Theme: Biodiversity

Indicators: BDIV_F01 — Change in species diversity as a result of climate change — outlook from EEA

Definition: The indicator represents number of species gained and lost as a result of climate change.

Model used: EUROMOVE

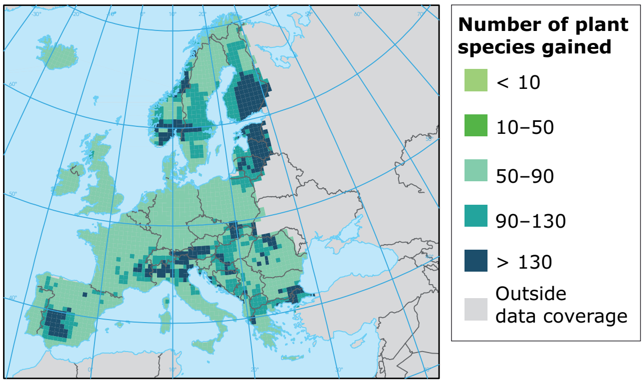
Ownership: European Environment Agency (EEA)

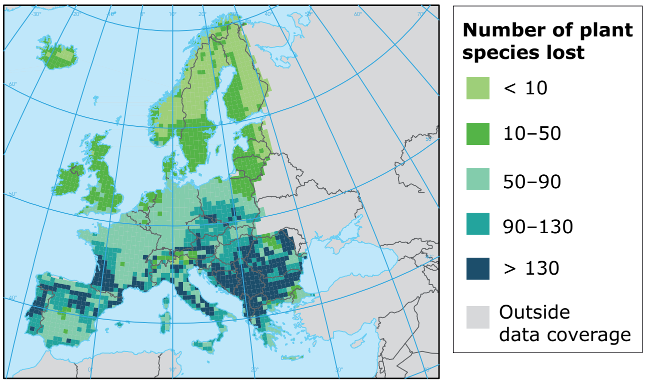
Temporal coverage: 2100

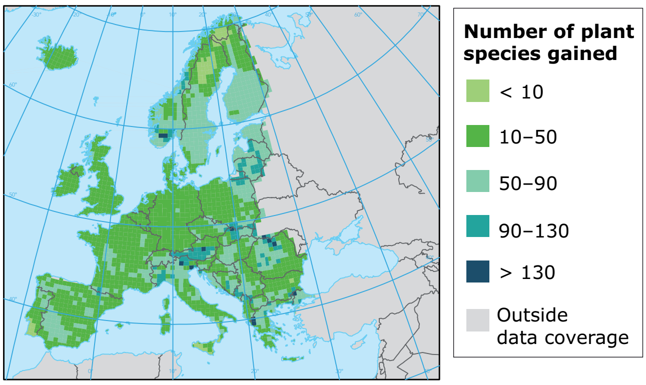
Geographical coverage: Austria, Belgium, Denmark, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Liechtenstein, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Slovakia, Slovenia, United Kingdom.

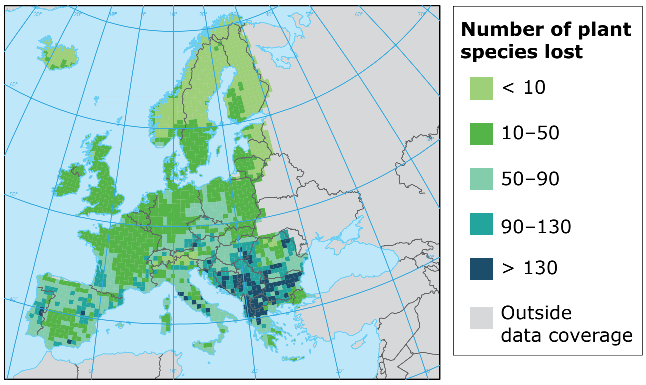
Policy question

What is the state and trend of biodiversity?









Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Significant changes in the distribution of plant species in Europe are expected by 2100 due to increase of global temperature by about 3.1 °C. Such temperature increase is going to be well above the long-term sustainable objective set in the 6th EAP. The South-western part and the most of the Eastern part (Russia) of Europe may suffer the highest changes in biodiversity; the loss of species might exceed 50 % by 2050. By 2100 most European Member States are expected to lose more than 50 species compared with the 1995 situation.

Note:

The most recent assessment is available in EEA Report No 4/2008: *Impacts of Europe's changing climate — 2008 indicator-based assessment.* Joint EEA-JRC-WHO report (September 2008).

Policy context

Pan-European policy context: On the Pan-European level, the Kiev resolution on Biodiversity was adopted during the fifth ministerial conference on Environment for Europe in 2003. It reinforces the objective to halt the loss of biodiversity at all levels by the year 2010. (Kiev Declaration from the Fifth Ministerial Conference — Environment for Europe 2003, Convention on the Conservation of European Wildlife and Natural Habitats — Bern Convention).

EU policy context: At the European level, the Council of the European Union adopted the European Strategy for Sustainable Development in 2001. One of the objectives of the Strategy was 'to halt the loss of biodiversity by 2010'. In June 2004, the EU Environment Council welcomed the set of biodiversity indicators referred to in the 'Message from Malahide' and based on the first set of indicators adopted under the Convention on biological diversity earlier that year. Other political instruments in Europe are also focusing on biodiversity. These include the 6th Environmental Action Programme and the European Community Biodiversity Strategy and Action Plan. (Communication of the European Commission to the Council and to the European Parliament on a European Community Biodiversity Strategy. COM (1998) 42, Environment 2010: Our future, our choice, 6th Environmental Action Programme, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. COM (2001) 31 final).

EECCA policy context: Development and implementation of national strategies and plans concerning biodiversity is the object for the governments of EECCA region. (EECCA Environmental Strategy).

Model used for indicators calculation — EUROMOVE model

Euromove is a species-based model using logistic regression equations to calculate occurrence probabilities for almost 1400 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.

The model is easy to use and makes use of all available digital information on plant species in Europe. The indicator recognizes climate change as the major determining factor of plant distribution. The indicator gives insight in the potential loss of plant biodiversity due to climate change.

References

EEA, 2005. *European environment outlook*. EEA Report No 4/2005. European Environment Agency, Copenhagen.

Data specifications

Data set title	Source
Input data to Euromove model — GDP	RIVM — The Netherlands Environmental Assessment Agency
Input data to Euromove model — Population	RIVM — The Netherlands Environmental Assessment Agency
Input data to Euromove model — Climate data	IIASA
Input data to Euromove model — Climate variables from IMAGE model	RIVM — The Netherlands Environmental Assessment Agency
Input data to Euromove model — Plant species	The Committee for Mapping the Flora of Europe
Output data from Euromove model — Number of species lost/gained due to climate change	

Uncertainties

Uncertainty related to the model

Factors that affect biodiversity, such as land use change, habitat loss, and fragmentation are not considered. For this reason, the results may differ from the actual future distribution. It can be proposed additional modules to complete prediction on these and other aspects. The use of the model and the indicator in a policy context is therefore limited, although the methodology has potential application to predict responses of keystone species.

Data uncertainty

Data quality is not consistently robust across Europe, particularly in Russia, and to a lesser extent in Spain and southern Italy.

Rationale uncertainty

N/A.

Climate change

CC_F01	**Projections of GHG emissions — outlooks from National Communications under UNFCCC**
CC_F02	**GHG emissions — outlook from IEA**
CC_F03	**GHG emissions — outlook from IIASA**
CC_F04	**GHG emissions — outlook from WBCSD**
CC_F05	**GHG emissions — outlook from MNP**
CC_F06	**GHG emissions — outlook from EEA**
CC_F07	**GHG concentrations — outlook from EEA**
CC_F10	**Global and European temperature — outlook from EEA**

Theme: Climate change

Indicators: CC_F01 — Projections of GHG emissions — outlooks from National Communications under UNFCCC

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions.

Model used: N/A

Ownership: European Environment Agency (EEA)

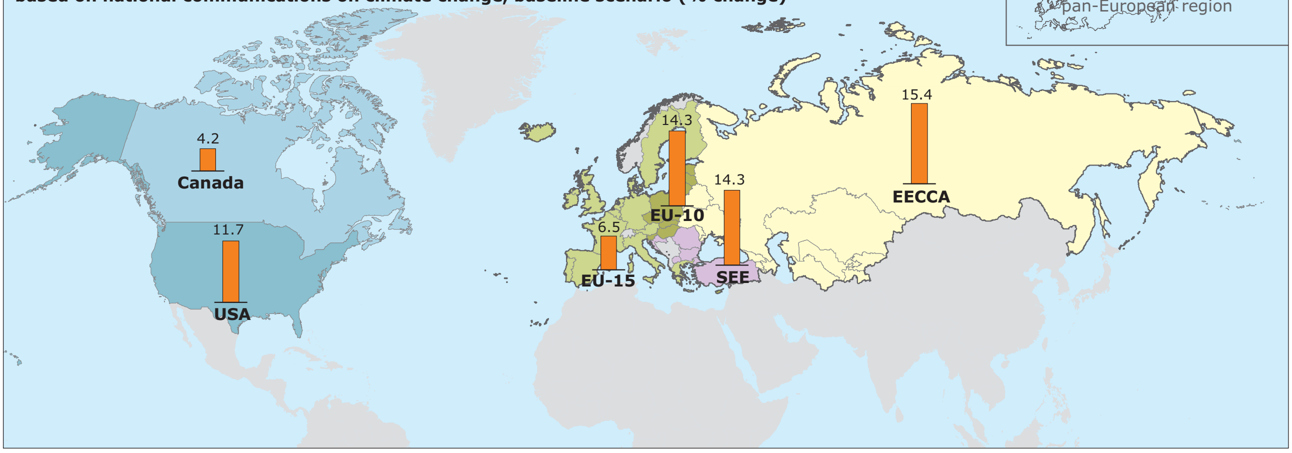
Temporal coverage: 1990–2020

Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **SEE:** Bulgaria, Croatia, the former Yugoslav Republic of Macedonia, Montenegro, Romania, Turkey; **EECCA:** Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, Russian Federation, Turkmenistan, Ukraine, Uzbekistan, **Canada, USA.**

Policy questions

What is the projected progress in GHG emissions reduction in European countries?

Projected change in GHG emissions (CO_2-equivalent/capita) from 2000 to 2020 based on national communications on climate change, baseline scenario (% change)



Source:
National Communications on Climate Change (UNFCC); EEA, 2007) *Europe's environment — The fourth assessment.* European Environment Agency, Copenhagen.

Example assessment from 2007

With current trends and policies,* GHG emissions per capita are expected to increase until 2020 in the EU-10, EECCA and SEE more than in EU-15, Canada and US. In absolute terms, US GHG emissions per capita are expected to stay the highest in the world.**

* *Baseline scenarios presented in the national communications of climate change.*

** *On 10 January 2007 the European Commission presented a package on climate change and energy which was endorsed by the European Council on 9 March 2007. It includes targets for the reduction of GHGs by 2020. This will influence the reported projections for the coming years.*

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

To date 40 countries in the Pan-European region ratified the Kyoto Protocol, notably: Annex I: Belarus, Bulgaria, Croatia, Romania, Russian Federation, Ukraine, EU-25. Non-Annex I countries: Albania, Armenia, Azerbaijan, Georgia, Kyrgyzstan, the former Yugoslav Republic of Macedonia, Republic of Moldova, Turkmenistan, and Uzbekistan.

Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008–2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

31 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 % from 1990 levels in the commitment period 2008–2012. (COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., Greenhouse gas monitoring mechanism, Sixth Environment Action Programme).

Model used

Projections of the GHG emission reported in the National Communications are calculated for different scenarios with the help of computer simulation models, which in turn utilize many assumptions on factors such as population growth, gross domestic product (GDP) growth, technology efficiency improvements, land-use changes, and the energy resource base.

The IPCC Special Report on Emissions Scenarios identified at least 17 models and more than 400 scenarios developed for the estimation of the GHG emissions (for more information see GHG Emission Scenario Database). In most cases the information about models used for calculation of the projection of the GHG emission is not reported in the National Communications on Climate Change submitted by the EECCA and SEE countries.

For some countries (Romania) projections are based on calculations carried out using the ENPEP (Energy and Power Evaluation Program) package program, developed by Argonne National Laboratory of US Department of Energy (DOE) and distributed by the International Atomic Energy Agency (IAEA). The models used are MAED (Model for Analyses of Energy Demand), WASP (Wiener Automatic Simulation Program), BALANCE and IMPACT. Other countries could have used different models and this could be investigated further.

References

UNFCC, 1997–2007. United Nations Framework Convention on Climate Change. National Communications on Climate Change.

Data specifications

Data set title	Source
Projections of GHG emissions	National Communications on Climate Change, UNFCCC

Uncertainties

Methodology uncertainty

Uncertainties in the projections in GHG emissions have not been assessed. The methodology and quality of the data differs widely between countries.

Different countries use different models to calculate their projections of the GHG emission. It is unclear to which extend the projections from different models are compatible. Simply to compare emissions levels for baseline scenario (and across different scenarios) for different countries is not sufficient to shed the light on internal consistency, plausibility, and comparability of data and the assumptions behind the scenarios. Analysis of the underlying driving forces (population growth, economic growth, energy consumption, and energy and carbon intensities) should thus also be an important part of the evaluation. Some of these driving forces are specified as model inputs, and some are derived from model outputs, so it is necessary to determine the assumed relationships among the main driving forces.

In most cases the information about models used for calculation of the projection of the GHG emission is not reported in the National Communications on Climate Change submitted by the EECCA and SEE countries.

Data uncertainty

1) The dates for submission of the National communications vary from 1998 (Armenia) to 2006 (Belarus, Ukraine, Russia). The models used for calculations of the projected GHG emissions by different countries use different scenarios reflecting various hypotheses related to economic growth, population growth, policy development, evolution of activities in the energy sector and other non-energy sectors, which contribute to GHG emissions. The assumptions for the projection of GHG emission in the National Communications produced in the earlier days may not sufficiently reflect current developments of the countries and additional analysis might be needed. Some for example claim that economic growth in some EECCA and SEE countries was not as high as it was expected and thus the projections of GHG emissions reported in the communications are higher than the current emission levels.
2) The units used for measurement differ (million-tonnes of GHG or million-tonnes of CO_2-equivalent). The normalization of the data to the CO_2 equivalent can be done using the coefficient, however it is unclear what coefficients can be used.
3) The dates for when simulations were run are unclear. It is however possible to assess the period of the simulation by date of publication of the national communications and the base year used for simulations.

Theme: **Climate change**

Indicators: **CC_F02 — GHG emissions — outlook from IEA**

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions.

Model used: World Energy Model (WEM)

Ownership: International Energy Agency (IEA)

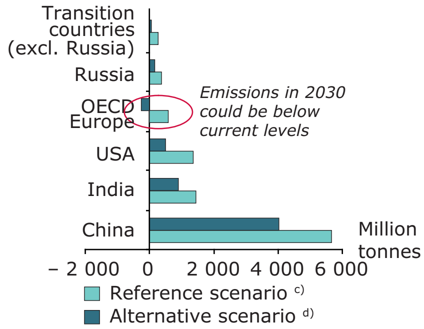
Temporal coverage: 1990–2030

Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

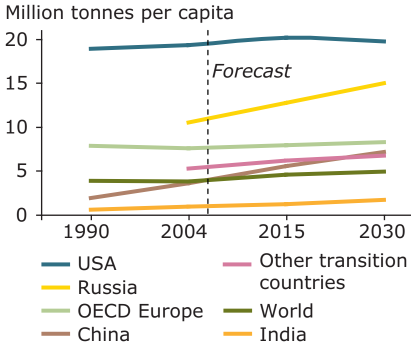
Policy questions

What is the projected progress in GHG emissions reduction in European countries?

Projected change in energy-related CO_2 emissions for IEA reference and alternative scenarios, 2004–2030



IEA estimates and projections of energy-related CO_2 emissions per capita from 1990 to 2030 c)



Source:

IEA — International Energy Agency, 2006. *World Energy Outlook 2006*. IEA, Paris. EEA, 2007. *Europe's environment — The fourth assessment*. European Environment Agency, Copenhagen.

Example assessment from 2006

Global energy-related emissions of CO_2*, the largest contributor to total GHG emissions, are expected to increase by 29 % up to 2030. China being the main engine for this growth. In terms of energy-related emissions per capita, Russia is expected to come close to the current largest emitter, the US.

However, if countries were to adopt all the energy security and energy-saving policies that they are currently considering to tackle CO_2 emissions**, total emissions avoided by 2030 could equal more than the current emissions of the US and Canada combined (or 16 % of the 2030 emissions in the IEA reference scenario), and energy-related CO_2 emissions in OECD Europe in 2030 could be less than today's level.

Note: The most recent assessment is available in *World Energy Outlook 2007*, IEA, 2007.

* *Projections are based on the International Energy Agency (IEA) reference case scenario, which takes into account government policies enacted and adopted by mid-2006, regardless of the implementation.*

** *IEA alternative policy scenario presents the situation if countries were to adopt all the energy security and energy policies they are currently considering.*

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

To date 40 countries in the Pan-European region ratified the Kyoto Protocol, notably: Annex I: Belarus, Bulgaria, Croatia, Romania, Russian Federation, Ukraine, EU-25. Non-Annex I countries: Albania, Armenia, Azerbaijan, Georgia, Kyrgyzstan, the former Yugoslav Republic of Macedonia, Republic of Moldova, Turkmenistan, and Uzbekistan.

Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008–2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

31 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 % from 1990 levels in the commitment period 2008–2012. (COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., Greenhouse gas monitoring mechanism, Sixth Environment Action Programme)

Model used — WEM model

The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1 (World Energy Outlook, 2004, p. 532) provides a simplified overview of the structure of the model. The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules. Primary demand for fossil fuels serves as input for the supply modules. Complete energy balances are compiled at a regional level, and the CO_2 emissions of each region are then calculated using derived carbon factors.

For each sector and fuel, CO_2 emissions are calculated by multiplying energy demand by an implied carbon emission factor. Implied emission factors for coal, oil and gas differ between sectors and regions, reflecting the product mix. They have been calculated from year 2002 IEA emission data for all regions.

The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. Reference case scenario takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented. Possible, potential or even unlikely future measures are not considered. The reference scenario is based on the UNSTAT projections of population growth (world average growth of 1 % per year for 2004–2030) and OECD and International Monetary Fund projections for economic development (world average growth 3.4 % per year for 2004–2030). It is assumed that energy-supply and energy use technologies become steadily more efficient, though at varying speeds for each fuel and each sector, depending on the potential for efficiency gains and the stage of technology development and commercialisation. New policies — excluded from the Reference scenario — would be needed to accelerate deployment of more efficient and cleaner technologies. IEA Alternative policy scenario of the WEO 2006 analyses the situation if countries were to adopt all the energy security and energy policies they are currently considering. These include efforts to improve efficiency in energy production and use, increase reliance on non-fossil fuels and sustain the domestic supply of oil and gas within net energy importing countries.

A more detailed description of the calculation of energy related indicators by the WEO model is presented in the catalogue under the indicators EE_F01, EE_F03, EE_F05, EE_F07, EE_F09.

The model has been updated and revised over years and the development process continues.

References

IEA, 2006. *World energy outlook 2006* (pp. 537, 538). International Atomic Agency (2006). OECD/IEA, Paris.

Data specifications

Data set title	Source
Input data to WEO model — technological developments	International Energy Egency
Input data to WEO model — fuel prices	International Energy Egency
Input data to WEO model — population	International Energy Egency
Input data to WEO model — economic growth	International Energy Egency
Input data to WEO model — electricity consumption	International Energy Egency
Input data to WEO model — electricity prices	International Energy Egency
Input data to WEO model — primary demand for fossil fuels	International Energy Egency
Outlook from WEO — CO_2 emissions	International Energy Egency

Uncertainties

Methodology uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties. Energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under. Reference case scenario takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented. Possible, potential or even unlikely future measures are not considered.

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause slower growing demand. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period.

Uncertainty about the outlook for economic growth in China is particularly acute.

The effects of resource availability and supply costs on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain — partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power.

Improvements in the efficiency of current energy technologies and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Uncertainties related to use of bio-fuels.

Data uncertainty

Major challenge is a reliable input data energy statistics. The statistics of IEA which provide a major input to the WEO, cover 130 countries worldwide. Most time-series begin in 1960 for OECD counties and in 1971 for non-OECD countries. Recently, however, maintaining the very high caliber of IEA statistics has become increasingly difficult, in many cases because national administrations have faced growing problems in maintaining the quality of their own statistics. Breaks in time series and missing data have become frequent in some countries. The lapses compromise the completeness of IEA statistics. They could seriously affect any type of analysis, including modeling and forecasting.

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: Climate change

Indicators: CC_F03 — GHG emissions — outlook from IIASA

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide(N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions. This indicator illustrates the projected trends in anthropogenic greenhouse gas emissions, particularly, for in methane (CH_4) under the baseline scenario (current legislation, CLE) and the Maximun Technical Feasible scenario (MTFR).

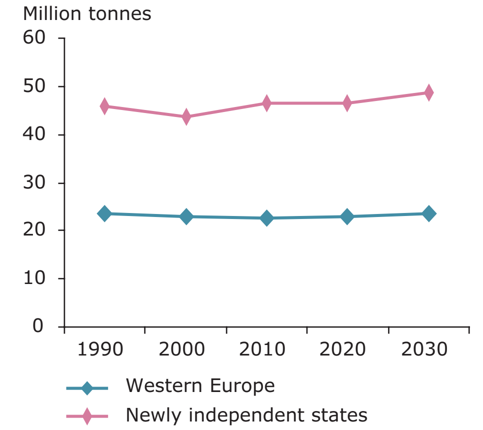
Model used: RAINS, EMEP

Ownership: International Institute for Applied Systems (IIASA)

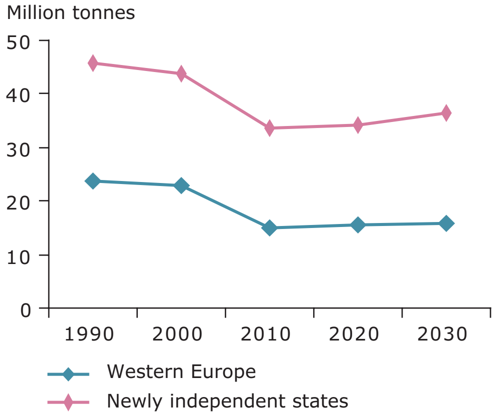
Temporal coverage: 1990–2030

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **By country:** Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom.

Projected CH_4 emissions from 1990 to 2030, RAINS model — current legislation scenario (CLE)



Projected CH_4 emissions from 1990 to 2030, RAINS model — most feasible reduction scenario



Source:

IIASA, 2005. Cofala, J.; Markus, A.; Mechler, R., 2005. *Scenarios of World Anthropogenic Emissions of Air Pollutants and Methane up to 2030*. International Institute for Applied Systems Analysis. Luxembourg, Austria.

Example assessment from 2005

According to the RAINS model under the 'current legislation' scenario, a 35 % increase of global anthropogenic CH4 emissions is expected between 2000 and 2030. CH4 emissions from all sectors are expected to grow due to increased economic activities and absence of wide-spread emission control measures. In Western Europe and Newly Independent states, overall CH_4 emissions will increase only slightly.

If all 'maximum technically feasible reductions' (MTFR scenario) were applied to the full extent, global CH_4 emissions would stabilise up to 2030, although at considerable cost. Under the MTFR scenario CH_4 emissions in Western Europe and Newly Independent States are expected to decrease by 31 % and 16 % respectively.

Note: The most recent assessment is available in: *Greenhouse gas emission trends and projections in Europe 2007*, EEA Report No 5/2007; and in EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N., *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

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Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008–2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

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Model used — RAINS model

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 (TarrasoI>*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).

References

IIASA, 2005. Cofala, J.; Markus, A.; Mechler, R., 2005. *Scenarios of World Anthropogenic Emissions of Air Pollutants and Methane up to 2030*. International Institute for Applied Systems Analysis. Laxemburg, Austria. Regional Air pollution Information and Simulation.

Data specifications

Data set title	Source
Input data for RAINS model — Emission factors CH_4	IIASA
Input data for RAINS model — Emission standards for Europe	Convention on Long-range Transboundary Air pollution
Input data for RAINS model — Emission standards other parts of the world	International Energy Agency
Input data for RAINS model — energy projections for EU countries from PRIMES model	DG-TREN Energy
Input data for RAINS model — energy projections from national sources	National Sources (Austria, Denmark, France, Ireland, Italy, Latvia, Netherlands, Portugal, Slovenia, United Kingdom, Russia)
Input data for RAINS model — livestock projectionist for the EU countries	DG-AGRI
Input data for RAINS model — livestock projections for other countries from FAO	Food and Agriculture Organization of the United Nations
Input data for RAINS model — livestock projections from national projections	National Sources (France, Ireland, Italy, Latvia, the Netherlands, Portugal, Slovenia, United Kingdom)
Input data for RAINS model — transport activity from TREMOVE model	DG-TREN
Output data from RAINS model, total and by sector — CH_4 emissions	IIASA — Atmospheric Pollution and Economic Development

Uncertainties

Uncertainty related to the model

RAINS model

A methodology has been developed to estimate uncertainties of emission calculations based on uncertainty estimates for the individual parameters of the calculation (Suutari *et al.,* 2001). It was found that uncertainties in modelled national emissions of SO_2 and NO_x in Europe typically lie in the range between 10 and 30 percent (Outlook from RAINS model). In general, the uncertainties are strongly dependent on the potential for error compensation. This compensation potential is larger (and uncertainties are smaller) if calculated emissions are composed of a larger number of similar-sized source categories, where the errors in input parameters are not correlated with each other. Thus, estimates of national total emissions are generally more certain than estimates of sectoral emissions. The uncertainty in input parameters showed that the actual uncertainties are critically influenced by the specific situation (pollutant, year, country). Generally, however, the emission factor is an important contributor to the uncertainty in estimates of historical emissions, while uncertainty in the activity data dominates the future estimates.
For more information see http://www.iiasa.ac.at/rains/review/suutari.pdf.

Data uncertainty

National projections used in our study reflect national governmental expectations and probably in many cases also merely policy ambitions. Thus there is no guarantee for international consistency, e.g. in the volumes of exports and imports or in the underlying assumptions on the development of oil prices. However, the value of this set of projections is that it reflects bottom-up expectations on economic development as seen today by the individual countries.For more information see methodology uncertainty.

Rationale uncertainty

N/A.

Theme: Climate change
Indicators: CC_F04 — GHG emissions — outlook from WBCSD

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions.

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

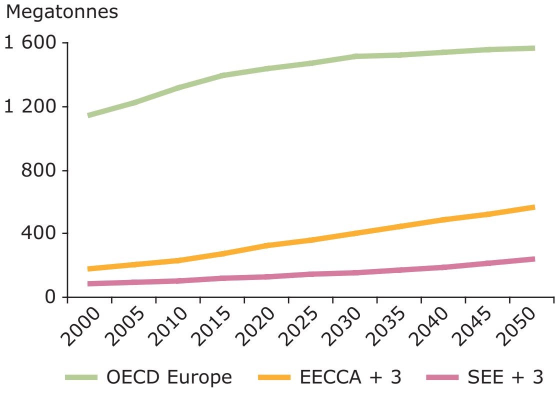
Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China.**

Policy question

What is the projected progress in GHG emissions reduction in European countries under baseline scenario?

Projections of total emissions of CO_2 from road transport from 2000 to 2050



Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva.

Example assessment from 2004

It is expected that GHG emissions from the transport sector will rise both by mode and by region. The projected* growth in GHG emissions regionally varies widely. The EECCA and SEE show much greater increases than in OECD Europe. This is due to the differences in projected rates of growth in transport activity and expectation that vehicle technologies and fuels required to enable lower greenhouse gas emissions will be introduced and widely used – but more slowly in EECCA and SEE than in OECD Europe.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

To date 40 countries in the Pan-European region ratified the Kyoto Protocol, notably: Annex I: Belarus, Bulgaria, Croatia, Romania, Russian Federation, Ukraine, EU-25. Non-Annex I countries: Albania, Armenia, Azerbaijan, Georgia, Kyrgyzstan, the former Yugoslav Republic of Macedonia, Republic of Moldova, Turkmenistan, and Uzbekistan.

Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008–2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

31 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 % from 1990 levels in the commitment period 2008–2012. (COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., Greenhouse gas monitoring mechanism, Sixth Environment Action Programme).

EU policy context (transport): The reduction of greenhouse gases and pollutant emissions, the security of energy supply and the balanced use of the various transport modes are the strategic priorities stated in the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide'. Moreover, all of these declared as priority research themes with a contribution to make to the implementation of the transport policy recommended in the White Paper.

Reducing greenhouse gas emissions in the transport sector is one of the priority actions of the The European Six Environmental action programme.

ECCA policy context (transport): Implement transport strategies for sustainable development in order to reduce greenhouse gas emissions, including through the development of better vehicle technologies that are more environmentally sound, affordable and socially acceptable (EECCA strategy).

Model used — IEA/SMP Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light-duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked. See table below.

References

Fulton, L., IEA/Eads, G., CRA, 2004. IEA/SMP Model Documentation and Reference Case Projection. World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf

Sectors/modes	Vehicle technologies/fuels	Regions	Variables
-Light-duty vehicles (cars, minivans, SUVs) -Medium trucks -Heavy-duty (long-haul) trucks -Mini-buses ('paratransit') -Large buses -2-3 wheelers -Aviation (Domestic +Int'l) -Rail freight -Rail passenger -National waterborne (Inland plus coastal) -Int'l shipping	-Internal combustion engine: -Gasoline -Diesel -LPG-CNG -Ethanol-Biodiesel -Hybrid -Electric ICE (same fuels) -Fuel-cell vehicle -Hydrogen (With feedstock differentiation for biofuelsand hydrogen)	-OECD Europe -OECD North America -OECD Pacific (Japan, Korea, Australia, NZ) -Former Soviet Union (FSU) -Eastern Europe -Middle East -China -India -Other Asia -Latin America -Africa	Passenger kilometres of travel -Vehicle sales (LDVs only) -Vehicle stocks -Average vehicle fuel efficiency -Vehicle travel -Fuel use-CO_2 emissions -Pollutant emissions (PM, NO_x, HC, CO, Pb) -Safety (road fatalities and injuries)

Data specifications

Data set title	Source
Input data to EIA/SMP model — GDP	International Energy Agency
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data
Outlook- greenhouse gas emissions from all vehicle types	World Business Council on Sustainable Development
Input to IEA/SMP model — a coefficient for CO_2 per unit fuel consumption output from IEA data base	International Energy Agency
Input to IEA/SMP model — factors for CO_2-equivalent emissions of CO_2, N_2O and CH_4 output from GM/LBST study	WBCSD
Input to IEA/SMP model — a coefficient for CO_2 per unit fuel consumption for methane output from US EIA data base	US Energy Information Administration

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.Not all technologies or variables are covered for all modes.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	FrtRail	PassRail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	●	●	●	●	●	●	i	i	
New vehicle characteristics(sales, fuel consumption)	●								
Stock-average energy intensity	●	●	●	●	●	●	i	i	
Calculation of energy use and vehicle CO_2 emissions	●	●	●	●	●	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	●	i	●	●	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	●	i	●	●	i	i	i	●

Note: ● = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Rationale uncertainty

The relevance of balanced modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: Climate change
Indicators: CC_F05 — GHG emissions — outlook from MNP

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions.

The HFCs, PFCs and SF_6 emissions are not included in the regional CO_2-equivalent emissions, since there is no regional historical emission data available, and the emissions scenarios of Fenhann (2000) are only specified for the four IPCC regions. Therefore the regional CO_2-equivalent emissions only consists of the emissions of the three major greenhouse gases: CO_2, CH_4, and N_2O.

Model used: IMAGE

Ownership: Netherlands Environmental Assessment Agency (MNP)

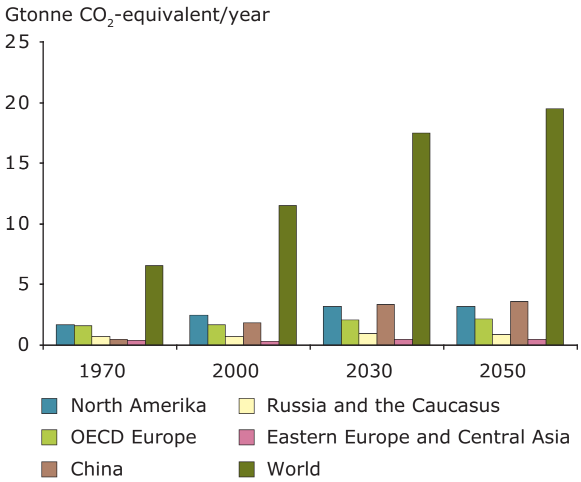
Temporal coverage: 1970–2100

Geographical coverage: OECD Europe: Andorra, Austria, Belgium, Denmark, Faeroe Islands, Finland, France, Germany, Gibraltar, Greece, Holy See, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Spain, Svalbard and Jan Ma; **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Yugoslavia; **Former USSR:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **South Asia:** Afganistan, Bangladesh, Bhutan, British Indian Ocean Territory, India, Maldives, Nepal, Pakistan, Sri Lanka; **East Asia:** China, Hong Kong, Democratic People's Republic of Korea, Republic of Korea, Macau, Mongolia, Taiwan; **Canada, USA.**

Policy questions

What could be the expected development of GHG emissions reduction in European countries?

Emission of GHG from energy use, industry use and land use, baseline



Source:

MNP, 2008; OECD, 2008. Netherlands Environmental Assessment Agency, and Organisation for Economic Co-operation and Development. *Background report to the OECD Environmental Outlook to 2030. Overviews, details, and methodology of model-based analysis.* Paris.

Example assessment from 2008

Total GHG emissions amount to 11.5 Gt C-equivalent in 2000 and are projected to be 17.5 Gt C-equivalent in 2030 and 19.5 Gt C-equivalent in 2050. This is consistent with a 37 % increase between 2005 and 2030, and a 52 % increase between 2005 and 2050. It is expected that emissions from OECD Europe and North America can increase by nearly one third from 2000–2050, emissions from Eastern Europe and Central Asia by almost 60 %, emissions from China nearly by double over the same period.

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

To date 40 countries in the Pan-European region ratified the Kyoto Protocol, notably: Annex I: Belarus, Bulgaria, Croatia, Romania, Russian Federation, Ukraine, EU-25. Non-Annex I countries: Albania, Armenia, Azerbaijan, Georgia, Kyrgyzstan, the former Yugoslav Republic of Macedonia, Republic of Moldova, Turkmenistan, and Uzbekistan.

Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008–2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

31 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 % from 1990 levels in the commitment period 2008–2012. (COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., Greenhouse gas monitoring mechanism, Sixth Environment Action Programme).

Model used for indicators calculation — IMAGE model

The Integrated Model to Assess the Global Environment (IMAGE) developed by the National Institute for Public Health and the Environment (RIVM), is a dynamic integrated assessment modeling framework for global change. The main objectives of IMAGE are to contribute to scientific understanding and support decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. To accomplish this, IMAGE provides:

- dynamic and long-term perspectives on the systemic consequences of global change
- insights into the impacts of global change
- a quantitative basis for analyzing the relative effectiveness of various policy options to address global change.

Components of IMAGE 2.2: In the IMAGE 2.2 framework the general equilibrium economy model, WorldScan, and the population model, PHOENIX, feed the basic information on economic and demographic developments for 17 world regions into three linked subsystems:

- The Energy-Industry System (EIS), which calculates regional energy consumption, energy efficiency improvements, fuel substitution, supply and trade of fossil fuels and renewable energy technologies. On the basis of energy use and industrial production, EIS computes emissions of greenhouse gases (GHG), ozone precursors and acidifying compounds.
- The Terrestrial Environment System (TES), which computes land-use changes on the basis of regional consumption, production and trading of food, animal feed, fodder, grass and timber, with consideration of local climatic and terrain properties. TES computes emissions from land-use changes, natural ecosystems and agricultural production systems, and the exchange of CO_2 between terrestrial ecosystems and the atmosphere.
- The Atmospheric Ocean System (AOS) calculates changes in atmospheric composition using the emissions and other factors in the EIS and TES, and by taking oceanic CO_2 uptake and atmospheric chemistry into consideration. Subsequently, AOS computes changes in climatic properties by resolving the changes in radiative forcing caused by greenhouse gases, aerosols and oceanic heat transport.

Modelling approach of IMAGE 2.2: Historical data for the 1765–1995 period are used to initialise the carbon cycle and climate system. IMAGE 2.2 simulations cover the 1970–2100 period. Data for 1970–1995 are used to calibrate EIS and TES. Simulations up to the year 2100 are made on the basis of scenario assumptions on, for example, demography, food and energy consumption and technology and trade. Although IMAGE 2.2 is global in application, it performs many of its calculations either on a high-resolution terrestrial 0.5 by 0.5 degree grid (land use and land cover) or for 17 world regions (energy, trade and emissions).

Use of Scenarios: The objective of the IMAGE 2.2 model is to explore the long-term dynamics of global environmental change, in particular, dynamics related to climate change. This requires an image of how the world system could evolve. Future greenhouse gas emissions, for instance, are the result of complex interacting demographic, techno-economic, socio-cultural and political forces. Scenarios are alternative images of how the future might unfold. They form an appropriate tool in analyzing how driving forces may influence future emissions and in assessing the associated uncertainties.

The Intergovernmental Panel on Climate Change (IPCC) published a set of new scenarios in the Special Report on Emissions Scenarios (SRES) (IPCC, 2000). These scenarios are based on a thorough review of the literature, the development of narrative 'storylines' and the quantification of these storylines using six different integrated models from different countries.

This CD-ROM represents the IMAGE 2.2 elaboration of the SRES storylines. Contrary to the original SRES scenarios, the scenarios on this CD-ROM do not focus solely on emissions, but also describe the possible environmental impacts of these scenarios . It should, however, be clear that the scenarios on this CD-ROM represent only one of the many possible elaborations of the SRES scenarios. In this respect, they reflect the authors' interpretations and valuation of only a part of past and present events, behaviours and structures. So-called 'disaster' scenarios are not included and none of the scenarios include new explicit climate policies. Summary of the scenarious presented in the table below:

References

MNP, 2001. *IMAGE 2.2 implementation of the SRES scenarios A comprehensive analysis of emissions, climate change and impacts in the 21st century.* Bilthoven: National Institute of Public Health and the Environment, 2001 (481508018).CD-ROM.

Storyline assumptions			
A1 family	B1 family	A2 family	B2 family
Stabilising population (9 billion in 2050)	Stabilising population (9 billion in 2050)	Growing population (13.5 billion in 2100); slowdown in fertility decline with lower income	Growing population (10.5 billion in 2100); in some regions slowdown in fertility decline with lower income
Globalisation, very high-growth high-tech	Globalisation, high-growth high-tech	Focus on regional [cultural] identity; environment low-priority	Focus on regional [cultural] identity; local/regional environment high-priority; non-effective in global environmental issues
Market-based capital and labour allocation	Balanced government and market in [economic] development	-	-
Orientation on profits and [technological] opportunities Convergence in regional income and rapid diffusion of technology; no trade barriers	Orientation on non-material quality of life aspects. Convergence in income and rapid diffusion of resource-efficient technology	No convergence in regional income and slow diffusion of technology; trade barriersIn some regions poor functioning markets and institutions	Orientation on non-material quality of life aspects. Varied regional economic and technology developments
Energy system dynamics			
A1 family	B1 family	A2 family	B2 family
Decline in energy-intensity due to innovations and high capital turnover rate	Strong focus on energy efficiency and sufficiency, service economy	Low rate of energy efficiency innovations, due to trade barriers and capital scarcity	Focus on energy efficiency and sufficiency, service economy
Preference for clean fuels and fast depletion cause fossil fuel prices to rise. This enables efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing	Large preference for clean fuels and depletion cause fossil fuel prices to rise. This further accelerates efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing	Coal use rises in many regions: seen as cheapest available fuel as oil and gas become more expensive/ unavailable. initially capital-intensive zero-carbon options penetrate in most regions only slowly	Preference for clean fuels and depletion cause fossil fuel prices to rise in some regions, inducing efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing
Food system dynamics			
A1 family	B1 family	A2 family	B2 family
Fast increase in the volume of trade in food and feed	Fast increase in the volume of trade in food and feed	Moderate increase in the volume of trade in food and feed	Moderate increase in the volume of trade in food and feed
Fast increase in food and livestock productivity	Fast increase in food and livestock productivity with high efficiency of fertiliser use	Slow increase in crop and livestock productivity	Moderate increase in food and livestock productivity
Fast increase in per capita consumption of livestock products as a result of GDP increase	Per capita consumption of livestock products is 10 % lower than in A1 scenario in 2050 and 20 % lower than in A1 in 2100	Slow increase in per capita consumption of livestock products as a result of GDP increase	Moderate increase in per capita consumption of livestock products as a result of GDP increase

Data specifications

Data set title	Source
Input data to IMAGE 2.2. Scenarios — population — output of PHONEX model	The National Institute for Public Health and the Environment
Input data to IMAGE 2.2. Scenarios — economic growth — output from WorldScan Model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — the potential distribution of natural vegetation and crops on the basis of climate conditions — output from TVM model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — demand for agricultural products (basic products, affluent products, feed products, wood products) — output from the Agricultural Economy Model (AEM)	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — updated land cover map (0.5 by 0.5 degree grid) — output from the Land-Cover Model (LCM)	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — use of primary and secondary energy carriers and feedstock — output from TIMER model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — production of energy carriers — output from TIMER model	The National Institute for Public Health and the Environment (RIVM)
Input data from IMAGE 2.2. Scenarios — Demand for modern and traditional biofuels — output of TIMER Model	The National Institute for Public Health and the Environment (RIVM)
Output data from INAGE 2.2. Scenarios — Energy-related and industrial emissions of greenhouse gases and atmospheric pollutants — output from TIMER Emissions Module	The National Institute for Public Health and the Environment (RIVM)

Uncertainties

Methodology uncertainty

Many unknowns and uncertainties in the climate system are not reflected in the IMAGE scenarios. Some of the major uncertainties in the causal chain are the climate sensitivity and regional climate-change patterns. The direct effects of a changed climate are changes in carbon uptake by the biosphere and oceans and in the distribution and productivity of crops, as well as shifts in ecosystems. Indirectly, many other processes are influenced, which can lead to the concentrations of greenhouse gases in the atmosphere being built up differently and to different land-use patterns. IMAGE simulates the consequences of these changes in an integrated fashion, accounting for interactions and feedbacks. The outcome is thus not necessarily a linear function of climate sensitivity.

These climate uncertainties were addressed by providing additional simulations to illustrate the uncertainty in the climate sensitivity and in the regional climate-change patterns.

Climate sensitivity. Climate sensitivity refers to long-term (equilibrium) change in global mean surface temperature following a doubling of the atmospheric concentration in CO_2 equivalents. According to IPCC, this climate sensitivity is between 1.5 °C and 4.5 °C. In earlier versions of IMAGE, the climate sensitivity generated by the climate model was 2.4 °C. Due to the rigid structure of these earlier versions, we were unable to change this and assess the consequences of such a change.

In IMAGE 2.2 a simpler climate model MAGICC (see Upwelling-Diffusion Climate Model) is incorporated, allowing to define the climate sensitivity. The default value for IMAGE runs is 2.5, which is the median value of the IPCC range (median differs from mean because the range is logarithmic).

To test the uncertainty related to the climate sensitivity, runs with respectively a low (1.5 °C) and high (4.5 °C) climate sensitivity were created. A pattern-scaling procedure is used to obtain regional and seasonal climate-change patterns using the calculated increase in global mean temperature.

Runs with changed climate sensitivity are provided for the A1F (A1F low, A1F high) and B1 (B1 low, B1 high) scenarios on the main disc (IMAGE team 2001a). These scenarios span the full range of the SRES emission scenarios and therefore adequately illustrate the uncertainty of different climate sensitivities.

Regional climate-change patterns. Climate-change patterns are not simulated explicitly in IMAGE. The global mean temperature increase, as calculated by IMAGE, is linked with the climate patterns generated by a general circulation model (GCM) for the atmosphere and oceans. This linking takes place using the standardized IPCC pattern-scaling approach (Carter *et al.,* 1994) and additional pattern-scaling for the climate response to sulphate aerosols forcing (Schlesinger *et al.,* 2000; see Geographical Pattern Scaling, GPS). GCMs are currently the best tools available for simulating the physical processes that determine global climate dynamics and regional climate patterns.

GCMs simulate climate over a continuous global grid with a spatial resolution of a few hundred kilometres and a temporal resolution of less than an hour.

Most GCMs agree on the global patterns of climate change: temperature increases above land are faster than above the oceans, high latitudes warm up more sharply than low latitudes, winter warms up more sharply than summers, total precipitation increases with increasing temperature, maritime regions generally get wetter, continental regions could get dryer.

Regionally, however, there are large differences between the different GCMs, especially in precipitation-change patterns.

IMAGE 2.2 runs with five different climate-change patterns are provided on the supplementary disc (IMAGE team 2001b, RIVM CD-ROM publication 481508019) for the A1F, B1 and A2 scenarios. The aim of this material is to illustrate the uncertainties in SRES climate-change scenarios resulting from these differences in GCMs. The first two scenarios span the full range of the SRES emission scenarios, the latter being based on a highly different narrative with different demographic and socio-economic assumptions. The three scenarios therefore adequately illustrate the uncertainty of different climate patterns. Differences in the runs for each scenario indicate some of the uncertainty caused by regional variation in climate-change patterns (not the global mean).

The scenarios for five different GCM runs from the IPCC data centre were implemented, which comprised:

- ECHAM4 of the Deutsches Klimarechenzentrum DKRZ in Germany
- CGCM1 of the Canadian Centre for Climate Modeling and Analysis in Canada
- GFDL-LR15-a of the Geophysical Fluid Dynamics Laboratory in the USA
- HADCM2 of the Hadley Centre for Climate Prediction and Research in the United Kingdom
- CSIRO-MK2 of Commonwealth Scientific and Industrial Research Organisation in Australia.

Data uncertainty

The HFCs, PFCs and SF_6 emissions are not included in the regional CO_2-equivalent emissions, since there is no regional historical emission data available, and the emissions scenarios of Fenhann (2000) are only specified for the four IPCC regions. Therefore the regional CO_2-equivalent emissions only consists of the emissions of the three major greenhouse gases: CO_2, CH_4, and N_2O.

Rationale uncertainty

In common with all attempts to describe future trends, the energy projections and GHG projections in the Outlook are subject to a wide range of uncertainties. The reliability of projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: Climate change

Indicators: CC_F06 — GHG emissions — outlook from EEA

Definition: Greenhouse gas emissions (total) refer to the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), weighted using their 100-year global warming potentials. National totals exclude emissions from natural resources and international bunker fuel emissions.

Model used: PRIMES, IMAGE, WEM

Ownership: European Environment Agency (EEA)

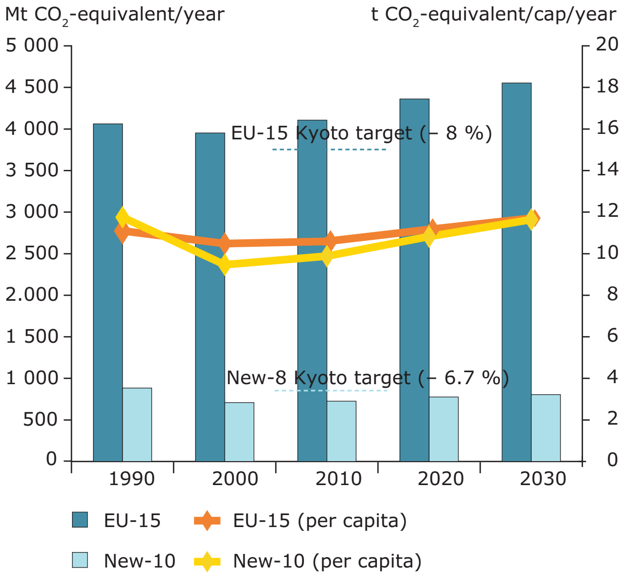
Temporal coverage: 1990–2030

Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy questions

What progress is projected towards meeting the Kyoto Protocol targets for Europe for reducing greenhouse gas (GHG) emissions to 2010: with current domestic policies and measures, with additional domestic policies and measures, and with additional use of the Kyoto mechanisms?

Total GHG emissions in Europe 1990-2030 (baseline scenario)



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

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.

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.

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

To date 40 countries in the Pan-European region ratified the Kyoto Protocol, notably: Annex I: Belarus, Bulgaria, Croatia, Romania, Russian Federation, Ukraine, EU-25. Non-Annex I countries: Albania, Armenia, Azerbaijan, Georgia, Kyrgyzstan, the former Yugoslav Republic of Macedonia, Republic of Moldova, Turkmenistan, and Uzbekistan.

Kazakhstan has signed but not ratified the protocol. It expects to enter into quantitative GHG reduction obligations for the period of 2008-2012 and expects to become a full participant of the three Kyoto mechanisms. (Strategy of the Republic of Kazakhstan on Climate Change). Bosnia and Herzegovina, Serbia and Montenegro, Tajikistan and Turkey have no commitments as they did not sign or ratify the Protocol.

31 countries and the EEC are required to reduce greenhouse gas emissions below levels specified for each of them in the treaty. The individual targets for Annex I Parties are listed in the Kyoto Protocol's Annex B. These add up to a total cut in greenhouse-gas emissions of at least 5 % from 1990 levels in the commitment period 2008-2012. (COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., Greenhouse gas monitoring mechanism, Sixth Environment Action Programme).

Model used

Projections of GHG emissions are produced using the PRIMES; IMAGE Scenarios Model and AEA technology approach (for methane).

IMAGE model

The Integrated Model to Assess the Global Environment (IMAGE) developed by the National Institute for Public Health and the Environment (RIVM), is a dynamic integrated assessment modeling framework for global change. The main objectives of IMAGE are to contribute to scientific understanding and support decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. To accomplish this, IMAGE provides: dynamic and long-term perspectives on the systemic consequences of global change; insights into the impacts of global change; a quantitative basis for analyzing the relative effectiveness of various policy options to address global change. See also forward-looking indicator: GHG emissions- outlook from IMAGE model.

Overview of the PRIMES Model

PRIMES, which is partial equilibrium model for the European Union energy system developed by, and maintained at, the National Technical University of Athens, E3M-Laboratory calculates energy consumption, energy efficiency improvements, fuel substitution, supply and trade of fossil fuels and renewable energy technologies (see description below).

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 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.

References

MNP, 2001. *IMAGE 2.2 implementation of the SRES scenarios A comprehensive analysis of emissions, climate change and impacts in the 21st century.* Bilthoven: National Institute of Public Health and the Environment, 2001 (481508018).CD-ROM.

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to IMAGE 2.2. Scenarios — demand for agricultural products (basic products, affluent products, feed products, wood products) â□' output from the Agricultural Economy Model (AEM)	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — economic growth â□' output from WorldScan Model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — population â□' output of PHONEX model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — the potential distribution of natural vegetation and crops on the basis of climate conditions — output from TVM model	The National Institute for Public Health and the Environment (RIVM)
Input data to IMAGE 2.2. Scenarios — updated land cover map (0.5 by 0.5 degree grid) — output from the Land-Cover Model (LCM)	The National Institute for Public Health and the Environment (RIVM)
Output data from PRIMES/IMAGE/AEA — emissions of greenhouse gases and atmospheric pollutants — output from Energy-Industry Emission Module of IMAGE	The National Institute for Public Health and the Environment (RIVM)
Output from PRIMES/IMAGE/AEA — emissions from land use — output from LUEM module of IMAGE	The National Institute for Public Health and the Environment (RIVM)
Output data from PRIMES/IMAGE/AEA — CO_2 energy emissions and other related emissions — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)
Input data to PRIMES — macro-economic data: demographics, antional accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumtpion and structure of activity variables — output from Eurostat data	Eurostat

Uncertainties

Methodology uncertainty

IMAGE model: Many unknowns and uncertainties in the climate system are not reflected in the IMAGE scenarios. Some of the major uncertainties in the causal chain are the climate sensitivity and regional climate-change patterns. The direct effects of a changed climate are changes in carbon uptake by the biosphere and oceans and in the distribution and productivity of crops, as well as shifts in ecosystems. Indirectly, many other processes are influenced, which can lead to the concentrations of greenhouse gases in the atmosphere being built up differently and to different land-use patterns. IMAGE simulates the consequences of these changes in an integrated fashion, accounting for interactions and feedbacks. The outcome is thus not necessarily a linear function of climate sensitivity.

These climate uncertainties were addressed by providing additional simulations to illustrate the uncertainty in the climate sensitivity and in the regional climate-change patterns.

See also forward-looking indicator: GHG emissions — outlook from IMAGE model.

PRIMES model: N/A.

Data uncertainty

Description of the date sets uncertainties is not found in the reference documentation.

Rationale uncertainty

In common with all attempts to describe future trends, the energy projections and GHG projections in the Outlook are subject to a wide range of uncertainties. The reliability of projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: Climate change

Indicators: CC_F07 — GHG concentrations — outlook from EEA

Definition: The indicator shows the measured trends and projections of greenhouse gas concentrations. The various greenhouse gases have been grouped in three different ways. In all cases the effect of greenhouse gas concentrations on the enhanced greenhouse effect is presented as CO_2-equivalent concentration. Global annual averages are considered.

Model used: IMAGE

Ownership: European Environment Agency (EEA)

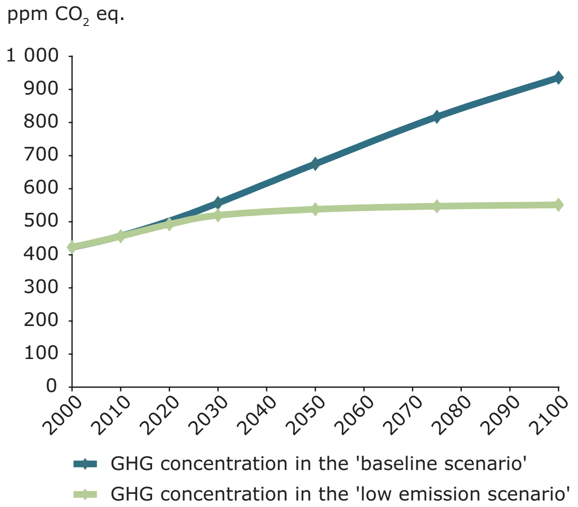
Temporal coverage: 2000–2100

Geographical coverage: Global.

Policy questions

Will GHG concentrations remain below 450 ppm CO_2-equivalent in the long term, the level needed to limit global temperature rise to 2 degrees Celsius (C) above pre-industrial levels?

Global GHG concentration change 2000-2100



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Under the baseline scenario the GHG atmospheric concentrations are expected to increase two times globally over the 2000–2100 period. The results of the low emission scenario suggest that the GHG atmospheric concentrations are expected to increase globally until 2050 and then they will be stabilised over the 2050–2100 period.

Thus reaching the Kyoto Protocol target concerning GHG concentrations in the EU depends significantly on the strength of the economy and on possible additional initiatives such as an enhances diffusion of renewable energy sources.

Note: Most recent assessment can be found at: IPCC (2007) Climate Change 2007: *The Physical Science Basis* c . eds. Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt K, Tignor MMB & Miller HL),. Working Group 1 Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Chapters 3 (Observations: Surface and Atmospheric Climate Change), 10 (Global Climate Projections),11 (Regional Climate Projections); and in the EEA Report No 4/2008: *Impacts of Europe's changing climate — 2008 indicator-based assessment*. Joint EEA-JRC-WHO report (September 2008).

Policy context

Global policy context: Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol. The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gases emissions world wide, entered into force on 16 February 2005. The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions (UN Framework Convention on Climate Change, UN Framework Convention on Climate Change).

EU policy context: The indicator is aimed at supporting assessment of progress towards the EU long-term target to limit global temperature increase to below 2 degrees C above pre-industrial levels, and, derived from this, stabilisation of GHG concentrations at well below 550 ppm CO_2-equivalent (Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002, laying down the sixth Community environment action programme), confirmed by the Environment Council conclusions of March 2005. (Sixth Environment Action Programme, Greenhouse gas monitoring mechanism).

EECCA policy context: There are no specific policies concerning atmospheric greenhouse gas concentrations in this region. However, in EECCA Environmental Strategy reduction of GHGs are defined as one of the aims. (EECCA Environmental Strategy)

Model used for indicators calculation — IMAGE model

The Integrated Model to Assess the Global Environment (IMAGE) developed by the National Institute for Public Health and the Environment (RIVM), is a dynamic integrated assessment modeling framework for global change. The main objectives of IMAGE are to contribute to scientific understanding and support decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. To accomplish this, IMAGE provides:

- dynamic and long-term perspectives on the systemic consequences of global change
- insights into the impacts of global change
- a quantitative basis for analyzing the relative effectiveness of various policy options to address global change.

Components of IMAGE 2.2

In the IMAGE 2.2 framework the general equilibrium economy model, WorldScan, and the population model, PHOENIX, feed the basic information on economic and demographic developments for 17 world regions into three linked subsystems:

- The Energy-Industry System (EIS), which calculates regional energy consumption, energy efficiency improvements, fuel substitution, supply and trade of fossil fuels and renewable energy technologies. On the basis of energy use and industrial production, EIS computes emissions of greenhouse gases (GHG), ozone precursors and acidifying compounds.
- The Terrestrial Environment System (TES), which computes land-use changes on the basis of regional consumption, production and trading of food, animal feed, fodder, grass and timber, with consideration of local climatic and terrain properties. TES computes emissions from land-use changes, natural ecosystems and agricultural production systems, and the exchange of CO_2 between terrestrial ecosystems and the atmosphere.
- The Atmospheric Ocean System (AOS) calculates changes in atmospheric composition using the emissions and other factors in the EIS and TES, and by taking oceanic CO_2 uptake and atmospheric chemistry into consideration. Subsequently, AOS computes changes in climatic properties by resolving the changes in radiative forcing caused by greenhouse gases, aerosols and oceanic heat transport.

Modelling approach of IMAGE 2.2

Historical data for the 1765–1995 period are used to initialise the carbon cycle and climate system. IMAGE 2.2 simulations cover the 1970–2100 period. Data for 1970–1995 are used to calibrate EIS and TES. Simulations up to the year 2100 are made on the basis of scenario assumptions on, for example, demography, food and energy consumption and technology and trade. Although IMAGE 2.2 is global in application, it performs many of its calculations either on a high-resolution terrestrial 0.5 by 0.5 degree grid (land use and land cover) or for 17 world regions (energy, trade and emissions).

References

MNP, 2001. *IMAGE 2.2 implementation of the SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century.* Bilthoven: National Institute of Public Health and the Environment, 2001 (481508018). CD-ROM.

Data specifications

Data set title	Source
Input data to IMAGE 2.2. Scenarios — Energy-related and industrial emissions of greenhouse gases and atmospheric pollutants â☐' output from TIMER Emissions Module	The National Institute for Public Health and the Environment (RIVM)(External source)
Output data from IMAGE 2.2 model — concentrations of GHGs	The National Institute for Public Health and the Environment (RIVM)

Uncertainties

Methodology uncertainty

Many unknowns and uncertainties in the climate system are not reflected in the IMAGE scenarios. Some of the major uncertainties in the causal chain are the climate sensitivity and regional climate-change patterns. The direct effects of a changed climate are changes in carbon uptake by the biosphere and oceans and in the distribution and productivity of crops, as well as shifts in ecosystems. Indirectly, many other processes are influenced, which can lead to the concentrations of greenhouse gases in the atmosphere being built up differently and to different land-use patterns. IMAGE simulates the consequences of these changes in an integrated fashion, accounting for interactions and feedbacks. The outcome is thus not necessarily a linear function of climate sensitivity.

These climate uncertainties were addressed by providing additional simulations to illustrate the uncertainty in the climate sensitivity and in the regional climate-change patterns.

Climate sensitivity

Climate sensitivity refers to long-term (equilibrium) change in global mean surface temperature following a doubling of the atmospheric concentration in CO_2 equivalents. According to IPCC, this climate sensitivity is between 1.5 °C and 4.5 °C. In earlier versions of IMAGE, the climate sensitivity generated by the climate model was 2.4 °C. Due to the rigid structure of these earlier versions, we were unable to change this and assess the consequences of such a change.

In IMAGE 2.2 a simpler climate model MAGICC (see Upwelling-Diffusion Climate Model) is incorporated, allowing to define the climate sensitivity. The default value for IMAGE runs is 2.5, which is the median value of the IPCC range (median differs from mean because the range is logarithmic).

To test the uncertainty related to the climate sensitivity, runs with respectively a low (1.5 °C) and high (4.5 °C) climate sensitivity were created. A pattern-scaling procedure is used to obtain regional and seasonal climate-change patterns using the calculated increase in global mean temperature.

Runs with changed climate sensitivity are provided for the A1F (A1F low, A1F high) and B1 (B1 low, B1 high) scenarios on the main disc (IMAGE team 2001a). These scenarios span the full range of the SRES emission scenarios and therefore adequately illustrate the uncertainty of different climate sensitivities.

Regional climate-change patterns

Climate-change patterns are not simulated explicitly in IMAGE. The global mean temperature increase, as calculated by IMAGE, is linked with the climate patterns generated by a general circulation model (GCM) for the atmosphere and oceans. This linking takes place using the standardized IPCC pattern-scaling approach (Carter *et al.,* 1994) and additional pattern-scaling for the climate response to sulphate aerosols forcing (Schlesinger *et al.,* 2000; see Geographical Pattern Scaling, GPS). GCMs are currently the best tools available for simulating the physical processes that determine global climate dynamics and regional climate patterns.

GCMs simulate climate over a continuous global grid with a spatial resolution of a few hundred kilometres and a temporal resolution of less than an hour.

Most GCMs agree on the global patterns of climate change:

* temperature increases above land are faster than above the oceans
* high latitudes warm up more sharply than low latitudes
* winter warms up more sharply than summers
* total precipitation increases with increasing temperature
* maritime regions generally get wetter
* continental regions could get dryer.

Regionally, however, there are large differences between the different GCMs, especially in precipitation-change patterns.

IMAGE 2.2 runs with five different climate-change patterns are provided on the supplementary disc (IMAGE team 2001b, RIVM CD-ROM publication 481508019) for the A1F, B1 and A2 scenarios. The aim of this material is to illustrate the uncertainties in SRES climate-change scenarios resulting from these differences in GCMs. The first two scenarios span the full range of the SRES emission scenarios, the latter being based on a highly different narrative with different demographic and socio-economic assumptions. The three scenarios therefore adequately illustrate the uncertainty of different climate patterns. Differences in the runs for each scenario indicate some of the uncertainty caused by regional variation in climate-change patterns (not the global mean).

The scenarios for five different GCM runs from the IPCC data centre were implemented, which comprised:

* ECHAM4 of the Deutsches Klimarechenzentrum DKRZ in Germany
* CGCM1 of the Canadian Centre for Climate Modelling and Analysis in Canada
* GFDL-LR15-a of the Geophysical Fluid Dynamics Laboratory in the USA
* HADCM2 of the Hadley Centre for Climate Prediction and Research in the United Kingdom
* CSIRO-MK2 of Commonwealth Scientific and Industrial Research Organisation in Australia.

Data uncertainty

The input data to the UDCM model is atmospheric concentrations of greenhouse gases and emissions of SO_2, which by itself is calculated on the basis of the other IMAGE 2.2. Models and bare all uncertainties related to those models (see more in methodology uncertainly).

Rationale uncertainty

The observed increase in average air temperature, particularly during the recent decades, is one of the clearest signals of global climate change.

The indicator shows trends in temperature data over time. Temperature is directly linked to the of climate change and is a state variable that changes in response to the pressures of global warming.

There is growing evidence that anthropogenic emissions of greenhouse gases are (mostly) responsible for the recently observed fast increases in average temperature. Natural factors like volcanoes and sun activity could explain to a large extent the temperature variability up to mid of the 20th century, but they can explain only a small part of the recent warming.

Theme: Climate change

Indicators: CC_F10 — Global and European temperature — outlook from EEA

Definition: The indicator shows trend in in annual average global surface temperature. The global average temperature change in the charts have been compared to be pre-industrial times 1765.

Model used: IMAGE

Ownership: European Environment Agency (EEA)

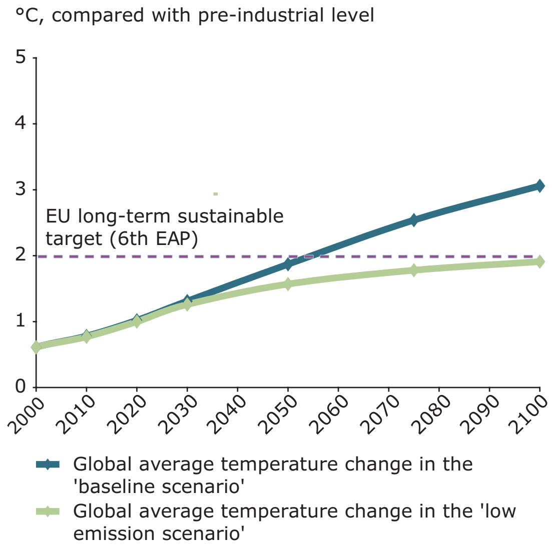
Temporal coverage: 2000–2100

Geographical coverage: Global.

Policy question

Will the European average temperature increase stay within the 2C target and will, the rate of European average temperature increase stay within 0.2C per decade?

Global temperature change 2000–2100



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

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

Note: The most recent projections is available from MNP (2008). OECD (2008). Netherlands Environmental Assessment Agency, and Organisation for Economic Co-operation and Development. Background report to the OECD Environmental Outlook to 2030. Overviews, details, and methodology of model-based analysis. Paris. 2008; and in the EEA Report No 4/2008: *Impacts of Europe's changing climate — 2008 indicator-based assessment.* Joint EEA-JRC-WHO report (September 2008).

Policy context

EU policy context: To avoid serious climate change impacts, the European Council proposed in its Sixth Environment Action Programme (6EAP, 2002), reaffirmed by the Environment Council and the European Council of 22–23 March 2005 (Presidency Conclusions, section IV (46), that the global average temperature increase should be limited to not more than 2 degrees C above pre-industrial levels (about 1.3 degrees C above current global mean temperature). In addition, some studies have proposed a 'sustainable' target of limiting the rate of anthropogenic warming to 0.1 to 0.2 degrees C per decade (Leemans and Hootsman, 1998, WBGU, 2003).

The targets for both absolute temperature change (i.e. 2 degrees C) and rate of change (i.e. 0.1-0.2 degrees C per decade) were initially derived from the migration rates of selected plant species and the occurrence of past natural temperature changes. Although studies have indicated that such changes might still result in impacts in various vulnerable regions, both targets have been confirmed as (a) suitable (target) from both a scientific and a political perspective (e.g. Leemans and Hootsmans, 1998, WBGU, 2003). (Sixth Environment Action Programme, Council Decision (2002/358/EC) of 25 April 2002, Greenhouse gas monitoring mechanism).

EECCA policy context: EECCA Environmental Strategy does not set any specific targets which can be measured with the help of this indicator.

Model used for indicators calculation — UDCM Model

The global surface temperature change since pre-industrial times (1765) is calculated in the upwelling-diffusion climate model (UDCM) which is included as a one of the main components into the IMAGE 2.2. SRES Scenarios Model. In the UDCM four boxes are distinguished: land in northern and southern hemisphere and ocean in northern and southern hemisphere. The temperature change of each of these boxes is based on the heat-absorbing capacity of the 40 oceanic layers. This heat-absorbing capacity is modeled for each oceanic box with an upwelling-diffusion energy-balance model. Therefore, each box has a different profile of temperature change. The global surface temperature is calculated as a weighted mean of the four boxes. The weights depend on the area within each box.

This indicator shows the most striking differences between low climate sensitivity runs (B1_low and A1F_low), high climate sensitivity runs (B1_high and A1F_high) and the main scenario runs (with medium climate sensitivity) (see uncertainties).

The Upwelling-Diffusion Climate Model (UDCM) of IMAGE 2.2 represents the core-model of the Atmospheric Ocean System (AOS). UDCM converts the concentrations of the different greenhouse gases and SO_2 emissions into radiative forcings and successively into temperature changes of the global-mean surface and the ocean. UDCM is based on the MAGICC-model of Climate Research Unit (CRU) (Hulme *et al.,* 2000). The MAGICC model is the most widely used simple climate model within the IPCC (2001). More details on MAGICC can be found in Raper *et al.* (1996) and Hulme *et al.* (2000). The implementation of MAGICC in IMAGE 2.2 and the calculation of the radiative forcings is described by Eickhout *et al.* (2001).

References

MNP, 2001. *IMAGE 2.2 implementation of the SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century.* Bilthoven: National Institute of Public Health and the Environment, 2001 (481508018). — CD-ROM - p. np.

Data specifications

Data set title	Source
Input data to IMAGE 2.2. UDCM model — atmospheric concentrations of greenhouse gases and emissions of SO_2 output from TCM, OMC and ACM	The National Institute for Public Health and the Environment
Output data from IMAGE 2.2. UDCM model — Global-mean surface temperature change and temperature change of the ocean	The National Institute for Public Health and the Environment

Uncertainties

Methodology uncertainty

Many unknowns and uncertainties in the climate system are not reflected in the IMAGE scenarios. Some of the major uncertainties in the causal chain are the climate sensitivity and regional climate-change patterns. The direct effects of a changed climate are changes in carbon uptake by the biosphere and oceans and in the distribution and productivity of crops, as well as shifts in ecosystems. Indirectly, many other processes are influenced, which can lead to the concentrations of greenhouse gases in the atmosphere being built up differently and to different land-use patterns. IMAGE simulates the consequences of these changes in an integrated fashion, accounting for interactions and feedbacks. The outcome is thus not necessarily a linear function of climate sensitivity.

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In IMAGE 2.2 a simpler climate model MAGICC (see Upwelling-Diffusion Climate Model) is incorporated, allowing to define the climate sensitivity. The default value for IMAGE runs is 2.5, which is the median value of the IPCC range (median differs from mean because the range is logarithmic).

To test the uncertainty related to the climate sensitivity, runs with respectively a low (1.5 °C) and high (4.5 °C) climate sensitivity were created. A pattern-scaling procedure is used to obtain regional and seasonal climate-change patterns using the calculated increase in global mean temperature.

Runs with changed climate sensitivity are provided for the A1F (A1F low, A1F high) and B1 (B1 low, B1 high) scenarios on the main disc (IMAGE team 2001a). These scenarios span the full range of the SRES emission scenarios and therefore adequately illustrate the uncertainty of different climate sensitivities.

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GCMs simulate climate over a continuous global grid with a spatial resolution of a few hundred kilometres and a temporal resolution of less than an hour.

Most GCMs agree on the global patterns of climate change:

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- winter warms up more sharply than summers
- total precipitation increases with increasing temperature
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Regionally, however, there are large differences between the different GCMs, especially in precipitation-change patterns.

IMAGE 2.2 runs with five different climate-change patterns are provided on the supplementary disc (IMAGE team 2001b, RIVM CD-ROM publication 481508019) for the A1F, B1 and A2 scenarios. The aim of this material is to illustrate the uncertainties in SRES climate-change scenarios resulting from these differences in GCMs. The first two scenarios span the full range of the SRES emission scenarios, the latter being based on a highly different narrative with different demographic and socio-economic assumptions. The three scenarios therefore adequately illustrate the uncertainty of different climate patterns. Differences in the runs for each scenario indicate some of the uncertainty caused by regional variation in climate-change patterns (not the global mean).

The scenarios for five different GCM runs from the IPCC data centre were implemented, which comprised:

- ECHAM4 of the Deutsches Klimarechenzentrum DKRZ in Germany
- CGCM1 of the Canadian Centre for Climate Modelling and Analysis in Canada
- GFDL-LR15-a of the Geophysical Fluid Dynamics Laboratory in the USA
- HADCM2 of the Hadley Centre for Climate Prediction and Research in the United Kingdom
- CSIRO-MK2 of Commonwealth Scientific and Industrial Research Organisation in Australia.

Data uncertainty

The input data to the UDCM model is atmospheric concentrations of greenhouse gases and emissions of SO_2, which by itself is calculated on the basis of the other IMAGE 2.2. Models and bare all uncertainties related to those models (see more in methodology uncertainly).

Rationale uncertainty

The observed increase in average air temperature, particularly during the recent decades, is one of the clearest signals of global climate change.

The indicator shows trends in temperature data over time. Temperature is directly linked to the question of climate change and is a state variable that changes in response to the pressures of global warming.

There is growing evidence that anthropogenic emissions of greenhouse gases are (mostly) responsible for the recently observed fast increases in average temperature. Natural factors like volcanoes and sun activity could explain to a large extent the temperature variability up to mid of the 20th century, but they can explain only a small part of the recent warming.

Energy

EE_F01	**Final energy consumption — outlook from IEA**
EE_F02	**Final energy consumption — outlook from EEA**
EE_F03	**Total energy intensity — outlook from IEA**
EE_F04	**Total energy intensity — outlook from EEA**
EE_F05	**Total energy consumption — outlook from IEA**
EE_F06	**Total energy consumption — outlook from EEA**
EE_F07	**Total electricity consumption — outlook from IEA**
EE_F08	**Total electricity consumption — outlook from EEA**
EE_F09	**Renewable energy consumption — outlook from IEA**
EE_F11	**Renewable energy consumption — outlook from EEA**
EE_F12	**Renewable electricity — outlook from EEA**
EE_F13	**Fuel prices — outlook from IEA**

Theme: Energy

Indicators: EE_F01 — Final energy consumption — outlook from IEA

Definition: Final energy consumption covers all energy supplied to the final consumer for all energy uses. It is usually disaggregated into the final end-use sectors: industry, transport, households, services and agriculture.

Model used: World Energy Model (WEM)

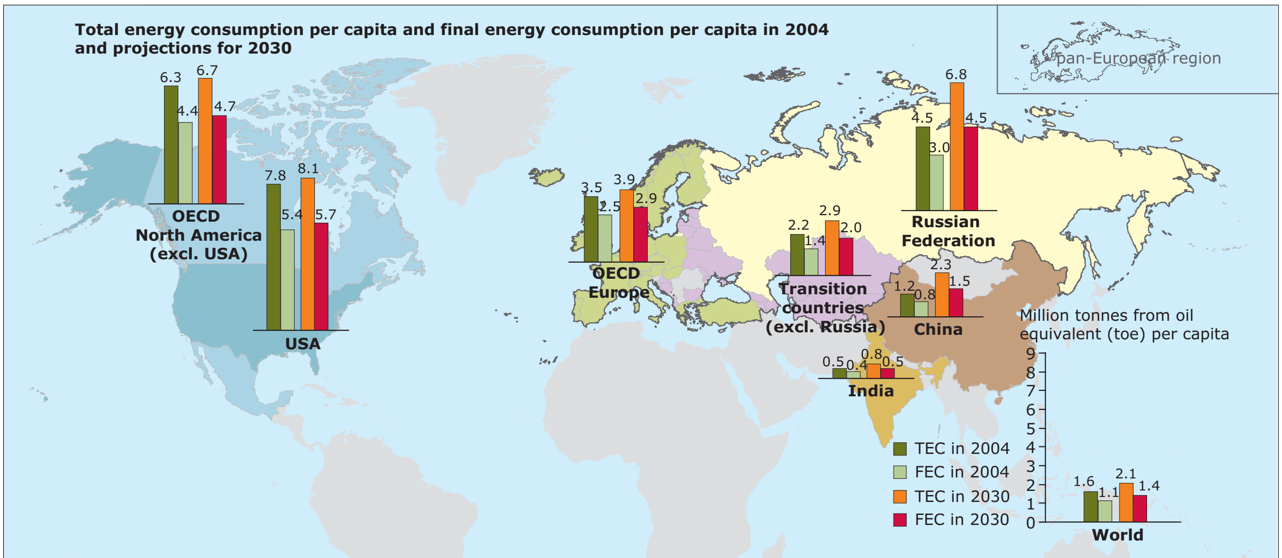
Ownership: International Energy Agency (IEA)

Temporal coverage: 2004–2030

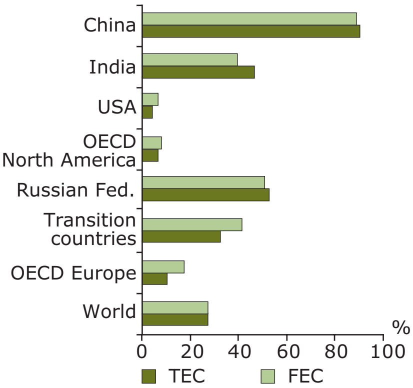
Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

Policy question

Are we using less final energy?



Projected percentage changes in TEC per capita and FEC per capita from 2004 to 2030



Source:

International Energy Agency, 2006. *World Energy Outlook 2006.* IEA, Paris; EEA, 2007. *Europe's environment — The fourth assessment.* European Environment Agency, Copenhagen.

Example assessment from 2006

If current technological trends continue and government policies that have been adopted are implemented*, world average total (TEC) and final (FEC) energy consumption per capita is expected to increase by about 27.5 % between 2004 and 2030. The major part of this increase is expected to come from China, India and the transition countries, which include Russia and other EECCA countries, SEE and some EU-10 countries.

In contrast to OECD Europe and North America, total energy consumption per capita is growing faster than final energy consumption per capita in Russia, India and China, reflecting the use of less efficient technologies.

Note: The most recent assessment is available in *World Energy Outlook* (IEA, 2007).

* *Projections are based on the IEA reference case scenario, which takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented. It is assumed that energy-supply and energy use technologies become steadily more efficient, though at varying speeds for each fuel and each sector, depending on the potential for efficiency gains and the stage of technology development and commercialisation.*

Policy context

Global policy context: The major documents that relate to trends of the energy consumption at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD,2002) in Agenda 21. In Agenda 21 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and consumption of different energy types. (World Summit on Sustainable Development Plan of Implementation).

Pan-European context: The recent pan-European policies concerning different aspects of energy consumption and efficiency have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region. Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: The recent Green Paper on Energy Efficiency (COM(2005)265 final) states that overall as much as 20 % of energy savings could be realized in a cost-effective way by 2020. It aims at identifying such cost-effective options and at opening a discussion on how to realise them. The recently agreed directive on energy end-use efficiency and energy services (COM(2003)739 final) sets indicative energy savings targets for Member States of 9 % for the ninth year of its application, above what would have been achieved otherwise. The role of achieving energy efficiency improvements is also stressed in the Commission's Green Paper on a European Strategy for sustainable, competitive, and secure energy (COM(2005)265 final) Green paper on energy efficiency or doing more with less. European Commission, COM(2003)739. Energy services directive proposal.

The Action Plan to Improve Energy Efficiency in the European Community (COM(2000)247 Final) outlined a wide range of policies and measures aimed at removing barriers to energy efficiency. It builds upon the Communication on 'Energy Efficiency in the European Community — Towards a Strategy for the Rational Use of Energy' (COM(98)246 Final), that was supported by the Council (Council Resolution (98/C 394/01) on energy efficiency in the European Community), and proposed an EU indicative target of reducing final energy intensity by 1 % per year above 'that which would have otherwise been attained' during the period 1998–2010. (Communication from the Commission to the Council and the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Action Plan to Improve Energy Efficiency in the European Community. (COM(2000)247 final), (COM(1998)246 final). Energy Strategy Communication, Council resolution on energy efficiency (98/C 394/01).

The reduction of final energy consumption is seen in the context of reaching the target of an 8 % reduction in greenhouse gas emissions by 2008–2012 from 1990 levels for the EU-15 and individual targets for most new Member-States, as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, and of enhancing the security of energy supply.

EECCA policy context: The main policy illustrating regional objectives of EECCA countries is EECCA Environment Strategy. One of the main goals is 'to contribute to improving environmental conditions and to implement the WSSD Implementation Plan in EECCA countries' regarding energy issues as well as Kiev Declaration's energy perfomance tasks. (EECCA Environmental Strategy).

Model used for indicators calculation — World Energy Model (WEM)

The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1. (World Energy Outlook, 2004, p.532) provides a simplified overview of the structure of the model. The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules. The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. The model has been updated and revised over years and the development process continues. In the WEM 2004 projections of Total Final Energy Consumption are made within 4 sectors: Industry, Transport, Residential and Services, and non-Energy Use sectors.

Industry sector: The industrial sector in the OECD regions is split into six sub-sectors: iron and steel, chemicals, paper and pulp, food and beverages, non-metallic minerals and other industry. For the non-OECD regions, the breakdown is typically based on four instead of six sub-sectors.

The output level of each sub-sector is modelled separately and is combined with projections of its fuel intensity to derive the consumption of each fuel by sub-sector.

Transport sector: Transport energy demand is split between passenger and freight and is broken down among light duty vehicles, buses, trucks, rail, aviation and navigation. Passenger cars and light trucks are subdivided by fuel used — gasoline, diesel, alternative fuels or hybrids of these. Freight trucks are divided between gasoline- and diesel-driven. The gap between test and on-road fuel efficiency is also projected.

For each region, activity levels for each mode of transport are estimated econometrically as a function of population, GDP and price. Additional assumptions to reflect passenger vehicle ownership saturation are also made. Transport activity is linked to price through elasticity of fuel cost per km, which is estimated for all modes except passenger buses and trains and inland navigation. This elasticity variable accounts for the 'rebound' effect of increased car use that follows improved fuel intensity.

Residential and services Sectors: For the certain number of the non-OECD regions, energy consumption in the aforementioned sectors has been calculated econometrically for each fuel as a function of GDP, the related fuel price and the lag of energy consumption. For the OECD regions and major non-OECD regions, the number of households using each fuel for water heating and space heating is projected econometrically, with some saturation limits on shares.

Lighting intensity and appliance intensity per household are then projected separately and combined with total household numbers to yield electricity demand for these end-uses.

The services sector model splits consumption by fuel into three end-uses: heating, hot water and cooking use (HHC); personal computer use (including related equipment); and other electricity end-uses, including ventilation, space cooling and lightning.

The procedures for calculation of the non-Energy Use sector was not identified in the World energy Outlook 2004 methodology description.

References

IEA, 2006. *World energy outlook 2006*. International Atomic Agency (2006), OECD/IEA, Paris (pp. 537, 538).

Data specifications

Data set title	Source
Input data to WEO model — technological developments	International Energy Agency
Input data to WEO model — fuel prices	International Energy Agency
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Input data to WEO model — economic growth	International Energy Agency
Input data to WEO model — electricity consumption	International Energy Agency
Input data to WEO model — electricity prices	International Energy Agency
Input data to WEO model — primary demand for fossil fuels	International Energy Agency
Output from WEO — Final energy consumption	International Energy Agency

Uncertainties

Methodology uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause demand to grow less rapidly. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period. Uncertainty about the outlook for economic growth in China is particularly acute.

The effects of resource availability and supply costs on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain — partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power.

Improvements in the efficiency of current energy technologies and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Data uncertainty

Major challenge is a reliable input data energy statistics. The statistics of IEA which provide a major input to the WEO, cover 130 countries worldwide. Most time-series begin in 1960 for OECD counties and in 1971 for non-OECD countries. Recently, however, maintaining the very high caliber of IEA statistics has become increasingly difficult, in many cases because national administrations have faced growing problems in maintaining the quality of their own statistics. Breaks in time series and missing data have become frequent in some countries. The lapses compromise the completeness of IEA statistics. They could seriously affect any type of analysis, including modeling and forecasting.

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments will take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

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Theme: Energy
Indicators: EE_F02 — Final energy consumption — outlook from EEA

Definition: Final energy consumption covers all energy supplied to the final consumer for all energy uses. It is usually disaggregated into the final end-use sectors: industry, transport, households, services and agriculture.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

Temporal coverage: 1990–2030

Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Are we using less final energy?

Final energy consumption in the EU-25 by sector

	Mtoe				
	1990	**2000**	**2010**	**2020**	**2030**
Industry	328.4	310.2	338.1	364.8	385.5
Domestic	412.2	433.3	482.3	522.7	556.4
Tertiary	144.8	154.3	173.7	193.9	217.8
Households	267.4	279.1	308.6	328.9	338.6
Transport	273.6	333.1	388.6	428.5	449.8
Total	**1 014**	**1 077**	**1 209**	**1 316**	**1 392**
EU-15	859	955	1077	1165	1229
New EU-10	155	121	132	151	163

Sources:

EC, 2003. Mantzos *et al.,* 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities. Luxembourg. 2003. EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

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

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: The major documents that relate to trends of the energy consumption at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD,2002) in Agenda 21. In Agenda 21 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and consumption of different energy types. (World Summit on Sustainable Development Plan of Implementation).

Pan-European context: The recent pan-European policies concerning different aspects of energy consumption and efficiency have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region. Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: The recent Green Paper on Energy Efficiency (COM(2005)265 final) states that overall as much as 20 % of energy savings could be realized in a cost-effective way by 2020. It aims at identifying such cost-effective options and at opening a discussion on how to realise them. The recently agreed directive on energy end-use efficiency and energy services (COM(2003) 739 final) sets indicative energy savings targets for Member States of 9 % for the ninth year of its application, above what would have been achieved otherwise. The role of achieving energy efficiency improvements is also stressed in the Commission's Green Paper on a European Strategy for sustainable, competitive, and secure energy (COM(2005)265 final. Green paper on energy efficiency or doing more with less. European Commission., (COM(2003)739). Energy services directive proposal).

The Action Plan to Improve Energy Efficiency in the European Community (COM(2000)247 Final) outlined a wide range of policies and measures aimed at removing barriers to energy efficiency. It builds upon the Communication on 'Energy Efficiency in the European Community — Towards a Strategy for the Rational Use of Energy' (COM(98)246 Final), that was supported by the Council (Council Resolution (98/C 394/01) on energy efficiency in the European Community), and proposed an EU indicative target of reducing final energy intensity by 1 % per year above 'that which would have otherwise been attained' during the period 1998-2010. (Communication from the Commission to the Council and the European Parliament, the European Economic and SocialCommittee and the Committee of the Regions: Action Plan to Improve Energy Efficiency in the European Community. (COM(2000)247 final), (COM(1998)246 final). Energy Strategy Communication, Council resolution on energy efficiency (98/C 394/01).

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EECCA policy context: The main policy illustrating regional objectives of EECCA countries is EECCA Environment Strategy. One of the main goals is 'to contribute to improving environmental conditions and to implement the WSSD Implementation Plan in EECCA countries' regarding energy issues as well as Kiev Declaration's energy performance tasks. (EECCA Environmental Strategy).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Final energy demand by fuel and sector — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

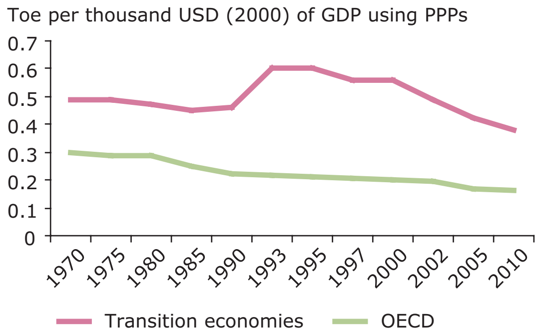
Theme: Energy
Indicators: EE_F03 — Total energy intensity — outlook from IEA

Definition: Total energy intensity is a measure of total primary energy use per unit of gross domestic product (GDP).
Model used: World Energy Model (WEM)
Ownership: International Energy Agency (IEA)
Temporal coverage: 1970–2030
Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

Policy question

Are we using less final energy per unit of GDP?

Projections of the primary energy intensity by region



Source:
International Energy Agency, 2006. *World Energy Outlook 2006.* IEA, Paris.

Example assessment from 2006

N/A.

Note: The most recent assessment is available in World Energy Outlook (IEA, 2007).

Policy context

Global policy context: The major documents that relate to trends of the energy consumption at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD,2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and consumption of different energy types.

Pan-European policy context: The recent pan-European policies concerning different aspects of energy efficiency, consumption and, therefore, intensity have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

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EECCA policy context: EECA regions has a several number of declarations that do not have indicative and numeral targets and provide some issues relating to improvement of management and integration in energy sectors as well as their implementation into climate change policies. The main policy where this concepts are highlighted is EECCA Environmental Strategy. (EECCA Environmental Strategy).

Model used for indicators calculation — World Energy Model (WEM)

The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1. (World Energy Outlook, 2004, p.532) provides a simplified overview of the structure of the model. The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules. The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. The model has been updated and revised over years and the development process continues. In the WEM 2004 projections of Total Final Energy Consumption are made within 4 sectors: Industry, Transport, Residential and Services, and non-Energy Use sectors.

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Input data to WEO model — primary demand for fossil fuels	International Energy Agency
Output from WEO — Final energy consumption	International Energy Agency

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Theme: Energy
Indicators: EE_F04 — Total energy intensity — outlook from EEA

Definition: Energy intensity is a ratio between the Total Energy Consumption and Gross Domestic Product calculated for a calendar year. Energy intensity is provided as a list of energy intensity indicators: for industry, residential, tertiary and transport. The indicators are measured in relative index where 1990th energy intensity level is measured as a point 100.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

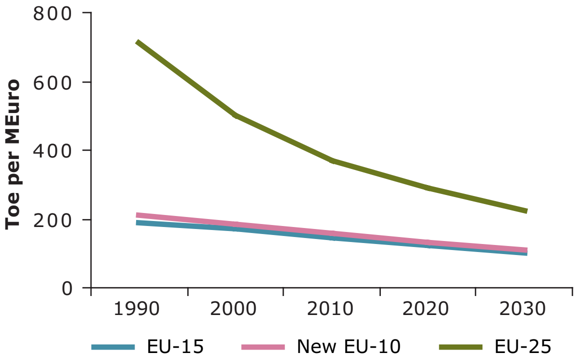
Temporal coverage: 1990–2030

Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Are we decoupling energy consumption from economic growth?

Evolution of energy intensity in EU-25



Sources:

EC, 2003. Mantzos *et al.*, 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities. Luxembourg. 2003

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Energy intensity will improve by 1.5 % per annum up to 2030 after having seen an improvement of 1.4 % per annum in the 1990s.

There has been a slowing down of energy intensity improvements in recent years following sluggish economic growth with lower capital turn-over towards energy efficient equipment; this raises energy consumption growth and has an adverse effect on the expected energy intensity improvement in this decade (only 1.1 % per annum).

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Pan-European policy context: The recent pan-European policies concerning different aspects of energy efficiency, consumption and, therefore, intensity have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: The importance of improving energy efficiency is highlighted in the Sixth Environment Action Plan and in the recently published Green Paper on a European Strategy for sustainable, competitive, and secure energy (COM(2006)105 final). The green paper on energy efficiency stresses the need for capping EU energy demand and improving efficiency (COM(2005)265 final). Green paper on energy efficiency or doing more with less. European Commission. The recently adopted directive on end-use energy efficiency and energy services aims at the improvement of energy end-use efficiency and sets an indicative energy savings targets of 9 % for the ninth year of its application above what would have been achieved otherwise. In addition, most of the new Member States have officially made energy efficiency a priority goal and all have some policies aimed at improving the energy intensity of the national economy. Tools used to promote energy efficiency include: financing mechanisms (state subsidies, low cost loans, state guarantees, energy performance contracting, etc.), mandatory obligations (energy efficiency law, appliance and building labels, heat and energy use standards, inspections, etc.), information (energy and environmental agencies, information centres, consulting services, awards, trainings, etc.). In some countries, national energy agencies provide subsidies for energy efficiency projects (for example, the Commercialising Energy Efficiency Fund in Hungary and several other countries, and Efficient Lighting Initiative in the Czech Republic, Hungary and Latvia) and there is Government and international support for Energy Services Companies. (Communication from the Commission to the Council and the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Action Plan to Improve Energy Efficiency in the European Community. (COM(2000)247 final), (COM(1998)246 final). Energy Strategy Communication, Council resolution on energy efficiency (98/C 394/01).

EECCA policy context: EECA regions has a several number of declarations that do not have indicative and numeral targets and provide some issues relating to improvement of management and integration in energy sectors as well as their implementation into climate change policies. The main policy where these concepts are highlighted is EECCA Environmental Strategy. (EECCA Environmental Strategy).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Energy intensity indicators for industry, residential, tertiary and transport sectors — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Energy

Indicators: EE_F05 — Total energy consumption — outlook from IEA

Definition: Total energy consumption is made up of production plus imports, minus exports, minus international marine bunkers plus/minus stock changes. It is also called Total primary energy supply or Gross inland energy consumption and represents the quantity of all energy necessary to satisfy inland consumption.

Model used: World Energy Model (WEM)

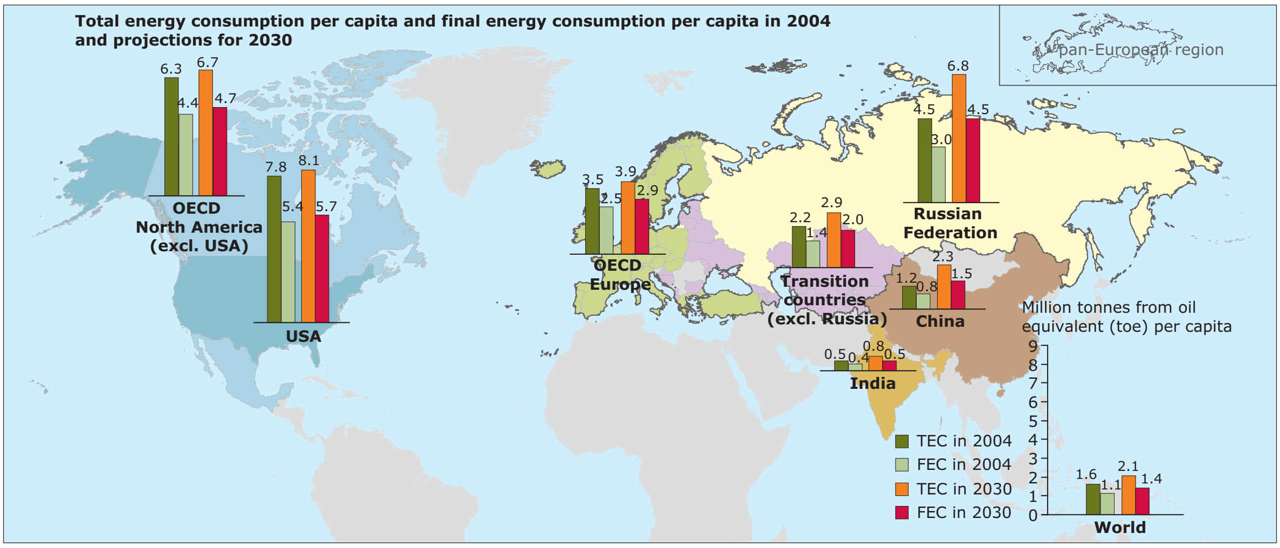
Ownership: International Energy Agency (IEA)

Temporal coverage: 2004–2030

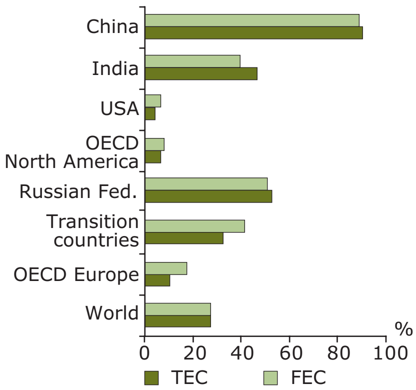
Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

Policy question

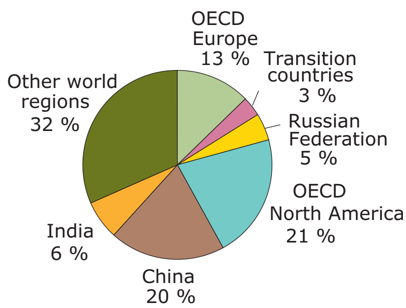
Are we consuming less energy?



Projected percentage changes in TEC per capita and FEC per capita from 2004 to 2030



Projected regional share in world TEC in 2030



Example assessment from 2006

If current technological trends continue and government policies that have been adopted are implemented*, world average total (TEC) and final (FEC) energy consumption per capita will increase by about 27.5 % between 2004 and 2030. The major part of this increase will come from China, India and the transition countries, which include Russia and other EECCA countries, SEE and some EU-10 countries.

In contrast to OECD Europe and North America, total energy consumption per capita in Russia, India and China is growing faster than final energy consumption per capita in Russia, India and China, reflecting the use of less efficient technologies, mostly for power generation.

Note: The most recent assessment is available in *World Energy Outlook* (IEA, 2007).

Sources:

IEA (2006). *World Energy Outlook 2006*, International Energy Agency, Paris; EEA (2007). *Europe's environment — The fourth assessment.* European Environment Agency, 2007. EEA, Copenhagen.

* *Projections are based on the IEA reference case scenario, which takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented.*

Policy context

Global policy context: The major documents that relate to trends of the total energy consumption (supply) at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD,2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and consumption of different energy types. (World Summit on Sustainable Development Plan of Implementation).

Pan-European policy context: The recent pan-European policies concerning different aspects of total energy consumption have been developed under different intentional fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy supply, production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote renewable energy supply to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: Total energy consumption disaggregated by fuel type provides an indication of the extent of environmental pressure caused (or at risk of being caused) by energy production and consumption. The relative shares of fossil fuels, nuclear power and renewable energies together with the total amount of energy consumption are valuable in determining the overall environmental burden of energy consumption in the EU. Trends in the share of these fuels will be one of the major determinants of whether the EU meets its target of reduction in greenhouse gas emissions as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The overall Kyoto target for the pre-2004 EU-15 Member States requires a 8 % reduction by 2008–2012 from base year levels (1990 for most greenhouse gases), while most new Member States have individual targets under the Kyoto Protocol. Moreover, the White Paper for a Community Strategy and Action Plan (COM(97)599 final) provides a framework for Member States action to develop renewable energy and sets an indicative target to increase the share of renewable energy in total energy consumption in the pre-2004 EU-15 to 12 % by 2010. (COM(2005)265 final). Green paper on energy efficiency or doing more with less. European Commission., (COM(97)599 final). Energy for the future., DG TREN Energy sources and demand management legislation.

EECCA policy context: The main policy illustrating regional objectives of EECCA countries is EECCA Environmental Strategy. One of the main goals is 'to contribute to improving environmental conditions and to implement the WSSD Implementation Plan in EECCA countries' regarding energy issues as well as Kiev Declaration's energy performance tasks. (EECCA Environmental Strategy).

Model used — World Energy Model (WEM)

The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1. (World Energy Outlook, 2004, p.532) provides a simplified overview of the structure of the model. The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules. The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. The model has been updated and revised over years and the development process continues. In the WEM 2004 projections of Total Final Energy Consumption are made within 4 sectors: Industry, Transport, Residential and Services, and non-Energy Use sectors.

Industry sector: The industrial sector in the OECD regions is split into six sub-sectors: iron and steel, chemicals, paper and pulp, food and beverages, non-metallic minerals and other industry. For the non-OECD regions, the breakdown is typically based on four instead of six sub-sectors.

The output level of each sub-sector is modelled separately and is combined with projections of its fuel intensity to derive the consumption of each fuel by sub-sector.

Transport sector: Transport energy demand is split between passenger and freight and is broken down among light duty vehicles, buses, trucks, rail, aviation and navigation. Passenger cars and light trucks are subdivided by fuel used — gasoline, diesel, alternative fuels or hybrids of these. Freight trucks are divided between gasoline- and diesel-driven. The gap between test and on-road fuel efficiency is also projected.

For each region, activity levels for each mode of transport are estimated econometrically as a function of population, GDP and price. Additional assumptions to reflect passenger vehicle ownership saturation are also made. Transport activity is linked to price through elasticity of fuel cost per km, which is estimated for all modes except passenger buses and trains and inland navigation. This elasticity variable accounts for the 'rebound' effect of increased car use that follows improved fuel intensity.

Residential and services sectors: For the certain number of the non-OECD regions, energy consumption in the aforementioned sectors has been calculated econometrically for each fuel as a function of GDP, the related fuel price and the lag of energy consumption. For the OECD regions and major non-OECD regions, the number of households using each fuel for water heating and space heating is projected econometrically, with some saturation limits on shares.

Lighting intensity and appliance intensity per household are then projected separately and combined with total household numbers to yield electricity demand for these end-uses.

The services sector model splits consumption by fuel into three end-uses: heating, hot water and cooking use (HHC); personal computer use (including related

 Forward-looking indicators by topic — Energy

equipment); and other electricity end-uses, including ventilation, space cooling and lightning.

The procedures for calculation of the non-Energy Use sector was not identified in the World energy Outlook 2004 methodology description.

References

IEA, 2006. *World energy outlook 2006*. International Atomic Agency (2006), OECD/IEA, Paris (pp. 537, 538).

Data specifications

Data set title	Source
Input data to WEO model — technological developments	International Energy Agency
Input data to WEO model — fuel prices	International Energy Agency
Input data to WEO model — population	International Energy Agency
Input data to WEO model — economic growth	International Energy Agency
Input data to WEO model — electricity consumption	International Energy Agency
Input data to WEO model — electricity prices	International Energy Agency
Input data to WEO model — primary demand for fossil fuels	International Energy Agency
Output from WEO — Final energy consumption	International Energy Agency

Uncertainties

Methodology uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause demand to grow less rapidly. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period.

Uncertainty about the outlook for economic growth in China is particularly acute.

The effects of resource availability and supply costs on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain — partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power.

Improvements in the efficiency of current energy technologies and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Data uncertainty

Major challenge is a reliable input data energy statistics. The statistics of IEA which provide a major input to the WEO, cover 130 countries worldwide. Most time-series begin in 1960 for OECD counties and in 1971 for non-OECD countries. Recently, however, maintaining the very high caliber of IEA statistics has become increasingly difficult, in many cases because national administrations have faced growing problems in maintaining the quality of their own statistics. Breaks in time series and missing data have become frequent in some countries. The lapses compromise the completeness of IEA statistics. They could seriously affect any type of analysis, including modelling and forecasting.

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments will take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: Energy

Indicators: EE_F06 — Total energy consumption — outlook from EEA

Definition:
Total energy consumption is made up of production plus imports, minus exports, minus international marine bunkers plus/ minus stock changes. It is also called Total primary energy supply or Gross inland energy consumption and represents the quantity of all energy necessary to satisfy inland consumption.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

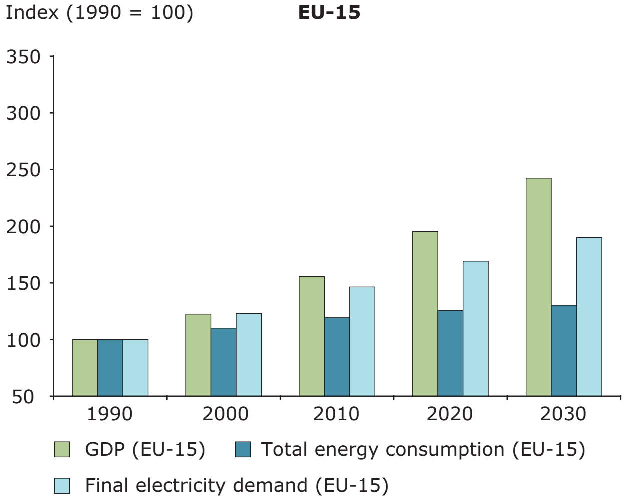
Temporal coverage: 1990–2030

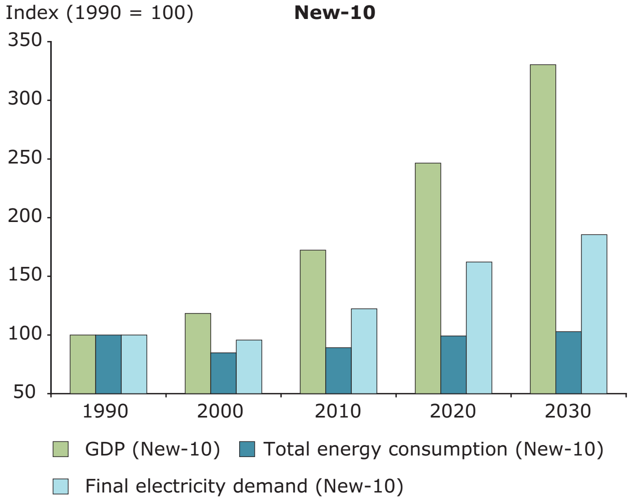
Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

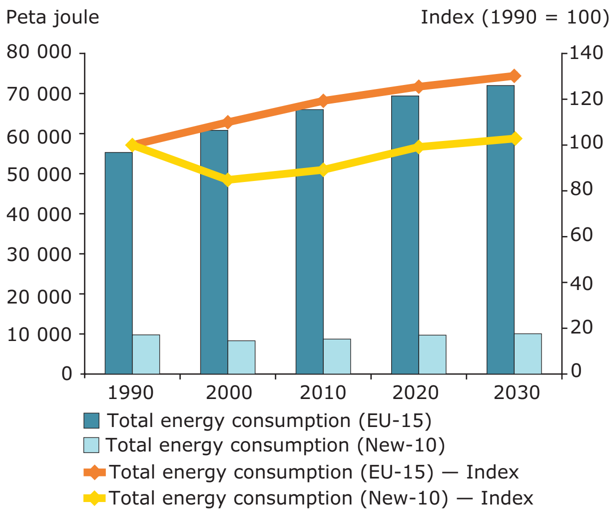
Are we consuming less energy?

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





Total energy consumption 1990–2030



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Total EU-25 energy consumption will continue to increase up to 2030. It is expected that in 2030 energy consumption will be 15 % higher than it was 2000; the growth rates of energy become smaller over time with consumption virtually stabilising post 2020 reflecting low economic growth and stagnating population.

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: The major documents that relate to trends of the total energy consumption (supply) at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD,2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and consumption of different energy types. (World Summit on Sustainable Development Plan of Implementation).

Pan-European policy context: The recent pan-European policies concerning different aspects of total energy consumption have been developed under different intentional fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy supply, production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote renewable energy supply to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: Total energy consumption disaggregated by fuel type provides an indication of the extent of environmental pressure caused (or at risk of being caused) by energy production and consumption. The relative shares of fossil fuels, nuclear power and renewable energies together with the total amount of energy consumption are valuable in determining the overall environmental burden of energy consumption in the EU. Trends in the share of these fuels will be one of the major determinants of whether the EU meets its target of reduction in greenhouse gas emissions as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The overall Kyoto target for the pre-2004 EU-15 Member States requires a 8 % reduction by 2008–2012 from base year levels (1990 for most greenhouse gases), while most new Member States have individual targets under the Kyoto Protocol. Moreover, the White Paper for a Community Strategy and Action Plan (COM(97)599 final) provides a framework for Member States action to develop renewable energy and sets an indicative target to increase the share of renewable energy in total energy consumption in the pre-2004 EU-15 to 12 % by 2010. (COM(2005)265 final). Green paper on energy efficiency or doing more with less. European Commission, (COM(97)599 final). Energy for the future, DG TREN Energy sources and demand management legislation.

EECCA policy context: The main policy illustrating regional objectives of EECCA countries is EECCA Environmental Strategy. One of the main goals is 'to contribute to improving environmental conditions and to implement the WSSD Implementation Plan in EECCA countries' regarding energy issues as well as Kiev Declaration's energy performance tasks. (EECCA Environmental Strategy).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Gross inland energy consumption — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Energy

Indicators: EE_F07 — Total electricity consumption — outlook from IEA

Definition: Electricity consumption is based on calculated consumption; this equals the energy supplied minus transmission and distribution losses.

Model used: World Energy Model (WEM)

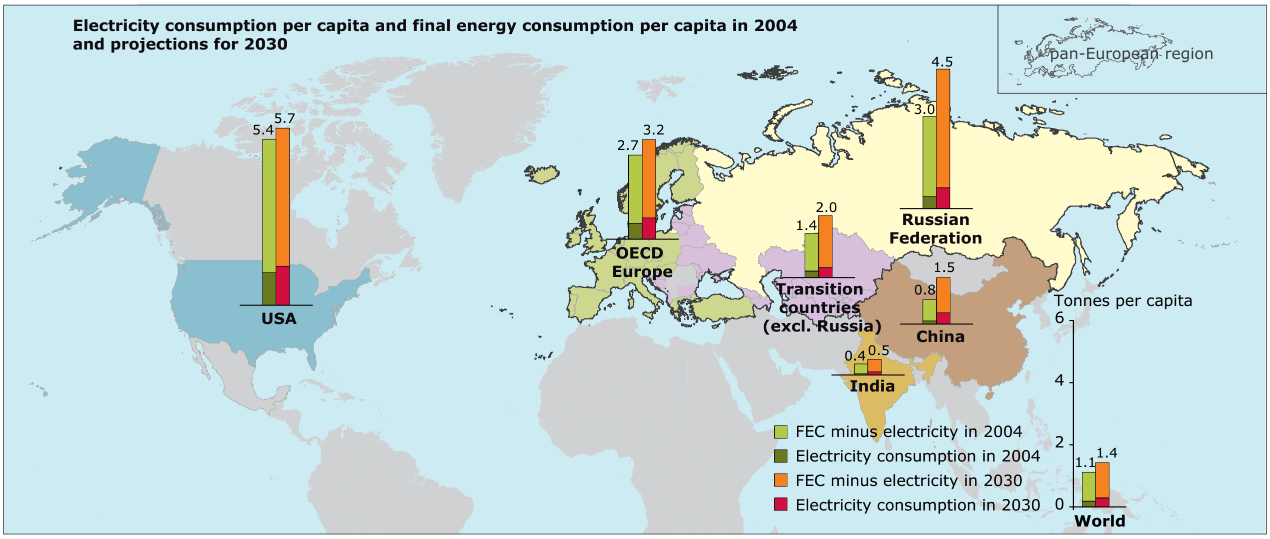
Ownership: International Energy Agency (IEA)

Temporal coverage: 2004–2030

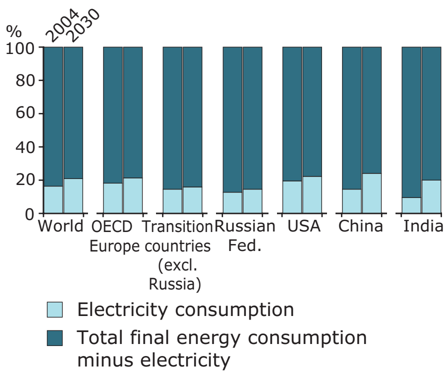
Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

Policy question

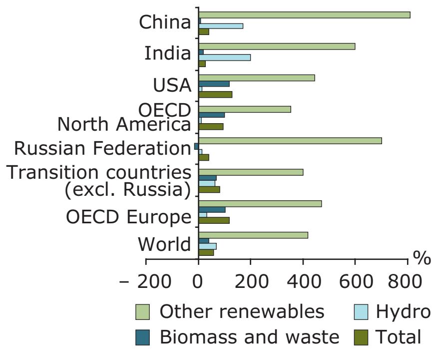
Are we consuming less energy?



Share of electricity consumption in final energy consumption by region in 2004 and projections for 2030



Projected percentage change in renewables consumption by type from 2004 to 2030



Sources:

International Energy Agency, 2006. *World Energy Outlook 2006.* IEA, Paris; EEA (2007). *Europe's environment — The fourth assessment.* European Environment Agency, 2007. EEA, Copenhagen.

Example assessment from 2006

If current technological trends continue and government policies that have been adopted are implemented *, electricity consumption per capita is expected to continue to grow in all regions/countries. The increase in the pan-European region from 2004 to 2030 is projected to be much smaller (up to 70 %) than in the Asian countries (200 % in China), but substantially higher than in USA (19 %).

The share of electricity consumption in total final energy consumption is projected to continue to grow worldwide, with the largest increases in China and India.

Note: The most recent assessment is available in World Energy Outlook 2007 (IEA, 2007).

* *Projections are based on the IEA reference case scenario, which takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented. It is assumed that energy-supply and energy use technologies become steadily more efficient, though at varying speeds for each fuel and each sector, depending on the potential for efficiency gains and the stage of technology development and commercialisation.*

Policy context

Global policy context: The major documents that relate to trends of the energy production and electricity generation at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD, 2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and production of different energy types, as well as more sustainable electricity generation. (World Summit on Sustainable Development Plan of Implementation).

Pan-European policy context: The recent pan-european policies concerning different aspects of energy production and electricity generation have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy production to meet environmental objectives. (Kiev Declaration 'Environment for Europe' (2003).

EU policy context: The EU indicative Combined Heat and Power target set in the Community Strategy on cogeneration to promote Combined Heat and Power, COM(97)514 final is provided a number of tools that are used to promote energy production and to shift electricity generation structure: financing mechanisms (state subsidies, low cost loans, state guarantees, energy performance contracting, etc.), mandatory obligations (energy efficiency law, appliance and building labels, heat and energy use standards, inspections, etc.), information (energy and environmental agencies, information centers, consulting services, awards, trainings, etc.). (Combined heat and power Communication (COM(97)514 final).

The reduction of final energy consumption, therefore, amount of electricity generation and total energy production are seen in the context of reaching the target of an 8 % reduction in greenhouse gas emissions by 2008–2012 from 1990 levels for the EU-15 and individual targets for most new Member-States, as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, and of enhancing the security of energy supply. 2006 EC Thematic Strategy on Waste makes an accent on structural changes in the European energy production in turn to more important role of wastes and biomasses as energy sources. Communication from the Commission to the Council and the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Action Plan to Improve Energy Efficiency in the European Community. (COM(2000)247 final), (COM(1998)246 final). Energy Strategy Communication, Council resolution on energy efficiency (98/C 394/01).

EECCA policy context: Energy efficiency and energy trade, and, consequently, energy and electricity productions are highlighted in the EECCA Environment Strategy. Moreover, there are negotiations concerning decisions about improvements in hydropower sector in Central Asia (EECCA Environmental Strategy, Cooperation Strategy to Promote the Rational and Efficient Use of Water and Energy Resources in Central Asia).

Model used for indicators calculation — World Energy Model (WEM)

The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1. (World Energy Outlook, 2004, p.532) provides a simplified overview of the structure of the model. The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. The model has been updated and revised over years and the development process continues.

The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation modules.

The projections of the energy demand are made with the use of the World Energy Model 2004 developed by International Energy Agency. The Electricity Generation is presented as a sub-module in the Power Generation and Heat Plants module.

The Power Generation and Heat Plants module. The power generation module calculates the following: amount of electricity generated by each type of plant to meet electricity demand (here is included electricity demand, own use and transmission, and distribution losses); amount of new generating capacity needed; type of new plants to be built; fuel consumption of the power generation sector; electricity prices.

Electricity generation is calculated using the demand for electricity and taking into account electricity used by power plants themselves and system losses. New generating capacity is the difference between total capacity requirements and plant retirements using assumed plant lives. The model considers the following types of plants: coal, oil and gas steam boilers; combined-cycle gas turbine (CCGT); open-cycle gas turbine (GT); integrated gasification combined cycle (IGCC); oil and gas internal combustion; fuel cell; nuclear; biomass; geothermal; wind (onshore); wind (offshore); hydro (conventional); hydro (pumped storage); solar (photovoltaics); solar (thermal) and tidal/wave.

Capacities for nuclear power are based on assumptions on government plans or are influenced by international fossil fuel prices where market conditions prevail.

Fossil fuel prices and efficiencies are used to rank plants in ascending order of their short-run marginal operating costs, allowing for assumed plant availability.

The marginal generation cost of the system is calculated, and this cost is then fed back to the demand model to determine the final electricity price.

The combined heat and power (CHP) option is considered for fossil-fuel and biomass plants. CHP, renewables and distributed generation are sub-modules of the power generation module.

Renewable module. The projections of renewable electricity generation were derived in a separate model. It has been assessed the future deployment of renewable energies for electricity generation and the investment needed for such deployment. For a detail description of this model — developed by Energy Economics Group (EEG) at Vienna University of Technology in co-operation with Wiener Zentrum fur Energie, Umwelt und Klima — see Resch *et al.* (2004). The methodology is illustrated in Figure C.6 p. 543 in World Energy Outlook 2004.

The model uses a database of dynamic cost-resource curves. The development of renewables is based on an assessment of potentials and costs for each source (biomass, hydro, photovoltaics, solar thermal electricity, geothermal electricity, on and offshore wind, tidal and wave).

References

IEA, 2006. *World energy outlook 2006.* International Atomic Agency (2006), OECD/IEA, Paris (pp. 537, 538).

Data specifications

Data set title	Source
Input data to WEO model — electricity consumption	International Energy Agency
Input data to WEO model — electricity prices	International Energy Agency
Input data to WEO model — fuel prices	International Energy Agency
Input data to WEO model — population	International Energy Agency
Input data to WEO model — primary demand for fossil fuels	International Energy Agency
Input data to WEO model — technological developments	International Energy Agency
Input data to WEO model — economic growth	International Energy Agency
Output from WEO — Electricity production and demand	International Energy Agency

Uncertainties

Methodology uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause demand to grow less rapidly. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period.

Uncertainty about the outlook for economic growth in China is particularly acute. The effects of resource availability and supply costs on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain — partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power. Improvements in the efficiency of current energy technologies and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Data uncertainty

Major challenge is a reliable input data energy statistics. The statistics of IEA which provide a major input to the WEO, cover 130 countries worldwide. Most time-series begin in 1960 for OECD counties and in 1971 for non-OECD countries. Recently, however, maintaining the very high caliber of IEA statistics has become increasingly difficult, in many cases because national administrations have faced growing problems in maintaining the quality of their own statistics. Breaks in time series and missing data have become frequent in some countries. The lapses compromise the completeness of IEA statistics. They could seriously affect any type of analysis, including modeling and forecasting.

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments will take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: Energy

Indicators: EE_F08 — Total electricity consumption — outlook from EEA

Definition: Electricity consumption is based on calculated consumption; this equals the energy supplied minus transmission and distribution losses.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

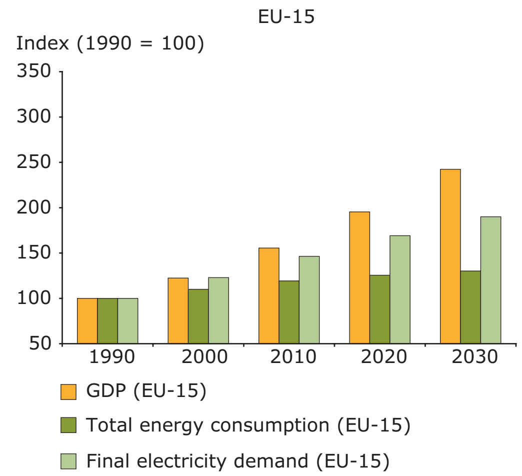
Temporal coverage: 1990–2030

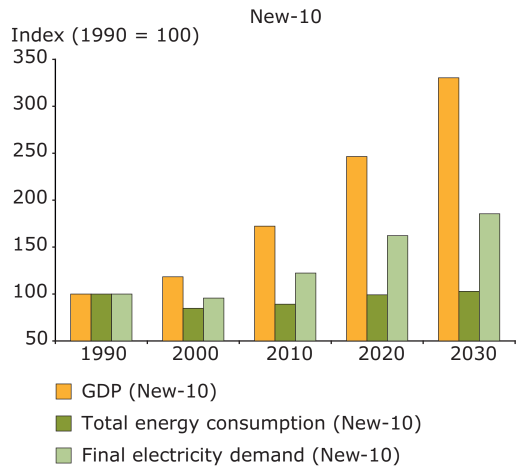
Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-10:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Are we consuming less electricity?

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





Source:

EC, 2003. Mantzos *et al.,* 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities. Luxembourg. 2003. EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Electricity consumption is expected to continue increasing while decoupling 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.

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: The major documents that relate to trends of the energy prodution and electricity generation at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD, 2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and production of different energy types, as well as more sustainable electricity generation. (World Summit on Sustainable Development Plan of Implementation).

Pan-European policy context: The recent pan-european policies concerning different aspects of energy production and electricity generation have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy production to meet environmental objectives (Kiev Declaration 'Environment for Europe' (2003)).

EU policy context: The EU indicative Combined Heat and Power target set in the Community Strategy on cogeneration to promote Combined Heat and Power, COM(97)514 final is provided a number of tools that are used to promote energy production and to shift electricity generation structure: financing mechanisms (state subsidies, low cost loans, state guarantees, energy performance contracting, etc.), mandatory obligations (energy efficiency law, appliance and building labels, heat and energy use standards, inspections, etc.), information (energy and environmental agencies, information centers, consulting services, awards, trainings, etc.). (Combined heat and power Communication (COM(97)514 final).

The reduction of final energy consumption, therefore, amount of electricity generation and total energy production are seen in the context of reaching the target of an 8 % reduction in greenhouse gas emissions by 2008–2012 from 1990 levels for the EU-15 and individual targets for most new Member-States, as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, and of enhancing the security of energy supply. 2006 EC Thematic Strategy on Waste makes an accent on structural changes in the European energy production in turn to more important role of wastes and biomasses as energy sources. (Communication from the Commission to the Council and the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Action Plan to Improve Energy Efficiency in the European Community. (COM(2000)247 final), (COM(1998)246 final). Energy Strategy Communication, Council resolution on energy efficiency (98/C 394/01).

EECCA policy context: Energy efficiency and energy trade, and, consequently, energy and electricity productions are highlighted in the EECCA Environment Strategy. Moreover, there are negotiations concerning decisions about improvements in hydropower sector in Central Asia (EECCA Environmental Strategy, Cooperation Strategy in Asia, 2004).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Electricity generation — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Energy

Indicators: EE_F09 — Renewable energy consumption — outlook from IEA

Definition: Renewable energy consumption is the ratio between the gross inland consumption of energy from renewable sources and the total (primary) gross inland energy consumption calculated for a calendar year. It is calculated as the sum of the gross inland consumption of energy from renewable sources. Renewable energy sources are defined as renewable non-fossil energy sources: hydropower, wind, solar, geothermal, wave, tidal, biomass, landfill gas, sewage treatment plant gas and biogases.

Model used: World Energy Model (WEM)

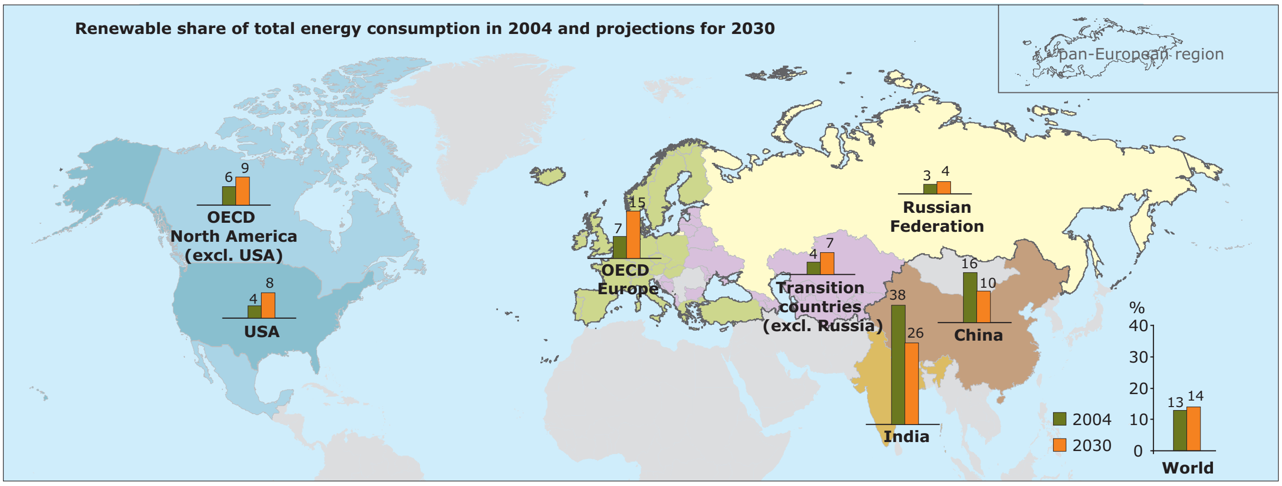
Ownership: International Energy Agency (IEA)

Temporal coverage: 2004–2030

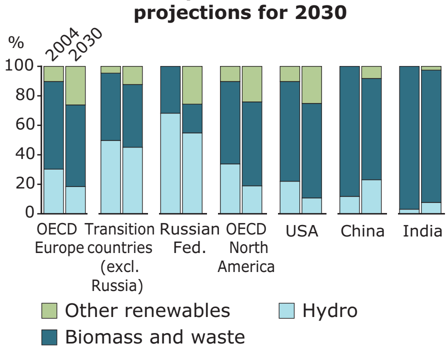
Geographical coverage: Transition countries, excluding the Russian Federation (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Serbia and Montenegro, the former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus, Malta); **the Russian Federation; OECD Europe** (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **USA; India; China.**

Policy question

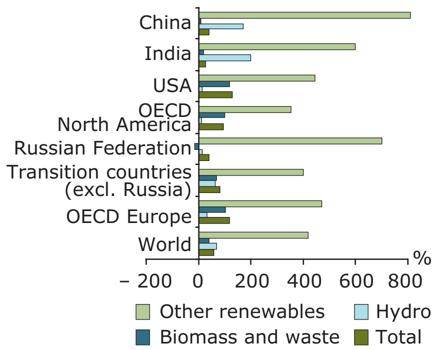
Are we switching to renewable sources?



Fuel shares in total renewable consumption in 2004 and projections for 2030



Projected percentage change in renewables consumption by type from 2004 to 2030



Example assessment from 2006

If current technological trends continue and government policies that have been adopted are implemented*, the use of renewable energy in the pan-European region is projected to increase, mainly because of the large increase in OECD Europe. Global renewable energy consumption is projected to increase from 1 475 Mtoe in 2004 to 2 349 Mtoe in 2030. The share of renewables in total energy consumption is projected to increase slightly (from 13 % in 2004 to 14 % in 2030), mainly because of the expected efforts in Europe and North America.

Although biomass would lose part of its share to other forms of energy, it is projected to continue to dominate the renewables market in all the regions except the Eastern part of Europe. Hydropower is expected to remain the second largest renewable source, but to remain the most important in the Eastern part of Europe (about 50 % in 2030). Non-hydro renewables** are projected to grow the fastest, but with their share in total energy consumption still only reaching 1.7 % in 2030 — up from 0.5 % today.

Sources:

IEA — International Energy Agency, 2006. *World Energy Outlook 2006.* IEA, Paris; EEA (2007). *Europe's environment — The fourth assessment.* European Environment Agency, 2007. EEA, Copenhagen.

Note: The most recent assessment is available in World Energy Outlook 2007 (IEA, 2007).

* *Projections are based on the IEA reference case scenario, which takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented.*

** *Non-hydro renewables — solar, geothermal, wind, tide and wave energy.*

Policy context

Global policy context: The Plan of Implementation adopted at WSSD is particularly concerning sustainable energy future. It aims to diversify energy supply by developing more cost-effective energy technologies such as renewable energy technologies including hydro-technologies. (World Summit on Sustainable Development Plan of Implementation).

Pan-European level: The Guidelines on Reforming Energy Pricing and Subsidies prepared jointly by the UNECE Committees on Environmental Policy and on Sustainable Energy (UNECE Guidelines) as a means of implementing the energy-related provisions of the Aarhus decisions have a number of ways how to meet increasing role of renewable energy within economic instruments and marketing mechanisms. (The Guidelines on Reforming Energy Pricing and Subsidies).

EU policy context: The White Paper for a Community Strategy and Action Plan (COM(97)599 final) provides a framework for Member States action to develop renewable energy and sets an indicative target to increase the share of renewable energy in total energy consumption in the EU-15 to 12 % by 2010. Specific targets have been set for the share of biofuels in the transport sector (5.75 % by 2010) and the share of renewable sources in gross electricity consumption (21 % by 2010). (COM(97)599 final). Energy for the future.

Furthermore, a discussion on future renewable energy targets has commenced. Recently, the European Council called for an Energy Policy in Europe which looks into longer term targets for the share of renewables in total energy consumption of *e.g.* 15 % by 2015 (European Council, 2006). The European Parliament called for a binding 20 % target for the share of renewables in total energy consumption by 2020, and noted that a share of 25 % could be provided by renewables in a more integrated approach that simultaneously focused on improving energy efficiency. Some Member States have set individual targets for the share of renewables in the long term. More recently, the European Commission launched a comprehensive 'energy package' (10/01/2007). The European Council of 8–9 March 2007 endorsed a binding target of a 20 % share of renewable energies in overall EU energy consumption by 2020. (COM(2006)105 final). Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission. European Commission's Energy Package (10/01/2007), European Council Conclusions (March 2007), DIRECTIVE 2001/77/EC Renewable electricity.

Increasing the share of renewable energies is considered to reduce greenhouse gas emission while enhancing energy supply security. Energy use (both energy production and final consumption) is the biggest contributor to greenhouse gas emissions in the EU. The energy-related share of emissions increased from 79 % in 1990 to 81.5 % in 2003. Increased market penetration of renewable energy will help to reach the EU commitment under the Kyoto Protocol of the United Nations Framework Convention on Climate Change. The overall Kyoto target for the pre-2004 EU-15 Member States requires a 8 % reduction in emissions of greenhouse gases by 2008–2012 from 1990 levels, while most new Member States have individual targets under the Kyoto Protocol. (Kyoto Protocol to the UN Framework Convention on Climate Change).

EECCA policy context: EECCA Strategy follows the proclamations of the Kiev Declaration. However, conceptions of the 'renewable energy consumption' are still developing in EECCA regions and are not proclaimed clearly in the current policies. (EECCA Environmental Strategy).

Model used for indicators calculation — World Energy Model (WEM)

The projections are made with use of the World Energy Model 2004 developed by International Energy Agency. The WEM is a mathematical model made up of five main modules: final energy demand, power generation; refinery and other transformation; fossil fuel supply and CO_2 emissions. Figure C1. (World Energy Outlook, 2004, p.532) provides a simplified overview of the structure of the model.

The main exogenous assumptions concern economic growth, demographics, international fossil fuel prices and technological developments. Electricity consumption and electricity prices dynamically link the final energy demand and power generation module.

The IEA's WEM is a principal tool used to generate detailed sector-by-sector and region-by-region projections for the Reference and the Alternative Scenarios. (see definitions of scenarios under section reference scenario). The model has been updated and revised over years and the development process continues.

In the WEM 2004 projections of Total Primary Energy Consumption and, consequently, Total Renewable Consumption are made within such categories as: coal, oil, gas, nuclear, hydro, biomass and waste, and other renewables. More detailed descriptions concerning calculating procedures by end-use sectors can be found in the methodology of the Total Primary Energy Consumption since the Renewable Energy Consumption is included into the Total Energy Consumption.

References

IEA, 2006. *World energy outlook 2006*. International Atomic Agency (2006), OECD/IEA, Paris (pp. 537, 538).

Data specifications

Data set title	Source
Input data to WEO model — technological developments	International Energy Agency
Input data to WEO model — fuel prices	International Energy Agency
Input data to WEO model — population	International Energy Agency
Input data to WEO model — economic growth	International Energy Agency
Input data to WEO model — electricity consumption	International Energy Agency
Input data to WEO model — electricity prices	International Energy Agency
Input data to WEO model — primary demand for fossil fuels	International Energy Agency
Outlook from WEO — Renewable energy consumption	International Energy Agency

Uncertainties

Methodology uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause demand to grow less rapidly. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period. Uncertainty about the outlook for economic growth in China is particularly acute.

The effects of resource availability and supply costs on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain — partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power.

Improvements in the efficiency of current energy technologies and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Data uncertainty

Major challenge is a reliable input data energy statistics. The statistics of IEA which provide a major input to the WEO, cover 130 countries worldwide. Most time-series begin in 1960 for OECD counties and in 1971 for non-OECD countries. Recently, however, maintaining the very high caliber of IEA statistics has become increasingly difficult, in many cases because national administrations have faced growing problems in maintaining the quality of their own statistics. Breaks in time series and missing data have become frequent in some countries. The lapses compromise the completeness of IEA statistics. They could seriously affect any type of analysis, including modeling and forecasting.

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments will take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Theme: **Energy**

Indicators: **EE_F11 — Renewable energy consumption — outlook from EEA**

Definition: Renewable energy consumption is the ratio between the gross inland consumption of energy from renewable sources and the total (primary) gross inland energy consumption calculated for a calendar year. It is calculated as the sum of the gross inland consumption of energy from renewable sources.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

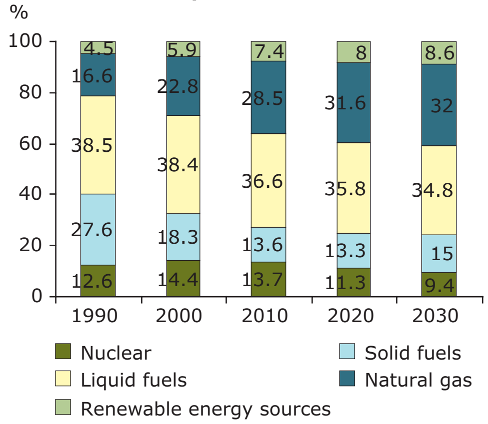
Temporal coverage: 1990–2030

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Are we switching to less polluting fuels to meet our energy consumption?

Projected structure of total energy consumption in the EU-25



Source:

EC, 2003. Mantzos *et al.,* 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities, Luxembourg; EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

The indicated policy targets for renewable energy sources are not expected to be met by the EU-25 as a whole. However, renewables increase more than all other fuels in relative terms (more than doubling their contribution from current levels by the year 2030). In absolute terms they increase by 135 mtoe from 2000 to 2030 contributing nearly as much as natural gas towards the increase of energy demand.

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: The Plan of Implementation adopted at WSSD is particularly concerning sustainable energy future. It aims to diversify energy supply by developing more cost-effective energy technologies such as renewable energy technologies including hydro-technologies. (World Summit on Sustainable Development Plan of Implementation).

Pan-European level: The Guidelines on Reforming Energy Pricing and Subsidies prepared jointly by the UNECE Committees on Environmental Policy and on Sustainable Energy (UNECE Guidelines) as a means of implementing the energy-related provisions of the Aarhus decisions have a number of ways how to meet increasing role of renewable energy within economic instruments and marketing mechanisms. (The Guidelines on Reforming Energy Pricing and Subsidies).

EU policy context: The White Paper for a Community Strategy and Action Plan (COM(97)599 final) provides a framework for Member States action to develop renewable energy and sets an indicative target to increase the share of renewable energy in total energy consumption in the EU-15 to 12 % by 2010. Specific targets have been set for the share of biofuels in the transport sector (5.75 % by 2010) and the share of renewable sources in gross electricity consumption (21 % by 2010). (COM(97)599 final). Energy for the future.)

Furthermore, a discussion on future renewable energy targets has commenced. Recently, the European Council called for an Energy Policy in Europe which looks into longer term targets for the share of renewables in total energy consumption of e.g. 15 % by 2015 (European Council, 2006). The European Parliament called for a binding 20 % target for the share of renewables in total energy consumption by 2020, and noted that a share of 25 % could be provided by renewables in a more integrated approach that simultaneously focused on improving energy efficiency. Some Member States have set individual targets for the share of renewables in the long term. More recently, the European Commission launched a comprehensive 'energy package' (10/01/2007). The European Council of 8–9 March 2007 endorsed a binding target of a 20 % share of renewable energies in overall EU energy consumption by 2020. (COM(2006)105 final). Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission. European Commission's Energy Package (10/01/2007), European Council Conclusions (March 2007), DIRECTIVE 2001/77/EC Renewable electricity).

Increasing the share of renewable energies is considered to reduce greenhouse gas emission while enhancing energy supply security. Energy use (both energy production and final consumption) is the biggest contributor to greenhouse gas emissions in the EU. The energy-related share of emissions increased from 79 % in 1990 to 81.5 % in 2003. Increased market penetration of renewable energy will help to reach the EU commitment under the Kyoto Protocol of the United Nations Framework Convention on Climate Change. The overall Kyoto target for the pre-2004 EU-15 Member States requires a 8 % reduction in emissions of greenhouse gases by 2008–2012 from 1990 levels, while most new Member States have individual targets under the Kyoto Protocol. (Kyoto Protocol to the UN Framework Convention on Climate Change).

EECCA policy context: EECCA Strategy follows the proclamations of the Kiev Declaration. However, conceptions of the 'renewable energy consumption' are still developing in EECCA regions and are not proclaimed clearly in the current policies. (EECCA Environmental Strategy).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Gross inland energy consumption (renewable energy forms module) — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Energy
Indicators: EE_F12 — Renewable electricity — outlook from EEA

Definition: Renewable electricity production is a part of the Electricity generation. Renewable electricity generation shows the total amount of electricity generated by certain type of power plants such as hydro and wind, thermal biomass plants.

Model used: PRIMES

Ownership: European Environment Agency (EEA)

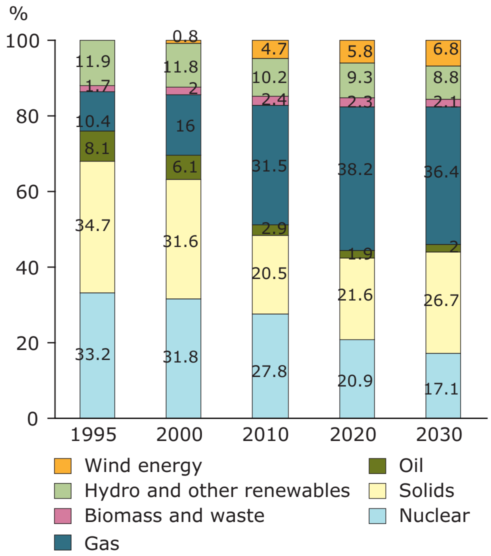
Temporal coverage: 1990–2030

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Are we switching to renewable energy sources to meet our electricity consumption?

Electricity generation by fuel in EU-25 from 1995 to 2030



Sources:

EC, 2003. Mantzos *et al.,* 2005 European Energy and Transport: Trends to 2030. Office for Official Publications of the European Communities. Luxembourg. 2003: EEA, 2005. *European environment outlook. EEA Report No 4/2005. European Environment Agency, Copenhagen.*

Example assessment from 2005

The renewables share in power generation is expected to raise to 18 % in 2010 — which falls however short of the indicative target of the renewables electricity directive (22 %) — indicating that the measures implemented in the Member States by the end of 2004 are not yet sufficient. In any case, the baseline shows a dynamic development in renewables penetration in electricity, as the renewables share is expected to rise further to 23 % in 2020 and 28 % in 2030.

This development is clearly driven by the high growth rates of wind energy — especially in this decade; but growth rates are still impressing in coming decades. In total, wind energy is expected to provide in 2030 twenty times as much electricity as was available from this source in 2000. The increase of wind over 30 years in absolute terms (420 TWh) corresponds to the total present day electricity consumption in the United Kingdom. In 2030, wind power is expected to produce more electricity than hydro.

Biomass use for power generation is also expected to rise considerably; solar photovoltaic has high growth rates from a small basis, while the additional contribution from hydro power is small as a result of limited additional potential and environmental restrictions.

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Global policy context: The major documents that relate to trends of the energy production and electricity generation at the global level were developed and presented during the World Summit on Sustainable Development in Johannesburg (WSSD, 2002) in Agenda 21. WSSD, 2002 aims to achieve a sustainable energy future, including diversified energy sources using cleaner technologies. Moreover, there is a number of sub-negotiations and declarations concerning more sustainable ratio in balance between a global energy supply and production of different energy types, as well as more sustainable electricity generation. (World Summit on Sustainable Development Plan of Implementation).

Pan-European policy context: The recent pan-European policies concerning different aspects of energy production and electricity generation have been developed under different international fora. The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines). Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy production to meet environmental objectives.

The Committee on Sustainable Energy seeks to reform energy prices and subsidies and ways how to carry out it to meet more sustainable energy production and consumption in the region (UNECE Guidelines).

Kiev Declaration 'Environment for Europe' (2003) aims at supporting further efforts to promote energy efficiency and renewable energy production to meet environmental objectives. Kiev Declaration 'Environment for Europe' (2003).

EU policy context: The EU indicative Combined Heat and Power target set in the Community Strategy on cogeneration to promote Combined Heat and Power, (COM(97)514 final) is provided a number of tools that are used to promote energy production and to shift electricity generation structure: financing mechanisms (state subsidies, low cost loans, state guarantees, energy performance contracting, etc.), mandatory obligations (energy efficiency law, appliance and building labels, heat and energy use standards, inspections, etc.), information (energy and environmental agencies, information centers, consulting services, awards, trainings, etc.). (Combined heat and power Communication (COM(97)514 final). The reduction of final energy consumption, therefore, amount of electricity generation and total energy production are seen in the context of reaching the target of an 8 % reduction in greenhouse gas emissions by 2008–2012 from 1990 levels for the EU-15 and individual targets for most new Member-States, as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, and of enhancing the security of energy supply. 2006 EC Thematic Strategy on Waste makes an accent on structural changes in the European energy production in turn to more important role of wastes and biomasses as energy sources.

Sixth Environment Action Programme, (COM(2006)105 final). Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission., An energy policy for the European Union. White Paper. (COM(1995)682 final).

EECCA policy context: Energy efficiency and energy trade, and, consequently, energy and electricity productions are highlighted in the EECCA Environment Strategy. Moreover, there are negotiations concerning decisions about improvements in hydropower sector in Central Asia (EECCA Environmental Strategy, Cooperation Strategy to Promote the Rational and Efficient Use of Water and Energy Resources in Central Asia).

Model used — 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 the calculations covers each of the EU Member States, EU candidate countries and Neighboring 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 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.

References

Mantzos, L., Capros, P. 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Gross inland energy consumption — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Energy
Indicators: EE_F13 — Fuel prices — outlook from IEA

Definition: Fuel energy prices represent a monetary market value of the qualitative characteristics of energy fuel resources.

Model used: World Energy Model (WEM)

Ownership: International Energy Agency (IEA)

Temporal coverage: 2000 – 2030

Geographical coverage: OECD Europe (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom); **Japan, USA.**

Policy question

Do fuel prices include environmental externalities?

Fossil-fuel price assumptions in the reference scenario (USD per unit)						
Real terms (year-2005 prices)	**Unit**	**2000**	**2005**	**2010**	**2015**	**2030**
IEA crude oil imports	Barrel	31.38	50.62	51.5	47.8	55.00
Natural gas						
US imports	MBtu	4.34	6.55	6.67	6.06	6.92
European imports	Mbtu	3.16	5.78	5.94	5.55	6.53
Japanese LNG imports	Mbtu	5.3	6.07	6.62	6.04	6.89
OECD stream coal imports	Tonne	37.51	62.45	55	55.8	60
Nominal terms						
IEA crude oil imports	Barrel	28.00	50.62	57.79	60.16	97.3
Natural gas						
US imports	MBtu	3.87	6.55	7.49	7.62	12.24
European imports	Mbtu	2.82	5.78	6.66	6.98	11.55
Japanese LNG imports	Mbtu	4.73	6.07	7.43	7.59	12.18
OECD stream coal imports	Tonne	33.47	62.45	61.74	70.19	106.14

Sources:

IEA — International Energy Agency, 2006. *World Energy Outlook 2006.* IEA, Paris.

Example assessment from 2006

On the basis of Reference scenario * it is expected that oil import price will average slightly over USD 60 per barrel through 2007, and then decline to about USD 47 by 2012 and rise again to USD 55 in 2030 (in real year-2005 dollars). In nominal terms, the price will reach USD 97 in 2030. Natural gas are assumed broadly to follow the trend in oil prices. The price of OECD steam coal imports is assumed to fall back slightly from a peak of USD 62 per tonne (in year-2005 dollars) in 2005 to around USD 55 in the next few years and ten to increase slowly to USD 60 in 2030.

Note: The most recent assessment is available in *World Energy Outlook 2007* (IEA, 2007).

* *Projections are based on the IEA reference case scenario, which takes into account government policies enacted and adopted by mid-2006, even though many of them have not been fully implemented.*

Most recent projections of the fuel prices are available in IEA Annual Energy Outlook, 2008. www.iea.org.

Policy context

Pan-European policy context: Reforming energy prices and subsidies is a main focus for a plethora of economical and environmental policy documents. UNECE Guidelines represent number of ways how to manage energy market with prices and subsidies modelling in more sustainable way. (UNECE Guidelines).

EU policy context: Sustainable Development Strategy 2001 deals with economical procedures to phase out subsidies to fossil fuel production and consumption by 2010. The current Green paper on energy efficiency make a point on development more efficient internal energy market. (A Sustainable Europe for a better world: A European Strategy for Sustainable Development", COM(2006)105 final. Green Paper on a European Strategy for sustainable, competitive, and secure energy. European Commission.)

EECCA policy context: EECCA Environmental Strategy reveals main efforts in the region to form more effective energy prices through support of regional trade markets and subsidies' reforming. (EECCA Environmental Strategy)

Model used for indicators calculation — World Energy Model (WEM)

Fuel prices are used as assumptions and the input data for World Energy Model 2006 (WEM). Fuel energy prices represent a monetary market value of the qualitative characteristics of energy fuel resources. Fuel energy prices are measured as amount of money in US dollars per amount of fuel. All real prices in the World Energy Outlook are expressed in year-2005 dollars unless otherwise specified. All prices are for bulk supplies exclusive of tax. Nominal prices assume inflation of 2.3 % per year from 2006.

The Reference Scenario projections are based on the average retail prices of each fuel used in final uses, power generation and other transformation sectors. These prices are derived from assumptions about the international prices of fossil fuels (see World Energy Outlook 2006, p. 62, table 1.3). Tax rates and excise duties are assumed to remain constant over the projection period. Final electricity prices are derived from marginal power-generation costs (which reflect the price of primary fossil-fuel inputs to generation, and the cost of hydropower, nuclear energy and renewables-based generation), and non-generation costs of supply. The fossil-fuel-price assumptions reflect our judgment of the prices that will be needed to stimulate sufficient investment in supply to meet projected demand over the projection period. Although the price paths follow smooth trends, prices are likely, in reality, to remain volatile.

References

IEA, 2006. *World energy outlook 2006*. International Atomic Agency, 2006. OECD/IEA, Paris. (pp. 537, 538).

Data specifications

Data set title	Source
Output from WEO — Fuel Prices — Input to WEM	International Energy Agency

Uncertainties

Methodology uncertainty

Macroeconomic conditions are, as ever, a critical source of uncertainty. Slower GDP growth than assumed in both scenarios would cause demand to grow less rapidly. Growth rates at the regional and country levels could be very different from those assumed here, especially over short periods. Political upheavals in some countries could have major implications for economic growth. Sustained high oil process which are not assumed in either of WEM scenarios — would curb economic growth in oil importing countries and globally in the neat term. The impact of structural economic changes, including the worldwide shift from manufacturing to service activities, is also uncertain, especially late in the projection period.

Uncertainty about the outlook for economic growth in China is particularly acute.

The effects of *resource availability and supply costs* on energy process are very uncertain. Resources of every type of energy are sufficient to meet projected demand through to 2030, but the future costs of extracting and transporting those resources is uncertain – partly because of lack of information about geophysical factor.

Changes in government energy and environmental policies and the adoption of new measures to address energy security and environmental concerns especially climate change, could have profound consequences for energy markets. Among the leading uncertainties in this area are: the production and pricing policies of oil-producing countries, the future of energy-market reforms, taxation and subsidy policies, the possible introduction of carbon dioxide emission-trading and the role of nuclear power.

Improvements in the efficiency of current *energy technologies* and the adoption of new ones along the energy supply chain are a key source of uncertainty for the global energy outlook. It is possible that hydrogen-based energy systems and carbon-sequestration technologies, which are now under development, could dramatically reduce carbon emissions associated with energy use. If they did so, they would radically alter the energy supply picture in long term. But these technologies are still a long way from ready to be commercialized on a large scale, and it is always difficult to predict when a technological breakthrough might occur.

It is uncertain whether all the investment in energy-supply infrastructure that will be needed over the projection period will be forthcoming. Ample financial resources exist at a global level to finance projected energy investments, but those investments have to compete with other sectors. More important than the absolute amount of finance available worldwide, or even locally, is the question of whether conditions in energy sector are right to attract the necessary capital. This factor is particularly uncertain in the transition economies and in developing nations, whose financial needs for energy development are much greater relative to the size of their economies than they are in OECD countries. In general, the risks involved in investing in energy in non-OECD countries are also greater, particularly for domestic electricity and downstream gas projects. More of the capital needed for energy projects will have to come from private and foreign sources than in the past. Crating an attractive investment framework and climate will be critical to mobilizing the necessary capital.

Prospects for *oil prices* remain extremely uncertain. The price assumptions described above (in methodology part) are significantly higher than assumed in the last edition of the Outlook. This revision reflects the continuing recent tighness of crude oil and refined-product markets, resulting, to a large extent, from tight product-upgrading capacity.

Data uncertainty

The projections from WEO should not be interpreted as a forecast of how energy markets are likely to develop. The Reference Scenario projections should rather be considered as a baseline vision of how the global energy system will evolve if governments will take no further action to affect its evolution beyond that which they have already committed themselves to.

Rationale uncertainty

In common with all attempts to describe future market trends, the energy projections presented in the Outlook are subject to a wide range of uncertainties energy markets could evolve in ways that are much different from either the Reference Scenario or the Alternative Policy Scenario. The reliability or WEM projections depends both on how well the model represents reality and on the validity of the assumptions it works under.

Terrestrial environment

Theme: **Terrestrial environment**

Indicators: **TELC_F01 — Land cover distribution and change — outlook from MNP**

Definition: Land cover distribution and change: presents information on distribution of land-cover types across the total world terrestrial area: agricultural and natural (tropical rain forest; tropical dry forest; tropical grassland and savannah; desert; Mediterranean forest, woodland and shrub; temperate broadleaf and mixed forest; temperate coniferous forest; temp grassland and steppe; boreal forest; tundra; polar; extensive grassland).

Model used: IMAGE

Ownership: Netherlands Environmental Assessment Agency (MNP)

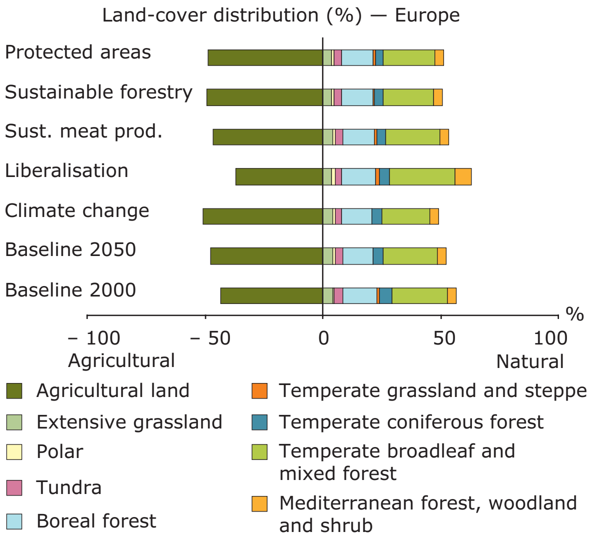
Temporal coverage: 2000–2050

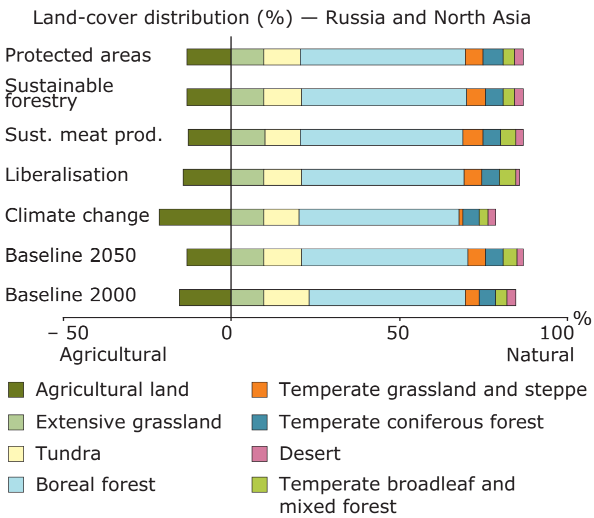
Geographical coverage: Russia and North Asia: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **Europe:** Austria, Belgium, Denmark, Cyprus, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Slovakia, Slovenia, United Kingdom.

Policy question

How much and in what proportions is agricultural, forest and other semi-natural and natural land being taken for urban and other artificial land development?

Land cover distribution in 2000 and 2050 under different scenarios





Example assessment from 2006

In the European region it is expected that agricultural activity lead to expanding agricultural areas over the 2000–2050 period, while in Russian Federation and North Asia region the amount of arable land is expected to decrease, as land is taken out of production. This land is available for restoration of natural biomes, mainly boreal and temperate forests, steppe and grasslands.

Note: Other recent assessment available in Rienks, W. A.(ed.), 2008. *The future of rural Europe. An anthology based on the results of the Eururalis 2.0 scenario study.* Wageningen University Research and Netherlands Environmental Assessment Agency. Wageningen, The Netherlands.

Source:

Cross-roads of Planet Earth's Life. Exploring means to meet the 2010 biodiversity target. Brink, B. J. E. ten, *et al.*, Netherlands Environmental Assessment Agency (MNP), 2006 (MNP report 555050001).

Policy context

Pan-European policy context: There are no international conventions or other policy documents at the Pan-European level efficiency of implementations of which can be measured by this indicator. Chapter 10 of Agenda 21 emphasizes importance of Integrated Approach to the Planning and Management of Land Resources and stimulates countries to use land resources in a more sustainable way. (World Summit on Sustainable Development Plan of Implementation).

EU policy context: However, there no directly related policy documents which regulate size and use of arable land for environmental reasons, the EU 6th Environmental Action Programme promotes the integration of biodiversity considerations in agricultural policies and encourages more environmentally responsible farming, including, where appropriate, extensive production methods, integrated farming practices, organic farming. Achievement of this objective can indirectly be measured by this indicator. If the indicators would include information about the organic farming by crops it can also reflect achievability of goals related to Organic farming. Organic farming is an environmentally sustainable form of agricultural production. Its legal framework is defined by Council Regulation 2092/91 and amendments. The adoption of organic farming methods by individual farmers is supported through agri-environment scheme payments and other rural development measures at Member State level. In 2004 the EU Commission published a 'European Action Plan for Organic Food and Farming' (COM(2004) 415 final) to further promote this farming system. 2006 EC Thematic Strategy on Waste makes an accent on structural changes in the European energy production in turn to more important role of wastes and biomasses as energy sources.

Model used: IMAGE

Model description

The global integrated environmental model IMAGE (notably a Land-Cover Model, which is an integral part of IMAGE) was used by MNP to assess changes in land-cover for the Global Biodiversity Outlook 2.

The objective of the Land-Cover Model (LCM) is to simulate global land-use and land-cover changes by reconciling the land-use demand with the land potential. The basic idea of the model is to keep changing gridded land cover within different world regions until the total demands for this region are satisfied.

Relations with other models

The LCM is driven by changes in the demand for food and feed as computed by the Agricultural Economy Model (AEM) and by changes in the potential vegetation as simulated by the Natural Vegetation Model (NVM). The output of the LCM is used by the Terrestrial Carbon Model (TCM), the Land-Use Emissions Model (LUEM) and the Land Degradation Model (LDM).

Model steps

Five steps can be distinguished within the model:

1) Adaptating of natural vegetation
   - Potential migration zones are calculated using maximum dispersal distances and migration rates
   - Potential and natural vegetation are compared at the grid-cell level
   - If differences are encountered:
     - the ability of those cells to adapt is assessed (i.e., for adaptation cells must be within the potential migration zone)
     - cells that are able to adapt will convert from the original to a new vegetation type using assumptions for transition periods.

2) Treating unsuitable land and extensive grassland
   - Extensive grassland is defined as land with 'grass and fodder species' with potential productivity less than 25% of the theoretical maximum potential
   - Extensive grasslands are fixed over time
   - Agricultural land, not being extensive grassland, is considered unsuitable or too marginal for agriculture if potential productivity drops below 10% of the theoretical maximum potential
   - Unsuitable land reverts back to its natural vegetation.

3) Extracting timber
   - Agricultural land, regrowth forest and protected reserves are excluded
   - Preferences of grid cells for timber extraction are based on:
     - minimal distance to agricultural land, regrowth forest, and large rivers and other bodies of water
     - forest coverage within a cell
     - random preference
   - Timber is extracted from cells with the highest preference values until regional timber demand is satisfied
   - Vegetation regrows to its original state after exploitation, unless it is converted into agricultural land.

4) Abandoning and reallocating existing agricultural land
   - Agricultural grid cells are sorted according to their crop productivity
   - The grid cell having the highest crop productivity from the previous time step a certain amount of the area within each cell is allocated to a particular crop on the basis of the 'local' potential productivity for that crop, as well as changes in regional demand
   - Agricultural land that is not allocated is taken out of production. This land is either not needed to meet crop demands or has become unsuitable to meet these demands
   - After being abandoned land, reverts back to its natural vegetation.

5) Expanding agricultural land

The following procedure is applied if additional agricultural land is needed to meet the demand:

- Agricultural land and protected bioreserves are excluded
- Preferences of grid cells for expansion of agricultural land are based on:
  - minimal distance to agricultural land and large rivers and other bodies of water
  - potential productivity of crops
  - population density
  - random preference
- Expansion of agricultural land starts with grid cells with highest preference values until regional crop demands are satisfied or until all suitable land is used
- Crops are allocated over these cells using potential productivity and remaining crops demand.

For a full description of the land-cover model, see Alcamo *et al.* (1998).

References

Alcamo *et al.*, 1998. Alcamo, J.; Leemans, R.; Kreileman, E., 1998. *Global Change Scenarios of the 21st Century. Results from the IMAGE 2.1 Model.* Elsevier, Amsterdam, 296 pp.

MNP, 2006. Edited by A.F. Bouwman, T. Kram and K. Klein Goldewijk. *Integrated modelling of global environmental change. An overview of IMAGE 2.4*. Netherlands.

Data specifications

Data set title	Source
Input for IMAGE model - Reduced potential productivity of crops	
Input for IMAGE model - Population density	
Input for IMAGE model - Management factors and cropping intensity	
Input for IMAGE model - Initial land-cover map from 1970	
Output of IMAGE model - updated land cover map (0.5 by 0.5 degree grid)	Netherlands Environmental Assessment Agency

Uncertainties

Methodology uncertainty

IMAGE

As a global Integrated Assessment Model, the focus of IMAGE is on large-scale, mostly first order drivers of global environmental change. Most of the relations in IMAGE can be characterized as reestablished but incomplete knowledge. A large number of uncertain relationships and model drivers that depend on human decisions can be varied.

For the energy sub-model (TIMER; de Vries *et al*., 2001), an elaborate uncertainty assessment pointed out that assumptions for technological improvement in the energy system and translation of human activities (such as human lifestyles, economic sector change, and energy efficiency) into energy demand were highly relevant for the model outcomes. Central to climate change modelling are the responses to increased greenhouse gas concentrations. In the IMAGE model this concerns the responses in global temperature increase and local climate shifts. Another model element relevant to the biodiversity issue is the implementation of specific land-use allocation rules determining conversion of natural biomes (see preference rules in Alcamo *et al*., 1998). These rules are most relevant for the calculated biodiversity value. Only a limited set of land-use change is implemented, that is obviously a simplification of actual land-use changes. This limits the assessment of careful land-use planning, for instance, bio-energy production and forest plantations on available, already impacted, areas instead of natural biomes.

GLOBIO

The unavoidable differences in the quality of datasets used create uncertainty in the estimated dose response relationships.

Especially low impact pressures, like grazing in grassland ecosystems, selective logging or nitrogen deposition close to critical load values have high uncertainty. For secondary vegetation a mean value is used, but a time dependent component (reflecting natural recovery) needs to be incorporated. Still, the order of the pressure effects on biodiversity to be far more certain than the exact values.

The climate dose-response relationship cannot be based on data that measure the climate effects directly, as most effects will show up in future. Therefore, the relationships are based on model exercises that estimate climate envelopes for species (Bakkenes *et al*., 2002) or vegetation types (Leemans & Eickhout, 2003). Meta analyses (Parmesan & Yohe, 2003; Walther *et al*.2002) and other model studies (Thomas *et al*., 2004) confirm the main tendencies of the IMAGE-GLOBIO3 exercises, but the modelled effects are relatively low.

Thus the effect of climate change might be underestimated in this study.

For fragmentation, five review studies on minimum area requirement (MAR) of animal species (data on 156 mammal and 76 bird species) were used. This study is biased towards the European region. Establishing dose-response relationship suffers from the different definitions of individual MAR, but the overall picture comparing the different studies is remarkably consistent.

GTAP

The agricultural production and land-use outcomes of the Computable General Equilibrium model (GTAP) are dependent on the demographic and macro-economic growth assumptions, which are both surrounded with considerable uncertainty. Land-use is dependent on the position and elasticity of the land-supply curve, and trade flows are very dependent on the values of the Armington elasticities, which are difficult to estimate.

Most importantly, macro-economic growth is surrounded with more uncertainty than demographic growth.

Data uncertainty

N/A.

Rationale uncertainty

N/A.

Theme: Terrestrial environment

Indicators: TELC_F02 — Land cover, use of arable land — outlook from EEA

Definition: This outlook indicator presents information on use of arable land by crop types: fodder; cereals; permanent crops and paddy; oilseeds and pulses; other arable crops areas and set aside and fallow land.

Model used: CAPSIM

Ownership: European Environment Agency

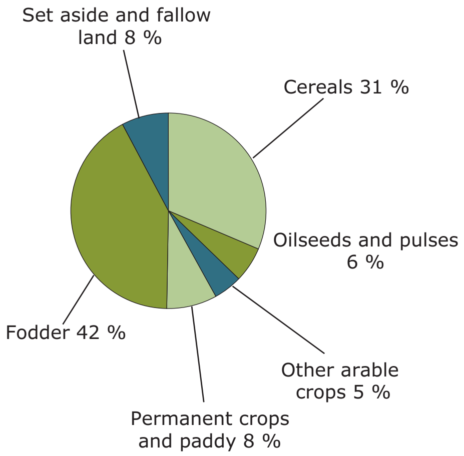
Temporal coverage: 2020

Geographical coverage: EU-23: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia.

Policy question

How much and in what proportions is forest and other semi-natural and natural land being taken for agricultural purposes?

Use of arable land (2020)



Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Harvested land is expected to continue to be used mainly for fodder and the production of cereals (80 % of the total area).

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 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.

Policy context

Pan-European policy context: There are no international conventions or other policy documents at the Pan-European level efficiency of implementations of which can be measured by this indicator. Chapter 10 of Agenda 21 emphasizes importance of Integrated Approach to the Planning and Management of Land Resources and stimulates countries to use land resources in a more sustainable way. (World Summit on Sustainable Development Plan of Implementation).

EU policy context: However, there no directly related policy documents which regulate size and use of arable land for environmental reasons, the EU 6th Environmental Action Programme promotes the integration of biodiversity considerations in agricultural policies and encourages more environmentally responsible farming, including, where appropriate, extensive production methods, integrated farming practices, organic farming. Achievement of this objective can indirectly be measured by this indicator. If the indicators would include information about the organic farming by crops it can also reflect achievability of goals related to Organic farming. Organic farming is an environmentally sustainable form of agricultural production. Its legal framework is defined by Council Regulation 2092/91 and amendments. The adoption of organic farming methods by individual farmers is supported through agri-environment scheme payments and other rural development measures at Member State level. In 2004 the EU Commission published a 'European Action Plan for Organic Food and Farming' (COM(2004) 415 final) to further promote this farming system.2006 EC Thematic Strategy on Waste makes an accent on structural changes in the European energy production in turn to more important role of wastes and biomasses as energy sources.

Model used for indicators calculation — CAPSIM model

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: European Commission (2004a); FAPRI, (2004); FAO (Bruinsma, 2003); and IFPRI (Rosenrant *et al*., 2001a and 2001b). CAPSIM is augmented by a calculation of nutrient balances (N, P, K) and gaseous emissions.

References

Witzke, H. P.; Zintl, A., 2005. *CAPSIM. Documentation of Model Structure and Implementation*. European Commission. Available online: http://www.uni-mannheim.de/edz/pdf/eurostat/05/KS-AZ-05-001-EN.pdf.

Data specifications

Data set title	Source
Input to CAPSIM model — population growth — output from Eurostat population data	Eurostat
Input to CAPSIM model — GDP growth — output from Eurostat data base	Eurostat
Input to CAPSIM model — household expenditure — output from Eurostat data base	Eurostat
Input to CAPSIM model — Euro/USD exchange rate — output from DG AGRI	European Commission, DG AGRI
Input to CAPSIM model — forecast assumptions for baseline scenario — output from DG AGRI	European Commission, DG AGRI
Input to CAPSIM model — forecast trends — output from FAPRI model	Food and Agricultural Policy Research Institute
Input to CAPSIM model — forecast trends — output from IFPRI model	Food and Agricultural Policy Research Institute
Input to CAPSIM — forecast trends — output from FAO	Food and Agriculture organization of the United Nations
Output from CAPSIM — arable land use change	Eurostat

Uncertainties

Model uncertainties

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 fertilisers 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.

Data uncertainty

N/A.

Uncertainty for indicators calculations

Land cover and land use changes can not be sufficiently represented solely by long term outlook because of the lack of sufficient understanding of the underlying dynamics.

Tourism

TOUR_F01 **Tourist arrivals — outlook from WTO**

Theme: Tourism

INDICATOR: **TOUR_F01 — Tourist arrivals — outlook from WTO**

Definition: International tourist arrivals are used to quantify the volume of international tourism. Data refer only to overnight visitors staying at least one night in collective or private accommodation in the country visited.The indicator of tourist arrivals provides all data referring to arrivals and not to actual number of people travelling. One person visiting the same country several times during the year is counted each time as a new arrival. Likewise, the same person visiting several countries during the same trip is counted each time as a new arrival.

Model used: WTO

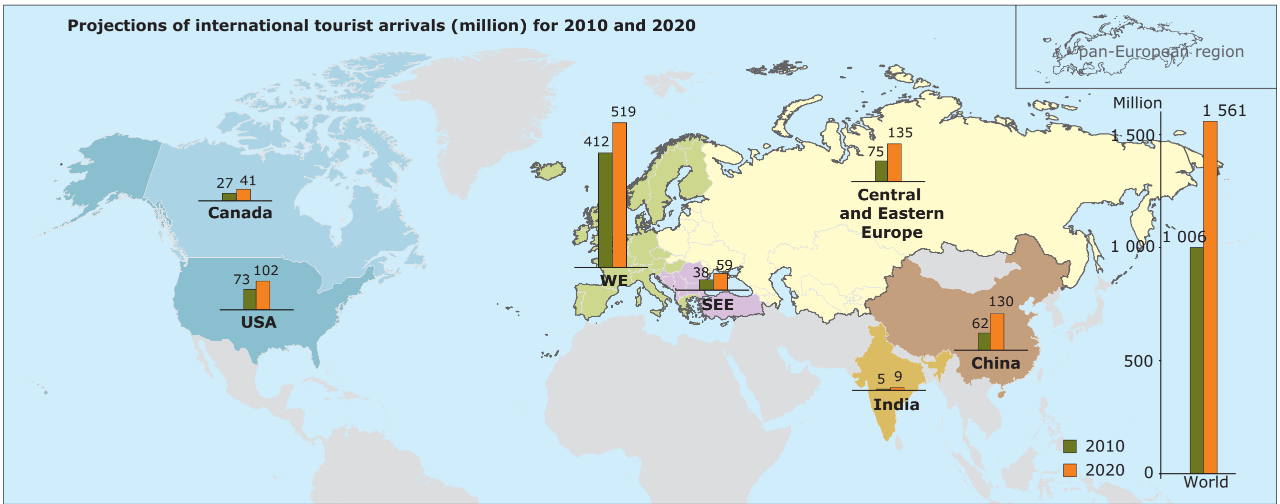
Ownership: World Tourism Organisation (WTO)

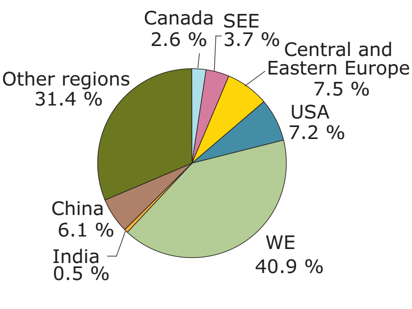
Temporal coverage: 2000, 2010, 2020

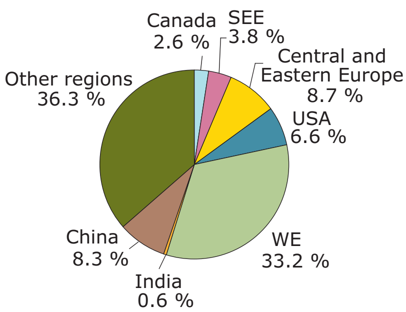
Geographical coverage: Western Europe (WE): Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland, Denmark, Finland, Iceland, Ireland, Norway, Sweden, United Kingdom, Greece, Hungary, Italy, Malta, Portugal, Slovenia, Spain, Cyprus, Czech Republic; **SEE:** Albania, Bulgaria, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Romania, Serbia and Montenegro, Turkey*;* **Central and Eastern Europe:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kyrgyzstan, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Poland, the Russian Federation, Slovakia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **Canada; USA; India; China**

Policy question

What are expected tourism pattern in the pan-European region?







Sources:

WTO (2001), *Tourism 2020. Vision: Global Forecast and Profiles of Segments*. World Tourism Organization; EEA (2007). *Europe's environment — The fourth assessment*. European Environment Agency, 2007. EEA, Copenhagen.

* *Projections are based on the World Tourism Organization's baseline scenario. This takes account of current economic, social and industry trends (including travel forecasts of aircraft manufacturers); considerations are also given to the wide range of individuals and organisations that present views on the future from one perspective or another.*

Example assessment from 2001

If current economic, social and industry trends continue*, tourism in the pan-European region and worldwide will grow at an average rate of 4.1 % a year. Very high increases in international tourist arrivals in some SEE and Central and Eastern European countries will result in additional pressures on the environment.

Globally, international tourist arrivals are projected to top 1 billion in 2010 and reach more than 1.6 billion in 2020, almost doubling the 2005 level.

Policy context

Recent policy developments introduce and aim to increase the sustainability of tourism but no compulsory targets have been set for the tourist industry. Below some policy documents referring to sustainable tourism are outlined.

Global context: Internationally, the role of tourism with regard to biological resources and the conservation of biodiversity has been addressed since 2004 within the Convention on Biological Diversity. This recognition, and other earlier international and UN statements provide a well-defined strategic framework for SDT, the need for which is now widely recognised. (UN Commission on Sustainable Development (CSD), seventh session, 1999. Decision 7/3 on tourism and sustainable development, UNWTO Global Code of Ethics for Tourism, 1999, Québec Declaration on Ecotourism, 2002, World Summit on Sustainable Development, Johannesburg, 2002. Article 43 of the Plan of Implementation, on the promotion of sustainable tourism and necessary actions, Sustainable Tourism — Eliminating Poverty (ST-EP) Initiative, 2002, Convention on Biological Diversity (CBD), COP 7 Decision VII/14 on 'Biological diversity and tourism', 2004, A Task Force on Sustainable Tourism, 2006 within the framework of the Marrakech Process — an international initiative to foster the implementation of Chapter III of the Johannesburg Plan of Implementation.).

Pan-European context: At the regional level, there are several initiatives to foster SDT that promote or give a priority to sustainable tourism. These include: the Mediterranean Strategy for Sustainable Development (2005); the Alpine Convention and its Protocols; the Agenda 21 for the Baltic Sea Region; the Framework Convention on the Protection and Sustainable Development of the Carpathians (2003).

EU context: A vision for European tourism was first set by the European Council in its Resolution of 21 May 2002. In November 2003, the Commission released a Communication on 'Basic orientations for the sustainability of European tourism' (European Commission, 2003). More significantly and recently, in March 2006, a further Commission Communication 'A renewed EU Tourism Policy: towards a stronger partnership for European Tourism' (European Commission, 2006a) suggested a framework for the development of the sector, also specifying supporting actions to promote its sustainability. Within this communication, tourism is considered as an important sector for tackling both growth and employment, the two main priorities set by the renewed Lisbon Strategy. A further key step in the process for promoting sustainable tourism will be the preparation of an Agenda 21 for European Tourism, to be finalised by 2007, broadly based on the reporting activity of the Tourism Sustainability Group launched in 2004.

EECCA and SEE context: While the absence of a tourism strategy at the regional level in EECCA (3) and SEE is evident, there are indications that tourism development is actually guided in these regions, as in several other European countries, through national policies and strategies, targeting either the whole industry or some of its segments.

Model used — WTO approach

A sophisticated forecasting models were not used due to certain characteristics of the WTO's data base (see uncertainties of the methodology) instead a pragmatic approach involving the adjustment of historical time series (where these are considered reliable) was used. The use of tourism arrivals as the parameter WTO's forecasts is necessitated by the fact that this is the category of data most widely reported by countries using the most standardised definitions. However, it is far from ideal, taking no account of length of stay or expenditure, but other data series are not sufficiently complete for these to be utilized for the detail of this forecast.

For the **Tourism 2020 Vision** study, the goal was to prepare forecasts for each of WTO's subregional pairs (i.e. 44 in total). A survey was conducted in late 1996/early 1997 with WTO's National Tourism Association (NTA)_ membership — 85 usable responses were received. A follow-up survey was undertaken in January 1998 with a dozen Asian NTAs to revise forecasts in the light of the Asian financial crisis. A second follow-up survey of 15 Asian NTAs was conducted in September 1998 in response to the deeping and spreading of the economic turmoil.

A survey was undertaken among travel industry leaders — tourism's 50 'visionaries' — about developments that directly (or indirectly) affect tourism. Extensive study was made of publications and other research conducted on economic, social and industry trends (including travel forecasts of aircraft manufacturers); and consideration was also given to the wide range of individuals and organisations who present views of the future from one perspective or another.

This programme of research has given the WTO team the informed knowledge to adjust the historical growth rates for the 44 subregional pairs up (or down) over the period to 2020. Validation research was conducted at regional seminars, where the key findings and conclusions which emerged were 'tested' through presentations and round-table debates in order to reach a consensus. The WTO's forecasts can be seen, therefore, to be both realistic and practical, and constitute a sound working basis on which strategies and plans can be developed and implemented.

References

World Tourism Organisation, 2001. *Tourism 2020 Vision*. Volume 7: Global Forecast and Profiles of market Segments, pp. 123.

Data specifications

Data set title	Source
Input data for WTO model — statistical data on tourism arrivals from national sources	WTO
Output from WTO model — number of tourist arrivals	World Tourism Organisation (UNWTO)

Uncertainties

Methodology uncertainty

WTO collects data from 211 countries and territories: not all of the data are complete; many destinations fail to submit their statistics in a timely fashion; revisions are common place; statistical procedures vary between countries — so it is not always compared like with like; countries change their data series making any long term series difficult, e.g. Spain in 1996.

Data uncertainty

See above.

Rationale uncertainty

Tourist behaviour remains a crucial factor for sustainability.The use of international tourist arrivals as the parameter for measuring environmental impact of the tourism industry is therefore relative. The impact of tourism is projected to increase as a result of greater affluence, lifestyle and demographic change, and growing incomes. Tourism at peak periods overwhelms the carrying capacity of some destinations.

Adjusted projections with qualitative information using participative and Delphi methods substantially reduced the uncertainties of the indicator calculation (see explanation of the validation process above).

Transport

Theme: Transport

Indicators: TERM_F01 — Passenger transport demand — outlook from WBCSD

Definition: This indicator is presented in two ways: (i) The number of kilometres travelled by persons in a given year by all modes of public transport (taxis, buses, trolleybuses, trams, underground, trains, inland water transport, maritime transport and airplanes) and by private transport. (ii) A breakdown of total passenger transport demand by mode (modal split: the share of each mode in total transport demand).

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

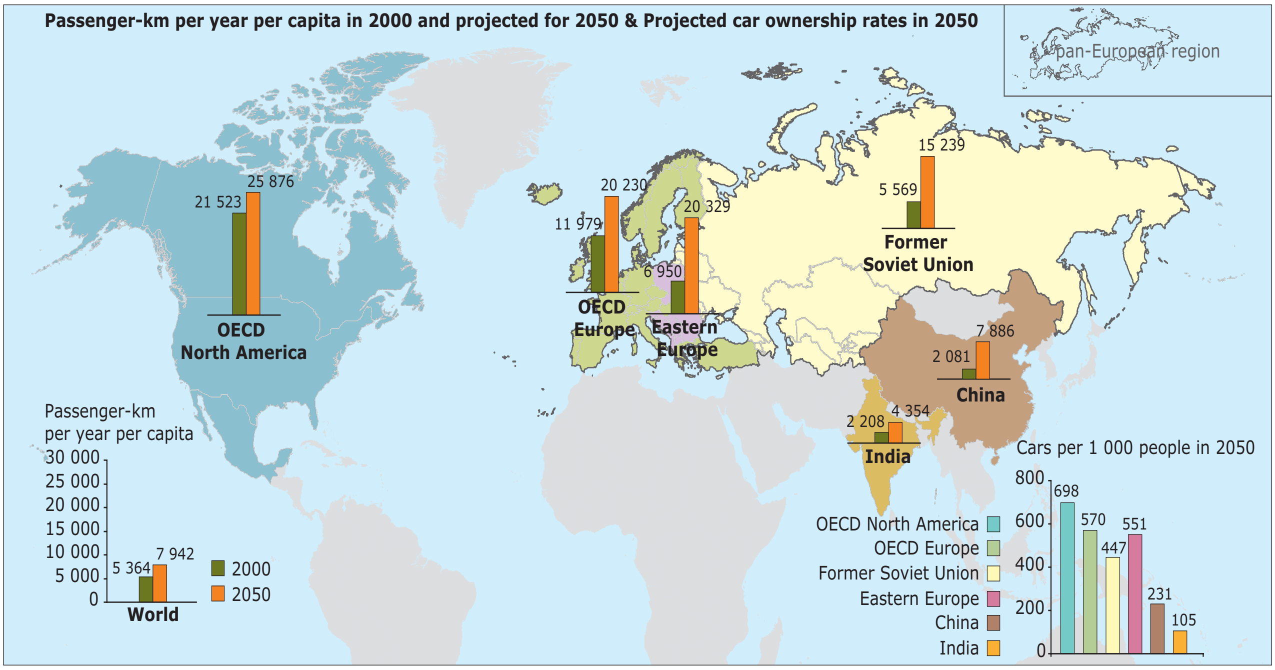
Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China.**

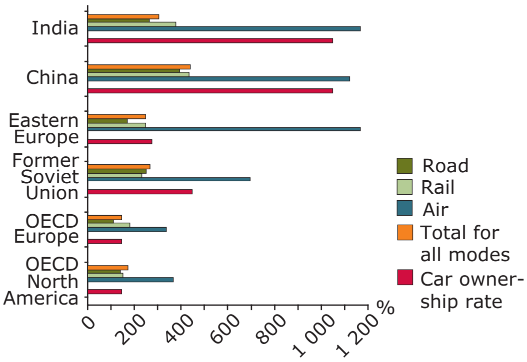
Policy question

Is there in Europe a trend of development of more sustainable ways of travelling in total inland passenger transport?

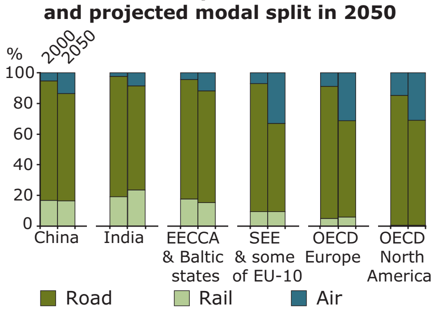
Is there in Europe a trend of decoupling of passenger transport demand from economic growth?



Projected percentage change in passenger transport by mode and car ownership rate from 2000 to 2050



Modal split in 2000 and projected modal split in 2050



Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva; EEA, 2007. *Europe's environment — The fourth assessment.* European Environment Agency, Copenhagen.

Example assessment from 2004

If present policies and technological trends continue*, passenger transport will continue to grow worldwide, but more rapidly in the fast-growing economies of Eastern Europe, China and India.

The modal shares of transport are also expected to shift in a less sustainable direction. Air passenger transport is projected to be the fastest-growing mode. This and road passenger transport together will continue to be the biggest contributors to transport-related CO_2 emissions.

An increase in passenger-km per capita of around 260 % is expected in non-EU Europe. This is more than in the EU and OECD North America and less than in China and India. Passenger-km per capita per year in Eastern Europe is projected almost to triple from 2000 to reach the OECD Europe level (about 20 000 passenger-km per capita per year) in 2050, while it will remain much lower in the rest of the EECCA region.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

EU policy context: The EU has set itself the objective to reduce the link between economic growth and passenger transport demand ('decoupling') in order to achieve more sustainable transport. Reducing the link between transport growth and GDP is a central theme in EU transport policy for reducing the negative impacts from transport:

- The objective of decoupling passenger transport demand from GDP was first mentioned in the Transport & Environment (T&E) integration strategy that was adopted by the Council of ministers in Helsinki. Here, the expected growth in transport demand was named as an area where urgent action was needed. In the sustainable development strategy that was adopted by the European Council in Gothenburg, the objective of decoupling is set in order to reduce congestion and other negative side-effects of transport. (The EU's Strategy for Sustainable Development).
- In the review of the T&E integration strategy in 2001 and 2002, the Council reaffirmed the objective of reducing the link between the growth of transport and GDP.
- In the Sixth Environment Action Programme, decoupling of economic growth and transport demand is named as one of the key objectives in order to deal with climate change and to alleviate health impacts from transport in urban areas. (Sixth Environment Action Programme).

Shifting transport from road to rail is an important strategic element in the EU transport policy. The objective was first formulated in the Sustainable Development Strategy (SDS). In the review of the T&E integration strategy in 2001 and 2002, the Council states that the modal split should remain stable for at least the next ten years, even with further traffic growth. (The EU's Strategy for Sustainable Development).

In the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide', the modal shift is central and the Commission proposes measures aimed at the modal shift. The White Paper on the Common Transport Policy also says that common transport policy alone will not provide all the answers. It must be part of an overall strategy integrating sustainable development, to include: a) economic policy and changes in the production process that influence demand for transport; b) land-use planning policy and in particular town planning; c) social and education policy; d) urban transport policy; e) budgetary and fiscal policy to, to link the internalisation of external, and especial environmental, costs with competition of trans-European network; f) competition policy, to ensure, in line with the objectives of high-quality public services, and in particularly in rail sector, that the opening-up of market is not harmed by the dominant companies already present on market; g) research policy for transport in Europe. (WHITE PAPER European transport policy for 2010: time to decide COM (2001) 370 final).

The European Neighbourhood Policy stressed that generating more trade and tourism between the Union and its neighbours, requires efficient, multimodal and sustainable transport systems. EU should develop an Actions plan for cooperation with its neighbors to improve the physical transport networks connecting the Union with neighboring countries, to step up aviation relations with partner countries with the aim to open up markets and to co-operate on safety and security issues. The Action Plans will also contain specific provisions to address the vulnerability of transport networks and services vis-A-vis terrorist attacks. The highest attention will be paid to enhance the security of air and maritime transport. (The European Neighbourhood Policy).

EECCA policy context: EECCA Environmental Strategy recognizes the need to incorporate environmental concerns into transport policies and sets this action as one of the Strategy objectives. (EECCA Environmental Strategy).

One of the actions selected by THE PEP is 'demand side management and modal shift and with special attention to the needs of the countries of Eastern Europe, Caucasus and Central Asia (EECCA) and of South-Eastern Europe, as well as issues related to ecologically particularly sensitive areas'. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology oriented detail and to allow fairly detailed bottom up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection.* World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Data specifications

Data set title	Source
Outlook — volume of passenger transport (total and by mode)	World Business Council on Sustainable Development
Input data to EIA/SMP model — GDP	International Energy Agency
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	Frt Rail	Pass Rail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	●	●	●	●	●	●	i	i	
New vehicle characteristics (sales, fuel consumption)	●								
Stock-average energy intensity	●	●	●	●	●	●	i	i	
Calculation of energy use and vehicle CO_2 emissions	●	●	●	●	●	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	●	i	●	●	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	●	i	●	●	i	i	i	●

Note: ● = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf

Rationale uncertainty

The relevance of the modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: **Transport**

Indicators: **TERM_F02 — Passenger transport demand — outlook from OECD**

Definition: Passenger transport demand is the total number of kilometres travelled by persons in a given year by all modes of transport (taxis, buses, trolleybuses, trams, underground, trains, inland water transport, maritime transport and airplanes) and by private transport. It can also be presented as a breakdown of total passenger transport demand by mode (modal split: the share of each mode in total transport demand).

Model used: MOVE II

Ownership: Organisation for Economic Co-operation and Development (OECD)

Temporal coverage: 1990–2020

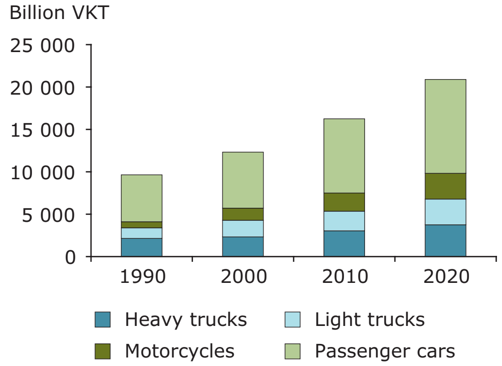
Geographical coverage: Global.

Policy question

Is there in Europe a trend of development of more sustainable ways of travelling in total inland passenger transport?

Is there in Europe a trend of decoupling of passenger transport demand from economic growth?

Motor vehicle kilometres travelled (VKT), 1990–2020



Source:

OECD, 2001. *OECD environmental outlook*. Organisation for Economic Co-operation and Development, Paris.

Example assessment

N/A.

Note: The most recent assessment is available in OECD's *Environmental Outlook to 2030*, OECD, 2008.

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

EU policy context: The EU has set itself the objective to reduce the link between economic growth and passenger transport demand ('decoupling') in order to achieve more sustainable transport. Reducing the link between transport growth and GDP is a central theme in EU transport policy for reducing the negative impacts from transport:

- The objective of decoupling passenger transport demand from GDP was first mentioned in the Transport & Environment (T&E) integration strategy that was adopted by the Council of ministers in Helsinki. Here, the expected growth in transport demand was named as an area where urgent action was needed. In the sustainable development strategy that was adopted by the European Council in Gothenburg, the objective of decoupling is set in order to reduce congestion and other negative side-effects of transport. (The EU's Strategy for Sustainable Development).
- In the review of the T&E integration strategy in 2001 and 2002, the Council reaffirmed the objective of reducing the link between the growth of transport and GDP.
- In the Sixth Community Environment Action Programme, decoupling of economic growth and transport demand is named as one of the key objectives in order to deal with climate change and to alleviate health impacts from transport in urban areas. (Sixth Environment Action Programme).

Shifting transport from road to rail is an important strategic element in the EU transport policy. The objective was first formulated in the Sustainable Development Strategy (SDS). In the review of the T&E integration strategy in 2001 and 2002, the Council states that the modal split should remain stable for at least the next ten years, even with further traffic growth. (The EU's Strategy for Sustainable Development).

In the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide', the modal shift is central and the Commission proposes measures aimed at the modal shift. The White Paper on the Common Transport Policy also says that common transport policy alone will not provide all the answers. It must be part of an overall strategy integrating sustainable development, to include: a) economic policy and changes in the production process that influence demand for transport; b) land-use planning policy and in particular town planning; c) social and education policy; d) urban transport policy; e) budgetary and fiscal policy to, to link the internalisation of external, and especial environmental, costs with competition of trans-European network; f) competition policy, to ensure, in line with the objectives of high-quality public services, and in particularly in rail sector, that the opening-up of market is not harmed by the dominant companies already present on market; g) research policy for transport in Europe. (WHITE PAPER European transport policy for 2010: time to decideCOM (2001) 370 final).

The European Neighbourhood Policy stressed that generating more trade and tourism between the Union and its neighbours, requires efficient, multimodal and sustainable transport systems. EU should develop an Actions plan for cooperation with its neighbors to improve the physical transport networks connecting the Union with neighboring countries, to step up aviation relations with partner countries with the aim to open up markets and to co-operate on safety and security issues. The Action Plans will also contain specific provisions to address the vulnerability of transport networks and services vis-A-vis terrorist attacks. The highest attention will be paid to enhance the security of air and maritime transport. (The European Neighbourhood Policy).

EECCA policy context: EECCA Environmental Strategy recognizes the need to incorporate environmental concerns into transport policies and sets this action as one of the Strategy objectives. (EECCA Environmental Strategy).

One of the actions selected by THE PEP is 'demand side management and modal shift and with special attention to the needs of the countries of Eastern Europe, Caucasus and Central Asia (EECCA) and of South-Eastern Europe, as well as issues related to ecologically particularly sensitive areas'. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

Model used — MOVE II model

The system is based on a calculation of the number of kilometers driven in a given region for each technology and each vehicle type in a given calendar year. For a given region and vehicle type, the age distribution vehicles were also estimated. Based on the age distribution, and knowledge of the emissions standards adopted or expected to be adopted in each country, a table was created which determined the technology type for each model year, the number of vehicles of that technology type in a given calendar year and the number kilometers driven by vehicles using that technology. Vehicle categories included light duty gasoline vehicles (passenger cars), light duty diesel vehicles, light duty gasoline trucks (including so called sport utility vehicles), light diesel trucks, heavy duty gasoline trucks and buses and motorcycles (including scooters). Emissions of each pollutant (CO, VOC, NO_X, N_2O, CH_4 and PM were then combined for each vehicle type for calendar years between 1990 and 2030. The emissions were calculated with the results of the detailed emission calculation models (e.g. MOBILE 6, COPERT an others).

The three primary drivers leading to increases in world's vehicle fleets are population growth, increased urbanization and economic improvements. The development of these drivers for the reference case was projected based on the eco-classical equilibrium model JOBS.

Reference scenario

The Reference Scenario is based on current activities and trends. It does not take into account the adoption or implementation of new policies. The base year for the outlook was 1995. The historical data for the vehicle stock were takes from the OECD statistics for OECD countries. Statistics for other regions where taken from the UNECE and The International Organization of Motor Vehicle Manufacturers. The total fuel use and fuel split was taken from the IEA statistics (based on the phone interview with Mr. Peter Wiederkehr).

The base year data used in JOBS model were mostly taken from GTAP (Global Trade Analysis Project, Version 4) data base developed by Purdue University with 1995 as a base year. In addition to the base year data, assumptions are made in the Reference Scenario concerning:

- total GDP developments (based on OECD Economic Developments projections);
- population growth (based on UN median fertility estimations).

References

OECD, 2001. *OECD environmental outlook*. Organisation for Economic Co-operation and Development, Paris.

Data specifications

Data set title	Source
Number of passenger cars (UNECE)	The United Nations Economic Commission for Europe (Transport division)
Total transport energy consumption by mode	The International Energy Agency
Transport fuel prices (IEA)	The International Energy Agency
Input data to MOVE II model — Vehicle stock by mode for OECD countries	Organisation for Economic Co-operation and Development
Input data to MOVE II model — Vehicle stock by mode for non-OECD countries (gap filling)	The International Organization of Motor Vehicle
Outlook — European passenger travel (car+motorcycles)	OECD environmental Outlook, 2001 (p. 171)
Input data to MOVE II model — Increased urbanization and economical improvements from JOBS model	Organisation for Economic Co-operation and Development

Uncertainties

Methodology uncertainty

To answer the policy question 'Is there in Europe a trend of decoupling of passenger transport demand from economic growth?' it is necessary to calculate the decoupling indicator, e.g. as the relation between the total volume of passenger transport (inland modes) and GDP (Gross Domestic Product). Ideally, it should be possible based on the data from the volume of transport activity for a region. However with the existing data it is hard to construct such decoupling indicator for the Former Soviet Union. This region is presented as a part of non-OECD countries together with together with Latin America, China, South East Asia, Africa. Should the methodology spreadsheets be available it should be possible to obtain there data. In order to answer the specific policy question: 'Is there in Europe a trend of reduction of car passenger transport and increase of rail passenger transport in total inland passenger transport in relative to other modes?' a modal split of a passenger transport should be presented for all transport categories. In the existing in OECD Outlook 2001 data the passenger transport include only road transport. Information for the rail passenger transport as well maritime transport is missing. It should also be noted that the modal spilt data are presented at the global level. Should the methodology spreadsheets be available it should be possible to obtain these data.

Model related uncertainty

The Move II model is static in the sense that all changes are introduced by the user. This provides on the one hand more flexibility to the user, but on the other hand, no checks for consistency or plausibility of the changes are done by the model. (based on the phone interview with Mr. Peter Wiederkehr).

Data uncertainty

1) Input data to Move II model:
The historical data taken from the international sources for the countries of the Former Union were not always accurate; some assumptions had to be made. It is unclear what these assumptions were. (based on the phone interview with Mr. Peter Wiederkehr).More on the uncertainties regarding input data can be found in the Outlook indictors from IEA/SPM model.

2) Output data from MOVE II model: In the OECD Environmental outlook the outlook data for transport activity by modal split is presented at global level. Disaggregated datasets for Europe should be requested.

Rationale uncertainty

N/A.

Theme: Transport
Indicators: TERM_F03 — Passenger transport demand — outlook from EEA

Definition: Passenger transport demand is the total number of kilometres travelled by persons in a given year by all modes of transport (taxis, buses, trolleybuses, trams, underground, trains, inland water transport, maritime transport and airplanes) and by private transport. It can also be presented as a breakdown of total passenger transport demand by mode (modal split: the share of each mode in total transport demand).

Model used: PRIMES

Ownership: European Environment Agency (EEA)

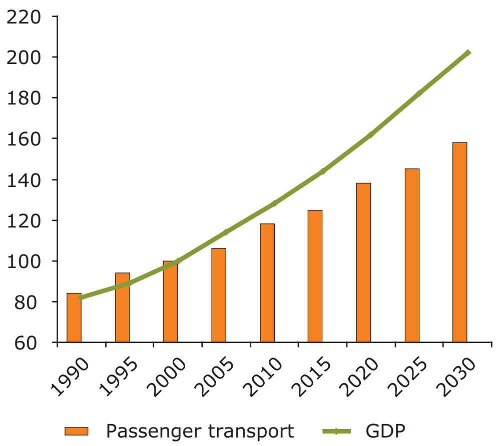
Temporal coverage: 1990–2030

Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

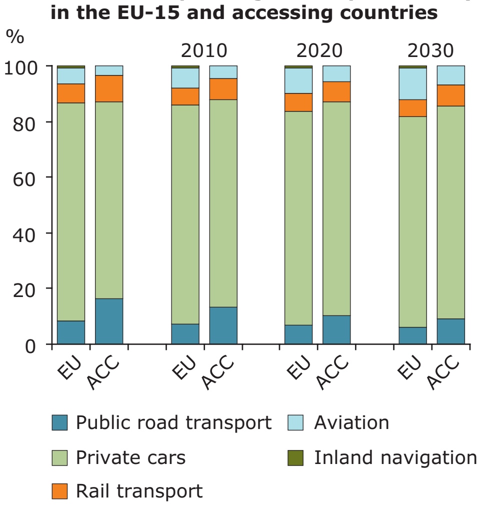
Policy question

Is there a trend of decoupling of passenger transport demand from economic growth in Europe?

Passenger transport activity growth for EU-25



Structure of the passenger transport activity in the EU-15 and accessing countries



Source: EC, 2003. Mantzos *et al.*, 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities. Luxembourg.

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Passenger transport demand is expected to decouple relatively from economic growth over the next 30 years, in line with the policy targets.

As regards 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 %).

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

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Model used — 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 the calculations 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 transport module of PRIMES has been developed to study mainly the penetration of new transport technologies and their effects on emissions, besides the evaluation of the energy consumption and emissions in the transport sector. The emphasis is on the use of car technologies and on the long term (2030). The model structure is kept deliberately simple as it is made to interact as demand module with supply modules (refineries, new fuel production) of PRIMES.

The transport sector distinguishes passenger transport and goods transport as separate sectors. They are further subdivided in sub-sectors according to the transport mode (road, air, etc.). At the level of the sub-sectors, the model structure defines several technology types (car technology types, for example), which correspond to the level of energy use.

The overall demand for transport (passenger kilometres, ton kilometres) is determined by income/activity growth and by the overall price of transport. The overall price of transport is determined endogenously, as a function of the modal split and of the price per mode. The split of the overall transport activity over the different modes is driven by the price per mode and by behavioural and structural parameters. The price per mode depends on the choice of technology for new investment and on past investment for each transport mode. The technologies for new investment are chosen, based on the lowest expected usage costs.

The stock of vehicles inherited from the previous period is expanded in function of the transport needs per mode. The new stock composition determines the stock for the next period and influences the aggregate price per mode.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Passenger transport activity	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

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.

Data uncertainty

No uncertainty has been specified.

Rationale uncertainty

The relevance of the modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: Transport

Indicators: TERM_F04 — Freight transport demand — outlook from WBCSD

Definition: Generally the indicator 'emissions of ozone precursors' tracks trends in anthropogenic emissions of ozone precursors: nitrogen oxides, carbon monoxide, methane and non methane volatile organic compounds, each weighted by their tropospheric ozone-forming potential

The outlook form IEA/SMP model provides information only for nitrogen oxides and carbon monoxide in transport sector

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

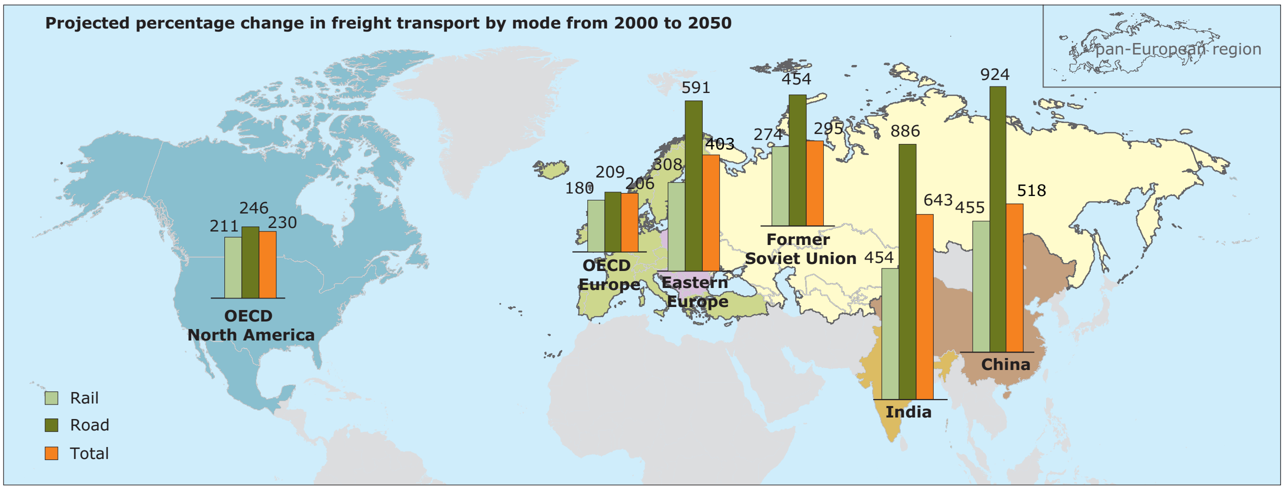
Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China.**

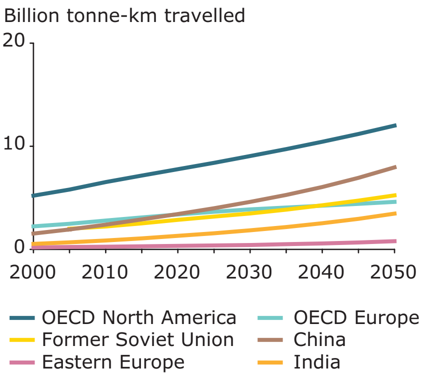
Policy question

Is there in Europe a trend of development of more sustainable ways of freight transport?

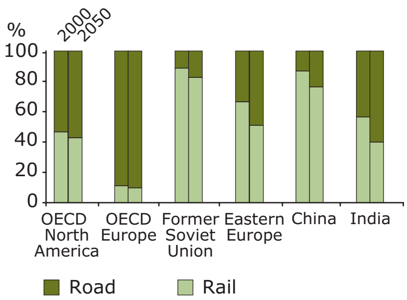
Is there in Europe a trend of decoupling of freight transport demand from economic growth?



Projections of total freight transport activity from 2000 to 2050



Freight transport modal split in 2000 and projected split in 2050



Sources:

WBCSD (2004). Mobility 2030: Meeting the Challenges to Sustainability. World Business Council for Sustainable Development. Geneva. 2004; EEA (2007a). *The pan-European environment: glimpses into an uncertain future*. European Environment Agency, 2007. EEA, Copenhagen.

Example assessment from 2004

If present policies and technological trends* continue, freight transport is projected to continue to grow worldwide. In the Pan-European region the most significant growth is expected in Eastern Europe, while worldwide amore rapid increase is projected in the fast-growing economies of China and India.

Worldwide road transport is expected to grow faster than rail transport. This is expected to lead to substantial shifts of the modal split of freight transport towards less sustainable modes.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

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- The objective of decoupling freight transport demand from GDP was first mentioned in the Transport & Environment (T&E) integration strategy that was adopted by the Council of ministers in Helsinki. Here, the expected growth in transport demand was named as an area where urgent action was needed. In the sustainable development strategy that was adopted by the European Council in Gothenburg, the objective of decoupling is set in order to reduce congestion and other negative side-effects of transport. (The EU's Strategy for Sustainable Development).
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Shifting freight from road to water and rail is an important strategic element in the EU transport policy. The objective was first formulated in the Sustainable Development Strategy ('SDS'). In the review of the T&E integration strategy in 2001 and 2002, the Council states that the modal split should remain stable for at least the next ten years, even with further traffic growth. In the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide', the Commission proposes a number of measures aimed at the modal shift. The White Paper on the Common Transport Policy also says that common transport policy alone will not provide all the answers. It must be part of an overall strategy integrating sustainable development, to include: a) economic policy and changes in the production process that influence demand for transport; b) land-use planning policy and in particular town planning; c) social and education policy; d) urban transport policy; e) budgetary and fiscal policy to, to link the internalisation of external, and especial environmental, costs with competition of trans-European network; f) competition policy, to ensure, in line with the objectives of high-quality public services, and in particularly in rail sector, that the opening-up of market is not harmed by the dominant companies already present on market; g) research policy for transport in Europe. WHITE PAPER European transport policy for 2010: time to decideCOM (2001) 370 final).

Motorways of the sea are alternative routes which could relieve bottlenecks on land. The member States are jointly invited to establish transnational maritime links. (TEN). The European Neighborhood Policy stressed that generating more trade and tourism between the Union and its neighbours, requires efficient, multimodal and sustainable transport systems. EU should develop an Actions plan for cooperation with its neighbors to improve the physical transport networks connecting the Union with neighboring countries, to step up aviation relations with partner countries with the aim to open up markets and to co-operate on safety and security issues. The Action Plans will also contain specific provisions to address the vulnerability of transport networks and services vis-A-vis terrorist attacks. The highest attention will be paid to enhance the security of air and maritime transport. (The European Neighborhood Policy).

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Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated.

The most detailed segment of the model covers light-duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection.* World Business Council for Sustainable Devopment. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Data specifications

Data set title	Source
Input data to IEA/SMP model — GDP (WEO)	World Energy Outlook
Outlook — volume of freight transport (total and by mode)	World Business Council on Sustainable Development
Input data for the IEA/SPM model — secondary data from different sources	Different sources specified in the description of the data

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	Frt Rail	Pass Rail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	●	●	●	●	●	●	i	i	
New vehicle characteristics (sales, fuel consumption)	●								
Stock-average energy intensity	●	●	●	●	●	●	i	i	
Calculation of energy use and vehicle CO_2 emissions	●	●	●	●	●	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	●	i	●	●	i	i	i	
New vehicle characteristics (sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	●	i	●	●	i	i	i	●

Note: ● = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf

Rationale uncertainty

The relevance of the modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: Transport

Indicators: TERM_F05 — Freight transport demand — outlook from OECD

Definition: Freight transport activity or freight transport demand is the total volume of freight transport in tonne-km travelled. Modal split covers heavy trucks and light trucks.

Model used: MOVE II

Ownership: Organisation for Economic Co-operation and Development (OECD)

Temporal coverage: 1990–2020

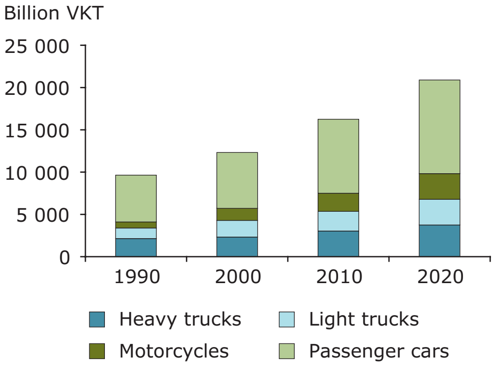
Geographical coverage: Global.

Policy question

Is there in Europe a trend of development of more sustainable ways of freight transport?

Is there in Europe a trend of decoupling of freight transport demand from economic growth?

Motor vehicle kilometres travelled (VKT), 1990–2020



Source:

OECD, 2001. *OECD environmental outlook*. Organisation for Economic Co-operation and Development, Paris.

Example assessment

N/A.

Note: The most recent assessment is available in OECD's *Environmental Outlook to 2030*, OECD, 2008.

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

EU policy context: The EU has set itself the objective to reduce the link between economic growth and freight transport demand ('decoupling') in order to achieve more sustainable transport.

Reducing the link between transport growth and GDP is a central theme in EU transport policy for reducing the negative impacts from transport:

- The objective of decoupling freight transport demand from GDP was first mentioned in the Transport & Environment (T&E) integration strategy that was adopted by the Council of ministers in Helsinki. Here, the expected growth in transport demand was named as an area where urgent action was needed. In the sustainable development strategy that was adopted by the European Council in Gothenburg, the objective of decoupling is set in order to reduce congestion and other negative side-effects of transport. (The EU's Strategy for Sustainable Development).
- In the review of the T&E integration strategy in 2001 and 2002, the Council reaffirmed the objective of reducing the link between the growth of transport and GDP.
- In the Sixth Community Environment Action Programme, decoupling of economic growth and transport demand is named as one of the key objectives in order to deal with climate change and to alleviate health impacts from transport in urban areas. (Sixth Environment Action Programme).

Shifting freight from road to water and rail is an important strategic element in the EU transport policy. The objective was first formulated in the Sustainable Development Strategy ('SDS'). In the review of the T&E integration strategy in 2001 and 2002, the Council states that the modal split should remain stable for at least the next ten years, even with further traffic growth. In the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide', the Commission proposes a number of measures aimed at the modal shift. The White Paper on the Common Transport Policy also says that common transport policy alone will not provide all the answers. It must be part of an overall strategy integrating sustainable development, to include: a) economic policy and changes in the production process that influence demand for transport; b) land-use planning policy and in particular town planning; c) social and education policy; d) urban transport policy; e) budgetary and fiscal policy to, to link the internalisation of external, and especial environmental, costs with competition of trans-European network; f) competition policy, to ensure, in line with the objectives of high-quality public services, and in particularly in rail sector, that the opening-up of market is not harmed by the dominant companies already present on market; g) research policy for transport in Europe. WHITE PAPER European transport policy for 2010: time to decideCOM (2001) 370 final).

Motorways of the sea are alternative routes which could relieve bottlenecks on land. The member States are jointly invited to establish transnational maritime links. (TEN). The European Neighborhood Policy stressed that generating more trade and tourism between the Union and its neighbours, requires efficient, multimodal and sustainable transport systems. EU should develop an Actions plan for cooperation with its neighbors to improve the physical transport networks connecting the Union with neighboring countries, to step up aviation relations with partner countries with the aim to open up markets and to co-operate on safety and security issues. The Action Plans will also contain specific provisions to address the vulnerability of transport networks and services vis-A-vis terrorist attacks. The highest attention will be paid to enhance the security of air and maritime transport. (The European Neighborhood Policy).

EECCA policy context: EECCA Environmental Strategy recognizes the need to incorporate environmental concerns into transport policies and sets this action as one of the Strategy objectives. (EECCA Environmental Strategy).

One of the actions selected by THE PEP is 'demand side management and modal shift and with special attention to the needs of the countries of Eastern Europe, Caucasus and Central Asia (EECCA) and of South-Eastern Europe, as well as issues related to ecologically particularly sensitive areas'. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

Model used — MOVE II

The system is based on a calculation of the number of kilometers driven in a given region for each technology and each vehicle type in a given calendar year. For a given region and vehicle type, the age distribution vehicles were also estimated. Based on the age distribution, and knowledge of the emissions standards adopted or expected to be adopted in each country, a table was created which determined the technology type for each model year, the number of vehicles of that technology type in a given calendar year and the number kilometers driven by vehicles using that technology. Vehicle categories included light duty gasoline vehicles (passenger cars), light duty diesel vehicles, light duty gasoline trucks (including so called sport utility vehicles), light diesel trucks, heavy duty gasoline trucks and buses and motorcycles (including scooters). Emissions of each pollutant (CO, VOC, NO_X, N_2O, CH_4 and PM were then combined for each vehicle type for calendar years between 1990 and 2030. The emissions were calculated with the results of the detailed emission calculation models (e.g. MOBILE 6, COPERT an others).

The three primary drivers leading to increases in world's vehicle fleets are population growth, increased urbanization and economic improvements. The development of these drivers for the reference case was projected based on the eco-classical equilibrium model JOBS (see more about the model here).

Reference scenario

The Reference Scenario is based on current activities and trends. It does not take into account the adoption or implementation of new policies.

The base year for the outlook was 1995. The historical data for the vehicle stock were takes from the OECD statistics for OECD countries. Statistics for other regions where taken from the UNECE and The International Organization of Motor Vehicle Manufacturers. The total fuel use and fuel split was taken from the IEA statistics (based on the phone interview with Mr. Peter Wiederkehr).

The base year data used in JOBS model were mostly taken from GTAP (Global Trade Analysis Project, Version 4) data base developed by Purdue University with 1995 as a base year. In addition to the base year data, assumptions are made in the Reference Scenario concerning:

– total GDP developments (based on OECD Economic Developments projections);
– population growth (based on UN median fertility estimations).

References

OECD, 2001. *OECD environmental outlook*. Organisation for Economic Co-operation and Development, Paris.

Data specifications

Data set title	Source
Number of passenger cars (UNECE)	The United Nations Economic Commission for Europe (Transport division)
Total transport energy consumption by mode	The International Energy Agency
Transport fuel prices (IEA)	The International Energy Agency
Input data to MOVE II model — Vehicle stock by mode for OECD countries	Organisation for Economic Co-operation and Development
Input data to MOVE II model — Vehicle stock by mode for non-OECD countries (gap filling)	The International Organization of Motor Vehicle
Outlook — European passenger travel (car+motorcycles)	OECD environmental Outlook, 2001 (p. 171)
Input data to MOVE II model — Increased urbanization and economical improvements from JOBS model	Organisation for Economic Co-operation and Development

Uncertainties

Methodology uncertainty

To answer the policy question 'Is there in Europe a trend of decoupling of passenger transport demand from economic growth?' it is necessary to calculate the decoupling indicator, e.g. as the relation between the total volume of passenger transport (inland modes) and GDP (Gross Domestic Product). Ideally, it should be possible based on the data from the volume of transport activity for a region. However with the existing data it is hard to construct such decoupling indicator for the Former Soviet Union. This region is presented as a part of non-OECD countries together with together with Latin America, China, South East Asia, Africa. Should the methodology spreadsheets be available it should be possible to obtain there data.

In order to answer the specific policy question: 'Is there in Europe a trend of reduction of car passenger transport and increase of rail passenger transport in total inland passenger transport in relative to other modes?' a modal split of a passenger transport should be presented for all transport categories. In the existing in OECD Outlook 2001 data the passenger transport include only road transport. Information for the rail passenger transport as well maritime transport is missing. It should also be noted that the modal spilt data are presented at the global level. Should the methodology spreadsheets be available it should be possible to obtain these data.

Model related uncertainty:

The Move II model is static in the sense that all changes are introduced by the user. This provides on the one hand more flexibility to the user, but on the other hand, no checks for consistency or plausibility of the changes are done by the model. (based on the phone interview with Mr. Peter Wiederkehr).

Data uncertainty

1) Input data to Move II model:
The historical data taken from the international sources for the countries of the Former Union were not always accurate; some assumptions had to be made. It is unclear what these assumptions were. (based on the phone interview with Mr. Peter Wiederkehr).More on the uncertainties regarding input data can be found in the Outlook indictors from IEA/SPM model.

2) Output data from MOVE II model:
In the OECD Environmental outlook the outlook data for transport activity by modal split is presented at global level. Disaggregated datasets for Europe should be requested.

Rationale uncertainty

The relevance of the modal split policy for environmental impact of freight transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a tonne-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. Additionally the differences in performance within specific modes can be substantial as for example old trains versus new trains. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or through sensitive areas). The magnitude of environmental effects from modal shifting may be limited, as modal shift is only an option for small market segments. Opportunities for modal shifting depend amongst others on the type of goods lifted — e.g. perishable goods or bulk goods — and the specific transport requirements for these goods.

Theme: Transport

Indicators: TERM_F06 — Freight transport demand — outlook from EEA

Definition:
Freight transport activity or freight transport demand is the total volume of freight transport in tonne-km travelled. Modal split covers public trucks, rail transport and inland navigation. It should be noted that inland navigation includes both waterborne inland transport activity and domestic sea shipping. However, international short sea shipping is not included in the above category as, according to Eurostat energy balances, energy needs for international shipping are allocated to bunkers

Model used: PRIMES

Ownership: European Environment Agency (EEA)

Temporal coverage: 1990–2030

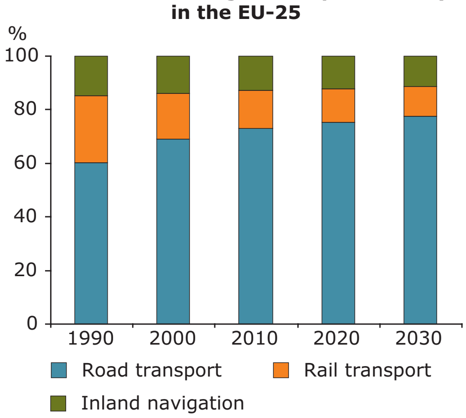
Geographical coverage: EU-25: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

Policy question

Is there in Europe a trend of development of more sustainable ways of freight transport?

Is there in Europe a trend of decoupling of freight transport demand from economic growth?

Structure of the freight transport activity in the EU-25



Freight transport activity growth for EU-25

Source:

EC, 2003. Mantzos *et al.*, 2005 *European Energy and Transport: Trends to 2030.* Office for Official Publications of the European Communities, Luxembourg; EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

Freight transport demand is expected to decouple relatively from economic growth over the next 30 years, in line with the policy targets.

With regard to the modal split of transport, no major technological substitution is expected over the 2000–2030 horizon. For freight transport, trucks are 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 %).

Note: The most recent assessment of the indicator is available at: EC (2008), Capros, P.; Mantzos, L.; Papandreu, V.; Tasios, N.; *European Energy and Transport: Trends to 2030 — Update 2007*. Office for Official Publications of the European Communities, Luxembourg, 2008.

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

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Model used — 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 the calculations 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 transport module of PRIMES has been developed to study mainly the penetration of new transport technologies and their effects on emissions, besides the evaluation of the energy consumption and emissions in the transport sector. The emphasis is on the use of car technologies and on the long term (2030). The model structure is kept deliberately simple as it is made to interact as demand module with supply modules (refineries, new fuel production) of PRIMES.

The transport sector distinguishes passenger transport and goods transport as separate sectors. They are further subdivided in sub-sectors according to the transport mode (road, air, etc.). At the level of the sub-sectors, the model structure defines several technology types (car technology types, for example), which correspond to the level of energy use.

The overall demand for transport (passenger kilometres, ton kilometres) is determined by income/activity growth and by the overall price of transport. The overall price of transport is determined endogenously, as a function of the modal split and of the price per mode. The split of the overall transport activity over the different modes is driven by the price per mode and by behavioural and structural parameters. The price per mode depends on the choice of technology for new investment and on past investment for each transport mode. The technologies for new investment are chosen, based on the lowest expected usage costs.

The stock of vehicles inherited from the previous period is expanded in function of the transport needs per mode. The new stock composition determines the stock for the next period and influences the aggregate price per mode.

References

Mantzos, L.; Capros, P., 2003. *The PRIMES Version 2 Energy System Model: Design and Features.* Institute for Communication and Computer Systems. Department of Electrical and Computer Engineering. National Technical University of Athens.

Data specifications

Data set title	Source
Input data to PRIMES — macro-economic data: demographics, national accounts, sectoral activity and income variables — output from Eurostat data	Eurostat
Input data to PRIMES model — structure of energy consumption and structure of activity variables — output from Eurostat data	Eurostat
Output data from PRIMES — Freight transport activity — output from PRIMES model	The Directorate-General for Energy and Transport (DG TREN)

Uncertainties

Methodology uncertainty

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.

Data uncertainty

No uncertainty has been specified.

Rationale uncertainty

The main policy question relates to whether freight demand is being decoupled from economic growth. Thus, one needs to monitor trends in the intensity of freight transport demand relative to changes in GDP at constant prices. The ratio of inland freight transport to GDP could increase even though the actual freight transport volume may fall. Similarly, the indicator could fall despite of a possible increase in the volume of freight transport. What makes the ratio increase or decrease is the relative change in the volume of freight transport (numerator) to gross domestic product (denominator). As long as the numerator increases more (or falls less) than the denominator, the indicator 'freight transport demand' will increase. The indicator does indeed summarise 'freight transport intensity'. From an environmental point of view, it is important not to overlook trends in the total volume of freight transport. The actual absolute values are key to understand environmental pressures originating from more demand for freight transport.

Intensity can be also explained using the concepts of relative and absolute decoupling. Relative decoupling in freight transport demand occurs when its volume grows at a rate below that of gross domestic product. In this case, however, the volume of freight may well increase as long as this increase is less rapid/strong than the one observed in economic activity. Absolute decoupling in freight transport demand occurs when the volume of freight transport falls. This is the necessary condition. Absolute decoupling is present if GDP increases or remains unchanged. If GDP falls, there is absolute decoupling only if the fall in freight volumes is stronger than the contraction in GDP. This is important since from a purely statistical point of view one could imagine a situation where no absolute decoupling is observed and yet this may be good for the environment. For example, both GDP and freight volumes could fall, with the latter falling less than the former. The fact that the volume of freight transport goes down is good for the environment but the hypothetical situation just described does not strictly correspond to absolute decoupling.

Even if two countries have the same freight transport intensity or show the same trend over time there could be important environmental differences between them. The link to the environmental pressure has to be made on the basis of the energy fuels used by the freight fleet. The primary fuel today is diesel but other options may be available in the future.

In relation to the modal split indicator (i.e. percentage share of road in total inland freight transport), what makes a share increase or decrease for a particular mode depends on the change in the volume of transport for that specific mode relative to the total volume of all modes vis a vis the relative changes observed for the other modes. That is, not only it depends on whether the volume of road freight transport increases or decreases but also on how the increase or decrease in the total volume of inland freight transport is distributed across the different modes. From an environmental point of view, the relative contribution of each mode to the total volume of freight transport has to be put in the wider context. Absolute (as opposed to relative) values of transport volumes for each mode are key to understand the environmental pressures.

Theme: Transport

Indicators: TERM_F07 — Car ownership — outlook from WBCSD

Definition: Car ownership is a number of cars per 1 000 inhabitants; passenger cars refer to motor vehicles other than two-wheelers, intended for the carriage of passenger and designed to seat no more than nine people (including the driver).

Model used: IEA/SMP

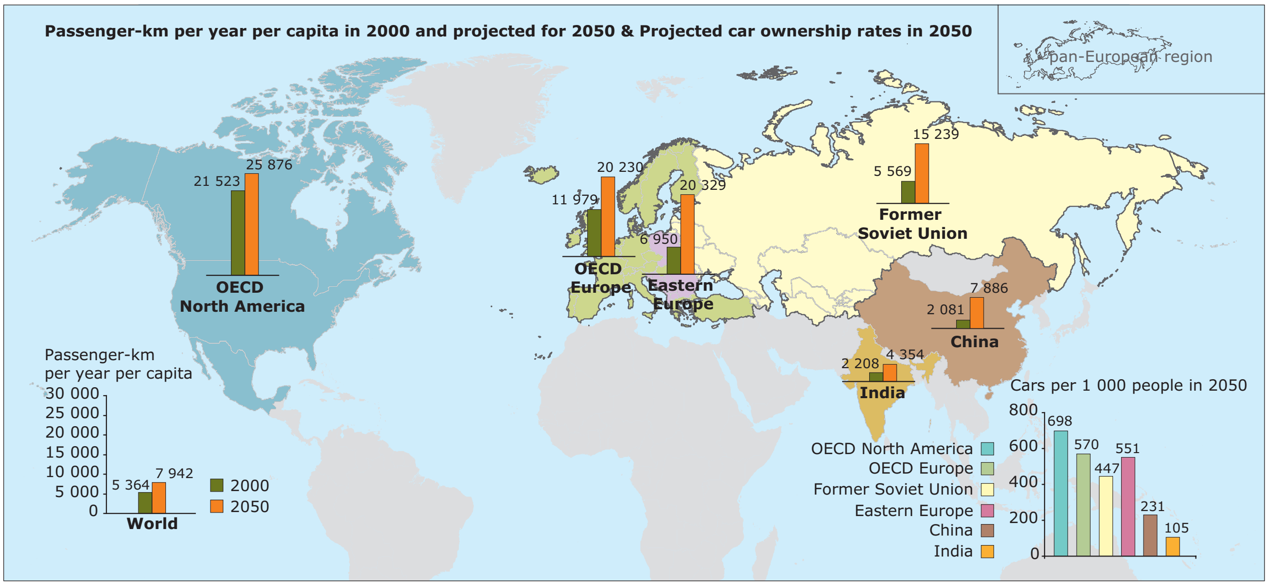
Ownership: World Business Council for Sustainable Development (WBCSD)

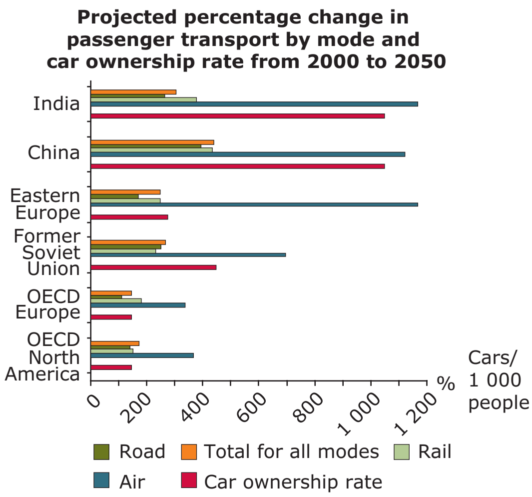
Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China.**

Policy question

Is there in Europe a trend of reduction of car passenger transport in total inland passenger transport in relative to other modes?





Example assessment from 2004

If present policies and technological trends continue *, car ownership rates are expected to increase globally, however at a faster rate in Eastern Europe, the former Soviet Union and China. In Eastern Europe and the former Soviet Union, car ownership per 1000 will exceed today's level in OECD Europe (390 cars/1000). Car ownership in China will increase from 13 to 230 cars/1000 in the period 2000–2050.

* *Projections are based on the reference case scenario — one possible set of future conditions, based on recent trends. Adjustments are made for expected deviations from recent trends due to factors such as existing policies, population projections, income projections and the expected availability of new technologies. No major new policies are assumed to be implemented beyond those already implemented in 2003, and no major technological breakthroughs.*

Source: WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva; EEA, 2007. *Europe's environment — The fourth assessment*. European Environment Agency, Copenhagen.

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

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In the White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide', the modal shift is central and the Commission proposes measures aimed at the modal shift. The White Paper on the Common Transport Policy also says that common transport policy alone will not provide all the answers. It must be part of an overall strategy integrating sustainable development, to include: a) economic policy and changes in the production process that influence demand for transport; b) land-use planning policy and in particular town planning; c) social and education policy; d) urban transport policy; e) budgetary and fiscal policy to, to link the internalisation of external, and especial environmental, costs with competition of trans-European network; f) competition policy, to ensure, in line with the objectives of high-quality public services, and in particularly in rail sector, that the opening-up of market is not harmed by the dominant companies already present on market; g) research policy for transport in Europe. (WHITE PAPER European transport policy for 2010: time to decideCOM (2001) 370 final).

The European Neighbourhood Policy stressed that generating more trade and tourism between the Union and its neighbours, requires efficient, multimodal and sustainable transport systems. EU should develop an Actions plan for cooperation with its neighbors to improve the physical transport networks connecting the Union with neighboring countries, to step up aviation relations with partner countries with the aim to open up markets and to co-operate on safety and security issues. The Action Plans will also contain specific provisions to address the vulnerability of transport networks and services vis-A-vis terrorist attacks. The highest attention will be paid to enhance the security of air and maritime transport. (The European Neighbourhood Policy).

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Model used — IEA/SMP Spreadsheet Model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology oriented detail and to allow fairly detailed bottom up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate.

The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NO_X, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated.

The most detailed segment of the model covers light duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection.* World Business Council for Sustainable Development, 2004. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Data specifications

Data set title	Source
Input for EIA/SMP model — total population projections — output from UN population model	United Nations population division
Input for EIA/SMP model — vehicle stocks — output from EIA/SMP model	World Business Council on Sustainable Development
Output from EIA/SMP model — car ownership rates	World Business Council on Sustainable Development

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	FrtRail	PassRail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	•	•	•	•	•	•	i	i	
New vehicle characteristics(sales, fuel consumption)	•								
Stock-average energy intensity	•	•	•	•	•	•	i	i	
Calculation of energy use and vehicle CO_2 emissions	•	•	•	•	•	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	•	i	•	•	i	i	i	
New vehicle characteristics(sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	•	i	•	•	i	i	i	•

Note: • = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable. For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf

Rationale uncertainty

The relevance of the modal split policy for environmental impact of passenger transport arises from differences in environmental performance (resource consumption, greenhouse gas emissions, pollutant and noise emissions, land consumption, accidents etc.) of transport modes. These differences are becoming smaller on a passenger-km basis, which makes it increasingly difficult to determine the direct and future overall environmental effects of modal shifting. The total environmental effect of modal shifting can in fact only be determined on a case-by-case basis, where local circumstances and specific local environmental effects can be taken into account (e.g. transport in urban areas or over long distances).

Theme: Transport

Indicators: TERM_F08 — Use of cleaner and alternative fuels — outlook from WBCSD

Definition: Cleaner and alternative fuels are measured in absolute and relative forms: i) as a percentage (relative) and ii) amount (absolute) of biofuels, gaseous fuels (CNG/LPG, hydrogen) and biodiesel in the total combined final energy consumption of gasoline, diesel and biofuels for transport.

The indicator is available for the following transport modes and vehicle technologies:

Sector/mode	Vehicle technology/fuels
	Internal combustion engine:
	◇ Gasoline
• Medium trucks	◇ Diesel
• Heavy-duty (long-haul trucks	◇ LPG-CNG
• Rail freight	◇ Ethanol
• National waterborne (Inland plus coastal)	◇ Biodiesel hybrid — Electric ICE (same fuels)
• Int'l shipping	Fuel-cell vehicle
	◇ Hydrogen
	With feedstock differentiation for biofuels and hydrogen)

Model used: IEA/SMP

Ownership: World Business Council for Sustainable Development (WBCSD)

Temporal coverage: 2000–2050

Geographical coverage: OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom; **OECD North America:** USA, Canada, Mexico; **Former Soviet Union:** Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Eastern Europe:** Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, the former Yugoslav Republic of Macedonia, Poland, Romania, Slovakia, Slovenia, Serbia and Montenegro; **India; China.**

Policy question

Is Europe's progress towards promoting cleaner and alternative fuels in transport satisfactory?

Projections of vehicle sales shares by vehicle type, for LDV mode						
	2000	**2005**	**2015**	**2025**	**2035**	**2045**
Gasoline						
OECD Europe	58.5 %	53.3 %	47.9 %	47.6 %	47.4 %	47.2 %
FSU	94 %	93.5 %	92.1 %	90.3 %	88.3 %	86.0 %
Eastern Europe	78 %	74 %	63.2 %	47.6 %	47.0 %	46.8 %
Gasoline hybrid						
OECD Europe	0.0 %	0.2 %	0.6 %	0.9 %	1.1 %	1.3 %
FSU	0.0 %	0.0 %	0.3 %	0.7 %	1.0 %	1.2 %
Eastern Europe	0.0 %	0.0 %	0.3 %	0.7 %	1.0 %	1.2 %
Diesel						
OECD Europe	40.0 %	45.0 %	50.0 %	50.0 %	50.0 %	50.0 %
FSU	5.0 %	5.5 %	6.7 %	8.1 %	9.7 %	11.8 %
Eastern Europe	20.0 %	24.0 %	34.6 %	49.8 %	50.0 %	50.0 %
Diesel hybrid	**Diesel hybrid set to near zero in reference case**					
OECD Europe	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
FSU	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Eastern Europe	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
LPG/CNG	**LPG/CNG current set to be about 25,000 vehicles per year worldwide.**					
OECD Europe	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %	1.5 %
FSU	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %
Eastern Europe	2.0 %	2.0 %	2.0 %	2.0 %	2.0 %	2.0 %
Fuel cell (hydrogen)	**Fuel cell currently set to be about 500 vehicles per year worldwide until 2010, 5,000 vehicles per year thereafter.**					
OECD Europe	0.000	0.000	0.000	0.000	0.000	0.000
FSU	0.000	0.000	0.000	0.000	0.000	0.000
Eastern Europe	0.000	0.000	0.000	0.000	0.000	0.000

Projections of overall biodiesel blend share into diesel fuel						
	2000	**2010**	**2020**	**2030**	**2040**	**2050**
OECD Europe	0.1 %	4.0 %	4.0 %	4.0 %	4.0 %	4.0 %
FSU	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Eastern Europe	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

Example assessment

N/A.

Source:

WBCSD, 2004. *Mobility 2030: Meeting the Challenges to Sustainability.* World Business Council for Sustainable Development, Geneva.

Policy context

Pan-European policy context: The large number of non binding policy instruments have been developed under fora such as Environment for Europe process, the European Council of Ministers of Transport (ECMT) and the UNECE/WTO Transport, Health and Environment Pan-European Programme (The PEP). The PEP was set up to address the key challenges to achieve more sustainable transport patterns and a closer integration of environmental and health concerns into transport policies. (UNECE/WTO Transport, Health and Environment Pan-European Programme).

EU policy context: The White Paper on the Common Transport Policy (CTP) 'European Transport Policy for 2010: Time to Decide' is a headlight policy which covers EU objections relatively to use of alternative and cleaner fuels. (WHITE PAPER European transport policy for 2010: time to decide COM (2001) 370 final). The main tasks provided in EU legislative documents provide more important role of biofuels as well as gaseous and alternative fuels. Reducing greenhouse gas emissions and, therefore, to increase role of biofuels in the transport sector is one of the priority actions of the 'The European Six Environmental action programme'.

ECCA policy context: EECCA Environmental Strategy recognizes the need to incorporate environmental concerns into transport policies and sets this action as one of the Strategy objectives. (EECCA Environmental Strategy).

Model used — SMP Spreadsheet model

The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology oriented detail and to allow fairly detailed bottom up modeling. The SMP spreadsheet model 1.60 is the most recent version and is available for a more detailed inspection (and use, though no user guide has been prepared and there are no plans, at this time, of providing on-going user support for the model. A very basic outline of how to use the model is provided in the first sheet of the model spreadsheet).

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. Rather, it is an 'accounting' model, anchored by the 'ASIF' identity:

- **A**ctivity (passenger and freight travel)
- **S**tructure (travel shares by mode and vehicle type)
- **I**ntensity (fuel efficiency)
- **F**uel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).

Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate. The modes, technologies, fuels, regions and basic variables are included in the spreadsheet model. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2 equivalent GHG emissions (from vehicles as well as upstream), PM, NO_x, HC, CO and Pb. Projections of safety (fatalities and injuries) are also incorporated. The most detailed segment of the model covers light duty vehicles. The flow chart on the page 4 of the Model Documentation provides an overview of the key linkages in the light-duty vehicle section of the model. For other passenger modes (such as buses, 2-wheelers), the approach is similar, however there is no stock model. Stocks are projected directly; vehicle sales needed to achieve these stocks is not currently tracked.

References

Fulton, L., IEA/Eads, G., CRA, 2004. *IEA/SMP Model Documentation and Reference Case Projection.* World Business Council for Sustainable Development. Available online: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Data specifications

Data set title	Source
Input data to IEA/SMP model — fuel use by all road vehicles — output from WEO 2002, IEA data	A data International Energy Agency
Output from IEA/SMP model — use of ethanol, biodiesel and hydrogen	World Business Council on Sustainable Development

Uncertainties

Uncertainties related to IEA/SMP transport model

The model does not include any representation of economic relationships (e.g. elasticities) nor does it track costs. The IEA has a cost-optimization model capable of this, the ETP model, but this model was not employed in the SMP's work due to its lack of transparency and its complexity.

Data uncertainty

The table below provides a simplified picture of what types of variables and the level ofdetail modelled for each major transport mode in the IEA/SMP transport spreadsheet model. As can be seen in the next table, there is a range of coverage by mode, as well as variations in the quality of the data available (indicated by x or i). In general, there is better data available for light-duty vehicles than for other modes, though for non-OECD regions most data is quite poor, except for aggregate estimates of transport energy consumption. New vehicle characteristics are only tracked for light-duty vehicles; existing stock is used as the basic vehicle indicator for all other modes.

	Auto	Air	Truck	FrtRail	PassRail	Buss	Mini-bus	2-3 wheel	Water
OECD regions									
Activity (passenger or tonne km)	●	●	●	●	●	●	i	i	
New vehicle characteristics(sales, fuel consumption)	●								
Stock-average energy intensity	●	●	●	●	●	●	i	i	
Calculation of energy use and vehicle CO_2 emissions	●	●	●	●	●	i	i	i	
Non-OECD regions									
Activity (passenger or tonne km)	i	●	i	●	●	i	i	i	
New vehicle characteristics(sales, fuel consumption)	i								
Stock-average energy intensity	i	i	i	i	i	i	i	i	
Calculation of energy use and vehicle CO_2 emissions	i	●	i	●	●	i	i	i	●

Note: ● = have data of fair to good reliability; i = have data but incomplete or of poor reliability; blank = have nothing or have not attempted to project. Note that data of fair reliability is available for energy use across all road vehicles in non-OECD countries, but breaking this out into various road modes (cars, trucks, buses, 2-wheelers) is difficult and relatively unreliable.For more information: http://www.wbcsd.org/web/publications/mobility/smp-model-document.pdf.

Rationale uncertainty

N/A.

Waste and material flows

WMF_F01	**Municipal waste generation — outlooks from National Communications under UNFCCC**
WMF_F02	**Municipal waste generation — outlook from OECD**
WMF_F03	**Municipal waste generation — outlook from EEA**
WMF_F04	**Generation and recycling of packaging waste — outlook from EEA**

Theme: Waste

Indicators: WMF_F01 — Municipal waste generation — outlooks from National Communications under UNFCCC

Definition: The indicator presents projections of municipal waste generation for the period 1990–2020. Past data on municipal waste refers to waste collected by or on behalf of municipalities; the main part originates from households, but waste from commerce and trade, office buildings, institutions and small businesses is also included. The definition excludes waste from municipal sewage networks and treatment.

Projected data were calculated by each country for the National Communication on Climate Change under UNFCCC as a function of GDP and population growth.

Model used: N/A.

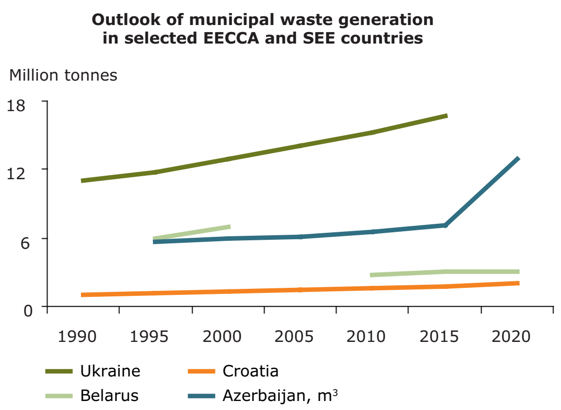
Ownership: United Nations Framework Convention on Climate Change (UNFCCC)

Temporal coverage: 1990–2020

Geographical coverage: Azerbaijan, Belarus, Croatia, Ukraine (potentially data can be available for all European countries preparing National Communications on Climate Change).

Policy question

What are the prospects of reduction of municipal solid waste?



Source:

IPCC — Intergovernmental Panel for Climate Change. National Communication of Climate Change (1998, 2000, 2001, 2003).

Example assessment from 2005

N/A.

Policy context

Global and Pan-European policy context: No international agreements exist for reduction of municipal waste generation.

EU policy context: 6th Community Environment Action Programme (Sixth Environment Action Programme) focuses on:

- Better resource efficiency and resource and waste management to bring about more sustainable production and consumption patterns, thereby decoupling the use of resources and the generation of waste from the rate of economic growth and aiming to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment.
- Achieving a significant overall reduction in the volumes of waste generated through waste prevention initiatives, better resource efficiency and a shift towards more sustainable production and consumption patterns.
- A significant reduction in the quantity of waste going to disposal and the volumes of hazardous waste produced while avoiding an increase of emissions to air, water and soil.
- Encouraging reuse, and for wastes that are still generated: Preference should be given to recovery and especially to recycling.

EU Thematic Strategy on the Prevention and Recycling of Waste (2005). Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on Waste.

The European Neighborhood Policy prioritises waste management as one of the key area for cooperation.

EECCA policy context: EECCA Environmental Strategy encourages development of inter-sector waste management action plans; national capacity building for the environmentally sound management of hazardous waste; implementation of integrated systems of monitoring of waste transfers; development of economic mechanisms to facilitate implementation of cleaner technologies and waste prevention and minimization as well as governmental support for waste treatment facilities; development of efficient programs for waste management and management of chemical risks; promotion of development of an integrated system for inventory of waste generation and accumulation (e.g. Protocol on Pollutant Release and Transfer Registers — PRTR). (EECCA Environmental Strategy).

Model used — projections from UNFCC National communications

No information about the models used for calculation of this outlook is available.

For calculation of this indicator the projections of municipal waste generation were extracted from the National Communications on Climate Change submitted by the countries to the UN Framework Convention on Climate Change. 17 National reports were screened, however data on the municipal waste management were available only in four reports for Azerbaijan, Belarus, Croatia and Ukraine.

The projections of the municipal waste generation in the National Communications directly correlate to the projected population growth and GDP growth. The assumptions regarding coefficients behind these linear functions are not reported in the Communications.

For further work the calculation of specific waste generation in kg per capita can be done. It can be calculated as the national amounts of municipal waste collected divided by the national population.

Due to the availability of data for Ukraine it is possible to calculate projected waste treatment distribution by method: municipal solid waste landfilled and municipal solid waste incinerated. The quantity treated by each method can be divided by the total amount of municipal waste collected and expressing it as percentage.

References

UNFCCC — National Communication on Climate Change.

Data specifications

Data set title	Source
Municipal waste generation — extracts from National Communications on Climate Change	UNFCCC — National Communication on Climate Change

Uncertainties

Methodology uncertainty

1) Solid waste production is expensive to measure at source; thus, consistent and comparable statistics are difficult to obtain. The indicator does not distinguish between toxic and hazardous wastes, and those more benign; nor does it cover waste stored on site. It is often confused with the amount of solid waste disposed, which is measured by recording the weight or volume of waste disposed at the disposal or treatment site.
Volume of waste produced may be significantly affected by the presence of particular wastes. For example, the inclusion of construction wastes in domestic refuse will greatly affect the waste density and hence the indicator. The actual method of storage of waste and its moisture content will also affect the waste density. The volume of waste produced is often affected by seasonal variations in the production of various agricultural foodstuffs.
2) The projections of the municipal waste generation in the National Communications directly correlate to the projected population growth. The assumptions regarding coefficients behind these linear functions are not reported in the Communications.The assumptions regarding the economic development and population growth should be taken into account when making an assessment.

Data uncertainty

1) The quantitative and qualitative data on the generation, use, disposal and environmental effects of wastes are unreliable in many countries of Eastern Europe, the Caucasus and Central Asia and do not meet priority demands. Thus the projections made based on this data bare a similar uncertainty. Some important waste streams are not properly monitored. Inventories are lacking in several countries of waste of high potential hazard, which were and continue to be dumped on landfill sites, especially in rural areas. Data quality is often uncertain; data collected is often incomplete; little work has been done to analyze or synthesize data for policy development and assessment through appropriate indicators.
2) The collected from the National Communications data have different measurement units: Ukraine, Croatia, Belarus — mln. tones; Azerbaijan — m^3
3) The indicator covers a limited geographical area. Data only for four countries exist: Azerbaijan, Belarus, Croatia, and Ukraine. Other countries done similar projections while preparing the report, but they are not presented in the report. In order to obtain such data the national focal points of other EECCA and SEE countries can be contacted.
4) The dates for when simulations were run are unclear. It is however possible to asses the period of the simulation by date of publication of the national communications and the base year used for simulations which are presented in the table below.

Rationale uncertainty

Linkages to Other Indicators: This indicator is intimately linked to other socio-economic and environmental indicators especially those related to income-level and economic growth. Those would include: rate of growth of urban population, Gross Domestic Product (GDP) per capita, waste disposal, and waste recycling.

Theme: Waste

Indicators: WMF_F02 — Municipal waste generation — outlook from OECD

Definition: The indicator presents the outlook of total amount of generated municipal waste per year by regions: Central and Easter Europe, Western Europe and non-OECD countries. The total % change from 1995 to 2020 allows to compare regional performance.

Model used: JOBS, POLESTAR

Ownership: Organisation for Economic Co-operation and Development (OECD)

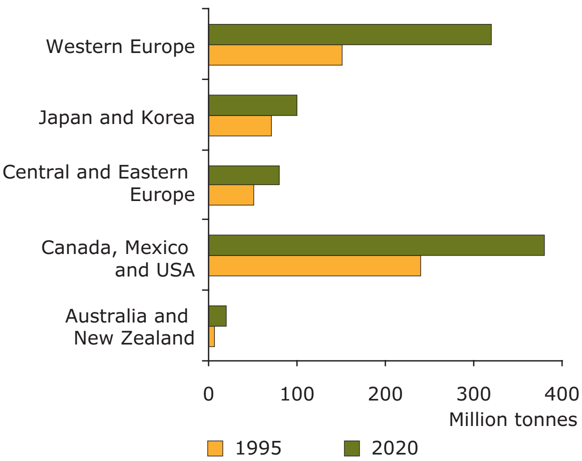
Temporal coverage: 1995, 2010 and 2020

Geographical coverage: Central and Eastern Europe — Czech Republic, Hungary, Poland, Slovak Republic, Turkey, Romania, Bulgaria; **Western Europe** — Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom; **Australia and New Zealand, Canada, Mexico and USA; Japan and Korea**.

Policy question

What are the prospects of reduction of municipal solid waste?

Municipal waste generation, 1995–2020



Source:

OECD, 2001. *OECD environmental outlook.* Organisation for Economic Co-operation and Development, Paris.

Example assessment

N/A.

Note: The most recent assessment is available in OECD's Environmental Outlook to 2030, OECD, 2008.

Policy context

Global and Pan-European policy context:
No international agreements exist for reduction of municipal waste generation.

EU policy context: 6th Community Environment Action Programme (Sixth Environment Action Programme) focuses on:

- Better resource efficiency and resource and waste management to bring about more sustainable production and consumption patterns, thereby decoupling the use of resources and the generation of waste from the rate of economic growth and aiming to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment.
- Achieving a significant overall reduction in the volumes of waste generated through waste prevention initiatives, better resource efficiency and a shift towards more sustainable production and consumption patterns.
- A significant reduction in the quantity of waste going to disposal and the volumes of hazardous waste produced while avoiding an increase of emissions to air, water and soil.
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Model used — OECD Model

The OECD model is based on two major models: JOBS and POLESTAR:

JOBS is a neo-classical equilibrium model that was initially constructed to asses economic impact of globalisation on individual regions of the world. JOBS is a version of LINKAGE model, used in OECD Linkages II project. The LINKAGE model was in turn derived from GREEN model that was used in series of analyses of policies to combat the Climate Change.

JOBS is designed for the analysis of dynamic scenarios, which are solved as a sequence of a static equilibria. The time periods are linked by exogenous population and labour supply growth, capital accumulation and productivity developments. The JOBS model is implemented with GAMS software, and includes flexible aggregation facility which may be set up to 50 sectors and 45 regions. For the OECD Environmental outlook it covers 26 sectors and 12 regions.

Sectors: rice, other crops, fisheries, livestock, forestry, minerals, coal, crude oil, natural gas extraction, petroleum and oil products, gas manufacture and distribution, electricity generation and distribution, meat from all types of animals, other food, chemicals, iron and steel, non-ferrous metals, wood products, pulp and paper publishing, motor vehicle manufacturing, other manufacturing, construction, water supply, trade and transport services, services, dwellings.

The production structure used in JOBs is presented at the Figure A1 of OECD Environmental outlook 2001, page 316. Input of the model — non-energy intermediate inputs, energy intermediate inputs, one category of labour, one type of capital and a natural resource factors used for the Forestry, Fisheries, Minerals, Coal, Natural Gas and Crude Oil Sectors. Demand, production and prices in all sectors and regions are determined simultaneously in JOBS. The assumed household income elasticities are among the important 'drivers' of the model. They reflect how much household demand for a given category of products will change when incomes change. The assumed substitution elasticities between various production factors are also important in determining simulation results. These elasticties tell how much the composition of factors use will change when the relative price between factors alters. The results from the JOBS model are fed into PoleStar framework with macroeconomic variables setting the scale of activities within the sectoral modules. Once the economic and demographic parameters have been entered, projections for environmental and resource pressured are developed.

PoleStar framework: Polestar is an accounting framework for combining economic, resource and environmental information to examine alternative development scenarios. The model algorithms and scenarios rely on an update on the Global Scenario Group's Bending the Curve scenarios (Raskin, *et al.*, 1998; Heaps, *et al*., 1998). The PoleStar System is applicable at national, regional and global scales. It allows customizing data structures, time horizons, and spatial boundaries — all of which can be changed in the course of an analysis. PoleStar is not a rigid model and it accepts information generated from formal models, from existing studies, or any other sources. PoleStar comes with an initial framework, the Basic Structure, which was modified so that the results from JOBS simulations could be used as drivers for environmental impacts simulated in the framework.

Polestar covers a number of issues including: energy, water resources, raw materials, agriculture, land use, solid waste generation and management, environmental loadings, income distribution and poverty.

More information about the Polestar Framework can be found http://www.wscsd.org/ejournal/article.php3?id_article=121.

Key model assumptions for the reference case: The base year data used in JOBS model were mostly taken from GTAP (Global Trade Analysis Project, Version 4) data base developed by Purdue University with 1995 as a base year. In addition to the base year data, assumptions are made in the Reference Scenario concerning:

- total GDP developments (based on OECD Economic Developments projections);
- population growth (based on UN median fertility estimations);
- labor supply (based on OECD Economic Developments projections and UN population data);
- supply and productivity of curtain agricultural inputs (based on OECD Agricultural Directorate analysis).

The assumptions on the assumed household income elasticities can be found in Annex 2 of the OECD Environmental outlook, 2001 (p.314). The *Reference Scenario* is based on Current activities and trends. It does not take into account the adoption or implementation of new policies. In the base year, waste generation rates in OECD regions, are based on data given in OECD Environmental Data Compendiums published by OECD in 1997 and 1999. In the remaining regions, waste generation rates in rural and urban areas are based on the default regional generation rates given in the report by Doorn M.R.J and M.A. Barlaz (1995) 'Estimate of Global Methane Emissions from landfills and Open Dumps' EPA 600/R-95-019 prepared for US Environmental Protection Agency Office of Research and Development. In the scenario, high-income OECD (including Europe) generation rates are, in accordance with developments over the last decade, assumed to increase at a slightly lower rate than GDP, while other regions converge toward the average rate in high-income OECD regions as income increase. For more information see OECD environmental outlook (2001) Annex 2 p.323.

References

OECD, 2001. *OECD environmental outlook.* Organisation for Economic Co-operation and Development, Paris. Description of the models and assumptions to the reference case are presented in the Annex 2, p. 313.

PoleStar framework: History, description of the model, software, publications, links.

Data specifications

Data set title	Source
Input data to JOBS model for economic projection, GDP, etc.	Global Trade Analysis Project, Version 4
Input data to PoleStar model — Waste generation rates in OECD regions	OECD Environmental Data 1997, 1999
Input data — waste generation rates in other regions	Doorn M.R.J and M.A. Barlaz (1995)
Outlook — Municipal waste generation from PoleStar model	OECD
Input data to the PoleStar model from the JOBS model — ecomomic development, GDP, level of urbanisation, etc.	OECD

Uncertainties

Methodology uncertainty
Uncertainties related to the models

Some selected limitations of the JOBs model: The model does not include the investment function which relates the overall level of investment to the expected rate of return. There is no forward-looking investment behavior incorporate in the model. Instead the value of investments in each year and region is equal to aggregate value of savings in the region. Aggregate savings in turn is derived from household behavior. *(should be investigated further)*

Limitations of the Polestar Framework: There is an important difference between Polestar and the global models introduced above: Polestar is not a dynamic simulation model, but static in the sense that all changes are introduced by the user. This provides on the one hand more flexibility to the user, but on the other hand, no checks for consistency or plausibility of the changes are done by the model.

Data uncertainty

1) OECD-countries: The base year data used for projections are taken from OECD Environmental Data Compendiums published by OECD in 1997 and 1999, for OECD countries. According to this source data is in some cases based on rough estimates and the projections bare these uncertainties.
Solid waste production is expensive to measure at source; thus, consistent and comparable statistics to feed the models are difficult to obtain. It is unclear whether the data sets for the model distinguish between toxic and hazardous wastes, and other; It is also uncler whether it covers waste stored on site. Sometimes it is confused with the amount of solid waste disposed, which is measured by recording the weight or volume of waste disposed at the disposal or treatment site.Volume of waste produced may be significantly affected by the presence of particular wastes. For example, the inclusion of construction wastes in domestic refuse will greatly affect the waste density and hence the indicator. The actual method of storage of waste and its moisture content will also affect the waste density. The volume of waste produced is often affected by seasonal variations in the production of various agricultural foodstuffs.

2) Non-OECD countries. The base year input data on waste generation in non-OECD countries come from Doorn M.R.J and M.A. Barlaz. For most countries, data on total waste in place are not available and had to be developed from waste generation rates. The total annual waste generation rate (Tg/yr) is obtained by multiplying Municipal waste generation rates with population data. Per capita MSW generation rates range from 1.7 to 1.9 kg/day for the U.S. and Canada. Per capita MSW generation rates in other developed countries are about 1.2 kg/day (also for Europe?). For developing countries, rates are about 0.8 kg/day for urban, and 0.3 kg/day for rural areas. Substantial uncertainty in the global estimates from this source results from a lack of data characterizing (1) country-specific waste generation, (2) waste management practices.

Rationale uncertainty
N/A.

Theme: Waste
Indicators: WMF_F03 — Municipal waste generation — outlook from EEA

Definition: The outlook indicator presents total municipal waste generation and by type of waste (paper and cardboard, glass, waste oils and used tires, packaging). It is expressed as index of waste generated in 2000. According to the definition from Eurostat municipal waste refers to waste collected by or on behalf of municipalities; the main part originates from households, but waste from commerce and trade, office buildings, institutions and small businesses is also included.

Model used: Waste and Material Flow model from EEA/ETC

Ownership: European Environment Agency (EEA)

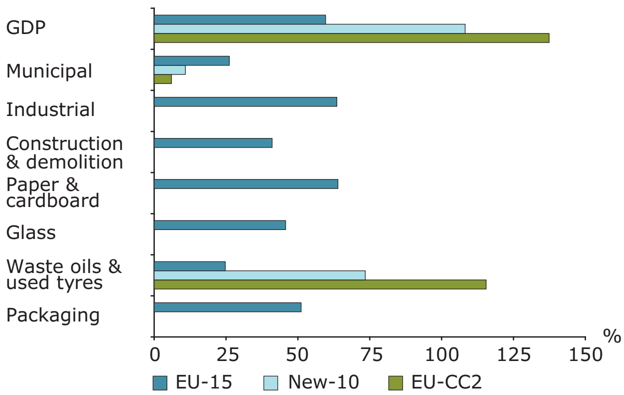
Temporal coverage: 2000–2020

Geographical coverage: EU-25: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Policy question

What are the prospects of reduction of municipal solid waste?

Growth in waste quantities and GDP (2020/2000) (ver. 1.00)



Source:
EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

In the EU-15, most municipal 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 for municipal wastes. AS municipal 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. The economic situation in Europe has a significant impact on municipal waste streams.

Note: The most recent assessment is available in EEA Briefing No 1/2008.

Policy context

Global and Pan-European policy context: No international agreements exist for reduction of municipal waste generation.

EU policy context: 6th Community Environment Action Programme (Sixth Environment Action Programme) focuses on:

- Better resource efficiency and resource and waste management to bring about more sustainable production and consumption patterns, thereby decoupling the use of resources and the generation of waste from the rate of economic growth and aiming to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment.
- Achieving a significant overall reduction in the volumes of waste generated through waste prevention initiatives, better resource efficiency and a shift towards more sustainable production and consumption patterns.
- A significant reduction in the quantity of waste going to disposal and the volumes of hazardous waste produced while avoiding an increase of emissions to air, water and soil.
- Encouraging reuse, and for wastes that are still generated: Preference should be given to recovery and especially to recycling.

EU Thematic Strategy on the Prevention and Recycling of Waste (2005). Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on Waste.

The European Neighborhood Policy prioritises waste management as one of the key area for cooperation.

EECCA policy context: *EECCA Environmental Strategy* encourages development of inter-sector waste management action plans; national capacity building for the environmentally sound management of hazardous waste; implementation of integrated systems of monitoring of waste transfers; development of economic mechanisms to facilitate implementation of cleaner technologies and waste prevention and minimization as well as governmental support for waste treatment facilities; development of efficient programs for waste management and management of chemical risks; promotion of development of an integrated system for inventory of waste generation and accumulation (e.g. Protocol on Pollutant Release and Transfer Registers — PRTR). (EECCA Environmental Strategy)

Model used — EEA/ETC WMF waste and material flows model

The EEA's European Topic Centre on Waste and Material Flows, in collaboration with the Riso National Laboratory, has developed a macro-econometric model that projects the generation of waste and materials flows at the national level. 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 tires are based on the 'car stock and end-of-life vehicles' vintage model developed by the Riso 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.

References

Skovgaard, M.; and Stephan Moll, S.; Andersen, F. M.; Larsen, H., 2005. *Outlook for waste and material flows. Baseline and alternative scenarios.* ETC/RWM working paper 2005/1.

Data specifications

Data set title	Source
Input data to Waste and Material Flows model — Population	DG TREN
Input data to Waste and Material Flows model — Average household size	DG TREN
Input data to Waste and Material Flows model — GDP	DG TREN
Input data to Waste and Material Flows model — Households expenditure	DG TREN
Input data to Waste and Material Flows model — Gross value added	DG TREN
Output data to Waste and Material Flows model — Waste municipal generation	EEA Waste Topic Center
Output data to Waste and Material Flows model — Biodegradable waste municipal generation	EEA Waste Topic Center

Uncertainties

Methodology uncertainty

There 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.

Data uncertainty

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.

Rationale uncertainty

N/A.

Theme: **Waste**

Indicators: **WMF_F04 — Generation and recycling of packaging waste — outlook from EEA**

Definition: Total packaging waste produced used in EU Member States. Recycling of packaging waste as a share of packaging used in EU Member States. The amount of packaging used is expected to equal the amount of packaging waste generated because of its short lifetime. This indicator shows generation of packaging waste.

Model used: Waste and Material Flow model from EEA/ETC

Ownership: European Environment Agency (EEA)

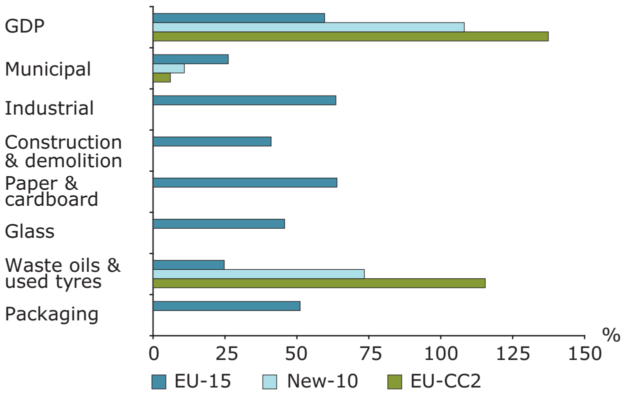
Temporal coverage: 2000–2020

Geographical coverage: EU-25: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Policy question

Are we preventing the generation of packaging waste?

Growth in waste quantities and GDP (2020/2000) (ver. 1.00)



Source:
EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

In the EU-15, most waste streams are expected to grow. Packaging waste is expected to increase on about 50 %. It I a bit less that industrial waste and paper and cardboard (about 64 %), but bigger than municipal waste (81) and waste oil and used tyres (about 25 %).

The results of the low economic growth variant suggest that the economic situation in Europe impacts significantly most of the waste streams, including packaging waste, with a decrease on average of about 15 %.

Policy context

Global policy context: No international agreements exist for reduction of municipal waste generation.

EU policy context: 6th Community Environment Action Programme (Sixth Environment Action Programme) focuses on:

- Better resource efficiency and resource and waste management to bring about more sustainable production and consumption patterns, thereby decoupling the use of resources and the generation of waste from the rate of economic growth and aiming to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment.
- Achieving a significant overall reduction in the volumes of waste generated through waste prevention initiatives, better resource efficiency and a shift towards more sustainable production and consumption patterns.
- A significant reduction in the quantity of waste going to disposal and the volumes of hazardous waste produced while avoiding an increase of emissions to air, water and soil.
- Encouraging reuse, and for wastes that are still generated: Preference should be given to recovery and especially to recycling.

EU Thematic Strategy on the Prevention and Recycling of Waste (2005). Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on Waste. Council Directive 94/62 of 15 December 1994 on packaging and packaging waste as amended by Directive 2004/12 of 11 February 2004 on packaging and packaging waste establishes targets for recycling and recovery of selected packaging materials (Directive 94/62/EC, packaging waste).

EECCA policy context: EECCA Environmental Strategy focuses on development of inter-sector waste management action plans.

Implementation of integrated systems of monitoring of waste transfers, development of economic mechanisms to facilitate implementation of cleaner technologies and waste prevention and minimization as well as governmental support for waste treatment facilities, development of efficient programs for waste management and management of chemical risks, promotion of development of an integrated system for inventory of waste generation and accumulation (EECCA Environmental Strategy)

Model used — EEA/ETC WMF waste and material flows model

The EEA's European Topic Centre on Waste and Material Flows, in collaboration with the Riso National Laboratory, has developed a macro-econometric model that projects the generation of waste and materials flows at the national level. 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 tires are based on the 'car stock and end-of-life vehicles' vintage model developed by the Riso 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.

References

Skovgaard, M.; and Stephan Moll, S.; Andersen, F. M.; Larsen, H., 2005. *Outlook for waste and material flows. Baseline and alternative scenarios.* ETC/RWM working paper 2005/1.

Data specifications

Data set title	Source
Output data to Waste and Material Flows model Packaging waste generation	EEA Waste Topic Center
Input data to Waste and Material Flows model Population	DG TREN
Input data to Waste and Material Flows model Average household size	DG TREN
Input data to Waste and Material Flows model Number of households	DG TREN
Input data to Waste and Material Flows model GDP	DG TREN
Input data to Waste and Material Flows model Households expenditure	DG TREN
Input data to Waste and Material Flows model Gross value added	DG TREN

Uncertainties

Methodology uncertainty
There 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.

Data uncertainty
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.

Rationale uncertainty
N/A.

Water

WQ_F01	**Use of freshwater resources — outlook from EEA**
WQ_F02	**Use of freshwater resources — outlook from UN SPECA**
WWEU_F01	**Urban wastewater treatment — outlook from EEA**
WWND_F01	**Floods and droughts — outlook from the University of Kassel**

Theme: Water

Indicators: WQ_F01 — Use of freshwater resources — outlook from EEA

Definition: The water exploitation index (WEI) is the annual total abstraction of freshwater divided by the annual total renewable freshwater resource, expressed in percentage terms. This indicator can be computed at the country level or, preferably, by river basin. A region is characterized as being under water stress, if it the water exploitation index exceeds 20 %, and under severe water stress if it exceeds 40 %. This indicator combines data on *water availability* and *water withdrawals*, and has thus also been referred to as withdrawals-to-availability index.

Alternatively, the underlying data can be used (i.e. data on water availability and water withdrawals for domestic use, industrial use, an agricultural use, respectively) to indicate separately:

The water availability index is defined as the average freshwater resources available per person in a country or river basins. Regions can be labelled as water scarce if this value drops below 1000 m^3 per person — however as the indicator uses population as a proxy for water uses it is less accurate.

Changes in annual water availability indicates the change in freshwater resources in a country or river basin over a given time period, primarily due to changes in upstream water use or climate change.
Changes in annual water abstraction indicates the change in water use in a country or river basin over a given time period.

Changes can be presented separately for different socio-economic activities, i.e. water for domestic use, for use in manufacturing and electricity production, and for agricultural purposes.

Model used: WaterGAP

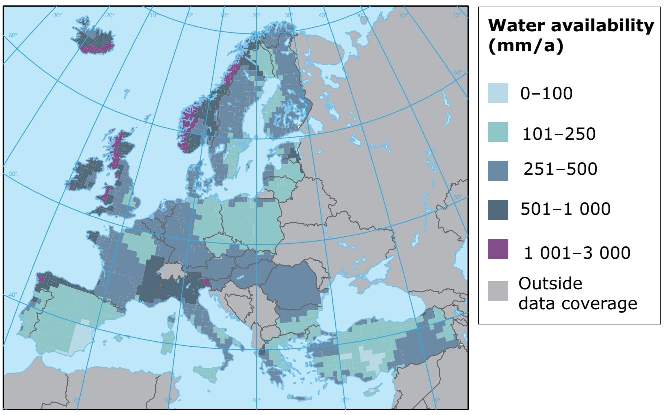
Ownership: European Environment Agency (EEA)

Temporal coverage: 2000–2030

Geographical coverage: Austria, Belgium, Denmark, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Liechtenstein, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Slovakia, Slovenia, United Kingdom.

Policy question

Is the abstraction rate of water use expected to be sustainable?



Source:
EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Example assessment from 2005

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 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.

Note: The most recent assessment can be found at IPCC (2007) Climate Change 2007: The Physical Science Basis c. eds. Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt K, Tignor MMB & Miller HL),. Working Group 1 Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Chapters 3 (Observations: Surface and Atmospheric Climate Change), 10 (Global Climate Projections), 11 (Regional Climate Projections).

Policy context

The indicator can be used to monitor a wide range of policies at global, regional and national levels. It provides, for example, the information on efficiency of water-use management plans.

Global policy context: At the global level problems of fresh water use and water stress are becoming ones of the most actual. The central aims were emphasized within UN 'Millennium Development Goals' (7th goal to ensure environmental sustainability) and include reduction of proportion people without access to safe drinking water.

Pan-European policy context: In 2002 the EU launched a Water Initiative (EUWI) designed to contribute to the achievements of the Millennium Development Goals (MDGs) and World Summit for Sustainable Development targets for drinking water and sanitation, within the context of an integrated approach to water resources management. The EUWI covers EU region as well as EECCA regions. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes was signed by 34 UNECE countries and the European Community. The Convention establishes main principles and rules for its Parties to develop and promote coordinated measures of sustainable use of water and related resources of transboundary rivers and international lakes, as well as of institutional mechanisms to be created for it. The UNECE Convention on the protection and Use of Transboundary Watercourses and International Lakes is an important instrument for the protection of freshwater resources and the development of transboundary water cooperation.

EU policy context: Achieving the objective of the EU's Sixth Environment Action Programme (2001–2010), to ensure that rates of extraction from water resources are sustainable over the long term, requires monitoring of the efficiency of water use in different economic sectors at the national, regional and local level. The WEI is part of the set of water indicators of several international organisations such as UNEP, OECD, Eurostat and the Mediterranean Blue Plan. There is an international consensus about the use of this indicator.

The indicator describes how the total water abstractions put pressure on water resources identifying those countries having high abstractions in relation to their resources and therefore prone to suffer water stress. The changes in WEI help to analyse how the changes in abstractions impact on the freshwater resources by adding pressure to them or by making them more sustainable.There is a number of agreements relate to European river water use management, for example of the oldest one is the International Commission for the Protection of the Rhine (ICPR). (Basel on July 11, 1950).

EECCA policy context: EECCA Environmental Strategy promotes sustainable water use based on long-term projection of available water resources. It sets goals to improve quality of waters (ecological, chemical) in national level as well in regional through the developed management of municipal water supply and sanitations. Also, the EECCA environment strategy has actions on development and implementation of integrated water management programmes based on river basin principles.Some sub-regional policies aim to stimulate development and implementation of action plans to improve water resource management systems.

A regional Cooperation strategy to promote the rational use and conservation of water resources in Central Asia focus on the sustainable use of freshwater in the Aral Sea Water Basin. The strategy helps to support achievability of targets set in the Aral Sea Basin Water Vision 2025 developed with support from UNESCO (SABAS vision). The document provides recommendations for water distribution, particularly within agriculture sector, as well as an accent on improving hydro electricity technologies with 'less losses of water' over the 2025 horizon.

Model used — 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.

References

Alcamo, J.; Doell, P.; Henrichs, T.; Kaspar, F.; Lehner, B.; Roesch, T.; and Siebert, S., 2003: Development and testing of the WaterGAP2 global model of water use and availability. *Hydrological Sciences Journal* 48(3): 317–337.

Floerke, M.; and Alcamo, J., 2004. *European Outlook on Water Use*. Center for Environmental Systems Research — University of Kassel, Final Report, EEA/RNC/03/007.

Data specifications

Data set title	Source
Input data to WaterGAP model — climate projections — output from ECHAM4/OPYC3 model data	The IPCC Data Distribution Centre
Input data to WaterGAP model — climate projections — output from HadCM3 model data	Hardley Centre for Climate Prediction and Research
Input data to WaterGAP model — population growth — output from UNSTAT data, medium scenario	United Nations Statistics Division
Input data to WaterGAP model — population distribution — output from CIESIN data	The Center for International Earth Sciences Information Network (CIESIN)
Input data to WaterGAP model — electricity production — output from IMAGE 2.1 data	The National Institute for Public Health and the Environment
Input data to WaterGAP model — GDP growth — output from IMAGE 2.1 data	The National Institute for Public Health and the Environment
Input data to WaterGAP model — irrigated area — output from digital map provided by Siebert and Döll (2001)	
Output data from WaterGAP — Water availability and water withdrawals, water exploitation index	

Uncertainties

Methodology uncertainty

Floerke and Alcamo (2004) presented a list of some of the main factors determining water use that are particularly uncertain in the European version of WaterGAP. In general, these also hold true for the global version.

Domestic — In most European countries the relationship between future income and water use seems to be well defined. However, in a countries undergoing a major economic transition, it is not possible to define a reliable relationship between income and water use. Another source of uncertainty in estimating future water use in the domestic sector is the future population of water users.

Manufacturing — The water use intensity of different industries is a major uncertainty in most countries. But perhaps more important is the water use of industries that are not now important but will become important over the next 30 years. Key questions are, what will these industries be and how much water will they use?

Electricity Production — Major uncertainties in this sector are the use lifetime of power stations, the percentage of new power stations having tower versus once-through cooling, and their future geographic location. Also important is the uncertainty of future thermal electricity production, and general electricity production trends.

Agriculture — Major unknowns in the agriculture sector are the future extent of irrigated crops, the types of crops to be irrigated, and future climate conditions.

Additional to the above, the uncertainty of the model's estimates on future water availability depend much on the reliability of the land use and climate data used.

Data uncertainty

See above 'methodological uncertainties'.

Additionally, data on current and past water use need to be considered with reservation due to the lack of common European definitions and procedures for calculating water abstraction and freshwater resources. For some countries in the European, Caucasus and Central Asia no reliable time series on water use by sector exist.

These data uncertainties affect model calibration and are propagated through to the modelled results.

Rationale uncertainty

Water stress indicators give an aggregate measure of the pressures that anthropogenic water use places on freshwater resources and related environmental systems. While this a good first categorization of water stress in different countries and river basins, this approach is not likely to be precise in distinguishing the different reasons of water stress due to data and model uncertainty.

It should be stressed, that this water stress indicator is calculated solely based on quantitative information and does not directly address water quality issue. Nevertheless it has been argued that high quantitative water stress values often also imply some qualitative water stress.

While higher levels of water stress often coincide with higher frequency in droughts, no direct relationship exists. Thus this indicator should only be used with care when addressing assessing droughts (although, with some methodological modifications this can, and has been, done).

Please note that water stress indicators are most useful when presented at the river basin scale, as country values are at risk of missing water stress prone river basins due to averaging. Thus any water stress indicator should always (also) be reported at the river basin level, if possible.

Theme: Water

Indicators: WQ_F02 — Use of freshwater resources — outlook from UN SPECA

Definition: The outlook presents projected water demand in Aral Sea Basin by sectors: drinking water supply, industry, fisheries, irrigation and farming, other. It also presents percentage change in the volume of water resources for two rivers of Aral Sea Basin (Syr Darya and Amu Darya) and projected percentage change in water use.

Model used: SPECA, SABAS

Ownership: United Nations Special Programme for Economies of the Central Asia (UN SPECA)

Temporal coverage: 2005–2025

Geographical coverage: Kazakhstan, Turkmenistan, Uzbekistan, Kyrgyzstan and Tajikistan.

Policy question

Is the abstraction rate of water use expected to be sustainable?

		Economic sector						
Country	**Years**	**Drinking water supply**	**Water supply in rural areas**	**Industry**	**Fisheries**	**Irrigation farming***	**Other**	**Total, km³**
Kazahkstan	2005	0.08	0.07	0.075	0.065	9.5	0.21	10
	2010	0.14	0.1	0.12	0.15	9.5	0.5	10.51
	2025	0.16	0.12	0.29	0.17	7.45	0.5	9.29
Kyrgyzstan**	2005	0.08	0.09	0.15	0.03	5.54	0.01	5.9
	2010	0.1	0.11	0.2	0.04	3.02	0.03	6.5
	2025	0.14	0.15	0.3	0.05	6.8	0.06	7.5
Tajikistan***	2005	0.5	0.75	0.65	0.1	11.9	0.4	14.3
	2010	0.7	0.9	0.8	0.15	13.15	0.3	16
	2025	1	1.1	1	0.2	14.5	0.2	18
Turkmenistan	2005	0.37	0.19	0.75	0.025	18	0	19.335
	2010	0.4	0.2	0.9	0.03	20	0	21.53
	2025	0.47	0.25	1.1	0.04	17.65	0	19.51
Uzbekistan	2005	2.65	1.39	1.35	1.05	56.56	0	63
	2010	2.7	1.4	1.39	1.32	52.4	0	59.2
	2025	5.85	1.63	1.46	2.24	48.02	0	59.2
Total in Aral Sea Basin	2005	3.68	2.49	2.975	1.27	101.5	0.62	112.535
	2010	4.04	2.71	3.41	1.69	101.07	0.83	113.75
	2025	7.62	3.25	4.15	2.7	94.42	0.76	112.9

* Irrigation volumes calculated taking into account efficiency ratios of main canals (on the borders between districts).

** Data from national reports prepared for the SPECA project.

*** In Tajikistan, according to its 2001 guidelines for the sound use and protection of water resources, expected total water use in 2005 may be about 20 km³.

Source:

UN SPECA, 2002. *Diagnostic report on water resources in Central Asia, United Nations Special Programme for Economies of the Central Asia*.

Example assessment from 2004

Three countries (Kazakhstan, Turkmenistan and Uzbekistan) in the lower part of the watershed, are aiming to stabilise long term water use, primarily through water conservation. The other two (Kyrgyzstan and Tajikistan) are planning for long-term growth in water use and are, therefore, proposing to start negotiations on a review of principles and practical arrangements regarding water allocation in Central Asia, in accordance with the decision taken in 1994 by the heads of Central Asian States.

The Scientific-Information Center of the Interstate Coordination Water Commission of the Central Asia offered its own version of long term water use development, which is based on a UNDP model and makes the assumption of a positive development of the regional economy (maintenance of low population growth, accelerated GDP growth, and a water use efficiency of up to 80 % of its potential maximum.

Policy context

The indicator can be used to monitor a wide range of policies at global, regional and national levels. It provides, for example, the information on efficiency of water-use management plans.

Global policy context: At the global level problems of fresh water use and water stress are becoming ones of the most actual. The central aims were emphasized within UN 'Millennium Development Goals' (7th goal to ensure environmental sustainability) and include reduction of proportion people without access to safe drinking water.

Pan-European policy context: In 2002 the EU launched a Water Initiative (EUWI) designed to contribute to the achievements of the Millennium Development Goals (MDGs) and World Summit for Sustainable Development targets for drinking water and sanitation, within the context of an integrated approach to water resources management. The EUWI covers EU region as well as EECCA regions. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes was signed by 34 UNECE countries and the European Community. The Convention establishes main principles and rules for its Parties to develop and promote coordinated measures of sustainable use of water and related resources of transboundary rivers and international lakes, as well as of institutional mechanisms to be created for it. The UNECE Convention on the protection and Use of Transboundary Watercourses and International Lakes is an important instrument for the protection of freshwater resources and the development of transboundary water cooperation.

EU policy context: Achieving the objective of the EU's Sixth Environment Action Programme (2001–2010), to ensure that rates of extraction from water resources are sustainable over the long term, requires monitoring of the efficiency of water use in different economic sectors at the national, regional and local level. The WEI is part of the set of water indicators of several international organisations such as UNEP, OECD, Eurostat and the Mediterranean Blue Plan. There is an international consensus about the use of this indicator.

The indicator describes how the total water abstractions put pressure on water resources identifying those countries having high abstractions in relation to their resources and therefore prone to suffer water stress. The changes in WEI help to analyse how the changes in abstractions impact on the freshwater resources by adding pressure to them or by making them more sustainable.

There is a number of agreements relate to European river water use management, for example of the oldest one is the International Commission for the Protection of the Rhine (ICPR). (Basel on 11 July 1950).

EECCA policy context: EECCA Environmental Strategy promotes sustainable water use based on long-term projection of available water resources. It sets goals to improve quality of waters (ecological, chemical) in national level as well in regional through the developed management of municipal water supply and sanitations. Also, the EECCA environment strategy has actions on development and implementation of integrated water management programmes based on river basin principles.

Some sub-regional policies aim to stimulate development and implementation of action plans to improve water resource management systems.

A regional Cooperation strategy to promote the rational use and conservation of water resources in Central Asia focus on the sustainable use of freshwater in the Aral Sea Water Basin. The strategy helps to support achievability of targets set in the Aral Sea Basin Water Vision 2025 developed with support from UNESCO (SABAS vision). The document provides recommendations for water distribution, particularly within agriculture sector, as well as an accent on improving hydro electricity technologies with 'less losses of water' over the 2025 horizon.

Model used for indicators calculation — UN SPECA model

Water demand (the abstraction of fresh water including for irrigation operations): These projections are based on estimates of water demand from past trends. The estimates are calculated based on national economic development programmes for each country. However such estimates were made only in the Kyrgyz and Tajik national reports for the SPECA project — UN Special Program for Economies of the Central Asia (i.e. policy initiatives). Other estimates were made from projections made in the draft Programme for the Aral Sea Basin, and from calculations based on a model prepared by the SABAS group for a United Nations Development Programme (UNDP) project. Two models provide estimates for the expected water demand in the Aral Sea basin (km^3/year) one is from the SPECA model, the other the SABAS model. The models provide estimates for 2005, 2010 and 2025 from Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The SPECA model also project the water demand for different economic sectors, i.e. drinking water supply, water supply in rural areas, industry, fisheries, irrigation farming and other sectors.

Changes in water availability and water use: Quantitative forecasts used by SPECA are based on various organizations on changes in water reserves and their use yield with significantly different results. Provides forecasts based on the water use model CROP WAT used by the Food and Agriculture Organization of the United Nations (FAO), and the following models of the development of climate change: The Geophysical Fluid Dynamics Laboratory (GFDL) model; The Goddard Institute for Space Studies (GISS) model; The UK Meteorological Office (UKMO) model; The Canadian Climate Center (CCCM) model.

Key model assumptions:

- for short-term forecasts provided by SPECA: economic stabilisation, with the financial and economic situation of all countries approaching a certain sustainable level.
- for medium-term forecasts provided by SPECA: during this period, the economic situation in

the region may change for the better, with all economic indicators returning to their 1990 levels.

- for long-term forecasts provided by SPECA: based on the most efficient use of water resources as well as optimal and mutually beneficial arrangements for regional cooperation.
- for long-term forecast provided by SIC ICWC (SABAS): is based on a UNDP model and makes the assumption of a positive development of the regional economy (maintenance of low population growth, accelerated GDP growth, and a water use efficiency of up to 80 % of its potential maximum).

References

UN SPECA, 2004. *Diagnostic report on energy resources in Central Asia.* UN Special Programme for Economies in Central Asia.

Data specifications

Data set title	Source
N/A.	N/A.

Uncertainties

Methodology uncertainty
N/A.

Data uncertainty
N/A.

Rationale uncertainty
No uncertainty has been specified.

Theme: Water

Indicators: WWEU_F01 — Urban wastewater treatment — outlook from EEA

Definition: Percentage of population connected to primary, secondary and tertiary wastewater treatment plants. The indicator illustrates:

1. current level and future changes in level (accordingly UWWT directive) of population connected to urban wastewater treatment (primary, secondary and tertiary);
2. current level and future changes (accordingly UWWT directive) of discharges of nitrogen and phosphorous from wastewater treatment plants.

Model used: Water Model from EEA/ETC

Ownership: European Environment Agency (EEA)

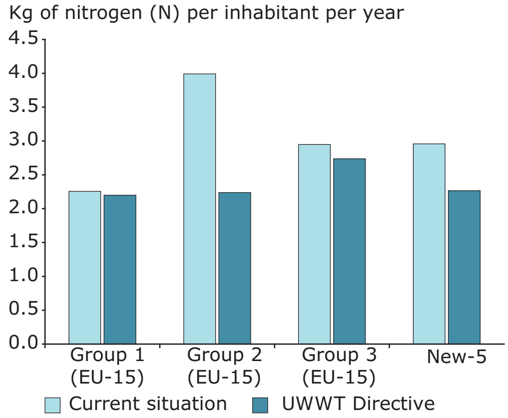
Temporal coverage: 2005, 2008–2015 (objectives of the UWWT Directives)

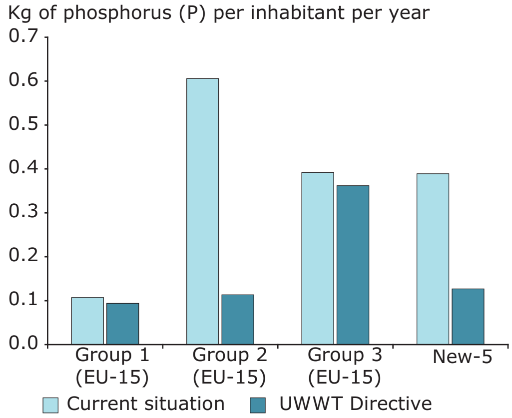
Geographical coverage: EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom; **EU-5:** Estonia, Hungary, Czech Republic, Poland, Slovenia.

Policy question

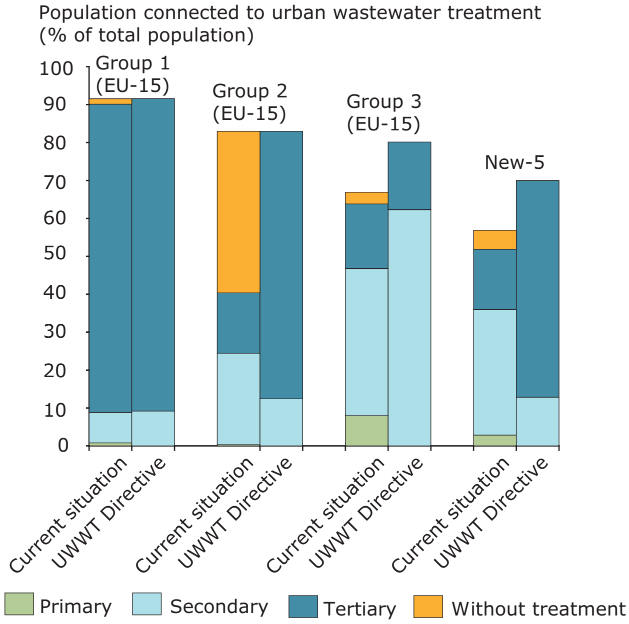
How effective are existing policies in reducing loading discharges of nutrients and organic matter?

Discharges of nitrogen and phosphorous from wastewater treatment plants





Current and projected levels of wastewater treatment in Europe



Example assessment from 2005

By increasing the connection rate of the European population and the use of tertiary treatment, implementation of the UWWT (Urban Wastewater Treaatment) 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).

Source:

EEA, 2005. *European environment outlook.* EEA Report No 4/2005. European Environment Agency, Copenhagen.

Policy context

The indicator can be used to monitor a wide range of policies at global, regional and national levels. It provides, for example, the information on efficiency of water-use management plans.

Global policy and Pan-European policy context: Indirectly the indicator can be useful within UN Millennium Development Goals and with the WSSD Plan of Implementation to ensure access to adequate drinking water and sanitation services (UN 'Millenium Development Goals').

EU policy context: The Urban Wastewater Treatment Directive (UWWT) prescribes the level of treatment required before discharge. It requires Member States to provide all agglomerations of more than 2 000 population equivalents (p.e.) with collecting systems. Secondary treatment (i.e. biological treatment) must be provided for all agglomerations of more than 2 000 p.e. discharging into fresh waters. Special requirements with intermediate deadlines depending on the sensitivity of the receiving waters are placed on agglomerations of more than 10 000 p.e. with various size classes of agglomerations. The performance of the treatment is assessed using 5 different determinants (BOD, COD, TSS, Ntot and Ptot). In the 15 Member States, there are about 20 000 agglomerations with more than 2 000 p.e., the population is 376 million inhabitants and the treatment capacity for the 8 181 agglomerations for which Member States provided detailed data is equivalent to organic matter from 469 million p.e.

For agglomerations smaller than described above and those equipped with a collecting system, the treatment must be appropriate, meaning that the discharge allows the receiving waters to meet the relevant quality objectives.

The WFD is asking for the estimation and identification of significant point and diffuse source pollution, in particular by substances listed in Annex VIII, from urban, industrial, agricultural and other installations and activities, based, inter alia, on information gathered under Articles 15 and 17 of Directive 91/271/EEC and other Directives. From the substances listed in the Annex VIII, the following are important for the indicator: substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.), materials in suspension, and substances which contribute to eutrophication (in particular, nitrates and phosphates). Member States should thus take the necessary steps to build a data collection system able to provide these data, urban source being one of the sources listed. The ultimate aim of this is to reach the target of the WFD that is a good chemical and biological status for all waters in 2015, the discharge of substances being one of the major problems to face. (Implementation of Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment, as amended by Commission Directive 98/15/EC of 27 February 1998).

EECCA policy context: EECCA Environmental Strategy reveals main efforts in the region to improve quality of water and wastewater collection through more effective institutional and regulatory framework. (EECCA Environmental Strategy).

Model used — EEA/ETC Water model

The methodology used consists of a simple techno-economic model developed by EEA European Topic Centre on Water in 2004, which links discharges of nutrients to population growth in areas connected to sewers and to developments in treatment technologies. The model 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 wastewater treatment directive (UWWT, 91/271/EEC) is fully implemented. The future wastewater treatment in Cyprus and Malta is uncertain.

Calculating future wastewater treatment and discharge from wastewater treatment plants are based on information on:

$Nutrient_{capita}$: nutrient (N and P) load by wastewater per capita and year

POP: population;

$\%POP_{connectedWWT}$: percentage of population connected to sewers, and water has a retention percentage equal to zero.

A simple formula is used for calculations above:

$Emissions = Nutrient_{capita} * POP * \%POP_{connectedWWT}$

$*(1-(\%retention/100)$.

More detailed information is available at: http://scenarios.ewindows.eu.org/reports/fol949029/fol040583/Water_quality_final_report.pdf.

References

Kristensen, P.; Fribourg-Blanc, B.; and Nixon, S., 2004. *Outlooks on Nutrient Discharges in Europe from Urban Wastewater Treatment Plants, Final Draft.* EEA European Topic Centre on Water. Available online at: http://scenarios.ew.eea.europa.eu/reports/fol949029/fol040583/Water_quality_final_report.pdf.

Data specifications

N/A.

Uncertainties

Methodology uncertainty

There is a lot of uncertainty about the actual implementation of the UWWT Directive in the individual countries. In the projections an assumption has been made that all agglomerations greater than 10000 p.e. discharging into sensitive areas will have tertiary treatment and other agglomerations greater than 2000 p.e. will have at least secondary. The category at least *secondary treatment* cannot be handled in quantitative projections so at least secondary treatment was set to *secondary treatment*. Countries may decide to have better treatment than required by the Directive. For countries with already high wastewater treatment the future WWT was set to the current level of WWT, however, information in national and regional SoE reports indicate that they are still upgrading there WWT plants.

There is an acknowledged important risk that the simplified calculations of future wastewater treatment presented in the methodology might be in conflict with the more detailed national assessment.

Data uncertainty

First the current data and information on wastewater treatment and population living in different sizes of agglomerations are limited. This makes it necessary to make assumptions with limited information available.

Secondly the information on the current level of wastewater treatment is for some countries uncertain and inconsistent. The missing and uncertain data markedly reduce the number of countries for which the wastewater treatment before and after can be compared with a sufficient confidence.

Rationale uncertainty

N/A.

Theme: **Water**

Indicators: **WWND_F01 — Floods and droughts — outlook from the University of Kassel**

Definition: According to WaterGAP model the indicator 'floods and droughts' provides the following objects:

- Drought events and deficit volumes are presented in the form of the **drought frequency distributions.** Within this indicator the concept of river flow drought (or hydrological drought) is adopted.
- Floods are presented in the form of the **flood frequency distributions or flood discharges.** Flood is defined strictly in terms of discharge. To answer to what extent a given discharge value is related to a real *flooding*, in terms of bursting river banks and setting a considerable area under water, in particular a high-resolutions elevation model is required.

Model used: WaterGAP

Ownership: University of Kassel

Temporal coverage: 1961–1990, 2020, 2070

Geographical coverage: Austria, Belgium, Denmark, Cyprus, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Liechtenstein, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Slovakia, Slovenia, United Kingdom

Policy question

In which European river basins can we expect a significant increase or severity of drought or flood events due to global change (including climate change)?

Example assessment from 2001

Floods: The region most prone to a rise in river flood frequencies is North-Eastern Europe, i.e. Sweden, Finland and Russia, with increases of 100-year flood discharges of over 25 % (today's 100-year floods would return every 10 years). Central and Southern Europe show a decreasing trend in future flood frequencies. Some smaller regions like the Wisla basin in Poland, the Irish Island or Portugal show indications for a rise in flood risk. For some regions like Italy or Greece, the two climate scenarios lead to contradictory results, allowing for no conclusions but rather reflecting the uncertainties of the model calculations.

Draughts: North and smaller parts of Central Europe (Germany, Alps) show a decreasing trend in future drought frequencies. The regions most prone to a rise in hydrological drought frequencies are Southern Europe, i.e. Portugal, Spain, Western France and Western Turkey, as well as parts of East-Central Europe, i.e. the Wisla basin in Poland, with increases of 100-year deficit volumes of over 25 % (today's 100-year droughts would return every 10 years). Also areas like Great Britain, Italy, Greece, the Balkan region and large areas in East-Central Europe show indications for a rise in drought risk.

Note:

The most recent assessment is available in EEA Report No 4/2008: *Impacts of Europe's changing climate — 2008 indicator-based assessment.* Joint EEA-JRC-WHO report (September 2008).

Source:

Floerke, M.; and Alcamo, J., 2004. *European Outlook on Water Use.* Center for Environmental Systems Research — University of Kassel, Final Report, EEA/RNC/03/007.

Policy context

Global policy context: At the global level problems of fresh water use and water stress are becoming ones of the most actual. The central aims were emphasized within UN 'Millennium Development Goals' (7th goal to ensure environmental sustainability) and include reduction of proportion people without access to safe drinking water.

Pan-European policy context: In 2002 the EU launched a Water Initiative (EUWI) designed to contribute to the achievements of the Millennium Development Goals (MDGs) and World Summit for Sustainable Development targets for drinking water and sanitation, within the context of an integrated approach to water resources management. The EUWI covers EU region as well as EECCA regions. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes was signed by 34 UNECE countries and the European Community. The Convention establishes main principles and rules for its Parties to develop and promote coordinated measures of sustainable use of water and related resources of transboundary rivers and international lakes, as well as of institutional mechanisms to be created for it. The UNECE Convention on the protection and Use of Transboundary Watercourses and International Lakes is an important instrument for the protection of freshwater resources and the development of transboundary water cooperation.

EU policy context: Achieving the objective of the EU's Sixth Environment Action Programme (2001–2010), to ensure that rates of extraction from water resources are sustainable over the long term, requires monitoring of the efficiency of water use in different economic sectors at the national, regional and local level. The WEI is part of the set of water indicators of several international organisations such as UNEP, OECD, Eurostat and the Mediterranean Blue Plan. There is an international consensus about the use of this indicator. The indicator describes how the total water abstractions put pressure on water resources identifying those countries having high abstractions in relation to their resources and therefore prone to suffer water stress. The changes in WEI help to analyse how the changes in abstractions impact on the freshwater resources by adding pressure to them or by making them more sustainable. There is a number of agreements relate to European river water use management, for example of the oldest one is the International Commission for the Protection of the Rhine (ICPR). (Basel on July 11, 1950).

EECCA policy context: EECCA Environmental Strategy promotes sustainable water use based on long-term projection of available water resources. The EECCA environment strategy has actions on development and implementation of integrated water management programmes based on river basin principles. Some sub-regional policies aim to stimulate development and implementation of action plans to improve water resource management systems. A regional Cooperation strategy to promote the rational use and conservation of water resources in Central Asia focus on the sustainable use of freshwater in the Aral Sea Water Basin. The strategy helps to support achievability of targets set in the Aral Sea Basin Water Vision 2025 developed with support from UNESCO (SABAS vision). The document provides recommendations for water distribution, particularly within agriculture sector, as well as an accent on improving hydro electricity technologies with 'less losses of water' over the 2025 horizon.

Number of transboundary rivers negotiations focus on sustain river's water use and are implemented for such river basins as Neman (Nemanus) and Western Dvina (Daugava); also for Dniester between Ukraine and Moldova.

Model used for indicators calculation — WaterGAP model

Indicators of flood and drought frequency distribution are calculated using the WaterGAP model (Water: Global Assessment and Prognosis; sversion 2.1). This is a global model that computes both water availability and water use on the river basin scale.

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 model uses both land use and climate data at a 0.5 x 0.5 degree latitude-longitude grid. Thus it can compute water availability for both past and present temperature and precipitation regimes, as well as using output from climate models for expected future conditions. A drainage direction map then allows the analysis of the water resources situation (including water stress) in all larger river basins. This methodology allows calculating water related indicators both on the country level and on the river basin scale, depending on what is more relevant to address specific policy questions.

A more detailed version of the model exists for EEA member states (except Iceland). Compared with the global version, the European model sees (i) improved country-level calibration for domestic water use, based on better abstraction data available in this region; (ii) the use of a data on the geographical explicit location of power station and their cooling water requirements; and (iii) estimates of water use for manufacturing presented separately for six water intensive industrial activities.

In order to derive today's and future drought and flood frequency distributions, the following procedure is applied in the same manner to all cells of the WaterGAP grid, as well as, for evaluation purposes, to the data of selected gauging stations:

For drought frequency distribution:

- Monthly discharge values are applied. This temporal resolution is used as

  a) the month is the usual time unit for river flow drought studies;
  b) WaterGAP is based on monthly climate data.

- A drought event is defined to start when the discharge falls below the threshold value and to end when the discharge exceeds the threshold. The deficit volume (or severity) of a such identified drought event is calculated by accumulating the monthly differences between threshold and actual discharge values over time.

- The frequently used median of monthly discharges, here calculated from the time series 1961–90, is applied as a constant threshold value for all data over time (both for today's calculations and for the future).
- The annual maximum series of drought deficit volumes is chosen.
- As drought calculations generally require long discharge series, the 30-year series 1961–90 is applied to calculate today's droughts (data before 1961 is considered increasingly uncertain). For the future scenarios, 30-year projections are applied (i.e. 2011–40 for the 2020s, 2061–91 for the 2070s; for more details on deriving the climate scenarios see http://www.usf.uni-kassel.de/usf/archiv/dokumente/kwws/5/ew_4_baselinea_low.pdf).
- In order to finally derive drought frequency probabilities, the commonly used Log-Pearson Type III distribution is fitted to the ranked annual maximum series. This leads to a statistical distribution function which can be inter- and extrapolated.

For flood frequency distribution:

- Daily discharge values (WaterGAP provides daily output) are applied. This temporal resolution is used as

  a) a longer time step is considered not appropriate for flood calculations,

  b) the day is the highest temporal resolution for which WaterGAP calculations are conceptually designed (e.g. pseudo-daily rainfall and temperature values are derived from given monthly averages), and

  c) no higher-resolution measurement data is available on a global scale for evaluation purposes.

- The annual maximum discharge series is chosen.
- As flood calculations generally require long discharge series, the 30-year series 1961–90 is applied to calculate today's floods (data before 1961 is considered increasingly uncertain). For the future scenarios, 30-year projections are applied (i.e. 2011–40 for the 2020s, 2061–91 for the 2070s; for more details on deriving the climate scenarios see: http://www.usf.uni-kassel.de/usf/archiv/dokumente/kwws/5/ew_4_baselinea_low.pdf).
- In order to finally derive flood frequency probabilities, the commonly used Log-Pearson Type III distribution is fitted to the ranked annual maximum series. This leads to a statistical distribution function which can be inter- and extrapolated.

References

Alcamo, J.; Doell, P.; Henrichs, T.; Kaspar, F.; Lehner, B.; Roesch, T.; and Siebert, S., 2003: Development and testing of the WaterGAP2 global model of water use and availability. *Hydrological Sciences Journal* 48(3): 317–337.

Floerke, M.; and Alcamo, J., 2004. *European Outlook on Water Use*. Center for Environmental Systems Research — University of Kassel, Final Report, EEA/RNC/03/007.

Data specifications

Data set title	Source
Input data to WaterGAP model — GDP growth — output from IMAGE 2.1 data	The National Institute for Public Health and the Environment
Input data to WaterGAP model — climate projections — output from ECHAM4/OPYC3 model data	The IPCC Data Distribution Centre
Input data to WaterGAP model — climate projections — output from HadCM3 model data	Hardley Centre for Climate Prediction and Research
Input data to WaterGAP model — electricity production — output from IMAGE 2.1 data	The National Institute for Public Health and the Environment
Input data to WaterGAP model — irrigated area — output from digital map provided by Siebert and Döll (2001)	Input data to WaterGAP model — irrigated area — output from digital map provided by Siebert and Döll (2001)
Input data to WaterGAP model — population growth — output from UNSTAT data, medium scenario	United Nations Statistics Division
Input data to WaterGAP model — population distribution — output from CIESIN data	the Center for International Earth Sciences Information Network (CIESIN)
Output data from WaterGAP — Flood and drought frequency distribution	

Uncertainties

Methodology uncertainty

List of uncertainties is presented below and particularly can be found in 'Data uncertainty'.

- Baseflow. The accuracy of the baseflow modeled by WaterGAP, however, is not fully evaluated yet as WaterGAP was originally developed for estimating long-term averages where the temporally explicit calculation of the baseflow component was only of secondary interest.
- Within this study only extrapolations up to 200–year droughts are analyzed as, when looking at the model and data uncertainties described above, any statements on more extreme events are not considered justified.
- For the drought frequency calculations the annual maximum series of drought deficit volumes is chosen. Thus, for every year the highest occurring deficit volume is selected. With this simple approach, however, multi-year droughts might be picked more than once.

Except aforementioned uncertainties Floerke and Alcamo (2004) presented a list of some of the main factors determining water use that are particularly uncertain in the European version of WaterGAP. In general, these also hold true for the global version.

Domestic — In most European countries the relationship between future income and water use seems to be well defined. However, in a countries undergoing a major economic transition, it is not possible to define a reliable relationship between income and water use. Another source of uncertainty in estimating future water use in the domestic sector is the future population of water users.

Manufacturing — The water use intensity of different industries is a major uncertainty in most countries. But perhaps more important is the water use of industries that are not now important but will become important over the next 30 years. Key questions are, what will these industries be and how much water will they use?

Electricity Production — Major uncertainties in this sector are the use lifetime of power stations, the percentage of new power stations having tower versus once-through cooling, and their future geographic location. Also important is the uncertainty of future thermal electricity production, and general electricity production trends.

Agriculture — Major unknowns in the agriculture sector are the future extent of irrigated crops, the types of crops to be irrigated, and future climate conditions.

Additional to the above, the uncertainty of the model's estimates on future water availability depend much on the reliability of the land use and climate data used.

Data uncertainty

Land cover: Although in principle WaterGAP is able to take into account the impact of changing land cover on runoff generation via its direct or indirect effect on root depth, albedo, soil moisture and interception, all following low flow calculations are performed without a change in land cover or land use. This is mainly due to the absence of realistic, reliable macroscale land use change scenarios, which are expected to be available at a later stage. For the interpretation of the results, this simplification has to be considered.

Wetlands, lakes and reservoirs: Although WaterGAP 2.1 distinguishes between lakes, reservoirs and wetlands, at present a rather simple non-linear storage approach is applied for all freshwater storage as no further data on reservoir control or retention behavior is available. As a consequence, WaterGAP will locally underestimate the possible human influence of drought mitigation. Also, there is no information on existing or planned canals for flow diversion implemented in the model. As a consequence, WaterGAP will locally underestimate the possible human influence of flood control.

Additionally, data on current and past water use need to be considered with reservation due to the lack of common European definitions and procedures for calculating water abstraction and freshwater resources. For some countries in the European, Caucasus and Central Asia no reliable time series on water use by sector exist.

These data uncertainties affect model calibration and are propagated through to the modeled results.

Rationale uncertainty

It should be noted, that in this indicator definition a flood is defined strictly in terms of discharge. To what extent a given discharge value is related to a real flooding, in terms of bursting river banks and setting a considerable area under water, is a complex question. To answer it, additional information would be required, in particular a high-resolution elevation model. These data are currently not available on a continental scale. However, knowing the frequencies and volumes of extreme flows is a step towards assessing the risks of river floods.

Within this indicator's definition the concept of river flow drought (or hydrological drought) is adopted. Still, for any drought study a consistent definition is important. The following categories of droughts are frequently used (Tate and Gustard, 2000): a) climatological drought (deficit in precipitation); b) agro-meteorological drought (deficit in soil water); c)river flow drought (deficit in river discharge); d) groundwater drought (deficit in groundwater storage); e) operational drought (conflict of water shortage and water management demands). However, there is no universally accepted definition of drought (Tate and Gustard, 2000).

Socio-economic

Theme: Socio-economic
Indicators: SE_F01 — GDP — outlook from OECD

Definition:
Gross domestic product (GDP) is the sum of gross value added by all resident producers in an economy, plus any product taxes, minus all subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets and degradation of natural resources. It is expressed in constant 2000 USD.

Model used: ENV-linkages

Ownership: Organisation for Economic Co-operation and Development (OECD)

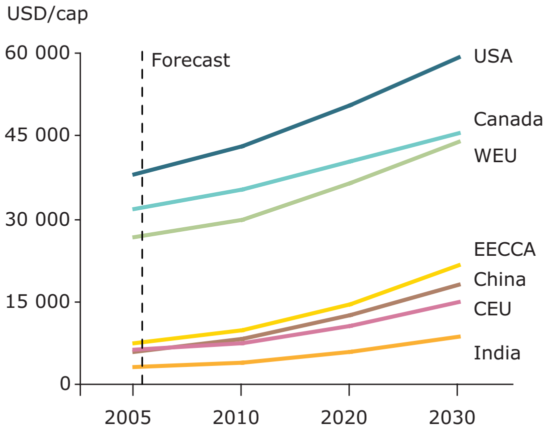
Temporal coverage: 2005–2030

Geographical coverage: Western Europe (WEU): Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom; **Central Europe (CEU):** Hungary, Poland, Czech Republic, Slovakia, Estonia, Latvia, Lithuania, Slovenia, Malta, Cyprus, Bulgaria, Romania, Albania, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Serbia and Montenegro; **EECCA:** Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, the Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **USA; Canada; India; China.**

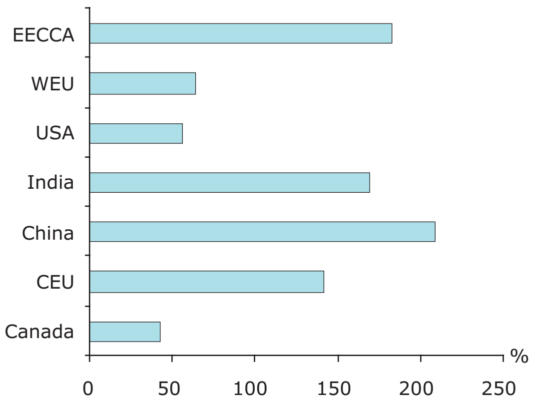
Policy question

What is the forecast of GDP ?

Gross domestic product per capita



Projected percentage change in GDP per capita from 2005 to 2030



Sources:

MNP (2008), OECD (2008). Netherlands Environmental Assessment Agency, and Organisation for Economic Co-operation and Development. Background report to the OECD Environmental Outlook to 2030. Overviews, details, and methodology of model-based analysis. Paris. 2008; EEA (2007). *Europe's environment — The fourth assessment*. European Environment Agency, 2007. EEA, Copenhagen.

Example assessment from 2008

In a no new policies scenario*, GDP is projected to continue to grow in absolute and per-capita terms in the whole pan-European region, more rapidly in the eastern parts, such as EECCA and SEE. Globally WEU, USA and Canada are projected to continue to have the highest GDP per capita. WEU will approach the levels of USA and Canada. However, the fastest-growing economies are expected to be China, India and EECCA.

GDP per capita is projected to increase globally, however at a quicker pace in EECCA, China, India and CEU. Although GPD per capita in WEU grows much more slowly (by 64 %) than in CEU (141 %) and EECCA (182 %), absolute values of GDP per capita in WEU in 2030 remains more than twice those in other European countries. The US is expected to have the highest GDP per capita in 2030, followed by Canada and WEU. China continues to be among the most impressively developing economies, with the highest increase in GDP per capita from 2000 to 2030 (more than 200 %). India stays below the world average, though with a large increase (169 %) from 2005 to 2030.

* *Projections are based on the baseline OECD scenario. The baseline is a no new policies scenario by design, without anticipating deliberate interventions requiring new or intensified policies in response to the projected developments. Population indicators were adopted from the most recently published UN demographic projection, and economic developments were taken from the economic baseline elaborated with the ENV Linkages model of the OECD.*

Policy context

Global context: At the global level problems of the growth of GDP and incomes of population are becoming ones of the most actual. Therefore, plethora of policies provides aims and goals concerning achievements of sustain GDP growth. The central aims have been provided within UN 'Millennium Development Goals' (1st goal to eradicate extreme poverty). It includes reduction of proportion people living on less than a dollar a day.

Pan-European and EECCA policy context: Almost all countries have their own programme of sustainable development with defined projections of GDP for further time periods.

EU context: At EU level there are some specific documents which cover development of poorest regions in EU (GDP is less than 75 % of average GDP in EU). Regional Policy was signed by EU parliament. The policy indices trends in higher GDP growth for such regions and defines main directions of investments to carry out that target. (Commission of the European Communities CEC (2001b): A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development (Commission's proposal to the Gothenburg European Council), COM (2001) 264 final, Brussels, 15.5.2001).

Model used — OECD model

Projections of domestic demand components and output (GDP) are made in 'real' terms, i.e. adjusted for inflation. Projections are made for the 2005–2050 period.

The OECD projections and the accompanying analysis have a clear focus on framing the policy debate in Member countries. Moreover, the OECD projection exercise distinguishes itself by a number of special features which are absent in most other forecasts:

1. The OECD assessments of the future trends of key macroeconomic variables are better characterised as conditional projections rather than forecasts, since they are conditional on a set of technical assumptions about nominal exchange rates and the path of oil- and non-oil commodity prices as well as on mandated macro policies. Thus, the OECD projections provide answers to questions like: 'What is likely to happen in country X if the government implements mandated fiscal measures?', or, 'On mandated policies, what kind of imbalances or pressure points are likely to develop over the next two years e.g. in the form of widening current account imbalances or higher unemployment?'. This in turn helps to identify potential problems in the economy and to foster a debate among policy makers about what can be done to achieve better outcomes.

2. The OECD projection process ensures that projections are consistent at the world level. First, consistency is sought through the OECD's 'internal' production process. The twice-yearly forecasting exercise starts with a broad exchange of views among OECD country experts and topic specialists. This provides a consistent starting point for the global outlook and its potential interactions with individual country projections through trade and financial linkages. Second, international consistency is ensured via a predetermined iteration process feeding through the OECD's INTERLINK world economic model, and by discussions between country and international trade experts.

3. There is a built-in 'reality check' as the OECD benefits from the participation of government experts and policy makers in arriving at its projections. The OECD holds extensive discussions on the projections and related analyses with Member country government experts and policy makers. The OECD meets with government and central bank economic forecasters to test its tentative conclusions against their knowledge of local conditions. The main lines of the Economic Outlook projections and analysis are presented to, and their policy implications discussed by, the OECD Economic Policy Committee, which is composed of senior officials from finance or economic ministries and central banks. Finally, country expertise is drawn from the surveys of Member and selected non-member economies published regularly by the OECD.

References

OECD, 2007. *Sources & Methods of the OECD Economic Outlook*. Organisation for Economic Co-operation and Development, Paris. Available online: http://www.oecd.org/document/14/0,3343,en_2649_34573_1847822_1_1_1_1,00.html.

Data specifications

Data set title	Source
Input data to the OECD model — Economic Database Inventory (National Statistical Institutes variables)	OECD
Output data from OECD model — GDP	OECD

Uncertainties

Methodology uncertainty

OECD projections are just that, projections and not predictions. Analysis enriches the projections and provides a framework for evaluating outcomes and recommending policy changes. As to the risks, analysis can only point to them, it cannot say precisely which ones will occur or when. Economics is not an exact science. It deals ultimately with human behaviour, which changes based on experience and expectations. And it must strive to adapt as economies and economic systems evolve. The OECD regularly reviews its projections for accuracy. A main purpose of these reviews is to isolate whether errors are due to data revisions, to the non-realization of underlying assumptions or to judgmental mistakes about economic conditions and forces shaping the outlook. Indeed sometimes projections show current policies leading to unsatisfactory outcomes, which may lead to policy changes, in turn showing up as (desirable) projection errors. Large projection errors typically occur around major turning points in economic activity. The reasons for this are subject to debate. They may be due to lapses in judgement or a decline in the predictive power of the information available at cyclical turning points. On the latest assessment of the accuracy of the OECD projections see Koutsogeorgopoulou (2000) and Lenain (2002).

Data uncertainty

No uncertainty has been specified.

Rationale uncertainty

As merely a gross measure of market activity, GDP only counts money transactions. The more things are excluded, such as care for the elderly and for children, home maintenance and cleaning, food preparation, and voluntary service for neighbourhood, church, and civic groups. This can be a serious problem in the economies of less-developed nations, where much production takes place in the household economy.

Furthermore, while GDP ignores everything that happens outside the realm of monetized exchange, regardless of the importance to well-being. It is outlined a number of similar situations under which GDP growth results from negative occurrences in society, including spending on stress treatment and other medical costs, ATM fees, traffic, gambling, and spending into debt and paying interest.

Moreover, GDP treats depletion of natural capital (assets) as current income — an obvious violation of good accounting principles. In addition, in the past when economists used gross national product (GNP) instead of GDP, it meant that the earnings of a multinational firm were attributed to the country where the firm was owned — and where the profits would eventually return.

More information about term uncertainty should be found at: http://www.wscsd.org/ejournal/article.php3?id_article=121.

Theme: Socio-economic

Indicators: SE_F02 — Total population — outlook from UNSTAT

Definition: Population includes all residents regardless of legal status and citizenships.

Model used: UN Population model

Ownership: United Nations Statistical Division (UNSTAT)

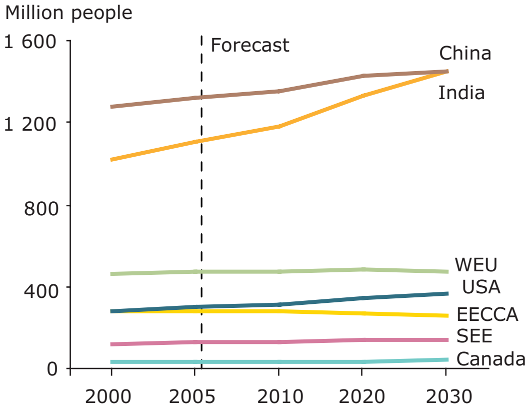
Temporal coverage: 2000–2030

Geographical coverage: Western Europe (WEU): Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom; **Central Europe (CEU):** Hungary, Poland, Czech Republic, Slovakia, Estonia, Latvia, Lithuania, Slovenia, Malta, Cyprus, Bulgaria, Romania, Albania, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Serbia and Montenegro; **EECCA:** Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, the Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; **USA; Canada; India; China.**

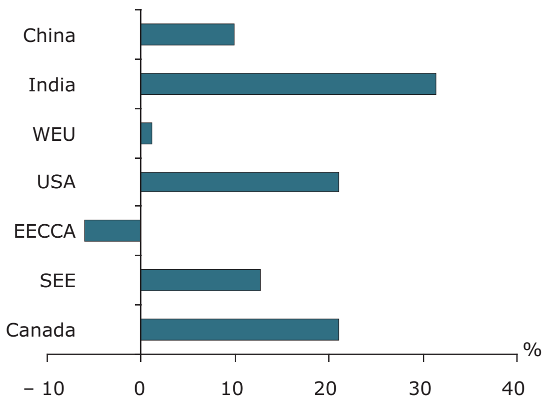
Policy question

What is the forecast of population growth?

Population from 2000 to 2030



Projected percentage change in total population from 2005 to 2030



Sources:

United Nations Population Division, 2007. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision.*

EEA (2007). Europe's environment — The fourth assessment. European Environment Agency, 2007. EEA, Copenhagen.

Example assessment from 2007

Total world population is projected to grow, with wide regional variations. China and India are likely to have the largest populations and maintain one of the highest growth rates in the world (especially India). In contrast, the EECCA population is forecasted to fall below the 2005 level. Other European regions are expected to have a small increase in population, taking migration factors into account.

Trends in Europe from 2005 to 2030 are expected to vary between regions. The WEU population grows by only 1.1 % to around 477 million. The highest growth (16 %) is projected for SEE, from 127 million in 2005 to more than 142 million in 2030. The population in EECCA decreases by 6.1 %, from 277 million in 2005 to 260 million by 2030. The most-populated countries, India and China, continue to grow with the largest increase (31 %) in India, with the population overtaking that in China around 2030. The total population of Canada and USA increases from 330 million in 2005 to 400 million by 2030.

Policy context

In general, demographic patterns are key to how environmental challenges unfold since they govern consumption and determine the demand for and use of resources, goods and environmental services. Generally speaking, population size and density within a region give a first indication of pressures on environmental resources, such as air pollution, freshwater use, land use and soil degradation, as well as biodiversity loss. The age structure of populations also inevitably shapes their consumption patterns and demands for environmental services.

There are no pan-European, EU and EECCA policies regulating total population. However, several of demographical strategies and policies exist at regional and national levels as well as migration legislations. Across the pan-European region, countries are seeking to halt immigration: the Russian Federation has proposed restrictive immigration laws, while the EU has stepped up the control of illegal immigration across its borders and partial restrictions across some EU Member States.

Model used — UN population model

The preparation of each new revision of the official estimates and projections of the United Nations involves two distinct processes: (a) the incorporation of all new and relevant information regarding the past demographic dynamics of the population of each country or area of the world; and (b) the formulation of detailed assumptions about the future paths of fertility, mortality and international migration. The data sources used and the methods applied in revising past estimates of demographic indicators (i.e., those referring to 1950–2005) are presented in volume III of World Population Prospects: The 2006 Revision (forthcoming).

The future population of each country is projected from an estimated population for 1 July 2005. Because actual population data is not necessarily available at this date, the 2005 estimate is based upon the most recent population data available for each country, derived usually from a census or population register, updated to 2005 using all available data on fertility, mortality and international migration. In cases where very recent data are not available, estimated demographic trends are short term projections from the most recent available data. Population data from all sources are evaluated for completeness, accuracy and consistency, and adjusted where necessary.

To project population until 2050, the United Nations Population Division applies assumptions regarding future trends in fertility, mortality, and migration. Because future trends cannot be known with certainty, a number of projection variants are produced.
This note presents the assumptions underlying the derivation of demographic indicators for the period starting in 2005 and ending in 2050. The 2006 Revision includes seven projection variants and three AIDS scenarios. The seven variants are: low, medium, high, constant-fertility, instant-replacement-fertility, constant-mortality, and zero-migration. The World Population Prospects Highlights focus on the medium variant of the 2006 Revision, and results from the first four variants are available on-line and traditionally published in volume I of World Population Prospects (forthcoming). The full set of results for all variants and scenarios are available only on CD-ROM.

The first five variants, namely, low, medium, high, constant-fertility and instant-replacement-fertility, differ among themselves exclusively in the assumptions made regarding the future path of fertility. The sixth variant, named constant-mortality, differs from the medium variant only with regard to the path followed by future mortality. The seventh variant, named zero-migration, differs from the medium variant only with regard to the path followed by future international migration. Variants differ from each other only for the period 2005–2050.

In addition, the 2006 Revision includes three AIDS scenarios named No-AIDS, high-AIDS and AIDS-vaccine. These scenarios are variations of the medium variant and differ from each other and from that variant on the path of mortality because they are based on different assumptions regarding the course of the HIV/AIDS epidemic. Note that only 62 countries are considered to be significantly affected by the epidemic. Consequently, the AIDS scenarios produce different projections only for those countries.

References

'Chapter VI. Methodology of the United Nations population estimates and projections' (pp. 100–104) in *World Population Prospects: The 2004 Revision, Volume III: Analytical Report*.

Data specifications

Data set title	Source
Input to UN population model — population data from national statistics	United Nations population division
Input data to UN population Model — assumptions on fertility, mortality and migration	United Nations population division
Output from UN population model — total population projections	United Nations population division

Uncertainties

Methodology uncertainty

N/A.

Data uncertainty

The future population of each country is projected starting with an estimated population for 1 July 2005. Because population data are not necessarily available for that date, the 2005 estimate is derived from the most recent population data available for each country, obtained usually from a population census or a population register, projected to 2005 using all available data on fertility, mortality and international migration trends between the reference date of the population data available and 1 July 2005. In cases where recent data on the components of population growth are not available, estimated demographic trends are projections based on the most recent available data. Population data from all sources are evaluated for completeness, accuracy and consistency, and adjusted as necessary[1].

Rationale uncertainty

N/A.

Annex 1 Outlook trends in the pan-European region

Example of the presentation of assessments of forward-looking indicators from various sources in the consistent manner

This Annex presents forward-looking indicators on the state of the environment in the pan-European region in the percentage of their expected change. The indicators are derived from studies developed by a number of international organisations. Different organisations use different regional definitions, which makes it difficult to provide an overview of future pan-European developments. In this Annex, however, an attempt is made to cluster the forward-looking indicators by sub-regions: Western and Central Europe (WCE), South Eastern Europe (SEE) and Eastern Europe, Caucasus, and Central Asia (EECCA) and present their respective procedural change.

Table Annex The pan-European region, sub-regions and countries (based on Belgrade report; EEA, 2007)

Region (Group)	Sub-groups		Countries
Western & Central Europe (WCE)	EU-25	EU-15	Austria (AT), Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES), Sweden (SE), United Kingdom (GB)
		EU-10	Cyprus (CY), Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT), Poland (PL), Slovakia (SK), Slovenia (SI)
	European Free Trade Association (EFTA)		Iceland (IS), Liechtenstein (LI), Norway (NO), Switzerland (CH)
	Other WCE countries		Andorra (AD), Monaco (MC), San Marino (SM)
EECCA countries	Caucasus		Armenia (AM), Azerbaijan (AZ), Georgia (GE)
	Central Asia		Kazakhstan (KZ), Kyrgyzstan (KG), Tajikistan (TJ), Turkmenistan (TM), Uzbekistan (UZ)
	Eastern Europe		Belarus (BY), Republic of Moldova (MD), Russian Federation (RU), Ukraine (UA)
South Eastern Europe (SEE)	Western Balkans		Albania (AL), Bosnia-Herzegovina (BA), Croatia (HR), the former Yugoslav Republic of Macedonia (MK), Serbia (RS)*, Montenegro (ME)*
	Other SEE countries		Bulgaria (BG)**, Romania (RO)**, Turkey (TR)

** **Note**: Bulgaria and Romania joined the European Union on 1 January 2007.

Table Other country groupings used in Annex 2

Region (Group)	Sub-groups	Countries
Western & Central Europe (WCE)	OECD-Europe	EU-15, EFTA, plus TU, CZ, SK, PL, HU
	Western Europe	EU-15, plus IS, NO, CH, MT
	Baltic States	EE, LT, LV
	Baltic States plus MT, CY	CY, EE, LV, LT, MT
EECCA countries	EECCA	AM, AZ, BY, GE, KZ, KG, RU, MD, TJ, TM, UA, UZ
	EECCA-7	AM, AZ, BY, KG, MD, RU, UA
	EECCA w/o Russia	AM, AZ, BY, GE, KZ, KG, MD, TJ, TM, UA, UZ
	EE (Eastern Europe)	BY, MD, UA, European part of RU
South Eastern Europe (SEE)	SEE w/o Turkey	AL, BA, BG, HR, MK, RO, RS, ME
	Western Balkans + Bulgaria	AL, BA, BG, HR, RS, ME, MK

Source: *The pan-European environment: Glimpses into an uncertain future*, EEA Report No 4/2007.

Forward-looking indicators for the pan-European region

Indicator	Time	WCE region		EECCA region		SEE region		Source
Population	2000 to 2030	WCE	+ 1 %	EECCA	– 6.1 %	SEE	+ 16 %	World population prospects. UN Population Division, 2007.
GDP	2005 to 2030	EU-15	+ 64 %	EECCA	+ 182 %	SEE w/o Turkey	+ 141 %	OECD Outlook, OECD (forthcoming).
		EU-10	+ 141 %					
Working age population per one person over 65	2000 to 2020	WCE	– 53 %	EECCA	– 51 %	SEE	– 61 %	World population prospects. UN Population Division, 2007.
Emissions of acidifying pollutants (SO_2)	2000 to 2020	EU-25	– 63 % to – 85 %	EECCA	– 1.5 %	SEE	– 33 %	EMEP Inventory Review. EMEP, 2005.
Emissions of acidifying pollutants (NO_X)	2000 to 2020	EU-25	– 46 % to – 69 %	EECCA	+ 48 %	SEE	– 16 %	
Emissions of acidifying pollutants (NH_3)	2000 to 2020	EU-25	– 5 % to – 42 %	EECCA	+ 36 %	SEE	+ 5 %	
Emissions of ozone precursors (NO_X)	2000 to 2020	EU-25	– 46 % to – 69 %	EECCA	+ 48 %	SEE	– 16 %	EMEP Inventory Review. EMEP, 2005.
Emissions of ozone precursors (HMVOC)	2000 to 2020	EU-25	– 45 % to – 62 %	EECCA	+ 38 %	SEE	– 26 %	
Emission of PM ($PM_{2.5}$)	2000 to 2020	EU-25	– 39 % to – 73 %	EECCA	– 2.4 %	SEE	– 13 %	EMEP Inventory Review. EMEP, 2005.
Emission of PM (PM_{10})	2000 to 2020	EU-25	– 38 % to – 67 %	EECCA	– 2.6 %	SEE	– 15 %	
Meat consumption per capita	2005 to 2015	EU-15	+ 0.3 %	EECCA	+ 13 %	SEE	+ 18 %	U.S. and World Agricultural Outlook. FAPRI, 2005.
		EU-10	+ 16 %					
Cereals production (wheat)	2005 to 2025	EU-15	+ 2.5 %	EECCA	+ 5 %	SEE	+ 5 %	
		EU-10	+ 11 %					
Municipal waste generation	2005 to 2020	EU-15	+ 26 %	EECCA-7	+ 138 %	RO and BU	+ 6 %	Projection of municipal waste for selected EECCA countries. ETC RWM, 2007.
		EU-10	+ 11 %					
Water Withdrawals	1995 to 2070	Western Europe w/o Austria CZ, HU, PL, SK, SL	– 18 % + 202 % + 130 %	Eastern Europe	+ 130 %	SEE w/o Turkey	+ 202 %	Euro Wasser: Model-based assessment of European Water Resources. CESR, University of Kassel, 2001.
		Baltic States						
Renewable energy consumption	2004 to 2030	OECD Europe	+ 118 % to + 155 %	EECCA w/o Russia	+ 61 % to + 75 %	Western Balkans + Bulgaria	+ 61 % to + 75 %	World energy outlook 2006. © OECD/IEA (2006), tables for Reference and Alternative Policy Scenario Projections, as modified by the EEA
		Baltic States plus MT, CY	+ 61 % to + 75 %	Russia	+ 10 % to + 15 %			
Electricity consumption per capita	2004 to 2030	OECD Europe	+ 18 % to + 38 %	EECCA w/o Russia	+ 46 % to + 58 %	Western Balkans + Bulgaria	+ 46 % to + 58 %	
		Baltic States plus MT, CY	+ 46 % to + 62 %	Russia	+ 55 % to + 70 %			

Indicator	Time	WCE region		EECCA region		SEE region		Source
Total energy consumption per capita	2004 to 2030	OECD Europe	+ 10 %	EECCA w/o Russia	+ 32 %	Western Balkans + Bulgaria	+ 32 %	
		Baltic States plus MT, CY		Russia	+ 52 %			
Final energy consumption per capita	2004 to 2030	OECD Europe	+ 17 %	EECCA w/o Russia	+ 41 %	Western Balkans + Bulgaria	+ 41 %	
		Baltic States plus MT, CY	+ 41 %	Russia	+ 51 %			
GHG emissions from National communications	2000 to 2020	EU-15	+ 6.5 %	EECCA	+ 15 %	SEE	+ 14 %	National Communications on Climate Change. UNFCC, 1997–2007.
		EU-10	+ 14 %					
Energy-related CO_2 emissions	2004 to 2030	OECD Europe	+ 6 % to + 14 %	EECCA w/o Russia	+ 9 % to + 25 %	Western Balkans + Bulgaria	+ 9 % to + 25 %	World energy outlook 2006. © OECD/IEA (2006), tables for Reference and Alternative Policy Scenario Projections, as modified by the EEA
		Baltic States plus MT, CY	+ 9 % to + 25 %					
Projection of temperature change	2000 to 2050	EU-25	+ 1°C to + 3.0 °C	EECCA	+ 1°C to + 3.0 °C	SEE	+ 1 °C to + 3.4 °C	National Communications on Climate Change, IPCC scenarios. UNFCC, 1997–2007.
Projection of precipitation change	2000 to 2050	EU-25	+ 2 % to + 3 % (4)	EECCA	– 6.1 % to + 35 %	SEE	– 5,4 % to + 26 %	National Communications on Climate Change. IPCC scenarios. UNFCC, 1997–2007.
Passenger transport demand, Baseline scenario	2000 to 2050	OECD Europe	+ 145 %	EECCA	+ 267 %	SEE w/o Turkey	+ 248 %	The Sustainable mobility project. WBCSD, 2002.
		PL, SK, SI	+ 248 %					
Freight transport demand	2000 to 2050	OECD Europe	+ 105 %	EECCA	+ 194 %	SEE w/o Turkey	+ 303 %	
		PL, SK, SI	+ 303 %					
Car ownership	2000 to 2050	OECD Europe	+ 46 %	EECCA	+ 347 %	SEE w/o Turkey	+ 174 %	
		PL,SK, SI	+ 174 %					
Fertiliser consumption	1997/1999 to 2030	Western Europe	+ 18 %	EECCA	+ 32 %	AL, BA, BG, HR	32 %	World Agriculture: Towards 2015/2030. A FAO Perspective. FAO, 2003
		Baltic States plus MT, CY	+ 32 %					
Mean Species Abundance	2000 to 2050	EU-25	– 12 %	EECCA	– 5 %	n/a		Cross-roads of Planet Earth's Life Exploring means to meet the 2010 biodiversity Target. MNP, 2006.
Tourist arrivals	2000 to 2020	WCE	+ 82 %	EECCA	+ 280 %	SEE	+ 289 %	Tourism 2020 Vision: Global Forecast and Profiles of Segments. WTO, 2002.
		EU-10	+ 280 %					

(4) Average European precipitation change. EEA, 2005.

Annex 2 Overview of available past and forward-looking indicators for Western Balkan countries

This annex presents overview of available data in Western Balkan region: past trend indicators related to EEA Core set indicators and correspondent outlooks. The work is still in progress. Availability of past data was assessed on the country level, and for the availability of outlooks, national and international models were considered. The assessment was made if an overall regional assessment could be made on the bases of available data. If this is possible, assessment will be made in the next stages of the work.

Past trend indicators

 – data is available in for West Balcan country and is easily compatible

 – data is available at the national level, but not compatible, countries use different methodologies for calculation of the indicator

 – data is not available
n/r — indicator is not relevant for the particular country
? — additional research is needed to identify availability.

Forward-looking indicators

 – data is available from different models on the country level and outlook can be build for the SEE region

 – data is available from the models of international organizations, but SEE is a part of a larger group of countries, such as Transition Economies (25 countries out of which 6 are SEE), Central Europe (17 countries out of which 7 are SEE) or Eastern Europe (10 countries out of which 7 are SEE)

 – data not available

n/r — not relevant as a future related indicator

Abbreviations in Annex 2 table	
AL	Albania
BA	Bosnia and Herzegovina
HR	Croatia
MK	the former Yugoslav Republic of Macedonia
RS	Serbia
ME	Montenegro

Source: The Environment in South-Eastern Europe: Trends and perspectives (household consumption, coast, seas) (EEA forthcoming, 2007 draft); UNEP/GRID-Arendal special research 2006/2007, implemented by Jasmina Bogdanovic.

EEA Core set of indicator		Past trend indicators							Forward-looking indicators						
		Available data						Assessment for the region possible	Available data						Assessment for the region possible
		AL	BA	HR	MK	RS and ME	region		AL	BA	HR	MK	RS and ME	region	
CSI 001	Emissions of acidifying substances	☹	😐	🙂	🙂	😐		Assessment at regional level is not possible.	🙂	🙂	🙂	🙂	🙂	🙂	SO_2: − 33 % NO_x: − 16 % NH_3:+ 15 % From 2000 to 2020
									Note: Smileys relate to NO_x, CO, NMVOCs; CH_4 is not included						
CSI 002	Emissions of ozone precursors	☹	😐	🙂	😐	?		Assessment at regional level is not possible.	🙂	🙂	🙂	🙂	🙂	🙂	?
CSI 003	Emissions of primary particles and secondary particulate precursors	☹	☹	🙂	☹	🙂		Assessment at regional level is not possible.	🙂	🙂	🙂	🙂	🙂	🙂	$PM_{2.5}$: − 13 % PM_{10}: − 15 % From 2000 to 2020
CSI 004	Exceedance of air quality limit values in urban areas	😐	😐	😐	😐	😐		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	☹	
CSI 005	Exposure of ecosystems to acidification, eutrophication and ozone	☹	☹	😐	☹	☹		Assessment at regional level is not possible. Regional basis.	☹	☹	☹	☹	☹	☹	
CSI 006	Production and consumption of ozone depleting substances	🙂	🙂	🙂	🙂	🙂	🙂	Consumption ODSs: − 89 % From 1995 to 2005.	☹	☹	☹	☹	☹	☹	
CSI 007	Threatened and protected species	🙂	😐	🙂	🙂	😐		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	☹	
CSI 008	Designated areas	😐	😐	😐	😐	😐		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	☹	
CSI 009	Species diversity		😐	🙂	😐	😐		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	☹	
CSI 010	Greenhouse gas emissions and removals	🙂	😐	🙂	🙂	☹		Assessment at regional level is not possible.				n/r			?
CSI 011	Projections of greenhouse gas emissions and removals	🙂	😐	🙂	🙂	😐		Assessment is possible, but not produced yet.	🙂	😐	🙂	🙂	😐	😐	+ 14 % from 2000 to 2020
CI 012	Global and European temperature	🙂	🙂	🙂	🙂	🙂		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	🙂	+ 3.1 % from 2000 to 2100
CSI 013	Atmospheric greenhouse gas concentrations	😐	☹	☹	🙂	☹		Assessment at regional level is not possible.	☹	☹	☹	☹	☹	☹	
CSI 014	Land take	🙂	🙂	🙂	🙂	🙂	😐	Assessment exists, but should be revised.	☹	☹	☹	☹	☹	☹	

EEA Core set of indicator		Past trend indicators							Forward-looking indicators						
		Available data						Assessment for the region possible	Available data						Assessment for the region possible
		AL	**BA**	**HR**	**MK**	**RS and ME**	**region**		**AL**	**BA**	**HR**	**MK**	**RS and ME**	**region**	
CSI 015	Progress in management of contaminated sites	☹	☹	😐	😐	😐		Assessment at regional level is not possible.	☹	☹	☹	☹	☹	☹	
CSI 016	Municipal waste generation	😐	☹	☺	☺	☹	😐	+ 10 % from 2003 to 2005 **Note:** indicator has been calculated, based on one time data collection, excluding Republic of Montenegro and Republic of Serbia.	☹	☹	☹	☹	☹	☹	
CSI 017	Generation and recycling of packaging waste	☹	☹	☺	😐	☹		Assessment at regional level is not possible.	☹	☹	☹	☹	☹	☹	
CSI 018		😐	😐	☺	☺	😐		Assessment is possible, but not produced yet.	☹	☹	☹	☹	☹	😐 Available as Water withdrawals. WB is presented as part of a larger region together with the 10 new EU members, RO and BG.	+ 202 % from 1995 to 2075
CSI 019		☺	☺	☺	☺	☺	☺	– 25 % from 2000 to 2005.	☹	☹	☹	☹	☹	☹	
CSI 020	Nutrients in freshwater	☺	☺	☺	☺	☺	😐	Assessment exists, but should be revised. N: increased from 1998 to 2005.	☹	☹	☹	☹	☹	☹	
CSI 021	Nutrients in transitional, coastal and marine waters	☺	☺	☺	n/r	n/r	☺	P: decreased from 1998 to 2005. Coastal water (AL, BA, CRO): 97.1 % of compliance with national standards in 2005.	☹	☹	☹	☹	☹	☹	
CSI 022	Bathing water quality	☺	😐	😐	😐	😐	😐	Inland water: decrease to 50.2 % in MK in 2005 and decline of 23.3 % in RS since 1999	☹	☹	☹	☹	☹	☹	

EEA Core set of indicator		**Past trend indicators**							**Forward-looking indicators**						
		Available data						Assessment for the region possible	Available data						Assessment for the region possible
		AL	**BA**	**HR**	**MK**	**RS and ME**	**region**		**AL**	**BA**	**HR**	**MK**	**RS and ME**	**region**	
CSI 023	Chlorophyll in transitional, coastal and marine waters	😐	☹️	🙂	n/r	n/r (RS) ? (ME)		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	
CSI 024	Urban wastewater treatment	☹️	☹️	🙂	☹️	🙂		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	
CSI 025	Gross nutrient balance	☹️	☹️	😐	😐	☹️		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	
CSI 026	Area under organic farming	☹️	☹️	🙂	🙂	☹️		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	
CSI 027	Final energy consumption by sector	🙂	🙂	🙂	🙂	🙂		Assessment is possible, but not produced yet.	☹️	☹️	☹️	☹️	☹️	😐 WB is presented as part of a larger region — Transition Economies together with BG, PL, RO, SL, SK.	+ 41 % (FEC per capita) from 2004 to 2030
CSI 028	Total energy intensity	🙂	🙂	🙂	🙂	🙂		Assessment is possible, but not produced yet.	☹️	☹️	☹️	☹️	☹️	☹️	Possible to calculate (data needs to be extracted)
CSI 029	Total energy consumption by fuel	🙂	🙂	🙂	🙂	🙂		Assessment is possible, but not produced yet.	☹️	☹️	☹️	☹️	☹️		+ 32 % (TEC per capita) from 2004 to 2030
CSI 030	Renewable energy consumption	🙂	🙂	🙂	🙂	🙂		Assessment is possible, but not produced yet.	Assessment is possible, but not produced yet.	☹️	☹️	☹️	☹️	☹️	+ 61 % to + 75 % from 2004 to 2030
CSI 031	Renewable electricity	🙂	🙂	🙂	🙂	🙂	🙂	− 2 % from 1999 to 2004.	Assessment is possible, but not produced yet.	☹️	☹️	☹️	☹️		+ 39 % from 2004 to 2030
CSI 032	Status of marine fish stocks	🙂	?	☹️	n/r	n/r (RS) ? (ME)		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	
CSI 033	Aquaculture production	😐	?	🙂	n/r	☹️ (RS) ? (ME)		Assessment at regional level is not possible.	☹️	☹️	☹️	☹️	☹️	☹️	

EEA Core set of indicator	Past trend indicators							Forward-looking indicators						
	Available data						Assessment for the region possible	Available data						Assessment for the region possible
	AL	**BA**	**HR**	**MK**	**RS and ME**	**region**		**AL**	**BA**	**HR**	**MK**	**RS and ME**	**region**	
CSI 034 Fishing fleet capacity	🙂	n/r	🙂	n/r	n/r (RS) ? (ME)	🙂	Power: + 43 % Tonnage: + 59 % Number of vessels: + 26 % From 2000 to 2003.	🙁	🙁	🙁	🙁	🙁	🙁	
CSI 035 Passenger transport demand	🙂	?	🙂	😐	🙂		Assessment at regional level is not possible	🙁	🙁	🙁	🙁	🙁	😐 WB is presented as part of a larger region — together with BG, PL, RO, SL, SK.	+ 248 % from 2000 to 2050 + 303 % from 2000 to 2050 Possible to calculate (data needs to be extracted)
CSI 036 Freight transport demand	🙂	?	🙂	😐	🙂		Assessment at regional level is not possible.	🙁	🙁	🙁	🙁	🙁		
CSI 037 Use of cleaner and alternative fuels	🙁	?	😐	😐	?		Assessment at regional level is not possible.	🙁	🙁	🙁	🙁	🙁		

Annex 3 List of references reviewed in 2006 for the forward-looking indicators input to the EEA Indicator Management Service — outlooks

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Annex 4 List of forward-looking indicators for SEE and EECCA but not included in the EEA Indicator Management Service — outlooks

List of forward-looking indicators for SEE and EECCA which were identified through the literature review in 2006 but not included in the EEA Indicator Management Service — outlooks

Theme: Agriculture

Meat production — outlook from FAPRI
Meat production — outlook from FAO
Cereals production&consumption — outlook from FAPRI
Cereals production&consumption — outlook from FAO
Oil crops — outlook from FAO
Vegetable oils — outlook from FAO

Theme: Air

Ammonia emissions by the livestock — outlook from FAO
Exeedence of critical levels for ozone — outlook from OECD
Exceedence of critical ozone loads for sensitive ecosystems — outlook from OECD

Theme: Biodiversity

Spatial distribution of biodiversity — outlook from MNP
Change in forest ecosystems composition due to climate change — outlooks from National Communication on Climate Change under UNFCCC

Theme: Climate change

GHG emissions (CO_2, CH_4, N_2O, PFCs, HFCs, SFs) — outlook from IIASA
Gross carbon sequestration per year by cropland soils — outlook from FAO

Theme: Energy

Total energy consumption by fues and sector — outlooks from National Communication on Climate Change under UNFCCC
Final energy consumption — outlooks from National Communication on Climate Change under UNFCCC
Total energy intensity — outlooks from National Communication on Climate Change under UNFCCC
Electric power generation and installed capacity — outlook from UNECE
Total oil production — outlook from USEIA
Change in developed hydropower potential — outlook from University of Kassel

Theme: Terrestrial

Soil errosion due to climate change – outlooks from National Communication on Climate Change under UNFCCC

Theme: Transport

Global passenger air travel, OECD

Theme: Water

Percentage change in annual water availability — outlook from University of Kassel
Water use by sector — outlook from University of Kassel
Water stress — outlook from University of Kassel
Area with severe water stress — outlook from University of Kassel
Population leaving in areas with severe water stress — outlook from University of Kassel
Population with access to safe drinking water — outlook from University of Kassel
Percentage of population without access to improved sanitation — UN prognosis

Abbreviations

EEA CSI	European Environmental Agency Core set of indicators
EECCA CSI	Eastern Europe Caucasus and Central Asia Core set of indicators
IMS	EEA Indicator Management Service
EECCA	Eastern Europe Caucasus and Central Asia
SEE	South Eastern Europe
WB	Western Balkans
EEA/ETC	EEA European Topic centre
FAO	Food and Agriculture Organisation
WBCSD	World Business council for sustainable development
LRTAP	Convention on Long-range Transboundary Air pollution, United Nation Economic Commission for Europe
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
MNP	The Netherlands Environmental Assessment Agency
OECD	Organisation for Economic Co-operation and Development
WTO	World Tourism Organisation
CAPSIM	Common Agricultural Policy Simulation Model
EMEP	European Monitoring and Evaluation Programme
GLOBIO	Global Methodology for Mapping Human Impacts on the Biosphere
GARP	Genetic Algorithm for Rule-Set Prediction
IMAGE	Integrated Model to Assess the Global Environment
RAINS	Regional Air pollution Information and Simulation
UN SPECA	United Nations Special Programme for the Economies of Central Asia
UNFCCC	United Nations Framework Convention on Climate Change
Water GAP	Water Global Assessment and Prognosis
NTA	National Tourism Association
WEM	World Energy Model
FAIR,	Framework to Access International Regimes for the Differentiations of Commitments
TIMER	Targets image energy regional model
EFTA	European Free Trade Association

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European Environment Agency

Catalogue of forward-looking indicators from selected sources
A contribution to the forward-looking component of a
shared environmental information system (SEIS/Forward)

2008 — 200 pp. — 21 x 29.7 cm

ISBN 978-92-9167-373-5
EEA Technical report series: ISSN 1725-2237
DOI 10.2800/48407

TH-AK-08-007-EN-N

European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: + 45 33 36 71 00
Fax: + 45 33 36 71 99

Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

ISBN 978-92-9167-373-5

9 789291 673735

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